CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

THE UNIVERSITY OF MICHIGAN

VOL. XX, No. 8, pp. 195–269 (24 pls., 4 figs.)

HINGEMENT AND CONTACT MARGIN STRUCTURE OF PALAEOCOPID OSTRACODES FROM SOME MIDDLE DEVONIAN FORMATIONS OF MICHIGAN, SOUTHWESTERN ONTARIO, AND WESTERN NEW YORK

BY

JAMES C. MELIK

With descriptions of three new species by Martin Weiss

Published with aid from the Paleontology Accessions Fund

MUSEUM OF PALEONTOLOGY
THE UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

Director: LEWIS B. KELLUM

The series of contributions from the Museum of Paleontology is a medium for the publication of papers based chiefly upon the collection in the Museum. When the number of pages issued is sufficient to make a volume, a title page and a table of contents will be sent to libraries on the mailing list, and to individuals upon request. A list of the separate papers may also be obtained. Correspondence should be directed to the Museum of Paleontology, The University of Michigan, Ann Arbor, Michigan.

VOLS. II–XIX. Parts of volumes may be obtained if available.

VOLUME XX

1. Upper Devonian and Lower Mississippian Pectinoid Pelecypods from Michigan, Ohio, Indiana, Iowa, and Missouri, by Thomas W. Hutchinson and Erwin C. Stumm. Pages 1–48, with 7 plates.
2. Two New Middle Devonian Species of the Starfish *Devonaster* from Southwestern Ontario, by Robert V. Kesling and Jean D. Wright. Pages 49–61, with 4 plates.
3. A Revision of the Ordovician Trilobite *Asaphus platycephalus* Stokes, by David G. Darby and Erwin C. Stumm. Pages 63–73, with 2 plates.
4. *Proctothylacocrinus esseri,* a New Crinoid from the Middle Devonian Silica Formation of Northwestern Ohio, by Robert V. Kesling. Pages 75–87, with 5 plates.
5. Additions to and Revision of the Oligocene Ruby Paper Shale Flora of Southwestern Montana, by Herman F. Becker. Pages 89–119, with 6 plates.
6. Stratigraphy and Paleontology of the McPherson Equus Beds (Sandahl Local Fauna), McPherson County, Kansas, by Holmes A. Semken. Pages 121–178, with 7 figs., 1 map.
7. *Trochiliscus bellatulus* Peck from the Middle Devonian Dundee Limestone of Northwestern Ohio, by Robert V. Kesling and Roger F. Boneham. Pages 179–194, with 3 plates.
8. Hingement and Contact Margin Structure of Palaeocopid Ostracodes from Some Middle Devonian Formations of Michigan, Southwestern Ontario, and Western New York, by James C. Melik, with descriptions of three new species by Martin Weiss. Pages 195–269, with 24 plates, 4 figures.

VOL. XX, No. 8, 195–269 (24 pls., 4 figs.) JUNE 15, 1966

HINGEMENT AND CONTACT MARGIN STRUCTURE OF PALAEOCOPID OSTRACODES FROM SOME MIDDLE DEVONIAN FORMATIONS OF MICHIGAN, SOUTHWESTERN ONTARIO, AND WESTERN NEW YORK

BY

JAMES C. MELIK

With descriptions of three new species by Martin Weiss

ABSTRACT

Hinges are seldom preserved in single valves and they are difficult to study in carapaces with crystalline steinkerns. The hinge and contact margin structure have been worked out on many Middle Devonian species from examination of a large number of single valves and of acetate peels prepared from complete carapaces. Peel series have also revealed other important features of shell morphology.

Five types of hinge structure were found to be represented in the Middle Devonian palaeocopid ostracodes:

I. Smooth contact of hinge areas.

II. Adont (a groove in one valve accommodating a bar of opposite valve).

III. Biversus (proposed for hingement consisting of a groove in each valve, accommodating a bar of opposite valve, and with each valve usually possessing either two cardinal teeth or two cardinal sockets.

IV. Prionodont (a groove in one valve and bar in opposite valve, each modified by minute sockets and teeth).

V. Complex (exceptions which do not fit other categories).

The results of this study may serve as a step toward the utilization of hingement as a taxonomic character in palaeocopid ostracodes.

Three new species are described by Martin Weiss herein.

CONTENTS

INTRODUCTION

THIS STUDY was undertaken to discover the types of hinge structure in palaeocopid ostracodes and to determine whether hingement has taxonomic significance. Well-preserved specimens were serially polished and acetate peels prepared.

Field collecting was done in Michigan, Ontario, and New York. All localities of Middle Devonian strata known to yield well-preserved ostracodes were visited. The samples were washed, screened, and picked in the laboratory at the Museum of Paleontology. Only the best specimens were studied.

Several techniques were tried to reveal hinge structure. Separation of valves from complete carapaces was found to be unsatisfactory. Isolated valves and peels from polished surfaces of carapaces show the structures in each valve and how they fit together.

The study of hingement and contact margin structures was completed in May, 1963. Three of the species concerned were discovered by Martin Weiss, and described in his doctoral dissertation in 1954. They are here published for the first time and are credited to Dr. Weiss.

Thanks are due to Professor Robert V. Kesling for directing this study. Through his efforts a Croft Parallel Grinding Instrument was obtained by a grant from the American Academy of Arts and Sciences. The author received grants from the Society of the Sigma Xi and from the Graduate Student Research Fund of The University of Michigan, offsetting part of

the expenses of collection and preparation. This paper was critically read by Professor Lewis B. Kellum, Professor Chester A. Arnold, and Professor Kesling. To all of them I express my sincere appreciation.

All specimens numbered herein are catalogued and deposited in the Museum of Paleontology of The University of Michigan, as denoted by the prefix UMMP.

PREVIOUS WORK

Although hingement is one of the most important characters used in classification of Mesozoic and Cenozoic ostracodes, it has been little used in the palaeocopid ostracodes. To the knowledge of the writer, only four papers have been published which concern palaeocopid hingement. In a paleontological note, Sohn (1949) stated that he observed opposing valves of specimens of the same species that possessed hinge elements which could not possibly "key" into one another. He observed that living fresh-water ostracodes open their valves only five to ten degrees in order to extrude their appendages, and suggested that Paleozoic ostracodes had very small opening angles also. He concluded that the ligament along the dorsal margin of Paleozoic ostracodes acted as an elastic medium that was compressed when the valves closed, and that "The groove and flange elements that compose the hinge structure of many groups of Paleozoic ostracodes served in part as a fulcrum and in part to strengthen the attachment of the ligament to the valves." Unfortunately, he gave no examples of species with non-complementary hingement in the two valves.

Levinson (1950) described the hingement of some Paleozoic podocopid and palaeocopid ostracodes and illustrated them by composite camera lucida drawings. Some of the palaeocopids which he illustrated appear to fit into the hinge-type categories as set up in the present study, but others would be classified as complex. He concluded (p. 65) that "There is no doubt that simple to fairly complex hingement occurs in the early Paleozoic ostracode genera, and that this hingement varies among genera so that it may be employed in classification, identification, and orientation." For some species he described the hingement of only a left or right valve. He did not attempt to set up hinge-type categories based on the species which he studied.

In a doctoral dissertation, Wainwright (1959) made serial sections from some Middle Silurian ostracodes, and observed the hingement of several single valves. He stated that an adont type hingement was present in the eight palaeocopid species which he studied. However, he found that *Eukloedenella sinuata* had a groove and bar present in each valve. In all cases he did not have both valves available for study. He stated (p. 61):

In summary, hingement of the species investigated in each case was of a simple bar and groove type, with only minor modification in the form of a groove bordering the hinge bar in the left valve of *Eukloedenella sinuata.* It was impossible to detect minor crenulations of the hinge structure in transverse section, but the presence or absence of cardinal teeth can almost certainly be determined. Observation of the exposed hinge areas of *Kloedenella cornuta* and *Paraechmina postica* showed no supplementary hinge structures. The hinge data presented here should not be interpreted as representative of the mode of hingement throughout the families represented by the species investigated, for it is indeed probable that an important structural element as the hinge would show some evolutionary modification through time.

Pokorný (1959) illustrated the hinge and contact margin structures of some palaeocopid ostracodes from the Silurian of Gotland. Assuming that palaeocopids possessed a duplicature, he homologized hinge elements with ridges on the contact margin. He also pointed out that the hingement of *Primitia bonnemai* is more complex than Levinson (1950, p. 67) had described it. The hingement of the species which Pokorný illustrated would have to be placed in the complex category of the present writer, with the exception of *Clavofabella multidentata,* which would fit into the biversus group.

Pokorný also stated (p. 339) that in some genera the hingement of the left and right valves at first glance did not appear to "key" into one another, but his detailed study showed that the valves were complementary in their hingement. He implied that Sohn (1949), who found opposite valves of the same species which apparently did not "key" into one another, did not make a thorough examination. Pokorný (p. 339) concluded that,

> The diversity of the free margin and hinge structures gives the paleontologist a very suitable tool for a radical improvement of the existing system of the Paleozoic ostracodes, which is based largely on the general form and sculpture. Both these features, however, are largely convergent and the conclusions made on their basis must be necessarily controlled on another basis.

Other papers concerned with hingement deal mainly with post-Paleozoic ostracoda. These include Zalányi (1929), Kingma (1948), Malkin (1953), Triebel (1950), Sylvester-Bradley (1956), Howe and Laurencich (1958), and Hanai (1961).

PROCEDURE

The hinge, contact margin, and shell structure of complete carapaces were studied by the peel method in a manner similar to that used by Kesling (1957) on *Hibbardia lacrimosa* (Swartz and Oriel). Below is a detailed description of the peel technique.

Many single valves with hingement preserved were found by sorting large numbers of specimens. Because most have been subjected to abrasion and corrosion, single valves may not reliably portray the hingement.

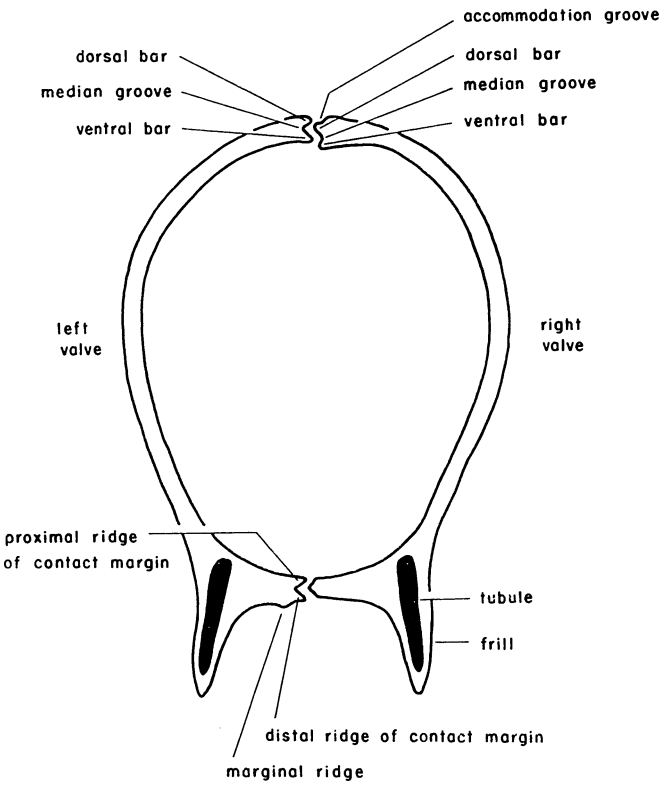


FIG. 1. Generalized cross section illustrating some features of the hinge and contact margin.

Other methods were tried in the attempt to reveal the hingement of complete carapaces. Calcining the specimens before embedding them in plastic often produced a difference in tone between the shell and steinkern. Staining the polished surface of an embedded carapace usually emphasized a difference between the shell and stienkern. Of several stains which were tried, alizarine red-S and Heeger's solution gave better results than others. Friedman (1959) gives an excellent presentation concerning the stains which can be used for carbonate minerals.

Attempts were made to separate the valves of complete carapaces having crystalline steinkerns, but no satisfactory method was found. An ultrasonic vibrator either shattered the specimens or left them unaffected. Subjecting the specimens to sudden extreme changes in temperature did not force the valves apart. Attempts to separate the valves with a razor blade resulted in breakage of the valves.

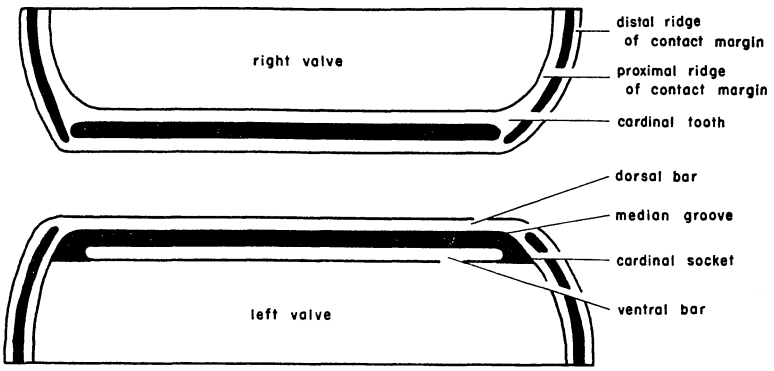


FIG. 2. Diagram of biversus hingement.

DEFINITION OF TERMS USED IN DESCRIPTION OF HINGEMENT

Accommodation groove.—Furrow above the hinge of one valve which accommodates dorsal edge of opposite valve when carapace is open.

Adont.—Hinge of bar-and-groove type, lacking teeth, with bar of one valve fitting into groove of opposite valve.

Biversus.—A term proposed for that type of hingement characterized by a groove in each valve, accommodating a bar of opposite valve, and with each valve usually possessing either two cardinal teeth or two cardinal sockets. The term is derived from the Latin *bi* (two) and *versus* (furrow).

Cardinal depression.—Depression at or near one or both cardinal corners of one valve, for reception of cardinal corner of opposite valve.

Cardinal socket.—Major depression at or near one or both extremeties of hinge, for reception of tooth borne by opposite valve.

Cardinal tooth.—Prominence at or near one or both extremeties of hinge, fitting into socket of opposite valve.

Contact margin.—Edge part of valves exclusive of hinge, in contact when valves are closed.

Distal ridge of contact margin.—Outer ridge of a rabbeted contact margin; may be the same as free edge in some cases.

Dorsal bar.—Distal bar of hinge if more than one bar is present.

Hingement.—Structures comprising articulation of valves; same as hinge.

Hinge area.—Surface involved in hingement of valves.

Hinge line.—Line along which valves articulate; it may coincide with dorsal margin or be depressed below it.

Hinge margin.—That part of dorsal border of valves adjoining the hinge.

Lophodont.—Three-element hingement consisting of short toothlike ridges at extremeties of median groove in one valve, and reverse arrangement of elements in opposite valve.

Median groove.—Groove present in hinge of one valve, bounded by dorsal and ventral bars; accommodates bar of opposite valve.

Prionodont.—Hinge similar to adont, but with toothlets and minute sockets along both bar and groove; same as taxadont and interdentate.

Proximal ridge of contact margin.—Inner ridge of a rabbeted contact margin.

Socket.—Hollow or pit in hinge area of one valve for reception of tooth in hinge of opposite valve.

Tooth.—Projection on hinge area of one valve fitting into socket of opposite valve.

Toothlet.—Minute tooth, generally in series.

Ventral bar.—Proximal bar of hinge if more than one bar is present.

STRATIGRAPHY

Stratigraphy of the areas where samples were collected is summarized below, with those formations from which specimens were actually studied marked by an asterisk.

In the northeastern part of the Southern Peninsula of Michigan, the Traverse strata have been described by Warthin and Cooper (1943). They classified the Traverse Group as follows:

Squaw Bay Limestone
Thunder Bay Limestone
Potter Farm Formation
*Norway Point Formation
Four Mile Dam Formation
Alpena Limestone
Newton Creek Limestone
*Genshaw Formation
Ferron Point Formation
*Rockport Quarry Limestone
*Bell Shale

The Traverse strata of the Little Traverse Bay area of Michigan were described by Pohl (1930). Cooper and Warthin (1942, p. 881) designate the strata as follows:

Petoskey Formation
Charlevoix Formation
*Gravel Point Formation
*Upper Blue Shale Member
*Lower Blue Shale Member

The strata of the Thedford-Arkona area of southwestern Ontario have been studied by Shimer and Grabau (1902), Stauffer (1915), Grabau

(1917, p. 34), Cooper and Warthin (1941), and Wright and Wright (1963). The accepted classification of the strata of this area is as follows:

Ipperwash Limestone
Petrolia Shale
*Widder Formation
Hungry Hollow Formation
*Arkona Shale

The Hamilton Group of western New York was studied by several early workers, and in 1930 Cooper redefined the group as follows:

Moscow Formation
Windom Shale
Kashong Shale
Menteth Limestone
Ludlow Formation
Deep Run Shale
Tichenor Limestone
*Wanakah Shale
*Ledyard Shale
*Centerfield Limestone
Skaneateles Formation
Levanna Black Shale
Stafford Limestone
Marcellus Formation

LOCALITIES

Those localities from which specimens are used in this study are listed. The numbers are those used in the Michigan Geological Survey and the Museum of Paleontology of The University of Michigan.

Michigan

LOCALITY

9. Abandoned quarry of Charlevoix Rock Products Company, about three-fourths mile west of Charlevoix, Charlevoix County. SE ¼, SE¼, sec. 28, T. 34 N., R. 8 W. Upper Blue Shale of the Gravel Point Formation. Collected by R. V. Kesling in June, 1962.

14. Quarry of the Penn-Dixie Cement Company (formerly the Petoskey Portland Cement Company) about two miles west of Petoskey, Emmet County. NE¼, NW ¼, SE¼, sec. 2, T. 34 N., R. 6 W. Upper Blue Shale and Lower Blue Shale of the Gravel Point Formation. Collected by J. C. Melik on October 6, 1962.

31*a*. Quarry of the Michigan Limestone Division of the U. S. Steel Corporation at Calcite, near Rogers City, Presque Isle County. SE part of T. 35 N., R. 5 E. and adjacent townships. Collection taken from sink filling in west wall, S. 10 E. of Quarry plant. Bell Shale. Collected by G. M. Ehlers, R. V. Kesling, and P. M. Kier on August 4, 1950.

31*b*. Quarry of the Michigan Limestone Division of the U. S. Steel Corporation at Calcite, near Rogers City, Presque Isle County. SE part of T. 35 N., R. 5 E. and adjacent townships. Collection from south end of quarry, six inches to ten feet above base of formation. Collected by G. M. Ehlers, R. V. Kesling, and M. Weiss on September 6, 1952.

31*c*. Quarry of the Michigan Limestone Division of the U. S. Steel Corporation at Calcite, near Rogers City, Presque Isle County. SE part of T. 35 N., R. 5 E. and adjacent townships. Sample taken from dump pile in central part of

quarry, just north of railroad tracks, formerly present as a sink filling. Bell Shale. Collected by J. C. Melik on October 7, 1962.

31*d*. Quarry of the Michigan Limestone Division of the U. S. Steel Corporation at Calcite, near Rogers City, Presque Isle County. SE part of T. 35 N., R. 5 E. and adjacent townships. Collection from basal six-inch crinoid layer. Bell Shale. Collected by G. M. Ehlers, R. V. Kesling, and M. Weiss on September 6, 1952.

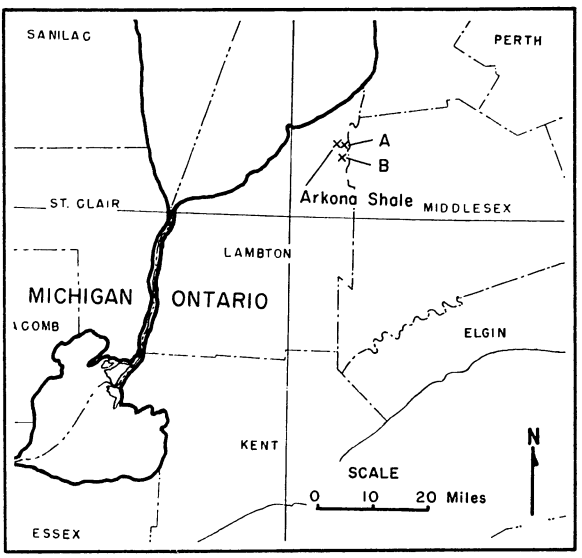


FIG. 3. Index map of Ontario localities.

38*a*. Abandoned quarry of Kelley's Island Lime and Transport Company, Rockport, Alpena County. Sec. 6, T. 32 N., R. 9 E. Sample from near drainage ditch, about one-fourth mile northwest of quarry buildings. Bell Shale. Collected by R. V. Kesling in June 1962, and J. C. Melik on October 7, 1962.

52. Road cut on west side of French Road, about four-tenths mile south of junction with West Long Lake Road, near E. line sec. 8, T. 32 N., R. 8 E., Alpena County. Killian's Member of Genshaw Formation. Collected by J. C. Melik on October 7, 1962.

Ontario

LOCALITY

A. Abandoned Bell's (or Jim Bell's) quarry on Ridge Road, 0.65 mile north of its junction with King's Highway 82, 1.2 miles east and 0.6 mile north of railroad station in Thedford, Lambton County. Widder Formation. Collected by Charles Southworth in 1952, and R. R. Hibbard on May 22, 1954.

B. Roadside exposure on west side of King's Highway 82, 1.35 miles southeast of railroad station in Thedford, Lambton County, opposite old farmhouse, near intersection of Ridge Road and Highway 82. Widder Formation. Collected by J. C. Melik on September 8, 1962.

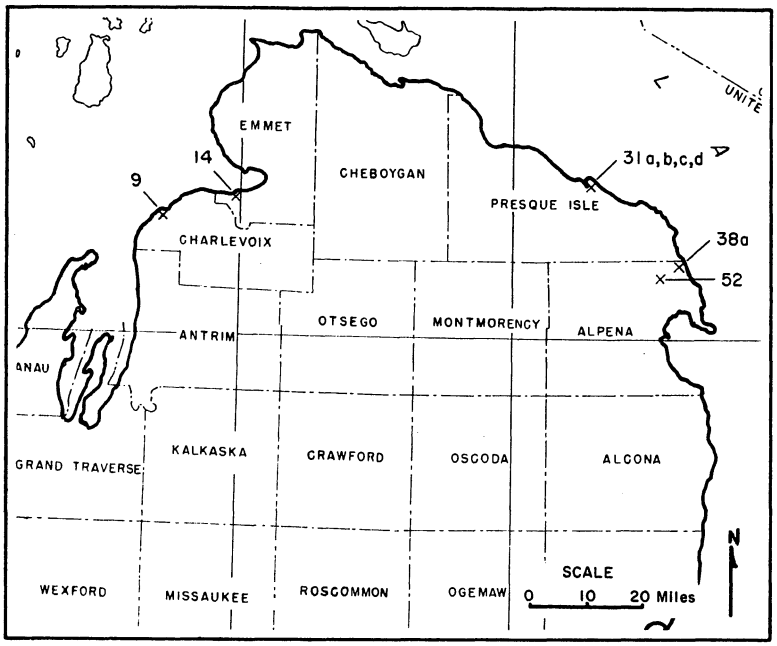


FIG. 4. Index map of Michigan localities.

Arkona Shale. Brick and tile yard, about 0.1 mile east of north-south road, and about one-half mile north of Thedford, Lambton County. Arkona Shale. Channel sample from 0 to 20 feet below "Encrinal Limestone." Collected by J. C. Melik on September 8, 1962.

New York

LOCALITY

Ledyard Shale. Roadside exposure south of cut of the Delaware, Lackawanna, and Western Railroad, 1.5 miles west of East Bethany, Genesee County. Ledyard Shale. Collected by G. M. Ehlers, R. V. Kesling, E. C. Stumm, and I. Reimann in May 1953.

Centerfield Limestone. Cut of the Delaware, Lackawanna, and Western Railroad, 1.5 miles west of East Bethany, Genesee County. Centerfield Limestone. Collected by J. C. Melik on August 29, 1962.

PEEL TECHNIQUE

Complete carapaces were first identified and photographed, then embedded in plastic. Embedding requires some trial and error practice before good results can be obtained. A supporting block about one-fourth to three-fourths inch thick is made by pouring catalyzed embedding plastic into a mold made from 1 by 3-inch glass microscope slides, which are ce-

mented together with Duco cement. The interior surface of the mold is lightly coated with mold release compound before pouring the liquid plastic. After the plastic has hardened, the block is broken free from the mold and its surfaces ground smooth with 1000-mesh carborundum powder. A grid system with letters or numbers is drawn on a surface of the block with India ink. The specimens are then mounted on this surface in the desired position, usually with their longitudinal axes perpendicular to the surface of the block. They are held in position by placing a small amount of gum of tragacanth at their point of contact with the block. Care must be taken while mounting each specimen, so as not to disturb the specimens mounted earlier.

About twenty specimens can be placed in the central area of each block. The block with its mounted specimens is then gently placed in a new mold similar to the first mold. Using a micropipette, one drop of catalyzed liquid plastic is carefully dropped onto each specimen. The liquid plastic is then gradually added between the specimens until it attains a depth sufficient to cover them all. This unit is allowed to set and then heat-cured according to the manufacturer's recommendations. Once again the entire block is freed from its mold and its surfaces are ground smooth.

A Croft Parallel Grinding Instrument, manufactured by the Cutrock Engineering Company, London, was used to grind the serial surfaces on which the peels were made. The instrument was modified slightly by using replaceable plate-glass plates as a grinding surface. A new glass plate was used for grinding each plastic block.

The plastic block containing the specimens is attached to a standard specimen holder of the instrument by a low melting-point wax, provided by the manufacturer. One-thousand mesh carborundum powder, lubricated with water, is placed on the glass plate as an abrasive. A low retaining ridge of paraffin is built up on the periphery of the plate to confine the abrasive and lubricant to its surface. The micrometer of the instrument is set for the desired interval before each period of grinding.

When the desired interval has been ground off, the specimen holder with the block attached is removed from the instrument and the block is submerged for forty seconds in one per cent hydrochloric acid. The time and concentration of acid can be varied slightly according to the size and composition of the specimen, to attain the desired depth of etching. Immediately after etching, the block is held under a gentle flow of water for about one minute. The etched surface is allowed to dry gradually; it must not be touched. The block is then placed in a box of sand with its etched surface up and is made horizontal with a small level. A 2 mm layer of peel solution is spread over the surface with an eye dropper. The peel must be left to

dry for a minimum of twenty hours before it can be removed. After its edges are loosened with a razor blade, the peel is pulled free and placed between two glass slides for handling.

The peel solution was made up as suggesed by Darrah (1936). It consists of parlodion, amyl acetate (or butyl acetate), xylene (or toluene), castor oil, and ether.

Small variations in solubility of different parts of the specimen result in differential etching by the acid. The etched surface of a carapace causes slight differences in relief in the peel. Some peels show details of the structure of the calcite in the shell, and of the calcium carbonate steinkern.

The peels were photographed using Adox KB-14 film in a 35-mm camera mounted on an American Optical Spencer Microstar microscope. Light was transmitted through a substage condenser lowered 10 mm from its highest position for a slight increase in contrast.

The peel method worked well in only about 30 per cent of the specimens sectioned. In many which showed little or no structure, the original shell material had been replaced with calcium carbonate of almost exactly the same composition as the steinkern, so that the material throughout the carapace was homogeneous. Some specimens were partly replaced by pyrite.

SYSTEMATIC PALEONTOLOGY AND DESCRIPTION OF HINGEMENT

Phylum ARTHROPODA
Class CRUSTACEA
Subclass OSTRACODA Latreille, 1802
Order PALAEOCOPIDA Henningsmoen, 1953
Suborder Beyrichicopina Scott, 1961
Superfamily Beyrichiacea Matthew, 1886
Family Beyrichiidae Matthew, 1886
Genus *Treposella* Ulrich and Bassler

Type species.—By designation of Ulrich and Bassler, 1908, p. 314, *Beyrichia lyoni* Ulrich, 1891, p. 190, Pl. 14, Figs. 2*a-c*, 3.

Treposella stellata Kesling
(Pl. XVI, Figs. 11-16)

?*Treposella reticulosa* (Bassler and Kellett). Warthin (*partim*), 1937, Card 20, Fig. A.
Treposella stellata Kesling, 1955*b*, pp. 277–79, Pl. 2, Figs. 1–3, Pl. 3, Figs. 1–6.

Hingement.—Adont. Hingement of right valve consisting of uniform bar extending entire length of hinge margin, bounded by shallow accommodation groove on dorsal margin. Hingement of left valve consisting of median groove extending entire length of hinge margin. Groove bounded by a dorsal bar and ventral bar.

Contact margin of right valve rabbeted to accommodate contact margin of left valve. Median groove of left valve accommodating bar of right valve; accommodation groove receiving dorsal bar of left valve upon opening of carapace. Hinge line about nine-tenths as long as entire carapace, including frill.

Remarks.—No complete carapaces were found. Ends are broken from left valve and anterior end is broken from right valve.

Occurrence.—Centerfield Limestone.

Types.—Hypotypes, one male right valve, UMMP 47566, and one incomplete male left valve, UMMP 47565.

Genus *Phlyctiscapha* Kesling

Type species.—By original designation, *Phlyctiscapha rockportensis* Kesling, 1953*c*, pp. 222-25, Pls. 1-2.

Phlyctiscapha subovata Smith
(Pl. I, Figs. 12-17; Pl. IV, Figs. 1-28;
Pl. V, Figs. 1-21, 31-35)

Phlyctiscapha subovata Smith, 1956, pp. 4–5, Pl. 1, Figs. 1–3; Stover, 1956, p. 1112, Pl. 115 ,Fig. 3.

Hingement.—Questionably adont. Although hinge structure not shown well in peel series, apparently consisting of shallow groove in right valve accommodating bar of left valve. Contact margin of left valve rabbeted to accommodate margin of right valve. Hinge line about seven-tenths as long as entire carapace.

Remarks.—No single valves were found. Ventral part of female carapace is deformed.

Peel series.—The peel series of a female specimen (Pl. IV, Figs. 1-28; Pl. V, Figs. 33-35), revealed two brood spaces, each of which contained an immature carapace. The immature carapaces first appear in the fifteenth peel from the posterior, and extend through the nineteenth peel (Pl. IV, Figs. 15-19, 27-28; Pl. V, Figs. 33-35). Thus they are at least 250 microns in length, and are situated from about three-fifths to four-fifths the distance from the posterior to the anterior end of the carapace. They lie with their sagittal plane inclined away from the sagittal plane of their parent, but have their longitudinal axis parallel to that of their parent. The ratio of carapace thickness to size in the immature instars is lower than that of the adult.

Internal walls mark the proximal limit of the brood space, but do not extend entirely to the ventral part of the carapace (Pl. V, Figs. 33-35).

In the female the thickness of the valves along the contact margin is greater than that in other parts of the carapace. The male has thicker valves in the entire ventral part of the carapace, than in the remainder of it.

In the male, the overlapping part of the contact margin of the left valve forms a V in cross section, and accommodates the contact margin of the right valve, which tapers to a sharp point in cross section. The contact margins of the female valves were deformed and their relationship could not be determined.

In *Phlyctiscapha rockportensis* there are also internal walls which mark the proximal limit of the brood space (Kesling, 1953*a*, Fig 1, Pl. 2, Figs. 8-13). Possible immature carapaces in the brood space of *Hibbardia lacrimosa* were pointed out by Kesling (1957, p. 33, Pl. 3, Figs. 13, 23).

Occurrence.—Centerfield Limestone.

Superfamily Drepanellacea Ulrich and Bassler, 1923
Family Aechminidae Bouček, 1956

Genus *Aechminaria* Coryell and Williamson

Type species.—By original designation, *Aechminaria nodosa* Coryell and Williamson, 1936, p. 5, Fig. 8.

Aechminaria hormathota Kesling
(Pl. I, Figs. 6-8; Pl. V, Figs. 22-30; Pl. VI, Figs 1-7)

Aechminaria hormathota Kesling, 1953*d*, pp. 5–7, Pl. 1, Figs. 21–22, 24–29.

Hingement.—Hinge structure not shown well in peel series, but hinge area of each valve apparently in smooth contact with that of opposite valve.

Contact margin of left valve rabbeted to accommodate contact margin of right valve; ventral part of free margin of left valve extending considerably beyond that of right valve.

Hinge line about seven-tenths as long as entire carapace.

Remarks.—No single valves were found. This is the first reported occurrence of this species in the Widder Formation.

Peel series.—(Pl. V, Figs. 22-30; Pl. VI, Figs. 1-7.) The ventral free margin of the left valve extends considerably beyond the ventral free margin of the right valve. The left valve increases in thickness at its contact margin by an outward swelling of the valve along the line in which it is in contact with the right valve. The right valve increases in thickness

just above the free margin by an outward swelling of the valve in this area. The contact margin of the right valve tapers to a thin edge.

The valves decrease slightly in thickness in the large central dorsal spines, as well as in S2 and L2 (Pl. V, Fig. 29; Pl. VI, Figs. 1-2).

Occurrence.—Widder Formation, localities A and B; Arkona Shale.

Family Bolliidae Bouček, 1956

Genus *Bollia* Jones and Holl

Type species.—By original designation, *Bollia bicollina* Jones and Holl, 1886, pp. 360-61, Pl. 12, Figs. 14*a-c*, 15-16.

Bollia hindei Jones
(Pl. XVI, Figs. 17-19)

Bollia hindei Jones, 1890, p. 540, Pl. 20, Fig. 5; (*partim*) Warthin, 1937, Card 41; Swartz and Swain, 1941, p. 419, Pl. 3, Figs. 5*a-f*; Stewart, 1950, p. 657, Pl. 85, Figs. 8–9; Stover, 1956, pp. 1108–9, Pl. 113, Fig. 11.

Bollia widderensis Coryell and Malkin, 1936, p. 2, Figs. 4, 4*a*.

Hingement.—Adont. Hingement of left valve consisting of well-defined deep median groove along entire length of hinge margin. Groove bounded by a dorsal bar and ventral bar. Right valve presumably possessing a bar accommodated by groove in left valve. Hinge line about seven-tenths as long as entire carapace.

Remarks.—No complete carapaces were found. This is the first reported occurrence of this species in the Arkona Shale.

Occurence.—Centerfield Limestone; Arkona Shale.

Type.—Hypotype, a left valve, UMMP 47567.

Genus *Ulrichia* Jones

Type species.—By original designation, *Ulrichia conradi* Jones, 1890, p. 544, Fig. 2.

Ulrichia spinifera Coryell and Malkin
(Pl. II, Figs. 7-9; Pl. VI, Figs. 12-38; Pl. XVI, Figs. 20-23; Pl. XVII, Figs. 14-15)

Ulrichia conradi Warthin, 1934, p. 213, Pl. 1, Fig. 10; Stewart, 1936, p. 747, Pl. 100, Figs. 17–18.

Ulrichia spinifera Coryell and Malkin, 1936, pp. 1–2, Figs. 1–2; (*partim*) Warthin, 1937, Card 94, Figs. 1, 1a, 2; Kesling 1952*b*, page 27, Pl. 4, Figs. 9–12; Kesling and Weiss, 1953, p. 19, Pl. 3, Figs. 32-35; Stover, 1956, p. 1109, Pl. 113, Figs. 14–17.

Hingement.—Hingement of right valve consisting of shallow groove tapering from anterior corner toward center of hinge, but apparently not reaching center; a similar, but poorly defined shallow groove tapering from posterior corner toward center of hinge. Hingement of left valve poorly preserved in all specimens examined, but apparently similar to that of right valve. Shallow groove tapering from anterior corner toward center of hinge; a similar groove tapers from posterior corner toward center of hinge.

Hinge structure poorly shown in peel series. Valves offset in specimen A (Pl. VI, Figs. 12-32); hence, contact relationships not to be interpreted from this series.

Relationship of hinge structure in the two valves uncertain. Contact margins of the valves meet evenly. Hinge line about nine-tenths as long as entire carapace.

Remarks.—Thirty-one single valves were examined in which all structures were well preserved except the hingement. This is the first reported occurrence of this species in the Widder Formation.

Peel series.—(Pl. VI, Figs. 12-38.) The thickness of the valves is greatest in the velate ridge and the venter and least in the pits of the reticulation. Most peels show a thin line extending through the central part of the velar ridge, from the inner surface to the outer surface of the valve.

Occurrence.—Widder Formation, localities A and B.

Types.—Hypotypes, one right valve, UMMP 47568, and one left valve, UMMP 47569.

Ulrichia fragilis Warthin

(Pl. I. Figs. 4-5; Pl. VI, Figs. 8-11, 48; Pl. XVI, Figs. 1-6)

Ulrichia fragilis Warthin, 1934, pp. 213–14, Pl. 1, Fig. 11; Stewart, 1936, p. 747, Pl. 100, Figs. 19–20; Warthin, 1937, Card 95; Kesling, 1952*b*, p. 27, Pl. 4, Figs. 9–12; Kesling and Weiss, 1953, p. 49, Pl. 3, Figs. 23–26; Stover, 1956, p. 1110, Pl. 113, Fig. 12.

Hingement.—Adont. Hingement of right valve consisting of sharp-edged bar extending entire length of hinge margin. Bar continuous with ridge of contact margin. Hingement of left valve consisting of distinct median groove extending entire length of hinge margin, expanding in width slightly at cardinal corners. Groove bounded by a dorsal bar and ventral bar. Dorsal bar continuous with distal ridge of contact margin and homologous to it.

Contact margin of left valve rabbeted to accommodate contact margin of right valve. Bar of right valve accommodated by the groove in left valve. Hinge line about four-fifths as long as entire carapace.

Remarks.—Only two right valves and one left valve were found out of 194 specimens examined, the rest being complete carapaces.

Peel series.—(Pl. VI, Figs. 8-11, 48.) The thickness of the valves is greatest through the velar ridges and venter, and least in the pits of the reticulation.

The overlapping part of the contact margin of the left valve is V-shaped in cross section, and the overlapped part of the right valve tapers abruptly to form a blunt point in cross section (Pl. VI, Fig. 48).

Occurrence.—Widder Formation, localities A and B; Bell Shale, locality 38*a*.

Types.—Hypotypes, one right valve, UMMP 47561, and one left valve, UMMP 47562.

Ulrichia illinearis Kesling
(Pl. I, Figs. 1-3; Pl. VI, Figs. 38-47)

Ulrichia illinearis Kesling, 1953*a*, pp. 199–200, Pl. 1, Figs. 28-32; Stover, 1956, p. 1110, Pl. 113, Fig. 13.

Hingement.—Probably adont. Hinge structure not shown well in peel series, but left valve apparently having a groove to accommodate a bar of the right valve.

Contact margin of the left valve rabbeted to accommodate contact margin of right valve. Hinge line about seven-tenths as long as entire carapace.

Remarks.—No single valves were found with hingement preserved. This is the first reported occurrence of this species in the Widder Formation, Centerfield Limestone, and Bell Shale.

Peel series.—(Pl. VI, Figs. 38-47.) A marginal ridge is shown to occur only on the left valve (Pl. VI, Figs. 41-44, 47), although from the exterior of the carapace it appeared that the ridge might be formed by both valves (Pl. I, Fig. 3). The thickness of the valves is greatest through the velate ridge and venter, and least in the pits of the reticulation.

The overlapping part of the contact margin of the left valve forms a shallow V in cross section, and the overlapped part of the right valve shows up as a blunt termination in cross section (Pl. VI, Fig. 47).

Occurrence.—Widder Formation, localities A and B; Arkona Shale; Centerfield Limestone; Bell Shale, locality 31*a*.

Family Kirkbyellidae Sohn, 1961

Genus *Kirkbyella* Coryell and Booth

Type species.—By original designation, *Kirkbyella typa* Coryell and Booth, 1933, p. 262, Pl. 3, Fig. 7.

Subgenus *Kirkbyella* Coryell and Booth, 1933
Kirkbyella (*Kirkbyella*) *bellipuncta* (Van Pelt)
(Pl. XVI, Figs. 7-10; Pl. XVII, Figs. 12-13)

Amphissites bellipunctus Van Pelt, 1933, p. 332, Pl. 39, Figs. 37-40.

Halliella bellipuncta Stewart, 1936, p. 746, Pl. 100, Figs. 15–16; Turner, 1939, p. 12, Pl. 1, Fig. 3; Kesling, 1952*b*, p. 26, Pl. 1, Figs. 16-20; Kesling and Weiss, 1953, p. 35, Pl. 3, Figs. 21–22; Loranger, 1954, p. 199, Pl. 2, Figs. 21–22; Loranger, 1963, pp. 7–8, Pl. 1, Figs. 3–4.

Kirkbyella bellipuncta Warthin, 1937, Card 80; Shimer and Shrock, 1944, p. 671, Pl. 282, Figs. 43–44.

Kirkbyella (*Kirkbyella*) *bellipuncta* Sohn, 1961, pp. 143–44, Pl. 12, Figs. 1–12, 24.

Kirkbyella bellipuncta transversa Stewart and Hendrix, 1945, p. 90, Pl. 10, Figs. 12–14.

Kirkbyella tora Stover, 1956, p. 1133, Pl. 119, Figs. 17–21.

Hingement.—Hingement of right valve consisting of smooth bar extending between cardinal corners. Bar increasing slightly in width toward cardinal corners and there continuous with ridge of contact margin. Shallow cardinal depressions at cardinal corners, but poorly preserved in all right valves examined. Hingement of left valve consisting of bar extending entire length of hinge margin and increasing slightly in width toward cardinal corners. Bar continuous with contact margin ridge and homologous to it.

In articulated hingement, bar of left valve apparently in juxtaposition with bar of right valve. Cardinal corners of left valve probably accommodated by shallow cardinal depressions of right valve. Hinge line about nine-tenths as long as entire carapace.

Remarks.—Many single valves were found, but few had their hingement preserved.

Peel series of this species showed no structure.

Occurrence.—Widder Formation, locality A; Bell Shale, locality 31*a;* Arkona Shale.

Types.—Hypotypes, one right valve, UMMP 47564, and one left valve, UMMP 47563.

Superfamily Hollinacea Swartz, 1936
Family Hollinidae Swartz, 1936

Genus *Abditoloculina* Kesling

Type species.—By original designation, *Abditoloculina insolita* Kesling, 1952*d*, p. 766, Pl. 111, Figs. 7–14.

Abditoloculina pulchra Kesling
(Pl. I, Figs. 18–23; Pl. VII, Figs. 1–31)

Abditoloculina pulchra Kesling, 1955*b*, pp. 274–76, Pl. 1, Figs. 1–19.

Hingement.—Adont. Hinge structure not shown well in peel series, but apparently consisting of shallow groove in left valve to accommodate a bar of right valve.

Contact margin of left valve rabbeted to accommodate contact margin of right valve. Hinge line about nine-tenths as long as entire carapace, in both male and female.

Remarks.—No single valves of this species were found.

Peel series.—(Pl. VII, Figs. 1–31.) In the male of this species the peels show thin lines extending through the central part of the velate ridge, from the inner surface to the outer surface of the valve. The lines do not reach the outer surface in all cases, however (Pl. VII, Figs. 15–30). They may bifurcate just before reaching the inner surface (Pl. VII, Fig. 30).

In the male the overlapping part of the contact margin of the left valve consists of a shelf, and the overlapped part of the right valve is sub-quadrangular in cross section (Pl. VII, Fig. 30). The thickness of the valves is greatest in the venter, and may vary slightly throughout different parts of the carapace (Pl. VII, Fig. 21).

The structure of the loculi of the female is well shown by the peel series. Those parts of the valves forming the lateral and dorsal walls of the loculi are not as thick as in the rest of the carapace (Pl. VII, Fig. 31). A velar ridge is present on each valve of the female, but the ridges are much closer together than in the male (compare Pl. 7, Fig. 31, to Fig. 30). A thin line extends through the central part of the velar ridge of the female, as well as the male, but in addition the female has a line extending into the outer wall of the loculi (Pl. 7, Figs. 6–11).

Two foreign objects with a sub-ovate cross section occur in two left loculi of the female (Pl. VII, Figs. 7, 13). These could perhaps be eggs, but their exact nature is a matter of conjecture.

The configuration of the overlapping and overlapped parts of the contact margins of the female are similar to those of the male.

The peel series shows that the spurs of both the male and female are hollow (Pl. VII, Figs. 8, 22–23).

Occurrence.—Centerfield Limestone.

Genus *Adelphobolbina* Stover

Type species.—*Ctenobolbina papillosa* Ulrich, 1891, p. 186, Pl. 15, Fis. 8a–c, by subsequent designation of Stover, 1956, pp. 1103–04.

Adelphobolbina medialis Stover
Pl. XVII, Figs. 1–6; Pl. XVIII, Figs. 1–6)

Adelphobolbina medalis Stover, 1956, pp. 1104–5, Pl. 112, Figs. 4–9.

Hingement.—Biversus. Hingement of right valve consisting of distinct median groove along entire length of hinge margin, increasing slightly in width toward cardinal corners. Groove bounded by a sharp dorsal bar and sharp ventral bar, both of uniform width. Terminations of proximal ridge of contact margin enlarged slightly to form low cardinal teeth.

Hingement of left valve consisting of cardinal sockets not confined ventrally; shallow median groove, increasing slightly in width toward cardinal corners, between cardinal sockets. Groove bounded by a dorsal and ventral bar, both low and narrow.

Contact margin of each valve rabbeted to accommodate contact margin of opposite valve. Dorsal bar of left valve fitting into median groove of right valve; ventral bar of right valve accommodated by groove of left valve, and cardinal sockets of left valve accommodating cardinal teeth of right valve. Hinge line about four-fifths as long as entire carapace, including frill, in both male and female. Outer edge of contact margin of each valve with a bead-like row of low papillae.

Hingement identical in both sexes.

Remarks.—This is the first reported occurrence of this species in the Ledyard Shale.

Occurrence.—Ledyard Shale.

Types.—Hypotypes, one broken female right valve, UMMP 47573; one female right valve, UMMP 47571; one broken female left valve, UMMP 47572, and one male left valve, UMMP 47570.

Adelphobolbina papillosa (Ulrich)
(Pl. III, Figs. 17–18; Pl. VIII, Figs. 1–14, 31)

Ctenobolbina papillosa Ulrich, 1891, p. 186, Pl. 15, Figs. 8*a–c*; Raymond, 1904, p. 174; Ulrich and Bassler, 1908, p. 310, Pl. 40, Figs. 21–22; Coryell and Malkin, 1936,

p. 3, Fig. 8; Swartz, 1936, Pl. 80, Figs. 1*f–g*; Warthin, 1937, Card 68, Figs. 8*a–c*; Levinson, 1950, p. 71, Fig. 10; Kesling and Tabor, 1953, p. 88, Pl. 3, Figs. 16–17.

Adelphobolbina papillosa Stover, 1956, pp. 1103–4; Kesling and Peterson, 1958, pp. 137–38, Pl. 2, Figs. 25–30.

Hingement.—Biversus. Peel series showing the hinge structure poorly.

Levinson (1950, p. 71) stated that the hingement of the right valve of this species "consists of a triangular anterior socket and an elongate posterior socket, with a ridge occupying the entire length of the dorsal margin of the socket. A groove is superimposed on the ridge and becomes indistinct as it nears the cardinal angles." The specimens which he observed, however, had only a fair degree of preservation. Bonnema (1930, p. 115) observed that a groove is present in the hinge of the left valve of this species.

Hinge line about four-fifths as long as the entire carapace, including the frill.

Peel series.—(Pl. VIII, Figs. 1–14, 31.) The frill is shown to contain tubules which do not extend entirely to either the inner surface of the valve or the outer edge of the frill (Pl. VIII, Fig. 31). Each tubule was probably originally hollow and later became filled with calcium carbonate. Proximal openings of the tubules into the carapace may have become sealed off by secretions from the hypodermis during the life of the ostracode.

The contact margin of the left valve is indented slightly to accommodate the contact margin at the right valve. The indentation is generally V-shaped in cross section. The left valve overlaps the right valve considerably (Pl. VIII, Figs. 7–12), but some of the overlap may be due to deformation of the valves after the animal had died.

The thickness of the valves is slightly greater in the dorsum and venter than in the lateral area.

Occurrence.—Centerfield Limestone.

Genus *Ctenoloculina* Bassler

Type species.—*Tetradella cicatricosa* Warthin, 1934, p. 209, Pl. I, Figs. 4–6, by subsequent designation of Bassler, 1941, pp. 22–23.

Ctenoloculina cicatricosa (Warthin)

(Pl. I, Figs. 9–11; Pl. VIII, Figs. 15–24; Pl. XVII, Figs. 8–11; Pl. XVIII, Figs. 13–16; Pl. XIX, Figs. 8–9)

Tetradella cicatricosa Warthin, 1934, p. 209, Pl. 1, Figs. 4–6; Bassler and Kellett, 1934, p. 479; Stewart, 1936, p. 748, Pl. 100, Figs. 23–24; Warthin, 1937, Card 54; (not *Tetradella ciactricosa* Coryell and Malkin, 1936, p. 3, Fig. 9.)

Ctenoloculina cicatricosa Bassler, 1941, pp. 22–23; Shimer and Shrock, 1944, p. 687, Pl. 281, Figs. 36–37; Stewart and Hendrix, 1945, p. 102, Pl. 11, Fig. 11; Kesling, 1951, Pl. 13, Figs. 1–2; Kesling, 1952*a*, pp. 247–290, Pls. 1–3; Kesling and McMillan, 1951, pp. 49–50, Pl. 4, Figs. 9–10; Kesling and Weiss, 1953, p. 44, Pl. 2, Figs. 9–14, Pl. 3, Fig. 1; Stover, 1956, p. 1105, Pl. 112, Figs. 15–16.

Ctenoloculina acanthopora Swartz and Oriel, 1948, p. 553, Pl. 79, Figs. 8–14.

Hingement.—Hingement of this species a true prionodont type (also termed taxodont or interdentate), but close examination necessary to discern this. Hingement of right valve consisting of very low bar, increasing slightly in width from posterior to anterior corner, having about 75 minute, evenly spaced, vertically elongate toothlets, alternating with 75 sockets. Bar continuous with ridge of contact margin.

Left valve with cardinal depressions, not confined ventrally, at anterior and posterior cardinal corners. Very shallow groove, increasing slightly in width from posterior to anterior, between depressions. Groove with about 75 minute, evenly spaced, vertically elongate toothlets, alternating with 75 sockets.

Contact margin of left valve rabbeted to accommodated contact margin of right valve; cardinal depressions of left valve accommodating cardinal corners of right valve. Bar of right valve fitting into groove of left valve; each toothlet of one valve accommodated by a socket in opposite valve. Hinge line about nine-tenths as long as entire carapace.

Remarks.—The Widder Formation, localty A, yielded many specimens with well preserved hingement.

Peel series.—(Pl. VIII, Figs. 15–24.) The female of this species shows thin lines extending from the inner surface of the valve, through the marginal ridge area frill, and walls of the loculi (Pl. VIII, Figs. 16–17, 19, 24). The lines may bifurcate before reaching the outer surface (Pl. 8, Fig. 20) and may entirely surround the loculi (Pl. 8, Fig. 24). The lines, however, do not reach the outer surface in all cases (Pl. 8, Figs. 17–18).

The marginal ridge is higher in the left valve than in the right (Pl. VIII, Figs. 19–22), and in the posterior part of the carapace the margin of the left valve extends considerably beyond that of the right (Pl. VIII, Figs. 15–17).

The rabbeted part of the contact margin of the left valve forms a shallow V, or is broadly rounded in cross section and it accommodates the edge of the right valve which tapers sharply to from a blunt point in cross section.

Parts of the inner surface of the valves are irregular (Pl. VIII, Figs. 22–23). It is conjectural as to whether this is an inherent feature of the valves, or is due to solution of the calcium carbonate in these areas. The

infilling of the carapace is heterogeneous and contained some pyrite. The structure of the loculi is well shown by the peel series (Pl. VIII, Figs. 19–24).

Kesling (1952*a*, Pls. 2 and 3) made polished sagittal and frontal sections of this species.

Occurrence.—Widder Formation, localities A and B; Bell Shale, locality 38a; Arkona Shale.

Types.—Hypotypes, one female right valve, UMMP 47575, and one female left valve, UMMP 47576.

Ctenoloculina myurilobata Kesling

(Pl. XVII, Fig. 7; XVIII, Figs. 11–12; Pl. XIX, Figs. 5–7)

Ctenoloculina myurilobata Kesling, 1952*c*, p. 48, Pl. 1, Figs. 10–15.

Hingement.—Prionodont, as in *Ctenoloculina cicatricosa*. Hingement of right valve consisting of very low bar, increasing slightly in width from posterior to anterior corner, with about 70 minute, evenly spaced, vertically elongate toothlets, alternating with 70 sockets. Bar continuous with ridge of contact margin.

Left valve with cardinal depressions, not confined ventrally, at anterior and posterior corners. Very shallow groove increasing slightly in width from posterior to anterior corner between depressions. Groove having about 70 minute, evenly spaced, vertically elongate toothlets, alternating with 70 sockets.

Contact margin of left valve rabbeted to accommodate contact margin of right valve; cardinal depressions of left valve accommodating cardinal corners of right valve. Bar of right valve fitting into groove of left valve, and each toothlet of one valve accommodated by a socket in opposite valve. Hinge line about nine-tenths as long as entire carapace in both male and female.

Remarks.—This is the first reported occurrence of this species in the Arkona Shale.

Occurrence.—Arkona Shale.

Types.—Hypotypes, one female right valve, UMMP 47579, and one female left valve, UMMP 47574.

Genus *Falsipollex* Kesling and McMillan

Type species.—By original designation, *Falsipollex altituberculatus* Kesling and McMillan, 1951, p. 68, Pl. 3, Figs. 1–3.

Falsipollex laxivelatus Kesling

(Pl. I, Figs. 24–26; Pl. VIII, Figs. 25–30; Pl. IX, Figs. 1–14)

Falsipollex sp. Kesling, 1951, Pl. 13, Figs. 7–8.
Falsipollex laxivelatus Kesling, 1952*c*, p. 51, Pl. 2, Figs. 1–9.
Hollinella senticosta Kesling, 1953*b*, pp. 211–212, Pl. 3, Figs. 22–23.

Hingement.—Adont. Hinge structures not shown well in peel series, but apparently consisting of groove in right valve to accommodate bar of left valve.

Contact margin of right valve rabbeted to accommodate contact margin of left valve. Hinge line about seven-tenths as long as entire carapace, including frill, on female of species.

Remarks.—No single valves were found with hingement preserved.

Peel series.—(Pl. VIII, Figs. 25–30; Pl. IX, Figs. 1–14.) The frill is shown to contain tubules which do not extend entirely to either the inner surface of the valve or the outer edge of the frill (Pl. IX, Figs. 9–14). It appeared however, from the exterior of the carapace, that the frill might be a structure of solid calcium carbonate (Pl. I, Figs. 24–26).

The overlapping part of the contact margin of the right valve forms a broad V in cross section, and the overlapped part of the left valve appears as a blunt termination in cross section (Pl. IX, Fig. 11).

All parts of the valves of this specimen are not clearly differentiated from the infilling of calcium carbonate.

Occurrence.—Arkona Shale.

Genus *Hollinella* Coryell

Type species.—By original designation, *Hollinella dentata* Coryell, 1928, pp. 377–78, Pl. 51, Fig. 1.

Hollinella bullata Kesling and McMillan

(Pl. XVIII, Figs. 9–10; Pl. XIX, Fig. 14)

Hollinella bullata Kesling and McMillan, 1951, p. 58, Pl. 1, Figs. 8–9.

Hingement.—Adont. Based on single male right valve with posterior end broken off. Median groove extending length of hinge margin of right valve, increasing in width near anterior cardinal corner, and probably also near posterior cardinal corner. Groove bounded by a dorsal bar and ventral bar, both of uniform width.

Hingement of left valve unknown, but valve presumably possessing a hinge bar extending the length of hinge margin and increasing in width near cardinal corners.

Contact margin of right valve rabbeted to accommodate contact margin of left valve. Median groove of right valve accommodating bar of left valve. Hinge line about nine-tenths as long as entire carapace.

Remarks.—Only a single male right valve was found.

Occurrence.—Bell Shale, locality 31d.

Type.—Hypotype, a right valve, UMMP 47578.

Hollinella horologiina Weiss, sp. nov.

(Pl. III, Figs. 15–16; Pl. XI, Figs. 9–22, 35–36; Pl. XIX, Figs. 1–4; Pl. XXI, Figs. 10–11)

DESCRIPTION BY MARTIN WEISS

Description of female.—Carapace subovate to subelliptical in lateral view. Hinge line straight. Anterior border curved, ventral border gently curved, posterior border acutely curved. L1 one-third of the length of the valve, gently arched. L2 a small swelling, separated from L1 by S1, a narrow, shallow groove. L1 and L2 confluent with ventral lobe. L3 a prominent hemispherical bulb, extending a little above the hinge line, occupying about one-half the height of the valve from the dorsum. S3 a deep, wide hourglass-shaped depression, dorsally confluent with S1. S3 distinct, but not so deep as S2, following the configuration of L3, anteriorly, and ventrally confluent with the sulcus ventral to L3. L4 gently arched, confluent with ventral lobe, sloping to adjacent borders. Ventral lobe separated from frill by a strongly arched groove.

Anterior and posterior cardinal angles about 120 degrees.

Frill not wide, extending from the anterior corner to about four-fifths the free border, curving outward throughout its length, its end flaring outward but not strongly so. In ventral view a flat-bottomed channel, never broad, becoming increasingly narrow anteriorly. Surface of valve and frill very finely granulose.

Dimensions of a left valve, the holotype: length, 1.55 mm; height, .90 mm; and width, .42 mm.

Description of male.—Outline of carapace, distribution of the lobation, and the surface ornamentation same as those of the female. Cardinal angles as in female.

Frill substantially wider than in the female, extending to same length, but markedly curved more outward. Flat-bottomed groove between marginal ridge and frill, wider than in male and not convergent anteriorly.

Dimensions of a left valve, the allotype: length, 1.60 mm; height, .90 mm; and width, .32 mm.

Remarks.—This species differs from *Hollinella amplilobata* Kesling and Tabor in the wider frill and the greater curvature of the posterior border, producing a less acute posterior cardinal angle. Immature specimens, however, are very similar.

The name of this species is derived from Latin *horologium* ("clock") and refers to the hourglass shape of S2.

Hingement.—Adont. Hingement of right valve consisting of distinct median groove extending entire length of hinge margin and increasing slightly in width toward cardinal corners. Groove bounded by a dorsal bar and ventral bar, both of uniform width.

Hingement of left valve consisting of prominent bar of uniform width extending entire length of hinge margin; shallow accommodation groove bounding the bar dorsally. Bar continuous with ridge of contact margin.

Contact margin of each valve rabbeted to accommodate contact margin of opposite valve. Median groove of right valve accommodating bar of left valve. Hingement identical in both sexes. Hinge line about nine-tenths as long as entire carapace, including frill, in both male and female.

Peel series.—(Pl. XI, Figs. 9–22, 35–36.) The frill is shown to contain tubules (Pl. XI, Figs. 15–18, 36), but they are not clearly defined by the peel series. It appeared, however, from the exterior of the carapace, that the frill did not contain tubules (Pl. II, Figs. 15–16).

The contact margin of the left valve appears as a shelf in cross section and accommodates the contact margin of the right valve which has a cross sectional shape of an inverted shelf (Pl. XI, Fig. 36). The thickness of the valves is slightly greater in the venter than in other parts of the carapace.

Occurrence.—Upper Blue Shale and Lower Blue Shale of Gravel Point Formation, locality 14.

Types.—Holotype UMMP 30922, allotype UMMP 30920, paratypes UMMP 30919, 30921, 30923–30924, 47580, 47581.

Hollinella nodiventriculata Weiss, sp. nov.

(Pl. II, Figs. 10–12; Pl. XI, Figs. 22–30; Pl. XVIII, Figs. 7–8; Pl. XIX, Fig. 13)

DESCRIPTION BY MARTIN WEISS

Description.—Valve subpyriform to subelliptical. Hinge line straight, anterior border round, posterior ventral and ventral border borders gently curved, posterior border acutely curved. L1 gently arched becoming slightly inflated near the dorsal border, confluent with ventral border. L2 a vertically

elongate node, separated from L1 by narrow, deep S1. S1 elongate, extending three-fourths of the height of the valve from the dorsal border. S2 wide, deep, confluent with sulcus ventral to L3 and slanting ventrally beneath L2. L3 a well developed, hemispherical bulb, extending slightly above the hinge line. S3 as deep as S2, ventrally confluent with sulcus ventral to L3, slanting posterodorsally, parallel to the well developed L4. L4 developed as a ridge parallel to the posterior border, extending about one-half the height of the valve.

Incurved frill, narrow, extending from the anterodorsal corner to posteroventral region, terminating in front of a prominent, round ventral node, the most strongly elevated feature of the valve. Groove between frill and marginal ridge, finely granulose. Entire surface finely granulose.

Anterior cardinal angle about 140 degrees; posterior cardinal angle about 125 degrees.

Dimorphism unknown.

Dimensions of a left valve, the holotype: length, 1.05 mm; height, .60 mm; width (including ventral node), .27 mm.

Remarks.—Four valves of this species were collected. They have a prominent ventral node and undivided lobe.

The name of this species is derived from Latin *nodus* ("a node") and *ventriculus* ("of the belly") and refers to the pominent ventral node.

Hingement.—Based mainly on a single left valve. Peel series not showing hinge structure well. Hingement of left valve consisting of shallow, subtriangular cardinal depressions, not confined ventrally, at cardinal corners; median groove of uniform width extending between depressions. Groove bounded by a dorsal bar and ventral bar. Dorsal bar continuous with ridge of contact margin and homologous to it.

Hingement of right valve unknown, but valve presumably possessing a hinge bar to fit into median groove of left valve. It may also possess a median groove to accommodate a bar of left valve. Cardinal depressions of left valve accommodating cardinal corners or cardinal teeth of right valve.

Contact margin of right valve rabbeted to accommodate contact margin of left valve. Hinge line about nine-tenths as long as entire carapace, including frill.

Peel series.—(Pl. XI, Figs. 22–30.) There is an indication that the frill may contain tubules, but the peels do not show them clearly (Pl. XI, Figs. 26–27, 30).

The overlapping part of the contact margin of the right valve appears as a shallow indentation in cross section, and the overlapped part of the left valve is broadly curved in cross section (Pl. XI, Figs. 25–26). A

foreign object is shown in the ventral one-half of the carapace in Pl. XI, Figs. 25–28.

Occurrence.—Upper Blue Shale of Gravel Point Formation, locality 9.

Types.—Holotype UMMP 30908, paratypes UMMP 30909–30910, 47577.

Hollinella devoniana (Van Pelt)

(Pl. II, Figs. 1–6; Pl. IX, Figs. 15–21; Pl. X, Figs. 1–20; Pl. XI, Figs. 1–8; Pl. XX, Figs. 1–8, 10–15)

Hollina devoniana Van Pelt, 1933, p. 327, Pl. 39, Figs. 33–36; Bassler and Kellett, 1934, p. 329; Warthin, 1937, Card 73, Figs. 33–36.

Hollinella acutangulata Kesling and McMillan, 1951, pp. 55–58, Pl. 5, Figs. 6–10.

Hollinella devoniana Kesling, 1954, p. 17, Pl. 2, Figs. 13–16.

Hingement.—Biversus. Hingement of right valve consisting of distinct median groove extending entire length of hinge margin and increasing slightly in width toward anterior corner. Median groove bounded by a dorsal bar and ventral bar also extending the length of hinge margin. Low cardinal teeth at extremities of ventral bar, formed by a slight enlargement of contact margin ridge at its terminations.

Hingement of left valve consisting of shallow median groove extending almost the entire length of hinge margin and increasing slightly in width toward anterior corner. Shallow, subtriangular cardinal socket, not confined ventrally, at each extremity of median groove. Median groove bounded by a dorsal bar continuous with distal ridge of contact margin and homologous to it. Ventral bar of left valve probably homologous to proximal ridge of contact margin, but cardinal sockets interrupting their continuity, making interpretation uncertain.

Contact margin of left valve rabbeted to accommodate contact margin of right valve. Median groove of left valve accommodating dorsal bar of right valve, and median groove of right valve accommodating ventral bar of left valve. Cardinal sockets of left valve fitting cardinal teeth of right valve. Hinge line about four-fifths as long as entire carapace, including frill, in both male and female.

Peel series.—(Pl. IX, Figs. 15–21; Pl. X, Figs. 1–20; Pl. XI, Figs. 1–8.) A marginal ridge is formed only on the left valve, by that part which overlaps the right valve. Tubules occur in the frill, but communicate neither with the interior of the carapace nor with the distal edge of the frill. They appear in all peel sections through the frill, probably because they lie adjacent to one another, and each etching dissolved the shell into

the next tubule. By viewing the exterior of the frill, there is no evidence of tubules (Pl. II, Figs. 1–6).

The overlapping part of the contact margin of the left valve forms a broad V in cross section, and accommodates the contact margin of the right valve which is tapered to form a blunt point in cross section.

The inner surface of the valves is very irregular in one specimen as shown by the cross peels (Pl. IX, Figs. 15–21; Pl. X, Figs. 1–15). In another specimen, from which frontal peels were made (Pl. X, Figs. 16–19; Pl. XI, Figs. 1–8), the irregularities are not as pronounced.

The thickness of the valves is slightly less in the L2 than in other parts of the carapace (Pl. XI, Figs. 2–3).

Occurrence.—Bell Shale, localities 31*a*, 31*b*, 31*c*, and 38*a*.

Types.—Hypotypes, 3 male right valves, UMMP 47585, 47586, and 47588; two male left valves, UMMP 47584, and 47587.

Hollinella labrosa Kesling and Weiss
(Pl. XXI, Figs. 1–6)

Hollinella labrosa Kesling and Weiss, 1953, pp. 35–38, Pl. 2, Figs. 1–4; Smith, 1959, p 36, Pl. 10, Figs. 8–15.

Hingement.—Biversus. Hingement of right valve consisting of median groove extending entire length of hinge margin, and increasing slightly in width near cardinal corners. Groove bounded by a dorsal bar and ventral bar of uniform width. Low cardinal teeth at extremities of ventral bar, formed by slight enlargement of inner contact margin ridge at its terminations.

Hingement of left valve consisting of prominent bar extending length of hinge margin and increasing slightly in width near cardinal corners. Bar continuous with proximal ridge of contact margin and homologous to it. Shallow groove ventral to bar, but not preserved along entire hinge line. Cardinal sockets not confined ventrally, ventral to extremities of bar.

Contact margin of each valve rabbeted to accommodate contact margin of opposite valve. Median groove of right valve accommodating bar of left valve, and cardinal sockets accommodating cardinal teeth. Distal ridge of contact margins of each valve ornamented with small evenly spaced tubercles. Hinge line about four-fifths as long as entire carapace, including frill, in both male and female.

Remarks.—No complete carapaces were found. This is the first reported occurrence of this species in the Centerfield Limestone and Arkona Shale.

Occurrence.—Centerfield Limestone; Arkona Shale.

Types.—Hypotypes, one female right valve, UMMP 47590, and one female left valve, UMMP 47589.

Hollinella acutilobata Weiss, sp. nov.
(Pl. XXII, Figs. 1–8, 11–18)

Hollinella kolmodini Kesling and McMillan, 1951, p. 55, Pl. 1, Fig. 10.
Not *Beyrichia kolmodoni* Jones, 1890, p. 538, Pl. 20, Fig. 6.

DESCRIPTION BY MARTIN WEISS

Description of male.—Carapace elongate, subelliptical to subovate. Left valve slightly overlapping right valve along free border. Anterior border subround, posterior and ventral borders very gently curved. L1 vertical, extending ventrally from dorsal border to a point two-thirds the height of the valve, becoming confluent at this point with ventral lobe making almost a right angle at the point of confluence. L2 a small vertically elongate node. L3 a prominent bulb extending from slightly above the hinge line to a point midway to ventral border. S1 and S2 forming a prominent, deep subrectangular area in the dorsal center part of the valve, about one-fourth the valve length and about one-half the height of the valve. The anterior ventral portion of this area occupied by L2. L2 separated from L1 and L3 by narrow ventral part of S1, and a wider part of S2. Ventral lobe becoming tumid and wide beneath S2, narrowing and terminating abruptly at a point below center of L3. A sulcus, as deep as S1 and S2, separating ventral lobe from L2 and L3. Surface of valve granulose with scattered papillae.

All lobes in strong relief and all sharply ridged.

Anterior cardinal angle about 130 degrees, posterior cardinal angle about 90 degrees.

Frill narrow, confluent with an anterior platform and with a platform in ventrum. Incurved frill extending from anterodorsal corner to posteroventral region, terminating in an outward flaring protuberance. Tuberculate marginal structure present.

Dimensions of male carapace, the holotype: length, 1.01 mm; height, .61 mm; and width, .42 mm.

Description of female.—Outline, lobation, and surface same as that of the male. L3 larger, more tumid than in male, and encroaching upon adjacent sulci. Cardinal angles as in male.

Frill not wide, more incurved than in male, terminating below anterior part of L3. Ventral to L4, a strong outward, posteriorly directed protuberance. Channel between ventral free margin and frill becoming very wide in central ventrum.

Dimensions of female left valve, the allotype: length, 1.08 mm; height, .66 mm; and width, .30 mm.

Remarks.—This species has been found only in the Bell Shale. Pl. 17, Figs. 1–3 (Weiss' thesis; not illustrated herein) shows views of three U. S. National Museum plesiotypes No. 42381 of *Hollinella kolmodini* (Jones). It is evident that the two species are distinct.

Hollinella acutilobata, sp. nov., does not closely resemble any other species in the distribution of its lobation on the valve surface or in the ridged nature of these lobes.

The name of this species is derived from Latin *acutus* ("sharpened") and *lobatus* ("lobed") and refers to the lobe ridges.

Hingement.—Complex. Hingement of right valve consisting of anterior cardinal socket and posterior cardinal socket; bulbous cardinal tooth anterior to posterior socket and smaller cardinal tooth posteroventral to posterior socket; small cardinal tooth anteroventral to anterior socket. Well-defined groove between posterior tooth and anterior socket, bounded by dorsal bar and ventral bar; dorsal bar bounding interior socket dorsally; sockets without confining ventral margin.

Hingement of left valve consisting of anterior cardinal tooth and posterior cardinal tooth; deep cardinal socket anterior to the posterior tooth, and a smaller socket ventral to the posterior tooth; a small socket anteroventral to anterior tooth. Shallow median groove between posterior socket and anterior tooth, bounded by prominent dorsal bar, and low ventral bar. Ventral bar seeming to form ventral border of posterior socket; anterior socket proximally unconfined.

Contact margin of right valve rabbeted to accommodate contact margin of left valve. Hinge elements of each valve "key" into those of opposite valve. Hinge line about four-fifths as long as entire carapace, including frill.

Remarks.—No complete carapaces were found. The hingement of this species is unique and cannot be placed in any of the existing hinge type categories. Because it is more advanced than any hollinid hingement, perhaps the species should be excluded from the hollinids and placed in a group by itself.

Occurence.—Traverse group (Bell Shale, localities 31*a*, 31*b*, and 38*b*).

Types.—Holotype UMMP 30906, allotype, UMMP 30905, paratypes, UMMP 30907, 47592–47595.

Genus *Ruptivelum* Kesling and Weiss, 1953

Type species.—By original designation, *Ruptivelum bacculatum* Kesling and Weiss, 1953, pp. 47–48; Pl. I, Figs. 22–30.

Ruptivelum bacculatum Kesling and Weiss
(Pl. II, Figs. 20–22; Pl. XI, Figs. 31–34, 37; Pl. XII, Figs. 1–6; Pl. XIX, Figs. 11–12; Pl. XX, Fig. 9)

Ruptivelum bacculatum Kesling and Weiss, 1953, pp. 47–48, Pl. 1, Figs. 23-30.

Hingement.—Adont. Hingement of right valve consisting of median groove along entire length of hinge margin, increasing slightly in width near anterior corner. Groove bounded by a dorsal bar and ventral bar.

Hingement of left valve consisting of bar extending entire length of hinge margin and increasing slightly in width toward anterior corner.

Contact margin of right valve rabbeted to accommodate contact margin of left valve. Median groove of right valve accommodating bar of left valve. Proximal ridge of contact margin of right valve bifurcating from dorsal and ventral hinge bars. Hinge line of female about four-fifths as long as entire carapace, including frill.

Remarks.—The illustrated specimens conform to the description of the species in all respects except in being slightly larger.

This is the first reported occurrence of this species in the Gravel Point and Widder Formations.

Peel series.—(Pl. XI, Figs. 31–34, 37; Pl. XII, Figs. 1–6.) Some peels show faint lines in the shell, about midway between the inner and outer surfaces, and extending parellel to these surfaces (Pl. XI, Fig. 32; Pl. XII, Figs. 2–3). They may be formed because of layering of the shell material.

Thin lines also extend into the frill, suggesting it is formed as a double-walled outfold of the valve (Pl. XI, Fig. 34; Pl. XII, Figs. 1–6).

The overlapping part of the contact margin of the right valve appears as a shallow indentation in cross section, and the overlapped part of the left valve is broadly curved in cross section.

Occurrence.—Lower Blue Shale of Gravel Point Formation; locality 14; Widder Formation.

Type.—Hypotype, a female right valve, UMMP 47583.

Genus *Subligaculum* Kesling and McMillan

Type species.—By original designation, *Subligaculum scrobiculatum* Kesling and McMillan, 1951, p. 65, Pl. 2, Figs. 1–4; Pl. 7, Figs. 1–8.

Subligaculum scrobiculatum Kesling and McMillan
(Pl. XIX, Fig. 10; Pl. XXI, Figs. 7–8)

Subligaculum scrobiculatum Kesling and McMillan, 1951, p. 65, Pl. 2, Figs. 1–4; Pl. 7, Figs. 1–8.

Hingement.—Adont. Hingement of right valve consisting of median groove extending entire length of hinge margin. Groove bounded by a dorsal bar and ventral bar of uniform width. Hingement of left valve unknown, but valve presumably possessing a hinge bar along entire length of hinge margin.

Contact margin of right valve rabbeted to accommodate contact margin of left valve. Median groove of right valve accommodating bar of left valve. Hinge line about nine-tenths as long as entire carapace.

Remarks.—Hinge description is based upon a poorly preserved male right valve. No complete carapaces were found.

Occurrence.—Bell Shale, locality 31*a*.

Type.—Hypotype, a male right valve, No. 47582.

Superfamily Kirkbyacea Ulrich and Bassler, 1906
Family Amphissitidae Knight, 1928
Genus *Amphissites* Girty

Type species.—By original designation, *Amphissities rugosus* Girty, 1910, p. 263 (no illustration); also by subsequent designation of Roundy, 1926, p. 7, Pl. 1, Figs. 1*a–c*.

Amphissites bernhageni Stewart and Hendrix
(Pl. III, Figs. 4–6; Pl. XII, Figs. 7–18; Pl. XXI, Fig 9;
Pl. XXII, Figs 9–10)

Amphissites bernhageni Stewart and Hendrix, 1945, p. 104, Pl. 11, Figs. 19–21; Sohn, 1961, p. 117.
Amphissites carmani Stewart and Hendrix, 1945, p. 106, Pl. 11, Figs. 22–24.
Amphissites shafferi Stewart and Hendrix, 1945, p. 106, Pl. 11, Figs. 25–27.

Hingement.—Adont. Hinge structure not shown in peel series. Hingement of left valve consisting of distinct median groove extending entire length of hinge margin, increasing in width from center to cardinal corners, being about twice as wide at cardinal corners as at center. Groove bounded by a dorsal bar and ventral bar. Ventral bar continuous with contact margin ridge. Goove not confined at anterior and posterior extremities.

No right valves found, but presumably the right valve having a bar to fit into median groove of left valve. Right valve overlapping left valve along entire free margin.

In their description of *A. bernhageni,* Stewart and Hendrix stated (1945, p. 104), "Hingement a linear groove in left valve into which edge of right valve fits."

Hinge line about seven-tenths as long as entire carapace.

Remarks.—This is the first reported occurrence of this genus in Michigan. Three complete carapaces and one left valve were found.

Peel series.—(Pl. XII, Figs. 7–18.) The right valve overlaps the left valve quite strongly, and causes the frill of the right valve to extend distally farther than that of the left valve (Pl. XII, Figs. 8–15). The contact margin of each valve tapers gradually to a thin edge, and appears as a sharp point in cross section.

Thin lines extend from the interior of the carapace into most elements of the reticulation, and also into the frill and contact margin.

The thickness of the valves is least in the pits of the reticulation.

Occurrence.—Bell Shale, locality 38*a*.

Type.—Hypotype, a left valve, UMMP 47591.

Family Arcyzonidae Kesling, 1961

Genus *Arcyzona* Kesling

Type species.—*Amphissites diadematus* Van Pelt, 1933, p. 329, Pl. 39, Figs. 11, 14, and 15, by subsequent designation of Kesling, 1952*b*, pp. 30–31.

Arcyzona apobathrota Kesling
(Pl. XXIII, Figs. 1–6)

Arcyzona apobathrota Kesling, 1952*b*, pp. 33–34, Pl. 5, Fig. 19; Sohn, 1961, p. 138.

Hingement.—Adont. Hingement of right valve consisting of well-defined median groove extending entire length of hinge margin, slightly wider in anterior one-third. Groove bounded by a dorsal bar which decreases in width toward anterior, and a ventral bar which increases in width toward anterior. Dorsal bar continuous with ridge of contact margin and homologous to it.

Hingement of left valve consisting of prominent bar extending entire length of hinge margin; bar continuous with ridge of contact margin and homologous to it.

Right valve overlapping left valve along entire contact margin. Median groove of right valve accommodating bar of left valve. Hinge line about two-thirds as long as entire carapace.

Remarks.—This is the first reported occurrence of this species in the Widder Formation.

Occurrence.—Widder Formation, locality A; Bell Shale, localities 31*a* and 38*a*.

Types.—Hypotypes, one right valve, UMMP 47597, and one left valve, UMMP 47596.

Arcyzona bythiclimacota Kesling

(Pl. III, Figs. 7–9; Pl. XII, Figs. 19–31; Pl. XIII, Figs. 1–4; Pl. XXIII, Figs. 7–12)

Arcyzona bythiclimacota Kesling, 1952*b*, pp. 32–33, Pl. 2, Fig. 10; Pl. 5, Figs. 12–16; Sohn, 1961, p. 138.

Amphissites diadematus Van Pelt (*partim*), 1933, pp. 329–31, Pl. 39, Fig. 8.

Hingement.—Adont. Hingement of right valve consisting of distinct median groove along entire length of hinge margin, slightly wider in anterior one-fourth. Groove bounded by a dorsal bar decreasing in width toward anterior, and a ventral bar increasing in width toward anterior. Anterior end of groove not confined anteroventrally, but ending abruptly at posterior end. Dorsal bar continuous with ridge of contact margin and homologous to it.

Hingement of left valve consisting of prominent bar along entire length of hinge margin; bar continuous with ridge of contact margin and homologous to it.

Right valve overlapping left valve along entire contact margin. Median groove of right valve accommodating bar of left valve. Hinge line about two-thirds as long as entire carapace.

Remarks.—This is the first reported occurrence of this species in the Arkona Shale.

Peel series.—(Pl. XII, Figs. 19–31; Pl. XIII, Figs. 1–4.) The right valve overlaps the left valve along the entire contact margin, and causes the velate ridge of the right valve to extend distally farther than that of the left valve. The contact margin of each valve tapers to an edge and appears pointed in most peel sections.

Some peels show thin lines extending from the inner surfaces of the carapace into the frill and elements of reticulation (Pl. XII, Fig. 31).

The thickness of the valves is least in the kirkbyan pit (Pl. XII, Fig. 28), and in the pits of the reticulation.

Occurrence.—Bell Shale, localities 31*a*, 31*b*, 31*c*, 31*d*, and 38*a*; Arkona Shale.

Types.—Hypotypes, one right valve, UMMP 47598, and one left valve, UMMP 47599.

Arcyzona campylactinota Kesling
(Pl. XXIV, Figs. 10–12)

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

Arcyzona campylactinota Kesling, 1952*b*, pp. 34–36, Pl. 2, Figs. 11–13; Pl. 5, Figs. 7–11; Sohn, 1961, p. 138.

Hingement.—Adont. Hingement of left valve consisting of prominent bar along entire length of hinge margin; bar continuous with ridge of contact margin and homologous to it. Hingement of right valve unknown, but presumably a median groove to accommodate bar of left valve. Hinge line about two-thirds as long as entire carapace.

Remarks.—Only a single valve was found with hingement preserved.

Occurrence.—Bell Shale, locality 31*a*.

Type.—Hypotype, a left valve, UMMP 47606.

Arcyzona diademata (Van Pelt)
(Pl. XXIII, Figs. 13–18)

Amphissites diadematus Van Pelt, 1933, p. 239, Pl. 39, Figs. 11, 14–15; Coryell and Malkin, 1936, p. 4, Fig. 10.

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

Arcyzona diademata Kesling, 1952*b*, p. 31, Pl. 2, Fig. 14; Pl. 4, Figs. 34–38; Pl. 5, Fig. 1; Sohn, 1961, p. 138, Pl. 7, Figs. 11–12.

Hingement.—Adont. Hingement of right valve consisting of median groove along entire length of hinge margin. Groove bounded by a dorsal bar and ventral bar, both of uniform width. Hingement of left valve consisting of distinct bar of uniform width along entire length of hinge margin; bar continuous with contact margin ridge and homologous to it.

Median groove of right valve accommodating bar of left valve. Right valve overlapping left valve along entire contact margin. Hinge line about two-thirds as long as entire carapace.

Remarks.—The illustrated left valve is of an immature individual and

the illustrated right valve is of a mature form. Many single valves were found but few had their hingement preserved.

A peel series made from one complete carapace revealed no structure.

This is the first reported occurrence of this species in the Arkona Shale and Widder Formation.

Occurrence.—Bell Shale, localities 31*a*, 31*b*, 31*c*, 31*d*, and 38*a*; Widder Formation, localities A and B; Arkona Shale.

Types.—Hypotyes, a right valve, UMMP 47600, and an immature left valve, UMMP 47601.

Arcyzona rhabdota Kesling

(Pl. II, Figs. 18–19; Pl. XIII, Figs. 5–13; Pl. XXIII, Figs. 19–21)

Arcyzona rhabdota Kesling, 1952*b*, pp. 31–32, Pl. 2, Figs. 8–9; Pl. 5, Figs. 2–6; Sohn, 1961, p. 138.

Hingement.—Adont. Hingement of right valve consisting of distinct median groove extending entire length of hinge margin, slightly wider in anterior one-fourth. Groove is bounded by a dorsal bar which decreases in width toward anterior, and a ventral bar, which increases in width toward anterior. Anterior end of groove not confined anteroventrally, ending abruptly at posterior end.

Hingement of left valve consisting of prominent bar extending entire length of hinge margin. Bar continuous with ridge of contact margin and homologous to it.

Right valve overlapping left valve along entire contact margin. Median groove of the right valve accommodating bar of left valve. Hinge line about two-thirds as long as entire carapace.

Remarks.—This is the first reported occurrence of this species in the Arkona Shale and Centerfield Limestone.

Peel series.—(Pl. XIII, Figs. 5–13.) The right valve overlaps the left valve along the entire contact margin, and causes the velate ridge of the right valve to extend distally farther than that of the left valve. The contact margin of each valve tapers to a sharp edge and appears pointed in most peel sections.

Most of the peels show thin lines extending from the inner surface of the valves into the frill and elements of reticulation (Pl. XIII, Figs. 7–12).

The thickness of the valves is least in the pits of the reticulation.

Occurrence.—Bell Shale, localities 31*a* and 31*d*; Arkona Shale; Centerfield Limestone.

Type.—Hypotype, a right valve, UMMP 47602.

Genus *Chironiptrum* Kesling

Type species.—By original designation, *Chironiptrum oiostathmicum* Kesling, 1952*b*, p. 36, Pl. 2, Figs. 5–7; Pl. 4, Figs. 26–33.

Chironiptrum oiostathmicum Kesling
(Pl. XXIV, Figs. 4–9)

Chironiptrum oiostathmicum Kesling 1952*b*, p. 36–37, Pl. 2, Figs. 5–7; Pl. 4, Figs. 26–33.

Hingement.—Adont. Hingement of right valve consisting of well-defined median groove extending entire length of hinge margin and increasing slightly in width toward cardinal corners. Narrow bars of uniform width bordering groove dorsally and ventrally. Extremities of groove ending abruptly at cardinal corners.

Hingement of left valve consisting of prominent bar extending entire length of hinge margin, increasing slightly in width toward cardinal corners. Bar continuous with ridge of contact margin and homologous to it.

Right valve rabbeted along entire free margin to accommodate free margin of left valve. Median groove of right valve accommodating bar of left valve. Hinge line about seven-tenths as long as entire carapace.

Remarks.—Peel series were made from several complete carapaces, but they revealed no structure.

Occurrence.—Bell Shale, localities 31*a*, 31*b*, and 31*d*.

Types.—Hypotypes, one right valve, No. 47605, and one left valve, No. 47604.

?Family Placideidae Schneider, 1956
Genus *Amphissella* Stover

Type species.—By original designation, *Amphissella papillosa* Stover, 1956, pp. 1134–35, Pl. 119, Figs. 11, 12.

Amphissella tenuis (Warthin)
(Pl. III, Figs. 1–3; Pl. XIII, Figs. 14–22; Pl. XIV, Fig. 25)
Pl. XXIV, Figs. 1–3)

Amphissites tenuis Warthin, 1934, pp. 215–16, Pl. 1, Fig. 13; Stover, 1956, p. 1134.

Hingement.—Hinge structure not shown in peel series. Hingement of left valve consisting of sharp bar of uniform width extending entire length of hinge margin; bar continuous with ridge of contact margin and homologous to it.

No right valves found with hingement preserved. Right valve probably with a median groove bounded by a dorsal and ventral bar. Groove accommodating bar of left valve. According to Sohn (1961, p. Q168) astracodes of the family Placideidae possess a bar-and-groove hingement. Hinge line about two-thirds as long as entire carapace, set slightly below dorsal border of the valves.

Remarks.—Many complete carapaces, but only a few single valves were found. No single right valves had their hingement preserved.

This is the first reported occurrence of this species in the Bell Shale.

Peel series.—(Pl. XIII, Figs. 14–22; Pl. XIV, Fig. 25.) A marginal ridge is present only on the left valve and is formed by the part of the contact margin which overlaps the right valve.

The overlapping part of the contact margin of the left valve forms a broad U in cross section, and the overlapped part of the right valve is gently curved in cross section (Pl. XIV, Fig. 25).

The thickness of the valves is least in the pits of the reticulation.

Occurrence.—Lower Blue Shale and Upper Blue Shale of Gravel Point Formation, locality 14; Upper Blue Shale of Gravel Point Formation, locality 9; Bell Shale, localities 31*a* and 31*d*.

Type.—Hypotype, one left valve, UMMP 47603.

Superfamily Oepikellacea Jaanusson, 1957
?Family Aparchitidae Jones, 1901

Genus *Aparchites* Jones

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

Aparchites crossotus Kesling

(Pl. II, Figs. 13–17; Pl. XIII, Figs. 23–24; Pl. XIV, Figs. 26–27)

Aparchites crossotus Kesling, 1952*b*, pp. 23–24, Pl. 1, Figs. 1–12; Pl. 2, Fig. 1.

Hingement.—Hinge structure not shown in peel series. From examination of holotype and paratypes, hingement of right valve consisting of median groove along entire length of hinge margin, becoming slightly wider toward each corner. Groove bounded by dorsal bar and ventral bar of uniform width.

Hingement of right valve consisting of bar extending entire length of hinge margin. Bar continuous with ridge of contact margin and homologous to it.

Contact margin of left valve rabbeted to accommodate contact margin of right valve. Median groove of right valve accommodating bar of left valve. Hinge line about four-fifths as long as entire carapace, set slightly below the dorsal border of the valves.

Remarks.—The adductor muscle scar of the sectioned specimen showed up well when the specimen was immersed in glycerine and viewed with transmitted light (Pl. 2, Figs. 16–17). The scar consists of an ovate area in the median part of the valve, within which are many small circular secondary scars.

Peel series.—(Pl. XIII, Figs. 23–24; Pl. XIV, Figs. 26–27.) The contact margin of the carapace is situated slightly proximal to the ventral border of the valves, and the hinge is slightly depressed.

The overlapping part of the contact margin of the left valve froms a shallow U in cross section, and the overlapped part of the right valve is tapered to form a point in cross section (Pl. XIV, Fig. 27).

The valves are essentially uniform in thickness throughout the entire carapace.

Occurrence.—Bell Shale, locality 31*a*.

Suborder Kloedenellocopina Scott, 1961
Superfamily Kloedenellacea Ulrich and Bassler, 1908
Family Kloedenellidae Ulrich and Bassler, 1908

Genus *Eukloedenella* Ulrich and Bassler

Type species.—By original designation, *Eukloedenella umbilicata* Ulrich and Bassler, 1923*b*, p. 669, Pl. 57, Figs. 8–12.

Eukloedenella subaequalis (Swartz and Oriel)
(Pl. III, Figs. 19–21; Pl. XV, Figs. 12–22)

Punctoprimitia subaequalis Swartz and Oriel, 1948, pp. 550–51, Pl. 79, Figs. 4–5; Kesling, 1952*b*, p. 25, Pl. 2, Figs. 2–4; Kesling and Weiss, 1953, pp. 34–35. Pl. 3, Figs. 2–7; Stover, 1956, p. 1112, Pl. 115, Figs. 23–27.

Hingement.—Adont. Hinge structure not well shown in peel series. Hingement of right valve apparently consisting of median groove to accommodate bar of left valve. Contact margins of valves meeting evenly without any overlap.

Remarks.—Wainwright (1959) reported that the hingement of *Eukloedenella sinuata* consists of a groove in both the left and right valves, with each groove being bounded by a dorsal and ventral bar, and with the groove of the right valve accommodating the dorsal bar of the left valve.

This is the first reported occurrence of this species in the Widder Formation and Arkona Shale.

Peel series.—(Pl. XV, Figs. 12–22.) The contact margins of the valves meet evenly, and each is tapered gradually to form a sharp point in cross section.

The thickness of the valves is least in the pits of the reticulation.

Occurrence.—Widder Formation, localities A and B; Arkona Shale; Upper Blue Shale of Gravel Point Formation, locality 14.

Genus *Kloedenella* Ulrich and Bassler, 1908

Type species.—*Kloedenia pennsylvanica* Jones, 1889, p. 341, Figs. 5*a*–6*d*, (not 7*a*–*b*, 8, or 9), by subsequent designation of Ulrich and Bassler, 1908, p. 304, Fig. 54; pp. 318, 340; Pl. 43, Figs. 1–3.

Kloedenella lophota Kesling and Kilgore
(Pl. III, Figs. 22–24; Pl. XIV, Figs. 1–14, 24)

Kloedenella lophota Kesling and Kilgore, 1952, p. 4, Pl. 1, Figs. 9–20.

Hingement.—Hinge structure not shown well in peel series. Right valve appearing to overlap left valve in posterior part of carapace. Hinge line slightly depressed. Contact margin of left valve rabbeted to accommodate contact margin of right valve.

Remarks.—No single valves were found. This is the first reported ocurrence of this species in the Arkona Shale.

Peel series.—(Pl. XIV, Figs. 1–14, 24.) The contact margin of the valves is slightly depressed from the ventral border. The greatest thickness of the valves is generally through the velate ridge.

Occurrence.—Arkona Shale; Upper Blue Shale of Gravel Point Formation, locality 14; Killian's Member of Genshaw Formation, locality 52.

Genus *Dizygopleura* Ulrich and Bassler

Type species.—By original designation, *Dizygopleura swartzi* Ulrich and Bassler, 1923*b*, p. 693, Pl. 62, Figs. 1–8.

Dizygopleura euglyphea Warthin
(Pl. III, Figs. 10–14; Pl. XIV, Figs. 15–23; Pl. XV, Figs. 1–11, 23–29; Pl. XXIV, Figs. 13–20)

Dizygopleura euglyphea Warthin, 1934, p. 210, Pl. 1, Fig. 7; Warthin, 1937, Card 57; Stewart and Hendrix, 1945, p. 90, Pl. 10, Figs. 6–8; Kesling and Weiss, 1953, p. 54, Pl. 3, Figs. 30–31.

Hingement.—Complex. Unusual feature in hingement the presence of a trianglar toothlike lateral extension of overlapping left valve in region of anteradorsal free margin. This feature, referred to as an anterior "cardinal tooth," but not part of the hingement proper, accommodated by triangular depression in right valve.

Right valve possessing shallow groove extending from posterior cardinal corner to triangular depression. Dorsal edge of left valve fitting into groove. Shallow accommodation groove present on dorsal hinge margin of left valve to accommodate right hinge margin upon opening of carapace. True, small knoblike cardinal tooth just anterior to triangular depression. Corresponding cardinal socket presumably present in the left valve, but obscured by matrix in this specimen.

Left valve overlapping right valve along entire contact margin. Hinge line about three-fourths as long as entire carapace.

Wainwright (1959) found a similar hingement in *Dizygopleura swartzi.*

Remarks.—The figured single right valve is of an adult male, and the figured single left valve is of an immature instar. The hingement of this species cannot be placed in any of the existing hingetype categories.

The specimens occurring in the black shale Killian's Member of the Genshaw Formation are considerably larger than those from other localities. The difference in size may be due to the differences in environment affecting the growth of the individuals, or it may be caused by other factors.

This is the first reported ocurrence of this species in the Arkona Shale and Genshaw Formation.

Peel series.—(Pl. XIV, Figs. 15–23; Pl. XV, Figs. 1–11, 23–29.) The first part of the cross peel series shows that the right valve overlaps the left valve (Pl. XIV, Figs. 15–23; Pl. XV, Figs. 1–6). At the "cardinal tooth" of the left valve (Pl. XV, Figs. 7–8), the left valve overlaps the right. Pyrite in the steinkern of the carapace caused details to be lost in the first part of the peel series.

The frontal peel series reveals that the thickness of the valves is less in the sulci than in other parts of the carapace (Pl. XV, Figs. 23–29).

Occurrence.—Arkona Shale; Upper Blue Shale and Lower Blue Shale of Gravel Point Formation, locality 14; Killian's Member of Genshaw Formation, locality 52.

Types.—Hypotypes, one male right valve, UMMP 47607, one immature left valve, UMMP 47608.

SUMMARY AND CONCLUSIONS

The five types of hinge structure represented in the Middle Devonian palaeocopid ostracodes are listed below, with the name of the species possessing each type. An asterisk indicates that the assignment is made on the basis of peel series only.

I. Smooth contact of hinge areas.

**Aechminaria hormathota* Kesling
Kirkbyella (Kirkbyella) bellipuncta (Van Pelt)

II. Adont (a groove in one valve accommodating a bar of opposite valve).

Treposella stellata Kesling
**Phlyctiscapha subovata* Smith
Bollia hindei (Jones)
Ulrichia fragilis Warthin
U. spinifera Coryell and Malkin
**U. illinearis* Kesling
**Abditoloculina pulchra* Kesling
**Falsipollex laxivelatus* Kesling
Hollinella bullata Kesling and McMillan
H. horologiina Weiss
H. nodiventriculata Weiss
Ruptivelum bacculatum Kesling and Weiss
Subligaculum scrobiculatum Kesling and McMillan
Amphissites bernhageni Stewart and Hendrix
Arcyzona apobathrota Kesling
A. bythiclimacota Kesling
A. campylactinota Kesling
A. diademata (Van Pelt)
A. rhabdota Kesling
Chironiptrum oiostathmicum Kesling
Aparchites crossotus Kesling
Eukloedenella subaequalis (Swartz and Oriel)

III. Biversus (proposed for hingement consisting of a groove in each valve accommodating a bar of opposite valve, and usually with two cardinal teeth or two cardinal sockets in each valve).

Adelphobolbina medialis Stover
A. papillosa (Ulrich)
Hollinella devoniana (Van Pelt)
H. labrosa Kesling and Weiss

IV. Prionodont (a groove in one valve and bar in opposite valve, each modified by minute sockets and teeth).

Ctenoloculina cicatrosa (Warthin)
C. myurilobata Kesling

V. Complex (two exceptions which do not fit other categories).

Hollinella acutilobata Weiss
Dizygopleura euglyphea Warthin

Hinge type I includes species of the families Aechminidae and Kirkbyellidae. Type II has species represented from the families Beyrichiidae, Bolliidae, Hollinidae, Amphissitidae, Arcyzonidae, Aparchitidae, and Kloedenellidae. Types III and IV have species only from the family Hollinidae.

In hinge type I, species of only the superfamily Drepanellacea occur. Type II has species represented from the superfamlies Beyrichiacea, Drepanellacea, Hollinacea, Kirkbyacea, Oepikellacea, and Kloedenellacea. Types III and IV have species only from the superfamily Hollinacea.

Hingement appears to have little relationship to the present classification of palaeocopid ostracodes.

The following species are placed in hinge groups on the basis of the hinge illustrations and descriptions of Levinson (1950), Wainwright (1959), and Pokorný (1959):

II. Adont

Beyrichia fittsi Roth
Dizygopleura swartzi Ulrich and Bassler

III. Biversus

Clavofabella multidentata Martinsson
Eukloedenella sinuata Ulrich and Bassler

V. Complex

Beyrichia dactyloscopica Martinsson
Beyrichia clavata (Kolmodin)
Triemilomatella prisca Jaanusson and Martinsson
Ulrichia bituberculata (M'Coy)
Primitiopsis bassleri Harris (lophodont hingement)
Bonneprimites bonnemai (Swartz)
Eridoconcha rugosa Ulrich and Bassler

The superfamily Youngiellacea includes a small group of ostracodes with prionodont hingement (Scott, 1961, p. Q85). They are known only from Mississippian and Pennsylvanian formations. To the knowledge of

the present writer, the Middle Devonian genus *Ctenoloculina* is the only other palaeocopid group to possess prionodont hingement. This suggests an affinity of *Ctenoloculina* to the Youngiellacea, and perhaps they had a common ancestor.

According to Scott (1961, p. Q84), the hingement of the Kirkbyacea resembles that found in the Kloedenellacea, suggesting a possible relationship between these superfamilies. The findings of the present writer substantiate this view, although Wainwright (1959) found that *Eukloedenella sinuata,* a species in the Kloedenellacea, has a more advanced hingement than the other species in the two groups.

Scott (1961, p. Q84) stated that so far as known, the hingement of the Beyrichiacea is of the primitive bar and groove type. However, Pokorný (1959) found that in two species of the Beyrichiacea, the hingement was more advanced.

According to Scott (1961, p. Q85) the Kloedenellacea are characterized by one valve strongly overlapping the other around all or a portion of the free margin of the smaller valve. The present writer has found that in *Eukloedenella subaequalis* the free margins of the valves meet evenly without any overlap. This species should perhaps be excluded from the Kloedenellacea.

The peel series revealed four relationships between the contact margins of the two valves: (1) the contact margins meet evenly, (2) one contact margin is rabbeted to accommodate the opposite contact margin, (3) both contact margins are rabbeted, or (4) the contact of one valve overlaps that of the opposite valve without either being rabbeted. The most common relationship is that in which one contact margin is rabbeted to accommodate the opposite contact margin.

In different species of a genus, more than one type of contact margin relationship may occur. All individuals of a species, however, have the same contact margin relationship.

In the peels of several species, thin lines extend through many elements of the reticulation and through the frill. These include *Ulrichia spinifera* Coryell and Malkin, *Abditoloculina pulchra* Kesling, *Ctenoloculina cicatricosa* (Warthin), *Amphissites bernhageni* Stewart and Hendrix, *Arcyzona bythiclimacota* Kesling, and *A. rhabdota* Kesling. Kesling (1957, p. 33) found that similar lines occur in the valves of *Hibbardia lacrimosa* (Swartz and Oriel). He concluded that each structural unit of the shell in the sides of the carapace was cupshaped, and bounded by the proximal half of the surrounding reticulation.

The peels show that some species of the family Hollinidae have tubules occurring in the frill, whereas others do not. Those species with tubules

are *Adelphobolbina papillosa* (Ulrich), *Falsipollex lexivelatus* Kesling, *Hollinella horologiina* Weiss, and *H. devoniana* (Van Pelt). The tubules neither communicate with the interior of the carapace, nor reach the outer edge of the frill. They were probably sealed off from the interor of the carapace by secretions from the hypodermis.

Kesling (1955*a*, p. 269) noted that tubules occur in the frill of the hollinid *Oepikium tenerum* (Öpik), and Martinsson (1962) shows that tubules occur in the frills of beyrichiids. Martinsson (1962, p. 72) states:

> The lumen in the tubules in the velar as well as in the marginal structure is easily observed when the structure is broken. They were formed in an initial stage of the calcification of the carapace by a morphological or physiological differentiation of the epithelium. If the epithelium was differentiated morphologically the processes corresponding to the tubules must have been retracted or resorbed before the calcification was completed; there is never any communication of the tubules with the domicilium of the carapace except in one case referred to below where the completion of the last moulting had been interrupted in an early stage. The normal velar tubule never has an external opening.

The presence or absence of tubules in the frill could be utilized as a taxonomic character in frill-bearing palaeocopid ostracodes.

The valves of recent ostracodes have an elastic ligament on the dorsal margin which functions to open the carapace when the adductor muscles relax (van Morkhoven, 1962, p. 11). No evidence of former ligament attachment was found on the palaeocopid specimens studied. It is assumed that they had a ligament on the dorsal border, as in recent ostracodes.

Hanai (1961, p. 345) found that the hingement of post-Paleozoic ostracodes has its origin from the marginal crests on the duplicature. He states that:

> On the surface of the calcified marginal duplicature, parellel crests [i.e., flange, selvage, and list] develop along the free margin. They fuse along the dorsal hinge margin, however, and progressively evolve from simple into complicated hingement through differentiation. Therefore, the hingement and the marginal crests on the duplicature are homologous.

Most workers do not believe that a duplicature was present in palaeocopid ostracodes, although Pokorný (1957, p. 11) suggests that they possessed one. He homologized hingement with contact margin features in some Silurian palaeocopid ostracodes (1959), applying the terms flange, selvage, and list to various ridges on the contact margin. He also used the terms hinge flange, hinge selvage, and hinge list to describe the hinge features which he homologized with contact margin ridges. Martinsson (1962, p. 66), however, does not fully agree with Pokorný's principle of homologization.

The peel series revealed no evidence of a duplicature like that of younger ostracodes in the specimens which were sectioned.

In some speciments one hinge bar is continuous with a contact margin ridge, and thus homologous to it. In one case the contact margin ridge bifurcates to form both hinge bars. Therefore at least a part of the hingement of some species has evolved from a contact margin ridge.

The hingement of most Paleozoic ostracodes is simpler than that of Mesozoic and Cenozoic forms. The most primitive palaeocopid hinge is a smooth contact between hinge areas. The adont hinge probably evolved from this, followed by a biversus hinge. The prionodont hinge developed from the adont through the development of minute crenulations on the bar and in the groove.

LITERATURE CITED

BASSLER, R. S. 1941. Ostracoda from the Devonian (Onondaga) Chert of Western Tennessee. Washington Acad. Sci. Journ., Vol. 31, No. 1, pp. 21–27.

——— and KELLETT, B. 1934. Bibliographic Index of Paleozoic Ostracoda. Geol. Soc. Amer. Special Paper No. 1, 500 pp.

BONNEMA, J. H. 1930. Orientation of the Carapaces of Paleozoic Ostracoda. Journ. Paleontol., Vol. 4, No. 2, pp. 109–20, 2 pls.

BOUČEK, B. 1956. Die Ostracoden Des Böhmischen Ludlows. Neues Jahrb., Beil. Bd. 76, Abt. B, Heft. 1, pp. 31–98, Pls. 2–6.

COOPER, G. A. 1930. Stratigraphy of the Hamilton Group of New York. Am. Journ. Sci., Vol. 31, No. 6, pp. 259–60.

——— and WARTHIN, A. S., JR. 1941. New Middle Devonian Stratigraphic Names. Wash. Acad. Sci. Journ., Vol. 31, No. 6, pp. 259–60.

——— and ———. 1942. New Devonian (Hamilton) Correlations. Bull. Geol. Soc. Amer., Vol. 53, pp. 873–88.

CORYELL, H. N. 1928. Some New Pennsylvanian Ostracoda. Journ. Paleontol., Vo. 2, No. 4, pp. 377–81, Pl. 51.

——— and BOOTH, R. T. 1933. Pennsylvanian Ostracoda: A continuation of the Study of the Ostracoda Fauna from the Wayland Shale, Graham, Texas. Amer. Midland Nat., Vol. 14, No. 2, pp. 258–78, Pls. 3–5.

——— and MALKIN, D. S. 1936. Some Hamilton Ostracodes from Arkona, Ontario. Amer. Mus. Novitates, No. 891, pp. 1–20, 2 pls.

——— and WILLIAMSON, M. 1936. A Study of the Ostracod Fauna of the Waldron Shale, Flat Rock Creek, Indiana. Amer. Mus. Novitates, No. 870, pp. 1–7, Pls. 14–15.

DARRAH, W. C. 1936. The Peel Method in Paleobotany. Bot. Mus. Leaflets, Harvard Univ., Vol. 4, No. 4, pp. 69–83.

FRIEDMAN, G.M. 1959. Identification of Carbonate Minerals. Journ. Sed. Petrology, Vol. 29, No. 1, pp. 87–97.

GIRTY, G. H. 1910. New Genera and Species of Carboniferous Fossils from The Fayetteville Shale of Arkansas. New York Acad. Sci., Annals, Vol. 20, pp. 189–238.

GRABAU, A. W. 1917. Age and Stratigraphic Relations of the Olentangy Shale of Central Ohio, with Remarks on the Prout Limestone and So-called Olentangy Shales of Northern Ohio. Journ. Geol., Vol. 25, No. 4, pp. 337–43.

HANAI, T. 1961. Studies on the Ostracoda from Japan: Hingement. Journ. Faculty of Science, Univ. Tokyo, Sec. 2, Vol. 13, Part 2, pp. 345–77.

HENNINGSMOEN, G. 1953. Classification of Paleozoic Straight-Hinged Ostracods. Norsk Geologisk Tidsskrift, Vol. 31, pp. 185–288, 2 pls.

HOWE, H. W., and LAURENCICH, L. 1958. Introduction to the Study of Cretaceous Ostracoda. Baton Rouge; Louisiana State Univ. Press, 536 pp.

JAANUSSON, V. 1957. Middle Ordovician Ostracods of Central and Southern Sweden. Bull. Geol. Instit. Univ. Uppsala, Vol. 37, pp. 173–442, Pls. 1–15.

JONES, T. R. 1889. Notes on Paleozoic Bivalved Entomostraca, No. 27. Ann. Mag. Nat. Hist., Ser. 6, Vol. 3, pp. 373–87.

——— 1890. On Some Devonian and Silurian Ostracoda from North America, France, and the Bosphorus. Quart. Journ. Geol. Soc. London, Vol. 46, pp. 534–56. Pls. 20–21.

——— 1901. Ostracoda. *In* CHAPMAN, F., On Some Fossils of Wenlock Age from Mulde, Near Klinteberg, Gotland. *Ibid.*, Ser. 7, Vol. 7, pp. 141–60, Pl. 3.

——— and HOLL, H. B. 1886. Notes on the Paleozoic Bivalves Entomostraca, No. 20. On the Genus *Beyrichia* and Some New Species. *Ibid.*, Ser. 5, Vol. 17, pp. 337–63, Pl. 12.

KESLING, R. V. 1951. Terminology of Ostracod Carapaces. Contrib. Mus. Paleontol. Univ. Mich., Vol. IX, No. 4, pp. 93–171, Pls. 1–18.

——— 1952*a*. A study of *Ctenoloculina cicatricosa* (Warthin). *Ibid.* Vol. IX, No. 8, pp. 247-90. Pls. 1–3.

——— 1952*b*. Ostracods of the Families Lepreditellidae, Primitiidae, Drepanellidae, Aechminidae, and Kirkbyidae from the Middle Devonian Bell Shale of Michigan. *Ibid.*, Vol. X, No. 2, pp. 21–44, Pls. 1–5.

——— 1952*c*. Ostracods of the Family Hollinidae from the Ferron Point Formation of Michigan. *Ibid.* Vol. X, No. 3, pp. 45–57, Pls. 1–2.

——— 1952*d*. Dimorphism in Devonian Hollinid Ostracods of North America. Journ. Paleontol., Vol. 26, No. 5, pp. 764–71, Pl. 111.

——— 1953*a*. Ostracods of the Family Drepanellidae from the Arkona Shale of Ontario. Contrib. Mus. Paleontol., Univ. Mich., Vol. X, No. 8, pp. 193–202, Pl. 1.

——— 1953*b*. Ostracods of the Family Hollinidae from the Arkona Shale of Ontario. *Ibid.*, Vol. X, No. 9, pp. 203–19, Pls. 1–4.

——— 1953*c*. A New Beyrichiid Ostracod from the Middle Devonian Rockport Quarry Limestone of Michigan. *Ibid.*, Vol. X, No. 10, pp. 221–29, Pls. 1–2.

——— 1953*d*. Ostracods of the Family Aechminidae from the Arkona Shale of Southern Ontario. *Ibid.*, Vol. XI, pp. 1–10, Pl. 1.

——— 1954. Ornamentation as a Character in Specific Differentiation of Ostracods. *Ibid.*, Vol. XII, No. 2, pp. 13-21, Pls. 1–2.

——— 1955*a*. Notes on Two Ordovician Ostracods from Estonia. *Ibid.* Vol. XII, No. 13, pp. 259–72, Pl. 1.

——— 1955*b*. Two new Species of Ostracods From the Centerfield Limestone of Western New York. *Ibid.*, Vol. XII, No. 14, pp. 277–79, Pls. 1–3.

——— 1957. A peel Technique for Ostracod Carapaces and Structures Revealed Therewith in *Hibbardia lacrimosa*. *Ibid.*, Vol. XIV, No. 4, pp. 27–40, Pls. 1–5.

——— R. V. 1961. Ontogeny of Ostracoda. *In:* Moore, R. C., *ed.,* Treatise on Invertebrate Paleontology, Pt. Q, Arthropoda, Ostracoda, pp. Q19–Q20, Lawrence, Kan.: Geol. Soc. Amer. and Univ. Kan. Press.

——— and KILGORE, J. E. 1952. Ostracods of the Families Leperditellidae, Drepanellidae, Glyptopleuridae, Kloedenellidae, Bairdiidae, Barychilinidae, and Thlipsuridae from the Genshaw Formation of Michigan. *Ibid.,* Vol. X, No. 1, pp. 1–19, Pls. 1–4.

——— and MCMILLAN, G. W. 1951. Ostracods of the Family Hollinidae from the Bell Shale of Michigan. *Ibid.,* Vol. IX, No. 2, pp. 45–81, Pls. 1–7.

——— and PETERSON, R. M. 1958. Middle Devonian Ostracods from the Falls of the Ohio. Micropaleontology, Vol. 4, No. 2, pp. 129–48, Pls. 1–2.

——— and TABOR, N. R. 1953 Ostracods of the Family Hollinidae from the Genshaw Formation of Michigan. Contrib. Mus. Paleontol. Univ. Mich., Vol. X, No. 5, pp. 83–100, Pls. 1–3.

——— and WEISS, M. 1953. Ostracods from the Norway Point Formation of Michigan. *Ibid.,* Vol. XI, No. 3, pp. 33–76, Pls. 1–5.

KINGMA, J. T. 1948. Contributions to the Knowledge of the Young-Caenozoic Ostracoda From the Maylayan Region. Utrecht: Kemink Printers, 119 pp., Pls. 1–11.

LATREILLE, P. A. 1802. Historie naturelle, Générale, et Particulière des Crustacés et des Insects, Vol. 3, Paris.

LEVINSON, S. A. 1950. The Hingement of Paleozoic Ostracoda and its Bearing on Orientation. Journ. Paleontol., Vol. 24, No. 1, pp. 63–75.

LORANGER, D. M. 1954. Ireton Micro-fossil Zones of Central and Northeastern Alberta. *In:* Clark, L. M., ed., Western Canada Sedimentary Basin, Tulsa, Olka.: Amer. Assoc. Petrol. Geol., pp. 182–203, Pls. 1–2.

——— 1963. Devonian Microfauna from Northeastern Alberta: Part I. Ostracoda, Orders Leperditicopida and Palaeocopida. Published by author, available at Evelyn DeMille Books Ltd., Calgary. 47 pp., 4 pls.

MALKIN, D. S. 1953. Biostratigraphic Study of Miocene Ostracoda of New Jersey, Maryland and Virginia. Journ. Paleontol., Vol. 27, No. 6, pp. 761–99. Pls. 78–81.

MARTINSSON, Anders. 1962. Ostracodes of the Family Beryichiidae from the Silurian of Gotland. Uppsala Univ., Bull. of Geol. Institutions, Vol. 41, 367 pp.

MATTHEW, G. F. 1886. Illustrations of the Fauna of the St. John Group Continued. No. III, Descriptions of New Genera and Species. Proc. and Trans. Royal Soc. Canada, Year 1885, Vol. 3, pp. 29–85, Pls. 5–7.

POHL, E. R. 1930. The Middle Devonian Traverse Group of Rocks in Michigan, a Summary of Existing Knowledge. Proc. U.S. Nat. Mus., Vol 76, Art. 14, No. 2811, pp. 1–34.

POKORNÝ, Vladimir. 1957. The Phylomorphogeny of the Hinge in Podocopida, and its Bearing on the Taxonomy. Acta Universitatis Carolinae, Geologica, No. 3, pp. 3–22.

——— 1959. Hinge and Free Structures of Some Silurian Ostracods. *Ibid.,* No. 3, pp. 321–41.

RAYMOND, P. E. 1904. The *Tropidoleptus* Fauna of Canandaigua Lake, New York, with the Ontogeny of Twenty Species. Ann. Carnegie Mus., Vol. 3, No. 1, pp. 79–177, Pls. 1–8.

ROUNDY, P. V. 1926. Mississippian Formations of San Saba County, Texas. Part II. The Micro-Fauna. U. S. Geol. Surv. Prof. Paper, No. -46, pp. 2–17, Pl. 1.

SCOTT, H. W. 1961. Classification of Ostracoda. *In:* MOORE, R. C., ed., Treatise on Invertebrate Paleontology, Pt. Q, Arthropoda, Ostracoda, pp. Q74–Q92, Lawrence, Kan.: Geol. Soc. Amer. and Univ. Kan. Press.

SHIMER, H. W., and GRABAU, A. W. 1902. Hamilton Group of Thedford, Ontario. Bull. Geol. Soc. Amer., Vol. 13, pp. 149–86.

——— and SHROCK, R. R. 1944. Index Fossils of North America. New York: John Wiley and Sons, Inc., pp. 660–93.

SMITH, M. L. 1956. Some Ostracods from the Middle Devonian Ledyard and Wanakah Members of the Ludlowville Formation in Western New York. Journ. Paleontol., Vol. 30, No. 1, pp. 1–8, Pl. 1.

SOHN, I. G. Hinge mechanism of Paleozoic Ostracoda. *Ibid.,* Vol. 23, No. 6, p. 691.

——— 1961. Revision of Some Paleozoic Ostracode Genera: *Aechminella, Amphissites, Kirkbyella,* and Related Genera. U. S. Geol. Survey, Prof. Paper 330B, pp. 107–60, Pls. 7–12.

STAUFFER, C. R. 1915. The Devonian of Southwestern Ontario. Canada Dept. Mines, Geol. Surv. Mem. 34, pp. 1–341.

STEWART, G. A. 1936. Ostracods of the Silica Shale, Middle Devonian of Ohio. Journ. Paleontol., Vol. 10, No. 8, pp. 739–63, Pls. 100–102.

——— 1950. Ostracoda from the Middle Devonian Bone Beds in Central Ohio. *Ibid.,* Vol. 24, No. 6, pp. 652–66, Pls. 85–86.

——— and HENDRIX, W. E. 1945. Ostracoda of the Plum Brook Shale, Erie County, Ohio. *Ibid.,* Vol. 19, No. 2, pp. 87–95, Pl. 10.

STOVER, L. E. 1956. Ostracoda from the Windom Shale (Hamilton) of Western New York. *Ibid.,* Vol 30, No. 5, pp. 1092–1142, Pls. 111–19.

SWARTZ, F. M. 1936. Revision of the Primitiidae and Beyrichiidae, with New Ostracodes from the Lower Devonian of Pennsylvania. *Ibid.,* V. 10, No. 7, pp. 541–86, Pls. 78–89.

——— and ORIEL, S. S. 1948. Ostracoda from the Middle Devonian Windom Beds in Western New York. *Ibid.,* Vol. 22, No. 5, pp. 541–66, Pls. 79–81.

——— and SWAIN, F. M. 1941. Ostracodes of the Middle Devonian Anondaga Beds of Central Pennsylvania. Bull. Geol. Soc. Amer., Vol. 52, pp. 381–458, Pls. 1–8.

SYLVESTER-BRADLEY, P. C. 1956. The Structure, Evolution, and Nomenclature of the Ostracod Hinge. British Mus. (Nat. History), Bull. Geol., Vol 3, No. 1, pp. 1–21, Pls. 1–4.

TRIEBEL, E. 1950. Homöomorphe Ostracoden-Gattungen. Senckenbergiana, Vol. 31, Nos. 5–6, pp. 313–30, Pls. 1–4.

TURNER, M. C. 1939. Middle Devonian Ostracoda from Oil Wells in Southwestern Ontario. Bull. Amer. Paleontol., Vol. 25, No. 88, pp. 5–32, Pl. 1.

ULRICH, E. O. 1891. New and Little Known American Paleozoic Ostracoda. Journ. Cincinnati Soc. Nat. Hist., Vol. 13, No. 4, pp. 173–211, Pls. 11–18.

——— and BASSLER, R. S. 1908. New American Paleozoic Ostracoda. Preliminary Revision of the Beyrichiidae, with Descriptions of New Genera. Proc. U. S. Nat. Mus., Vol. 35, pp. 277–340, Pls. 37–44.

——— and BASSLER, R. S. 1923*a*. Paleozoic Ostracoda: Their Morphology, Classification, and Occurrence. Maryland Geol. Surv., Silurian Vol., pp. 271–391.

——— and BASSLER, R. S. 1923*b*. Systematic Paleontology of Silurian Deposits (Ostracoda). *Ibid.,* pp. 500–704, Pls. 36–65.

VAN MORKHOVEN, F. P. C. M. 1962. Post-Paleozoic Ostracoda, Their Morphology, Taxonomy, and Economic Use. Vol. I, General. New York: Elsevier Publ. Co., 204 pp.

VAN PELT, H. L. 1933. Some Ostracodes from the Bell Shale, Middle Devonian, of Michigan. Journ. Paleontol., Vol. 7, No. 3, pp. 325–42, Pl. 39.

WAINWRIGHT, J. 1959. Morphology and Taxonomy of Some Middle Silurian Ostracoda. Microfilm of Thesis, 1959, Univ. Illinois, 128 pp.

WARTHIN, A. S., JR. 1934. Common Ostracoda of the Traverse Group. Contrib. Mus. Paleontol. Univ. Mich., Vol. IV, No. 12, pp. 205–26, Pl. 1.

——— 1937. Type Invertebrate Fossils of North America (Devonian) Beyrichiacea. Philadelphia: Wagner Free Institute of Science, Cards 1–105.

——— and COOPER, G. A. 1943. Traverse Rocks of Thunder Bay Region, Michigan. Bull. Amer. Assoc. Petrol., Vol. 27, No. 5, pp. 571–95.

WRIGHT, J. D. and WRIGHT, E. P. 1963. The Middle Devonian Ipperwash Limestone of Southwestern Ontario and Two New Brachiopods Therefrom. Contrib. Mus. Paleontol. Univ. Mich., Vol. XVIII, No. 7, pp. 117–34, Pls. 1–3.

ZALÁNYI, B. 1929. Morphosystematische Studien über fossile Muschel-Krebse. Geol. Hungarica, Ser. Paleontol., fasc. 5, pp. 1–152, Pls. 1–4.

Submitted for publication, October 28, 1965

PLATES

EXPLANATION OF PLATE I

(All figures × 30; specimens destroyed by sectioning)

PAGE

Ulrichia illinearis Kesling 211

FIGS. 1–3. Right lateral, dorsal, and ventral views of carapace. Widder Formation, locality B.

Ulrichia fragilis Warthin 210

FIGS. 4–5. Left lateral and dorsal views of carapace. Widder Formation, locality B.

Aechminaria hormathota Kesling 208

FIGS 6–8. Right lateral, dorsal, and ventral views of carapace. Widder Formation, locality A.

Ctenoloculina cicatricosa (Warthin) 215

FIGS. 9–11. Left lateral, dorsal, and ventral views of carapace. Widder Formation, locality B.

Phlyctiscapha subovata Smith 207

FIGS. 12–14. Right lateral, dorsal, and ventral views of specimen B, a male carapace. Centerfield Limestone.

FIGS. 15–17. Left lateral, dorsal, and ventral views of specimen A, a female carapace. Centerfield Limestone.

Abditoloculina pulchra Kesling 213

FIGS. 18–20. Right lateral, dorsal, and ventral views of specimen A, a female carapace. Centerfield Limestone.

FIGS. 21–23. Left lateral, dorsal, and ventral views of specimen B, a male carapace. Centerfield Limestone.

Falsipollex laxivelatus Kesling and McMillan 218

FIGS. 24–26. Right lateral, dorsal, and ventral views of female carapace. Arkona Shale.

PLATE I

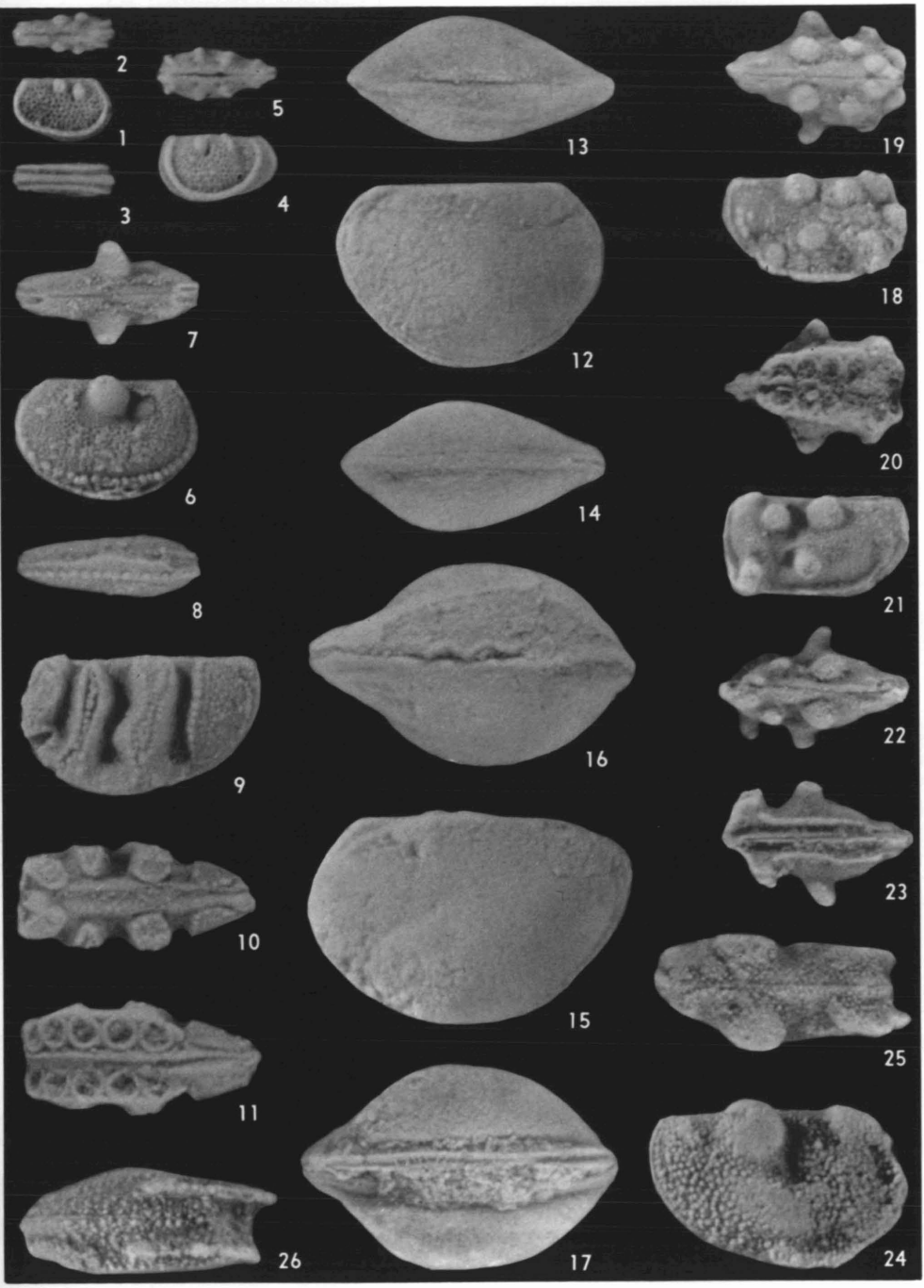
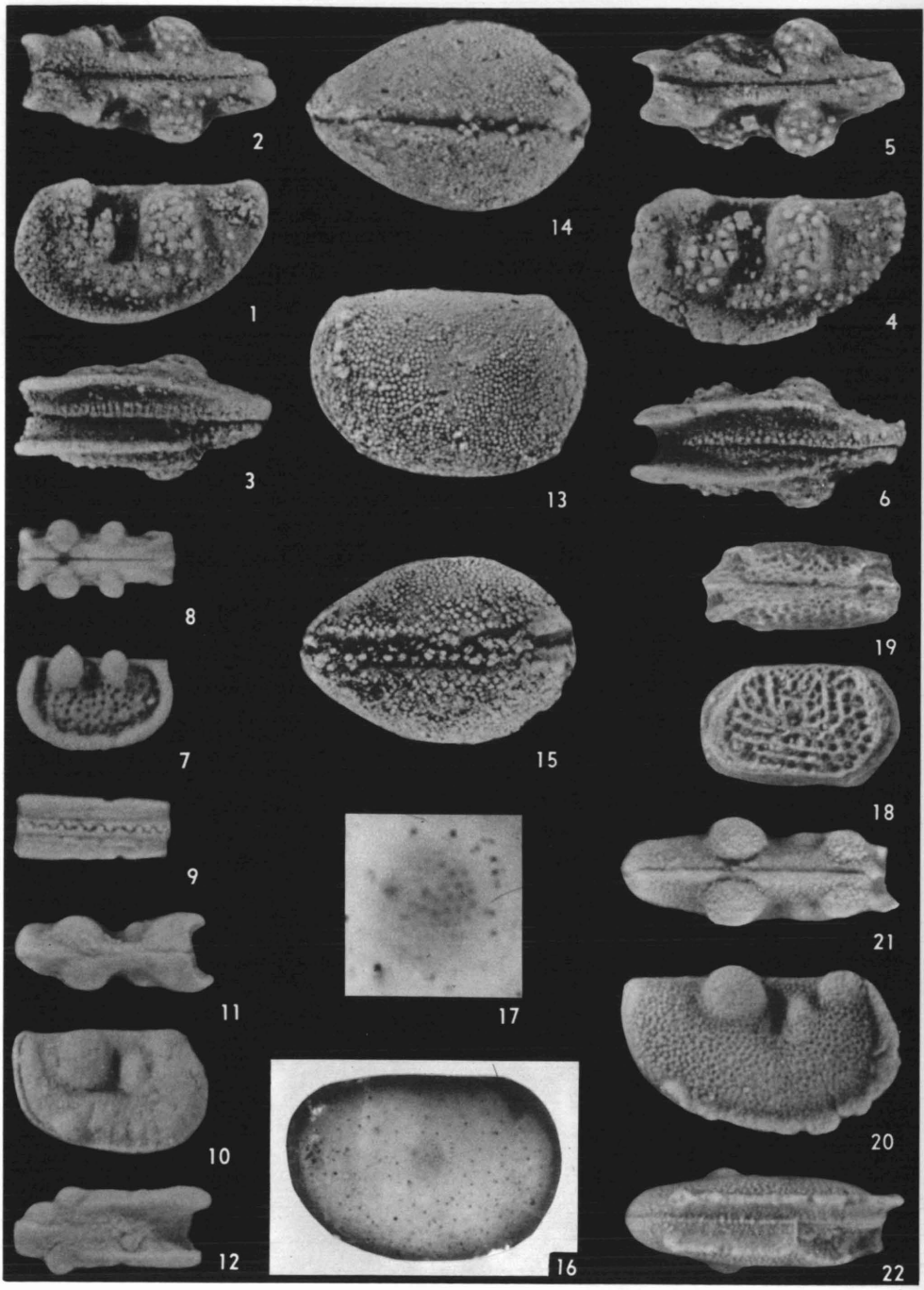


PLATE II



EXPLANATION OF PLATE II

(All figures × 30, except as noted; specimens destroyed by sectioning.)

PAGE

Hollinella devoniana (Van Pelt) 222

FIGS. 1–3. Left lateral, dorsal, and ventral views of specimen B, a male carapace, Bell Shale, locality 31*a*.

FIGS. 4–6. Left lateral, dorsal, and ventral views of specimen A, a female carapace. Bell Shale, locality 31*a*.

Ulrichia spinifera Coryell and Malkin 209

FIGS. 7–9. Left lateral, dorsal, and ventral views of specimen B, and adult carapace. Widder Formation, locality A.

Hollinella nodiventriculata Weiss, sp. nov. 220

FIGS. 10–12. Right lateral, dorsal, and ventral views of carapace. Upper Blue Shale of Gravel Point Formation, locality 9.

Aparchites crossotus Kesling 233

FIGS. 13–15. Right lateral, dorsal, and ventral views of carapace. Bell Shale, locality 31*a*.

FIGS. 16. Right lateral view of same specimen, photographed in glycerine with transmitted light, showing muscle scar pattern at center of valve.

FIG. 17. Enlargement of muscle scar shown in Fig. 16, × 85.

Arcyzona rhabdota Kesling 231

FIGS. 18–19. Left lateral and dorsal views of carapace, Bell Shale, locality 31*a*.

Ruptivelum bacculatum Kesling and Weiss 226

FIGS. 20–22. Right lateral, dorsal, and ventral views of female carapace. Anteroventral part of left valve missing. Widder Formation, locality A.

EXPLANATION OF PLATE III

(All figures × 30; specimens were destroyed by sectioning.)

PAGE

Amphissella tenuis (Warthin) 232

FIGS. 1–3. Left lateral, dorsal, and ventral views of carapace. Upper Blue Shale of Gravel Point Formation, locality 14.

Amphissites bernghageni Stewart and Hendrix 227

FIGS. 4–6. Left lateral, dorsal, and ventral views of carapace. Bell Shale, locality 38*a*.

Arcyzona bythiclimacota Kesling 229

FIGS. 7–9. Left lateral, dorsal, and ventral views of carapace. Bell Shale, locality 38*a*.

Dizygopleura euglyphea Warthin 235

FIGS. 10–11. Right lateral and dorsal views of specimen B, a female carapace. Killian's Member of Genshaw Formation, locality 52.

FIGS. 12–14. Right lateral, dorsal, and ventral views of specimen A, a male carapace. Bell Shale, locality 31*b*.

Hollinella horologiina Weiss, sp. nov. 219

FIGS. 15–16. Left lateral and dorsal views of female carapace. Lower Blue Shale of Gravel Point Formation, locality 14.

Adelphobolbina papillosa (Ulrich) 214

FIGS. 17–18. Left lateral and dorsal views of male carapace. Centerfield Limestone.

Eukloedenella subaequalis (Swartz and Oriel) 234

FIGS. 19–21. Left lateral, dorsal, and ventral views of carapace. Widder Shale, locality A.

Kloedenella lophota Kesling and Kilgore 235

FIGS. 22–24. Right lateral, dorsal, and ventral views of male carapace. Killian's Member of Genshaw Formation, locality 52.

PLATE III

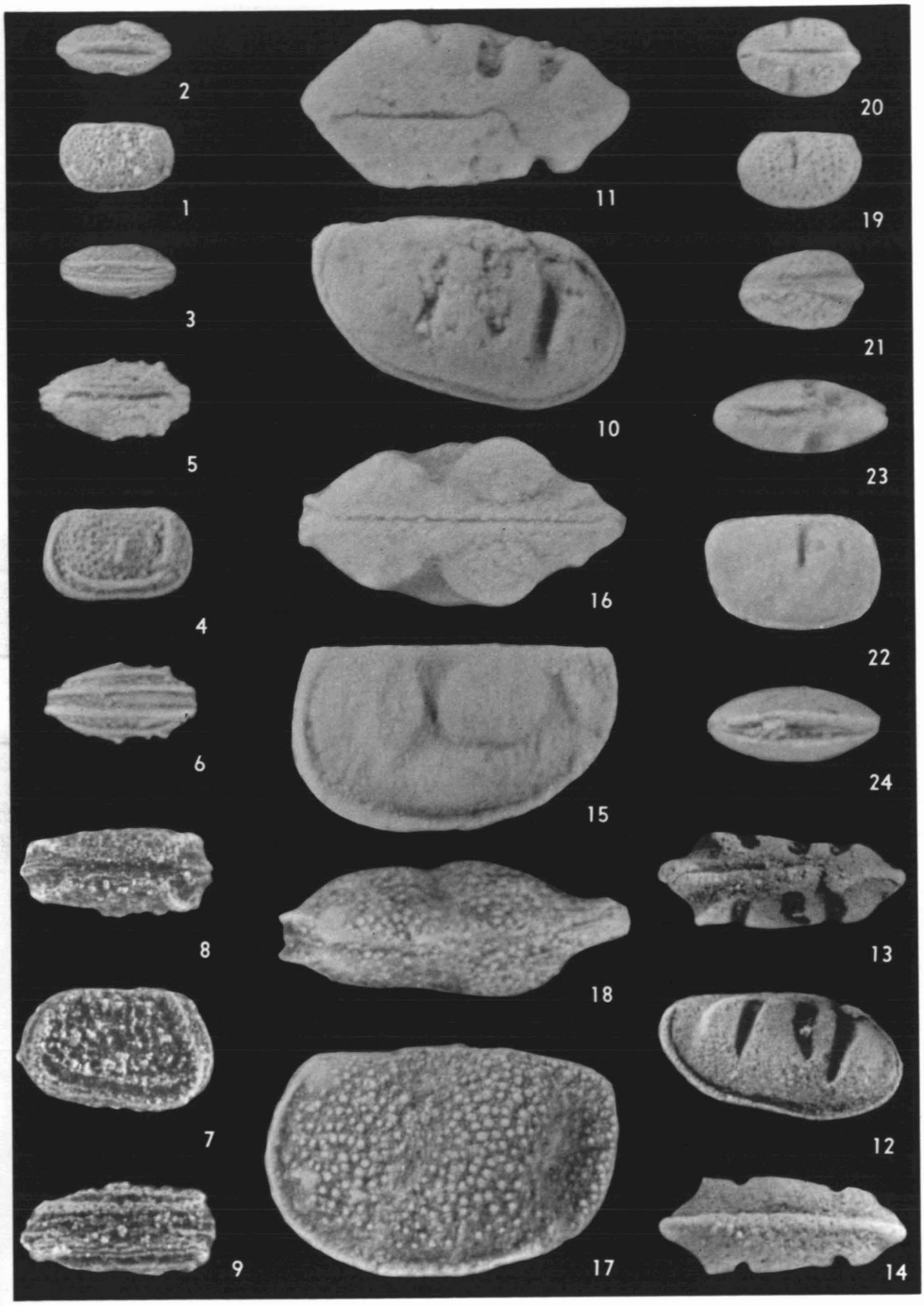
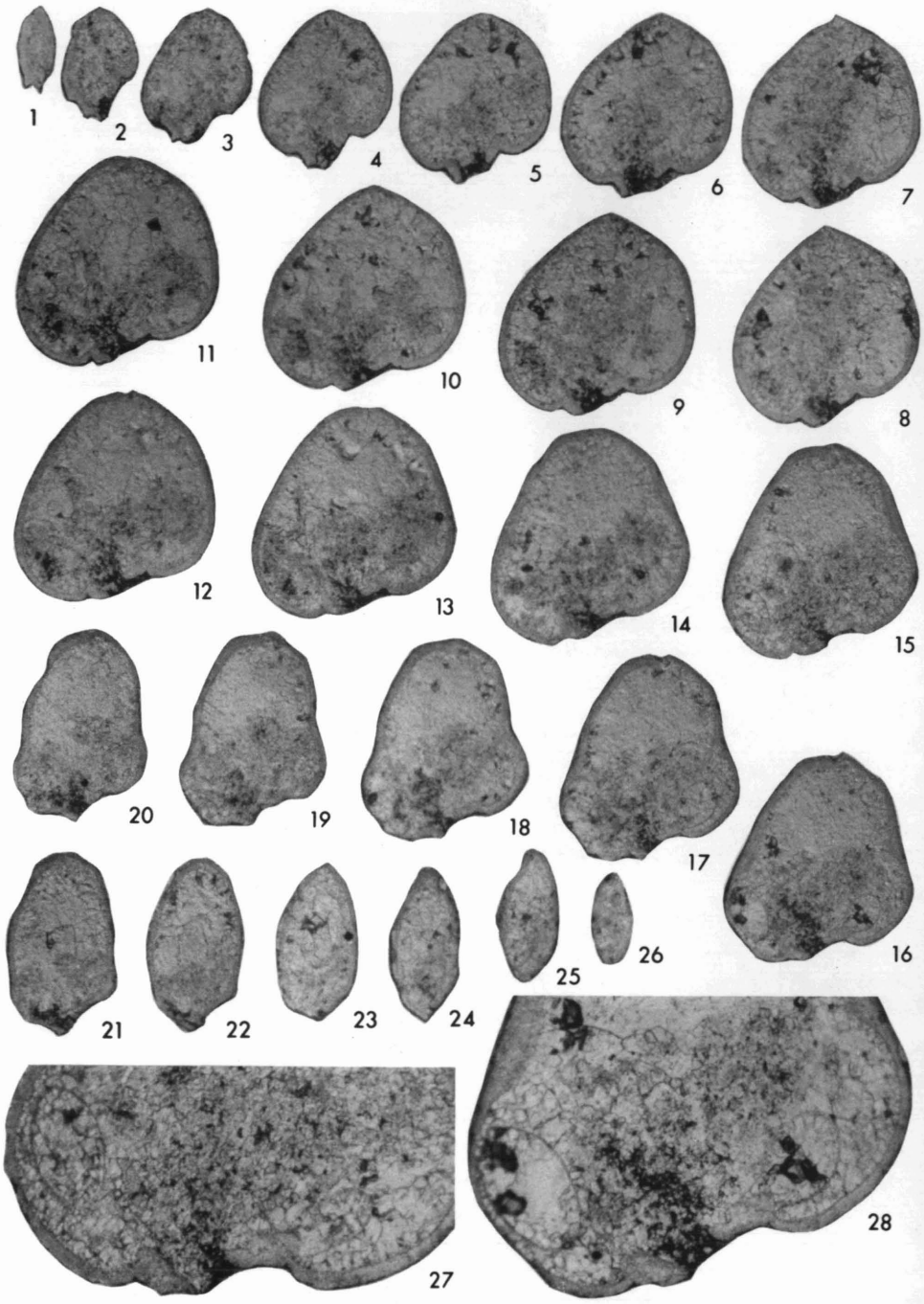


PLATE IV



EXPLANATION OF PLATE IV

(Right valve on right side, left valve on left.)

PAGE

Phlyctiscapha subovata Smith 207

Specimen A (female) illustrated in Pl. I, Figs. 15–17.

FIGS. 1–26. Cross peel series at 50 micron intervals from posterior to anterior. Figs. 15-19 show two immature carapaces in brood pouches. Specimen A. × 30.

FIGS. 27–28. Enlargements of parts of peels shown in Figs. 15 and 16, respectively, illustrating immature carapaces in brood pouches. Specimen A. × 75.

EXPLANATION OF PLATE V

(Right valve on right side, left valve on left.)

PAGE

Phlyctiscapha subovata Smith 207

Specimen B (male) illustrated in Pl. I, FIGS. 12–14.

FIGS. 1–21. Cross peel series at 50 micron intervals from posterior to anterior. Specimen B. × 30.

FIGS. 31–32. Enlargements of parts of peels shown in Figs. 13 and 12 respectively, illustrating details of hinge and contact margin. Specimen B. × 30.

FIGS. 33–35. Enlargements of parts of peels shown in Pl. IV, Figs. 17–19, respectively, illustrating immature carapaces in brood pouches. Specimen A. × 30.

Aechminaria hormathota Kesling 208

Specimen illustrated in Pl. I, FIGS. 6–8.

FIGS. 22–30. First part of cross peel series at 50 micron intervals from posterior to anterior; series completed on Plate VI. × 60.

PLATE V

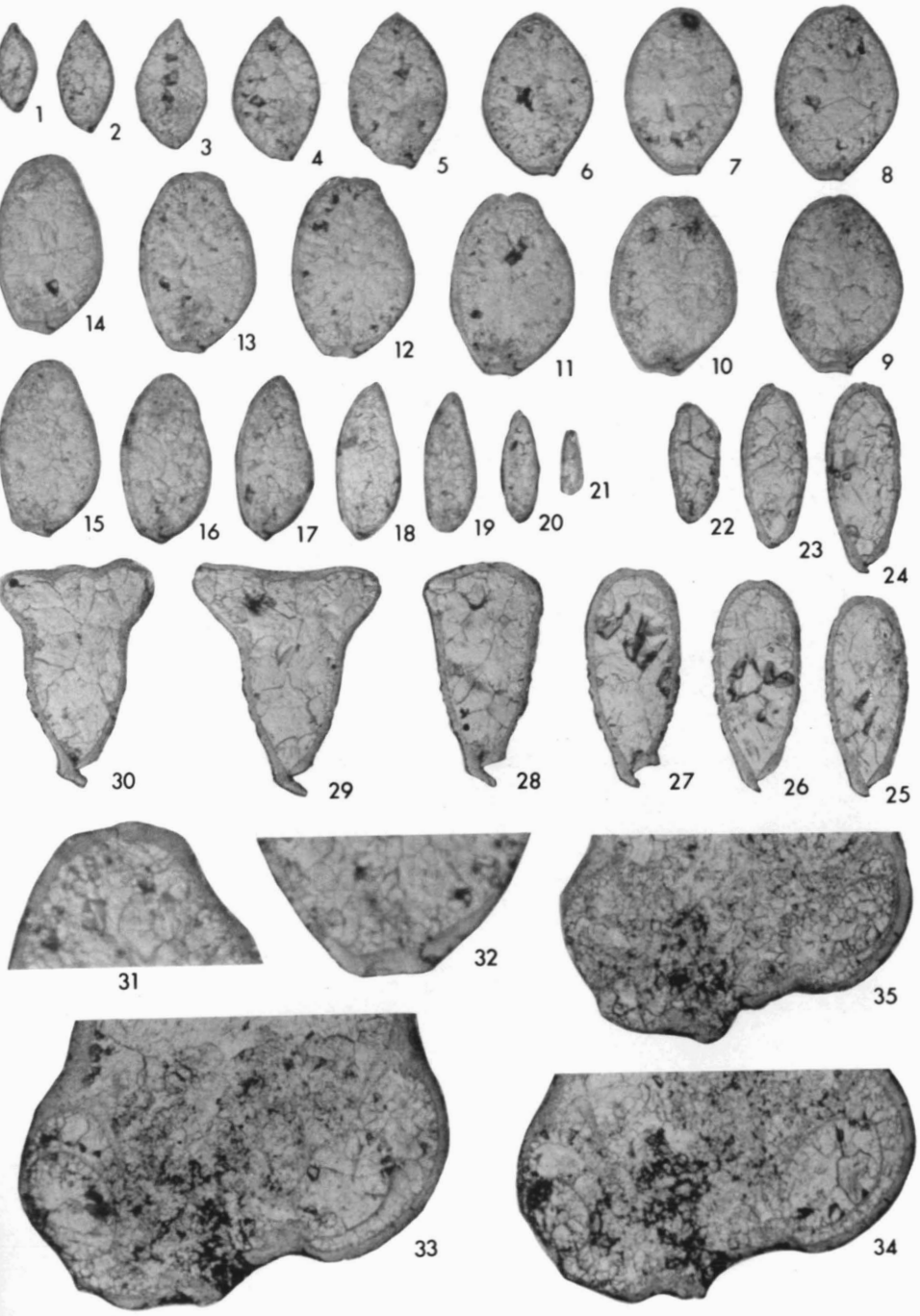
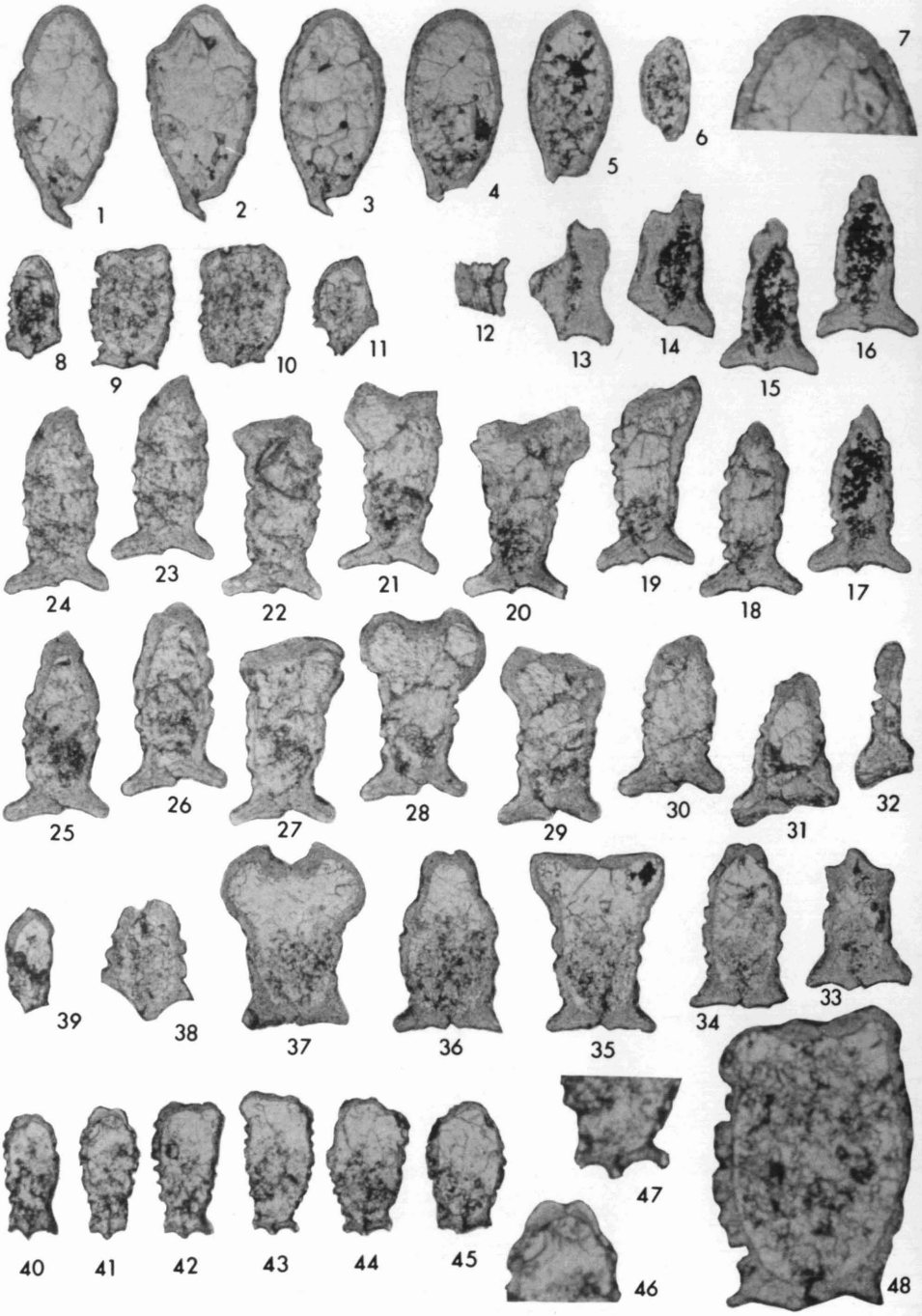

1
2
3
4
5
6
7
8
14
13
12
11
10
9
15
16
17
18
19
20
21
22
23
24
30
29
28
27
26
25
31
32
35
33
34

PLATE VI


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
24
23
22
21
20
19
18
17
25
26
27
28
29
30
31
32
39
38
37
36
35
34
33
40
41
42
43
44
45
47
46
48

EXPLANATION OF PLATE VI

(Right valve on right side, left valve on left.)

PAGE

Aechminaria hormathota Kesling 208

Specimen illustrated in Pl. I, FIGS. 6–8.

FIGS. 1–6. Last part of cross peel series at 50 micron intervals from posterior to anterior; first part of series on Plate V. × 60.

FIG. 7. Enlargement of part of peel shown in Pl. V, Fig. 25, illustrating details of hinge. × 150.

Ulrichia fragilis Warthin 210

Specimen illustrated in Pl. I, Figs. 4–5.

FIGS. 8–11. Cross peel series at 100 micron intervals from posterior to anterior × 60.

FIG. 48. Enlargement of peel shown in Fig. 9, illustrating details of hinge and contact margin. × 150.

Ulrichia spinifera Coryell and Malkin 209

Specimen A, an adult carapace, not illustrated.

FIGS. 12–32. Cross peel series at 33.3 micron intervals from posterior to anterior. Valves offset; hence, contact relationships should not be interpreted from this series. Specimen A. × 60.

Specimen B illustrated in Pl. II, FIGS. 7–9.

FIGS. 33–38. Cross peel series at 100 micron intervals from posterior to anterior. Specimen B. × 60.

Ulrichia illinearis Kesling 211

Specimen illustrated in Pl. I, FIGS. 1–3.

FIGS. 39–45. Cross peel series at 50 micron intervals from posterior to anterior. × 75.

FIGS. 46–47. Enlargements of parts of peels shown in FIGS. 41 and 43, respectively, illustrating details of hinge and contact margin. × 150.

EXPLANATION OF PLATE VII

(Right valve on right side, left valve on left.)

PAGE

Abditoloculina pulchra Kesling 213

Specimen A (female) illustrated in Pl. I, FIGS. 18–20.

FIGS. 1–14. Cross peel series at 50 micron intervals from posterior to anterior. Specimen A. × 60.

FIG. 31. Enlargment of part of peel shown in FIG. 7, illustrating details of contact margin and two loculi. Specimen A. × 150.

Specimen B (male) illustrated in Pl. I, FIGS. 21–23.

FIGS. 15–28. Cross peel series at 50 micron intervals from posterior to anterior. Specimen B. × 60.

FIGS. 20–30. Enlargements of parts of peel shown in FIG. 22, illustrating details of hinge and contact margin. Specimen B. × 150.

PLATE VII

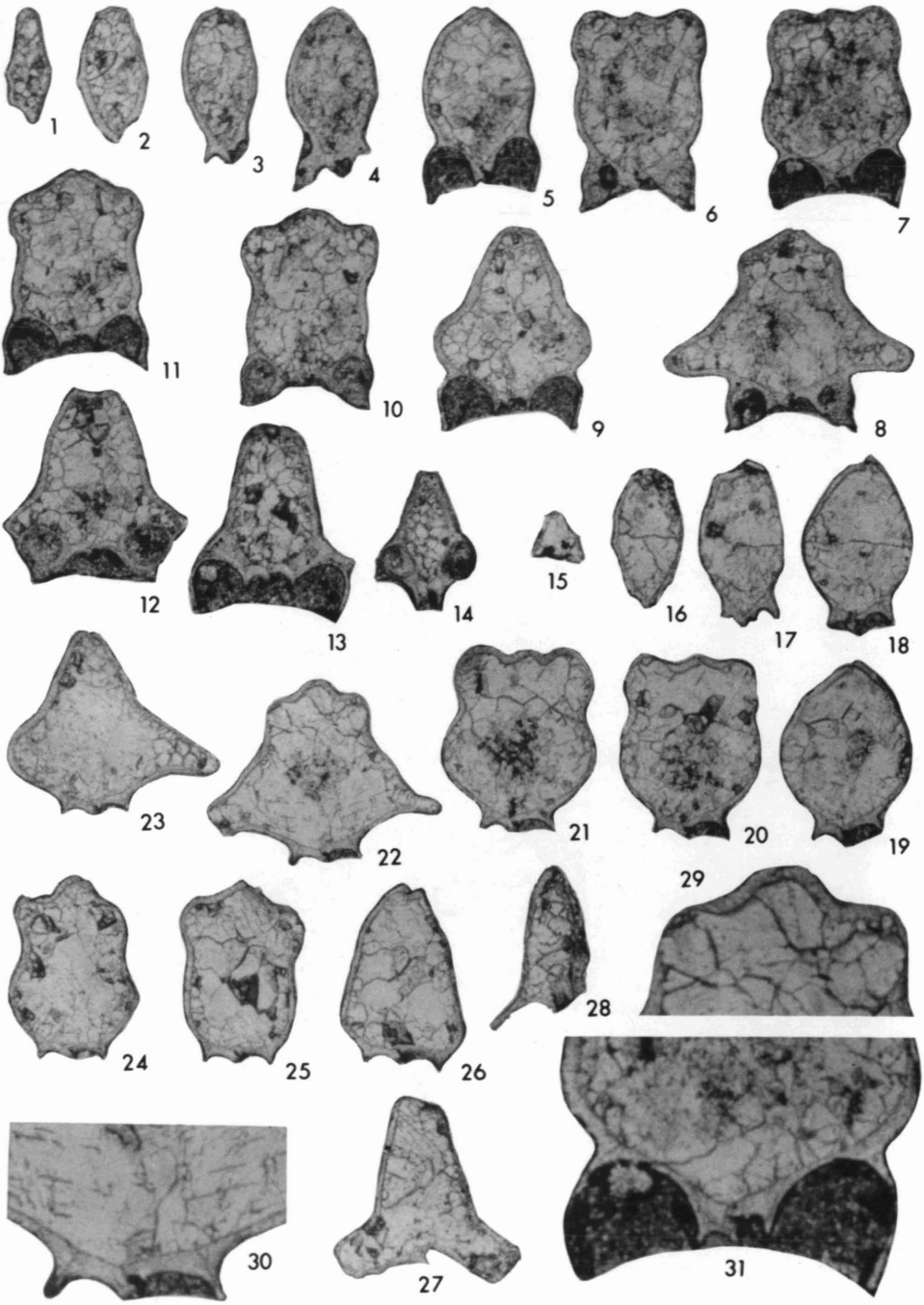
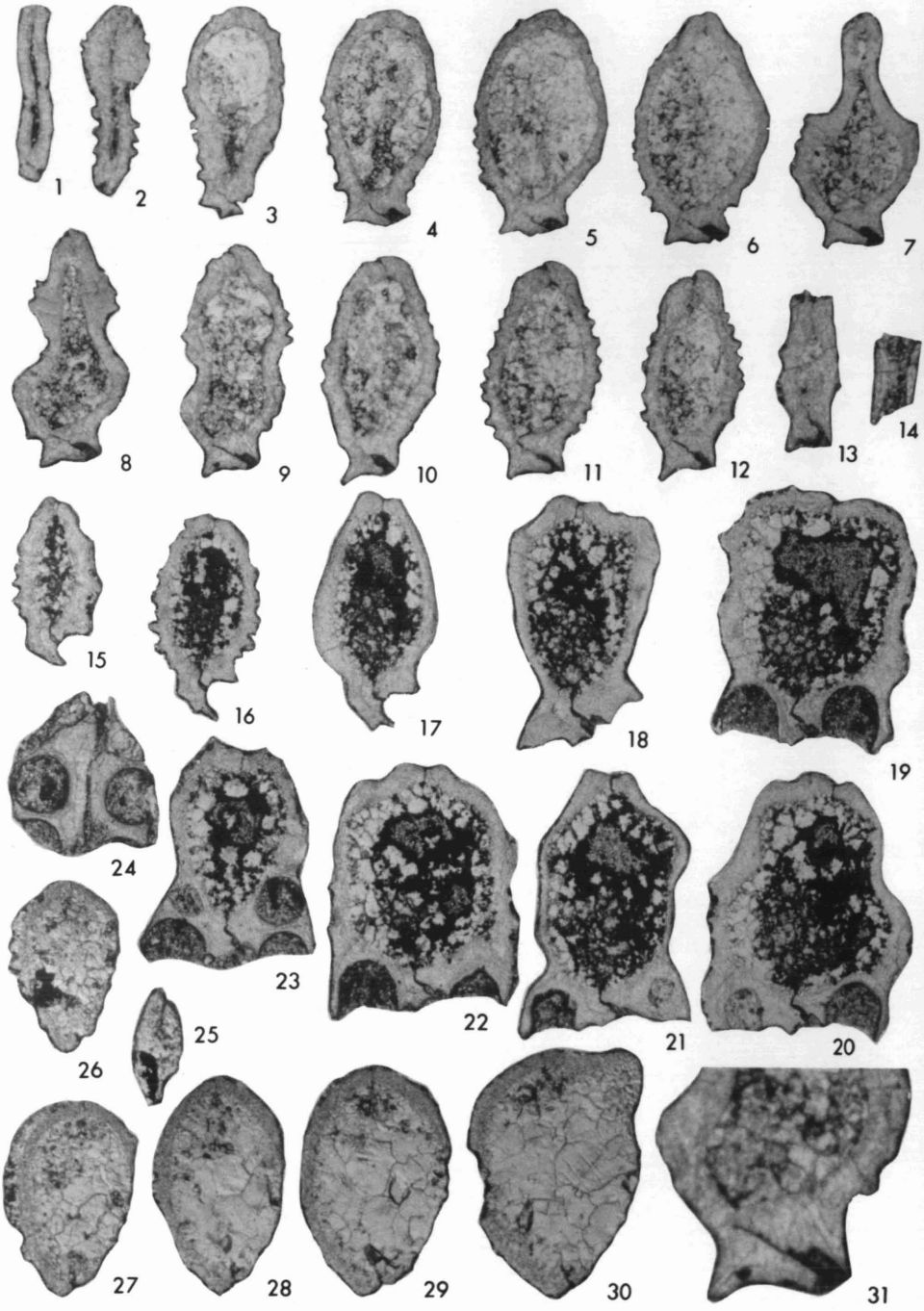

1
2
3
4
5
6
7
11
10
9
8
12
13
14
15
16
17
18
23
22
21
20
19
29
24
25
26
28
30
27
31

PLATE VIII


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
24
23
22
21
20
26
25
27
28
29
30
31

EXPLANATION OF PLATE VIII

(Right valve on right side, left valve on left.)

PAGE

Adelphobolbina papillosa (Ulrich) 214

Specimen illustrated in Pl. III, FIGS. 17–18.

FIGS. 1–14. Cross peel series at approximate 100 micron intervals from posterior to anterior. × 30.

FIG. 31. Enlargement of part of peel shown in FIG. 9, illustrating details of contact margin and frill structure. × 75.

Ctenoloculina cicatricosa (Warthin) 215

Specimen illustrated in Pl. I, FIGS. 9–11.

FIGS. 15–24. Cross peel series at 100 micron intervals from posterior to anterior. Black portions of carapace infilling represent pyrite. × 60.

Falsipollex laxivelatus Kesling and McMillan 218

Specimen illustrated in Pl. I, FIGS. 24–26.

FIGS. 25–30. First part of cross peel series at 50 micron intervals from posterior to anterior; last part of series on Plate IX. × 60.

EXPLANATION OF PLATE IX

(Right valve on right side, left valve on left.)

PAGE

Falsipollex laxivelatus Kesling and McMillan 218

Specimen illustrated in Pl. I, FIGS. 24–26.

FIGS. 1–14. Last part of cross peel series at 50 micron intervals from posterior to anterior; first part of series on Plate VIII. × 60.

Hollinella devoniana (Van Pelt) 222

Specimen A (female) illustrated in Pl. II, FIGS. 4–6.

FIGS. 15–21. First part of cross peel series at 50 micon intervals from posterior to anterior; last part of series on Plate X. Specimen A. × 60.

PLATE IX

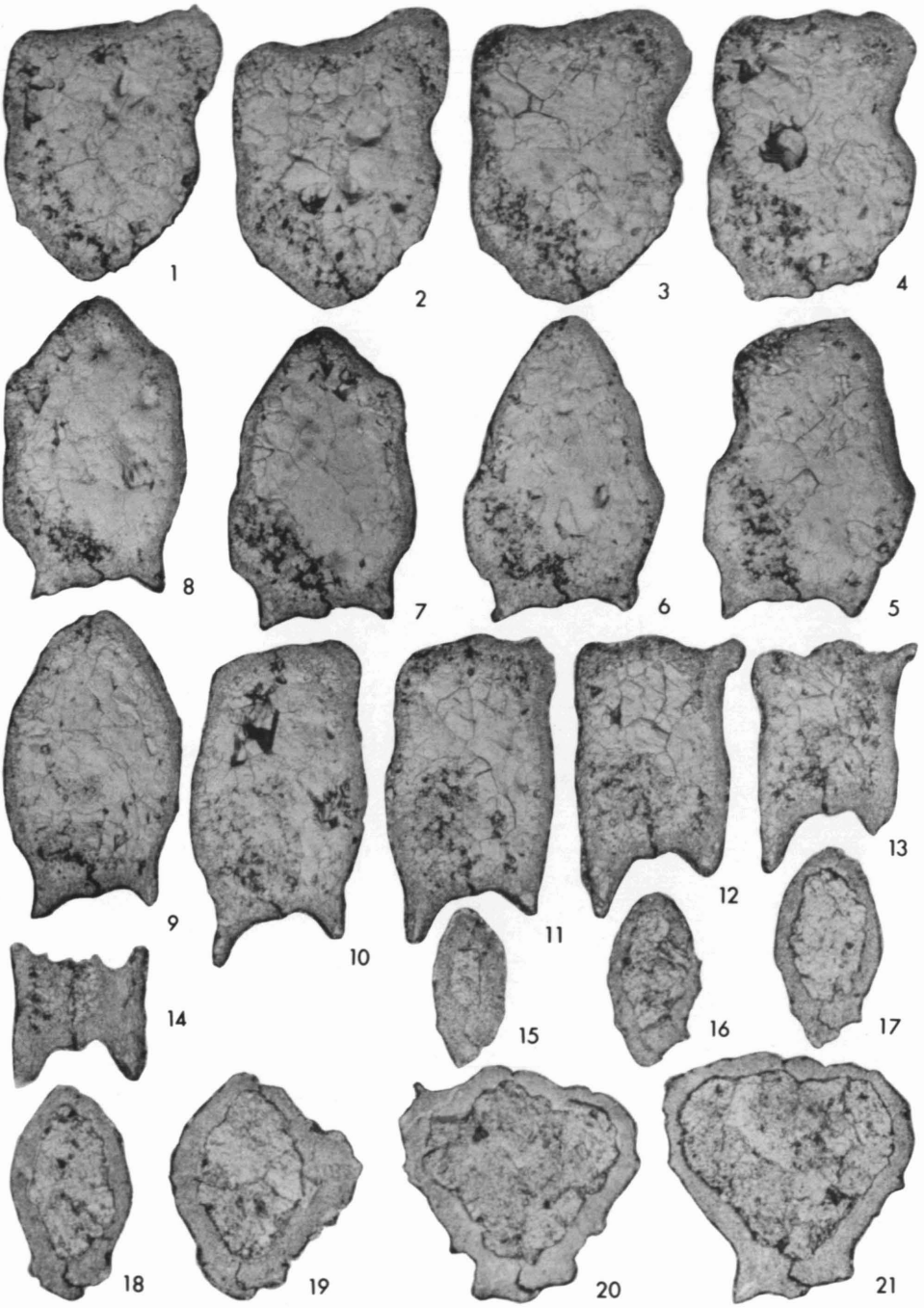
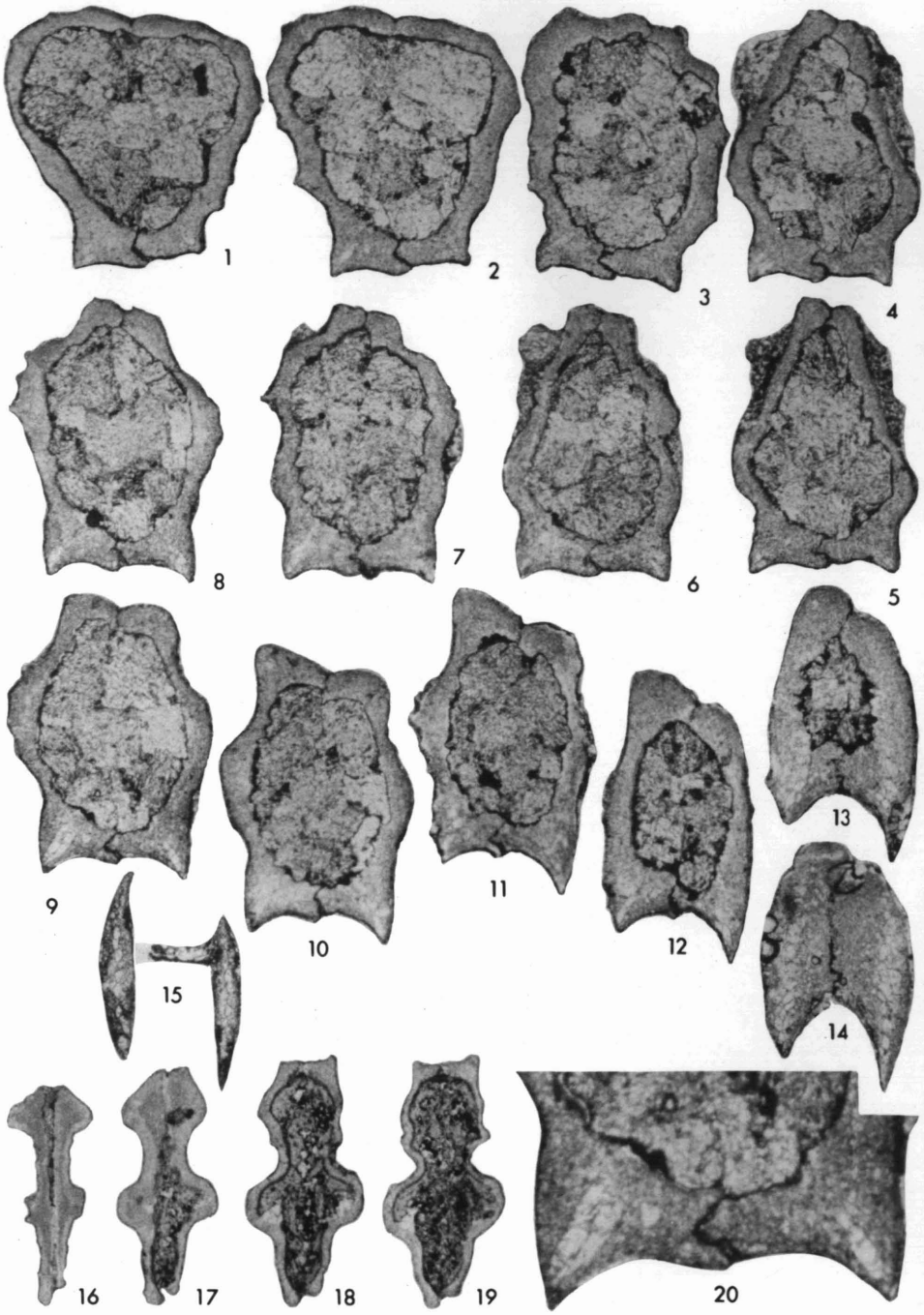


PLATE X



EXPLANATION OF PLATE X

(Right valve on right side, left valve on left.)

PAGE

Hollinella devoniana (Van Pelt) 222

Specimen A (female) illustrated in Pl. II, FIGS. 4–6.

FIGS. 1–15. Last part of cross peel series at 50 micron intervals from posterior to anterior; first part of series on Plate IX. Specimen A. × 60.

FIG. 20. Enlargement of part of peel shown in FIG. 9, illustrating details of contact margin and frill structure. Specimen A. × 150.

Specimen B (male) illustrated in Pl. II, FIGS. 1–3.

FIGS. 16–19. First part of frontal peel series at 50 micron intervals from dorsal to ventral; last part of series on Plate XI. Specimen B. × 30.

EXPLANATION OF PLATE XI

(Right valve on right side, left valve on left.)

PAGE

Hollinella devoniana (Van Pelt) 222

Specimen B (male) illustrated in Pl. II, FIGS. 1–3.

FIGS. 1–8. Last part of frontal peel series at 50 micron intervals from dorsal to ventral; first part of series on Plate X. Specimen B. × 30.

Hollinella horologiina Weiss, sp. nov. 219

Specimen illustrated in Pl. III, FIGS. 15–16.

FIGS. 9–22. Cross peel series at 100 micron intervals from posterior to anterior. × 30.

FIG. 35. Enlargement of part of peel of FIG. 14, illustrating details of hinge. × 150.

FIG. 36. Enlargement of part of peel of FIG. 15, illustrating details of contact margin. × 60.

Hollinella nodiventriculata Weiss, sp. nov. 220

Specimen illustrated in Pl. II, FIGS. 10–12.

FIGS. 23–30. Cross peel series at 100 micron intervals from posterior to anterior. × 60.

Ruptivelum bacculatum Kesling and Weiss 226

Specimen illustrated in Pl. II, FIGS. 20–22.

FIGS. 31–34. First part of cross peel series at 100 micron intervals from posterior to anterior; last part of series on Plate XII. × 60.

FIG. 37. Enlargement of part of peel shown in FIG. 33, illustrating details of hinge. × 150.

PLATE XI

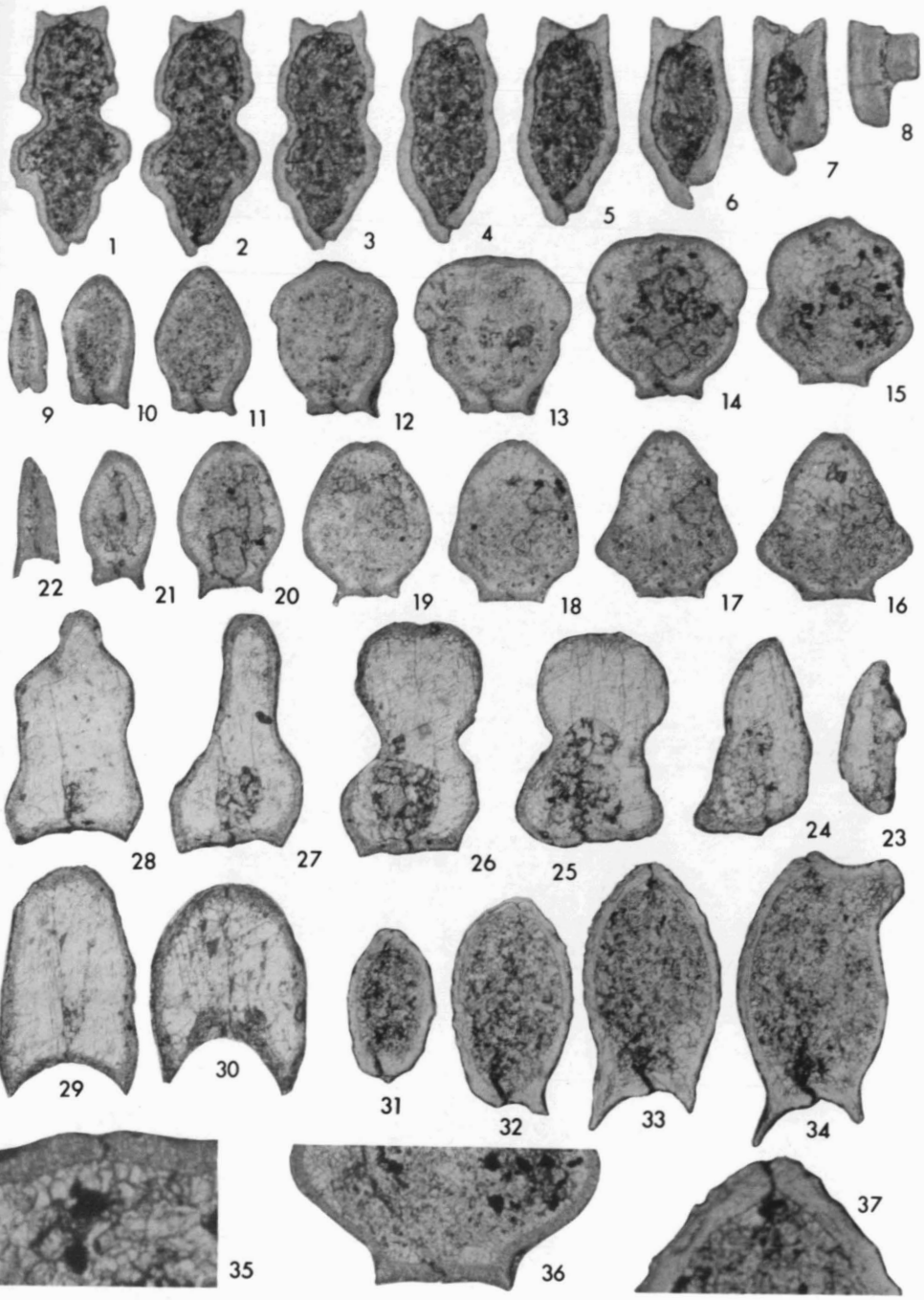
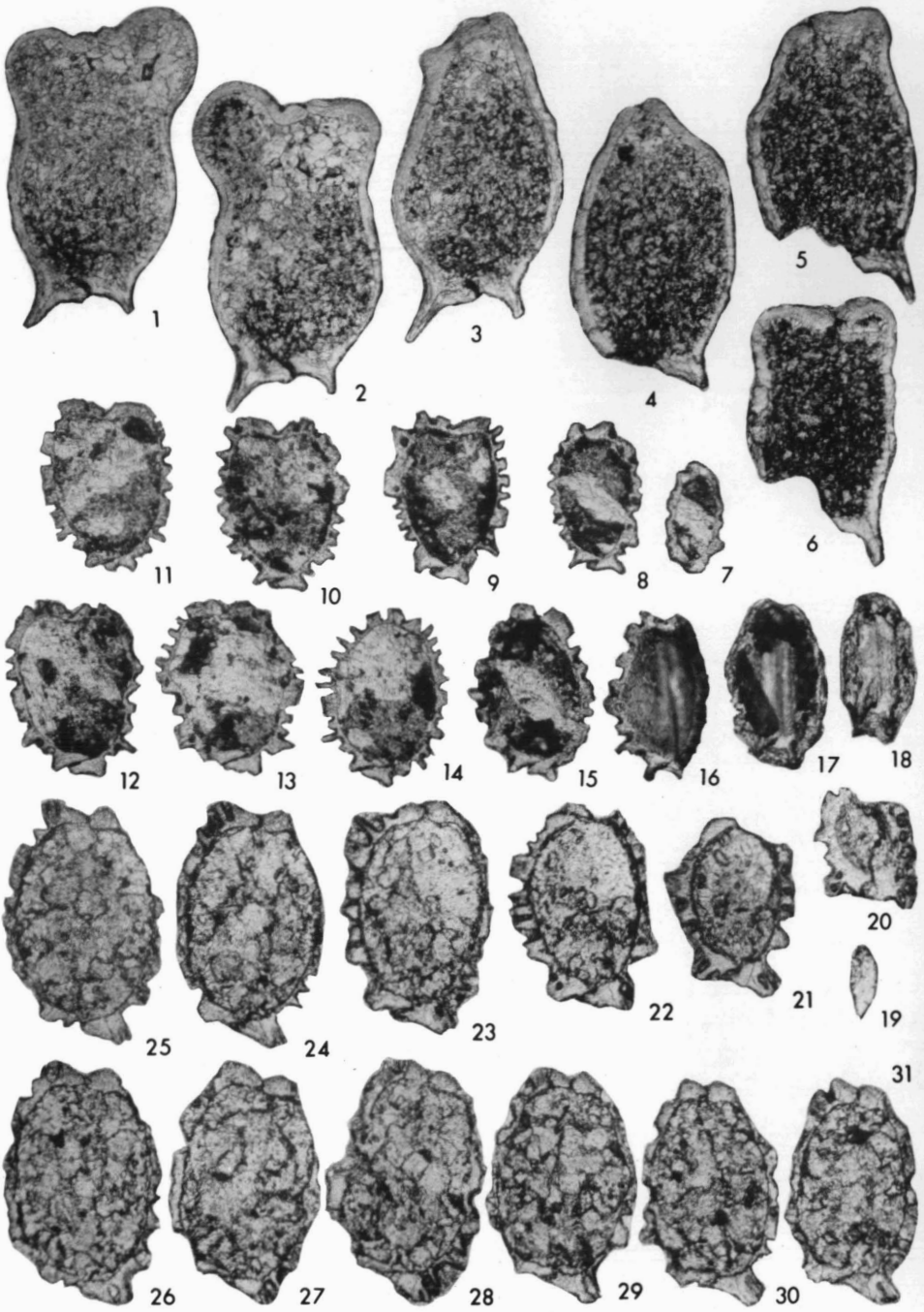

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
22
21
20
19
18
17
16
28
27
26
25
24
23
29
30
31
32
33
34
35
36
37

PLATE XII


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

EXPLANATION OF PLATE XII

(Right valve on right side, left valve on left.)

PAGE

Ruptivelum bacculatum Kesling and Weiss 226

Specimen illustrated in Pl. II, FIGS. 20–22.

FIGS. 1–6. Last part of cross peel series at 100 micron intervals from posterior to anterior; first part of series on Plate XI. Anteroventral part of left valve is missing. × 60.

Amphissites bernhageni Stewart and Hendrix 227

Specimen illustrated in Pl. III, FIGS. 4–6.

FIGS. 7–18. Cross peel series at 50 micron intervals from posterior to anterior. × 60.

Arcyzona bythiclimacota Kesling 229

Specimen illustrated in Pl. III, FIGS. 7–9.

FIGS. 19–31. First part of cross peel series at 50 micron intervals from posterior to anterior; last part of series on Plate XIII. × 60.

EXPLANATION OF PLATE XIII

(Right valve on right side, left valve on left.)

PAGE

Arcyzona bythiclimacota Kesling 229

Specimen illustrated in Pl. III, FIGS. 7–9.

FIGS. 1–4. Last part of cross peel series at 50 micron intervals from posterior to anterior; first part of series on Plate XII. × 60.

Arcyzona rhabdota Kesling 231

Specimen illustrated in Pl. II, FIGS. 18–19.

FIGS. 5–13. Cross peel series at 100 micron intervals from posterior to anterior. × 60.

Amphissella tenuis (Warthin) 232

Specimen illustrated in Pl. III, FIGS. 1–3.

FIGS. 14–22. Cross peel series at 50 micron intervals from posterior to anterior. × 75.

Aparchites crossotus Kesling 233

Specimen illustrated in Pl. II, FIGS. 13–17.

FIGS. 23–34. Cross peel series at 100 micron intervals from posterior to anterior. × 30.

PLATE XIII

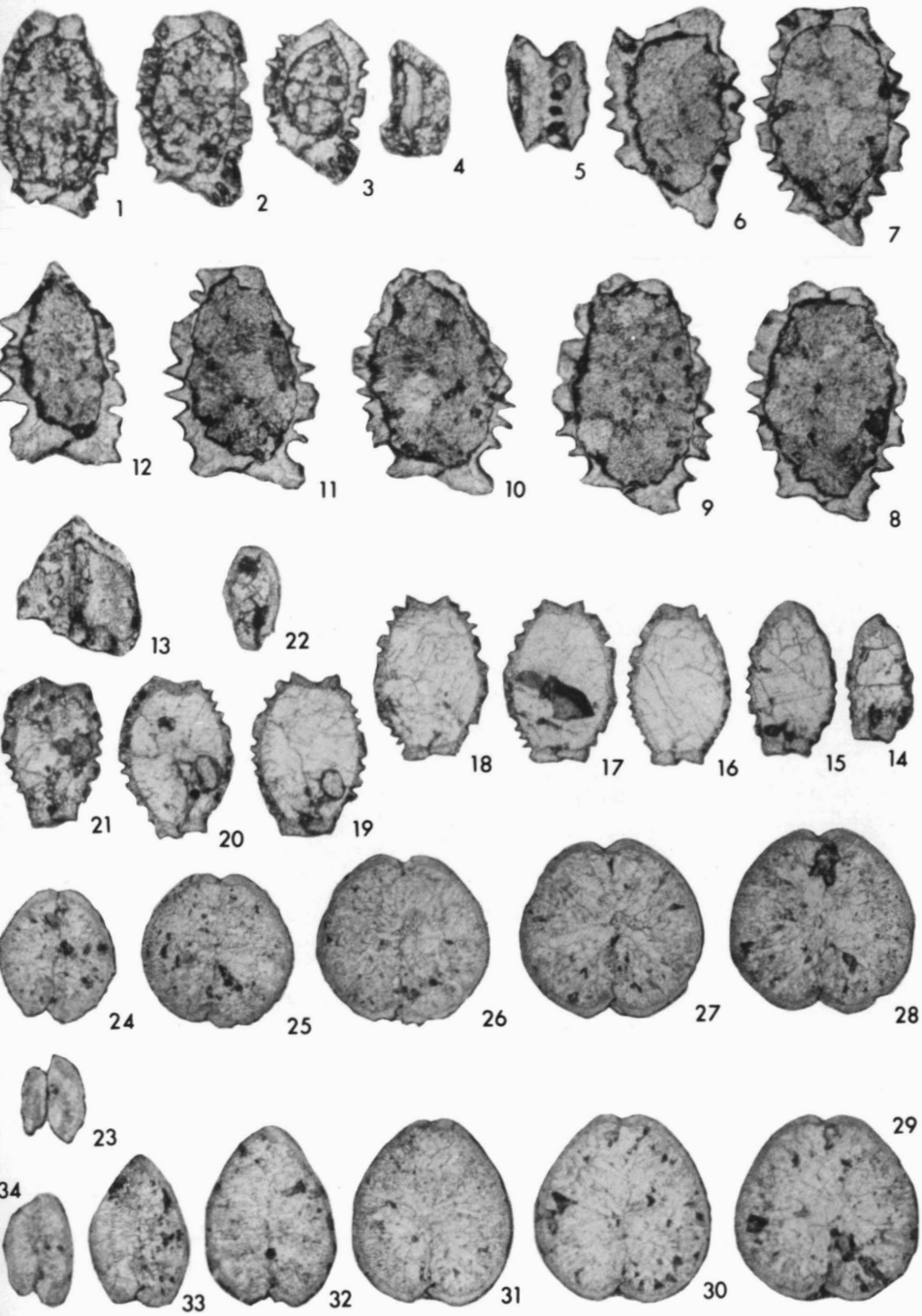
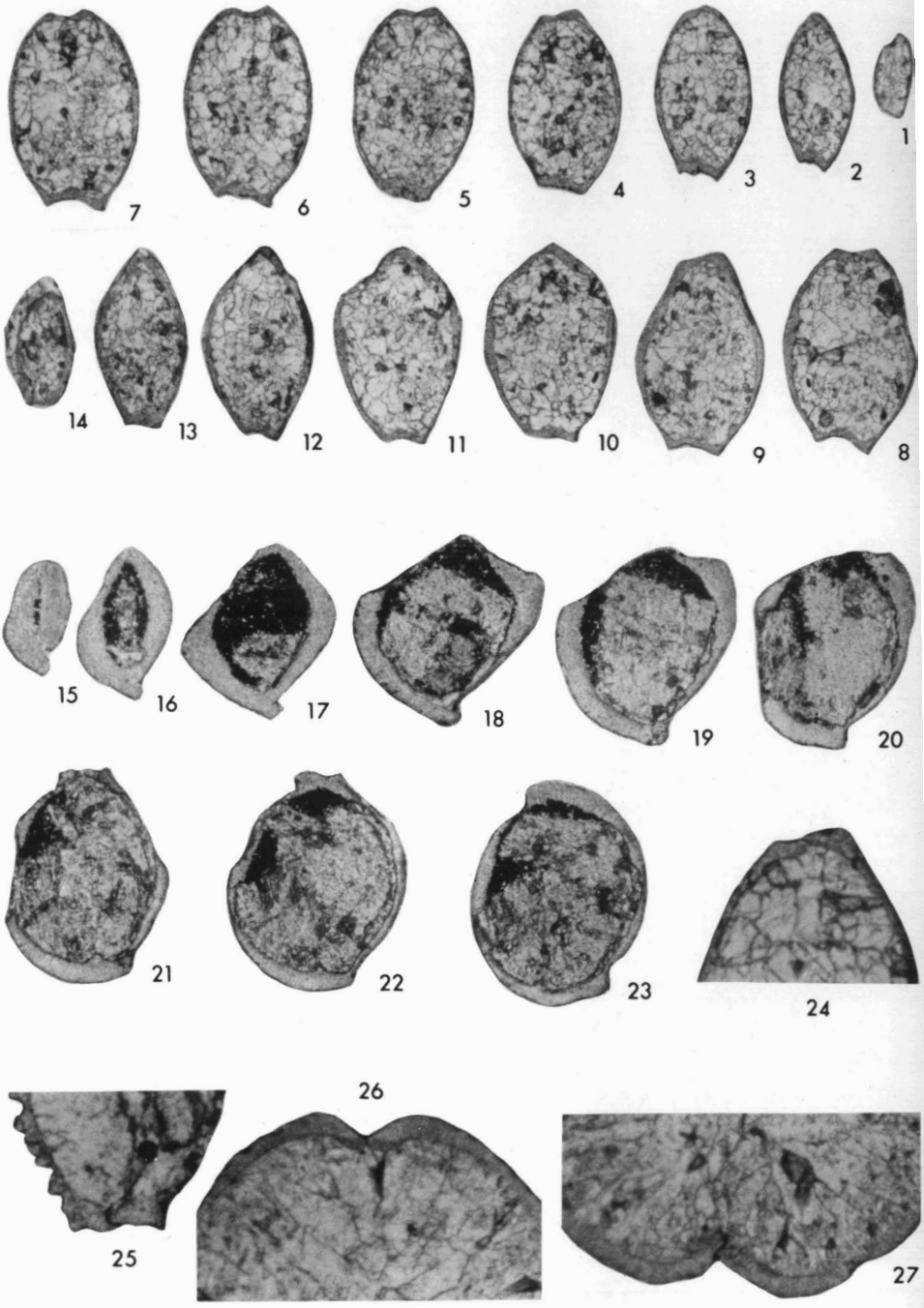

1
2
3
4
5
6
7
12
11
10
9
8
13
22
21
20
19
18
17
16
15
14
24
25
26
27
28
23
34
33
32
31
30
29

PLATE XIV



EXPLANATION OF PLATE XIV

(Right valve on right side, left valve on left.)

PAGE

Kloedenella lophota Kesling and Kilgore 235

Specimen illustrated in Pl. III, FIGS. 22–24.

FIGS. 1–14. Cross peel series at 50 micron intervals from posterior to anterior. × 60.

FIG. 24. Enlargement of part of peel shown in FIG. 3, illustrating overlap of left valve by right valve at hinge. × 150.

Dizygopleura euglyphea Warthin 235

Specimen A (male) illustrated in Pl. III, FIGS. 12–14.

FIGS. 15–23. First part of cross peel series at 50 micron intervals from posterior to anterior. Last part of series is on plate XV. Specimen A. × 60.

Amphissella tenuis (Warthin) 232

Specimen illustrated in Pl. III, FIGS. 1–3.

FIG. 25. Enlargement of part of peel shown in Pl. XIII, FIG. 20, illustrating details of contact margin. × 150.

Aparchites crossotus Kesling 233

Specimen illustrated in Pl. III, FIGS. 13–15.

FIGS. 26–27. Enlargements of parts of peels shown in Pl. XIII, FIGS. 27 and 28, respectively, illustrating details of hinge and contact margin. × 75.

EXPLANATION OF PLATE XV

(Right valve on right side, left valve on left.)

PAGE

Dizygopleura euglyphea Warthin 235

Specimen A (male) illustrated in Pl. III, FIGS. 12–14.

FIGS. 1–11. Last part of cross peel series at 50 micron intervals from posterior to anterior; first part of series is on plate XIV. Specimen A. × 60.

Specimen B (female) illustrated in Pl. III, FIGS. 10–11.

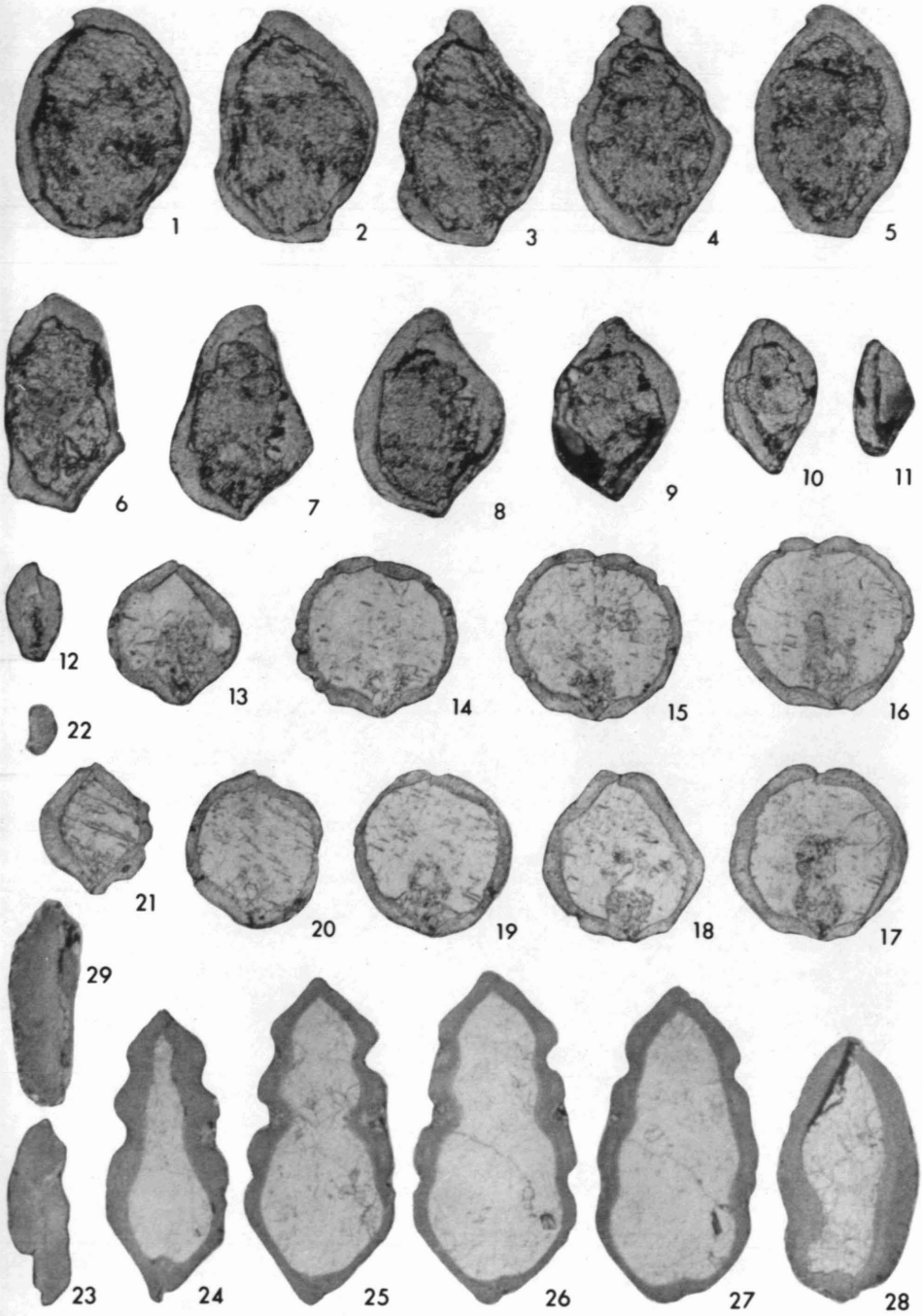
FIGS. 23–29. Frontal peel series at approximate 100 micron intervals from dorsal to ventral. Specimen B. × 30.

Eukloedenella subaequalis (Swartz and Oriel) 234

Specimen illustrated in Pl. III, FIGS. 19–21.

FIGS. 12–22. Cross peel series at 50 micron intervals from posterior to anterior. × 75.

PLATE XV



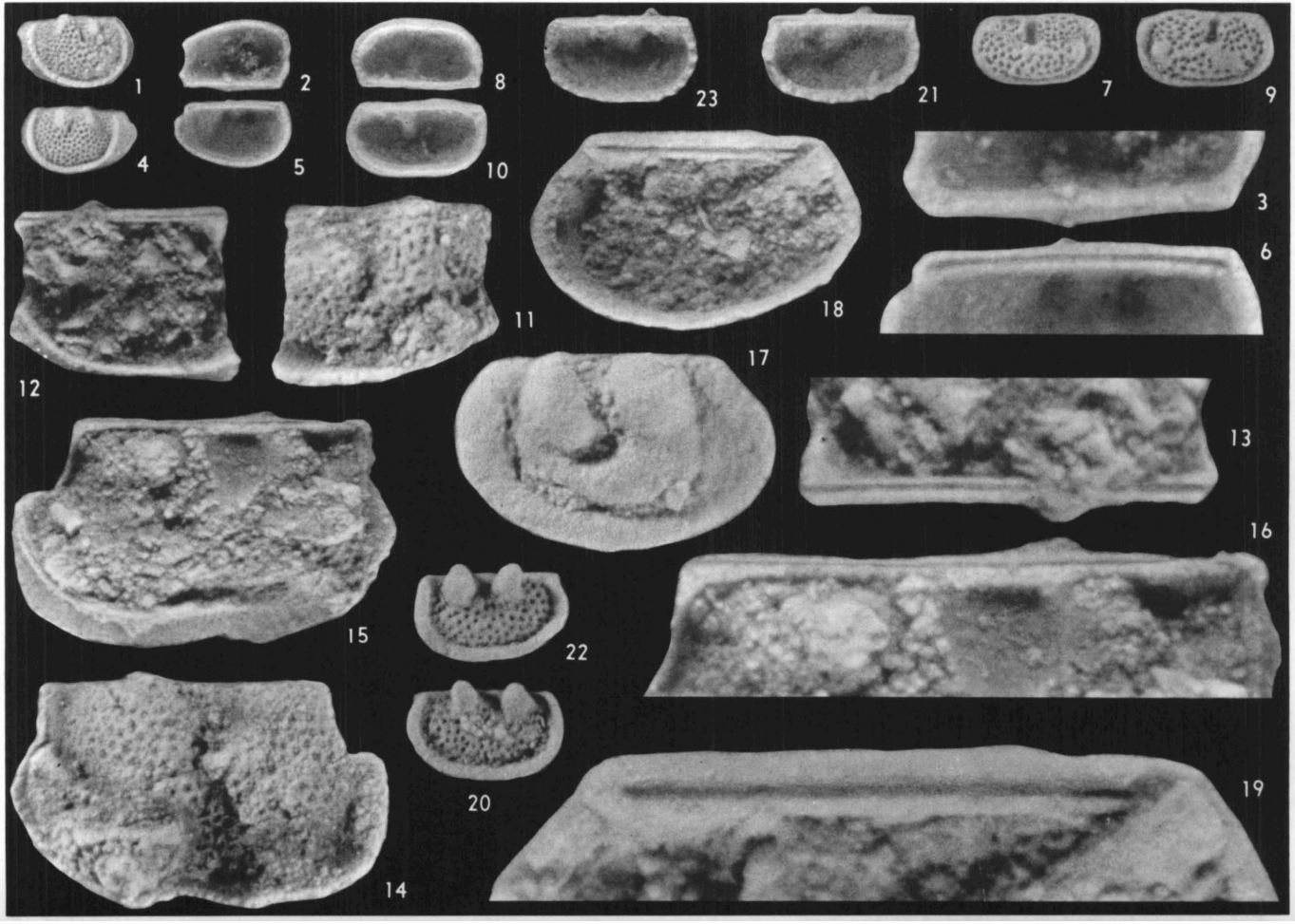


PLATE XVI

EXPLANATION OF PLATE XVI

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Ulrichia fragilis Warthin 210

FIG. 1–3. Lateral, inverted interior, and inverted hinge views of right valve. Figure 3, × 100. Hypotype UMMP 47561. Widder Formation, locality B.

FIGS. 4–6. Lateral, interior, and hinge views of left valve. Figure 6, × 100. Hypotype UMMP 47562. Widder Formation, locality A.

Kirkbyella (Kirkbyella) bellipuncta (Van Pelt) 212

FIGS. 7–8. Lateral and inverted interior views of left valve. Hypotype UMMP 47563. Widder Formation, locality A.

FIGS. 9–10. Lateral and interior views of right valve. Hypotype UMMP 47564. Widder Formation, locality A.

Treposella stellata Kesling 206

FIGS. 11–13. Laterial, interior, and inverted hinge views of incomplete male left valve. Figure 13, × 60. Hypotype UMMP 47565. Centerfield Limestone.

FIGS. 14–16. Lateral, interior, and hinge views of male right valve. Figure 16, × 60. Hypotype UMMP 47566. Centerfield Limestone.

Bollia hindei Jones 209

FIGS. 17–19. Lateral, interior, and hinge views of left valve. Figure 19, × 75. Hypotype UMMP 47567. Centerfield Limestone.

Ulrichia spinifera Coryell and Malkin 209

FIGS. 20–21. Lateral and interior views of right valve. Hypotype UMMP 47568. Widder Formation, locality B.

FIGS. 22–23. Lateral and interior views of left valve. Hypotype UMMP 47569. Widder Formation, locality A.

EXPLANATION OF PLATE XVII

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Adelphobobina medialis Stover 214

FIGS. 1–2. Inverted interior and inverted hinge views of male left valve. Figure 2, × 60. Hypotype UMMP 47570. Ledyard Shale.

FIGS. 3–4. Interior and hinge views of female right valve. Figure 4, × 60. Hypotype UMMP 47571. Ledyard Shale.

FIG. 5. Inverted hinge view of female left valve. × 60. Hypotype UMMP 47572. This valve the mate to right valve illustrated in figure 6. Valve broken but cemented together. Ledyard Shale.

FIG. 6. Hinge view of female right valve. × 60. Hypotype UMMP 47573. This valve the mate to left valve illustrated in figure 5. Valve broken but cemented together. Ledyard Shale.

Ctenoloculina myurilobata Kesling 217

FIG. 7. Lateral view of female left valve. Hypotype UMMP 47574. Arkona Shale.

Ctenoloculina cicatricosa (Warthin) .....

FIGS. 8–9. Lateral and dorsal views of female right valve. Hypotype UMMP 47575. Widder Formation, locality A.

FIGS. 10–11. Lateral and dorsal views of female left valve. Hypotype 47576. Widder Formation, locality A.

Kirkbyella (Kirkbyella) bellipuncta (Van Pelt) 212

FIG. 12. Inverted hinge view of left valve. × 75. Hypotype UMMP 47563. Widder Formation, locality A.

FIG. 13. Hinge view of right valve. × 75. Hypotype UMMP 47564. Widder Formation, locality A.

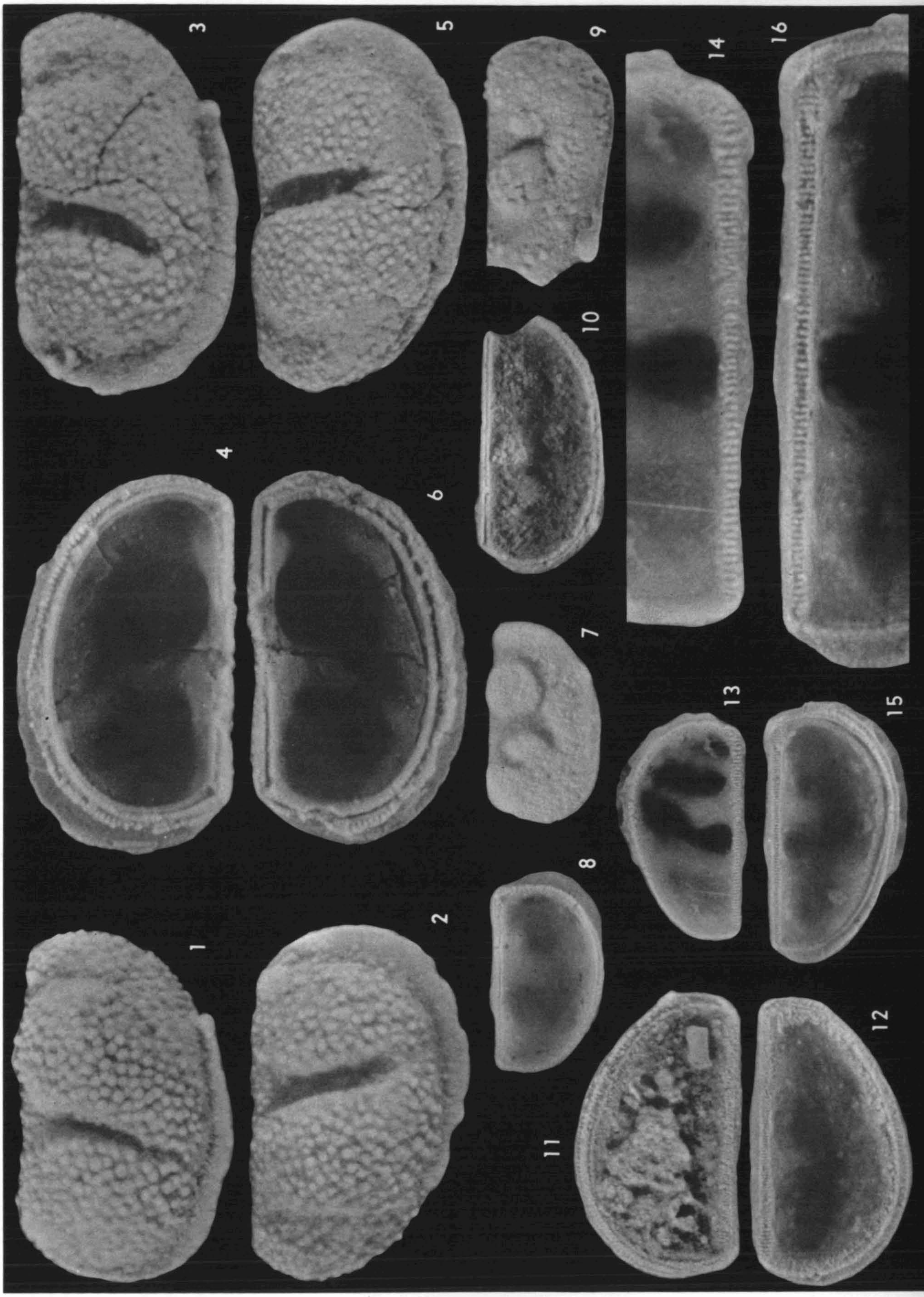
Ulrichia spinifera Coryell and Malkin 209

FIG. 14. Inverted hinge view of left valve. × 75. Hypotype UMMP 47569. Widder Formation, locality A.

FIG. 15. Hinge view of right valve. × 75. Hypotype UMMP 47568. Widder Formation, locality B.

PLATE XVII

PLATE XVIII



EXPLANATION OF PLATE XVIII

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Adelphobobina medialis Stover 214

FIG. 1. Lateral view of male left valve. Hypotype UMMP 47570. Ledyard Shale.

FIG. 2. Lateral view of female right valve. Hypotype UMMP 47571. Ledyard Shale.

FIGS. 3–4. Lateral and inverted interior views of female left valve. Hypotype UMMP 47572. This valve the mate to right valve illustrated in figures 5 and 6. Valve broken but cemented together. Ledyard Shale.

FIGS. 5–6. Lateral and interior views of female right valve. Hypotype UMMP 47573. This valve the mate to left valve illustrated in figures 3 and 4. Valve broken but cemented together. Ledyard Shale.

Hollinella nodiventriculata Weiss, sp. nov. 220

FIGS. 7–8. Lateral and interior views of left valve. Paratype UMMP 47577. Upper Blue Shale of Gravel Point Formation, locality 9.

Hollinella bullata Kesling and McMillan .....

FIGS. 9–10. Lateral and interior views of male right valve. Hypotype UMMP 47578. Bell Shale, locality 31d.

Ctenoloculina myurilobata Kesling 217

FIG. 11. Inverted interior view of female left valve. Hypotype UMMP 47574. Arkona Shale.

FIG. 12. Interior view of female right valve. Hypotype UMMP 47579. Arkona Shale.

Ctenoloculina cicatricosa (Warthin) 215

FIGS. 13–14. Inverted interior and inverted hinge views of female right valve. Figure 14, × 75. Hypotype UMMP 47575. Widder Formation, locality A.

FIGS. 15–16. Interior and hinge views of female left valve. Figure 16, × 75. Hypotype UMMP 47576. Widder Formation, locality A.

EXPLANATION OF PLATE XIX

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Hollinella horologiina Weiss 219

FIGS. 1–2. Lateral and inverted interior views of male right valve. Hypotype UMMP 47580. Lower Blue Shale of Gravel Point Formation, locality 14.

FIGS. 3–4. Lateral and interior views of male left valve. Hypotype UMMP 47581. Lower Blue Shale of Gravel Point Formation, locality 14.

Ctenoloculina myurilobata Kesling 217

FIGS. 5–6. Lateral and hinge views of female right valve. Figure 6, × 75. Hypotype UMMP 47579. Arkona Shale

FIG. 7. Inverted hinge view of female left valve. × 75. Hypotype 47574. Arkona Shale.

Ctenoloculina cicatricosa (Warthin) 215

FIG. 8. Dorsal view of female right valve. × 75. Hypotype UMMP 47575. Toothlets are visible on hinge bar. Widder Formation, locality A.

FIG. 9. Dorsal view of female left valve. × 75. Hypotype UMMP 47575. Widder Formation, locality A.

Subligaculum scrobiculatum Kesling and McMillan 227

FIG. 10. Lateral view of male right valve. Hypotype UMMP 47582. Bell Shale, locality 31*a*.

Ruptivelum bacculatum Kesling and Weiss 226

FIGS. 11–12. Lateral and interior views of female right valve. Hypotype UMMP 47583. Lower Blue Shale of Gravel Point Formation, locality 14.

Hollinella nodiventriculata Weiss, sp. nov. 220

FIG. 13. Hinge view of left valve. × 75. Paratype UMMP 47577. Upper Blue Shale of Gravel Point Formation, locality 9.

Hollinella bullata Kesling and McMillan 218

FIG. 14. Hinge view of male right valve. × 75. Hypotype UMMP 47578. Bell Shale, locality 31*d*.

PLATE XIX

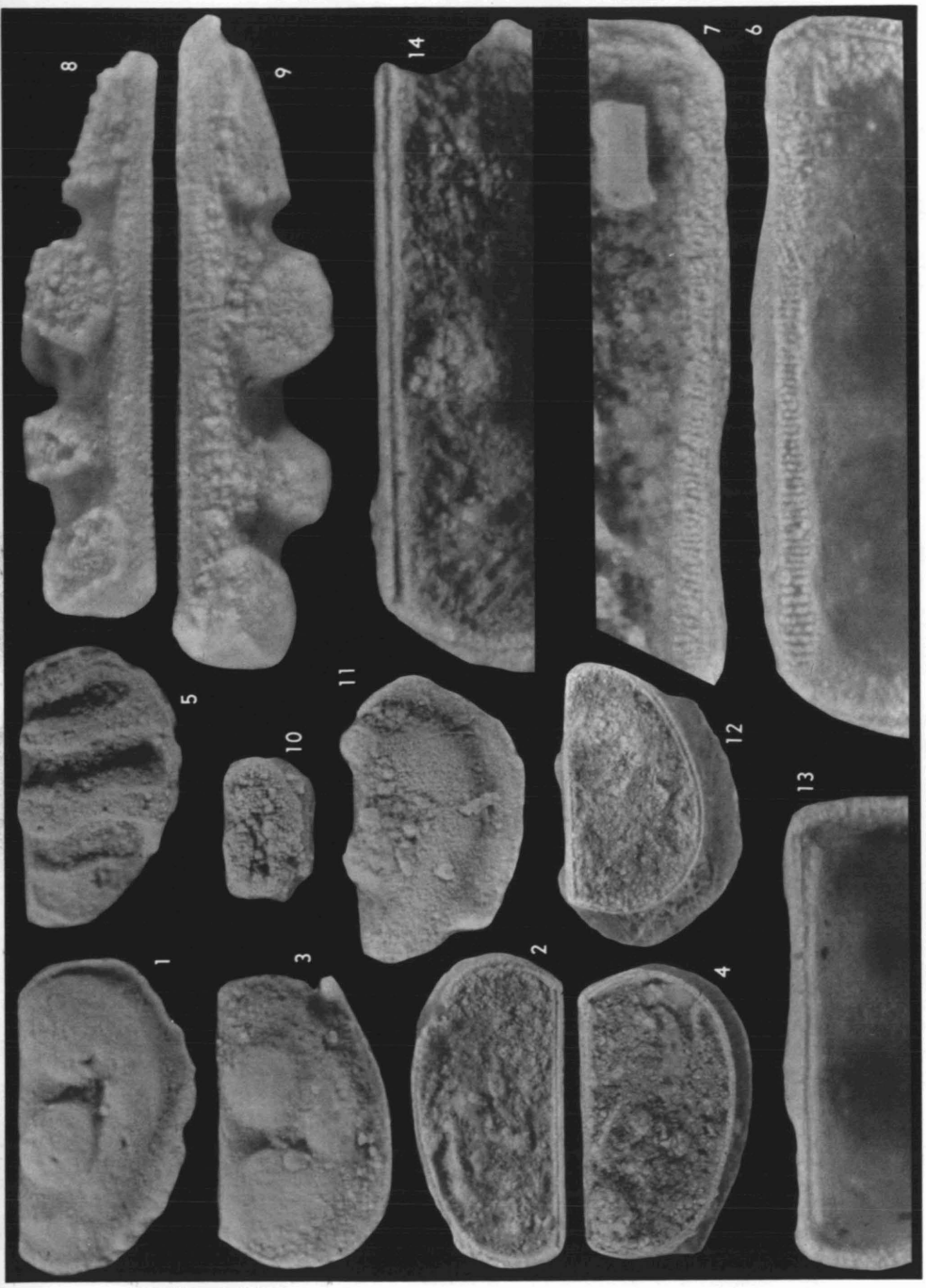


PLATE XX

EXPLANATION OF PLATE XX

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Hollinela devoniana (Van Pelt) 222

FIGS. 1–3. Lateral, inverted interior, and inverted hinge views of male left valve. Figure 3, × 75. Hypotype UMMP 47584. Bell Shale, locality 31*b*.

FIGS. 4–6. Lateral, interior, and hinge views of male right valve. Figure 6, × 75. Hypotype UMMP 47585. Bell Shale, locality 31*a*.

FIGS. 7–8. Lateral and interior views of male right valve. Hypotype 47586. Valve treated with a solution of silver nitrate to form reflecting surface. Bell Shale, locality 31*a*.

FIGS. 10–12. Lateral, inverted interior, and inverted hinge views of male left valve. Figure 12, × 75. Hypotype UMMP 47587. Bell Shale, locality 31*a*.

FIGS. 13–15. Lateral, interior, and hinge views of male right valve. Figure 15, × 75. Hypotype UMMP 47588. Bell Shale, locality 31*a*.

Ruptivelum bacculatum Kesling and Weiss 226

FIG. 9. Hinge view of female right valve. × 75. Hypotype UMMP 47583. Lower Blue Shale of Gravel Point Formation, locality 14.

EXPLANATION OF PLATE XXI

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Hollinella labrosa Kesling and Weiss 223

FIGS. 1–3. Lateral, inverted interior, and inverted hinge views of female left valve. Figure 3, × 60. Hypotype UMMP 47589. Centerfield Limestone.

FIGS. 4–6. Lateral, interior, and hinge views of female right valve. Figure 6, × 20. Hypotype UMMP 47590. Centerfield Limestone.

Subligaculum scrobiculatum Kesling and McMillan 227

FIGS. 7–8. Interior and hinge views of male right valve. Figure 8, × 75. Hypotype UMMP 47582. Bell Shale, locality 31*a*.

Amphissites bernhageni Stewart and Hendrix 227

FIG. 9. Hinge view of left valve. × 100. Hypotype UMMP 47591. Bell Shale locality 38*a*.

Hollinella horologiina Weiss, sp. nov. 219

FIG. 10. Hinge view of male left valve. × 75. Paratype UMMP 47581. Lower Blue Shale of Gravel Point Formation, locality 14.

FIG. 11. Hinge view of male right valve. × 75. Paratype UMMP 47580. Lower Blue Shale of Gravel Point Formation, locality 14.

PLATE XXI

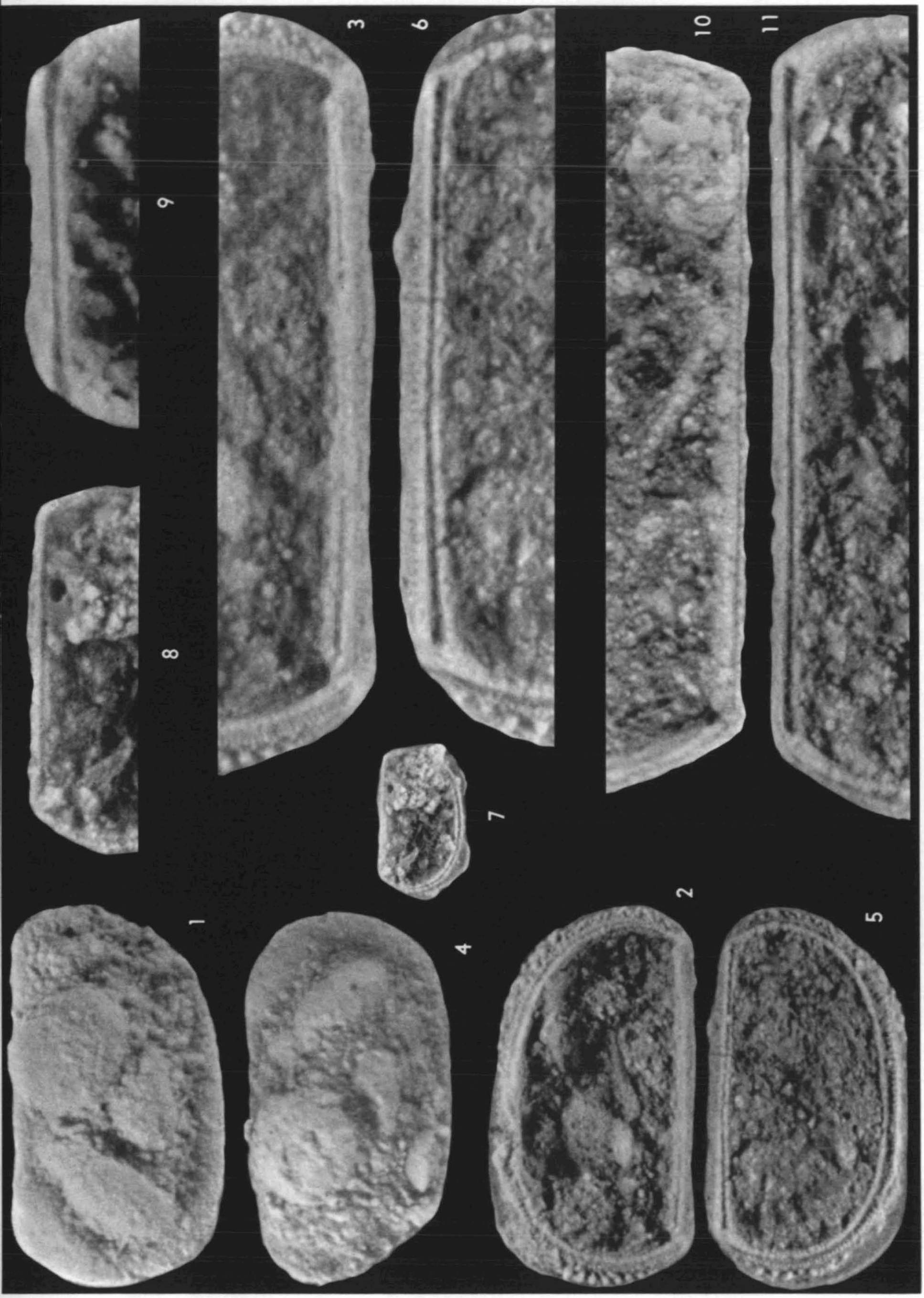
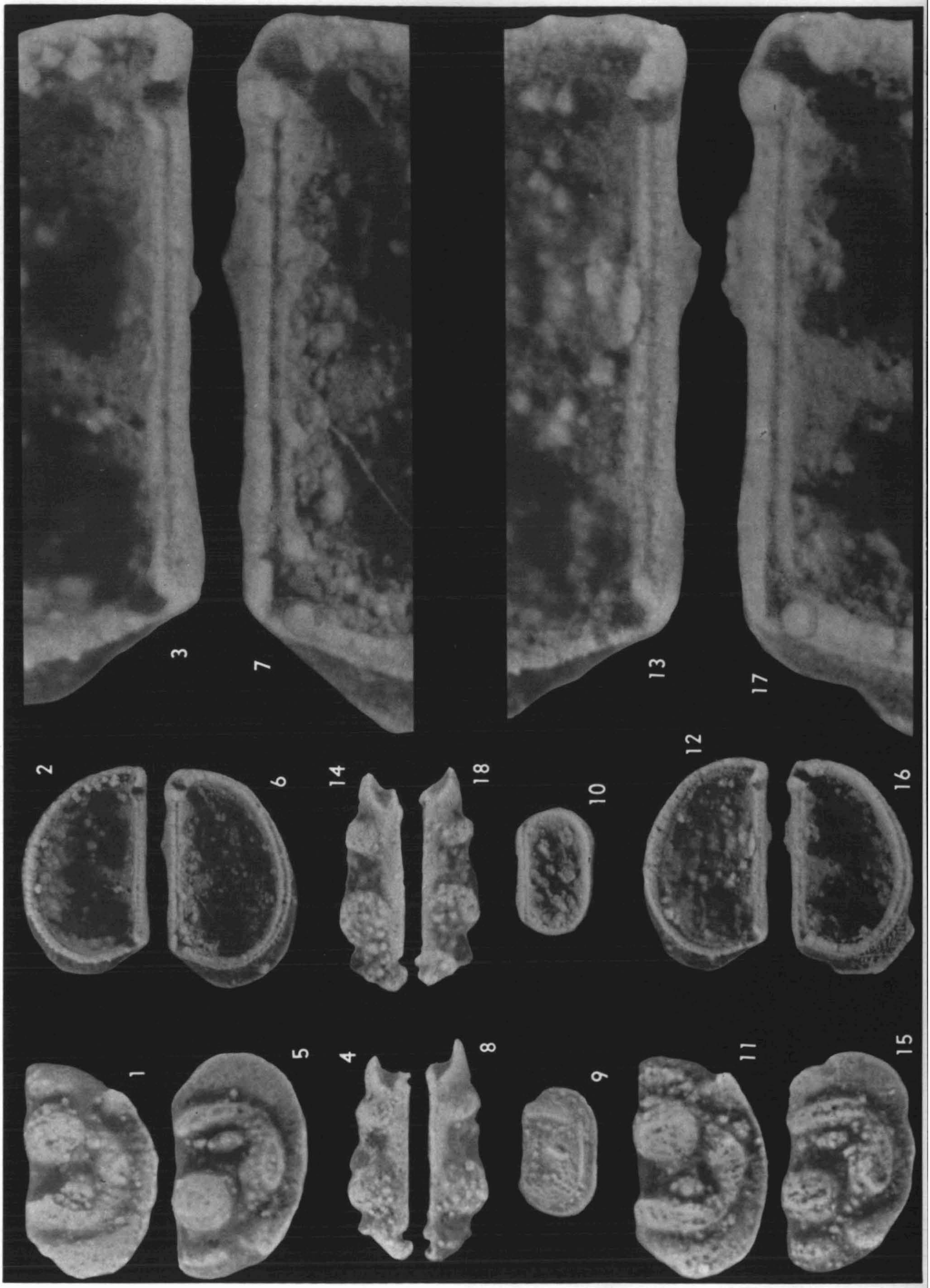


PLATE XXII



EXPLANATION OF PLATE XXII

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Hollinella acutilobata Weiss 224

FIGS. 1–4. Lateral, inverted interior, inverted hinge, and dorsal views of left valve. Figure 3, × 100. Paratype UMMP 47592. Bell Shale, locality 31*a*.

FIGS. 5–8. Lateral, interior, hinge, and dorsal views of right valve. Figure 7, × 100. Paratype UMMP 47593. Bell Shale, locality 31*a*.

FIGS. 11–14. Lateral, inverted interior, inverted hinge, and dorsal views of left valve. Figure 13, × 100. Paratype UMMP 47594. Bell Shale, locality 31*a*.

FIGS. 15–18. Lateral, interior, hinge, and dorsal views of right valve. Figure 17, × 100. Paratype UMMP 47595. Bell Shale, locality 31*a*.

Amphissites bernhageni Stewart and Hendrix 227

FIGS. 9–10. Lateral and interior views of left valve. Hypotype UMMP 47591. Bell Shale, locality 38*a*.

EXPLANATION OF PLATE XXIII

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Arcyzona apobathrota Kesling 228

FIGS. 1–3. Lateral, interior, and inverted hinge views of left valve. Figure 3, × 75. Hypotype UMMP 47596. Widder Formation, locality A.

FIGS. 4–6. Lateral, interior, and hinge views of right valve. Figure 6, × 75. Hypotype UMMP 47597. Widder Formation, locality A.

Arcyzona bythiclimacota Kesling 229

FIGS. 7–9. Lateral, interior, and hinge views of right valve. Figure 9, × 75. Hypotype UMMP 47598. Bell Shale, locality 31*a*.

FIGS. 10–12. Lateral, interior, and inverted hinge views of left valve. Figure 12, × 75. Hypotype UMMP 47599. Bell Shale, locality 31*a*.

Arcyzona diademata (Van Pelt) 230

FIGS. 13–15. Lateral, interior, and hinge views of right valve. Figure 15, × 75. Hypotype UMMP 47600. Bell Shale, locality 38*a*.

FIGS. 16–18. Lateral, interior, and hinge views of left valve of immature instar. Figure 18, × 75. Hypotype UMMP 47601. Bell Shale, locality 38*a*.

Arcyzona rhabdota Kesling 231

FIGS. 19–21. Lateral, interior, and hinge views of right valve. Figure 21, × 75. Hypotype UMMP 47602. Bell Shale, locality 31*a*.

PLATE XXIII

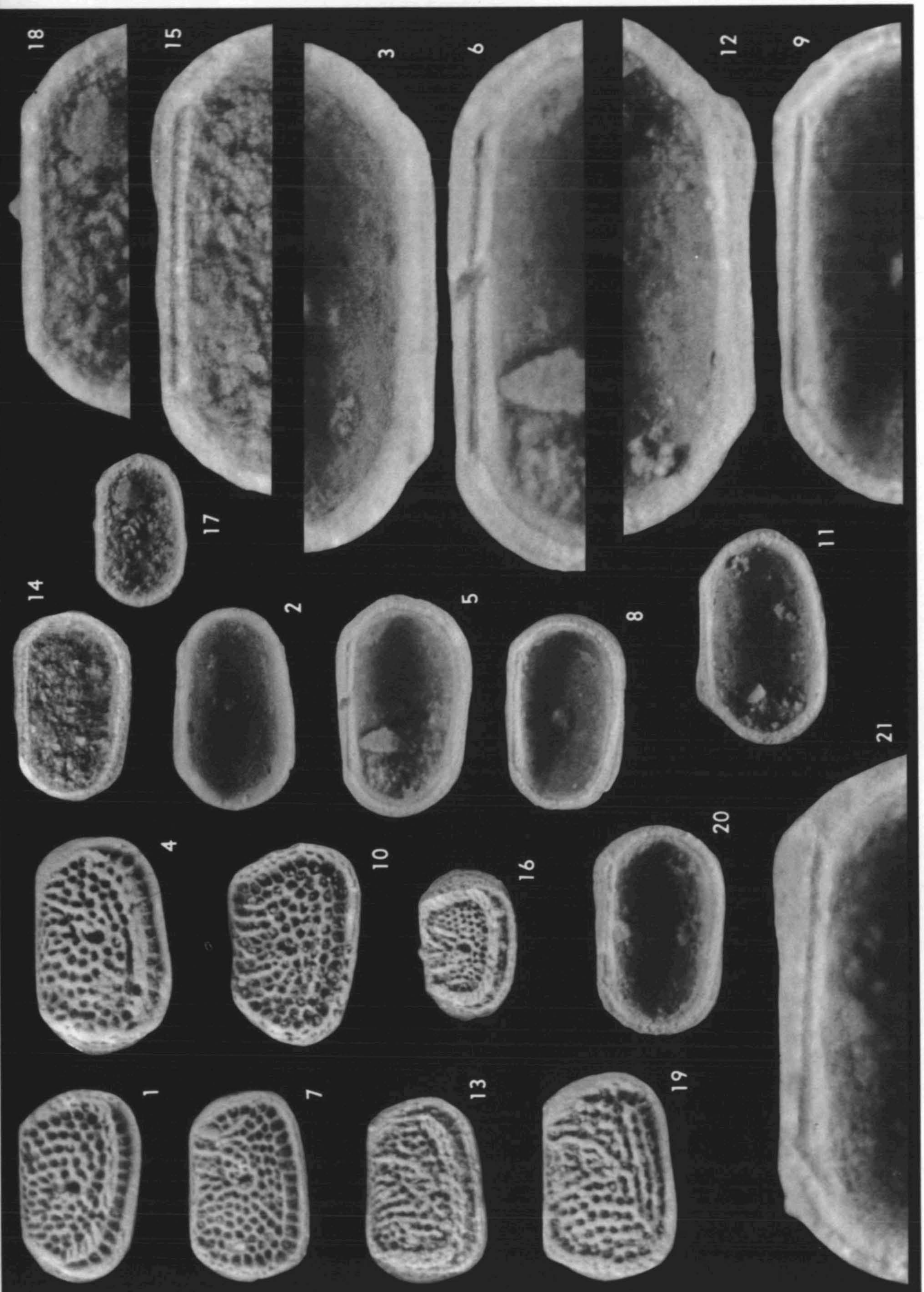
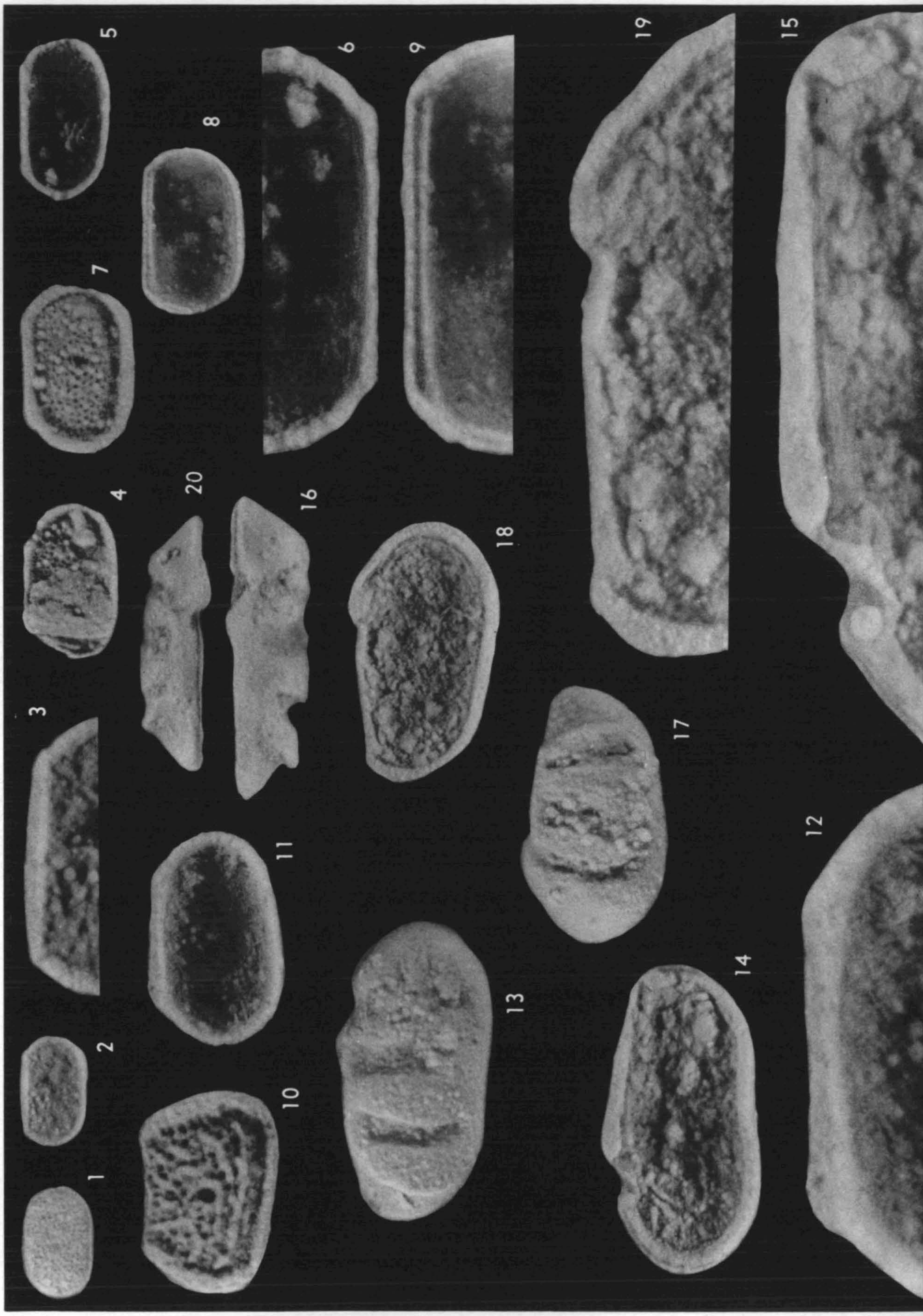


PLATE XXIV



EXPLANATION OF PLATE XXIV

(All figures × 30 except as indicated. Some photographs were retouched to emphasize hinge details.)

PAGE

Amphissella tenuis (Warthin) 232

FIGS. 1–3. Lateral, interior, and hinge views of left valve. Figure 3, × 75. Hypotype UMMP 47603. Lower Blue Shale of Gravel Point Formation, locality 14.

Chironiptrum oiostathmicum Kesling 232

FIGS. 4-6. Lateral, interior, and inverted hinge views of left valve. Figure 6, × 75. Hypotype UMMP 47604. Lateral surface of valve is largely covered by matrix. Bell Shale, locality 31*a*.

FIGS. 7–9. Lateral, interior, and hinge views of right valve. Figure 9, × 75. Hypotype UMMP 47605. Bell Shale, locality 31*a*.

Arcyzona campylactinota Kesling 230

FIGS. 10–12. Lateral, interior, and hinge views of left valve. Figure 12, × 75. Hypotype UMMP 47606. Bell Shale, locality 31*a*.

Dizygopleura euglyphea Warthin 235

FIGS. 13–16. Lateral, interior, hinge, and dorsal views of male right valve. Figure 15, × 75. Hypotype UMMP 47607. Arkona Shale.

FIGS. 17–20. Lateral, interior, hinge, and dorsal views of immature left valve. Figure 19, × 75. Hypotype UMMP 47608. Arkona Shale.

E-0266-149-12C