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CAMBRIAN GEOLOGY AND PALEONTOLOGY

III

No. 5. CAMBRIAN TRILOBITES

(With Plates 45 to 67)

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INTRODUCTION

This is the third of a series of papers on Cambrian Geology and Paleontology that bears the title "Cambrian Trilobites." Reference to earlier papers may be found on page 160 of this volume.

The present paper deals principally with the species of the genera *Corynexochus, Dolichometopus, Bathyuriscus, Asaphiscus,* and *Blountia,* and more incidentally with species of the genera *Illænurus, Lisania, Marjumia, Maryvillia, Mesonacis, Ogygopsis,* and *Orria.*

The genus *Corynexochus* and its subgenus *Bonnia* are of special interest to the geologist, as the geographic distribution of the species *C. senectus* and the two closely related species of *Bonnia—C.* (*Bonnia*) *parvulus* and *C.* (*Bonnia*) *fieldensis*—afford a means of

comparing the Lower Cambrian fauna of the St. Lawrence-Newfoundland area with that of the Lower Cambrian Mount Whyte formation of the Canadian Rocky Mountain region adjoining the Canadian Pacific Railway. In these widely separated areas we find *Corynexochus senectus* and the closely related forms of *Bonnia—C.* (*B.*) *parvulus* and *C.* (*B.*) *fieldensis*—associated[1] with typical forms of the Mesonacidæ, two of which are illustrated on plate 45 of this paper. I hope in a future paper to consider this subject both from its stratigraphic and paleontologic aspects.

The genus *Coryncxochus* may have been the primitive type from which the more highly developed genera *Bathyuriscus* and *Dolichometopus* descended, or it may be that they had a common ancestor in early Lower Cambrian time. My first conclusion was to refer *Bathyuriscus* to the Bathyuridæ, but as the relations with *Corynexochus* became more apparent it seemed more in accord with what appeared to be the natural evolution of the Corynexochidæ to consider *Bathyuriscus* as linked with *Corynexochus* in a line of descent that passed into *Dolichometopus*. This would place the Bathyuridæ as an offshoot from some *Bathyuriscus*-like ancestor in late Cambrian or early post-Cambrian time.

The Middle Cambrian genera *Olenoides, Neolenus,* and *Oryctocephalus* have in the glabella, palpebral (ocular) ridge and pygidium characters that serve to bring the family Oryctocephalidæ Beecher close to the Corynexochidæ, and it is possible that *Olenoides* and *Neolenus* should be placed under the latter family or a subfamily of it.

I now have a considerable series of undescribed Cambrian trilobites that have been grouped under genera and species, and of which figures have been made for illustration. These will be studied and descriptions prepared for publication as opportunity permits.

DESCRIPTIONS OF GENERA AND SPECIES

Family Corynexochidæ Angelin

Corynexochidæ Angelin [1852] 1854, [1878] Pal. Scandinavica, 2d. ed., 1854, p. 59. (Names family under genus *Corynexochus* but does not describe it.)

Opisthoparia with cephalon and pygidium subequal in size or with pygidium smaller than the cephalon. Glabella usually expanded anteriorly and with only narrow limb and border in front. Eyes of medium to large size, with strong palpebral lobe and with palpebral

[1] See lists accompanying description of *Corynexochus senectus* (pp. 321-322).

(ocular) ridge crossing fixed cheek. Thorax with 7 to 11 segments; pleural furrows broad and usually straight. Pygidium more or less strongly ribbed. Surface of test apparently punctate and with irregular, inosculating, fine, sharp ridges which may be smooth or broken up into granulated ridges.

The typical genus of this family is *Corynexochus,* and of the subfamily Dolichometopinæ the typical genera are *Bathyuriscus* and *Dolichometopus. Corynexochus* and *Bathyuriscus* originate in the upper portion of the Lower Cambrian. *Corynexochus* has four Lower and five Middle Cambrian species. Its subgenus *Bonnia* is confined to the Lower Cambrian, as far as known. *Dolichometopus* with its large cephalon and pygidium has 13 Middle Cambrian species. *Bathyuriscus* has two species in the upper portion of the Lower Cambrian, *B. batis* and *B. primus,* and twenty species in the Middle Cambrian. The line of descent indicated in Cambrian time is from a *Corynexochus*-like ancestor to *Bathyuriscus* and *Dolichometopus.*

The pleural lobes of the pygidium of young specimens of *Dolichometopus* are ribbed as in *Corynexochus,* and thus suggest that the genus descended from a *Corynexochus*-like ancestor. The glabella and eyes of some forms of *Dolichometopus* approach some species of *Olenoides.*

The thoracic pleural segments of *Corynexochus* are often similar in character to those of *Dorypyge,* and there is also a resemblance in the glabella of some of the species of the subgenus *Bonnia.*

Genus *Corynexochus* Angelin.—Cephalon larger than the pygidium. Glabella expanded anteriorly and with glabellar furrows.

Subgenus *Bonnia.*—Glabella with sides subparallel and with slight traces of glabellar furrows.

Subfamily Dolichometopinæ.—Corynexochidæ with glabella expanded in front or with subparallel sides.

Genus *Dolichometopus* Angelin.—Cephalon and pygidium subequal in size. Glabella nearly smooth.

Genus *Bathyuriscus* Meek.—Cephalon usually larger than pygidium. Glabella with distinct furrows.

Genus CORYNEXOCHUS Angelin

Corynexochus Angelin, [1852] 1854, [1878] Pal. Scandinavica, 2d ed., 1854, p. 59. (Latin diagnosis of genus. First species, *C. spinulosus,* p. 59, pl. 33, figs. 9, 9*a,* 11?.)

Corynexochus Zittel, 1885, Handbuch d. Pal., Vol. 2, Munich, p. 602. (Brief diagnosis of genus.)

Karlia Walcott, 1889, Proc. U. S. Nat. Mus. for 1888, Vol. 11, p. 444. (Genus described.)

Corynexochus MATTHEW, 1899, Trans. Royal Soc. Canada, 2d ser., Vol. 5, Sec. 4, p. 47. (Mentions genus and describes new species, *C. romingeri.*)

Corynexochus LINDSTRÖM, 1901, Kongl. Sven. Vet.-Akad. Handl., Vol. 34, No. 8, p. 22. (Lists genus in connection with development of "facial ridge.")

Corynexochus GRÖNWALL, 1902, Danmarks Geol. Unders. Vol. 2, No. 13, Bornholms Paradoxideslag, p. 136. (Names *C. spinulosus* Angelin as the type and describes and illustrates the cranidium and associated pygidium; also describes and illustrates a new species, *C. bornholmiensis.*)

Karlia WALCOTT, 1916, Smithsonian Misc. Coll., Vol. 64, No. 3, p. 223. (Description reprinted from 1889 and type species illustrated.)

Description.—General form of dorsal shield longitudinally oval, moderately convex. Cephalon transversely semicircular with genal angles rounded or extended backward in sharp spines; marginal border narrow, rounded or slightly flattened; in front widening toward the genal angles; posterior margin and occipital ring defined by a well-marked furrow. The facial sutures cut the anterior margin so as to leave a small antero-lateral space next to the glabella and curve inward to the base of the eyes, over which they arch; back of the eyes they extend obliquely outward and backward nearly to the genal angles.

Glabella elongate, expanded anteriorly and contracting gradually in width from the little pits in which the dorsal furrows terminate anteriorly; marked in varying degrees of strength by two or three pairs of rather short lateral furrows, the posterior two pairs of which, if present, slope obliquely inward and backward.

Occipital ring clearly defined, broadly rounded and low, or narrow and high, with or without a median spine. On *Corynexochus senectus* it is without a spine (pl. 56, fig. 1). *Corynexochus spinulosus* has a small node at the center (pl. 55, fig. 1), and *Corynexochus bubaris* has a rather strong occipital spine (pl. 56, fig. 3*c*). Occipital furrow varying in width and depth, but distinct and clear in all species.

Fixed cheeks moderately convex, with large, roughly triangular postero-lateral limbs, narrow to medium width of central section, and small antero-lateral limbs; palpebral lobes one-sixth to one-fourth the length of the cranidium with a narrow palpebral ridge coming around the eye and extending obliquely inward and forward across the fixed cheek to the dorsal furrow beside the glabella. Free cheeks narrow, usually with a genal spine, but may be rounded posteriorly as in *C. minor* (pl. 55, fig. 6).

Thorax with 7 (*C. minor*) or 8 (*C. bubaris*) segments; strongly trilobed and moderately convex; pleural lobes flattened, with the segments terminating rather abruptly in blunt points (*C. minor*) or rounded (*C. stephenensis*); pleural furrow broad, straight with narrow margins from dorsal furrow to where it abruptly narrows near the termination of the segment.

Pygidium semicircular in outline, moderately convex, strongly lobed, and with a narrow, well-defined, slightly rounded border that has two or more short, sharp marginal spines projecting from it; axial lobe with 3 to 5 rings and a terminal section; pleural lobes marked by 3 to 5 flat segments that are separated by shallow furrows, and with only the faintest trace of pleural furrows.

Hypostoma (pl. 55, fig. 6*a*) much like that of *Bathyuriscus*.

Surface of test punctate in varying degree owing to size and number of punctæ; it is often marked by fine, irregular, inosculating ridges that may be sharp and unbroken or broader and carrying small tubercles so as to give a granular appearance to the surface (*C. bubaris*, p. 314).

Dimensions.—Most of the species are small. *Corynexochus bubaris*, the largest, reaches 25 to 30 mm. in length, and *C. minor* rarely more than 5 mm.

Genotype.—*Corynexochus spinulosus* Angelin [Pal. Scandinavica, 1854, p. 59].

Stratigraphic range.—*Corynexochus senectus, C. brennus, C. bubaris, C. clavatus,* and *C. capito* occur in the upper portion of the Lower Cambrian on the eastern side of the North American Continent. From the Middle Cambrian, *C. spinulosus, C. bornholmiensis, C. delagei* from northwestern Europe, *C. minor* from eastern Newfoundland, and *C. stephenensis* from eastern British Columbia and southern Idaho.

Geographic distribution.—This has been outlined above under Stratigraphic Range.

Observations.—It was not until Grönwall published figures of *Corynexochus spinulosus* in 1902 that the type of genus was made known so that it could be compared with other forms. Angelin's figures are too diagrammatic, as may be seen by comparing them with Grönwall's. The cranidium of *Corynexochus* is somewhat similar to that of *Dolichometopus*, but a comparison of the figures of the types of the two species (compare figs. 3, 4, pl. 50, with figs. 1, 1*a*, pl. 55) shows marked differences. *Corynexochus* also differs from *Bathyuriscus* (pl. 46, figs. 2, 2*a-b*) in its glabella, fixed cheeks, thorax, etc.

Grönwall, in writing of *Corynexochus,* stated that the genus was " founded by Angelin on two species: *C. spinulosus* from the Andrarum limestone, of which the head is known and the pygidium is cited with ?, and *C. umbonatus* from the *Orthoceras* limestone, of which only the pygidium is known. The former pygidium is of a type which can hardly belong to the head figured, hence it is best to follow Matthew's example, and consider the head of *C. spinulosus* as a type for the genus, which doubtless should be referred to the Olenidæ, and placed near *Dolichometopus.*" [1] The second species, *C. umbonatus,* clearly does not belong under *Corynexochus.*

Through the courtesy of Professor Gerhard Holm, of Stockholm, and the kindness of Dr. Karl Grönwall, I have received wax impressions of Angelin's type specimens of *Corynexochus spinulosus* on which he based his description and illustrations. By comparison of these with the cranidia of *C. minor* (pl. 55, figs. 6, 6*a-d*) it appears that *C. minor* is a representative form of the genus. It has the same type of cranidium (compare figs. 1 and 6*b,* pl. 55), and the associated pygidium is similar. This indicates that the dorsal shield of *C. spinulosus* was similar in form to that of *C. minor. Corynexochus senectus* (pl. 55, figs. 7, 7*a*; pl. 56, figs. 1, 1*a-g*) has a less expanded glabella, but with that exception it is as far as known congeneric with *C. spinulosus.* For the species having a glabella with subparallel sides I have proposed the subgenus *Bonnia.*

Species of Corynexochus.—The species now referred to *Corynexochus* are:

Corynexochus bornholmiensis Grönwall (pl. 55, fig. 2), Middle Cambrian.
Corynexochus brennus Walcott (pl. 57, fig. 3), Lower Cambrian.
Corynexochus bubaris Walcott (pl. 56, fig. 2), Lower Cambrian.
Corynexochus capito Walcott (pl. 57, fig. 2), Lower Cambrian.
Corynexochus clavatus (Walcott) (pl. 55, fig. 4), Lower Cambrian.
Corynexochus delagei Miquel (pl. 55, fig. 3), Middle Cambrian.
Corynexochus minor Walcott (pl. 55, fig. 6), Middle Cambrian.
Corynexochus senectus (Billings) (pl. 56, fig. 1), Lower Cambrian.
Corynexochus spinulosus Angelin (pl. 55, fig. 1), Middle Cambrian.
Corynexochus stephenensis (Walcott) (pl. 55, fig. 5) Middle Cambrian.

Generic reference of species heretofore placed under Corynexochus and now referred as follows:

Corynexochus romingeri Matthew = *Corynexochus stephenensis* (Walcott).
Corynexochus ? umbonatus Angelin = *Aeglina.*

[1] Bornholms Paradoxideslag, Danmarks Geol. Undersøgelse, Vol. 2, No. 13, 1902, p. 136.

CORYNEXOCHUS BORNHOLMIENSIS Grönwall

Plate 55, figs. 2, 2*a-b*

Corynexochus bornholmiensis GRÖNWALL, 1902, Danmarks Geol. Unders., Vol. 2, No. 13, Bornholms Paradoxideslag, p. 137, pl. 4, figs. 1*a*, 1*b*, 2; p. 217. (Described and figured as a new species.)

Original description (in substance).—" Only the central part of the head and the tail are known. Head anteriorly without a sharp margin, curved, with a considerably expanded front. Dorsal grooves diverge from the back toward the front, and end in a small pit; they are somewhat depressed posteriorly so that the front is club-formed or somewhat pear-shaped. The front is anteriorly broadly rounded, and in this place twice as broad as at the occipital ring. There are either no lateral grooves, or two to three pairs, very weak and short. The branches of the facial suture cut off a small part of the anterior border outside of the front, and diverge strongly, going in an almost straight line to the posterior margin of the head, whereby the fixed cheeks attain an almost triangular periphery. The eyes are crescentic in shape, medium large, occupying the foremost half of the distance from the front to the posterior margin of the head. The cheeks are pretty strongly curved, but not so smooth as the front. The occipital groove is distinct, broadest along the outside. The occipital ring narrow, with a little, short spine.

" The pygidial shield is almost flat, about semicircular in form, and retains its border. The median lobe is distinctly delineated, narrow, and almost the length of the entire pygidium; it has 4 or 5 segments, which in the flat lateral lobes appear as indistinct ribs alternating with the rings on the median lobe.

" The cranidium is flat, with fine, depressed points.

" Dimensions:

Length of head	5	mm.
Width of head	6	"
Width of glabella anteriorly	3.5	"
Width of occipital ring	1.5	"

" Two specimens of the head and two of the tail are in the Mineralogical Museum, associated with *Paradoxides tessini* and *Agnostus parvifrons* from Borregaard, Øle Aa. In the Museum of Stockholm there are 13 specimens of the head and six of the tail, which the writer examined through the courtesy of Professor Lindström. All are preserved in limestone, labeled Bornholm, which contains only very little of other petrifactions. One specimen is associated with *Agnostus nathorsti, Hyolithes socialis, Acrotreta*

socialis, and *Raphistoma ? bröggeri.* These fossils show that the species is from about the Andrarum limestone horizon.

Formation and locality.—Middle Cambrian: Limestone at Borregaard, Bornholm Island, Denmark.

CORYNEXOCHUS BRENNUS, new species

Plate 57, figs. 3, 3*a-b*

This species came from a boulder of light gray arenaceous limestone derived from the conglomerate at Bic Harbor. It differs from *C. senectus* in having a beautifully ornamented outer surface and a narrow, sharply elevated occipital ring. The surface of the glabella has fine, sharp, irregular ridges arranged in a roughly concentric manner about its longitudinal center, and is very similar to the surface of *Corynexochus* (*Bonnia*) *parvulus* (pl. 64, fig. 6). The test between the fine ridges is minutely punctate. The associated pygidia are more transverse and smoother than the pygidium of *C. senectus* or *C. bubaris.* The largest cranidium has a length of 7 mm.

A single pygidium from (locality 2r) 2 miles west of the railway station at Bic appears to belong to this species. It was associated in the same rock with fragments of *Callavia bicensis* and *Zacanthoides.*

Formation and locality.—Lower Cambrian: (2 o) Limestone boulders in conglomerate on shore at east entrance to harbor at Bic; also doubtfully (2r) limestone boulders in a cut on the Intercolonial Railway, 2 miles (3.2 km.) west of Bic railway station, both in Rimouski County, Quebec, Canada.

CORYNEXOCHUS BUBARIS, new species

Plate 56, figs. 2, 2*a-b*, 3, 3*a-f*

This species differs from *C. senectus* in having a strongly granulated surface, sharply elevated occipital ring with a small, sharp median spine, and more strongly ribbed pygidium. The granulated surface is formed by little nodes that appear to rise from irregular ridges, the interspaces of which are finely punctate; when the thin exterior layer of the test is rubbed off or exfoliated the inner layer appears to be punctate. An enrolled specimen shows eight segments, and the pygidium three rings and a terminal section.

The granulated surface of this species is of the same character as that of *Corynexochus* (*Bonnia*) *busa* Walcott (pl. 60, fig. 3*c*).

The pygidium not only has a minute fringing spine at the end of the anterior border of the first anchylosed segment, but also similar minute spines opposite the second and third segments. This character

brings the pygidium near to those of *Eurycare, Peltura* and other genera having fringing spines on the border of the pygidium.

The type specimens of this species are from a limestone boulder in the Bic conglomerate and preserve the exterior surface, while those identified with it from Vermont are in a shaly sandstone, and those from Pennsylvania are in an arenaceous limestone. The latter sometimes show traces of the granular surface so beautifully preserved in the limestone matrix.

Specimens from the limestone near Emigsville, Pennsylvania (locality 49w), show a granulated surface and an occipital spine characteristic of the species.

Formation and locality.—Lower Cambrian: (20) Limestone boulders in conglomerate on shore at east entrance to harbor at Bic, Rimouski County, Quebec, Canada.

(49) Sandstone on Codorus Creek 0.125 mile (0.2 km.) below Meyer's mill, near Emigsville; (49a) sandstone on the Liverpool road, south of the schoolhouse, 3 miles (4.8 km.) northwest of York; and (49w) limestone in railroad cut, 0.25 mile (0.4 km.) south of Emigsville railroad station; all three localities in York County, Pennsylvania.

CORYNEXOCHUS CAPITO, new species

Plate 57, figs. 2, 2*a-e*

Protypus senectus Billings, Walcott, 1886, Bull. U. S. Geol. Surv., Vol. 30, p. 213, pl. 31, figs. 2, 2*a-c*. (Prints original description with comments and illustrates two cranidia and one associated pygidium from Vermont.)

Protypus senectus Lesley, 1889, Geol. Surv., Pa., Rept. P. 4, p. 784, 2 text figs. only. (Compares with Angelin's *Corynexochus spinulosus* and reproduces Walcott's figures of 1886.)

Protypus senectus Walcott, 1891, Tenth Ann. Rept. U. S. Geol. Surv., p. 655, pl. 98, figs. 7, 7*a-c*. (Reproduces figures of 1886.)

This form was formerly identified as the species *senectus,* but with the specimens now available for study from Vermont and York (Pennsylvania) it appears that a distinct species is present that is neither *C. senectus* nor *C. bubaris.* The normal glabella is broader than in other species and almost devoid of side furrows. Anterior border narrow and close to the glabella; palpebral lobes small and narrow; occipital ring narrow and high at the posterior center but without a spine as far as can be determined.

The associated pygidia are larger and more rugged in appearance than those associated with *C. senectus.* There is a small, short,

anterior marginal spine as in the latter species. Axial lobe with three or four rings and a terminal section; pleural lobes with three broad flat segments separated by narrow shallow grooves.

All the specimens are from arenaceous shale and decomposed arenaceous limestone.

Formation and locality.—Lower Cambrian: (25) Shaly sandstone just above Parkers quarry, Georgia, Franklin County, Vermont.

Also (48b) York formation; roadside, north of Highland Park, York, York County, Pennsylvania.

CORYNEXOCHUS CLAVATUS (Walcott)

Plate 55, figs. 4, 4*a-b*

Ptychoparia ? (Subgenus ?) *clavata* Walcott, 1887, American Jour. Sci., 3d ser., Vol. 34, p. 198, pl. 1, fig. 3. (Note on the species and illustration of a cranidium.)

Protypus ? clavatus Walcott, 1891, Tenth Ann. Rept. U. S. Geol. Surv., p. 656, pl. 98, fig. 4. (Republishes note and illustration of 1887.)

These minute cranidia, the largest 2.5 mm. in length, have the characters of the typical form of *Corynexochus* as illustrated by figure 1, plate 55, of this paper. The American Lower Cambrian species differs from *C. spinulosus* of the Middle Cambrian of Sweden in having a broader fixed cheek in front of the ocular ridge and a proportionally greater widening of the anterior half of the glabella. The glabella has four pairs of furrows, the posterior pair united across the glabella by a short transverse furrow. The palpebral lobes are of medium size and quite prominent. Anteriorly they unite with the ridge which extends across the fixed cheeks to the dorsal furrow beside the glabella.

Surface marked by irregular exceedingly fine elevated lines or sharp ridges arranged concentrically about the anterior portion of the glabella and more or less transversely across the posterior portion. These lines can only be seen by the aid of a rather strong lens.

Corynexochus clavatus is the oldest known species of the genus. It is associated with a large and typical Lower Cambrian fauna at several localities. The associated fauna includes (locality numbers in parentheses):

Micromitra (*Iphidella*) *pannula* (White) (38*a*)
Obolus prindlei (Walcott) (38*a*)
Lingulella granvillensis Walcott (38*a*)
Lingulella sp. (38*a*)
Botsfordia cælata (Hall) (33, 38*a*, 39, 43*a*)
Yorkia ? washingtonensis Walcott (38*a*)
Acrotreta emmonsi Walcott (38*a*)

Acrotreta sagittalis taconica (Walcott) (33, 38*a*, 39, 43*a*)
Nisusia festinata (Billings) (38*a*)
Billingsella salemensis (Walcott) (33)
Archæocyathus dwighti Walcott (33, 39)
Protospongia sp. (38*a*, 43*a*)
Platyceras primævum Billings (38*a*)
Hyolithellus micans (Billings) (33, 38*a*)
Hyolithellus micans rugosa Walcott (38*a*)
Hyolithes americanus Billings (33, 38*a*)
Hyolithes communis Billings (33)
Hyolithes impar Ford (33, 38*a*, 43*a*)
Stenotheca elongata Walcott (33)
Stenotheca rugosa (Hall) (33)
Agnostus desideratus Walcott (43*a*)
Agnostus sp. (38*a*)
Eodiscus connexus Walcott (38*a*, 43*a*)
Eodiscus speciosus Ford (33, 38*a*, 39, 43*a*)
Goniodiscus lobatus (Hall) (33, 38*a*, 43*a*)
Elliptocephala asaphoides Emmons (33, 38*a*)
Ptychoparia cf. *adamsi* (Billings) (33, 38*a*, 43*a*)
Ptychoparia fitchi Walcott (38*a*)
Ptychoparia sp. (38a)
Zacanthoides catoni Walcott (33, 38*a*, 43*a*)
Olenoides fordi Walcott (38*a*)
Solenopleura tumida Walcott (33)

Formation and locality.—Lower Cambrian: (43a) Limestone 1 mile (1.6 km.) east-northeast of Salem, Cambridge quadrangle (U. S. G. S.); (33) limestone on the roadside near Rock Hill Schoolhouse, near North Greenwich, about 5 miles (8 km.) north-northeast of Greenwich, Cambridge quadrangle (U. S. G. S.); (38a) limestone 2 miles (3.2 km.) south of North Granville, on the road which turns south from the road running between that village and Truthville, 4 miles (6.4 km.) west-northwest of Granville, Fort Ann quadrangle (U. S. G. S.); and (39) limestone south of the Delaware and Hudson Railroad track, on the road running south-southwest from Low Hampton, about 5 miles (8 km.) east-northeast of Whitehall, Whitehall quadrangle (U. S. G. S.), all in Washington County, New York.

CORYNEXOCHUS DELAGEI Miquel

Plate 55, figs. 3, 3*a*

Corynexochus delagei MIQUEL, 1905, Bull. Soc. géol. France, 4th ser., Vol. 5, p. 481, pl. 15, figs. 4, 4*a-b*. (Describes and illustrates cranidium and pygidium.)

Original description.—"The roughly triangular head, with a rounded top, in the majority of specimens is more crushed, more

semicircular in the large forms, which are perhaps accidentally depressed by compression.

"The glabella has, much more, even, than in all the other species of the genus, the *clavate* form described by authors. Very narrow in the lower part and often compressed at the base, it expands abruptly, toward the middle of its height, into a regular oval, sometimes a complete circle. It has its dorsal furrows accentuated and stands out in relief above them; there is no trace of lateral furrows; the occipital furrow is hardly distinct; but below it, however, the occipital ring appears, very narrow, convex, and rounded, and terminates in a spine quite apparent to the naked eye on certain specimens.

"The facial suture becomes detached at two-thirds the height of the glabella, at the point where the convexity of the latter is most marked, and descends toward the base by an almost straight line, sometimes slightly convex, so as to give to the fixed cheeks a very narrow, triangular form. The very small eyes are scarcely visible. The free cheek is always lacking. Thorax unknown.

"The pygidium has the form of a semicircle, generally a little depressed; the axis, much in relief, well marked, is narrow and long, without quite reaching the lower margin; we count under the lens five and perhaps six rings. The lateral lobes have the first pleura apparent; the others are more effaced and scarcely visible.

"The test is without punctation.

"*Analogies and differences.*—*Corynexochus delagei* is by far the most specialized of the species which I am describing; it constitutes the only *Corynexochus* known up to the present from the lower beds of the Acadian; it is very clearly distinguished at first sight from *Corynexochus spinulosus* Ang. and from *Corynexochus romingeri* Matt., which belong, in Scania [Skåne] and at Mount Stephen, to the beds with *Paradoxides forchhammeri* Ang. of the upper Acadian. It is nearer *Corynexochus bornholmiensis* Grönw. from the middle Acadian of Borregaard, in the island of Bornholm; but it is distinguished from that by the rounded form of the top of the glabella, by the great convexity of the base of the dorsal furrows, by the complete absence of lateral furrows, and by the effacement of the rings and the pleuræ of the pygidium."

M. J. Miquel very kindly sent me a specimen of the cranidium and one of the pygidium, which are illustrated on plate 55, figures 3, 3*a*. These have a more striking resemblance to the Newfoundland *C. minor* Walcott (pl. 55, fig. 6) than to the geographically nearer *C. spinulosus* Angelin and *C. bornholmiensis* Grönwall.

Formation and locality.—Middle Cambrian: (152d) Calcareous shales; Cambrian section of Coulouma, "Montagne Noire," Hérault, France.

CORYNEXOCHUS MINOR (Walcott)

Plate 55, figs. 6, 6*a-d*

Karlia minor Walcott, 1889, Proc. U. S. Nat. Mus. for 1888, Vol. 11, p. 445. (Description of species.)

Karlia minor Walcott, 1916, Smithsonian Misc. Coll., Vol. 64, No. 3, p. 224, pl. 36, figs. 7, 7*a-c*. (Description and illustration of species.)

The description of this species may be found on page 224 of this volume. It is illustrated in this paper in order to afford direct comparison with the other species referred to *Corynexochus*.

Formation and locality.—Middle Cambrian: (1) Manuels formation; Manuels Brook, Conception Bay, Newfoundland.

CORYNEXOCHUS SENECTUS (Billings)

Plate 55, figs. 7, 7*a-c;* plate 56, figs. 1, 1*a-g*

Bathyurus senectus Billings, 1861, Geol. Surv., Canada, Pal. Foss., Vol. I, p. 15, text figs. 19, 20. (Describes and illustrates a cranidium and associated pygidium.)

Bathyurus senectus Billings, 1862, Geol. Vermont, Vol. 2, p. 953, text figs. 359, 360. (Same as above.)

Bathyurus senectus Billings, 1862, Rept. Economic Geol. Vermont, Hager, p. 225, text figs. 359, 360. (Same as above.)

Bathyurus senectus Billings, 1863, Geol. Canada, Geol. Surv., Canada, p. 286, text fig. 298 (fig. only). (Same figures as above.)

Bathyuriscus senectus Matthew, 1897, Trans. Royal Soc. Canada, 2d ser., Vol. 3, Sec. 4, p. 196, pl. 4, fig. 4. (Describes and illustrates the supposed type specimen and refers the species to *Bathyuriscus* and compares it with *Paradoxides*.)

Original description.—"Glabella subcylindrical, clavate, strongly convex, one-fourth wider at the front margin than at the neck segment, sides nearly straight, front obtusely rounded and presenting a strong convex elevation, neck furrow extending all across, three pairs of glabella furrows represented by small but distinct and obtuse indentations in the sides. Fixed cheeks rather strongly convex. Eyes of moderate size, semicircular; a line drawn across the head at about one-third the length of the glabella from behind would pass through them, and they are distant from the side of the glabella about the width of the neck segment. The front of the head is surrounded

by a narrow border which appears to be flat; there appears to be some evidence of a spine on the neck segment.

"The pygidium found in the same fragment of stone with one of the specimens of the glabella of this species is in all general characters that of *Bathyurus*. It is semicircular, convex, axis cylindrical, strongly convex, terminating behind with an abruptly rounded descent, six annulations, the first three or four most strongly defined. The lateral lobes have four segments each, separated by strong rounded furrows; there is a narrow entire margin all round with a distinct groove inside, which appears, however, to be interrupted at the end of the axis.

"The dimensions of the most perfect specimens are as follows:

"Glabella—length, $3\frac{1}{2}$ lines; width at neck segment, $1\frac{1}{2}$ lines, at the front, 2 lines; distance of the eye from the side of the glabella, $1\frac{1}{2}$ lines. The eye appears to be about three-quarters of a line in length.

"Pygidium—length, 3 lines; width at anterior margin, $5\frac{1}{2}$ lines; width of axis, 1 line."

With a number of well-preserved cranidia for study, I find that the occipital segment is elevated slightly toward the center, but that it does not have a spine as suggested by the specimens studied by Billings. Matthew, after studying the material used by Billings, states that he found the surface consisting of anastomosing raised lines on the front half of the glabella; these become broken into a granulated surface on the back of the glabella and cheeks, with finer granulations in the furrows than elsewhere.[1] To his description we may add that the outer surface of the test is punctate and also marked by a fine inosculating network of elevated lines or ridges that are usually obscure and difficult to see even with a strong pocket lens. The granulation mentioned by Matthew shows in the specimens before me either on the summit of the fine ridges or on the cast of the inner surface of the test. Their appearance varies with the amount of rubbing down the test has received or the condition of its preservation in its matrix. The associated hypostomas and pygidia have the same kind of surface as the glabella. From Bonne Bay specimens I find all the associated pygidia have a short spine on each side that is apparently the continuation across the border of the anterior rounded margin of the axial lobe of the pygidium. This same type of pygidium is also associated with *Corynexochus* (*Bonnia*) *parvulus*

[1] Trans. Royal Soc. Canada, 2d ser., Vol. 3, Sec. 4, 1897, p. 197.

(Billings) (pl. 57, fig. 1*c*), as already indicated by Matthew.[1] Many pygidia associated with the cranidia appear to have smooth antero-lateral margins, but usually a trace of the spine may be found by careful removal of the matrix.

The associated pygidium described and figured by Billings has six annulations on the axial lobe and four on the pleural lobes, as in *C. bubaris*. This pygidium may belong with the cranidium, but I find from the Bonne Bay locality that nearly all the pygidia are shorter and have only four to five annulations including the terminal one, and three to four that extend out onto the pleural lobes. The collection from Bonne Bay includes over 100 cranidia, and as many associated pygidia, and there are no other species of this type associated with them. Even *Corynexochus* (*Bonnia*) *parvulus* is absent. The pygidium figured by Billings is much like that of *C. bubaris* (pl. 56, fig. 3*d*), which has four annulations in the axial lobe and three on the pleural lobes.

The cranidia are sometimes distorted so as to make elongate and narrow forms; these are illustrated on plate 56, figure 1*c*.

Billings gives l'Anse au Loup on the Straits of Belle Isle as the type locality of the species. Although we have quite large collections from that area, no specimens of the species have been recognized, but at Bonne Bay on the west side of Newfoundland the fragments of the dorsal shield occur in large numbers in association with the following fauna (locality 41 l):

Micromitra (*Paterina*) *labradorica* (Billings)
Botsfordia cælata (Hall)
Kutorgina cingulata (Billings)
Quebecia n. sp.
Obolella chromatica Billings
Pelagiella primævum Billings
Helcionella rugosa (Hall)
Hyolithes billingsi Walcott
Hyolithes princeps Billings
Hyolithes communis Billings
Hyolithellus micans (Billings)
Salterella pulchella Billings
Salterella rugosa Billings
Olenellus thompsoni crassimarginatus Walcott
Corynexochus senectus (Billings)

The bed above the limestone of 41 l contains fragments of *Olenellus* and numbers of *Salterella*.

[1] Trans. Royal Soc. Canada, 2d ser., Vol. 3, Sec. 4, 1897, pl. 4, fig. 5*b*.

At Bic Harbor on the St. Lawrence, *C. senectus* occurs in boulders of light gray limestone associated with fragments of *Olenellus thompsoni* and the following species (locality **20**):

Micromitra (Paterina) bella (Billings)
Micromitra (Paterina) labradorica (Billings)
Bicia gemma (Billings)
Kutorgina cingulata (Billings)
Obolella crassa (Hall)
Botsfordia celata (Hall)
Yorkia wanneri ? Walcott
Nisusia festinata (Billings)
Discinella sp.
Corynexochus (Bonnia) parvulus (Billings)
Corynexochus bubaris Walcott
Zacanthoides spinosus Walcott ?
Olenellus thompsoni Hall

At all three localities *C. senectus* occurs at the upper horizon of the "*Olenellus*" or Lower Cambrian fauna, and in none of them is it known to be immediately succeeded by the "*Paradoxides*" or Middle Cambrian fauna.

The species as identified from locality **61d** in British Columbia is represented by large numbers of the cranidium and associated pygydia that vary among themselves very much as the specimens from western Newfoundland. The limestone matrix at the two localities is nearly similar in color and appearance and the associated fauna is very similar. The fauna listed in each instance is from the same layer of limestone containing *Corynexochus senectus*. The horizon of the layer at locality **61d** is near the top of the Lower Cambrian Mount Whyte formation, and at locality **411** in Newfoundland near the summit of the Lower Cambrian (*Olenellus*) series.

The fauna of locality **61d** includes:

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
Zacanthoides
Ptychoparia 2 spp.
Mesonacis gilberti (Meek)

Formation and locality.—Lower Cambrian: Billings gives l'Anse au Loup on the north shore of the Straits of Belle Isle (Labrador) as the type locality.

Collections made for the United States National Museum contain specimens of the species from five localities, as follows:

(41 l) Bonne Bay, east shore of East Arm, west coast of Newfoundland; (2 o) limestone boulders in conglomerate on shore line at east entrance to harbor at Bic, Rimouski County, Quebec, both in Canada.

(49w) Limestone in railroad cut, 0.25 mile (0.4 km.) south of Emigsville, York County, Pennsylvania.

(61d) Mount Whyte formation; southwest slope of Mount Shaffer on Canyon side, on trail to Lake McArthur, 8.5 miles (13.6 km.) south of Hector Station, on Canadian Pacific Railroad, British Columbia, Canada.

Also from (16g): Hard arenaceous shales; Paymaster Mining Camp, 0.25 mile (0.4 km.) west of Esmeralda, Esmeralda County, Nevada.

CORYNEXOCHUS SPINULOSUS Angelin

Plate 55, figs. 1, 1*a-b*

Corynexochus spinulosus ANGELIN [1852, 1854], 1878, Pal. Scandinavica, 3d ed., Holmiae, p. 59, pl. 33, figs. 9, 11 ?. (Described and figured as a new species.)

Corynexochus spinulosus GRÖNWALL, 1902, Danmarks Geol. Unders., Vol. 2, No. 13, p. 139, pl. 4, figs. 3*a-b*, 4. (Describes and illustrates type specimens.)

Dr. Karl A. Grönwall studied the type specimens of this species which are in the Museum at Stockholm, and in substance wrote the following description:

"Head without margin, anteriorly strongly curved. Length greater than breadth. Front narrow or club-form, delimited with deep, similar dorsal grooves. Lateral grooves, 3 pairs, short and flat; the most posterior pair of grooves are directed backward, nearly enclosing a pair of basal lobes. Eyes small, cheeks narrow, occipital ring moderately broad with a spine. The surface of the cranidium, with densely impressed fine points.

"Considering the pygidial shield, I am in great uncertainty. Angelin illustrates one with spines in margin, which does not show much resemblance to that of *C. bornholmiensis*. Professor Holm told me that he had not succeeded in finding a pygidium for *C. spinulosus* in the Stockholm Museum. Among the heads there was, however, a

small pygidium which appears to me to belong to *C. spinulosus,* and of which for this reason I give a figure (pl. 55, fig. 1*b*) and describe it. Pygidium semicircular in form, with an entire margin. Median lobe about five-sixths of the entire length of the pygidium, curved, with three rings, which on the flat lateral lobes are continued by two broad, indistinct ribs, which alternate with the annular or the rings of the median lobe. Along the posterior margin of the pygidium there is a flat furrow, which indicates a doublure around the pygidium. If this pygidium actually belongs to *C. spinulosus* Angelin, we shall be obliged to change its name, as it refers to a character which does not belong to the species in question. From this description and the figures, the difference between the two closely allied Scandinavian species appears clear enough."

It may be as Grönwall states, that the pygidium illustrated by the diagrammatic figure of Angelin does not belong with the cranidium named *C. spinulosus,* but from our finding somewhat similar spines on the border of the pygidium of *C. bubaris* it is not improbable that Angelin was correct in placing the pygidium he found associated with *C. spinulosus* under the same species.

Formation and locality.—Middle Cambrian: Andrarum limestone at Andrarum, Skåne, Sweden.

CORYNEXOCHUS STEPHENENSIS (Walcott)

Plate 55, figs. 5, 5*a-c*

Menocephalus salteri ? Billings, Rominger, 1887, Proc. Acad. Nat. Sci., Philadelphia, Pt. 1, p. 16, pl. 1, fig. 6. (Described and figured.)

Karlia stephenensis Walcott, 1889, Proc. U. S. Nat. Mus., Vol. 11, p. 445. (Described.)

Corynexochus roemingeri Matthew, 1899, Trans. Royal Soc. Canada, 2d ser., Vol. 5, Sec. 4, p. 47. (Calls attention to error in description of 1889, and proposes specific name *Corynexochus roemingeri* for Dr. Rominger's specmiens.

Karlia stephenensis Walcott, 1908, Canadian Alpine Jour., Vol. 1, No. 2, pl. 3, fig. 4. (Specimen figured.)

Karlia stephenensis Walcott, 1916, Smithsonian Misc. Coll., Vol. 64, No. 3, p. 224, pl. 36, fig. 8. (Described and figured.)

The size of this species was erroneously stated by me in 1889. Dr. Rominger's type specimen when being studied was placed in a tray with specimens referred to *Protypus,* and the measurements assigned to the species *stephenensis* were taken by error from *Protypus hitchcocki* which happened to be in the tray.

I inserted an illustration of the type of the species *stephenensis* alongside that of *Karlia minor* in my last paper on Cambrian trilo-

bites,[1] and in the text, page 225, had the brief note copied that accompanied the naming of the species in 1889. This illustration of the type and description were inserted to afford the means of comparison with *Karlia minor* just before I was leaving for the field, and I did not look up Dr. G. F. Matthew's paper in which he describes the same form as *Corynexochus roemingeri* Matthew.[2] In this paper Dr. Matthew calls attention to my error in assigning so large a size to the species identified as *Menocephalus salteri ?* by Rominger, and proposes the specific name *Corynexochus roemingeri* for Dr. Rominger's specimens. As it was the species described and illustrated by Dr. Rominger to which the name *Karlia stephenensis* was given, the error in measurement does not cancel that name in favor of the more recent one proposed by Dr. Matthew.

The average length of the dorsal shield of *C. stephenensis* is about 14 mm. There are seven thoracic segments, and three anchylosed segments and a terminal section in the axial lobe of the pygidium. The three axial segments of the pygidium are extended obliquely backward on the pleural lobes as flat, broad segments separated by narrow, shallow furrows.

The specimens of this species occur in a very fine arenaceous shale and none show the original test.

A single cranidium from the Burgess shale at about the same horizon appears to be punctate. This cranidium 1 mm. in length has the glabella very much expanded anteriorly and large, tumid fixed cheeks (pl. 55, fig. 5*a*).

Formation and locality.—Middle Cambrian: (14s) *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 2,700 feet (823 m.) below the Upper Cambrian, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad; also (35k) Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, above Field on the Canadian Pacific Railroad, both in British Columbia, Canada.

BONNIA, new subgenus

Bonnia is proposed as a subgenus of *Corynexochus* with *Bathyurus parvulus* Billings as the genotype.

The subgenus differs from the genus in having a glabella with subparallel sides and only slight traces of glabellar furrows; other part-

[1] Smithsonian Misc. Coll., Vol. 64, 1916, pl. 36, fig. 8.

[2] Trans. Royal Soc. Canada, 2d ser., Vol. 5, 1899, p. 47.

as far as known are essentially the same as *Corynexochus*. The surface of the test of *C.* (*Bonnia*) *parvulus* is punctate and marked by irregular, inosculating, very fine ridges or raised lines that are arranged more or less concentrically about the highest part of the glabella, also about the node on the occipital ring. (See pl. 57, fig. 1; pl. 64, fig. 6.)

The associated pygidia have the anterior border extended into a short spine at the antero-lateral angles and the axial lobe has only two well-defined rings.

Although there are large numbers of the cranidia and pygidia of the species *parvulus,* nothing is known of the thorax. The associated free cheeks have a rather strong genal spine.

Matthew refers the species *parvulus* to *Dorypyge,*[1] but a comparison with the genotype of *Dorypyge* shows that while the glabella is somewhat similar,[2] there are differences in form and surface markings and the associated pygidia are quite unlike. The test of *Dorypyge* is dense and granulated and that of *Bonnia* is punctate and ornamented with elevated lines or fine sharp ridges or granulated. The spines at the end of the anterior border of *Bonnia* can hardly correlate the pygidium with that of *Dorypyge.* For comparison, figures of the genotype of *Dorypyge* are illustrated on plate 64, figures 7, 7*a-c*.

The species now referred to the subgenus *Bonnia* are:

Corynexochus (*Bonnia*) *parvulus* (Billings) (pl. 57, fig. 1), Lower Cambrian.

Corynexochus (*Bonnia*) *busa* Walcott (pl. 60, fig. 3), Lower Cambrian.

Corynexochus (*Bonnia*) *fieldensis* Walcott (pl. 57, fig. 4), Lower Cambrian.

CORYNEXOCHUS (BONNIA) BUSA, new species

Plate 57, fig. 1*a;* plate 60, figs. 3, 3*a-c*

This species is represented by specimens of the cranidium and associated pygidium, the surface characters of which are similar to those of the pygidium. The cranidium is similar in form to that of *C.* (*Bonnia*) *parvulus* except that the fixed cheek is narrower and three pairs of short glabellar furrows are to be seen by the unaided eye.

A small median spine appears to have been broken off of the occipital ring.

The most striking difference is the granulated outer surface of the test on both the glabella, fixed cheeks and associated pygidium; this

[1] Trans. Royal Soc. Canada, 2d ser., Vol. 3, Sec. 4, 1897, p. 197.

[2] See *Dorypyge richthofeni* Dames, figs. 1, 1*a-c,* pl. 8, Research in China, Vol. 3, Cambrian Faunas of China, 1913, Carnegie Inst. of Washington.

granulation is formed on the lines of the fine ridges very much as they occur on *Corynexochus bubaris*.

The associated pygidium is more transverse than that referred to *C.* (*Bonnia*) *parvulus* and also closely granulated.

The largest cranidium has a length of 7 mm.

Formation and locality.—Lower Cambrian: (20) Limestone boulders in conglomerate; on shore at east entrance to harbor at Bic, Rimouski County, Quebec, Canada.

CORYNEXOCHUS (BONNIA) FIELDENSIS (Walcott)

Plate 57, figs. 4, 4*a-b*

Protypus fieldensis Walcott, 1908, Smithsonian Misc. Coll., Vol. 53, p. 215. (Listed.)

Corynexochus (*Bonnia*) *fieldensis* differs from *C.* (*Bonnia*) *parvulus* (Billings) in details of cranidium and pygidium. The glabella is proportionally more elongate in specimens embedded in the same character of limestone; the axial lobe of the associated pygidium is less elevated posteriorly.

The differences are slight but persistent, and if occurring in specimens from the same locality and layer of rock would probably receive little attention. With the localities 2,000 miles (3,200 km.) distant from each other, they are given more weight.

The associated pygidium has the same kind of spines at the outer end of the frontal margin, and the rings of the axial lobe and their extension on the pleural lobes are the same except that those of *C.* (*B.*) *parvulus* are more clearly defined.

The occipital ring has a small median spine on the posterior margin very similar to that of *C.* (*B.*) *parvulus*.

Surface of test punctate and only faintly marked by fine, irregular, inosculating ridges.

The average length of the cranidium is about 9 mm.

The separate cranidia and pygidia occur in great numbers in the limestone of the Mount Whyte formation in association with *Mesonacis gilberti* and *O. canadensis*. On Mount Bosworth (locality 35h) the fauna includes:

Nisusia festinata (Billings)
Scenella varians Walcott
Hyolithellus
Ptychoparia
Agraulos
Olenellus canadensis Walcott
Mesonacis gilberti (Meek)
Corynexochus (*Bonnia*) *fieldensis* Walcott

This species is of unusual interest as it is the representative in the Rocky Mountain Cambrian fauna of *C.* (*Bonnia*) *parvulus* of Labrador, which is associated with a Lower Cambrian fauna.

Formation and locality.—Lower Cambrian: (35l) Mount Whyte formation; at the base of the formation, on the south slope of Ptarmigan Pass, head of Corral Creek, 9 miles (14.4 km.) north-northeast of Laggan, Alberta; (35f) Mount Stephen section of Mount Whyte formation; about 300 feet (95 m.) below the top of the Lower Cambrian, in bluish-black and gray limestone (18 feet = 5.5 m.) forming No. 6 of the formation, and (57i) about 175 feet below the top of the Lower Cambrian in brownish-gray quartzitic sandstone (32 feet) forming 4 of Mount Whyte formation, Mount Stephen section, just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia; and (35h) about 375 feet (114 m.) below the Middle Cambrian in the shales of No. 4 of the Mount Whyte formation,[1] on Mount Bosworth, north of the Canadian Pacific Railway between Hector and Stephen, on the Continental Divide between British Columbia and Alberta, all in Canada.

CORYNEXOCHUS (BONNIA) PARVULUS (Billings)

Plate 57, figs. 1, 1*b-c;* plate 64, fig. 6

Bathyurus parvulus BILLINGS, 1861, Geol. Surv., Canada, Pal. Foss., Vol. 1, p. 16, text fig. 21. (Describes and illustrates a cranidium.)

Bathyurus parvulus BILLINGS, 1862, Geol. Vermont, Vol. 2, p. 953, text fig. 361. (Same as above.)

Bathyurus parvulus BILLINGS, 1862, Rept. Economic Geol. Vermont, Hager, p. 225, text fig. 361. (Same as above.)

Bathyurus parvulus BILLINGS, 1863, Geol. Canada, Geol. Surv., Canada, p. 286, fig. 299 (fig. only.) (Same figure as above.)

Protypus senectus parvulus WALCOTT, 1886, Bull. U. S. Geol. Surv., No. 30, p. 213. (Considers Billings's *Bathyurus parvulus* a variety of *Protypus senectus.*)

Dorypyge parvula MATTHEW, 1897, Trans. Royal Soc. Canada, 2d ser., Vol. 3, Sec. 4, pp. 187, 197, pl. 4, figs. 5, 5*a*. (Refers species to *Dorypyge* and describes and illustrates cranidium and associated pygidium.)

Compare *Menocephalus salteri* DEVINE, 1863, Canadian Nat. and Geol., Vol. 8, p. 210. (Illustrates and describes this species or one closely related.)

With the exception of the outline of the glabella, the cranidium of this species is not unlike that of *Corynexochus senectus* Billings. The glabella, however, is somewhat like that of *Dorypyge* (pl. 64, figs. 7, 7*a*) and *Pagodia*,[2] but, as we have learned from many examples,

[1] Smithsonian Misc. Coll., Vol. 53, 1908, p. 214.

[2] Idem, Vol. 57, 1912, pl. 44, figs. 13, 14.

the same type of cranidium may have quite a different thorax and pygidium and belong to distinct genera.

Very perfect specimens of the glabella of *C.* (*Bonnia*) *parvulus* have very faint traces of lateral furrows close to the dorsal furrow, but usually the furrows are not readily determined to be present. The occipital ring rises gently at its posterior center, and a blunt, very small and short spine projects backward from the edge; the base of the spine is surrounded on its sides and front by concentrically arranged, sharp, irregular, fine ridges. The associated free cheek has a relatively strong genal angle.

Corynexochus (*Bonnia*) *parvulus* is associated at locality 4k with *Callavia bicensis* Walcott. At locality 41i, with *Micromitra, Nisusia, Obolella, Hyolithes communis* Billings, *Callavia* sp., and *Olenellus thompsoni* Hall. For the fauna at locality 20, see description of *Corynexochus senectus,* p. 319.

Matthew names a variety *angifrons* from a specimen of a cranidium preserved as a cast in sandstone, that is " sensibly narrower " and that has scarcely a trace of glabellar furrows. The locality is unknown. He suggests Vermont. The figures suggest a compressed cranidium of *C.* (*Bonnia*) *parvulus.*

With the poor illustration of *Menocephalus salteri* Devine,[1] it is difficult to make a close comparison between it and *C.* (*Bonnia*) *parvulus* Billings, but there is a most striking similarity in the cranidium and pygidium of the two forms, and the description of the thoracic segments of *M. salteri* corresponds to that of the thoracic segments of *Corynexochus.* Both have a " broad, deep groove extending outwards to the tips, which are bent down." The lower limestones of Point Levis are formed of limestone boulders in a limestone matrix, and *Salterella pulchella* Billings, a Lower Cambrian species from l'Anse au Loup, has been found there.[2] This fact prepares us to expect other Lower Cambrian fossils in some of the boulders, as is the case at Bic, Trois Pistoles, and other localities along the south shore of the St. Lawrence River.

Formation and locality.—Lower Cambrian: (41k) 80 feet (21 m.) above base of limestone series, or zone 2; Point Amour, east side of Forteau Bay, and (41i and 41m) the surface of *Olenellus* layer; top of hill back of Mrs. Flinn's house, Forteau, Forteau Bay, north shore Straits of Belle Isle, Labrador; (20) limestone boulders in conglomerate, on shore at east entrance to harbor at Bic; also (2r) in a cut on

[1] Canadian Nat. and Geol., Vol. 8, 1863, p. 210, text fig.

[2] Bull. U. S. Geol. Survey, No. 30, 1886, p. 144, pl. 13, figs. 3, 3*a*.

the Intercolonial Railway, 2 miles (3.2 km.) west of Bic Railway station, both in Rimouski County, Quebec, all in Canada.

Subfamily DOLICHOMETOPINÆ

Genus BATHYURISCUS Meek

Bathyuriscus MEEK, 1873, Sixth Ann. Rept. U. S. Geol. Surv., Terr., p. 484. (Suggests name for species *haydeni* if the latter belongs to a new genus.)

Bathyuriscus WALCOTT, 1866, Bull. U. S. Geol. Surv., No. 30, p. 215. (Describes and discusses genus with illustration of new species, *B. howelli.*)

Bathyuriscus MATTHEW, 1897, Trans. Royal Soc. Canada, 2d ser., Vol 3, Sec. 4, p. 195. (Considers *Bathyuriscus* a subgenus of *Dolichometopus* Angelin.)

Bathyuriscus MATTHEW, 1899, Trans. Royal Soc. Canada, 2d ser., Vol. 5, Sec. 4, p. 63. (Suggests that *Bathyuriscus* may have been derived from *Anomocare.*)

Bathyuriscus LORENZ, 1906, Zeits. deuts. geol. Gesells., Vol. 58, pp. 74, 75. (Decides that *Bathyuriscus* is a subgenus of *Dolichometopus.*)

Bornemannia WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, pp. 213, 214. (Name given in lists of fossils from 1*c* and 3 of geologic section.)

Bathyuriscus GRABAU and SHIMER, 1910, North American Index Fossils, Vol. 2, p. 287. (Brief description of genus and illustration of *B. productus, B. howelli,* and *B. rotundatus.*)

Since the publication of my note on *Bathyuriscus* in 1886[1] considerable additional material has been found that adds to our knowledge of the genus and the species grouped under it.

Description.—General form elongate oval. Axial and pleural lobes strongly defined. Cephalon transversely semi-circular with genal angles extended backward in spines of medium length. Marginal border narrow in front, widening towards the genal angles where it merges into the genal spines; posterior margin and occipital ring usually defined by a well-marked furrow. The facial sutures cut the anterior margin a short distance each side of the line of the greatest expansion of the glabella and curve obliquely inward to the anterior base of the eye lobes; encircling the latter, they continue obliquely outward and cut the posterior margin a short distance inside the base of the genal spine. Glabella elongate, usually expanded towards the broadly rounded front and narrowing slightly midway; marked by three or four pairs of short lateral furrows, the posterior two pairs of which are extended obliquely inward and backward, and the anterior more or less obliquely forward. Occipital segment well-defined and in some species rising at the center to form a base for

[1] Bull. U. S. Geol. Survey, No. 30, pp. 215-216.

a small, sharp spine that extends obliquely upward and backward. Fixed cheeks moderately convex, with strong postero-lateral limbs, narrow central section, and small antero-lateral limbs; a well-defined palpebral ridge curves around the eye and extends obliquely forward across the cheek to the dorsal furrow beside the glabella; palpebral lobes narrow and varying in length from one-fourth to more than one-half the length of the cephalon. Free cheeks of medium width and terminating posteriorly in a sharp genal spine; visual surface of eye narrow and elongate.

Thorax with 8 to 9 segments. (The genotype has nine.) Each segment has a node or spine on the median axis and a very distinct, rather broad pleural furrow that extends nearly to the outer termination of the segment. In the type species, *B. haydeni* (pl. 46, fig. 2), a narrow, elongate triangular ridge extends from the axis out into the pleural furrow; this character is strongest in *B. ornatus* (pl. 46, fig. 4), and traces of it are found in all the species now referred to the genus. The pleural lobes of the segments curve slightly backward and terminate in a short falcate point.

Pygidium semicircular in outline. Median axis nearly as long as the pygidium, convex and marked by several transverse furrows that outline transverse segments; both furrows and segments extend across the pleural lobe to a narrow border.

Hypostoma of *B. howelli,* rounded subtriangular in outline; central portion oval, convex and separated posteriorly by a shallow curved furrow, from a low transverse tubercle; a narrow margin merges into rather large posterior wings that form the anterior section of the hypostoma.

Surface with many very fine, irregular, inosculating ridges that give it a roughened appearance, and when slightly weathered it looks as though there were fine shallow pits thickly scattered over the surface.

Dimensions.—The largest specimen of the dorsal shield of the type species *B. haydeni,* has a length of 21 mm.; *B. rotundatus* reaches 52 mm., while *B. ornatus* is 21 mm., and *B. anax* 37 mm. in length. Separated cranidia and pygidia of *B. anax* indicate that the entire dorsal shield sometimes was 90 mm. or more in length. *B.* (*Poliella*) *primus,* the oldest known species, has a length of 30 mm., and fragments indicate individuals that were 46 mm. long. The largest entire dorsal shield of *B. atossa* has a length of 41 mm., but fragments and pygidia indicate that the species sometimes attained a length of 50 mm. or more.

Genotype.—*Bathyuriscus haydeni* Meek.

Stratigraphic range.—As far as known, *Bathyuriscus* and its subgenus *Poliella* are found in the upper portion of the Lower Cambrian as *B.* (*Poliella*) *primus,* which is abundant in the siliceous strata occurring in the upper part of the Mount Whyte formation, and *B. batis,* which is associated with *Mesonacis gilberti* in southwestern Nevada, *B. belus* and *B. belesis* from Montana and doubtfully of Lower Cambrian age. The greatest development of the genus is in the Middle Cambrian formations: *Bathyuriscus* (*Poliella*) *probus* in the Marjum formation of Utah; *B. haydeni* and *B.* (*Poliella*) *powersi* occur in the Gallatin limestone; *B. howelli,* in the Chisholm shale; *B. adæus, B.* (*Poliella*) *occidentalis, B. ornatus,* and *B. rotundatus, Ogygopsis* shale of Stephen formation; *B.* (*Poliella*) *sylla,* Chetang formation; *B. anax, B.* (*Poliella*) *anteros, B. atossa, B. ? bithus,* and *B.* (*Poliella*) *caranus,* Spence shale horizon at base of the Ute formation; *B. bantius,* sandstone of Rome formation; *B.* (*Poliella*) *balus,* shales of the York formation, and *Bathyuriscus* sp., Conasauga formation.

Geographic distribution.—Nevada, *B. howelli* and *B. batis.* Northern Utah, *B. anax* and *B. bithus.* Southern Idaho, *B.* (*Poliella*) *anteros, B. atossa, B. belesis,* and *B. belus.* Montana, *B. haydeni* and *B.* (*Poliella*) *powersi.* Eastern British Columbia at Mount Stephen, *B. adæus, B. rotundatus, B. ornatus, B.* (*Poliella*) *occidentalis,* and *B.* (*Poliella*) *primus.* The last species also occurs near Lake Louise in western Alberta. In the Robson Peak section, British Columbia, *Bathyuriscus* (*Poliella*) *sylla.* Eastern Tennessee, *B. bantius.* Central Pennsylvania, *B.* (*Poliella*) *balus.* The genus appears to be represented in Asia by *B. stoliczkai,* which is found in Kashmir, northern India.

Observations.—I have heretofore included *Ogygia producta* Hall and Whitfield under *Bathyuriscus,* but with present information it is necessary to refer that species and several others to the genus *Dolichometopus,* as they differ materially from the typical forms of *Bathyuriscus.* My impression of the latter genus was so influenced in 1886 by the study of fragments of (*Ogygia*) *Bathyuriscus producta* Hall and Whitfield that I concluded that that species was a typical form of *Bathyuriscus* and when I found a species not generically related to *producta* I listed it as a new genus and species.[1]

Another confusing form was the species now known as *Bathyuriscus* (*Poliella*) *occidentalis* (Matthew) (pl. 46, fig. 3). Matthew's

[1] *Bornemannia prima:* Smithsonian Misc. Coll., Vol. 53, 1908, pp. 213, 214.

illustration was diagrammatic and did not suggest the closely allied form now described as *B.* (*Poliella*) *primus* (pl. 46, fig. 6), which occurs 2,150 feet lower in the Mt. Stephen section.

The Lower Cambrian species *Bathyuriscus* (*Poliella*) *primus* has a small compact pygidium similar in relative size to that of *B.* (*Poliella*) *powersi,* which is associated with the type species, *B. haydeni,* which has a large pygidium.

Comparison of Bathyuriscus with Other Genera.

Zacanthoides.[1]—The type species of *Bathyuriscus, B. haydeni,* has a very distinctive cranidium characterized by (1) a narrow, convex glabella that expands in front of the anterior pair of lateral furrows; (2) a pair of posterior, oblique lateral furrows that are united by a transverse furrow, and (3) three pairs of short lateral furrows, the anterior two of which extend obliquely forward. This combination of characters is almost identical with that of the glabella of *Zacanthoides spinosus* Walcott.[2] The cranidium of *B. haydeni* has also a long palpebral lobe, narrow fixed cheek, short frontal limb much like those of *Z. spinosus,* and the occipital spines on the thoracic segments are of the same type in the two forms, but the pygidia of the two genera are unlike and very distinctive.

Corynexochus.—It may be compared with the Lower and Middle Cambrian genus *Corynexochus,*[3] from which it differs in the form of its glabella, pleural furrows of thoracic segments, and pygidium.

Vanuxemella.[4]—It differs from *Vanuxemella* in the same way as from *Corynexochus,* and *Vanuxemella* has but five thoracic segments.

Dolichometopus.[5]—It differs from this genus in having distinct glabellar furrows, more numerous thoracic segments, and in the presence of distinct furrows on the pleural lobes of the pygidium. The two genera, however, closely approach each other in such species as *Dolichometopus? bessus* (pl. 51, figs. 3, 3*a-b*) and *Bathyuriscus bantius* (pl. 49, figs. 2, 2*a-c*).

Genesis.—Bathyuriscus appears to have been derived from a Lower Cambrian ancestor that also gave rise to the allied genera *Dolichometopus, Corynexochus* and its subgenus *Bonnia.*

[1] American Jour. Sci., Vol. 36, 1888, p. 165. Smithsonian Misc. Coll., Vol. 53, 1908, p. 26.

[2] Canadian Alpine Jour., Vol. 1, No. 2, 1908, pl. 4, fig. 1.

[3] Pal. Scandinavica, Angelin, 1854, p. 59, pl. 33, fig. 9.

[4] Smithsonian Misc. Coll., 1916, Vol. 64, No. 3, p. 220.

[5] Pal. Scandinavica, Angelin, 1854, p. 72.

Species of Bathyuriscus.—The species now referred to *Bathyuriscus* are:

Bathyuriscus adæus Walcott (pl. 47, fig. 3), Middle Cambrian.
Bathyuriscus anax Walcott (pl. 48, fig. 1), Middle Cambrian.
Bathyuriscus atossa Walcott (pl. 48, fig. 2), Middle Cambrian.
Bathyuriscus bantius Walcott (pl. 49, fig. 2), Middle Cambrian.
Bathyuriscus batis Walcott (pl. 48, fig. 4), Lower Cambrian.
Bathyuriscus belesis Walcott (pl. 50, fig. 1), Lower ? Cambrian.
Bathyuriscus belus Walcott (pl. 50, fig. 2), Lower ? Cambrian.
Bathyuriscus ? bithus Walcott (pl. 47, fig. 4), Middle Cambrian.
Bathyuriscus haydeni (Meek) (pl. 46, fig. 2), Middle Cambrian.
Bathyuriscus howelli Walcott (pl. 47, fig. 1), Middle Cambrian.
Bathyuriscus manchuriensis Walcott (pl. 49, fig. 4), Middle Cambrian.
Bathyuriscus ornatus Walcott (pl. 46, fig. 4), Middle Cambrian.
Bathyuriscus rotundatus (Rominger) (pl. 47, fig. 2), Middle Cambrian.
Bathyuriscus stoliczkai Reed, Middle ? Cambrian.
Bathyuriscus sp. undt. (1) (pl. 49, fig. 3), Middle Cambrian.
Bathyuriscus ? sp. undt. (2) (pl. 65, fig. 5), Middle Cambrian.
Bathyuriscus (*Poliella*) *anteros* Walcott (pl. 46, fig. 5), Middle Cambrian.
Bathyuriscus (*Poliella*) *balus* Walcott (pl. 49, fig. 1), Middle Cambrian.
Bathyuriscus (*Poliella*) *caranus* Walcott (pl. 46, fig. 8), Middle Cambrian.
Bathyuriscus (*Poliella*) *occidentalis* (Matthew) (pl. 46, fig. 3), Middle Cambrian.
Bathyuriscus (*Poliella*) *powersi* Walcott (pl. 46, fig. 1), Middle Cambrian.
Bathyuriscus (*Poliella*) *primus* Walcott (pl. 46, fig. 6), Lower Cambrian.
Bathyuriscus (*Poliella*) *probus* Walcott (pl. 65, fig. 2), Middle Cambrian.
Bathyuriscus (*Poliella*) *sylla* Walcott (pl. 48, fig. 3), Middle Cambrian.
Bathyuriscus (*Poliella*) sp. undt. (1) (pl. 46, fig. 7), Lower Cambrian.

Generic reference of species heretofore placed under Bathyuriscus and now referred to other genera is as follows:

Bathyuriscus asiaticus Lorenz = *Dolichometopus.*
Bathyuriscus (*Kootenia*) *dawsoni* Walcott = *Kootenia.*
Bathyuriscus productus (Hall and Whitfield) = *Dolichometopus.*
Bathyuriscus pupa Matthew = *Bathyuriscus occidentalis* Matthew.
Bathyuriscus senectus Matthew (1897) = *Corynexochus.*
Bathyuriscus sp. undt. (from China) Walcott = *Dolichometopus.*
Bathyuriscus sp. undt. Walcott (1899) = *Anomocare ?*

BATHYURISCUS ADÆUS, new species

Plate 47, figs. 3, 3*a-c*

This species is closely related to *Bathyuriscus rotundatus.* It differs: (a) in having a broader space between the front of the glabella and the anterior edge of the cranidium; (b) in having the outer angle of the thoracic pleura (genal angle) less rounded and the triangular tubercle at the inner end of the pleural furrow somewhat

stronger; (c) in having one or two more rings on the median lobe of the pygidium, and in having the first segment of the pygidium extended as a short spine beyond the border.

There are nine thoracic segments and six segments in the axis of the pygidium that continue across the pleural lobes to the margin.

The largest specimen of the dorsal shield in the collection has a length of 40 mm.

Formation and locality.—Middle Cambrian: (58j) Stephen formation; about 1,900 feet (579 m.) above the Lower Cambrian and 3,100 feet (945 m.) below the Upper Cambrian, near the base of the limestone forming 2 of the Stephen formation, on the east side of Mount Stephen about 3,000 feet (914 m.) above the Canadian Pacific Railway track (north of the tunnel), 3 miles (4.8 km.) east of Field; and (61j) yellow-weathering band of calcareo-argillaceous shale; west slope of Mount Field, near Burgess Pass ridge, about 3,000 feet above Field, on Canadian Pacific Railway, British Columbia, Canada.

BATHYURISCUS ANAX, new species

Plate 48, figs. 1, 1*a-d*

Bathyuriscus productus (Hall and Whitfield) Walcott (In part), 1886, Bull. 30, U. S. Geol. Surv., pl. 30, figs. 1, 1*a*, 1*b*, 1*g*, 1*h*. (The specimens illustrated by the above figures are all from Big Cottonwood Canyon, Wasatch Mountains, and are now considered as belonging to the species *B. anax*.)

This fine species is readily separated from the species now referred to as *Dolichometopus productus* by the form of its glabella and the character of its pygidium. It also has one more thoracic segment. It differs from *B. atossa* in having one less thoracic segment (8), a longer palpebral lobe and broader axial lobe on thorax and pygidium; *B. atossa* also has an occipital spine that has not yet been seen on *B. anax*. It is closely related to *B. rotundatus* except that it has one less thoracic segment and longer palpebral lobes.

The specimens from Big Cottonwood Canyon (30a) show only the cranidium and pygidium, but these appear to be identical with similar parts from further north in the Wasatch Range (55e), and they are not identical with *Dolichometopus productus,* with which I placed them in 1886.

The largest entire dorsal shield has a length of 40 mm., and the outer surface is slightly roughened by shallow pits.

Formation and locality.—Middle Cambrian: (55e) Spence shale horizon of the Ute formation; about 100 feet (30.5 m.) above the Brigham quartzite, at the mouth of the first small canyon south of

Wasatch Canyon, east of Lakeview Ranch, Boxelder County; and (30a) shale on north side of Big Cottonwood Canyon, 1 mile (1.6 km.) below Argenta, in the Wasatch Mountains southeast of Salt Lake City, Salt Lake County, both in Utah.

BATHYURISCUS ATOSSA, new species

Plate 48, figs. 2, 2a-b

In size and general characters this species at once suggests *B. anax* (pl. 48, fig. 1) and *B. rotundatus* (pl. 47, fig. 2a). The three species also occur at about the same horizon in the Middle Cambrian section. *Bathyuriscus atossa* differs from *B. anax* in having one more thoracic segment (9), a shorter palpebral lobe and relatively narrower axial lobe both in thorax and pygidium.

From *B. rotundatus* it differs in having a relatively narrower median axis in thorax and pygidium, and the axial lobe is shorter in the pygidium. The tubercle at the inner end of the pleural furrow is also stronger than in the other species mentioned. I identified this species with *B. rotundatus* in my field notes, but a closer comparison seems to indicate that although closely allied they differ in detail sufficiently to distinguish them as distinct species.

Formation and locality.—Middle Cambrian: (55c) Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

BATHYURISCUS BANTIUS, new species

Plate 49, figs. 2, 2a-c

This species is represented by only the cranidia and associated pygidia as casts in a shaly sandstone of the Rome formation. The cranidia vary in outline, especially in the glabella, owing mainly to distortion caused by compression and some lateral motion in the sandy matrix. The one illustrated (fig. 2) has a length of 9 mm. and it appears to have nearly its original form and convexity. The glabella is marked by the usual oblique posterior pair of furrows and three shorter pairs, the anterior of which slope a little forward from the dorsal furrow, beside the glabella. The eye lobes are much like those of *B. haydeni*. The associated pygidia have from 6 to 7

rings in the axial lobe that are well defined by narrow furrows on the pleural lobes. Surface unknown.

There appears to be a gradation in size among the cranidia from 9 mm. up to 24 mm. in length, and the associated pygidia from 3 mm. to 23 mm. in length.

It is possible that a second species is represented in the larger specimens, but with the material now in hand this is too uncertain to base a species on.

No traces of the test or outer surface have been found.

At locality **9a** this species is associated with:

Lingulella desiderata (Walcott)
Lingulella similis (Walcott)
Ptychoparia sp. undt.

At locality **11** it is associated with:

Lingulella ino (Walcott)
Lingulella tarpa (Walcott)

And at locality **14a** with:

Micromitra alabamaensis (Walcott)
Obolus willisi (Walcott)
Obolus (*Westonia*) *ella* (Hall and Whitfield)
Lingulella similis (Walcott)
Wimanella saffordi (Walcott)
Ptychoparia sp. undt.

Formation and locality.—Middle Cambrian: Rome formation: (**9**) Shaly sandstone on southeastern slope of ridge 1 mile (1.6 km.) north of the northwest corner of Harlan Knob, about 4 miles (6.4 km.) northeast of Rogersville; and (**9a**) on the south shore of the Holston River at Melinda Ferry, 5 miles (8 km.) southwest of Rogersville, both in Hawkins County; (**11**) sandstones and shales of the Rome formation, about 1 mile (1.6 km.) east of Post Oak Springs, Roane County; (**11b**) in ridge, at Woods Creek Gap, 6 miles (9.6 km.) northeast of Knoxville; also (**12b**) southeast end of McAnnallys Ridge, 12 miles (19.3 km.) northeast of Knoxville; and (**14a**) along First Gap Creek, 4 miles (6.4 km.) north-northeast of Knoxville, all three in Knox County, and all in Tennessee.

BATHYURISCUS BATIS, new species

Plate 48, figs. 4, 4*a*

This fine species has 8 thoracic segments, a strong glabella, and a large pygidium. It occurs in a hard siliceous rock in which the

specimens are compressed and slightly distorted. No traces of the test or outer surface have been seen.

The glabella is not well preserved in any of the seven specimens before me. One of them is similar in outline to the glabella of *Protypus hitchcocki* (Whitfield),[1] but that species is quite unlike *B. batis* in other characters. One glabella suggests *Dorypyge* and three the glabella of *B. primus*.

The pygidium with its 5 or 6 anchylosed segments is not unlike that of *B. haydeni* and *B. atossa*.

The largest dorsal shield has a length of 38 mm.

The only associated species is *Mesonacis gilberti* (Meek) Walcott.

Formation and locality.—Lower Cambrian: (59p) Millers Mountain, 10 miles (16 km.) north of Columbus and west of Belleville, Esmeralda County, Nevada.

BATHYURISCUS BELESIS, new species

Plate 50, figs. 1, 1*a-i*

The form from locality 4v I referred to *"Bathyuriscus productus"*[2] in my field notes, but comparison shows that it varies in having the anterior half of the glabella more expanded and stronger indications of glabellar furrows. The pleural lobes of the thoracic segments are also terminated in a more abrupt point than those of *D. productus*. The adult pygidium is sometimes similar to that of *D. productus* (pl. 53, fig. 4*a*), but a pygidium 2 mm. in length has the anchylosed pleural segments as clearly defined as in the type specimens of *B. haydeni*, while the larger pygidia have more or less traces of grooves or ridges on the pleural lobes. The pleural ridges on a small pygidium 2 mm. in length are more rounded and the furrows narrower than in adult pygidia or in the pygidia of *B. belus* (pl. 50, figs. 2, 2*a-c*) or *B. anax* (pl. 48, figs. 1, 1*a-d*).

The cranidium of *B. belesis*, while similar in form to that of *B. belus*, differs in its shorter, more anterior palpebral lobe and larger postero-lateral limb and the absence of well-defined glabellar furrows.

Exterior surface unknown. The largest cranidium in the collection has a length of 23 mm. and the largest pygidium 18 mm.

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[1] Bull. American Mus. Nat. Hist., Vol. 1, 1884, p. 148, pl. 14, fig. 13.

[2] Smithsonian Misc. Coll., Vol. 53, No. 5, 1908, Walcott, Cambrian sections of the Cordilleran area, pp. 202-203.

The fauna associated with this species at the type locality (4v) as far as identified includes:

Micromitra (*Iphidella*) *pannula* (White)
Obolus (*Westonia*) *ella* (Hall and Whitfield)
Acrothele colleni Walcott
Acrothele panderi Walcott
Wimanella simplex Walcott
Ptychoparia sp.
Olenopsis americanus Walcott
Vanuxemella contracta Walcott

A single pygidium from locality 4q appears to be identical with the pygidia of this species. It is associated with:

Micromitra (*Iphidella*) *nyssa* Walcott
Micromitra (*Iphidella*) *pannula* (White)
Wimanella simplex Walcott
Acrothele colleni Walcott
Ptychoparia 3 spp.
Zacanthoides

Formation and locality.—Lower ? Cambrian: (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, in a shale which corresponds in stratigraphic position to shale No. 6 of the Dearborn River section,[1] Gordon Creek, 6 miles from South Fork of Flathead River, Ovando quadrangle (U. S. G. S.), Powell County, Montana.

Also doubtfully from (locality 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 which corresponds in position to the upper part of shale No. 6 of the Dearborn River section,[1] on the ridge between Gordon and Youngs Creeks, about halfway between Gordon Mountain and Cardinal Peak, Ovando quadrangle (U. S. G. S.), Powell County, Montana.

BATHYURISCUS BELUS, new species

Plate 50, figs. 2, 2*a-d*

This species attains a larger size than either *B. anax* or *B. atossa*, and differs from them in minor details of the cranidium and pygidium. There is a faint trace of pleural furrows on the lateral lobes of the pygidium, whereas in *B. anax* and *B. atossa* they are strongly defined. The variations from *B. belesis* are mentioned under that species.

[1] Smithsonian Misc. Coll., Vol. 53, No. 5, 1908, Walcott, Cambrian sections of the Cordilleran area, p. 202.

The largest cranidium has a length of 19 mm. and the largest pygidium has a length of 22 mm. and a width of 37 mm.

There are six cranidia and six pygidia in the collection at locality 4w that were associated in the same thin layer of sandstone. The associated fossils are *Wimanella simplex, Ptychoparia* sp. undt., and *Zacanthoides* sp. undt. As the two latter do not have a pygidium of the *Bathyuriscus* type, I think we are fairly safe in tentatively considering the pygidia as belonging with the cranidia referred to *Bathyuriscus.*

An associated hypostoma of the *Bathyuriscus* form has the surface of its central portion marked by fine, sharp, irregularly concentric ridges. None of the cranidia or pygidia appear to have the outer surface of the test. They occur as casts in a very fine, chocolate-colored, arenaceous shale.

Formation and locality.—Lower ? Cambrian: (4w) 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 which corresponds in position to shale No. 6 of the Dearborn River section,[1] on Youngs Creek, about 5 miles (8 km.) from its junction with Danaher Creek; and (8j) about 575 feet (175.3 m.) above the unconformable base of the Cambrian in a shale which corresponds in position to shale No. 4 of the Dearborn River section,[1] on the ridge between Gordon and Youngs Creeks, about halfway between Gordon Mountain and Cardinal Peak; both in Ovando quadrangle (U. S. G. S.), Powell County, Montana.

BATHYURISCUS ? BITHUS, new species

Plate 47, figs. 4, 4*a*

This species is based on two pygidia that indicate a form larger than any known species of *Bathyuriscus,* in this respect approaching *Dolichometopus tontoensis* (pl. 51, figs. 1, 1*f*, 1*g*). The axial lobe has six indicated segments and a terminal section, the segments extending obliquely backward on the pleural lobes and nearly across the broad, flattened margin.

Surface slightly roughened by fine, irregular, inosculating ridges that on the border are subparallel to the outer margin.

The larger pygidium has a portion of a thoracic segment attached to it. It has a length of 33 mm. The smaller pygidium is 20 mm. in length.

[1] Smithsonian Misc. Coll., Vol. 53, No. 5, 1908, Walcott, Cambrian sections of the Cordilleran area, p. 202.

These pygidia are placed in *Bathyuriscus* rather than *Dolichometopus* on account of the distinctness of the segments on the pleural lobes.

Formation and locality.—Middle Cambrian: Spence shale member of the Ute formation: (55c) about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

Also, Spence shale horizon of the Ute formation: (55e) about 100 feet (30.5 m.) above the Brigham quartzite, at the mouth of the first small canyon south of Wasatch Canyon, east of Lakeview Ranch, Boxelder County, Utah.

BATHYURISCUS HAYDENI (Meek)

Plate 46, figs. 2, 2*a-b*

Bathyurus ? haydeni MEEK, 1873, Sixth Ann. Rept., U. S. Geol. Surv. Terr., p. 482. (Detailed description of species and comparison with species of several genera.)

Description.—General form elliptical to elongate oval; moderately convex, with pleural lobes slightly flattened. Cephalon probably semicircular with genal angles extended backward in short spines as in closely allied species. Glabella narrow, convex, and expanding in advance of the palpebral lobes to the broadly rounded front; occipital furrow strong, arching slightly forward from the sides towards the center; occipital ring strong, convex, and rising towards the center as though it may have had a node or short spine near its posterior margin; the posterior pair of glabellar furrows are quite strong; they commence about opposite the center of the palpebral lobe and extend obliquely backward and inward to a shallow connecting transverse furrow which delimits a transverse posterior lobe about as wide as the occipital ring; the next succeeding anterior pair of furrows are short and inclined a little backward, while the third pair extended directly inward as slight, short indentations, and the fourth very short and distinct pair are directed slightly forward.

Fixed cheeks narrow, with strong elongate palpebral lobes which extend across them anteriorly as a narrow ridge to the dorsal furrow, the lobe on each side being separated by a narrow furrow; the eye lobe appears to have been about one-fifth the length of the head; anteriorly the fixed cheek merges into a narrow area and posteriorly

into an elongate postero-lateral limb that is furrowed by a well-defined groove that delimits a rim that is very narrow near the axial lobe and broader towards the facial suture. Free cheeks unknown.

"Thorax consisting of 9 segments; axial lobe very narrow, or only about two-thirds as wide as the lateral lobes, tapering gradually backward, and moderately convex; lateral lobes flattened, and lower than the axial; pleuræ broadly and deeply furrowed, and having their free ends apparently falcate.

"Pygidium intermediate between semicircular and semielliptical, its length being about two-thirds its breadth, while its posterior margin is rounded in outline, and its anterior nearly straight across; mesial lobe as narrow, proportionally, as that of the thorax, convex, tapering very gradually backward, and nearly reaching the posterior border, showing five or six well-defined segments, with space enough for one or two more behind those; lateral lobes flat, with five or six broadly furrowed segments that extend to, but not upon, a very narrow, slightly thickened and flattened, smooth margin."[1]

To the above may now be added: A node or short spine occurs at the center of each segment of the convex axial lobe of the thorax and pygidium. There is an oval swelling on each side of the axial segments of the thorax close to the longitudinal dorsal furrow and a triangular node-like swelling in the pleural furrow of each segment with the narrow base of the triangle abutting against the dorsal furrow. This peculiar form of swelling is best seen in *B. ornatus* (pl. 46, figs. 4, 4*a*). The terminal section of the pygidium is continued down as a low ridge to the slightly incurved posterior margin.

Surface smooth or finely roughened by very minute irregular ridges or granules.

Dimensions.—The largest entire specimen has a length of 30 mm. Associated pygidia indicate a length of 40 mm. for some specimens.

Observations.—The material illustrating *B. haydeni* is not as good as for some other species, but it is sufficient to show the principal characters and that its pygidium is unlike that of any other species referred to the genus.

Formation and locality.—Middle Cambrian: (302) Gallatin limestone; east of West Gallatin River, above Gallatin, Gallatin County, Montana.

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[1] Quoted from Meek's description, p. 483.

BATHYURISCUS HOWELLI Walcott

Plate 47, figs. 1, 1*a-b*

Bathyuriscus howelli Walcott, 1886, Bull. U. S. Geol. Surv., No. 30, p. 216, pl. 30, figs. 2, 2*a*. (Describes and illustrates species.)

Bathyuriscus howelli Walcott, 1888, American Jour. Sci., 3d ser., Vol. 36, p. 165. (Considers *Embolimus* [=*Bathyuriscus*] *rotundatus* Rominger [1887] identical with this species.)

Not *Bathyuriscus howelli* Matthew, 1899, Trans. Royal Soc. Canada, 2d ser., Vol. 5, Sec. 4, p. 50. (Describes the young of *Embolimus* [=*Bathyuriscus*] *rotundatus* Rominger, following Walcott in identification of the latter species as *B. howelli*.)

Bathyuriscus howelli Toll, 1899, Mem. l'Acad. Imp. Sci. St. Petersburg, 8th ser., Vol. 8, No. 10, p. 30, pl. 2, fig. 11. (Identifies a pygidium from the Cambrian of Siberia as *B. howelli*, and illustrates same.)

Not *Bathyuriscus howelli* Woodward, 1902, Geol. Mag., Dec. 4, Vol. 9, p. 532, text fig. 2. (Discusses species when studying specimens of *Embolimus* [=*Bathyuriscus*] *rotundata* Rominger and illustrates by a diagrammatic figure of the latter species.)

Bathyuriscus howelli Pack, 1906, Jour. Geol., Vol. 14, p. 296, pl. 2, figs. 2, 2*a*. (Comments on species and illustrates a cranidium and pygidium.)

Not *Bathyuriscus howelli* Walcott, 1908, Smithsonian Misc. Coll., Vol. 53, p. 198. (Named as occurring in Spence Shale. The species is now referred to *Bathyuriscus rotundatus* (Rominger).)

Bathyuriscus howelli Grabau and Shimer, 1910, North American Index Fossils, Vol. 2, p. 287, fig. 1592. (Brief description and reproduces Walcott's figure of 1886.)

This is a rather rare form in the collections I have seen from the vicinity of Pioche. It occurs in a compact argillaceous shale with a group of species characteristic of the Middle Cambrian fauna. Very little has been added to our knowledge of the species since its first description in 1886. Pack (1906) illustrates a glabella that has a fourth pair of small, short, anterior furrows that with the third pair extend slightly forward from the dorsal furrow.

In 1881[1] when reviewing Dr. Rominger's paper on "Primordial Fossils from Mt. Stephen"[2] and some collections from Mt. Stephen I identified *Embolimus* [=*Bathyuriscus*] *rotundatus* Rominger as identical with *B. howelli*. Two errors were made in this paper: I mistook the crushed-down, postero-lateral limb of the cranidium of *B. howelli* for a thoracic segment, thus giving the latter species nine thoracic segments instead of eight, and owing to rather unfavorable specimens of *B. rotundatus* I did not note other differences which

[1] American Jour. Sci., 3d ser., Vol. 36, 1888, p. 165.

[2] Proc. Acad. Nat. Sci., Philadelphia, 1887, pp. 12-19, pl. 1.

with fine specimens for comparison I find to exist. The differences between the two species consist principally in the greater expansion of the frontal portion of the glabella of *B. howelli.* It also has more elongate palpebral lobes, narrower postero-lateral limbs of the cranidium, one less thoracic segment and a shorter median lobe and a broader border on the pygidium. These differences are shown by the illustrations of the two species on plate 47, figures 1 and 2.

The elongate triangular tubercle at the inner end of the thoracic pleural furrows is small in *B. howelli* as compared with *B. ornatus* (pl. 46, fig. 4), but it is about as strong as in *B. haydeni* (pl. 46, fig. 2) and *B.* (*Poliella*) *powersi* (pl. 46, fig. 1).

Formation and locality.—Middle Cambrian: (31) Chisholm shale; Chisholm mine, southwest slope of Ely Mountains, 3 miles (4.8 km.) northwest of Pioche, Lincoln County, Nevada.

Mr. F. J. Pack records this species from several mine dumps that cut into the Chisholm shale about 2 miles west of Pioche.[1]

BATHYURISCUS MANCHURIENSIS Walcott

Plate 49, figs. 4, 4*a-c*

Bathyuriscus manchuriensis WALCOTT, 1911, Smithsonian Misc. Coll., Vol. 57, No. 4, pp. 97-99, pl. 16, fig. 4. (Described and discussed as a new species essentially as below.)

Bathyuriscus manchuriensis WALCOTT, 1913, Research in China, Vol. 3, p. 219, pl. 23, figs. 2, 2*a-f*. (Describes and illustrates species.)

This species is founded on numerous specimens of the cranidium, free cheeks, thoracic segments, and pygidium that are compressed in a fine argillaceous shale. Unfortunately, there are no entire specimens of the dorsal shield.

As restored by combining the free cheeks and cranidium, the cephalon is semicircular in outline and moderately convex. It is bordered by a narrow, slightly rounded margin that is separated by a sharply defined, narrow furrow from the glabella and the slope of the free cheeks. The posterior border is very narrow, elevated, and separated from the fixed cheek by strongly defined furrow; the palpebral lobes are narrow and a little less than one-fourth the length of the cephalon. Genal angles extended into short, sharp, backward-curving spines. The cranidium is broad at the base, narrowing toward the front; the antero-lateral limbs are very small and disappear where the palpebral lobe touches the dorsal furrow; the

[1] Jour. Geol., Vol. 14, 1906, p. 297.

postero-lateral limbs and narrow fixed cheeks merge into each other so as to form transversely subtriangular areas, with the narrow palpebral lobes on their front outer margins.

Glabella large, subquadrangular in outline, and separated from the fixed cheeks by clearly defined dorsal furrows; its sides are nearly parallel or slightly diverging; front broadly rounded, almost transverse; surface marked by five pairs of furrows, the posterior of which extends obliquely across the posterior portion nearly to the center and separates a small triangular lobe on each side; the next two anterior pairs of furrows are short and extend inward at right angles to the side of the glabella; the anterior pair is nearly opposite the front end of the palpebral lobe; the anterior furrows are short and extend obliquely inward subparallel to the front margin of the glabella. Occipital ring narrow at the sides, widening toward the center, where it is marked by a small, sharp node a little back of the transverse center. Free cheeks large and surmounted on the inner side by a narrow eye-lobe. The facial sutures cut the posterior margin a little within the genal angle and extend obliquely inward and slightly forward to the base of the eye-lobes; curving over and around the eye-lobes, they extend forward and downward, cutting the front margin on a line with the posterior base of the eye-lobe. Number of thoracic segments unknown. Single specimens of the segments show that the axial lobe was nearly as wide as the pleural lobes, that it was moderately convex, and that a small node occurs at the center of each segment near the posterior margin; also that on the outer side of each segment a rounded transverse node is outlined from the main body of the segment by a slightly oblique transverse furrow; pleural lobes nearly flat out to the geniculation, where they curve gently downward; each pleura has a furrow that is broad at its inner end next to the axial lobe and gradually narrows to the geniculation, where it terminates within the somewhat broadly rounded, outer extremity; in well-preserved specimens a rounded ridge starts near the inner end of the pleural furrow and extends outward one-fourth of the length of the furrow.

The associated pygidia are semicircular, with the anterior margin almost transverse in the compressed specimens. The axial lobe is large and quite distinctly marked; it is divided by three transverse furrows into three rings and a terminal section that ends posteriorly just within the outer border; a small node occurs near the posterior margin at the center of each ring; five anchylosed segments are

outlined on the pleural lobes by furrows that progressively curve more and more backward from the first to the posterior one, which adjoins the terminal segment; the furrows all terminate within the narrow, slightly flattened border.

The casts of the outer surface indicate that it was smooth or minutely granulose.

This species appears to be quite distinct from any that has been described. The quadrangular glabella with nearly parallel sides distinguishes it from *Bathyuriscus howelli* Walcott.

Formation and locality.—Middle Cambrian: (35 o, 36g, 36h) Fuchóu series, shales about 130 feet (40 m.) above the white quartzite; collected near a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.[1]

Collected by J. P. Iddings and Li San.

BATHYURISCUS ORNATUS Walcott

Plate 46, figs. 4, 4*a-b*

Bathyuriscus ornatus Walcott, 1908, Smithsonian Misc. Coll., Vol. 53, p. 39, pl. 1, figs. 1-3. (Describes and illustrates species.)

Bathyuriscus ornatus Walcott, 1908, Canadian Alpine Jour., Vol. 1, No. 2, pl. 3, fig. 3. (Republishes fig. 1 of previous paper.)

This form was described in detail in 1908. It is so strongly marked by the triangular tubercle in the thoracic pleural furrow and by the absence of genal spines that there is little chance of its being mistaken for any other known species of the genus.

Formation and locality.—Middle Cambrian: (14s) About 2,300 feet (701 m.) above the Lower Cambrian and 2,700 feet (823 m.) below the Upper Cambrian, in the *Ogygopsis* zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad, British Columbia, Canada.

BATHYURISCUS ROTUNDATUS (Rominger)

Plate 47, figs. 2, 2*a-b*

Embolimus rotundata Rominger, 1887, Proc. Acad. Nat. Sci. Phil., p. 16, pl. 1, figs. 4, 5. (Describes and illustrates species.)

Bathyuriscus howelli Walcott, 1888, American Jour. Sci., 3d ser., Vol. 36, p. 165. (Considers *Embolimus rotundatus* Rominger as identical with *Bathyuriscus howelli*.)

[1] For general section giving stratigraphic relations, see Blackwelder, Research in China, Vol. 1, Pt. 1, 1907, p. 92.

Bathyuriscus howelli MATTHEW, 1899, Trans. Royal Soc. Canada, 2d ser., Vol. 5, Sec. 4, p. 50. (Follows Walcott in identifying specimens of *Embolimus* [=*Bathyuriscus*] *rotundatus* Rominger as *Bathyuriscus howelli* and describes specimens of the young of the species.)

Bathyuriscus howelli WOODWARD, 1902, Geol. Mag., Dec. 4, Vol. 9, p. 532, text fig. 2. (Follows Matthew when studying specimens of *Embolimus* [=*Bathyuriscus*] *rotundatus* Rominger.)

Bathyuriscus rotundatus WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, p. 41. (Mentions species in comparisons with *Bathyuriscus ornatus*.)

Bathyuriscus rotundatus WALCOTT, 1908, Idem, p. 198. (Lists species as *Bathyuriscus howelli* as occurring in Spence Shale.)

Bathyuriscus rotundatus WALCOTT, 1908, Canadian Alpine Jour., Vol. 1, No. 2, pl. 4, fig. 2. (Illustrates species by figure which is reproduced as fig. 2, pl. 47 of this paper.)

Bathyuriscus rotundatus GRABAU and SHIMER, 1910, North American Index Fossils, Vol. 2, p. 288, fig. 1593. (Brief description and reproduction of Walcott's figure of 1908.)

As mentioned under *Bathyuriscus howelli,* I identified this species by error with *B. howelli.* It differs from the latter in having a less expanded glabella, less elongate palpebral lobes, broader postero-lateral limbs on the cranidium; one more thoracic segment (nine) and a longer median lobe and narrower margin on the pygidium. The differences are shown by figures 1 and *2a,* plate 47.

A single pygidium was found in a thin-bedded limestone (locality **57j**) just beneath the *Ogygopsis* shale on Mount Stephen that is closely related to the pygidium of this species.

Formation and locality.—Middle Cambrian: Stephen formation; (**14s**) about 2,300 feet (701 m.) above the Lower Cambrian and 2,700 feet (823 m.) below the Upper Cambrian, in the *Ogygopsis* zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen; (**57j**) about 2,000 feet (609.6 m.) above the Lower Cambrian in the limestone forming 2 of the Stephen formation, just east of the "fossil bed" on the northwest slope of Mount Stephen; and (**35k**) Burgess shale member of the Stephen formation on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northeast of Burgess Pass, all three above Field on the Canadian Pacific Railway, British Columbia, Canada.

BATHYURISCUS STOLICZKAI Reed

Bathyuriscus ? stoliczkai REED, 1910, Mem. Geol. Surv., India, ser. 15, Vol. 7, Mem. No. 1, Cambrian Fossils of Spiti, p. 37, pl. 5, figs. 5-8. (Species described and figured.)

Mr. F. R. C. Reed has given a very detailed description of this species, and the illustrations are excellent. He very kindly sent me

the specimens for examination two years ago, and from notes made before returning them I find that I considered the species to belong to the genus *Bathyuriscus*. Mr. Reed thought that there were 12 or 13 thoracic segments. I could not make out more than eleven, and the casts of the type specimens now before me do not appear to have more than eleven. The back of the occipital segments shows in the specimen from which his figure 7 is taken, and the last segment referred to the thorax in his figure 8 seems to belong to the pygidium.

The form of the cranidium, thoracic segments, and pygidium relate this species most nearly to *B. rotundatus* (pl. 47, fig. 2).

Formation and locality.—Middle Cambrian: Valley of the Parahio, Spiti, Kashmir, India.

BATHYURISCUS, species undetermined (1)

Plate 49, figs. 3, 3*a*

A species of *Bathyuriscus* not unlike *B. atossa* (pl. 48, fig. 2) occurs in the Conasauga shales of Alabama. A distorted cranidium, a free cheek, six thoracic segments and a fairly good pygidium occur on fragments of the shale, but as they are not united and there is only one specimen of each part, I do not think it worth while to base a species on them. The pygidium has a length of 10 mm. with an axial lobe 8 mm. in length; the latter has four well-defined rings that are extended across the pleural lobes as flattened bands separated by narrow furrows; there is also a trace of a shallow pleural furrow.

Formation and locality.—Middle Cambrian: (16e) Conasauga formation; cut on East and West Railway, 1 mile (1.6 km.) southwest of Piedmont, Calhoun County, Alabama.

BATHYURISCUS ? species undetermined (2)

Plate 65, fig. 5

A large species, related to *Bathyuriscus adœus* (pl. 47, figs. 3, 3*a*) by the form of the pygidium, has a single pair of sharp spines projecting from the antero-lateral angles; it has eight rings and a terminal section in the axial lobe; the anchylosed segments are shown on the pleural lobes as seven or eight shallow furrows separated by narrow ridges; a narrow strong border merges into the border spines which extend obliquely backward.

Formation and locality.—Middle Cambrian: (11p) Marjum formation; limestone of 1*e* of section, about 2,000 feet (609.6 m.) above the Lower Cambrian and 1,010 feet (307 m.) below the Upper Cam-

brian, in the long cliff about 2.5 miles (4 km.) east-southeast of Marjum Pass, House Range, Millard County, Utah.

POLIELLA, new subgenus

The species *B.* (*Poliella*) *powersi, B.* (*Poliella*) *anteros, B.* (*Poliella*) *occidentalis, B.* (*Poliella*) *primus, B.* (*Poliella*) *caranus, B.* (*Poliella*) *sylla, B.* (*Poliella*) *balus,* and *B.* (*Poliella*) *probus* all suggest by their small and different pygidia a subgeneric distinction from the typical species of *Bathyuriscus, B. haydeni,* and for them I propose the subgenus *Poliella.*

The range in the number of thoracic segments is from 7 (*B.* (*Poliella*) *caranus* (pl. 46, fig. 8)) to 11 (*B.* (*Poliella*) *powersi* (pl. 46, fig. 1)). *Bathyuriscus* (*Poliella*) *powersi,* of the Middle Cambrian, with its 11 segments and small pygidium, is a primitive form of *Poliella,* while *B.* (*Poliella*) *primus,* of the Lower Cambrian, has a more highly developed *Dolichometopus*-like cephalon, eight thoracic segments, and a very well developed though small pygidium.

Genotype.—Bathyuriscus (*Poliella*) *anteros* Walcott.

Observations.—Most of the species of *Poliella* are small. Of the two larger species, *B.* (*Poliella*) *primus* has a length of 27 mm., and *B.* (*Poliella*) *balus* about 30 mm.

The stratigraphic range and geographic distribution are given under the genus *Bathyuriscus* (p. 330).

BATHYURISCUS (POLIELLA) ANTEROS, new species

Plate 46, fig. 5

This neat species has a relatively large cephalon, nine thoracic segments and a small pygidium. Of the eight entire dorsal shields found the largest has a length of 18 mm. It is similar in general character to *B.* (*Poliella*) *occidentalis* (pl. 46, fig. 3), but differs in having a larger palpebral lobe and a smaller pygidium in proportion to the thorax. How much this may be owing to the imperfection of the specimen of *B.* (*Poliella*) *occidentalis,* it is difficult to determine. The latter occurs in a hard, very fine-grained arenaceous shale, and *B.* (*Poliella*) *anteros* in a moderately compact argillaceous shale in which the specimens retain much of their original convexity.

Bathyuriscus (*Poliella*) *anteros* differs from *B. haydeni* in many details of the cranidium, thorax, and especially the pygidium. A comparison with *B.* (*Poliella*) *primus* will be found under that species.

Formation and locality.—Middle Cambrian: (55c) Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

BATHYURISCUS (POLIELLA) BALUS, new species

Plate 49, figs. 1, 1*a-g*

This is one of the species occurring in an argillaceous shale that has been compressed and distorted more or less by the movement in the sediment. Fortunately its remains are abundant and afford data from which a very fair conception of the species may be obtained.

Bathyuriscus (*Poliella*) *balus* has the elongate eye lobe and small pygidium characteristic of *B.* (*Poliella*) *powersi* (pl. 46, fig. 1) and *B.* (*Poliella*) *primus* (pl. 46, figs. 6, 6*a-b*). Specimens occur with nine and others with 10 thoracic segments. The sharp spines on the occipital ring of the cranidium and the median lobe of all of the thoracic segments are similar to those of *B.* (*Poliella*) *powersi*. Surface not preserved.

The larger specimens range from 25 to 30 mm. in length.

This species is associated with:

Lingulella sp. undt. (48d)
Acrothele yorkensis Walcott (48d)
Acrotreta (48d)
Cystid plates (48)
Agnostus (48, 48d)
Ptychoparia (48)

Formation and locality.—Middle ? Cambrian: York ? formation; (48) cellar diggings, corner of Penn and North Streets; and (48d) argillaceous shales in railroad cut alongside of Gas House, both in City of York, York County, Pennsylvania.

BATHYURISCUS (POLIELLA) CARANUS, new species

Plate 46, fig. 8

This fine little species, 10 mm. in length, is represented in the collections by one specimen of the dorsal shield exclusive of the free cheeks. It has seven thoracic segments, the pleural furrows of which are broad near the axial lobe and narrowing gradually toward the abrupt outer termination of the segment. Surface slightly roughened by very fine, irregular inosculating edges.

This small species is somewhat similar to *B.* (*Poliella*) *anteros* (pl. 46, fig. 5); it differs in having seven instead of nine thoracic segments, more abrupt terminations of the thoracic segments, a proportionally larger glabella and broader pygidium.

Formation and locality.—Middle Cambrian: (55c) Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

BATHYURISCUS (POLIELLA) OCCIDENTALIS (Matthew)

Plate 46, fig. 3

Dolichometopus occidentalis MATTHEW, 1899, Trans. Royal Soc. Canada, 2d ser., Vol. 5, Sec. 4, No. 2, p. 49, pl. 2, fig. 2. (Describes species and illustrates with a somewhat diagrammatic figure.)

Bathyuriscus pupa MATTHEW, 1899, Idem, p. 51, pl. 2, fig. 5. (This appears to be a laterally compressed specimen of *B. occidentalis.*)

Bathyuriscus occidentalis WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, p. 41. (Places species in genus *Bathyuriscus.*)

Bathyuriscus occidentalis WALCOTT, 1908, Canadian Alpine Jour., Vol. 1, No. 2, pl. 3, fig. 2. (Illustrates type specimen.)

This small and rare species has a relatively broader glabella, nine thoracic segments, and a short pygidium with one or two rings in its axial lobe; the triangular swelling in the pleural furrow next to the dorsal furrow is scarcely visible. Only one specimen, and that a matrix, has been found and identified. This has a length of 12.5 mm.

For comparison with *B.* (*Poliella*) *anteros* (pl. 46, fig. 5), see description of the latter (p. 349).

Formation and locality.—Middle Cambrian: (14s) Stephen formation; *Ogygopsis* shale, northwest slope of Mount Stephen, above Field, on the Canadian Pacific Railroad, British Columbia, Canada.

BATHYURISCUS (POLIELLA) POWERSI, new species

Plate 46, fig.1

This very clearly defined species is similar to *B. haydeni* in cranidium and thorax, except that it has 11 thoracic segments and a more expanded frontal lobe to the glabella. Its greatest variation is in the pygidium, which has but three rings and a terminal section in its axial lobe and corresponding smaller pleural lobes and a rather strong border. The base of a small spine is preserved at the center of the

median lobe of each thoracic segment and apparently on the occipital ring of the cranidium. The differences between it and other species are clearly shown by the illustrations.

The only known dorsal shield preserving cranidium, thorax, and pygidium has a length of 21 mm. The surface is similar to that of *B. haydeni*. The type specimen was collected by Mr. Sydney Powers of a Harvard University geological party, and is now in the Museum of Comparative Zoölogy.

Formation and locality.—Middle Cambrian: Gallatin limestone; Pole Creek, a branch of Cherry Creek, Gallatin County, Montana.

BATHYURISCUS (POLIELLA) PRIMUS (Walcott)

Plate 46, figs. 6, 6*a-d*

Bornemannia prima Walcott, 1908, Canadian Alpine Jour., Vol. 1, No. 2, p. 241. (Listed.)

Bornemannia prima Walcott, 1908, Smithsonian Misc. Coll., Vol. 53, pp. 213, 214. (Lists species in geological section under new generic name *Bornemannia*. This was prior to the present study of the genus *Bathyuriscus*.)

The description of *B. haydeni* applies to this species fairly well until the pygidium is considered. The pygidium of *B. haydeni* (pl. 46, figs. 2, 2*b*) is much larger in proportion to the thorax and cephalon and it also varies in outline, number of segments, length of axial lobe, and width of pleural lobes. The short, relatively small pygidium of B. (*Poliella*) *primus* is similar to that of *B.* (*Poliella*) *anteros* (pl. 46, fig. 5) and *B.* (*Poliella*) *occidentalis* (pl. 46, fig. 3).

Three specimens referred to *B.* (*Poliella*) *primus* have nine segments (fig. 6*b*) and six have eight thoracic segments each.

The occipital segment rises and extends slightly backward at the center, where the base of a small spine is shown on several specimens. A similar spine also occurs at the center of the axial lobe of each thoracic segment.

There is considerable variation in the depth and size of the postero-lateral limb of the cranidium in associated specimens and from more or less widely separated localities. The two extremes of this character are shown in figures 6, 6*a* and 6*b*, the postero-lateral limb of the latter being much deeper and larger, which is the case in the greater number of specimens.

The largest dorsal shield in the collection has a length of 27 mm.

Bathyuriscus (*Poliella*) *primus* is the oldest known species of the subgenus. It occurs at several horizons of the Mount Whyte forma-

tion[1] in the Mount Stephen section. Its horizon is indicated by its being stratigraphically beneath both *Olenellus canadensis* and *Mesonacis gilberti* and *Corynexochus* (*Bonnia*) *fieldensis,* all of which are characteristic of the upper portion of the Lower Cambrian fauna.

At locality 35m *B.* (*Poliella*) *primus* is associated with *Agraulos statór* Walcott.

At locality 35e with:

Micromitra (*Paterina*) *wapta* Walcott
Obolus parvus Walcott
Acrothele colleni Walcott
Hyolithes billingsi Walcott
Olenopsis agnesensis Walcott
Ptychoparia sp.
Albertella sp.

At locality 57r with:

Micromitra (*Paterina*) *labradorica* var.
Micromitra (*Iphidella*) *pannula* (White)
Acrotreta sagittalis taconica (Walcott)
Ptychoparia 3 spp.

At locality 57e with:

Acrothele colleni Walcott
Acrotreta sagittalis taconica (Walcott)
Scenella varians Walcott
Stenotheca elongata Walcott
Albertella sp.
Olenellus canadensis Walcott

At locality 57t with:

Hyolithes billingsi Walcott
Scenella varians Walcott
Ptychoparia, 2 spp.
Olenopsis agnesensis Walcott

At locality 58s with:

Micromitra (*Paterina*) *labradorica* var.
Micromitra (*Iphidella*) *pannula* (White)
Acrotreta sagittalis taconica (Walcott)
Ptychoparia 3 spp.

Formation and locality.—Lower Cambrian: Mount Whyte formation: (35e) Dark-gray, siliceous shale of the Lakes Louise and Agnes Cambrian section; amphitheatre between Popes Peak and Mount Whyte, south of Lake Agnes, south of Laggan, on the Canadian

[1] Canadian Alpine Journal, Vol. 1, No. 2, (Sept.) 1908, pp. 240-242.

Pacific Railway; (35m) *Albertella* zone; 3 miles (4.8 km.) southwest of the head of Lake Louise, on east slope of Mount Whyte; (58d) Castle Mountain section, and (58t) shale, both just below the big cliff on the east shoulder of Castle Mountain, north of Canadian Pacific Railway, all in Alberta, Canada.

Localities 58k, 57e, 57r, 57t, and 58s are also Mount Whyte formation, slightly different horizons; just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia, Canada.

BATHYURISCUS (POLIELLA) PROBUS, new species

Plate 65, figs. 2, 2*a*

This species is represented by several cranidia and associated pygidia. The cranidium is much like that of *B. haydeni* and *B.* (*Poliella*) *powersi* (see pl. 46, figs. 1, 2). The associated pygidia differ very materially from both species. The short axial lobe, almost concave margin, and elongate outline suggest reference to *Coosia* rather than to *Bathyuriscus*. It is quite probable that the discovery of an entire dorsal shield would result in referring *B.* (*Poliella*) *probus* to a new genus or subgenus.

Formation and locality.—Middle Cambrian: (11 o) Limestone of Marjum formation about 2,750 feet (838.2 m.) above the Lower Cambrian and 300 feet (92 m.) below the Upper Cambrian,[1] at the base of the limestone forming 1*a* of the Marjum formation; about 4 miles (6.4 km.) southeast of Antelope Springs in the spur at the junction of the Deseret and Swasey Spring roads, House Range, Millard County, Utah.

BATHYURISCUS (POLIELLA) SYLLA, new species

Plate 48, figs. 3, 3*a-f*

This species belongs to that section of the genus *Bathyuriscus* represented by *B.* (*Poliella*) *anteros* (pl. 46, fig. 5). It has the expanded frontal portion of the glabella, falcate termination of the thoracic segments, and relatively small pygidium as compared with that of *B. haydeni* (pl. 46, figs. 2, 2*b*). One specimen preserves the pygidium and four thoracic segments, but none shows the entire thorax. The glabella has four pair of furrows; the two anterior are

[1] This distance is given as 1,650 feet (502.9 m.) [Monogr. 51, U. S. Geol. Surv., 1912, p. 179], but since that reference was published the Weeks formation has been referred to the Upper Cambrian [Smithsonian Misc. Coll., Vol. 64, 1916, p. 161], which removes 1,390 feet of strata from the Middle Cambrian to the Upper Cambrian in the House Range section.

faint and short and extend obliquely forward, and an occipital spine is indicated by the rising of the center of the occipital ring with a broken spot at the highest point.

The expansion of the glabella is much like that of *B. howelli* (pl. 47, fig. 1).

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.

BATHYURISCUS (POLIELLA), species undetermined (1)

Plate 46, fig. 7

This species is represented by two relatively large pygidia that have the general outline of the pygidium of *B. (Poliella) primus* (pl. 46, figs. 6, 6*a*). The anterior ring of the axial lobe is clearly outlined and carries a median spine with a large base; the second and third rings do not carry a spine; the axial rings extend obliquely across the pleural lobes, but they are not marked by pleural furrows. Surface of test not preserved.

Formation and locality.—Lower Cambrian: (35e) Mount Whyte formation; dark-gray, siliceous shale of the Lakes Louise and Agnes Cambrian section; amphitheatre between Popes Peak and Mount Whyte, south of Lake Agnes, south of Laggan, on the Canadian Pacific Railway, in western Alberta, Canada.

Genus DOLICHOMETOPUS Angelin

Dolichometopus Angelin, 1852, Pal. Scandinavica, Pt. 1, Crustacea formationis transitionis, Lipsiæ, p. 72. (Genus named and described under family Corynexochidæ.)

Dolichometopus Angelin, 1854, Idem. (Reprint of the preceding.)

Not *Dolichometopus ?* Billings, 1865, Pal. Foss., Vol. 1, pp. 268-269, 352. (Refers three Canadian species to the genus, none of which belong to it.)

Dolichometopus Angelin, 1878, Pal. Scandinavica, 3d ed., Holmiæ, p. 72. (Reprint of description of 1852 and 1854.)

Not *Dolichometopus* Woodward, 1884, Geol. Mag., new ser., Dec. 3, Vol. 1, p. 343. (Quotes Angelin's description and adds further details. Species described now referred to *Redlichia* Cossmann.)

Dolichometopus Zittel, 1885, Handbuch d. Pal., Vol. 2, Munich, p. 599. (Brief description of genus.)

Dolichometopus Miller, 1889, North American Geol. and Pal., p. 545. (Repeats description, and adds etymology of name as from Gr. *dolichos*, long, and *metope*, panel or space between two hollows. Doubts its being an American genus.)

Dolichometopus KOKEN, 1896, Die Leitfossilien, Leipzig, p. 15. (Briefly described under family Paradoxididæ.)

Dolichometopus FRECH, 1897, Leth. geog., Pt. 1, Leth. Pal., Vol. 2, p. 65. (Relates the genus *Niobe* to *Dolichometopus,* and identifies the latter with *Bathyuriscus* Walcott.)

Dolichometopus MATTHEW, 1897, Trans. Royal Soc. Canada, 2d ser., Vol. 3, Sec. 4, p. 184. (Discusses the genus and illustrates Angelin's type.)

Dolichometopus MATTHEW, 1897, Idem, p. 195. (Suggests that Billings's *Bathyuriscus,* extended by Walcott, is a subgenus of *Dolichometopus.*)

Amphoton LORENZ, 1906, Zeits. deuts. geol. Gesells., Vol. 58, Pt. 2, p. 75. (Described as a new genus.)

Dolichometopus LORENZ, 1906, Idem, p. 74, text figure. (Compares *Dolichometopus* and *Bathyuriscus.*)

Dolichometopus WALCOTT, 1913, Research in China, Vol. 3, Carnegie Inst. of Washington, Pub. No. 54, p. 215. (Briefly discusses genus and refers Lorenz's *Amphoton* to *Dolichometopus.*)

General form elongate oval, distinctly trilobed and rather convex. Cephalon semicircular with postero-lateral angles prolonged in sharp spines; cranidium large, with strong fixed cheeks, long postero-lateral limbs and inconspicuous antero-lateral limbs; glabella more or less broadened anteriorly and slightly contracted midway; very faint traces of three pairs of short glabellar furrows are to be seen on cast of the interior of the test of specimens of the type species[1] and more definite furrows on *D. productus*; frontal limb narrow, slightly rounded or flattened and with a furrow of varying size and depth between it and the glabella; occipital ring broad and defined from the glabella by a shallow, gently concave furrow; none of the species appear to have an occipital spine although it might be expected on *D. tontoensis;* palpebral lobes elongate and varying in the various species from one-fifth (*D. tontoensis*) to three-fifths of the length of the cranidium (*D. productus*); free cheeks of medium size and terminating in a strong spine at the genal angle. The facial sutures cut the posterior border of the cephalon at about the genal angles and then extend inward and forward to the base of the narrow eye lobes near which they curve; in front of the eyes the sutures extend forward with a gentle outward and then inward curve so as to cut the front margin on a line with the sides of the front portion of the glabella.

Thorax with seven segments; axial lobe strong and marked by a short median spine or tubercle on each segment, *D. tontoensis,* or apparently smooth, *D. productus*; pleural lobes with each segment

[1] Specimens of the cranidium of *D. suecicus* from the Andrarum limestone at Andrarum are now in the collection of the United States National Museum (C. D. W.).

having a distinct furrow crossing from the inner anterior side to the posterior outer side; the anterior outer half of each segment has a sloping faceted surface and the segments terminate in a more or less sharp falcate end.

Pygidium large with the anterior margin arched slightly forward; axial lobe convex with from five to seven transverse segments and a terminal section; pleural lobes with a broad margin and more or less faintly marked by shallow, narrow furrows that serve to indicate the outward extension of the anchylosed segments of the axial lobe.

Surface of the type species and of all species as far as known punctate (except possibly *D. acadicus* Matthew) and also marked by very fine irregular raised lines.

Dimensions.—Fragments of *D. suecicus* indicate that the entire dorsal shield was about 65 mm. in length in some specimens. Examples of *D. tontoensis* in the collection are 95 mm. in length.

Genotype.—Dolichometopus suecicus Angelin.

Stratigraphic range.—As far as known *Dolichometopus* is confined to Middle Cambrian formations.

Geographic distribution.—The genotype *D. suecicus* comes from Andrarum, Sweden. *Dolichometopus acadicus* Matthew, a somewhat closely related species to *D. suecicus,* is found in the province of New Brunswick, Canada. *Dolichometopus productus* ranged on both the Atlantic and Pacific sides of the North American Continent. It has its representative in northern Georgia and eastern Tennessee; northern Arizona and northern Utah. *Dolichometopus tontoensis* is found in the Grand Canyon of the Colorado in northern Arizona. *Dolichometopus bion* in southern Idaho; *D. baton* and *D.? bessus* in central Montana, and *D. boccar* along the Rocky Mountain Continental Divide on the line of the Canadian Pacific and Grand Trunk railroads. In Eastern China the genus is abundantly represented by *D. (?) alceste, D. (?) deois, D. (?) derceto,* and *D. (?) dirce.*

Observations.—The species referred to *Dolichometopus* and *Bathyuriscus* in this paper have long been confused by me and by others. Now I think we may define *Dolichometopus* as characterized by seven thoracic segments, a glabella almost free from lateral furrows, and a pygidium only faintly marked on its axis by transverse furrows that are extended onto the pleural lobes only as a trace, if at all. The genus *Bathyuriscus* (restricted) has from eight to nine thoracic segments, a more expanded glabella marked by distinct lateral furrows, and a pygidium with distinct axial rings and anchylosed segments on the pleural lobes.

Dr. Fritz Frech[1] says of *Dolichometopus* and allied genera: "*Niobe* is directly connected with *Dolichometopus* (*Dol. suecicus* Ang., Tril., Taf. 37, fig. 9), as Brögger already conjectured. *Dolichometopus* is identical with *Bathyuriscus* Walcott. The American recognized species with complete specimens accord with Asaphidæ in respect to the size of the pygidium, the course of the facial sutures, and the number of rings (8). Also *Symphysurus* is to be traced down from *Dolichometopus*."

On text plate B, facing p. 39, he places *Ogygopsis klotzi* (Rominger) and *Bathyuriscus occidentalis* Matthew in the genus *Dolichometopus,* although he leaves Matthew's *Bathyuriscus pupa* (a probable synonym of *Bathyuriscus occidentalis*) under the genus *Bathyuriscus.*

Dr. Th. Lorenz[2] concludes that *Bathyuriscus* is a subgenus of *Dolichometopus.* He says: "The genus *Bathyuriscus* is without doubt closely related to the Swedish genus *Dolichometopus* Angelin. The difference consists in that *Bathyuriscus* has a stronger relief, deeper glabellar furrows, and on the back part of the fixed cheeks a ridge, which is produced by the posterior course of the facial suture. *Dolichometopus* has a perfectly flat, furrowless glabella; furthermore the facial suture extends from the posterior eye angles quite direct to the posterior border without cutting out a narrow ridge as in *Bathyuriscus.* There is also a difference between the two genera in the position of the eye curves. The cause of this is that in *Dolichometopus* the posterior eye angles are situated farther from the glabella. Despite all this the form relationship of the two genera is very close, so that I hold *Bathyuriscus* as a subgenus of *Dolichometopus,* as Matthew did. Equal rank for the two genera, as Frech has done in his Lethæa, I cannot commend. It is further worthy of note that the related genus *Dolichometopus* is a guide fossil [Leitfossil] for the uppermost Middle Cambrian in Sweden."

He then compares *D. acadicus* Matthew and his own *Bathyuriscus asiaticus* Lorenz and says: "Herein the generic distinction between *Dolichometopus* and *Bathyuriscus* finds expression. They agree in the two semicircular eye lobes, the erect position of the eyes, the club-shaped glabella flattened towards the front and the flat occipital furrow. The shell structure in both is of the finest granulation. Nevertheless identification of *Dolichometopus acadicus* Matthew and *Bathyuriscus asiaticus* is not therefore permissible."[3]

[1] Leth. geog., Pt. 1, Leth. Pal., Vol. 2, 1897, p. 65.

[2] Zeitschrift der deutschen geologischen Gesellschaft, Vol. 58, Pt. 2, 1906, p. 74.

[3] Idem, p. 75.

Asiatic species.—The eastern Asiatic species of the genus all differ from the Swedish and American species in their associated pygidia. The latter have fewer segments in the axial lobe and more distinct prolongation of the axial segments on the pleural lobes. The pygidia are more like those of the species of *Bathyuriscus* with small pygidium such as *B.* (*Poliella*) *powersi* (pl. 46, fig. 1) and *B.* (*Poliella*) *primus* (pl. 46, fig. 6). If we had entire specimens of the dorsal shield of *D.* (*?*) *deois* and other Asiatic species, so that there could be no doubt that the associated pygidia belong with the cranidia, I should not hesitate to make a new subgenus of *Dolichometopus* to include them. *Dolichometopus* (*?*) *deois* (pl. 54, figs. 1, 1*a-h*) is the most abundant of the Chinese species in the form of dismembered parts of the dorsal shield, and it is found in both shale and limestone.

There also appears to be a subgenus of *Dolichometopus* indicated by *D. ? bessus* (pl. 51, fig. 3). It is characterized by a smaller pygidium very much as in the group of species of the subgenus *Poliella* (p. 349) which are those species of *Bathyuriscus* characterized by a small pygidium. Further collecting and study may result in separating *D. ? bessus* and several of the species illustrated on plate 54 as subgeneric species of *Dolichometopus*.

Species of Dolichometopus.—The species now referred to *Dolichometopus* are:

Dolichometopus acadicus Matthew (pl. 53, fig. 1), Middle Cambrian.
Dolichometopus (*?*) *alceste* Walcott (pl. 54, fig. 3), Middle Cambrian.
Dolichometopus baton Walcott (pl. 51, fig. 2), Middle Cambrian.
Dolichometopus ? bessus Walcott (pl. 51, fig. 3), Middle Cambrian.
Dolichometopus bion Walcott (pl. 52, fig. 2), Middle Cambrian.
Dolichometopus boccar Walcott (pl. 52, fig. 1), Middle Cambrian.
Dolichometopus (*?*) *deois* Walcott (pl. 54, fig. 1), Middle Cambrian.
Dolichometopus (*?*) *derceto* Walcott (pl. 54, fig. 4), Middle Cambrian.
Dolichometopus (*?*) *dirce* Walcott (pl. 54, fig. 5), Middle Cambrian.
Dolichometopus ? expansus (Walcott) (pl. 53, fig. 5), Middle Cambrian.
Dolichometopus productus (Hall and Whitfield) (pl. 53, fig. 2), Middle Cambrian.
Dolichometopus suecicus Angelin (pl. 50, figs. 3, 4), Middle Cambrian.
Dolichometopus tontoensis Walcott (pl. 51, fig. 1), Middle Cambrian.

Generic reference of species heretofore placed under Dolichometopus and now referred as follows:

Dolichometopus (*?*) *convexus* Billings = *Bolbocephalus* Whitfield ?
Dolichometopus (*?*) *gibberulus* Billings = *Platycolpus* Raymond ?
Dolichometopus hyrie Walcott = *Anomocare*.
Dolichometopus occidentalis Matthew = *Bathyuriscus*.
Dolichometopus (*?*) *rarus* Billings = *Bolbocephalus* Whitfield ?
Dolichometopus tatei Woodward = *Redlichia* Cossmann.

DOLICHOMETOPUS ACADICUS Matthew

Plate 53, figs. 1, 1*a-c*

Dolichometopus acadicus MATTHEW, 1897, Trans. Royal Soc. Canada, 2d ser., Vol. 3, Sec. 4, p. 185, pl. 3, figs. 6*a-d*. (Described and figured as a new species.)

Dolichometopus acadicus Matthew, LORENZ, 1906, Zeits. deuts. geol. Gesells., Vol. 58, Pt. 2, p. 75. (Compares *D. acadicus* with his *Bathyuriscus asiaticus*.)

Original description.—"Body covered with a very smooth test.

"Head-shield margined all round and having an intramarginal furrow. Eyes large, furnished with a semicircular orbital lobe. The facial suture curves backward and downward behind the eyes, and has a direct extension forward before the eyes. Glabella distinctly outlined, bent downward in front, subclavate, without furrows, rather squarish in front, extending to the anterior marginal fold, about twice as long as the width at the base. Occipital ring lenticular in outline, divided from the glabella by a shallow furrow. Fixed cheeks narrow, width about half of that of the glabella at the base. Posterior angles of the middle piece produced backward and bent downward. The eye lobes are as long as the width of the glabella in front. . . . .

"A pygidium, which also occurs with the above heads and cheeks, is not unlike that of an *Anomocare*, but differs in having a blunter and stouter rachis than is usual with pygidia of this genus; we regard it as probably the pygidium of the *Dolichometopus*. It has a rather narrow prominent rachis, having four faintly marked rings, besides the more distinct half-ring in front; the side lobes have three faintly marked ribs, besides that at the front margin; the lateral margins are flattened and without a fold.

Sculpture.—"This consists of a minute granulation, made visible only with a lens.

Size.—"Length of the head-shield, 11 mm.; width of the middle piece of the head, 10 mm. Length of the movable cheek, 10 mm.; width, 5 mm. Length of pygidium, 6 mm.; width, 10 mm. . . . .

"This species differs from the Swedish form (*Dolichometopus suecicus*) by Angelin,[1] in having a more direct suture before and behind the eye, and a longer eye lobe. It differs from the same species as figured by Brögger[2] in the course of the dorsal suture, and in the less numerous joints in the rachis of the pygidium."

[1] Pal. Scand., pl. 37, figs. 9, 9*b-c*.

[2] Om Paradox. skifrene v. Krekling, Nyf Mag. for Naturvidensk., 1879, pl. 3, figs. 12, 12*a*.

On account of not being able at present to obtain the type specimens of this species, the original figures of Matthew are reproduced on plate 53, figures 1, 1*a-c*.

Formation and locality.—Middle Cambrian: Hastings Cove, about 0.75 mile (1.2 km.) from Torryburn Station on the Intercolonial Railroad, New Brunswick, Canada. Collection of Dr. George F. Matthew.

DOLICHOMETOPUS (?) ALCESTE Walcott

Plate 54, figs. 3, 3*a-b*

Dolichometopus alceste Walcott, 1905, Proc. U. S. Nat. Mus., Vol. 29, p. 94. (Species described as below.)

Dolichometopus alceste Walcott, 1913, Research in China, Vol. 3, p. 215, pl. 22, figs. 3, 3*a-b*. (Described and illustrated.)

This species occurs at the same locality as *D.* (*?*) *deois*, but not in the same bed of limestone. It differs from *D.* (*?*) *deois* in having a much more convex glabella with nearly parallel sides. Glabella marked by a posterior pair of furrows, extending inward and backward so as nearly to cut off a small, subtriangular lobe at the base of the glabella; also three pairs of short, faintly impressed furrows that extend in at right angles to the side of the glabella; occipital furrow and ring unknown; dorsal furrow shallow but well defined.

Fixed cheeks very narrow; they slope down into the strong furrow just within the narrow palpebral lobe and anteriorly slope down to the frontal limb; the rim of the palpebral lobe crosses the narrow fixed cheek, forming a very short palpebral ridge; frontal limb short, nearly flat.

The exterior surface, under a strong lens, shows a few fine, scattered punctules. The inner surface of the frontal limb, where exposed by a breaking away of a portion of the shell, is strongly punctate.

The only specimen of the glabella of this species has a length of 12 mm., with a width at the palpebral ridges of 8 mm.; the frontal limb has a length of 1.5 mm.

Formation and locality.—Middle Cambrian: (C4) In limestone nodules at the base of the lower shale member of the Kiu-lung group,[1] 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shantung, China.

[1] Blackwelder, Research in China, Pub. No. 54, Carnegie Institution of Washington, Vol. 1, Pt. 1, 1907, Chap. 2, Stratigraphy of Shan-tung, pp. 37 and 40 (second list of fossils), and fig. 10 (bed 4), p. 38.

DOLICHOMETOPUS BATON, new species

Plate 51, figs. 2, 2*a-b*

This species is preserved in a fine, dark argillaceous shale. The largest dorsal shield has a length of nearly 60 mm. As far as can be determined, the surface of the test was finely punctate. Seven thoracic segments of the usual form except that the extremities narrow more rapidly to a sharp, slightly backward curving point.

Dolichometopus baton differs from *D. suecicus, D. productus, D. boccar* and *D. bion* by its smaller palpebral lobe and termination of the pleural lobes of the thoracic segments. From *D. ? bessus* is differs in position and relative size of palpebral lobes and more transverse pygidium. The thoracic segments are quite similar in both species.

Formation and locality.—Middle Cambrian: (3j) Wolsey ? shale; above the quartzitic sandstones in a shale corresponding in position to the upper part of shale No. 6 of the Dearborn River section,[1] about 6 miles (9.6 km.) west-northwest of Scapegoat Mountain on the Continental Divide between Bar Creek and the headwaters of the south fork of the North Fork of Sun River, Coopers Lake quadrangle (U. S. G. S.), Powell County, Montana.

DOLICHOMETOPUS ? BESSUS, new species

Plate 51, figs. 3, 3*a-c*

Fragments of this species contained in a fine, buff-colored, argillaceous shale indicate that the dorsal shield attained a length of 30 mm. A smaller entire specimen has a length of 22 mm. The outer surface of the test appears to have been punctate and the seven thoracic segments terminate in sharp, gently curved points very similar to those of *D. baton* (pl. 51, fig. 2).

Dolichometopus ? bessus differs from its most nearly related species, *D. baton,* by its smaller palpebral lobe and its more elongate pygidium which is also more abruptly curved backward at the anterolateral margin.

This species has many of the characters of *Bathyuriscus bantius* (pl. 49, figs. 2, 2*a*), and brings the genera *Dolichometopus* and *Bathyuriscus* very close to each other.

Formation and locality.—Middle Cambrian: (62i) Wolsey shale interbedded in upper part of Flathead sandstone, Sixteen Mile Can-

[1] Smithsonian Misc. Coll., Vol. 53, No. 5, 1908, Walcott, Cambrian sections of the Cordilleran area, p. 202.

yon, 0.25 mile (0.4 km.) below Sixteen Post Office, Meagher County, Montana.

DOLICHOMETOPUS BION, new species

Plate 52, figs. 2, 2*a-c*

Bathyuriscus productus (Hall and Whitfield) WALCOTT, 1908, Smithsonian Misc. Coll., Vol. 53, p. 198. (Named in list of fossils found in 1 of Spence shale.)

This is one of the largest species of the genus. It differs from *D. productus* (pl. 53, figs. 2, 2*a-d*, 3, 3*a*, 4, 4*a*) in position of the palpebral lobes and more expanded glabella. The associated pygidium has a shorter axial lobe and broader border. Outer surface of test in cast nearly smooth.

Only one cranidium has been found. This has a length of 16 mm. The largest associated pygidium has a length of 32 mm. The outlines of the pygidium vary owing to impression and distortion in the argillaceous shale.

Formation and locality.—Middle Cambrian: (55c) Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

DOLICHOMETOPUS BOCCAR, new species

Plate 52, figs. 1, 1*a-f*

This interesting species at once suggests *D. productus* (pl. 53, figs. 2, 2*a-d*, 3, 3*a*, 4, 4*a*). It differs in the more posterior position of the palpebral lobes in relation to the length of the glabella. Compare figures 3*a* and 4*a*, plate 53, with figures 1 and 1*c*, plate 52. The pygidia of the two species are very much alike.

The stratigraphic horizon of the specimen of *D. productus* from Mount Stephen, British Columbia, is in the lower portion of the *Ogygopsis* shale [1] and that of *D. boccar* about 200 feet below in limestones of 2*d* in the Mount Bosworth section.[2]

A species apparently identical with this was found in a loose block of limestone on the southwest side of Moose Pass at the head of Moose River in which the glabella and palpebral lobes have about the same form, also the pygidium.

[1] Smithsonian Misc. Coll., Vol. 53, 1908, p. 210.

[2] Idem, p. 211.

The largest dorsal shield has a length of 50 mm. A large cranidium indicates that some entire specimens were at least 70 mm. in length.

The outer surface of the test is preserved on only one specimen of the cranidium. This shows exceedingly fine, irregular, waving, sharp elevated lines. This outer surface usually adheres to the matrix, the inner layer of the test appearing smooth or punctate according to the condition of preservation.

Specimens of a cranidium and pygidium occur in Middle Cambrian limestone in northern Utah that resemble those parts in *Dolichometopus boccar* except that the axis of the pygidium is proportionally shorter. This form was identified as *Bathyuriscus=Dolichometopus productus* (Hall and Whitfield),[1] but with our present information the identification is not considered good. The best specimens of *D.* cf. *boccar* are from locality (55p) Middle Cambrian: Langston formation; massive-bedded, bluish-gray limestone 44 feet; 400 feet (120 m.) above the Lower Cambrian Brigham formation; about 7 miles (14.4 km.) above the mouth of Blacksmith Fork Canyon and 10 miles (16.1 km.) east of Hyrum, Cache County, Utah. Fragments of a similar form occur in the same section in the Langston formation about 50 feet higher in 1*a* of the section. These were originally identified as *Bathyuriscus=Dolichometopus productus.*

Dolichometopus productus occurs in the Ute formation about 100 feet higher in 1 of the Blacksmith Fork section.

Formation and locality.—Middle Cambrian: (57g, 57u) Stephen formation; about 1,700 feet (518 m.) above the Lower Cambrian and 3,250 feet (991 m.) below the Upper Cambrian, in the calcareous shales forming *2d* of the Stephen formation,[2] on Mount Bosworth, north of the Canadian Pacific Railway between Hector and Stephen, on the Continental Divide between British Columbia and Alberta; (14s) near the base of the *Ogygopsis* zone of the Stephen formation, just east of the great "fossil bed" on the northwest slope of Mount Stephen, above Field, on the Canadian Pacific Railroad, British Columbia; (58m) about 1,000 feet (305 m.) above the top of the Lower Cambrian in bluish-black and gray limestone (138 feet) of the Stephen formation, Castle Mountain section; northeast slope of Castle Mountain, facing amphitheater, north of Canadian Pacific Railway, Alberta; and (61r') formation unknown; from a block on

[1] Smithsonian Misc. Coll., Vol. 53, 1908, p. 198. List under 1*a* and 1*b*.
[2] Idem, Cambrian sections of the Cordilleran area, p. 211.

Moose Pass, between Moose River and Calumet Creek, 10 miles (16.1 km.) east-northeast of the summit of Robson Peak, northwest of Yellowhead Pass, Robson Park, British Columbia, all in Canada.

DOLICHOMETOPUS (?) DEOIS Walcott

Plate 54, figs. 1, 1*a-m*, 2

Dolichometopus deois Walcott, 1905, Proc. U. S. Nat. Mus., Vol. 29, p. 94. (Described and discussed as a new species essentially as below.)

Bathyuriscus asiaticus Lorenz, 1906, Zeits. deuts. geol. Gesells., Vol. 58, Pt. 2, p. 73, pl. 5, figs. 1-5. (Species characterized and illustrated)

Amphoton steinmanni Lorenz, 1906, Idem, Vol. 58, Pt. 2, p. 75, pl. 4, figs. 15-17. (Species characterized and illustrated.)

Dolichometopus deois Walcott, 1913, Research in China, Vol. 3, p. 216, pl. 21, figs. 13, 13*a-d;* pl. 22, figs. 1, 1*a-h*, 2, 2*a-b*. (Species described as below and correlated with the two preceding species of synonymy.)

This species is represented by the central portions of the cephalon, associated pygidia, hypostomæ and thoracic segments. Glabella and fixed cheeks moderately convex; glabella prominent, moderately convex, and marked by three pairs of rather short, very faintly impressed furrows; the sides of the glabella are subparallel for a short distance near the base and then are gently inclined outward to the rounded front margin; occipital furrow shallow, rounded, and merging into the strong occipital ring; the latter is narrow at sides, broadening rather rapidly to the base of a small, backward-sloping occipital spine; in front the glabella curves rather abruptly downward, giving the anterior portion a convex appearance; dorsal furrow shallow and distinctly defined at sides of glabella.

Fixed cheeks narrow, slightly convex, and sloping posteriorly downward to an elongate postero-lateral limb; in front of the palpebral lobe the cheeks slope abruptly down to the frontal limb; palpebral lobes a little longer than one-third the length of the cephalon; there does not appear to be any definite palpebral ridge; the elevated rim of the palpebral slope lobe approaches closely to the dorsal furrow, where it is merged into the downward slope of the fixed cheek; frontal limb short and slightly convex.

Surface apparently smooth under a strong lens in specimens from some localities, while in others it is minutely punctate. This appears to depend somewhat on the character of the matrix and condition of preservation.

On the anterior portion of a cast of a specimen of the glabella there is indicated a very short fourth furrow close to the antero-lateral angle; the same specimen also shows what is the frontal limb

in other cephala divided into a short frontal limb and a narrow, slightly upturned rim.

The largest cephalon in the collection has a length of 17 mm.

This species differs from the type of the genus, *D. suecicus* Angelin [1852, Ed. 1878, p. 73], in the greater convexity of the glabella, more convex frontal limb, and other minor details of the glabella and fixed cheeks; from *D.* (*?*) *dirce* (pl. 54, fig. 5) it differs in the greater expansion of the glabella in front, and from *D.* (*?*) *derceto* (pl. 54, fig. 4) in the configuration of the frontal limb.

Bathyuriscus asiaticus Lorenz (see pl. 54, figs. 1*d*, 2) is founded on specimens of the cranidium that are more or less flattened by compression. *Amphoton steinmanni* Lorenz was founded on small, convex cranidia. Both forms are abundantly represented among the specimens of *Dolichometopus* (*?*) *deois* both in Shan-tung and Manchuria.

Through the courtesy of Dr. Deecke, of the University of Freiburg, I had the opportunity of directly comparing the specimens of Lorenz with the type specimens of *D.* (*?*) *deois*.

I find in the large series of specimens in our collections that the test is finely punctate as in *Anomocare,* but that in others it is not possible to observe the punctæ. This is especially true of the specimens that have been compressed in the limestone. One of the specimens of the cranidium of this species, described by Lorenz as *Bathyuriscus asiaticus* (see pl. 54, fig. 1*d*), shows both smooth and punctate surface, according to the condition of preservation.

Formation and locality.—Middle Cambrian: (**C1** and **C2**) Lower shale member of the Kiu-lung group,[1] 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, and (**C4**) limestone nodules at the base of the lower shale member of the Kiu-lung group,[2] 3 miles (4.8 km.) southwest of Yen-chuang, Sin-t'ai district, Shan-tung, China.

Also from locality **C19**, uppermost layers of the Ch'ang-hia limestone,[3] at Ch'ang-hia, Shan-tung, China.

Also from locality **C57**, limestone nodules in the lower shale member of the Kiu-lung group,[4] 3 miles (4.8 km.) south of Kao-

[1] Blackwelder, Research in China, Pub. No. 54, Carnegie Inst. of Washington, Vol. 1, Pt. 1, 1907, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38.

[2] Idem, second list of fossils.

[3] Idem, p. 33 (part of last list of fossils).

[4] Idem, pp. 37 and 40 (first list of fossils).

kia-p'u, and 4 miles (6.4 km.) north of Sin-t'ai-hién, Sin-t'ai district, Shan-tung, China.

Also from localities: (35 o) Fu-chóu series, shales about 130 feet (40 m.) above the white quartzite [1] collected in drainage cuts a short distance back from the bluff forming the shore of Tschang-hsing-tau Island; (35p) shales about 80 feet (24 m.) above the white quartzite,[1] and (35r) limestones near the base of the series just above the white quartzite,[1] the latter two collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

DOLICHOMETOPUS (?) DERCETO Walcott

Plate 54, figs. 4, 4*a*

Dolichometopus derceto WALCOTT, 1905, Proc. U. S. Nat. Mus., Vol. 29, p. 95. (Described as a new species as below.)

Dolichometopus derceto WALCOTT, 1913, Research in China, Vol. 3, p. 217, pl. 22, figs. 4, 4*a*. (Described and illustrated.)

This species is known only by the central portions of the cephalon, exclusive of the free cheeks. Glabella moderately convex and expanding slightly in width from the base to the rounded front; the surface is marked by two pairs of rather strong, short furrows opposite the palpebral lobe; occipital furrow strong and rather deep; occipital ring narrow at the sides, rising and widening to form the base for a small, sharp occipital spine; dorsal furrow strong on the sides of the glabella.

Fixed cheeks narrow, convex; palpebral lobe narrow, elongate, almost touching the dorsal furrow in front; postero-lateral limb of medium length, marked by a strong furrow parallel to the posterior margin; frontal limb narrow, slightly concave, and almost concealed by the overhanging, almost tumid frontal portion of the glabella.

Surface smooth under a strong lens.

The largest of the three cephala representing this species has a length of 7 mm., exclusive of the occipital spine.

Formation and locality.—Middle Cambrian: (C1 and C2) Lower shale of the Kiu-lung group,[2] 2 miles (3.2 km.) south of Yen-chuang, Sin-t'ai district, Shan-tung, China.

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[1] Blackwelder, Research in China, Pub. No. 54, Carnegie Inst. of Washington, Vol. 1, Pt. 1, 1907, p. 92, for general section giving stratigraphic relations.

[2] Idem, pp. 37 and 40 (part of the third list of fossils), and fig. 10 (beds 4 and 5), p. 38.

DOLICHOMETOPUS (?) DIRCE Walcott

Plate 54, figs. 5, 5*a-b*

Dolichometopus dirce Walcott, 1905, Proc. U. S. Nat. Museum, Vol. 29, p. 96. (Characterized as a new species as below.)

Dolichometopus dirce Walcott, 1913, Research in China, Vol. 3, p. 218, pl. 22, figs. 5, 5*a-b*. (Described and illustrated.)

Only the central portions of the cephalon of this species are known. It differs from *D.* (*?*) *deois* (pl. 54, fig. 1) in the nearly parallel sides of the glabella, the absence of glabellar furrows, and the very short, almost flat, frontal limb. The occipital lobe is nearly one-half the length of the cephalon.

Surface under strong magnifier smooth.

The type specimen of the cephalon has a length of 11 mm.

Formation and locality.—Middle Cambrian: (C24) Near top of black oolite group in the uppermost layers of the Ch'ang-hia formation,[1] 2 miles (3.2 km.) east of Ch'ang-hia, Shan-tung, China.

DOLICHOMETOPUS ? EXPANSUS (Walcott)

Plate 53, figs. 5, 5*a*

Dicellocephalus ? expansus Walcott, 1884, Monogr. U. S. Geol. Survey, Vol. 8, p. 45, pl. 9, fig. 19. (Description and illustration of cranidium.)

Dicellocephalus ? quadriceps Hall and Whitfield, Walcott, 1884, Monogr. U. S. Geol. Surv., Vol. 8, p. 45, pl. 9, fig. 24. (Describes occurrence of species and illustrates a cranidium distorted by longitudinal compression.)

Dicellocephalus (*?*) *expansus* Matthew, 1893, Trans. Royal Soc. Canada, Vol. 10, Sec. 4, p. 11, footnote. (Considers generic reference as doubtful.)

Dolichometopus expansus (Walcott), 1914, Smithsonian Misc. Coll., Vol. 57, p. 350. (Change of generic reference of species.)

Original description.[2]—Glabella elongate subquadrangular or subclavate, the base about one-fifth narrower than the front; surface convex and without perceptible furrows; occipital furrow distinctly defined; occipital ring strong with a small spine on the center of the posterior portion; dorsal furrows well defined along the sides of the glabella; fixed cheeks of medium width, palpebral lobes unknown; an ocular (?) ridge crosses the anterior portion of the right fixed cheek so as to indicate a moderate sized eye lobe between it and the postero-lateral limb; frontal limb as a narrow rim; postero-lateral

[1] Blackwelder, Research in China, Pub. No. 54, Carnegie Inst. of Washington, Vol. 1, Pt. 1, 1907, p. 33 (part of last list of fossils).

[2] Walcott, Monographs U. S. Geological Survey, Vol. 8, 1884, pp. 45-46.

limbs rather narrow, extended and marked by a strong furrow within the posterior margin.

Surface finely punctate.

Observations.—The generic reference is not entirely satisfactory, but with only the cranidium for comparison, I think we may place it with *Dolichometopus* until further data are obtained. The presence of a small occipital spine seems to be indicated by a circular break in the test, but this may be deceptive. A similar break occurs on a specimen of *D. boccar,* but we know from an unbroken specimen that only a minute node has been broken away.

The specimen of *D. ? expansus* occurs in a compact limestone. It was associated with:

Billingsella whitfieldi (Walcott)
Orusia ? eurekensis (Walcott)
Orusia lenticularis (Wahlenberg)
Stenotheca elongata Walcott
Agnostus bidens Meek
Zacanthoides spinosus Walcott

Formation and locality.—Middle Cambrian: (55b) Eldorado limestone;[1] near summit of west side of Secret Canyon, Eureka District [Hague, 1892, Atlas], Eureka County, Nevada.

DOLICHOMETOPUS PRODUCTUS (Hall and Whitfield)

Plate 53, figs. 2, 2*a-e*, 3, 3*a-b*, 4, 4*a*

Ogygia producta Hall and Whitfield, 1877, U. S. Geol. Expl. 40th Parallel, Vol. 4, p. 244, pl. 2, figs. 31-34. (Original description and illustration of species.)

Ogygia parabola Hall and Whitfield, 1877, Idem, p. 245, pl. 2, fig. 35. (Describes and illustrates a pygidium which was referred to *Bathyuriscus productus* (Hall and Whitfield) by Walcott in 1886.)

Niobe producta Brögger, 1886, Om alderen af *Olenellus* zone i Nordamerika, p. 211. (Refers species to genus *Niobe.*)

Bathyuriscus productus Walcott, 1886, Bull. U. S. Geol. Surv., No. 30, p. 217, pl. 30, figs. 1, 1*a-i* (in part). (Describes and illustrates species. The specimens illustrated by figs. 1, 1*a-b*, 1*g*, and 1*h* are now referred to *Dolichometopus anax.*)

Bathyuriscus productus Miller, 1889, North American Geol. and Pal., p. 533, text fig. 972. (Brief description and 1 figure copied from Walcott.)

Bathyuriscus productus Pack, 1906, Jour. Geol., Vol. 14, p. 297, pl. 2, figs. 3, 3*a-b*. (Mentions occurrence of species in "Pioche" Mountain and illustrates a cranidium and two pygidia.)

[1] Walcott, Smithsonian Misc. Coll., Vol. 53, 1908, p. 184.

Bathyuriscus productus GRABAU and SHIMER, 1910, North American Index Fossils, Vol. 2, p. 287, fig. 1591. (Brief description and figure of cranidium and pygidium after Walcott.)

The head and pygidium of this species are much like those of the type species of *Dolichometopus, D. succicus.* The thorax has seven segments, the pleuræ of which have a rather strong furrow that extends from the anterior inner side diagonally across the segment ending about midway where it begins to curve backward to its rather sharp falcate termination.

Specimens of the dorsal shield from the type locality vary from 50 to 60 mm. in length, and cranidia from the Pioche Mountains, Nevada, indicate a length of 75 mm.

The species has a wide geographic distribution and occurs in a variety of rocks. The type specimens are from a very finely arenaceous, Middle Cambrian shale found in East Canyon, Oquirrh Range, Utah. They are compressed and flattened in the shale, but a fairly good conception of the species may be obtained from them. The specimens from the Chisholm shale near Pioche, Nevada, are somewhat better preserved, but they do not retain the original test, and the surface markings are lost with the exception of the fine striæ on the surface of the doublure of the pygidium.

Another interesting locality is at the north end of the McDowell Mountains at River Bed Station, where a form closely allied to this occurs in a limestone. It was identified as *Bathyurellus wheeleri,*[1] but the head is that of *Dolichometopus* and it has the thorax and pygidium of the character of that of *D. productus* as it appears when not flattened in shale.

The species is represented in the Bright Angel arenaceous shales of the Grand Canyon, Arizona, by a number of entire dorsal shields (pl. 53, figs. 4, 4*a*). These appear to have the elongate palpebral lobe and relatively narrow glabella of specimens from the type locality, and the thorax and pygidium are essentially the same.

The specimens from the southern Appalachians are preserved in argillaceous and siliceous shales and limestone. As far as the material available affords the means for comparison, they appear to belong with *D. productus* or a closely related species. A broken specimen from a siliceous shale (locality 10) has seven thoracic segments, and entire associated cranidia and pygidia appear to be similar to the specimens in the shales of the type locality of the species. The specimens in the limestone (locality 14) are strongly convex.

[1] Geog. and Geol., Expl. West 100th Meridian, Vol. 3, 1875, p. 181.

Dolichometopus productus differs from *D. boccar* (pl. 52) in the more anterior position of the palpebral lobes in relation to the length of the glabella, but in the thorax and pygidium they are very closely related.

For a long time I considered *D. productus* as a typical form of *Bathyuriscus,* but with the present study of all the material the species is referred to *Dolichometopus.* (See notes under the latter genus.)

Formation and locality.—Middle Cambrian: (329e, locality of type specimens) Shales in East Canyon above Ophir City, and (3c) about 75 feet (22.9 m.) above the quartzitic sandstones of the Cambrian at Ophir City, west side of Oquirrh Range; also (152c) limestone at north end of McDowell Mountains, River Bed Station, Old State Road; (11s) shales just above Simpson Spring, about 20 miles (32.2 km.) west-southwest of Vernon, on the stage road from Vernon to Fish Spring; and (3f) siliceous shales above concretionary limestone, Onaqui Mountains, 10 miles (16.1 km.) southwest of Grantsville; all five in Tooele County, Utah; also (3v) Chisholm formation, pinkish argillaceous shale, 5.5 miles (8.8 km.) west of Antelope Springs, in Dome Canyon, on road west over the House Range, Millard County; and (30f) Howell formation about 330 feet (101 m.) above the Lower Cambrian, in bluish-black, massive limestone forming 1*f* of the Howell formation; on east side of Dome Canyon, about 1.5 miles (2.4 km.) from its mouth, and five-sixths of a mile (1.33 km.) west of Antelope Springs; also (31s) Howell formation, about 490 feet (149.4 m.) above the Lower Cambrian in limestone interbedded in pinkish argillaceous shale forming 1*d* of the Howell formation; south side of Dome Canyon, about 1 mile (1.6 km.) below the divide and 3 miles (4.8 km.) west-southwest of Antelope Springs (localities 3v, 30f, 31s are all in Millard County, Utah); and (31) Chisholm shale at the Chisholm Mine, southwest slope of Ely Mountains, 3 miles (4.8 km.) northwest of Pioche, Lincoln County, Nevada; also (74e) Bright Angel shale 100 feet (32 m.) above Tapeats sandstone; on west side of Cameron trail, about 0.5 mile (0.8 km.) north of Indian Garden Spring; south side Grand Canyon of the Colorado River, Coconino County, Arizona.

Also (9) Rome formation, shaly sandstone on southeastern slope of ridge 1 mile (1.6 km.) north of the northwest corner of Harlan Knob, about 4 miles (6.4 km.) northeast of Rogersville [see Keith, 1905, areal geology sheet], Hawkins County; and (10) drab shales, western end of Shooks Gap, in Bays Mountains, 10 miles (16.1 km.)

southeast of Knoxville, Knox County; both in Tennessee; (14) Conasauga formation, limestones overlying the sandstones of the Rome formation, near the wagon road and in a quarry near the railroad track, 7 miles (11.2 km.) southwest of Rome [see Hayes, 1902, historical geology sheet], and (142a) railroad cut on west side of Big Cedar Bridge, 3 miles (4.8 km.) northeast of Cave Spring, both in Floyd County, Georgia.

DOLICHOMETOPUS SUECICUS Angelin

Plate 50, figs. 3, 3*a-b*, 4, 4*a*

Dolichometopus svecicus Angelin, 1852 [Reprint 1854, 1878], Pal. Scandinavica, 1st ed., Lipsiæ, p. 73, pl. 37, fig. 9. (Original description and illustration.)

Dolichometopus suecicus Linnarsson, 1873, Geol. Fören. Stockholm Förhandl., Vol. 1, No. 13, p. 246. (Refers to occurrence of species.)

Dolichometopus suecicus Brögger, 1878, Nyt Mag. for Naturvid., Vol. 24, p. 46, pl. 3, fig. 12. (Notes occurrence of species at Krekling and illustrates a cranidium and pygidium.)

Dolichometopus suecicus Matthew, 1897, Trans. Royal Soc. Canada, 2d ser., Vol. 3, Sec. 4, pp. 184, 185, pl. 3, figs. 7*a*, 7*b*. (Reproduces top view and side outline of a drawing of the type cranidium of the species.)

Dolichometopus suecicus Lorenz, 1906, Zeits. deuts. geol. Gesells., Vol. 58, Pt. 1, p. 74, text fig. (Compares *Dolichometopus* and *Bathyuriscus* and illustrates *D. svecicus* Angelin.)

Of this species only the cranidium and associated pygidium are known to me. Now that we have several species of *Dolichometopus* represented by the entire dorsal shield, there is little, if any, doubt that the pygidium is correctly referred to the species. Dr. Matthew has illustrated the type specimen,[1] (pl. 50, fig. 4) and in this paper I am illustrating the cranidium and pygidium as found in the Andrarum limestone at Andrarum. The largest cranidium has a length of 21 mm.

Surface of test punctate and when not worn smooth marked by fine, sharp, irregular, inosculating ridges, those on the glabella more or less concentric in relation to the central portion and on the occipital ring subparallel to the posterior margin.

By reflected light traces of three pairs of glabellar furrows may be seen, and the matrix of the test of the glabella shows slight impressions of glabellar furrows.

[1] Trans. Royal Soc. Canada, 2d ser., Vol. 3, 1897, Sec. 4, pl. 3, figs. 7*a*, 7*b*.

Formation and locality.—Middle Cambrian: (8w) Andrarum limestone; *Paradoxides forchhammeri* zone, at Andrarum, 20 miles (32.2 km.) northwest of Simrishamn, Province of Christianstad, Sweden.

DOLICHOMETOPUS TONTOENSIS, new species

Plate 51, figs. 1, 1*a-h*

This fine species I found in the upper beds of the Tonto sandstone in 1882 in the form of casts in a hard sandstone. Entire specimens were first collected and presented to the United States National Museum in 1911 by Mr. Niles J. Cameron, of Grand Canyon, Arizona. The latter are compressed in a greenish, very fine arenaceous shale, but do not retain the outer test.

The species differs from *D. productus* (pl. 53) in having a smaller palpebral lobe, a median spine on each thoracic segment and the anchylosed segments of the axial lobe of the pygidium, also in the enlargement of the fifth thoracic segment. This character is present in the 13 specimens preserving the thorax, and is not present in the 11 associated specimens of *D. productus*. This species also attains a larger size than any other of the genus. One entire dorsal shield has a length of 97 mm., and an associated pygidium indicates that specimens existed of 110 mm. in length. The next largest species, as far as known, is *D. bion* (pl. 52, fig. 2*b*).

The combination of small eye lobe, median spine on thoracic segments and enlarged fifth thoracic segment, suggests a reversion to primitive characters in this species that might be recognized by a subgeneric name if further investigation justifies it.

At locality 74 this species is associated with the following fauna in a brownish-weathering, bedded sandstone:

Micromitra pealei (Walcott)
Micromitra (*Paterina*) *crenistria* (Walcott)
Micromitra (*Paterina*) *superba* (Walcott)
Micromitra (*Iphidella*) *pannula* (White)
Obolus zetus (Walcott)
Obolus (*Westonia*) *chuarensis* (Walcott)
Obolus (*Westonia*) *euglyphus* (Walcott)
Lingulella lineolata (Walcott)
Lingulella perattenuata (Whitfield)
Billingsella obscura Walcott
Alokistocare althea Walcott

In the arenaceous shale of locality 74e (about 100-120 feet above the horizon of locality 74) I found

Obolus (*Westonia*) *chuarensis* Walcott
Eocystites ? undt. species
Hyolithes
Alokistocare althea Walcott
Dolichometopus productus (Hall and Whitfield)
Dolichometopus tontoensis Walcott

Formation and locality.—Middle Cambrian: (74e) Bright Angel shale 100 feet (32 m.) above Tapeats sandstone. On west side of Cameron trail about 0.5 mile (0.8 km.) north of Indian Garden Spring, south side Grand Canyon of Colorado River, Coconino County; and (74) Tapeats sandstone; about 300 feet (91.4 m.) above its base, at the head of Nunkoweap Valley, Grand Canyon of the Colorado River, both in Arizona.

HOUSIA, new subgenus

This form is distinguished from *Dolichometopus* by its small palpebral lobe, absence of genal spine on free cheek, form of termination of pleural lobe of thoracic segments, and outline of normal form of pygidium. Surface unknown. Fragments of the only species referred to *Housia* indicate a length of 7.5 to 8 cm.

Genotype.—*Dolichometopus* (*Housia*) *varro* Walcott.

The one species now referred to *Housia* is from the central portion of the Upper Cambrian in the House Range of western Utah.

DOLICHOMETOPUS (HOUSIA) VARRO, new species

Plate 65, figs. 1, 1*a-e*

The general characters of this species have been given in connection with the subgenus *Housia*. Only one specimen of the cranidium was found, although 11 free cheeks and five pygidia were collected. That it was a fairly large species is shown by a thoracic segment 40 mm. in length and several large free cheeks.

Formation and locality.—Upper Cambrian: (30 1) Orr formation; about 2,790 feet (860 m.) above the Middle Cambrian and 1,900 feet (579.1 m.) below the top of the Upper Cambrian, in shales forming 1*b* of the Orr formation[1] on Orr Ridge, about 5 miles (8 km.) south of Marjum Pass; also (30y) in slightly metamorphosed shales sup-

[1] Smithsonian Misc. Coll., Vol. 53, 1908, p. 176.

posed to be the equivalent of *1b* of the Orr Ridge section above the granite contact on top of the ridge north of Notch Peak, both in House Range, Millard County, Utah.

Family Asaphidæ Burmeister

Subfamily Ogygiocarinæ Raymond

Ogygiocarinæ Raymond, 1913, Zittel-Eastman's Paleontology, p. 718.

Opisthoparia with large subequal cephalon and pygidium, prominent eyes, palpebral (ocular) ridge crossing free cheeks, thorax with 7 to 11 segments.

Hypostoma rounded. Middle Cambrian to Ordovician.

Dr. Raymond has included *Megalaspis* and other genera of a similar character under Ogygiocarinæ, but with our present information I am inclined to include only *Ogygiocaris* Angelin, *Ogygopsis* Walcott, *Orria* Walcott, *Asaphiscus* Meek, and *Blountia* and *Maryvillia* are provisionally referred to the subfamily.

Genus OGYGOPSIS Walcott

Ogygopsis Walcott, 1888, Proc. U. S. Nat. Mus., Vol. 11, p. 446. (Names *Ogygia klotzi* Rominger as genotype of genus.)

Ogygopsis Miller, 1892, North American Geol. and Pal., First Appendix to 1889 Ed., p. 710. (Brief note on genus.)

Ogygopsis Grabau and Shimer, 1910, North American Index Fos., Vol. 2, p. 289. (Brief description of genus.)

Ogygopsis Raymond, 1912, Trans. Roy. Soc. Canada, 3d ser., Vol. 5, Sec. 4, p. 116. (Discusses development and relationship of genus.)

Dorsal shield elongate-elliptical in outline; axial lobe distinct; pleural lobes broad. Cephalon shorter and broader than the pygidium, semicircular in outline with genal angles produced into short spines. The facial sutures cut the posterior border just within the genal angles and extend inward and forward with a slight sigmoid curve to the base of the eye; arching over the eye lobes they curve gently outward and then inward to the frontal border, which they cut across obliquely inward; the outer border is rather narrow in front of the glabella and of medium width on the free cheeks; the posterior border is narrow and separated by a strong furrow from the body of the fixed cheeks.

Cranidium with a large glabella; large free cheeks and strong postero-lateral limbs; glabella nearly as long as the cranidium, slightly widened towards the front: moderately convex and marked by a

pair of strong postero-lateral furrows and three pairs of faint, short furrows, the posterior two pairs of which extend obliquely inward and backward, while the two anterior pairs extend inward and slightly forward; occipital ring smooth, rather strong and with a well-defined occipital furrow separating it from the glabella. Fixed cheeks of narrow to medium width; postero- and antero-lateral limbs broad; palpebral lobes small. Free cheeks large, broad, and marked by strong venation radiating from the base of the eye lobe outward to the outer border.

Thorax with eight segments; axial lobe narrow, each segment marked by a small, sharp median node situated on a slight forward-arching fold of the surface near the posterior margin; pleural lobes wide and rather flat; pleural furrows strong; they extend across from the anterior, inner side of the pleura to the outer posterior side.

Pygidium large, with a distinct axial lobe divided into eight or more rings that are continued out onto the broad pleural lobes as broad, shallow furrows separated by narrow ridges; the furrows terminate just within a narrow border.

Surface of exterior test marked by a very fine shallow pitting.

Genotype.—*Ogygia klotzi* Rominger [1887, Proc. Acad. Nat. Sci. Phil., p. 12, pl. 1, fig. 1].

Stratigraphic range.—*Ogygopsis klotzi* occurs in the Stephen formation of the Middle Cambrian about 3,000 feet below the Upper Cambrian and 2,000 feet above the Lower Cambrian.

Geographic distribution.—This is a Cordilleran genus as far as known. *Ogygopsis klotzi* occurs at Mount Stephen in eastern British Columbia on the line of the Canadian Pacific Railway, also in the Wasatch Range of northern Utah.

Observations.—*Ogygopsis* recalls at once *Ogygiocaris* Angelin, as represented by *Ogygiocaris dilitata* (Brünn) and *O. buchii* (Brongniart). The most marked differences between the two genera are in the presence of well-defined palpebral (ocular) ridges on the fixed cheeks of *Ogygopsis,* and in general, the more primitive character of the glabella and cephalon.

The genus *Orria* differs from *Ogygopsis* in the almost entire absence of fixed cheeks, large palpebral lobes, very narrow postero-lateral limbs, broad, straight pleural furrows and shorter axial lobe of pygidium.

Both *Ogygopsis* and *Orria* foreshadow in the Middle Cambrian time the Lower Ordovician genera of the Ogygiocarinæ, *Ogygopsis* being nearer to *Ogygiocaris* than *Orria.*

OGYGOPSIS KLOTZI (Rominger)

Plate 66, figs. 1, 1*a-b*

Ogygia klotzi Rominger, 1887, Proc. Acad. Nat. Sci., Phil., p. 12, pl. 1, fig. 1. (Describes and illustrates species.)

Ogygia ? klotzi Walcott, 1888, American Jour. Sci., 3d ser., Vol. 36, p. 166. (Notes difference between this species and typical forms of *Ogygia*.)

Ogygopsis klotzi Walcott, 1889, Proc. U. S. Nat. Mus., Vol. 11, p. 446. (Proposes *Ogygopsis* with *Ogygia klotzi* as the genotype.)

Ogygia (*Ogygopsis*) *klotzi* Matthew, 1899, Trans. Royal Soc. Canada, 2d ser., Vol. 5, Sec. 4, p. 58. (Describes species and supposed young of same.)

Ogygopsis klotzi Woodward, 1902, Geol. Mag., Dec. 4, Vol. 9, p. 530, text fig. 1. (Describes and discusses species and its relations to other genera. Gives outline figure.)

Ogygopsis klotzi Walcott, 1908, Canadian Alpine Jour., Vol. 1, No. 2, pl. 4, fig. 4. (Illustrates entire dorsal shield.)

Ogygopsis klotzi Grabau and Shimer, 1910, North American Index Fos., Vol. 2, p. 289, fig. 1597. (Description and reproduction of Walcott's figure of 1908.)

The characters of this species have been given in the description of the genus *Ogygopsis*. There is no closely related Cambrian species with which it may be compared. *Orria elegans* of the Middle Cambrian has a somewhat similar pygidium, but the differences in the thoracic pleural furrows, fixed cheeks, and palpebral lobes are of generic value.

The nearest Ordovician form appears to be *Ogygiocaris buchii* (Brongniart),[1] from which it differs in its glabella, palpebral lobes, presence of palpebral (ocular) ridge on fixed cheeks, and axial lobe of thorax and pygidium.

Ogygopsis klotzi is the most abundant fossil at the Mount Stephen locality, and hundreds of specimens of the dorsal shield without the free cheeks have been collected. The vertical range of the species in the Stephen formation is about 200 feet (60 m.). Its vertical range at locality 55e in Utah as far as known is only a few feet. The very limited geographic range of the species in British Columbia is most noticeable, and it is limited so far as known to one other locality in Utah.

Dimensions.—The largest dorsal shield in the collection has a length of 11 cm.

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[1] Monogr. British Trilobites, Salter, Pal. Soc., 1864-1883, p. 125, pls. 14, 15.

Matthew describes two small specimens of the dorsal shield as follows:[1]

. . . . In the 11 mm. tests (one-tenth of the length of the adult) there are tubercles on the thoracic rings for the attachment of spines; in one example these spines are attached to back of the rings; that of the occipital ring crosses two joints of the thorax, and that on the last joint of the thorax crosses three rings of the pygidium. In the adult all these spines have disappeared except that the fifth joint is sometimes seen to have a short spine. In the young shields the geniculation of the pleuræ, and the relief of the rachis are more pronounced than in the adult.

In the 11 mm. test there are eight joints in the thorax and 10 in the pygidium, and eight costæ on the side lobes of the latter. At this age, then, the species had the full number of joints in the thorax, but lacked two of the full number in the pygidium. Tests of 22 mm. length had an additional joint in the pygidium, and in tests 35 mm. long, the full number was attained.

A difference from the adult is observable in the length of the eye lobe of the young: in these the proportion between the length of the anterior extension of the suture of the eye lobe, and of the posterior extension are respectively 1, 1, 2; in the adult it is 1½, 1, 2½ or 3. This contraction of the eye lobe is in accordance with what has been observed in other genera, *e. g. Paradoxides.*

I find that the minute spine or tubercle is almost invariably crushed and left in the matrix, so that all that remains is the small base on the transversely lined or corrugated posterior part of the axial portion of the thoracic segment.

From Dr. Matthew's description of the spines on the 11 mm. specimen, it may be that he had a young specimen of *Neolenus serratus* or *Zacanthoides spinosus,* which are very abundant in association with *O. klotzi.*

Formation and locality.—Middle Cambrian: (14s) *Ogygopsis* zone of the Stephen formation; about 2,300 feet (707 m.) above the Lower Cambrian and 3,540 feet (1,089 m.) below the Upper Cambrian; at the great "fossil bed" on the northwest slope of Mount Stephen; and (58r) about 2,200 feet (676.9 m.) above the Lower Cambrian, and 3,725 feet (1,146 m.) below the Upper Cambrian, in the limestones forming 2 of the Stephen formation, in the amphitheater between Mounts Stephen and Dennis, both localities above Field on the Canadian Pacific Railway, British Columbia, Canada.

Also (55e) Spence shale horizon of the Ute formation; about 100 feet (30.5 m.) above the Brigham quartzite, at the mouth of the first small canyon south of Wasatch Canyon, east of Lakeview Ranch, 5 miles (8 km.) north of Brigham, Boxelder County, Utah.

[1] Trans. Roy. Soc. Canada, 2d ser., Vol. 5, Sec. 4, 1899, p. 58. Specimens in Museum of University of Toronto, Canada.

ORRIA, new genus

General form elliptical, moderately convex. Cephalon semicircular with a border of medium width terminating at the genal angles in a short spine; the glabella widens very slightly towards the front and is marked by a distinct pair of oblique posterior furrows that are connected by a very shallow transverse furrow; second pair of furrows short and extending less obliquely backward onto the glabella; third pair short and nearly at right angles to the side of the glabella; fourth and anterior pair extending inward and a little forward;[1] occipital ring of medium width and marked on the posterior side by a narrow band that is broadest at the center and sloping away at the sides; it has the appearance of a crowding forward of transverse lines toward the base of the small tubercle; a minute, sharp-pointed tubercle occurs at the front center margin of this band which is also marked by irregular raised lines subparallel to the front margin of the band. A similar band and tubercle occurs on each of the thoracic segments and the anchylosed segments of the pygidium. Fixed cheeks little more than a line between the glabella and rather large palpebral lobes; they merge posteriorly into narrow lateral limbs that extend out beyond the line of the termination of the thoracic segments; each limb has a broad, shallow intramarginal furrow that occupies nearly all of its surface; anteriorly the fixed cheek is very narrow and curves forward to merge into a very narrow frontal border in advance of the glabella; palpebral lobes a little less than one-third the length of the cranidium; the raised outer margin extends anteriorly across the very narrow space between the anterior end of the eye lobe and the glabella, and thus forms a very short palpebral (ocular) ridge.

Free cheeks large and rising gradually from the groove within the outer border to the base of the elongate, narrow eye lobe; their most marked character is the system of strong, irregular inosculating ridges that radiate from the base of the eye outward to the intramarginal furrow.

Thorax with nine transverse segments that are all of nearly the same transverse length; axial lobe convex and marked by a minute median tubercle as described above in connection with the occipital ring; pleural lobes nearly flat with each segment terminating abruptly, the postero-lateral edge having a very short, blunt spine; pleural furrows broad and occupying nearly the entire width of the

[1] The glabella is very much like that of *Bathyuriscus*, see plate 46.

segment from the central axis out to its blunt termination at the end of the segment.

Pygidium large, border very narrow; axial lobe convex, about two-thirds the length of the pygidium, and divided into seven rings and a terminal section; the rings are similar to those of the axial lobe of the thorax and have a similar band and central tubercle; the pleural lobes are broad and marked by eight broad, shallow furrows and a posterior pair that appear to come out of the posterior section of the axis; each broad furrow is separated from those adjoining by two narrow, sharp ridges with a narrow furrow between them that represents the anchylosed line of separation of the original segmentation now united to form the pygidium.

Surface minutely granular; the venation on the free cheeks and the lines on the axial lobe of the thorax and pygidium have been characterized above.

Genotype.—*Orria elegans* Walcott.

Dimensions.—The largest dorsal shield of the genus as now known has a length of 7 cm. A large pygidium indicates that the individual to which it belonged was at least 9 cm. in length.

Stratigraphic and geographic range.—The one known species occurs in the Middle Cambrian Marjum formation in western Utah.

Observations.—*Orria* is an *Ogygopsis*-like form that differs from the latter in several marked characters.

1. The cephalon is smaller in proportion to the thorax and pygidium. (a) Fixed cheeks nearly absent between palpebral lobes and glabella; (b) palpebral lobes large and close to glabella; postero-lateral limbs long and narrow; antero-lateral limbs only a narrow space between the gabella and facial sutures; facial sutures accord with differences in fixed cheeks and limbs.

2. Pleural furrows of thoracic segments broad and straight instead of narrow and diagonal.

3. Median axis about two-thirds the length of the pygidium.

The relation of *Orria* to other genera of the Ogygiocarinæ is not any nearer than to *Ogygopsis*. Its relatively smaller cephalon, large palpebral lobes, and narrow fixed cheeks suggest *Ogygiocaris buchii* (Brongniart), but the pleural furrows and axial lobe of pygidium are quite distinct.

The resemblance between the cephalon of *Orria* and *Bathyuriscus* (pl. 46) indicates that they originated from a similar ancestral type. Both *Orria* and *Ogygopsis* suggest a stage of development between *Bathyuriscus* and *Ogygiocaris*.

ORRIA ELEGANS, new species

Plate 66, figs. 2, *2a-b*

The characters of this species are given in the description of the genus *Orria,* and there is no other species of the genus with which to compare it. Two nearly entire dorsal shields and many fragments were collected from the dark shaly limestone forming *1c* of the Marjum formation.[1] The associated fauna, which is listed under description of *Marjumia typa* (p. 402), is large and varied and indicates a most favorable environment for the development and growth of large trilobites.

Formation and locality.—Middle Cambrian: (11 q) Marjum formation; about 2,300 feet (707 m.) above the Lower Cambrian, and 660 feet (203 m.) below the Upper Cambrian, in the limestone forming *1c* of the Marjum formation, 2.5 miles (4 km.) east of Antelope Springs, in west face of ridge east of Wheeler amphitheater, House Range, Millard County, Utah.

Genus ASAPHISCUS Meek

Asaphiscus Meek, 1873, Sixth Ann. Rept. U. S. Geol. Surv. Terr., p. 485, footnote. (Founds genus on *Asaphiscus wheeleri,* then an unpublished species, and comments on genus.)

Asaphiscus Walcott, 1875 [1877], Twenty-eighth Rept. N. Y. State Mus. Nat. History, doc. ed., p. 94, footnote. (Considers *Asaphiscus* as similar to *Bathyurus.* This is corrected in 1886.)

Asaphiscus Walcott, 1879, Idem, p. 94, footnote. (Repeats preceding reference.)

Asaphiscus Walcott, 1886, Bull. U. S. Geol. Surv., No. 30, p. 219. (Gives Meek's description and with comments.)

Asaphiscus Miller, 1889, North American Geol. and Pal., p. 530. (Meek's description and figure of *A. wheeleri.*)

Asaphiscus Grabau and Shimer, 1910, North American Index Fossils, Vol. 2, p. 289. (Brief note and figure of *A. wheeleri.*)

Dorsal shield subelliptical, moderately convex, distinctly trilobed. Cephalon semicircular in outline with genal angles rounded or prolonged into spines of moderate length; border rounded, strong and clearly defined all about the cephalon; glabella subconical in outline, rounded convex and with only slight traces of a pair of oblique posterior lateral furrows and two pairs of short, faint anterior furrows; occipital furrow shallow and only faintly separating the glabella and occipital ring; fixed cheeks about one-half the width of the glabella, posteriorly they merge into a rather large postero-lateral

[1] Smithsonian Misc. Coll., Vol. 53, 1908, pp. 179-180.

limb and anteriorly into the broad frontal limb; palpebral lobe of medium size and located just back of the transverse center of the cranidium. Very slight traces of palpebral ridges crossing the fixed cheeks. The facial sutures cut the posterior margin within the genal angles and extend obliquely inward to the posterior end of the eye lobe, in front of the latter they extend gently outward and incurve across the frontal border. Free cheeks about one-fourth the width of the cephalon; they rise rather rapidly to the base of the narrow eye lobe and may or may not terminate in a genal spine.

Thorax with from 7 to 11 segments; pleuræ with strong longitudinal furrow, and usually short falcate ends. The axial portion of the segment may be smooth or have a central node or small spine.

Pygidium relatively large and with a strong convex axial lobe that is divided into several transverse rings by narrow furrows that are slightly indicated on the pleural lobes by shallow furrows; border usually broad and slightly flattened.

Surface smooth or marked by shallow pits, and rarely it is granulated.

Genotype.—*Asaphiscus wheeleri* Meek.

Stratigraphic range.—Middle Cambrian to Upper Cambrian.

Geographic distribution.—The genus is represented by nine species in the Cordilleran area of Montana, Wyoming, and Utah; two doubtful species in the Appalachian area of Pennsylvania, and one species in Manchuria, China. It may be represented in Europe, but in the preliminary study I have not recognized it.

Observations.—The cranidium of *Asaphiscus* differs from that of *Anomocare* in its shorter, smaller eyes and elongate glabella with well-defined lateral furrows and in form of frontal limb and border. The pygidium of the genotype *Asaphiscus wheeleri* differs from that of the genotype *Anomocare lævc* Angelin in having a much longer axial lobe and narrower border, but these characters may be variable in species referred to either genus.

Anomocarella differs from *Asaphiscus* in its shorter, smaller eyes, shorter and broader glabella in proportion to its width at the base, and in its smaller pygidium which has a narrow border.

The cranidium of *Asaphiscus* is not unlike that of *Liostracus,* but the other parts of the dorsal shield differ greatly. *Asaphiscus* has characters that relate it closely to *Ptychoparia.* The cranidium has the same form of glabella, fixed cheeks and palpebral lobes. The pleural furrows do not start away from beside the axial lobe as abruptly as in the genotype of *Ptychoparia, P. striata,* but in other

species it is difficult to indicate any difference of value in the thorax except fewer thoracic segments. The pygidium of *Bathyuriscus* is proportionately larger, and has a broader and flatter border. It is not difficult to grade specimens of *Ptychoparia* that serve to establish a strong connection between the two genera. We now have a number of species represented by cranidia which it is very difficult to assign to either genus without feeling that the discovery of entire specimens may make a new reference necessary.

A group of species that are closely related to each other in form of cephalon, thorax, and less so in pygidium, includes *A. (?) capella, A. camma, A. calenus,* and *A. iddingsi.* They all differ from *A. wheeleri* in having strong genal spines on the cephalon, and longer and sharper terminations on the thoracic segments. The pygidium of *A. (?) capella* varies most widely from that of *A. wheeleri.*

The small and interesting group of species from the Upper Cambrian Weeks formation of Utah, *A. ? minor, A. ? granulatus,* and *A. ? unispinus* are small in size and they have a strong genal spine that is lacking in the genotype *A. wheeleri.* The variation in the number of thoracic segments, seven to 11, is also unusual. These species and those of the Upper Cambrian of the Appalachian region, *A. ? agatho, A. ? anaxis, A. ? duris,* and *A. ? florus,* all appear to be degenerate descendants of the large *A. wheeleri* type of the Middle Cambrian fauna and all indicate an undetermined genus or subgenus.

The species now referred to *Asaphiscus* are:

Asaphiscus calenus Walcott, Middle Cambrian, Montana (pl. 60, fig. 1).
Asaphiscus camma Walcott, Middle Cambrian, Montana (pl. 60, fig. 2).
Asaphiscus (?) capella Walcott, Middle Cambrian, Montana (pl. 59, fig. 2).
Asaphiscus ? granulatus Walcott, Upper Cambrian, Utah (pl. 61, fig. 2).
Asaphiscus iddingsi Walcott, Middle Cambrian, Manchuria, China (pl. 59, fig. 1).
Asaphiscus ? minor Walcott, Upper Cambrian, Utah (pl. 61, fig. 3).
Asaphiscus ? unispinus Walcott, Upper Cambrian, Utah (pl. 61, fig. 1).
Asaphiscus wheeleri Meek, Middle Cambrian, Utah (pl. 58, fig. 1).
Asaphiscus sp. undt. (3), Upper Cambrian, Utah.
Asaphiscus sp. undt. (1), Middle Cambrian, Wyoming.
Asaphiscus ? sp. undt. (2), Upper Cambrian, Tennessee (pl. 63, fig. 3).
Asaphiscus ? agatho Walcott,[1] Upper Cambrian, Pennsylvania; Tennessee (pl. 63, fig. 9).
Asaphiscus ? anaxis Walcott, Upper Cambrian, Pennsylvania (pl. 63, fig. 2).
Asaphiscus calanus Walcott, Middle Cambrian, Virginia (pl. 61, fig. 8).
Asaphiscus ? duris Walcott, Upper Cambrian ?, Pennsylvania (pl. 63, fig. 8).

[1] Arranged alphabetically after dividing into western and eastern series.

Asaphiscus ? florus Walcott, Upper Cambrian ?, Pennsylvania (pl. 63, fig. 6).

Asaphiscus ? cf. *florus* Walcott; Upper Cambrian ?, Pennsylvania (pl. 63, fig. 7).

ASAPHISCUS CALANUS, new species

Plate 61, figs. 8, 8*a*

This species is most nearly related to *Asaphiscus* (*?*) *capella*. It differs in the form of the frontal limb and glabella of the cranidium. The axial lobe of the associated pygidium is also shorter and the border wider. The specimens are preserved as casts in a fine-grained, arenaceous, shaly rock.

Formation and locality.—Middle Cambrian: (47h) Arenaceous shales; Wolf Creek, 6 miles (9.6 km.) below Rocky Gap, Bland County, Virginia.

ASAPHISCUS CALENUS, new species

Plate 60, figs. 1, 1*a-c*

This species at once recalls *A. wheeleri* and *A.* (*?*) *capella*. It differs from the former in the form of the frontal limb and border, glabella, termination of thoracic segments, and form of pygidium. From *A.* (*?*) *capella* it is distinguished by its pygidium and minor details of the cephalon. It is more nearly related to *A. camma,* but differs in the relative width of the frontal limb and border, shorter eye lobes, and in having a less transverse pygidium.

The largest dorsal shield in the collection has a length of 43 mm. and nine thoracic segments.

Formation and locality.—Middle Cambrian: (5f) Wolsey shale; in Meagher County on the road to Wolsey, about 4 miles (6.4 km.) south of the divide at the head of Sawmill Creek, and 11 miles (17.7 km.) south of Neihart, Little Belt Mountains quadrangle (U. S. G. S.), and (62j) upper portion of Wolsey shale below Meagher limestone; 2 miles (3.2 km.) east of Logan, on north side of Gallatin River, Gallatin County, Montana.

ASAPHISCUS CAMMA, new species

Plate 60, figs. 2, 2*a-c*

This species is characterized by its relatively long eye lobes, broader glabella, and narrower frontal border, when compared with *A.* (*?*) *capella* and *A. calenus*. Its pygidium is more transverse than that of

those species or of *A. iddingsi.* It also has 10 segments in the thorax and the related species have nine.

The largest pygidium in the collection has a length of 15 mm., which indicates a length of 50 mm. for the dorsal shield to which it belonged.

Formation and locality.—Middle Cambrian: (4g) Wolsey shale; 5 miles (8 km.) east-northeast of Logan and 1 mile (1.6 km.) north of junction of East and West Gallatin Rivers [Three Forks sheet (U. S. G. S.)], Gallatin County, Montana.

ASAPHISCUS (?) CAPELLA, new species

Plate 59, figs. 2, 2*a-c*

The cephalon and thorax of this species are much like the same parts in *A. wheeleri* except that *A.* (*?*) *capella* has genal spines on the free cheeks and a more distinctly concave frontal border. Its pygidium differs decidedly from that of *A. wheeleri* in having a very wide, sloping, and slightly concave border section and doublure, that terminates within a narrow border; a tapering axial lobe that is three-fifths the length of the pygidium is extended across the wide lower slope as a low, rounded ridge that expands towards the posterior margin and merges into it; the seven rings on the axis extend outward and backward across the pleural lobes as slightly rounded, nearly flat segments, that terminate by merging into the narrow border.

The largest dorsal shield has a length of 56 mm., and nine thoracic segments, and a small node at the center of each segment and the occipital ring.

The pygidium, large eyes, and terminations of thoracic segments suggest a different generic reference, but I am not prepared to make it at present.

Formation and locality.—Middle Cambrian: (54z) Wolsey shale; Half Moon Pass, Big Snowy Mountains, Fergus County, Montana.

ASAPHISCUS ? GRANULATUS, new species

Plate 61, figs. 2, 2*a*

This species differs from *A. ? minor* in having 10 thoracic segments, a strong median spine on the axial lobe of the ninth segment, and in its granulated surface. The surface of the test is minutely granular with large granules scattered over the cephalon and a row

of about 14 large granules on each thoracic segment and about 10 or less on each of the four anchylosed segments of the pygidium.

The spine on the ninth thoracic segment has a strong base and is extended back over the pygidium.

There are two specimens in the collection; the larger has a length of 23 mm. with two segments crowded under the cephalon, and the other has 10 thoracic segments and the pygidium.

Formation and locality.—Upper Cambrian: (30n) Weeks formation; about 3,750 feet (1,143 m.) above the Lower Cambrian in shales forming 1*c* of the Weeks formation, on the north side of Weeks Canyon, about 4 miles (6.4 km.) south of Marjum Pass, House Range, Millard County, Utah.

ASAPHISCUS IDDINGSI Walcott

Plate 59, figs. 1, 1*a-b*

Asaphiscus iddingsi Walcott, 1911, Smithsonian Misc. Coll., Vol. 57, No. 4, pp. 99-101, pl. 16, fig. 3. (Described and discussed as a new species essentially as below.)

Asaphiscus iddingsi Walcott, 1913, Research in China, Vol. 3, Cambrian Faunas of China, p. 221, pl. 23, figs. 1, 1*a-b*. (Described as below.)

Dorsal shield longitudinally oval in outline, moderately convex. Cephalon semicircular in outline; a little more than one-third of the entire length of the dorsal shield; bordered by a nearly flat or slightly rounded margin that passes at the genal angle into a moderately strong genal spine; within the genal spine a rounded posterior border is separated from the fixed cheek by a rounded, clearly defined furrow; the intramarginal furrow is shallow and rounded. Cranidium moderately convex and roughly subquadrate in outline; the frontal limb is slightly convex and, with the anterior portion of the glabella and the front margin, forms a gentle slope that is broken only by the slight dorsal furrow in front of the glabella and the shallow intramarginal furrow; the frontal limb merges on the sides into the fixed cheeks, which are a little less than one-half the width of the glabella; posteriorly the fixed cheeks merge into relatively small postero-lateral limbs; palpebral lobe narrow and extended in front as a low ridge that crosses the fixed cheek to the dorsal furrow near the antero-lateral angle of the glabella; that portion of the palpebral lobe above the eye is about one-fourth the length of the cephalon.

Glabella large, slightly narrower in front than at the occipital furrow; sides nearly straight and slightly converging, frontal margin broadly rounded; surface marked by very faint impressions of three

pairs of glabellar furrows, which can only be seen where the surface is very perfectly preserved. Occipital ring about as wide as the frontal margin and separated from the glabella by a shallow furrow that terminates on the side slightly in advance of the posterior intramarginal furrow. Free cheeks about as wide opposite the eye as the fixed cheeks; eye lobe about one-fourth the length of the cephalon. Postero-lateral angle continued backward into a moderately strong spine. The facial sutures cut the posterior margin just within the genal angle and extend obliquely inward with a slightly sigmoid curvature to the base of the eye-lobes; curving over and around the eye-lobes, they pass forward and a little outward, cutting the frontal margin obliquely.

Thorax with nine segments; axial lobe moderately convex, slightly narrower than the pleural lobes in compressed specimens; on the outer side of each segment a low, rounded node or ridge is separated from the main body of the segment by a slightly oblique furrow transverse to the segment; pleural lobes slightly convex, nearly flat out to the geniculation, where they curve slightly downward and backward; each pleura has a well-defined furrow starting near the inner anterior margin and extending backward to the center of the pleura at the geniculation, where it curves slightly backward and terminates on the broadly rounded, slightly falcate end of the pleura.

Pygidium roughly semicircular in outline, one-fourth the length of the dorsal shield; anterior margin nearly transverse at the axial lobe and curving slightly backward to conform to the curvature of the last thoracic segment; axial lobe moderately convex and tapering gradually toward its posterior section, which is just within the nearly flat marginal border; it is divided by four transverse furrows into four rings and a terminal section; three anchylosed pleural segments are outlined on the pleural lobes by furrows that curve backward and terminate on the inner margin of the doublure; this line is continued forward on the pleural lobes of the thorax, terminating on each side opposite the posterior end of the facial suture.

Surface of specimens preserved in the limestone nearly smooth or marked by very minute shallow pits.

Dimensions.—A dorsal shield 30 mm. in length has the following dimensions:

Cephalon:

	mm.
Length	11.0
Length of eye-lobe	3.5
Width at posterior margin	20.0
Width of glabella at posterior margin	6.0

Thorax:

Length	12.0
Width at fourth segment	19.0
Width of axial lobe at first segment	5.5
Width of axial lobe at ninth segment	4.0

Pygidium:

Length	7.0
Width at union with thorax	12.0

Fragments of this species are quite abundant in the limestones and interbedded shales. A few entire specimens are found in a fine argillaceous shale a short distance above the white quartzite at the base of the section, and it is from the best specimens of these that the above description was drawn, together with specimens of the cranidium in the limestone.

In general outline and appearance *Asaphiscus iddingsi* approaches the type of the genus, *A. wheeleri* Meek (p. 390). *Asaphiscus iddingsi* has a genal spine, a longer eye-lobe, a proportionately shorter cephalon, and nine, instead of eight, segments in the thorax.

Formation and locality.—Middle Cambrian: (35r and 36e) Fu-chóu series, shales interbedded with limestones near the base of the series just above the white quartzite [see Blackwelder, Research in China, Vol. 1, Pt. 1, p. 92, for general section giving stratigraphic relations]; collected in a low bluff on the shore of Tschang-hsing-tau Island, east of Niang-niang-kung, Liau-tung, Manchuria, China.

Collected by J. P. Iddings and Li San.

ASAPHISCUS ? MINOR, new species

Plate 61, figs. 3, 3*a-b*

Asaphiscus minor Walcott, 1908, Smithsonian Misc. Coll., Vol. 53, p. 178. (Name listed in fauna of Weeks formation.)

This is a small species with only seven thoracic segments and with rather strong genal spines. It has four rings and a terminal section on the axial lobe of the pygidium and four flat segments on the pleural lobes separated by narrow, shallow furrows.

Surface of test apparently finely granulated. The average length of the dorsal shield is about 14 mm. One has a length of 17 mm. *Asaphiscus ? minor* differs from *A. ? granulatus* and *A. ? unispinus* in having seven thoracic segments and in the absence of a thoracic

spine, and from *A. ? granulatus* in the absence of coarse granulations. It is the most abundant species, as over 60 specimens were found, while only two of *A. ? granulatus* and nine of *A. ? unispinus* were collected in the same band of shaly limestone.

Formation and locality.—Upper Cambrian: Weeks formation; (30n) about 3,750 feet (1,143 m.) above the Lower Cambrian in shales forming 1*c* of the Weeks formation,[1] and (30 o) about 3,950 feet (1,204 m.) above the Lower Cambrian in the shaly limestones forming 1*b* of the Weeks formation, both on the north side of Weeks Canyon, about 4 miles (6.4 km.) south of Marjum Pass; also (14v) shales of unknown stratigraphic horizon collected 1 mile (1.6 km.) south of Rainbow Valley, all in House Range,[2] Millard County, Utah.

ASAPHISCUS ? UNISPINUS, new species

Plate 61, fig. 1

This species resembles *Asaphiscus ? minor* in general appearance, but it has 10 thoracic segments instead of seven, and the eighth segment has a strong median spine on its axial lobe that extends back over the two posterior segments and the pygidium. From *A. ? granulatus* it differs in surface, number of thoracic segments, 10 instead of 11, and in having the thoracic spine on the eighth instead of the ninth segment.

Test dense and apparently minutely granulated.

There are nine specimens of this species in the collection, and all of them were associated in the shaly limestone with *A. ? minor* and at locality 30n with *A. ? granulatus*.

Formation and locality.—Upper Cambrian: Weeks formation; (30n) about 3,750 feet (1,143 m.) above the Lower Cambrian in shales forming 1*c* of the Weeks formation,[3] and (30 o) about 3,950 feet (1,204 m.) above the Lower Cambrian in the shaly limestones forming 1*b* of the Weeks formation, both on the north side of Weeks Canyon, about 4 miles (6.4 km.) south of Marjum Pass; also (14v) shales of unknown stratigraphic horizon collected 1 mile (1.6 km.) south of Rainbow Valley, all in House Range,[4] Millard County, Utah.

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[1] Walcott, Smithsonian Misc. Coll., Vol. 53, 1908, p. 178.
[2] Idem, pl. 13.
[3] Idem, pl. 178.
[4] Idem, pl. 13.

ASAPHISCUS WHEELERI Meek

Plate 58, figs. 1, 1*a-g*

Bathyurellus (*Asaphiscus*) *wheeleri* MEEK, 1873, Sixth Ann. Rept. U. S. Geol. Survey Terr., p. 485, footnote. (Brief description.)

Asaphiscus wheeleri WHITE, 1875, Rept. U. S. Geog. and Geol. Expl. and Surv., West 100th Merid., Vol. 4, p. 43, pl. 2, figs. 1*a-f*. (Describes and illustrates species.)

Asaphiscus wheeleri WALCOTT, 1886, Bull. U. S. Geol. Surv., No. 30, p. 220, pl. 31, figs. 3, 3*a*; pl. 25, fig. 9. (Describes and gives restored figure of species.)

Asaphiscus wheeleri MILLER, 1889, North American Geol. and Pal., p. 530, text fig. 965. (Brief description and one figure.)

Asaphiscus wheeleri GRABAU and SHIMER, 1910, North American Index Fossils, Vol. 2, p. 289, fig. 1596. (Illustrates with reduced figure from Walcott.)

The description by White gives a very good conception of the dorsal shield of this species. Its most marked difference when compared with other species is the absence of genal spines. Specimens of the entire dorsal shield and the separate cephala and pygidia are very abundant in the Wheeler formation, east of Antelope Springs.

Formation and locality.—Middle Cambrian: (3s, 3t, 8g, 4) Wheeler formation; about 1,700 feet (518.2 m.) above the Lower Cambrian and 2,700 feet (823 m.) below the Upper Cambrian in the shaly limestones and calcareous shales of the Wheeler formation, in the eastern part of Wheeler Amphitheater, east of Antelope Springs, House Range; and (15b) same horizon; near Swasey Spring, House Range, all in Millard County, Utah.

Also (10y, 10z) Marjum formation; about 2,900 feet (884 m.) above the Lower Cambrian and 1,500 feet (457.2 m.) below the Upper Cambrian in the central part of the limestone forming 1*a* of the Marjum limestone about 1 mile (1.6 km.) south-southwest of Marjum Pass, House Range, Millard County, Utah.

ASAPHISCUS, species undetermined (1)

A number of pygidia that occur in a thin-bedded, dark-blue limestone in northern Wyoming have the general appearance of the pygidium of *Asaphiscus* (*?*) *capella,* and the associated free cheek has a genal spine and is more like that of *A.* (*?*) *capella,* but in the absence of a cranidium it is difficult to make even a tentative specific identification.

Formation and locality.—Middle Cambrian: (4d) Limestone; divide at head of Sheep Creek, north end of Teton Range, Wyoming.

ASAPHISCUS ?, species undetermined (2)

Plate 63, figs. 3, 3*a*

This species is represented by a single pygidium that is doubtfully referred to *Asaphiscus*. Its appearance and characters are shown by the illustration.

Formation and locality.—Upper Cambrian: (119) Maryville limestone; beneath Nolichucky shale, on Cub Creek, 1.5 miles (2.4 km.) southeast of Morristown, Hamblen County, Tennessee.

ASAPHISCUS, species undetermined (3)

This species is represented by a pygidium of the *Asaphiscus* (*?*) *capella* form and four crushed thoracic segments. It is noteworthy as being larger than other species referred to *Asaphiscus*. The pygidium has a length of 11 mm. and an anterior width of 19 mm.

Formation and locality.—Upper Cambrian: (30 o) Weeks formation; about 3,950 feet (1,204 m.) above the Lower Cambrian in the shaly limestones forming 1*b* of the Weeks formation, on the north side of Weeks Canyon, about 4 miles (6.4 km.) south of Marjum Pass, House Range, Millard County, Utah.

DOUBTFUL SPECIES OF ASAPHISCUS

The following species from the Upper Cambrian or later formations are tentatively referred to *Asaphiscus* pending the discovery of better material that may lead to a more correct interpretation of their generic relations.

ASAPHISCUS ? AGATHO, new species

Plate 63, figs. 9, 9*a*

This species is represented by a small *Asaphiscus*-like cranidium that is much like the cranidium of *Asaphiscus ? florus*. It differs in the width of the frontal limb and border and a narrower posterolateral limb. Length of cranidium, 5 mm. The associated pygidium is illustrated by figure 9*a*.

Formation and locality.—Upper Cambrian ?: (107g) Kittatinny ? limestone; 100 feet more or less of limestone in middle of sandy dolomite 1,000 feet thick or more; 0.5 mile (0.8 km.) west of Drab, Blair County, Huntingdon quadrangle (U. S. G. S.), Pennsylvania.

Also from (123a) Maryville limestone; 4 miles (6.4 km.) northeast of Rogersville, Hawkins County, Tennessee.

ASAPHISCUS ? ANAXIS, new species

Plate 63, figs. 2, 2a

This species is represented by a number of cranidia from 7 to 16 mm. in length. It is characterized by a narrow, upturned frontal border and rather broad, strong glabella and occipital ring.

Surface as far as known slightly roughened by what may be a fine granulation.

Cranidia of a similar type occur at several localities in the Maryville limestone.

Formation and locality.—Upper Cambrian: (107) Maryville limestone; Bull Run Ridge, northwest of Copper Ridge, 11 miles (17.7 km.) northwest of Knoxville, Knox County; (119) beneath Nolichucky shale, on Cub Creek, 1.5 miles (2.4 km.) southeast of Morristown, Hamblen County; also (123b) top of Maryville limestone, near base of Nolichucky shale; Rogersville, 0.5 mile (0.8 km.) east of depot on left of railway, in wagon road, and (125) north side of big creek below Harlan's mill, 4 miles (6.4 km.) northeast of Rogersville, last two in Hawkins County, all in Tennessee.

ASAPHISCUS ? DURIS, new species

Plate 63, figs. 8, 8a

The cranidium representing this species is not unlike that of *A. ? florus,* figure 6, but is proportionally broader, and its outer surface is closely granulated.

Formation and locality.—Upper Cambrian ?: (107f); about 2 miles (3.2 km.) north of Bakers Summit, Bedford County, Pennsylvania.

ASAPHISCUS ? FLORUS, new species

Plate 63, figs. 6, 6a-b

This is a small species, the cranidium of which would have been referred to *Ptychoparia* or *Liostracus* except that the associated pygidium has a slightly concave border and the anchylosed segments are clearly of the *Asaphiscus* type.

Formation and locality.—Upper Cambrian ?: (107g) Kittatinny ? limestone; Drab, Blair County, Pennsylvania.

A similar form occurs at locality 107e, Upper Cambrian ?: Kittatinny ?; limestone in lower part of upper quartzite division of the "Kittatinny"; 1 mile (1.6 km.) southwest of Ore Hill, and 4 miles (6.4 km.) south of Roaring Spring, in Bedford County, Hollidaysburg quadrangle (U. S. G. S.), Pennsylvania.

ASAPHISCUS ? cf. FLORUS, new species

Plate 63, fig. 7

This form is represented by a broken cranidium. It is closely related to *Asaphiscus ? florus,* except that the frontal limb is larger and the palpebral lobes a little longer in proportion to the length of the cranidium.

Formation and locality.—Upper Cambrian ?: (107e) Kittatinny ? limestone; 1 mile (1.6 km.) southwest of Ore Hill and 4 miles (6.4 km.) south of Roaring Spring, Bedford County, Pennsylvania.

BLAINIA, new subgenus

Blainia differs from *Asaphiscus* in the compact form of its convex dorsal shield and in its general appearance when compared directly with the dorsal shield of *Asaphiscus wheeleri,* the type of the genus. The pleural thoracic furrows are narrower than in the genotype, *A.* (*Blainia*) *gregarius;* the pygidium has a narrower outline and the pleural furrows extend down to the outer margin which gives quite a different aspect as compared with the broad, smooth border on the pygidium of *A. wheeleri.*

The species referred to *Blainia* have nine thoracic segments and six to 11 distinct anchylosed segments in the pygidium.

Genotype.—*Asaphiscus* (*Blainia*) *gregarius* Walcott.

As far as known, the subgenus is confined to one horizon of the Middle Cambrian Conasauga shales in Cherokee County, Alabama. *Asaphiscus* (*Blainia*) *gregarius* is a very abundant form on the siliceous nodules embedded in the shale and *A.* (*B.*) *paula* and *A.* (*B.*) *elongatus* are relatively rare.

ASAPHISCUS (BLAINIA) ELONGATUS, new species

Plate 63, figs. 4, 4*a*, 5, 5*a*

This is a large species represented by cranidia, and a pygidium that may or may not belong with the cranidium. The cranidium appears to be congeneric with that of the other species referred to *Asaphiscus* (*Blainia*), but it differs specifically in the elongate outline of the glabella, also of the pygidium, if the one referred to the species really belongs with it.

The form of the glabella and palpebral lobe is much like that of *A.* (*B.*) *paula,* but the frontal border curves backward at the center in front of the glabella. The associated pygidium is elongate and formed of about 12 anchylosed segments. From its size and form

it seems quite probable that it belongs with the cranidium to which it is referred.

Surface of both cranidium and pygidium finely granulated. The largest cranidium has a length of 21 mm. and associated pygidium of 19 mm. With the thorax of proportional length the dorsal shield would have a length of 60 mm., which would make it the largest species of the subgenus *Blainia*.

Formation and locality.—Middle Cambrian: (90x) Conasauga formation; in and attached to the outer surface of siliceous nodules in a dark argillaceous shale of the lower Conasauga formation; 3 miles (4.8 km.) east of Center, near Blaine, Coosa Valley, Cherokee County, Alabama.

ASAPHISCUS (BLAINIA) GLABRA, new species

Plate 63, figs. 1, 1*a-e*

This species is known only by the cranidium and associated pygidium and fragments of thoracic segments. The cranidium is much like that of *A.* (*B.*) *gregarius,* differing only in the relative widths of the frontal limb and border and slightly broader fixed cheeks. The associated pygidium differs in form, width of border, and length of axial lobe.

Exterior surface finely granulated. Judging from the separate parts, the dorsal shield probably equalled if not exceeded the size of the dorsal shield of *A.* (*B.*) *gregarius* and *A.* (*B.*) *paula.*

The fossils associated with *A.* (*B.*) *glabra* are *Hyolithes, Ptychoparia* sp., and a fine species of an undetermined *Olenoides.*

Formation and locality.—Middle Cambrian: (107x) Conasauga formation; compact oolitic limestone in boulder on hillside, Bull Run Knobs near creek, west of Copper Ridge, 2 miles (3.2 km.) south of Heiskell, Knox County, and 11 miles (17.7 km.) northwest of Knoxville, Tennessee.

ASAPHISCUS (BLAINIA) GREGARIUS, new species

Plate 62, figs. 1, 1*a-i*

This species is so well illustrated by the figures of plate 61 that a general description is unnecessary. The cephalon has rather large, free cheeks with medium size genal spines; the glabella is marked by three pairs of side furrows in the smaller specimens, as shown by figure 1*e,* but in the larger they are very slightly marked; the nine thoracic segments have narrow diagonal pleural furrows and a rather abrupt termination of the ends of the segments. The pygi-

dium has a narrow, convex axial lobe with seven to eight not very strongly defined rings that extend obliquely across the pleural lobes as flat segments separated by narrow, shallow furrows; the doublure is broad (fig. 1*f*) and finely striated.

Surface with fine, irregular granules set very close to each other and sometimes with a tendency to follow irregular lines that suggest that the granulation results from the breaking up of fine ridges.

The largest dorsal shield has a length of 43 mm.

Cephalon	13 mm.
Thorax	19 "
Pygidium	11 "
Width of thorax	20 "

Two enrolled specimens (see fig. 1*h*) show that the animal rolled up very much as in genera of the Asaphidæ, Proteidæ, etc.

This species is one of the most abundant of those occurring on the siliceous nodules of the Conasauga shales. It is associated with a large and varied fauna of a Middle Cambrian facies. One of the associated species, *A.* (*B.*) *paula,* is somewhat similar in form but differs in details of the cranidium and pygidium.

Formation and locality.—Middle Cambrian: (90x) Conasauga formation; in and attached to the outer surface of siliceous nodules in a dark argillaceous shale of the lower Conasauga formation; 3 miles (4.8 km.) east of Center, near Blaine, Coosa Valley, Cherokee County, Alabama.

Also (56y) fine, arenaceous, buff-colored shales; 1.75 miles (2.8 km.) southwest of Greenback, on the railroad just north of wagon-road crossing, Loudon County, Tennessee.

ASAPHISCUS (BLAINIA) PAULA, new species

Plate 62, figs. 2, 2*a-b*

This species has the same general characters of *A.* (*B.*) *gregarius,* such as form, nine segments in thorax, finely granulated surface, and size. It differs in outline of glabella and smaller palpebral lobes of cranidium, and the pygidium is quite dissimilar in details as may be seen by comparing figures 1*a,* 1*f,* 1*g* of plate 62 with figures 2, 2*a.* The same comparison may be extended to *A.* (*B.*) *glabra* (pl. 63, figs. 1, 1*a,* 1*b*).

The largest dorsal shield has a length of 45 mm.

Formation and locality.—Middle Cambrian: (90x) Conasauga formation; in and attached to the outer surface of siliceous nodules in a dark argillaceous shale of the lower Conasauga formation; 3

miles (4.8 km.) east of Center, near Blaine, Coosa Valley; and (112) argillaceous shale carrying fossiliferous cherty nodules of 90x; 5 miles (8 km.) east-southeast of Center, both in Cherokee County, Alabama.

BLOUNTIA, new genus

General form of dorsal shield broadly elliptical, convex. Cephalon semicircular in outline with genal angles produced into short spines; border slightly rounded to convex; frontal limb of medium width and clearly defined. Glabella convex, slightly narrowing to a broadly round front, smooth or with slight traces of glabellar furrows; occipital ring flat or slightly rounded and separated from glabella by a narrow and often very indistinct furrow. Fixed cheeks narrow to medium width; postero-lateral limbs large, and anterior to the small palpebral lobes the cheeks curve slightly outward; a low, inconspicuous palpebral ridge crosses from the palpebral lobe to the slight dorsal groove beside the glabella. Palpebral lobe and eye small and situated about halfway of the length of the head, or in front of its transverse center. Free cheeks with border extended into a genal spine.

Thorax with convex axis and seven flat segments that curve abruptly downward at the geniculation, which gives a flattened appearance to the pleural lobes out to the geniculation; extremities of segments slightly falcate and with an enrollment facet on their anterior side; pleural furrow very shallow and best seen at the geniculation; it appears to start at the inner anterior margin of the segment and to extend diagonally across the segment to the posterior side of the narrowing space back of the enrollment facet.

Pygidium semioval in outline; axis convex, two-thirds or more of the length of the pygidium; axis and pleural lobes smooth or with indications of anchylosed segments; in the genotype the segments are indicated by a slight change of color along the lines of the furrows that usually outline the segments. The interior of the test shows seven or eight segments much more strongly outlined on the axis.

Surface dense and smooth as far as known.

Dimensions.—The only entire dorsal shield has a length of about 7 mm. Several cranidia indicate that some dorsal shields had a length of 10 mm. None of the species appear to have attained a much larger size.

Genotype.—Blountia mimula Walcott.

Stratigraphic range.—All of the species now referred to *Blountia* are from the Maryville limestone formation of the Middle Cambrian.

Geographic distribution.—All known species are from the eastern portion of the state of Tennessee.

Observations.—The genus *Blountia* includes a number of small trilobites that apparently came from the same line of descent as *Asaphiscus* and allied forms. It may be a degenerate from an *Asaphiscus*-like ancestor. The species *B. mimula* is represented by many cranidia and pygidia and one nearly entire dorsal shield.

A number of the species are represented by cranidia that might be referred to *Anomocarella* Walcott or *Liostracus* Angelin except that they have a general appearance that suggests a different genus. These include all of the following species except *B. anser* and *B. mimula*. *Blountia mimula* has but seven thoracic segments.

The species referred to the genus are:

Blountia ? alemon Walcott; Upper Cambrian (pl. 61, fig. 6).
Blountia alethes Walcott; Upper Cambrian (pl. 64, fig. 1).
Blountia alexas Walcott; Upper Cambrian (pl. 61, fig. 5).
Blountia amage Walcott; Upper Cambrian (pl. 64, fig. 3).
Blountia andreas Walcott; Upper Cambrian (pl. 64, fig. 2).
Blountia anser Walcott; Upper Cambrian (pl. 61, fig. 7).
Blountia mimula Walcott; Upper Cambrian (pl. 61, fig. 4).

BLOUNTIA ? ALEMON, new species

Plate 61, figs. 6, 6*a*

This is a small species distinguished by a broad glabella, small palpebral lobes, large postero-lateral limbs, and short frontal limbs from other species referred to the genus. The strong occipital furrow and narrow frontal limb suggest that it belongs to some other genus. The cranidium has a length of 4 mm.

Formation and locality.—Upper Cambrian: (119) Maryville limestone, beneath Nolichucky shale; on Cub Creek, 1.5 miles (2.4 km.) southeast of Morristown, Hamblen County, Tennessee.

BLOUNTIA ALETHES, new species

Plate 64, figs. 1, 1*a-c*

This form differs from *Blountia mimula* in the form of its cranidium, glabella, palpebral lobes, and its associated pygidium. A large cranidium has a length of 8 mm., and an associated pygidium

doubtfully referred to the species has about the same length. The cranidium of *Blountia amage* is in the outline of its glabella and palpebral lobes nearer to *B. alethes* than any other species of the genus.

Formation and locality.—Upper Cambrian: (123b) Maryville limestone; Rogersville, 0.5 mile (0.8 km.) east of depot on left of railway in wagon road, Hawkins County, Tennessee.

BLOUNTIA ALEXAS, new species

Plate 61, figs. 5, 5*a*

This form is most nearly related to *Blountia anser;* it differs in the wider frontal border of the cranidium, shorter glabella, and smaller palpebral lobe. The glabella appears to be smooth.

Formation and locality.—Upper Cambrian: (125) Maryville limestone; north side of big creek below Harlan's mill, 4 miles (6.4 km.) northeast of Rogersville, Hawkins County, Tennessee.

BLOUNTIA AMAGE, new species

Plate 64, figs. 3, 3*a*

This form is characterized by its slightly conical, smooth glabella, gently rounded frontal limb and margin, and distinctly dorsal furrows. A cranidium has a length of 5 mm. An associated pygidium illustrated by figure 3*a* has a length of 6 mm.

The cranidium of *B. amage* is much like those of *B. alethes* and *B. andreas* (pl. 64, figs. 1, 2) except that they all differ in the details of the frontal limb and border from it and from each other.

The associated pygidium (fig. 3*a*) is somewhat similar to that associated with the cranidium of *B. alethes* (fig. 1*b*).

The cranidium has a length of 5.5 mm.

Formation and locality.—Upper Cambrian: (107) Conasauga formation (Maryville limestone); Bull Run Ridge, northwest of Copper Ridge, 11 miles (17.7 km.) northwest of Knoxville, Knox County, Tennessee.

BLOUNTIA ANDREAS, new species

Plate 64, fig. 2

This species is represented by a single specimen of the cranidium which is characterized by its broad frontal border and relatively short broad glabella which has a well-defined occipital furrow.

Formation and locality.—Upper Cambrian: (102a) Maryville limestone; summit of limestone, exposure at west end of limestone and shale knob, *first* right-hand road from Kingsport pike, 1.25 miles (2 km.) east of Rogersville, Hawkins County, Tennessee.

BLOUNTIA ANSER, new species

Plate 61, figs. 7, 7*a-b*

This very neat little species suggests in its cranidium *B. mimula,* but it differs in its frontal border and very narrow frontal limb. The associated pygidium is more like the pygidium associated with the cranidium of *B. alethes.*

One cranidium has a length of 3 mm. and a second 4 mm.

Formation and locality.—Upper Cambrian: (120) Maryville limestone; north of Bays Mountain, 2 to 3 miles (3.2 to 4.8 km.) south of New Market, Jefferson County, 18 miles (28.6 km.) east-northeast of Knoxville, Tennessee.

BLOUNTIA MIMULA, new species

Plate 61, figs. 4, 4*a-c*

One nearly entire dorsal shield of this species is taken as the genotype of the genus and is described in the generic description. It is the only specimen showing the seven segments of the thorax. *Blountia mimula* has thus far been found in limestones of the Appalachian region in Tennessee.

Formation and locality.—Upper Cambrian: (120) Maryville limestone; north of Bays Mountain, 2 to 3 miles (3.2 to 4.8 km.) south of New Market, Jefferson County, 18 miles (28.6 km.) east-northeast of Knoxville; (107c) west base of Copper Ridge; 11 miles (17.6 km.) northwest of Knoxville; (107n) Conasauga formation (Nolichucky shale zone); limestones and shales at the base of the Knox dolomite, west of the top of Copper Ridge, near the Southern Railway cut, about 10 miles (16.1 km.) northwest of Knoxville (Briceville folio); (119) Maryville limestone, beneath Nolichucky shale; on Cub Creek, 1.5 miles (2.4 km.) southeast of Morristown, Hamblen County; (121a) 4 miles (6.4 km.) northeast of Rogersville, Hawkins County, on side of road leading from southeast of Harlans Knob to Amis postoffice; (123b) top of Maryville limestone, near base of Nolichucky shale; Rogersville, 0.5 mile (0.8 km.) east of depot on left of railway in wagon road, Hawkins County; and (125) north side of big creek below Harlan's Mill, 4 miles (6.4 km.) northeast of Rogersville, Hawkins County, all in Tennessee.

In addition to the above localities, pygidia have been tentatively referred to *B. mimula* from two other localities:

(117b) Maryville limestone; Buckingham Ford road, 3.5 miles (5.6 km.) southeast of Greeneville, Greene County, Tennessee; and (139a) Conasauga formation; bluish limestones in shales on road near Wades Gap, near Chepultepec, Jefferson County, Alabama.

MARYVILLIA, new genus

The cranidium is not unlike that of *Blountia* except that the frontal limb and border merge into each other without a very definite line of demarcation between them. The smooth glabella, medium width of fixed cheeks and medium size palpebral lobes all are similar to the same parts of *Blountia,* but at the same time there is a suppressing of the relief of the glabella and fixed cheeks that gives a very distinctive character to the cranidium. The pygidia associated with the cranidia of both species, *M. arion* and *M. ariston,* are elongate with about 14 anchylosed segments as shown by the interior of the test of the axial lobe (pl. 64, figs. 4*a* and 5*a*). This type of pygidium suggests transition from *Blountia* to *Tsinania* as represented by such species as *T. canens* Walcott, *T. ceres* Walcott, *T. dictys* from the Upper Cambrian of eastern China.[1]

Surface of exterior of test with shallow pits and on some specimens it is apparently punctate.

Genotype.—Maryvillia arion Walcott.

MARYVILLIA ARION, new species

Plate 64, figs. 4, 4*a-c*

This species is represented by numerous specimens of the cranidium and pygidium from localities where both were associated in the same hand specimens of limestone. It is this association in different localities that leads to the conclusion that the cranidium and pygidium belong to one species.

The characters of the cranidium are well indicated by figures 4, 4′. The very narrow occipital ring with the almost flat glabella and the rapidly sloping, fixed cheeks are the most noticeable features.

The pygidium is found only as the interior of the test and the cast of it; the test clings in the matrix owing to its roughened outer surface which is more or less compactly covered by shallow pits or

[1] Research in China, Vol. 3, The Cambrian Faunas of China, 1913, pl. 23, figs. 3*b*, 3*c*, 4*a*, 5*a*, 6.

punctæ; the inner surface of the depressed axial lobe of the pygidium is marked by from 14 to 16 narrow rings that are extended rather faintly across the pleural lobes.

The largest cranidium has a length of 12 mm. and pygidium of 11 mm.

Maryvillia arion differs from *M. ariston* in the form of the frontal limb and border of the cranidium and the shape of the associated pygidium. Both species occur in the Maryville limestone but not at the same localities.

Formation and locality.—Upper Cambrian: (123b) Maryville limestone near its top beneath the Nolichucky shale; 0.5 mile (0.8 km.) east of depot on left of railway in wagon road, Rogersville, Hawkins County; (119) beneath Nolichucky shale, on Cub Creek, 1.5 miles (2.4 km.) southeast of Morristown, Hamblen County; and (107c) west base of Copper Ridge; 11 miles (17.7 km.) northwest of Knoxville, Knox County, all in Tennessee.

MARYVILLIA ARISTON, new species

Plate 64, figs. 5, 5*a*

Maryvillia ariston is known by its cranidium and a type of pygidium that is associated with it. It has the general characters of *M. arion,* but differs in the form of the combined frontal limb and border, and its associated pygidium is more elongate; the latter has 16 or more rings in its axial lobe and nearly smooth pleural lobes.

Surface of outer test finely pitted, apparently nearly punctate; inner surface of test finely granulated.

The largest cranidium has a length of 11 mm. and the pygidium 13 mm.

Formation and locality.—Upper Cambrian: (120) Maryville limestone; north of Bays Mountain, 2 to 3 miles (3.2 to 4.8 km.) south of New Market, Jefferson County, 18 miles (28.6 km.) east-northeast of Knoxville; and (126a) east side of Gap Creek section, 10 miles (16 km.) east of Knoxville, Knox County, both in Tennessee.

Family OLENIDÆ Burmeister

MARJUMIA, new genus

This genus appears to unite characters found in several genera. The cephalon is essentially that of *Asaphiscus,* the thorax that of *Ptychoparia,* and the pygidium that of several genera of the Olenidæ, such as *Peltura scarabæoides* Wahlenberg and *Parabolina megalops* Moberg.

The thorax has 14 segments, and the pygidium four and a terminal section on the axis. There are usually three pairs of border spines, but in one specimen there are four pairs (see pl. 65, fig. 4*a*). On the under side the base of the spines merges into the doublure (fig. 4*b*). The pygidium of *M. callas* has only one pair of border spines at its antero-lateral angle. These resemble closely the border spines of *Corynexochus* (*Bonnia*) *parvulus*. The variation in the number of border spines is not necessarily of generic value, and it may be in some instances of less than specific value.

Surface marked by fine, shallow pits.

The largest entire specimen of the dorsal shield of *Marjumia typa* has a length of 73 mm.

Genotype.—*Marjumia typa* Walcott.

The stratigraphic range is limited to the Marjum formation. *Marjumia typa* occurs about 250 feet (76 m.) and 575 feet (176 m.) below *M. callas*. As far as now known, species of the genus occur only in the House Range of western Utah.

MARJUMIA CALLAS, new species

Plate 65, figs. 3, 3*a-b*

This species is represented by specimens of the cranidium, free cheeks and pygidium. The cranidium and free cheeks are much like those parts in *Marjumia typa* except that the side furrows of the glabella are very faint in *M. callas*. The pygidium differs from that of *M. typa* in having but one marginal spine on each side and a shorter axis. The border spine appears to be a continuation of the anterior anchylosed segment that is merged into the border where it crosses and extends outward beyond it.

Surface of cranidium and pygidium marked by very fine shallow pittings. The largest cranidium has a length of 17 mm.

Formation and locality.—Middle Cambrian: (31r) Marjum formation; gray limestone forming lower portion of 1*a* of the section in cliff facing northeast, 1 mile (1.6 km.) southeast of Marjum Pass, House Range, Millard County, Utah.

MARJUMIA TYPA Walcott

Plate 65, figs. 4, 4*a-b*

Owenella typa Walcott, 1908, Smithsonian Misc. Coll., Vol. 53, p. 180 (Name listed under 1*c*, 1*d*. *Owenella* was preoccupied.)

The principal characters of this species are outlined in the remarks on the genus *Marjumia*. The species is quite abundant in dark-gray,

shaly limestones in association with a large Middle Cambrian fauna as follows at locality 11 q:

Micromitra sculptilis (Meek)
Micromitra (Iphidella) pannula ophirensis (Walcott)
Obolus mcconnelli pelias (Walcott)
Obolus rotundatus (Walcott)
Lingulella arguta (Walcott)
Acrothele subsidua (White)
Acrothele subsidua lævis Walcott
Acrotreta attenuata Meek
Acrotreta ophirensis Walcott
Eoorthis remnicha (N. H. Winchell)
Eoorthis thyone Walcott
Syntrophia ? unxia Walcott
Agnostus 3 spp.
Ptychoparia
Neolenus inflatus Walcott
Neolenus intermedius Walcott
Neolenus superbus Walcott
Orria elegans Walcott

Formation and locality.—Middle Cambrian: (11q, 30g) Marjum formation; about 2,300 feet (701 m.) above the Lower Cambrian, and 660 feet (203 m.) below the Upper Cambrian, in the limestone forming 1*c* of the Marjum formation, 2.5 miles (4 km.) east of Antelope Springs, in west face of ridge east of Wheeler Amphitheater, House Range; also (3x) same locality but slightly lower horizon, 1*d* of section; all in Millard County, Utah.

Genus LISANIA Walcott

Lisania Walcott, 1911, Smithsonian Misc. Coll., Vol. 57, p. 82. (Describes genus.)

Lisania Walcott, 1913, Research in China, Vol. 3, The Cambrian Faunas of China, p. 163. (Describes genus and illustrates genotype.)

Genotype.—*Anomocarella bura* Walcott.

Lisania has hitherto been identified only from China. The new species *L. ? breviloba,* from the Upper Cambrian of the Appalachian Province of North America and larger than any of the Chinese species, is doubtfully referred to the genus.

Lisania differs from *Pagodia* in having a longer eye lobe, narrower free cheeks, flatter frontal margin. *Pagodia* occurs with the Upper Cambrian fauna, *Lisania* with the Middle Cambrian fauna. From *Chuangia* it differs in its narrower frontal border, narrower fixed cheeks and quite unlike associated pygidium. The three genera, *Lisania, Pagodia,* and *Chuangia,* all have a strong, nearly smooth

glabella and a narrow frontal margin, and do not appear to come within the limits of *Agraulos, Anomocare, Ptychoparia, Coosia* or *Solenopleura.*

LISANIA ? BREVILOBA, new species

Plate 66, figs. 3, 3*a-c*

With only the cranidia of the type species for comparison it is difficult to identify this species as belonging to the genus, especially as the frontal border of *L. bura* has both a frontal limb and border of the *Anomocarella* type and *L. ? breviloba* has a flat or slightly concave frontal limb without a trace of a frontal border; in this character it is similar to the species *Lisania alala,*[1] from China. Not wishing to create a new genus to include *L. ? breviloba,* it is tentatively referred to *Lisania.*

The characters of the species are fairly well exhibited by the illustrations. The surface of the test is roughened by small shallow pits that on some specimens appear to go deep into its layers and give the surface a punctate appearance.

The largest cranidium has a length of 13 mm. A broken specimen (fig. 3) has nine segments of the thorax attached to a cranidium. A small cranidium (fig. 3*b*) indicates a rather large palpebral lobe, and ridge crossing the fixed cheek which is a character of species referred to *Lisania.* A pygidium (fig. 3*c*) was associated in the same rock with the cranidia and may be tentatively considered as possibly belonging to this species.

Formation and locality.—Upper Cambrian: (118a) Maryville limestone; Bird Bridge road, 1.5 miles (2.4 km.) south of Greeneville, Greene County, Tennessee.

Family Illaenidæ Corda

Genus ILLÆNURUS Hall

Illœnurus Hall, 1863, Sixteenth Ann. Rept., New York State Cab. Nat. Hist., p. 176. (Describes genus and the genotype *Illœnurus quadratus.*)

Illœnurus Hall, 1867, Trans. Albany Inst., Vol. V, p. 167. (Reprint of paper of 1863.)

The genus *Illœnurus* was proposed by Dr. James Hall for what he considered to be an *Illœnus*-like trilobite of the "Primordial" fauna. The quadrate form of the cranidium and large free cheeks distin-

[1] Research in China, Vol 3, The Cambrian Faunas of China, p. 165, pl. 15, figs. 19, 19′.

guishing it from *Illœnus*. He did not compare it with *Symphysurus* Goldfuss, which has a somewhat quadrate cranidium as represented in its genotype *Asaphus palpebrosus* Dalman.[1]

Dr. W. C. Brögger described a new species of trilobite from a cephalon and pygidium, which he named *Symphysurus incipiens*,[2] that is evidently congeneric with *Symphysurus palpebrosus*. He also describes (p. 60) and illustrates (pl. 111, figs. 9-11) another species, *S. augustatus* Sars and Boeck, that appears to be congeneric with Hall's genus *Illœnurus*. This brings up the question of the distinction between *Symphysurus* and *Illœnurus*.

The genotype of *Symphysurus, S. palpebrosus,* appears to be a form nearer to *Asaphus* than to *Illœnus*. It has a distinctly marked cranidium with large eyes and a glabella expanded anteriorly. The thorax has eight segments and the pygidium has a distinct median lobe.

In contrast with *Symphysurus, Illœnurus* more nearly resembles *Illœnus*. The facial sutures in front of the eyes are subparallel to the longitudinal axis of the body; there are 10 segments of the *Illœnus* type in the thorax and a transverse pygidium with only a slight indication of a central lobe. The eye of *Illœnurus* is also smaller and less prominent, and the free cheek is proportionally larger.

Illœnurus should be compared with *Psilocephalus* Salter,[3] although the latter differs in cranidium, thorax and pygidium from *Illœnurus*.

Illœnurus appears to be the progenitor in late Upper Cambrian time, and early post-Cambrian, of *Illœnus*, a genus that obtained a great development in Ordovician and Silurian times.

In America there are no other species that appear to be congeneric with *Illœnurus quadratus*.

Among species previously referred to *Illœnurus* the following are now placed under other genera:

Illœnurus canens Walcott, 1905 = *Tsinania* Walcott.
Illœnurus ceres Walcott, 1905 = *Tsinania* Walcott.
Illœnurus columbiana Weller, 1903 = *Platycolpus* Raymond, 1913.
Illœnurus convexa Whitfield, 1878 = *Platycolpus* Raymond, 1913.
Illœnurus ? dia Walcott, ? = ?
Illœnurus dictys Walcott, 1905 = *Tsinania* Walcott.
Illœnurus eurekensis Walcott, ? = *Platycolpus* Raymond, 1913.
Illœnurus spp. *a* and *b* Walcott,[4] 1913 = *Asaphus?*

[1] Ueber die Palæaden, Trilobiten, Nürnberg, 1828, p. 48, pl. 4, figs. *2a-c*.
[2] Sil. Etagen 2 und 3, Kristiania, 1882, p. 58, pl. 1, figs. 1, 2.
[3] Mem. Geol. Surv. Great Britain, Vol. 3, 1866, p. 315, pl. 6, figs. 9-12.
[4] Smithsonian Misc. Coll., Vol. 57, 1913, p. 336.

Illœnurus sp. Walcott,[1] 1908 = *Tsinania* Walcott.
Illœnurus sp. Walcott,[2] 1908 = Undt.
Illœnurus sp. Walcott,[3] 1908 = *Asaphus ?*

ILLÆNURUS QUADRATUS Hall

Plate 45, figs. 1, 1*a-e*

Illœnurus quadratus HALL, 1863, Sixteenth Ann. Rep., N. Y. State Cab. Nat. Hist., p. 176, pl. 7, figs. 52-57. (Description and illustration of species.)
Illœnurus quadratus HALL, 1867, Trans. Albany Inst., Vol. 5, p. 168, pl. 2, figs. 52-57. (Reprint of paper of 1863.)
Illœnurus quadratus CHAMBERLIN, 1883, Geol. Wisconsin, Vol. 1, p. 130, figs. 16 L-P. (Reproduces figures of Hall.)

To Hall's detailed description of the dismembered dorsal shield of this species I am now able to add that the thorax has 11 segments and that the pygidium is much smaller proportionally than the cephalon.

Formation and locality.—Upper Cambrian: (78) St. Lawrence formation; Osceola, Polk County, and (85) Prairie du Sac, Sauk County, Wisconsin.

(113) La Grange Mountain or Barn Bluff, near Red Wing, Goodhue County, Minnesota.

Family MESONACIDÆ Walcott. 1891

Genus MESONACIS Walcott, 1885

See *Mesonacis* WALCOTT, 1910, Smithsonian Misc. Coll., Vol. 53, p. 261.

MESONACIS GILBERTI (Meek)

Plate 45, fig. 3

Olenellus gilberti MEEK, 1874. For synonymy see Smithsonian Misc. Coll., Vol. 53, 1910, pp. 324, 325.

The discovery of a large, fine specimen of this species by Mr. Edward Sampson, of Philadelphia, affords the data upon which to change the generic reference of the species *gilberti* from *Olenellus* to *Mesonacis*. The specimen is almost a perfect dorsal shield 20 cm. in length. On the fifteenth thoracic segment a long median spine is attached that extends back over seven or eight small segments and a small plate-like pygidium.

This species appears to be represented by the same variations in both Nevada and British Columbia, Canada. These include variation

[1] Smithsonian Misc. Coll., Vol. 53, 1908, p. 175, 1*a*.
[2] Idem, Vol. 53, 1908, p. 177, 2*a*.
[3] Idem, Vol. 53, 1908, p. 192, 1.

in width of border; width of frontal limb, and distance of eye from posterior margin.

A comparison with *Mesonacis vermontana* shows many points of resemblance between the Appalachian and Cordilleran species. The two are illustrated side by side on plate 45.

Formation and locality.—Lower Cambrian: (35n) Mount Whyte formation; eastern slope of Mount Odaray, below McArthur Pass, west-southwest of Lake O'Hara, British Columbia, Canada.

For other localities, see Smithsonian Misc. Coll., Vol. 53, 1910, pp. 329, 330.

Order PROPARIA Beecher

Family EODISCIDÆ Raymond

Eodiscidæ RAYMOND, 1913, Ottawa Nat., Vol. 27, p. 102.

The discovery of the eye and free cheeks of *Pagetia bootes* and *P. clytia,* with the facial sutures, cutting the margin posterior to the eye and in advance of the genal angles, places this section of the Eodiscidæ with the order Proparia and carries with it the closely related forms such as *Eodiscus punctatus, E. scanicus,* etc., that are not known to have had facial sutures and free cheeks.

For the species of the Eodiscidæ that have eyes and free cheeks and which otherwise are closely related to *Eodiscus punctatus* Salter, I propose the generic name *Pagetia.* This genus represents a stage of evolution of the free cheek and facial sutures corresponding to that of *Burlingia,*[1] but the large pygidium and cephalon indicate that it is an instance of reversion in the free cheeks and facial sutures to a primitive type, while the other parts of the dorsal shield indicate an advanced stage of development. If this conclusion is correct, these forms of the Eodiscidæ support the view of Professor Swinnerton[2] that the Proparian type is a reversion to a primitive type and not an evolution through the Opisthoparia to a more advanced type.

Genus PAGETIA, new genus

This genus is proposed for the forms of Eodiscidæ in which the eye, the free cheeks, and facial sutures are developed.

Genotype.—*Pagetia bootes* Walcott.

Stratigraphic range and geographic distribution.—The two known species occur in the Middle Cambrian, one (*P. bootes*) in the Burgess shale member of the Stephen formation, north of Field, British

[1] Smithsonian Misc. Coll., Vol. 53, 1908, p. 14.

[2] Geol. Mag., Dec. 6, Vol. 2, 1915, p. 545.

Columbia, and the other (*P. clytia*) in the Middle Cambrian, Spence shale member of the Ute formation in southern Idaho.

PAGETIA BOOTES, new species

Plate 67, figs. 1, 1*a-f*

I have been collecting material representing the Eodiscidæ[1] for many years, and hope within a few years to describe and illustrate the various forms that appear to belong in the family. At present two species that have eyes and facial sutures of the Proparia type appear to be of such interest as to warrant the publication of a preliminary notice of them.

Pagetia bootes has the same general form as *Eodiscus punctatus*, but it differs most radically in having true eye lobes and palpebral ridges across the fixed cheeks. The median caudal spine is also a marked character of *P. bootes*. The outer surface of the latter is slightly roughened by an obscure granulation that in places is so irregular that an obscure pitting is suggested.

The average length of the dorsal shield is from 5 to 7 mm.

As the illustrations exhibit the character of the dorsal shield, I will not describe the species in detail.

Formation and locality.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation; on the west slope of the ridge between Mount Field and Wapta Peak, 1 mile (1.6 km.) northwest of Burgess Pass, above Field, British Columbia, Canada.

PAGETIA CLYTIA, new species

Plate 67, figs. 2, 2*a-e*

This species differs from *P. bootes* in its uniformly smaller size, greater proportional space between the glabella and frontal margin, more transverse cephalon and pygidium.

The dorsal shield averages from 2 to 3 mm. in length as compared with 5 to 7 mm. for *P. bootes*. Surface minutely granular.

Formation and locality.—Middle Cambrian: (55c) Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

[1] Raymond, Ottawa Naturalist, Vol. 27, 1913, p. 102.

NEW FORMATION NAME

CHISHOLM SHALES

Type locality.—Vicinity of Chisholm Mine and Half Moon Gulch, 2 to 3 miles northwest of Pioche, Lincoln County, Nevada.

Derivation.—From Chisholm Mine.

Character.—Pinkish-colored, compact, argillaceous shale with a few interbedded layers of limestone 3 to 15 inches in thickness.

Thickness.—About 100 feet in vicinity of Chisholm Mine and 125 feet in the Highland Range section.

Organic remains.—Middle Cambrian. At the Chisholm Mine (locality 31):

Eocystites ? longidactylus Walcott
Micromitra (Iphidella) pannula (White)
Obolus (Westonia) ella (Hall and Whitfield)
Lingulella dubia (Walcott)
Hyolithes billingsi Walcott
Zacanthoides typicalis Walcott
Ptychoparia piochensis Walcott
Anomocare ? parvum Walcott
Bathyuriscus howelli Walcott
Dolichometopus productus (Hall and Whitfield)

Observations.—The stratigraphic position of the Chisholm shale, as noted in the Highland Range section,[1] is about 1,200 feet (370 m.) above the Lower Cambrian with 3,000 feet of Cambrian limestones above it. In the upper portion of the latter limestone I found in 1887 the following (locality 88):

Owenella antiquata (Whitfield)
Sinuopea, 3 undt. spp.
Hyolithes attenuatus Walcott
Hyolithes ? corrugatus Walcott
Hyolithes curvatus Walcott
Dikelocephalus cf. *D. minnesotensis* Owen
Saukia pepinensis (Owen)
Eurekia dissimilis (Walcott)
Conaspis[2] sp. undt.
Arethusina ?? americana Walcott

This is the fauna listed on page 35, Bull. 30, U. S. Geol. Surv., 1886, and page 318, Bull. 81, U. S. Geol. Surv., 1891. The species

[1] Bull. U. S. Geol. Surv., No. 81, 1891, p. 318, Bed No. 21.
[2] New genus.

listed as *Illœnurus* in 1886 and 1891 has not been found in the collection.

The stratigraphic position of the Chisholm shale corresponds in a general way to the Spence shale of the Ute formation of southern Idaho.[1]

[1] Smithsonian Misc. Coll., Vol. 53, 1908, pp. 7, 8, and 197.

DESCRIPTION OF PLATE 45

PAGE

Illœnurus quadratus Hall 406

FIGS. 1, 1*a*. (× 1.5.) Dorsal and side views of the cast of a dorsal shield preserved in fine-grained sandstone. U. S. National Museum, Catalogue No. 62614. (Locality **78.**)

1*b*. (Natural size.) Dorsal shield flattened in very fine-grained arenaceous shale. U. S. National Museum, Catalogue No. 62615.

From locality **85,** Upper Cambrian: Prairie du Sac, Wisconsin.

1*c*, 1*c'*. (× 1.5.) Dorsal and side views of a well-preserved cephalon from the same layer of sandstone as the specimen represented by fig. 1. U. S. National Museum, Catalogue No. 62616. (Locality **78.**)

1*d*, 1*d'*. (× 1.5.) Dorsal and side views of a cranidium, showing the form of the palpebral lobes and the course of the facial sutures. U. S. National Museum, Catalogue No. 62617.

From locality **78b,** Upper Cambrian: Saint Lawrence formation; Saint Croix River, near Osceola, Wisconsin.

1*e*. (× 1.5.) A pygidium associated with the specimens represented by figs. 1 and 1*c*. U. S. National Museum, Catalogue No. 62618.

The specimens represented by figs. 1, 1*c*, and 1*e* are from locality **78,** Upper Cambrian: Saint Lawrence formation; Saint Croix River, Osceola, Wisconsin.

Mesonacis vermontana (Hall) 407

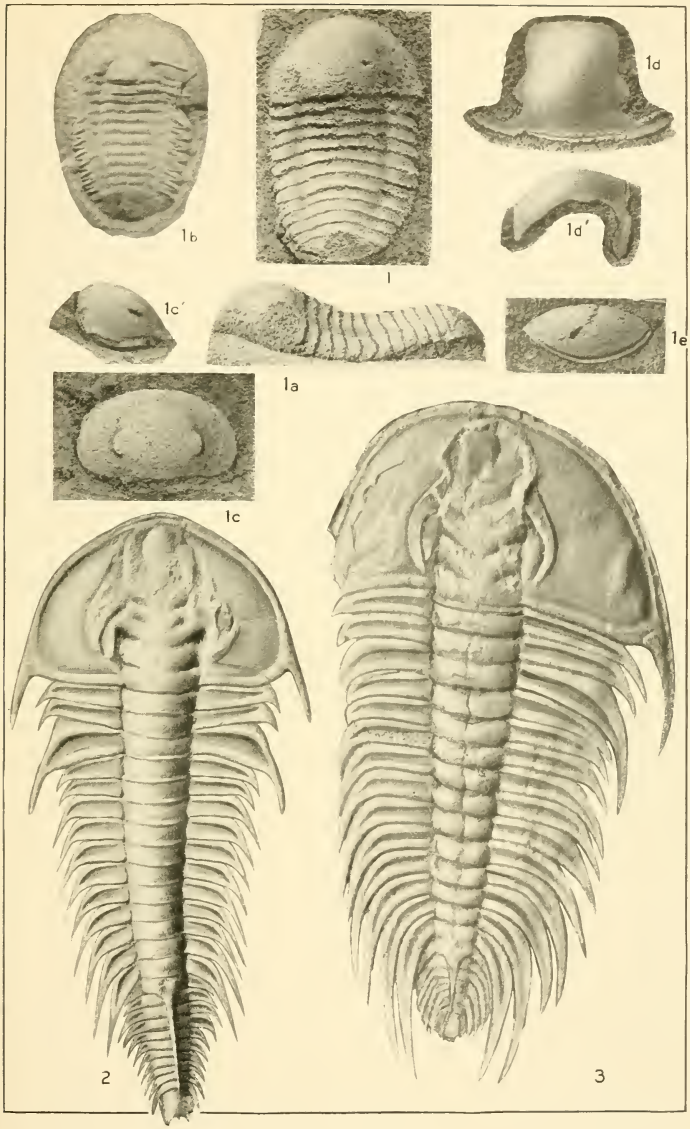
FIG. 2. (Natural size.) An entire dorsal shield from the type locality (**25**) at Georgia, Vermont, showing 14 thoracic segments of the *Olenellus* type, the spine-bearing segment, and ten segments of the *Mesonacis* type. U. S. National Museum, Catalogue No. 15399*a*.

From locality **25,** Lower Cambrian: Siliceous or finely arenaceous shale just above Parker's quarry, Georgia township, Franklin County, Vermont.

The specimen represented by fig. 2 has been figured by Walcott, Smithsonian Misc. Coll., Vol. 53, No. 6, 1910, pl. 26, fig. 1.

Mesonacis gilberti (Meek) 406

FIG. 3. (About ½ natural size.) The illustration is taken from a plaster cast of the specimen now in the Geological Museum of Princeton University, Princeton, New Jersey, which was from locality **35n,** Lower Cambrian: Mount Whyte formation; eastern slope of Mount Odaray, above McArthur Pass, British Columbia, Canada. Plastotype. U. S. National Museum, Catalogue No. 62619.



CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 46

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Bathyuriscus (*Poliella*) *powersi* Walcott 351

FIG. 1. (×2.) Type specimen of dorsal shield exclusive of free cheeks. Original specimen in collections Museum of Comparative Zoölogy, Cambridge, Massachusetts. Plastotype U. S. National Museum, Catalogue No. 62620.

The original specimen was collected from the Gallatin limestone, Pole Creek, Gallatin County, Montana.

Bathyuriscus haydeni (Meek) 341

FIG. 2. (×1.5.) Photograph of the best specimen used by Meek in describing species. Note the large pygidium. U. S. National Museum, Catalogue No. 7863.

2*a*. (×2.) Cast of a cranidium. U. S. National Museum, Catalogue No. 7863.

2*b*. (×2.) Pygidium. U. S. National Museum, Catalogue No. 7863.

The specimens represented by figs. 2, 2*a* and 2*b* are weathered out on surface of dark, thin-bedded limestone at locality **302**, Middle Cambrian: Limestone east of West Gallatin River, above Gallatin City, Gallatin County, Montana.

Bathyuriscus (*Poliella*) *occidentalis* (Matthew) 351

FIG. 3. (×2.5.) Illustration from plaster cast made in matrix which is the type specimen of the species. Plastotype U. S. National Museum, Catalogue No. 62621. The specimen is from locality **148**, Middle Cambrian: *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 2,700 feet (823 m.) below the Upper Cambrian in the *Ogygopsis* zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad, British Columbia, Canada.

This figure is the same as that on plate 3, fig. 2, Canadian Alpine Journal, Vol. 1, No. 2, 1908.

Bathyuriscus ornatus Walcott 346

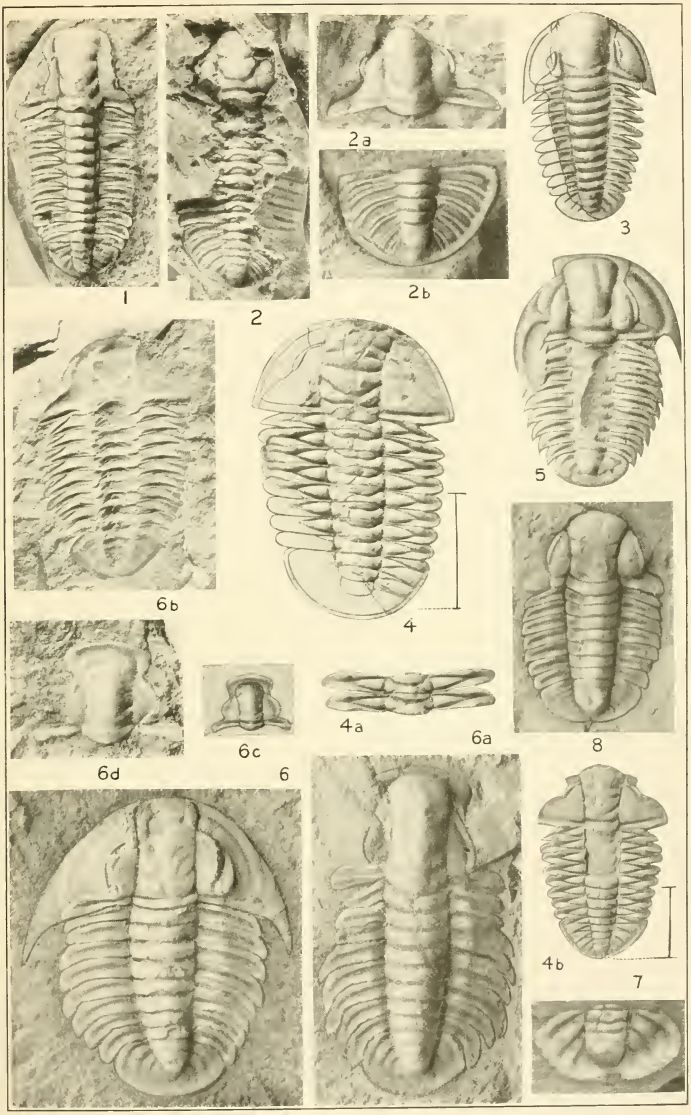
FIG. 4. (×2.) A broken specimen, showing character of cephalon and thorax. U. S. National Museum, Catalogue No. 53420.

4*a*. (×3.) Two segments of the thorax enlarged to show the details of the axial and pleural lobes. U. S. National Museum, Catalogue No. 53423.

4*b*. (×2.25.) A small, nearly entire dorsal shield, with the exception of the free cheeks. U. S. National Museum, Catalogue No. 53421.

These figures are the same as those on plate 1, figs. 1, 3, 2, respectively, Smithsonian Miscellaneous Collections, Vol. 53, 1908; and 4 is also used on plate 3, fig. 3, Canadian Alpine Jour., Vol. 1, No. 2, 1908.

The specimens are from locality **148**, Middle Cambrian: *Ogygopsis* zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad, British Columbia, Canada.



BATHYURISCUS

PAGE

Bathyuriscus (*Poliella*) *anteros* Walcott 349

FIG. 5. (×2.25.) A crushed dorsal shield, the type specimen of the species. U. S. National Museum, Catalogue No. 62622.

From locality **55c,** Middle Cambrian: Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

Bathyuriscus (*Poliella*) *primus* (Walcott) 352

FIG. 6. (×3.) An entire dorsal shield shortened by compression and slight distortion in the shale. U. S. National Museum, Catalogue No. 62623.

6*a*. (×3.) Dorsal shield laterally compressed by slight distortion in the shale. U. S. National Museum, Catalogue No. 62624.

The specimens represented by figs. 6 and 6*a* are from locality **35m,** Lower Cambrian: Mount Whyte formation (*Albertella* zone); 3 miles (4.8 km.) southwest of the head of Lake Louise, on east slope of Mount Whyte, Alberta, Canada.

6*b*. (×2.) Matrix of a dorsal shield that is slightly distorted, and its cranidium has an unusually large and deep posterolateral limb. U. S. National Museum, Catalogue No. 62625.

From locality **35e,** Lower Cambrian: Mount Whyte formation, Lakes Louise and Agnes Cambrian section; amphitheatre between Popes Peak and Mount Whyte, south of Lake Agnes, south of Laggan, on the Canadian Pacific Railway, in western Alberta, Canada.

6*c* (Natural size) and 6*d* (×2). Cranidium from an arenaceous shale. U. S. National Museum, Catalogue No. 62626.

From locality **58t,** Lower Cambrian: Sandy shale about 150 feet (45.7 m.) below the Middle Cambrian, just below the big cliff on the east shoulder of Castle Mountain, north of the Canadian Pacific Railway, Alberta, Canada.

Bathyuriscus (*Poliella*) sp. undt. (1) 355

FIG. 7. (Natural size.) Top view of pygidium. U. S. National Museum, Catalogue No. 62627.

From locality **35e,** Lower Cambrian: Mount Whyte formation, Lakes Louise and Agnes Cambrian section; amphitheatre between Popes Peak and Mount Whyte, south of Lake Agnes, south of Laggan, on the Canadian Pacific Railway, in western Alberta, Canada.

Bathyuriscus (*Poliella*) *caranus* Walcott 350

FIG. 8. (×4.) An entire dorsal shield exclusive of the free cheeks. This is the type specimen of the species. U. S. National Museum, Catalogue No. 62628.

From locality **55c,** Middle Cambrian: Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles west-southwest of Liberty and 15 miles west of Montpelier, Bear Lake County, Idaho.

DESCRIPTION OF PLATE 47

PAGE

Bathyuriscus howelli Walcott 343

FIG. 1. (× 2.) Type specimen of the species. The pleural lobes are flattened a little in the shale. U. S. National Museum, Catalogue No. 15457.

1*a*. (× 2.) Cranidium partly crushed in the shale. U. S. National Museum, Catalogue No. 15457*a*.

1*b*. (× 2.) Pygidium partly crushed in the shale. U. S. National Museum, Catalogue No. 15457*b*.

The specimens represented by figs. 1, 1*a-b* are from the same layer of very fine arenaceous shale. 1 and 1*a* were illustrated on plate 30, figs. 2, 2*a*, in 1886 (Bull. U. S. Geol. Surv., No. 30).

From locality **31**, Middle Cambrian: Chisholm shales, at the Chisholm Mine, southwest slope of Ely Mountains, 3 miles (4.8 km.) northwest of Pioche, Lincoln County, Nevada.

Bathyuriscus rotundatus (Rominger) 346

FIG. 2. (× 1.5.) A dorsal shield that has been elongated by lateral compression in the shale. The free cheeks are restored in outline U. S. National Museum, Catalogue No. 62629.

This figure was used on plate 4, fig. 2, in 1908 (Canadian Alpine Jour., Vol. 1, No. 2).

2*a*. (× 1.5.) A very well-preserved dorsal shield. U. S. National Museum, Catalogue No. 62630.

2*b*. (Natural size.) A pencil and ink drawing of a small dorsal shield in which the slightly broken parts have been drawn as if unbroken.

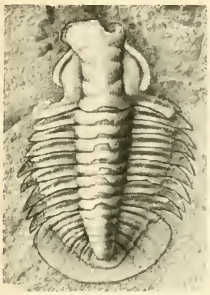
The specimens represented by figs. 2 and 2*a* are from locality **14s**, Middle Cambrian: *Ogygopsis* zone of the Stephen formation; about 2,300 feet (701 m.) above the Lower Cambrian and 2,700 feet (823 m.) below the Upper Cambrian in the *Ogygopsis* zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railroad, British Columbia, Canada.

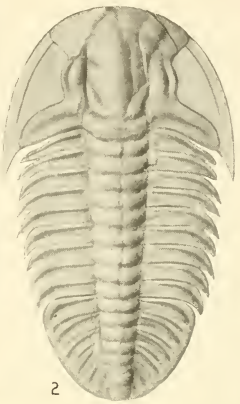
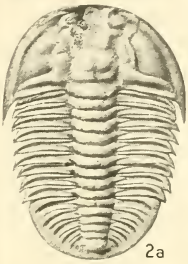
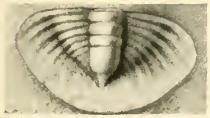
Bathyuriscus adæus Walcott 334

FIG. 3. (Natural size.) A broken dorsal shield restored in part. U. S. National Museum, Catalogue No. 62631.

3*a*. (× 2.) Cranidium. U. S. National Museum, Catalogue No. 62632.

3*b*. (× 1.5.) Pygidium that is of the same character as that of *Bathyuriscus rotundatus*. U. S. National Museum, Catalogue No. 62633.








BATHYURISCUS

Bathyuriscus adœus Walcott—Continued. PAGE

3*c*. (×2.) Thoracic segments. U. S. National Museum, Catalogue No. 62634.

The specimens represented by figs. 3, 3*a-c* are from locality **58j**, Middle Cambrian: Stephen formation about 1,900 feet (579 m.) above the Lower Cambrian and 3,100 feet (945 m.) below the Upper Cambrian, near the base of the limestone forming 2 of the Stephen formation, on the east side of Mount Stephen about 3,000 feet (914 m.) above the Canadian Pacific Railway track (north of the tunnel), 3 miles (4.8 km.) east of Field, British Columbia, Canada.

Bathyuriscus ? bithus Walcott 340

FIG. 4. (Natural size.) Cranidium somewhat crushed in the argillaceous shale. U. S. National Museum, Catalogue No. 62635.

4*a*. (Natural size.) Fragment of a large pygidium. U. S. National Museum, Catalogue No. 62636.

The specimens represented by figs. 4 and 4*a* are from locality **55c**, Middle Cambrian: Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

DESCRIPTION OF PLATE 48

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Bathyuriscus anax Walcott 335

FIG. 1. (×1.25.) Dorsal shield flattened in fine arenaceous shale. U. S. National Museum, Catalogue No. 62637.

1*a*. (Natural size.) Cranidium flattened in shale. U. S. National Museum, Catalogue No. 62638.

1*b*. (Natural size.) Cranidium compressed and elongated in the shale. U. S. National Museum, Catalogue No. 62641. (**30a.**)

1*c*. (×2.) Pygidium flattened in shale. U. S. National Museum, Catalogue No. 62639.

1*d*. (×3.) Hypostoma partly restored from an associated specimen. U. S. National Museum, Catalogue No. 62640.

The specimens represented by figs. 1, 1*a*, 1*c*, and 1*d* are from locality **55e**, Middle Cambrian: Spence shale horizon of the Ute formation; about 100 feet (30.5 m.) above the Brigham quartzite, at the mouth of the first small canyon south of Wasatch Canyon, east of Lakeview Ranch, Boxelder County, Utah.

The specimen represented by fig. 1*b* is from locality **30a**, Middle Cambrian: Shale on north side of Big Cottonwood Canyon, 1 mile (1.6 km.) below Argenta, in the Wasatch Mountains southeast of Salt Lake City, Salt Lake County, Utah.

Bathyuriscus atossa Walcott 336

FIG. 2. (×1.5.) A very fine dorsal shield flattened in argillaceous shale. U. S. National Museum, Catalogue No. 62642.

2*a*. (×2.) Cranidium. Note spine on occipital ring. U. S. National Museum, Catalogue No. 62643.

2*b*. (×3.) Cranidium. U. S. National Museum, Catalogue No. 62644.

The specimens represented by figs. 2, 2*a-b* are from locality **55c**, Middle Cambrian: Spence shale member of the Ute formation; about 50 feet (15.2 m.) above the Brigham quartzite, and 2,755 feet (839.7 m.) below the Upper Cambrian, in a ravine running up into Danish Flat from Mill Canyon, about 6 miles (9.6 km.) west-southwest of Liberty and 15 miles (24.2 km.) west of Montpelier, Bear Lake County, Idaho.

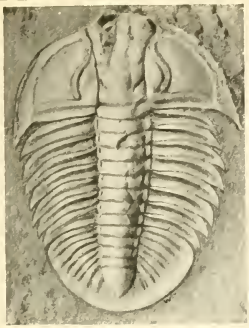
Bathyuriscus (*Poliella*) *sylla* Walcott 354

FIG. 3. (×2.) Cranidium and free cheek. U. S. National Museum, Catalogue No. 62645.

3*a*. (×2.) Four thoracic segments and pygidium. U. S. National Museum, Catalogue No. 62646.

3*b*. (×1.5.) Free cheek. U. S. National Museum, Catalogue No. 62647.

3*c*. (×2.) Free cheek. U. S. National Museum, Catalogue No. 62648.



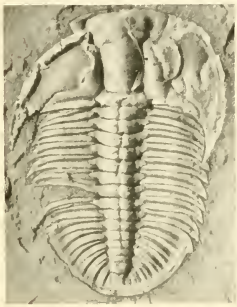
1

1a

1b

1c

1d



2

2a

2b

3b

3

3c

3d

3a

3f

3d′

3e

4

4a

BATHYURISCUS

Bathyuriscus (*Poliella*) *sylla* Walcott—Continued. PAGE

3d. (×3.) Pygidium. U. S. National Museum, Catalogue No. 62649.

3e. (×3.) A small cranidium showing glabellar furrows. U. S. National Museum, Catalogue No. 62650.

3f. (×3.) Hypostoma with ears restored in outline. U. S. National Museum, Catalogue No. 62651.

The specimens represented by figs. 3, *3a-f* are from locality **61 0,** Middle Cambrian: 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.

Bathyuriscus batis Walcott 337

FIG. 4. (Natural size.) Natural casts of distorted and compressed specimens in a fine quartzitic sandstone. U. S. National Museum, Catalogue No. 62652.

4a. (Natural size.) Dorsal shield, broadened by flattening in matrix. U. S. National Museum, Catalogue No. 62653.

The specimens represented by figs. 4 and *4a* are from locality **59p,** Lower Cambrian: Millers Mountain, 10 miles (16 km.) north of Columbus and west of Belleville, Esmeralda County, Nevada.

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Bathyuriscus (Poliella) balus Walcott 350

FIG. 1. (×2.) Diagrammatic outline restored from distorted and compressed specimens.

1*a*. (Natural size.) Diagrammatic outline from a distorted dorsal shield preserving the median spine of the thorax. U. S. National Museum, Catalogue No. 62654.

1*b*. (×2.) Cranidium. U. S. National Museum, Catalogue No. 62655.

1*c*. (×2.) Broken cranidium and compressed thoracic segments. U. S. National Museum, Catalogue No. 62656.

1*d*. (×2.) Crushed cranidium. U. S. National Museum, Catalogue No. 62657.

1*e*. (Natural size.) Laterally compressed dorsal shield. U. S. National Museum, Catalogue No. 62658.

1*f*. (×2.) Dorsal shield longitudinally compressed. U. S. National Museum, Catalogue No. 62659.

1*g*. (×2.) Dorsal shield obliquely compressed and distorted. U. S. National Museum, Catalogue No. 62660.

All the specimens represented by figs. 1. 1*a-g*, are casts in a fine argillaceo-arenaceous shale, at localities **48, 48d,** Middle ? Cambrian: York ? formation; City of York, York County, Pennsylvania.

Bathyuriscus bantius Walcott 336

FIG. 2. (×2.) Cranidium. U. S. National Museum, Catalogue No. 62661.

2*a*. (×2.) Pygidium associated with specimen represented by fig. 2. U. S. National Museum, Catalogue No. 62662.

2*b*. (×2.) Associated hypostoma. U. S. National Museum, Catalogue No. 62663.

2*c*. (Natural size.) A large associated pygidium. U. S. National Museum, Catalogue No. 62664. (**11.**)

The specimens represented by figs. 2, 2*a-b*, are from a shaly sandstone of locality **12b,** Middle Cambrian: Rome formation; 12 miles (19.3 km.) northeast of Knoxville; and fig. 2*c*, from the same formation (locality **11**), 1 mile (1.6 km.) east of Post Oak Springs, Roane County, both in Tennessee.

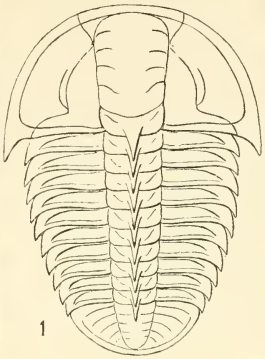
Bathyuriscus sp. undt. (1) 348

FIG. 3. (×2.) Cranidium. U. S. National Museum, Catalogue No. 62665.

3*a*. (Natural size.) Pygidium. U. S. National Museum, Catalogue No. 62666.

The specimens represented by figs. 3 and 3*a* are from locality **16e,** Middle Cambrian: Shales of Conasauga formation; railway cut 1 mile (1.6 km.) southwest of Piedmont, Calhoun County, Alabama.


1c


1


1b


1e


1d


1a


2


1g


1f


2a


2c


2c′


2b


3


4b


4a

4c


3a


4

BATHYURISCUS

PAGE

Bathyuriscus manchuriensis Walcott 344

FIG. 4. (×3.) Pygidium. U. S. National Museum, Catalogue No. 58273.

4*a*, 4*b*. (×3.) Cranidia flattened in argillaceous shale. These two cranidia are on a piece of shale recorded in U. S. National Museum Catalogue as No. 57587.

4*c*. (×3.) Thoracic segment. U. S. National Museum, Catalogue No. 58272.

The specimens illustrated by figs. 4, 4*a-ca* are from locality **36h**, Middle Cambrian: Fu-chóu series, argillaceous shales, Liau-tung, Manchuria, China.

The above figures are reproduced from plate 23, figs. 2, 2*b*, and 2*c* of Cambrian Faunas of China (Carnegie Inst. of Washington, Research in China, Vol. 3, 1913).

DESCRIPTION OF PLATE 50

PAGE

Bathyuriscus belesis Walcott 338

FIG. 1. (Natural size.) Cranidium compressed in shale. U. S. National Museum, Catalogue No. 62667..

1*a*. (Natural size.) Associated free cheek. U. S. National Museum, Catalogue No. 62668.

1*b*. (×4.) Small cranidium. U. S. National Museum, Catalogue No. 62669.

1*c*, 1*c'*. (×2.) Dorsal view and profile of a small pygidium. U. S. National Museum, Catalogue No. 62670.

1*d*. (×2.) A more elongate pygidium than that represented by fig. 1*c*. U. S. National Museum, Catalogue No. 62671.

1*e*, 1*e'*. (×6.) A small associated pygidium (and side outline) that has well-defined furrows on the pleural lobes. U. S. National Museum, Catalogue No. 62672.

1*f*. (×2.) Hypostoma. U. S. National Museum, Catalogue No. 62673.

1*g*. (×2.) Posterior portion of an hypostoma. U. S. National Museum, Catalogue No. 62674.

1*h*, 1*i*. (×2.) Portions of thoracic segments. U. S. National Museum, Catalogue Nos. 62675, 62676.

All of the specimens illustrated by figs. 1, 1*a-i*, are flattened in a fine Lower ? Cambrian argillaceo-arenaceous shale that occurs at locality **4v**, Gordon Creek, Powell County, Montana.

Bathyuriscus belus Walcott 339

FIG. 2. (×2.) Cranidium that has lost much of its convexity by being crushed in the shale. U. S. National Museum, Catalogue No. 62677.

2*a*. (×2.) A cranidium preserving the postero-lateral limbs. U. S. National Museum, Catalogue No. 62678.

2*b*. (×4.) A small associated pygidium. U. S. National Museum, Catalogue No. 62679.

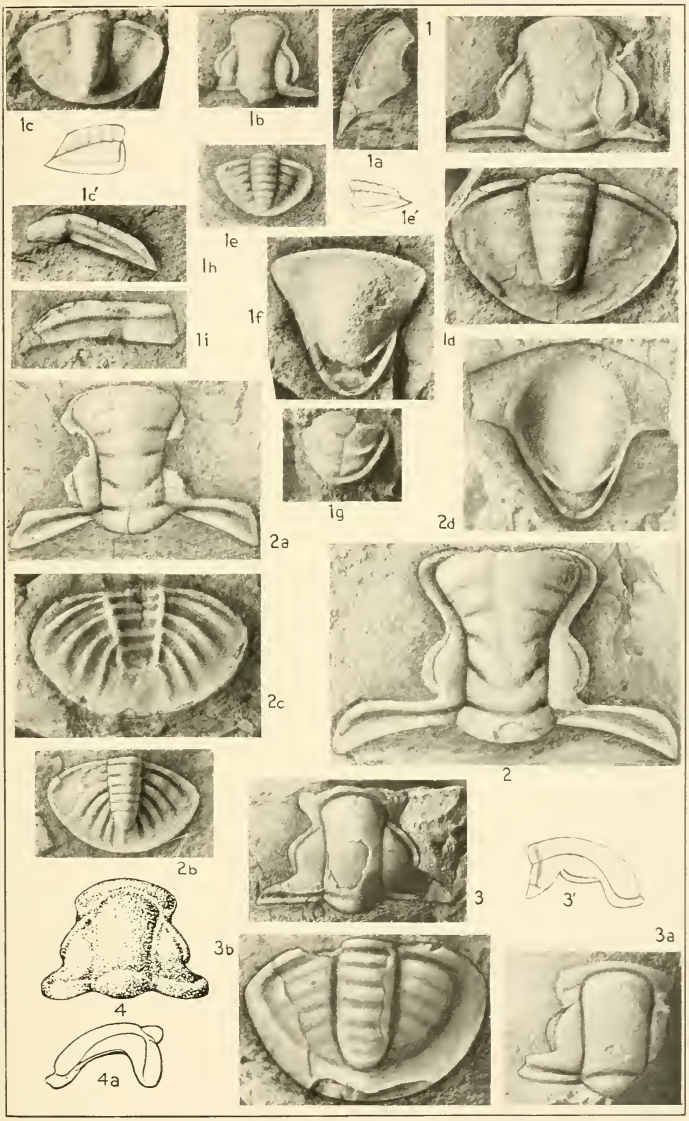
2*c*. (Natural size.) Matrix of a large pygidium. U. S. National Museum, Catalogue No. 62680.

2*d*. (×4.) Associated hypostoma on rock with specimen represented by fig. 2*b*. U. S. National Museum, Catalogue No. 62681.

The specimens represented by figs. 2, 2*a-d*, are more or less flattened in a fine arenaceo-argillaceous shale at locality **4w**, Lower ? Cambrian: Youngs Creek, Powell County, Montana.

Dolichometopus suecicus Angelin 372

FIGS. 3, 3'. (Natural size.) Dorsal and side views of a cranidium retaining a portion of the outer test. U. S. National Museum, Catalogue No. 62682.



CAMBRIAN TRILOBITES

Dolichometopus succicus Angelin—Continued. PAGE

3*a*. (Natural size.) Dorsal view of a cranidium from which the outer surface has been exfoliated. U. S. National Museum, Catalogue No. 62683.

3*b*. (× 3.) Dorsal view of a pygidium associated with the cranidium of this species. U. S. National Museum, Catalogue No. 62684.

The specimens represented by figs. 3, 3′, 3*a-b*′, are from locality **8w**, Middle Cambrian: Limestones of *Paradoxides forchhammeri* zone at Andrarum, Sweden.

4, 4*a*. (Natural size.) Reproduction of figures by Matthew, which were drawn from Angelin's type specimen now in the Museum at Stockholm. (Trans. Roy. Soc. Canada. 2d ser., Vol. 3, 1897, Sec. 4, pl. 3, figs. 7*a*, 7*b*.)

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Dolichometopus tontoensis Walcott 373

FIG. 1. (Natural size.) A nearly complete dorsal shield, showing enlarged fifth segment. U. S. National Museum, Catalogue No. 62685.

1*a*. (Natural size.) A broken dorsal shield, with median nodes on thoracic segments. U. S. National Museum, Catalogue No. 62686.

The specimens represented by figs. 1 and 1*a* are from locality **74e**, Middle Cambrian: Bright Angel shales; Grand Canyon, Arizona.

1*b*. (Natural size.) Hypostoma and side profile. U. S. National Museum, Catalogue No. 62687.

1*c*. (Natural size.) Small convex cranidium. U. S. National Museum, Catalogue No. 62688.

1*d*. (Natural size.) Cranidium. U. S. National Museum, Catalogue No. 62689.

1*d'*. (× 2.) Free cheek. U. S. National Museum, Catalogue No. 62690.

1*d''*. (Natural size.) Free cheek. U. S. National Museum, Catalogue No. 62691.

1*e*. (Natural size.) Thoracic segment. Right half restored. U. S. National Museum, Catalogue No. 62692.

1*f*. (Natural size.) Large pygidium. U. S. National Museum, Catalogue No. 62693.

1*g*, 1*g'*. (Natural size.) Dorsal and side views of a pygidium. U. S. National Museum, Catalogue No. 62694.

1*h*. (Natural size.) Small pygidium. U. S. National Museum, Catalogue No. 62695.

The specimens represented by figs. 1*b-h* occur as casts in a hard gray sandstone and retain most of their natural convexity. They are from locality **74**, Middle Cambrian: Tapeats sandstone; Nunkoweap Valley, Grand Canyon, Arizona.

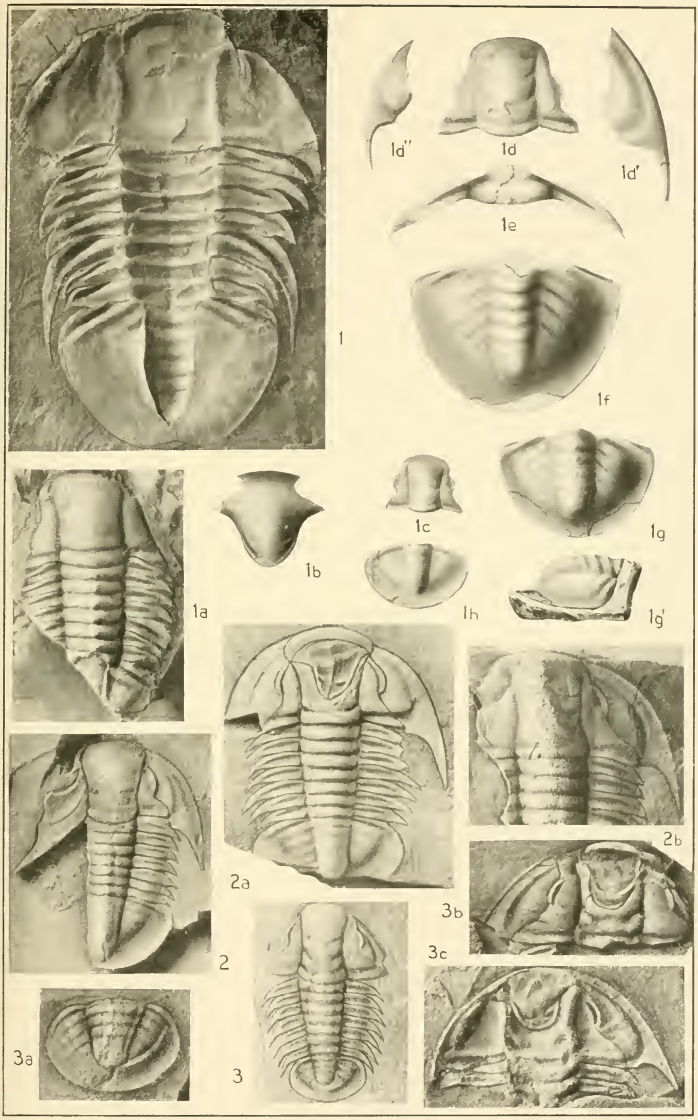
Dolichometopus baton Walcott 362

FIG. 2. (× 2.) Broken dorsal shield, partly restored. U. S. National Museum, Catalogue No. 62696.

2*a*. (× 3.) Imperfect dorsal shield with hypostoma showing beneath the glabella. U. S. National Museum, Catalogue No. 62697.

2*b*. (× 2.) Cranidium with free cheeks outlined. U. S. National Museum, Catalogue No. 62698.

The specimens represented by figs. 2, 2*a-b* are from a fine argillaceous shale at locality **3j**, Middle Cambrian: Wolsey ? shale; 6 miles (9.6 km.) west-northwest of Scapegoat Mountain, Powell County, Montana.



DOLICHOMETOPUS

Dolichometopus ? bessus Walcott 362

FIG. 3. (× 2.5.) Broken dorsal shield, showing characters of species. U. S. National Museum, Catalogue No. 62699.

3*a*. (× 2.) Pygidium. U. S. National Museum, Catalogue No. 62700.

3*b*. (× 2.) Cephalon and hypostoma in position. U. S. National Museum, Catalogue No. 62701.

3*c*. (× 2.) Matrix of the specimen represented by fig. 3*b*.

The specimens represented by figs. 3, 3*a-b* are flattened in a fine argillaceous shale from locality **62i**, Middle Cambrian: Sixteen Mile Canyon, Meagher County, Montana.

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Dolichometopus boccar Walcott 363

FIG. 1. (Natural size.) Matrix of a dorsal shield, flattened in very fine arenaceous or siliceous shale. U. S. National Museum, Catalogue No. 62702.

From locality **14s,** Middle Cambrian: Stephen formation; Mount Stephen, British Columbia, Canada.

1*a*. (Natural size.) Partially restored figure of a dorsal shield. U. S. National Museum, Catalogue No. 62703.

1*b*. (Natural size.) Cranidium embedded in compact limestone. U. S. National Museum, Catalogue No. 62704.

1*c*. (Natural size.) Cranidium flattened in shaly limestone. U. S. National Museum, Catalogue No. 62705.

1*d*. (× 4.) Hypostoma. U. S. National Museum, Catalogue No. 62706.

1*e*. (Natural size.) Pygidium and five thoracic segments flattened in shaly limestone. U. S. National Museum, Catalogue No. 62707.

1*f*, 1*f'*. (× 2.) Dorsal and side views of a pygidium preserved in compact limestone. U. S. National Museum, Catalogue No. 62708.

The specimens represented by figs. 1*a-f* are from limestone at locality **57g,** Middle Cambrian: Stephen formation; Mount Bosworth, British Columbia, Canada.

Dolichometopus bion Walcott 363

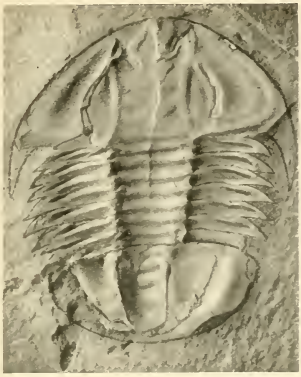
FIG. 2. (× 1.5.) Cranidium. U. S. National Museum, Catalogue No. 62709.

2*a*. (Natural size.) Matrix of a pygidium. U. S. National Museum, Catalogue No. 62710.

2*b*. (Natural size.) A large pygidium. U. S. National Museum, Catalogue No. 62711.

2*c*. (× 3.) A small pygidium enlarged. U. S. National Museum, Catalogue No. 62712.

The specimens represented by figs. 2, 2*a-c* occur in a fine argillaceous shale at locality **55c,** Middle Cambrian: Spence shale; 15 miles (24 km.) west of Montpelier, Idaho.

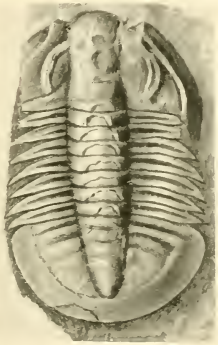


1

2

2a

2b

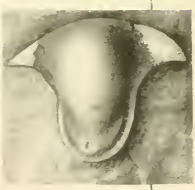


1a

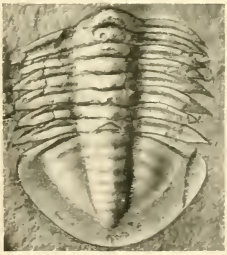
1b

2c

1c



1d



1e

1f

1f'

DOLICHOMETOPUS

DESCRIPTION OF PLATE 53

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Dolichometopus acadicus Matthew 360

FIG. 1. (×2.) Cranidium.

1*a*. (×2.) Outline of cranidium.

1*b*. (×2.) Free cheek.

1*c*. (×2.) Associated pygidium.

The above figures are reproduced from Matthew (Trans. Roy. Soc. Canada, 2d ser., Vol. 3, Sec. 4, 1897, pl. 3, figs. 6, 6*a-d*). The type specimens are in the collection of Dr. George F. Matthew, St. John, New Brunswick, Canada.

Locality, Hastings Cove, New Brunswick, Canada.

Dolichometopus productus (Hall and Whitfield) 369

FIG. 2. (Natural size.) Figure of a dorsal shield drawn from several specimens. The portion below the diagonal line is one piece. U. S. National Museum, Catalogue No. 15459.

This figure was published by me in 1886 (Bull. U. S. Geol. Surv., No. 30, pl. 30, fig. 1*i*).

2*a*. (Natural size.) Crushed and distorted cranidium. U. S. National Museum, Catalogue No. 15456*a*.

2*b*. (Natural size.) Crushed and distorted free cheek. U. S. National Museum, Catalogue No. 15456*b*.

2*c*. (Natural size.) Crushed and distorted pygidium and seven thoracic segments. U. S. National Museum, Catalogue No. 15456*c*.

2*d*. (Natural size.) Crushed and distorted pygidium. U. S. National Museum, Catalogue No. 15456*d*.

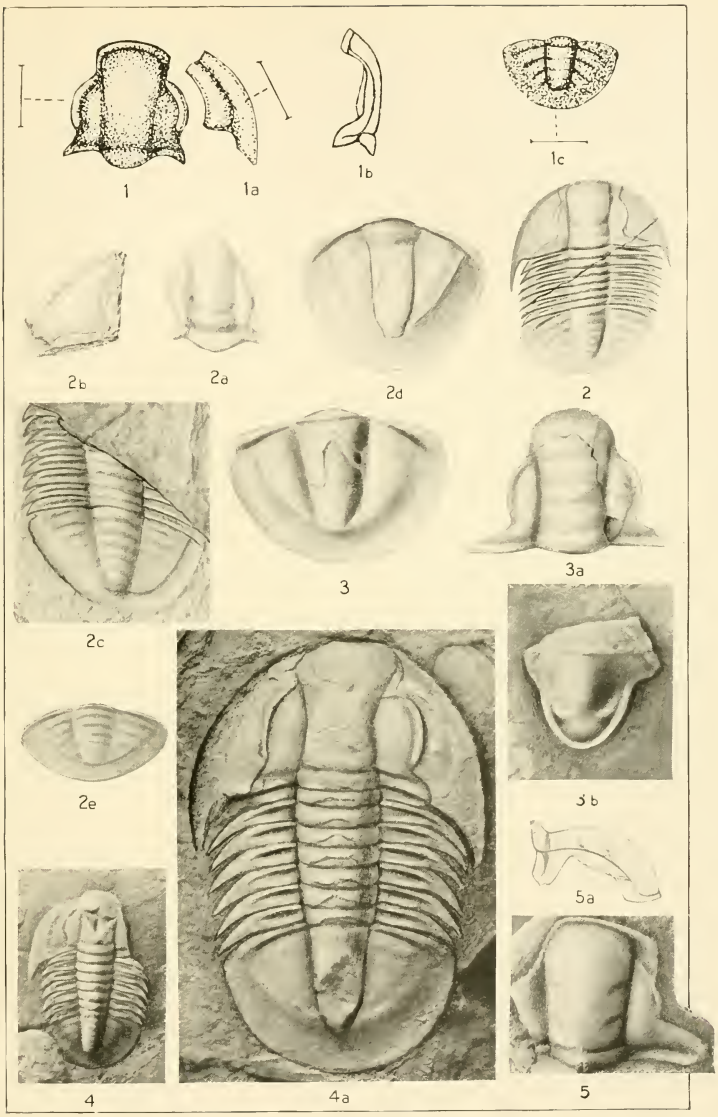
2*e*. (Natural size.) Crushed and distorted pygidium. U. S. National Museum, Catalogue No. 15456*e*.

The specimens represented by figs. 2*a-e* are the types illustrated by Hall and Whitfield on plate 2, figs. 31, 32, 33, 34, of the species *producta* and fig. 34 of the species *parabola* (Geol. Expl. 40th Par., Vol. 4, 1877).

The specimen represented by fig. 2 is from locality **3c**, Middle Cambrian: above Ophir City; and those by figs. 2*a-e* are from East Canyon, both in Oquirrh Range, Utah.

3. (Natural size.) Pygidium. U. S. National Museum, Catalogue No. 15455*a*.

3*a*. (Natural size.) Cranidium. U. S. National Museum, Catalogue No. 15455*b*.



DOLICHOMETOPUS

DESCRIPTION OF PLATE 54

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Dolichometopus (?) *deois* Walcott 365

FIG. 1. (×2.) Cranidium crushed down and flattened in shale. U. S. National Museum, Catalogue No. 58235.

1*a*. (×2.) Free cheek associated with the specimen represented by fig. 1. U. S. National Museum, Catalogue No. 58237.

1*b*. (×2.) Matrix of a pygidium associated in the same shale with the specimen represented by fig. 1. U. S. National Museum, Catalogue No. 58238.

1*c*. (×2.) Pygidium with test removed, associated in shale with specimens represented by figs. 1, 1*a*, and 1*b*. U. S. National Museum, Catalogue No. 58239.

All of the specimens represented by figs. 1, 1*a-c*, are in argillaceous shale, from locality **35 o**, Middle Cambrian: Fu-chóu series, Liau-tung, Manchuria, China. [See Research in China, Pub. No. 54, Carnegie Inst. of Washington, Vol. 3, 1913, Walcott, Cambrian Faunas of China, pl. 21, figs. 13, 13*b*, 13*c* and 13*d*, respectively.]

1*d*. (×1.5.) Cranidium referred to *Bathyuriscus asiaticus* Lorenz, by Lorenz. This occurs in shaly limestone. Plastotype U. S. National Museum, Catalogue No. 58539. Collected by Dr. Th. Lorenz at Wang-tschuang, Shan-tung, China. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 2*b*.]

1*e*, 1*e'*. (×2.) Dorsal view and side outline of a cranidium. U. S. National Museum, Catalogue No. 58242. From locality **C 57**, Middle Cambrian: Kiu-lung group, south of Kao-kia-p'u, Shan-tung, China. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 1*b*.]

1*f*, 1*f'*. (×2.) Dorsal view and side outline of a cranidium. From locality **C 1**, Middle Cambrian: Kiu-lung group, 2 miles (3.2 km.) south of Yen-chuang, Shan-tung, China. U. S. National Museum, Catalogue No. 58240. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 1.]

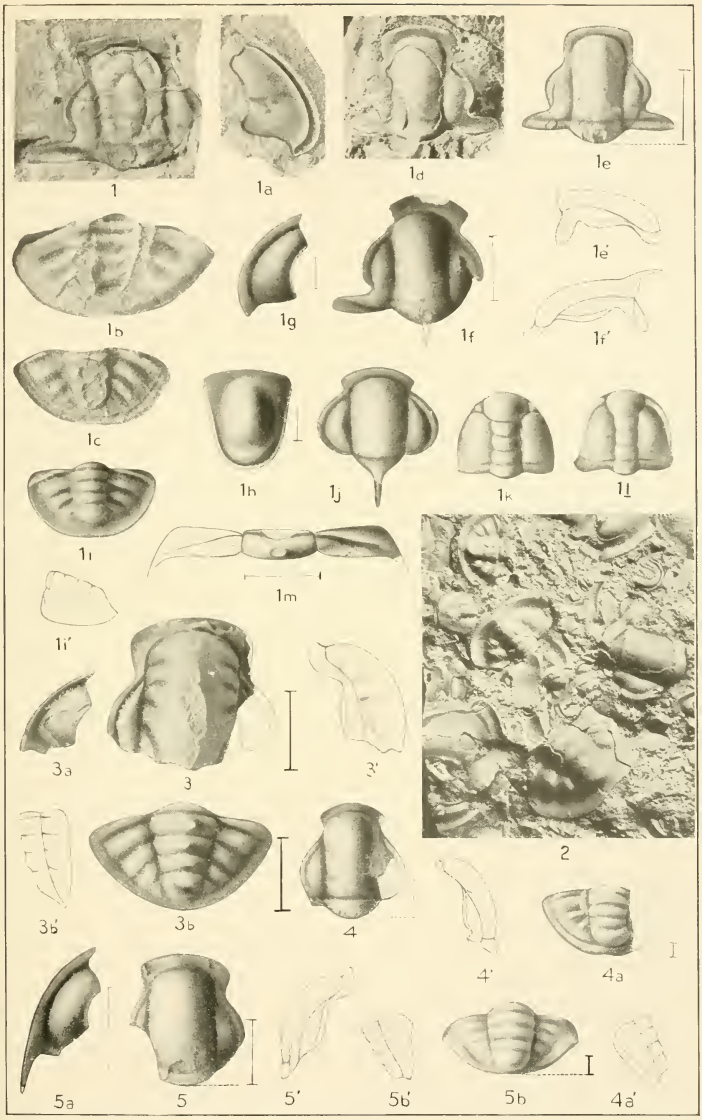
1*g*. (×3.) Free cheek, associated with specimen represented by fig. 1*f*. U. S. National Museum, Catalogue No. 58241. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 1*a*.]

1*h*. (×3.) Hypostoma associated with specimen represented by fig. 1*e*. U. S. National Museum, Catalogue No. 58243. From locality **C 57**, Middle Cambrian: Kiu-lung group, south of Kao-kia-p'u, Shan-tung, China. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 1*c*.]

1*i*, 1*i'*. (Natural size.) Dorsal view and side outline of a pygidium from locality **C 4**, in limestone, a little below the layer from which the specimen represented by fig. 1*f* was collected. U. S. National Museum, Catalogue No. 58248. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 1*h*.]

1*j*. (×10.) Cranidium of a young individual associated with specimen represented by fig. 1*c*. (**C 57.**) U. S. National Museum, Catalogue No. 58246. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 1*f*.]

1*k*, 1*l*. (×15.) Nepionic stages in the development of a trilobite, probably of this species. From locality **C 57**, Middle Cambrian: Kiu-lung group, south of Kao-kia-p'u, Shan-tung, China. U. S. National Museum, Catalogue Nos. 58244 and 58245. [See Walcott, Cambrian Faunas of China, pl. 22, figs. 1*d* and 1*e*.]



DOLICHOMETOPUS

Dolichometopus (?) *deois* Walcott—Continued. PAGE

1*m*. (× 3.) Thoracic segment, associated with the specimen represented by fig. 1*e*. (**C57**.) U. S. National Museum, Catalogue No. 58247. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 1*g*.]

2. (× 1.5.) Photograph of one of the fragments of limestone collected by Dr. Th. Lorenz at Wang-tschuang, Shan-tung, China. The pygidia were referred to *Bathyuriscus asiaticus* Lorenz, by Lorenz, and the cranidia on the other side of the same piece of shaly limestone to the same species. (See fig. 1*d* above.) Plastotype. U. S. National Museum, Catalogue No. 58538. [See Lorenz, Zeits. deuts. geol. Gesells., Vol. 58, 1906, pl. 5, figs. 1-5. Also Walcott, Cambrian Faunas of China, pl. 22, fig. 2.]

Dolichometopus (?) *alceste* Walcott 361

FIGS. 3, 3′. (× 2.) Type specimen showing parts of cranidium in front of occipital furrow; with side outline of same. From locality **C 4**, Middle Cambrian: Kiu-lung group, south of Yen-chuang, Shan-tung, China. U. S. National Museum, Catalogue No. 58249. [See Walcott, Cambrian Faunas of China, pl. 22, figs. 3, 3′.]

3*a*. (Natural size.) Free cheek associated with this species at locality **C 4**. U. S. National Museum, Catalogue No. 58250. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 3*a*.]

3*b*, 3*b*′. (× 1.5.) Pygidium associated with this species a little lower in the section (**C 1**). U. S. National Museum, Catalogue No. 58251. [See Walcott, Cambrian Faunas of China, pl. 22, figs. 3*b*, 3*b*′.]

Dolichometopus (?) *derceto* Walcott 367

FIGS. 4, 4′. (× 3.) Type specimen showing portions of the cranidium; and side outline of same. From locality **C 1**, Middle Cambrian: Kiu-lung group, south of Yen-chuang, Shan-tung, China. U. S. National Museum, Catalogue No. 58252. [See Walcott, Cambrian Faunas of China, pl. 22, figs. 4, 4′.]

4*a*, 4*a*′. (× 3.) Fragment of a pygidium (and side outline) from locality **C 2**, just above the locality of specimen represented by fig. 4. U. S. National Museum, Catalogue No. 58253. [See Walcott, Cambrian Faunas of China, pl. 22, figs. 4*a*, 4*a*′.]

Dolichometopus (?) *dirce* Walcott 368

FIGS. 5, 5′. (× 2.) Type specimen, showing central parts of cranidium; and side outline of same. From locality **C 24**, Middle Cambrian: Ch'ang-hia formation, east of Ch'ang-hia, Shan-tung, China. U. S. National Museum, Catalogue No. 58254. [See Walcott, Cambrian Faunas of China, pl. 22, figs. 5, 5′.]

5*a*. (Natural size.) Large free cheek associated with specimen represented by fig. 5. U. S. National Museum, Catalogue No. 58255. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 5*a*.]

5*b*, 5*b*′. (× 4.) Small pygidium associated with specimen represented by fig. 5. U. S. National Museum, Catalogue No. 58256. [See Walcott, Cambrian Faunas of China, pl. 22, fig. 5*b*.]

DESCRIPTION OF PLATE 55

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Corynexochus spinulosus Angelin 323

FIG. 1. (×4.) Cranidium.

1*a*. (×4.) Side view of cranidium represented by fig. 1.

1*b*. (×4.) A small pygidium associated with cranidia of this species.

The above figures are from Grönwall, plate 4, figs. 3*a*, 3*b*, who illustrated the type specimens of Angelin, which are now in the Museum at Stockholm. They come from the *Paradoxides forchhammeri* zone, Andrarum limestone at Andrarum, Sweden.

Corynexochus bornholmiensis Grönwall 313

FIGS. 2, 2*a*. (×4.) Dorsal and side views of the typical cranidium.

2*b*. (×4.). Pygidium associated with the cranidium represented by figs. 2, 2*a*.

The above figures are from Grönwall, plate 4, figs. 1*a*, 1*b*, 2. The type specimens are in the Mineralogical Museum [at Stockholm?]. They came from the *Agnostus nathorsti* zone of the Middle Cambrian limestone of Bornholm Island.

Corynexochus delagei Miquel 317

FIG. 3. (×4.) Cranidium laterally compressed and distorted. U. S. National Museum, Catalogue No. 62715.

3*a*. (×4.) Pygidium compressed and distorted. U. S. National Museum, Catalogue No. 62716.

The specimens represented by figs. 3, 3*a* are from locality **152d**, Middle Cambrian: calcareous shale of Coulouma, Hérault, France.

Corynexochus clavatus (Walcott) 316

FIGS. 4, 4′. (×6.) Dorsal and side views of the type specimen of cranidium. U. S. National Museum, Catalogue No. 17454*a*.

4*a*. (×12.) Diagrammatic figure based on several specimens of the cranidium. This figure is the same as that published in 1887, American Jour. Sci., Vol. 34, plate 1, fig. 3; idem, 1891, Tenth Ann. Rept., U. S. Geol. Surv., plate 98, fig. 4.

4*b*. (×6.) A minute cranidium. U. S. National Museum, Catalogue No. 17454*b*.

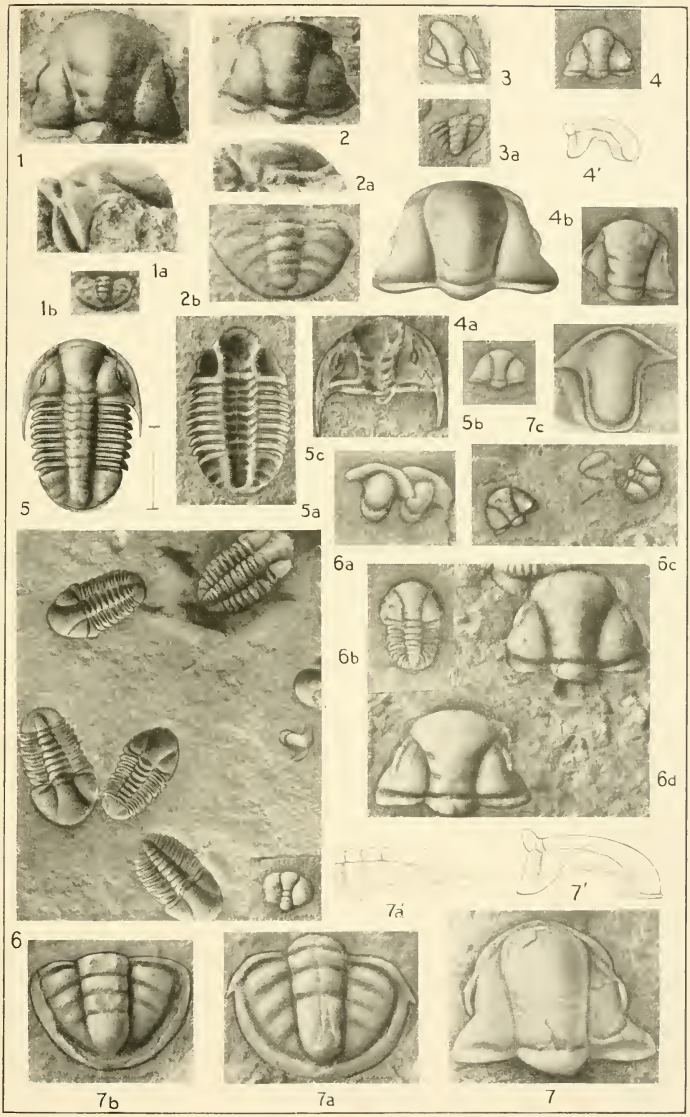
The specimens represented by figs. 4, 4*b* are from the Lower Cambrian limestone of localities **38a** and **43a**, Washington County, New York.

Corynexochus stephenensis (Walcott) 324

FIGS. 5, 5*a*. (×2.) Nearly entire dorsal shield with the free cheeks restored from other specimens and matrix of same. U. S. National Museum, Catalogue No. 61731.

From locality **14s**, Middle Cambrian: Stephen formation; Mount Stephen, British Columbia, Canada.

This is the same figure as that of pl. 3, fig. 4 (Canadian Alpine Jour., Vol. 1, 1908) and fig. 8, pl. 36 (Smithsonian Misc. Coll., Vol. 64, 1915). It is reproduced here in order that direct comparison may be made with other species of *Corynexochus*.



CORYNEXOCHUS

Coryuexochus stephenensis (Walcott)—Continued. PAGE

5*b*. (×8.) A minute cranidium tentatively referred to this species. U. S. National Museum, Catalogue No. 62717.

From locality **35k**, Middle Cambrian: Burgess shale; 1 mile (1.6 km.) northeast of Burgess Pass, British Columbia, Canada.

5*c*. (×2.) Matrix of cranidium. U. S. National Museum, Catalogue No. 62718.

From locality **14s**, Middle Cambrian: Stephen formation; Mount Stephen, British Columbia, Canada.

Coryuexochus minor (Walcott) 319

FIG. 6. (×6.) Group of specimens on a fragment of shale. U. S. National Museum, Catalogue No. 26703.

6*a*. (×8.) Form of hypostoma abundantly associated with this species. U. S. National Museum, Catalogue No. 62719.

6*b*. (×8.) Small dorsal shield with three thoracic segments. U. S. National Museum, Catalogue No. 61730.

The specimens represented by figs. 6, 6*b* were illustrated by figs. 7, 7*b*, plate 36, Smithsonian Misc. Coll., Vol. 64, 1915.

6*c*, 6*d*. (×8.) Cranidia illustrating variation in form from small specimens 0.5 mm. in length to adult size. U. S. National Museum, Catalogue Nos. 6*c*, 62720, and 6*d*, 62721.

The specimens represented by figs. 6, 6*a-d* are from locality **1**, Middle Cambrian: Manuels River, above Conception Bay, near Topsail Head, Newfoundland.

Coryuexochus scuectus (Billings) (see pl. 56, figs. 1, 1*a-g*) 319

FIGS. 7, 7′. (×3.) Dorsal and side views of a partially exfoliated cranidium, with slight indication of lateral glabellar furrows. U. S. National Museum, Catalogue No. 62722.

7*a*, 7*a*′. (×3.) An associated pygidium that has been slightly elongated. U. S. National Museum, Catalogue No. 62723.

7*b*. (×3.) Associated pygidium, partly flattened by compression. U. S. National Museum, Catalogue No. 62724.

7*c*. (×4.) Associated hypostoma. U. S. National Museum, Catalogue No. 62725.

The specimens represented by figs. 7*a-b* are from locality **61d**, Lower Cambrian: Mount Whyte formation; southwest slope of Mount Shaffer, British Columbia, Canada.

DESCRIPTION OF PLATE 56

PAGE

Corynexochus senectus (Billings) (see pl. 55, figs. 7, 7*a-c*) 319

FIGS. 1, 1′. (×3.) Dorsal view and side outline of cranidium with most of test exfoliated. U. S. National Museum, Catalogue No. 62726.

1*a*, 1*b*. (×5.) Small cranidia somewhat distorted. U. S. National Museum, Catalogue Nos. 62727, 62728.

1*c*, 1*c*′. (×4.) Cranidia shortened by slight distortion, with side outline of the longest one. U. S. National Museum, Catalogue No. 62729.

1*d*. (×6.) Associated hypostoma. U. S. National Museum, Catalogue No. 62730.

1*e*, 1*e*′. (×4.) Dorsal and side view of a pygidium. U. S. National Museum, Catalogue No. 62731.

1*f*. (×4.) Fragment of a pygidium showing an antero-lateral spine and a trace of a second spine back of it. U. S. National Museum, Catalogue No. 62732.

1*g*. (×4.) Small pygidium. U. S. National Museum, Catalogue No. 62733.

The specimens represented by figs. 1, 1*a-g*, are from limestone at locality **41 l**, Lower Cambrian: Bonne Bay, Newfoundland.

Corynexochus bubaris Walcott 314

FIGS. 2, 2′. (×3.) Dorsal and side view of a laterally compressed cranidium. U. S. National Museum, Catalogue No. 62734.

2*a*. (×3.) Side view of a convex cranidium. U. S. National Museum, Catalogue No. 62735.

2*b*. (×8.) Ridged surface of a glabella. U. S. National Museum, Catalogue No. 62736.

The specimens represented by figs. 2, 2*a-b* are from limestone at locality **2 o**, Lower Cambrian: Bic Harbor, Quebec, Canada.

3, 3′. (×2.) Dorsal and side view of a large cranidium. U. S. National Museum, Catalogue No. 62737.

3*a*. (×3.) Free cheek with outline of spine restored from another specimen. U. S. National Museum, Catalogue No. 62738.

3*b*, 3*b*′, 3*b*″. (×3.) Dorsal, side and front views of a very perfect and convex cranidium. U. S. National Museum, Catalogue No. 62739.

3*c*, 3*c*′. (×3.) Dorsal and side view of a cranidium shortened by distortion. U. S. National Museum, Catalogue No. 62740.

3*d*, 3*d*′. (×2.) Dorsal and side view of a large pygidium. U. S. National Museum, Catalogue No. 62741.


1


1′


1a


1b


1d


1e′

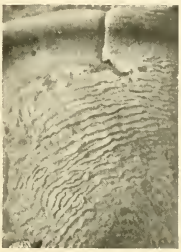

1f


1c


1c′


1e

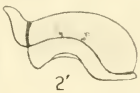

1g

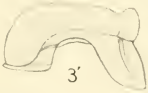

2b

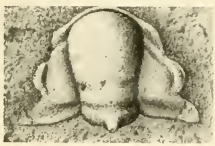

2

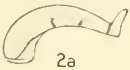

3


3a


2′


3′

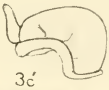

3b


2a


3c

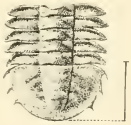

3b″


3b′


3c′


3d


3d′


3e


3f

Corynexochus bubaris Walcott—Continued. PAGE

3*e*. (×2.) Pen and ink sketch of five thoracic segments and pygidium. The original specimen has crumbled on the surface so that it cannot be photographed. U. S. National Museum, Catalogue No. 62742.

3*f*. (×4.) Hypostoma. U. S. National Museum, Catalogue No. 62743.

The specimens represented by figs. 3, 3*a-g* are from a leached calcareous sandstone at locality **49**, Lower Cambrian: near Emigsville, York County, Pennsylvania.

DESCRIPTION OF PLATE 57

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Corynexochus (*Bonnia*) *parvulus* (Billings) (see pl. 64, fig. 6)..... 328

FIG. 1. (× 10.) Enlargement of cranidium shown by 1*b*, to illustrate surface.

1*b*, 1*b*′. (× 3.) Dorsal and side views of a finely preserved cranidium. U. S. National Museum, Catalogue No. 62744.

1*c*, 1*c*′. (× 3.) Dorsal and side views of a pygidium. U. S. National Museum, Catalogue No. 62745.

The specimens represented by figs. 1, 1*b-c* are from the limestone of locality **41k**, Lower Cambrian: Forteau Bay, Labrador.

Corynexochus (*Bonnia*) *busa* Walcott (see pl. 60, figs. 3, 3*a-c*)..... 326

FIG. 1*a*. (× 10.) Enlargement of surface of specimen figured on pl. 60, fig. 3*a*. U. S. National Museum, Catalogue No. 62774.

Corynexochus capito Walcott 315

FIGS. 2, 2′. (× 2.) Dorsal view and side outline of a convex cranidium. U. S. National Museum, Catalogue No. 62746.

2*a*, 2*a*′. (× 1.5.) Pygidium (and side outline) associated with the specimen represented by fig. 2. U. S. National Museum, Catalogue No. 62747.

The specimens represented by figs. 2, 2*a* occur in a leached calcareous sandstone at locality **48b**, Lower Cambrian: York formation; roadside north of Highland Park, York, Pennsylvania.

2*b*. (× 2.) Cranidium flattened by compression in shaly sandstone. U. S. National Museum, Catalogue No. 15421*a*.

2*c*, 2*d*. (× 2.) Cranidia distorted by lateral compression. U. S. National Museum, Catalogue Nos. 15421*b*, 15421*c*.

2*e*, 2*e*′. (× 2.) Dorsal and side views of a slightly compressed pygidium. U. S. National Museum, Catalogue No. 15421*d*.

The specimens represented by figs. 2*b*, 2*c-e* are illustrated by Walcott on plate 31, figs. 2, 2*a*, 2*b*, Bull. U. S. Geol. Surv., No. 30, 1886, and later as indicated in synonymy of species.

The specimens occur in an impure shaly sandstone at locality **25**, Lower Cambrian: just above Parker's quarry, Georgia, Franklin County, Vermont.

Corynexochus brennus Walcott 314

FIG. 3. (× 4.) Dorsal view of the type specimen of the cranidium. U. S. National Museum, Catalogue No. 62748.

3*a*. (× 2.) A larger pygidium of the same type as that represented by fig. 3*b*. U. S. National Museum, Catalogue No. 62749.

3*b*, 3*b*′. (× 4.) Dorsal view and side outline of a small pygidium associated with the specimens represented by figs. 3, 3*a*. U. S. National Museum, Catalogue No. 62750.

The specimens represented by figs. 3, 3*a-b* are from a limestone boulder of the Bic conglomerate at locality **2 0**, Lower Cambrian: Bic Harbor, Quebec, Canada.


1


1b'


1b


1c'


1c


1a


2'


2


2a


2b


2c


2a'

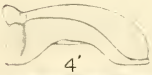

2d


2e

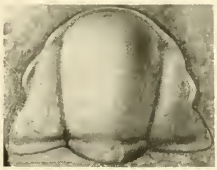

3


3b'


3a


4'


3b


4


4a'


4a


4b

PAGE

Corynexochus (*Bonnia*) *fieldensis* (Walcott) 327

FIGS. 4, 4′. (× 3.) Dorsal and side views of the type cranidium. U. S. National Museum, Catalogue No. 62751.

4*a*, 4*a*′. (× 3.) Dorsal and side views of a pygidium associated with the cranidium represented by fig. 5. U. S. National Museum, Catalogue No. 62752.

4*b*. (× 4.) Associated hypostoma. U. S. National Museum, Catalogue No. 62753.

The specimens represented by figs. 4, 4*a-b* are from the limestone of locality **35 l**, Lower Cambrian: Ptarmigan Pass, Alberta, Canada.

DESCRIPTION OF PLATE 58

PAGE

Asaphiscus wheeleri Meek 390

FIG. 1. (Natural size.) This is the largest entire dorsal shield known to me. It was found by Mr. G. K. Gilbert of the Wheeler Survey. U. S. National Museum, Catalogue No. 62754.

1*a*. (× 2.) Restoration based upon a nearly entire dorsal shield and the specimens represented by figs. 1*b*, 1*c*, 1*d*, 1*f*. U. S. National Museum, Catalogue No. 62755.

1*b*. (× 1.5.) A medium size dorsal shield, somewhat broken by compression in the shale. U. S. National Museum, Catalogue No. 62756.

1*c*. (× 3.) Small dorsal shield with very perfect thorax and pygidium. U. S. National Museum, Catalogue No. 62757.

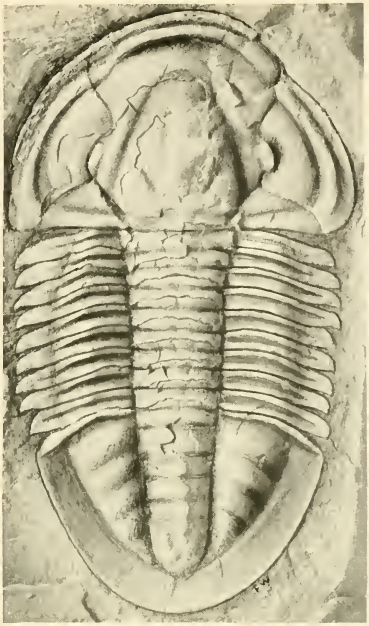
1*d*. (× 2.) Fragment of the anterior half of a cranidium, retaining its original convexity. U. S. National Museum, Catalogue No. 62758.

1*e*. (Natural size.) This is a photograph of one of the type specimens illustrated by fig. 1*c*, plate 2 (Geog. and Geol. Explor. and Surv. west of 100th Merid., 1875, Vol. 4, Pt. 1). U. S. National Museum, Catalogue No. 15460 [= 8576].

1*f*. (× 2.) Interior of a pygidium showing very clearly the anchylosed segments of the axis and pleural lobes. U. S. National Museum, Catalogue No. 62759.

1*g*. (× 2.) A convex pygidium, showing characters similar to those of the pygidium of *Dolichometopus productus* (pl. 53, fig. 3). U. S. National Museum, Catalogue No. 62760.

The specimens illustrated by figs. 1, 1*a-g*, are from localities **3s** and **4**, Upper Cambrian: Wheeler formation; east of Antelope Springs, House Range, Utah.



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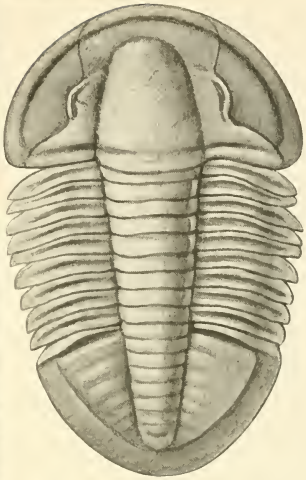
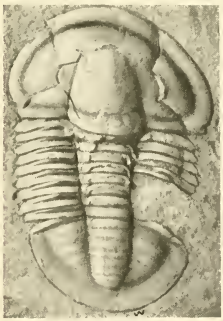
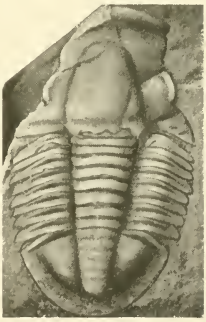


1a



1b

1e



1c

1g

1d

1f

CREPICEPHALUS WHEELERI Meek

DESCRIPTION OF PLATE 59

PAGE

Asaphiscus iddingsi Walcott 386

FIG. 1. (× 2.) Dorsal shield flattened in argillaceous shale. U. S. National Museum, Catalogue No. 57586.

1*a*. (× 2.) Cranidium, from limestone associated with the shale mentioned under fig. 1. U. S. National Museum, Catalogue No. 58269. (Locality **35r.**)

1*b*. (× 3.) A smaller cranidium, associated with the specimen represented by fig. 1*a*. U. S. National Museum, Catalogue No. 58270.

The specimens represented by figs. 1, 1*a-b*, are from localities **35r** and **36e:** Middle Cambrian; Fu-chóu series; shale interbedded in limestone, Liau-tung, Manchuria.

These figures were published, pl. 23, figs. 1, 1*a-b* (Research in China, Vol. 3, Carnegie Inst. of Washington, Pub. No. 54, Cambrian Faunas of China).

Asaphiscus (*?*) *capella* Walcott 385

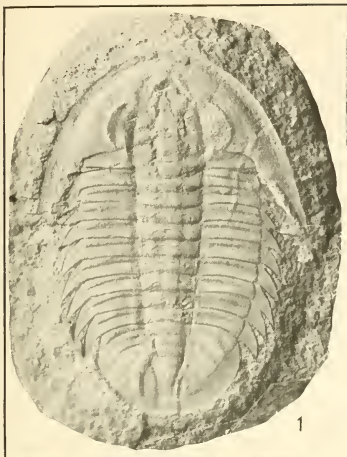
FIG. 2. (× 2.) Restoration based on a nearly entire specimen of the dorsal shield and the specimens represented by figs. 2*a*, 2*b*, 2*c*. U. S. National Museum, Catalogue No. 62761.

2*a*. (× 2.) Cranidium outlining the slightly concave frontal border. U. S. National Museum, Catalogue No. 62762.

2*b*. (Natural size.) Matrix of a crushed and broken dorsal shield, showing wavy doublure of cranidium. U. S. National Museum, Catalogue No. 62763.

2*c*. (Natural size.) Impressions of pygidium in fine-grained shale. U. S. National Museum, Catalogue No. 62764.

The specimens represented by figs. 2, 2*a-c* are from locality **54z,** Middle Cambrian: Wolsey shale; Half Moon Pass, Big Snowy Mountains, Montana.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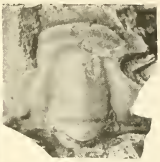
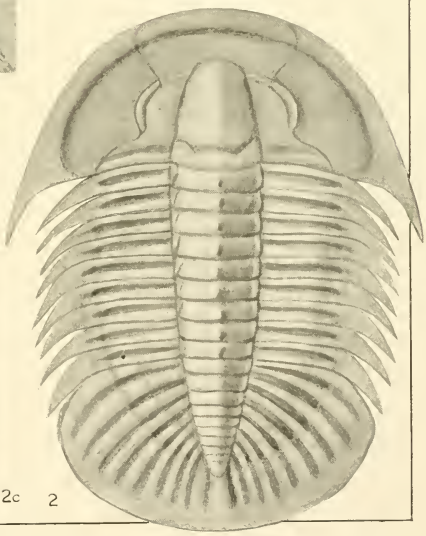
1a


1b


2b


2a


2c


2

ASAPHISCUS

DESCRIPTION OF PLATE 60

PAGE

Asaphiscus calenus Walcott 384

FIG. 1. (×2.) Entire dorsal shield. The right free cheek and frontal limb are restored. U. S. National Museum, Catalogue No. 62765.

1*a*. (×2.) Interior of a dorsal shield with the right free cheek restored. U. S. National Museum, Catalogue No. 62766.

1*b*. (×2.) Pygidium and attached thoracic segments. U. S. National Museum, Catalogue No. 62767.

1*c*. (×2.) A broken cephalon preserving the strong palpebral (ocular) ridge and glabella furrows. U. S. National Museum, Catalogue No. 62768.

The specimens represented by figs. 1, 1*a-c* are compressed in a fine argillaceous shale at locality **5f**, Middle Cambrian: Wolsey shale; 11 miles south of Neihart, in Meagher County, Montana.

Asaphiscus camma Walcott 384

FIG. 2. (×3.) A small dorsal shield illustrating the character of the species. U. S. National Museum, Catalogue No. 62769.

2*a*. (×2.) A cranidium preserving strong palpebral ridges. U. S. National Museum, Catalogue No. 62770.

2*b*. (Natural size.) Pygidium. U. S. National Museum, Catalogue No. 62771.

2*c*. (×4.) Hypostoma associated with this species. U. S. National Museum, Catalogue No. 62772.

The specimens represented by figs. 2, 2*a-c* are compressed in a fine argillaceous shale at locality **4g**, Middle Cambrian: Wolsey shale; 5 miles east-northeast of Logan, Gallatin County, Montana.

Corynexochus (*Bonnia*) *busa* Walcott (see pl. 57, fig. 1*a*) 326

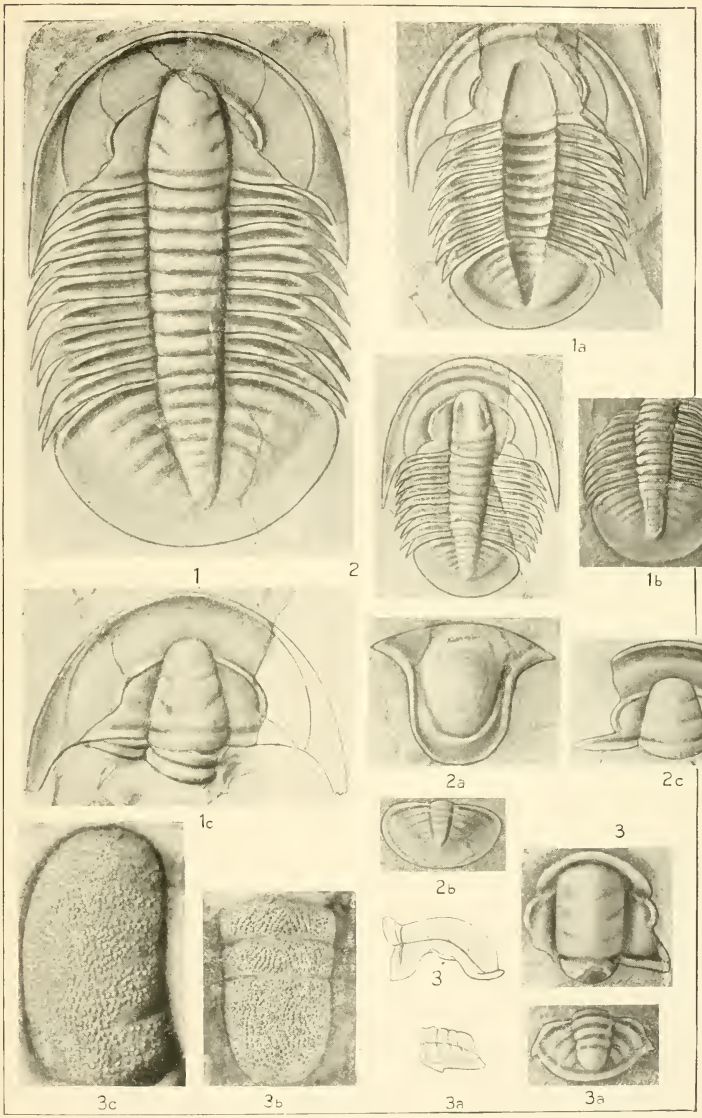
FIGS. 3, 3′. (×3.) Top and side views of a broken cranidium that retains its convexity. U. S. National Museum, Catalogue No. 62773.

3*a*, 3*a*′. (×4.) Top and side views of a small, finely preserved pygidium. U. S. National Museum, Catalogue No. 62774.

3*b*. (×10.) Surface of axial lobe of pygidium of specimen represented by fig. 3*a*.

3*c*. (×8.) Surface of glabella of specimen represented by fig. 3.

The specimens represented by figs. 6, 6*a-c* occur in a compact gray limestone at locality **2 0**, Lower Cambrian: Bic Harbor, Province of Quebec, Canada.



CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 61

PAGE

Asaphiscus ? unispinus Walcott 389

FIG. 1. (×3.) An unusually perfect dorsal shield, partially flattened in shaly limestone. U. S. National Museum, Catalogue No. 62775.

From locality **30n**, Upper Cambrian: Weeks formation; Weeks Canyon, House Range, Utah.

Asaphiscus ? granulatus Walcott 385

FIG. 2. (×3.) Thorax and pygidium partly crushed in the calcareous shale. U. S. National Museum, Catalogue No. 62776.

2*a*. (×2.) Nearly entire dorsal shield, which is the type specimen of the species. U. S. National Museum, Catalogue No. 62777.

The specimens represented by figs. 2 and 2*a* are from locality **30n**, Upper Cambrian: Weeks formation; Weeks Canyon, House Range, Utah.

Asaphiscus ? minor Walcott 388

FIG. 3. (×3.) Very perfect dorsal shield. U. S. National Museum, Catalogue No. 62778.

3*a*. (×3.) Interior of a dorsal shield, showing the doublure of the cephalon and pygidium and position of hypostoma. U. S. National Museum, Catalogue No. 62779.

3*b*. (×3.) Group of interiors of the dorsal shield, showing hypostoma in place. U. S. National Museum, Catalogue No. 62780.

The specimens represented by figs. 3, 3*a-b*, are from locality **30n**, Upper Cambrian: Weeks formation; Weeks Canyon, House Range, Utah.

Blountia mimula Walcott 399

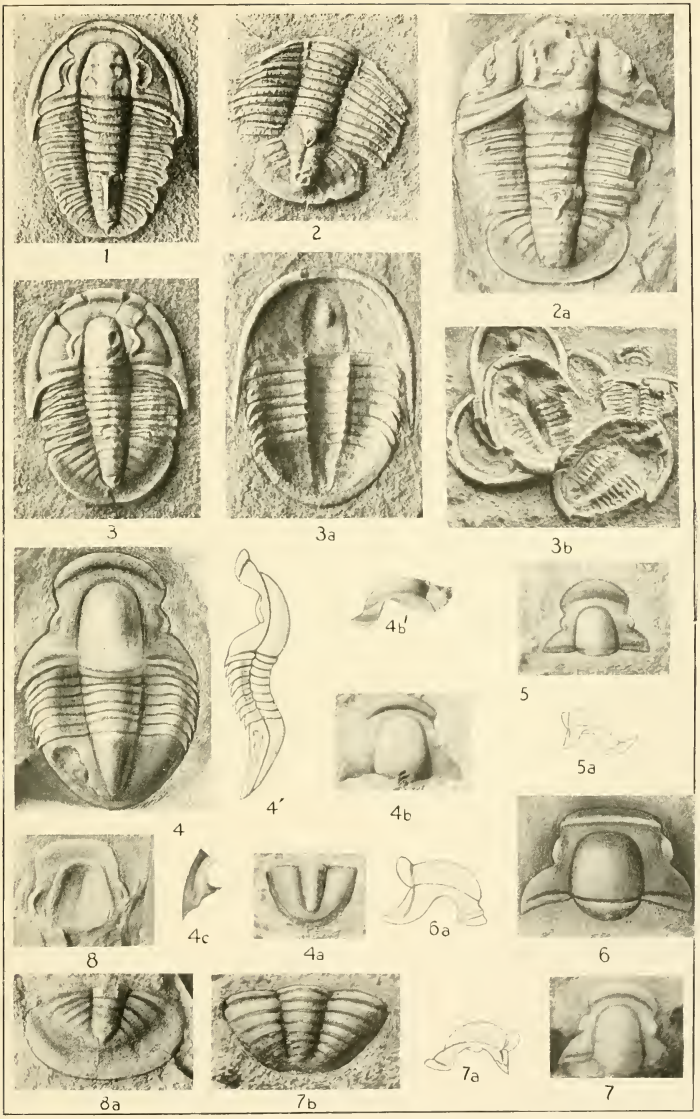
FIGS. 4, 4′. (×8.) Dorsal and side views of a dorsal shield without the free cheeks. This is the type of the genus *Blountia*. U. S. National Museum, Catalogue No. 62781.

4*a*. (×4.) A small pygidium. U. S. National Museum, Catalogue No. 62782.

4*b*, 4*b*′. (×4.) Dorsal and side views of a small cranidium. U. S. National Museum, Catalogue No. 62783.

4*c*. (×2.) A free cheek associated with 4*b*. U. S. National Museum, Catalogue No. 62784.

The specimen represented by fig. 4 is from locality **120**, Upper Cambrian: Maryville limestone; 2 to 3 miles south of New Market, Jefferson County, and those represented by figs. 4*a*, 4*b*, and 4*c* in same limestone at locality **107c**, 11 miles northwest of Knoxville, both in Tennessee.



CAMBRIAN TRILOBITES

PAGE

Blountia alexas Walcott 398

FIGS. 5, 5*a*. (×3.) Dorsal and side views of the type cranidium. U. S. National Museum, Catalogue No. 62785.

The specimen represented by fig. 5 is from locality **125**, Upper Cambrian: Maryville limestone; 4 miles northeast of Rogersville, Hawkins County, Tennessee.

Blountia ? alemon Walcott 397

FIGS. 6, 6*a*. (×5.) Dorsal and side views of the type cranidium. U. S. National Museum, Catalogue No. 62786.

The specimen represented by fig. 6 is from locality **119**, Upper Cambrian: Maryville limestone; 1.5 miles southeast of Morristown, Hamblen County, Tennessee.

Blountia anser Walcott 399

FIGS. 7, 7*a*. (×5.) Dorsal view and side outline of type cranidium. U. S. National Museum, Catalogue No. 62787.

7*b*. (×5.) Pygidium associated with cranidium represented by fig. 7. U. S. National Museum, Catalogue No. 62788.

The specimens represented by figs. 7, 7*b* are from locality **120**, Upper Cambrian: Maryville limestone; 2 to 3 miles south of New Market, Jefferson County, Tennessee.

Asaphiscus calanus Walcott 384

FIG. 8. (Natural size.) Cast of interior of a broken cranidium. U. S. National Museum, Catalogue No. 62789.

8*a*. (Natural size.) Pygidium associated with the cranidium represented by fig. 8. U. S. National Museum, Catalogue No. 62790.

The specimens represented by figs. 8, 8*a* are from a fine shaly sandstone at locality **47h**, Middle Cambrian: Wolf Creek, 6 miles below Rocky Gap, Bland County, Virginia.

DESCRIPTION OF PLATE 62

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Asaphiscus (*Blainia*) *gregarius* Walcott 394

FIG. 1. (×2.) Dorsal views of a small, imperfect dorsal shield that has a convex cranidium. U. S. National Museum, Catalogue No. 62791.

1*a*, 1*a*′. (Natural size.) Dorsal and side views of a dorsal shield with a well-preserved pygidium. The free cheeks are restored from another specimen. U. S. National Museum, Catalogue No. 62792.

1*b*. (Natural size.) Dorsal view of a somewhat broken up dorsal shield. U. S. National Museum, Catalogue No. 62793.

1*b*′. (Natural size.) Side view of a broken dorsal shield, showing the profile of the cranidium. U. S. National Museum, Catalogue No. 62794.

1*c*, 1*c*′. (×4.) Associated hypostoma and side outline. U. S. National Museum, Catalogue No. 62795.

1*d*, 1*d*′. (Natural size.) Dorsal and side views of a finely preserved pygidium. U. S. National Museum, Catalogue No. 62796.

1*e*. (×3.) A small dorsal shield partially concealed in the matrix; the covered parts are restored in outline. U. S. National Museum, Catalogue No. 62797.

1*f*. (×2.) Interior of a smaller pygidium with a broad, striated doublure. U. S. National Museum, Catalogue No. 62798.

1*g*, 1*g*′. (Natural size.) Dorsal and side views of a finely preserved pygidium. U. S. National Museum, Catalogue No. 62799.

1*h*. (×2.) An enrolled dorsal shield. U. S. National Museum, Catalogue No. 62800.

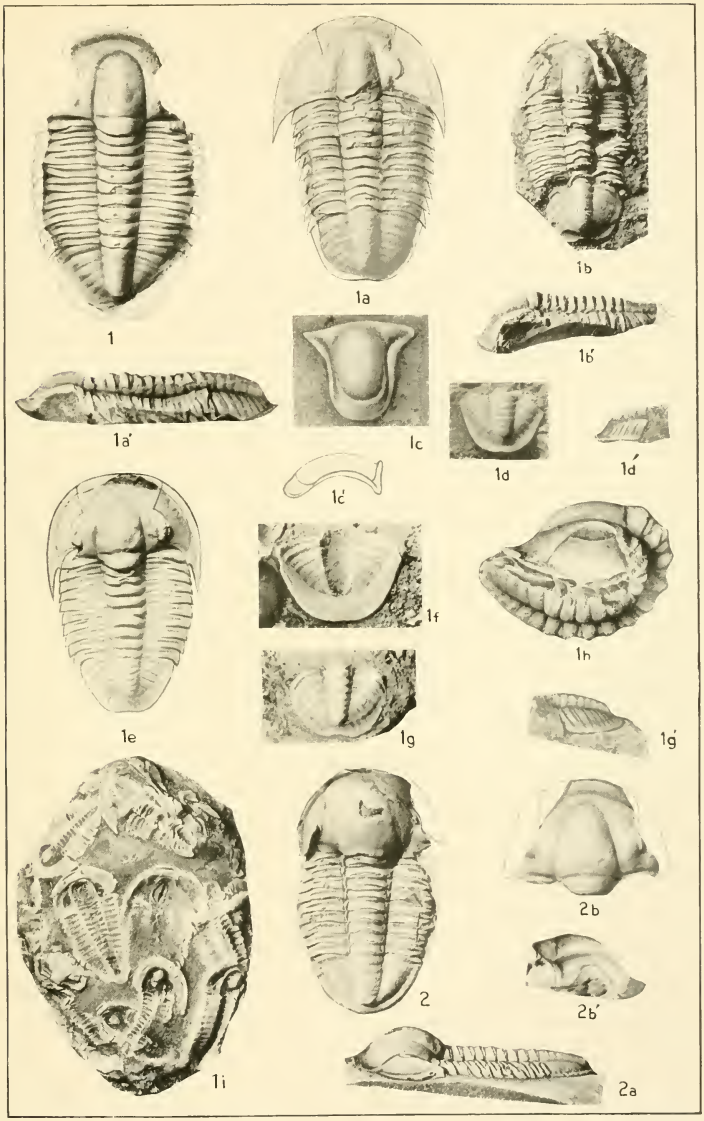
1*i*. (Natural size.) A group of small dorsal shields adhering to the surface of a siliceous concretion. U. S. National Museum, Catalogue No. 62801.

Asaphiscus (*Blainia*) *paula* Walcott 395

FIGS. 2, 2*a*. (Natural size.) Dorsal and side views of an almost entire dorsal shield. U. S. National Museum, Catalogue No. 62802.

2*b*, 2*b*′. (Natural size.) Dorsal and side views of a fine cranidium. U. S. National Museum, Catalogue No. 62803.

The specimens represented by figs. 1, 1*a-i*, 2, 2*a-b* are attached to the outer surface of siliceous nodules that are embedded in a dark argillaceous shale of the lower Conasauga formation: Middle Cambrian; (90x) 3 miles east of Center, near Blaine, Cherokee County, Alabama.



ASAPHISCUS (BLAINIA)

DESCRIPTION OF PLATE 63

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Asaphiscus (*Blainia*) *glabra* Walcott 394

FIGS. 1, 1*a*. (× 1.5.) Dorsal and side views of a convex cranidium. U. S. National Museum, Catalogue No. 62804.

1*b*, 1*b'*. (Natural size.) Dorsal and side views of a large, partially exfoliated pygidium. U. S. National Museum, Catalogue No. 62805.

1*c*, 1*c'*. (× 3.) Dorsal and side views of a small pygidium. U. S. National Museum, Catalogue No. 62806.

1*d*, 1*d'*. (× 2.) Dorsal and side views of a natural cast of the interior of the test of a pygidium. U. S. National Museum, Catalogue No. 62807.

1*e*. (Natural size.) Fragment of a thoracic segment. U. S. National Museum, Catalogue No. 62808.

The specimens represented by figs. 1, 1*a-e* were associated in a block of the Maryville limestone at locality **107x**, Upper Cambrian: 11 miles northwest of Knoxville, Tennessee.

Asaphiscus ? anaxis Walcott 392

FIGS. 2, 2*a*. (× 2.) Dorsal view and side outline of a broken cranidium. U. S. National Museum, Catalogue No. 62809.

The specimen represented by fig. 2 is from locality **119**, Upper Cambrian: Maryville limestone; 1.5 miles southeast of Morristown, Hamblen County, Tennessee.

Asaphiscus ? sp. undt. (2) 391

FIGS. 3, 3*a*. (Natural size.) Dorsal and side views of pygidium. U. S. National Museum, Catalogue No. 62810. From locality **119**, see fig. 2.

Asaphiscus (*Blainia*) *elongatus* Walcott 393

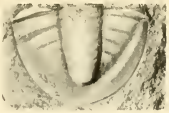
FIG. 4. (Natural size.) Dorsal view of the type cranidium. U. S. National Museum, Catalogue No. 62811.

4*a*. (Natural size.) A nearly entire cranidium. U. S. National Museum, Catalogue No. 62812.

5, 5*a*. (Natural size.) Dorsal and side views of a large pygidium associated with the specimens represented by figs. 4, 4*a*. U. S. National Museum, Catalogue No. 62813.

The specimens represented by figs. 4, 4*a*, 5, 5*a* are attached to the outer surface of siliceous nodules that are embedded in a dark argillaceous shale of the lower Conasauga formation: Middle Cambrian: (**90x**) 3 miles east of Center, near Blaine, Cherokee County, Alabama.

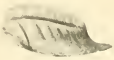

1


1b


1c


1d


1a


1b'


1c'


1d'

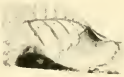

2


3

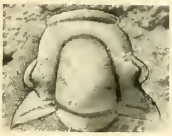

4


1e


2a


3a


4a


6


6a


5

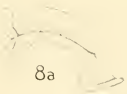

5a


6'


6b


7


8


8a


7'


9


9'


9a

PAGE

Asaphiscus ? florus Walcott 392

FIGS. 6, 6′. (×5.) Dorsal view and side outline of the type cranidium. U. S. National Museum, Catalogue No. 62814.

6*a*. (×5.) A small cranidium without glabellar furrows. U. S. National Museum, Catalogue No. 62815.

6*b*. (×2.) An associated pygidium. U. S. National Museum, Catalogue No. 62816.

The specimens represented by figs. 6, 6*a-b* are from locality **107g,** Upper Cambrian ?: Kittatinny ? limestone at Drab, Blair County, Pennsylvania.

Asaphiscus ? cf. *florus* Walcott 393

FIG. 7. (×4.) Dorsal view and side outline of cranidium. U. S. National Museum, Catalogue No. 62817.

The specimen represented by fig. 7 is from locality **107e,** Upper Cambrian ?: Kittatinny ? limestone; southwest of Ore Hill, 4 miles south of Roaring Spring, Bedford County, Pennsylvania.

Asaphiscus ? duris Walcott 392

FIGS. 8, 8*a*. (×3.) Dorsal view and side outline of the type cranidium. U. S. National Museum, Catalogue No. 62818.

The specimen represented by fig. 8 is from locality **107f,** Upper Cambrian ?: 2 miles north of Bakers Summit, Bedford County, Pennsylvania.

Asaphiscus ? agatho Walcott 391

FIGS. 9, 9′. (×4.) Dorsal view and side outline of type cranidium. U. S. National Museum, Catalogue No. 62819.

9*a*. (×4.) Pygidium associated in same piece of limestone with cranidium represented by fig. 9. U. S. National Museum, Catalogue No. 62820.

The specimen represented by figs. 9, 9*a* is from locality **123a,** Maryville limestone; 4 miles northeast of Rogersville, Hawkins County, Tennessee.

DESCRIPTION OF PLATE 64

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Blountia alethes Walcott 397

FIGS. 1, 1*a*. (×2.) Dorsal view and side outline of the type cranidium. U. S. National Museum, Catalogue No. 62821.

1*b*, 1*b*′. (×2.) Pygidium and side outline associated with the cranidium represented by fig. 1. U. S. National Museum, Catalogue No. 62822.

1*c*. Natural size view of 1*b*.

The specimens represented are from locality **123b,** Upper Cambrian: Maryville limestone; Rogersville, Hawkins County, Tennessee.

Blountia andreas Walcott 398

FIGS. 2, 2′. (×3.) Dorsal view and side outline of the type cranidium. U. S. National Museum, Catalogue No. 62823.

The specimen represented is from locality **102a,** Upper Cambrian: Maryville limestone; 1.25 miles east of Rogersville, Hawkins County, Tennessee.

Blountia amage Walcott 398

FIGS. 3, 3′. (×4.) Dorsal view and side outline of the type cranidium. U. S. National Museum, Catalogue No. 62824.

3*a*. (×2.) Pygidium associated with the cranidium represented by fig. 3. U. S. National Museum, Catalogue No. 62825.

The specimens represented are from locality **107,** Upper Cambrian: Conasauga formation (Maryville limestone); 11 miles northwest of Knoxville, Tennessee.

Maryvillia arion Walcott 400

FIGS. 4, 4′. (×2.) Dorsal view and side outline of the type cranidium. U. S. National Museum, Catalogue No. 62826.

4*a*, 4*a*′. (Natural size.) Dorsal view and side outline of pygidium associated with the cranidium fig. 4. U. S. National Museum, Catalogue No. 62827.

4*b*. Natural size view of fig. 4.

4*c*. (Natural size.) A small pygidium. U. S. National Museum, Catalogue No. 62828.

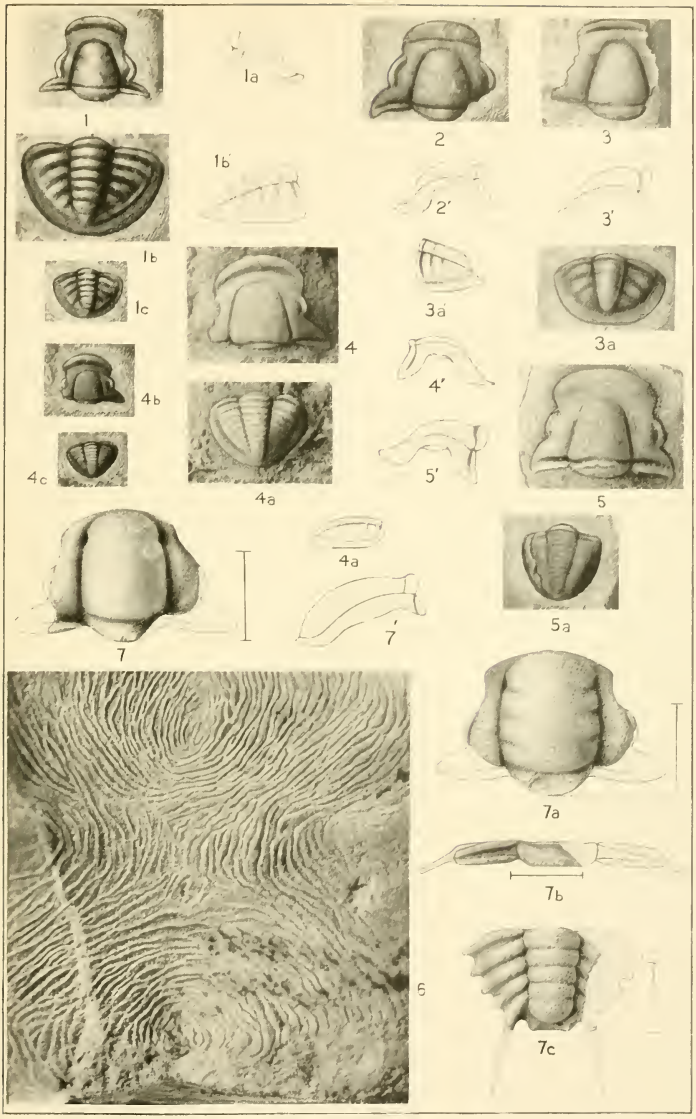
The specimens represented are from locality **123b,** Upper Cambrian: Maryville limestone; Rogersville, Tennessee.

Maryvillia ariston Walcott 401

FIGS. 5, 5′. (×1.5.) Dorsal view and side outline of the type cranidium. U. S. National Museum, Catalogue No. 62829.

5*a*. (Natural size.) Pygidium associated with the cranidium fig. 5. U. S. National Museum, Catalogue No. 62830.

The specimens represented are from locality **120,** Upper Cambrian: Maryville limestone; north of Bays Mountain, 2 to 3 miles south of New Market, Jefferson County, and 18 miles east-northeast of Knoxville, Tennessee.



CAMBRIAN TRILOBITES

PAGE

Corynexochus (*Bonnia*) *parvulus* (Billings). (See plate 57.) 328

FIG. 6. (×8.) Enlargement of the surface of the occipital ring and posterior portion of the glabella. U. S. National Museum, Catalogue No. 62744.

(Note description and locality from plate 57, fig. 1*b*.)

Dorypyge richthofeni Dames 328

FIG. 7. (×1.5.) Cranidium with finely granulated surface and side outline. From locality **C1**, Middle Cambrian: Kiu-lung group; south of Yen-chuang, Shan-tung. U. S. National Museum, Catalogue No. 57876.

7*a*. (×1.5.) Central parts of a cephalon showing glabellar furrows and coarse granulations. From locality **C19**, Middle Cambrian: Ch'ang-hia limestone at Ch'ang-hia, Shan-tung. U. S. National Museum, Catalogue No. 57878.

7*b*. (×2.) Thoracic segment showing straight pleural groove. From locality **C29**, Middle Cambrian: Ch'ang-hia limestone; west of Ch'ang-hia, Shan-tung. U. S. National Museum, Catalogue No. 57881.

7*c*. (×1.5.) Top and side views of pygidium associated with 6*a*. (**C19**) U. S. National Museum, Catalogue No. 57879.

The above figures are reproduced from plate 8, figs. 1, 1*a*, 1*d* and 1*c*, respectively, Research in China, Vol. 3, Cambrian Faunas of China, 1913, Carnegie Inst. of Washington.

DESCRIPTION OF PLATE 65

PAGE

Dolichometopus (*Housia*) *varro* Walcott 374

FIG. 1. (Natural size.) Broken cranidium. U. S. National Museum, Catalogue No. 62831.

1*a*, 1*b*. (×2.) Free cheeks associated with the cranidium fig. 1. U. S. National Museum, Catalogue Nos. 62832, 62833.

1*c*. (Natural size.) Associated thoracic segment. U. S. National Museum, Catalogue No. 62834.

1*d*. (×2.) Distorted pygidium. U. S. National Museum, Catalogue No. 62835.

1*e*. (Natural size.) Pygidium with the posterior segment of the thorax attached. U. S. National Museum, Catalogue No. 62836.

The specimens represented by figs. 1, 1*a-d* are from locality **30y** (=**301**), Upper Cambrian: Orr formation; on Orr Ridge, about 5 miles south of Marjum Pass, House Range, Millard County, Utah.

Bathyuriscus (*Poliella*) *probus* Walcott 354

FIGS. 2, 2′. (×4.) Dorsal and side view of the type cranidium. U. S. National Museum, Catalogue No. 62837.

2*a*, 2*a*′. (×5.) Pygidium associated with the cranidium of fig. 2. U. S. National Museum, Catalogue No. 62838.

The specimens represented by figs. 2, 2*a* are from locality **110**, Middle Cambrian: Marjum formation; 4 miles southeast of Antelope Springs, House Range, Utah.

Marjumia callas Walcott 402

FIG. 3. (×1.5.) Dorsal view and side outline of the type cranidium. U. S. National Museum, Catalogue No. 62839.

3*a*. (×3.) Free cheek associated with cranidium fig. 3. U. S. National Museum, Catalogue No. 62840.

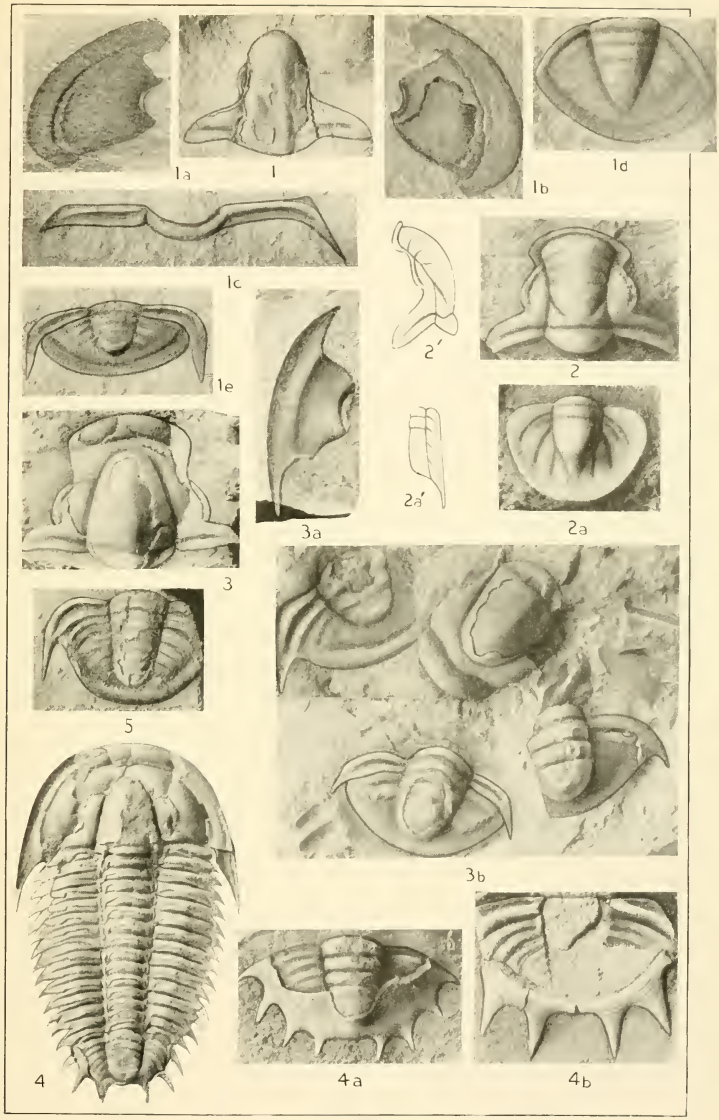
3*b*. (×3.) Group of three pygidia and one broken cranidium. U. S. National Museum, Catalogue No. 62841.

The specimens represented by figs. 3, 3*a-b* are from locality **31r**, Middle Cambrian: Marjum formation; 1 mile southeast of Marjum Pass, House Range, Utah.

Marjumia typa Walcott 402

FIG. 4. (Natural size.) Entire dorsal shield. The type of the species. U. S. National Museum, Catalogue No. 62842.

4*a*. (×3.) Pygidium with test partly exfoliated. U. S. National Museum, Catalogue No. 62843.



CAMBRIAN TRILOBITES

Marjumia typa Walcott—Continued. PAGE

4*b*. (×2.) Under side of a pygidium showing doublure and four spines. U. S. National Museum, Catalogue No. 62844.

The specimens represented by figs. 4, 4*a-b* are from locality **11q**, Middle Cambrian: Marjum formation; hard calcareous shales, 2.5 miles east of Antelope Springs, Millard County, Utah.

Bathyuriscus ? sp. undt. (2) 348

FIG. 5. (Natural size.) Pygidium with a single antero-lateral spine, as in *Marjumia callas*, fig. 3b. U. S. National Museum, Catalogue No. 62845.

The specimen represented is from locality **11p**, Middle Cambrian: Marjum formation; 2.5 miles southeast of Marjum Pass, House Range, Utah.

DESCRIPTION OF PLATE 66

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Ogygopsis klotzi (Rominger) 377

FIG. 1. (Natural size.) Large, nearly perfect, compressed specimen of the dorsal shield. U. S. National Museum, Catalogue No. 62846.

This figure is the same as that on plate 4, fig. 4, Canadian Alpine Journal [Vol. 1, 1908].

1*a*. (Natural size.) Outline of a small specimen illustrating the proportionally smaller pygidium. U. S. National Museum, Catalogue No. 62847.

1*b*. (Natural size.) An hypostoma, associated with figs. 1 and 1*a*. U. S. National Museum, Catalogue No. 62848.

The specimens represented by figs. 1, 1*a-b* are from locality **14s**, Middle Cambrian: Stephen formation; Mount Stephen, British Columbia, Canada.

Orria elegans Walcott 381

FIG. 2. (Natural size.) Dorsal shield and the type specimen of the genus and species. The free cheeks have been restored from other specimens. U. S. National Museum, Catalogue No. 62849.

2*a*, 2*a'*, 2*b*, 2*b'*. Natural size and enlarged figures of free cheeks, associated in the same rock with the specimen represented by fig. 2. U. S. National Museum, Catalogue Nos. 62850, 62851.

The specimens represented by figs. 2, 2*a-b* are from locality **11q**, Middle Cambrian: Marjum formation; hard calcareous shales, 2.5 miles east of Antelope Springs, Millard County, Utah.

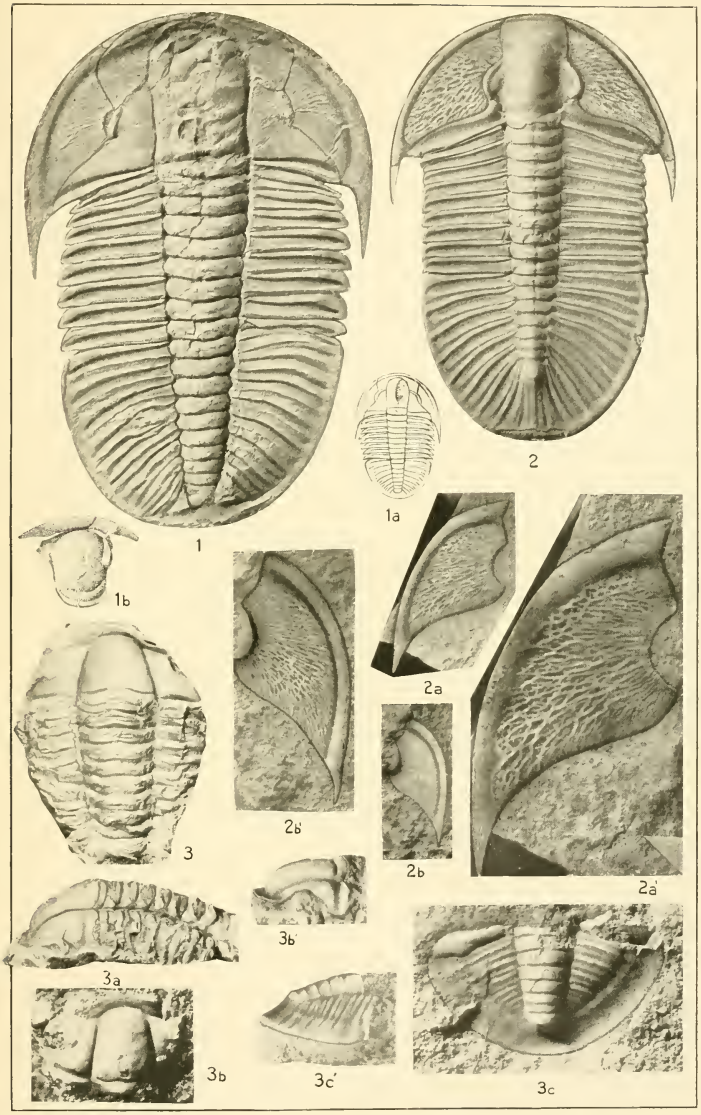
Lisania ? breviloba Walcott 404

FIGS. 3, 3*a*. (Natural size.) Dorsal and side views of broken cranidium with portions of nine thoracic segments attached. This is the type specimen of the species. U. S. National Museum, Catalogue No. 62852.

3*b*, 3*b'*. (× 4.) Dorsal and side views of a small cranidium. U. S. National Museum, Catalogue No. 62853.

3*c*, 3*c'*. (× 4.) Dorsal and side views of a small associated pygidium enlarged to show the segmentation of the axis and pleural lobes. U. S. National Museum, Catalogue No. 62854.

The specimens represented by figs. 3, 3*a-c* are from locality **118a**, Upper Cambrian: Maryville limestone; 1.5 miles south of Greeneville, Greene County, Tennessee.



CAMBRIAN TRILOBITES

DESCRIPTION OF PLATE 67

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Pagetia bootes Walcott 408

FIG. 1. (×8.) Specimen showing palpebral ridge, eye lobe and facial suture on right side, occipital spine and caudal spine which is partially turned over so as to indicate that it is slightly angular on the upper side. U. S. National Museum, Catalogue No. 62855.

1*a*. (×8.) Specimen with palpebral ridge, traces of two pairs of short glabellar furrows, right eye and facial suture. U. S. National Museum, Catalogue No. 62856.

1*b*. (×8.) Dorsal shield with free cheeks displaced. U. S. National Museum, Catalogue No. 62857.

1*c*. (×8.) A broken cephalon with glabella and a large occipital spine that is as long, if not longer than the glabella. U. S. National Museum, Catalogue No. 62858.

1*d*. (×8.) Dorsal shield with the right free cheek and eye detached from the fixed cheek. U. S. National Museum, Catalogue No. 62859.

1*e*. (×8.) A fine dorsal shield with the palpebral ridges, facial suture on right side, and base of caudal spine. U. S. National Museum, Catalogue No. 62860.

1*e'*. (×8.) Side outline view based on the specimens represented by figs. 1 and 1*c*.

1*f*. (×8.) Matrix of a dorsal shield from which the free cheeks have been displaced. This specimen is on the same piece of shale as that represented by fig. 1*c*. U. S. National Museum, Catalogue No. 62861.

The specimens represented by figs. 1, 1*a-f* are from locality **35k**, Middle Cambrian: Burgess shale; Burgess Pass, British Columbia, Canada.

Pagetia clytia Walcott 408

FIG. 2. (×10.) Two specimens of the dorsal shield with the lower one preserving the free cheeks and elevated palpebral lobes. U. S. National Museum, Catalogue No. 62862.

2*a*. (×10.) Cephalon with palpebral lobes and free cheeks displaced or crushed down in the soft shale. U. S. National Museum, Catalogue No. 62863.

2*b*. (×10.) Dorsal view and side outline of a cephalon with base of occipital spine, slight traces of glabellar furrows, left side palpebral lobe and faint trace of palpebral ridge; free cheeks displaced. U. S. National Museum, Catalogue No. 62864.

2*c*. (×11.) Wash drawing based on photograph of a cephalon with free cheeks displaced. U. S. National Museum, Catalogue No. 62865.

2*d*. (×11.) Wash drawing based on photograph of a pygidium. U. S. National Museum, Catalogue No. 62866.

2*e*. (×11.) Wash drawing based on a photograph of a dorsal shield. The eyes and facial sutures are too diagrammatic. This drawing was made in 1907 before the discovery of *Pagetia bootes* in 1909. U. S. National Museum, Catalogue No. 62867.

The specimens represented by figs. 2, 2*a-e* are from locality **55c**, Middle Cambrian: Spence shale; 15 miles (24.2 km.) west of Montpelier, Idaho.

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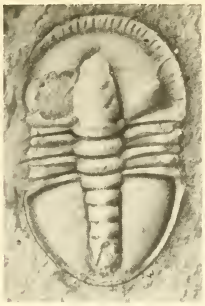

1a

1b

1e'

1c

1d

1e

1f

2c

2a

2

2e

2d

2b'

2b

INDEX

The references in **heavy-faced** type refer to the locality numbers and the pages upon which the genera and species are described and figured.