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## FAUNA OF THE CAMBRIAN CADIZ FORMATION, MARBLE MOUNTAINS, CALIFORNIA

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### INTRODUCTION

This report is based upon a study of the Middle Cambrian fauna of the Cadiz formation in the Marble Mountains, San Bernardino County, California. The presence of this fauna at an apparently new locality was first noted by Dr. John H. Bradley, Jr., in the course of reconnaissance work in 1932. An extensive collection was made in the spring of 1934 by Dr. Bradley and the author. Laboratory and library facilities for the preparation of the specimens secured were provided by the Los Angeles Museum, to which thanks are due. The author wishes to express his appreciation of the loan of several Walcott publications by Prof. A. J. Tiejie, of the direction of the work by Dr. Bradley, and of valuable suggestions by Prof. B. F. Howell.

### PREVIOUS WORK

The reports of Darton,<sup>1</sup> Cavins,<sup>2</sup> and Clark<sup>3</sup> first indicated the presence of fossiliferous Middle Cambrian rocks in the Marble Mountains. Clark's material was restudied and re-described by Resser.<sup>4</sup> Subsequent collections by Hazzard,<sup>5</sup> reported upon by Crickmay, slightly increased the faunal list. The knowledge of the Middle Cambrian in the Marble Mountains has recently been summarized in a paper by Hazzard and the author.<sup>6</sup>

<sup>1</sup> N. H. Darton: Discovery of Cambrian Rocks in Southeastern California, *Jour. Geol.*, vol. 15, 1907, p. 470. ———: Guidebook of the Western United States, Part C, The Santa Fe Route, U. S. Geol. Surv., Bull 613, 1915.

<sup>2</sup> O. A. Cavins: Unpublished thesis, Univ. of Calif., 1915.

<sup>3</sup> C. W. Clark: Lower and Middle Cambrian Formations of the Mohave Desert, *Univ. Calif. Pub. Bull. Dept. Geol. Sci.*, vol. 13, no. 1, 1921, pp. 1-7.

<sup>4</sup> C. E. Resser: Cambrian Fossils from the Mohave Desert, *Smithsonian Misc. Coll.*, vol. 81, no. 2, 1928, pp. 1-14.

<sup>5</sup> J. C. Hazzard: Notes on the Cambrian Rocks of the Eastern Mohave Desert, California, with a Paleontological Report by C. H. Crickmay, *Univ. Calif. Pub. Bull. Dept. Geol. Sci.*, vol. 23, no. 2, 1933, pp. 57-80.

<sup>6</sup> J. C. Hazzard and J. F. Mason: Stratigraphy and Lithology of the Middle Cambrian Formations of the Providence and Marble Mountains, San Bernardino County, California, *Proceedings of the Paleontological Society, Pacific Coast Branch*, April, 1935, Meeting (in press).

## LOCATION AND STRATIGRAPHIC POSITION

The new locality is at the south-eastern extremity of the Marble Mountains, two and three-quarter miles east-north-east of Cadiz, a station on the Santa Fé Railroad 100 miles east of Barstow. It is situated on two small saddles at the crest of a projecting fault block. The stratigraphy of the formation has been fully dealt with in the reports of Hazzard<sup>7</sup> and Hazzard and Mason.<sup>8</sup> As established in the latter, the Cadiz formation consists of the upper 375 feet of the quartzite and shale unit originally noted as containing both Lower and Middle Cambrian fossils. The lower 100 feet of the unit as originally described is not included within the Cadiz formation as it is known to contain Mesonacidae. The exact contact between the Lower and Middle Cambrian beds has not been determined, but it is placed provisionally, at a buff, oolitic limestone and limy, glauconitic sandstone horizon about 100 feet above the top of the Lower Cambrian algal limestone. The fossils of the present report came from a thin-bedded limestone which weathers into small buff-colored blocks and plates, and from an underlying green shale. The thin-bedded limestone is immediately overlain by the heavy, dark gray limestone of the Bonanza King formation (Middle Cambrian). The green shale is probably not more than 50 feet lower in the formation.

## FAUNA

The fossils collected from this new locality are as follows:

*Chancelloria eros* Walcott.  
*Hyalolithes princeps* Billings  
*H.* sp. indet.  
*Iphidella pannula* (White)  
*Westonia ella* (Hall and Whitfield)  
*Billingsella highlandensis* (Walcott)  
*Acrocephalites* ? *trifossatus* sp. nov.  
*Alokistocare linnarssoni* (Walcott)  
*Amecephalus piomensis* (Walcott)  
*A.* *strangulatus* sp. nov.  
*Anomocarella* ? *spatha* sp. nov.  
*Anoria lodensis* (Clark)  
*Bathyriscus howelli* (Walcott)  
*B.* *maximus* sp. nov.  
*Corynexochus* ? sp.  
*Dolichometopus productus* (Hall and Whitfield)  
*Pagetia clytia* ? Walcott  
*Zacanthoides typicalis* (Walcott)  
*Dorypyge quadriceps* (Hall and Whitfield)

<sup>7</sup> J. C. Hazzard: op. cit., p. 64.

<sup>8</sup> J. C. Hazzard and J. F. Mason: loc. cit.

In addition the following species have been reported from the Cadiz formation in the Marble Mountains by Crickmay:<sup>9</sup>

Acrocephalites sp. indet.  
Bathyriscus belesis Walcott  
Dolichometopus productus (Hall and Whitfield), var.  
D. lodensis (Clark,  
"Ptychoparia" sp. indet.

There are at least twenty species in the fauna of the Cadiz formation as known from the vicinity of the type locality, comprising more than thirteen trilobites (four of them new), three brachiopods, two molluscs, and one siliceous sponge.

#### CORRELATION

The most closely related fauna is that of the Chisholm shale, described from the vicinity of Pioche, Nevada.<sup>10</sup> More recently Pack<sup>11</sup> has reported upon that fauna, describing several new species. The faunas of the two formations have at least eight species in common. Burling<sup>12</sup> correlated the Chisholm shale with the Spence shale of Utah and Idaho and the Stephen formation of British Columbia. All are of lower Middle Cambrian age.

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<sup>9</sup> J. C. Hazzard: op. cit., pp. 74-75.

<sup>10</sup> C. D. Walcott: Second Contribution to the Studies on the Cambrian Faunas of North America, U. S. Geol. Surv., Bull. 30, 1885: Cambrian Geology and Paleontology, III, No. 5, Cambrian Trilobites, Smithsonian Misc. Coll., vol. 64, no. 5, 1916, pp. 409-410.

<sup>11</sup> F. J. Pack: Cambrian Fossils from the Pioche Mountains, Nevada, Jour. Geol., vol. 14, no. 4, 1906, pp. 290 ff.

<sup>12</sup> L. D. Burling: Lower Cambrian Stratigraphy of the North American Cordillera, with discussion of Albertella and related faunas, Geol. Surv. Can., Mus. Bull. 2, art. 6, 1914.

## DESCRIPTIONS OF SPECIES

Phylum PORIFERA

Genus *Chancelloria* Walcott

*Chancelloria eros* Walcott

Plate 15, fig. 1

*Chancelloria eros* Walcott, 1920, *Smithsonian Misc. Coll.*, vol. 67, no. 6, p. 329, pl. 86, figs. 2, 2a-c; pl. 88, figs. 1, 1a-f.

Several detached spicules are referred to this species. They agree well with the type-description, save for their larger size. They are all five (?) or six-rayed, and one specimen shows a great development of two rays on opposite sides of the central disk, the other four being reduced. The same specimen has the surface of the central disk produced upward, to form a short, stubby vertical ray. The spicules are broken, so that the following measurements can not give an accurate idea of the proportions.

### MEASUREMENTS

Greatest extension of rays.	14. mm.	5.8 mm.	8. mm.
Length of longest ray . . . .	6.7	4.	3.7
Greatest diameter of ray . .	1.1	.9	1.1
Diameter of central disk . .	1.6	1.1	...

Horizon and Locality: Burgess shale member and Ogygopsis zone of the Stephen formation, near Field, British Columbia; Cadiz formation, Marble Mountains, California.

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Phylum MOLLUSCA

Class Gastropoda

Order Opisthobranchia Milne Edwards

Suborder Pteropoda Cuvier

Family Hyolithidae Nicholson

Genus *Hyolithes* Eichwald

*Hyolithes princeps* Billings

*Hyolithes princeps* Billings, 1872, *Can. Nat.*, new ser., vol. 6, p. 216, figs. 4a-b of p. 213; Walcott, 1886, *U. S. Geol. Surv.*, *Bull.* 30, p. 135, pl. 13, figs. 5, 5a-b.

This species is represented in the Cadiz fauna by a great many specimens, which weather out of the limestone. On none are the surface markings discernible. The length varies from 1 to 3 inches.

Horizon and Locality: Bic conglomerate, Province of Quebec, Canada; Silver Peak, Nevada; Cadiz formation, Marble Mountains, California.

Hyolithes sp. indet.

Among the numerous specimens of pteropods that weather out of the limestones of the Cadiz formation, the shorter are referred to an undetermined species, smaller than *Hyolithes princeps*. The most common pteropod reported from the Nevada area is *H. billingsi* Walcott, but that species is smaller than any of the Cadiz specimens.

Horizon and Locality: Cadiz formation, Marble Mountains, California.

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Phylum BRACHIOPODA  
Order ATREMATA Beecher  
Super-family RUSTELLACEA Walcott  
Family PATERINIDAE Schuchert  
Genus Iphidella Walcott  
*Iphidella panulla* (White)

*Micromitra (Iphidella) panulla* Walcott, 1912, *U. S. Geol. Surv., Mon.* 51, pp. 361-364, text fig. 32, pl. 4, figs. 1, 1a-t, 3, 3a. See complete bibliography in this reference, p. 361.

A few broken shells are referred to this species, identified by means of the distinctive surface markings. Nothing can be added to the knowledge of the species from the present material.

Horizon and Locality (in addition to those occurrences enumerated in Walcott, 1912, *op. cit.*, pp. 363-364: Cadiz formation, Marble Mountains, California.

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Superfamily OBOLACEA Schuchert  
Family OBOLIDAE King  
Subfamily OBOLINAE Dall  
Genus *Westonia* Walcott  
*Westonia ella* (Hall and Whitfield)

*Obolus (Westonia) ella* Walcott, 1912, *U. S. Geol. Surv., Mon.* 51, pp. 455-458, pl. 33, figs. 3, 3a-c, pl. 47, figs. 1, 1a-p. See complete bibliography in this reference, pp. 455-456.

The present specimens possess no features not as yet described.

Horizon and Locality (in addition to those occurrences enumerated in Walcott, 1912, *op. cit.*, pp. 457-458): Cadiz formation, Marble Mountains, California.

Order PROTREMATA Beecher  
Superfamily ORTHACEA Walcott and Schuchert  
Family BILLINGSSELLIDAE Schuchert  
Subfamily BILLINGSSELLINAE Walcott  
Genus Billingsella Hall and Clarke  
Billingsella highlandensis (Walcott)

*Orthis ? highlandensis* Walcott, 1886, *U. S. Geol. Surv., Bull.* 30, pp. 119-120, pl. 8, figs. 3, 3a-b; Walcott, 1891, *U. S. Geol. Surv., Tenth Ann. Rep.*, p. 612, pl. 72, figs. 5, 5a-b.

*Billingsella highlandensis* Walcott, 1904, *Proc. U. S. Nat. Mus.*, vol. 28, pp. 237-238; Walcott, 1912, *U. S. Geol. Surv., Mon.* 51, pp. 756-757, pl. 87, figs. 4, 4a-c.

The present specimen is a cast of the interior of a dorsal valve, similar to that figured by Walcott (1912, *op. cit.*, pl. 87, fig. 4c). It adds nothing to the knowledge of this species, save increasing the geographic distribution.

Horizon and Locality: Pioche shale, Pioche, Nevada; idem, Highland Range, Nevada; Cadiz formation, Marble Mountains, California.

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Phylum ARTHROPODA  
Subphylum BRANCHIATA  
Class CRUSTACEA  
Subclass TRILOBITA Walch  
Order OPISTHOPARIA Beecher  
Family CONOCORYPHIDAE Angelin  
Genus Acrocephalites Wallerius  
*Acrocephalites ? trifossatus* sp. nov.\*

Plate 15, figs. 2, 3

Six cranidia from this collection are referred to this species. The glabella is pyramidal, though truncated at a height equal to the width of its base by the flat frontal limb which meets the glabella abruptly. The dorsal furrows are rounded and fairly well impressed. The occipital furrow is strong, and slightly sinuous, bending forward as it crosses the axis. Three pairs of strong glabellar furrows are present, nearly equidistant and decreasing in strength anteriorly. The first pair is at right angles to the axis; the two posterior pairs are slightly inclined. The neck ring may have had a median spine; there is a hole at that point on one specimen. The frontal limb is narrow and concave, not separated from the upturned rim. There is an obscure boss on one specimen. The rim is not thickened, but the recurvment is undiminished from suture to suture.

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\* This is probably not a true *Acrocephalites*, and is thought to be a member of a new genus ancestral to that form.

The fixed cheeks are bulbous, nearly as high as the glabella; they extend a little farther forward than that portion, and descend in an even curve to the frontal limb, being separated from the rim by a rounded groove. From the rounded anterior angles of the glabella strong palpebral ridges spring out. These curve gently back to a point at which they are even with the posterior glabellar furrows. The eyes are a distance from the glabella equal to the anterior breadth of that body. The facial sutures diverge slightly as they come back from the rim to meet the palpebral ridges even with the first glabellar furrows, where the ridges are trending strongly backward. The sutures skirt the ridges for a short distance, and then diverge rapidly. The postero-lateral limbs are narrowly triangular, with thickened trailing edges and rounded grooves just in front. The surface is strongly tuberculate.

#### MEASUREMENTS

Length of cranium (to neck furrow) ..	6.5 mm.	8.7 mm.	4. mm.	4.8 mm.	7. mm.
Length of glabella (to neck furrow) ..	5.	6.	3.	3.6	5.
Width of glabella anteriorly .....	3.5	3.7	1.8	2.5	3.
Width of glabella posteriorly .....	5.2	6.2	3.2	3.8	5.3
Length of postero- lateral limb .....	4.8	5.	...	3.5	...

This species is characterized by its strong curving palpebral ridges, truncato-pyramidal glabella, upturned frontal rim, and tuberculate surface. The tuberculate surface and general features of the glabella cause the tentative reference to the genus *Acrocephalites* Wallerius. But that genus has no palpebral ridges. From *Alokistocare* Lorenz the present species differs in the surface markings, strong glabellar furrows, and short, upturned frontal rim. This species falls between these two genera, though it is probably generically related to several species referred to them. *Acrocephalites haynesi* Walcott is similar, but differs in having a strong median spine on the neck ring, rather obscure palpebral ridges, short postero-lateral limbs, a strong rounded frontal limb, and the surface coarsely granulated. *Alokistocare* ? *labrosum* Walcott differs in the strong rounded frontal rim, pitted surface, and triangular neck ring. *Acrocephalites insignis* Walcott is smaller and has a wider neck ring, shallow glabellar furrows, and granulose surface.

Horizon and Locality: Cadiz formation, Marble Mountains, California.

Genus *Alokistocare* Lorenz  
*Alokistocare linnarssoni* (Walcott)

Plate 15, fig. 4

*Ptychoparia ? linnarssoni* Walcott, 1884, *U. S. Geol. Surv., Mon.*  
8, p. 47, pl. 9, figs. 18, 18a.

*Alokistocare linnarssoni* Walcott, 1916, *Smithsonian Misc. Coll.*,  
vol. 64, no. 3, p. 185, pl. 25, figs. 7, 7a.

This species is represented in the present collection by the cranidium of a single large specimen. The glabella is pyramidal in shape, but truncated at a height apparently equal to the width of the base by a straight anterior margin. Laterally and at the front the glabella is set off from the rest of the cranidium by deep furrows. No glabellar furrows are visible, and the posterior extremity is broken off. The frontal limb is broad, terminating in a shallow groove which bends forward where it passes the glabella. The enlargement of the frontal limb thus afforded is occupied by a large low boss. The frontal rim is narrower than the frontal limb, gently upturned, and not thickened.

Rising from the limb in even slopes, the fixed cheeks are higher than the glabella. Due to the imperfect condition of the surface, the palpebral ridges are not apparent. The facial suture, except for its gently rounded anterior extension on the rim, is broken away. The surface is covered by heavy but rather obscure tubercles and by irregular depressed lines covering the boss and fixed cheeks. The weathered surface of the type specimen is said to be either minutely pitted or punctate. The present specimen is impunctate but it agrees in other points very well. It may be noted that there is a tendency for the frontal limb to break off at the bottom of the frontal groove, leaving the boss projecting forward. A specimen which has suffered such damage is shown by Walcott (1916, fig. 7a). The present specimen shows a crack at this point, though the rim is still attached.

MEASUREMENTS

Length of cranidium .....	8. mm.
Length of glabella .....	4.
Width of glabella anteriorly .....	2.5
Width of glabella posteriorly .....	3.5
Width of frontal limb .....	2.
Width of frontal rim .....	1.5

This specimen falls into the genus *Alokistocare* Lorenz by reason of the boss extending forward onto the frontal rim. The tuberculate surface, however, is an indication that revision of *Alokistocare* and *Acrocephalites* Wallerius is necessary. In general, the surface of the former is said by Walcott to be punctate, and that of the latter to be tuberculate. The present material



is not sufficient to warrant a new generic assignment of this species.\* The species showing the greatest similarity to *Alokitocare linnarssoni* is *A. ? prospectense* (Walcott). The latter differs in having a shorter cranidium and the palpebral ridges situated farther back. From *A. subcoronatum* (Hall and Whitfield) the present species may be distinguished by its greater length and a more distinct boss on the frontal limb. *A. althea* Walcott has a long cranidium, but the frontal limb is proportionately shorter and the boss is not so large.

Horizon and locality: Secret Canyon shale, Eureka, Nevada; Orr formation, Fish Spring Range and Fish Creek Range, Tooele County, Utah; Cadiz formation, Marble Mountains, California.

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Family OLENIDAE Burmeister  
Genus Amecephalus Walcott  
*Amecephalus piochensis* (Walcott)

Plate 15, figs. 5, 6, 7

*Ptychoparia piochensis* Walcott, 1886, *U. S. Geol. Surv., Bull.* 30, p. 201, pl. 26, figs. 2, 2a-b, pl. 28, 1, 2, 2a-e; Pack, 1906, *Jour. Geol.*, vol. 14, p. 297, pl. 2, figs. 4, 4a-c; Grabau and Shimer, 1910, *N. A. Index Fossils*, vol. 2, p. 276, fig. 1575.

*Amecephalus piochensis* Walcott, 1924, *Smithsonian Misc. Coll.*, vol. 75, p. 54, pl. 9, fig. 1; Walcott, 1925, *idem*, vol. 75, p. 66, pl. 15, fig. 8.

*Liostracus piochensis* Lorenz, 1926, *Zeits. D. D. geol. Gesell.*, bd. 58, heft 1, p. 61.

This species is represented in the collection from this new locality by numerous cranidia and by one hypostoma. The surface of the cranidium is smooth, except for the insculpting lines on the frontal limb. The hypostoma is quadrate, with broad short anterior auriculate projections. Its body is a raised circular area, and a semicircular bulbous posterior extension is separated from it by a furrow. A little in front of the point at which the furrow crosses the axis the edges of the hypostoma are brought to very small points. The length is over 6.5 mm., and the width at the "points" just mentioned is 5.4 mm.

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\* See note at the end of this paper.

As Reed has shown<sup>13</sup> the value of the characteristics by which Lorenz split up the group of species referred to *Ptychoparia sensu lato* is open to question. Inasmuch as Walcott preferred to include *Liostracus piochensis* Lorenz in the synonymy of the species selected as the genotype of *Amecephalus*, his usage is followed here.

Walcott's description of the genus *Amecephalus* states that there are "three sets of glabellar furrows," but his illustrations and line drawing show four\* Those specimens of the present collection which display the details of the glabella have four pairs of furrows. The presence and size of the boss on the frontal limb are quite variable. It occasionally extends forward onto the frontal rim. If, as Walcott suggests, the genus *Acrocephalites* is related to *Amecephalus*, this characteristic may be of considerable significance. Indeed, the similarity of *Amecephalus piochensis* (Walcott), *Acrocephalites americanus* Walcott, and *Alokistocare subcoronatum* (Hall and Whitfield) leads one to suspect that these species are congeneric, though the first and last mentioned are genotypes. The principal difference between them is in the character of the surface markings. Other than irregular inosculating lines, the surface of *Amecephalus* is smooth. The surface of *Acrocephalites americanus* has similar lines, and is covered by scattered tubercles. *Alokistocare subcoronatum* is marked by similar lines, and Walcott remarked that the surface was possibly pitted or punctate.

Horizon and Locality: Chisholm formation, Pioche, Nevada; idem, Highland Range, Nevada; Spence shale, House Range, Utah; idem, Wasatch Canyon, Utah; Cadiz formation, Marble Mountains, California.

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*Amecephalus strangulatus*, sp. nov.

Plate 15, figs. 8, 9

Cranidium subquadrate; glabella pyramidal, though truncated at its anterior end by a rather straight transverse line. The dorsal furrows are shallow but distinct and are continuous around the forward end of the glabella. There is an occipital furrow, slightly impressed as it crosses the axis, deeper at the sides. The neck ring is of moderate width, with a low median node. The glabella has four short lateral furrows, slightly oblique and bending back as they approach the median line. This results in a keel.

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<sup>13</sup> F. R. C. Reed: The Cambrian Fossils of Spiti, *Palaeontologia Indica*, series 15, vol. 7, mem. no. 1, 1910.

\* The rear furrow of these four may not be a true glabellar furrow.

The fixed cheeks are equal in width to the anterior width of the glabella, not elevated greatly, and highest opposite the anterior end of the glabella. The palpebral ridges spring backward from a point just back of the anterior angles of the glabella. They are quite prominent and pursue an arcuate course to within a short distance of the posterior edge of the cranidium. Frontal limb broad and marked in front of the glabella by a prominent elongate boss which extends forward onto the upturned frontal rim. Laterally the frontal limb is concave. The facial sutures cut directly backward from the frontal rim, though curving slightly as they pass the ocular lobes, and then turn sharply outward to form narrow postero-lateral limbs. These are about twice the width of the fixed cheeks in length, and marked by deep furrows a little back of the occipital furrow. The surface is finely tuberculate. Fine inosculating lines cover the frontal limb and the border in front of the palpebral lobes. A single specimen has a smooth surface, but shows the other features of the species.

MEASUREMENTS

Length of cranidium .....	7.8 mm.	10. mm.	23. mm.	... mm.
Length of glabella .....	4.6	5.2	12.	...
Width of glabella anteriorly..	2.5	2.9	6.5	3.
Width of glabella posteriorly...	3.8	4.	10.	4.2
Width between extremities of postero-lateral limbs ... ..	...	...	...	14.

This species differs from *Amecephalus piochensis* Walcott, the only other described member of the genus, in having a distinct neck ring, a median occipital node, and a tuberculate surface.

Horizon and Locality: Cadiz formation, Marble Mountains, California.

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Family DIKELOCEPHALIDAE Miller

Genus Anomocarella Walcott

*Anomocarella* ? *spatha* sp. nov.

Pl. 15, fig. 10

This species is represented in the present collection by seven cranidia. Cranidium semi-circular in outline; glabella subrectangular to subtriangular, two-thirds the length of the cranidium, the anterior corners rounded so that the anterior end is arcuate. A sinuous, shallow furrow sets off an occipital ring, broad and with no apparent node. Glabellar furrows three in number, very weak, visible only as lateral pits. The glabella, the highest part of the cephalon, is bordered by distinct dorsal furrows, which lessen in depth as they curve around the anterior end.

The frontal limb is a convex slope connecting the elevated cheek areas and not separated from them. It is equal in width to the frontal rim. The rim is a somewhat flattened margin of the elevated glabella, cheeks, and limb, which descend in an even curve to the rim. The depressed line separating the limb and cheeks from the rim is bent backwards as it passes the glabella, forming an obtuse angle at that point. The fixed cheeks are as wide as the anterior width of the glabella, and nearly as high. The palpebral ridges are visible on but one specimen, curving back from near the front of the glabella. The outline of the cheeks is not apparent, for the specimens are broken. The surface is covered by small but distinct tubercles.

#### MEASUREMENTS

Length of cranium . . . . .	8. mm.	. . . mm.	5.2 mm.	. . . mm.
Length of glabella . . . . .	5.2	7.	3.8	. . .
Width of glabella anteriorly . .	3.2	4.3	2.	2.
Width of glabella posteriorly .	4.3	5.8	2.7	2.8
Width of frontal limb . . . . .	1.5	. . .	.8	. . .
Width of frontal rim . . . . .	1.5	. . .	.6	. . .
Width of occipital ring . . . . .	. . .	1.	.5	. . .

*Anomocarella* is characterized by the absence of glabellar furrows, and by a relatively narrow, flattened frontal rim. The sides of the glabella are parallel, or but slightly converging forward (as in the genotype, *A. chinensis* Walcott). The palpebral ridges of the species assigned to this genus are in general not distinct. The present species varies from the preceding in the three pairs of glabellar furrows (faint, to be sure) and in the more pyramidal glabella. It may be compared with species of the genus *Ctenocephalus*, from which it differs in the angulation of the frontal furrow and narrower fixed cheeks. From *Armonia* it is distinguished by the relatively wider frontal limb and border. The present cranidia are similar in outline to *Crepicephalus augusta* Walcott (U. S. Geol. Surv., Bull. 30, 1886, p. 208), but differ in having a flat frontal border instead of the thickened frontal rim of the Nevada form.

Family CORYNEXCHIDAE Angelin

Genus Anoria Walcott

*Anoria lodensis* (Clark)

Plate 15, figs. 11, 12

*Bathyriscus howelli lodensis* Clark, 1921, *Univ. Calif. Pub. Bull. Dept. Geol. Sci.*, vol. 13, no. 1, p. 6.

*Dolichometopus ? lodensis* Resser, 1928, *Smithsonian Misc. Coll.*, vol. 81, no. 2, p. 10, pl. 3, fig. 9.

This species is represented in the present collection by one incomplete crushed carapace, an hypostoma, and a single thoracic segment. General form ovate; cephalon, thorax, and pygidium of nearly equal length. The glabella is elongate, expanding forward, the fore part quite bulbous. The dorsal furrows are but slightly defined behind, and deepen near their anterior end. No glabellar furrows are visible. From the posterior side of the glabellar bulb the palpebral ridges curve widely backwards to meet the small ocular lobes, which are situated far back and inclined forward and outward. The eye lobe is about half the width of the glabella distant from that part. The glabella appears to be terminal, with no frontal limb or rim, but the preservation of this area is not good. The facial sutures curve evenly around the fore part of the glabella and meet the palpebral ridges two millimeters from their origins. Their posterior extension is obscure. The fixed and free cheeks are equal in width when measured at an angle of  $45^\circ$  to the axis, but the free cheek widens backwards. Both the fixed and free cheeks are two-thirds the width of the glabella at its narrowest point. The margins of the free cheek are prolonged at the postero-lateral angles into sturdy sharp spines.

The thorax is composed of seven segments. The pleurae bend backwards and terminate in distinctly pointed spines. The pleural groove is broad and distinct, and slightly oblique, but it disappears before the terminal spine is reached. The fifth segment is prolonged into a sharp spine, longer than the genal spine and extending back of the forward edge of the pygidium. It is inclined outward so as not to overlap that portion of the carapace. The axial lobes of the thoracic segments have low median spines. The pygidium is broad and elliptical in outline. Neither pleural furrows or border are visible.

The associated hypostoma is roughly triangular. The central area rises gently from the margins. The posterior end is marked by a transverse furrow, back of which is a rather bulbous ridge.

#### MEASUREMENTS

Length of carapace .....	43. mm.
Length of glabella .....	14.
Width of glabella anteriorly .....	9.
Width of glabella posteriorly .....	7.
Length of palpebral ridges .....	6.
Distance to eye from posterior margin of cephalon ..	1.5
Width between genal spines .....	29.
Length of thorax .....	15.
Width between spines of the fifth pleurae .....	29.5
Length of pygidium .....	13.5
Width of pygidium .....	25.
Length of hypostoma .....	5.2
Width of hypostoma anteriorly .....	4.
Length of posterior segment .....	1.

The original description merely states that *Bathyriscus howelli lodensis* has eight thoracic segments and an elongate fifth segment. The subsequent reference by Resser was based on the holotype. The present topotype differs in having seven segments in the thorax. It is possible that the thickened anterior edge of the pygidium of the holotype was mistaken for an eighth segment. Otherwise, the agreement is close. Walcott described the closely allied species *Anoria tontoensis* from the Grand Canyon. The large curved palpebral ridges preclude the assignment of the present specimen to that species, the only one heretofore placed in *Anoria*. The genus is characterized by the lack of any frontal limb or rim on the cephalon. The remainder of the carapace is similar to the thorax and pygidium of *Dolichomctopus*. The primitive character of the genus is apparent in the elongate pleural segments present in the species assigned to it, *A. tontoensis* Walcott and *A. lodensis* (Clark).

Horizon and Locality: Cadiz formation, Marble Mountains, California.

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Genus *Bathyriscus* Meek  
*Bathyriscus howelli* Walcott

Plate 15, fig. 13

*Bathyriscus howelli* Walcott, 1886, *U. S. Geol. Serv., Bull.* 30, p. 216, pl. 30, figs. 2, 2a; Walcott, 1888, *Am. Jour. Sci.*, (3), vol. 36, p. 165; Toll, 1899, *Mém. l'Acad. Imp. Sci. St. Petersburg*, (8), vol. 8, no. 10, p. 30, pl. 2, fig. 11; Grabau and Shimer, 1910, *N. A. Index. Fossils*, vol. 2, p. 287, fig. 1592; Walcott, 1916, *Smithsonian Misc. Coll.*, vol. 64, p. 343, pl. 47, figs. 1, 1a-b.

Not *Bathyriscus howelli* Pack, 1906, *Jour. Geol.*, vol. 14, p. 296, pl. 2, figs. 2, 2a.

This species is represented in the present collection by a number of cranidia. The expansion of the glabella forward is not so great as in the type specimen. The third pair of glabellar furrows is not visible on any of these specimens, and the second is nearly obsolete. The occipital furrow and first glabellar furrow are deeply indented and nearly equal in strength, save that the glabellar furrow does not cross the axis. The palpebral ridges in the present specimens are like those of the holotype, but on one immature specimen they are very close to the glabella, greatly cutting down the area of the fixed cheeks.

MEASUREMENTS

Length of glabella . . . . .	5.5 mm.	7.5 mm.	3.8 mm.	4.8 mm.
Width of glabella anteriorly .	3.	4.	2.	2.8
Width of glabella posteriorly .	2.5	3.	1.8	2.2
Width of occipital ring . . . . .	1.	1.2	.8	.9
Length of palpebral ridge . . . .	3.	4.	2.	2.8
Width of fixed cheek . . . . .	1.5	2.	1.	1.

Horizon and Locality: Spence shale, Wasatch Canyon, Utah; Chisholm shale, Pioche, Nevada; idem, Highland Range, Nevada; Cadiz formation, Marble Mountains, California.

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*Bathyriscus maximus* sp. nov.

Plate 15, figs. 14, 15, 16

*Bathyriscus howelli* Pack, 1906, *Jour. Geol.*, vol. 14, p. 296, pl. 2, figs. 2, 2a.

Not *Bathyriscus howelli* Walcott, 1886, *U. S. Geol. Surv., Bull.* 30, p. 216, pl. 30, figs. 2, 2a.

This species was incompletely described by Pack as *Bathyriscus howelli*, emending Walcott's description of that species. Pack states that the specimens from Pioche showed an elongate glabella, expanding in front of the eyes. The glabella was marked by four pairs of furrows, the posterior pair inclined backwards,

the next directly transverse, and the anterior pairs inclined forward. A frontal margin well developed laterally formed auriculate corners. The length of his illustrated specimen was fifteen millimeters. The reference to Walcott's species was a "tentative assignment."

The present collection contains several cranidia, an hypostoma, and a number of pygidia. The glabella displays the characters pointed out by Pack, except for the auriculate corners. There is considerable longitudinal convexity in the present specimens. The hypostoma has the frontal margins broken away. Its body is a broadly convex round area. Back of this is a semicircular area, the outer edge of which is flattened. This area is set off from the body by a pair of sharp ridges extending inward and backwards from the margin but not meeting across the axis. These ridges are set in a broad shallow furrow extending around the posterior end of the body.

The pygidium is semicircular and elevated, but with a wide flattened border. The highly convex axial lobe tapers backward slightly through five segments and then disappears in a rounded terminal segment as it approaches the border. The pleural lobes are crossed by five narrow rounded furrows, each originating near the middle of an axial segment and extending outward to midway of the flattened border. The more posterior furrows are directed more definitely backward. The margin of the pygidium is even, save for a broad reëntrant angle where it crosses the axial line on a few large specimens. The doublure is wider than the dorsal flattened area, and is marked by numerous fine lines more or less parallel to the margin and decreasing in frequency toward it.

#### MEASUREMENTS

##### Glabella

Length .....	19. mm.	13. mm.	16.5 mm.	... mm.	14. mm.
Width anteriorly ...	10.3	9.7	10.	...	9.
Width posteriorly ..	7.3	6.4	7.3	4.9	5.5
Width of fixed cheek	3.4	3.4	4.3	2.7	3.3

##### Hypostoma

Length .....	7.6 mm.
Width .....	7.2
Width at furrow ...	5.1

##### Pygidium

Length .....	7.7 mm.	19. mm.
Width .....	15.	30.
Length of axial lobe .....	6.	15.4
Median width of axial lobe ...	2.6	5.8



This large species may be compared with *Bathyriscus howelli*, from which it differs in size, in the forward expansion of the glabella and the additional fourth pair of glabellar furrows, and in the terminal indentation and the five segments of the pygidium.

Horizon and Locality: Cadiz formation, Marble Mountains, California; Chisholm shale, Pioche, Nevada; idem, Highland Range, Nevada.

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Genus *Corynexochus* Angelin

*Corynexochus* ? sp.

Plate 15, fig. 17

A single hypostoma in the present collection is referred to the above genus. It is similar in shape to the hypostoma of *Corynexochus senectus* (Billings), but much too large to be referred to that species. It is possible that it belongs to one of the *Corynexochidae* described in this paper, but there is no species associated with this hypostoma to which it can with certainty be referred. The assignment is doubtful, then, owing to the absence of dorsal shield fragments.

MEASUREMENTS

Length .....	7. mm.
Width at lateral projections .....	9.5
Width posteriorly .....	5.
Width of axial lobe, inside furrow .....	3.8
Length of segment set off by furrow ....	1.1

Horizon and Locality: Cadiz formation, Marble Mountains, California.

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Genus *DOLICHOMETOPUS* Angelin

*Dolichometopus productus* (Hall and Whitfield)

*Ogygia producta* Hall and Whitfield, 1877, *U. S. Geol. Expl. 40th Parallel*, vol. 4, p. 244, pl. 2, figs. 31-34.

*Ogygia parabola* Hall and Whitfield, 1877, *idem*, vol. 4, p. 245, pl. 2, fig. 35.

*Niobe producta* Brogger, 1886, *G. Foren. Stockholm, Forh.*, vol. 8, p. 211.

*Bathyriscus productus* Walcott, 1886, *U. S. Geol. Surv., Bull.* 30, p. 217, pl. 30, fig. 1c-f, 1i; Miller, 1889, *N. A. Geol. and Pal.*, p. 533, text fig. 972; Pack, 1906, *Jour. Geol.*, vol. 14, p. 297, pl. 2, figs. 3, 3a-b; Grabau and Shimer, 1910, *N. A. Index Fossils*, vol. 2, p. 287, fig. 1591.

*Dolichometopus productus* Walcott, 1916, *Smithsonian Misc. Coll.*, vol. 64, p. 369, pl. 53, figs. 2, 2a-e, 3, 3a-b, 4, 4a.

This common species is represented in the Marble Mountains fauna by numerous pygidia and a few cranidia. The glabella of the present specimens are nearly rectangular, thus approaching the original types from the Oquirrh Range, Utah, more closely than the specimens from the Chisholm shale figured by Walcott. The palpebral ridges are farther back than in the types, and their position corresponds to that of the ridges on the Nevada specimens.

The pygidia have the usual shape for the species, with a wide brim and unsegmented axial lobe. On several specimens the lobe ends posteriorly in a rather sharp point intersecting the brim. In others it ends at the edge of the brim in a rounded terminal segment. A few specimens indicate the presence of five transverse furrows, the anterior furrow being the most prominent. One specimen displays three very faint furrows on the pleural lobes, inclined slightly backward, in addition to the deep furrow just back of the anterior edge.

Horizon and Locality: Ophir formation, Oquirrh Range; McDowell Mountains; Chisholm shale, House Range; Simpson Spring, Tooele County; Onaqui Mountains; Howell formation, House Range, all in Utah. Chisholm shale, Pioche, Nevada; Bright Angel shale, Grand Canyon, Arizona; Cadiz formation, Marble Mountains, California. Also in the Rome formation, Hawkins County, Tennessee; Bays Mountains, Knox County, Tennessee; Conasauga formation, Floyd County, Georgia.

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Genus PAGETIA Walcott  
*Pagetia clytia* ? Walcott

*Pagetia clytia* Walcott, 1916, *Smithsonian Misc. Coll.*, vol. 64, p. 408, pl. 67, figs. 2, 2a-e.

A single pygidium from the present collection is referred to this Spence shale species. It is semicircular, with a brim which merges into the thickened forward edge. The axial lobe is high, rounded, and cut by distinct furrows into five segments, the last being the longest. The tip is bluntly pointed, and does not intersect the rim. The pleural lobes are faintly marked by furrows trending outward and but slightly backward. The number of furrows can not be determined, but there are at least two. The pygidium measures 1.2 millimeters in length.

Though the agreement with the Idaho specimens is quite close, the present specimen is questionably assigned to this species. It is possible that it represents a youthful stage of any of several

of the Corynexochidae. But its small size, the constant width of the axial lobe, the five segments, all seem to indicate *Pagetia clytia*.

Horizon and Locality: Spence shale, Bear Lake County, Idaho; Cadiz formation, Marble Mountains, California.

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Family ORYCTOCEPHALIDAE Beecher  
 Genus ZACANTHOIDES Walcott  
*Zacanthoides typicalis* (Walcott)

*Olenoides typicalis* Walcott, 1886, *U. S. Geol. Surv.*, Bull. 30, p. 183, pl. 25, figs. 2, 2a.

*Zacanthoides typicalis* Walcott, 1888, *Am. Jour. Sci.*, (3), vol. 36, p. 165.

This species is represented in the author's collection by two cranidia and a pygidium. The glabella is long and narrow, tapering slightly forward, with at least three pairs of obscure oblique glabellar furrows, extending one-third the distance across the glabella. Fixed cheeks wide and semicircular, bounded by prominent palpebral ridges. The ocular lobe extends to the furrow of the postero-lateral limb, which is midway between the posterior glabellar furrow and the occipital furrow. Dorsal furrow nearly obsolete. Palpebral ridges meet the glabella in front of the third glabellar furrows, but far back of the anterior end of the glabella. Facial sutures converge rapidly from the frontal rim to the margin of the glabella, and then follow the curve of the palpebral ridges and lobes. The frontal limb is bent gently upward.

MEASUREMENTS

Length of glabella (to neck ring) . . . . .	3.8 mm.	8.6 mm.
Width of glabella anteriorly . . . . .	1.4	4.3
Width of glabella posteriorly . . . . .	2.2	4.9
Maximum width between facial sutures . . .	4.1	9.6

Horizon and Locality: Chisholm shale, Pioche, Nevada; idem, Highland Range, Nevada; Spence shale, House Range, Utah; Cadiz formation, Marble Mountains, California.

Genus *Dorypyge* Dames

*Dorypyge quadriceps* (Hall and Whitfield)

Plate 15, figs. 18-22

*Dikellocephalus quadriceps* Hall and Whitfield, 1877, *U. S. Geol. Expl. 40th Parallel*, vol. 4, pt. 2, p. 240, pl. 1, figs. 37-40.

*Dicellocephalus* ? *quadriceps* Walcott, 1884, *U. S. Geol. Surv., Mon.* 8, p. 45, pl. 9, fig. 24.

*Olenoides quadriceps* Walcott, 1886, *U. S. Geol. Surv., Bull.* 30, p. 187, pl. 29, figs. 1, 1a-c; Walcott, 1888, *Am. Jour. Sci.*, (3), vol. 36, p. 165; Walcott, 1890; *U. S. Geol. Surv., Tenth Ann. Rep.*, p. 646, pl. 94, figs. 4, 4a-c.

*Dorypyge quadriceps* Dames, 1884, *China (Richtofen)*, vol. 4, p. 23; Walcott, 1889, *Proc. U. S. Nat. Mus.*, vol. 11, p. 441; Matthew 1897, *Trans. Royal Soc. Canada*, (2), vol. 3, sec. 4, p. 186.

This species is represented by numerous cranidia and pygidia and two hypostomas. The agreement with the following description (condensed) of Hall and Whitfield is fairly good:

Glabella and fixed cheeks quadrangular, with an arcuate front margin. Glabella elongate quadrangular, slightly expanded in front, somewhat inflated. Three pairs of very faint glabellar furrows. Occipital furrow distinct; neck ring strong. A prominent median spine on the posterior margin has a wide base and is directed upward and backward. Fixed cheeks of moderate size, strongly convex. Eye lobes small, situated behind the mid-section; ocular ridges distinct, inclined forward from eye to glabella. Facial sutures begin directly in front of the eye lobe and cut back in a straight line to the eye. Pygidium paraboloid, with twelve strong, but short, spines, the central four shortest. Axis narrow, highly convex with five rings. Lateral lobes broad, convex, marked by four ribs ending in spines.

The hypostomas in the present collection were found closely associated with parts of the dorsal shield of this species. The shape is subrectangular save for the antero-lateral projections. The anterior margin is evenly arcuate. The body is ovate, and moderately elevated. It is surrounded by a flat narrow rim, which is extended to form the narrowly triangular antero-lateral projections.

The size of the type specimens figured by Hall and Whitfield is less than the average size of the present specimens. But those authors note the occurrence of much larger forms, even larger than the present examples. The expansion forward, by which Walcott distinguished *Olenoides* from *Dorypyge*, is not a prominent feature. In the latter genus a pair of indentations

beside the forward end of the glabella causes a constriction of that body. This feature is seen on a few of the present specimens but is not at all usual. The other distinction between the two genera is the character of the pleural furrows of the pygidium. In these specimens the furrow is narrow and the intervening ridges broad, thus corresponding to the pygidial furrows of *Dorypyge*.

#### MEASUREMENTS

##### Cranidium

Length .....	15.5 mm.	... mm.	7. mm.
Width between eyes .....	17.5	...	9.
Width of glabella .....	8.3	...	4.
Width of neck ring .....	3.	...	1.2
Length of postero-lateral limb ...		8.	3.5
Width of postero-lateral limb ...		3.3	1.4

##### Hypostoma

Length .....		7. mm.	... mm.
Width at anterior corners (broken) ...		7.	7.
Width of body .....		3.	3.8

##### Pygidium

Length .....		11. mm.	7. mm.
Width anteriorly .....		16.5	11.
Width of axial lobe anteriorly .....		5.1	2.6
Width of axial lobe posteriorly .....		4.4	2.2

Horizon and Locality: Ute formation, Blacksmith Fork, Utah; Eureka, Nevada; Liau-tung, Manchuria; Cadiz formation, Marble Mountains, California.

#### NOTE

In a paper by Dr. Resser,\* published after the preparation of this paper in the spring of 1934, numerous genera and species are revised. *Alokistocare linnarssoni* (Walcott) is made the genotype of *Eldoradia* Resser. *Amecephalus piochensis* (Walcott) is removed to *Alokistocare* Lorenz, and *Amecephalus strangulatus* sp. nov. is included in Resser's *Alokistocare piochensis*. Dr. Resser anticipated the writer in the publication of the opinion that "*Acrocephalites*" *americanus* Walcott, "*Amecephalus*" *piochensis* (Walcott), and *Alokistocare subcoronatum* (Hall and Whitfield) are congeneric. *Anoria lodensis* (Clark) and *Dolichometopus productus* (Hall and Whitfield) are placed in *Glossopleura* Poulsen. *Bathyriscus howelli* Walcott is put into *Clavaspidella* Poulsen, but Pack's "*B. howelli*," here referred to *B. maximus* sp. nov., is not mentioned.

\* C. E. Resser: Nomenclature of Some Cambrian Trilobites, Smithsonian Misc. Coll., vol. 93, no. 5, 1935.

LEGEND FOR PLATE 15

1. *Chancelloria eros* Walcott. Plesiotype, a six-rayed spicule with two extended rays and a vertical ray. Los Angeles Museum No. A 2471-1.
- 2, 3. *Acrocephalites ? trifossatus* Mason. Cranidia of cotypes. L. A. Mus. No. A 2471-2, A 2471-3.
4. *Alokistocare linnarssoni* (Walcott). Cranidium of plesiotype. L. A. Mus. No. A 2471-4.
- 5, 6. *Amecephalus piochensis* (Walcott). Cranidia of plesiotypes. L. A. Mus. No. . . . .
7. *Idem*. Hypostoma of plesiotype. L. A. Mus. No. . . .
8. *Amecephalus strangulatus* Mason. Cranidium of holotype. L. A. Mus. No. A 2471-8.
9. *Idem*. Cranidium of paratype. L. A. Mus. No. A 2471-9.
10. *Anomocarella ? spatha* Mason. Cranidium of holotype. L. A. Mus. No. A 2471-10.
11. *Anoria lodensis* (Clark). Carapace of topotype-plesiotype. L. A. Mus. No. A 2471-11.
12. *Idem*. Hypostoma of topotype-plesiotype. L. A. Mus. No. A 2471-12.
13. *Bathyriscus howelli* Walcott. Cranidium of plesiotype. L. A. Mus. No. A 2471-13.
14. *Bathyriscus maximus* Mason. Cranidium of cotype. L. A. Mus. No. A 2471-14.
15. *Idem*. Hypostoma of cotype. L. A. Mus. No. A 2471-15.
16. *Idem*. Pygidium of cotype. L. A. Mus. No. A 2471-16.
17. *Corynexochus ? sp.* Hypostoma. L. A. Mus. No. A 2471-17.
- 18, 19, 20. *Dorypyge quadriceps* (Hall and Whitfield). Cranidia of plesiotypes. L. A. Mus. No. A 2471-18, 19, 20.
21. *Idem*. Hypostoma of plesiotype. L. A. Mus. No. A 2471-21.
22. *Idem*. Pygidium of plesiotype. L. A. Mus. No. A 2471 22.

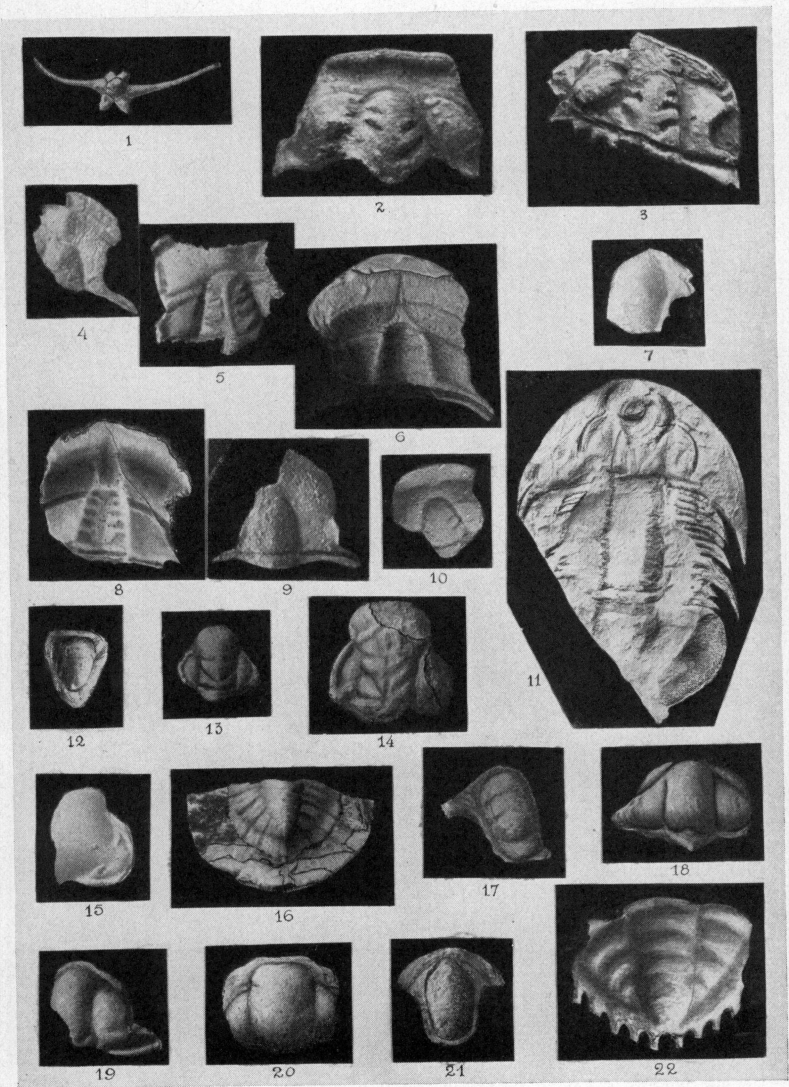


PLATE 15