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OSTRACODA OF THE SILURIAN DECKER AND MANLIUS LIMESTONES IN NEW JERSEY AND EASTERN NEW YORK

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ABSTRACT—Descriptions and illustrations are given for 44 ostracode species of the Decker, Rondout and Manlius limestones of the William Nearpass quarries and Dalton Nearpass farm in northwestern New Jersey, and at Austin's Glen and Trilobite Mountain in New York. One brachiopod variety is proposed. The ostracode species are distributed through 11 families and 23 genera. Thirty-two species and one variety are new, and there are eight new genera. Holotype or syntype specimens of 13 of Weller's ostracode species have been restudied and are refigured and redescribed. Stratigraphic sections are described to provide details of the ostracode occurrences, and zonal potentialities are considered. There is an extensive and distinctive suite of ostracode species in the uppermost part of the Decker limestone, and at least one well characterized species occurs in middle beds. Species of *Leperditia* are common in the Rondout limestone, where other observed ostracodes include only some unidentified specimens of *Kloedenella* and more questionably of *Eukloedenella*. Ostracodes are numerous and diversified in the Manlius limestone, and include several distinctive species that range throughout the formation, whereas others are restricted to lower, upper, and possibly middle beds. Successive changes of the ostracode assemblages and other faunal groups in part are evolutionary, but in part reflect modifications in environment that affected the animal communities as a whole.

New genera described are: *Bonneprimites*, *Limbinaria*, *Pseudobeyrichia*, *Lophokloedenia*, *Myomphalus*, *Welleriopsis*, *Saccarchites*, *Thlipsuropsis*. New species (genotypes marked with asterisks) are: *Bonneprimites? breviformis*, *Aechmina eupunctella*, *Limbinaria multipunctata**, *L. paucipunctata*, *L. biangulata*, *Richina zygalis*, *Parabolbina cuneospinosa*, *Velibeyrichia reticulosaccula*, *V. paucigranulosa*, *Dibolbina macrosulcata*, *Pseudobeyrichia perornata**, *Kloedenia duplicipunctata*, *K. crassipunctata*, *K. aparchoides*, *Lophokloedenia eufimbriata*, *Myomphalus dorsinodosus**, *Welleriopsis diplocystulidis**, *Mesomphalus rhomboidalis*, *M. striatellus*, *Saccarchites saccularis**, *Bolbiprimitia limbata*, *B. teresaccula*, *Euklo edenella cicatrix*, *E. manliensis*, *Kloedenella bipustulata*, *K. parvisulcata*, *Dizygopleura angustisulcata*, *Thlipsuropsis diploglyptulidis**, *T. longisulcata*, *T. digitata*, *Parahealdia? convexioris*; new varieties are: *Welleriopsis jerseyensis* var. *microreticulidis*, *Choneles jerseyensis* var. *nondivergens*.

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INTRODUCTION AND ACKNOWLEDGMENTS

FAUNAS of the successive Decker, Rondout and Manlius limestones of the old William Nearpass quarries in north-western New Jersey, were described a half-century ago by Stuart Weller (1903) to furnish an important milestone in study of the Late Silurian stratigraphy and paleontology of the Appalachian region.

Ostracoda are numerous in some of the Decker-Manlius beds. Fifteen ostracode species from these strata were recognized by Weller, in association with larger assemblages of corals, bryozoans, brachiopods, mollusks and trilobites. Further promise that ostracodes will be invaluable for zonation and correlation of the Decker-Manlius sediments became apparent with discovery of numerous highly ornamented specimens in collections obtained by F. M. Swartz near Catskill, New York in 1929, and at the William Nearpass quarries and Dalton Nearpass farm in New Jersey in 1937.

As a step in establishing characters and ranges of the ostracode species, arrangements were made in 1939 for restudy and reillustration of Weller's type specimens, and work was also begun on part of the new collections. Loan of Weller's ostracode types was secured through the kindness of Meredith E. Johnson, State Geologist of New Jersey. The collections from the Manlius at Austin's Glen were obtained under the cordial guidance of George H. Chadwick during a trip sponsored by the Pennsylvania Geological Survey. The Nearpass section was studied during a visit with A. B. Cleaves to eastern Pennsylvania and adjoining areas, also supported by the Survey. Specimens investigated in the early part of the

study were in part photographed by F. M. Swain under a grant-in-aid from the Council on Research of The Pennsylvania State University, and were described at that time by F. C. Whitmore, Jr., in his Master's thesis. About half of the photographs have been prepared in more recent years by F. M. Swartz.

The type specimens of Weller's ostracode species are housed among collections of the New Jersey Geological Survey at Newark, New Jersey. Types of new species together with numerous other mounted specimens are retained at present in the mounted fossil collections of F. M. Swartz at The Pennsylvania State University, University Park, Pennsylvania, but will at a future date be offered to the United States National Museum, Washington.

CORRELATION PROBLEMS OF THE DECKER,
RONDOUT AND MANLIUS LIME-
STONES OF NEW JERSEY

In the half-century since publication of Weller's studies, correlation of the Decker, Rondout and Manlius limestones of New Jersey has been subject to varying opinions. Problems still remain that probably can be benefited by tracing zones of the ostracodes now recognized in the Nearpass quarries and Austin's Glen areas, as well as by work with additional new ostracode species.

Using corals, brachiopods and trilobites, Weller in 1903 correlated the "Decker Ferry" or Decker formation with the "Coralline" or Cobleskill limestone of east-central New York. Following the opinion of James Hall, Weller supposed that the Cobleskill and, hence, the Decker limestone were deposited concurrently with Middle Silurian

Niagaran sediments of western New York; but he called attention to marked faunal differences that he attributed to nearly complete isolation of easterly and westerly basins. The overlying Rondout limestone was correlated with part of the type Rondout limestone of the Kingston area of eastern New York. The Manlius was identified by the *Howellella vanuxemi-Tentaculites gyracanthus* fauna that distinguishes the type Manlius or "Tentaculite" limestone in central New York.

The Late and not Middle Silurian, post-Niagaran and post-Salina age of the Cobleskill and, consequently, of the Decker limestone was soon recognized independently by C. A. Hartnagel (1903) and Charles Schuchert (1903). Hartnagel traced the Cobleskill westwards in New York, and found it the essential correlate of the Late Silurian, post-Niagaran Akron dolomite of the Buffalo area. Schuchert called attention to occurrence of the Decker limestone species *Chonetes jerseyensis* in the Cobleskill limestone of New York and also in Late Silurian sediments in western Maryland that subsequently were named Keyser limestone. Hartnagel, unlike Weller, correlated only the upper part of the Decker limestone of New Jersey with the Cobleskill limestone of New York. *Halysites* and *Favosites* corals of the Cobleskill limestone, that had influenced Hall's opinion of Middle Silurian age, are recurrent due to return of favorable marine waters to New York subsequent to the Vernon-Salina interval of deposition of red and green muds, dolomites and evaporites.

A further change in interpretation, involving relations of the Nearpass quarry sequence, subsequently was advocated by E. O. Ulrich (1912). Ulrich concluded that the Decker limestone of New Jersey, and its correlatives in the lower part of the Keyser limestone of Maryland, are represented in central New York not by the Cobleskill limestone but instead by considerably younger strata included in the upper Manlius by other authors. Ulrich believed that the type Manlius of central New York needs to be redefined and restricted to beds below his supposed Decker equivalents. He further concluded that these "Decker-age" strata in central New York, the Decker-

Rondout-Manlius limestones of New Jersey, and the Keyser limestone of Maryland, properly are members of the Helderberg group and belong in the Lower Devonian series.

Ulrich's interpretations of 1912 were advanced in discussion of Late Silurian and Early Devonian strata of parts of Maryland and West Virginia, and were never fully developed by presentation of factual data about the central New York succession. Unpublished work by Russel M. Logie gives much evidence that the Decker limestone of New Jersey is older than the type Manlius of central New York, and includes equivalents of the Cobleskill formation. (See notes in Chadwick, 1944.)

The present paleontologic studies were undertaken against this background of stratigraphic problems. In the Nearpass-Austin's Glen area, the ostracodes include numerous species that have very distinctive characters and that are limited in stratigraphic range. If these promising zonal ostracodes can be traced to central New York as well as southwestward to Pennsylvania, Maryland and the Virginias, they should help to place on a firmer basis the Late Silurian correlations of the region.

In the mid-Paleozoic strata in general, Ostracoda where present tend to furnish good zonation because of rapid evolutionary changes reflected in their fossil shells. By contrast, the brachiopod *Howellella vanuxemi* and the pteropod or pteropod-like *Tentaculites gyracanthus*, that characterize the Manlius limestone in central New York, appear to owe their local stratigraphic restriction to details of the paleogeographic-environmental history of the region. In Maryland and parts of the Virginias, *Howellella vanuxemi*, as currently understood, marks zones in the upper part of the Keyser limestone, the lower-middle part of the subjacent Tonoloway limestone, and sporadically in the middle part of the still lower Wills Creek shale. The zones thus are recurrent through about a thousand feet of the Upper Silurian succession. If the *Howellella vanuxemi* occurrences in the thin Manlius limestone of central New York and in the Manlius of northern New Jersey are indicative of close equivalence, the reason

apparently lies not in the short interval between creation and extinction of the species, but rather in its introduction by the same marine incursion. Varieties of *Tertaculites gyracæ* thus likewise have been reported in Maryland in recurrent zones, in both the Tonoloway and Keyser limestones.

The ranges of additional zonal species of the Cobleskill-Manlius and Decker-Manlius sequences in New York and New Jersey similarly may be affected by the environmental history of the region. The ostracodes will at least give supplementary data; and, in-so-far as ostracode zones can be established on evolutionary changes in closely related species of short time ranges, they should be especially valuable in detailed correlations of the strata enclosing them.

ORDER OF DISCUSSION

Sections at the William Nearpass quarries, on the nearby Dalton Nearpass farm, and at Austin's Glen will be described to show relations of ostracode occurrences in local sequences of the Decker, Rondout and Manlius limestones. Zonal values of the ostracode species and some paleoecologic implications of the ostracode and other faunas, will then be discussed. Specific and generic descriptions are given in the section on Systematic Paleontology.

DESCRIPTION OF LOCALITIES
AND SECTIONS

William Nearpass quarries.—The William Nearpass quarries section described by Weller (1903), is exposed in small hillside cuts located in Sussex County, New Jersey, near the easterly foot of Wallpack Ridge, 3 miles south of Port Jervis, New York, at about 45° 20' 5" north latitude, 74° 42' 40" west longitude in the western part of the Port Jervis quadrangle. The quarries are so inconspicuous, long abandoned and overgrown that they are not well known by the residents of the neighborhood. Nevertheless, they still provide the most complete exposures of the Decker, Rondout and Manlius limestones known to the writers in New Jersey.

Weller's account of the William Nearpass section is given below with minor modifications in descriptions of lithology, and with additional records of ostracode occurrences. Thickness figures, given to the inch by Weller, are rounded off to the half-foot. The notations concerning numbers of individuals, including (r)=rare, (c)=common, (a)=abundant, are intended to suggest degrees of abundance as roughly estimated during preparation and removal of specimens from well lithified limestone slabs, by use of a needle under a microscope.

	Thickness in feet	Bed Total
Lower Devonian		
Helderberg group		
Coeymans limestone		
Concealed.		
Medium- to thick-bedded, gray, coarsely crystalline crinoidal limestone, concealed 3 to 8 feet above base. Basal contact well defined, contrasting with the finely crystalline limestone of the Manlius formation. <i>Gypidula coeymanensis</i> fauna, with some masses of <i>Favosites helderbergiae</i> . Weller also reported: <i>Stromatopora concentrica</i> , <i>Ptilodictya lobata</i> , <i>Lichenalia tortu</i> , <i>Monotrypa sphaerica</i> , <i>Stropheodonta varistriata</i> , <i>S. planulata</i> , <i>Strophonella punctulifera</i> , " <i>Rhynchonella</i> " <i>semiplicata</i> , " <i>R.</i> " <i>transversa</i> , <i>Uncinulus mutabilis</i> , <i>Atrypa reticularis</i> , " <i>Spirifer</i> " <i>cyclopterus</i> , <i>Meristella laevis</i> , <i>Actinopteria communis</i> , <i>Platyceras</i> sp., <i>Tentaculites elongatus</i> , <i>Proetus protuberans</i> and <i>Dalmanites pleuroptyx</i> . In new collections from upper half: <i>Mesomphalus striatellus</i> var. (r); <i>Kloe-denia</i> sp. (r)	15	15
Thickness of exposed Coeymans limestone		15
Upper Silurian		
Manlius limestone		
Medium- to thick-bedded, finely crystalline, dark bluish-gray limestone, tending to break into irregular, lumpy fragments. Makes prominent wall near top of the old, slightly recessed quarry bluff. (This is 2A26 of Weller's description.) There are a few stromat-		

Thickness
in feet
Bed Total

oporoids 2 feet below top. Weller reported: <i>Stropheodonta varistriata</i> , "Rhynchonella" sp., <i>Centronella? biplicata</i> , <i>Howellella vanuxemi</i> , <i>Orthoceras</i> sp., <i>Kloedenia montaguensis</i> . New collections include the following species at 1½ feet below top: <i>Pholidops</i> sp. (r), <i>Stropheodonta varistriata</i> (c), <i>Schuchertella</i> sp. (r); <i>Howellella vanuxemi</i> (c); <i>Kloedenia crassipunctata</i> (c), <i>K. montaguensis</i> (c), <i>K. cf. K. kummeli</i> (r), <i>Welleriopsis diplocystulus</i> (c), <i>Mesomphalus</i> sp. (r), <i>Eukloedenella manliensis</i> (c), <i>Kloedenella bipustulata</i> (c), <i>Dizygopleura</i> sp. (r), <i>Bythocypris</i> sp. (r). At 2 feet below top: <i>Schuchertella</i> sp. (r), <i>Stropheodonta varistriata</i> (c), <i>Howellella vanuxemi</i> (c), <i>Centronella? sp.</i> (r), <i>Megambonia aviculoides</i> (r), <i>Loxonema? sp.</i> (c), <i>Kloedenia crassipunctata</i> (c), <i>K. montaguensis</i> (r), <i>Welleriopsis diplocystulus</i> (c), <i>Saccarchites? sp.</i> (r), <i>Phlyctiscapha? sp.</i> (c), <i>Kloedenella bipustulata</i> (r-c), <i>Bythocypris nearpassi</i> (r). At 3 feet below top: <i>Stropheodonta</i> sp. (r), <i>Howellella vanuxemi</i> (c), <i>Centronella? biplicata</i> (r), <i>Tentaculites gyracanthus</i> (r-c), <i>Pseudobeyrichia perornata</i> (r), <i>Bolbiprimitia limbata</i> (r), <i>Kloedenia duplicipunctata</i> (r), <i>K. crassipunctata</i> (r-c), <i>K. montaguensis</i> (c), <i>Lophokloedenia cf. L. manliensis</i> (r), <i>Welleriopsis diplocystulus</i> (c), <i>Mesomphalus</i> sp. (r), <i>Saccarchites? sp.</i> (r), <i>Phlyctiscapha? sp.</i> (c), <i>Eukloedenella manliensis</i> (r), <i>Kloedenella bipustulata</i> (c), <i>Bythocypris</i> sp. (r). At 7 to 9 feet below top: <i>Stropheodonta</i> sp. (r), <i>Schuchertella cf. S. interstriata</i> (r), <i>Howellella vanuxemi</i> (c), <i>Actinopteria</i> sp. (r), <i>Tentaculites gyracanthus</i> (c), <i>Bolbiprimitia limbata</i> (r), <i>B. limbata</i> var. <i>longula</i> (r), <i>Kloedenia crassipunctata</i> (r), <i>K. montaguensis</i> (c), <i>Phlyctiscapha? sp.</i> (r), <i>Eukloedenella cf. manliensis</i> (r), <i>Kloedenella bipustulata</i> (c), <i>Thlipsuropsis digitata</i> (r), <i>Parahealdia? convexoris</i> (r), <i>Bythocypris</i> sp. (r).....		12	35
Thick-bedded, dark bluish-gray, finely crystalline limestone, in part weathering to somewhat lumpy fragments. (2A25 of Weller). Weller reported: <i>Stropheodonta varistriata</i> , <i>Centronella (?) biplicata</i> , <i>Howellella vanuxemi</i> , <i>Kloedenia montaguensis</i> var. <i>smocki</i> . New collections include at about 15 feet below top of Manlius: crinoid stems (r), <i>Stropheodonta varistriata</i> (c), <i>Schuchertella</i> sp. (r), <i>Howellella vanuxemi</i> (c), <i>Centronella?</i> , sp. (r), <i>Loxonema? sp.</i> (c-a), <i>Tentaculites gyracanthus</i> (c), <i>Paraboldina cuneospinosa</i> (r), <i>Veli-beyrichia reticulosaccula</i> (r), <i>Mesomphalus</i> sp. (r), <i>Kloedenia duplicipunctata</i> (r), <i>K. crassipunctata</i> (c), <i>K. montaguensis</i> (r), <i>Saccarchites saccularis</i> (r), <i>Phlyctiscapha? sp.</i> (c), <i>Kloedenella bipustulata</i> (r), <i>Bythocypris</i> sp. (r). At about 21 feet below top of Manlius: <i>Schuchertella</i> sp. (r), <i>Howellella vanuxemi</i> (r), <i>Leperditia</i> sp. (r), <i>Lophokloedenia manliensis</i> (r), <i>Welleriopsis jerseyensis</i> (r).....		10	23
Medium- to thick-bedded, somewhat argillaceous, dark blue, finely crystalline limestone, breaking into irregular, lumpy masses. (2A24 and 2A23 of Weller.) In upper 5 feet Weller reported: <i>Stropheodonta varistriata</i> , <i>Howellella vanuxemi</i> , <i>Megambonia aviculoides</i> , <i>Holopea antiqua</i> , <i>Tentaculites gyracanthus</i> , undetermined cephalopod, <i>Leperditia alta</i> , <i>Lophokloedenia kummeli</i> ; in lower 1½ feet: <i>Leperditia alta</i>		6½	13
Medium- to thick-bedded, dark blue, dense to finely crystalline limestone, breaking into lumpy fragments. (2A22 and 2A21 of Weller.) Basal contact is well defined. Stromatoporoids are common in the upper 4½ feet, rarer in basal 2 feet. In upper 4½ feet Weller reported: <i>Leperditia alta</i> , <i>Lophokloedenia manliensis</i> ; in lower 2 feet: <i>Megambonia aviculoides</i> , <i>Leperditia alta</i> , <i>Kloedenia? sp.</i> At 2 feet above base in new collections: cup coral (r), <i>Centronella? sp.</i> (r), <i>Leperditia alta</i> (c), <i>Bolbiprimitia limbata</i> (c), <i>Lophokloedenia manliensis</i> (c), <i>Welleriopsis jerseyensis</i> var. <i>microreticulis</i> (c), <i>Kloedenella</i> aff. <i>K. bipustulata</i> vars. (r-c), <i>Bythocypris</i> sp. (c).....		6½	6½
Thickness of Manlius limestone.....			35
Rondout limestone			
Thin-bedded, locally crumpled, argillaceous limestone or calcareous shale, with some bands of dense limestone. (2A20.) Weller reported <i>Leperditia alta</i> . In several loose slabs: <i>Liopleria</i> sp. (r).....		15	39
Pethstone bed: Thick-bedded, siliceous, dolomitic limestone, weathering buff. Residue left after boiling in acid is coherent, and consists of a porous network of white, non-detrital silica. (2A19.) One of samples contains some minute, smooth-surfaced, indeterminate, questionable ostracodes.....		5	24
Thin-bedded, argillaceous and siliceous limestone or calcareous shale. (2A18.) Weller reported <i>Leperditia alta</i> . At 18 feet above base of Rondout: <i>Herrmannina welleri</i> (c)...		5½	19
Fine-grained, light gray brittle limestone. (2A17.) Weller reported: <i>Hyattidina? lamellosa</i> (one specimen), <i>Herrmannina welleri</i> . In new collections, a thin layer near top of unit contains <i>Hyattidina? lamellosa</i> (c), <i>Herrmannina welleri</i> (c), <i>Kloedenella</i> sp. (c). In many of the <i>Kloedenella</i> specimens, as well as in some of those of the <i>Hyattidina</i> , the valves are conjoined and the enclosed space is filled with sparry calcite.....		2½	13½
Thin-bedded, unfossiliferous argillaceous and siliceous limestone or calcareous shale.			

	Thickness in feet	Bed Total
(2A16.)	1	11
Fine-grained, dark limestone. (2A15.) Weller reported: <i>Leperditia elongata</i> . In new collections, at 6 feet above base of Rondout: <i>Schuchertella interstriata</i> (one specimen). At 4 feet: <i>Leperditia altiscalaris</i> (c)	6½	10
Argillaceous limestone or calcareous shale, with some thin interlayers of purer limestone. (2A14.) Base poorly defined. <i>Leperditia</i> sp.	3½	3½
Thickness of Rondout limestone		39
Decker limestone		
Medium-bedded, bluish-gray crystalline, sparingly crinoidal limestone in beds 6 to 10 inches thick, separated by thin shaly partings. (2A13.) Weller included beds 2A13 to 2A9 in the <i>Stenocisma</i> ("Atrypa") <i>lamellata</i> zone. In 2A13 he reported: <i>Pholidops ovata</i> , <i>Camarotoechia litchfieldensis</i> ("Rhynchonella agglomerata"), <i>Stenocisma lamellata</i> , <i>Whitfieldella nucleolata</i> , <i>Actinopteria</i> sp., undetermined pelecypods and gastropods, <i>Kloedenia deckerensis</i> , <i>K. sussexensis</i> , <i>Zygobeyrichia nearpassi</i> , <i>Welleriopsis jerseyensis</i> . In new collections at 2 feet below top of Decker: <i>Pholidops ovata</i> (c), <i>Rhipidomella preoblata</i> (r), <i>Schuchertella</i> sp. (r), <i>Camarotoechia litchfieldensis</i> (c), <i>Wilsonia globosa</i> (r), <i>Atrypa reticularis</i> (c), <i>Whitfieldella?</i> sp. (r), <i>Proetus pachydermatus</i> (r), <i>Otarion</i> sp. (r), <i>Calymene camerata</i> (c), <i>Limbinaria paucipunctata</i> (a), <i>Velibeyrichia paucigranulosa</i> (c), <i>Dibolbina macrosulcata</i> (rr), <i>Mesomphalus rhomboidalis</i> (c), <i>M. rhomboidalis</i> var. <i>multipunctata</i> (r), <i>Kloedenia deckerensis</i> (a), <i>K. sussexensis</i> (r), <i>Zygobeyrichia nearpassi</i> (c), <i>Welleriopsis jerseyensis</i> (r), <i>Eukloedenella cicatrix</i> (c), <i>Kloedenella parvisulcata</i> (c), <i>Dizygopleura angustisulcata</i> (a), <i>D. cf. D. clarkei</i> (r). At 3 feet below top of Decker limestone: <i>Pholidops ovata</i> (r), <i>Wilsonia globosa</i> (r), <i>Stenocisma lamellata</i> (c), <i>Whitfieldella nucleolata</i> (r), <i>Calymene camerata</i> (r), <i>Limbinaria paucipunctata</i> (c), <i>Bolbiprimitia</i> sp. (r), <i>Kloedenia deckerensis</i> (c), <i>Zygobeyrichia nearpassi</i> (c), <i>Eukloedenella cicatrix</i> (c), <i>Kloedenella parvisulcata</i> (c), <i>Dizygopleura angustisulcata</i> (c), <i>D. cf. D. clarkei</i> (r), <i>Thlipsuropsis</i> sp. (r), <i>Bythocypris</i> sp. (r)	4	52
Coralline beds: Irregularly bedded limestone, breaking into lumpy masses, and containing much fragmental coralline and shell material. (2A12.) Weller reported: <i>Zaphrentis</i> sp., <i>Diphyphyllum integumentum</i> , <i>Cladopora rectilineata</i> , <i>Favosites pyriformis</i> , <i>Cyathophyllum inaequalis</i> , <i>Halysites catenularia</i> , <i>Stromatopora concentrica</i> , <i>Cyphotrypa</i> (<i>Monotrypa</i>) <i>corrugata</i> , <i>Spirorbis</i> sp., <i>Pholidops ovata</i> , <i>Stropheodonta bipartita</i> , <i>Leptaena rhomboidalis</i> , <i>Schuchertella interstriata</i> , <i>Camarotoechia litchfieldensis</i> , <i>Wilsonia globosa</i> , <i>Stenocisma lamellata</i> , <i>Rhynchospirina formosa</i> , <i>Whitfieldella nucleolata</i> , <i>Actinopteria reticulata</i> , <i>Proetus pachydermatus</i> , <i>Calymene camerata</i> , <i>Kloedenia sussexensis</i> , <i>Zygobeyrichia barretti</i> . Ostracodes are very rare in these strata; none have been observed in the new collections.	6 7½	48 42
Blocky calcareous shale, with thin bands of limestone. (2A11.)		
Bluish, finely crystalline, in part somewhat crinoidal, fossiliferous limestone (2A10), with 9 inches of shale (2A9) at base. In 2A10 Weller reported: <i>Cladopora rectilineata</i> , <i>Escharopora siluriana</i> , <i>Stropheodonta bipartita</i> , <i>Schuchertella interstriata</i> , <i>S. deckerensis</i> , <i>Leptaena rhomboidalis</i> , " <i>Dalmanella</i> " <i>postelegantula</i> , <i>Camarotoechia litchfieldensis</i> , <i>Stenocisma lamellata</i> , <i>Spirifer vanuxemi</i> var. <i>minor</i> , <i>Whitfieldella</i> sp., <i>Mytilarca</i> sp., <i>Pterinea "emacerata"</i> , <i>Proetus pachydermatus</i> . At 31 feet above base of Decker limestone: <i>Limbinaria biangulata</i> (r)	8	34½
<i>Ptilodictya frondosa</i> zone: Medium-bedded, light gray, coarsely crystalline, highly crinoidal limestone in beds up to 9 inches thick, with some thin shale partings; beds near middle are reddish, hematitic; the hematite in part forms coatings on oolites, in part extends into the pores of and tends to replace crinoid fragments and perhaps other shell material. (2A8.) Weller reported: <i>Favosites</i> sp., <i>Cladopora rectilineata</i> , <i>Cyphotrypa corrugata</i> , <i>Vermipora</i> sp., <i>Ptilodictya frondosa</i> , <i>Lichenalia</i> sp., <i>Stropheodonta bipartita</i> , <i>Leptaena rhomboidalis</i> , <i>Schuchertella deckerensis</i> , <i>Chonetes jerseyensis</i> , " <i>Orthis</i> " <i>flabellites</i> , " <i>Dalmanella</i> " <i>postelegantula</i> , <i>Rhipidomella preoblata</i> , <i>Gypidula circularis</i> , <i>Stenocisma deckerensis</i> , <i>Camarotoechia litchfieldensis</i> , <i>Atrypa reticularis</i> , <i>Spirifer</i> sp., <i>Calymene camerata</i> . The 4-inch frond-like zoaria of <i>Ptilodictya frondosa</i> are conspicuous in some layers of this unit. The zone contains the highest observed occurrences of <i>Chonetes jerseyensis</i> . Ostracodes are rare; a few specimens of <i>Dibolbina</i> sp. and <i>Dizygopleura</i> sp. were found in material from these strata, but are not satisfactory for identification.	2½	26½
Thin-bedded shale, with thin bands of fossiliferous, crystalline limestone, 5 inches, above, 8 inches crystalline limestone, below. (2A7 and 2A6.) Weller reported: <i>Stropheodonta bipartita</i> , <i>Chonetes jerseyensis</i> , <i>Camarotoechia litchfieldensis</i> , <i>Bythocypris nearpassi</i> .		

	Thickness in feet	
	Bed	Total
Beds 2A7 to 2A3 were included in the <i>Chonetes jerseyensis</i> zone by Weller; however, he also reported the species in 2A8.	1½	24
Fissile, calcareous shale with some thin bands of limestone. (2A5.) No fossils observed	6½	22½
Thick-bedded, light gray, crystalline, somewhat crinoidal limestone, with some thin, irregular shaly laminae. (2A4.) Fossils numerous, but less perfectly preserved than in the subjacent bed. Weller reported: <i>Favosites</i> sp., <i>Cyphotrypa corrugata</i> , <i>Lichenalia</i> sp., <i>Stropheodonta bipartita</i> , <i>Schuchertella deckerensis</i> , <i>Chonetes jerseyensis</i> , " <i>Dalmanella</i> " <i>postelegantula</i> , <i>Stenocisma deckerensis</i> , <i>Camarotoechia litchfieldensis</i> , <i>Atrypa reticularis</i> , " <i>Spirifer</i> " cf. <i>modestus</i> (" <i>Reticularia bicostata</i> "), <i>Cyrtina magnaplicata</i> , <i>Platyceras</i> sp..	14	16
Crystalline, highly crinoidal, sparingly arenaceous limestone. (2A3.) In collected material, the profuse crinoid plates tend to be partly replaced by limonite. The grains of quartz sand form less than 5 per cent of the rock; they are well rounded and commonly measure 0.5 to 1 mm. in diameter. Weller reported: <i>Zaphrentis</i> sp., <i>Cyphotrypa corrugata</i> , <i>Pholidops ovata</i> , <i>Stropheodonta bipartita</i> , <i>Schuchertella deckerensis</i> , <i>Chonetes jerseyensis</i> , " <i>Dalmanella</i> " <i>postelegantula</i> , <i>Stenocisma deckerensis</i> , <i>Camarotoechia litchfieldensis</i> , <i>Atrypa reticularis</i> , " <i>Spirifer</i> " cf. <i>modestus</i> (" <i>Reticularia bicostata</i> "), <i>Edmondia?</i> <i>deckerensis</i> , <i>Pterinea</i> sp., <i>Ptychopteria?</i> <i>subquadrata</i> , <i>Mytilarca obliqua</i> , <i>Straparollus</i> sp., <i>Loxonema</i> sp., <i>Orthoceras</i> sp., <i>Goniophora</i> sp., <i>Proetus?</i> <i>depressus</i> , " <i>Dalmanites</i> " <i>aspinosa</i> . New collections contain <i>Chonetes jerseyensis</i> (c), <i>C. jerseyensis</i> var. <i>nondivergens</i> (c), and a few poor Ostracoda, including <i>Dibolbina</i> sp. (r), <i>Bonneprimites breviformis</i> (r), <i>Dizgopleura</i> sp. (r), <i>Limbinaria?</i> sp. (r)	2	2
Thickness of Decker limestone.		52
Bossardville limestone		
Dark blue to black, dense laminated limestone, weathering light bluish-gray; the laminae commonly are about ¼-½ inch in thickness interspersed with a few layers reaching 3 inches. <i>Leperditia</i> sp. (c) about 2 feet below top.		12
Concealed.		—
Thickness exposed uppermost Bossardville limestone.		12

Dalton Nearpass farm, New Jersey.—Lower Devonian Oriskany and Helderberg beds, and the Upper Silurian Manlius limestone are relatively well exposed from the summit to the eastern foot of Wallpack Ridge on the farm of Dalton Nearpass in Sussex County, New Jersey, 2½ miles south of Port Jervis, New York, at about 74° 42.2' west longitude, 41° 20.4–20.2' north latitude in the western part of the Port Jervis quadrangle. The lane leading from the Dalton Nearpass house to small quarries in the Manlius near the foot of the ridge is shown on the April, 1908, edition of the Port Jervis sheet. The Rondout limestone and upper part of the Decker limestone are incompletely exposed.

The stratigraphic succession and thicknesses of the Coeymans and Manlius are closely similar to those at the William Nearpass quarries a short half-mile to the southwest, and will not be detailed.

Ostracode faunules were collected as follows:

Lower Devonian Coeymans limestone

Thlipsuropsis digitata (r) in slab from upper part of the formation.

Late Silurian Manlius limestone

In ostracode-rich layers in lower half-foot of the Manlius: Cup coral (r), *Howellella vanuxemi* (r), gastropod undetermined (r), *Herrmannina altoides* (c), *Pseudobeyrichia perornata* (r), *Kloedenia crassipunctata* (r), *K. aparchoides* (r), *Lophokloedenia manliensis* (a), *Myomphalus dorsinodosus* (r), *Saccarchites* (?) sp. (r), *Kloedenella bipustulata* (r-c). This is the *Lophokloe denia manliensis* fauna.

Decker limestone

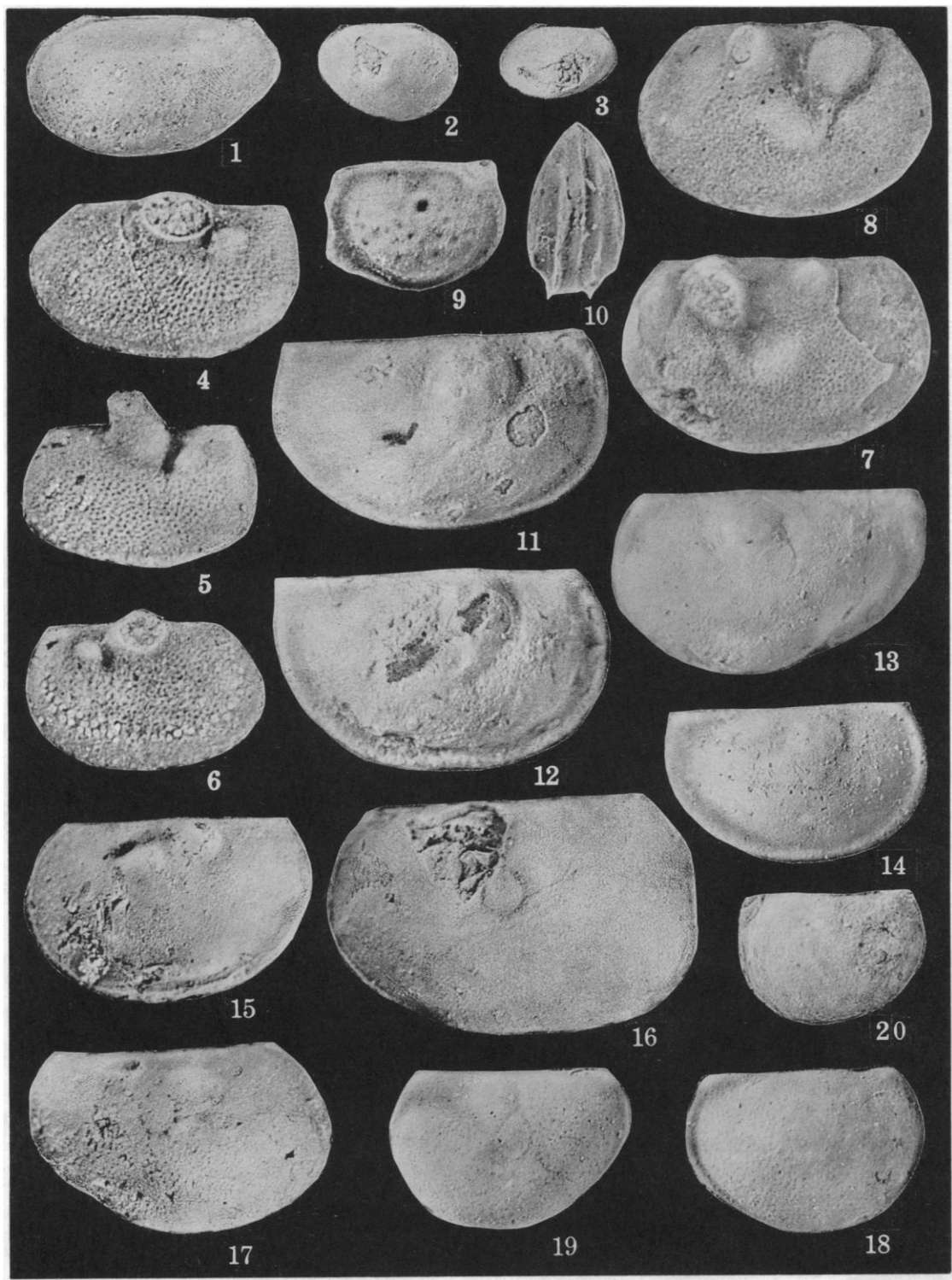
Loose, ostracode-bearing slabs of two types were discovered in a small pit just south of the Dalton Nearpass farm lane at the foot of the rise to Wallpack Ridge. The

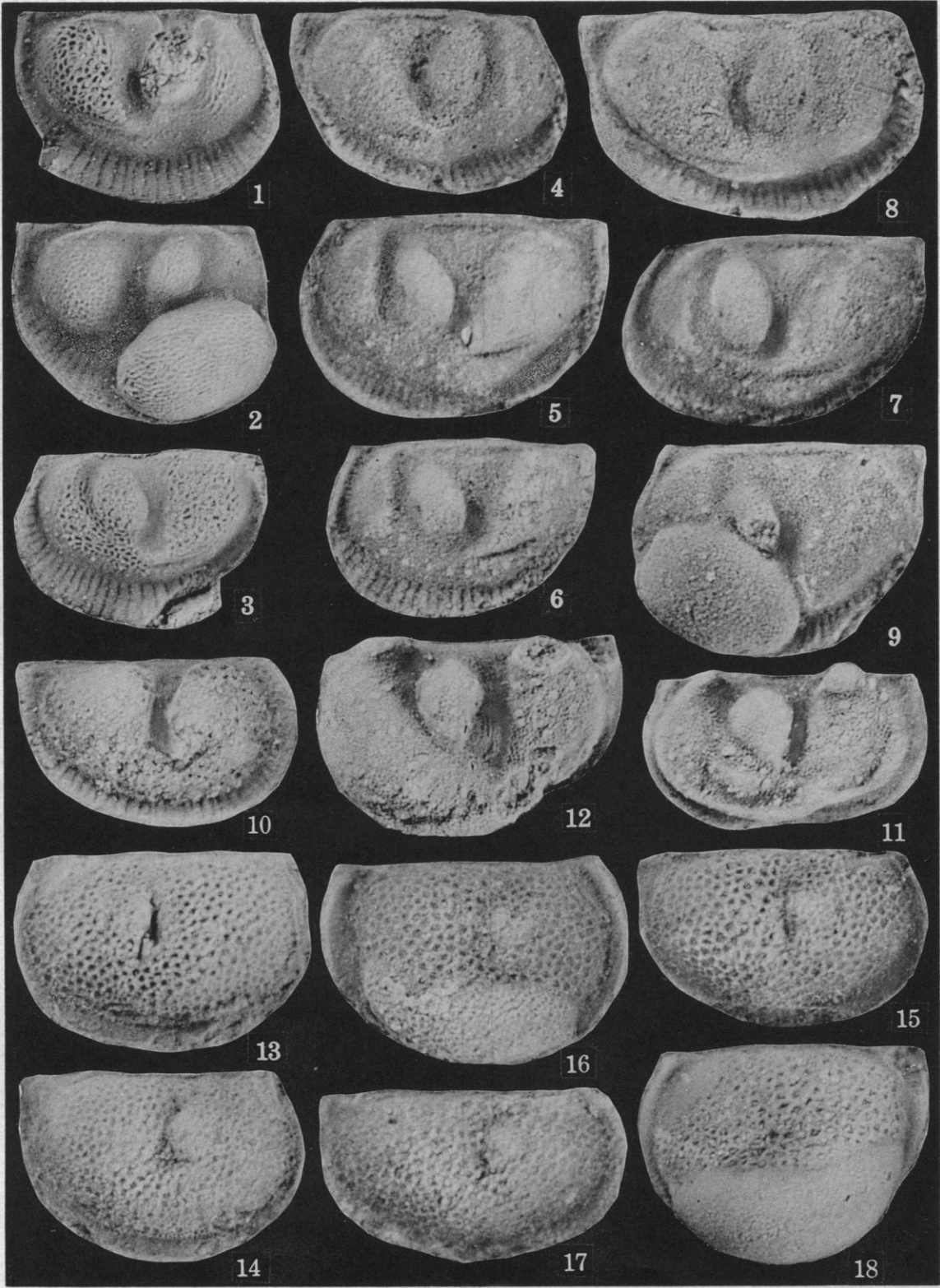
position of the pit is about 20 to 25 feet stratigraphically below the summit of the Decker limestone, and it appeared likely that the loose slabs had been dug from the pit.

Slabs of type 1 consist of reddish crystalline, crinoidal limestone, and contain *Stropheodonta bipartita* (c), *Stenocisma deckerensis* (r), *Limbinaria biangulata* (c), *Thlipsuroopsis longisulcata* (r).

EXPLANATION OF PLATE 103

- FIG. 1—*Leperditia elongata* Weller. The holotype right valve, $\times 3$, showing the elongate form, the weakly defined terminal borders. New Jersey Geological Survey Coll. 6369; William Nearpass quarries, New Jersey, 4 to 10 feet above base of Rondout limestone (2A15). (p. 1050)
- 2,3—*Hermannina altoides* (Weller). Two of the syntype valves, a left and a right valve, $\times 3$. The left valve especially shows the posterior border that distinguishes *H. altoides* from *H. alta*. New Jersey Geological Survey Coll. 6367; Flatbrookville, New Jersey, lower part of Decker limestone (109B). (p. 1051)
- 4-6—*Aechmina eupunctella* Swartz & Whitmore, n.sp. 4,5, The syntype right valves, $\times 45$. In 4 the dorso-median spine is broken at its base, in 5 the tip of the spine is missing. Both specimens show the pit and adjacent node antero-ventral to the base of the spine, as well as the fine surface puncta. 6, A left valve, $\times 50$, the dorso-median spine broken. The peculiar, punctate pustules occurring in a band paralleling the free margins have not been observed in other specimens. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1054)
- 7,8—*Richina zygalis* Swartz & Whitmore, n. sp. The syntype left and right valves, $\times 47$, showing the distinct yoke-ridge joining the dorsal nodes. In 7, the conical point of the posterior node is preserved, the fine puncta of the shell surface are clearly shown and the pit of the median sulcus is visible. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1058)
- 9,10—*Limbinaria paucipunctata* Swartz & Whitmore, n. gen., n. sp. Right and ventral views of holotype female shell, $\times 30$, showing incompletely the posteriorly expanded dimorphic flange of each valve, the pit antero-dorsal to the center of the valve, the shallow, scattered surface pits. William Nearpass quarries, New Jersey, 3 feet below top of Decker limestone and 1 foot above coralline bed. (p. 1057)
- 11-14—*Kloedenia aparchoides* Swartz & Whitmore, n. sp. 11-13, The syntype valves, $\times 20$. 11,12, Two male right valves, showing the obscure kloedenid lobation, broad submarginal border, and extremes of prominence of the posterior cardinal angle. 13, A female left valve; the rounded, raised spot at the ventral end of the median sulcus evidently reflects the adductor scar. 14, A small male right valve, $\times 20$. 11-13 from quarry beside lane ascending eastern side of Trilobite Mountain, 1.2 miles northeast of Tristate, Orange County, New York, Manlius limestone 40 feet below lowest exposed beds of Coeymans limestone; 14 from quarries near southeast foot of Wallpack Ridge, on Dalton Nearpass farm, New Jersey, basal 2 feet of Manlius limestone. (p. 1067)
- 15-17—*Myomphalus dorsinodosus* Swartz & Whitmore, n. gen., n. sp. 15,16, Views of syntypes, $\times 25$. 15, A male left valve; the two subdorsal nodes are well preserved; in this valve there is an oblique furrow above the more anterior node; the submarginal border is weakly defined; there are obscure, scattered granules on the anterior slope. 16, An exceptionally large female right valve; the weakly defined, ventral dimorphic pouch is relatively long. Antero-ventral to the broken section of the surface is a well-defined adductor spot. 17, A smaller female right valve, $\times 25$, with shorter dimorphic pouch, well defined adductor spot. 15,16, from quarries near southeast foot of Wallpack Ridge, on Dalton Nearpass farm, New Jersey, basal 2 feet of Manlius limestone. 17 from quarry beside lane ascending eastern slope of Trilobite mountain, 1.2 miles northeast of Tristate, Orange County, New York; Manlius limestone 40 feet below lowest exposed Coeymans limestone. (p. 1074)
- 18,19—*Saccarchites saccularis* Swartz & Whitmore, n. gen., n. sp. The syntypes, $\times 20$. 18, A male right valve showing the aparchitid suppression of lobation. The submedian adductor spot and surface puncta are well preserved. There is a very faint depressed line above the muscle spot and an obscure suggestion of a vestige of a median lobe anterior to the depressed line. 19, A female left valve with large but poorly defined anteroventral dimorphic pouch, well preserved adductor spot, faint surface puncta. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1080)
- 20—*Phlyctiscapha?* sp. A male left valve, $\times 20$, showing the inequality of the ends, and oblique ventral margin. The greater portion of the specimen is weathered light gray, leaving a darker band that parallels the free margins and is incorrectly suggestive of a submarginal furrow. William Nearpass quarries, New Jersey, 7 to 9 feet below top of Manlius limestone. (p. 1081)





Slabs of type 2 are gray, finely crystalline, and contain *Leperditia scalaris* (a) without other fossils.

The fauna, lithology, and stratigraphic position of the slabs of type 1 suggest a position at or slightly above the top of the *Ptilodictya frondosa* beds of the William Nearpass section; the *L. scalaris* slabs presumably come from about the same horizon although the species is not known at the William Nearpass quarries.

East slope of Trilobite Mountain, New York.—Trilobite Mountain is a hill 300 to 400 feet high, extending for 2 miles northeast of Tristate village near Port Jervis, Orange County, New York, in the west-central part of the Port Jervis quadrangle. Geologically, the hill is a continuation of Wallpack Ridge southwest of Tristate. The

stratigraphy, structure, and faunas of the hill were described by Shimer in 1905; the name Trilobite Mountain comes from the profusion of *Corycephalus* ("Dalmanites") *dentatus* in thin layers in the Lower Devonian Port Jervis limestone.

Ostracode-rich layers were found in the Manlius limestone at a small quarry alongside the road on the eastern slope of the hill, 1.2 miles northeast of Tristate at about 78° 39.7' west longitude, 41° 21.8' north latitude. The section at the quarry is as follows:

Lower Devonian
Helderberg group
Coeymans limestone

Thick-bedded gray, crystalline crinoidal limestone containing the characteristic *Gypidula coeymanensis* fauna. 20 feet

EXPLANATION OF PLATE 104

- FIG. 1-3—*Velibeyrichia reticulosaccula* Swartz & Whitmore, n. sp. Views of syntypes $\times 35$. 1, A male right valve showing the furrow of the post-ventral slope, the indentation of the frill. 2, A female right valve showing the reticulose ornament of the dimorphic pouch, the crest adjoining the hinge, the lack of post-ventral indentation of the frill. 3, A male left valve, the cardinal angles imperfect. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1059)
- 4-9—*Velibeyrichia paucigranulosa* Swartz & Whitmore, n. sp. Views of syntypes, $\times 48$. 4-7, A male right valve, and three male left valves, showing small differences in shape and size, but persistence of the sparse granules, the furrow of the post-ventral slope, the sharp summit at the posterior margin of the anterior lobe, the shallow furrow defining the low crest that parallels part of the hinge, the swelling at the dorsal end of the median sulcus. 8, A large male right valve. In 8 the more minute set of surface granules can be seen. 9, A female left valve. William Nearpass quarries, New Jersey, 2 feet below top of Decker limestone. (p. 1060)
- 10—*Dibolbina macrosulcata* Swartz & Whitmore, n. sp. The holotype, a male right valve, $\times 35$, showing the strong median sulcus; some of the surface pits are visible, though most of them are clogged with matrix. William Nearpass quarries, New Jersey, 2 feet below top of Decker limestone. (p. 1061)
- 11, 12—*Pseudobeyrichia perornata* Swartz & Whitmore, n. gen., n. sp. 11, The holotype male left valve, $\times 46$, showing the dorsal nodes of the terminal lobes, the granules surmounting the minutely punctulose surface, the short ridge anteroventral to the median lobe, and the submarginal ridge that may be a vestige of the velibeyrichiid type of frill. William Nearpass quarries, Wallpack Ridge, New Jersey, 3 feet below top of Manlius limestone. 12, A female left valve. The striate ventral part of the median sulcus may reflect the adductor scar. Quarries near southeastern foot of Wallpack ridge, near lane of Dalton Nearpass farm, New Jersey, north of William Nearpass quarries; basal foot of Manlius limestone. (p. 1062)
- 13-17—*Bolbiprimitia limbata* Swartz & Whitmore, n. sp. The syntypes, about $\times 47$. 13, A male left valve showing the broad marginal flange and narrow, short median sulcus. Anterior margin imperfect. 14, 15, Two male right valves, the second relatively elongate. 16, A female right valve, showing the finely punctate, medioventral dimorphic pouch which, in conjunction with the posterior lobe, has a cornucopia-like appearance. William Nearpass quarries, New Jersey, 2 feet above base of Manlius limestone. 17, A male right valve, $\times 45$, decidedly more than normally elongate, perhaps due to distortion. William Nearpass quarries, New Jersey, 7 to 9 feet below top of Manlius limestone. (p. 1082)
- 18—*Bolbiprimitia teresaccula* Swartz & Whitmore, n. sp. The holotype female left valve, $\times 45$, showing the smooth-surfaced dimorphic pouch, and reduction of the median sulcus to a small pit. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1082)

Late Silurian	
Manlius limestone	
Concealed; may include at top 5 or 10 feet of Coeymans limestone.	38 feet
Medium-bedded, finely crystalline, bluish-gray limestone, poorly exposed in quarry floor and along road. At 2 feet below top: <i>Howellella vanuxemi</i> (r-c), <i>Leperditia</i> sp. (r), <i>Kloedenia crassipunctata</i> (r), <i>K. aparchoides</i> (c), <i>Lophokloedenia manliensis</i> (c), <i>L. kummeli</i> (r), <i>Myomphalus dor-</i>	
<i>sinodosus</i> (r), <i>Eukloedenella</i> sp. (r), <i>Kloedenella bipustulata</i> (r)	5 feet
Concealed.	
The ostracodes found in the Manlius beds in this quarry represent the <i>Lophokloedenia manliensis</i> subzone, characteristic of the lower part of the Manlius at the William Nearpass section 3½ miles to the southwest.	
	Thickness Feet
Lower Devonian	
Helderberg group	
Alsen limestone	
Cherty siliceous limestone. <i>Spirifer concinnus</i> fauna. Port Ewen beds may be represented in upper part	40-45
Becraft limestone	
Crystalline, crinoidal limestone; some shale interlayers in lower part. <i>Spirifer concinnus</i> , <i>Aspidocrinus</i> fauna	60
New Scotland shaly limestone	
Fossiliferous, argillaceous limestone; <i>Eospirifer macropleurus</i> fauna	120
Kalkberg limestone	
Dark, finely crystalline, impure limestone, with seams of black chert. <i>Bilobites varicus</i> , <i>Eospirifer macropleurus</i> , <i>Gypidula coeymanensis</i> fauna	35
Coeymans limestone	
Crystalline, crinoidal, sparingly siliceous limestone. <i>Gypidula coeymanensis</i> fauna	15
Thickness of Helderberg group	275
Late Silurian	
Manlius limestone	
Dark blue, finely crystalline to dense, in part laminated limestone. In part the "ribbon" beds have a peculiar columnar jointing due to superposed mudcracks. There are several stromatoporoid beds. <i>Howellella vanuxemi</i> , <i>Tentaculites gyracanthus</i> fauna. Slabs collected by F. M. Swartz at a horizon not less than 2 nor more than 5 feet below top of Manlius contain: crinoidal plates (c), <i>Stropheodonta varistriata</i> (c), <i>Howellella vanuxemi</i> (c), <i>Trematospira?</i> sp. (r), <i>Centronella</i> cf. <i>C. biplicata</i> (r), <i>Actinopteria reticulata</i> var. (r), <i>Aechmina eupunctella</i> (r), <i>Richina zygalis</i> (r), <i>Parabolbina cuneospinosa</i> (c), <i>Velibeyrichia reticulosaccula</i> (c), <i>Kloedenia duplicipunctata</i> (c), <i>K. crassipunctata</i> (c), <i>Lophokloedenia eufimbriata</i> (c), <i>Mesomphalus striatellus</i> (c), <i>Bolbiprimitia terresaccula</i> (r), <i>Saccarchites sacularis</i> (c), <i>Phlyctiscapha?</i> sp. (c), <i>Eukloedenella</i> cf. <i>E. manliensis</i> (r), <i>Kloedenella bipustulata</i> (c-a), <i>Thlipsuropsis diploglyptulis</i> (r), <i>Parahealdia</i> sp. (r), <i>Cavellina</i> sp. (r), <i>Bythocypris</i> sp. (c). Abundance of <i>Kloedenia crassipunctata</i> and <i>K. duplicipunctata</i> in association with <i>Kloedenella bipustulata</i> suggests the middle to upper part of the Manlius of the Nearpass quarries, but the full Austin's Glen assemblage has not been duplicated in the Nearpass section	50
Rondout limestone	
Impure limestone, the lower part arenaceous	6- 8
Thickness of Late Silurian Manlius and Rondout beds	56-58
(Unconformity)	
Middle Ordovician	
Normanskill shale and sandstone	

Austin's Glen, New York.—During a visit to Austin's Glen, near Catskill, New York, in 1929 under the guidance of G. H. Chadwick, F. M. Swartz collected slabs from the upper part of the Manlius limestone that have proven to have an especially rich suite of ostracodes, corresponding in part to assemblages found in the upper portion of the Manlius limestone at the William Nearpass quarries in New Jersey.

Austin's Glen is a small gorge cut by Catskill Creek between hills capped by Lower Devonian sediments. It is in the north-central part of the Catskill quadrangle, $2\frac{1}{2}$ miles northwest of Catskill, Greene County, New York, at about $73^{\circ} 53\frac{1}{2}'$ west longitude, $42^{\circ} 14\frac{1}{2}'$ north latitude.

The Helderbergian-Late Silurian section found in the gorge is given below, on the basis of Chadwick's (1944) description. The ostracodes listed in the upper part of the Manlius were obtained from the slabs collected by Swartz in 1929.

LIST OF SPECIES

The ostracodes described in the present paper are named in the following list, which also gives their respective horizons and localities of occurrence. Description of *Limbinaria multipunctata* Swartz, n. gen., n. sp., of the Tonoloway limestone of Virginia and Tennessee, is introduced in this report to provide a basis for discussion of species of the genus that occur in New Jersey. A description of the brachiopod, *Chonetes jerseyensis* var. *nondivergens* Swartz, n. var., is given in a brief appendix at the end of the systematic descriptions of the Ostracoda.

In a previous paper on Leperditidae, Swartz (1949) described and illustrated specimens of the following species, obtained from the Nearpass quarries area: *Leperditia scalaris* Jones, Decker limestone; *L. altiscalaris* Swartz, Rondout limestone; *Herrmannina welleri* Swartz, Rondout limestone.

The species here described are as follows:

- Family Leperditidae Jones
 - Subfamily Leperditinae Swartz
 - Genus *Leperditia* Rouault
 - Leperditia elongata* Weller
 - Rondout limestone, New Jersey
 - Genus *Herrmannina* Kegel
 - Herrmannina altoides* (Weller)
 - Decker limestone, New Jersey
 - Subfamily Conchoprimitiinae Henningsmoen
 - Genus *Bonneprimites* Swartz & Whitmore, n. gen.
 - Bonneprimites* (?) *breviformis* Swartz & Whitmore, n. sp.
 - Decker limestone, New Jersey
- Family Aechminidae (Boucek)
 - Genus *Aechmina* Jones & Holl
 - Aechmina eupunctella* Swartz & Whitmore, n. sp.
 - Manlius limestone, New York
- Family Primitiopsidae Swartz
 - Genus *Limbinaria* Swartz, n. gen.
 - Limbinaria multipunctata* Swartz n. sp.,
 - Tonoloway limestone, Virginia and Tennessee
 - Limbinaria paucipunctata* Swartz & Whitmore, n. sp.
 - Decker limestone, New Jersey
 - Limbinaria biangulata* Swartz & Whitmore, n. sp.
 - Decker limestone, New Jersey
- Family Drepanellidae (Ulrich & Bassler)
 - Genus *Richina* Coryell & Malkin
 - Richina zygalis* Swartz & Whitmore, n. sp.
 - Manlius limestone, New York
- Family Hollinidae Swartz
 - Genus *Parabolbina* Swartz

Parabolbina cuneospinosa Swartz & Whitmore, n. sp.

Manlius limestone, New York and New Jersey

Family Beyrichiidae Ulrich

Genus *Velibeyrichia* Henningsmoen

Velibeyrichia reticulosaccula Swartz & Whitmore, n. sp.

Manlius limestone, New York and New Jersey

Velibeyrichia paucigranulosa Swartz & Whitmore, n. sp.

Decker limestone, New Jersey

Genus *Dibolbina* Ulrich and Bassler

Dibolbina macrosulcata Swartz & Whitmore, n. sp.

Decker limestone, New Jersey

Genus *Pseudobeyrichia* Swartz & Whitmore, n. gen.

Pseudobeyrichia perornata Swartz & Whitmore, n. sp.

Manlius limestone, New Jersey

Family Zygobolbidae Ulrich & Bassler

Subfamily Kloedeninae Ulrich & Bassler

Genus *Kloedenia* Jones & Holl

Kloedenia deckerensis (Weller)

Decker limestone, New Jersey

Kloedenia sussexensis (Weller)

Decker limestone, New Jersey

Kloedenia duplicipunctata Swartz & Whitmore, n. sp.

Manlius limestone, New York and New Jersey

Kloedenia crassipunctata Swartz & Whitmore, n. sp.

Manlius limestone, New York and New Jersey

Kloedenia montaguensis (Weller)

Manlius limestone, New Jersey

Kloedenia montaguensis var. *smocki* (Weller)

Manlius limestone, New Jersey

Kloedenia aparchoides Swartz & Whitmore, n. sp.

Manlius limestone, New York and New Jersey

Genus *Lophokloedenia* Swartz & Whitmore, n. gen.

Lophokloedenia manliensis (Weller)

Manlius limestone, New Jersey and New York

Lophokloedenia kummeli (Weller)

Manlius limestone, New Jersey and New York

Lophokloedenia eufimbriata Swartz & Whitmore, n. sp.

Manlius limestone, New York

Genus *Zygobeyrichia* Ulrich

Zygobeyrichia barretti (Weller)

Decker limestone, New Jersey

Zygobeyrichia nearpassi (Weller)

Decker limestone, New Jersey

Genus *Myomphalus* Swartz & Whitmore, n. gen.

Myomphalus dorsinodosus Swartz & Whitmore, n. sp.

Manlius limestone, New Jersey and New York

Genus *Welleriopsis* Swartz & Whitmore, n. gen.

Welleriopsis diplocystulis Swartz & Whitmore, n. sp.

Manlius limestone, New Jersey

Welleriopsis jerseyensis (Weller)

Decker limestone, New Jersey

Welleriopsis jerseyensis var. *microreticulis* Swartz & Whitmore, n. var.

Manlius limestone, New Jersey

Genus *Mesomphalus* Ulrich & Bassler

- Mesomphalus rhomboidalis* Swartz & Whitmore n. sp.
Decker limestone, New Jersey
- Mesomphalus striatellus* Swartz & Whitmore, n. sp.
Manlius limestone, New York; variant in Coeymans limestone, New Jersey
- Genus *Saccarchites* Swartz & Whitmore, n. gen.
Saccarchites saccularis Swartz & Whitmore, n. sp.
Manlius limestone, New York and New Jersey
- Genus *Phlyctiscapha* Kesling
Phlyctiscapha? sp.
Manlius limestone, New York and New Jersey
- Genus *Bolbioprimitia* Kay
Bolbioprimitia limbata Swartz & Whitmore, n. sp.
Manlius limestone, New Jersey
Bolbioprimitia teresaccula Swartz & Whitmore, n. sp.
Manlius limestone, New York
- Family Kloedenellidae Ulrich & Bassler
Genus *Eukloedenella* Ulrich & Bassler
Eukloedenella cicatrix Swartz & Whitmore, n. sp.
Decker limestone, New Jersey
Eukloedenella manliensis Swartz & Whitmore, n. sp.
Manlius limestone, New Jersey
- Genus *Kloedenella* Ulrich & Bassler
Kloedenella bipustulata Swartz & Whitmore, n. sp.
Manlius limestone, New York and New Jersey
Kloedenella parvisulcata Swartz & Whitmore, n. sp.
Decker limestone, New Jersey
- Genus *Dizygopleura* Ulrich & Bassler
Dizygopleura angustisulcata Swartz & Whitmore, n. sp.
Decker limestone, New Jersey
Dizygopleura cf. *D. clarkei* (Jones)
Decker limestone, New Jersey
- Family Thlipsuridae Ulrich
Genus *Thlipsuropsis* Swartz & Whitmore, n. g.
Thlipsuropsis diploglyptulis Swartz & Whitmore, n. sp.
Manlius limestone, New Jersey
Thlipsuropsis longisulcata Swartz & Whitmore, n. sp.
Decker limestone, New Jersey
Thlipsuropsis digitata Swartz & Whitmore, n. sp.
Coeymans limestone, New Jersey
- Family Healdiidae Harlton
Genus *Parahealdia* Coryell & Cuskey
Parahealdia? convexoris Swartz & Whitmore, n. sp.
Manlius limestone, New Jersey

GENERAL ZONAL VALUES OF THE DECKER-MANLIUS OSTRACODA

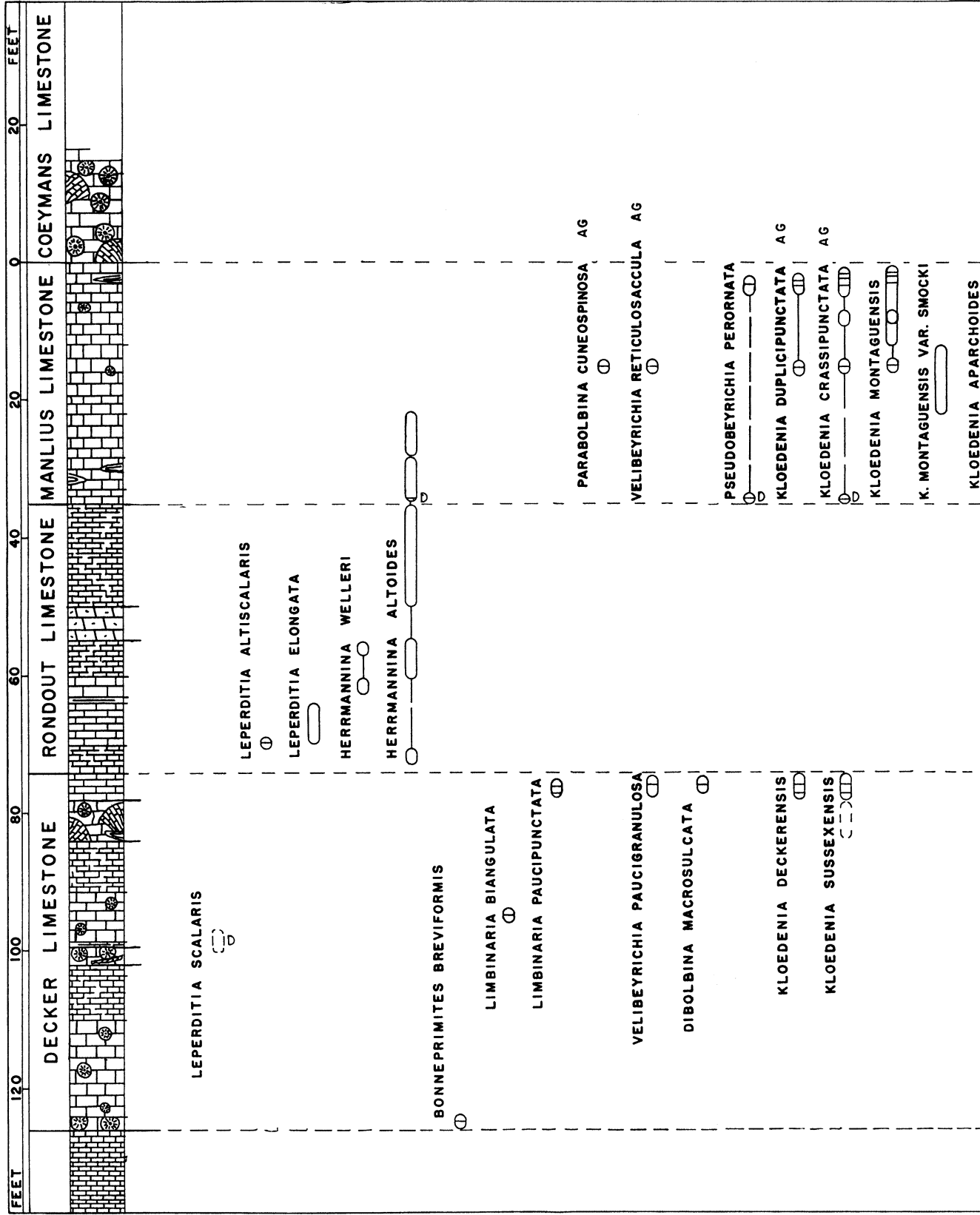
The Ostracoda here described from the Decker, Rondout and Manlius limestones are numerous and diversified, are well characterized by distinctive features of shape, ornament or dimorphism, and generally appear to be restricted in stratigraphic range. They have important zonal possibilities that are summarized in Table 1, which also serves to indicate relationships to zones




























based on other fossil groups. Their occurrences at the William Nearpass quarries are illustrated in further detail by the bar graphs of Text-fig. 1, and similar graphs are given for non-ostracodes in Text-fig. 2.

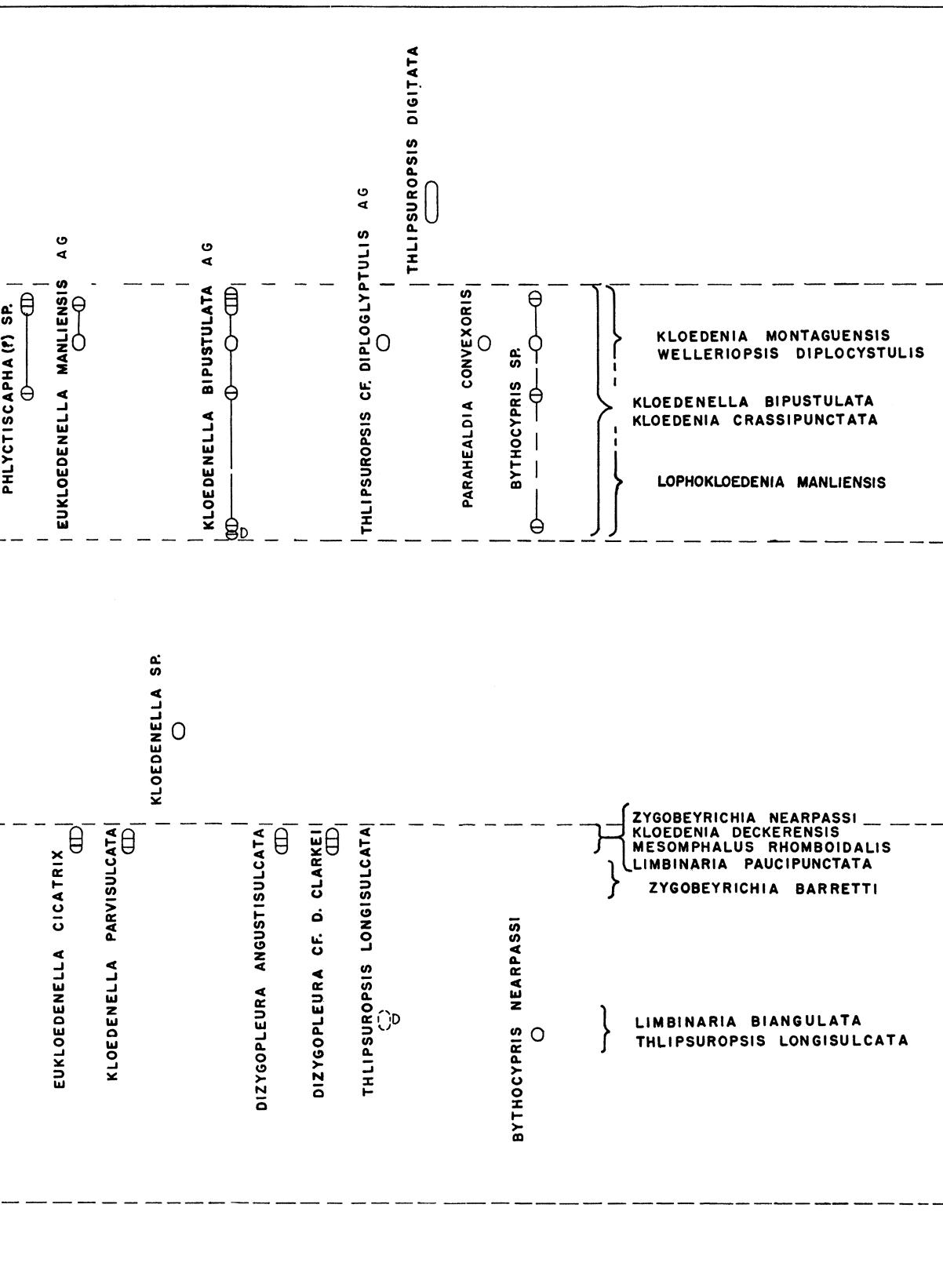
The ostracodes and non-ostracodes of each of the successive zones of Table 1 will be considered, in order to review their significance for correlation and to help lay a basis for inferences about their paleoecologic relationships.

TABLE 1. ZONAL OCCURRENCES OF OSTRACODE AND NON-OSTRACODE SPECIES AT THE WILLIAM NEARPASS QUARRIES, NEW JERSEY

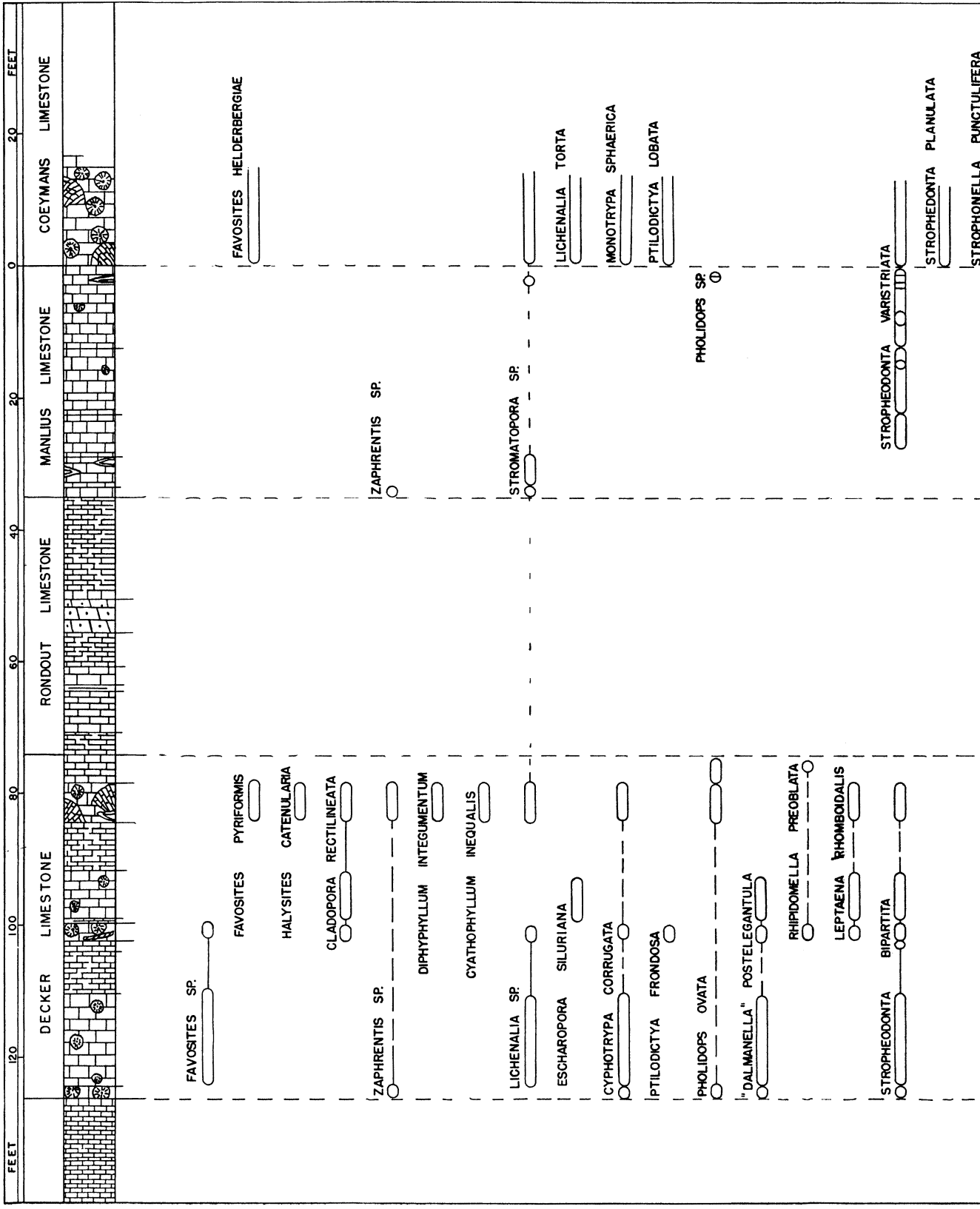
Manlius limestone	
<i>Kloedenella bipustulata</i> , <i>Kloedenia crassipunctata</i> zone	<i>Howellella vanuxemi</i> , <i>Tentaculites gyracanthus</i> zone
In upper half: <i>Kloedenia montaguensis</i> , <i>Welleriopsis diplocystulus</i> subzone, with <i>Kloedenia crassipunctata</i> more common than at lower levels.	In upper half: <i>Stropheodonta varistriata</i> , <i>Centronella? biplicata</i> .
In middle beds: <i>Parabolbina cuneospinosa</i> , <i>Velibeyrichia reticulosaccula</i> , <i>Parahealdia? convexoris</i> are represented by rare examples; more data are needed concerning their subzonal values.	
In lower beds: <i>Lophokloedenia manliensis</i> subzone, with <i>Myomphalus dorsinodosus</i> .	
Rondout limestone	
<i>Herrmannina welleri</i> and <i>Leperditia altiscalaris</i> .	Fossils other than Leperditiidae and some Kloedenellidae are very rare, except for <i>Hyatidina? lamellosa</i> in one thin bed.
Decker limestone	
<i>Stenocisma lamellata</i> zone	
In upper beds: <i>Limbinaria paucipunctata</i> , <i>Velibeyrichia paucigramulosa</i> , <i>Kloedenia deckerensis</i> , <i>Zygobeyrichia nearpassi</i> , <i>Welleriopsis jerseyensis</i> , <i>Eukloedenella cicatrix</i> subzone.	<i>Calymene camerata</i> occurs in upper and middle parts, and also in uppermost beds of <i>Chonetes jerseyensis</i> zone.
In middle beds: ostracodes rare, although Weller reported <i>Zygobeyrichia barretti</i> .	In middle beds: coralline subzone with occurrences of <i>Cyathophyllum inequalis</i> , <i>Diphyphyllum integumentum</i> , <i>Halysites</i> cf. <i>H. catenularia</i> . <i>Cladopora rectilineata</i> occurs here and in upper part of <i>Chonetes jerseyensis</i> zone. <i>Schuchertella interstriata</i> occurs in middle and lower parts of <i>Stenocisma lamellata</i> zone.
In lower beds, and perhaps in upper part of <i>Chonetes jerseyensis</i> zone: occurrences of <i>Limbinaria biangulata</i> , <i>Leperditia scalaris</i> .	
<i>Chonetes jerseyensis</i> zone	
Near base: <i>Bonneprimites? breviformis</i> . Identifiable ostracodes not observed in higher beds at William Nearpass quarries, though loose slabs from Dalton Nearpass farm that may have come from uppermost <i>Chonetes jerseyensis</i> beds, contain <i>Limbinaria biangulata</i> and <i>Thlipsuropsis longisulcata</i> .	In uppermost beds: <i>Ptilodictya frondosa</i> subzone with occurrence of <i>Gypidula circularis</i> .
	Throughout <i>Chonetes jerseyensis</i> zone: <i>Cyphotrypa corrugata</i> , <i>Stenocisma deckerensis</i> ; throughout zone and occurring in basal part of <i>Stenocisma lamellata</i> zone: <i>Stropheodonta bipartita</i> , <i>Schuchertella deckerensis</i> ; in lower half of zone: " <i>Spirifer</i> " cf. <i>modestus</i> .
FAUNAS OF THE <i>Chonetes jerseyensis</i> AND <i>Stenocisma lamellata</i> ZONES OF THE DECKER LIMESTONE	
The strikingly ornamented <i>Chonetes jerseyensis</i> , that Weller discovered in the lower 27 feet of the Decker limestone, disappears in higher Decker beds that contain <i>Stenocisma lamellata</i> of the Cobleskill limestone of New York. This and associated faunal changes led Weller to distinguish the <i>Chonetes jerseyensis</i> zone of the lower Decker from the <i>Stenocisma lamellata</i> zone of the upper part.	
Weller obtained a large fauna from the <i>Chonetes jerseyensis</i> beds at the Nearpass quarries. His identified species include one coral, two bryozoans, fourteen brachiopods, three pelecypods, three trilobites and one ostracode. Material listed only on a generic basis adds two more corals, one bryozoan, three gastropods and one cephalopod. New collections have not added appreciably to the known non-ostracode fauna of the zone.	
The <i>Chonetes jerseyensis</i> fauna has proven invaluable in correlation of Upper Silurian sediments in the middle Appalachians. <i>Chonetes jerseyensis</i> itself is distinctively ornamented by the peculiar anteriorward curvature of its lateral costellae and by angulation of the post-lateral costellae from the cardinal margin. It has been found with such Decker associates as <i>Cyphotrypa cor-</i>	



KLOEDENIA DECKERENSIS		KLOEDENIA DUPLICIPUNCTATA	AG	
KLOEDENIA SUSSEXENSIS		KLOEDENIA CRASSIPUNCTATA	AG	
		KLOEDENIA MONTAGUENSIS		
		K. MONTAGUENSIS VAR. SMOCKI		
		KLOEDENIA APARCHOIDES		
		LOPHOKLOEDENIA MANLIENSIS		
		LOPHOKLOEDENIA KUMMELI		
			KLOEDENIA SP.	
ZYGOBEYRICHIA BARRETTI		MYOMPHALUS DORSINODOSUS		
ZYGOBEYRICHIA NEARPASSI		W. JERSEYENSIS MICRORETICULIS		
WELLERIOPSIS JERSEYENSIS		WELLERIOPSIS DIPLOCYSTULIS		
MESOMPHALUS RHOMBODALIS		MESOMPHALUS SP.		
		MESOMPHALUS STRIATELLUS VAR.		
		BOLBIPRIMITIA LIMBATA		
		SACCARCHITES SACCULARIS	AG	
		PHLYCTISCAPHA (?) SP.		
EUKLOEDENELLA CICATRIX		EUKLOEDENELLA MANLIENSIS	AG	
KLOEDENELLA PARVISULCATA				
		KLOEDENELLA SP.		
		KLOEDENELLA BIPUSTULATA	AG	



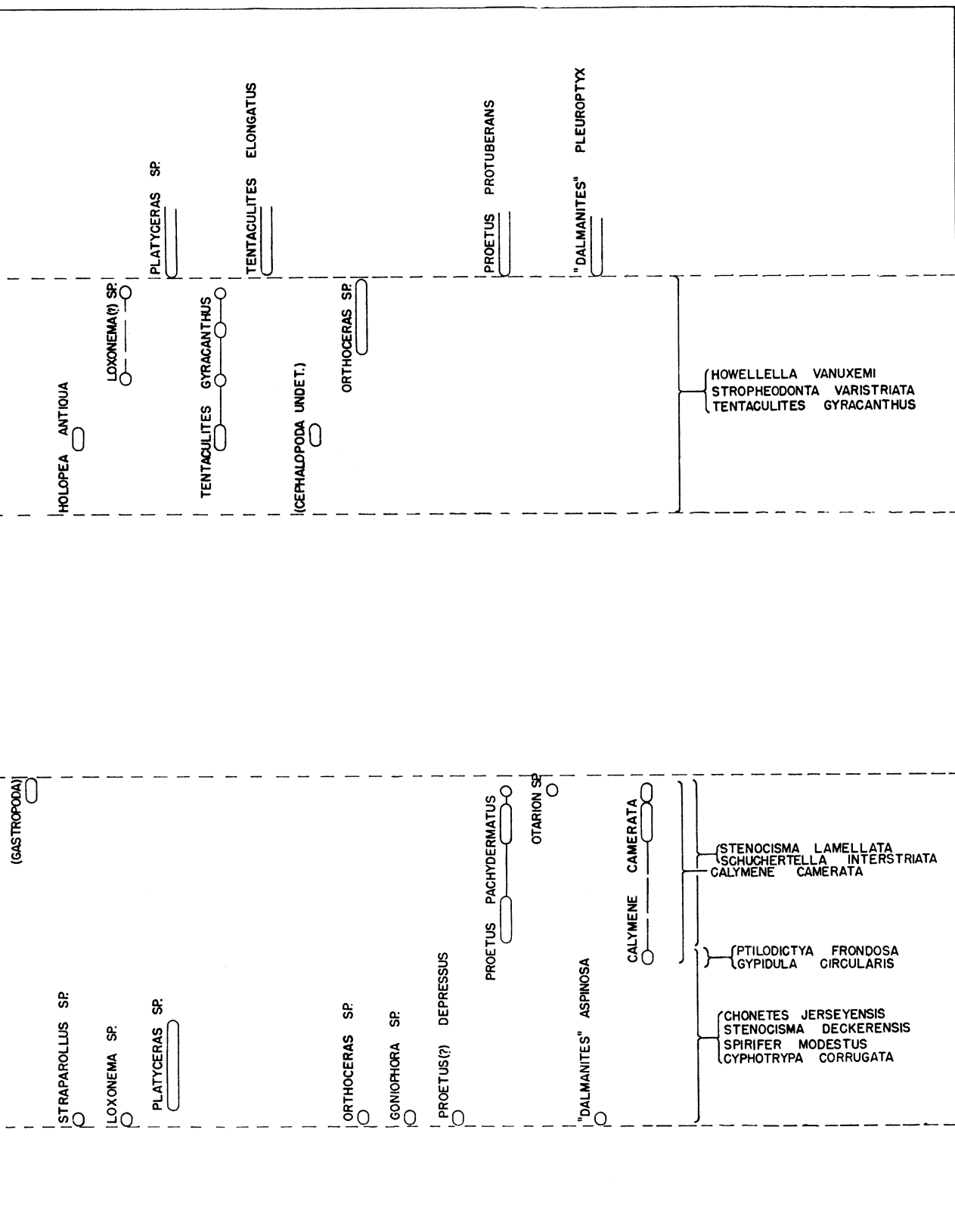
TEXT-FIG. 1.—Ranges of ostracode species in the William Nearpass quarries section, New Jersey. Occurrences are also included from the basal Manlius and middle Decker of the Dalton Nearpass farm section, and are denoted by the letter "D," placed to the right of the respective graphs at the proper horizons. The letters "AG" following names of several species of the Manlius limestone, indicate that these species also occur in the uppermost beds of the Manlius limestone at Austin's Glen, New York.



DALMANELLA POSTLEGANTULA
RHIDONELLA PREOBLATA
LEPTAENA RHOMBODALIS
STROPHEODONTA BIPARTITA
SCHUCHERTELLA DECKERENSIS
SCHUCHERTELLA INTERSTRIATA
CHONETES JERSEYENSIS
C. JERSEYENSIS VAR. NONDIVERGENS
WILSONIA GLOBOSA
CAMAROTOECHIA LITCHFIELDENSIS
STENOCISMA DECKERENSIS
STENOCISMA LAMELLATA
GYPIDULA CIRCULARIS
ATRYPA RETICULARIS
HOWELLELLA VANUXEMI VAR. MINOR
"SPIRIFER" CF. MODESTUS
CYRTINA MAGNAPLICATA

STROPHEODONTA VARIESTRIATA
STROPHEODONTA PLANULATA
STROPHONELLA PUNCTULIFERA
SCHUCHERTELLA SP.
"RHYNCHONELLA" SP.
UNCINULUS MUTABILIS
CAMAROTOECHIA (?) TRANSVERSA
CAMAROTOECHIA (?) SEMPPLICATA
GYPIDULA COEYMANENSIS
ATRYPA RETICULARIS
HOWELLELLA VANUXEMI
"SPIRIFER" CYCLOPTERUS





TEXT-FIG. 2—Ranges of coral, Bryozoa, brachiopod, mollusk and trilobite species in the William Nearpass quarries section, New Jersey.

rugata, *Schuchertella deckerensis* and *Stenocisma deckerensis* in lower Decker beds in eastern Pennsylvania as well as in the lower half of the Keyser limestone in central Pennsylvania, western Maryland, north-eastern West Virginia and northwestern and westcentral Virginia. "*Spirifer*" cf. "*S.*" *modestus* of the Decker beds is very close to if not identical with "*S.*" *modestus* that is persistent in lower Keyser beds.

Zoaria of the bryozoan, *Ptilodictya frondosa*, are conspicuous in a thin subzone at the top of the *Chonetes jerseyensis* beds at the Nearpass quarries. The species has not been reported elsewhere except at one nearby locality. *Gypidula circularis* of the *P. frondosa* beds is represented by a single, poor specimen so that its possible relationship to the abundant *G. prognostica* of the middle Keyser remains uncertain.

The fauna of the *Stenocisma lamellata* zone of the upper Decker is comparable in abundance and diversity to that of the underlying *Chonetes jerseyensis* zone. Corals and ostracodes are more numerous, though they reach their respective maxima in differing strata. The identified species include five corals, one stromatoporoid, two bryozoa, 11 brachiopods, two pelecypods, two trilobites and 14 ostracodes.

Species of the Cobleskill limestone of New York are more numerous in the *Stenocisma lamellata* zone of the Decker limestone than in the *Chonetes jerseyensis* beds. In addition to *Stropheodonta bipartita* and *Camarotoechia litchfieldensis* which range throughout the Decker formation, and *Cladopora rectilineata* and *Calymene camerata* which appear in the *Ptilodictya frondosa* beds but are more abundant in the *Stenocisma lamellata* zone, the Cobleskill species include *Stenocisma lamellata* itself together with *Cyathophyllum inequalis*, *Halysites* cf. *H. catenularia*, *Schuchertella interstriata* and *Whitfieldella nucleolata*.

Marked faunal changes occur within the 25-foot succession of the *Stenocisma lamellata* beds of the Nearpass quarries. In the lower 15 feet brachiopods are common, including *S. lamellata*, *Schuchertella interstriata* and *S. deckerensis*. The coral *Cladopora rectilineata* is not abundant. There are some bryozoans and pelecypods. Ostracodes are rare although *Limbinaria biangulata*

gives zonal promise because of its distinctive ornament. The next higher 6 feet of limestone constitute a coralline bed, and contain a profusion of heads and fragments of *Cladopora rectilineata*, *Favosites pyriformis*, *Halysites* cf. *H. catenularis*, *Diphyphyllum integumentum* and *Cyathophyllum inequalis*. The Cobleskill brachiopods, *Schuchertella interstriata*, *Stenocisma lamellata* and *Whitfieldella nucleolata* are common, as is the Cobleskill trilobite, *Calymene camerata*. Ostracodes are very rare; none were observed in the present study, although Weller reported *Kloedenia sussexensis* and *Zygobeyrichia barretti*. In the highest 4 feet of the zone, corals again are rare, but brachiopods are common and there is sudden introduction of a profusion of strikingly ornamented ostracodes, of which *Limbinaria paucipunctata*, *Velibeyrichia paucigranulosa*, *Mesomphalus rhomboidalis*, *Kloedenia deckerensis*, *K. sussexensis*, *Zygobeyrichia nearpassi*, *Welleriopsis jerseyensis* and *Eukloedenella cicatrix* all give promise as aids for future stratigraphic correlations.

The fossil faunas thus give strong evidence of close geologic age equivalence of the Decker limestone with the lower half of the Keyser limestone of central Pennsylvania, western Maryland and the Virginias, and the fauna of the Cobleskill limestone of New York is especially well represented within the *Stenocisma lamellata* zone. In future refinements of the present correlations, however, consideration will need to be given to seeming anomalies of occurrence of a number of the species that have been used for zonal purposes. For example, *Stenocisma lamellata* is common in the Keyser limestone in the lower part of the zone of *Chonetes jerseyensis*, rather than above the range of the latter species as in the Decker limestone. A variety occurs in Maryland in the Tonoloway limestone below the Keyser, but generally has fewer ribs than typical examples from the Cobleskill of New York. *Cladopora rectilineata* and *Cyathophyllum inequalis* locally are common in the *Chonetes jerseyensis* zone of the Keyser limestone, and *Calymene camerata* reaches its maximum abundance in the Keyser in the same zone.

The differences in comparative ranges of *Chonetes jerseyensis*, *Stenocisma lamellata*

and some of their associates in the Keyser as compared to the Decker limestone, limit, in secondary degree, the refinements in age correlation that can be inferred from them. The differences must fundamentally stem from local variations in history of the environments that affected the bottom-living organisms, and their values for paleoecologic interpretations are likely to more than outweigh the minor limitations for correlation.

Further work with ostracodes with their apparently short time spans, may contribute to future analyses of the age relations of the Decker, Keyser and Cobleskill limestones. The large suite of ostracodes of the uppermost Decker beds include numerous species that should be useful in correlation. Swartz is elsewhere describing several ostracode species from the Cobleskill of New York, none of which are represented in the Decker assemblages. The presently known ostracode species of the Decker are generally not known in the Keyser limestone, except that *Zygobeyrichia barretti* reported by Weller from the upper Decker is profuse in the Keyser in the lower part of the *Chonetes jerseyensis* zone, together with *Leperditia scalaris* which was obtained loose from presumed middle Decker beds at the Dalton Nearpass farm. The occurrences of *Zygobeyrichia barretti* suggest that *Chonetes jerseyensis* may range in the Keyser limestone into beds appreciably younger than those in which it occurs in the Decker limestone in New Jersey. Further ostracode discoveries in the Decker limestone as well as in the Keyser and Cobleskill limestones may aid solution of these details of the correlations that now are good though not final approximations.

FAUNA OF THE RONDOUT LIMESTONE AT THE NEARPASS QUARRIES, NEW JERSEY

The Rondout limestone, as defined by Weller at the Nearpass quarries, consists mostly of dark, dense, in part siliceous and in part argillaceous limestones, that in general lack faunas of the brachiopod, kloedenid-beyrichiid-ostracode type which are so strikingly developed in the underlying Decker and overlying Manlius sediments. Leperditidae are abundant in some beds, and Kloedenellidae are fairly common although identifiable material has not yet

been worked up. There are some pelecypods. Brachiopods are represented by *Hyattidina? lamellosa*, common in one thin limestone bed, and by a single specimen of the Decker-Cobleskill species, *Schuchertella interstriata*. *H.? lamellosa* is not yet known at other localities.

Among the Leperditidae, *Herrmannina welleri* is a large and comparatively quadrate form that may prove useful for correlation. *Leperditia altiscalaris* is a relatively high version of *L. scalaris* of the Decker, Akron and early Keyser beds. *L. elongata* is presently known from a single right valve, so that its specific characters are not adequately established. *L. alta* has been reported from Manlius as well as Rondout beds.

The disappearance of kloedenid-beyrichiid ostracodes at the top of the Decker limestone, and their reappearance at the base of the Manlius beds, clearly reflect environmental changes that accompanied sedimentation, and for many of the constituent species may not closely indicate biozonal limits of range. Nevertheless, the ostracodes of the upper Decker and basal Manlius differ so greatly in their specific membership, that they may still serve as the most useful available means of interpreting the regional relations of the boundaries of the Rondout with its adjoining formations.

FAUNA OF THE MANLIUS LIMESTONE AT THE NEARPASS QUARRIES, NEW JERSEY

The Manlius limestone at the William and Dalton Nearpass quarries in New Jersey, contains the brachiopods *Stropheodonta varistriata* and *Howellella vanuxemi*, and the pteropod or pteropod-like species, *Tentaculites gyracanthus*, all three of which are significant species of the type Manlius limestone of central New York. One additional brachiopod, *Centronella? biplicata*, is moderately common, and is of further interest because it is the earliest occurring terebratulid known in the Nearpass region. Other recognized non-ostracodes are rare, and do not offer much promise for detailed correlation studies. They include the brachiopods *Schuchertella* cf. *S. interstriata*, *Pholidops* sp., "*Rhynchonella*" sp.; the pelecypods *Megambonia aviculoidae* and *Actinopteria* sp.; the gastropods *Holopea antiqwa* and *Loxonema* sp.; and an unidentified orthoceratoid cephalopod. There are oc-

casional bryozoans, that presumably would repay investigation. Stromatoporoids occur in several beds in the lower and upper parts of the formation. Crinoid plates are present but in general are not abundant.

Ostracodes are more abundant and diversified in the Manlius of the Nearpass area than all other studied fossils combined. There are 22 named species, two provisionally distinguished varieties, and two species identified on a generic basis only. Many of the species are well ornamented and distinctive, and are promising for zonal work.

The Manlius limestone as a whole at the Nearpass quarries, can be considered the zone of *Kloedenella bipustulata* and *Kloedenia crassipunctata*, on the basis of two ostracode species that range about from its base to its top, and that are common and readily identifiable. *Kloedenella bipustulata* has two small nodes at the summit of its posterior slope. *Kloedenia crassipunctata* is marked by sharply impressed, coarse pits. Other species that range more or less throughout the Manlius include the marginally frilled *Bobbiprimitia limbata*, and the strikingly sculptured *Pseudobeyrichia perornata* which has been found near the top of the Manlius at the William Nearpass quarries and near the base at the Dalton Nearpass farm, and that would deserve greater emphasis were it not so rare.

On the basis of species that apparently have shorter stratigraphic ranges, an upper and a lower ostracode subzone can be recognized within the *Kloedenella bipustulata*-*Kloedenia crassipunctata* zone of the Manlius limestone. With further work it may be possible to distinguish a third, intermediate subzone.

The lower ostracode subzone of the Manlius beds is characterized especially by *Lophokloedenia manliensis*, which is subquadrate in form, has a finely pitted surface, and bears the generically distinctive node in the dorsal part of the median sulcus. *Welleriopsis jerseyensis* var. *microreticulis* of this subzone is somewhat questionably separated from *W. jerseyensis* of the highest Decker, but is readily distinguishable from *W. diplocystulis* of middle and upper parts of the Manlius limestone. Two additional species that appear to be distinctive of the lower Manlius subzone are *Kloedenia apar-*

choides and especially *Myomphalus dorsinodosus*, which have been obtained in association with *Lophokloedenia manliensis* in basal Manlius beds at the Dalton Nearpass farm and at a section on Trilobite Mountain, New York.

In the upper half of the Manlius at the Nearpass quarries, *Kloedenia montaguensis* with its inflated ventral slope, and *Welleriopsis diplocystulis* with its granulose surface and elongate dimorphic pouch, are especially distinctive. *Kloedenia duplicipunctata* is an additional significant species, related to *K. crassipunctata* which is more common here than at lower levels. *Eukloedenella manliensis* of this subzone has a simplicity of lobation that may limit its value as a zonal species.

Several species obtained with the lower occurrences of *Kloedenia montaguensis* and *Welleriopsis diplocystulis*, have not been found in the abundantly fossiliferous material collected from the upper 5 feet of the subzone, so that their ranges need further study. At 7 to 9 feet below the top of the Manlius, *Parahealdia? convexoris* is present though uncommon, and one poor specimen was found that questionably represents *Thlipsuropsis diploglyptulis*. At 15 feet below the top, there are rare valves of *Parabolina cuneospinosa* and *Velibeyrichia reticulosaccula*. The two latter species are common to abundant, together with *Thlipsuropsis diploglyptulis*, in the highest Manlius at Austin's Glen, New York, where neither *Kloedenia montaguensis* or *Welleriopsis diplocystulis* were observed in the present study.

FAUNA NEAR TOP OF MANLIUS LIMESTONE AT AUSTIN'S GLEN, NEW YORK

The slabs collected near the top of the Manlius limestone at Austin's Glen, New York, contain the Manlius brachiopods *Stropheodonta varistriata*, *Howellella vanuxemi*, and *Centronella? cf. C. biplicata*. Among the many ostracodes, *Kloedenella bipustulata* and *Kloedenia crassipunctata* are abundant, giving evidence of the same major ostracode zone that is represented by the Manlius limestone of the Nearpass quarries.

The associated ostracodes include *Kloedenia duplicipunctata* and *Eukloedenella manliensis* that occur at the Nearpass quar-

ries in the upper 15 feet of the Manlius limestone, and *Parabolbina cuneospinosa* and *Velibeyrichia reticulosaccula* that are rare 15 feet below the top of the formation. These ostracodes, as well as the relative abundance of *Kloedenia crassipunctata*, all suggest relationship with middle to upper parts of the Manlius of the Nearpass area. Correlation is however complicated by absence in the Austin's Glen collections of the abundant *Kloedenia montaguensis* and *Welleriopsis diplocystulis* that appear to be especially characteristic of the upper Manlius subzone at the Nearpass quarries; and conversely the greater or less abundance at Austin's Glen of *Aechmina eupunctella*, *Richina zygalis*, *Lophokloedenia eufimbriata*, *Mesomphalus striatella* and *Bolbiprimitia teresacculus* which are as yet wanting in the Nearpass collections. Further collecting will be needed to determine whether the ostracodes from Austin's Glen belong, as is suggested by the *Parabolbina* and *Velibeyrichia*, to a middle Manlius subzone not adequately represented in the studied Nearpass collections, or whether they less possibly are indicative of a horizon younger than the highest Manlius beds of the Nearpass section.

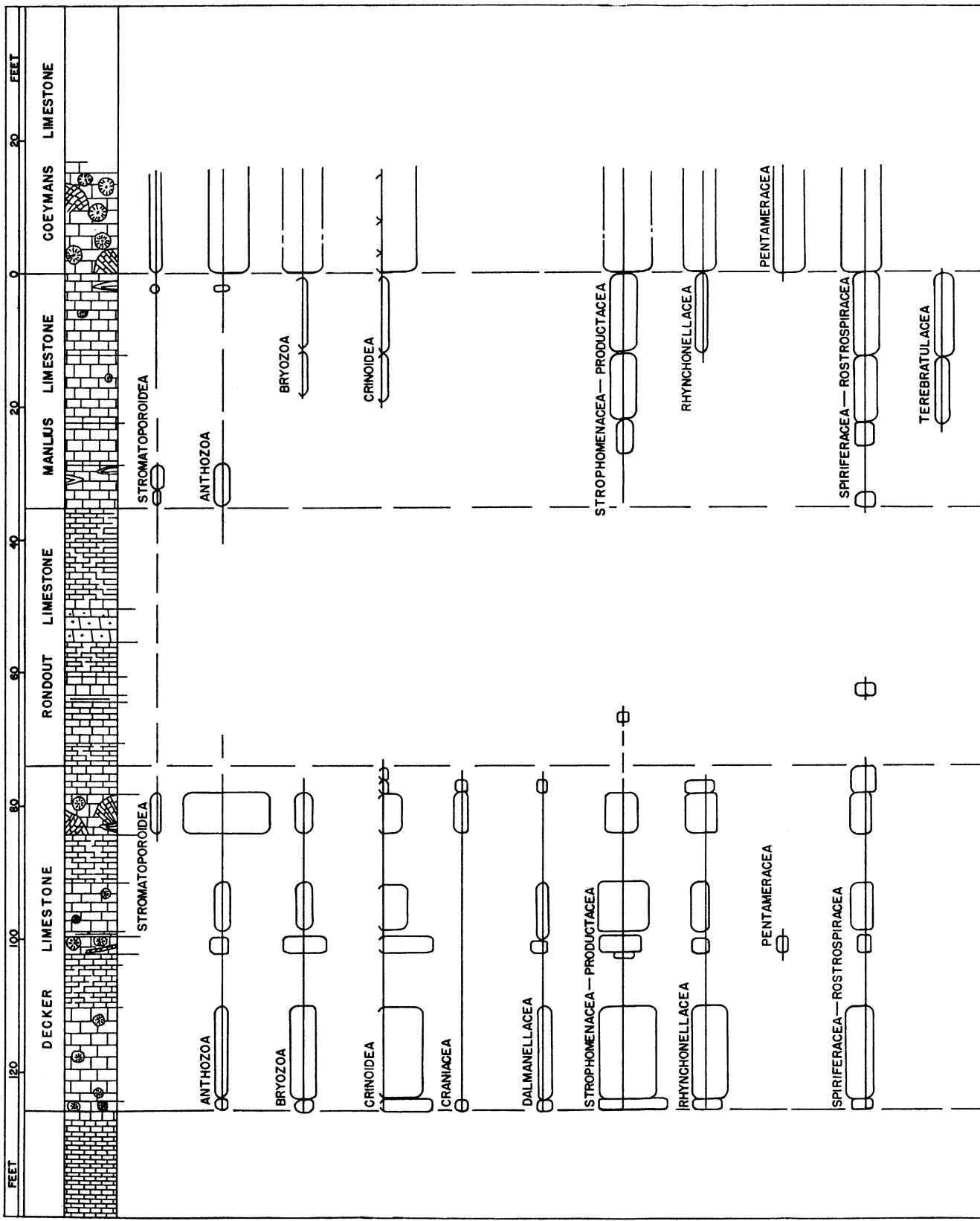
ANIMAL COMMUNITIES AND THEIR PALEOECOLOGIC IMPLICATIONS

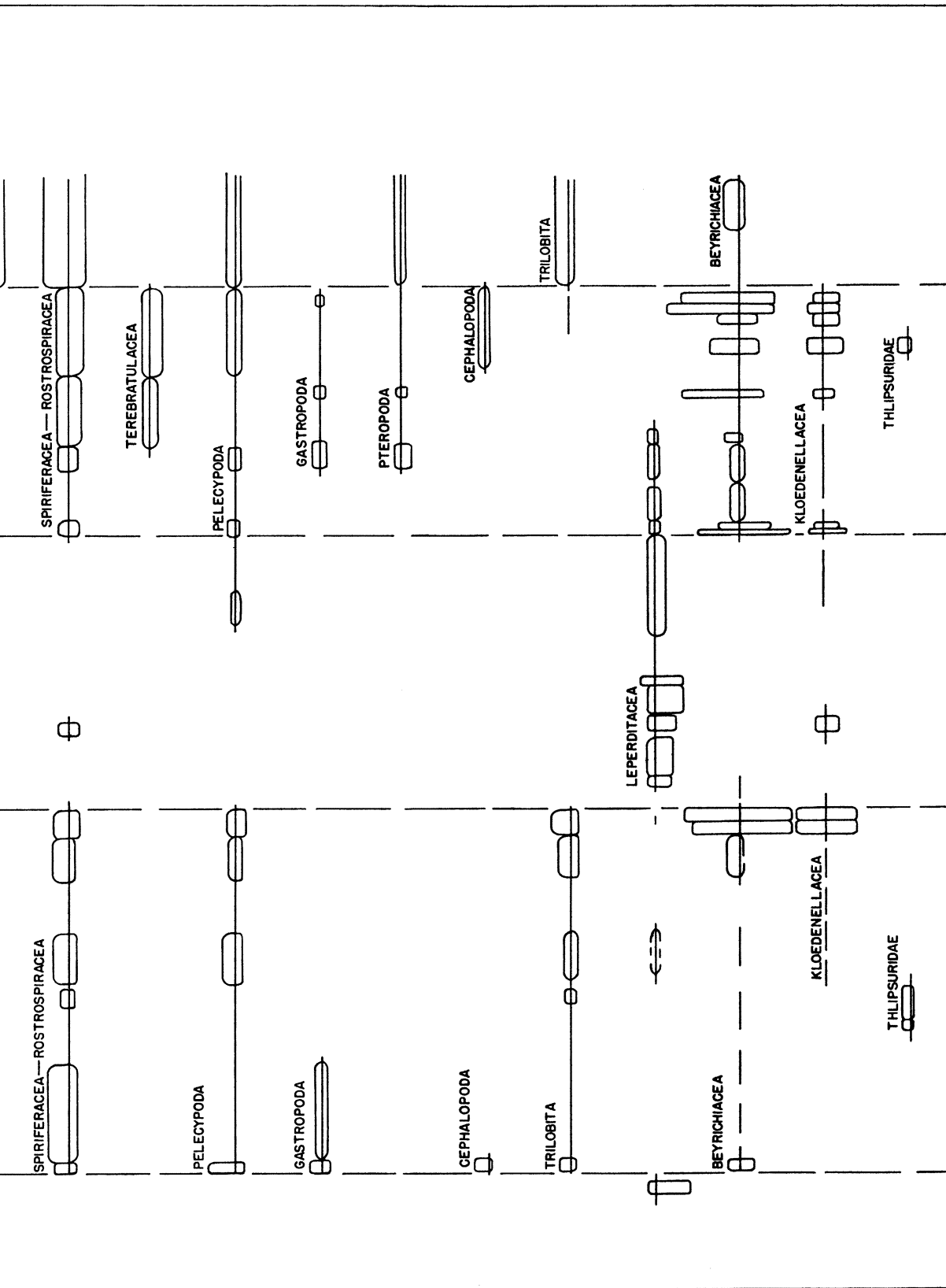
The fossils of the Decker, Rondout and Manlius limestones give evidence that during accumulation of these sediments the animal communities of the ancient sea floor in what is now the Nearpass quarries region underwent marked changes in their general nature as well as in their species membership. (See Text-fig. 3.) Observed fossils afford favorable and perhaps reasonably comprehensive records of the more common corals, brachiopods, mollusks, trilobites and ostracodes of the successive assemblages, and some knowledge of the stromatoporoids and crinoids, even though they no more than suggest the possible flourishing of associated algae, protozoans, non-shelled coelenterates, worm-like organisms, and the more fragiley carapaced crustaceans. The changes in the fossil faunas thus are significant not only for stratigraphic zonation as previously discussed, but also because of their values for paleoecologic interpretations.

In the Decker limestone, much more than in the Rondout and Manlius, the shelly fossil faunas are both abundant and diversified. Brachiopods are numerous and include representatives of at least six of the orders of the phylum. With the associated corals, bryozoans and crinoids, they give evidence of bottom waters that were marine, well oxygenated, abounding in food, and probably warm and fairly shallow. Trilobites and ostracodes, with some pelecypods and gastropods and one cephalopod, add to the variety of the faunal assemblage.

In striking contrast to the faunas of the Decker beds, the fossils of the overlying Rondout limestone generally include few forms other than Leperditidae, which are rare or absent in most parts of the Decker limestone, together with some Kloedenellidae. The marked faunal impoverishment may well have been occasioned by lowered salinity of the Rondout waters. As one working hypothesis, it might be imagined that the surface of Rondout sedimentation approximated sea level over extensive areas so that impaired currents of discontinuous, shallow sheets of water were unable to maintain the salinities required for abundant shelly bottom life. Limy mud flats, subject to mud-cracking such as occurs in some Rondout layers, may have been widely though discontinuously emergent.

In the Manlius limestone, above the Rondout formation, shelly fossil faunas again increase in abundance, though they do not regain the diversity found in the Decker assemblages. Stromatoporoids occur at several levels and some bryozoans are found in middle to upper beds. Crinoid plates are present, but do not form the crinoidal bands represented by several of the Decker strata. Brachiopods individually are common or even profuse in some layers, but rarely include more than two or three species. Mollusks are represented by some high-spired gastropods, and by the presumed pteropod, *Tentaculites gyracanthus*, which is moderately common at a number of horizons. Trilobites, fairly common in the Decker, have not been found in the Manlius. Leperditidae including several Rondout species, occur in the lower third of the Manlius, although they disappear in higher beds. The non-leperditiid ostracodes form much the





Text-Fig. 3.—General characters of the fossil faunas of the Decker, Rondout and Manlius limestones of the William and Dalton Nearpass quarries, New Jersey. The left half of each bar graph is indicative of the number of recognized species, including forms listed on a generic basis only; the right half of each bar graph suggests in a very qualitative way the general abundance of individuals, on the basis of observations incidental to preparatory work on the studied collections, but estimates of abundance could be greatly improved by field observations made more particularly for this purpose.

most abundant and diversified element of the studied *Manlius* faunas, and are distinctly more numerous than in all but the uppermost beds of the Decker limestone.

The local conditions for marine bottom life evidently were much improved during *Manlius* sedimentation as compared to the interval of Rondout deposition, but in some such factor or factors as water salinity, oxygenation, temperature or depth, had not re-attained a balance wholly favorable to most of the groups of marine bottom dwellers that had flourished in the Decker seas, and that were to return in profusion in Coeymans time. Gentle to moderate rather than strong movement of the bottom waters is suggested by the well preserved ostracodes that occur at many levels in the *Manlius*. Concentrations of the fragile carapaces suggest local shifting on the floor of sedimentation, but the valves in general show little abrasion and were buried in the accumulating sediment rather than destroyed or swept to other areas.

Superimposed on the major changes in general nature of the animal communities by which the diversified shelly faunas of the Decker gave place to the impoverished groups of the Rondout and these in turn to the again-enlarged assemblages of the *Manlius*, were second order changes that are reflected within each of the three formations. For example, in the Decker beds, the limestones 4 to 10 feet below the upper boundary contain numerous small coralline heads and fragments in which six coral species have been distinguished. Bryozoans and brachiopods are fairly common, and mollusks and trilobites are represented. Crinoid fragments occur though they are not profuse. Ostracodes, however, are very rare; a few specimens were reported by Weller but none have been observed in material collected for the present study. In contrast, the next overlying, highest 4 feet of the Decker limestone abound in ostracodes, but corals are rare although brachiopods are common. The fossils of both of these limestone bodies represent marine bottom dwellers, but the changes in assemblage suggest appreciable ecologic modifications. It is possible that the shift in faunal character marks a significant stage in the transition from the more favorable Decker environments to the

conditions that caused impoverishment of the Rondout assemblages. On the other hand, it is by no means unlikely that communities differing in such fashion coexisted within relatively short distances on the Decker sea floor, in more exposed areas of active coral growth as compared to locally protected niches more favorable for both ostracode life and preservation.

In the middle and lower parts of the Decker limestone, brachiopods are common at many levels and generally are associated with bryozoans, trilobites and a few mollusks. Corals occur but are not numerous. Some of the beds abound in crinoid fragments. Ostracodes are not well represented. The brachiopod-bearing and crinoid-rich layers must again reflect sedimentation in shallow, well-oxygenated marine waters of near-oceanic salinities, though the depths may have been slightly greater than those in which corals flourished to form the coralline bed of the upper part of the Decker formation. Bottom currents and wave agitation probably were fairly vigorous in and near the banks of crinoid fragments, and transport may have modified local though probably not the over-all abundances of the shelly remains as compared to the living communities that they represent.

In the shaly Decker interbeds in which fossils have not been recognized (see Text-fig. 3), further study will be required to determine whether shells are as sparse as seems apparent, and if so to obtain clues as to whether their rarity reflects temporary or local paucity of shelled life, or local destruction or removal of shell material.

In the Rondout limestone, most beds appear to lack fossils other than *Leperditidae* and some *Kloedenellidae*, and even these groups apparently are wanting in other layers. Abundance of the *Leperditidae* in strata lacking brachiopods, crinoids and bryozoa such as those that abound in the Decker limestone, gives support to the view that the *leperditids* flourished chiefly in environments not favorable for the majority of the diversified bottom organisms of the shallow, well-oxygenated, normally saline areas of the Middle Paleozoic seas, and perhaps that they more largely inhabited waters of appreciably lowered or heightened salinities.

In the Rondout collections, brachiopods are common only in material from one thin limestone layer about 13 feet above the base of the formation. The observed specimens from this layer represent the single species, *Hyattidina? lamellosa* (Weller). The enclosing limestone is comparatively pure. Associated fossils include *Herrmannina welleri* together with a species of *Kloedenella*. In many of the *Kloedenella* specimens the valves are joined together, and the shell interior is filled with sparry calcite. Many of the *Hyattidina* shells also have the valves conjoined. Evidently the bottom waters were locally quiet during deposition of this stratum, and there was little shifting of even the thin, 1-mm. long kloedenellid shells after death of the enclosed animals. In some of the other Rondout layers, however, there are both kloedenellid and larger leperditid valves that are separated and generally aligned along the bedding, giving evidence of gentle to moderate movement of the bottom waters. There is thus evidence of enough water activity to suggest that the oxygen content was not sufficiently lowered to account for the very marked impoverishment of the Rondout shelly faunas, and it is more likely that the cause lies in lowered salinity.

Other than the *Hyattidina* occurrences, brachiopods have been found in the Rondout at the Nearpass quarries only at 6 feet above the base of the formation, where a single valve of *Schuchertella interstriata* was discovered. A few pelecypod valves occur in several loose slabs coming apparently from the upper 15 feet of the formation. No stromatoporoids, corals, crinoid plates, bryozoans, trilobites or beyrichiid-kloedenid ostracodes have as yet been recognized.

In the Manlius, as in the Decker and Rondout sediments, the general nature of the faunas undergoes appreciable change at successive stratigraphic levels. The beyrichiid-kloedenid and kloedenellid ostracodes are less affected than other fossil groups; their representatives are common to abundant in individual layers in lower, middle and upper parts of the formation, though they vary in number from bed to bed, perhaps in part due to drifting of their easily moved valves into local depressions on the sea floor. Leperditids on the other hand, continue from the Rondout into the lower part of the Manlius

but are rare or absent in the middle and higher parts. The concomitant increase in numbers of *Howellella vanuxemi*, *Strophodonta varistriata* and *Centronella? biplicata* gives evidence of a trend toward more normal salinity in the gradually changing Manlius waters, as does the coming in of *Tentaculites gyrancanthus*.

Striking changes thus take place in the fossil faunas of successive parts of the Decker-Rondout-Manlius limestones. Further collecting is likely to show somewhat greater continuity of occurrence through some of the beds in which no fossils were observed in the present study, but is not likely to modify significantly the basic patterns that are evidenced in the accompanying graphs. Separation of shell pieces and alignment along bedding give evidence of local drifting of material on the sea floor, and in the coralline bed of the upper Decker many shells are worn and fragmented. In general, however, even the easily moved ostracode valves are well preserved and have nearly complete margins, and so suggest that their transport was local and does not greatly affect the faunal record. The faunal changes reveal both evolution of related species that will be invaluable in regional correlation, and changes in over-all faunal nature that reflect modifications in the water environments that affected growth of the shelly bottom life, perhaps at times in a local fashion and at other times on a regional basis. Both types of change are invaluable for interpretation of the history of the organisms and of the environments and paleogeography of sedimentation.

ADDUCTOR SCARS

Rounded marks, that evidently are external reflections of adductor scars, are visible in accompanying illustrations of valves of *Myomphalus dorsinodosus*, *Saccarchites saccularis*, *Kloedenia aparchoides*, *Bonneprimites breviformis* and *Thlipsuropsis diploglyptulis*. Additional specimens with possible muscle marks are figured for *Richina zygalis*, *Velibeyrichia reticulosaccula*, *Pseudobeyrichia perornata*, *Lophokloedenia eufimbriata*, *Kloedenia montaguensis* and *K. sussexensis*. In the *Myomphalus*, the striking appearance of the mark in one of the studied specimens is given recognition by the proposed generic name.

The presumed adductor marks of the specimens of Beyrichiidae and Kloedeninae occur persistently in the lower part of the median sulcus, except that in *Saccarchites saccularis* the sulcus is no more than a faint depression above the mark. The mark also lies directly below a short median sulcus in *Bonneprimites breviformis*, which provisionally is listed with the Leperditellidae.

The location of the marks accords with Bonnema's (1934) view that the median sulcus of the primitiid-beyrichiid-kloedeninid ostracodes is associated with the position of adductor attachment.

In *Thlipsuropsis diploglyptulis* of the Thlipsuridae the adductor mark is submedian in location. It does not occur in a depression.

Muscle marks were not studied in the two specimens of *Leperditia* described in the present paper. Details have been given elsewhere (Swartz, 1949) of adductor and other scars of specimens of *Leperditia scalaris*, *L. altiscalaris* and *Herrmannina welleri*, obtained from Decker and Rondout beds of the Neapass quarries area.

The ostracode specimens studied for the present report occur in well lithified limestones so that it is difficult to determine details of the muscle scars. Except in the previously described Leperditidae, subordinate features have not been observed in the adductor scars, and no accessory scars have been observed in the region of the anterior sulcus, such as were reported in several European species by Hessland (1949).

ORIENTATIONS USED FOR DESCRIPTION

In accompanying descriptions, the straight-backed primitiid-beyrichiid-kloedeninid-hollinid as well as the kloedenellid ostracodes are oriented so that the median lobe and anterior sulcus, where present, are anterior to the median sulcus, and so that the less prominent cardinal angle as well as the full or plenate end of the shell normally are anterior in location. The convex-backed Thlipsuridae are oriented so that supposed adductor locations are anterior to midlength, and in one species so that subterminal spines have a posteriorward tilt.

The orientation used for the straight-backed forms accords with that advocated for many years by Bonnema (1909, 1934). It was employed by Swartz (1933) in the

Kloedenellidae so that dimorphic swellings discovered in numerous Silurian species of the family would be posterior in location, and subsequently was extended with much uncertainty to other groups (Swartz, 1936), even though the dimorphic structures of several families are in consequence placed near the anterior end of the shell. Evidence favoring general use of this orientation for the straight-backed families has been further strengthened by Triebel (1941), who called attention to the possibility that the second sulcus of bisulcate species may reflect location of muscle attachments that should be anterior to midlength, and the likelihood that large spines of the valve surface should have a posteriorward rather than anteriorward tilt in order to reduce snagging against obstructions.

There is much plausibility to Triebel's (1941) view that large spines of the valve wall should have a posteriorward tilt, on the basis of comparisons with the posteriorward tilt of large spines in living species and their closer fossil relatives as well as from the general supposition that trouble with snagging would be lessened. Triebel's suggestion that the second sulcus where present may reflect the locus of interior attachment of muscles such as those of the mandibles and antennae, also deserves careful consideration and investigation. Scars of secondary muscles plausibly including those of mandibles, antennae and other appendages and even of the abdomen, are extensively developed anterior to midlength in the Leperditidae (Swartz, 1949). Hessland (1949) has illustrated one internal mold of each of five species of primitiid-beyrichiid-tetradellid ostracodes, in which there are spots at the position of the second sulcus and elsewhere in the area of the margin of the median lobe, that may reflect scars of such secondary muscles. Additional search is needed for other occurrences of such secondary muscle marks, and more highly magnified figures of the marks in Hessland's specimens would aid judgment about their significance.

In the straight-backed species described in the present paper, numerous valves give evidence of the association of the median sulcus with the place of adductor attachment, in the fashion recognized many years ago by Bonnema. The location of the median sulcus with respect to midlength does

not however afford a very satisfactory basis for either comparative or absolute orientation of the specimens: at least, it varies markedly in position with respect to midlength on the basis of orientations here employed using interrelationships of the median sulcus, median lobe, second sulcus, and less prominent cardinal angle.

The observed variation in location of median sulcus with respect to midlength appears to have considerable relation to the complexity of sulcation. In Kloedenellidae, the median sulcus is distinctly anterior to midlength as here understood in the unisulcate *Eukloedenella cicatrix*, less markedly so in the unisulcate *E. manliensis*; in the bisulcate *Kloedenella bipustulata* and *K. parvisulcata* it varies from slightly anteromedian to slightly postmedian. The median sulcus or median pit also tends to occur appreciably anterior to midlength in unisulcate members of other families, such as *Richina zygalis* of the Drepanellidae, *Aechmina eupunctella* of the Aechminidae, *Limbinaria paucipunctata* of the Primitiopsidae, *Parabolbina cuneospinosa* of the Hollinidae and *Saccarchites saccularis* and *Bolbiprimitia limbata* of the Kloedeninae. It is submedian in location in *Mesomphalus rhomboidalis* of the Kloedeninae, which is unisulcate but has an appreciably developed median lobe and a faint suggestion of a second sulcus.

Virtually all of the remaining straight-backed, non-leperditiid ostracodes described in this paper are bisulcate, and in general the median sulcus is appreciably posterior and not anterior to midlength according to the orientations here employed.

Hypotheses concerning control of the adductor position include diverse possibilities, such as the suppositions that an anterior adductor location would aid control of the valves when opened as the animal moved forward against stresses of the water medium, or that the location is controlled morphologically rather than dynamically by relative size of the cephalic as compared to thoracic and abdominal parts of the ostracode animal. According to the first supposition, the principal part of the adductor might be shifted posteriorward, provided secondary adductor strands are developed at a more anteriorward location or if antennal or mandibular muscles might in some

way serve as subordinate adductors: this supposition would also provide an explanation of the second sulcus of the bisulcate forms. The parallelism in the posteriorward shift in locus of the median sulcus and presumably of the adductor in members of divergent families tends to suggest that the cause more probably was dynamic than strictly morphologic.

SYSTEMATIC PALEONTOLOGY
Family LEPERDITHIDAE Jones
Subfamily LEPERDITIINAE Swartz
Genus LEPERDITIA Rouault
LEPERDITIA ELONGATA Weller
Pl. 103, fig. 1

Leperditia elongata WELLER, 1903, Geol. Survey, New Jersey, Paleont., vol. 3, p. 259, pl. 23, fig. 13.

Leperditia elongata ULRICH & BASSLER, 1923, Maryland Geol. Survey, Silurian, p. 747, pl. 36, fig. 1,2.

Shell dorsally truncate, elongate subovate, the height about six-tenths of length. Hinge margin straight for about seven-tenths of greatest length; cardinal angles distinct, subequally obtuse. Posterior margin higher and more broadly and regularly rounded than anterior margin; ventral margin convex, fuller posteriorly than anteriorly. Hinge detail not observed.

Surface of valve moderately convex; greatest convexity anterior to midlength. Narrow borders parallel the terminal margins. Eye tubercle distinct, located about one-sixth distance below dorsal margin, one-third from anterior margin. Details of muscle scars not studied. Surface seemingly without fine ornament.

Length 12 mm., height 7 mm.

Relationships.—*Leperditia elongata* is characterized, as its name suggests, by its relatively elongate form.

Only the holotype right valve of *L. elongata* has been definitely identified for the species. Information is needed about the form of the left valve, and especially about presence or absence of a leperditiid dorsal swelling. *L. elongata* may in fact prove to be a right valve of *Leperditia scalaris* Jones, since its form and general characters agree closely with those of right valves of *L. scalaris* figured by Swartz (1949) from loose material obtained from the Decker? limestone on the Dalton Nearpass farm, New

Jersey. Pending further information, however, the valve is here refigured using Weller's name for it.

Occurrence.—William Nearpass quarries, New Jersey, 4 to 10 feet above base of Rondout limestone.

Genus HERRMANNINA Kegel
HERRMANNINA ALTOIDES (Weller)
Pl. 103, fig. 2,3

Leperditia altoides WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 252, pl. 23, fig. 1,2.

Shell dorsally truncate, bluntly subovoid in outline, the height more than two-thirds of length in a left valve. Hinge relatively short, about six-tenths of length. Cardinal angles distinct but obtuse. Posterior margin broadly rounded; anterior margin more narrowly curved; ventral margin strongly convex, fullest behind midlength. Details of hinge and overlap not observed.

Surface moderately convex, greatest convexity anterior to midlength. A narrow border parallels posterior margin. Eye tubercle low, situated about one-fourth distance from dorsal margin, one-third distance from anterior margin.

Details of muscle scars not studied.

The figured syntype left valve measures length 7 mm., height 5 mm. The figured right valve measures length 6 mm., height 3.5 mm.

Relationships.—*Herrmannina altoides* lacks the post-dorsal swelling of the left valve that characterizes members of *Leperditia* proper.

H. altoides was distinguished by Weller (1903) from *Leperditia alta* (Conrad) Jones, 1856, because of the narrow border margining the posterior edge.

Occurrence.—Lower part of Decker limestone, Flatbrookville, New Jersey.

Family LEPERDITELLIDAE Ulrich & Bassler
Subfamily CONCHOPRIMITIINAE
Henningsmoen

Genus BONNEPRIMITES Swartz & Whitmore, n.gen.

Shell elongate subovoid, truncated dorsally by straight hinge that is somewhat shorter than greatest length of shell; free edges without strong overlap; hinge in genotype bears faint longitudinal grooves and ridges that may have supported ligament

and that did not necessarily interlock; surface of valve convex, not umbonate, bearing a single subvertical, dorso-submedian sulcus, lacking ridges, knobs, submarginal rim or frill, or grooves representative of margins of early-stage valve molts; dimorphism apparently wanting.

Genotype.—*Primitia bonnemai* Swartz, 1936, from Silurian beds, Island of Gotland.

Relationships.—Rediscovery by Warthin (1948) of the designation by S. A. Miller in 1889 of *Beyrichia strangulata* McCoy as the genotype of *Primitia* Jones & Holl, has required reorganization of both *Primitia* and the family Primitiidae (e.g., Henningsmoen, 1953.) *Primitia* as based on *P. strangulata* includes species that are unisulcate to weakly lobate, and that have an anteroventral frill that is converted into a pouch in the female dimorph. The non-frilled and apparently non-dimorphic "*Primitia*" *bonnemai*, and similarly "*Beyrichia*" *mundula* Jones which for many years was considered the genotype of *Primitia*, accordingly must be removed from *Primitia*. *Bonneprimites* is here proposed at least to include "*P.*" *bonnemai*.

The family relationships of *Bonneprimites* are obscure. Tentatively, the genus is listed under the subfamily Conchoprimitiinae Henningsmoen, since it agrees in general form, unisulcation and lack of submarginal rim or frill with *Conchoprimites* Hessland of this subfamily. As compared to the latter genus, it lacks grooves paralleling the free margins that presumably represent edge impressions of early-stage valve molts, and is not known to have the strong "blood-canals" that occur at least in *Conchoprimitia socialis vulgaris* Henningsmoen (1954a).

Further information is especially needed concerning the statement by Öpik (1953) that in his studies of numerous Silurian ostracodes from the drift of Germany, and the Silurian of the Island of Gotland, "every *Primitia* of the *mundula* group 'without any border' proved to be a male, and could be matched to corresponding forms having a posterior, open, brood-chamber-like structure. Generally speaking, *Primitia* in this sense behaves like the genus *Primitiopsis* Jones." (Öpik, 1953, p. 30.) Since the type specimens of *Bonneprimites bonnemai* came

from the Silurian of the Island of Gotland and are so suggestive of "*Primitia*" *mundula* that they had tentatively been identified under this name in the collections of J. H. Bonnema who kindly sent them to Swartz for study, reinvestigation should be undertaken to search for possible primitiopsis dimorphism. However, in view of Bonnema's extensive work with dimorphic Primitiopsidae, and the excellent preservation and apparent abundance of *Bonneprimites bonnemai* in Bonnema's collections, it will be surprising if specimens showing primitiopsis dimorphism will be found in this species.

With future discoveries of additional, interlinking species, consideration will also need to be given to possible relations of

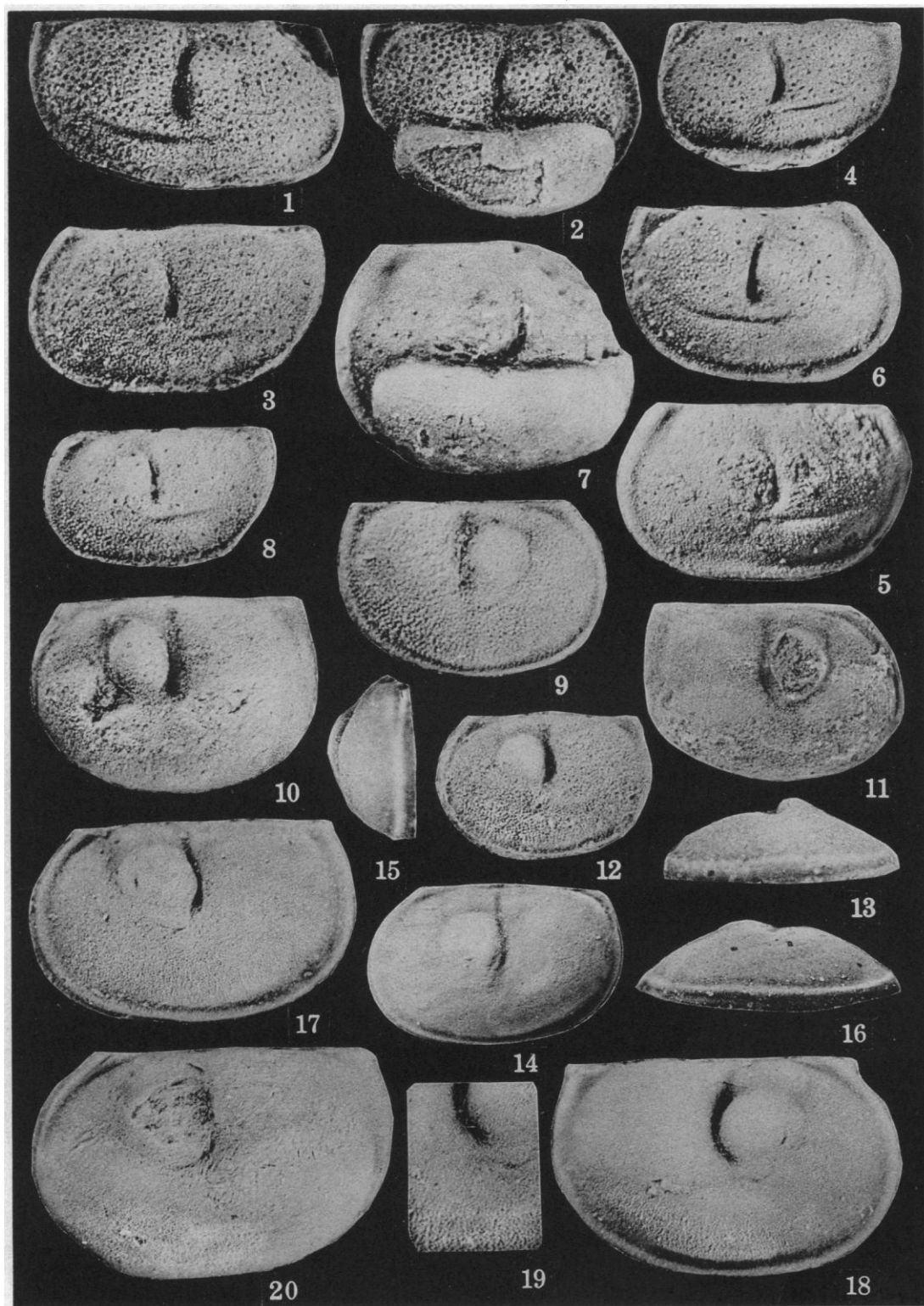
Bonneprimities, as well as of *Milleratia* Swartz (1936), to members of the Kloedenellidae.

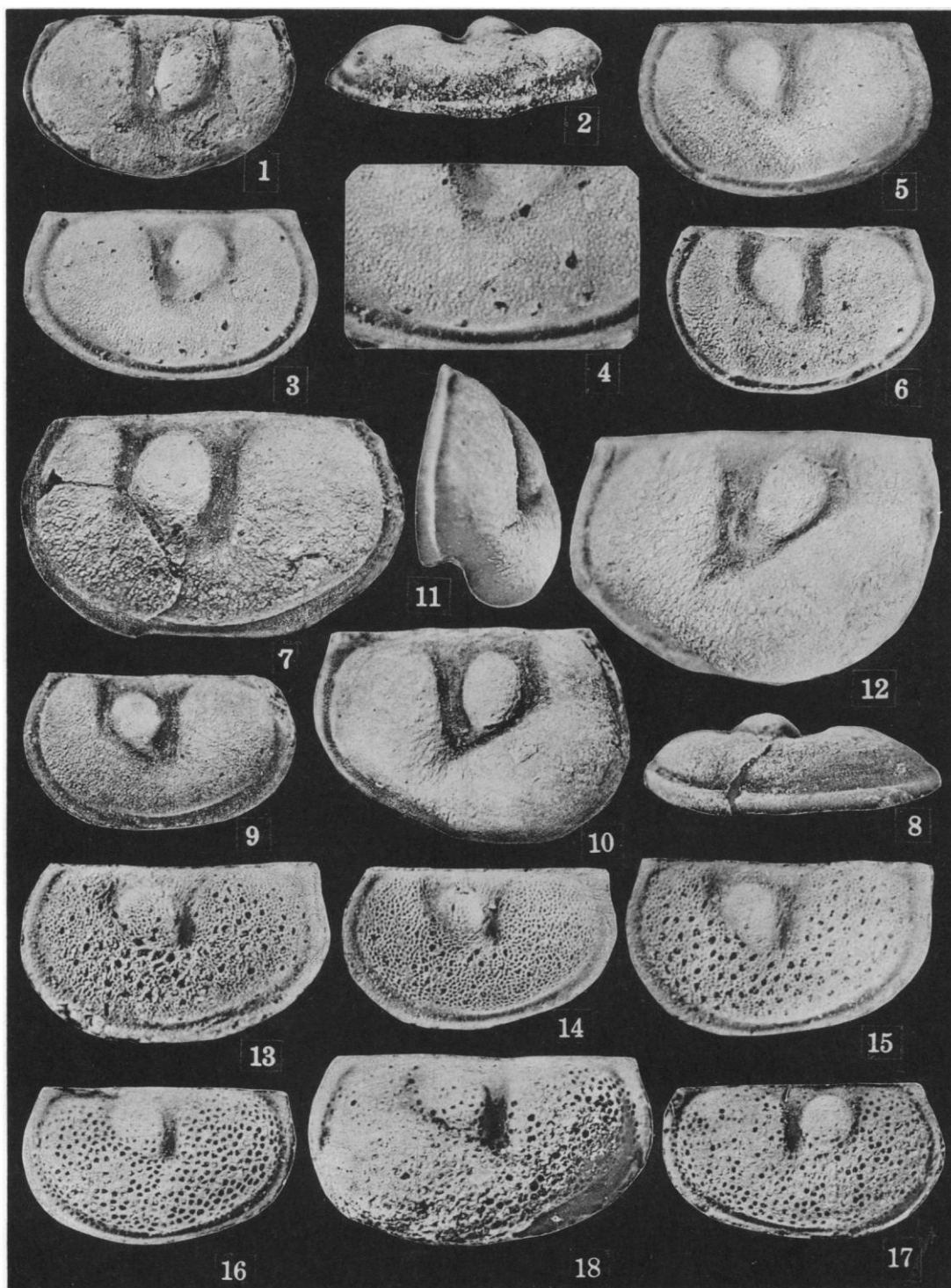
In addition to *Bonneprimites bonnemai*, *Beyrichia mundula* Jones may be listed provisionally in *Bonneprimites* pending further information concerning the dimorphism discussed by Öpik, and *Bonneprimites? breviformis* Swartz & Whitmore, n. sp., likewise can be included in the genus on a tentative basis. In all of these species, the difficulty with classification reflects lack of knowledge of structures that provide favorable clarification of interrelationships.

Occurrence.—The type material for *Bonneprimites bonnemai* comes from talus of Silurian marl, in the brick quarries at

EXPLANATION OF PLATE 105

- FIG. 1-4—*Mesomphalus rhomboidalis* Swartz & Whitmore, n. sp. 1,2, The syntypes $\times 35$. 1, A male right valve, the anterior cardinal angle restored. The specimen shows the elongate, rhomboidal form of the species, the numerous puncta with finely granulose interspaces, and the longitudinal furrow of the post-ventral slope. 2, A female right valve, with the distinctive mesomphalid, medioventral, elongate dimorphic pouch. William Nearpass quarries, New Jersey, 2 feet below top of Decker limestone. 3, A male left valve, $\times 35$, with sparse puncta. 4, A smaller "male" left valve, $\times 35$, preserving a medioventral flange or frill. This probably is a valve of an immature female, the ventral flange representing an undeveloped dimorphic pouch. William Nearpass quarries, New Jersey, 2 feet below top of Decker limestone. (p. 1077)
- 5-7—*Mesomphalus striatellus* Swartz & Whitmore, n. sp., 5, A male left valve, $\times 35$, referred to the species with some question. 6, The holotype male right valve, $\times 35$, showing the up-curved, faint anterior extension of the furrow of the ventral slope, the sparse puncta, the obtuse but prominent posterior cardinal angle. 7, An associated, imperfect female left valve, $\times 35$. 5 from William Nearpass quarries, New Jersey, 8 to 15 feet above base of Coeymans limestone; 6,7, from Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1078)
- 8—*Mesomphalus* sp. A small male left valve, $\times 35$, suggestive of *M. striatellus* in sparseness of puncta; however, the posterior cardinal angle is prominent and suggests *M. rhomboidalis*, and there is little trace of any anterior extension of the ventral furrow. The specimen may be an immature molt that does not completely illustrate the adult characters. William Nearpass quarries, New Jersey, $1\frac{1}{2}$ feet below top of Manlius limestone. (p. 1079)
- 9-13—*Welleriopsis diplocystulus* Swartz & Whitmore, n. gen., n. sp. 9-11, The syntypes. 9, A male right valve, $\times 35$, showing outline proportions, the rounded median lobe not reaching the dorsal margin, the minutely punctate-granulose ornament. 10,11, A female left valve, $\times 30$, and a female right valve, $\times 25$, showing the elongate ventral dimorphic pouch of the genus, tending to be divided into two parts by the indentation associated with the median lobe. 12,13, A male left valve, $\times 25$, and ventral view of a male right valve, $\times 30$. William Nearpass quarries, New Jersey, upper part of Manlius limestone; 9 is from 3 feet below top; 10,11,13 from $1\frac{1}{2}$ feet below top; 12 from 2 feet below top. (p. 1075)
- 14-16—*Welleriopsis jerseyensis* (Weller). Side, anterior, and ventral views of the holotype male left valve, $\times 19$, showing the rather large but low median lobe, its dorsal margin well below the dorsal margin of the valve. New Jersey Geological Survey Coll. 5932, from William Nearpass quarries, New Jersey, upper 4 feet of Decker limestone (2A13). (p. 1075)
- 17-20—*Welleriopsis jerseyensis* var. *microreticulatus* Swartz & Whitmore, n. var. Views of the syntype valves. 17, A male left valve, $\times 25$. 18,19, A male right valve, $\times 25$, and part of surface near median sulcus, $\times 36$, showing the curved, relatively short median sulcus, the well marked cardinal angles. The punctate-reticulate surface ornament is minute even with the enlargement given in fig. 19. 20, A female left valve, $\times 25$, the median lobe imperfect. William Nearpass quarries, 2 feet above base of Manlius limestone. (p. 1076)





Mulde, Island of Gotland. The type specimen of *B.?* *mundula*, British Museum No. I 6880, is from T. R. Jones' "No. 1 limestone" specimen from the Silurian drift, Berlin, Germany. *B.?* *breviformis* occurs in the basal part of the late Silurian Decker limestone, New Jersey.

BONNEPRIMITES? BREVIFORMIS Swartz & Whitmore, n.sp.
Pl. 110, fig. 20-22

Shell short, subquadrate in outline, height about four-fifths of length. Dorsal margin straight for about four-fifths of length; anterior cardinal bend rounded; posterior angle obtuse, not very prominent. Ventral margin convex in outline; terminal margins subequally rounded.

Surface of valve convex, rising steeply from posterior margin, much more gently from anterior margin, reaching greatest con-

vexity about one-fifth distance from posterior margin. Median sulcus is located slightly posterior to midlength; the sulcus is short, reaching only about one-fourth distance from dorsal to ventral margin; it does not reach an obscure, small rounded depression at about midheight of valve, that evidently is external expression of adductor attachment. Area anterior to sulcus is very faintly swollen, forming a scarcely discernible suggestion of a median lobe. Surface of valve smooth. Dimorphism not known.

The syntype valves measure length 0.9 mm., height 0.7 to 0.75 mm.

Relationships.—*Bonneprimites?* *breviformis* differs from the genotype, *B. bonnemai*, in its much shorter form, in the postmedian location of the maximum convexity, and in the shortness and dorsal location of the median sulcus, which does not extend to the locus of the muscle spot. If additional spe-

EXPLANATION OF PLATE 106

- FIG. 1-6—*Kloedenia deckerensis* (Weller). 1, 2, Side and ventral views, $\times 17$, of holotype male right valve, showing the strongly elevated lobes. Judging from the illustrated topotype material the holotype has been somewhat deformed. New Jersey Geological Survey Coll. 7344; William Nearpass quarries, New Jersey, upper 4 feet of Decker limestone (2A13). 3, 4, A male right valve, $\times 20$, and part of surface of same, $\times 35$, showing the minute surface granules. 5, 6, Two male left valves, $\times 20$, showing constancy of outline of shell, form of lobes including the obliquely directed, narrowed ventral part of the median lobe. In 6 especially, there is a faint suggestion of a zygobeyrichiid ventral extension of the anterior furrow. 3, 4 from William Nearpass quarries, New Jersey, 3 feet below top of Decker limestone or 1 foot above coralline bed; 5, 6 from same locality, 2 feet below top of Decker limestone. (p. 1063)
- 7-12—*Kloedenia sussexensis* (Weller). 7-9, Views of syntype valves, 7, 8, Side and ventral views of a slightly imperfect male left valve, $\times 24$, and $\times 18$, respectively, showing in 7 the coarser papillae interspersed with the fine granules of the type occurring in *K. deckerensis*. 9, A male left valve, $\times 17$, the posterior cardinal angle imperfect. The outline of shell, character of marginal border, form of the median and other lobes, and weak zygobeyrichiid extension of the anterior furrow, show the close relationship with *K. deckerensis*. 10, 11, Side and posterior views of female right valve, $\times 17$; this is the specimen used by Weller (1903) as the type of *Beyrichia perinflata*. 12, Another female right valve, $\times 19$, the ornament of the posterior and median lobes well preserved; the mark near the ventral end of the median sulcus may reflect the adductor scar. 7-9, New Jersey Geological Survey Coll. 7355, William Nearpass quarries, New Jersey, upper 4 feet of Decker limestone (2A12). 10, 11, New Jersey Geological Survey Coll. 7338, same locality, horizon 2A13. 12 from same locality, 2 feet below top of Decker limestone. (p. 1064)
- 13-15—*Kloedenia duplicipunctata* Swartz & Whitmore, n. sp. 13, The holotype, a male left valve, $\times 35$, showing the scattered, large puncta, and smaller puncta of the interspaces. The shell resembles that of *K. sussexensis* in its outline and in proportions of its lobes. William Nearpass quarries, New Jersey, 20 feet above base of Manlius limestone. 14, 15, Two male left valves, $\times 35$, showing variations in numbers of the coarser puncta; in 15 there is close approach to *K. crassipunctata*. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1065)
- 16-18—*Kloedenia crassipunctata* Swartz & Whitmore, n. sp. The syntypes, $\times 20$. 16, 17, A male left valve and male right valve, showing the characteristically coarse puncta, the obliquely directed, narrowed ventral part of the median lobe. 18, A female left valve. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1065)

cies with comparable dorsal location of the sulcus are discovered, their separation in a distinct genus could well be justified.

The external, rounded adductor spot of *Bonneprimites? brevisformis* may aid future consideration of the relations of the species. No well defined spot of this type was observed by Swartz in the type specimens of *B. bonnemai*. The spot is suggestive of the rounded marks of some of the specimens of *Kloedenia*, *Myomphalus* and *Saccarchites* that are illustrated in the present paper.

In the Nearpass quarries collections, *Bonneprimites? brevisformis* is represented by only three specimens. Larger collections are needed to provide more assurance concerning possible dimorphism. The three collected specimens agree closely with each other in dorsal profile as well as in lateral aspect.

Occurrence.—Rare in basal 2 feet of Decker limestone, William Nearpass quarries, New Jersey.

Family AECHMINIDAE Boucek
Genus AECHMINA Jones & Holl
AECHMINA EUPUNCTELLA Swartz &
Whitmore, n. sp.
Pl. 103, fig. 4-6

Shell dorsally truncate, subovate in outline; hinge margin straight for about four-fifths of length; height without spine about three-fifths of length; anterior cardinal angle slightly obtuse, posterior angle more obtuse. Anterior margin higher than other, but blunter and not projecting so far beyond limits of hinge. Ventral margin moderately convex, fuller anteriorly. Hingement and overlap not observed.

Surface of valve moderately convex, surmounted by a stout, dorso-median spine, the diameter of its base about one-fourth of length of valve. One observed valve preserves a portion of spine which projects at an angle of about 30 degrees from plane of conjunction of valves and is also tilted posteriorly; length of spine and nature of its terminus remain, however, undetermined. The small, sharply depressed pit anterior to base of spine is in turn bordered antero-ventrally by a well defined, small rounded knob.

Surface of valve is marked by sharply impressed, small puncta, the interspaces nearly equal to diameter of pits. Small gran-

ules tend to form a line paralleling ventral margin of valve. In one specimen, there is a belt of broad-tipped, medially pitted granules placed well within and paralleling free margins; no granules of this type are found on other two studied examples.

The larger syntype right valve measures length 0.88 mm., height 0.51 mm.

Relationships.—*Aechmina eupunctella* has the pit antero-ventral to the base of the dorso-median spine, that was considered by Ulrich & Bassler (1923) to be one of the distinguishing features of *Paraechmina*, but it lacks the marginal ridge of the characteristic members of that genus. *Aechmina bigeneris* Swartz, 1936, and *A. spinoterminata* Swartz, 1936, similarly have the pit but not the marginal ridge, and bear submarginal spines somewhat suggestive of those of the *Aechmina* genotype, *A. bovina* Jones. Warthin has listed *A. bigeneris* and *A. spinoterminata* under *Aechminaria* Coryell & Cuskley, 1934, but close relationship to the type of that genus does not appear well assured. Restudy of *Aechmina bovina* would be most helpful, to determine whether it may have some degree of development of the paraechminid pit, even though none is shown in Jones' figures.

Aechmina eupunctella lacks the submarginal spines of *A. bigeneris* and *A. spinoterminata*, and the node adjacent to the paraechminid pit is stronger. The surface puncta, and the curvature of the posterior as compared to the anterior margin may also prove distinctive.

Occurrence.—Rare 3 to 5 feet below top of Manlius limestone, Austin's Glen, New York.

Family PRIMITIOPSIDAE Swartz
Genus LIMBINARIA Swartz, n.gen.

Shell subovate, truncated dorsally by straight hinge, its length approaching total length of shell; cardinal angles prominent; right valve overlaps slightly on left along free margins. Surface of valve has a comparatively large, somewhat elevated medial area, varyingly pitted or grooved; a rounded submedian pit is well developed and presumably reflects locus of adductor attachment; in one dimorph, a more or less continuous, narrow ridge or rim parallels margins of valve, dorsally as well as along other mar-

gins, and is offset farther from valve edge in vicinity of cardinal angles than elsewhere; in other dimorph, a broad, typically flat flange or frill extends along one terminal margin and adjacent portion of ventral margin, and evidently is developed from corresponding parts of submarginal ridge of non-frilled dimorph. If submedian pit, presumably representative of adductor location, is antero-median in location, then dimorphic frill occurs along posterior and post-ventral margins.

Genotype.—*Limbinaria multipunctata* Swartz, n. sp., Late Silurian Tonoloway limestone, Virginia and Tennessee.

Relationships.—At the time of discovery of the non-frilled dimorph of *Limbinaria multipunctata*, it was thought that the species belonged to the multipunctate group of thlipsurids that has been included in *Octonaria* Jones, and that the truncate margin was ventral in position. Discovery of the frill-bearing dimorph controverted both this classification and orientation, and forced consideration of relationships with non-thlipsurid families.

The type of dimorphism found in *Limbinaria*, in which the broad, thin, more or less terminal frill of one dimorph is wanting in the other dimorph, is suggestive of the dimorphism that characterizes various genera of the family Hollinidae Swartz. However, the general ornament of *Limbinaria*, with its pitted or grooved medial area, rounded submedian pit, and submarginal ridge of the non-frilled dimorph, diverges markedly from the generally sulcate-lobate, in part node-bearing ornament of the Hollinidae. The locus of the submedian pit, on the assumption that it represents the position of adductor attachment, gives some reason to believe that the frill of *Limbinaria* may occur at the end of the shell opposite that on which the frill is found in the Hollinidae, and in any event the submedian pit in *Limbinaria* occurs on the side of mid-length of the shell away from rather than toward the end bearing the frill.

The straight hinge of *Limbinaria*, the submedian pit, the surface pitting and lack of lobation, and the presence of a dimorphic expansion at the end of the shell away from the position of the median pit, all favor comparison with *Primitiopsis planifrons* Jones,

the genotype of *Primitiopsis* Jones, and hence *Limbinaria* is here listed with *Primitiopsis* in the Primitiopsidae. The dimorphic frill in *Limbinaria multipunctata* differs from that of *Primitiopsis planifrons*, since in the latter species the frill or flange is confined to the end of the valve and does not extend along part of the ventral margin, and the frill is incurved distally so that the outer edge of the frill of one valve meets that of the opposing valve when the shell is closed. In *Primitiopsis dorsoplicata* Henningsmoen (1954b), however, the dimorphic frill or velum extends along most of the ventral margin and is said to be "flat." *P. dorsoplicata* is smooth surfaced, has only a weak suggestion of a short, dorso-submedian furrow, and has a strong crest paralleling the dorsal margin.

The species that currently appear to belong in *Limbinaria* are as follows:

Limbinaria multipunctata Swartz, n.sp., Late Silurian Tonoloway limestone, Virginia and Tennessee.

Limbinaria paucipunctata Swartz & Whitmore, n.sp., Late Silurian Decker limestone, New Jersey.

Limbinaria biangulata Swartz & Whitmore, n.sp., Late Silurian Decker limestone, New Jersey.

The following additional species may belong in *Limbinaria*:

Octonaria altoonensis Swartz, 1932, Late Silurian Keyser limestone, central Pennsylvania.

Octonaria? angulata Ulrich & Bassler, 1913, Late Silurian. Keyser limestone, Maryland.

Octonaria muricata Ulrich & Bassler, 1923, Late Silurian Tonoloway limestone, Maryland and Virginia.

No dimorphic frills or flanges have yet been discovered in *Limbinaria biangulata*, or in "*Octonaria*" *altoonensis*, "*O.*" *angulata* or "*O.*" *muricata*. Lack of observed frilled dimorphs is not surprising in *Limbinaria biangulata*, and *L.? altoonensis* which are represented in available collections by only a few specimens. Swartz has obtained more than a dozen specimens of *L.? muricata*, so that lack of observed frilled dimorphs raises a somewhat greater question concerning inclusion of the species in *Limbinaria*. In both *L.? muricata* and *L.? angulata*, the medial

elevated area is longitudinally grooved rather than pitted, so that it may prove desirable to place these species in a distinct genus, even if primitiopsid dimorphism can be found in them.

Limbinaria? altoonensis, *L.? angulata* and *L.? muricata* have heretofore been illustrated with the truncate margin in the octonarid, ventral position. If they are proper members of *Limbinaria*, the truncate margin is the dorsal margin.

Occurrence.—The species that can now be included in *Limbinaria* have been found in Late Silurian limestones in Virginia, Tennessee, Maryland and New Jersey.

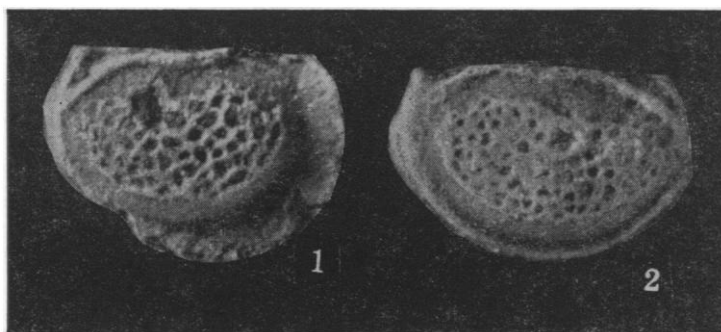
LIMBINARIA MULTIPUNCTATA Swartz, n.sp.
Text-fig. 4a,b

Shell proper subelliptical in outline, truncated dorsally by straight hinge which is

dorsal to midpoint. A narrow ridge lies near and about parallel to median part of dorsal margin; it angles downward anteriorly and extends nearly to anterior margin; posteriorly, there is a less pronounced downward bend to this ridge. In frill-less dimorph there is a low, ventral submarginal ridge, lying about along line of attachment of frill of other dimorph, and becoming weaker along ends of valve; in frilled dimorph a comparable ridge is weakly developed close to anterior edge of valve.

The frill bearing, holotype valve measures length 0.85 mm., height 0.70 mm., height apart from frill about 0.50 mm.

Relationships.—*Limbinaria multipunctata* has been studied by Swartz in the course of an investigation of ostracodes of the Late Silurian Tonoloway limestone of Virginia and some nearby areas in West Virginia and



TEXT-FIG. 4.—*Limbinaria multipunctata* Swartz, n. gen., n. sp. 1. The holotype female left valve; $\times 45$, showing the characteristic surface ornament and dimorphic flange. The largest depression is a break in the wall of the valve; the normal pit presumably indicative of the adductor location is slightly posterior to the lower end of the break. 2. A nearly perfect male right valve $\times 45$. The submarginal rim is almost perfectly preserved; the surface puncta are not as coarse as those of the holotype, and in part are clogged with matrix. *Hindella congregata* beds of Tonoloway limestone, gap in Little Mountain at Healing Springs, Virginia.

about five-sixths of greatest length. Cardinal angles subequal, obtuse but prominent. Terminal and ventral margins proper are rounded; in one dimorph a frill of moderate width extends submarginally from posterior cardinal angle to a point in front of middle of ventral margin.

Surface of valve is moderately convex. A large, somewhat elevated, obliquely elongated medial region is irregularly marked by moderately coarse puncta, about 70 to 80 in number, and there is one larger pit antero-

Tennessee; it is described in the present paper in order to introduce the genus *Limbinaria*, which is represented by two species in the collections from the William Nearpass quarries area.

Although only a few specimens of *Limbinaria multipunctata* have been found at this time, preservation is satisfactory to show their ornament and the dimorphic characters.

Occurrence.—Very rare, *Hindella congregata* beds of the Tonoloway limestone, gap

in Little Mountain at Healing Springs, Virginia; very rare, Tonoloway or Sneedville limestone, Mulberry gap, Tennessee.

LIMBINARIA PAUCIPUNCTATA Swartz &
Whitmore, n. sp.
Pl. 103, fig. 9,10

Shell of non-frilled dimorph subovate in outline, truncated dorsally by straight hinge extending for nearly nine-tenths of greatest length. Anterior cardinal angle prominent, about a right angle, set off by a gentle sub-jacent emargination. Posterior angle slightly obtuse. Terminal margins rounded, posterior margin extended slightly beyond hinge. Ventral margin convex, somewhat fuller posteriorly than anteriorly, almost subangulate post-medially at position of greatest height, which is about three-fourths of greatest length.

Right valve overlaps gently on left along free margins.

Surface of valve strongly convex, the convexity strongest below and somewhat behind center of valve, the slopes to ventral and posterior margins distinctly steeper than those to dorsal and anterior edges. In non-frilled dimorph, a low ridge extends close to and parallel to hinge edge of valve, angling downward in vicinity of anterior cardinal angle, and a low ridge more or less continuous with dorsal ridge also parallel free margins. Within space enclosed by submarginal ridges, a comparatively large, elevated area is marked by rather widely spaced, moderately coarse pits, about 20 in number, and there is one much stronger, dorso-submedian pit that is located slightly anterior to midlength of valve; from posterior and ventral margins of the pitted area, surface descends abruptly toward submarginal ridge; anteriorly and dorsally the slope is more gentle, margin of elevated area is poorly defined, and general surface pitting does not as a rule extend dorsal to a line running through submedian pit.

In the frilled, presumably female dimorph, a smooth submarginal frill or flange extends along posterior portion of valve, and continues with gradually narrowing width along half or more of ventral margin, from whence it continues as a low rim like that of non-frilled dimorph.

A male valve measures length 0.76 mm., height 0.56 mm. A female valve, including the dimorphic frill, measures length 0.84 mm., height 0.6 mm.

Relationships.—*Limbinaria paucipunctata* is similar to *L. multipunctata* Swartz, n. sp., in general shape, the ridge paralleling the dorsal and free margins that in one dimorph is expanded posteriorly and post-ventrally to form a dimorphic frill, the surface puncta and stronger dorso-submedian pit of the medial sculptured area. However, the medial sculptured area though proportionately larger is much less well defined, and the pits are much more widely spaced and less numerous, numbering about 20 as compared to about 70 to 80 in *L. multipunctata*.

Occurrence.—Common 1 foot above top of coralline bed of upper part of Decker limestone, in zone 2A13 of Weller (1903), at the William Nearpass quarries, New Jersey.

LIMBINARIA BIANGULATA Swartz &
Whitmore, n. sp.
Pl. 110, fig. 7-9

Shell dorsally truncate, subovoid in outline; cardinal angles obtuse but well defined; anterior margin somewhat higher and fuller ventrally than posterior margin; ventral margin strongly convex; greatest height about three-quarters of length, situated somewhat anterior to midlength.

Surface of valve moderately convex. Median raised and sculptured area measures about two-thirds of length and half of height of valve; its longitudinal axis is oblique, closer to dorsal margin posteriorly than anteriorly; surface of raised area bears about eight coarse, flat-floored depressions, the dorso-median depression largest and having its floor marked by a sharply impressed, rounded pit. Broad flange surrounding median elevated area is bounded by a submarginal, well elevated, continuous ridge or rim, closely adjacent to valve edges dorsally and ventrally, more distant terminally and especially near the dorsal angles.

The larger syntype valve measures length 0.9 mm., height 0.7 mm.

Relationships.—No frill-bearing dimorph has been discovered among the observed specimens of *Limbinaria biangulata*, but the

shape of the valve, the character and extent of the submarginal rim, and the form and obliquity of the medial elevated and pitted area are so similar to the corresponding features of the non-frilled dimorph of *Limbinaria multipunctata*, that close relationship to that species appears to be assured.

Limbinaria biangulata is also very suggestive of *Octonaria altoonensis* Swartz, 1932, except that it is smaller and the medial elevated area is marked by only eight instead of twenty-three pits or depressions. No frill-bearing dimorph has been discovered in "*Octonaria*" *altoonensis*, but *Limbinaria biangulata* forms a connecting link that tends to bring this species and also the somewhat differently ornamented *Octonaria? angulata* Ulrich & Bassler, 1913, and *Octonaria muricata* Ulrich & Bassler, 1923, into the genus *Limbinaria*.

Occurrence.—The syntype valves of *Limbinaria biangulata* come from slabs of Decker limestone obtained loose in a pit near the southeastern foot of Wallpack Ridge, on the Dalton Nearpass farm, New Jersey. The slabs appear to represent a horizon near the middle part of the Decker limestone. One imperfect valve was discovered in material collected 31 feet above the base of the Decker at the William Nearpass quarries.

Family DREPANELLIDAE Ulrich & Bassler
Genus RICHINA Coryell & Malkin
RICHINA ZYGALIS Swartz &
Whitmore, n. sp.
Pl. 103, fig. 7,8

Shell elongate subelliptical in outline, truncated dorsally by hinge which extends for about two-thirds of greatest length. Cardinal angles subequal, distinct but obtuse. Height about three-fourths of length. Ends subequal in curvature and extension beyond hinge; ventral margin moderately convex, somewhat fuller anterior to mid-length. Edges of valve lie about in a plane; details of hinge and overlap not determined.

Surface of valve moderately convex, rising steeply from margins. Median sulcus is slightly less than one-half of distance from anterior end, and has a small rounded depression about one-fourth distance below dorsal margin, that presumably reflects internal adductor scar. Anterior to sulcus and

closely adjacent to it is a well-elevated, rounded node, surmounted by a tiny point or spinelet; posterior to sulcus and somewhat farther from it is a conical node with pointed summit. A weak yoke connects these nodes around ventral end of sulcus; yoke extends ventrally from anterior node as a narrow, not quite vertical limb, then bends sharply upward toward posterior node, broadening as a low swelling and then becoming low and almost obsolete.

General surface is minutely punctate.

The syntype left valve measures length 0.97 mm., height 0.76 mm.

Relationships.—*Richina truncata* Coryell & Malkin, 1936, has obtuse cardinal angles, and one rounded, one conical node much as in *R. zygalis*. There is, however, little if any suggestion of a yoke connecting the dorsal nodes, the surface is described as being finely granulose rather than punctate, and the ends of the shell are more unequal.

The genus *Richina* was compared by Coryell & Malkin (1936) with *Ulrichia* Jones, 1890. In form of the dorsal nodes and lack of marginal ridge, *Richina* is very much closer to the section of *Bollia* represented by *Bollia hindei* Jones, 1890, and *B. widderensis* Coryell & Malkin, 1936, and further resemblance to the *Bollia* species of this type is furnished by the yoke-ridge of the new *Richina zygalis*.

Occurrence.—Very rare, 2 to 5 feet below top of Manlius limestone, Austin's Glen, New York.

Family HOLLINIDAE Swartz
Genus PARABOLBINA Swartz
PARABOLBINA CUNEOSPINOSA Swartz &
Whitmore, n. sp.
Pl. 110, fig. 1-6

Shell elongate subquadrate in outline; hinge straight, extending nearly nine-tenths of length of valve; cardinal angles obtuse but fairly well defined. Curvature of anterior margin is comparatively regular; posterior margin is recessive in lower part. Ventral margin is gently convex in male valves. Greatest height of male valve is slightly more than half of length.

Surface of valve rises steeply from margins, then flattens toward broadly convex summit. Just anterior to midlength, a well-defined, subvertical sulcus extends almost

halfway from dorsal to ventral margin. Walls of sulcus are steep, about parallel; on anterior side of sulcus is an obscure, node-like swelling.

In male valves, there is a small, wedge-like spine close to antero-ventral bend of the margin, and a similar, scarcely larger spine occurs near ventral margin about one-quarter of distance from posterior end. In female valve, there is a dimorphic frill with ends about at locations of spines of male valve. Frill has four radially-directed depressed lines, with broad intervening undulations; surfaces of undulations are marked by fine radial striae.

Surface of valve is minutely granulose.

A male valve measures length 0.68 mm., height 0.37 mm. A female valve, including frill, measures length 0.76 mm., height 0.46 mm.

Relationships.—*Parabolbina cuneospinosa* is more elongate and more equal ended than are *P. granosa* (Ulrich, 1890) and *P. limbata* Swartz, 1936. In *P. limbata* the two spines of the male valve are much stronger and more conical than are those of *P. cuneospinosa*, and in the female valve the posterior spine is retained and projects beyond the edge of the dimorphic frill.

Occurrence.—Rare 2 to 5 feet below top of Manlius limestone, Austin's Glen, New York; very rare, 15 feet below top of Manlius limestone, William Nearpass quarries, New Jersey.

Family BEYRICHIIDAE Ulrich

Genus VELIBEYRICHIA Henningsmoen

VELIBEYRICHIA RETICULOSACCULA

Swartz & Whitmore, n. sp.

Pl. 104, fig. 1-3

Shell subovoid in outline, truncated dorsally by straight hinge which is but little shorter than greatest length. Anterior cardinal angle somewhat obtuse; posterior angle about a right angle, its tip slightly produced. Margins of valve obscured by frill; anterior margin higher than posterior, extended slightly beyond hinge. Greatest height is about three-fourths of length, somewhat antero-median in location.

Submarginal frill is radially striate, with 9 or 10 striae in 0.5 mm.; these are crossed by more minute concentric striae, about 7 in 0.1 mm. Frill diverges from plane of con-

junction of valves, so that its outer margin is bent decidedly upwards as valve is observed with plane of conjunction in a horizontal position; in male valves, frill extends along ventral margin with a width nearly one-fourth of total height of valve; frill narrows gradually as it curves upward along anterior margin; postero-ventrally, frill is abruptly narrowed, its width reduced by more than half; it then narrows gradually along posterior margin, but retains radial striae. In observed female valves, abrupt postero-ventral narrowing of frill does not occur; antero-ventrally, frill is swollen into a highly elevated, ovoid dimorphic pouch, its summit rising above that of surface lobes.

Area enclosed by frill is trilobate. Median sulcus is moderately broad, deepened ventrally, lies slightly behind midlength, and extends about three-fourths distance from dorsal margin to inner edge of frill. Anterior furrow shorter, narrower, curving along anterior margin of somewhat oblique, highly elevated median lobe. Posterior lobe is moderately convex, and is about twice as wide as small or anterior lobe. Dorsal end of anterior lobe narrows and curves posteriorward, then continues into a low dorsal crest that extends parallel to hinge margin, above upper ends of median lobe and two sulci, to about middle of dorsal margin of large lobe.

Surfaces of lobes reticulate, the pits generally irregular in shape. Surface of dimorphic pouch also reticulate, its reticulation tending to be aligned lengthwise the pouch. Below median sulcus in male valves, on ventral slope of yoke joining large lobe to median lobe, a shallow groove extends in lengthwise direction of valve; this groove has not been observed on female valves.

A male valve, including frill, measures length 1.22 mm., height 0.83 mm.; a female valve measures length 1.17 mm., height 0.89 mm.

Relationships.—*Velibeyrichia reticulosaccula* is distinguished by the coarseness of its reticulate ornament, in conjunction with the low crest paralleling the hinge and the shallow groove that in male valves lies below the ventral end of the median sulcus. The reticulate ornament of the dimorphic pouch, upon which the name is based, is beautifully preserved on the figured female valve.

In recognition of the persistence in nu-

merous related species of the combination of the radially striated frill, the three undivided lobes, and the swollen anteroventral dimorphic pouch that are characteristically displayed in the *Velibeyrichia* genotype, *Beyrichia moodeyi* Ulrich & Bassler, just as in *Velibeyrichia reticulosaccula* and *V. paucigranulosa*, the writers are using *Velibeyrichia* as a distinct genus rather than as a subgenus of *Beyrichia* as was proposed by Henningsmoen (1954b). The writers had expected to propose the same generic grouping, with the same genotype species, and had employed for it the name, *Limbabeyrichia*, in earlier drafts of the present manuscript.

One of the distinctive features of the type of frill that is developed in *Velibeyrichia*, is an inner compartmentation that was described by Swartz in a letter to N. de B. Hornibrook discussing relations of the recent South Pacific species, *Puncia novozelandica* and *Manawa tryphena*, to Paleozoic beyrichiids. (See Hornibrook, 1949.) The frill of *Velibeyrichia moodeyi*, and of various species of *Dibolbina*, *Apatobolbina* and *Eurychilina*, has been discovered by Swartz to be a doubly walled structure, having internal partitions at the locations of the radial striae of the external surface. In Swartz' opinion, the nature of this frill provides an important link between *Eurychilina* and *Velibeyrichia* that tends to support the arrangement of the eurychiliniids and velibeyrichiids in a single family, in the fashion that was proposed by Swartz in 1936. It may be possible to continue to employ the name Beyrichiidae Jones for this generally frill-bearing family, since both the non-frilled *Battus tuberculatus* Kloeden, 1834, which for many years was regarded as the genotype of *Beyrichia* McCoy, and the non-frilled *Beyrichia kloedeni* McCoy, 1846, for which a better case as genotype can probably be made in view of remarks made by McCoy in 1851, can reasonably be interpreted as derivatives from normally frilled members of the *Eurychilina-Velibeyrichia* group.

Occurrence.—*Velibeyrichia reticulosaccula* is common 2 to 5 feet below the top of the Manlius limestone, Austin's Glen, New York. Rare 18 feet above base of Manlius limestone, William Nearpass quarries, New Jersey.

VELIBEYRICHIA PAUCIGRANULOSA

Swartz & Whitmore, n. sp.

Pl. 104, fig. 4-9

Shell subrhombic in outline, posterior cardinal angle produced so that posterior margin makes an acute angle with hinge; anterior angle obtuse with curved anterior margin extending beyond hinge for about one-eighth of valve length. Hinge extends for about seven-eighths of greatest length. Greatest height, including frill, is about two-thirds of length, and is antero-median.

Submarginal frill marked by about 12 radial striae in 0.5 mm.; it is relatively narrow, its width about one-sixth of total height of valve; its outer edge is bent decidedly upwards as valve is observed with plane of conjunction in horizontal position; frill narrows along terminal margins, without any abrupt change in width.

Surface enclosed by frill is trilobate. Median sulcus lies slightly behind midlength, and extends about two-thirds of distance from dorsal margin to inner edge of frill; median sulcus is deep ventrally, but shallows dorsally where its margins flare outwards; widened area tends to have an obscure median swelling. Anterior sulcus shallow though nearly as long as median sulcus; it is defined anteriorly by cuesta-like summit of anterior lobe. Large or posterior lobe highly elevated; its summit, posterior to deep part of median sulcus, rises about to level of median lobe. Median lobe slightly oblique, not reaching dorsal margin. Anterior lobe less than half width of posterior lobe; its posteriorly curving, dorsal tip extends into a low, narrow crest that parallels hinge margin, extending above dorsal ends of median lobe and two sulci, reaching dorsal margin of large lobe, where an obscure extension angles downward obliquely from hinge.

Dimorphic pouch of female valve is large, highly elevated, subovoid, elongated parallel to antero-ventral margin.

Surfaces of lobes bear low, obscure, distant granules; in one valve there are additional, closely spaced, much more minute granules. Ventral slope of large lobe is marked by a longitudinally disposed groove.

A male valve measures length 1.05 mm., height 0.71 mm. A female valve measures length 1.03 mm., height 0.73 mm.

Relationships.—*Velibeyrichia paucigranu-*

losa resembles *V. reticulosaccula* in the dorsal crest and ventral groove of the large lobe; but the outline tends to be subrhombic and more elongate, and the surface is granulose rather than strongly reticulate.

The longitudinally disposed groove of the ventral slope of the large lobe of both *Velibeyrichia reticulosaccula* and *V. paucigranulosa*, appears to be comparable to the "fissus" illustrated in a similar position by Henningsmoen (1954b) in specimens from the Oslo region, Norway, which he has referred to *Beyrichia kloedeni* McCoy.

The groove in the latter material appears to be a shorter counterpart of the longer grooves of *Eobeyrichia zygophora* Henningsmoen (1954b), which in turn are suggestive in their location and extent of the grooves of such species as *Conchoprimites tolli* that have been interpreted as the impression of the free margin of an early-stage valve-molt.

Occurrence.—*Velibeyrichia paucigranulosa* is common 2 feet above top of coralline bed of upper part of Decker limestone, William Nearpass quarries, New Jersey.

Genus DIBOLBINA Ulrich & Bassler
DIBOLBINA MACROSULCATA Swartz &
Whitmore, n. sp.
Pl. 104, fig. 10

Shell subovate in outline, truncated dorsally by straight hinge line extending about nine-tenths of greatest length. Posterior cardinal angle acute, protuberant; anterior angle rounded. Anterior margin broadly and regularly rounded; posterior margin recessive in lower part; ventral margin moderately convex in outline.

Valve margined along free edges by a comparatively narrow frill, its width about one-tenth of greatest length of valve, its surface marked by numerous radial depressed lines that reflect partitions of inner crevice of frill. Area within frill strongly convex; greatest convexity, just posterior to lower part of median sulcus, is about one-fourth of greatest length of valve. Median sulcus deeply impressed, its walls rising steeply to adjacent lobe surfaces; sulcus is located just anterior to midlength; it extends more than half distance from dorsal margin of valve to ventral margin of frill, or two-thirds distance from dorsal margin of valve to inner margin of frill; sulcus is subvertical in disposition, but curves anteriorward in lower

part. A low swelling of posterior portion of anterior lobe is suggestive of a beyrichiid median lobe. Surfaces of lobes marked by numerous shallow pits, the interspaces about equal to pit diameters.

Female dimorph not observed.

The holotype male valve measures length 1.2 mm., height 0.8 mm.

Relationships.—*Dibolbina macrosulcata* is distinguished by the convexity of the valve, and depth and length of the median sulcus.

Occurrence.—Rare 2 feet below top of Decker limestone, William Nearpass quarries, New Jersey.

Genus PSEUDOBeyrichia Swartz &
Whitmore, n. gen.

Shell subovate to subelliptical in outline, truncated dorsally by long straight hinge, and having both cardinal angles well defined. Surface trilobate; median lobe well elevated; terminal lobes less convex, not transected by cross furrows; median sulcus strong, anterior sulcus shallow; lobate area of male valve enclosed except dorsally by an elevated, comparatively narrow rim that roughly parallels free margins; dimorphic pouch elongate, extending in genotype along free margin from anterior cardinal angle to a point behind midlength of valve; surface in genotype marked by both small puncta and comparatively coarse pustules.

Genotype.—*Pseudobeyrichia perornata* Swartz & Whitmore, n. sp.

Relationships.—On the basis of general shape of shell, trilobation of surface with its strongly elevated median lobe, anteroventral dimorphic pouch, and the strong but comparatively narrow or thin submarginal ridge, *Pseudobeyrichia perornata* appears to the writers to be closer to members of *Velibeyrichia* and *Beyrichia*, than to members of *Kloedenia* with which it might otherwise be compared. The submarginal ridge is simple as compared to the radially marked frill of *Velibeyrichia* and the spinose submarginal ridge of *Beyrichia kloedeni* as illustrated by Henningsmoen (1954b). The rim might be compared with the submarginal rim of *Nodobeyrichia* Henningsmoen (1954b), in which genus however the anterior and posterior lobes are cut by transverse furrows. The dimorphic pouch is more elongate than are those of known members of the three latter genera, and there is no suggestion of the de-

pression anteroventral to the median lobe that is well marked in many species of *Veli-beyrichia*, although it is faint in the species *V. reticulosaccula* and *V. paucigranulosa* that are described in this paper. The longitudinally directed furrow of the posterior lobe of the latter two species, which has a well marked counterpart in *Beyrichia kloedeni*, is not represented in *Pseudobeyrichia perornata*.

Occurrence.—The only species now referred to *Pseudobeyrichia* is *P. perornata* of the late Silurian Manlius limestone of New Jersey.

PSEUDOBeyrichia PERORNATA Swartz &
Whitmore, n. sp.
Pl. 104, fig. 11,12

Shell elongate subelliptical in outline, truncated dorsally by straight hinge, that extends about eight-ninths of greatest length. Anterior angle somewhat obtuse but well defined; posterior angle a little more nearly a right angle. Ends rounded, subequal in height; ventral margin medially sinuate. Height of male shell scarcely more than half of length. Edges of valve lie about in a plane.

Surface of valve well elevated, trilobate. Median sulcus well marked, subvertical; situated scarcely posterior to midlength of valve, and extending slightly more than halfway from dorsal to ventral margin. Anterior sulcus shallow, poorly defined. Median lobe strongly elevated, its summit rising above plane of valve-margins for a distance about one-third of length of valve; this lobe is obpyriform in shape, its dorsal margin rounded and not reaching dorsal margin of valve; vertical axis of lobe is slightly oblique; diameter of lobe is about two-ninths length of valve. Anterior lobe relatively broad, low; posterior lobe is strongly elevated, rising with moderate slope from its posterior margin, then dropping abruptly to median sulcus. A strong, rounded node occurs at dorsal extremity of posterior lobe, and there is a similar node at dorsal end of anterior lobe; a node antero-ventral to median lobe is elongated lengthwise valve. Submarginal ridge is narrow, well elevated, extends from vicinity of posterior cardinal angle about to dorsal node of anterior lobe; ventrally and slightly posterior to midlength of valve, rim is bent

slightly inward and has an angulation on its inner side; at this place it rises to a sharp eminence about twice as high as adjacent parts of rim.

In female valve, dimorphic pouch is strongly swollen, overhangs antero-ventral margin of valve, and extends from near anterior cardinal angle to a point about one-third in front of posterior margin of valve.

Surfaces of lobes and of dimorphic pouch of female valve are minutely and regularly punctate; this ornament is surmounted by scattered pustules.

In figured female valve, ventral part of median sulcus has obscure, subvertical striae that may reflect adductor scar.

The holotype male valve measures length 1.0 mm., height 0.5 mm.; the figured female valve measures length 1.1 mm., height 0.8 mm.

Relationships.—*Pseudobeyrichia perornata* is unique among known species in the characters of its ornament. Its general relationships are considered in the discussion of the genus.

Occurrence.—Rare 3 feet below top of Manlius limestone, William Nearpass quarries, Wallpack Ridge, New Jersey; rare in basal foot of Manlius on Dalton Nearpass farm.

Family ZYGObolbidae Ulrich & Bassler
Subfamily KLoedeninae Ulrich & Bassler
Genus KLoedenia Jones & Holl

The genus *Kloedenia* includes trilobed Kloedeninae, in which median lobe is a rounded, elevated dorso-antromedian knob, bounded by subvertical median and anterior sulci that commonly extend about half of distance from dorsal to ventral margin, setting off a smaller anterior and larger posterior lobe that tend to be broadly rounded with summits that do not deviate greatly from general convexity of valve surface; there is little or no development of a ventral extension of anterior sulcus; dimorphic pouch of female valve is a well-defined, antero-ventral swelling, somewhat elongated parallel to antero-ventral margin. A narrow flattened border margins free edges of each valve.

Genotype.—*Beyrichia wilckensiana* Jones of the Silurian *Beyrichia* limestone boulders of northern Germany.

Relationships.—The general character of lobation found in *Kloedenia* is shared by several other genera that differ in particular features of ornament or in character of the dimorphic swelling. Thus in *Zygobeyrichia* Ulrich there is a distinct ventral extension of the anterior sulcus and accompanying yoke-like connection of the ventral parts of the median and posterior lobes; in *Welleria* Ulrich & Bassler the margins of the dimorphic swelling are very poorly defined; in *Welleriopsis* Swartz & Whitmore, n. gen., the dimorphic pouch is an elongate, ventral rather than antero-ventral structure; *Lophokloedenia* Swartz & Whitmore, n. gen., is especially close to *Kloedenia* but its members are very closely knit by presence of a low crest that extends posteriorward from the dorsal end of the anterior lobe and terminates at a knob located in the dorsal portion of the median sulcus.

The members of *Kloedenia* that are here described from the Decker and Manlius limestones, include one group of four species that show distinct interrelationship, especially in character of the median lobe, and two additional species that diverge in aspect both from the first four and from each other.

In the group of four species, the median lobe has an obliquely directed ventral extension and hence is obliquely obpyriform. *Kloedenia sussexensis* differs from the associated *K. deckerensis* in having coarse pustules that overset the granules common to both; in both, there is some development of a zygobeyrichiid extension of the anterior sulcus, but there is little sign of the ventro-median zygose swelling of typical members of *Zygobeyrichia*. *Kloedenia duplicipunctata* and *K. crassipunctata* of the Manlius limestone resemble *K. sussexensis* and *K. deckerensis* in general shape of shell and proportionate size of lobes as well as in the obliquely obpyriform aspect of the median lobe, but lack any trace of the zygobeyrichioid furrow. In *K. duplicipunctata*, the lobe surfaces are marked by both fine and coarse puncta, whereas in *K. crassipunctata* the coarse puncta are crowded together and finer pits are lacking on the narrow interspaces.

In *Kloedenia montaguensis*, the outline is less elongate than in *K. sussexensis* and its close allies, and the obliquely obpyriform aspect of the median lobe is less pronounced;

the lobes are comparatively more elevated, the median sulcus is long and deep, and the ventral region connecting the median and posterior lobes is swollen in a manner suggestive of *Zygobeyrichia* although there is no zygobeyrichiid ventral extension of the anterior sulcus. *Kloedenia montaguensis* var. *smocki* was separated from *K. montaguensis* by Weller because of greater length of the one known valve, and is of questionable significance.

Kloedenia aparchoides represents another special play upon the generic characters, in which the surface lobation and sulcation are exceptionally subdued.

Groupings such as are outlined above deserve further consideration in future studies of *Kloedenia*, in the search for better understanding of the large assemblage of species that has been referred to this genus. Investigations are especially needed that will more clearly define the characters of the genotype and its closer relatives.

Occurrence.—Silurian and Devonian, North America and Europe.

KLOEDENIA DECKERENSIS (Weller)

Pl. 106, fig. 1-6

Beyrichia deckerensis WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 256, pl. 23, fig. 11.

Kloedenia manliensis deckerensis ULRICH & BASSLER, 1908, U. S. Nat. Mus. Proc., vol. 35 (1908), p. 301. —, BASSLER, 1915, U. S. Nat. Mus. Bull., vol. 92, p. 685. —, BASSLER & KELLETT, 1934, Geol. Soc. Am., Special Paper no. 1, p. 363.

Male shell dorsally truncate, elongate subovate in outline. Hinge straight for about seven-eighths of greatest length. Cardinal angles obtuse, subequal. Anterior margin higher, more broadly rounded than posterior; ventral margin moderately convex, fullest in front of midlength; greatest height of valve is about three-fifths of greatest length.

Surface of valve rising steeply from margins to moderately convex general surface of lobes, the rise interrupted by a flattened border that parallels free edges. Median lobe obpyriform in outline, its ventral extension obliquely directed; this lobe does not reach dorsal margin of valve; its diameter is about one-fifth of valve length; its summit is moderately elevated, rounded. Median

sulcus is subvertical, moderate in width, and extends more than half of distance from dorsal to ventral margin. Anterior sulcus is moderately deep in upper fourth of valve; a faint ventral continuation bends posteriorward along flank of median lobe; below main part of anterior sulcus a faint, subvertical furrow crosses ventral slope of valve.

Surfaces of lobes bear minute, closely spaced granules.

The type male right valve measures length 2.24 mm., height 1.4 mm.

Relationships.—*Kloedenia deckerensis* closely resembles *K. sussexensis* in size, form of shell, proportions of lobes and sulci. It differs chiefly in lack of the coarse pustules that in that species overset the more minute surface granules.

Occurrence.—The holotype male left valve of *Kloedenia deckerensis* came from Weller's horizon 2A13, in upper 4 feet of Decker limestone, William Nearpass quarries, New Jersey. The species is common in new collections 2 and 3 feet below the top of the Decker at this locality.

KLOEDENIA SUSSEXENSIS (Weller)

Pl. 106, fig. 7-12

Beyrichia sussexensis WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 253, pl. 23, fig. 3,4.

Beyrichia perinflata WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 254, pl. 23, fig. 6.

Kloedenia sussexensis ULRICH & BASSLER, 1908, U. S. Nat. Mus., Proc., vol. 35, p. 302, pl. 38, fig. 19,20. —, BASSLER & KELLETT, 1934, Geol. Soc. Am., Special Paper no. 1, p. 366.

Male shell dorsally truncate, elongate subelliptical to subovate in outline. Hinge extends about seven-eighths of length of shell, with region above median sulcus and median lobe tending to project slightly above hinge proper. Anterior angle obtuse; posterior angle sharp, slightly extended. Anterior margin moderately and rather regularly convex in outline; anterior end is slightly higher than posterior end and projects somewhat farther beyond limits of hinge. Ventral margin moderately convex, fullest in front of midlength; greatest height of valve is about three-fifths of length.

Surface moderately convex, rising steeply from free edges before flattening to form a

rather narrow submarginal border. Median lobe rounded with a small, oblique ventral extension; this lobe does not reach dorsal margin of valve; its diameter is about two-ninths of valve-length. Median sulcus fairly deep, moderately wide, slightly enlarged ventrally along flank of median lobe, extending nearly three-fifths of distance from dorsal to ventral margin. Anterior sulcus shorter and narrower; a faint continuation bends posteriorward along flank of median lobe. Anterior lobe about three-fifths as wide as posterior lobe. Yoke-region, joining ventral ends of anterior and posterior lobes, is somewhat swollen below median sulcus and drops steeply to ventral part of submarginal border; below main part of anterior sulcus a faint depression crosses ventral slope above submarginal border.

In female valve, dimorphic pouch is strongly swollen; it lies along and overhangs part of antero-ventral border; its length is nearly two-thirds of length of valve; its dorsal margin is moderately well defined.

Surfaces of lobes bear minute, closely crowded granules surmounted by coarser, more distant pustules.

The holotype male valve measures length 2.4 mm., height 1.5 mm.

Relationships.—*Kloedenia sussexensis* is suggestive of *K. deckerensis*, especially as represented by the new specimens here illustrated. It differs from the latter material chiefly in presence of the coarse pustules ornamenting the surfaces of the lobes.

Female examples of *K. sussexensis* were named *Beyrichia perinflata* by Weller (1903), since their dimorphic nature was not recognized.

Male valves of *K. sussexensis* and the closely related *K. deckerensis* have a furrow on the ventral slope in line with the main part of the anterior sulcus, and hence suggest the genus *Zygobeyrichia*. The two species have been left in *Kloedenia* since the furrow is weak, and since the zygoose ventral region connecting the posterior and median lobes is not markedly swollen.

Occurrence.—The type specimens of *K. sussexensis* and *K. "perinflata"* reportedly came from beds 4 to 10 feet below the top of the Decker limestone, at the William Nearpass quarries, New Jersey. No ostra-

codes were observed by the authors in new collections from these levels.

KLOEDENIA DUPLICIPUNCTATA Swartz
& Whitmore, n. sp.
Pl. 106, fig. 13-15

Shell dorsally truncate, elongate subovate in outline. Hinge extends about nine-tenths of length of shell. Posterior cardinal angle protuberant, about a right angle; anterior angle obtuse. Anterior margin rather regularly rounded, projecting beyond hinge for about a tenth of shell length. Posterior margin subvertical above, rounding below into ventral margin which is moderately convex, fullest anteromedially where height of shell is about three-tenths of length.

Valve moderately convex, rising steeply from free edges, before flattening to form a submarginal border of moderate width. Median lobe rounded, obliquely obpyriform in outline, not reaching to dorsal margin; diameter is about one-fifth of length of valve. Median sulcus well defined in lower part, moderate in width, extending subvertically for about three-sevenths of distance from dorsal to ventral margin. Anterior sulcus shorter, weakening rapidly in its ventral part where it curves against median lobe. Anterior lobe nearly two-thirds as wide as posterior lobe, narrowed somewhat in dorsal part.

Surfaces of lobes are marked by rather distant, more or less irregularly spaced, coarse puncta, with finer puncta on broad interspaces. Number of coarse pits is variable; few of coarse pits occur on median lobe.

The holotype valve measures length 1.2 mm., height 0.8 mm.

Relationships.—*Kloedenia duplicipunctata* is closely related to *K. crassipunctata*, as is shown especially by transitional individuals in which the coarse pits are increasingly numerous. There is close agreement in the character of the coarse pits, and likewise in the proportions of the shell, of the lobes, and of the sulci.

Occurrence.—Fairly common 2 to 5 feet below top of Manlius limestone, Austin's Glen, New York. Rare 3 feet and 15 feet below top of Manlius limestone, William Nearpass quarries, New Jersey.

KLOEDENIA CRASSIPUNCTATA Swartz
& Whitmore, n. sp.
Pl. 106, fig. 16-18

Shell dorsally truncate, elongate subovate in outline. Hinge extends about nine-tenths of greatest length. Cardinal angles well defined; posterior angle scarcely obtuse, anterior angle somewhat more so. Anterior margin higher and more regularly rounded than posterior margin, extended about twice as far beyond limits of hinge. Ventral margin moderately convex, fullest in front of midlength. Greatest height of valve is about four-sevenths of greatest length.

Surface of valve moderately convex. A submarginal, flattened border extends along free edges. Median sulcus is deepened somewhat ventrally, and extends a trifle less than halfway from dorsal to ventral margin. Anterior sulcus narrow, faint weakening ventrally, reaching about a third of distance from dorsal to ventral margin; a faint extension curves along anterior flank of median lobe. Median lobe obliquely obpyriform; moderate in size, its diameter about one-fifth of length of shell; it does not reach dorsal margin of valve; its summit rises slightly above summits of other lobes. Anterior lobe relatively wide, its width about two-thirds that of posterior lobe and almost two-fifths of length of valve.

Surfaces of lobes are coarsely punctate, the pits fairly deep, flat-floored, separated by rather narrow reticulations. There are about five pits in 0.3 mm.

In a female valve, brood pouch is elongate-ovate, overhanging anteroventral margin of valve and extending for about two-thirds of valve length. Surface of pouch is coarsely reticulate like surfaces of lobes.

A male valve measures length 1.68 mm., height 0.98 mm. A large female valve measures 2.24 mm., height 1.26 mm.

Relationships.—*Kloedenia crassipunctata* is an important zonal fossil for the upper part of the Manlius both near Catskill, New York, and in northwestern New Jersey, and occurs more sparingly in the lower part of the formation. It is distinguished primarily by the coarse pitting. The outline is relatively elongate for the genus.

Occurrence.—Abundant 2 to 5 feet below

top of Manlius limestone, Austin's Glen, New York. Rare to common $1\frac{1}{2}$ feet, 2 feet, 3 feet, 7 to 9 feet, and 15 feet below top of Manlius limestone, William Nearpass quarries, New Jersey. Rare, basal half-foot of Manlius limestone, Dalton Nearpass farm. Rare, lower part of Manlius limestone, small quarry on Trilobite Mountain, New York, 1.2 miles northeast of Tristate village.

KLOEDENIA MONTAGUENSIS (Weller)

Pl. 108, fig. 1-8

Beyrichia montaguensis WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 267, pl. 24, fig. 23.

Kloedenia montaguensis ULRICH & BASSLER, 1908, U. S. Nat. Mus., Proc., vol. 35, p. 301. —, BASSLER & KELLETT, 1934, Geol. Soc. Am., Special Paper no. 1, p. 364.

Shell relatively high, dorsally truncate subovate in outline, with hinge about nine-tenths of greatest length. Posterior cardinal angle slightly obtuse, sharpened in many valves by a gentle subadjacent emargination. Anterior cardinal angle somewhat more obtuse but well defined. Anterior margin convex, most extended and most sharply curved just above midheight, projecting beyond hinge for about one-fifteenth of length of shell. Posterior margin gently convex above, somewhat recessive below. Ventral margin in left valve tends to be truncate and almost straight for half of length of shell; in right valve this truncation is weak or lacking. Greatest height is post-median in location and is about two-thirds of length.

Surface of valve strongly convex, rising steeply from free edges to outer margin of flattened, submarginal border. In left valve, border is broadest at either end of subtruncate portion of ventral border; in right valve, border is somewhat narrowed along ventral margin.

Median lobe rounded, strongly elevated; it is large, the diameter a quarter or more of length of valve; it does not reach dorsal margin of valve. Median sulcus moderately wide and relatively deep; it is distinctly post-median in location, and extends three-fifths or more of distance from dorsal to ventral margin. Anterior sulcus moderately strong, curving along flank of median lobe. Anterior lobe sickle-shaped, its width about three-fifths that of posterior lobe.

Ventral to median sulcus, yoke connecting

ventral portion of posterior lobe with region below median lobe is swollen, projects ventrally, and drops with a very steep slope to adjacent part of submarginal border.

Dimorphic pouch of female extends along and overhangs part of anteroventral margin of valve; length of pouch is about two-thirds of length of valve. Dorsal margin of pouch is moderately well defined.

Surfaces of lobes are minutely punctate in well preserved valves. The puncta with their intervening reticulations tend to be surmounted by coarse but low and fairly distant pustules. These pustules are strongly developed and numerous on dimorphic pouch of figured female valve.

The larger of the cotype, male left valves measures length 2.4 mm., height 1.6 mm. The figured female valve measures length 2.94 mm., height 1.99 mm.

Relationships.—*Kloedenia montaguensis* differs from its variety *K. m. var. smocki* in the proportionately greater height of the valve.

The strongly swollen ventral yoke or zygosity of *K. montaguensis* suggests the genus *Zygobeyrichia*, but the ventral prolongation of the anterior sulcus that characterizes members of that genus is not developed.

Occurrence.—William Nearpass quarries, New Jersey, $1\frac{1}{2}$ to 3 feet, 6 to 8 feet, and 13 feet below top of Manlius limestone.

KLOEDENIA MONTAGUENSIS var.

SMOCKI (Weller)

Pl. 108, fig. 9,10

Beyrichia smocki WELLER, 1903, Geol. Survey New Jersey, vol. 3, p. 268, pl. 24, fig. 24.

Kloedenia smocki ULRICH & BASSLER, 1908, U. S. Nat. Mus., Proc., vol. 35, p. 302. —, BASSLER & KELLETT, 1934, Geol. Soc. Am., Special Paper no. 1, p. 365.

Restudy of the holotype specimen of *Beyrichia smocki* Weller shows it to be a right valve which in form and proportions of lobes, sulci and border agrees closely with valves of *Kloedenia montaguensis*, except that the whole valve is more elongate than is normal for the latter species, and the surface does not show the fine punctation that is well developed in most of its studied examples. The ratio of length to height in the specimen of *K. m. var. smocki* is 1.73 to 1 as compared to 1.5 to 1 in the larger of the cotype valves of *K. montaguensis*.

sis. The border is much narrower ventrally in the holotype of *K. m.* var. *smocki* than in the cotypes of *K. montaguensis*, but this reflects the fact that the cotype specimens of *K. montaguensis* are left valves; in right valves of *K. montaguensis* the border is narrowed ventrally about as in the holotype right valve of *K. m.* var. *smocki*.

It appears at this time that *K. m.* var. *smocki* can not be separated from *K. montaguensis* except as a questionable variety; it should not be accorded even this status unless further collecting should give evidence that it is representative of an assemblage of elongate, smooth-surfaced individuals. It is not unlikely that the elongation of *K. m.* var. *smocki* may be due to distortion rather than a difference of original growth, and that the apparent smoothness of surface is due to imperfect preservation. The single specimen does not give adequate answer to the problem.

The specimen of *K. m.* var. *smocki* measures length 2.6 mm., height 1.5 mm.

Occurrence.—The holotype valve of *K. m.* var. *smocki* came from beds 13 to 23 feet above the base of the Manlius at the William Nearpass quarries, New Jersey, in horizon 2A25 of Weller's section.

KLOEDENIA cf. *K. MONTAGUENSIS* (Weller)
Pl. 108, fig. 11–13

Associated with typical examples of *Kloedenia montaguensis* in the upper part of the Manlius limestone at the William Nearpass quarries, are smaller and proportionately somewhat longer *Kloedenia* valves in which the yoke connecting the ventral end of the posterior lobe with the region below the median lobe is less strongly swollen than is normal for that species. These smaller valves do however resemble *K. montaguensis* in form and large size of the median lobe, in the sickle-like form of the anterior lobe, and in character of the surface puncta. It is reasonably plausible that these valves represent immature individuals or at least immature molts of *K. montaguensis*, that had not fully developed the adult characters of the species. They are separately listed here and on the accompanying plate, to draw attention to both their differences and similarities.

A male left valve of this smaller group measures length 1.8 mm., height 1.1 mm., as compared to length 2.4 mm., and height 1.6 mm. for the cotype male left valve of *Kloedenia montaguensis* illustrated in Pl. 108 fig. 3.

Occurrence.—The specimens here described were obtained at 1½, 2, and 7 to 9 feet below the top of the Manlius limestone, at the William Nearpass quarries, New Jersey.

KLOEDENIA APARCHOIDES Swartz
& Whitmore, n. sp.
Pl. 103, fig. 11–14

Shell dorsally truncate, subovate in outline; hinge margin straight, about nine-tenths of greatest length; anterior cardinal angle obtuse, posterior angle nearly a right angle. Anterior margin convex in outline, fuller in front of midlength.

Hingement and overlap not observed.

Surface of valve moderately convex, weakly trilobate, the two sulci shallow and intervening median lobe low. Median sulcus is located slightly posterior to midlength (six-tenths from anterior margin in a representative male valve), and its ventral end is about one-third distance from dorsal margin. Anterior sulcus is similar in length, situated about halfway from median sulcus to anterior margin. A broad flattened border parallels free margin. In female valve, dimorphic pouch extends along antero-ventral and medio-ventral regions for about three-fourths length of valve.

In the illustrated female valve (Pl. 103, fig. 13) there is a rounded spot at ventral end of median sulcus, evidently reflecting the adductor scar.

A male valve measures length 2.5 mm., height 1.45 mm.

Relationships.—The bisulcation and trilobation of *Kloedenia aparchoides* are subdued, giving the species an *Aparchites*-like aspect as compared to more characteristic members of *Kloedenia*. Nevertheless, the trilobation is appreciably developed, and the dimorphic pouch is of normal *Kloedenia* type. The weak trilobation of *K. aparchoides* helps to show that the essentially non-sulcate *Saccarchites saccharis* may with reasonable assurance be accorded membership in the Kloedeninae. The adductor scar marks of

Kloedenia aparchoides and *Myomphalus dor-sinodosus* are comparable to those of *Saccar-chites saccularis*.

The weak trilobation, broad submarginal border and elongate, unequal-ended form provide distinctive specific features for *Kloedenia aparchoides*.

Occurrence.—Lower part of Manlius limestone, quarry near lane ascending eastern side of Trilobite Mountain, New York, and at quarries on Dalton Nearpass farm, New Jersey.

Genus LOPHOKLOEDENIA Swartz
& Whitmore, n. gen.

Shell dorsally truncate, subovoid; hinge margin straight and long; cardinal angles well defined; surface trilobate; median lobe rounded, bordered by subvertical median

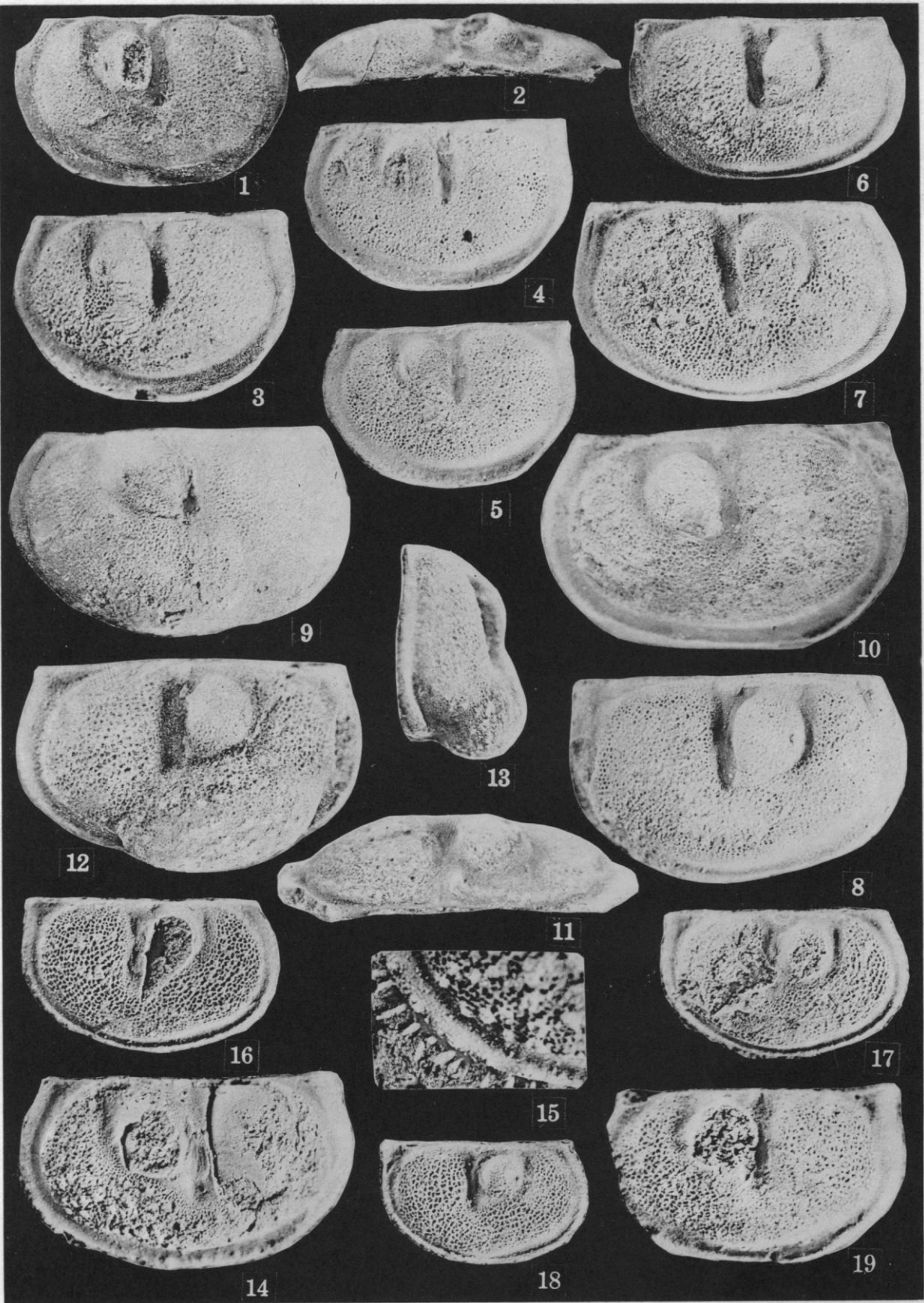
and anterior sulci that extend about half-way from dorsal to ventral margin; anterior and posterior lobes broadly convex, confluent ventrally with broadly convex general surface of valve; dorsal end of anterior lobe continues into a low and narrow ridge or crest that extends posteriorward dorsal to median lobe and terminates at a low node in dorsal part of median sulcus; a narrow flattened border parallels free margins; dimorphic swelling is well defined, antero-ventral in location.

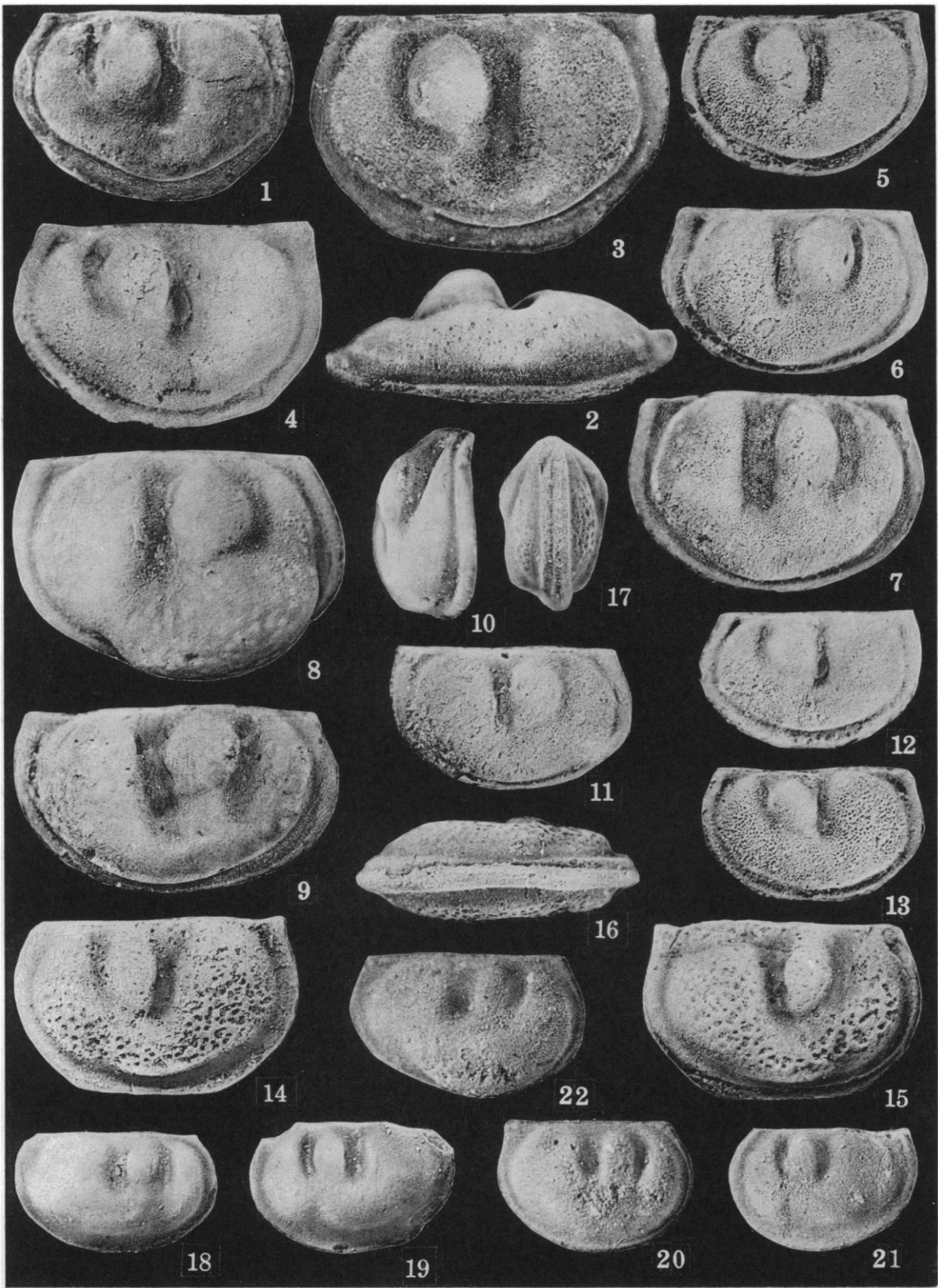
Genotype.—*Beyrichia manliensis* Weller.

Relationships.—The known members of *Lophokloedenia* agree in shell morphology with *Kloedenia* as now understood, except for the narrow dorsal ridge or crest that extends posteriorward from the dorsal end of the anterior lobe and terminates in a

EXPLANATION OF PLATE 107

- FIG. 1-9—*Lophokloedenia manliensis* (Weller). 1,2, Side and dorsal views of the holotype male left valve, $\times 17$ and $\times 22$, respectively, showing the wide border, the regular surface puncta, the small node in the dorsal part of the median sulcus and the low ridge by which it is connected to the dorsal end of the anterior lobe, the vertical sides and gently convex summit of the median lobe. New Jersey Geological Survey Coll. 7341. 3-5. Three male left valves, $\times 20$, showing constancy of form and ornament, the broad ventral section of the border with its medially truncate outline. 6-8. Three male right valves showing narrower border, and the persistently greater length of this valve with greatest height about at midlength. 9. A female left valve, $\times 17$, believed to belong to this species. 1,2, from William Nearpass quarries, New Jersey, 2 to $6\frac{1}{2}$ feet above base of Manlius limestone (2A22); 3, from same quarries, 2 feet above base of Manlius limestone; 4,5,8, from quarries near lane on Dalton Nearpass farm, New Jersey, basal 2 feet of Manlius limestone; 6,7,9, from quarry beside lane on east side of Trilobite Mountain, 1.2 miles northeast of Tristate, Orange County, New York, Manlius limestone 40 feet below lowest exposed beds of Coeymans limestone. (p. 1069)
- 10-13—*Lophokloedenia kummeli* (Weller). 10,11, Side and dorsal views of the holotype male left valve, $\times 17$. The surface ornament is badly clogged with matrix, but some of the pustules surmounting the punctate-reticulate ornament are visible. The pustulose ridge extending from the dorsal end of the anterior lobe to the node in the dorsal part of the median sulcus, is well shown in the dorsal view. New Jersey Geological Survey Coll. 7323. William Nearpass quarries, New Jersey, 8 to 13 feet above base of Manlius limestone (2A24). 12,13, Side and anterior views, $\times 15$, of a female right valve with surmounting pustules especially well developed on the dimorphic pouch. Lane on east side of Trilobite Mountain, 1.2 miles northeast of Tristate, Orange County, New York, Manlius limestone 40 feet below lowest exposed beds of Coeymans limestone. (p. 1070)
- 14-18—*Lophokloedenia eufimbriata* Swartz & Whitmore, n. sp. 14,15, Views of syntypes. 14, A relatively complete male left valve, $\times 17$, showing the elongate form, strong pustules surmounting the reticulate-punctate ornament of the lobes, the pustules of the bordering rim, and the node at the dorsal end of the median sulcus. The rounded mark in the ventral part of the median sulcus may be a reflection of the muscle scar. 15, Post-ventral part of a right valve, $\times 38$, showing the spinelets radiating from the actual edge of the valve. 16-18, Three smaller male right valves, $\times 20$; basal parts of the marginal spinelets are preserved in 16 and 17; lack of coarse pustules in 18 may be due to immaturity. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1071)
- 19—*Lophokloedenia* cf. *L. kummeli* (Weller). A male left valve, $\times 20$. This specimen is suggestive of *L. eufimbriata* in comparative length, and the surface puncta are relatively coarse. However, it agrees with *L. kummeli* rather than *L. eufimbriata* in the non-pustulose rim of the submarginal border, and in the medial straightness of the ventral outline. William Nearpass quarries, New Jersey, $1\frac{1}{4}$ feet below top of Manlius limestone. (p. 1071)





node located in the dorsal part of the median sulcus.

Occurrence.—The three species referred to *Lophokloedenia* occur in the Manlius limestone at the Nearpass quarries, New Jersey, and at Trilobite Mountain and Austin's Glen, New York.

LOPHOKLOEDENIA MANLIENSIS (Weller)

Pl. 107, fig. 1–9

Beyrichia manliensis WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 268, pl. 23, fig. 10.

Kloedenia manliensis ULRICH & BASSLER, 1908, U. S. Nat. Mus., Proc., vol. 35, p. 301, pl. 38, fig. 21. —, BASSLER & KELLETT, 1934, Geol. Soc. Am., Special Paper no. 1, p. 363.

Shell subelliptical to subovate in outline, truncated dorsally by long straight hinge which extends for about nine-tenths of greatest length. Left valve higher than right, presumably to allow for ventral overlap on right valve. Posterior cardinal angle nearly a right angle, sharpened by a slight subjacent emargination. Anterior cardinal angle obtuse. Anterior margin rounded, extending beyond hinge for nearly a tenth of length of valve; in right more than in left valve, anterior margin is fuller below than above midheight. Posterior margin gently curved in upper part, more rapidly rounded below. Ventral margin medially truncate in outline in left but not in right valve. Great-

EXPLANATION OF PLATE 108

- FIG. 1–8—*Kloedenia montaguensis* (Weller). 1–3, The cotype male left valves, with a ventral view of the second specimen; 1 is $\times 17$, 2 is $\times 21$, 3 is $\times 23$. The wide, ventrally truncated marginal border, large median lobe, long median sulcus, and strong ventral zygosity yoking the median and posterior lobes, are well shown. The minute surface punctation is visible in fig. 2, and the surmounting pustules can be observed on the anterior lobe. 4, 5, Two male left valves, $\times 14$ and $\times 16$, respectively; in 4, the deep part of the median sulcus may reflect the adductor location. 6, 7, Two male right valves, $\times 13$ and $\times 21$, respectively, showing proportions of valve, form of ventral zygosity, ventral narrowness of marginal border, and lack of truncation of curvature of ventral margin. In 7, the pustules surmounting the general punctation are well shown on part of the posterior lobe. 8, A female right valve, $\times 10$. The surface pustules are strongly developed, especially on the dimorphic pouch. 1–3, New Jersey Geological Survey Coll. 7336, William Nearpass quarries, New Jersey, beds 2A26, 23 to 35 feet above base of Manlius limestone. Other specimens are also from the Manlius limestone at this locality; 4 is from beds 3 feet below top of Manlius; 5 and 7 are from beds $1\frac{1}{2}$ feet below top; 6 and 8 are from beds 7 to 9 feet below top. (p. 1066)
- 9, 10—*Kloedenia montaguensis* var. *smocki* (Weller). Side and posterior views of the holotype male right valve, $\times 22$, showing the similarity to *K. montaguensis* proper, but the lesser height of the valve and the smooth lobes. The elongation may be due to distortion. New Jersey Geological Survey Coll. 5934, William Nearpass quarries, New Jersey, beds 2A25, 13 to 23 feet above base of Manlius limestone. (p. 1066)
- 11–13—*Kloedenia* cf. *K. montaguensis* (Weller). A “male” right valve and two “male” left valves, $\times 20$. These small specimens probably are immature examples of *K. montaguensis*, but differ appreciably from the larger valves. In 12 and 13 especially, the strong ventral zygosity of typical, larger specimens of *K. montaguensis* is wanting. The right valve, fig. 11, is suggestive of *K. montaguensis* var. *smocki*. Fig. 13 especially shows the surface punctation, and the obliquely directed ventral extension of the median lobe. 11, 12 from William Nearpass quarries, New Jersey, $1\frac{1}{2}$ feet below top of Manlius limestone; 13 from same locality, 2 feet below top of Manlius limestone. (p. 1067)
- 14–17—*Zygobeyrichia barretti* (Weller). Left and right valve views, and ventral and posterior views of the holotype male shell, $\times 26$, showing marginal overlap of left valve on right valve, wider and ventrally truncated submarginal border of left valve, rather narrow median lobe, and the coarse surface puncta. New Jersey Geological Survey Coll. 5933, William Nearpass quarries, New Jersey, beds 2A12, 42 to 48 feet above base of Decker limestone. (p. 1072)
- 18–22—*Zygobeyrichia nearpassi* (Weller). 18, 19, The syntype male right and left valves, $\times 22$, showing details of the smooth-surfaced lobes. The cardinal angles are imperfect. 20, 21, A male right valve and male left valve, $\times 21$, preserving the cardinal angles; 21 shows lack of ventral truncation that characterizes the left valve in *Z. barretti* in fig. 14. 22, A female right valve, $\times 20$, showing form of the dimorphic pouch. 18, 19, New Jersey Geological Survey Coll. 6365, William Nearpass quarries, New Jersey, beds 2A13, 48 to 52 feet above base of Decker limestone; 20 from same locality, 3 feet below top of Decker limestone; 21, 22 from same locality, 2 feet below top of Decker limestone. (p. 1072)

est height in left valve is three-fifths to two-thirds of length; in right valve greatest height tends to be less than three-fifths of length.

Hingement and overlap not directly observed, but from inequality in outline of valves it is reasonably clear that left valve overlaps right along ventral and probably along terminal margins.

Surface of valves moderately convex; surface rises steeply from free edges, then suddenly flattens to form a submarginal border that extends from cardinal angle to cardinal angle; border widens along ventral part of left valve, where surface is sharply inflected at outer edge of border; in right valve, border is narrowed along ventral margin.

Median lobe is rounded, knob-like, rises slightly higher than other lobes, and does not quite reach dorsal margin of valve. Median sulcus lies slightly posterior to mid-length of valve; it is well defined though moderate in width, is straight and subvertical, and reaches about halfway from dorsal to ventral margin. At dorsal end of median sulcus is a well defined node. Anterior sulcus is narrower and shorter than median sulcus, and curves along adjoining margin of median lobe. Anterior lobe is about two-thirds as wide as large posterior lobe; a narrow, low ridge curves posteriorward from dorsal end of anterior lobe and connects to node at dorsal end of median sulcus.

Surfaces of lobes are minutely, rather evenly punctate.

Though males of *L. manliensis* are common to abundant on some of studied slabs, females were not observed except for one example whose reference to the species is rendered somewhat questionable by lack of node at dorsal end of median sulcus. Anterior sulcus is weaker than in observed male valves. Dimorphic pouch is large, lies along and in part overhangs antero-ventral margin of valve, and is poorly defined along its dorsal margin.

The holotype valve measures length 2.5 mm., height 1.6 mm.

Relationships.—*Lophokloedenia manliensis* is closely related to *L. kummeli* (Weller) in general nature of the lobation, character of surface punctation, and notably in presence of the dorsal ridge and its terminal

node. Left valves of *L. kummeli* tend to be appreciably more elongate than those of *L. manliensis*, and nodose thickenings surmount the punctate-reticulate surface ornament.

Occurrence.—The holotype specimen of *Lophokloedenia manliensis* came from beds 2 to 6½ feet above base of the Manlius limestone at the William Nearpass quarries, New Jersey (2A22). The species is common 2 feet above the base of the Manlius, rare 14 feet above the base in new collections from this locality; one specimen 32 feet above the base or 3 feet below the top is questionably referred to the species. *L. manliensis* is common to abundant in the basal half-foot of the Manlius on the Dalton Nearpass farm about a half-mile north of the William Nearpass quarries, and is common in lower Manlius beds, 40 feet below the lowest exposed beds of Coeymans limestone, in a quarry on the east slope of Trilobite Mountain, 2 miles northeast of Tristate, New York.

LOPHOKLOEDENIA KUMMELI (Weller)

Pl. 107, fig. 10–13

Beyrichia kummeli WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 266, pl. 24, fig. 21.

Kloedenia kummeli ULRICH & BASSLER, 1908, U. S. Nat. Mus., Proc., vol. 35, p. 301. —, ULRICH & BASSLER, 1913, Md. Geol. Survey, Lower Devonian, p. 531, pl. 97, fig. 16. —, BASSLER & KELLETT, 1934, Geol. Soc. Am., Special Paper no. 1, p. 363.

Shell more or less subquadrate in outline, with ventral margin of left valve truncate for about half of length of valve and not very divergent from hinge. Greatest height post-median, about three-tenths of length. Hinge line straight for about nine-tenths of length. Posterior cardinal angle about a right angle, set off by a slight subadjacent emargination; anterior angle obtuse but sharp. Anterior margin rounded, projecting beyond hinge about one-tenth length of valve; posterior margin subvertical above, curving into ventral margin below.

Surface of valve moderately convex, rising steeply from free edges and then flattening abruptly to form submarginal border that extends from one cardinal angle to the other. On left valve, outer edge of border

is carinate, slightly upturned along ventral margin.

Median lobe rounded, its summit rising a trifle above summits of other lobes; its diameter is slightly less than a fourth of length of valve; it does not reach dorsal margin. Median sulcus is well marked, moderate in width, subvertical, and extends halfway or scarcely more of distance from dorsal to ventral margin; at dorsal end of sulcus there is a well defined node. Anterior sulcus shorter, shallower and narrower than median sulcus; it tends to curve along adjoining flank of median lobe. Anterior lobe is about two-thirds of width of posterior lobe; it narrows dorsally where it continues into a narrow ridge that extends posteriorward to node at dorsal end of median sulcus. Posterior lobe reaches greatest convexity slightly behind posterior part of median sulcus.

Dimorphic pouch of female valve is almost two-thirds as long as valve. It extends along and overhangs more anterior part of ventral margin; its dorsal margin is moderately well defined.

Surfaces of lobes and of dimorphic pouch are marked by fine, somewhat irregularly shaped pits, separated by narrow reticulations; the reticulations are locally thickened, forming irregular pustules that are especially prominent on dimorphic pouch of illustrated female valve.

The holotype male valve measures length 4 mm., height 2.1 mm.

Relationships.—*Lophokloedenia kummeli* is very close to *L. manliensis* in form of lobes and sulci, presence of the peculiar node at the dorsal end of the median sulcus, and in general nature of the surface puncta. It differs in the proportionately greater length of the left valve, and in the tendency to develop pustules surmounting the general punctate-reticulate surface ornament.

Occurrence.—The holotype specimen of *L. kummeli* came from Weller's horizon 2A24, 8 to 13 feet above the base of the Manlius limestone at the William Nearpass quarries. A few poor specimens from 1½ feet below the top of the Manlius at this locality have been questionably referred to the species. It is represented by excellent but rare examples in lower beds of the Man-

lius, 40 feet below the lowest exposed beds of Coeymans limestone at a quarry on the east slope of Trilobite Mountain, 1.2 miles northeast of Tristate, New York.

LOPHOKLOEDENIA cf. *L.*

KUMMELI (Weller)

Pl. 107, fig. 19

Relationships.—The occurrence of several specimens more or less intermediate in character between *Lophokloedenia kummeli* and *L. eufimbriata*, is exemplified by illustration of a male left valve from the upper part of the Manlius limestone in New Jersey. The specimen resembles *L. eufimbriata* in comparative length of valve and in coarseness of the pustules surmounting the general puncto-reticulation of the surface. However, the pustules that ornament the marginal rim in *L. eufimbriata* are wanting and the ventral margin is less convex in outline.

Occurrence.—Rare 1½ feet below top of Manlius limestone, William Nearpass quarries, New Jersey.

LOPHOKLOEDENIA EUFIMBRIATA Swartz

& Whitmore, n. sp.

Pl. 107, fig. 14-18

Shell elongate, subelliptical to subovate in outline, truncated dorsally by straight hinge that extends about nine-tenths of length of shell. In a large left valve, cardinal angles are sharp but somewhat obtuse; ends are similar in height, their rounding comparatively regular; ventral margin is moderately and fairly regularly convex in outline. In some smaller right valves, questionably referred to species since mature ornament is not fully developed, anterior margin is convexly rounded, fuller below than above; posterior margin is subvertical in upper part, recessive below; ventral margin is regularly curved, fullest anterior to mid-length. Height of shell is about three-fifths of length.

Surface of valve moderately convex, rising steeply from free edges, then flattening to form a submarginal border of moderate width; border has a shallow, inner groove setting off a somewhat elevated outer rim.

Median lobe rounded, rather prominent, not reaching dorsal margin of valve; its diameter is about one-fifth of length of

valve. Median sulcus moderate in width, deepened ventrally; it is situated slightly posterior to midlength of valve and extends subvertically for nearly three-fifths of distance from dorsal to ventral margin; a mark near ventral end of sulcus in one of syntype valves apparently reflects adductor scar; a distinct node occurs in dorsal part of median sulcus.

Anterior sulcus shorter than median sulcus, its narrowed and shallowed ventral part curving along adjoining flank of median lobe. Anterior lobe about two-thirds as wide as posterior lobe, narrowed dorsally where it continues into a low, narrow ridged that connects with node at dorsal end of median sulcus.

Surfaces of lobes are marked by irregularly shaped puncta separated by narrow reticulations; in large specimens, at least, this punctate-reticulate ornament is surmounted by numerous, low but coarse pustules; comparable pustules form a row along elevated outer rim of submarginal border of free edges. In large left valves, tiny subcylindrical spinelets lying about in plane of conjunction radiate outward from actual free edge of valve.

A large male left valve measures length 3.2 mm., height 1.9 mm.

Relationships.—*Lophokloedenia eufimbriata* is named from the tiny spinelets that radiate from the free edges of left valves, at least at mature stages. The spinelets presumably are lacking in right valves, to allow some marginal overlap.

The close relationship of *L. eufimbriata* to *L. manliensis* and especially to *L. kummeli* is evidenced by the general form of the lobes and sulci, and presence of the small node at the dorsal end of the median sulcus. On *L. manliensis*, the surfaces of the lobes are punctate-reticulate, without surmounting pustules, and the border is smooth. On *L. kummeli*, the punctate-reticulate surface detail is surmounted by pustules, somewhat as in *L. eufimbriata*, but the pustules are weaker and less numerous, the border does not bear pustules along its outer rim, and so far as known the radiating spinelets of the free edges of the left valve are not present.

Occurrence.—Fairly common, 2 to 5 feet below top of Manlius limestone, Austin's Glen, New York.

Genus ZYGOBEYRICHIA Ulrich
ZYGOBEYRICHIA BARRETTI (Weller)

Pl. 108, fig. 14-17

Beyrichia barretti WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 254, pl. 23, fig. 9.

Kloedenia barretti ULRICH & BASSLER, 1908, U. S. Nat. Mus., Proc., vol. 35, p. 301. —, ULRICH & BASSLER, 1913, Md. Geol. Survey, Lower Devonian, p. 532, pl. 97, fig. 17.

Male shell subquadrate to almost subpentagonal in outline; hinge line straight, extending about nine-tenths of greatest length; cardinal angles obtuse, with a slight emargination below posterior angle. In left valve, ventral margin is truncate and almost straight for half of shell-length; the truncated section is not quite parallel to hinge. Anterior end extends slightly farther beyond hinge than does the other, so that swing of shell is toward anterior end, though greatest height, equalling about two-thirds of length, is about three-fifths distance from anterior end of shell.

Right valve overlaps left along free margins.

A submarginal, flattened border extends along free edges of each valve, from one cardinal angle to the other; at outer margin of border, which is rounded ventrally, more angulated terminally, the valve wall bends abruptly downward to form flanges by which left valve overlaps on right.

Surface within border moderately convex, rising steeply from ventral part of border, and sloping more gently toward dorsal margin, so that greatest convexity is below midheight, except for elevated summit of median lobe. Median lobe elongated in dorso-ventral direction of shell; its antero-ventral margin is oblique, defined by a moderately abrupt flattening of surface; summit of lobe slopes rather gradually toward hinge. Median sulcus is just posterior to midlength of valve; it is deepened in its ventral part where it extends somewhat below midheight; it is not quite perpendicular to hinge but swings slightly toward anterior end of shell. Anterior sulcus is weaker than median sulcus; its shallow ventral extension curves along flank of median lobe; a shallow depression extends upward from ventral margin, about in line with main part of anterior sulcus, and helps to define the moderately swollen, ventral zygotity that

tends to join ventral parts of posterior and median lobes. Posterior or large lobe nearly twice as wide as anterior lobe.

Surfaces of lobes are marked by irregularly shaped, coarse, flat-floored pits, the intervening reticulate ridges wide, irregular.

The holotype shell measures length 2 mm., height 1.1 mm.

Relationships.—The large, irregularly shaped, flat-floored pits of *Z. barretti* provide a very distinctive character for the species.

The holotype of *Z. barretti* furnishes one of the rare examples of conjoined valves in the Kloedeninae, and is of interest because it gives information about the marginal overlap of the valves. The zygobeyrichiid ventro-median swelling and post-median, subventral furrow are well marked.

Occurrence.—According to Weller's records, the type specimen of *Zygobeyrichia barretti* came from the upper part of the Decker limestone, from the beds numbered 2A12 in his description of the William Nearpass section. These beds are above the range of *Chonetes jerseyensis*. Specimens obtained in Pennsylvania by F. M. Swartz occur in abundance at the base of the *Chonetes jerseyensis* zone of the Keyser limestone.

ZYGUBEYRICHIA NEARPASSI (Weller)

Pl. 108, fig. 18–22

Beyrichia nearpassi WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 255, pl. 23, fig. 7, 8.

Kloedenia nearpassi ULRICH & BASSLER, U. S. Nat. Mus., Proc., vol. 35, p. 301, 304, fig. 55, 56.

—, ULRICH & BASSLER, 1913, Md. Geol. Survey, Lower Devonian, p. 530, pl. 97, fig. 12, 13.

Male shell subelliptical in outline, truncated dorsally by long hinge which is about five-sixths of greatest length of shell. Cardinal angles well defined, anterior angle more obtuse than the other. Posterior margin gently curved in upper part, recessive below; anterior margin more regularly curved, fuller below, extending about twice as far beyond hinge as does posterior margin. Ventral margin moderately convex. Greatest height about two-thirds of greatest length.

A submarginal, flattened border extends

along free margins from one cardinal angle to the other, and is somewhat broader ventrally than along terminal margins; border is wider in left valve than in right; apparently reflecting marginal overlap by left valve.

Surface enclosed by flattened border is moderately convex. Posterior lobe is strongly convex, almost as broad as the other two lobes combined. Median lobe is subglobular, its summit rising about as high as that of posterior lobe, and sloping gradually toward hinge margin. Median sulcus lies almost exactly at midlength, is deepened ventrally, and extends about halfway from dorsal to ventral margin. Anterior sulcus is narrower than median sulcus, curves slightly along flank of median lobe; it does not reach quite to midheight, but passes ventrally into an obscure prolongation that deepens as it extends down the ventral slope.

Surfaces of lobes are smooth.

In a female valve, the antero-ventral dimorphic pouch is moderate in size, not very well defined dorsally, and overhangs marginal border.

A male valve measures length 1.5 mm., height 0.9 mm. A female valve measures length 1.5 mm., height 1.0 mm.

Relationships.—*Zygobeyrichia nearpassi* differs from *Z. barretti* in the convexity in outline of the ventral margin of the left valve, as well as in absence of the strikingly developed pits of ventral surfaces.

Occurrence.—Very abundant in upper 4 feet of Decker limestone, at horizon 2A13 of Weller's section, William Nearpass quarries, New Jersey.

Genus MYOMPHALUS Swartz & Whitmore, n. gen.

Shell dorsally truncate subovoid, the hinge margin straight and long, the cardinal angles well defined. Median sulcus weak, bordered on each side by a rounded knob. Dimorphic pouch poorly defined, elongate, typically extending along middle and anterior parts of ventral margin.

Genotype.—*Myomphalus dorsinodosus* Swartz & Whitmore, n. sp.

Relationships.—*Myomphalus dorsinodosus*, the only species now referable to *Myomphalus*, is somewhat suggestive of *Mes-*

omphalus Ulrich & Bassler in elongation and longitudinal direction of the dimorphic pouch, and the two nodes are suggestive of those shown in the original figures of *Mesomphalus hartleyi*. In *Mesomphalus*, however, the dimorphic pouch is far better defined and is located along the middle of the ventral margin; the node behind the median sulcus has proven to be very weak; the node shown by the artist in front of the median sulcus is obscure if not non-existent; furthermore, male valves of *Mesomphalus* have a peculiar longitudinal crease that is lacking in *Myomphalus dorsinodosus*. *Myomphalus dorsinodosus* is probably best regarded as a peculiar, not truly lobate offshoot of *Kloedenia*; *K. aparchoides* of the present paper appears to be a comparatively close relative, even though it preserves the trilobation of *Kloedenia* and lacks subdorsal nodes of the type present in *dorsinodosus*.

The name *Myomphalus* has been used in recognition of the strong muscle marks of the two figured female valves of *M. dorsinodosus*.

Occurrence.—Rare to common near base of Manlius limestone, Dalton Nearpass farm, New Jersey, and quarry on east side of Trilobite Mountain, New York.

MYOMPHALUS DORSINODOSUS Swartz
& Whitmore, n. sp.
Pl. 103, fig. 15-17

Male shell subovate in outline, truncated dorsally by straight hinge extending about three-fourths of greatest length. Cardinal angles about equally obtuse, fairly well defined. Anterior end higher than posterior, more broadly rounded and extending slightly farther beyond hinge; posterior end recessive below. Ventral margin moderately convex. Greatest height lies about two-fifths of distance from anterior end, and is about seven-tenths of length. Details of hinge and overlap not determined.

Surface of valve moderately convex, with a narrow, submarginal flattening or border along free edges. Two small, rounded nodes occur near dorsal margin, one on each side of weak median sulcus; more posterior node is slightly posterior to midlength and lies close to dorsal margin; more anterior node is slightly smaller, lies just anterior to midlength, is farther from dorsal margin, and in figured male valve has an oblique depres-

sion along its antero-dorsal margin. In each of two figured female valves, there is a circular spot about one-third below dorsal margin, directly below the depression or obscure median sulcus located between dorsal nodes; the spot is circumscribed by a depressed line, and evidently is an external reflection of adductor scar of inner surface of valve.

In female valves there is a large ventral dimorphic swelling, its longitudinal axis roughly parallel to that of valve; anterior end of swelling extends to anterior end of valve; posterior end is about one-quarter of distance from posterior end of valve. Dorsal margin of the swelling is very poorly defined; ventrally, the swelling overhangs edge of valve.

Surface of valve is ornamented by very obscure, distant granules.

The figured male valve measures length 1.8 mm., height 1.1 mm. The large female valve measures length 2.3 mm., height 1.5 mm.

Relationships.—*Myomphalus dorsinodosus* is *Kloedenia*-like in general form of valve, straightness of hinge and form of dimorphic pouch, and is clearly a member of the Kloedeninae. However, the bisulcation and trilobation of *Kloedenia*-type are obscure, and the two dorso-submedian knobs seem to be unmatched in previously described Kloedeninae.

Occurrence.—Rare in basal 2 feet of Manlius limestone, Dalton Nearpass farm section, Wallpack Ridge, New Jersey; rare in Manlius limestone 40 feet below lowest exposed Coeymans limestone, at a quarry near road up the east side of Trilobite Mountain, 1.2 miles northeast of Tristate, New York.

Genus WELLERIOPSIS Swartz
& Whitmore, n. gen.

Trilobed, *Welleria*-like Kloedeninae, in which dimorphic pouch forms a sausage-like swelling that extends virtually the entire length of ventral part of female valve, and tends to be fairly well defined along its upper margin. Dorso-median lobe rounded, knob-like, not reaching dorsal margin of valve; median sulcus well defined; anterior sulcus almost obsolete; a narrow border parallels free margins.

Genotype.—*Welleriopsis diplocystulis* Swartz & Whitmore, n. sp.

Relationships.—Male valves of *Welleriopsis* have the appearance of *Welleria* Ulrich & Bassler, 1923, but the dimorphic pouch of the female valve is much more elongate, is ventro-median rather than antero-median in location, and is more or less defined along its dorsal margin. *Welleria* was proposed, on the other hand, because in *Welleria obliqua* Ulrich & Bassler, 1923, of the Tonoloway of Maryland, the female pouch is an undefined swelling, comparable in size and location to the pouch of *Kloedenia*, but lacking dorsal definition. The undefined pouch of *Welleria obliqua* occupies only about half of length of valve.

An elongate subcylindrical, ventrally located dimorphic pouch somewhat like that of *Welleriopsis*, occurs in *Mesomphalus* Ulrich & Bassler, 1913, but in that genus the median lobe is very poorly defined and a longitudinal crease or furrow marks the ventral slope of the posterior lobe.

Occurrence.—Decker and Manlius limestones of New Jersey; questionably from the Keyser limestone in West Virginia.

WELLERIOPSIS DIPLOCYSTULIS Swartz
& Whitmore, n. sp.

Pl. 105, fig. 9-13

Shell relatively short, subelliptical to almost subquadrate in outline; hinge margin straight, extending nearly nine-tenths of greatest length. Anterior angle obtuse; posterior cardinal angle more nearly a right angle. Posterior margin subvertical and very gently convex in upper two-thirds, then curving more rapidly to the moderately convex, ventral margin. Anterior margin broadly convex, projecting beyond hinge for about one-tenth of valve length. Height of male valve nearly two-thirds of length.

Surface of valve rather strongly convex, reaching its maximum in antero-median part of large, posterior lobe, except for the still more highly elevated summit of median lobe. Median lobe does not reach dorsal margin of valve; it is moderate in size, slightly oblique. Median sulcus extends a trifle below midheight of valve; it is subvertical, well defined, its ventral tip curving slightly around median lobe. Anterior sulcus about obsolete, appearing only as a faint, slightly depressed line curving along flank of median lobe. Posterior lobe broad, the descent to median sulcus abrupt. A nar-

row border parallels free edges of valve, and is defined on its inner and outer sides by shallow grooves.

Dimorphic pouch of female valve strongly elevated, extending almost full length of valve; its dorsal margin is well defined, and lies near midheight of valve, being a little higher anteriorly than posteriorly; dorsal margin of pouch is indented beneath median lobe, tending to separate pouch into two parts. Pouch overhangs ventral margin of valve.

Surfaces of lobes finely punctate-reticulate.

A male valve measures length 0.98 mm., height 0.62 mm.; a female valve measures length 1.24 mm., height 0.84 mm. There are about 4 surface puncta in 0.1 mm.

Relationships.—*Welleriopsis diplocystulis* approaches *W. jerseyensis* (Weller) in outline and character of lobation; but the surface is finely punctate-reticulate rather than smooth, and the median lobe proportionately smaller but more elevated.

Occurrence.—Common 32, 33, and 33½ feet above base of Manlius limestone, William Nearpass quarries, New Jersey.

WELLERIOPSIS JERSEYENSIS (Weller)
Pl. 105, fig. 14-16

Beyrichia jerseyensis WELLER, 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 255, pl. 23, fig. 5.

Kloedenia jerseyensis ULRICH & BASSLER, 1908, U. S. Nat. Mus., Proc. vol. 35, p. 301.—, BASSLER & KELLET, 1934, Geol. Soc. Am., Special Paper no. 1, p. 362.

Male shell subovoid in outline, truncated dorsally by straight hinge that extends slightly more than three-fourths of greatest length. Posterior cardinal angle fairly sharp, slightly obtuse; anterior angle much more obtuse. Posterior margin nearly straight in upper part, curving more rapidly near midheight and swinging into gently convex ventral margin. Anterior margin strongly curved, fullest below, extending beyond hinge for about a sixth of valve-length.

Surface of valve moderately convex; greatest convexity occurs on posterior lobe just posterior to lower end of median sulcus, except for the slightly more elevated summit of median lobe. Median lobe subquadrate, not more than moderately elevated, its summit highest posteriorly; it is relatively large, its diameter about a fourth of valve

length; dorsal margin of median lobe is about one-fifth distance below hinge margin. Median sulcus is slightly posterior to mid-length; it extends as a narrow, moderately deep furrow from hinge for nearly two-thirds distance to ventral margin, with a slight anteriorward curve in its lower part. Anterior sulcus nearly obsolete, represented by an abrupt flattening which defines upper part of anterior margin of median lobe, whence a shallow vestigial depressed line extends toward hinge margin.

A low submarginal ridge parallels free edges, and is defined on both its inner and outer sides by shallow grooves. A narrow, low ridge also crosses post-dorsal corner of posterior lobe close to posterior cardinal angle.

Surface in finely preserved material is devoid of fine detail.

The holotype valve measures length 2.2 mm., height 1.4 mm.

Relationships.—Female examples of *W. jerseyensis* proper have not been discovered; but in the closely related variety, *W. j. var. microreticulis*, the dimorphic pouch has the exceptionally elongate, subcylindrical form observed in *Welleriopsis diplocystulis*, and its dorsal margin is indented below the median lobe. The male valves of *W. jerseyensis* approach those of *W. diplocystulis* in form, but are less subquadrate, the posterior end more extended beyond the hinge; furthermore, the median lobe is distinctly larger and not so strongly elevated, and the surface is smooth rather than finely punctate.

Occurrence.—Rare in upper 4 feet of Decker limestone, in 2A13 of Weller's section, William Nearpass quarries, New Jersey. The species has been reported from the Keyser limestone, one mile west of Tomahawk, West Virginia, but this record will need to be rechecked, with discovery of female as well as male valves.

WELLERIOPSIS JERSEYENSIS
var. MICRORETICULIS
Swartz & Whitmore, n. var.
Pl. 105, fig. 17-20

Male valves closely similar in outline and form and convexity of lobes to those of *Welleriopsis jerseyensis* proper; but surface is very minutely punctate-reticulate, and

median lobe tends to be more rounded with median sulcus shorter and more curved. Posterior cardinal angle may prove to be somewhat sharper.

On a large female valve, dimorphic pouch is elongate, occupying full ventral half of valve, and overhanging ventral edge. Dorsal margin of pouch is weakly defined, though discernible; it is distinctly indented below median lobe.

A male valve measures length 1.82 mm., height 1.12 mm. The large figured female valve measures length 2.38 mm., height 1.54 mm. There are about 6 surface puncta in 0.1 mm.

Relationships.—The variety *W. j. var. microreticulis* is very close to *Welleriopsis jerseyensis* proper, and may prove to be questionable in value. Tentatively at least it is thought wise to call attention to its slight differences, since its valves from the basal part of the Manlius are persistently though very minutely punctate, whereas no such ornament is observable on the finely preserved *W. jerseyensis* specimens from the upper part of the Decker limestone. The slightly shorter and more curved median sulcus may also prove to have value, although all these small differentials need confirmation through future collecting.

As compared to the minutely punctate *W. j. var. microreticulis*, *Welleriopsis diplocystulis* of higher parts of the Manlius is more distinctly punctate, and the median lobe is smaller in diameter and more elevated.

Occurrence.—Common 2 feet above base of Manlius limestone, William Nearpass quarries, New Jersey.

Genus MESOMPHALUS Ulrich & Bassler

The genus *Mesomphalus* was proposed by Ulrich & Bassler (1913), using as the genotype *M. hartleyi* Ulrich & Bassler of the Keyser limestone of Maryland. Especially characteristic of the genus is an elongate, sausage-shaped dimorphic pouch, extending along the middle half or more of the ventral margin. As originally figured, *M. hartleyi* has a short submedian sulcus bordered at about midheight of the valve by one node on its anterior side, another on its posterior side. The valve surface is reticulose-papillose.

Among the ostracodes of the Decker, Manlius, and Coeymans at the Nearpass quarries and Austin's Glen are a number of species with the mesomphalid type of dimorphic pouch. These ostracodes have a peculiar longitudinal furrow that creases the ventral slope of the large, posterior lobe and in some instances extends across the anterior lobe as well. There is no more than a faint suggestion of a median lobe anterior to the median sulcus. Specimens with the same ventral crease occur in collections of F. M. Swartz from the upper part of the Keyser limestone in Virginia.

Because of the peculiar crease and lack of nodes of the type illustrated for *Mesomphalus hartleyi*, the new species were for a time thought to represent a new genus. However, Miss Jean Berdan, who was provided with photographs of our species for use in her studies of Manlius ostracodes in the Yale collections, re-examined the type of *Mesomphalus hartleyi* and has advised us that that species has a longitudinal crease and that the node before the sulcus is weak, the node posterior to it scarcely perceptible if not wholly wanting. The *M. hartleyi* specimens were subsequently examined by F. C. Whitmore, Jr.

Redescription.—On the basis of this information about *M. hartleyi*, and using also the species described in the present report, *Mesomphalus* can be redescribed as follows:

Shell subovate to subrhomboidal, truncated dorsally by long straight hinge. A well defined, subvertical median sulcus extends about halfway from dorsal to ventral margins, and is weak in its upper part; in front of this sulcus, a median lobe tends to be obscurely developed, set off by a faint anterior sulcus-like depression. In male valve, a narrow crease or depressed line extends length-wise valve, crossing part of ventral slope of posterior lobe; a faint extension of this furrow crosses anterior lobe in some species. A low rim parallels free edges; in some examples ventral part of rim is expanded and forms a narrow, ventral frill. In female valve, there is a well defined, ventro-median dimorphic pouch elongated length-wise valve.

Genotype.—*Mesomphalus hartleyi* Ulrich & Bassler.

Relationships.—The weakly trilobate sur-

face, longitudinal crease, and longitudinally elongate, strongly convex, medio-ventral dimorphic pouch are distinctive features of *Mesomphalus*.

The ventral frill of some valves of *Mesomphalus* is not, so far as is now known, internally compartmented in the manner characteristic of *Velibeyrichia* and its closer allies. The frill may prove to be a structure of immature female valves, that in adult females is expanded to form the dimorphic pouch. In some well-preserved valves lacking the dimorphic pouch, a ventral frill is definitely absent.

An elongate, ventral dimorphic pouch, suggestive of that of *Mesomphalus* but less elevated, is characteristic of the new genus, *Welleriopsis*. *Myomphalus* also has an elongate, but still less well defined ventral pouch.

Because the ventral frill may not be a true character of male valves, and since it seemingly lacks the internal compartmentation of velibeyrichiid type, *Mesomphalus* is for the present referred to the Kloedeninae and not to the Beyrichiidae.

Occurrence.—Late Silurian and earliest Devonian of Maryland, Virginia, New York, New Jersey.

MESOMPHALUS RHOMBOIDALIS

Swartz & Whitmore, n. sp.

Pl. 105, fig. 1-4

Shell elongate subrhomboidal in outline, length nearly twice height in observed male valves. Hinge straight for about eight-ninths of greatest length. Anterior cardinal angle obtuse; posterior angle about a right angle. Anterior margin rounded, fullest below, extending beyond hinge; posterior margin not extending appreciably beyond hinge, recessive in its lower part. Ventral margin gently convex, fuller in anterior half. Edges of valve lie in a plane.

Surface of valve moderately convex, rising steeply in male valves from free edges to a narrow submarginal border, which in a few specimens is expanded ventrally to form a thin, narrow frill. Median sulcus narrow but well marked; it lies about at mid-length and extends nearly three-fifths of distance from dorsal to ventral margin. Anterior to median sulcus is a low, obscure median lobe that is moderate in width and

does not reach dorsal margin. There is no more than a faint suggestion of an anterior sulcus.

A narrow crease or furrow extends posteriorward from beneath median sulcus, for about two-thirds distance across ventral slope of posterior lobe; crease is slightly curved, roughly paralleling adjacent part of ventral margin.

In female valve, dimorphic pouch is four-fifths as long as valve; its width in direction of height of valve is less than half its length; its ends are bluntly rounded, its dorsal margin slightly concave in outline; it is sharply defined dorsally and terminally; it lies along and overhangs ventral margin, and extends almost as close to anterior as to posterior end of valve.

Surfaces of lobes bear numerous small puncta; interspaces are about twice as wide to four times as wide as diameters of puncta and are minutely granulose.

A male valve measures length 1.27 mm., height 0.92 mm.; a female valve measures length 1.4 mm., height 0.77 mm.

Relationships.—New studies of *Mesomphalus hartleyi* Ulrich & Bassler, 1913, are needed to more fully establish its characters and to provide a basis for detailed comparisons with the *M. rhomboidalis* and *M. striatellus* of this paper.

In the specimens of *Mesomphalus rhomboidalis* from the uppermost Decker at the Nearpass quarries, the surface pits usually are numerous, so that the width of the interspaces is commonly about twice as wide as the diameters of the pits. In some specimens, however, there are fewer pits, so that the interspaces are distinctly wider.

Mesomphalus rhomboidalis is more elongate than *M. striatellus* Swartz & Whitmore, n. sp., and lacks the extensions of the longitudinal furrow that are found in the latter species.

Occurrence.—Moderately common 2 feet below top of Decker limestone, William Nearpass quarries, New Jersey.

MESOMPHALUS STRIATELLUS Swartz
& Whitmore, n. sp.
Pl. 105, fig. 5-7

Shell somewhat subovoid in outline, truncated by straight hinge which extends for about three-fourths of greatest length.

Cardinal angles well defined, anterior angle more obtuse than the other. Anterior margin rounded, slightly fuller below than above, extending beyond hinge about twice as far as does posterior margin, which is slightly lower, rounded, somewhat recessive in its lower part. Ventral margin gently convex. In male valve, greatest height is postmedian, about six-tenths of length. Edges lie in a plane.

Surface of valve moderately convex, rising steeply in male valves from free edges to a narrow submarginal border defined on its inner side by a distinct furrow. In holotype male valve, at least, it is reasonably clear that ventral part of border was not expanded as a frill. Median sulcus is narrow; it lies slightly posterior to midlength; it does not reach dorsal margin; its ventral end is situated about three-fifths of distance below dorsal margin. Anterior to median sulcus, there is an obscurely defined, weak median lobe, not reaching dorsal margin; there is only a faint suggestion of an anterior sulcus.

Beginning below median lobe, a narrow crease or furrow extends posteriorwards for three-fourths or more of distance across posterior lobe, curving upwards posteriorly; anteriorly, a faint extension of crease curves upward toward anterior cardinal angle.

In female valve, dimorphic pouch is well defined, sausage-shaped with ends bluntly rounded, its length more than twice its breadth; it extends along and overhangs ventral margin.

Surfaces of lobes are minutely granulose and bear a few scattered puncta.

The holotype male valve measures length 1.27 mm., height 0.78 mm.

Relationships.—No trace of the upcurved, anterior extension of the longitudinal crease or stria of *M. striatellus* has been observed in *Mesomphalus rhomboidalis*. *M. striatellus* also is proportionately shorter and higher than *M. rhomboidalis*.

The longitudinal crease or furrow of *M. striatellus* is reminiscent of the grooves that parallel the free margins of the valves in species of *Ectodermites*, *Eridoconcha*, *Schmidtella*, *Conchoprimitia* and *Conchoprimites*, and that have been interpreted as edges or impressions of edges of early stage molts. (Cf. Levinson, 1951; Henningsmoen, 1954b).

Whether or not the longer crease or furrow of *Mesomphalus striatellus* and the shorter crease of *M. rhomboidalis* actually were developed in this fashion, the feature appears to be sufficiently persistent in character from specimen to specimen so that it can be employed in specific determinations.

Occurrence.—*Mesomphalus striatellus* is common 2 to 5 feet below top of Manlius limestone, Austin's Glen, New York. A somewhat more subquadrate variety is rare at 8 to 15 feet above base of Coeymans limestone, William Nearpass quarries, New Jersey.

MESOMPHALUS sp.
Pl. 105, fig. 8

A specimen found in slabs collected near the top of the Manlius limestone at the Nearpass quarries, is suggestive of *Mesomphalus striatellus* in sparseness of surface pits, but differs in lack of an observable, anteriorward extension of the longitudinal crease as well as in greater prominence of the postdorsal region of the valve. The specimen is slightly smaller than the holotype of *M. striatellus*, measuring length 1.0 mm., height 0.6 mm., as compared to length 1.27 mm., height 0.78 mm. The specimen is illustrated as an aid to future investigations of the Manlius mesomphalids.

Occurrence.—Rare 1½ feet below top of Manlius limestone, William Nearpass quarries, New Jersey.

Genus SACCARCHITES Swartz
& Whitmore, n. gen.

Shell subovoid, truncated dorsally by straight hinge which is somewhat shorter than greatest length of shell; cardinal angles well defined; presumed anterior end higher and more broadly rounded than posterior; in a fragment of one shell, the questionably identified left valve overlaps right along free margins.

Surface of valve convex, not umbonate; sulci are not appreciably developed, although faint depressions visible with favorable cross-lighting may give an obscure suggestion of a dorso-submedian sulcus and in some specimens of an anterior sulcus, corresponding in position to the sulci of *Kloedenia*. On some well preserved valves, an external sub-ovoid median spot reflects

location of adductor scar of inner surface. A low submarginal angulation borders free edges.

Female valve has a large, poorly defined dimorphic swelling that parallels and overhangs anteroventral margin.

Genotype.—*Saccarchites saccularis* Swartz & Whitmore, n. sp.

Relationships.—In form of shell, essentially non-sulcate surface and inconspicuous submarginal angulation, male valves of *Saccarchites saccularis* are reminiscent of the genus *Aparchites*. The proposed name has been chosen to emphasize both this similarity and the differentiating presence of the dimorphic "sac" or pouch, of which no counterpart is now known in *Aparchites*. Relationship to *Kloedenia* rather than to *Aparchites* is suggested by the form and location of the pouch, and by the very faint depressed lines of the genotype that correspond to kloedenid sulci. *Saccarchites saccularis* appears to be a kloedenid in which the suppression of sulci observed in *Kloedenia aparchoides* is carried farther toward completion.

Structures comparable in many ways to those of *Saccarchites saccularis* are displayed by *Phlyctiscapha rockportensis* Kesling (1953) and *P. apleta* Kesling (1954), of Middle Devonian formations of Michigan. These species likewise are straight hinged, unequal ended, non-sulcate, with an inconspicuous angulation paralleling the free edges, and somewhat like *Saccarchites saccularis* have in one dimorph a poorly defined but comparatively large swelling that parallels and overhangs one ventro-terminal margin. Unlike the dimorphic swelling in *Saccarchites saccularis*, however, the swelling in *Phlyctiscapha rockportensis* and in *P. apleta* occurs toward the narrowly rounded or antiplenate end of the valve rather than toward the more broadly rounded or plenate end, and is accordingly considered by Kesling to be postventral in *Phlyctiscapha* on the same basis of comparative plenation of the ends of the shell that leads to the supposition that the pouch is anteroventral in *Saccarchites*. More objectively, perhaps, it can be said that if the more broadly rounded or plenate ends of the shells of the two genera represent equivalent ends of the original animals, whether anterior or posterior, then

the dimorphic swellings occur toward opposing ends of the shells; whereas if the dimorphic swellings of both genera occur at equivalent ends in terms of the original animals, then the comparative plication of the ends of the shells is reversed and there should have been corresponding differences in relative development of the cephalic as contrasted with the more posterior parts of the animals. Whichever of these alternative conditions may be correct, differentiation on at least the generic level appears to be justified.

Occurrence.—*Saccarchites saccularis* and some comparable forms that require further study, occur in the Late Silurian Manlius limestone of eastern New York and northwestern New Jersey.

SACCARCHITES SACCULARIS Swartz
& Whitmore, n. sp.
Pl. 103, fig. 18,19

Shell dorsally truncate, subovate in outline; dorsal margin straight for about four-fifths of greatest length; cardinal angles distinct, subequally obtuse; anterior margin somewhat higher and more broadly rounded than posterior margin, generally projecting somewhat farther beyond limits of hinge; greatest height about two-thirds of greatest length, located about at midlength of shell; ventral margin more convex anteriorly than posteriorly. Hinge surface not seen, but valves are equal externally in vicinity of hinge; in one fragment of a shell, free edge of questionable left valve laps over free edge of other valve.

Surface of male valve broadly convex, not umbonate, the greatest convexity about one-third of greatest length and located one-third or slightly more of distance from posterior end; a low angulation parallels free edges and sets off a narrow flattened submarginal border on anterior and posterior ends but not ventrally; some valves preserve an ovoid submedian mark that evidently reflects adductor scar of inner surface; midpoint of mark is slightly above and anterior to midpoint of valve; mark is dorsally acuminate, its point of acumination slightly more posterior in location than is midpoint of mark; dorsal to point of acumination of mark is a very faint depressed

line that appears to be a vestige of a dorso-submedian sulcus, and in some valves there is an even more obscure depression about halfway farther toward anterior cardinal angle; in two observed internal molds of male valves, both of weak external depressions are represented by more distinct though shallow grooves, evidencing some thickening of floors of depressions, and in dorso-submedian groove there is a small rounded pit located about one-fifth distance above dorsal margin of impression of adductor scar, that represents an elevated point on inner surface of valve.

In female valve, a large and poorly defined dimorphic swelling borders and overhangs anteroventral margin; anterodorsal end of swelling is about one-sixth distance below anterior cardinal angle, ventroposterior end is nearly three-quarters distance from anterior end of valve.

Surface of valve and of dimorphic swelling, but not of adductor mark and border, bears minute pits, numbering about 5 in 0.2 mm., the interspaces flat and three to four times as wide as pits.

The syntype male and female valves each measure approximately length 1.8 mm., height 1.25 mm.

Relationships.—The form and position of the dimorphic pouch or swelling of *Saccarchites saccularis*, and the faint dorso-submedian and more anterior depressed lines that appear to represent kloedenid sulci, support the view that the species is a fairly close relative of members of *Kloedenia*.

Associated with the specimens having the proportions of the illustrated syntype male valve of *Saccarchites saccularis*, are other valves of lesser height in which a characteristic example measures length 1.7 mm., height 1.0 mm., so that ratio of length of height is about 1.7 to 1 as compared to 1.5 to 1 in *S. saccularis*. So far as now known, the greater comparative length reflects natural growth rather than post-depositional deformation, and among observed specimens the group does not show continuous variance with normal *S. saccularis*. In further work it may prove desirable to treat the elongate specimens as representatives of a distinct species. No pouch-bearing dimorph of comparable outline has been ob-

served in the present study, and external marks and vestiges of kloedenid sulci are obscure or wanting. In some of the specimens, the terminal submarginal borders are comparatively wide.

Another kind of variant is represented by an additional valve in the Austin's Glen collections, in which the size and shape are comparable to those of the male syntype of *Saccarchites saccularis* but the surface puncta are stronger and more numerous, and there is little evidence of an external adductor mark or of the vestiges of kloedenid sulci.

Occurrence.—*Saccarchites saccularis* is represented by five specimens of characteristic aspect from the beds 2 to 5 feet below the top of the Manlius limestone at Austin's Glen, and by one specimen from 15 feet below the top of the Manlius at the William Nearpass quarries. Seven additional specimens from Austin's Glen and three from 1½ to 2 feet below the top of the Manlius at the William Nearpass quarries, belong to the unnamed elongate form. Saccarchitid valves in which the puncta are coarser than is normal for *S. saccularis* include the one specimen from Austin's Glen and several from the basal foot of the Manlius limestone at the Dalton Nearpass quarries.

Genus PHLYCTISCAPHA Kesling

PHLYCTISCAPHA? sp.

Pl. 103, fig. 20

Relationships.—In addition to the normal examples of *Saccarchites saccularis* and the valves of the unnamed variant of comparable length but lesser height, the collections from both Austin's Glen and the Nearpass quarries include other *Saccarchites*-like specimens that are smaller and comparatively short and high, the length and height in several representative examples measuring respectively 1.4 and 1.0 mm., 1.3 and 0.95 mm., and 1.1 and 0.8 mm. In some the inequality of the ends is as marked as in the valve illustrated in Pl. 103, fig. 20, in others the ends are more equal although the direction of swing shown in the illustrated valve tends to be maintained. The maximum convexity of these valves is about half the height and generally is located about one-third the distance from the plicate or "anterior" end, whereas the maximum con-

vexity is about one-third the distance from the antiplicate or "posterior" end in *Saccarchites saccularis*. Adductor marks have not been discovered in the small specimens, and no trace of kloedenid sulci has been observed.

It is possible that some of the small specimens of the collections may represent immature instars of *Saccarchites saccularis*. However, three well-preserved valves from the Nearpass quarries, measuring about 1.3 mm. in length and 1 mm. in height, bear dimorphic pouches and thus must be considered to be adult specimens. In these valves, the pouch occurs along and overhangs the ventro-antiplicate or "post-ventral" margin rather than along the ventro-adplicate or "antero-ventral" margin as in *Saccarchites saccularis*; the valves thus agree in location of the dimorphic pouches with *Phlyctiscapha* Kesling, 1953, and as in *P. rockportensis* Kesling and *P. apleta* Kesling the pouches merge "postdorsally" with the general convexity of the valve, but are better defined along the "anterior" margin by an escarpment-like drop or semisulcus. The small specimens from Austin's Glen and the Nearpass quarries are hence listed under the term, *Phlyctiscapha?* sp., pending future preparation of photographs of the pouch-bearing valves.

Information about muscle scar location would be desirable in *Phlyctiscapha?* sp., as a further check on relative orientation as compared to *Saccarchites saccularis*. It is not impossible that the difference with respect to the original animals is one of direction of plication rather than of reversal of location of the dimorphic pouches and place of maximum convexity. Such considerations will affect eventual interpretation of the biologic relationships of the two forms.

Occurrence.—The non-pouched valve of *Phlyctiscapha?* sp. that is illustrated in Pl. 103, fig. 20, was obtained in beds 7 to 9 feet below the top of the Manlius limestone at the William Nearpass quarries, New Jersey. Two well-preserved pouch-bearing specimens were obtained 2 feet below the top of the Manlius at the same locality, and a third was found at 15 feet below the top. Nonpouched valves are fairly common at 2 feet, 3 feet and 15 feet below the top of

the Manlius at the William Nearpass quarries, and also in the beds 2 to 5 feet below the top of the Manlius at Austin's Glen.

Genus BOLBIPRIMITIA Kay
BOLBIPRIMITIA LIMBATA Swartz &
Whitmore, n. sp.
Pl. 104, fig. 13-17

Shell moderately elongate, subovoid in outline, truncated dorsally by straight hinge that extends about eight-ninths of greatest length. Anterior cardinal angle obtuse, posterior angle about a right angle or slightly acute. Anterior margin broadly and rather regularly rounded; posterior margin tends to be somewhat recessive in lower part; ventral margin convex. Greatest height including frill averages about two-thirds of greatest length. Hingement and overlap not observed.

Valve moderately convex; greatest convexity is just below midheight in posterior lobe. Median sulcus is narrow, lies anterior to midlength, and extends between points respectively about one-quarter and one-half distance below dorsal margin of valve. An obscure swelling anterior to median sulcus is suggestive of a median lobe. A frill or flange of moderate width extends along free margins; it is not radially striate, and inner compartmentation of velibeyrichiid type has not been observed. In female valves, there is a longitudinally elongate, ventro-median dimorphic swelling that joins with ventral part of posterior lobe in a cornucopia-like fashion.

Surface of valve where enclosed by frill is coarsely reticulate, the pits somewhat irregular in shape and without regular arrangement. Surface of dimorphic pouch of female valve is more finely pitted.

A characteristic male valve measures length 0.9 mm., height 0.6 mm. A female valve measures length 1.1 mm., height 0.7 mm. One male valve that is illustrated on an accompanying plate is unusually elongate, the ratio of height to length being 0.55 to 1 as compared to ratios of 0.65 and more to 1 in more typical specimens. The difference in ratio may have resulted from distortion during compaction of the sediment, rather than from differing growth.

Relationships.—The dimorphic pouch of *Bolbiprimitia limbata* joins with the pos-

terior lobe in cornucopia-like form as is true in the genotype, *B. fissurella* (Ulrich & Bassler). The marginal frill or flange is stronger than in previously described species of the genus, but so far as known does not have the inner compartmentation that characterizes the frills of *Velibeyrichia* and its allies. *Bolbiprimitia teresaccula*, described on following pages, has a smooth and not a punctate dimorphic pouch.

Occurrence.—Common 2 feet above base of Manlius limestone, William Nearpass quarries, New Jersey. Also fairly common 3 feet and 7 to 9 feet below the top of the Manlius at the same locality.

BOLBIPRIMITIA TERESACCUA
Swartz & Whitmore, n. sp.
Pl. 104, fig. 18

Shell subovate in outline, truncated dorsally by straight hinge that extends for about nine-tenths of greatest length. Anterior cardinal angle obtuse, posterior angle a right angle or slightly acute. Anterior margin broadly and regularly rounded; posterior margin somewhat recessive below. In the single known female valve on which species is founded, height is three-fourths of length. Hingement and overlap not observed.

Female valve rather strongly convex; greatest convexity except for dimorphic pouch is in posterior lobe about at midheight of valve. A flattened border or shoulder extends along terminal margins, and presumably would be continuous ventrally in male valves. Median sulcus is represented by a rounded umbilicus-like depression slightly anterior to midpoint of valve. Female dimorphic pouch is strongly swollen, extends along ventral margin for about five-sixths total length of valve, and merges posteriorly with ventral part of posterior lobe.

Surface of dimorphic pouch is smooth; otherwise lobate area enclosed by marginal border is coarsely reticulate, the pits somewhat irregular in shape and without regular arrangement.

The holotype female valve measures length 1.0 mm., height 0.75 mm.

Relationships.—The surface puncta of *Bolbiprimitia teresaccula* resemble those of *B. limbata* in size, irregular shape, and lack

of well-defined arrangement. The female dimorphic pouch, however, is smooth-surfaced and not punctate, is more elongate and more swollen; the median sulcus is an umbilicus-like depression instead of a vertically elongated cleft; the valve is somewhat more swollen in the region of slope to the hinge; and the shell is proportionately less elongate.

Occurrence.—The holotype female valve and only known specimen comes from 2 to 5 feet below the top of the Manlius limestone at Austin's Glen, New York.

Family KLOEDENELLIDAE

Ulrich & Bassler

Genus EUKLOEDENELLA

Ulrich & Bassler

EUKLOEDENELLA CICATRIX Swartz

& Whitmore, n. sp.

Pl. 109, fig. 1-3

Male shell subrectangular in outline. Hinge margin slightly sinuate in right valve due to low, post-median dorsal crest; anterior cardinal angle rounded; posterior cardinal angle more distinct but obtuse. Anterior margin regularly convex in outline, rounding gradually into gently curved ventral margin; posterior margin gently convex in outline, bending rapidly to ventral margin.

Surface of valve moderately convex. Median sulcus is moderate in size and depth, extends to about one-third distance below dorsal margin, and is located about two-fifths of distance from anterior margin. Median lobe is small, obscure. Anterior sulcus is virtually obsolete. A distinct, narrow, low ridge or carina extends lengthwise the valve about at midheight, bending slightly downward in its anterior part; the carina dies out on both anterior and posterior quarters of valve. Surface has some small scattered pits.

In female valve, posterior quarter of valve is swollen, forming an undefined dimorphic pouch.

Relationships.—The peculiar longitudinal carina of *E. cicatrix* provides a distinctive specific feature.

Occurrence.—Rare 3 feet below top of Decker limestone, William Nearpass quarries, New Jersey.

EUKLOEDENELLA MANLIENSIS Swartz

& Whitmore, n. sp.

Pl. 109, fig. 4-6

Male shell subrhomboidal in side view; dorsal and ventral margins about parallel; anterior margin rounded, fullest below; posterior margin less convex, recessive below. Anterior cardinal bend rounded, posterior cardinal angle obtuse. Ventral margin gently sinuate. In dorsal view male shell is subovate, relatively thick for genus, the ends not strongly unequal in thickness. Hinge tooth of left valve about obsolete, represented only by a gently arched projection set off on its posterior side by a small indentation that accommodates a slight projection of margin of right valve.

Surface of valve rises steeply from margins to gently convex summit of valve. Median sulcus shallow, weak, extending about one-third distance from dorsal margin, located just in front of midlength of valve. Anterior sulcus almost obsolete; located one-third distance from anterior margin.

Surface of valve probably smooth or very nearly so, the preservation somewhat imperfect in studied specimens.

Female valve distinctly longer than male specimens, swollen posteriorly into a bulbous but poorly defined dimorphic pouch.

The syntype male shell measures length 1.1 mm., height 0.8 mm. The female valve measures length 1.3 mm., height 0.7 mm.

Relationships.—*Eukloedenella manliensis* is distinguished by the location and weakness of the sulci, and the thickness of the male shell.

Occurrence.—Common 1½ feet, rare 3 feet, rare 7 to 9 feet below top of Manlius limestone, William Nearpass quarries, New Jersey.

Genus KLOEDENELLA Ulrich

& Bassler

KLOEDENELLA BIPUSTULATA Swartz

& Whitmore, n. sp.

Pl. 109, fig. 7-15

Male shell subrectangular in side view. Anterior margin rounded; posterior margin comparatively truncate; ventral margin gently convex to slightly sinuate. Posterior cardinal angle obtuse; anterior cardinal bend rounded, in some specimens having a

gentle hump at hinge tooth of left valve. Height of male valve commonly is about two-thirds of length. In dorsal view, male shell is almost arrow-shaped, thickest about one-sixth distance from posterior end. Anterior hinge-tooth of left valve is moderately strong, forming a broad-based, low triangle. Left valve overlaps slightly on right along free margins.

Surface of male valve moderately convex, rising steeply with a concave curvature from posterior margin to a crest that characteristically is surmounted by two distinct nodes, one near dorsal margin and one near ventral. Median sulcus is strongly impressed, moderate in width, is located just in front of midlength of valve, and extends about two-fifths distance from dorsal to ventral margins. Anterior sulcus is narrower, slightly longer, and is located less than one-third distance from anterior margin.

Node of dorsal part of posterior crest of valve is somewhat variable, and is weakly developed in some of specimens retained in *K. bipustulata*. Post-ventral node is more stable in development.

Female valves are larger and longer than males, and have a strongly swollen though poorly defined dimorphic pouch, that modi-

fies posterior end of valve so that nodes of male valve are wanting.

A characteristic male valve measures length 0.7 mm., height 0.45 mm. A large female valve measures length 1.0 mm., height 0.6 mm.

Relationships.—The two nodes at the summit of the posterior slope of the male valve make *Kloedenella bipustulata* an exceptionally well characterized species, that should be very useful in future zonation of the Manlius limestone.

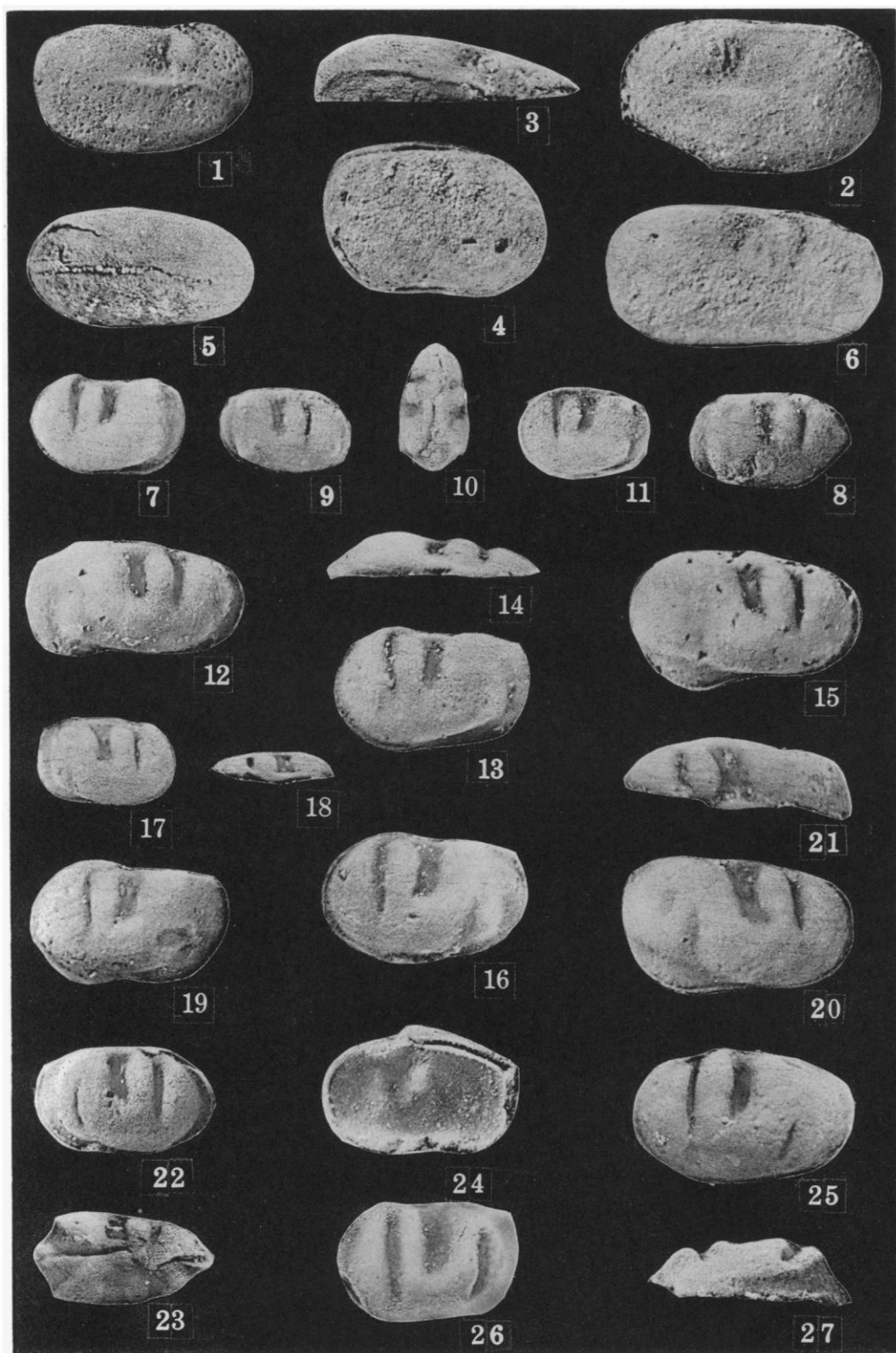
Associated with the characteristic examples in which the two distinctive nodes are well developed, are other specimens in which the more dorsal node, especially, is variable in strength. In some of the larger male valves the more ventral node tends to become a carination, extended dorsally along the summit of the posterior slope of the valve. It may be that the differences in these male valves are in part ontogenetic.

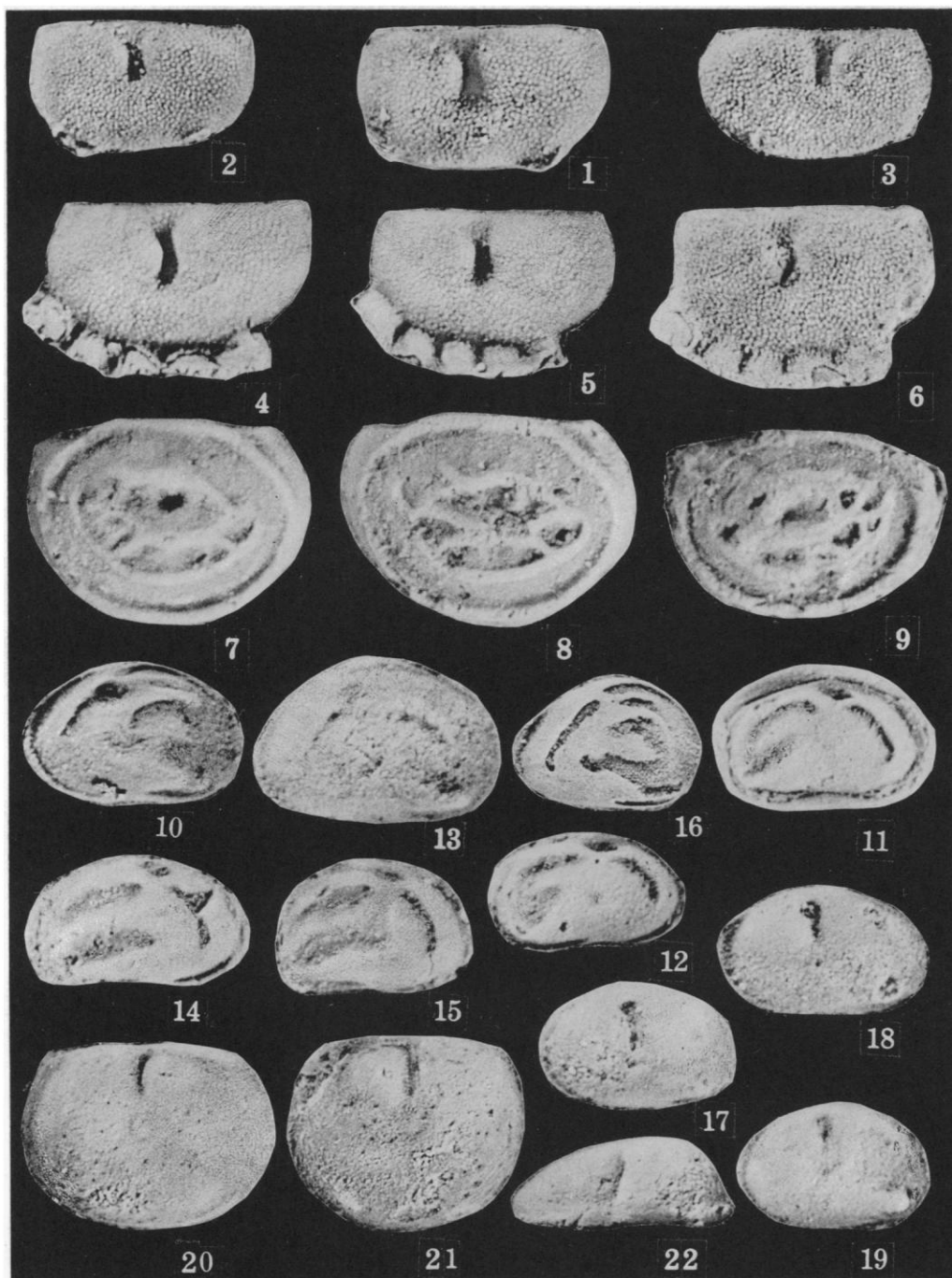
Occurrence.—Common to abundant 2 to 5 feet below top of Manlius limestone, Austin's Glen, New York. Common 1½ feet, rare to common 2 feet, common 3 feet, common 7 to 9 feet, rare 15 feet below top of Manlius, William Nearpass quarries, New Jersey. A variant with the posterior nodes

EXPLANATION OF PLATE 109

All views about $\times 30$

- FIG. 1-3—*Eukloedenella cicatrix* Swartz & Whitmore, n. sp. Views of syntypes. 1, Male right valve, showing longitudinal ridge. 2,3, Lateral and dorsal views of female left valve, the longitudinal ridge less strongly developed; in 3 the dorsal crest is well shown. William Nearpass quarries, New Jersey, 3 feet below top of Decker limestone. (p. 1083)
- 4-6—*Eukloedenella manliensis* Swartz & Whitmore, n. sp. Views of syntypes. 4,5, Right and dorsal views of male (?) shell. 6, An elongate, presumably female right valve. William Nearpass quarries, New Jersey, 1½ feet below top of Manlius limestone. (p. 1083)
- 7-15—*Kloedenella bipustulata* Swartz & Whitmore, n. sp. 7-11, The syntypes. 7,8, Male left and right valves, showing the two nodes at the crest of the posterior slope. 9-11, Right, dorsal, and left views of a small male shell. 12, An elongate male right valve. 13,14, Side and dorsal views of a male left valve, a variant in which the post-dorsal node is about obsolete. 15, A female right valve. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1083)
- 16-21—*Kloedenella parvisulcata* Swartz & Whitmore, n. sp. 16, The holotype, a male left valve, showing the small post-ventral furrow, and the close resemblance to *K. bipustulata* in form and lobation. 17,18, Side and dorsal views of a small male right valve. 19, A male left valve questionably referred to the species. 20,21, Side and dorsal views of a female right valve. William Nearpass quarries, New Jersey, 3 feet below top of Decker limestone. (p. 1085)
- 22-25—*Dizygopleura angustisulcata* Swartz & Whitmore, n. sp. 22,23, Right and dorsal views of the holotype male shell. 24, Interior of a male right valve, showing the longitudinal hinge-groove posterior to notch for the hinge-tooth. 25, Female left valve. William Nearpass quarries, 3 feet below top of Decker limestone. (p. 1086)
- 26,27—*Dizygopleura* cf. *D. clarkei* (Jones). Side and ventral views of male left valve. William Nearpass quarries, 3 feet below top of Decker limestone. (p. 1086)





scarcely developed, is common 2 feet above base of the Manlius at the William Nearpass quarries, New Jersey.

KLOEDENELLA PARVISULCATA Swartz
& Whitmore, n. sp.
Pl. 109, fig. 16-21

Male shell subrhombic in outline; anterior margin strongly curved; posterior margin less convex and somewhat recessive below. Ventral margin varying from gently convex to slightly sinuate. Height of male valve is about two-thirds of length. Hinge-tooth of left valve is short, broad-based.

Surface of male valve moderately convex, greatest convexity behind midlength.

Median sulcus well impressed, moderate in width, extending more than two-fifths of distance from dorsal to ventral margin, located slightly more than one-fourth distance from anterior margin. A short posterior sulcus creases post-ventral part of the valve, setting off a low posterior lobe at summit of steep posterior slope.

Female valve is distinctly longer than male valve, and has a strongly swollen posterior dimorphic pouch defined antero-ventrally by posterior sulcus.

The holotype male left valve measures length 0.9 mm., height 0.6 mm. A female valve measures length 1.1 mm., height 0.6 mm.

EXPLANATION OF PLATE 110

- FIG. 1-6—*Parabolbina cuneospinosa* Swartz & Whitmore, n. sp. 1,2, Views, $\times 50$, of the syntype male left valves, showing the small ventral spines, and the granulose surface. 3, A male right valve, $\times 47$. 4-6, Three female left valves; 4, $\times 45$, 5 and 6, $\times 50$, showing the dimorphic frill with broad radial undulations and fine radial striae. 1-5, from Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone; 6 from William Nearpass quarries, New Jersey, 15 feet below top of Manlius limestone. (p. 1058)
- 7-9—*Limbinaria biangulata* Swartz & Whitmore, n. gen., n. sp. 7,8, The syntype right valves, $\times 45$. The ornament and presumed adductor pit are exceptionally well preserved in 7. 9, A left valve, $\times 45$. These specimens were photographed in *Octonaria*-like fashion with the convex margin in dorsal location, so that as now oriented the lighting is from the lower right. 7,8, Dalton Nearpass farm, New Jersey, Decker limestone slabs loose in pit near southeastern foot of Wallpack ridge. 9, William Nearpass quarries, New Jersey, 31 feet above base of Decker limestone. (p. 1057)
- 10-12—*Thlipsuropsis diploglyptulis* Swartz & Whitmore, n. gen., n. sp. 10,11, Presumed left and right views of the holotype shell, $\times 45$, showing the markedly different aspect of the opposing valves, and in 11 the overlap along all margins of the left valve on the right valve. In 11 the hinge appears to be represented by the straight portion of the contact line, to the left of the dorso-median pit. 12, A right valve, $\times 45$, showing better than in 11 the shortness of the more ventral of the posterior furrows of this valve. Austin's Glen, New York, 2 to 5 feet below top of Manlius limestone. (p. 1087)
- 13—*Thlipsuropsis* sp. Left view of a poorly preserved shell, $\times 48$. This may represent *T. diploglyptulis*, but the ornament is too imperfect for confident identification. William Nearpass quarries, New Jersey, 7 to 9 feet below top of Manlius limestone. (p. 1087)
- 14,15—*Thlipsuropsis longisulcata* Swartz & Whitmore, n. gen., n. sp. The syntype right valves, $\times 50$ and $\times 55$, respectively, showing the long post-ventral furrow. In 14, the triangular depression extending from the antero-dorsal furrow is a break in the shell wall. Dalton Nearpass farm, New Jersey, Decker limestone slabs loose in pit near southeastern foot of Wallpack Ridge. (p. 1088)
- 16—*Thlipsuropsis digitata* Swartz & Whitmore, n. gen., n. sp. The holotype left valve, $\times 34$, showing the details of the furrows. Dalton Nearpass farm, New Jersey, upper part of Coeymans limestone. (p. 1088)
- 17-19—*Parahealdia? convexoris* Swartz & Whitmore, n. sp. Views of syntype left valves, $\times 48$, $\times 50$, and $\times 60$, respectively. The posterior spinose projections are best preserved in 19, although their positions are well shown by the broken bases in 18. The strongly convex dorsal margin is abnormal for *Parahealdia* as its members have been illustrated. William Nearpass quarries, New Jersey, 7 to 9 feet below top of Manlius limestone. (p. 1089)
- 20-22—*Bonneprimites? breviformis* Swartz & Whitmore, n. sp. Views of the syntype male right and left valves, and dorsal view of the right valve, $\times 36$. The rounded depression below the median sulcus evidently reflects the adductor scar. William Nearpass quarries, New Jersey, 1 to 2 feet above base of Decker limestone. (p. 1053)

Relationships.—*Kloedenella parvisulcata* closely resembles *K. bipustulata* in general shape of shell, and in form, size, and location of the median and posterior sulci, and of the dimorphic swelling of the female valve. It differs however in lack of the posterior nodes and in presence of a short post-ventral sulcus. In view of these marked similarities and since *K. parvisulcata* occurs in the older stratigraphic horizon, it is likely that the species is ancestral to *K. bipustulata*. This seeming relation to *K. bipustulata* has prompted the writers to place *K. parvisulcata* in *Kloedenella* rather than in *Dizygopleura*, where it might be classed because of the short post-ventral sulcus.

Occurrence.—Common at 2 feet and 3 feet below top of Decker limestone, William Nearpass quarries, New Jersey.

Genus DIZYGOPLEURA Ulrich & Bassler
DIZYGOPLEURA ANGUSTISULCATA
Swartz & Whitmore, n. sp.
Pl. 109, fig. 22–25

Male shell subrhomboid in lateral view; dorsal margin nearly straight; anterior margin strongly convex, fuller below midheight; posterior margin recessive ventrally; ventral margin straight to slightly sinuate; posterior cardinal angle obtuse; anterior cardinal bend rounded. In dorsal view, male shell is arrow-shaped, with greatest thickness about one-eighth distance from posterior margin near summits of concave posterior slopes of valves. Hinge tooth of left valve is strongly developed, triangular, bears an extension of anterior sulcus, and is bordered on its posterior side by a small tooth-like projection of margin of right valve.

Interior of a right valve shows a well-marked longitudinal groove on hinge surface posterior to sulcus accommodating tooth of left valve; groove evidently received bar-like margin of edge of left valve.

Surface of male valve rather strongly convex, rising from posterior margin with a steep, concave slope to an escarpment-like crest. Median sulcus well impressed, moderate in width, extending not quite half-way from dorsal to ventral margin, located about at midlength of valve. Anterior sulcus narrower, extending about two-thirds distance from dorsal to ventral margin, located not

quite one-third distance from anterior margin. Posterior sulcus is very narrow, shallow, lies a little in front of and parallels crest at summit of posterior slope of valve, and extends from about one-quarter below dorsal margin to one-quarter above ventral margin of shell. There is a narrow flattened border along anterior margin.

In female valve, posterior end of valve is more convex, and posterior slope of valve is convex and not concave as in male valve. Posterior sulcus tends to be reduced to a narrow furrow restricted to ventral half of valve.

The holotype male shell measures length 0.87 mm., height 0.53 mm. A female valve measures length 0.9 mm., height 0.62 mm.

Relationships.—*Dizygopleura angustisulcata* is named from the distinctively narrow posterior sulcus. The anterior sulcus is relatively short for a species of *Dizygopleura*.

The longitudinal furrow of the posterior half of the hinge surface of *D. angustisulcata* may occur in many species of *Dizygopleura*, but is not readily observable in specimens from the well-lithified limestones of the Appalachian mid-Paleozoics. Such grooves do not seem to have been previously recognized in Silurian-Devonian Kloedenellidae.

Occurrence.—Common 2 feet and 3 feet below top of Decker limestone, William Nearpass quarries, New Jersey.

DIZYGOPLEURA cf. *D. CLARKEI* (Jones)
Pl. 109, fig. 26, 27

Beyrichia clarkei JONES, 1890, Geol. Soc. London, Quart. Jour., vol. 46, p. 17, text-fig. 2.
Dizygopleura clarkei ULRICH & BASSLER, 1923, Md. Geol. Survey, Silurian, p. 698, pl. 62, fig. 31, 32.—BASSLER & KELLETT, 1934, Geol. Soc. Am., Special Paper no. 1, p. 289.

Male valve subrectangular to somewhat subrhombic in lateral view. Hinge margin straight, at least in left valve; posterior cardinal angle well defined, somewhat obtuse; anterior cardinal bend rounded; anterior margin strongly convex, slightly fuller below than above middle; posterior margin gently curved, somewhat recessive in lower part; ventral margin straight to slightly sinuate.

Surface of male valve rather strongly convex, rising steeply and with a concave slope from posterior margin and somewhat less steeply from anterior margin; general sum-

mit region, as seen in ventral view, is relatively flat from crest of anterior lobe to crest of posterior lobe. Median sulcus deeply impressed, fairly broad, extending more than half distance from dorsal to ventral margin, located about at midlength of valve. Anterior sulcus deep, moderate in width, extending about four-fifths distance from dorsal to ventral margin, located about three-tenths distance from anterior margin. Posterior sulcus deep, moderate in width, closed both dorsally and ventrally, extending from about one-quarter below dorsal margin to one-quarter above ventral margin.

The illustrated male left valve measures length 0.76 mm., height 0.53 mm.

Relationships.—The type valve of *Dizygopleura clarkei*, refigured by Ulrich & Bassler (1923), may be a female valve. Both the holotype specimen and topotype material need to be restudied to more fully establish the characters of male and female valves.

Occurrence.—The male left valve figured on an accompanying plate was obtained 2 to 3 feet below the top of the Decker limestone, at the William Nearpass quarries, New Jersey. Jones' holotype specimen came from the lower part of the Manlius limestone, near Schoharie, New York.

Family THLIPSURIDAE Ulrich
Genus THLIPSUOPSIS Swartz &
Whitmore, n. gen.

Markedly inequivalved Thlipsuridae, in which the larger, left valve has a thlipsurid, posterior depressed area confluent with anteriorly projecting furrows, whereas in the smaller, right valve the thlipsurid depressed area is wanting. A narrow furrow roughly parallels the antero-dorsal margin.

Genotype.—*Thlipsuopsis diploglyptulis* Swartz & Whitmore, n. sp.

Relationships.—The opposing valves of *Thlipsuopsis diploglyptulis* differ so greatly in aspect that they were attributed to different genera until conjoined valves were discovered. The left valve has the appearance of *Thlipsura* whereas the right valve is suggestive of *Thlipsurella*.

The three new species here included in *Thlipsuopsis* are very close relatives and form a very compact group. In *T. longisulcata*, the post-ventral sulcus is longer than

in *T. diploglyptulis*; in *T. digitata* the antero-dorsal furrow of the left valve is hooked antero-ventrally and lacks the post-dorsally located pit of *T. diploglyptulis*.

Some evidence for orientation of *Thlipsuopsis* and perhaps of *Thlipsura* is furnished by *Thlipsuopsis diploglyptulis*. In the illustrated holotype with its conjoined valves, the smaller, right valve exhibits a shallowly depressed, submedian, rounded external mark that with reasonable certainty reflects the adductor scar; if the scar is antero-median in location, the unisulcate end of the valve is the anterior end, and in the larger, left valve the thlipsurid depression occurs at the posterior end. This orientation further is favored by position of a straight portion of the dorsal contact line of the valves, that occurs above the bisulcate end of the smaller valve and appears to represent the actual location of the hinge.

Occurrence.—The three species here referred to *Thlipsuopsis* occur in the Late Silurian Decker and Manlius limestones, and Early Devonian Coeymans limestone of northwestern New Jersey and eastern New York.

THLIPSUOPSIS DIPLOGLYPTULIS

Swartz & Whitmore, n. sp.

Pl. 110, fig. 10–12, 13?

Shell subreniform in outline; dorsal margin convex; ventral margin nearly straight for about two-thirds length of shell; anterior margin somewhat more narrowly curved than posterior. Greatest height submedian, about five-sevenths of greatest length.

Left valve overlaps and projects well beyond right valve along all margins, so that actual contact line is visible only in right-valve view of shell. Posterior half of dorsal part of contact is straight and adjacent margins of valves are beveled, suggesting that straight section may represent location of actual hinge.

Surfaces of valves moderately convex; greatest convexity is about one-third from posterior end. In left valve, a *Thlipsura*-like, relatively depressed but nevertheless convex area borders posterior margin. Five shallow furrows extend anteriorward from depressed area; most dorsal furrow is narrow, curves forward closely adjacent to dorsal margin, and extends beyond midlength of

shell; second furrow is similarly curved, narrow, shorter; third furrow is broader, sickle-shaped, narrows anteriorly and diverges from more dorsal furrows; fourth furrow broad and better defined posteriorly, with a shallower anterior portion that extends beyond midlength of valve, the most anterior portion curved with a downward convexity. Fifth furrow is narrow, short, close to ventral margin. A sixth furrow, not connected with posterior depressed area, parallels antero-dorsal margin, and is enlarged as a pit post-dorsally. In the four ridges separating the five, more posterior furrows, dorsalmost ridge is narrow, low; second ridge is slightly enlarged and elevated terminally; third ridge low, rather narrow; fourth ridge has a short, abruptly narrowed and hooked terminus. A narrow, low rim closely parallels anterior margin of valve.

In right valve, posterior depressed area is wanting; there are two posterior furrows, the dorsal one subparallel to post-dorsal margin, extending about two-fifths length of valve, the lower furrow about one-third length of valve, markedly divergent from ventral margin. A third furrow parallels antero-dorsal margin, and is not confluent with a dorso-median pit. Below pit in right valve of holotype shell, slightly above and anterior to midpoint of valve, is a round, very shallow depression that evidently reflects adductor scar.

The holotype shell measures length 0.7 mm., height 0.5 mm.

Relationships.—The right valve of *Thlipsuropsis diploglyptulis* closely resembles that of *T. longisulcata*, but the post-ventral furrow is distinctly shorter. The left valve differs from the holotype valve of *T. digitata* in the enlarged pit of the antero-dorsal furrow, the terminal elevation and enlargement of the ridge separating the second and third posterior furrows, and the shortness and hooked character of the terminus of the ridge separating the fourth and fifth furrows.

Occurrence.—Rare 2 to 5 feet below top of Manlius limestone, Austin's Glen, New York. A poorly preserved valve that may belong to the species was found in beds 7 to 9 feet below top of the Manlius limestone at the William Nearpass quarries, New Jersey.

THLIPSUOPSIS LONGISULCATA

Swartz & Whitmore, n. sp.

Pl. 110, fig. 14.15

Left valve and hence full outline of shell not known. Right valve reniform in outline; dorsal margin moderately and rather regularly convex; posterior margin blunt; anterior margin more rounded but fuller below than above; ventral margin gently sinuate.

Surface of right valve moderately convex, rising rather steeply, especially at posterior end, from a narrow, flattened marginal flange. Surface of right valve trisulcate: two posterior furrows are sublongitudinal in direction, more or less closed posteriorly; post-dorsal furrow roughly parallels post-dorsal margin of valve; its anterior end does not quite reach midlength of valve; post-ventral furrow is about parallel to post-dorsal furrow, somewhat divergent from ventral margin of valve; its slightly down-curved end extends slightly anterior to midlength. Anterior furrow is narrower but about equal in length to posterior furrows, and parallels anterior margin; its dorsal end is closed, and does not reach a pit-like depression impressed in dorsal slope of valve slightly anterior to midlength.

The larger syntype right valve measures length 0.6 mm., height 0.4 mm.

Relationships.—The right valves of *Thlipsuropsis longisulcatus* closely resemble those of *T. diploglyptulis*, but the post-ventral furrow is decidedly longer, and the anterior furrow tends to be less oblique to the ventral margin of the valve.

Occurrence.—Rare in loose slabs of Decker limestone found in pit on Dalton Nearpass farm at the southeastern foot of Wallpack Ridge, New Jersey, in association with *Stenocisma deckerensis* and *Limbinaria biangulata*.

THLIPSUOPSIS DIGITATA Swartz

& Whitmore, n. sp.

Pl. 110, fig. 16

Shell as known from a single, well preserved left valve, ovoid subreniform in side view; dorsal margin strongly convex, fuller posteriorly than anteriorly; posterior margin higher and more broadly rounded than anterior; ventral margin nearly straight for about half length of valve. Greatest height

slightly post-median, about five-eighths of length. Hingement and overlap not observed.

Surface of left valve rather strongly convex, its greatest convexity about one-third distance from posterior margin. A comparatively depressed but nevertheless convex area borders posterior margin, and from it five furrows extend anteriorward across posterior half of valve. Two simple, narrow furrows on dorsal slope curve parallel to dorsal margin; upper furrow extends slightly beyond midlength of valve, second furrow is shorter; third furrow is broader, more rapidly curved, sickle-shaped, terminates at midlength of valve; fourth furrow well defined, diverges anteriorly from ventral margin of valve, extends beyond midlength where it is peculiarly curved, probably margining ventral side of area of adductor attachment; fifth furrow narrow, simple, short, lying close to ventral margin. In anterior half of valve a sixth furrow roughly parallels antero-dorsal margin, is hooked at its more ventral end, slightly widened near its more posterior end. A narrow flange is set off along part of anterior margin. Of four ridges separating posterior furrows, most dorsal ridge is narrow, simple; second ridge narrows rapidly from broad, distal portion, its curving posterior end having a low extension that continues across part of floor of depressed area; third ridge is broadened medially, narrowed terminally; fourth ridge has a sharply narrowed, elongate terminus.

Floors of the two larger, medio-posterior furrows are very minutely punctate-reticulate, and there is a suggestion of still more minute punctuation on more elevated parts of valve surface.

The holotype left valve measures length 0.8 mm., height 0.5 mm.

Relationships.—The sculpturing of the left valve of *Thlipsuropsis digitata* is very similar to that of *T. diploglyptulis* and warrants the supposition that the species will similarly have the contrastingly ornamented valves that characterize the genus.

Superimposed on the similarities of the left valves of *T. digitata* and *T. diploglyptulis* are a series of small differences that appear to warrant specific separation, especially in view of the difference in stratigraphic occurrence. Additional specimens

of *T. digitata* will be needed to show which of the differences in ornament are most persistent. As compared to *T. diploglyptulis*, the holotype left valve of *T. digitata* is more ovoid in shape; the anterior sulcus is more elongate and ventrally hooked, and lacks the definitely widened and rounded pit near the dorsal end; in the ridges separating the posterior furrows, the second ridge is a ventrally curving, low extension, whereas that of *T. diploglyptulis* is more elevated and has a slightly enlarged terminus; the third ridge is broad; the fourth ridge has an elongate narrow terminus, as compared to the shorter, hooked terminus found in *T. diploglyptulis*.

Occurrence.—One specimen in upper part of Lower Devonian Coeymans limestone, quarries on Dalton Nearpass farm, New Jersey.

Family HEALDIIDAE Harlton

Genus PARAHEALDIA Coryell & Cuskley

PARAHEALDIA? CONVEXORIS Swartz

& Whitmore, n. sp.

Pl. 110, fig. 17-19

Shell minute; outline subreniform; dorsal margin rather strongly convex, ventral margin about straight for more than half of length of shell; ends rounded, subequal. Height is about two-thirds of length. Hingement and overlap not observed.

Surface of valve moderately convex. A median sulcus, broadest above, and located slightly anterior to midlength, extends between points about one-fifth and one-half distance below dorsal margin. Two small, posteriorwardly directed spinelets occur at summit of slope rising from posterior margin; one of spinelets is near dorsal and one near ventral margin of valve.

The largest of three syntype valves measures length 0.6 mm., height 0.4 mm.

Relationships.—*Parahealdia? convexoris* differs from the genotype, *P. pecorella*, Coryell & Cuskley, 1934, in the convexity of the dorsal margin, and in this respect recalls *P.? centralis* Swartz, 1936. In the latter species, there is a submedian, rounded pit rather than a vertically elongated sulcus as in *P.? convexoris*.

Although *Parahealdia? convexoris* is here listed under the family Healdiidae, the median sulcus, subterminal spines and sub-

reniform outline give it an aspect suggestive of some members of the Thlipsuridae.

Occurrence.—Rare 7 to 9 feet below top of Manlius limestone, William Nearpass quarries, New Jersey.

APPENDIX

BRACHIOPODA

Genus *CHONETES* Fischer

CHONETES JERSEYENSIS var. *NON-DIVERGENS* Swartz, n. var.

Chonetes jerseyensis WELLER (part), 1903, Geol. Survey New Jersey, Paleont., vol. 3, p. 230–231, pl. 20, fig. 16, not fig. 12, 15; status of immature specimens shown in fig. 11, 13, 14 is uncertain.

Shell subrectangular in outline; length about two-thirds of width; cardinal angles not extended; anterior margin gently convex, bending more rapidly into the gently convex lateral margins. Pedicle valve depressed convex; cardinal area low, beak not prominent; each cardinal slope bears 6 or 7 small, obliquely directed spines. Brachial valve about flat. Surface marked by fairly coarse radial costellae, which increase by implantation and bifurcation and number 8 or 9 in 5 mm. near anterior margin. In adult as well as immature specimens, lateral costellae are about straight, and do not diverge appreciably from cardinal margins.

Length of holotype ventral valve 13 mm., width 19 mm.

Relationships.—In describing *Chonetes jerseyensis* in 1903, Weller called attention to the anterior curvature of the lateral costellae that is a very distinctive feature of many characteristic large valves of the species, but concluded that there is continuous variation into associated, generally smaller valves in which there is little if any such curvature. The anterior curvature of the lateral costellae, and an associated divergence of the postlateral costellae from the hinge, are striking and useful features of most specimens of *Chonetes jerseyensis* of the lower half of the Keyser limestone of central Pennsylvania, Maryland and the Virginias. At some localities in eastern Pennsylvania, however, such as at a small quarry on the road from Schuylkill Haven to Adamsdale (see Swartz, F. M., 1941, in Swartz, C. K., and Swartz, F. M., Early Devonian and Late Silurian formations of

southeastern Pennsylvania, Geol. Soc. Am. Bull., vol. 52, p. 1134), there are assemblages in which there is an abundance of specimens with essentially straight postlateral ribs which are not appreciably divergent from the cardinal margin, and in which there are few if any valves with divergent postlateral ribs. It accordingly seems desirable to call attention to the structural differences by use of the term, *nondivergens*, and to emphasize the possibility that the material with the non-divergent postlateral costellae may be developed chiefly in the earlier occurrences of *Chonetes jerseyensis* as a whole.

The specimen shown by Weller (1903) in his pl. 20, fig. 16, is proposed as the holotype of the variety, *C. j.* var. *nondivergens*; the smaller specimens shown in fig. 11, 13 and 14 are immature valves so that their relation to the variety is less clear. It is further proposed that the valves shown in fig. 12 and 15 of the same plate should be regarded as the synlectotypes of *Chonetes jerseyensis*.

Occurrence.—William Nearpass quarries, New Jersey, lower 2 feet of Decker limestone. Quarry on road from Schuylkill Haven to Adamsdale, Pennsylvania. 12 to 16 feet below unconformity at top of Keyser limestone.

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