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OSTRACODS OF THE FAMILIES  
LEPERDITELLIDAE, PRIMITIIDAE,  
DREPANELLIDAE, AECHMINIDAE,  
AND KIRKBYIDAE  
FROM THE MIDDLE DEVONIAN  
BELL SHALE OF MICHIGAN

BY  
ROBERT V. KESLING



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CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

UNIVERSITY OF MICHIGAN MUSEUM OF PALEONTOLOGY

*Director:* LEWIS B. KELLUM

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INTRODUCTION

THE ostracods described in this paper belong to the families Leperditellidae, Primitiidae, Drepanellidae, Aechminidae, and Kirkbyidae, and are from the Middle Devonian Bell shale of Michigan. Three new genera and ten new species are defined. Previous work on the ostracod fauna of the Bell shale has been done by Van Pelt (1933), Kesling (1951), and Kesling and McMillan (1951). Warthin (1934) described Bell shale species in his study of the ostracods of the Traverse group.

The Bell shale, the basal formation of the Middle Devonian Traverse group of Michigan, occurs as strata overlying the Rogers City limestone and as sink fillings in this limestone. In the quarry of the Michigan Limestone and Chemical Company at Calcite, near Rogers City, Presque Isle County, Michigan, some of these sink fillings are exposed and several others have been removed in quarrying operations. The basal ten feet of the Bell shale above the Rogers City limestone are also exposed in this quarry. The middle part of the formation may be present in the sink fillings. The upper ten feet of the Bell shale are exposed below the Rock-

port Quarry limestone along a drainage ditch in the abandoned quarry of the Kelley's Island Lime and Transport Company in the northeastern part of Alpena County.

The relative positions of the strata of many exposures of Bell shale are not known. Differences in the larger invertebrate faunas in the sink fillings show that the strata of all fillings do not occupy the same stratigraphic positions. Furthermore, field evidence does not indicate the exact relationship of the strata of Bell shale in sinks to the strata not in sinks.

The author is very grateful to Dr. G. M. Ehlers and Dr. E. C. Stumm for some of the samples used in this study, and also wishes to express appreciation to Mrs. Janet Henderson for separating some specimens from the rest of the samples and for her preliminary work on the classification.

All types are catalogued and deposited in the Museum of Paleontology of the University of Michigan.

#### REGISTER OF LOCALITIES

The ostracods from the Bell shale that are listed and described in this paper were collected from the following localities:

##### LOCALITY

1. Bell shale formerly present as a sink filling in Rogers City limestone in the quarry of the Michigan Limestone and Chemical Company at Calcite, near Rogers City, Presque Isle County, about one-half mile southeast of the quarry crusher. The exposure has been completely removed by quarrying and no additional material can be obtained. The sample was collected by George M. Ehlers in 1926.
2. Basal ten feet of Bell shale overlying Rogers City limestone in the south wall of the Michigan Limestone and Chemical Company quarry, NW  $\frac{1}{4}$  NE.  $\frac{1}{4}$  sec. 1, T. 34 N., R. 5 E., at Calcite, Presque Isle County. Collected by Robert V. Kesling in 1949.
3. Bell shale removed from sink filling in the Rogers City limestone by quarrying operations in the quarry of the Michigan Limestone and Chemical Company at Calcite, Presque Isle County, and now present as a dump pile, NE.  $\frac{1}{4}$  NW.  $\frac{1}{4}$  sec. 36, T. 35 N., R. 5 E., at the junction of the main quarry road and the road leading to the dumping area. Collected by George M. Ehlers and Robert V. Kesling in 1950.
4. Bell shale present as a sink filling in the Rogers City limestone in the south wall of the quarry of the Michigan Limestone and Chemical Company at Calcite, Presque Isle County, N.  $\frac{1}{2}$  NE.  $\frac{1}{4}$  sec. 1, T. 34 N., R. 5 E. Collected by George M. Ehlers, Erwin C. Stumm, and Robert V. Kesling in 1949.
5. Bell shale removed from sink filling in the Rogers City limestone by quarrying operations in the Michigan Limestone and Chemical Company quarry, at Calcite, Presque Isle County, and now present as a dump pile, S.  $\frac{1}{4}$  SE.  $\frac{1}{4}$

sec. 25, T. 35 N., R. 5 E., on east side of secondary north-south quarry road east of the quarry powder houses. Collected by George M. Ehlers and Robert V. Kesling in 1950.

6. Upper ten feet of Bell shale below contact with Rockport Quarry limestone, in the Rockport, Alpena County, quarry of the Kelley's Island Lime and Transport Company, exposed in a drainage ditch, west of the quarry buildings, NW.  $\frac{1}{4}$  sec. 6, T. 32 N., R 9 E. Collected by George M. Ehlers, Erwin C. Stumm, and Robert V. Kesling in 1949.

#### SYSTEMATIC DESCRIPTIONS

### Phylum ARTHROPODA

#### Class CRUSTACEA

#### Order OSTRACODA

#### Superfamily Leperditieacea

#### Family Leperditellidae Ulrich and Bassler 1906

#### Genus *Aparchites* Jones

*Genotype*.—By original designation, *Aparchites whiteavesi* Jones, 1889, p. 384; Figs. 5, 6; Pl. 17, Fig. 10.

#### *Aparchites crossotus*, sp. nov.

(Pl. I, Figs. 1-12; Pl. II, Fig. 1)

*Description*.—Each valve subovate in lateral view. Dorsal border straight, anterior border rounded, ventral border gently rounded, and posterior border rounded. Dorsal border approximately four-fifths of length. Outline of lateral surface as seen in anterior view and in ventral view curved evenly but asymmetrically. Greatest width slightly ventral and slightly posterior. Greatest height nearly median, slightly anterior.

Anterior cardinal angle about 135 degrees; posterior cardinal angle about 125 degrees.

Two rows of short spines parallel to ventral half of free edge. Spines in first row well defined, near free edge. Spines in second row slightly smaller and spaced with less regularity, separated from those in first row by about one-fourth the width of the valve. Surface ornamented by small low granules except for a small ventral area having distantly spaced very small spines.

Hinge of right valve with shallow groove; end parts of this groove slightly deeper than middle part. Ventral part of free edge a short distance dorsal to ventral border.

Muscle scar visible in lateral view as large dark spot in dorsocentral

part of valve. Holotype showing parts of dark circle around dark spot, suggesting complex muscle scar.

Dimensions of holotype, a right valve: length, .98 mm.; height, .66 mm.; and width, .36 mm. Dimensions of paratype No. 27576, another right valve: length, 1.05 mm.; height, .71 mm.; and width, .40 mm.

*Remarks.*—This species is distinguished from others of *Aparchites* by the two rows of short spines parallel to the ventral part of the free edge, by the curvature of its outline in ventral view, and by the ornamentation of the lateral surface.

All specimens contain some crystals of pyrite replacing the original shell material.

The name of this species is derived from Greek κροσσωτος (“fringed”) and refers to the rows of short spines.

*Occurrence.*—Locality No. 1.

*Types.*—Holotype, an adult right valve, No. 27578; paratypes, one adult right valve, No. 27576, two immature left valves, Nos. 27577 and 27579, and an immature right valve (slightly crushed), No. 27591.

### Sphenicibysis, gen. nov.

*Description.*—Carapace nearly equivalved, subovate to subelliptical in lateral view. Dorsal border straight, free border curved throughout its length. Surface of each valve divided into lateral and marginal surfaces. Lateral surface separated from marginal surface by a sharp bend extending from anterior corner to posterior corner. Carapace nearly triangular in anterior view; the sides of the triangle formed by the lateral surface of the left valve, the lateral surface of the right valve, and the marginal surfaces.

Cardinal angles well defined.

*Remarks.*—This genus closely resembles *Sacclatia* Kay (1940, p. 242) from the Middle Ordovician strata. It differs from *Sacclatia* in having nearly flat lateral surfaces and in having the sharp bend in each valve complete from one corner to the other, separating all the marginal surface from the lateral surface. Furthermore, *Sphenicibysis hypoderota*, sp. nov., lacks the ventral lateral extensions described in several species of *Sacclatia*. As seen in ventral view, each bend of *Sphenicibysis* is very near the outline, whereas each bend of *Sacclatia* is closer to the plane of closure.

The name of this genus is derived from Greek σφην, m. (“wedge”) and κιβουσις, f. (“a wallet, a pocket”).

*Genotype.*—*Sphenicibysis hypoderota*, sp. nov.

**Sphenicibysis hypoderota**, sp. nov.

(Pl. I, Figs. 13-15)

*Description*.—Carapace nearly equivalved, subelliptical in lateral view. Free border with slight swing. Dorsal border straight, anterior border slightly curved, ventral and posterior borders evenly rounded. Greatest width ventral. Greatest height nearly median, slightly anterior. Carapace subtriangular in anterior view, lanceolate in ventral view. Lateral surface of each valve only slightly convex, separated from marginal surface by a sharp bend extending from anterior corner to posterior corner. Marginal surface flat as seen in anterior view. Bend of left valve meeting that of right valve at anterior corner and at posterior corner, at each junction forming an angle of about 22 degrees as seen in anterior and posterior views.

Anterior cardinal angle about 105 degrees; posterior cardinal angle approximately 120 degrees. Posterior corner subrounded.

Bend of each valve ornamented by small partly fused papillae. Surface of rest of valve granular.

Dimensions of holotype, a complete carapace: length, .74 mm.; height, .66 mm.; and width, .36 mm.

*Remarks*.—This species has unusual ornamentation on the bend of each valve and distinctive outlines in ventral and anterior views.

The name of this species is derived from Greek ὑποδερῖς, f. (“a necklace”) and refers to the ornamentation of each valve.

*Occurrence*.—Locality No. 1.

*Type*.—Holotype, a complete carapace, No. 27580.

## Superfamily Beyrichiacea

Family Primitiidae Ulrich and Bassler 1923

Genus *Punctoprimitia* Stewart and Hendrix

*Genotype*.—*Haploprimitia simplex* Stewart, 1936, p. 743; Pl. 100, Fig. 5, by subsequent designation of Stewart and Hendrix, 1945, p. 90.

*Punctoprimitia subaequalis* Swartz and Oriol

(Pl. II, Figs. 2-4)

*Punctoprimitia subaequalis* Swartz and Oriol, 1948, pp. 550-51; Pl. 79, Figs. 4-5.

*Occurrence*.—Localities Nos. 1 and 2.

*Types*.—Hypotypes, three right valves, Nos. 27592-27594.

Genus *Halliella* Ulrich

*Genotype*.—*Primitia? sculptilis* Ulrich, 1890, p. 136; Pl. 8, Fig. 6, by subsequent designation of Ulrich, 1891, p. 184.

*Halliella bellipuncta* (Van Pelt)

(Pl. I, Figs. 16-25)

*Amphisites bellipuncta* Van Pelt, 1933, p. 332; Pl. 39, Figs. 37-40.*Halliella bellipuncta* Warthin, 1934, p. 208; Pl. I, Fig. 2.*Halliella bellipuncta* Stewart, 1936, p. 746; Pl. 100, Figs. 15-16.*Kirkbyella bellipuncta* Warthin, 1937, Card 80.*Halliella bellipuncta* Turner, 1939, p. 12; Pl. I, Fig. 3.*Kirkbyella bellipuncta* Shimer and Shrock, 1944, p. 671; Pl. 282, Figs. 43-44.

*Remarks.*—Specimens from the Bell shale show variations in the ratio of height to length and in the shape of the ventrolateral extensions. These variations appear to be caused by individual differences rather than by dimorphism.

*Occurrence.*—Localities Nos. 1 and 2.

*Types.*—Hypotypes, three right valves, Nos. 27581, 27583, 27588, and seven left valves, Nos. 27582, 27584-27587, 27589, and 27590.

## Family Drepanellidae Swartz 1936

Genus *Ulrichia* Jones

*Genotype.*—By original designation, *Ulrichia conradi* Jones, 1890, p. 544; Fig. 2.

*Ulrichia conradi* Jones

(Pl. IV, Figs. 13-21)

*Ulrichia conradi* Jones, 1890, p. 544; Fig. 2.*Ulrichia conradi* Jones, 1891, p. 95; Pl. 11, Fig. 13.*Ulrichia conradi* Whiteaves, 1898, p. 409.*Ulrichia conradi* Bassler, in Cleland, 1911, p. 145; Pl. 44, Fig. 6.*Ulrichia conradi* Kindle, 1912, p. 115; Pl. 9, Fig. 12.*Ulrichia conradi* Ulrich and Bassler, 1923, pp. 299 and 301.*Ulrichia conradi* Knight, 1928, p. 252.*Ulrichia conradi* Bassler and Kellett, 1934, p. 17.*Ulrichia conradi* Shimer and Shrock, 1944, p. 667; Pl. 281, Fig. 38.*non Ulrichia conradi* Warthin, 1934, p. 213; Pl. I, Fig. 10.*non Ulrichia conradi* Stewart, 1936, p. 747; Pl. 100, Figs. 17-18.*non Ulrichia conradi* Warthin (partim), 1937, Card 94, Figs. 1, 1a, 2.*non Ulrichia conradi* Stewart and Hendrix, 1945, p. 89; Pl. 10, Fig. 2.

*Remarks.*—*Ulrichia conradi* Jones has been confused with *U. spinifera* Coryell and Malkin by some authors. Both species occur in the Bell shale. Specimens of the two species can be easily classified either from a lateral or from an interior view. As seen in lateral view, *Ulrichia conradi* has nodes of unequal size with the anterior node larger, whereas *U. spinifera* has nodes of equal size. Furthermore, the anterior node of *U. conradi* is



elongate and sloping, but both nodes of *U. spinifera* are nearly vertical. As seen in interior view, the marginal ridge of *U. conradi* is smooth, but the marginal ridge of *U. spinifera* is ornamented with small spines. These characteristics of the two species are summarized in Table I.

*Ulrichia conradi* has two delicate dorsal spines, one at the anterior corner and the other at the posterior corner. The posterior spine is slightly longer than the anterior. Since these spines are not mentioned in other descriptions, they may have been broken off in the specimens previously studied.

The specimens from the Bell shale have nodes of the same size and form as those shown in Jones' original illustration.

*Occurrence.*—Localities Nos. 1 and 2.

*Types.*—Hypotypes, three right valves, Nos. 27617, 27619, and 27620, and three left valves, Nos. 27618, 27621, and 27622.

*Ulrichia spinifera* Coryell and Malkin

(Pl. IV, Figs. 9–12)

*Ulrichia spinifera* Coryell and Malkin, 1936, pp. 1–2; Figs. 1–2.

*Ulrichia conradi* Warthin, 1934, p. 213; Pl. I, Fig. 10.

*Ulrichia conradi* Stewart, 1936, p. 747; Pl. 100, Figs. 17–18.

*Ulrichia conradi* Warthin (partim), 1937, Card 94, Figs. 1, 1a, 2.

*Remarks.*—The differences between this species and *Ulrichia conradi* Jones are discussed above and are summarized in Table I.

*Occurrence.*—Localities Nos. 1 and 2.

*Types.*—Hypotypes, two left valves, Nos. 27615 and 27616.

*Ulrichia fragilis* Warthin

(Pl. IV, Figs. 22–24)

*Ulrichia fragilis* Warthin, 1934, pp. 213–14; Pl. I, Fig. 11.

*Ulrichia fragilis* Stewart, 1936, p. 747; Pl. 100, Figs. 19–20.

*Ulrichia fragilis* Warthin, 1937, Card 95.

*Occurrence.*—Locality No. 2.

*Types.*—Hypotypes, one right valve, No. 27623, one left valve, No. 27624, and one carapace, No. 27625.

*Ulrichia* sp.

(Pl. IV., Fig. 25)

*Description.*—Small valve, subelliptical in outline. Two small smooth

nodes in centrodorsal area. Smooth velate ridge around free border. Lateral surface subreticulate with numerous small pits.

*Remarks.*—This specimen appears to be an immature valve of either *Ulrichia conradi* Jones, *Ulrichia spinifera* Coryell and Malkin, or *Ulrichia acricula*, sp. nov.

*Occurrence.*—Locality No. 2.

*Specimen.*—One left valve, No. 27626.

### *Ulrichia acricula*, sp. nov.

(Pl. IV, Figs. 1-8)

*Description.*—Carapace nearly equivalved, subelliptical in lateral view. Hinge line straight, approximately seven-eighths of the length. Anterior border evenly curved, ventral border very gently curved, and posterior border subrounded. Lateral surfaces subparallel as seen in dorsal view. Distinct velate ridge around free border of each valve from anterior to posterior corner, confluent with smaller marginal ridge at the corners but separated from it ventrally by a channel. Two stout hollow spines in dorsal part of each valve, projecting above hinge line.

Cardinal angles distinct, altered in some specimens by crushing and distortion of the valves. Anterior cardinal angle about 110 degrees; posterior cardinal angle about 100 degrees.

Large spines and velate ridge smooth. Lateral surface subreticulate with numerous small pits. Small marginal ridge with about fifteen small pointed spines evenly spaced along the free edge. Of the two large dorsal spines on each valve, the anterior spine is knoblike and shorter, the posterior spine subconical, its apex dorsal and posterior to the base, and its axis inclined toward the center of the carapace.

Dimensions of holotype, a left valve: length, .65 mm.; height (including posterior spine), .43 mm.; width (including spine), .17 mm.; and distance from hinge line to ventral border, .36 mm.

*Remarks.*—This species is similar to *Ulrichia spinifera* Coryell and Malkin and to *Ulrichia conradi* Jones. Table I is a summary of some characteristics of these three species. *Ulrichia acricula*, sp. nov., differs from *U. spinifera* in the form of the posterior large spine.

The name of this species is derived from Latin *acriculus* ("somewhat pointed") and refers to the shape of the posterior spine.

*Occurrence.*—Locality No. 2.

*Types.*—Holotype, adult left valve, No. 27614; paratypes, one complete carapace, No. 27613, and two crushed carapaces, Nos. 27611 and 27612.

TABLE I  
SOME CHARACTERISTICS OF THREE SPECIES OF *Ulrichia*

Species	Marginal Ridge	Size of Nodes	Slope of Nodes	Corners
<i>U. conradi</i>	Smooth	Anterior larger	Anterior sloping	Above hinge line
<i>U. spinifera</i>	With small spines	Equal	Both vertical	Even with hinge line
<i>U. acricula</i>		Posterior larger	Posterior sloping	

Family Aechminidae Swartz 1936

Genus *Aechmina* Jones and Holl

*Genotype*.—By original designation, *Aechmina cuspidata* Jones and Holl, 1869, p. 218; Fig. 2; Pl. 14, Fig. 8.

***Aechmina choanobasota*, sp. nov.**

(Pl. II, Figs. 15–25; Pl. III, Figs. 1–20)

*Description*.—Valves small, delicate. Very long hollow spine in centro-dorsal part of each valve. Except for spine, each valve subelliptical in lateral view and evenly curved in ventral and anterior views. Hinge line straight, anterior border subrounded, ventral border gently and evenly curved, and posterior border narrowly rounded. Spine as long or longer than the rest of the valve, with the diameter of its base equal to about one-half the length. As seen in lateral view, spine directed backward with its apex dorsal to the posterior one-fourth of the rest of the valve. Anterior edge of spine curved inwardly, posterior edge nearly straight. As seen in anterior view, axis of spine inclined to the plane of closure of the valves at an angle of approximately 45 degrees. Base of spine flaring, and its junction with the rest of the valve inconspicuous except in posterior part. Slight development of a ridge along the anterior edge of some specimens.

Anterior cardinal angle about 120 degrees; posterior cardinal angle about 140 degrees.

Surface smooth.

Dimensions of holotype, a right valve: length, .65 mm.; height (including spine), .80 mm.; width (including spine), .45 mm.; greatest diameter (along axis of spine), 1.00 mm.; and distance from hinge line to ventral border .32 mm.

*Remarks*.—This species resembles *Aechmina marginata* Ulrich (1891, p. 184, Pl. 16, Fig. 5) from which it differs in having the base of the spine

wider and in having the axis of the spine much more inclined as seen in lateral view.

Specimens of *Aechmina choanobasota*, sp. nov., show variations in the length of the spine, in the ratio of height to length, and in the development of the anterior ridge. All other dimensions have little variation.

The name of this species is derived from Greek *χοανη*, f. ("funnel") and *βασις*, f. ("base") and refers to the flaring base of the large spine.

*Occurrence*.—Localities Nos. 1 and 2.

*Types*.—Holotype, a right valve, No. 27609; paratypes, six left valves, Nos. 27601, 27602, 27604, 27606, 27608, and 27610, and three right valves, Nos. 27603, 27605, and 27607.

#### Family Kirkbyidae Ulrich and Bassler 1906

##### *Arcyzona*, gen. nov.

*Description*.—Carapace nearly equivalved, subquadrate to subelliptical in lateral view. Dorsal border straight, anterior border subrounded to rounded, ventral border straight or slightly curved, and posterior border subrounded. Large pit near center of each valve. Node on interior of valve opposite pit. Muscle scars on interior node. No lobes or nodes on exterior surface. Velate ridge in all species; carina also present in some species.

Cardinal angles unequally obtuse in most species, with the anterior angle larger.

Surface coarsely reticulate in all species.

*Remarks*.—Chalmer L. Cooper (1941, pp. 47–49) has restricted the genus *Amphissites* to those species closely related to the genotype, *Amphissites rugosus* Girty (1910, p. 235). *Amphissites*, as restricted, is subquadrate in outline. It has a single central node, a small pit posteroventral to the node, a velate ridge, one or more carinae, and a dorsal ridge parallel to the hinge line. Ostracods with these characteristics are found in formations of the Mississippian, Pennsylvanian, and Permian periods. *Arcyzona*, as defined, differs from *Amphissites* in lacking a central node and in having a larger pit and coarser reticulation on the lateral surface.

Cooper (1941, p. 49) described the genus *Ectodemites* to include kirkbyan ostracods which lack the distinctly subquadrate outline of *Amphissites* and have only a slight swelling above the subcentral pit. *Arcyzona* has no such swelling above its pit and the pit is in the center of the valve. Furthermore, in comparison with *Ectodemites*, *Arcyzona* has a larger pit and coarser reticulation.

*Arcyzona* includes most species from the Devonian which have been assigned to *Amphissites*.

The name of this genus is derived from Greek ἀρκυς, f. ("net") and ζώνη, f. ("girdle") and refers to the reticulation.

*Genotype*.—*Amphissites diadematus* Van Pelt.

*Arcyzona diademata* (Van Pelt)

(Pl. II, Fig. 14; Pl. IV, Figs. 34–38; Pl. V, Fig 1)

*Amphissites diadematus* Van Pelt, 1933, p. 239; Pl. 39, Figs. 11, 14–15.

*Amphissites diadematus* Coryell and Malkin, 1936, p. 4, Fig. 10.

*Amphissites subquadratus* Warthin (partim), 1937, Card 102, Figs. 11, 14–15.

*Occurrence*.—Localities Nos. 1, 2, and 4.

*Types*.—Hypotypes, one carapace, No. 27639, five right valves, Nos. 27635–27638, and 27640, and one left valve, No. 27600.

*Arcyzona rhabdota*, sp. nov.

(Pl. II, Figs. 8–9; Pl. V, Figs. 2–6)

*Description*.—Carapace subquadrate with greatest height posterior. Dorsal border straight, about three-fourths of length; anterior border rounded, ventral border straight, and posterior border subrounded. Lateral surface rather flat. Large deep pit near center of valve; diameter of pit about one-sixth the height. Thick velate ridge from anterior corner to posterior corner; anterior part of ridge subrounded, ventral part straight, and posterior part gently curved.

Corners subrounded. Anterior cardinal angle approximately 130 degrees; posterior cardinal angle about 120 degrees.

Lateral surface coarsely reticulate. Certain ridges of the reticulation at a higher level than the others; higher ridges including rim around central pit, subvertical ridges in dorsal half of lateral surface, and four equally spaced ridges parallel to the ventral border in the ventral half of the lateral surface. Velate ridge ornamented by few broad low crests along its length and by short crests at right angles to the direction of the ridge, forming a reticulation; ornamentation of velate ridge indistinct in some specimens.

Small low broad marginal ridge. Rounded node on interior of valve opposite the external pit. Dimensions of holotype, a right valve: length, .90 mm.; height, .56 mm.; and width, .18 mm.

*Remarks*.—This species has no carinae, unless the four raised ridges of the reticulation in the ventral half of the lateral surface are so interpreted. These ridges are all the same height and in this description are interpreted as part of the ornamentation. This species differs from *Arcyzona bythi-climacota*, sp. nov., and *A. campylactinota*, sp. nov., in lacking any distinct carinae. Some characteristics of the six species of *Arcyzona* found in the Bell shale are summarized in Table II.

The name of this species is derived from Greek  $\rho\alpha\beta\delta\omega\tau\omicron\varsigma$  ("striped") and refers to the raised ridges in the ventral half of each valve.

*Occurrence*.—Localities Nos. 1, 3, 4, and 5.

*Types*.—Holotype, one right valve, No. 27596; paratypes, five right valves, Nos. 27597 and 27641-27644, and one carapace, No. 27645.

TABLE II  
SOME CHARACTERISTICS OF SIX SPECIES OF *Arcyzona*

Species	Velate ridge	Carina	Reticulation	
<i>A. diademata</i>	Not reaching corners	Complete	Even	
<i>A. homalosagenota</i>	Complete	None		
<i>A. apobathrota</i>		Joining vclate ridge		
<i>A. rhabdota</i>		Only even ridges present	With raised ridges	One level
<i>A. bythiclimacota</i>		Made of two ridges		Two levels
<i>A. campylactinota</i>				

***Arcyzona bythiclimacota*, sp. nov.**

(Pl. II, Fig. 10; Pl. V, Figs. 12-16)

*Amphissites diadematus* Van Pelt (partim), 1933, Pl. 39, Fig. 8.

*Description*.—Carapace subquadrate with greatest height posterior. Dorsal border straight, anterior border subrounded, ventral border straight, and posterior border subrounded. Deep central pit, its diameter about one-sixth the height. Thick velate ridge from anterior corner to posterior corner, in most specimens bounded by the free border. Lateral surface flat or gently arched, except parts forming a groove adjacent to ventral part of velate ridge.

Corners subrounded. Anterior cardinal angle about 130 degrees; posterior angle about 120 degrees.

Lateral surface coarsely reticulate. Vertical ridges of the reticulation in the anterodorsal part of valve at a higher level than other ridges. Two long ridges forming a carinate structure parallel to ventral border. These ridges, about three-fourths the length of the valve, set close together about midway between the pit and the ventral border; about ten short ridges from one long ridge to the other, the long ridges scalloped inward at their junctions with the short ridges, giving the whole carinate structure the

appearance of a chain. Velate ridge ornamented by several small closely spaced crests along its length; these crests linked together by short connecting crests to form a very small elongate reticulation. Lateral surface between velate ridge and carinate structure ornamented by short ridges at right angles to the direction of the velate ridge; these short ridges slightly lower than the other surface ornamentation.

As seen in ventral view, lateral surfaces nearly parallel, only slightly inflated. Small marginal ridge, separated from velate ridge by wide shallow channel.

Dimensions of holotype, a left valve: length, 1.01 mm.; height, .64 mm., and width, .24 mm.

*Remarks.*—This species is very similar to *Arcyzona rhabdota*, sp. nov., from which it differs in having a carinate structure and in having larger reticulations adjacent to the velate ridge. In Table II some characteristics of this species are compared with those of other species of *Arcyzona* from the Bell shale.

The name of this species is derived from Greek βυθιος ("sunken") and κλιμαξ, f. ("ladder") and refers to the form of the reticulation between the velate ridge and the carinate structure.

*Occurrence.*—Localities Nos. 1, 3, and 4.

*Types.*—Holotype, a left valve, No. 27652; paratypes, one left valve, No. 27651, and four right valves, Nos. 27598 and 27653–27655.

### *Arcyzona apobathrota*, sp. nov.

(Pl. V, Fig. 19)

*Description.*—Carapace subquadrate with greatest height posterior. Dorsal border straight, about two-thirds of the length; anterior border subrounded, ventral border straight, and posterior border subrounded. Deep pit near center of valve, its diameter about one-ninth the height. Thick velate ridge from anterior corner to posterior corner, nearly parallel to free border. Lateral surface gently arched.

Corners subrounded.

Lateral surface reticulate. All ridges forming the reticulation of about the same height. Carina in ventral part of valve, parallel to velate ridge. Carina formed of two incompletely fused ridges, at their posterior end about the same height as the velate ridge and joined to it. Carina decreasing in height toward the anterior end and terminating behind the antero-ventral part of the velate ridge. Velate ridge indistinctly reticulate with low ridges.

As seen in ventral view, lateral surface nearly parallel to free edge. Small marginal ridge.

Dimensions of holotype, a complete carapace: length, .86 mm.; height, .58 mm.; and width, .38 mm.

*Remarks.*—This species is distinguished from the other species of *Arcyzona* described in this paper by the form of the carina and by the even reticulation on the lateral surface.

The name of this species is derived from Greek ἀποβαθρα, f. ("gangway, gangplank of a ship") and refers to the form of the carina.

*Occurrence.*—Localities Nos. 1, 2, and 6.

*Type.*—Holotype, a complete carapace, No. 27658.

### *Arcyzona homalosagenota*, sp. nov.

(Pl. V, Figs. 17–18)

*Description.*—Carapace subquadrate with greatest height posterior. Dorsal border straight, about three-fourths of the length; anterior border subrounded, ventral border straight, and posterior border gently curved. Deep pit near center of valve, its diameter about one-seventh the height. Velate ridge from anterior corner to posterior corner. Lateral surface gently arched.

Corners subrounded. Anterior cardinal angle about 120 degrees; posterior cardinal angle slightly less.

Lateral surface reticulate. All ridges forming the reticulation of about the same height. No carina. Velate ridge with low indistinct reticulation.

As seen in ventral view, lateral surfaces nearly parallel. Small marginal ridge.

Dimensions of holotype, a right valve: length, .87 mm.; height, .53 mm.; and width, .26 mm.

*Remarks.*—This species differs from other species of *Arcyzona* described in this paper in having even reticulation and in lacking a carina (see Table II).

The name of this species is derived from Greek ὀμαλος ("level") and σαγήνη, f. ("a seine, a net") and refers to the even reticulation.

*Occurrence.*—Localities Nos. 1, 2, and 4.

*Types.*—Holotype, a right valve, No. 27656; paratype, another complete carapace, No. 27657.

### *Arcyzona campylactinota*, sp. nov.

(Pl. II, Figs. 11–13; Pl. V, Figs. 7–11)

*Amphissites subquadratus* Stewart, 1936, p. 752; Pl. 101, Figs. 5–6.



*Description.*—Carapace subquadrate with greatest height posterior. Dorsal border straight, about two-thirds of the length; anterior border subrounded, ventral border straight, and posterior border subrounded. Near the center of the valve, a pit with diameter about one-sixth of the height.

Corners subrounded. Anterior cardinal angle slightly larger than the posterior cardinal angle.

Surface ornamented with a complex reticulation made of ridges of two heights. Lower ridges only slightly above rest of lateral surface, and indistinct in specimens coated with ammonium chloride. Higher ridges in a distinctive pattern; those in dorsal part of lateral surface crooked, arranged roughly as radii from the center of the pit; those in ventral part of lateral surface nearly parallel to ventral border. Carina near velate ridge, composed of two ridges parallel to ventral border and joined together by short ridges. Carina terminating anteriorly and posteriorly near the velate ridge. Velate ridge ornamented by a reticulation composed of small crests; higher crests of this reticulation nearly parallel to direction of the ridge, but branching toward the posterior. Some of the branching crests terminating at intervals, the number of crests on one part of the ridge being about the same in number as on any other part.

As seen in ventral view, lateral surfaces flat and parallel. Small marginal ridge on each valve ornamented with very small closely spaced denticles. Channel between marginal ridge and velate ridge, shallow in anterior and posterior parts and deeper in ventral part.

Dimensions of holotype, a complete valve: length, 1.09 mm.; height, .65 mm., and width, .40 mm.

*Remarks.*—This species differs from other species of *Arcyzona* in having ridges of two heights in the reticulation, the distinctive pattern of the high ridges, and the carina made of two ridges with short connecting ridges.

Stewart (1936, p. 752) says the specimens she studied from the Silica shale have characteristics of *Amphissites subquadratus* Ulrich. She believes that young forms have a reticulate surface, but the older a more convex carapace with the reticulation developed into ridges. Some species of *Arcyzona* in the Bell shale have even reticulation (for example, *A. homalosagenota*, sp. nov.), whereas other species have some ridges of the reticulation higher than the others (for example, *A. campylactinota*, sp. nov., and *A. rhabdota*, sp. nov.), although the size of the largest specimens in one of these species is about the same as that in the other species.

The specimen illustrated by Stewart (1936, Pl. 101, Figs. 5–6) lacks certain characteristics of the genus *Amphissites*. It lacks a central node and a ridge parallel to the hinge line and it has a large subcircular pit and

coarse reticulation. It properly belongs to the genus *Arcyzona*, gen. nov., and probably to the species *A. campylactinota*, sp. nov.

The name of this species is derived from Greek *καμπυλος* ("bent, crooked") and *ακτις*, f. ("ray, beam") and refers to the higher ridges of the reticulation in the dorsal part of the lateral surface.

*Occurrence*.—Localities Nos. 1, 2, 3, and 4.

*Types*.—Holotype, a complete carapace, No. 27599. Paratypes, two right valves, Nos. 27647–27648, one left valve, No. 27649, and two carapaces, Nos. 27646 and 27650.

### **Chironiptrum**, gen. nov.

*Description*.—Valves subelliptical to subquadrate. No development of lobes, and lateral surface flat or gently arched. Frill completely surrounding lateral surface. Deep pit near center of valve. Node on interior of valve opposite deep pit. Surface reticulate.

*Remarks*.—The unusual development of the frill distinguishes this genus from other genera of the Kirkbyidae.

The name of this genus is derived from Greek *χειρονιπτρον*, n. ("hand basin") and refers to the shape of the valve.

*Genotype*.—*Chironiptrum oiostathmicum*, sp. nov.

### **Chironiptrum oiostathmicum**, sp. nov.

(Pl. II, Figs. 5–7; Pl. IV, Figs. 26–33)

*Description*.—Valves subelliptical to subquadrate. Hinge line straight. Anterior border rounded, ventral border nearly straight, and posterior border rounded. Deep pit near center of valve. Lateral surface completely surrounded by wide flaring frill. Outline of unusual frill subelliptical, except for two flat spurlike projections pointing posteriorly, one at the anterodorsal corner and the other at the posterodorsal corner. Projections delicate and broken from many specimens. Frill widest at posteroventral part and narrowest in anterodorsal part. Lateral surface very gently arched. Greatest width slightly posterior.

Cardinal angles approximately 120 degrees.

Frill and channel smooth. Lateral surface finely but distinctly reticulate. Lateral surface also ornamented by scattered large subspherical papillae located at intersections of the small sharp ridges forming the reticulation.

Valves thin as seen in anterior and ventral views. Small marginal ridge with small regularly spaced delicate denticles; space between denticles

about twice the diameter of each denticle. Frill separated from hinge and from small marginal ridge by narrow continuous channel. Node on interior of valve opposite this pit.

Dimensions of holotype, a right valve: length, .75 mm.; height, .49 mm.; and width, .12 mm.

*Remarks.*—This beautiful species has unusual ornamentation of the lateral surface.

The name of this species is derived from the Greek *οἶς*, f. ("sheep") and *σταθμος*, m. ("fold, stall") and is suggested by the resemblance of the scattered round papillae and the surrounding high frill to sheep and the walls of a fold.

*Occurrence.*—Localities Nos. 1, 4, and 5.

*Types.*—Holotype, a right valve, No. 27595; paratypes, five right valves, Nos. 27627–27631, and three left valves, Nos. 27632–27634.

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**PLATES**

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PLATE I

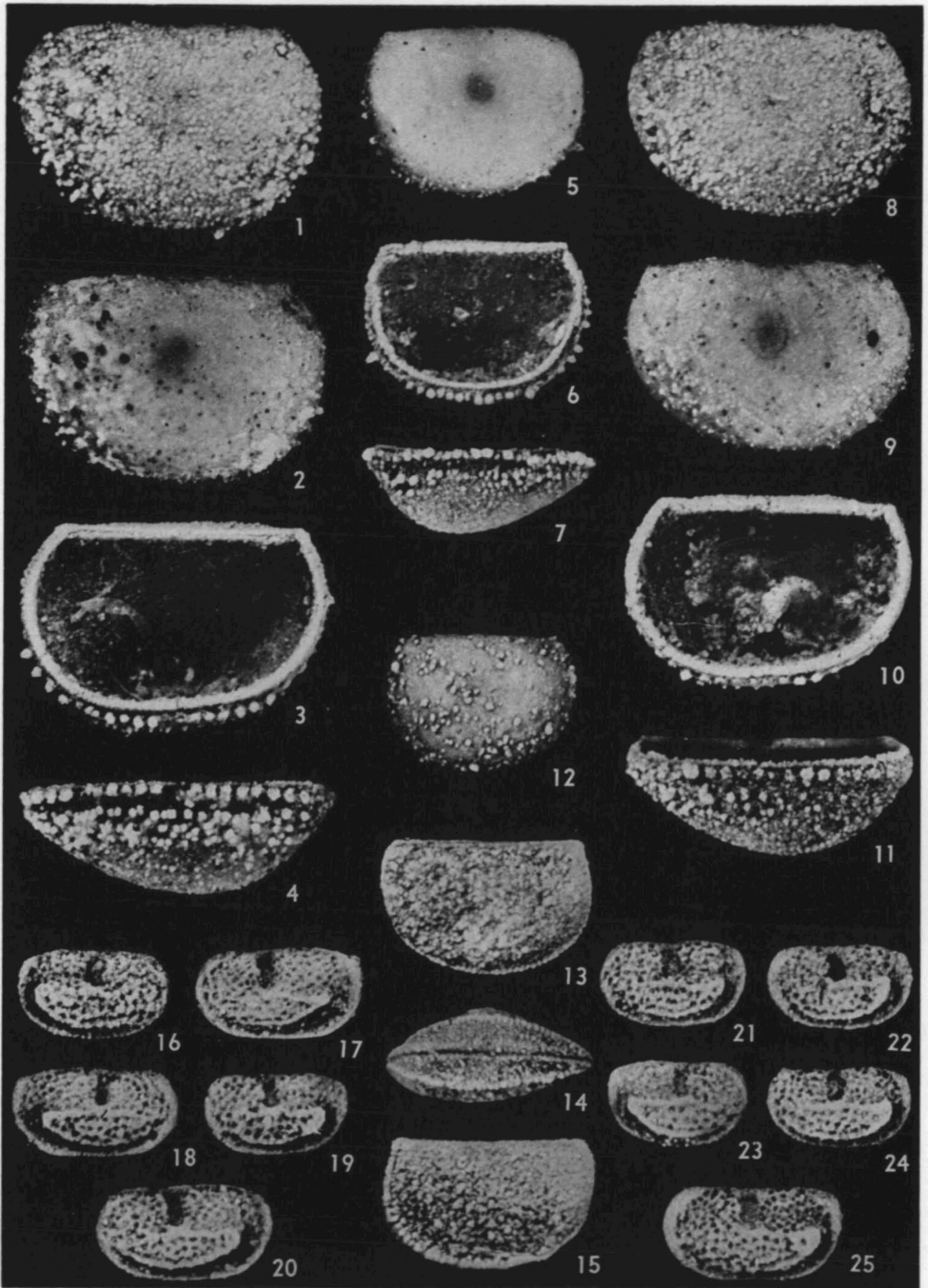
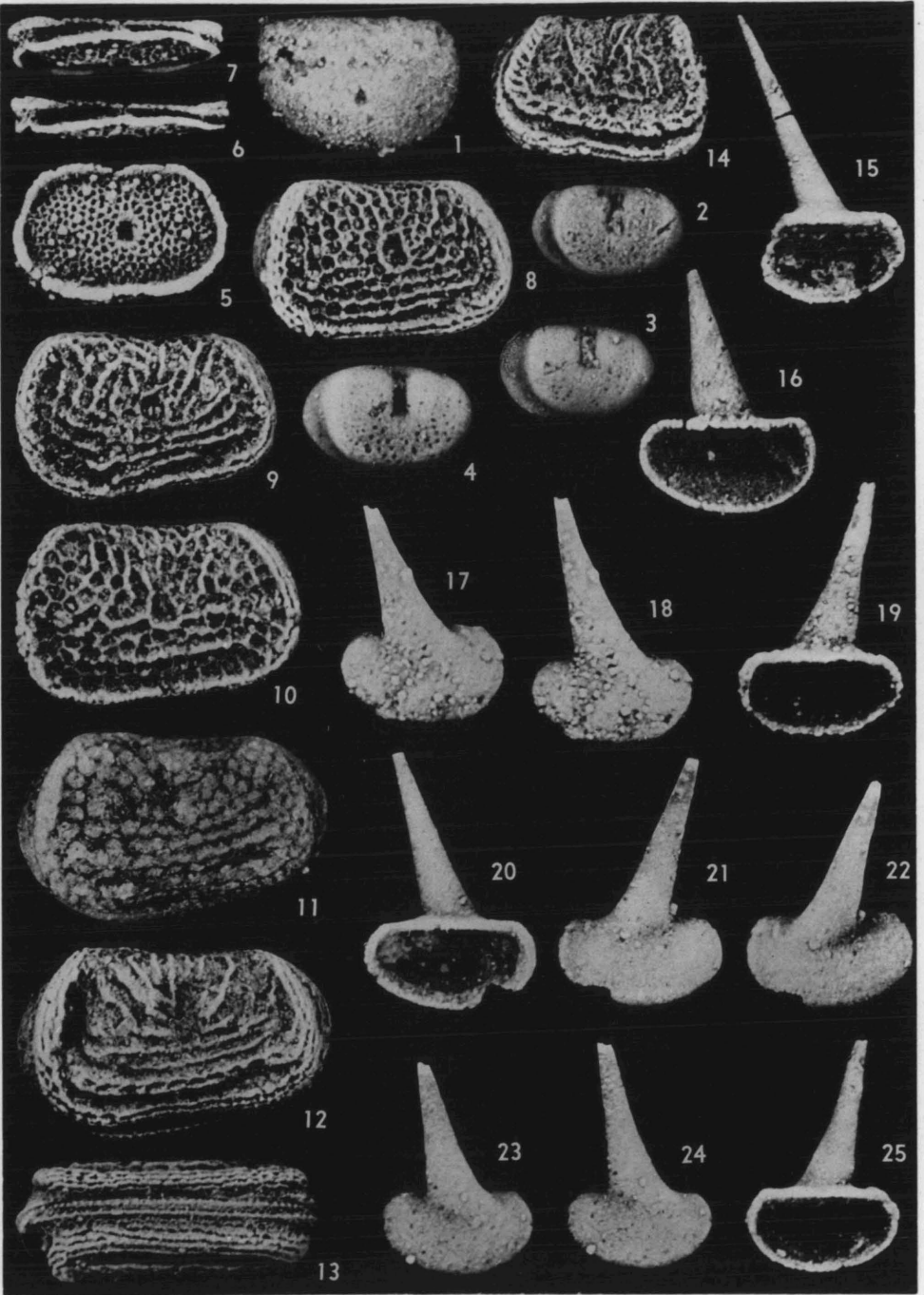


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## EXPLANATION OF PLATE II

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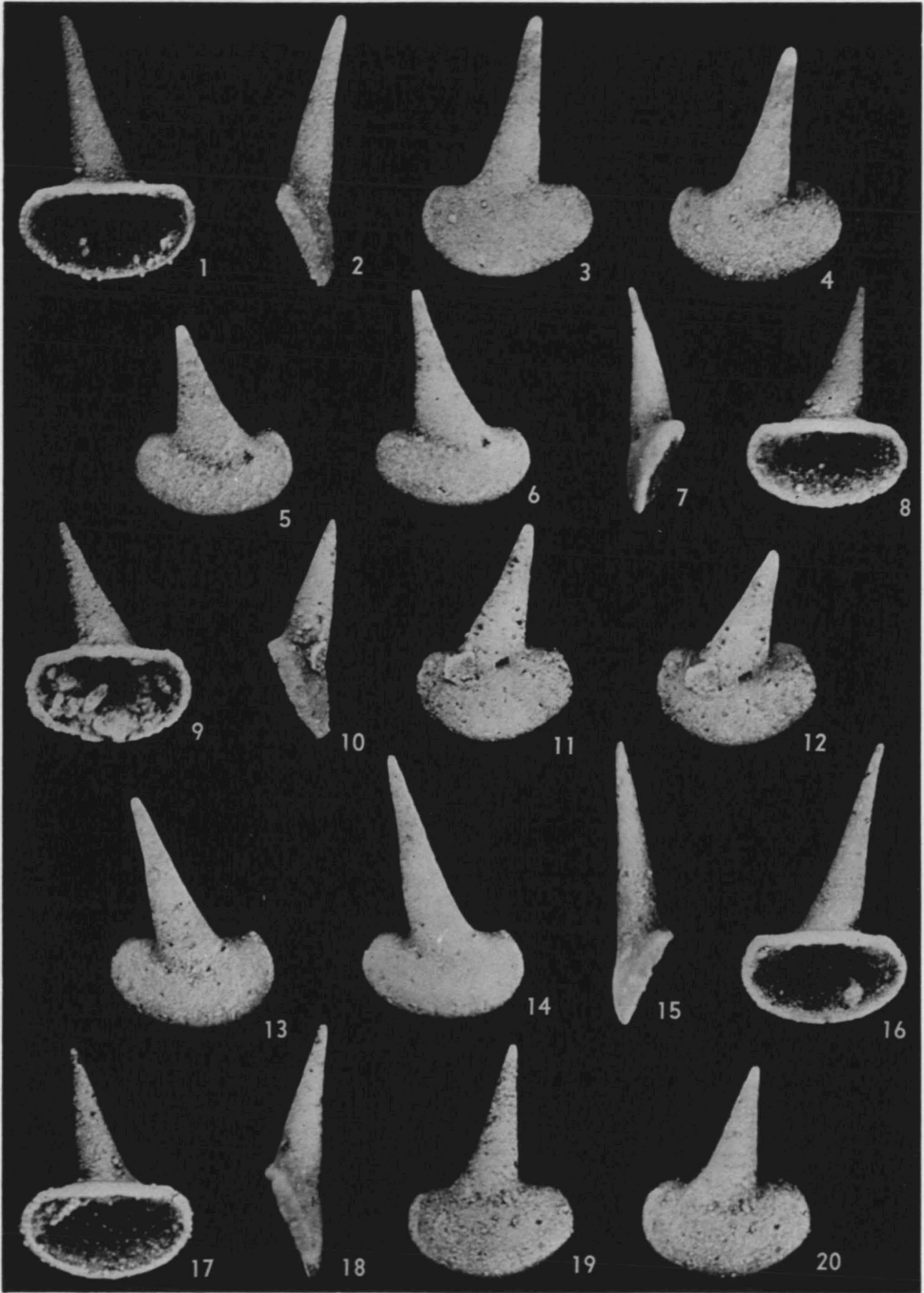
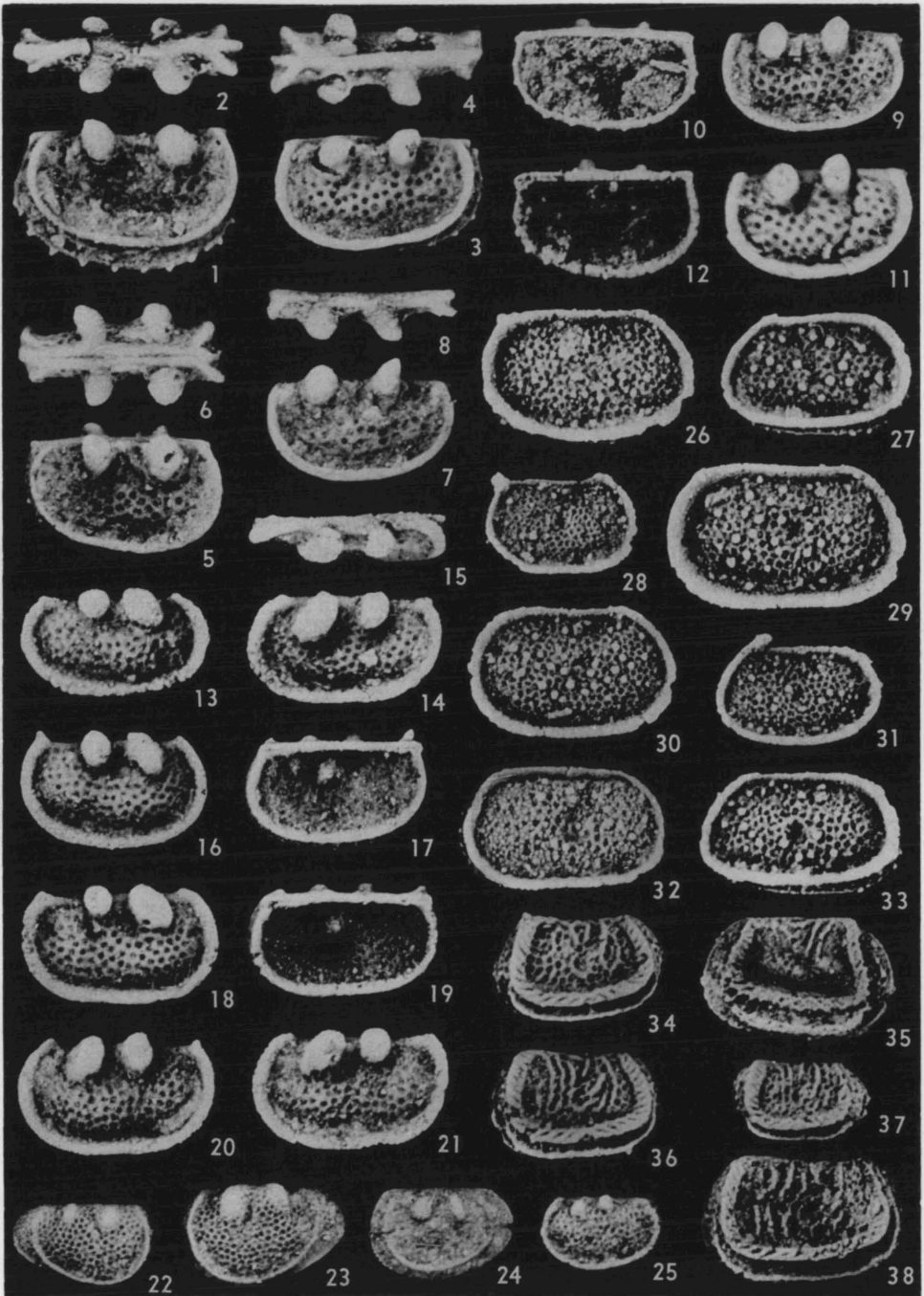


PLATE IV



## EXPLANATION OF PLATE IV

(All figures  $\times 40$ )

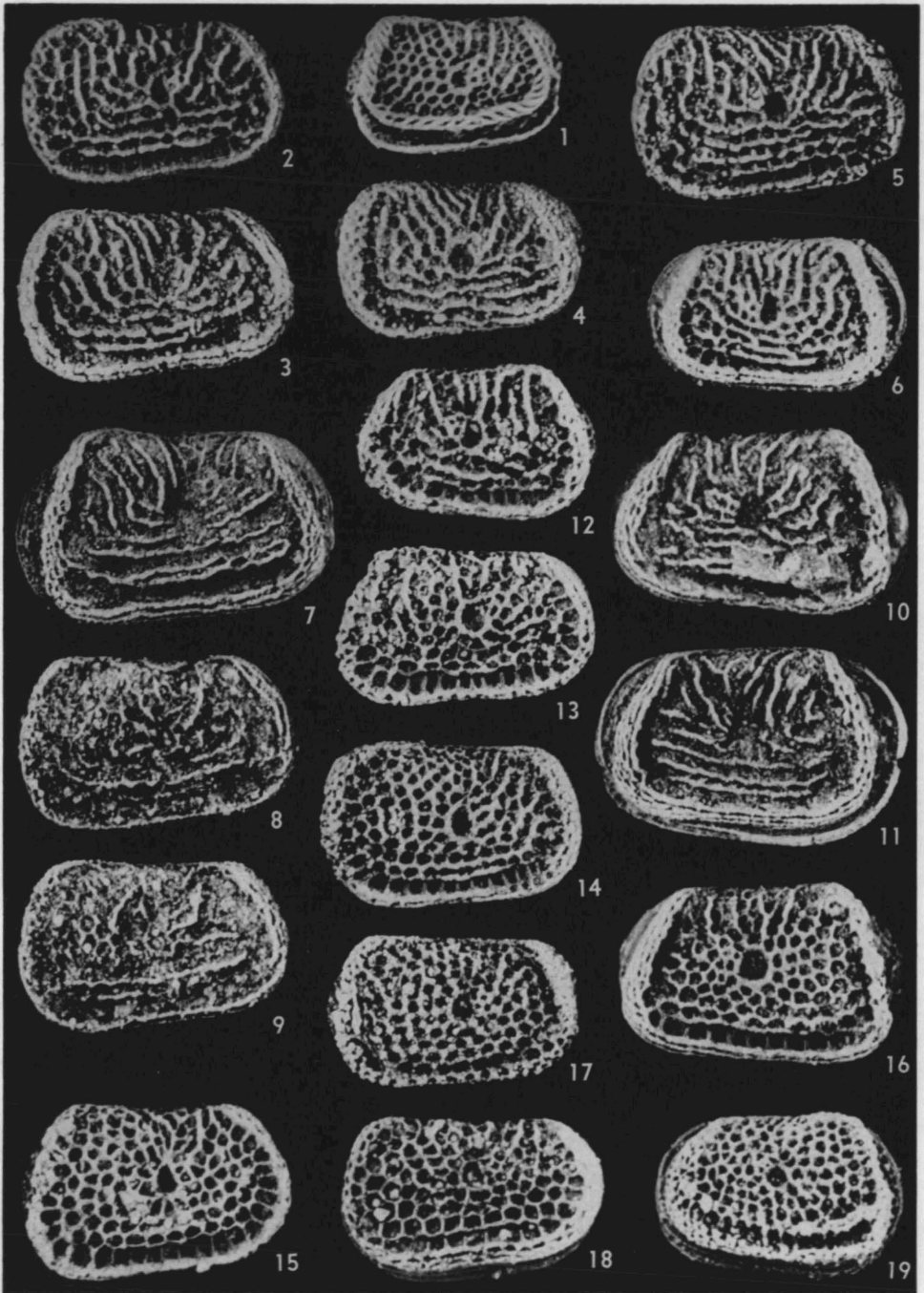
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PLATE V







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