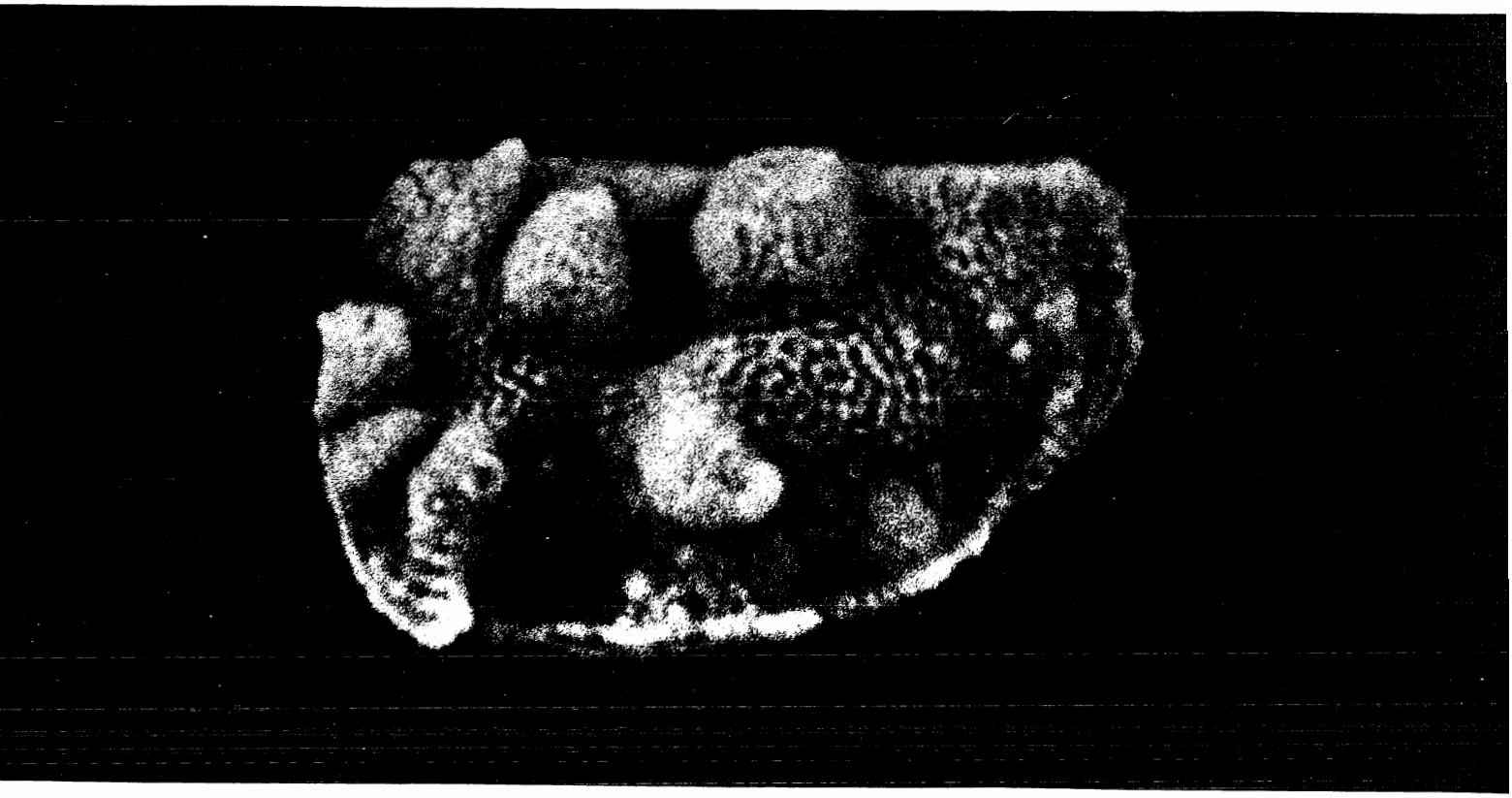
# Dimorphic Middle Devonian Paleocopan Ostracoda of the Great Lakes Region

Robert V. Kesling and Ruth B. Chilman



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FRONT COVER: *Abditoloculina pulchra,* UMMP 60274, from the Centerfield Formation of western New York; left lateral view of female carapace, × 125

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# DIMORPHIC MIDDLE DEVONIAN PALEOCOPAN OSTRACODA OF THE GREAT LAKES REGION

# RUTH BERNER CHILMAN

**24 July 1907 to 26 November 1984**

Despite continuing illness during the last two decades of her life, Ruth Berner Chilman maintained her devotion to micropaleontology. She particularly loved the Devonian Ostracoda, and her talents and energy were directed unselfishly and unstintingly to their collection, extraction, and preparation. She kept absorbed in her work, even though suffering in the terminal years.

Ruth was a kind, gentle lady. Her passing is a great loss, not only to science, but to all mankind. Regretfully, she did not live to see this, her final publication.

# Dimorphic Middle Devonian Paleocopan Ostracoda of the Great Lakes Region

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# ABSTRACT

Some three hundred eighty million years ago, the region now forming the basins of the Great Lakes was a shallow sea. Through its waters swarmed myriads of tiny diverse bivalved crustaceans—the Ostracoda. Most of them were benthonic, bottom-dwellers that scavenged over the floor of this tropical sea, able to swim briefly if at all because of the weighty shell.

Even though Middle Devonian ostracods have been studied for nearly a century in this region, new species and even new genera are still being discovered. Many of these mid-Paleozoic forms belong to an extinct order, the Paleocopa, distinguished by their long straight hinge, extending nearly the full length of the carapace. Among the paleocopan ostracods, those which display dimorphism in the form of the carapace are particularly intriguing. These differences within each species are generally attributed to sexual changes in morphology, which appear only in adulthood, after the final ecdysis (or molting) for growth.

Dimorphism of three distinct types has been noted in these Paleocopa, each restricted to its superfamily: beyrichiacean, primitiopsacean, and hollinacean. Beyrichiacean dimorphism occurs solely in the superfamily Beyrichiacea; it is marked by the adult appearance of a crumina or pouch in each valve of one dimorph, with no suggestion of such a structure in the valves of the other dimorph. The occurrence of very young instars of the same species within the cruminae of certain beyrichiaceans that have been sectioned, supports the contention that they served as brood-pouches to protect the offspring.

Dimorphism of the primitiopsacean and hollinacean types involves differences in adult development of the velar structure. In the Primitiopsacea, the velar structure of the presumed female is extended posteriorly beyond the domicilium or living chamber as a convex frill in each valve. These rear frills of the two valves seldom meet at their distal ends, but may have afforded protection for the young of the species.

Hollinacean dimorphism involves only the anterior and ventral parts of each valve. The presumed male closely resembles the immature instars of its species in many groups, but in some it (as well as the presumed female) differs from the juveniles in the form of the velar structure. The dimorphism is more strongly expressed in some families of the Hollinacea than in others. The family Ctenoloculinidae has females with loculi, small pocket-like structures, formed between the frill and the margin of the valve; the exact function of loculi has never been satisfactorily determined. The family Hollinidae has the velar structure expressed as a frill, strongly developed and incurved, in the presumed female; in many forms it is reduced to a pair of spurs in each valve in the male. Dimorphism in the Hollinellidae remains open for interpretation. In *Adelphobolbina* and *Hollinella*, one adult form has the frill separated from the margin of the valve by a smooth concave antrum or channel, whereas the other has this ventral area flat and ornamented, somewhat constricted anteroventrally. Many authors, by convention, refer to the former as the male, even though its frill is often wider than that of the presumed female; here, we suggest that the wider frill and associated smooth antrum are characters of the female. In *Ruptivelum*, the frill of the presumed male is like that of the female except that it is separated into two sections. In *Flaccivelum*, one dimorph has a wide frill and ample parallel-sided antrum; the other has only a velar ridge which nears the margin anteroventrally.

In this publication, we list 93 species of dimorphic paleocopan ostracods. Our new genera include *Leprestola* (Beyrichiacea, family Beyrichiidae, subfamily Treposellinae) and *Bisphenella*, *Labrosavelum*, and *Physcocalyptra* (Hollinacea, family Holli-

nellidae). The fauna contains the following new species: *Leprestola mediopratensis*, *Phlyctiscapha dubia*, *Sulcicuneus latus*, *S. minutus*, *Ctenoloculina acrolobata*, *C. amblycentrota*, *C. apletolobata*, *C. araea*, *C. didyma*, *C. ectenolobata*, *C. rhadina*, *C. widderensis*, *Hercynobolbina levis*, *Subligaculum quadribursatum*, *Tetrasacculua quaternarius*, *Falsipollex simplilobatus*, *Bisphenella nodosa*, *B. rana*, *Flaccivelum excertum*, *F. papillosum*, *Hollinella* (*Keslingella*) *alpensis*, *H.* (*K.*) *angustivelata*, *H.* (*K.*) *magnambitata*, *Labrosavelum pyriforme*, *L. sphaericum*, and *Physcocalyptra pomphosa*. The species are illustrated on 72 plates.

# ACKNOWLEDGMENTS

Many friends contributed to this project, and we gratefully acknowledge their help. First, there are those who assisted in collecting the field samples from which the specimens were extracted. Many micropaleontology students of the senior author, dating back to 1950, accompanied him to field studies and collecting in Michigan and Ontario—and later spent hours preparing samples, picking out the specimens, sorting by family, and (in some cases) classifying to species. Others also contributed. Jean D. (Mrs. E. P.) Wright brought back carefully labeled samples from the Thedford-Arkona region of Ontario in the 1950's and 1960's, as did the late Joe Poppelreiter in subsequent years. Irving Reimann, emeritus Curator of Exhibits at the Museum of Paleontology, acted as the field guide to localities in western New York. Karoly Kutasi, before retiring as photographer at the Museum, assisted field work in many ways, as well as printing thousands of photomicrographs for previous studies. Michael and John Topor, members of the Friends of UMMP, recently brought back additional samples from Ontario. There were others who contributed to collecting in lesser, but greatly appreciated ways.

Second, we are indebted to those who printed the photographs used in this publication. Paul Koch, Victor Torres, and Linda Krakker, students at the Museum of Paleontology, spent many hours in the dark room to turn out thousands of prints, from which 1381 were selected for inclusion in the plates. George Junne, photographer for the Museum of Paleontology, prepared the lettering for the cover and title page.

Third, we are very thankful to Susan Goldenberg, who typed the manuscript onto computer storage, and to Prof. G. R. Smith for his attention to printing arrangements.

Lastly, we are deeply indebted to the patience and understanding of our spouses, Amelia Bradham Kesling and William Chilman. They gave whole-hearted encouragement and support throughout the project.

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# INTRODUCTION

Middle Devonian shales of the Great Lakes region contain a wealth of well-preserved Ostracoda. From them, we have recovered over 300 species. In this study, we describe only the Beyrichiacea, Primitiopsacea, and Hollinacea—the three superfamilies of the suborder Beyrichicopina which are characterized by distinct dimorphism.

Research on these abundant ostracods offers the opportunity to complete the faunal list, to revise some previous works, and to examine the geographic and stratigraphic distributions of the various species. This challenge has involved some three years effort on our part. Even so, we strongly suspect that much remains to be discovered. Among the more than ten thousand ostracods collected and prepared, several species are represented by less than ten specimens; undoubtedly, new species will some day be found as new localities become available.

With so much excellent material at hand, the temptation to make new taxa is strong. Ostracods from one locality show certain peculiarities of lobation, slight change in adult size, or development of dimorphic structures different from those at other localities. Each sample may divulge some individuals which do not precisely match those from another. This is the dilemma of the ostracodologist (as well as other paleontologists): lumping into too few taxa can never reveal fine distinctions necessary for detection of lineages in evolution or for applications in stratigraphy; but splitting into too many taxa creates a welter of names which readily obscures the identification and use of Ostracoda.

We have added *some* new taxa—but only after careful consideration of the purpose they can actually or potentially serve. Of the 21 genera described, four are new; and of the 94 species and subspecies, 23 species and 1 subspecies are new. We feel confident that all of our new taxa contribute to the understanding of the diversity and evolutionary changes within the superfamilies. As shown by our illustrations, appreciable latitude has been allotted to most species, so that the number of subspecies has been restricted to a minimum. To stress our reasoning for the classification we use herein, we have included keys to the genera in each family and to the species included in each genus. These keys are admittedly artificial, at least in part, inasmuch as they include only the ostracods found in the Great Lakes region. Nevertheless, we trust they will prove to be of assistance to future workers.

Ostracod faunas acquire added value when they are catalogued both geographically and stratigraphically, for only thereby can we hope to establish the locale and the time of a particular speciation event, the migration and spread of species, and their longevity. Our table of occurrences reveals that certain of the species were notably unsuccessful, being restricted to a single formation in one local area, whereas others were ubiquitous, existing throughout Middle Devonian time in all areas of the Great Lakes region. Numerous species are restricted to northern Michigan, some to western New York, a few to Ontario, and only one to southern Michigan-northwestern Ohio. As will be shown in our tabulation of species occurrences, the largest fauna of a local area occurs in northern Michigan; this might have been anticipated for two reasons. First, the Middle Devonian Traverse Group there includes formations older, equivalent, and younger than the Centerfield Formation of New York, whereas the sequence in New York has yielded faunas only from Centerfield and younger strata and the sequence in Ohio-southern Michigan has ostracods only from pre-Centerfield strata. Second, the Traverse Group of northern Michigan consists of numerous alternating calcareous and non-calcareous shales, so that the strata represent varying depths of water and resultant sedimentation.

Three areas produced faunas of Centerfield and younger age: northern Michigan, Ontario, and western New York. Suprisingly, Ontario, situated between Michigan and New York, has the smallest fauna during this interval. One might have expected that faunal exchanges with the neighboring areas would have resulted in the largest fauna being centered in Ontario; instead, it is found in northern Michigan. Evidently, northern Michigan continued to be a significant locus of speciation, with over half of its ostracod fauna endemic.

Despite our intensive investigation of the Middle Devonian Ostracoda in the Great Lakes region, we cannot confidently suggest the evolutionary history of the families represented nor trace the origin of most genera. As for the phylogeny of the species within each genus, we can only say that certain genera seem to show trends or lineages whereas others are highly suspect. Numerous species seem to be indigenous to a local ecological situation, so that they are restricted to a particular formation. For example, the very distinctive *Hollinella (Keslingella) alpenensis* is found only in the shale unit of

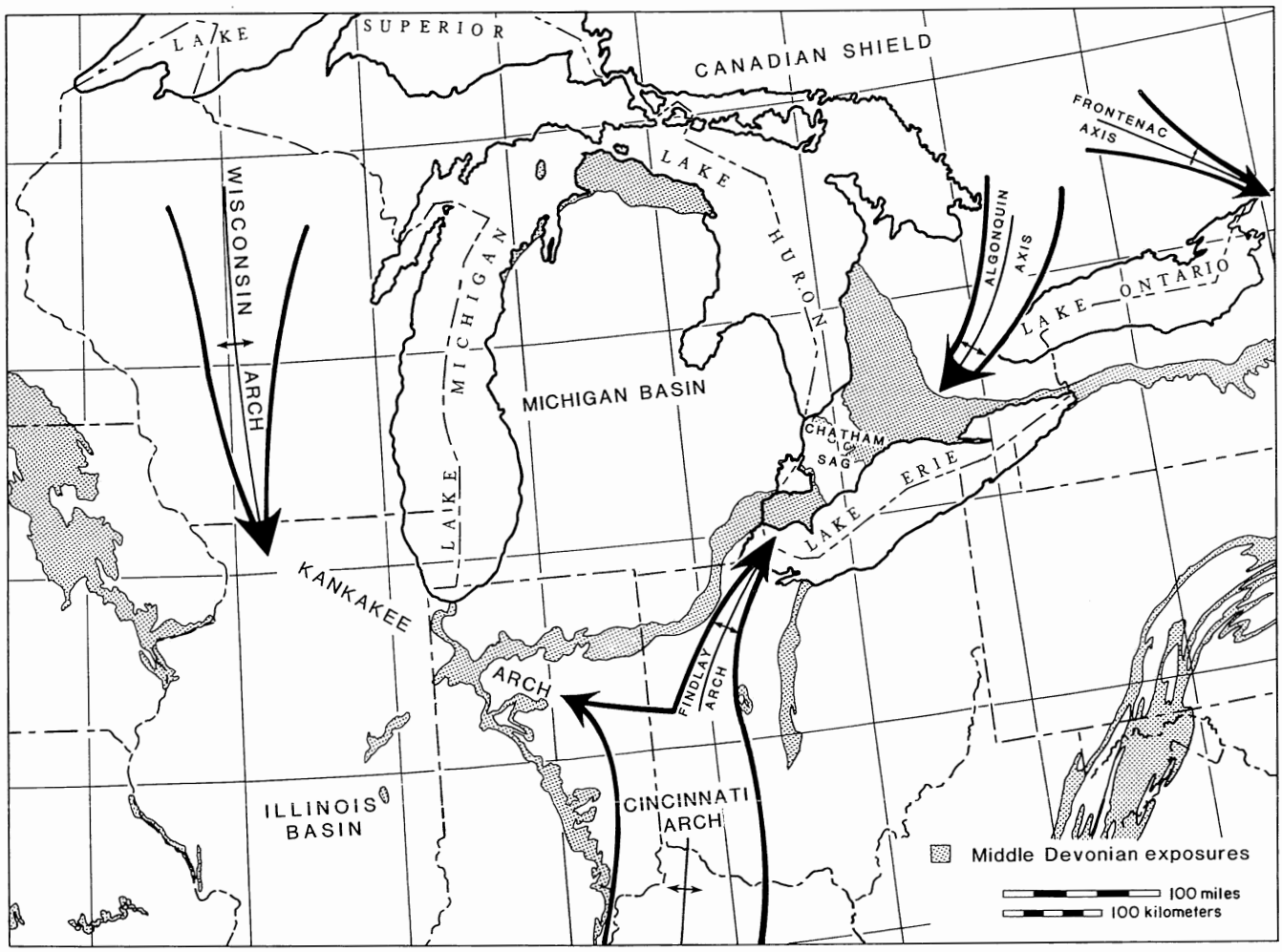


Figure 1. Geologic and tectonic map of Great Lakes region, showing distribution of Middle Devonian strata.

the Alpena Limestone, probably deposited between reefs in relatively shallow water. Or, for another example, *Ctenoloculina araea,* a dwarf among species of its genus, occurs only in the exceptionally pure argillaceous shales of the Norway Point Formation, most certainly laid down in deep and quiet water. Such restricted species appear to be unproductive offshoots from the main stem of evolution in their genus; on the other hand, they could be the only discovered species of a lineage yet to be made known.

Peculiar morphological structures should likely reflect functional specialization. Yet their interpretation can be deceptive or, at best, indecisive. For example, *Physcocalyptra pomphosa,* an ostracod possessing (as its name implies) a blister-like inflation in the anteroventral section of its frill, combines the lobation of a hollinellid and the inflated frill of a eurychilinid. The species could be interpreted as the last surviving eurychilinid which had adopted hollinellid lobation, or as a hollinellid which mimicked the frill of a eurychilinid. Only because we regard lobation as a more stable and conservative character than the frill, do we classify *Physcocalyptra pomphosa* as a hollinellid ostracod. If we could be certain of the function served by the inflated section of the frill, we could state with assurance how this genus differed from others of the family in adapting to its environment.

Hence, many challenging questions remain unanswered at this time. Our coverage of the Middle Devonian Beyrichiacea, Primitiopsacea, and Hollinacea in the Great Lakes region is reasonably nearly complete. It displays the diversity of Ostracoda occurring together at one time. From this data base, we trust that future investigators will solve problems of paleoecology, phylogeny, paleoautecology, paleosynecology, community successions, and, ultimately, correlations. The goal is always to understand evolution, to correctly interpret circumstantial evidence, and to establish the prime forces that

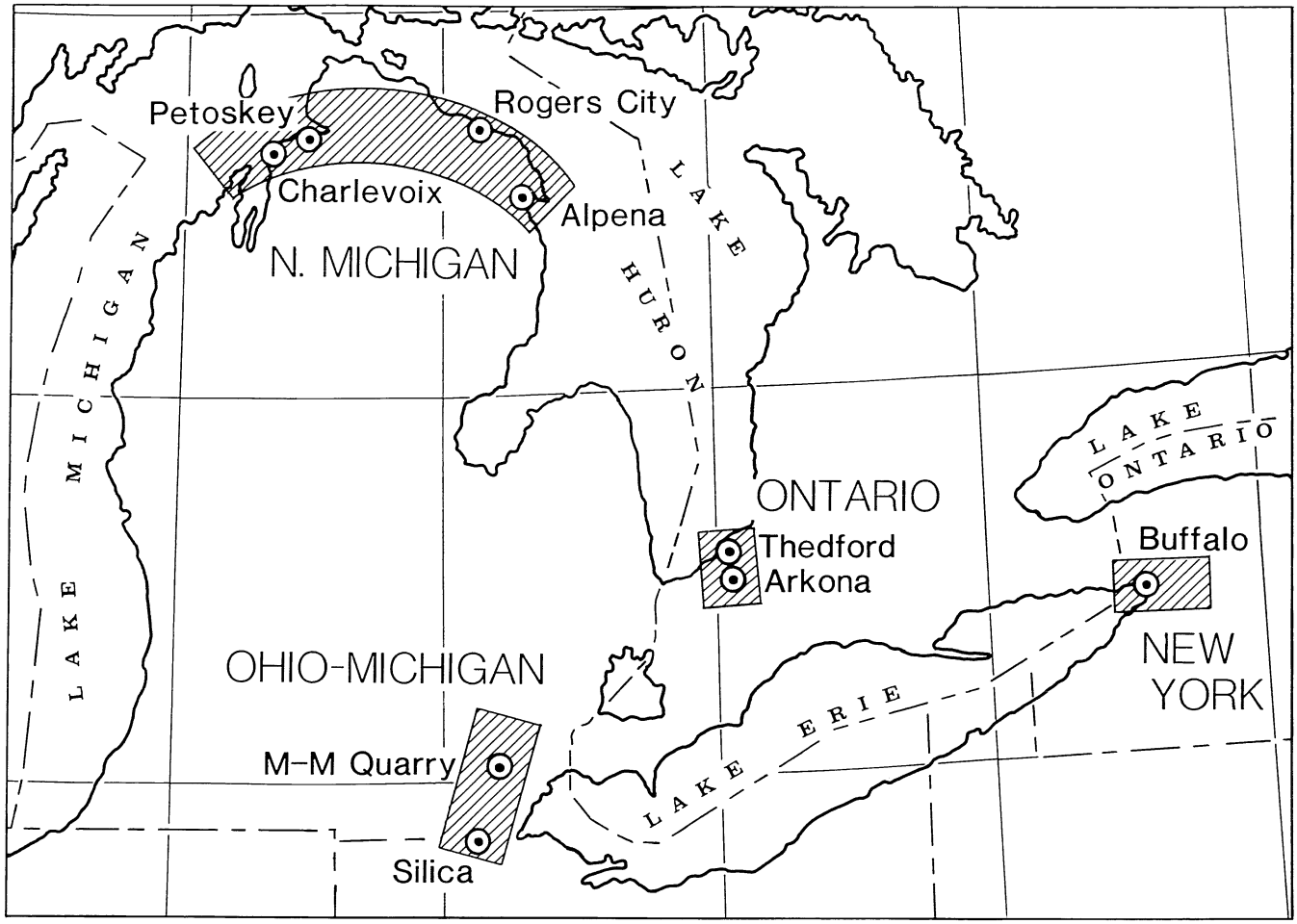


Figure 2. Map of areas from which collections were made of the dimorphic paleocopan Ostracoda described in this publication.

have molded the physical and biological factors which have produced life forms through the ages.

## DIMORPHISM IN PALEOCOPAN OSTRACODA

In a large group of Paleocopa, including the ostracods described in this publication, the carapaces secreted by the adult male and female differ. Whereas one might suspect, as has been suggested, that all such differences were connected in one way or another with brood care, this has not been proven except in the beyrichiids. Those well-preserved beyrichiid female carapaces which have been sectioned reveal young of the species inside the cruminae, or brood pouches. In other ostracods, however, the dimorphism may have evolved to facilitate copulation.

Dimorphism in the paleocopan ostracods is of three basic types, each restricted to its superfamily: beyrichiacean, primitiopsacean, and hollinacean. Beyrichiacean dimorphism is characterized by the adult appearance of a crumina (pouch) in each valve of one dimorph, with no suggestion of any such structure in the other dimorph (Text-figs. 4,5). The occurrence of young inside the crumina strongly supports the contention that the individuals bearing these structures are females, and that the adult carapaces retaining the shape of those of the immature instars are male. Beyrichiacean dimorphism is invariably distinct, although the degree of cruminal development is much greater in the subfamily Beyrichiinae than in either the Treposellinae or the Kloedeniinae.

In the superfamilies Primitiopsacea and Hollinacea, dimorphism involves differences in the adult expression of velar structures. In primitiopsacean dimorphism, this structure extends posteriorly beyond the domicilium, or living chamber, in each female valve; it is weakly developed or (more commonly) absent in the male valve. *Sulcicuneus* has a convex frill in each female valve, and in

<table>
<tr><th>Northwestern MICHIGAN</th><th>Northeastern MICHIGAN</th><th>NW OHIO–SE MICHIGAN</th><th>Western ONTARIO</th><th>Western NEW YORK</th></tr>
<tr><td></td><td>Thunder Bay Ls.</td><td rowspan="5"></td><td></td><td rowspan="2"></td></tr>
<tr><td>Petoskey Fm.</td><td>Potter Farm Fm.</td><td rowspan="3">Ipperwash Fm.</td></tr>
<tr><td rowspan="3"></td><td></td><td>Windom Shale</td></tr>
<tr><td>Norway Point Fm.</td><td>Wanakah Shale</td></tr>
<tr><td></td><td>Widder Fm.</td><td>Ledyard Shale</td></tr>
<tr><td>Charlevoix Ls.</td><td>Four Mile Dam Fm.</td><td>Ten Mile Creek Dol.</td><td>Hungry Hollow Fm.</td><td>Centerfield Fm.</td></tr>
<tr><td rowspan="3">Gravel Point Fm.</td><td>Alpena Limestone</td><td rowspan="6">Silica Shale</td><td rowspan="3">Arkona Shale</td><td rowspan="6"></td></tr>
<tr><td>Newton Creek Fm.</td></tr>
<tr><td>Genshaw Fm.</td></tr>
<tr><td rowspan="3"></td><td>Ferron Point Fm.</td></tr>
<tr><td>Rockport Quarry Ls.</td><td rowspan="2"></td></tr>
<tr><td>Bell Shale</td></tr>
</table>

Figure 3. Correlation chart of Middle Devonian formations in the Great Lakes region.

a closed carapace the left and right frills may meet, or nearly meet (Text-fig. 6); thus, they may have afforded some protection for the young. In other genera of the Primitiopsacea, however, the dimorphic structure in each female valve is reduced to a velar ridge, so that the function of dimorphism in the superfamily remains clouded with doubt.

Hollinacean dimorphism always concerns velar differences in the anterior and ventral parts of each valve, never in the posterior part. In all cases, the presumed male closely resembles the immature instars of its species in shape; in most genera, it also resembles the young in velar structure, but in a few it has a velar structure different from that of juveniles. (The latter has been referred to by some authors as "trimorphism," although we avoid that term.)

Hollinacean dimorphism is expressed so much more strongly in some families than in others, and in such drastic variations in the female velar structure, that it can itself be separated into types. Of those ostracods we describe, three types within the general hollinacean type can be distinguished: ctenoloculinid, hollinid, and hollinellid.

Females of the family Ctenoloculinidae have their frill of each valve connected to the domicilium by a number of partitions, dividing the intervening space into small pockets, or loculi (Text-figs. 7,8). (The fact that these loculi cannot be seen in lateral view, and are thus

Table 1—Distribution of Middle Devonian dimorphic Paleocopa in the Great Lakes region. (*) denotes type occurrence; (+) denotes other occurrences.

| *Species* | OHIO-MICH | ONTARIO,CAN | | | NEW YORK STATE | | | | | | | TRAVERSE, N.MICHIGAN | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Petoskey | Gravel Pt | Potter Farm | Norway Pt | Dock Str | Genshaw | Ferron Pt | Bell Sh | Windom | Kashong | Wanakah | Ledyard | Centerfield | Ipperwash | Widder | Hungry Hol | Arkona | Silica |
| *BEYRICHIACEA* | | | | | | | | | | | | | | | | | | |
| *Hibbardia lacrimosa* | | | | | + | + | + | * | + | + | + | | | | · | | + | + |
| *Leprestola mediopratensis* | | | | | | * | | | | | | | | | | | | |
| *Phlyctiscapha apleta* | + | | + | + | | | | + | | | | * | + | + | + | | + | + |
| *P. dubia* | | | | | | | | | | | | | | | | | + | * |
| *P. rockportensis* | | | | | | | | | | | * | | + | | | | + | |
| *P. subovata* | | | | | | + | | * | | + | | | | | | | | |
| *Treposella stellata* | | | | | | * | | | | | | | | | | | | |
| *Welleria aftonensis* | | | | | | | | | | | | | | | | | * | |
| *W. bisulcata* | | | | | | | + | * | | + | | | | | | | | |
| PRIMITIOPSACEA | | | | | | | | | | | | | | | | | | |
| *Sulcicuneus latus* | | | | | | | | | | | | | + | | | | + | * |
| *S. minutus* | | | | | | | | | | | | | | | * | | | |
| *S. porrectinatius* | | | | | | | | | | | * | | | | | | | |
| HOLLINACEA | | | | | | | | | | | | | | | | | | |
| FAMILY CTENOLOCULINIDAE | | | | | | | | | | | | | | | | | | |
| *Abditoloculina insolita* | | | | | | | | | | | | | + | | + | | + | + |
| *A. pulchra* | | | | | | * | | | | + | | | | | | | | |
| *Ctenoloculina acanthina* | + | * | | + | | + | | + | + | + | | + | | + | | | | |
| *C. acrolobata* | | * | | | | | | | | | | | | | | | | |
| *C. amblycentrota* | | | | | | | | | * | | | | | | | | | |
| *C. apletolobata* | | | | | | | | | | | | * | | | | | | |
| *C. araea* | | | | | | | | | | | | | | | * | | | |
| *C. cicatricosa* | + | + | + | + | + | + | + | + | + | + | + | + | | + | * | + | | + |
| *C. didyma* | | * | | | | | | | | | | | | | | | | |
| *C. ectenolobata* | | | | | | | | * | | | | | | | | | | |
| *C. eurybathrota* | + | + | + | | + | + | | + | | + | + | * | + | + | | | | + |
| *C. myurilobata* | + | + | + | + | + | + | + | + | + | + | | * | | | + | + | | |
| *C. platyzanclota* | | * | | | | | | | | | | + | | | | | | |
| *C. rhadina* | | * | | | | | | | | | | | | | | | | |
| *C. thliberilobata* | | * | | | | | | | | | | | | | | | | |
| *C. widderensis* | | | | * | | | | + | | | | | | | | | | |
| *Hercynobolbina levis* | | | | | | | | | | | | | | | + | + | | * |
| *Subligaculum aculeatum* | | | | | | | | + | + | * | | | | | | | | |
| *S. bifidum* | * | | | | | | | | | | | | | | | | | |
| *S. biorthogonium* | | | | | | | | | | | | | | | * | | + | + |
| *S. calcaratum* | | * | + | + | | | | | | | | | | | | | | |
| *S. laciniosum* | | | | | | | | | ? | + | | * | + | | | | | + |
| *S. proclivisulcatum* | | | | | | | | | | | | + | * | | | | | |
| *S. quadribursatum* | | | | | | | | + | * | | | | | | | | | |
| *S. recurvisulcatum* | | | | | | | | | | | * | | | | | | | |
| *S. scrobiculatum* | + | | | | | | | | | | * | | | | | | | |
| *S. tribursatum* | | | | | | | | + | | | | * | | | | | | |
| *S. trullatum* | | | | | | | | | | | | | | | * | | | |
| *Tetrasacculus bilobus* | * | | | + | | | | | | | + | | + | | + | | + | |
| *T. magnivelatus* | | + | | | | | | | | | * | + | ? | | | | | ? |
| *T. paeneloculatus* | | + | | | + | | ? | ? | | | + | | | | * | | ? | |
| *T. paeneteichus* | | | | | | | | + | + | * | | | | | | | | |
| *T. quarternarius* | | | | | | | | | | | | | | * | | | | |

Table 1—(continued)

| *Species* | OHIO-MICH | ONTARIO,CAN | | | | NEW YORK STATE | | | | | TRAVERSE, N.MICHIGAN | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Petoskey | Gravel Pt | Potter Farm | Norway Pt | Dock Str | Genshaw | Ferron Pt | Bell Sh | Windom | Kashong | Wanakah | Ledyard | Centerfield | Ipperwash | Widder | Hungry Hol | Arkona | Silica |
| FAMILY HOLLINIDAE | | | | | | | | | | | | | | | | | | |
| *Falsipollex altituberculatus* | | | | | | | | | | | * | | + | | | | | |
| *F. ampliatus* | | | | | | | | | * | | | | | | | | | |
| *F. equipapillatus* | | | | | | | | | | | | | | | * | | | + |
| *F. lativelatus* | + | + | | + | | | | + | + | | * | + | | | + | | | |
| *F. laxivelatus* | + | + | ? | + | | | | | | + | * | + | | | + | | | |
| *F. minimus* | | | | | | | | | | | | | * | | | | | |
| *F. simplilobatus* | | | | | + | | | + | + | * | | | | | | | | |
| *F. valgus* | + | + | | + | | | | | | | + | * | | | + | | | |
| *Hanaites platus* | + | | + | | | + | | | | + | * | | + | + | | | | |
| *Hollina pyxidata* | | + | | | | | | | | | + | * | | | | | + | |
| FAMILY HOLLINELLIDAE | | | | | | | | | | | | | | | | | | |
| *Adelphobolbina medialis* | | | + | ? | | + | + | + | + | * | | | | | | | | |
| *A. megalia* | | | | | | | | | | | | | * | | | | | ? |
| *A. spicata* | + | | | | | | | | | | * | | | | | | | |
| *A. trilobata* | * | + | | + | | | | + | | | + | + | + | | | | | |
| *Bisphenella deminuta* | | | | | | | | | | | | | + | | | | | |
| *B. nodosa* | | | | | | | | | | | | | | | | | | * |
| *B. rana* | | | | | | | | | | | | | | | | | * | |
| *Flaccivelum excertum* | | | | | | | | | | | * | | | | | | | |
| *F. papillosum* | | | | | | | | | | | * | | | | | | | |
| *F. teleutea* | | | | | | | | | | | + | | * | | | | + | + |
| *Hollinella (K.) acutilobata* | | | | | | | | | | | * | | | | | | | |
| *H. (K.) alpenensis* | | | | | | | | | | | | | * | | | | | |
| *H. (K.) ampla* | | | | | | | | | | | | | | | * | | + | |
| *H. (K.) ampulla* | | | | | | | | | | * | | | | | | | | |
| *H. (K.) angustivelata* | | | | | | | | | | | + | | | | | | | |
| *H. (K.) antespinosa* | + | + | + | + | | + | + | + | + | + | + | + | + | + | + | | + | + |
| *H. (K.) auroriradiata* | | | | | | | | | | | * | + | + | | + | + | + | + |
| *H. (K.) bullata* | | | | | | | | | | | * | | | | | | | |
| *H. (K.) devoniana* | | | | | | | | + | | | * | | | | | | | |
| *H. (K.) epakra* | | | | | | | | | | + | | | | | | | | |
| *H. (K.) horologiina* | | | | | | | | | | | | | | | | + | * | |
| *H. (K.) inclinisulcata* | | | | | | | | | | | | | | | * | | | + |
| *H. (K.) magnambitata* | | | | | | | | | | | | | | | | | | * |
| *H. (K.) magnilobata* | | | | | | | | | | | * | | | | | | | |
| *H. (K.) n. nodiventriculata* | | | | | | | | | | | | | | | | | * | |
| *H. (K.) n. incompta* | | | | | | | | | | | | | | | | * | | |
| *H. (K.) plauta* | | | | | | + | + | | | + | | | * | | | | | |
| *H. (K.) porrecta* | | | | | | | | | | | * | | | | | | | |
| *H. (K.) productilobata* | | | | | | | | | | | * | | | | | | | |
| *H. (K.) pumila* | + | + | | | | | | | | | | * | | | + | | + | |
| *H. (K.) sella* | | | | | | + | | + | + | * | | | | | | | | |
| *H. (K.) tendilobata* | | | | | | | | | | | | + | | | * | | + | + |
| *H. (K.) vegrandis* | | | | | | | | | | | | | * | + | | + | | + |
| *Labrosavelum labrosum* | | | | | | | | | | | + | | | | * | | + | |
| *L. pyriforme* | | | | + | + | | | | | | + | + | + | | | * | | + |
| *L. retusilobata* | ? | | | | | + | | + | | * | | | | | | | | |
| *L. sphaericum* | + | | + | * | | | | | | | | | | | | | | |
| *Physcocalyptra pomphosa* | | | * | | | | | | | | | | | | | | | |
| *Ruptivelum bacculatum* | | | | | | | | | | | + | | | | * | | + | + |

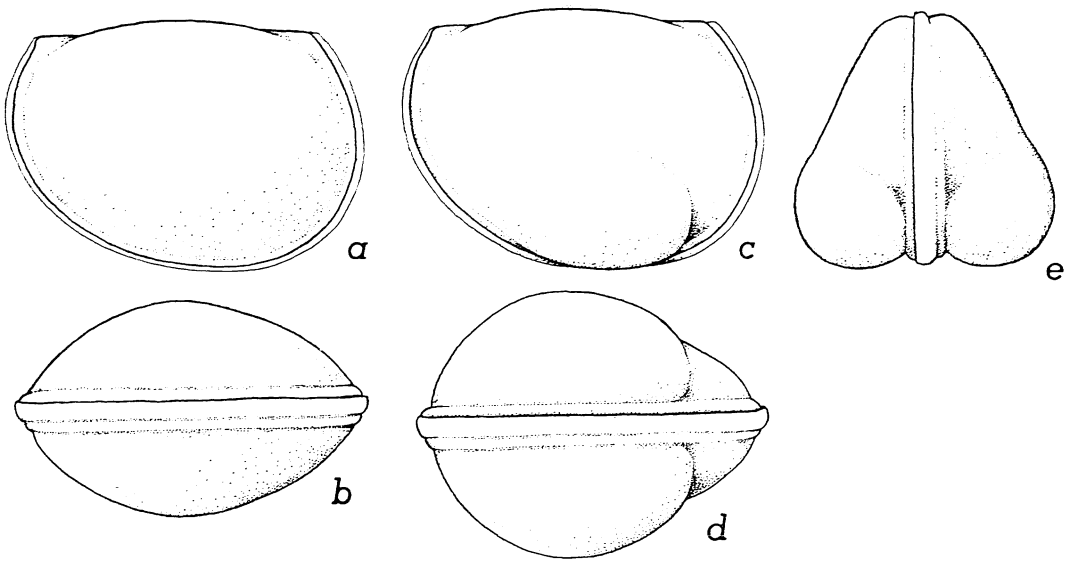


Figure 4. Dimorphism of the beyrichiacean type shown in *Phlyctiscapha rockportensis*. *a,b,* right lateral and ventral views of male carapace. *c-e,* right lateral, ventral, and anterior views of female carapace.

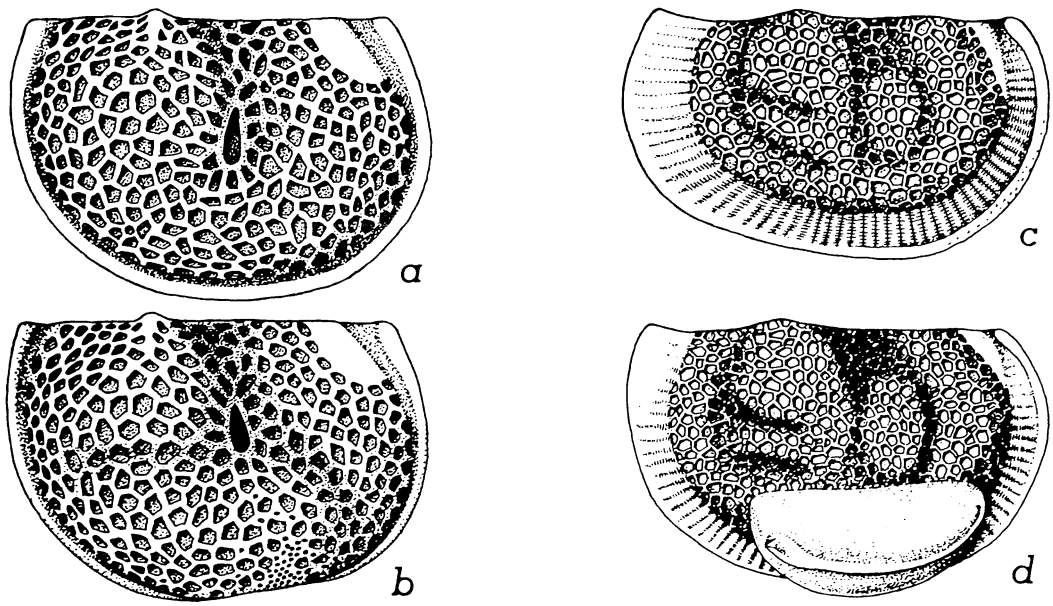


Figure 5. Dimorphism of the beyrichiacean type. *a,b, Hibbardia lacrimosa,* right lateral views of male and female carapaces. *c,d, Treposella stellata,* right lateral views of male and female carapaces.

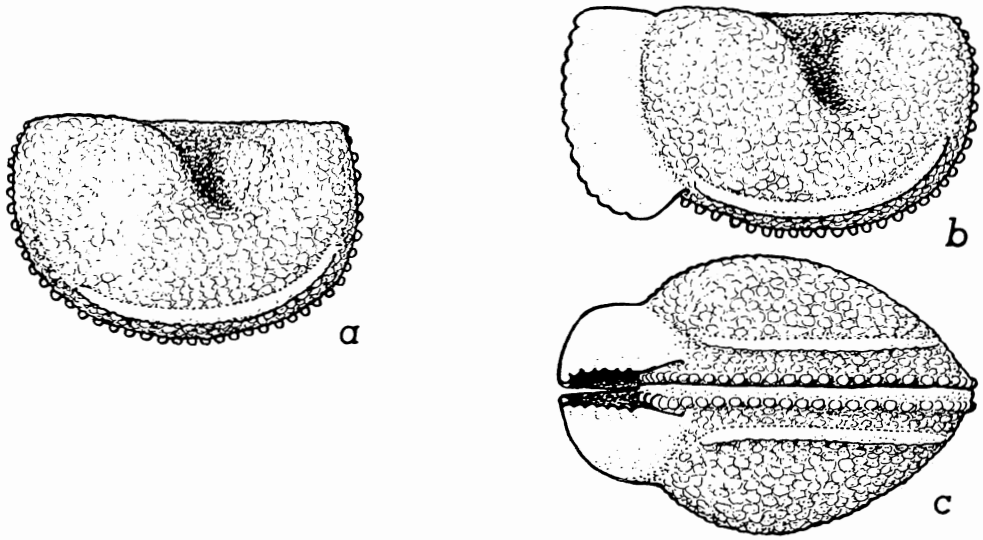


Figure 6. Dimorphism of the primitiopsacean type shown in *Sulcicuneus porrectinatius*. *a*, right lateral view of male carapace. *b,c*, right lateral and ventral views of female carapace.

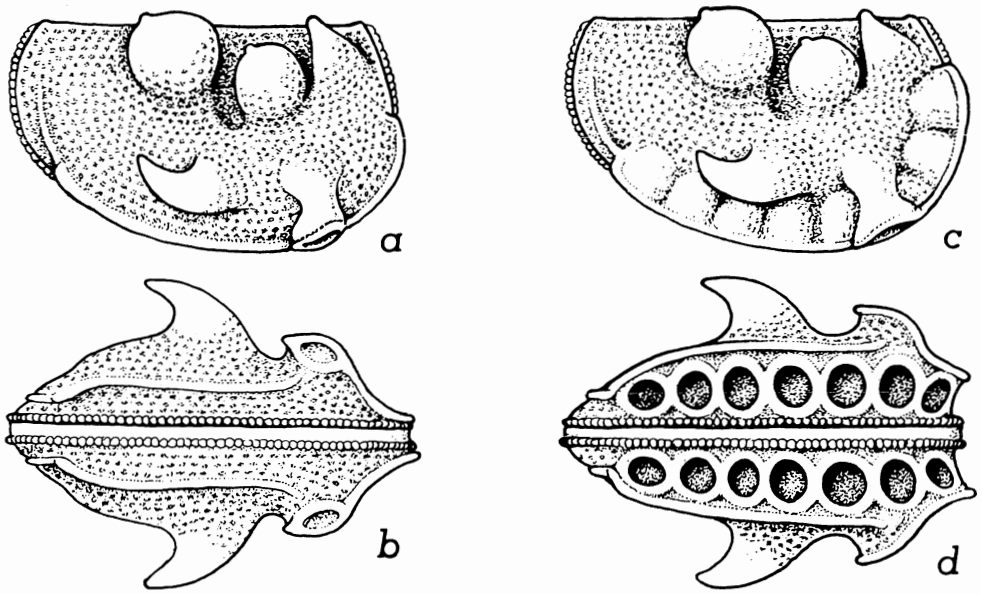


Figure 7. Dimorphism of the ctenoloculinid type shown in *Abditoloculina pulchra*. *a,b*, right lateral and ventral views of male carapace. *c,d*, right lateral and ventral views of female carapace.

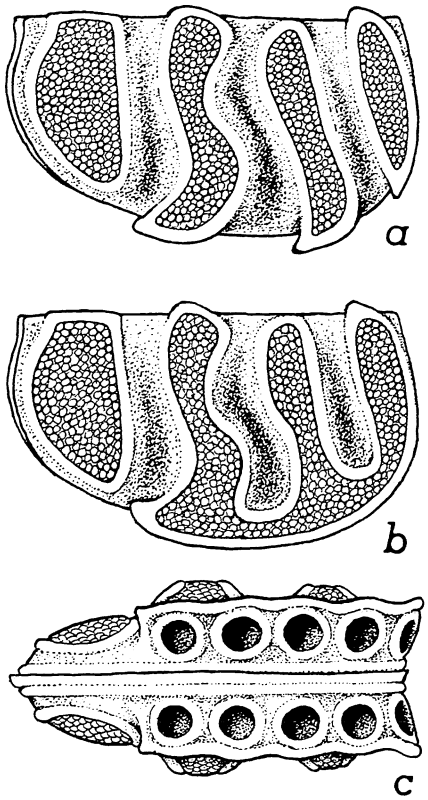


Figure 8. Dimorphism of the ctenoloculinid type shown in *Ctenoloculina cicatricosa*. *a*, right lateral view of male carapace. *b,c*, right lateral and ventral views of female carapace.

"hidden," suggested the family name.) The exact function of loculi has not been satisfactorily determined; some authorities have suggested that each loculus served to house a developing egg, but others are inclined to believe that the whole female dimorphic apparatus evolved to support the carapace on soft substrate. Whatever its use, the ctenoloculinid female dimorph cannot possibly be confused with the male, which has only spurs to mark the location of the velar structure.

The females of the family Hollinidae have their frills strongly developed, in many species incurved, whereas the males possess only a pair of spurs in each valve (one anteroventral, the other ventral). In *Hollina* (Text-fig. 9), the spurs of the male are projecting tips of the valves, but in species of *Falsipollex* (Text-figs. 10,11), they are discrete, solid structures. In all hollinids, the spurs of the male lie in the general plane corresponding to that occupied by the frill in the female.

The dimorphism in the Hollinellidae has been variously interpreted as to which sex had the wider frill. The problem is confounded by the fact that the dimorphic differences in many species are so minor they are difficult to detect. In its best development, one dimorph has a wide frill separated from the edge of the valve by a wide, smooth groove (the antrum), but the other dimorph has a narrow frill, incurved anteroventrally, adjacent to a flat, ornamented marginal area. Because in such Ordovician ostracods as the piretellids *Piretella*, *Oepikium*, and *Uhakiella* and the eurychilinids *Eurychilina* and *Platybolbina*, the dimorph with the more incurved velar structures is designated the female, some authors have called the narrow-frilled hollinellids the females because of the incurvature, and the wider-frilled forms with the antrum the males. However, because the dimorphs of ctenoloculinids and hollinids which have the greater velar expression are females, herein we designate the wider-frilled forms with antra as females (Text-fig. 12).

In the genus *Flaccivelum*, the dimorphism is extreme, the velar structure of the male being reduced to a ridge. In the genus *Ruptivelum*, the frill in each valve of the female is complete, whereas that in the male is interrupted ventrally so that it is separated into two parts; thus, the male dimorph resembles, to a degree, that of the males in the ctenoloculinids and hollinids. Because the lobation in *Ruptivelum* so closely duplicates that of *Hollinella*, the genus is assigned without question to the Hollinellidae.

Obviously, much remains to be discovered about the function and evolution of dimorphism in the paleocopan ostracods.

## GEOLOGY

Nowhere in the Great Lakes region is there exposed an uninterrupted sequence of Middle Devonian strata. The stratigraphic column must be pieced together from rocks exposed in natural outcrops, road cuts, and quarries and from subsurface samples obtained from well cores. Surprisingly, very few intervals are completely hidden from the surface.

Because the limestone units do not readily yield up their microfaunas, very little is known of the ostracods which lived in the nearshore environment. As is the case with most other ostracodologists, we have concentrated our sampling and extractions on the shale units. Thus, we cannot claim to present a complete paleoecological analysis of Middle Devonian Ostracoda in this region.

The following is a condensed and abbreviated account of the geology of the Great Lakes region. It is included to give the stratigraphic placement of the formations sampled and to delineate the four local areas which were investigated.

In Michigan, Lake Michigan and Lake Huron lie in troughs marking the former outcrop of the thick Upper Silurian salt deposits, which readily dissolved soon after their exposure on the margin of the Michigan Basin. After solution of the salt, in the belt where Lake Michigan, the Straits of Mackinac, and Lake Huron are now situated, the collapsed overlying beds (as much as 600 feet thick)

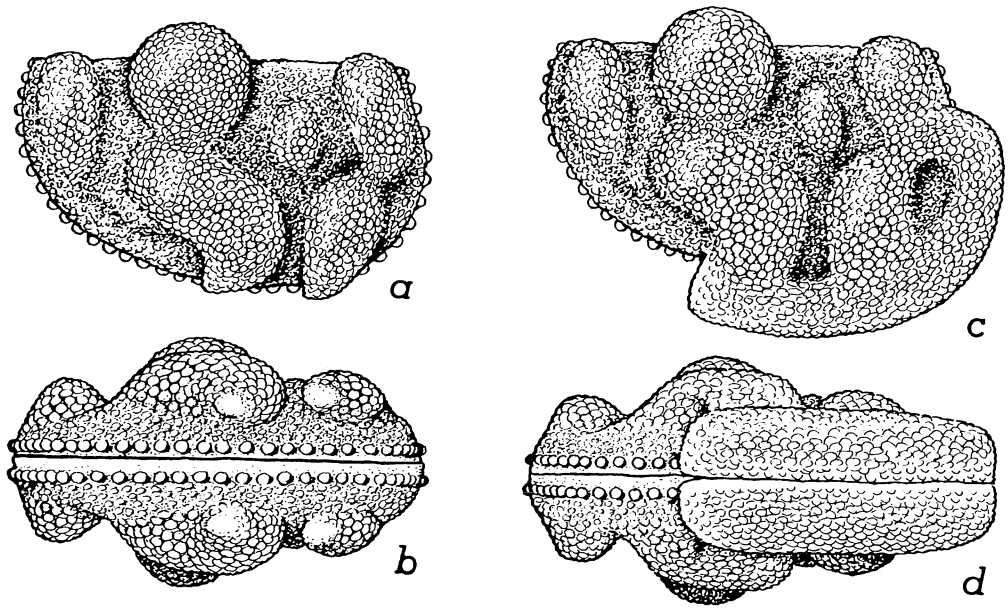


Figure 9. Dimorphism of the hollinid type shown in *Hollina pyxidata*. *a,b*, right lateral and ventral views of male carapace. *c,d*, right lateral and ventral views of female carapace.

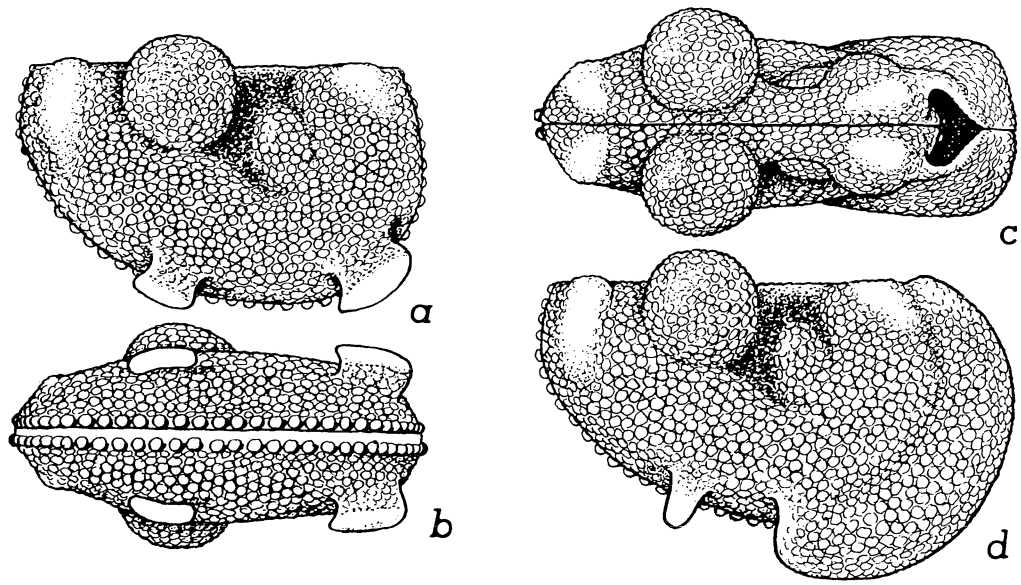


Figure 10. Dimorphism of the hollinid type shown in *Falsipollex laxivelatus*, *a,b*, right lateral and ventral views of male carapace. *c,d*, dorsal and right lateral views of female carapace.

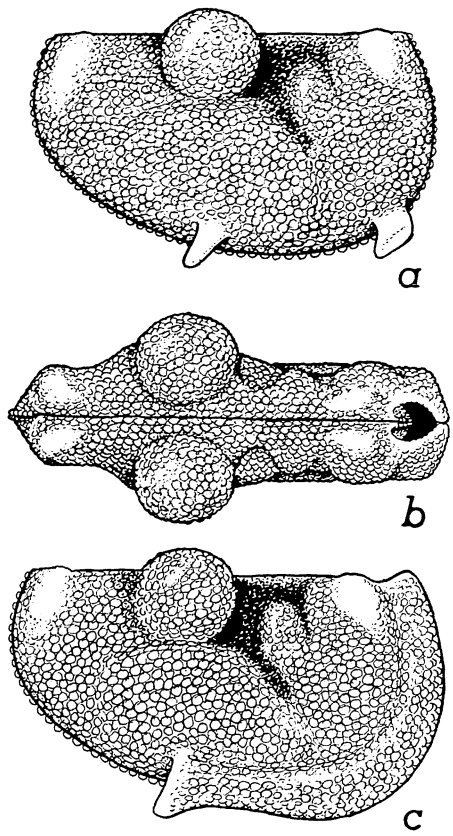


Figure 11. Dimorphism of the hollinid type shown in *Falsipollex lativelatus*. *a*, right lateral view of male carapace. *b,c*, dorsal and right lateral views of female carapace.

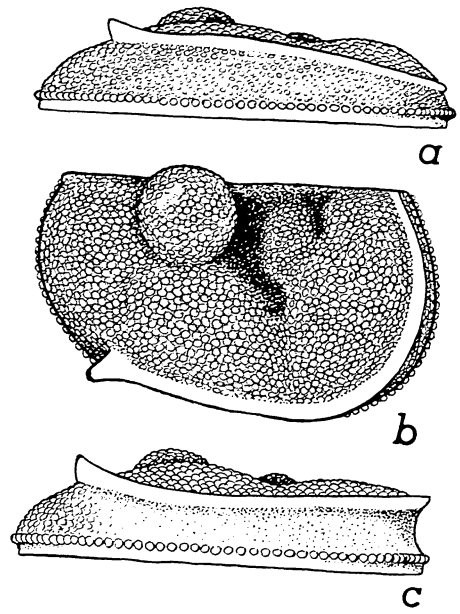


Figure 12. Dimorphism of the hollinellid type shown in *Hollinella pumila*. *a*, ventral view of male right valve. *b,c*, lateral and ventral views of female right valve.

formed a breccia, locally resistant, which can be seen on Mackinac Island, the northern approach to the Mackinac Bridge, and at isolated spots such as St. Anthony's Rock, Castle Rock, and Rabbit Back. As a result of this episode of salt solution and collapse in the Michigan Basin, the Middle Silurian and older rocks are isolated in the Upper (Northern) Peninsula and the Devonian and younger rocks in the Lower (Southern) Peninsula of the state, where formations crop out or lie just below the glacial veneer in a pattern of concentric rings (Text-fig. 1). The Middle Devonian formations comprise the Traverse Group in Michigan, particularly well developed across the northern margin of the Lower Peninsula and exposed intermittently from Alpena County on the east to Charlevoix County on the west.

About two hundred miles to the south, on the southeast margin of the Michigan Basin, in southeastern Michigan and northwestern Ohio, the only Middle Devonian formation yielding an extensive ostracod fauna is the Silica Shale. It is an equivalent of the lower part of the Traverse Group in northern Michigan. It is overlain by the Ten Mile Creek Dolomite, which is correlated with the Four Mile Dam Formation of northern Michigan, the Hungry Hollow Formation of Ontario, and the Centerfield Formation of western New York.

Extending eastward in the Chatham Sag (Text-fig. 1), the Middle Devonian strata reach into western Ontario, where they are exposed around Thedford and Arkona. The outcrop area of Middle Silurian rocks also extends southeastward, away from the southern part of Lake Huron, before curving eastward to form Niagara Falls between Lake Erie and Lake Ontario. Thus, the cuesta of resistant Silurian rocks forms the northern boundary of the Devonian rocks across western Ontario.

South of Niagara Falls, Devonian rocks continue into New York state. The western part of that state, around Erie County, has numerous exposures of the sequence of formations comprising the Middle Devonian Hamilton Group. The Hamilton Group, equivalent to much of the Traverse Group of Michigan, contains ostracod faunas in the Centerfield and younger formations.

Hence, in the Great Lakes region there are four major areas which produce extensive ostracod faunas: southeastern Michigan and northwestern Ohio, northern Michigan, western Ontario, and western New York. These four areas are distinctive geologically as well as geographi-

cally, even though the outcrops are not widely separated and the formations can be traced in subsurface.

For at least most of Middle Devonian time, the Great Lakes region lay under a common sea, although from time to time local areas were either emergent or too shallow to retain sediments. Thus during early Middle Devonian time no ostracod-bearing strata were laid down in western New York, and during late Middle Devonian time none were deposited in northwestern Ohio-southeastern Michigan.

Probably the most complete section of Middle Devonian strata in the Great Lakes region is that of northern Michigan. There, exposures of the Traverse Group in Alpena and Presque Isle counties contain over 550 feet of shales and limestones, which have been divided into ten formations of Middle Devonian age and one of Late Devonian. Even in the area of northern Michigan, drastic lateral changes in lithology necessitate new formational terminology, and the exposures in Charlevoix and Emmet counties are divided into different formations than those in Alpena and Presque Isle counties.

Stratigraphically, the ostracod-bearing formations in the four areas can be divided into those of pre-Centerfield age and those of Centerfield and younger age. The pre-Centerfield formations include the Silica Shale of southeastern Michigan-northwestern Ohio, the Arkona Shale of Ontario, and the Bell Shale, Ferron Point Formation, Genshaw Formation, Alpena Limestone, and the Gravel Point Formation of northern Michigan. The Centerfield Formation of western New York is correlated with the Four Mile Dam Formation of northern Michigan and the Hungry Hollow Formation of Ontario. Younger strata are not exposed in the southeastern Michigan-northwestern Ohio area; elsewhere, they are represented by the Norway Point, Potter Farm, and Petoskey formations of northern Michigan, the Widder and Ipperwash formations of Ontario, and the Ledyard, Wanakah, Kashong, and Windom formations of western New York.

Inasmuch as several species range throughout the Middle Devonian and occur in practically all formations, we are led to presume that their span of existence occupied an especially brief interval in the geologic history of the Great Lakes region.

## LOCALITIES

### *Ohio-southeastern Michigan Localities*

### SILICA SHALE

The only shale formation of Middle Devonian age in this area is the Silica Shale, predominantly a soft, gray, clay shale with a few more calcareous beds. It has the characteristics of the Bell Shale and the upper part of the Ferron Point Formation in northern Michigan, and may be a southern extension of those deposits. Although the Silica Shale is not deeply covered by drift in any part of this area, it is principally known from quarry exposures. The few natural outcrops along stream valleys are mostly masked by slump and vegetation.

1) Quarries formerly operated by the Medusa Portland Cement Company in Lucas County, Ohio. These quarries are fully described and indicated on maps in Kesling and Chilman, 1978, vol. 1. Subsequently, they were sold to the France Stone Company, and are no longer available for collecting. Collections of new material were made from 1950 to 1978 by R. V. Kesling and from 1970 to 1978 by R. B. Chilman.

2) Rocks exposed by quarrying operations of the Martin-Marietta Quarry, now abandoned, in Augusta Township, Washtenaw County, Michigan. This ill-fated quarry was flooded with sulphide-charged water, filled, and abandoned. The strata have been extensively shifted by bulldozing in opening the original quarry and later in filling the pit. Material collected by Kesling and Chilman at various times since 1960.

### *Northern Michigan Localities*

### BELL SHALE

The Bell Shale, lowest formation of the Traverse Group, is exposed in Alpena and Presque Isle Counties, Michigan. Because it is predominantly a thick (75 to 80 feet), soft, gray, clay shale, it does not maintain natural exposures; within a year after exposure, the formation is modified by extensive slumping and soon thereafter covered over by vegetation. Many of the occurrences are as sink fillings in the highly soluble underlying Rogers City Limestone. Where the Rogers City is actively quarried for flux stone in the steel industry and for crushed stone, the sink fillings of Bell Shale are regarded as undesirable contaminants; quarrymen selectively remove the shale and dump it in abandoned sections of the quarry floor. These occurrences do not permit stratigraphic placement in the formation, for it is not known how far the shale layers dropped into the sink nor even from what part of the filling they were obtained.

1) Lower six feet of Bell Shale, from contact with underlying Rogers City Limestone above quarry wall, quarry of Michigan Limestone Division of U. S. Steel Corporation at Calcite (adjoining Rogers City), NE1/4 sec. 1, T34N, R5E. Presque Isle County, Mich. Collected by R. V. Kesling in 1949.

2) Sink filling in Rogers City Limestone at above quarry, NE1/4 sec. 26, T35N, R5E. Exposure since removed by quarrying. Collected by G. M. Ehlers in 1926.

3) Upper 10 feet of formation, exposed in drainage ditch of the abandoned Kelley's Island Lime and Transport Company quarry, NW1/4 sec. 6, T32N, R9E, Rockport, northeastern corner of Alpena County, Mich., about 1/4 mile northwest of old quarry buildings. Collected by Kesling in 1949.

4) Dump piles near center of quarry of Michigan Limestone Division of U. S. Steel Corporation, Calcite,

Michigan. Collected by R. B. Chilman in 1970.

5) Dump piles in above quarry, sec. 23, T35N, R5E. Collected by R. B. Chilman in 1970.

6) Sink filling in west wall of above quarry. Collected by Kesling and M. Weiss in 1952.

7) Sink filling in west wall of above quarry. Collected by Chilman in 1972.

8) Same as locality 3; collected by Chilman in 1970.

9) Same as locality 3; collected by Chilman in 1972.

10) Exposures between west wall of quarry of Presque Isle Corporation (formerly Lake-of-the-Woods Quarry) and East Grand Lake Road, W1/2 sec. 2, T33N, R8E, Presque Isle County, Mich. Collected by Chilman in 1971.

## FERRON POINT FORMATION

The lower part of the formation consists of alternating thin beds of soft shale and argillaceous limestone, with only a very few natural exposures. The upper part, below the more resistant lower Genshaw limestones, consists of about 20 feet of soft gray shale that has no natural exposures.

1) Shale layer 6-inches thick in lower half of formation exposed in ledge above west quarry wall of abandoned quarry of Kelley's Island Lime and Transport Company, NW1/4, sec. 6, T32N, R9E, Rockport, northeastern corner of Alpena County. (Loc. 1 of Kesling, 1952c, p. 46). Collected by Kesling in 1949.

2) Abandoned quarry of Onaway Limestone Company (now part of Onaway State Park) on shore of Black Lake, exposed above Rockport Quarry Limestone, NW1/4 sec. 7, T35N, R2E, western margin of Presque Isle County. Collected by Kesling and G. M. Ehlers in 1950.

3) Upper half of formation exposed in abandoned shale pit of old Alpena Portland Cement Company, about 8 miles northeast of Alpena, SE1/4 sec. 18, T32N, R9E, Alpena County. Collected by G. M. Ehlers, E. C. Stumm, and Kesling in 1949. (Locality 3 of Kesling, 1952c, p. 46).

4) Dump piles of shale from lower part of formation, at southeast wall of abandoned Kelley's Island Quarry, NW1/4, sec. 6, T32N, R9E, Rockport, Alpena County. Collected by Chilman in 1968, 1970, and 1972.

5) Bluish-gray shale unit 10 1/2 to 12 1/2 feet above base, containing numerous *Mucrospirifer prolificus*, exposed at Locality 1. Collected by Ehlers.

6) Gray calcareous shale near top of exposures at above locality. Collected by Ehlers, Stumm, and Kesling in 1949.

7) Same as locality 2, upper 2 1/2 to 3 feet of exposure. Collected by Porter M. Kier in 1950.

## GENSHAW FORMATION

The Genshaw, more resistant than either the Bell Shale or Ferron Point formations, has some natural exposures, particularly the resistant Killians Member near the middle of the formation. The lowest part of the formation is resistant calcareous shale to limestone; a little higher in the formation softer shales are intercalated between the limestone units. The Killians Member consists of dark gray to black shales and limestones, notably high in silica content. The basal 6 feet of this member is a gray calcareous shale containing numerous *Cyrtina umbonata alpenensis*; this unit produces fine ostracod specimens, whereas the overlying black limestones yield none. The upper part of the Genshaw Formation is about 35 feet of argillaceous limestone, overlain by the dark crystalline limestone of the Newton Creek Formation.

1) Exposures low on bank of Swan Creek just upstream from its intersection with US 23, NW corner sec. 17, T34N, R6E, about 5 1/2 miles southeast of Rogers City, Presque Isle County. Collected by Chilman in 1970.

2) Road cut on south side of US 23 about 1/10 mile east of its junction with M-65, about 2 miles east of Swan Creek, SW1/4 sec. 15, T34N, R6E, Presque Isle County. Collected by Kesling.

3) Exposures in bed and banks of Rainy River less than 1/4 mile below Rainy River Falls, about 3 1/2 miles east of Rowe School and about midway between Ocqueoc and Onaway, reached by Vermilya "Highway" off Porter Road, S1/2 sec. 26, T35N, R2E, western Presque Isle County. Collected by G. M. Ehlers, M. Weiss, and Kesling in 1952.

4) Uppermost unit of formation exposed in drainage ditches in floor of Huron Portland Cement Company (formerly Michigan Alkali Company) in Alpena, W1/4 sec. 13, T31N, R8E, Alpena County. Collected by Chilman in 1972.

5) Roadside and field exposures containing *Sieberella romingeri* along East Grand Lake Road (CO 405) and on Rabiteau farm, W1/4 NW1/4 sec. 35, T33N, R8E, southeastern Presque Isle County. Collected by Kesling.

6) Road cut of gray shale containing numerous *Cyrtina umbonata alpenensis*, about 1/2 mile south of old Le Roy's Resort, at and near junction of West Long Lake Road and entrance to Martin's Resort, center W1/4 sec. 32, T33N, R8E, Presque Isle County. Collected by Ehlers and Kesling in 1952 and by Chilman in 1972.

7) Roadside exposures of shale containing *Cyrtina umbonata alpenensis*, along French Road about 1/8 mile south of its junction with West Long Lake Road, east line sec. 8, T32N, R8E, Alpena County. Collected by Kesling in 1970.

## ALPENA LIMESTONE

Most of the formation is a limestone, which in many places in the northern part of the Southern Peninsula contains reefs. The main part of the formation is so hard and dense that no ostracods can be located within it. The following is the only known exception.

1) Exposures in old Michigan Alkali Quarry (now

owned by Huron Portland Cement Company) in Alpena, W1/4 sec. 13, T31N, R8E, Alpena County. The ostracods are all from a 1-foot shale unit about 30 feet above the base of the formation. When the quarry was operated by Michigan Alkali Company, this unit provided a convenient quarrying level and the shale was exposed and weathered over a rather large area. Later, the Huron Portland Cement Company purchased the property and abandoned selective quarrying; as a result, the entire face of the formation was then cut back by blasting, so that occurrences of the unweathered shale can no longer be ascertained in the quarried rubble. Collected by Kesling in 1949.

## FOUR MILE DAM FORMATION

This formation contains two contrasting lithologies: a lower 8 feet of bluish-gray soft shale and an upper 13 feet of limestone, which is developed as a massive reef at the type locality. The shale, known as the Dock Street Clay Member, is the only unit to yield microfossils; it is also noted for its excellent specimens of crinoids, especially *Dolatocrinus* and *Megistocrinus*, as well as other invertebrates. The only exposures of the Dock Street Clay are those made by quarrying operations in the city of Alpena. For many years, the only exposures were in the Thunder Bay Quarry (now abandoned and used for disposal of fly-ash); in recent years, however, this unit has been encountered in bulldozing operations as the Huron Portland Cement Company Quarry on the east side of Wessel Road is enlarged northward. 1) Exposures of soft gray shale along old railroad cut formerly leading from abandoned Thunder Bay Quarry to loading docks on Thunder Bay, about one city block west of Wessel Road in Alpena, NE1/4 sec. 14, T31N, R8E, Alpena County. Collected by Kesling in 1950.

## NORWAY POINT FORMATION

The formation, 52 feet thick, consists mostly of soft gray shale. The lower ten feet contains alternating thin shale and limestone units and a thin limestone bed occurs near the middle of the formation. Most of the few natural exposures of shale along Thunder Bay River are badly slumped, but their approximate stratigraphic position is evident.

1) Shale exposure on southwest bank of Thunder Bay River about 1 mile downstream from Four Mile Dam (formerly called Fletcher Dam, Three Mile Dam, and Broadwell's Saw Mill), formerly part of the F. N. Potter farm, E1/4 sec. 18 and NW1/4 SW1/4 sec. 17, T31N, R8E, Alpena County. Collected by Ehlers, Stumm, and Kesling in 1949 and by Ehlers, Weiss, and Kesling in 1952. Ostracods light in color and nearly translucent, many small and preserving fragile features.

2) Shale exposures on south bank and in bed of Thunder Bay River just below Four Mile Dam, exposed as steeply sloping beds draped over remnant of bioherm core in underlying Four Mile Dam Formation, 1/4 mile south of center, sec. 7, T31N, R8E, Alpena County. Collected by Chilman in 1970 and later by Steve Mitchell.

3) Calcareous shale exposure at above locality about 20 feet above core rock of underlying bioherm. Collected by Ehlers in 1949. Ostracods poorly preserved.

4) Shale containing numerous *Spinocyrtia granulosa* exposed near water level on southwest bank of Thunder Bay River just downstream from Norway Point Dam (also called Seven Mile Dam), NE1/4 sec. 12, T31N, R7E, Alpena County. Collected by Ehlers, Stumm, and Kesling in 1949.

5) Softer clay shales overlying beds of Locality 4. Collected by Ehlers, Stumm, and Kesling in 1949. These beds contain better preserved ostracods than those of the *Spinocyrtia granulosa* unit.

6) Layers at Locality 1 about 4 feet above river level in mid-July 1926. Collected by A. S. Warthin, Jr. in 1926.

7) Layers at Locality 1 about 9 feet above river level in mid-July 1926. Collected by Warthin in 1926.

8) Layers at Locality 1 about 14 feet above river level in mid-July 1926. Collected by Warthin in 1926.

9) Layers at Locality 1 about 19 feet above river level in mid-July 1926. Collected by Warthin in 1926.

## POTTER FARM FORMATION

This thickest formation (102 feet) of the Traverse Group is made up of numerous alternating shale and limestone units. It is more resistant than the underlying Norway Point Formation and has more natural outcrops. Because nearly all of the shale beds are somewhat calcareous, microfossils are best obtained from material that has been weathered for several years.

1) Shale pit dug in northwest corner of Evergreen Cemetery and adjacent field exposures, exposing highly fossiliferous beds, western edge of city of Alpena just north of M32, SW1/4 sec. 21, T31N, R8E, Alpena County. Collected by Patricia Rutkowski in 1971. Whereas ostracods are relatively scarce, they are very well preserved and clean; many are nearly transparent.

2) Same as Locality 1. Collected by Michael and John Topor in 1979.

3) Exposures in ditches alongside Burkholder Road, about 1/10 mile north of Locality 1, NW1/4 SW1/4 sec. 21, T31N, R8E, Alpena County. Collected by Ehlers in 1959 and by Chilman in 1970. Very good preservation of ostracods and macrofossils.

4) Same as Locality 3. Collected by P. Rutkowski in 1973.

5) Thin shale beds alternating witih argillaceous limestone exposed in roadside ditch along Hobbs Drive, a short distance south of its junction with M32, NW1/4,

sec. 28, T31N, R8E, Alpena County. Collected by Chilman in 1972. Few ostracods.

6) Calcareous shales and argillaceous limestones exposed on north side of Long Rapids Road and south side of Orchard Hill, between Herron Road and Martin Road, near center sec. 31, T32N, R7E, Alpena County. Collected by Kesling in 1968. Very few ostracods.

## GRAVEL POINT FORMATION

This formation in the north-central (Afton-Onaway) and the northwest (Petoskey-Charlevoix) regions of the Lower Peninsula is the approximate equivalent of the Alpena Limestone in Alpena and Presque Isle counties to the east. At Black Lake, in westernmost Presque Isle County, the thick shale units of Alpena County have thinned or thinned out completely: the Ferron Point Formation is reduced from 80 to 9 feet and the Four Mile Dam and Norway Point Formations are missing. In the Onaway region, the Killians Member of the Genshaw Formation is overlain by the Koehler Limestone, a thin-bedded lagoonal deposit, and no trace can be found of the upper part of the Genshaw or the Newton Creek.

The Gravel Point and the underlying Koehler together comprise 270 feet of strata, predominantly limestones. In the Afton-Onaway region the Gravel Point is overlain by the Beebe School Formation, 110 feet of thin limestones, calcareous shales, and a few beds of soft shale. Farther to the west, in Emmet and Charlevoix Counties along Lake Michigan, the Gravel Point is overlain by the Charlevoix Formation, 20 to 30 feet of limestone. In succession above the Charlevoix are the Petoskey and Whiskey Creek formations.

The units of the Gravel Point which yield most ostracods are two shaly units at and near the top of the formation, known as the "Upper Blue Shale" and "Lower Blue Shale."

1) "Upper Blue Shale" unit exposed in Penn-Dixie Quarry (formerly owned by Petoskey Portland Cement Company), about 1 mile southwest of Petoskey, between US 31 and Lake Michigan, sampled east of quarry buildings, SW1/4 sec. 2, T34N, R6W, Emmet County. Collected by Ehlers and Kesling in 1957.

2) "Upper Blue Shale" unit exposed in former abandoned Bell Quarry (also called Rose Quarry), the quarry since incorporated into Penn-Dixie Quarry and no longer identifiable, near NE corner sec. 8, T3N, R6W. Collected by Ehlers, Weiss, and Kesling in 1952.

3) Same as Locality 1. Collected by Ehlers in 1956.

4) "Upper Blue Shale" unit once exposed in former Charlevoix Rock Products Company Quarry (now filled with dumped soil from Medusa Portland Cement Company Quarry), about 3/4 mile west of Charlevoix, SE1/4 SE1/4 sec. 28, T34N, R8W, Charlevoix County. Collected by Kesling in 1953.

5) "Upper Blue Shale" unit exposed in abandoned Wolverine Quarry (once operated by Charlevoix Lime and Stone Company) in floor and drainage ditch, SE1/4 SE1/4 sec. 29, T34N, R8W, Charlevoix County. Collected by Kesling in 1976. Material badly weathered and containing many broken valves of ostracods.

6) "Upper Blue Shale" unit exposed in present Medusa Portland Cement Company Quarry, about 2 miles southwest of Charlevoix, SW1/4 sec. 28 and/or NW1/4 sec. 33, T34N, R8W, Charlevoix County. Collected by Kesling in 1973.

7) Same as Locality 6. Collected by Kesling in 1976.

8) "*Welleria aftonensis* zone" exposed in the Campbell Stone Company Quarry, about 3/4 mile north of Afton in sec. 36, T35N, R2W, Cheboygan County; quarry intermittently operated by the Cheboygan County Highway Commission for road metal and crushed stone. Collected by Kesling in 1949 and 1950.

9) Uppermost strata of formation exposed in ledge facing Little Traverse Bay near former site of Pennsylvania Railroad station in Bay View, NW1/4 sec. 33, T35N, R5W, Emmet County. Collected by Kesling in 1949 and several subsequent years; by Ehlers, Weiss, and Kesling in 1952; and by Jane Elizabeth Inch Smith in 1955.

## PETOSKEY FORMATION

The Petoskey is predominantly limestone, with some beds of calcareous shale near the base and in the middle of the formation. The resistant upper limestone units form natural exposures along Lake Michigan southwest of Charlevoix and north of Norwood, but the lower half is seen only in quarries and road cuts.

1) Lower units of formation exposed in 1933 in ditch on east side of Encampment Avenue in Bay View, extending from western intersection of the street and US 31 southward for about 50 yards (since paved over and inaccessible), sample estimated to have been about 27 feet above base of the formation, near center of east line of sec. 32, T35N, R5W, Emmet County. Collected by Ehlers in 1933.

2) Thin interbedded limestone, calcareous shale, and softer shale layers exposed on north side of abandoned Kegomic Quarry (also called Mud Lake Quarry and Old Brewery Quarry), between US 31 and M131 and not far northwest of their intersection, between Pickerel Lake Road and Pennsylvania Railroad, about 1 mile east of Bay View, SE1/4, SW1/4 sec. 27, T35N, R5W, Emmet County. Collected by Ehlers, Weiss, and Kesling in 1952. This sample contains about the same fauna as Locality 1.

3) Same as Locality 2. Collected by Kesling in 1973.

*Ontario Localities*

## ARKONA SHALE

This formation, the lowest beds of which are concealed, crops out along the Ausable River and is exposed in the quarry of the brickyard at Thedford. Everywhere it is a soft gray shale, remarkably uniform, with only a few resistant layers, most of which consist of crinoidal "hash." It is overlain by the Hungry Hollow Formation, a much more resistant formation.

1) Light gray, highly fossiliferous shale weathering easily to soft clay, sampled about 22 feet below Encrinal Limestone Member of the Hungry Hollow Formation, exposed in the brick and tile yard about 1/2 mile north of Thedford and about 1/8 mile east of the road, Bosanquet Township, Lambton County. Collected by E. P. and J. D. Wright in 1952.

2) Same as Locality 1 but stratigraphic position not known. Collected by R. R. Hibbard in 1955 and by Chilman in 1971.

3) Light gray shale weathering easily to clay, containing many small pyritized fossils all covered by limonitic stain and known locally to collectors as the "Miniature Beds," particularly rich in brachiopods of the genus *Leptalosia*, about 15 feet below the Encrinal Limestone Member in east bank and bed of Ausable River near its junction with Rock Glen, about 1 mile northeast of Arkona, West Williams Township, Middlesex County. Collected by E. P. and J. D. Wright in 1952.

4) Same as Locality 3. Collected by E. C. Stumm in 1951 and by Joseph Poppelreiter in 1971.

5) Clay pit on south bank of Ausable River at Hungry Hollow, just west of the old bridge, West Williams Township, Middlesex County. Collected by Chilman in 1971 and by John and Michael Topor in 1979.

6) Clay pit on north bank of Ausable River at Hungry Hollow, West Williams Township, Middlesex County. Collected by Chilman in 1971.

7) Road cut north of Thedford brick and tile yard, containing same fauna and preservation as "Miniature Beds" at Rock Glen, Bosanquet Township, Lambtor County. Collected by Poppelreiter.

8) Outcrops on farm formerly owned by the late Robert Fraser and known as "Fraser's farm," north bank of Ausable River, about 2 3/4 miles northeast of Arkona, West Williams Township, Middlesex County. Collected by Poppelreiter in 1970 and 1971.

9) Gray shale cropping out on south bank of Ausable River, known as "Crinoid Hill," a short distance downstream from Locality 8, Bosanquet Township, Lambton County. Collected by Poppelreiter in 1978.

10) Gray shale cropping out on north bank of Ausable River about 4 feet below Encrinal Limestone Member of Hungry Hollow Formation, West Williams Township, Middlesex County. Collected by Kesling in early 1950's.

## HUNGRY HOLLOW FORMATION

This formation is readily separable into a lower Encrinal Limestone Member and an upper Coral Zone Member. It is more resistant than the underlying soft shales of the Arkona, and crops out as ledges along stream cuts.

1) Outcrops above old clay pit piles at Hungry Hollow, strata above Encrinal Limestone, West Williams Township, Lambton County. Collected by Poppelreiter and by Chilman in 1971.

2) Shaly material from slumped pile near old bridge at Hungry Hollow. Collected by Steven Mitchell in 1964.

3) Ledge on right side of road leading to shale pit at Hungry Hollow. Collected by Chilman in 1971.

4) Brick and tile yard about 1/2 mile north of Thedford and about 1/8 mile east of road, exposures made by bulldozing operations preparatory to removal of Hungry Hollow strata to make the underlying Arkona Shale accessible for quarrying, mostly on east margin of quarry, Bosanquet Township, Lambton County. Collected by Poppelreiter and by Chilman in 1971.

5) Exposures along service road behind Schramm residence. Collected by Poppelreiter in 1971.

## WIDDER FORMATION

This formation is less resistant than the underlying Hungry Hollow Formation, and the shale tends to slump in exposures in the banks along the Ausable River.

1) Roadside exposures along Highway 82 about 1.3 miles southeast of Thedford, at former site of the village of Widder; beds contain numerous brachiopods, particularly *Cyrtina*, West Williams Township, Lambton County. Collected by Ehlers, Wright, and Poppelreiter in 1970.

2) Roadside exposures along Highway 82 about 2 1/2 miles northwest of Thedford, Lambton County. Collected by R. R. Hibbard and J. D. Wright in 1955.

3) Shallow quarry known as Jim Bell's Quarry (since filled in and obliterated) in Thedford, just northwest of intersection of Ridge Road and north boundary road of Thedford, just north of tracks of Canadian National Railways, thought to be the uppermost shale layer of the formation, Lambton County. Collected by Chilman in 1971.

4) Gray shale in east bank of Ausable River at Hungry Hollow, about 1/3 mile downstream from clay pit, known as the "High Banks," Lambton County. Collected by Poppelreiter in 1971 and by Melvin and Charlene Berry in 1976.

5) Roadside exposures along Ridge Road, leading northwest from former site of Widder and passing north and east of the brick and tile yards, beds containing numerous *Mucrospirifer*, Lambton County. Collected by Poppelreiter in 1971.

## IPPERWASH FORMATION

This predominantly limestone formation lies just below the Upper Devonian black shales. Some beds are sufficiently argillaceous to yield microfossils, but most are too hard.

1) Material removed from ditch leading to Lake Huron in Kettle Point Indian Reservation, exposed from below black Kettle Point Shale (Upper Devonian) by blasting to deepen boat wells in 1957, about 2 miles south of Kettle Point and 3 miles west of Ravenswood, Bosanquet Township, Lambton County. Collected by J. D. Wright in 1971.

2) Outcrops along shore at Ipperwash Provincial Park on Lake Huron, at and near Stony Point, about 3 miles east of Kettle Point, and about 2 miles north-northeast of Ravenswood, Bosanquet Township, Lambton County. Collected by R. R. Hibbard.

### *Western New York Localities*

## CENTERFIELD FORMATION

These interbedded argillaceous limestone, calcareous shale, and softer shale layers are, by some, regarded as the Centerfield Limestone Member of the Ludlowville Formation. Here, we consider them to constitute a formation.

1) Strata exposed in cut of the Delaware, Lackawanna, and Western Railway, about 1 1/2 miles west of East Bethany, Genesee County. Collected by R. R. Hibbard and Kesling in 1953.

2) Field exposures on north side of Sumner Road, just west of Simons Road, 2 miles northeast of Darien, Genesee County. Collected by Hibbard in 1946, 1947, and 1952.

3) Strata exposed on north side of tracks of the Delaware, Lackawanna, and Western Railway and along nearby tributary of North Tonawanda Creek, about 2 1/2 miles west of East Bethany and 3/4 mile east of mile 357 of Francis Road, Genesee County. Collected by George McIntosh in 1977.

4) Shales from 2 1/2 miles west of East Alexander (no other data given). Collected by Hibbard around 1946.

## LEDYARD SHALE

The soft gray shales, many dark gray, are much less resistant than the underlying Centerfield Formation. With advanced weathering on slopes, they tend to slump.

1) Soft dark shales in field exposure on west side of Bethany Center Road, just south of the cut of the Delaware, Lackawanna, and Western Railway, 1 1/2 miles west of East Bethany, Genesee County. Collected by Hibbard around 1946 and by Hibbard and Kesling in 1953.

2) Exposures on west side of Bethany Center Road about 1/4 mile south of Locality 1, Genesee County. Collected by Hibbard around 1946.

## WANAKAH FORMATION

These shales, by some geologists regarded as a member of the Ludlowville Formation, are here considered to be a formation.

1) Gray shale weathering easily to clay, very rich in ostracods, from the upper part of the formation, exposed along road 2 miles southeast of East Bethany, Genesee County. Collected by R. R. Hibbard in 1950.

2) Shales rich in *Pleurodictyum* exposed in abandoned shale pit off Big Tree Road and just east of the railroad tracks at Bay View, Hamburg Township, Erie County. Collected by Hibbard before 1952.

3) Same as Locality 2. Collected by Hibbard in 1955.

4) Same as Locality 2. Collected by George McIntosh in 1977.

5) Shale containing numerous *Strophodonta demissa* exposed along Rush Creek, near abandoned electric railroad tracks at Highland Acres, Erie County. Collected by Hibbard before 1952.

6) Soft shale of *Strophodonta demissa* beds exposed in railroad cut at Highland Acres, near Locality 4, Erie County. Collected by McIntosh in 1977.

7) Shale exposed along Avery's Creek near Mt. Vernon, Erie County. Collected by Hibbard in 1955.

## KASHONG SHALE

These shales are somewhat calcareous, and ostracods are rather difficult to extract and clean.

1) Shale exposed in railroad cut at the Ratsof Salt Shaft at Wadsworth, Livingston County. Collected by R. R. Hibbard around 1950.

2) Same as Locality 1. Collected by G. McIntosh in 1979.

3) Shale exposed along Walker Road near Ray, Genesee County. Collected by Hibbard in 1947.

4) Shale layers exposed along Black Creek, 2 1/2 miles southwest of East Bethany, Genesee County. Collected by Hibbard and Kesling in 1953.

5) Shale exposed in pit of abandoned brick and tile yard along White Creek, 3/4 miles north of US 20 and about 2 to 3 miles south of East Bethany, Genesee County. Collected by G. M. Ehlers and Kesling in 1953.

6) Shale exposed in small quarry of the Peck and Wood Tile Factory, 1 mile southeast of East Bethany, Genesee County. Collected by McIntosh in 1979.

## WINDOM SHALE

The Windom Shale contains beds of clay shale which produce clean microfossils.

1) Shales cropping out on north bank of a small pond (the pond may have been excavated), about 3/10 mile south of the intersection of Route 63 and Starr Road, Genesee County. Collected by R. R. Hibbard in 1957.

2) Strata exposed in railroad cut at Highland Acres, Erie County. Collected by Hibbard in 1948.

3) Strata exposed in the Penn-Dixie Quarry (old Olivieri Quarry) at Bay View, Hamburg Township, Erie County. Collected by G. McIntosh in 1977.

4) Strata exposed on north side of tracks of Delaware, Lackawanna, and Western Railway and along tributary to Little Tonawanda Creek, about 1 1/2 miles east of Milepost 357 of Francis Road and about 2 1/2 miles west of East Bethany, Genesee County. Collected by McIntosh in 1977.

## SYSTEMATIC DESCRIPTIONS

## Class OSTRACODA Latreille 1802

## Superorder PALEOCOPA Henningsmoen 1953

## Order PALEOCOPIDA Henningsmoen 1953

*Diagnosis.*—Ostracoda with a straight and usually long hinge line, best seen in interior view of isolated valve, may be partly obscured in lateral view by dorsal hump or extension of one or more lobes. Dimorphism present or absent.

*Remarks.*—The majority of Middle Devonian species belong to this extinct order. Only a few are devoid of distinctive lobation and/or ornamentation. Adductor muscle scars, visible in well-preserved and well-cleaned valves, are composed of an aggregate of tiny scars, never discrete; in lobate species, the adductor muscle scars are situated on the interior ridge marking the position of S2.

The hinge is variable, but never as complex as that in most round-backed ostracods; in some genera, the hinge is a simple tongue-and-groove composed of a hinge list in one valve fitted between upper and lower hinge ridges in the other, whereas in others, the hinge list in both valves is crenulate; in either case, most paleocopidans have a cardinal interruption at each end of the hinge which may reach the extreme development as a socket at the end of the list to accommodate a tooth on the inner ridge of the opposing valve.

Closure is complete. In most genera, a contact list in one valve fits into a contact groove in the other. The vast majority of forms have left/right overlap, but a few exceptions are known.

*Range.*—Lower Ordovician to Middle Permian.

### Suborder BEYRICHICOPINA Scott 1961

*Diagnosis.*—Paleocopida in which overlap is not strong, scarcely discernible in lateral view. Corners distinctly angular at both ends of valve. Dimorphism (if present) of cruminal, velar, or histial type, never kloedenellid.

### Superfamily BEYRICHIACEA Matthew 1886

*Diagnosis.*—Dimorphism of the cruminal type, with anteroventral to ventral crumina or brood pouch externally protuberant and internally forming enlargement of domicilium in female.

### Family Beyrichiidae Matthew 1886

*Diganosis.*—Beyrichiacea with long hinge line. Subfamily Treposellinae Henningsmoen 1954

*Diagnosis.*—Beyrichiid ostracods with crumina located anteroventrally to ventrally, in lateral view with a distinct boundary, at least anteriorly, expressed as a semisulcus.

### Genus *Treposella* Ulrich and Bassler 1908

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

*Diagnosis.*—Treposelline ostracods with crumina of female valve distinct from lateral surface of valve all around its periphery.

#### *Treposella stellata* Kesling

Pl. 36, figs. 1–6

*Treposella stellata* Kesling, 1955a, p. 277–279, pl. 2, figs. 1–3; pl. 3, figs. 1–6. [Centerfield Formation. Holotype UMMP 30501, female right valve.]

*T. stellata* Kesling, 1957c, p. 58,62,63; pl. 6, figs. 4,5.

*T. stellata* Kesling and Rogers, 1957, p. 997–1008, pl. 127, figs. 5–7.

*T. stellata* Melik, 1966, p. 206,207, pl. 16, figs. 11–16.

*T. stellata* Kesling, 1969, p. 296,298, text-figs. 13e,13f.

*Diagnosis.*—Lateral surface of valve in male and female covered with reticulation of polygonal meshes. Ridges around each mesh with tiny sharp projections toward center of mesh, producing a similarity to an asterisk. Frill broad, expecially posteriorly, reaching posterior corner of valve, striate by reason of internal tubules; frill of female encroaching onto crumina from both ends but discontinuous. Crumina ventral and elongate, covered with fine granules and bearing a distal crest through three-fourths its length.

*Remarks.*—Specimens are rare and usually damaged.

*Occurrence.*—Known only from Centerfield Formation in western New York.

*Illustrated specimens.*—Paratype UMMP 30502, loc. 2; 64563, loc. 2; and 64564–64566, loc. 1.

### Genus *Hibbardia* Kesling 1953

*Type species.*—By subsequent designation of Kesling, 1953, p. 19, *Amphissites lacrimosus* Swartz and Oriel, 1948, p. 553,554, pl. 79, fig. 15.

*Diagnosis.*—Treposelline ostracods with reticulate lateral surface. Crumina distinct from lateral surface of female valve only along its anterior border, there forming

KEY TO GENERA OF FAMILY BEYRICHIIDAE

1. Crumina (brood pouch) of female valve as seen in lateral view expressed as a strong ventral inflation (as compared with the male dimorph), without distinct boundary ..... ..... Subfamily Kloedeniinae, genus *Welleria*

   Crumina of female valve as seen in lateral view with a boundary, at least anteriorly, usually marked as a semisulcus or concave junction with rest of valve ..... Subfamily Treposellinae .. 2

2. Crumina distinct from lateral surface all around its periphery ..... Genus *Treposella*

   Crumina posteriorly blending into rest of valve, distinct from lateral surface only along anterior border ..... 3

3. Valves smooth and non-lobate ..... Genus *Phlyctiscapha*

   Valves ornamented and lobate ..... 4

4. Valves reticulate; anterior border of crumina forming distinct semisulcus with rest of valve ..... Genus *Hibbardia*

   Valves ornamented with pitted reticulation, coarse papillae, tubercles, and irregular blister-like elevations, with the larger elements concentrated on lobes, leaving sulci smooth or finely punctate; anterior border of crumina joining rest of valve along a concave change in slope, not sharply set off ..... ..... Genus *Leprestola*

a semisulcus; posteriorly, crumina blending into rest of valve. Crumina reticulate like lateral surface except for ventral patch adjacent to frill, there finely reticulate. Frill relatively narrow but strong, extending from corner to corner in male, encroaching onto crumina in female but interrupted.

*Remarks.*—This genus is distinguished from *Phlyctiscapha* and *Leprestola* by its reticulate ornamentation.

*Hibbardia lacrimosa* (Swartz and Oriel)

Pl. 23, figs. 1–14; pl. 24, figs. 1–10; pl. 26. fig. 12

*Amphissites lacrimosus* Swartz and Oriel, 1948, p. 553, 554, pl. 79, fig. 15.

*Hibbardia lacrimosa* Kesling, 1953c, p. 19–24, pl. 8, figs 1–20; pl. 9, figs. 1–18.

*H. lacrimosa* Kesling, 1954b, p. 16, pl. 1, figs. 1–20.

*H. lacrimosa* Kesling, 1957a, p. 27–40, pl. 1, figs, 1–40; pl. 2, figs. 1–22; pl. 3, figs. 1–23; pl. 4, figs. 1–17; pl. 5, figs. 1-20.

*H. lacrimosa* Kesling, 1957c, p. 66, pl. 7, figs. 1–3.

*H. lacrimosa* Kesling and Rogers, 1957, p. 1001, pl. 127, figs. 22–26.

*H. lacrimosa* Kesling, 1969, p. 298, text-fig. 13k, l.

*Diagnosis.*—Same as for the genus.

*Remarks.*—Structures of the shell and interior were studied in serial surfaces by Kesling (1957a). Among other features, he showed that the female valve has a rodlike structure on the interior between the crumina and the rest of the domicilium. The edge of the overlapping right valve is rabetted to fit the rather blunt free edge of the left valve. Apart from the very deep reticulation, the shell is rather thin. The pit for S2 is internally expressed as an obtuse cone for attachment of the adductor muscles.

*Occurrence.*—Common in western New York, especially in Centerfield Formation and Wanakah Formation, but also occurring in the Ledyard, Kashong, and Windom Shales. Rare in Ipperwash Formation of Ontario and in Bell Shale, Gravel Point Formation, and Petoskey Formation of Michigan.

*Illustrated specimens.*—UMMP 64567–64570 (Wanakah Formation, loc. 3); 64571 (Centerfield Formation, loc. 2); 64572–64574 (Wanakah Formation, loc. 5); 64575 and 64648 (Bell Shale, loc. 4); 64576 (Petoskey Formation, loc. 1); 64577 and 64578 (Kashong Shale, loc. 1); 64579 and 64580 (Windom Shale, loc. 1); and 64581 and 64582 (Gravel Point Formation, loc. 5).

Genus ***Leprestola*** n. gen.

*Type species.*—Herein designated, *Leprestola mediopratensis* n. sp.

*Derivatio nominis.*—From the Greek *lepros* ("leprous, warty, rough") and *stolos* ("armor"), referring to the ornamentation of the carapace and forming an anagram of *Treposella*, a genus to which it has similarities in the form of the crumina.

*Diagnosis.*—Treposelline ostracods with lateral surface ornamented with a reticulation of shallow pitting plus various sizes of large papillae, tubercles, and irregular blister-like elevations, producing a rough texture with larger elements concentrated on lobes. Crumina posteriorly blending into rest of valve, ventrally overhanging ventral edge of valve, and anteriorly poorly defined but with a change of slope at the junction with the rest of the valve. Velar structure a low rim, discontinuous below crumina in female valve.

*Description.*—Same as for the type species.

*Remarks.*—This genus, known only from its type species, has distinctive ornamentation, which separates it from the smooth *Phlyctiscapha* and the reticulate *Hibbardia*. Its crumina is not as well defined anteriorly as that of other treposellines.

***Leprestola mediopratensis*** n. sp.

Pl. 22, figs. 1–17; pl. 24, figs. 14–21

*Derivatio nominis.*—From the Latin *medius* ("central, middle") and *pratum* ("field, meadow"), referring to its only known occurrence in the Centerfield Formation of New York.

*Description.*—Large, adult valves reaching 1.8 mm long. Valves elongate elliptical, nearly as plenate posteriorly as anteriorly, with very little swing. Hinge line straight, only the tip of L3 projecting above it. Corners not sharp, modified in adult valve by small rounded extensions of dorsal margin. Anterior and posterior borders round with center of curvature only slightly above center of valve; ventral border gently convex with center of curvature well above dorsal border.

Each valve lobate, with L2 and L3 the best defined lobes. L2 vertically elongate, set well below dorsal border, well defined around its total perimeter in adults but less so in juveniles. L1 rather low and practically confluent ventrally with rest of valve, separated from L2 by only a shallow depression for S1. L3 rather low for a beyrichiid, more or less an inflation of the lateral surface but bearing a very prominent dorsal spine projecting above the hinge line; posteriorly L3 merging with rest of valve. S2 prominent behind L2, deepest just behind ventral end of L2, shallow dorsally and merging with shallow S1.

Crumina of female valve spacious but poorly defined in lateral view; crumina posteriorly confluent with posterior part of valve, anteriorly sloping into anterior part of valve without a distinct semisulcus, and ventrally overhanging ventral edge of valve. Crumina best seen in end view. Very low but thick velar ridge, extending from corner to corner in male valve, fading out in ventral (overhanging) part of crumina in female valve. Ridge may bear discrete papillae, particularly in adult male valves.

Valves ornamented with a basic pitted reticulation, with assorted sizes of large papillae, tubercles, and low irregular blister-like elevations, with larger elements concentrataed on L1, ventral lobe, L3, and posterior part of valve and absent from S1 and S2. S2 may have fine pits or punctae. Ornamentation increasing with ontogeny, becoming stronger and more varied in late instars. Spine atop L3 directed upward, very prominent in some specimens.

*Remarks.*—Although rare, this ostracod is distinctive. The only question about its classification is to which subfamily it should be assigned. The indefinite boundary of the crumina gives it resemblance to the Kloedeniinae, so that *Leprestola* has only slightly better anterior definition of its crumina than does *Welleria*. On the other hand, its well-developed ornamentation is more like that of some Treposellinae, such as *Treposella* and *Hibbardia*. The spine atop L3 is reminiscent of the protuberance in *Hibbardia*, being situated in the same place; the deeper part of S2 in *Leprestola* is in the same location as the pit in *Hibbardia*. Influenced by these resemblances, we have placed the new genus in the Treposellinae.

Despite the relatively thick shell, many adult specimens have been broken, a far greater percentage than in other ostracod species from the same formation. Perhaps this is due to the absence of strong lobation in such large carapaces.

The ontogeny of *Leptrestola mediopratensis* seems fairly well established by the juveniles associated with the adult carapaces. They demonstrate distinct but rather gradual changes, the most striking of which is in ornamentation. Very young instars have low, close-set, fine papillae, scarcely above granule size, that impart an even, pebbly texture to the valve. In somewhat older instars, the small papillae in the basic field of ornamentation tend to join at their junctions so that the pattern becomes more nearly reticulate. Still older instars are marked by the further strengthening of the junctions between the small papillae to make the reticulation more obvious, a network of small ridgelets around punctae; this stage is also marked by the introduction of scattered larger papillae, particularly on the ventral lobe. In the adult, the punctae of the reticulation deepen and become exaggerated, and the larger papillae tend to fuse and enlarge into highly irregular verrucose processes unlike those we have seen in any other Ostracoda.

Ontogeny also involves the form of S2. In young instars it is shallow even at its ventral end and it slopes slightly backward from the hinge line; in older and adult instars, S2 is deep at its ventral end and is practically vertical. S1 also becomes better developed.

Another feature which appears to change with age is the relationship of L2 to the rather undefined L1. In

young instars, L2 has little more than a semisulcus (rather than a sulcus) at its anterior border, there rising above the general level of L1 without an intervening groove; but in adults, L2 has a distinct S1 groove separating it from L1.

*Occurrence.*—Known only in western New York from the Centerfield Formation.

*Types.*—Holotype UMMP 60231, a female left valve (loc. 1). Paratypes 60205, 60234, 64548–64552, and 64647 (loc. 1); and 60206-60209, 60230, 60232, and 60233 (loc. 2).

## Genus *Phlyctiscapha* Kesling 1953

*Type species.*—By original designation, *Phlyctiscapha rockportensis* Kesling, 1953b, p. 222–225, pls. 1,2.

*Diagnosis.*—Treposelline ostracods with smooth valves. Crumina distinct from lateral surface of valve only along its anterior border, there forming a distinct semisulcus. Velar structure reduced to an inconspicuous low ridge parallel and close to the marginal ridge of each valve and extending from corner to corner in both dimorphs, but becoming indistinct near both corners.

*Remarks.*—*Phlyctiscapha* is one of the few genera of Paleocopida to lack lobation, and the only beyrichiid with velar structure so greatly reduced. Unlike other treposelline ostracods, its valves are smooth as well as non-lobate, so that accurate placement depends upon the female with the typical treposelline crumina.

### *Phlyctiscapha apleta* Kesling 1954

Pl. 64, figs. 1–5; pl. 65, figs. 11–18; pl. 66, fig. 17

*Phlyctiscapha apleta* Kesling, 1954a, pl. 188–190, pl. 1, figs. 1–15. [Ferron Point Formation. Holotype UMMP 30482, complete female carapace.]

*P. apleta* Kesling and Chilman, 1978, p. 40, pl. 34, figs. 1–10; pl. 35, figs. 1–11; pl. 36, figs. 5–20; pl. 37, figs. 1–20.

*Diagnosis.*—Carapace large, adults exceeding 1.7 mm, but relatively narrow, with width of male less than half the length. Overlap in some specimens L/R and in others R/L.

*Remarks.*—This species usually occurs with young instars as well as adults in the same sample. Because of its smooth surface and lack of strong velar structure, nearly all specimens show little distortion and can be used in ontogenetic studies of Przibram's Law of crustacean growth series. This species was used by Kesling and Chilman (1978, p. 40–43) for such a study. They found that this species does indeed double its carapace size from one instar to the next.

*Occurrence.*—Ohio: Silica Shale. Michigan: Silica Shale Ferron Point Formation, Genshaw Formation, Dock Street Clay Member of the Four Mile Dam Formation, Norway Point Formation, Gravel Point Formation, and Petoskey Formation. Ontario: Hungry Hollow Formation and Widder Formation. New York: Wanakah Shale (rare).

*Illustrated specimens.*—UMMP 30482, holotype (Ferron Point Formation, loc. 3); 64605 (Ferron Point Formation, loc. 3); 58740 (Widder Formation, loc. 3); 64604, 64606, and 64607 (Gravel Point, loc. 2); and 64608–64611 (Gravel Point Formation, loc. 5).

### ***Phlyctiscapha dubia*** Smith n. sp.

Pl. 66, figs. 9–16; pl. 68, figs. 1,2

*Derivatio nominis.*—From the Latin *dubius* ("uncertain, doubtful"), referring to previous confusion of this species with *Phlyctiscapha apleta.*

*Authorship.*—This species was first distinguished by Jane Elizabeth Inch Smith in her doctoral dissertation at The University of Michigan in 1959. It was never formally published, and is herein set forth as a new species and credited to her.

*Diagnosis.*—Anterior and posterior borders about equally rounded and confluent with ventral border, so that free border is but little modified from two-thirds of a circle. Crumina of female rotund in ventral view.

*Description.*—Carapace rather large, adults reaching 1.6 mm long. In lateral view, valves about equally rounded anteriorly and posteriorly, with free border only slightly modified from arc of a circle with center between midheight and dorsal border. In end and dorsal views, juvenile and male carapaces rounded and sublanceolate; female carapace modified from sublanceolate outline by ventral cruminae. Greatest width slightly posterior. Hinge line straight, long, only slightly below low dorsal hump in adults and practically forming dorsal border in juveniles. Somewhat less convex corner areas slightly set off from rest of lateral surface. Valves non-lobate and smooth. Velar ridge low and inconspicuous. Overlap mostly R/L, but some specimens with L/R.

*Remarks.*—The plenate posterior half of the carapace readily distinguishes this species from *Phlyctiscapha apleta*, which has a long posteroventral border that is only gently convex, and from *P. subovata*, which has an angulation between its posterodorsal and posteroventral borders.

*Occurrence.*—Known only from the uppermost unit of the Gravel Point Formation, informally called the "Upper Blue Shale," and from the Petoskey Formation.

*Types.*—Holotype UMMP 39033, female carapace (Petoskey Formation, loc. 2). Paratypes UMMP 39025 and 39039 (Gravel Point Formation, loc. 5), 39027 (Gravel Point Formation, loc. 1), and 39029 (Gravel Point Formation, loc. 2).

### *Phlyctiscapha rockportensis* Kesling 1953

Pl. 64, figs. 6–14; pl. 66, figs. 1–8

*Phlyctiscapha rockportensis* Kesling, 1953b, p. 222–225, pl. 1, figs. 1-20; pl. 2, figs. 1–19. [Rockport Quarry Limestone. Holotype UMMP 29603, complete female carapace.]

*P. rockportensis* Kesling, 1954a, pl. 1, figs. 16–18.

*P. rockportensis* Tillman, 1984, p. 237, figs. 1G-L.

KEY TO SPECIES OF *PHLYCTISCAPHA*

1. Adult carapace small, less than 1.4 mm long; crumina of female rotund, so that width/height ratio is nearly 1.0; overlap invariably L/R in known carapaces ..... *P. rockportensis*

   Adult carapace larger than 1.4 mm, most reaching 1.6 mm; width/height ratio about 0.9; overlap L/R or R/L, both types found in same sample ..... 2

2. Posterodorsal and posteroventral borders forming somewhat rounded but distinct angulation above midheight ..... *P. subovata*

   Posterodorsal and posteroventral borders confluent, without any suggestion of angulation ..... 3

3. Crumina of female rotund in ventral view; posterior and anterior borders about equally subround, making orientation of carapace difficult except by position of greatest width ..... *P. dubia*

   Crumina gently tapering anteriorly and posteriorly as seen in ventral view; posterodorsal border round with small radius of curvature, and posteroventral border long and gently convex, both very different from evenly rounded anteroventral and anterior borders and making orientation obvious in lateral view ..... *P. apleta*

*Diagnosis.*—Carapace small, adults less than 1.4 mm long, but relatively wide, with width of males and juveniles equal to or more than half the length. Overlap invariably L/R.

*Remarks.*—Although the type locality is given as the basal Rockport Quarry Limestone, it is possible that specimens there are reworked from the uppermost underlying Bell Shale.

The specimens are found at the type locality well preserved, juveniles as well as adults, except for occasional pitting of the smooth surface. All juveniles maintain the same proportions and shape as the adult male. Polished surfaces of female carapaces have revealed (Kesling, 1953b, pl. 2, figs. 8–18) that each valve has a partition within it extending from about the middle of the valve to the free edge and separating the anterior part of the crumina from the rest of the domicilium.

This species occurs rarely except at the type locality.

*Occurrence.*—Upper 10 feet of Bell Shale, lowermost unit of Rockport Quarry Limestone (may be reworked Bell Shale), Genshaw Formation, and Gravel Point Formation.

*Illustrated specimens.*—Holotype UMMP 29603 Rockport Quarry Limestone; see Bell Shale loc. 3). Paratype 29610 (same loc.). UMMP 64592 and 64597 (same loc.); 64593–64596 (Genshaw Formation, loc. 6); and 64612 (Gravel Point Formation, loc. 4).

*Phlyctiscapha subovata* Smith 1956

Pl. 65, figs. 1–10

*Phlyctiscapha subovata* Smith, 1956, p. 4,5, pl. 1, figs. 1–3. [Wanakah Shale. Holotype NYSM 10717, juvenile carapace.]

*Diagnosis.*—Both posterodorsal and posteroventral borders gently convex, forming a slightly rounded but distinct angulation. Overlap variable, both L/R and R/L types occurring in the same sample.

*Remarks.*—Only the posterior angulation in the lateral outline distinguishes this species from the otherwise similar *Phlyctiscapha apleta*. If we can rely upon first occurrences, *P. apleta* evolved first in Michigan in Ferron Point time, and by Centerfield (=Four Mile Dam) time had given rise to the exclusively New York *P. subovata*. No specimen from Michigan can be interpreted as *P. subovata* nor can any from New York be interpreted as *P. apleta*, so the two forms remain geographically isolated throughout most of the Middle Devonian, insofar as actual records are concerned. *Phlyctiscapha apleta* has been found in the Widder Formation of Ontario, but that formation is younger than the oldest occurrence of *P. subovata* in New York. Hence, the full story of the relationship of the two is not documented.

*Occurrence.*—Centerfield Formation, Wanakah Formation, and Windom Shale.

*Illustrated specimens.*—UMMP 64598 and 64600 (Wanakah Formation, loc. 3); 64599 (Wanakah Formation, loc. 1); 64601 and 64602 (Centerfield Formation, loc. 2); and 64603 (Windom Shale, loc. 3). Subfamily Kloedeniinae Ulrich and Bassler 1923 =Family Welleriellidae Abushik, 1971.

*Diagnosis.*—Beyrichiid ostracods with crumina expressed in lateral view as a strong ventral inflation without distinct boundary with the rest of the valve.

*Remarks.*—Despite the number of works on beyrichiid ostracods by competent ostracodologists, we retain some uncertainty about the subfamily divisions of the family. Particularly the forms which have poorly defined cruminae situated mostly ventrally, as well as some with anteroventral inflations, have been variously assigned to different subfamilies—apparently according to the acquaintance of the investigator with other beyrichiids. Here, we have used the old classification of Ulrich and Bassler, being unconvinced that such genera as *Welleria*, *Welleriella*, *Kloedeniopsis*, and *Welleriopsis* differ sufficiently from *Kloedenia* to warrant different subfamily or subfamilies.

## Genus *Welleria* Ulrich and Bassler 1923

*Type species.*—By original designation, *Welleria obliqua* Ulrich and Bassler, 1923, p. 641, emended by Kesling and Soronen, 1957, p. 43,44.

*Diagnosis.*—Kloedeniine ostracods with free border smoothly curved. Two short sulci (S1 and S2 limited to dorsal part of each valve and outlining dorsal part of L2; smoothly arched ventral lobe confluent with at least L1 and the spacious L3, usually also with ventral end of L2. Crumina formed by a great inflation of the ventral lobe in the female, overhanging free edge and dorsally confluent with rest of the valve.

*Remarks.*—Kesling (1955b, p. 63,64) restudied the type species of *Kloedenia* and *Welleria*, analyzed their differences, and revised their descriptions. By his interpretation, the crumina and ventral lobe of *Kloedenia* are restricted to the anterior four-fifths of the lower half of the valve and have a definite separation from the posterior margin, whereas the crumina and ventral lobe of *Welleria* occupy the ventral part of the valve without demarcation; as a result, the mid-point of the ventral lobe appears to be definitely anterior and below L2 in *Kloedenia*, but at midlength and behind L2 in *Welleria*.

Admittedly, the whole group of kloedeniine ostracods is poorly understood. Especially valuable would be an attempt to trace the various lineages from Silurian ancestors into Middle Devonian forms. Inasmuch as the subfamily (or subfamilies) spread into the Canadian Arctic and into Russia, the revision will require appreciable effort to compare all the known species.

### *Welleria aftonensis* Warthin 1934

Pl. 24, figs. 11–13; pl. 25, figs. 1–13; pl. 26, figs. 1–11

*Welleria aftonensis* Warthin, 1934, p. 208, pl. 1, fig. 3. [Gravel Point Point Formation. Holotype UMMP 14533, right valve.]

*W. aftonensis* Warthin, 1937, card 32.

*W. aftonensis* Kelly and Smith, 1947, p. 457.

*W. aftonensis* Kesling and Soronen, 1957, p. 41–45, pl. 1, figs. 1–72; pl. 2, figs. 1,2; pl. 3, figs. 1–6; pl. 4, figs. 1–5.

*Diagnosis.*—Valves rotund in both dimorphs. L2 well defined except at its junction with ventral lobe. Corners distinct and angular. Free border evenly curved, round at anterior and posterior ends. Front part of L3 forming hump, protuberant above hinge line.

*Remarks.*—The abundance of this species in the petroleum-rich lagoonal bed of the Gravel Point, probably hypersaline, and its rarity in other strata point to an exceptional adaptation to a particular ecology. In the "*Welleria aftonensis* zone" of the Gravel Point, in which it is the only ostracod and indeed the only invertebrate, myriads are concentrated in a matrix of clay fragments interpreted by Kesling and Soronen (1957, p. 47–50) as reworked remnants of sun-cracked laminae from nearby shores. They expressed little doubt that *Welleria aftonensis* thrived in a large lagoon with oxygen so deficient that petroliferous residues still exist; most specimens can be readily chipped from the hard limy matrix because of a film of oil coating their carapaces. Many isolated valves can be found stacked or nested, with consecutively smaller toward the middle of the stack; most likely, these were molted valves, which settled in the unusual association from gentle currents.

A remarkably similar occurrence was reported for *Welleria meadowlakensis* by Kesling and Takagi (1961, p. 43–51), which is found in drill cores penetrating the Middle Devonian Elk Point Formation of Saskatchewan. The ostracods evidently lived in a channel from the open sea to the east feeding into an evaporite basin in northern Alberta. Some of them were found encased in clear halite. We can easily conclude that Middle Devonian species of *Welleria*, such as *W. aftonensis* and *W. meadowlakensis*, thrived in environments which excluded their contemporaries among the Paleocopa.

Only minor differences separate *Welleria aftonensis* from *W. bisculcata*, the other species found in the Great Lakes region. *Welleria aftonensis* has a prominent subspherical L2 set well below the hinge line and an almost vertical S1, whereas *W. bisulcata* has an L2 tapering upward to near the hinge line and an S1 that is directed forward and downward.

*Welleria aftonensis* resembles *W. meadowlakensis* from western Canada more closely. The latter species has a sharper anterior corner with a tip protuberant forward, its ventral lobe is only moderately convex, its L2 is smaller, its S2 shallower, and the hump on its L3 is dorsally round and not inclined forward; in addition, the anterior cardinal angle of *W. aftonensis* is nearly 130°, whereas that of *W. meadowlakensis* is only about 110° or less.

KEY TO SPECIES OF *WELLERIA*

S2 prominent, suboval to round, set well below the hinge line; S1 nearly vertical; carapace wide, with length/width ratio of male about 1.6; surface very smooth ..... *W. aftonensis*

S2 not much more elevated than adjacent lobes, strongly tapered dorsally and nearly reaching the hinge line; S1 directed anteroventrally; carapace relatively narrow, with length/width ratio of male about 2.0; surface of well-preserved specimens displaying fine pitting in more or less reticulate pattern ... *W. bisulcata*

*Occurrence.*—Known only from the Gravel Point Formation, in which it is abundant only in the "*Welleria aftonensis* zone" and rare in other units of the formation.

*Illustrated specimens.*—UMMP 33676, 33677, 33679, 33681, 33685, 33689, 33694, 33700, 33702, 33704, 33712, 33714, 33717, 33718, and 33721 (Gravel Point Formation, loc. 8); and 64591 (Gravel Point, loc. 4).

*Welleria bisulcata* Smith

Pl. 25, figs. 14–23; pl. 26, figs. 13–16

*Welleria bisulcata* Smith, 1956, p. 5, pl. 1, figs. 8–11. [Wanakah Shale. Holotype NYSM 10720, male carapace.]

*Diagnosis.*—L2 very elongate and strongly tapering upward, nearly to hinge line. S1 inclined forward and down, S2 deep and narrow.

*Remarks.*—*Welleria bisulcata* is a much thinner species than *W. aftonensis*; adult males may be twice as long as wide, whereas those of *W. aftonensis* are scarcely more than 1.6 as long as wide. Further, well-preserved specimens of *W. bisulcata* show a surface of fine pitting in a reticulate pattern, but the surface of *W. aftonensis* is very smooth. The two species are readily distinguished by the prominently rounded and larger L2 in *W. aftonensis* and the less elevated, long and tapered L2 in *W. bisulcata*.

Unlike *Welleria aftonensis* and *W. meadowlakensis*, which have been found in abundance in evaporitic habitats, *W. bisulcata* has, to date, been found in normal marine strata.

*Occurrence.*—Found only in New York. Ledyard Shale, Wanakah Shale, and Windom Shale.

*Illustrated specimens.*—UMMP 64583 (Windom Shale, loc. 3); 64584-64588 (Wanakah Shale, loc. 4); 64589 (Wanakah Shale, loc. 1); and 64590 (Wanakah Shale, loc. 3).

Superfamily PRIMITIOPSACEA Swartz 1936

*Diagnosis.*—Dimorphism exterior and posterior, in most genera consisting of a dolon developed in each female valve as a flange-like extension on the back end of the valve and extending beyond the domicilium; in some, dolon accompanied by an additional perimarginal ridge set close alongside the posterior part of the marginal ridge. Dolon variously interpreted as enlarged section of velar or adventral structure or as special structure; whatever its form, dolon always external and dimorphism not involving any part of domicilium. Male without any form of posterior dolon, but otherwise like female.

*Range.*—Ordovician to Permian.

Family PRIMITIOPSIDAE Swartz 1936

*Diagnosis.*—Same as for the superfamily.

Genus *Sulcicuneus* Kesling 1951

*Type species.*—By original designation, *Sulcicuneus porrectinatius* Kesling, 1951, p. 221–230, pl. 1, figs. 1–21; pl. 2, figs. 1–9; pl. 3, figs. 1–39 [herein corrected from *porrectinatium*].

*Diagnosis.*—Dolon developed as a long flange on posterior part of female valve, extending well behind domicilium, with dolons of opposite valves usually incurved distally and in some specimens forming a "false pouch" in the closed carapace. Both dimorphs with velar or adventral ridge set apart from the marginal ridge or free edge. Both dimorphs with a deep and conspicuous S2 extending from hinge line to prominent ventral lobe.

*Remarks.*—The prominent wide sulcus distinguishes this genus from other primitiopsids; most are non-lobate. In contrast to many of the Middle Devonian genera, which have R/L overlap and a contact groove in the larger right valve, *Sulcicuneus* has L/R overlap, a contact groove in the left valve, and a simple contact list along the free edge of the smaller right valve.

*Sulcicuneus porrectinatius* Kesling

Pl. 60, figs. 18–25

*Sulcicuneus porrectinatium* Kesling, 1951, p. 221–230, pl. 1, figs. 1–21; pl. 2, figs. 1–9; pl. 3, figs. 1–39; Kesling,

KEY TO SPECIES OF *SULCICUNEUS*

1. Carapace small, adult female valve only about 0.5 mm long; posterior dolon in each female valve a thick ridge, not extending far behind domicilium; velar or adventral ridge very low and faint, set close to contact edge of valve; ventral lobe not strongly convex below and behind S2 ..... *S. minutus*

   Carapace of medium size, adult female valve 0.75 mm or longer; posterior dolon in each female valve flange-like and extending well behind domicilium, its distal edge formed by a row of fused denticles or papillae; left and right dolons of a carapace usually incurved distally, in some specimens practically meeting to form a "false pouch" or chamberette in the closed carapace; velar or adventral ridge low but sharp and distinct, set well away from the contact edge of the valve; ventral lobe convex below S2 and reaching its greatest lateral extension in posterocentral area of valve ..... 2

2. Ventral lobe gently convex, not sharply angled in posterocentral part of valve, there sloping down to the end of the domicilium; width/length ratio in female carapace little more than 0.5 .. *S. porrectinatius*

   Ventral lobe flared outward below and behind S2 to narrowly rounded distal edge; in posterocentral part of valve, ventral lobe with abrupt descent, at its greatest extension forming a narrowly rounded corner as viewed ventrally or dorsally; width/length ratio in female carapace nearly 0.7 ..... *S. latus*

1969, text-fig. 21d-f. [Bell Shale, Holotype UMMP 26626, female carapace.]

*Diagnosis.*—Female valve 0.75 mm or longer. Dolon long, projecting well behind free edge of valve, distally bearing a row of fused denticles. Dolon usually incurved in distal part, in some specimens the two dolons enclosing a "false pouch" or chamberette in the closed carapace, but in most preserving a permanent opening to the rear. Ventral lobe gently convex, not flared or bearing a distal angulation.

*Remarks.*—This species is readily distinguished from *Sulcicuneus latus*, of about the same size, by the gentle convexity of its ventral lobe; it is also proportionally longer in female carapaces (including the dolons). It can scarcely be confused with the much smaller *S. minutus*, from which it further differs in having a well-developed flange-like, relatively thin dolon instead of a thick ridge.

The dolons of *S. porrectinatius* form a cylinder or even an enclosure when the valves are closed. Whether this space was utilized for brood care remains uncertain, particularly since many primitiopsid ostracods have such small dimorphic differences that identification of the female requires close inspection. Certainly, the majority of primitiopsids do not have dolons ample enough to have served as housing and protection of the young. The location of the female dolons would have been a hindrance in mating, and presuably necessitated special copulatory adaptations.

*Occurrence.*—Bell Shale and Petoskey Formation (rare, only one specimen, in the latter).

*Illustrated specimens.*—All from Bell Shale. UMMP 60258, 60259, 60326, and 64803 (loc. 4); and 60325 (loc. 8).

### ***Sulcicuneus latus*** n. sp.

Pl. 60, figs. 1-15

*Derivatio nominis.*—From the Latin *latus* ("broad"), referring to the outward extent of the ventral lobe.

*Description.*—Carapace of medium size, with adult female valves 0.75 mm or longer. Hinge line long and straight. Valves subelliptical in lateral view, with gently curved ventral border, rounded anterior border, and slight swing. Carapace kite-shaped in end view, with side angles formed by angulation of wide ventral lobes. Greatest width near posterior end of ventral lobes; as viewed ventrally, carapace gently tapered forward from position of greatest width.

S2 broad at dorsal border, tapering and becoming

deeper downward, and nearly reaching midheight. L2 scarcely discernible. Ventral lobe flared strongly outward below and behind S2, with a narrowly rounded angulation forming a bend along its middle; ventral lobe enlarging posteriorly to form a narrowly rounded corner as seen from below, at the point of greatest width, thence rapidly descending in a concavity to the posterior border of the male or to the dolon of the female.

Dolons large, distally bearing row of fused denticles, each dolon distally incurved to some degree. Velar or adventral ridge sharp but low, set well away from margin on the ventral slope of the ventral lobe. Carapace smooth to finely granulose.

*Remarks.*—*Sulcicuneus porrectinatius* is rare above Bell Shale and *S. latus* is only found above the Bell Shale. The close similarities of their sulci, lateral outlines, and development of dolons suggest that they are closely related. No intermediate forms have been discovered between *S. porrectinatius* with its gently convex ventral lobe and *S. latus* with its strongly flared and angulated ventral lobe, so the evolutionary history of the two species cannot be precisely determined.

*Occurrence.*—Genshaw Formation, Gravel Point Formation, and Petoskey Formation of Michigan.

*Types.*—Holotype UMMP 38891, female carapace (Petoskey Formation, loc. 2). Paratyes UMMP 60119 (Genshaw Formation, loc. 6); 60188 (Gravel Point Formation, loc. 2); and 60260, 60261, 60331, 60332, and 60802 (Gravel Point Formation, loc. 1).

### ***Sulcicuneus minutus*** n. sp.

Pl. 60, figs. 16,17

*Derivatio nominis.*—From the Latin *minutus* ("small, tiny"), referring to the diminutive size of the holotype and only known specimen, a female right valve.

*Description.*—Small, the female right valve and only known specimen only about 0.5 mm long. Hinge line straight, anterior border subround, and ventral border gently convex. Valves not wide, with lobation subdued.

L1 developed as a prominent thick ridge along the anterior margin of the valve. S2 distinct but not deep, reaching from dorsal border to about midheight. Ventral lobe not inflated, relatively low. Velar or adventral ridge very low and faint, set close to margin.

Dolon a thick vertical ridge, not extending far behind the posterior free edge of the valve. Surface smooth to slightly granulose.

*Remarks.*—The very short and thick dolon suggests that this species could readily be made a separate genus. However, since only the holotype is known, it seems advisable to us to assign it to *Sulcicuneus.*

*Occurrence.*—Known only from the holotype found in the Norway Point Formation.

*Type.*—Holotype UMMP 60235, a female right valve (loc. 1).

## Superfamily HOLLINACEA Swartz 1936

*Diagnosis.*—Dimorphism of the velar type, exterior and not involving the domicilium, never posterior or cruminal.

## Family CTENOLOCULINIDAE Jaanusson and Martinsson 1956

*Diagnosis.*—Dimorphism involving loculi or scalloped frill in female valve.

## Subfamily CTENOLOCULININAE Jaanusson and Martinsson 1956

*Diagnosis.*—Female valve with loculi between frill and marginal structure. Valves quadrilobate.

### Genus *Ctenoloculina* Bassler 1941

*Type species.*—*Tetradella cicatricosa* Warthin, 1934, p. 209, pl. 1, figs. 4–6, by subsequent designation of Bassler, 1941, p. 22,23.

*Diagnosis.*—Ctenoloculinine ostracods with L2 and L3 vertically elongate, reaching in male to dimorphic spurs at ventral border, and all lobes rimmed around ornamented areas. All three sulci long and smooth, extending to ventral border in male.

*Remarks.*—*Ctenoloculina* is perhaps the most distinctive genus of the middle Paleozoic hollinaceans. Its elongate lobes with ornamented areas set off by rims, the long deep sulci of the male valve, and the six well-defined loculi between frill and margin of the female valve can scarcely be confused with features of other genera of the superfamily Hollinacea. The genus which most closely resembles certain species of *Ctenoloculina* is *Hercynobolbina.* Both have elongate lobes and the same adult dimorphism. The difference is, by definition, that the lobes in *Ctenoloculina* have ornamented areas, whereas those in *Hercynobolbina* have none; nevertheless, such species as *Ctenoloculina araea* and *C. ectenolobata* have very narrow ornamented areas, which in some specimens tend to be pinched out by convergence and fusion of the lateral rims in portions of L2 and L3, whereas a few specimens of *Hercynobolbina levis* have parts of the outer surfaces of L2 and L3, which are typically smooth, split medially to form narrow clefts between rims, and in rare instances appear to have a few papillae to technically constitute a very restricted ornamented area. These are the rare exceptions, and most specimens of *Ctenoloculina* and *Hercynobolbina* present no dubious or anomalous characters.

Within the genus *Ctenoloculina*, however, some forms seem to blend into others, so that question arises as to whether they can clearly, unequivocally, and with justification be separated into species. In fact, now and then a specimen is found which displays features so nearly intermediate between otherwise clearly defined species as

*KEY TO GENERA OF HOLLINACEA*

1. Female with loculi or locular antrum below scalloped frill in each valve ..... Family CTENOLOCULINIDAE .. 3

   Female without loculi or locular antrum ..... 2

2. Female with simple dolonal antrum formed below incurved frill; if broad, frill terminating below or ahead of L3 and, if narrow, continuing behind L3 as a low and tapering ridgelike section ..... ..... Family HOLLINIDAE .. 7

   Female with well-developed frill or velar ridge not curved inward, extending posteriorly as far as the rear edge of L3 or beyond, and terminating in a spurlike thickening ..... ..... Family HOLLINELLIDAE .. 10

3. Female quadrilobate, with several deep, well-developed loculi in each valve ..... Subfamily CTENOLOCULININAE ... 4

   Female tending to be bilobate, with only shallow loculi or locular antrum in each valve ..... Subfamily PARABOLBININAE ... 6

4. Both male and female with bulbous L3 and two ventral spurlike extensions in each valve, those of the female situated *above* the frill and not part of the velar structures ..... Genus *Abditoloculina*

   In both dimorphs, L3 narrow and vertically elongate, never bulbous; no spurlike extensions above the frill ..... 5

5. All four lobes sharply defined, each centrally ornamented with reticulation or papillae; L1, like L2 and L3, vertically elongate and L4 large and extending nearly to ventral border .... Genus *Ctenoloculina*

   Lobes unornamented; L1 and L4 not sharply defined if at all, typically blending into rest of lateral surface ..... Genus *Hercynobolbina*

6. Long sinuous S2 extending to the narrow frill in the female and to ventral border in the male; velar structures of male consisting of sharp anteroventral spur and short ventral ridge in each valve ..... Genus *Tetrasacculus*

   Short S2 terminating at about midheight of valve and never bisecting ventral lobe; velar structures of male consisting of a short frill or very broad spur anteroventrally and a distinct tapered spur ventrally to posteroventrally ..... Genus *Subligaculum*

7. Lobation involving most or all of valve, with L2 a distinct node, L4 a well-defined lobule, and L1 and L3 elongate and extending to frill in female; S2 long, reaching ventral border in male and to frill in female; velar structures in male consisting only of ventral tips of L1 and L3 ..... Subfamily HOLLININAE, genus *Hollina*

   Lobation restricted to dorsal half of valve; S2 terminating near middle of valve ..... 8

8. L3 developed as a small conical projection set well behind S2; L2 indistinct or absent; dimorphism consisting of a long, very narrow frill in the male and a slightly wider frill in the female; anteroventral flat, spurlike projection in each valve of both dimorphs, may be velar ..... Subfamily HANAITINAE, genus *Hanaites*

L3 developed as a large bulb; L2 a distinct pre-adductorial node; dimorphism consisting of an anteroventral and a ventral to posteroventral spur in each male valve and a frill in each female valve; no anteroventral spurlike projection in either dimorph ..... Subfamily FALSIPOLLICINAE .. 9

9. Frill of female broad, incurved, extending posteriorly to position below L3 ..... Genus *Falsipollex*

Frill of female narrow, restricted to anterior end of valve, with a separate small posteroventral velar spur ..... Genus *Parabolbinella*

10. S2 long, extending to frill, bisecting ventral lobe ..... 11

S2 terminating near middle of valve ..... 12

11. Carapace large, some exceeding 1.5 mm long; lobation coarse, with large oval lobule representing posterior part of ventral lobe; L2 fused with anterior part of ventral lobe to form a large, sloping ridge; frill and shell very thick ..... Genus *Labrosavelum*

Carapace small, less than 1.0 mm long; lobation distinct but not coarse, with posterior part of ventral lobe protuberant and acuminate; L2 a small pre-adductorial node separated from anterior part of ventral lobe; frill and shell not very thick .... Genus *Bisphenella*

12. L3 definitely bulbous, with a clear ventral boundary ..... 13

L3 large and inflated but confluent with ventral lobe, its dorsal border forming a hump extending above hinge line ..... 15

13. Frill thick; dimorphism expressed as a ventrally interrupted frill in the male and an uninterrupted frill in the female ..... Genus *Ruptivelum*

Frill thin; dimorphism expressed as differences in width, curvature, and position of frill ..... 14

14. Frill of female very broad, with a sausage-shaped section reminiscent of that in certain eurychilinids, strongly convex outward and distally incurved ..... Genus *Physcocalyptra*

Frill of female relatively narrow, without any sausage-shaped inflated section ..... Genus *Hollinella*, Subgenus *Keslingella*

15. L3 strongly inflated, with distinct posterior boundary; dimorphism expressed as a wider and more incurved frill and a broader, unconstricted, unornamented antrum in the male and a narrower frill and an ornamented and anteroventrally constricted venter in the female; surface papillose ..... Genus *Adelphobolbina*

L3 not strongly inflated, the lobation dominated by a long, shallow, sinuous S2; dimorphism expressed as a velar ridge or narrow frill in the male and a broader and incurved frill in the female; velar structure confluent with ventral lobe, its proximal boundary indistinguishable in lateral view; surface smooth or finely granulose ..... Genus *Flaccivelum*

to raise the possibility of hybridization. The unusual specimen does not seem to be a genetic anomaly or mutant, inasmuch as other specimens can be seen to have most characters like one species but one or more characters that are diagnostic of another species. More likely, in our opinion, local populations may have experienced rapid genetic drift; in the incomplete paleontologic record, the progression leading to the extreme form remains unknown.

One should not anticipate that all characters diagnostic of a new species arose simultaneously. It must be acknowledged that even the ostracodologist who is a "lumper" would be forced to recognize perhaps eight species of *Ctenoloculina* within the Middle Devonian of the Great Lakes region; he who is a "splitter" might not be satisfied with less than three times that number. In brief, for a genus noted for its variability and numerous species within a relatively brief span of geologic time, one should not consider it exceptional to discover several specimens which are somewhere close to the ancestral form of two or more species.

Some species, notably *Ctenoloculina acanthina*, *C. cicatricosa*, and *C. myurilobata*, occur not only in nearly all formations in one area but throughout the Great Lakes region, from Michigan to New York. *Ctenoloculina eurybathrota* is also widespread, but has not yet been found in a few formations. These ubiquitous species are in contrast to such species as *C. acrolobata*, *C. didyma*, *C. rhadina*, and *C. thliberilobata* known only from the Arkona Shale, *C. apletolobata* known only from the Ferron Point Formation, *C. araea* known only from the Norway Point Formation, and *C. amblycentrota* known only from the Kashong Shale. Such differences in species longevity and distribution indicate rapid evolution of the genus during Middle Devonian time, and may point to a few species as constituting the major lines from which the other short-lived species sprang at intervals.

Additional studies are needed to determine if the genus *Ctenoloculina* can be divided into a *C. cicatricosa* lineage in which the female L2 and L3 continue across the frill to the ventral border, a *C. eurybathrota* lineage with ornamented areas restricted and evenly papillose, and a *C. acanthina* lineage in which the restricted areas and their rims bear additional larger papillae or spinelets. Adult carapaces in each of these suggested lineages vary greatly in size, making the divisions far from convincing.

William Collier (1971) made a cladistic study of *Ctenoloculina* species known at the time. The oldest known species, *C. punctocarinata* Swartz and Swain, occurs in the Onondaga Formation in Pennsylvania and West Virginia; little is known of it beyond the original description, and field searches have failed to uncover additional specimens. According to Collier's analysis (1971, p. 368), other species can be traced back to *C. exocha* Kesling and Peterson from the Jeffersonville Limestone in southern Indiana. The European species appear to have been derived from two American species: *C. beckeri* Adamczak from *C. cicatricosa* and *C. latisulcata* Adamczak, *C. skalyensis* Adamczak, and *C. vulgaris* Adamczak from *C. eurybathrota*. Collier (1971, p. 368) considered *C. platyzanclota* as the ancestor of later Middle Devonian species.

A particular feature of *Ctenoloculina* that is not fully understood functionally is the ornamented areas of the lobes. These consist of two layers (Kesling, 1954, p. 17, 18; Adamczak, 1968, p. 29). The thicker inner layer, next to the domicilium, is separated from the very thin and delicate outer layer by pillars. The problem lies in being able to discern whether the thin outer layer is present, for the papillae on the outer layer may not have the development or spacing of the pillars below. In many species, the outer layer is not known in any specimen, and the apparent coarse "papillae" are actually the remains of the pillars. Further, these pillars themselves are subject to abrasion and corrosion, so that they are not equally preserved in all specimens. We suspect that the carapace wall in *Hercynobolbina* similarly contains a thin elongate "blister" running through the middle of the lobes, in the position corresponding to the pillars in *Ctenoloculina*; thus the clefts with bordering rims observed in a few specimens of *Hercynobolbina levis* may be simply removal by abrasion or corrosion of the delicate smooth outer layer.

We cannot know whether the spaces between pillars in *Ctenoloculina* and within the proposed "blisters" in *Hercynobolbina* were originally filled with fluid or gas. In either case, they made the carapace lighter in weight, and if gas-filled may have been significant in buoyancy. This factor may have permitted the species with large ornamented areas of the lobes to have been partially nektonic, in contrast with the probably wholly benthonic species with narrow ornamented areas.

*Ctenoloculina acanthina* Kesling

Pl. 1, figs. 1–5; pl. 2, figs. 1–9

*Ctenoloculina acanthina* Kesling, 1953a, p. 206, 207, pl. 2, figs. 1–13. [Arkona Shale. Holotype UMMP 28940, complete female carapace.]

*C. acanthina* Kesling and Chilman, 1978, vol. 1, p. 58, 59; vol. 2, pl. 16, figs. 1,2; pl. 17, figs. 10–20; pl. 21, figs. 1–10; pl. 111, figs. 3,4.

*Diagnosis.*—Female valve with ornamented area of frill variously constricted below S2. Conspicuous spinelets or large papillae scattered on rims around certain lobes, some also on ornamented areas of the lobes, mostly associated with L4 but also occurring on L3; few if any on L2 and L1. Ventral ends of L2 and L3 in female valve with low rims if any, not sharply set off from frill. Ventral half of L3 only moderately broad in male, constricted very little at junction with spur. Dorsal end of L1 variously rounded or pointed.

*Remarks.*—This species, found in northwestern Ohio,

KEY TO SPECIES OF *CTENOLOCULINA*

1. Female valve with ornamented areas of L2 and/or L3 extending onto frill, practically reaching its distal edge ..... 2

   Female valve with ornamented areas of L2 and L3 not on frill ..... 7

2. Adult carapace well over 1.0 mm long ..... 3

   Adult carapace 1.0 mm or less in length ..... 6

3. Ornamented area of L2 very narrow and straight,, in female valve may be constricted at its junction with frill; ornamented area of L3 in female valve narrowly connected to that of frill and in some specimens separate; adult carapace averaging 1.0 mm long .. *C. myurilobata*

   Ornamented area of L2 fairly wide; female valve with ornamented areas of L2 and L3 continuing onto frill; adult carapace usually longer than 1.1 mm ..... 4

4. Adult carapaces averaging about 1.2 mm long; adult male valve with L2 spur rather long and sharply acuminate ..... *C. cicatricosa*

   Adult carapaces averaging nearly 1.4 mm long; adult male valve with L2 spur rather blunt and rounded ventrally ..... 5

5. Female valve with ornamented areas of L2 and L3 variously constricted near middle, or so pinched as to leave only a groove connecting dorsal and ventral segments, or completely divided into two parts, or (in a few specimens) over half of area undeveloped; in every female specimen found, at least one of the two middle lobes extending far onto frill and wide at its ventral end; male valve with L2 spur rather blunt ventrally; lobes evenly papillose ..... *C. thliberilobata*

   Female valve with ornamented area of L2 unconstricted, that of L3 only slightly constricted in its middle, both areas extending onto frill; lobes with punctae between fine papillae ..... *C. amblycentrota*

6. Adult carapace only about 0.6 mm long; L2 and L3 with extremely narrow ornamented areas ..... *C. araea*

   Adult carapace nearly 1.0 mm long; L2 and L3 with narrow but conspicuous ornamented areas ..... *C. ectenolobata*

7. Female valve with ornamented area of frill behind L1 broad, its sides subparallel throughout ..... 8

   Female valve with ornamented area of frill behind L1 variously constricted or reduced ..... 9

8. Valves very elongate, posteriorly strongly tapered to acuminate posterior corner; domicilium at least twice as long as high; female valve with ornamented area of frill having papillae of same size and distribution as those of lobes; male valve with L2 and L3 expanded ventrally and, in some specimens, rather narrow dorsally; adult male valve with spurs on L2 and L3 rather blunt ..... *C. rhadina*

Valves not elongate, posterior cardinal angle obtuse; domicilium only about half again as long as high; female valve with papillae in ornamented area of frill much lower and more densely packed than those on lobes; male valves, apparently of this species, without notable ventral expansions of L2 and L3; male spurs on L2 and L3 rather acuminate ..... *C. platyzanclota*

9. Rims around lobes smooth or with very low papillae; papillae in ornamented areas of lobes of about equal size with very few larger ones, if any ..... 10

Rims around some lobes bearing conspicuous spinelets or large papillae; a few such structures usually in ornamented areas of lobes, particularly L3 ..... 11

10. L2 and L3 of average width for the genus; S1 only slightly narrower than S3; rims of L2 and L3 continuous around ventral end of ornamented area, clearly separating it from frill ..... *C. eurybathrota*

L2 and L3 notably broad, the latter ventrally nearly as broad as L4; S1 very narrow; ornamented areas of L2 and L3 ventrally separated from lateral surface of frill by a very low ridge, or not at all ..... *C. apletolobata*

11. Most spinelets associated with L4, a few scattered on rims of L3 and L2, rarely on ornamented areas of L2 and L3; female valve with rims of L2 and L3 ventrally terminated abruptly at frill ..... 12

Few if any spinelets associated with L4, most on the three front lobes; female valve with rims of L2 and L3 extending to surface of frill and usually confluent with it ..... 13

12. Female with ornamented areas of L2 and L3 ventrally rimmed and distinct from frill; male with ventral part of L3 very broad but constricted sharply at junction with spur ..... *C. widderensis*

Female with ornamented areas of L2 and L3 having low ventral rims if any, not sharply set off from frill; male with ventral part of L3 only moderately broad, constricted very little at junction with spur; dorsal end of L1 variously rounded or pointed ..... *C. acanthina*

13. Dorsal end of L2 below hinge line, but provided with single central spinelet on the rim directed upward and extending to or above hinge line, emphasizing upward taper of lobe; female valve with small L1, much lower and less developed than dorsal end of L2 ..... *C. acrolobata*

Dorsal end of L2 near hinge line, rather flat, typically with a spinelet on rim at each corner (like a pair of horns), emphasizing its blunt termination; female valve with L1 distinctly developed and elevated (although not quite as strongly as the dorsal end of L2 next to it) ..... *C. didyma*

western Ontario, and northern Michigan, has not been identified from formations in western New York. It is very similar to *Ctenoloculina widderensis* from western Ontario, from which the female differs in having a very low rim (if any) separating the ornamented areas of L2 and L3 from the frill, and from which the male differs in having a narrow ventral half of L3 and little constriction at the junction of the spurs. It is also similar to the smaller *Ctenoloculina acrolobata* and *C. didyma*, from which it differs in having more spinelets associated with L4 and few on the ornamented areas of L2 and L3; the female of *C. acanthina* also has the rims of L2 and L3 ventrally terminated abruptly at the frill, whereas those of *C. acrolobata* and *C. didyma* may be confluent with the adjacent part of the frill.

*Occurrence.*—Ohio: Silica Shale. Michigan: Silica Shale, Ferron Point Formation, and Dock Street Shale Member of Four Mile Dam Formation. Ontario: Arkona Shale and Widder Formation. New York: Centerfield Formation, Wanakah Shale, Kashong Shale, and Windom Shale.

*Illustrated specimens.*—UMMP 28944 (Arkona Shale, loc. 1); 58387, 58398 (Arkona Shale, loc. 10); 64621, 64622 (Arkona Shale, loc. 6); 64624 (Arkona Shale, loc. 9); 58401 (Widder Formation, loc. 3); 58402 (Ferron Point Formation, loc. 3); and 60295 (Centerfield Formation, loc. 1).

### ***Ctenoloculina acrolobata*** n. sp.

Pl. 3, figs. 1–10

*Derivatio nominis.*—From the Greek *akros* ("tip") and *lobos* ("lobe"), referring to the spinelet at the dorsal end of L2.

*Description.*—Carapace of medium size for the genus. Female valves subelliptical in lateral view, with height/length ratio about .60. Overlap left/right, as usual in genus. Hinge line straight, with dorsal end of L2 and spinelet of L2 projecting slightly above. Anterior border subround with center of curvature near midheight, ventral border rounded with center of curvature near dorsal border, and posterior border subround with center of curvature above midheight.

Each valve distinctly quadrilobate with distinct ornamented areas within rims. In female, L1 very short, L2 and L3 terminating at wide frill, and L4 about half again as wide as L3. L2 wide, its sides subparallel but tapered at dorsal end. L3 slightly constricted at its middle, widest near its ventral end. Sulci deep, only slightly inclined anteroventrally from dorsal border. S2 slightly expanded in the middle to conform with constriction of L3.

Frill of female wide, its distal edge provided with a narrow ornamented area delineated by faint rim and constricted below S2. Most of wide frill conspicuously smooth, not sharply separated from L1, L2, and L3 by angulation. Frill tapered to rear point at junction of rims around ornamented area, extending behind S3.

Ornamented areas of lobes and frill very finely papillose in outer layer. Where outer layer spalled off or worn through, pillars fairly coarse, about two columns in L2. Rims around L2 and L3 more or less merging or confluent with surface of frill, not separated from it by distinct bend. Large tapered papillae or spinelets scattered along rims of lobes, with one prominent spinelet at dorsal tip of L2. Few if any spinelets interspersed with fine papillae on L4, but some may be present on L2 and L3.

Female with six loculi in each valve, each rimmed and adjacent to the ventral rim around ornamented area of frill; rims around circular loculi papillose. Marginal ridge of valve not adjacent to locular rims in female, developed as distinct papillae.

Male unknown with certainty.

*Remarks.*—This new species, known only from the Arkona Shale in which it is associated with the similar *Ctenoloculina acanthina* and *C. didyma*, contains one specimen which is distinctly smaller than the others. The small specimen, UMMP 60282, is only about 0.79 mm long, whereas others, including the holotype, UMMP 60283, average about 0.95 mm long. Because it agrees in morphology with the rest, the small specimen is here included in *C. acrolobata*.

It is impossible to tell if some of the smaller male specimens from the Arkona Shale are adults of this species or perhaps juveniles of the somewhat larger *C. acanthina*.

The new species is smaller than *Ctenoloculina acanthina*, with which it occurs in the Arkona Shale, and the slightly younger *C. widderensis*. It differs from both in having more spinelets or large tapered papillae associated with the front lobes and fewer with L4 and in having the rims of L2 and L3 more nearly confluent with the smooth surface of the frill in the female. It differs from *C. didyma*, also confined to the Arkona Shale insofar as known, in having the dorsal end of L2 tapered and terminated by one conspicuous spinelet and in having a smaller L1.

*Occurrence.*—Known only from the Arkona Shale.

*Types.*—Holotype UMMP 60283 (loc. 6). Paratypes 60282, 60283, 60284 (loc. 6), 58392, 58397 (loc. 10).

### ***Ctenoloculina amblycentrota*** n. sp.

Pl. 2, figs. 10–13; pl. 3, figs. 20–22

*Derivatio nominis.*—From the Greek *amblys* ("blunt") and *kentros* ("spurred"), referring to the blunt spur on L2 in the male.

*Description.*—Carapace large for the genus. Valves subelliptical in lateral view. Hinge line straight, with dorsal ends of L1 and L3 extending slightly above it, L2 ending dorsally slightly below it, and L4 about even with it. Anterior border subround with center of curvature above midheight, ventral border round with center of curvature near dorsal border, and posterior border subround with center of curvature about at dorsal border.

Each valve distinctly quadrilobate with ornamented

areas outlined by papillose rims. In male, L1 large and well developed for genus, rounded dorsally and acuminate ventrally, with parallel sides and nearly or fully as wide as L2. L2 with parallel sides, rounded dorsal end, and rather blunt ventral end with the posteroventral corner rather sharp-angled. L3 about the same width as L2 except for anterior indentation above midheight, its dorsal end subround and its ventral end conspicuously blunt and bearing a posteriorly directed tip at its posteroventral corner. L4 large, more or less D-shaped. Sulci well developed, smooth, deeply incised; S2 wider than S1 or S3.

Female valve with L1, L2, and L3 extending onto frill. L1 ventrally joined to frill at a lateral bend; L3 slightly constricted at its junction with frill but continuous with it. Frill with low bordering rim distally and a very low rim outlining the ornamented area proximally and continuous with rims of L1, L2, and L3. Greatest constriction of ornamented area of frill below S2.

Ornamentation of lobes and frill very distinctive, the outer surface consisting of small distinct papillae evenly but widely spaced and intervening tiny punctae. A few papillae and punctae on L2 and L3 larger than the remainder.

Female valves with six rimmed loculi each. Marginal ridge present. Edge of left valve expanded to frill-like undulating posterior section, fragile but preserved in some valves, projecting well beyond rest of valve.

*Remarks.*—This new species is similar to the slightly smaller *Ctenoloculina cicatricosa*, from which it differs in having blunter ventral ends of L2 and L3 and much less development of spurs in the male. It also resembles *Ctenoloculina thliberilobata* of about the same size, from which it differs in lacking various constrictions of the ornamented areas of the lobes. *Ctenoloculina amblycentrota* differs from both the mentioned species in having punctae within the ornamented areas of the lobes.

*Occurrence.*—Known only from the Kashong Shale.

*Types.*—Holotype UMMP 60293 (loc. 2). Paratypes 60289, 60292 (loc. 2), and 60290, 60291, (loc. 3).

### ***Ctenoloculina apletolobata*** n. sp.

Pl. 61, figs. 23–26; pl. 69, figs. 26–40

*Derivatio nominis.*—From the Greek *apletos* ("immense") and *lobos* ("lobe"), referring to the exceptionally broad L2 and L3 lobes.

*Description.*—Carapace of medium size for the genus, adult female 1.0 mm long or slightly less. Hinge line straight. Dorsal ends of L1 and L3 extending slightly above hinge line. Valves subelliptical to subpyriform in lateral view, with height/length ratio of about 0.55 in female, less in male and juveniles. Anterior border subround with center of curvature above midheight, ventral border round with center of curvature at or above dorsal border, posteroventral border gently convex, and posterodorsal border subrounded, in well-preserved specimens modified in lateral view by frill-like development of submarginal ridge.

Each valve distinctly quadrilobate. In male, L1 acuminate both dorsally to a spine-like tip and ventrally to a sharp downwardly directed spur; the narrowest of all lobes. Male L2 very wide, slightly constricted at the junction with the spur; spur at posteroventral corner of lobe, protuberant, directed backward with rounded tip. Male L3 very wide ventrally, with an embayment in the front border just above midheight, ventrally protuberant and ending in a sharp posteroventral spur pointed backward; posterior edge of L3 nearly straight, only slightly indented if at all. Male L4 only a little wider than ventral part of L3, more or less D-shaped with a slight posterodorsal indentation. All lobes of male conspicuously rimmed.

In female, L1 posteriorly constricted at its confluence with the frill but dorsally acuminate to a spine-like tip, fairly well developed for the genus, limited to dorsal one-third of the valve. Female L2 conspicuously wide for the genus, not extending onto frill, its dorsal end round and its ventral end blunt. Female L3 much wider ventrally than dorsally, not extending onto frill, its anterior edge conspicuously indented. Female L4 like that of male. S1 very narrow, practically a groove; S2 ventrally constricted by anterior expansion of L3; and L3 of intermediate width. All sulci smooth.

Female frill smooth in proximal part, its distal edge bearing a narrow ornamented area typically expanded below L2 and L3, strongly constricted below S2 and tapering to posterior tip. Six loculi in each valve, each loculus provided with papillose rim. Rims of loculi tangent to rim along distal edge of frill, slightly separated from marginal rim. Marginal rim present. Edge of overlapping left valve in all adults expanded posteriorly into a frill-like projection of elongate fused denticles.

Ornamented areas of lobes and frill papillose (outer surface not preserved). Some papillae of larger diameter but fairly low on rims of lobes and a few such on L2 and L3 ornamented areas.

*Remarks.*—This species most closely resembles *C. eurybathrota*, from which it differs in having a wider L2 and narrower S1, the female frill less flared, and the female L2 and L3 slightly longer and separated from the smooth area of the frill by a very low rim if any; the ornamented areas of L2 and L3 in well-preserved specimens of *C. eurybathrota* have a strong continuation of the rims along the ventral border, clearly separating them from the frill. The papillae on the rims and the larger papillae on the ornamented areas of the lobes are lower and less developed in *C. apletolobata* than in *C. acanthina*.

*Occurrence.*—Known only from the upper part of the Ferron Point Formation.

*Types.*—Holotype UMMP 60264. Paratypes 58402, 60244, and 65074-65082. All from loc. 3.

### ***Ctenoloculina araea*** n. sp.

Pl. 4, figs. 17–20

*Derivatio nominis.*—From the Greek *araios* ("thin, narrow"), referring to the very restricted ornamented areas of L2 and L3.

*Description.*—Carapace small for the genus, adult females about 0.85 mm long. Hinge line straight. Dorsal ends of L1 and L3 rounded but may extend slightly above hinge line. Valves subelliptical in lateral view, with height/length ratio of about 0.60 in female. Anterior border with center of curvature above midheight, ventral border with center of curvature near dorsal border, posteroventral border with center at or near dorsal border, and posterodorsal border of smaller radius. Anterior cardinal angle slightly greater than posterior.

Each valve distinctly quadrilobate, with prominent sulci. In male, L1 and L2 distincly inclined forward, forming an angle of about 75° with the hinge line; L3 inclined forward at a somewhat lesser angle. L1 of male with acuminate tip forming spur, L2 protuberant ventrally in a spur, and L3 bearing posteriorly directed spur. L1 of female short, more or less confluent with frill above midheight; L2 long, extending onto frill, may be panduriform by median constriction; L3 constricted above midheight and at junction with frill, its ventralmost section in some expanded to ventral edge of frill. L4 in both dimorphs rather small, relatively narrow. Lobes with low rims around ornamented areas, variously modified.

Ornamented area of L3 with strong constriction above midheight, nearly divided in two. Area of L1 very narrow. Ornamented area of L2 in male about as wide as that of L3; in female, very narrow, may be separated into two parts by strong median constriction of the lobe. Lobes ornamented with small papillae. No larger papillae or spinelets associated with rims around lobes. Sulci and frill smooth to granulose.

Female valve with six loculi, each with low rim. Each valve with low marginal ridge.

*Remarks.*—This new species is smaller than other species of *Ctenoloculina*. In the constriction of the ornamented areas of the lobes, it has some resemblance to the much larger *C. thliberilobata*.

*Occurrence.*—Known only from Norway Point Formation.

*Types.*—Holotype UMMP 60286. Paratypes 60285, 60287, 60288. All from loc. 1.

### *Ctenoloculina cicatricosa* (Warthin)

Pl. 1, figs. 6–15; pl. 5, figs. 12,13

*Tetradella cicatricosa* Warthin, 1934, p. 209, pl. 1, figs. 4–6. [Norway Point Formation, Holotype UMMP 14534, complete female carapace.]

*Ctenoloculina cicatricosa* Kesling and Chilman, 1978, vol. 1, p. 58; vol. 2, pl. 5, figs. 1–22; pl. 6, figs. 10–19; pl. 16, figs. 3–6; pl. 17, figs. 7–9; pl. 18, figs. 1–20; pl. 19, figs. 1–18; others.

*Diagnosis.*—Adult carapace about 1.2 mm long. Female valve with ornamented areas of L2 and L3 extending onto frill and practically reaching its ventral edge. Ornamented area of L2 fairly wide. Spur on L2 of male long and sharply acuminate, particularly long in some juveniles.

*Remarks.*—This species, without spinelets associated with the lobes, has the general form in the female of *C. myurilobata*, *C. thliberilobata*, and *C. amblycentrota*. All four have distinct ornamented areas of the lobes surrounded by rims and all are fairly large for the genus. *Ctenoloculina cicatricosa* can be distinguished from *C. myurilobata* by its much wider ornamented area of L2 and by the extension of L2 and L3 onto the frill of the female, both lobes reaching the edge of the frill. This species is not quite as large as *C. thliberilobata* or *C. amblycentrota*, with adult carapaces averaging about 1.2 mm long compared with about 1.4 in the latter two. In addition, the male of *C. cicatricosa* has a rather long and sharply acuminate spur on L2, whereas the males of *C. amblycentrota* and *C. thliberilobata* have rather blunt terminations of L2 with the spur more or less a rounded projection at the posteroventral corner. This species has the ornamented areas of L2 and L3 fully developed, whereas those of *C. thliberilobata* are variously constricted in one part or another. *C. amblycentrota* differs from all other species of the genus in having papillae in the ornamented areas of the lobes spaced more widely, with tiny punctae between them.

*Occurrence.*—Ohio: Silica Shale. Michigan: Silica Shale, Bell Shale, Ferron Point Formation, Four Mile Dam Formation, Norway Point Formation, Potter Farm Formation, and Petoskey Formation. Ontario: Arkona Shale, Hungry Hollow Formation, Widder Formation, and Ipperwash Limestone. New York: Centerfield Formation, Ledyard Shale, Wanakah Shale, Kashong Shale, and Windom Formation.

*Illustrated specimens.*—UMMP 58151, 58160 (Silica Shale, Ohio, loc. 1); 58171 (Ipperwash Limestone, loc. 2); 58407, 58409 (Norway Point Formation, loc. 1); 58421 (Ferron Point Formation, loc. 3); 60299 (Arkona Shale, loc. 1); 60301 (Petoskey Formation, loc. 1); and 64640 (Dock Street Clay Member of Four Mile Dam Formation, loc. 1).

### ***Ctenoloculina didyma*** n. sp.

Pl. 3, figs. 11–19; pl. 5, figs. 15–20

*Derivatio nominis.*—From the Greek *didymos* ("twin"), referring to the pair of spinelets at dorsal end of L2 which give the lobe protuberant corners.

*Description.*—Carapace rather small for the genus, with adults less than 1 mm long. Valves suboval in lateral view. Hinge line straight, with dorsal ends of L1 and L3 extending slightly above it; L2 in most specimens even with hinge line except for protuberant spinelets. Anterior and posterior borders subround with center of curvature above midheight; ventral border round with center of

curvature near dorsal border, slightly above in some specimens, slightly below in others. Adult female valves varying in proportions, with height/length ratio from about 0.55 to 0.65.

Each valve distinctly quadrilobate with ornamented area elevated and outlined by rims. In male, L1 well developed and acuminate ventrally. L2 wide with subparallel sides. L3 with constriction above midheight and strong ventral expansion. L4 fairly small for the genus, only slightly wider than widest part of L3. L2 and L3 terminating ventrally rather bluntly, with spurs directed backward at posteroventral corners. Sulci well developed, with S2 the widest and S1 the narrowest.

Female valve with L1, L2, and L3 terminating at frill. Ornamented area of frill narrow, with constriction below S2, tapering to posterior point and anteriorly terminating below front half of L1.

Ornamentation of outer layer of lobes finely papillose; where outer layer worn away, pillars forming medium-size papillae. Few larger papillae or spinelets associated with L4; most concentrated on rims of L3 and L2. Dorsal end of L2 characteristically with a small spinelet at each corner, producing distinctive shape. Dorsal end of L3 fairly bluntly rounded, in some specimens with spinelets at corners.

Female valve with six loculi, each rimmed. Marginal ridge denticulate. Edge of overlapping left valve expanded posteriorly to form a flange.

*Remarks.*—This new species is close to *C. acrolobata* in having the larger papillae or spinelets concentrated in front of L4; it differs in typically having two spinelets at dorsal end of L2 instead of one, and in having a wider L1 in both male and female valves. It differs from both *C. widderensis* and *C. acanthina* in having greater development of spinelets on the forward lobes instead of L4, and (to judge from available specimens) in having lower and blunter spinelets.

*Occurrence.*—Known only from the Arkona Shale, loc. 3; all specimens from the unit known to collectors as the "Miniature Beds" because of the small specimens of all kinds of invertebrates found in it.

*Types.*—Holotype UMMP 60281. Paratypes 60262, 60263, 60266, 60279, 60280, and 64634-64636.

### ***Ctenoloculina ectenolobata*** n. sp.

Pl. 5, fig. 14

*Derivatio nominis.*—From the Greek *ektenes* ("drawn-out, stretched") and *lobos* ("lobe"), referring to the very elongate lobes, especially L2 and L3, which in the female extend from the dorsal border to the ventral edge of the frill.

*Description.*—Carapace rather small for the genus; adult female about 0.9 mm long as preserved, probably about 0.95 originally. Hinge line straight, with rounded ends of L1 and L3 extending very slightly above it. Valve suboval to subpyriform in lateral view, with height/length ratio probably about 0.70. Anterior and ventral border round with center of curvature just above midheight, tapering from ventral border. In holotype and only specimen, a female right valve, L1 and L2 narrow but elongate, L3 slightly wider with inconspicuous constrictions above midheight and at junction with frill; all three lobes extending fully across frill to ventral border. L4 as preserved very narrow, apparently only a little wider originally. Sulci deep and wide.

Ornamented areas of lobes with rims, bearing medium-size papillae (probably pillars originally supporting outer layer). No spinelets of larger papillae associated with lobes. Frill without distal ornamented area. Six loculi with narrow rims. Hinge list crenulate with cardinal interruptions at ends.

*Remarks.*—Although this species is known from only a female valve, it is distinct from all others of the genus. It is definitely smaller than *C. cicatricosa*, *C. myurilobata*, *C. thliberilobata*, and *C. amblycentrota*, the other species in which the lobes of the female extend across the frill.

*Occurrence.*—Known only from the Wanakah Formation at loc. 6.

*Type.*—Holotype UMMP 60265.

### *Ctenoloculina eurybathrota* Kesling

Pl. 5, figs. 1–11; pl. 8, figs. 1,2

*Ctenoloculina eurybathrota* Kesling, 1952c, p. 46–48, pl. 1, figs. 1–9. [Ferron Point Formation. Holotype UMMP 28025, female right valve.]

*C. eurybathrota* Kesling and Chilman, 1978, vol. 1, p. 59; vol. 2, pl. 17, figs. 1–6.

*Diagnosis.*—Female valve with ornamented areas of L2 and L3 not encroaching onto frill. Ornamented area of frill variously constricted below S2. Rims around lobes smooth; no larger papillae or spinelets on ornamented areas of lobes. Ornamented areas of L2 and L3 of average development for genus, not especially wide. Ventral ends of L2 and L3 in female with continuation of rims, sharply bounding them from frill area.

*Remarks.*—This distinctive species is widespread and fairly common in many formations. It differs from *C. cicatricosa*, *C. myurilobata*, *C. thliberilobata*, and *C. amblycentrota* in having its L1, L2, and L3 terminating ventrally at the frill and not extending across it. Among the species of *Ctenoloculina* in which the lobes do not encroach onto the frill, *C. eurybathrota* can be distinguished from *C. rhadina* and *C. platyzanclota* by its much narrower ornamented area of the frill; it further differs from *C. rhadina* in having much less swing in the valves. This species lacks spinelets and large papillae on the rims and ornamented areas of the lobes, which sets it apart from *C. acanthina*, *C. acrolobata*, *C. didyma*, and *C. widderensis*.

*Ctenoloculina eurybathrota* most closely resembles *C. apletolobata*. The latter, however, has a much wider L2

and L3 and a narrower S1; the ventral end of its L3 is particularly wide, nearly as wide as L4; and the ornamented areas of L2 and L3 in the female are ventrally separated from the frill by a very low ridge or not at all, whereas these areas in *C. eurybathrota* have the rims continuous around the ventral ends and clearly separating them from the frill.

*Occurrence.*—Ohio: Silica Shale. Michigan: Silica Shale, Bell Shale, Ferron Point Formation, Genshaw Formation, Dock Street Clay Member of Four Mile Dam Formation, and Petoskey Formation. Ontario: Arkona Shale, Hungry Hollow Formation, and Ipperwash Formation. New York: Centerfield Formation, Wanakah Formation, and Windom Shale.

*Illustrated specimens.*—UMMP 58478, 58479, 64641, and 64643 (Arkona Shale, loc. 1); 60169 (Ferron Point Formation, loc. 3); 60245 (Centerfield Formation, loc. 2); and 60246 (Wanakah Formation, loc. 1).

*Ctenoloculina myurilobata* Kesling

Pl. 4, figs. 1–16; pl. 6, figs. 1–13

*Ctenoloculina myurilobata* Kesling, 1952c, p. 48, pl. 1, figs. 10–15. [Ferron Point Formation. Holotype UMMP 28029, female carapace.]

*C. myurilobata* Melik, 1966, p. 217, pl. 17, fig. 7; pl. 18, figs. 11,12; pl. 19, figs. 5–7.

*C. myurilobata* Collier, 1971, p. 373, 374, pl. 2, figs. 9–15.

*C. myurilobata* Bless and Jordan, 1971, p. 874.

*Diagnosis.*—Adult carapace about 1.0 mm long. Female with ornamented areas of L2 and L3 extending across frill, in some reaching ventral edge. Ornamented area of L2 very narrow and straight, in female valve may be constricted at its junction with frill; ornamented area of L3 narrower than in other species, in female valve narrowed at proximal boundary of frill and in some specimens there divided.

*Remarks.*—This species, first described from the Ferron Point Formation in northeastern Michigan, is most common in the Widder Formation of Ontario. It most closely resembles the other species of *Ctenoloculina* which have the ornamented areas of L2 and L3 in the female valve extending onto or across the frill. Unlike *C. cicatricosa*, about the same size, its L2 is particularly narrow and straight, and in many specimens is constricted at its junction with the frill, and its L3 has the ornamented area tapered ventrally so that, in some specimens, it does not reach the distal edge of the frill. It differs from the larger *C. thliberilobata* in lacking the various constrictions of L2 and L3 and in never having the ventral end of either of these lobes expanded upon the frill. It differs from *C. amblycentrota* in lacking punctae in the ornamented areas of the lobes and in its much narrower L2.

*Occurrence.*—Fairly common in Widder Formation in Ontario. Fairly rare in other formations, but remarkably widespread. Ohio: Silica Shale (very rare). Michigan: Ferron Point Formation, Norway Point Formation, and Potter Farm Formation. Ontario: Arkona Shale, Hungry Hollow Formation, Widder Formation, and Ipperwash Formation. New York: Centerfield Formation, Ledyard Shale, Wanakah Formation, Kashong Shale, and Windom Shale.

*Illustrated specimens.*—UMMP 58487, 58488, 58493, 58501, 54502, 58511, 58515, 58518, 58527–58529, and 60237–60239 (Widder Formation, loc. 1); 58538, 58540, 58542, and 58544 (Widder Formation, loc. 3).

*Ctenoloculina platyzanclota* Kesling

Pl. 8, figs. 3–16; pl. 10, figs. 1–4; pl. 12, figs. 1,2

*Ctenoloculina platyzanclota* Kesling, 1953a, p. 208, 209, pl. 2, figs. 20–24. [Arkona Shale. Holotype UMMP 28953, female right valve.]

*C. platyzanclota* Tillman, 1970, p. 210.

*C. platyzanclota* Collier, 1971, p. 374, pl. 3, figs. 1–3.

*C. platyzanclota* Bless and Jordan, 1971, p. 874.

*Diagnosis.*—Female valve with ornamented area of frill broad, its sides parallel throughout. L2 and L3 not encroaching onto frill. Valves not strongly elongate or posteriorly tapered, only moderate swing.

*Remarks.*—Relatively sparse and known only from the Arkona Shale in Ontario and the equivalent Ferron Point Formation in northeastern Michigan, this species is clearly distinct. The ornamented areas of L2 and L3 in the female do not extend onto the frill, which separates it from *C. cicatricosa*, *C. amblycentrota*, *C. myurilobata*, and *C. thliberilobata*. It is much larger than *C. araea* and *C. ectenolobata*, which have the lobes extending onto the frill.

*Ctenoloculina platyzanclota* differs from *C. acanthina*, *C. acrolobata*, *C. didyma*, and *C. widderensis* in lacking spinelets or large papillae on the rims and ornamented areas of the lobes. Unlike *C. eurybathrota* and *C. apletolobata*, the ornamented area of the frill is wide throughout its length. In this, it resembles *C. rhadina*, but lacks the elongation of the valves, the posterior taper, and the exaggerated swing.

*Occurrence.*—Michigan: Ferron Point Formation. Ontario: Arkona Shale.

*Illustrated specimens.*—UMMP 58550, 58557, 58558, 58567, 58573, and 60241 (Arkona Shale, loc. 1); 58583, 58589, and 58592 (Arkona Shale, loc. 5); 60277 and 60278 (Arkona Shale, loc. 7); and 60243 (Ferron Point Formation, loc. 3).

***Ctenoloculina rhadina*** n. sp.

Pl. 15, figs. 9–23

*Derivatio nominis.*—From the Greek *rhadinos* ("slender, tapering"), referring to the elongate, posteriorly strongly tapered valves.

*Description.*—Carapace medium size for the genus.

Valves elongate subpyriform in lateral view. Hinge line long and straight, with dorsal rounded ends of L1 and L3 extending slightly above it and rounded end of L2 about even with it. Anterior and ventral borders round, with center of curvature near junction of S2 and hingeline; posterior border gently convex, the posterior end of the valve tapering to posterior corner to produce an exceptional swing. Carapace rather wide as viewed dorsally or ventrally, with greatest width through L3, nearly twice the greatest width through L4.

Each valve distinctly quadrilobate. Male valve with L2 strongly inclined forward from hinge line, expecially in immature instars, in some specimens at an angle as great as 70° with the hinge line. L1 and L3 also inclined. L1 well developed. L2 with constriction just above midheight, with S1 having a slight geniculation at its middle. L3 rather strongly constricted above midheight, its ventral part fairly wide. Spur on L2 directed posteroventrally; ventral end of L2 subtriangular, its front side distinctly truncate. Spur on L3 rather inconspicuous, a tip at the posterior corner of the sharply truncate ventral end of the lobe. L4 well developed, but with its posteroventral edge affected by the posterior elongation of the valve. Sulci wide and deep. Male and juvenile valves with height/length ratios slightly more than 0.50.

Female valve with wide ornamented area of frill, only slightly constricted at its junction with that of L1. L2 and L3 terminating at the frill, not encroaching onto it. Rims around ornamented areas of lobes and frill. Female valve with height/length ratio less than 0.50.

Ornamented areas of lobes and frill very finely papillose; where outer layer worn away (seldom on L4), pillars forming medium size papillae. Male and juvenile specimens without larger papillae, but female with a few larger papillae, mostly associated with the rims of L3 and L2. Female with six loculi, each rimmed. Marginal ridge with very low denticles, nearly smooth, edge of overlapping left valve expanded posteriorly to form a flange.

*Remarks.*—The exceptional swing of the valves and the inclination of L2 and L3 are sufficient to distinguish this species from *C. platyzanclota*, which it resembles in having a wide ornamented area of the frill. *C. rhadina* is the most elongate of all *Ctenoloculina* species.

*Occurrence.*—Known only from the Arkona Shale in Ontario.

*Types.*—Holotype UMMP 60270 (Arkona Shale, loc. 5). Paratypes 60267–60269, 60271, 60272, and 64629 (Arkona Shale, loc. 5); and 60296 (Arkona Shale, loc. 4).

### *Ctenoloculina thliberilobata* Kesling

Pl. 9, figs. 1–17; pl. 10, figs. 5–12; pl. 11, figs. 1–11; pl. 12, figs. 3–14; pl. 13, figs. 8–16

*Ctenoloculina thliberilobata* Kesling, 1953a, p. 204–206, pl. 1, figs. 4-13; pl. 2, figs. 14–16. [Arkona Shale. Holotype UMMP 28929, complete female carapace.]

*C. thliberilobata* Collier, 1971, p. 375, pl. 3, figs. 8–12.

*C. thliberilobata* Kesling, 1954b, p. 17, 18, pl. 2, figs. 17–23.

*C. thliberilobata* Bless and Jordan, 1971, p. 874.

*Diagnosis.*—Carapace large, about 1.4 mm long. Spur on L2 of male rather blunt; L2 termination nearly horizontal. Ornamented areas of L2 and L3 extending onto and practically across frill of female, exceptionally variable; ventral end of one or both expanded into triangular area; one or both lobes constricted in middle and in some specimens separated into dorsal and ventral areas; in extreme cases, lacking in half of one or the other lobe. Ornamented areas of lobes evenly papillose.

*Remarks.*—This is undoubtedly the most variable of all *Ctenoloculina* species in the form of L2 and L3. The ornamented areas are variously constricted near the middle in these lobes; some are so pinched as to leave only a cleft between the two halves, others are completely separated into two halves, a few have one half without any ornamentation, and some are notably constricted but with dorsal and ventral halves fully connected. In all valves, however, the ventral end of L2, L3, or both is greatly expanded ventrally to form a subtriangular ornamented field on the frill, with a wide side along the edge of the frill.

In addition to the variations in lobation, this species is larger than *C. cicatricosa* and has rather blunt ventral terminations of L2 and L3 in the male, with the spurs protruding only slightly and directed posteriorly instead of posteroventrally. *C. thliberilobata* differs from *C. amblycentrota* in having a definite constriction of L2 and in lacking punctae between the papillae in the ornamented areas of the lobes.

*Occurrence.*—Known only from the Arkona Shale.

*Illustrated specimens.*—UMMP 57993, 57994, 57998, 58002, 58006-58009, 58011, 58012, 58014, 58016, 58017, 58019, 58020, 58022, 58025–58027, 58029, 58033, 58036, 58038, 58039, 58043, 58044, 58046, 58051, 58052, 58054, 58057, 58061, 58063, 58067, 58068, 58071, 58072, 58078, 58083, 58088, 58089, 58095, 58099, 58102, 58104, 58106, 58107, 58111, and 60248 (Arkona Shale, loc. 1); and 60249 (Arkona Shale, loc. 7).

### ***Ctenoloculina widderensis*** n. sp.

Pl. 13, figs. 1–7; pl. 14, figs. 1–11

*Derivatio nominis.*—From the site of the former village of Widder, Ontario, where excellent specimens occur in the type locality of the Widder Formation.

*Description.*—Carapace medium size for the genus, adults about 1.2 mm long. Valve subelliptical to subpyriform in lateral view. Hinge line long, with L1 extending well above it and L3 slightly above it. Anterior border round with center of curvature below hinge line; ventral border subround with center of curvature well above hinge line; posteroventral border below L4 gently convex; and posterodorsal end of valve narrowly rounded.

Each valve distinctly quadrilobate; ornamented areas of lobes outlined by rims. Male valve with all lobes slanting forward and down, forming an angle of about 80° with the hinge line. L1 well developed, acuminate dorsally and in some well-preserved specimens terminating in a blunt spine, its ventral end constricted and provided with a blunt, ventrally-directed spur. L2 rather wide, its sides parallel, rounded dorsally and blunt ventrally, constricted at its junction with the projecting spur. L3 large, slightly constricted above midheight, its ventral part greatly expanded and constricted at its junction with the spur; spur with gently convex ventral end and short backwardly directed tip. L4 large, with anterior rim straight or slightly concave. slanting down and forward, its ventral rim long and parallel to the border of the valve. S2 wide in its dorsal half, S1 very narrow, and S3 intermediate; all sulci deep and well defined.

Female valve with L2 and L3 bearing rims around their entire perimeters, distinctly setting them apart from the frill surface. Ventral end of S3 strongly expanded. Frill with ornamented area surrounded by rim continuous with that of L1; ornamented area constricted below S1 and S2, expanded below L2 and L3, and tapering to posterior end. Some well-preserved valves showing rounded spinelet at dorsal end of L1. Each female valve with six rimmed loculi; positions of loculi seen in lateral view as convexities on the smooth part of the frill above the ornamented area.

Ornamentation of lobes and frill finely papillose; wherever outer layer missing (as in most specimens), pillars forming papillae of medium spacing for the genus. Much larger papillae or rounded spinelets associated with ornamented areas of lobes and frill, in many specimens concentrated on L4 but nevertheless occuring also on the front lobes as well as on the rim of the female frill.

Marginal ridge denticulate with rounded denticles or papillae, becoming obscure below L4. Edge of overlapping left valve extending posteriorly as a delicate but ample flange.

*Remarks.*—This species most closely resembles *C. acanthina*, from which it can readily be distinguished by the great expansion of the ventral part of L3, the constrictions of L2 and L3 at their junctions with the spurs in the male, and by the strong ventral development of the rims of L2 and L3 in the female. Unlike *C. acrolobata* and *C. didyma*, this species has many of the large papillae associated with L4 and it shows a broader L2 and much wider ventral part of L3.

*Occurrence.*—Known only from the Widder Formation in Ontario and Wanakah Shale in western New York.

*Types.*—Holotype UMMP 64627, a male carapace (Widder Formation, loc. 1). Paratypes 58400 (Widder Formation, loc. 3); 64625, 64626, and 64628 (Widder Formation, loc. 1); and 64630–64633 (Wanakah Formation, loc. 1).

## Genus *Abditoloculina* Kesling 1952

*Type species.*—By original designation, *Abditoloculina insolita* Kesling, 1952b, p. 765, 767, 768, pl. 3, figs. 7–14.

*Diagnosis.*—Ctenoloculinine ostracods with L3 bulbous, L4 low, and L1 and L2 forming nodes in dorsal half of valve. Ventral lobe with spurlike projections below L1 and S2, the latter larger and may extend outward and backward in a sweeping arc; projections situated in female valve above the frill. Female valve with loculi; frill of male divided into two segments, the anterior extending from the corner of the valve, along the ventral edge of the anterior projection, and ending at its tip; the posterior segment of the frill starting midway between end of the anterior segment and the marginal ridge, and extending back to posteroventral area of valve, parallel to the marginal ridge throughout and entirely below the posterior projection of the ventral lobe.

*Remarks.*—The lobation of this genus is much more like that of *Hollinella* of the Hollinellidae than like *Ctenoloculina* of the Ctenoloculinidae. However, its locular dimorphism is identical to that of *Ctenoloculina*, so that, despite its peculiar lobation, *Abditoloculina* can be included in the subfamily Ctenoloculininae.

The bizarre projections from the ventral lobe are hollow. They are definitely part of the lobation rather than velar. Their use is conjectural; they may have served to keep the carapace upright, acting as outriggers.

The peculiar dimorphic form of the frill in the male, divided into two segments with the anterior one following the ventral edge of a protuberant part of the lobation, is like that in species of *Tetrasacculus*. It has no resemblance whatever to the spurs on L1, L2, and L3 in *Ctenoloculina*.

### *Abditoloculina insolita* Kesling

Pl. 62, figs. 18–20; pl. 68, figs. 14–16

*Abditoloculina insolita* Kesling, 1952b, p. 766–768, pl. lll, figs. 7–14; text-fig. 1. [Jeffersonville Limestone. Holotype UMMP 27781, female left valve.]

*A. insolita* Kesling and Peterson, 1958, p. 133, pl. 1, figs. 39–41, 56-59.

*A. insolita* Bless and Jordan, 1971, p. 874.

*Diagnosis.*—Female valve with seven loculi. Valves nearly smooth, ornamented with shallow dents, hardly discernible. Anterior projection of ventral lobe subconical, inclined slightly backward; posterior projection very long, extending far out from rest of valve and strongly curved backward, tapered to narrowly rounded tip. L3 provided with a posterodorsal spinelike tip; L1 dorsally acuminate to a rather sharp tip projecting above hinge line, and a very small projecting tip on the posterodorsal part of the rounded L2 in some specimens. Spinelet on dorsal border between L3 and posterior corner.

*Remarks.*—As in *Ctenoloculina*, each loculus is rimmed and circular. The positions of the loculi are

KEY TO SPECIES OF *ABDITOLOCULINA*

Valve nearly smooth, ornamented with faint reticulation of shallow dents; female valve with all seven loculi about equal and circular; small sharp tip or small spike atop L3 and directed backward; small but distinct spine on dorsal border between L3 and posterior corner, and a small spine at anterior corner; ventrocentral spur below L3 in female long and slender ..... *A. insolita*

Valve ornamented with distinct reticulation on lateral surface made up of variously developed punctae, locally vermiculate, fading out on prominent lobes; female valve with anteriormost and posteriormost loculi tending to be oval, so that series of loculi appears to taper at each end; bulbous L3 without any additional protuberance or, at most, a very faint tubercle; no dorsal border spine behind L3 and little or no development of a small protuberance at the anterior corner; ventrocentral spur below L3 in female stout and tapered, not slender ..... *A. pulchra*

clearly defined in lateral view as separate strong convexities between the lateral surface and the prominent rim of the frill. In this, it differs from the other species of the genus found in the Jeffersonville Limestone.

It differs from *Abditoloculina pulchra* in having the posterior projection of the ventral lobe longer and thinner, less distinct ornamentation, and all seven loculi about equal instead of gradational. In addition, the anterior projection of the ventral lobe extends onto the female frill as a dumbbell-shaped structure in *A. pulchra*, whereas it is conical and separate from the frill in *A. insolita*.

*Occurrence.*—Jeffersonville Limestone of southern Indiana and Norway Point and Gravel Point formations of Michigan. A damaged specimen, UMMP 60236, may belong to this species; it occurs in the Petoskey Formation (loc. 3). Four incomplete and damaged specimens from the Gravel Point Formation (loc. 3), all catalogued as UMMP 65084, seem to lack the small projecting dorsal tip between L3 and the posterior corner, but agree in other observable characters with this species; until better-preserved specimens are found, we deem it advisable to call them *Abditoloculina* sp.

*Illustrated specimens.*—UMMP 30840 and 30843, both from Gravel Point Formation, loc. 3.

*Abditoloculina pulchra* Kesling

Pl. 7, figs. 1–21; pl. 62, figs. 6–17; pl. 68, figs. 24–26

*Abditoloculina pulchra* Kesling, 1955a, p. 274–276, pl. 1, figs. 1–9. [Centerfield Formation. Holotype UMMP 30497, female carapace.]

*A. pulchra* Melik, 1966, p. 213, 214, pl. 1, figs. 18–23; pl. 7, figs. 1–30.

*A. pulchra* Bless and Jordan, 1971, p. 874.

*Diagnosis.*—Female valve with seven loculi, of which the end ones may be more oval and slightly smaller than the rest. Valves with distinct reticultation of dents or punctae, locally vermiculate but decreasing or fading into granulation on prominent lobes. L3 bulbous, provided with at most a very faint tubercle on is posterodorsal part. L1 with very thin and delicate dorsal spinelet in adult valve, directed upward and backward; L2 with very faint posterodorsal protuberance if any. No projecting dorsal tip between L3 and posterior corner.

*Remarks.*—The rimmed loculi appear to decrease at each end of the series, with the first and last tending to be oval and smaller instead of round. The anterior protuberance of the ventral lobe has an upper and a lower prominence, giving it a dumbbell shape, particularly developed in the female valve, where the lower prominence overlies the frill and nearly or quite reaches the ventral border; the anterior protuberance in *A. insolita* is simple and rounded conical. This species further differs from *A. insolita* in its deeper and distinctive ornamentation and its thicker and somewhat shorter posterior protuberance of the ventral lobe. In both species, the anterior segment of the velar ridge or narrow frill in the male extends along the ventral edge of the anterior protuberance, terminating at its end in a tiny circle around a central pit.

*Occurrence.*—Found only in New York. Most specimens from the Centerfield Formation; one from the Windom Shale.

*Illustrated specimens.*—Holotype UMMP 30497 (Centerfield Formation, loc. 2). Paratypes UMMP 30487 and 30500 (Centerfield, loc. 2). UMMP 60134–60136 and 60273–60276 (Centerfield, loc. 2); and 60251 (Windom Shale, loc. 1).

### Genus *Hercynobolbina* Blumenstengel 1969

*Type species.*—By original designation, *Hercynobolbina latiantrum* Blumenstengel, 1969, p. 732.

*Diagnosis.*—Ctenoloculinine ostracods with L2 and L3 vertically elongate, reaching to dimorphic spurs in male. Lobes tending to be effaced, usually without any rims or ornamented areas, but in some specimens with traces of ornament along midline of lobes. All three sulci long, not deeply incised.

*Remarks.*—Specimens of *Hercynobolbina* have not been found in such abundance that a few could be readily sacrificed to polished surfaces. Thus, we have little knowledge by which to compare the shell structure of this genus with that of *Ctenoloculina*. Inasmuch as the major difference between the two concerns the ornamented areas of the lobes, it would be very valuable to prepare polished surfaces or thin sections of *Hercynobolbina* specimens to determine if they also have two layers of shell material in the mid-portion of the lobes. The traces of "ornament" seen in a few specimens of *H. levis* suggest that they are remains of tiny pillars originally between the main part of the shell and a thin outer veneer, just as in *Ctenoloculina*.

#### ***Hercynobolbina levis*** Weiss n. sp.

Pl. 15, figs. 1–8; pl. 61, figs. 27–31; pl. 71, figs. 7–10

*Derivatio nominis.*—From the Latin *laevis* or *levis* ("smooth"), referring to the smooth surface of lobes in most specimens.

*Authorship.*—In his unpublished doctoral dissertation of 1954, Martin Weiss recognized this as a distinct species, although he assigned it then to *Ctenoloculina*. We here credit him as author.

*Description.*—Carapace small, adult valves about 1.0 mm long. Valves suboval in lateral view. Hinge line long and straight. Anterior border subround, ventral border gently round and confluent with posteroventral border, and posterodorsal border narrowly round. Valve with slight swing.

Each valve quadrilobate, but lobes tending to be poorly defined and somewhat irregular. Male valves with long L1, L2, and L3, at least the latter two terminating with projecting spurs. L4 wider than other lobes but not conspicuously so. Sulci long and rather shallow, extending through entire valve in male. L2 and L3 of female merging with frill.

Female with six loculi in each valve. In most specimens, entire surface smooth but somewhat irregular; in some, traces of "ornament" on middle parts of the long lobes, but none with well-developed ornamented areas. Marginal ridge parallel to free edge.

*Remarks.*—In comparison with *Hercynobolbina latiantrum* Blumenstengel, this American species has six loculi rather than five, shorter ventral processes, and deeper sulci.

*Occurrence.*—Norway Point Formation (rare), Potter Farm Formation (rare), and Petoskey Formation, all in Michigan.

*Types.*—Holotype UMMP 38843, female left valve (Petoskey Formation, loc. 2). Paratypes UMMP 30833, 30835, 30836, 38842 (Petoskey Formation, loc. 2); 64753 (Petoskey, loc. 3); 64649, 64650, and 64751 (Norway Point Formation, loc. 1); and 64752 (Potter Farm Formation, loc. 1).

### Subfamily Parabolbininae Bless and Jordan 1971

*Diagnosis.*—Female valve with scalloped frill or adventral structure in each valve, never with fully developed loculi. Valves tending to be bilobate, with prominent S2 sulcus; lobes not vertically narrow or rimmed.

*Remarks.*—Unlike genera of the Ctenoloculininae, those of this subfamily are never distinctly quadrilobate, and L2 is usually indistinct and fused with L1 to some degree. Even though L3 is inflated in some species, it is never bulbous and its precise boundaries are not defined. The main lobation comes from the well-defined and conspicuous S2.

The female in this subfamily has a distinct frill or sharp velar ridge bearing scallops; in some species, the scallops of the two valves meet distally to enclose "chamberettes" in the closed carapace, whereas in others they only serve to outline "false pouches" in the closed carapace. Because there is no inner wall bounding either of these structures, they are readily distinguished from true loculi of Ctenoloculininae.

### Genus *Subligaculum* Kesling and McMillan 1951

*Type species.*—By original designation, *Subligaculum scrobiculatum* Kesling and McMillan, 1951, p. 65, 66, pl. 2, figs. 1–4; pl. 7, figs. 1-8.

*Diagnosis.*—S2 terminating near midheight of the valve. Ventral lobe entire in both dimorphs. Scalloped frill of female tending to remain wide in all species. Dimorphic structures of male valve consisting of two spurs, with the anterior the larger and in some developed as a short section of frill, the posterior a tapered spine and in some tending to be effaced. L3 somewhat inflated, but never bulbous or with distinct boundaries.

*Remarks.*—The ventral abbreviation of the major sulcus separates this genus from *Tetrasacculus*. In addition, the male has distinct spurs, rather than disjunct segments of a velar ridge.

*Subligaculum aculeatum* Stover

Pl. 56, figs. 12–14

*Subligaculum aculeatum* Stover, 1956, p. 1107, pl. 3, figs. 18–20.

[Windom Shale. Holotype NYSM 10830, female carapace.]

*S. aculeatum* Bless and Jordan, 1971, p. 876.

*Diagnosis.*—No posterocentral depression in valve. Female valve with four scallops in frill and a distinct posteroventral spur; frill wide throughout. Valves with papillae but lacking any pattern of underlying reticulation.

*Remarks.*—This species is most closely related to *S. calcaratum*, from which it differs in having a wider frill and no reticulation underlying the papillose ornamentation. The frill itself bears little if any ornamentation, and the scallops do not incurve sufficiently to form "chamberettes" in the closed carapace.

*Occurrence.*—Known only from New York. Wanakah, Kashong, and Windom Shales.

*Illustrated specimens.*—UMMP 65063–65065 (Windom Shale, loc. 1).

*Subligaculum bifidum* (Stewart)

Pl. 55, figs. 9–14; pl. 56, figs. 34–44

*Tetrasacculus bifidus* Stewart, 1936, p. 745, pl. 100, figs. 12–14. [Silica Shale. Holotype OSU 18175.]

*Subligaculum bifidum* Kesling and Chilman, 1978, p. 59, pl. 31, figs. 27–34; pl. 33, figs. 17–32.

*Diagnosis.*—No posterocentral depression in valve. Frill of female valve forming halves of four "chamberettes" and posteriorly terminating abruptly. Groove from S2 to posteroventral border usually absent; if present scarcely discernible.

*Remarks.*—This species, common in the Silica Shale, shows only minor differences from *Subligaculum recurvisulcatum* from the Bell Shale and could be regarded as its senior synonym. The difference appears to lie in the development of a shallow recurved groove between S2 and the posteroventral border in the latter, and in the short continuation of the frill edge behind the rear "chamberette." In other characters, the two populations seem to be alike.

*Occurrence.*—Silica Shale of Ohio and southern Michigan.

*Illustrated specimens.*—UMMP 30973, 30974, 59004 (Silica Shale, Ohio); and 59002, 59005, 59006, 65072, 65073 (Silica Shale, Michigan).

*Subligaculum biorthogonium* Kesling and Weiss

Pl. 56, figs. 1–7

*Subligaculum biorthogonium* Kesling and Weiss, 1953, p. 46,47, pl. 2, Figs. 18–20. [Norway Point Formation. Holotype UMMP 27390, female left valve.]

*Diagnosis.*—No posterocentral depression. Female valve without posterior spur behind frill; frill unornamented or granulose, forming only "half-loculi" by its scallops. L2 poorly defined. S2 ventrally confluent with narrow but well-defined horizontal groove extending forward below L2 and backward below L3.

*Remarks.*—This species agrees with *Subligaculum proclivisulcatum* except in its lack of inclination in the groove adjoining S2, its slightly larger papillae, and somewhat wider female frill anteroventrally. It is distinct from *S. recurvisulcatum* and *S. bifidum*, both of which have female valves forming "chamberettes" in the closed carapace. It differs from *S. laciniosum* in lacking sharply projecting "points" between the scallops and (in some specimens) at the end of the frill.

*Occurrence.*—Found only in Michigan in the Norway Point Formation, Gravel Point Formation, and (rarely) in the Petoskey Formation.

*Illustrated specimens.*—Holotype UMMP 27390 (Norway Point Formation, loc. 1). Paratype 27389 (Norway Point Formation, loc. 1). UMMP 30947 (Norway Point, loc. 1); 30980 (Petoskey Formation, loc. 2); and 30981 (Gravel Point Formation, loc. 9).

*Subligaculum calcaratum* Kesling

Pl. 55, figs. 15–28; pl. 56, figs. 15–22; pl. 69, figs. 17–25

*Subligaculum calcaratum* Kesling, 1953a, p. 209, 210, pl. 1, figs. 14–20; pl. 4, figs. 30, 31, 34, 35. [Arkona Shale. Holotype UMMP 28935, female carapace.]

*S. calcaratum* Bless and Jordan, 1971, p. 876.

*Diagnosis.*—No posterocentral depression. Female valve with a distinct spur behind the frill; frill narrow, unornamented, forming open "half-loculi," the posterior scallop formed by only a low ridge. Surface finely reticulate below papillae.

*Remarks.*—This species differs from *Subligaculum quadribursatum* in having a much narrower and unornamented frill. It is very close to *S. aculeatum*, from which it is distinguished by its posteriorly tapered frill and by the reticulate pattern underlying the papillae.

*Occurrence.*—Found only in Ontario in the Arkona Shale and, rarely, in the Hungry Hollow Formation and the Widder Formation.

*Illustrated specimens.*—Holotype UMMP 28935 (Arkona Shale, loc. 3). Paratypes 28936, 28937, and 28975 (Arkona Shale, loc. 3). UMMP 65047, 65048, and 65050–65052 (Arkona Shale, loc. 5); 65053 and 65054 (Arkona Shale, loc. 7); and 48950, 65044, 65045, and 65049 (Widder Formation, loc. 1).

*Subligaculum laciniosum* Kesling

Pl. 55, figs. 29–40

*Subligaculum laciniosum* Kesling, 1952c, p. 54,55, pl. 2, figs. 16–18. [Ferron Point Formation. Holotype UMMP 28047, female carapace.]

KEY TO SPECIES OF *SUBLIGACULUM*

1. Three scallops on outside of frill in female valve, each marking cuplike depression on inner surface of frill and forming complete "chamberette" in closed carapace ..... *S. tribursatum*

   Four scallops on outside of frill in female valve ..... 2

2. Distinct posterocentral depression or pit, circular, connected anteriorly to base of S2 by a groove ..... 3

   No posterocentral circular depression (although a groove may extend from ventral end of S2) ..... 4

3. Distinct groove from posterocentral depression to posteroventral edge of valve; anterior "spur" of male rather wide and frill-like, with rows of tiny papillae parallel to distal edge; frill of female wide, forming nearly complete "chamberettes" in closed carapace; papillae of medium size ..... *S. scrobiculatum*

   No groove leading ventrally from posterocentral depression; anterior "spur" of male developed as a narrow section of frill without any papillae; frill of female narrow, outlining "half-loculi" in closed carapace; papillae small, fine ..... *S. trullatum*

4. Female valve with a distinct posteroventral spur separated from end of frill ..... 5

   Female valve without a posteroventral spur ..... 7

5. Female frill papillose, forming wide complete "chamberettes" in closed carapace ..... *S. quadribursatum*

   Female frill unornamented, forming open "half-loculi" in closed carapace ..... 6

6. Female frill wide throughout; no indication of reticulation underlying papillae ..... *S. aculeatum*

   Female frill narrow, tapering posteriorly with posterior scallop only a low ridge; surface finely reticulate below papillae .. *S. calcaratum*

*S. laciniosum* Stover, 1956, p. 1108, pl. 111, figs. 15–17.
*S. laciniosum* Bless and Jordan, 1971, p. 876.

*Diagnosis.*—No posterocentral depression. Female valve without spur behind frill; frill unornamented, forming "half-loculi" with scallops, with sharply projecting "points" between scallops and (in some specimens) at posterior end of frill. Papillose ornamentation continuing to posterior border.

*Remarks.*—This species is distinguished from most others of the genus by its sharply projecting "points" between the scallops. It differs from *Subligaculum biorthogonius* and *S. proclivisulcatum* in lacking an extended groove adjoining the ventral end of S2 and in lacking a smooth to granulose posterior margin.

Except for the occurrence reported by Stover in the Windom of New York (1956), it is not known outside Michigan. We have carefully compared the Michigan specimens with those from Ontario and New York, and believe that *S. laciniosum* is distinct from them.

*Occurrence.*—Ferron Point Formation, Genshaw Formation, and Petoskey Formation of Michigan, and Windom Shale of New York. A damaged specimen from the Kashong Shale of New York may possibly belong to this species, but we are uncertain.

*Illustrated specimens.*—All from the upper part of the Ferron Point Formation at loc. 3. Holotype UMMP 28047. Paratype 28048. UMMP 30946 and 65066–65069.

7. Female frill wide, papillose, forming "chamberettes" in most specimens; L2 moderately well defined ..... 8

   Female frill unornamented or, at most, granulose, forming open "half-loculi"; L2 poorly defined ..... 9

8. Groove from ventral end of S2 shallow, extending posteriorly, then curving downward to posterior edge of valve; frill in many valves extending behind posterior "chamberette" for a short distance and, in extreme cases, forming a diminutive fifth "chamberette" ..... *S. recurvisulcatum*

   Groove leading to posteroventral edge of valve rarely developed at all; frill terminating abruptly at rear edge of fourth "chamberette" ..... *S. bifidum*

9. S2 very little expanded anteriorly or posteriorly at its ventral end; female frill narrow but extended into sharply projecting "points" between scallops and may terminate posteriorly in a spinelike projection; papillose ornamentation of lateral surface continuing to posterior border ..... *S. laciniosum*

   S2 ventrally confluent with narrow but well-defined groove extending forward below L2 and posteriorly below L3 to form a T; female frill of medium width, may or may not have "points" projecting outward between scallops; posterior margin of each valve smooth to granulose, practically free of papillae ..... 10

10. Female frill moderately wide anteroventrally, tapering posteriorly; groove adjoining S2 horizontal, the two together forming a Roman T; papillae of medium size ..... *S. biorthogonium*

    Female frill rather narrow throughout, may develop projecting "points" between scallops; groove adjoining S2 straight but inclined anteroventrally, the two together forming an italic *T*; papillae small ..... *S. proclivisulcatum*

*Subligaculum proclivisulcatum* Kesling and Tabor
Pl. 56, figs. 8–11

*Subligaculum proclivisulcatum* Kesling and Tabor, 1953, p. 95,96, pl. 1, figs. 3,4. [Genshaw Formation. Holotype UMMP 28053, female carapace.]

*S. proclivisulcatum* Bless and Jordan, 1971, p. 876.

*Diagnosis.*—No posterocentral depression. Female valve with no spur behind frill; frill unornamented, forming "half-loculi," narrow throughout, may develop projecting "points" between scallops. S2 joined ventrally to an inclined groove extending anteroventrally below L2 and posteriorly below L3. Posterior margin of valve smooth to granulose; rest of valve ornamented with small papillae.

*Remarks.*—This species may develop projecting "points" between the scallops like those of *S. laciniosum* from the underlying Ferron Point Formation; however, the latter has very little development of a groove adjoining the base of S2 and its ornamentation continues to be papillose to the posterior border. *Subligaculum proclivisulcatum* more closely resembles *S. biorthogonium*, from which it differs in the inclination of the groove adjoining S2 and in its somewhat smaller papillae.

Despite its distinctive features, this species is rarely found.

*Occurrence.*—Found only in Michigan in the Ferron Point Formation and the Genshaw Formation.

*Illustrated specimens.*—Both from the Genshaw Formation at loc. 6, in the unit known locally as the *Cyrtina umbonata alpenensis* zone. Holotype UMMP 28053. UMMP 30963.

***Subligaculum quadribursatum*** n. sp.
Pl. 55, figs. 41–45; pl. 69, figs. 1–5

*Derivatio nominis.*—From the Latin *quadrus* ("fourfold") and *bursa* ("pouch, pocket"), referring to the four well-devloped "chamberettes" formed by the scallops of the frills in a closed carapace.

*Description.*—Carapace rather robust. Adult female valve about 0.85 mm long, with height/length ratio about 0.7. Valves strongly plenate, with free border more narrowly rounded at anteroventral and posteroventral corners than elsewhere. Hinge line straight, with anterior cardinal angle much greater than the posterior.

L2 and L1 fully fused, together forming a prominent lobe extending outward nearly as far as the posterior lobe. S2 fairly wide but its edges poorly defined, ventrally joined to a shallow groove. No well-defined posterocentral pit, but a depressed area extending behind ventral end of S2 and just a short distance in front of it, without well-defined boundaries.

Frill of female set well forward, its posterior termination below S2. Scallops well defined in lateral view, protuberant. A spine or spur located on posteroventral margin well behind frill and separated from it by nearly half the length of the frill, small and rounded but very distinct. Male with spurs poorly defined.

Surface, including frill of female, ornamented with papillae, low, rounded, and so closely set as to form a reticulation; size of papillae decreasing onto and across frill. Marginal area of valve in male slightly elevated and rounded.

*Remarks.*—The form of the frill in the female is very distinctive. No other species is known to have four scallops so closely spaced or to terminate so far forward on the valve. The new species differs from *Subligaculum aculeatum* and *S. calcaratum* further in having the female frill ornamented and distally incurved to form complete "chamberettes" in the closed carapace.

*Occurrence.*—Known only from New York, where excellent specimens have been found in the Kashong Shale and a few in the Wanakah Shale.

*Types.*—Holotype UMMP 65058, female left valve (Kashong Shale, loc. 1). Paratypes UMMP 65057 (Wanakah Shale, loc. 4); 65061 and 65062 (Kashong Shale, loc. 1); 65059 (Kashong, loc. 3); and 65060 (Kashong, loc. 4).

*Subligaculum recurvisulcatum* Kesling and McMillan

Pl. 58, figs. 17–21; pl. 69, figs. 6–8

*Subligaculum recurvisulcatum* Kesling and McMillan, 1951, p. 66,67, pl. 2, figs. 5–12. [Bell Shale. Holotype UMMP 26681, male carapace.]

*S. recurvisulcatum* Bless and Jordan, 1971, p. 876.

*Diagnosis.*—No posterocentral pit or depression, but a shallow groove from ventral end of S2 extending posteriorly, then curving downward to posteroventral edge of valve; may become indistinct in compressed specimens. Female valve without spur behind frill; frill wide, papillose, and forming "chamberettes" in most specimens, continuing as a low ridge behind last scallop and, in extreme cases, forming a diminutive fifth "chamberette." L2 moderately well defined, not completely fused with either L1 or ventral lobe.

*Remarks.*—This species is easily confused with *Subligaculum bifidum*, differing only in the better developed groove leading from S2 to the posteroventral border and in the continuation of the frill for a short distance behind the fourth "chamberette." It is readily separated from *Subligaculum scrobiculatum*, with which it occurs in the Bell Shale, by the absence of a posterocentral pit and by its less well defined L2.

*Occurrence.*—Known only from the Bell Shale of Michigan.

*Illustrated specimens.*—All from the Bell Shale at loc. 2. Paratypes UMMP 26682–26684, 26696, and 26700.

*Subligaculum scrobiculatum* Kesling and McMillan

Pl. 55, figs. 1–8; pl. 56, figs. 29–33; pl. 58, figs. 22,23; pl. 69, figs. 14–16

*Subligaculum scrobiculatum* Kesling and McMillan, 1951, p. 65,66, pl. 2, figs. 1–4; pl. 7, figs. 1–8. [Bell Shale. Holotype UMMP 26638, male right valve.]

*S. scrobiculatum* Kesling and Chilman, 1978, p. 59,60, pl. 31, figs. 15–26; pl. 32, figs. 1–16; pl. 36, figs. 1–4; pl. 104, figs. 17–20; pl. 116, fig. 4.

*Diagnosis.*—Posterocentral depression or pit in each valve, connected by a shallower groove, inclined anteroventrally to vertically, to the posteroventral border. Anterior spur of male valve developed as a short section of frill, rather wide and provided with rows of tiny papillae parallel to its distal edge. Female frill wide, forming nearly complete "chamberettes" in the closed carapace.

*Remarks.*—This, the type species of the genus, has some features which are not characteristic of other species now included in *Subligaculum*; these include the posterocentral pit, which finds its maximum expression herein, and the exceptional size and form of the anterior spur in the male. *Subligaculum trullatum*, which occurs in younger strata of the same region, also has a posterocentral pit, but it is not connected by a groove leading to the posteroventral border; *S. trullatum* also has a much narrower frill, the scallops of which outline "half-loculi" instead of "chamberettes."

*Occurrence.*—Found only in the Bell Shale of Michigan and the Silica Shale of Ohio and Michigan, so that it may be the oldest as well as the type species of the genus.

*Illustrated specimens.*—Holotype UMMP 26638 (Bell Shale, loc. 2). Paratypes 26639, 26655, 26688, and 26783–26785 (Bell Shale, loc. 2). UMMP 65070 and 65071 (Silica Shale of Ohio).

*Subligaculum tribursatum* Kesling

Pl. 56, figs. 23–28

*Subligaculum tribursatum* Kesling, 1952c, p. 54, pl. 2, figs. 14,15. [Ferron Point Formation. Holotype UMMP 28046, female right valve.]

*S. tribursatum* Bless and Jo

*Diagnosis.*—Female valve with only three scallops; frill wide and forming complete "chamberettes."

*Remarks.*—This species is unique in having only three scallops in the female frill. The holotype is from the Ferron Point Formation. Two female carapaces from the Wanakah Formation of New York differ slightly from it in having less development of a depression leading posteriorly from the base of S2, a smaller posterior spur behind the frill, and more prominent papillae. Nevertheless, they agree with the type in having only three scallops, and we here include them in the species.

*Occurrence.*—Ferron Point Formation and Wanakah Shale.

*Illustrated specimens.*—Holotype UMMP 28046 (Ferron Point Formation, loc. 3). UMMP 65055 and 65056 (Wanakah Shale, loc. 1).

*Subligaculum trullatum* Kesling and Weiss

Pl. 69, figs. 9–13

*Subligaculum trullatum* Kesling and Weiss, 1953, p. 45,46, pl. 2, figs. 15–17. [Norway Point Formation. Holotype UMMP 27367, male right valve.]

*S. trullatum* Bless and Jordan, 1971, p. 876.

*Diagnosis.*—Posterocentral depression or pit, not connected to posteroventral border by a groove. Frill of female valve too narrow to allow development of "chamberettes" in closed carapace.

*Remarks.*—This species appears to be a descendant of the older *Subligaculum scrobiculatum*, evolving by the loss of the groove connecting the posterocentral pit to the posteroventral border, decreasing the width of the frill, and reducing the size of the papillae. It does not seem to have been in the same lineage as *Subligaculum tribursatum*, which is found in the intermediate Ferron Point Formation and which differs from both *S. scrobiculatum* and *S. trullatum* by the loss of the posterior scallop on the female frill.

*Occurrence.*—Known only from the Norway Point Formation of Michigan, in which it is rare.

*Illustrated specimens.*—Holotype UMMP 27367 (loc. 1). UMMP 30964 and 65046 (loc. 1).

## Genus *Tetrasacculus* Stewart 1936

*Type species.*—By original designation, *Tetrasacculus bilobus* Stewart, 1936, p. 744, 745, pl. 100, figs. 8–11.

*Diagnosis.*—S2 long and sinuous, in the male extending from hinge line to ventral border and in female extending to the narrow frill. Dimorphic velar structures of male consisting of sharp narrow ridge divided into two segments, with the anterior one ending on a ventral protuberance in front of S2 and flaring outward to its tip, and the posterior one beginning between the protuberance and the free edge and extending parallel to the free edge to the posteroventral part of the valve.

*Remarks.*—The great length of S2, reaching the ventral border in the male, distinguishes this genus from *Subligaculum* and, indeed, from most other Hollinacea. The lateral surface of the valve in the female is ventrally flared outward to accommodate the spacious locular structures, so that the carapace appears subtriangular in end view. The male is not as wide ventrally, although the spurlike protuberance in front of S2 is directed outward as well as downward.

*Tetrasacculus bilobus* Stewart

Pl. 48, figs. 5–17; pl. 52, figs. 14–17

*Tetrasacculus bilobus* Stewart, 1936, p. 744,745, pl. 100, figs. 8–11. [Silica Formation. Syntypes OSU 18174, a male and a female carapace.]

*T. bilobus* Kesling and Chilman, 1978, p. 60, pl. 30, figs. 1–53; pl. 31, figs. 1–10; pl. 117, figs. 1,2.

*Diagnosis.*—Frill of female valve extending behind third loculus by the width of that loculus or more. Height of female valve about two-thirds the length. Reticulation deep and distinct.

*Remarks.*—This species differs from *Tetrasacculus paeneloculatus* in having greater posterior extent of the female frill, higher valves, and deeper reticulation. Its frill does not form a complete fourth loculus, such as that present in *T. quaternarius* and *T. paeneteichus.*

*Tetrasacculus bilobus* is one of the common ostracods in the Silica Formation, both in Ohio and in Michigan. For one reason or another, the specimens found there are much better preserved than those found in northern Michigan and Ontario. In lateral view, some of the female specimens from the Silica Formation appear to have four loculi; however, as can be seen in ventral view, the last section of frill lacks a complete wall between the frill and the last margin of the valve and thus, technically, *T. bilobus* has but three loculi.

*Occurrence.*—Silica Formation of Ohio and southern Michigan; Bell Shale, Genshaw Formation, Norway Point Formation, and Gravel Point Formation of northern Michigan; and the Widder Formation of Ontario. Not present in New York.

*Illustrated specimens.*—UMMP 64929–64934 (Widder Formation, loc. 1); 64949 and 64950 (Gravel Point Formation, loc. 1); and 64960-64962 (Genshaw Formation, loc. 6).

*Tetrasacculus magnivelatus* Kesling and McMillan

Pl. 48, figs. 18–27

*Tetrasacculus magnivelatus* Kesling and McMillan, 1951, p. 51, pl. 1, figs. 6,7. [Bell Shale. Holotype UMMP 26715, female left valve.]

*T. magnivelatus* Kesling and Tabor, 1952, p. 95, pl. 1, figs. 5–8.

*T. magnivelatus* Kesling, 1953a, pl. 213, pl. 4, figs. 1–21.

*T. magnivelatus* Tillman, 1970, p. 210, Table 1. non *T.* cf. *magnivelatus* Stover, 1956, p. 1107, pl. 112, figs. 19,20.

KEY TO SPECIES OF *TETRASACCULUS*

1. Female with four complete loculi in each valve (with additional incomplete loculus behind) ..... 2

   Female with three complete loculi in each valve (with additional incomplete loculus behind) ..... 3

2. Loculi set close to margin of valve, with little space between rims and marginal ridge; female valve elongate, nearly twice as long as high; male carapace wide, its width about three-fourths the length; sulcus (S2) geniculate, ventrally angled down between second and third loculi in female ..... *T. quaternarius*

   Loculi separated from margin of valve, with a section of ventrum exposed between rims and marginal ridge; female valve not very elongate, its length/height ratio about 1.7; male carapace only moderately wide, its width less than two-thirds the length; sulcus (S2) slanting evenly and rather straight ..... *T. paeneteichus*

3. Both male and female valves with ventrocentral inflation just behind S2, overlying the third loculus in the female; frill of female extending very little behind the third loculus; female valve elongate, nearly twice as long as high ..... *T. magnivelatus*

   Neither male nor female valve with distinct ventrocentral inflation; frill of female extending behind third loculus by at least half the width of that loculus; female with ovate valve, ratio of length/height 1.75 or less ..... 4

4. Frill of female valve extending behind third loculus by about half the width of that loculus; reticulation rather shallow; female valve with length/height ratio about 1.75 ..... *T. paeneloculatus*

   Frill of female valve extending behind third loculus by the width of that loculus or more; reticulation deep and distinct; female valve with length/height ratio about 1.5 ..... *T. bilobus*

*Diagnosis.*—Female valve with three complete loculi and little extension behind third loculus. Both dimorphs bearing characteristic ventrocentral inflation just behind S2. Valves elongate, with female valve about twice as long as high. Segments of velar ridge in male nearly joined, the posterior one set far out from the marginal ridge and posteriorly curved upward around ventrocentral inflation, in extreme cases forming a U with the opening facing forward.

*Remarks.*—The specimens described by Kesling and Tabor from the Genshaw Formation have the frill of the female valve extended well behind the third loculus. Because they agree in other details with the types, particularly in elongation of the valves, we include them in *T. magnivelatus*. The specimens described by Stover (1956) from the Windom Shale, however, are so different that we cannot accept them herein; Stover himself listed them under "*Tetrasacculus* cf. *T. magnivelatus*" and pointed out differences from the types. Until better specimens of this kind are found, they could best be designated as *Tetrasacculus* sp.

The unusually wide separation of the posterior segment of the velar ridge from the marginal ridge in the male, as well as its exceptional upward curvature, suffices to distinguish it from males of other *Tetrasacculus* species known. The female is separated from females of other species by its elongation of valve, posterocentral inflation, and termination of the frill shortly behind the third loculus.

*Occurrence.*—Bell Shale, Ferron Point Formation, and (?) Genshaw Formation of northern Michigan; one specimen from the Petoskey Formation may also belong

here. Arkona Shale of Ontario, which yields excellently preserved but relatively rare specimens.

*Illustrated specimens.*—UMMP 64967–64969 (Arkona Shale, loc. 4); and 30957 (Arkona Shale, loc. 3).

*Tetrasacculus paeneloculatus* Kesling and Weiss

Pl. 44, figs. 1–27; pl. 52, figs. 18–22

*Tetrasacculus paeneloculatus* Kesling and Weiss, 1953, p. 42,43, pl. 1, figs. 14–18. [Norway Point Formation. Holotype UMMP 27350, broken female right valve.]

*Diagnosis.*—Female valve with three complete loculi and an extension of the frill behind the third loculus by about half the width of that loculus. Height/length ratio of female valve about 1.75; male valve also moderately elongate. No ventrocentral strong inflation. Reticulation shallow.

*Remarks.*—This species is much less elongate than *Tetrasacculus magnivelatus*. In comparison with *T. bilobus*, it is more elongate, it has shallower reticulation, and the frill of the female does not extend posteriorly as far behind the third loculus.

*Occurrence.*—Bell Shale, Norway Point Formation, and (?) Gravel Point Formation of northern Michigan. (?) Ledyard Shale and (?) Wanakah Shale of New York. Arkona Shale and Ipperwash Formation of Ontario.

*Illustrated specimens.*—UMMP 64824–64829 and 64955–64959 (Arkona Shale, loc. 4); 64951–64953 (Gravel Point Formation, loc. 1); and 64954 (Ipperwash Formation, loc. 1).

*Tetrasacculus paeneteichus* Stover

Pl. 48, figs. 1–4; pl. 52, figs. 5–13

*Tetrasacculus paeneteichus* Stover, 1956, p. 1106, 1107, pl. 113, figs. 1–6. [Windom Shale. Holotype NYSM 10848, female carapace.]

*T. paeneteichus* Bless and Jordan, 1971, p. 877.

*Diagnosis.*—Female valve with four complete loculi and short extension of frill behind the last loculus. Loculi separated from marginal ridge by section of ventrum exposed to their rims. Valves not very elongate, the length/height ratio of female valve about 1.7. S2 slanting evenly, nearly straight.

*Remarks.*—The number of loculi is the same in this and in *Tetrasacculus quaternarius* from Michigan. The latter, however, has valves more elongate, very little space between the locular rims and the marginal ridge, and a geniculate S2.

*Tetrasacculus paeneteichus* is probably the youngest species of the genus; *T. bilobus* may be the oldest in the Great Lakes region. If so, the general evolution of the genus seems to have involved the posterior addition of loculi in the female valve.

*Occurrence.*—Known only from the Wanakah Shale, Kashong Shale, and Windom Shale of western New York.

*Illustrated specimens.*—UMMP 64939 and 64940 (Kashong Shale, loc. 6); 64944–64948 and 64970 (Kashong Shale, loc. 1); 64941 (Wanakah Shale, loc. 1); and 64942 and 64943 (Windom Shale, loc. 2).

***Tetrasacculus quaternarius*** n. sp.

Pl. 44, figs. 28–36

*Derivatio nominis.*—From the Latin *quaternarius* ("containing four each"), referring to the four complete loculi in each female valve.

*Description.*—Valve elongate, about twice as long as high. Dorsal border long and straight, not projecting above hinge line. Anterior border round with center of curvature slightly above midheight; ventral and posterior borders confluent and evenly rounded with center of curvature above hinge line. Male with inflated ventral lobe behind S2; inflation of ventral lobe in female masked by wide extent of frill. Female carapace subtriangular in end view. Male carapace wide, its width about three-fourths the length.

Female valve with frill enclosing four complete loculi and extending behind the fourth loculus. Loculi very large and set close to margin of the valve, allowing little space between rims and marginal ridge. Male with posterior segment of velar ridge subdued but extending well behind ventrocentral inflation.

Sulcus (S2) geniculate, ventrally angled down between second and third loculi in female valve. Reticulation low, fading out toward posterior border but covering frill of female.

*Remarks.*—The full development of four loculi and the extension of the frill posteriorly separates this species from *Tetrasacculus bilobus*, *T. paeneloculatus*, and *T. magnivelatus*. In this respect, *T. quaternarius* resembles *T. paeneteichus* from western New York, but it has more elongate valves, wider male carapace, larger loculi reaching close to marginal ridge, and a geniculation in S2. In addition, the anteroventral spurlike projections of the male valves, which bear the anterior segment of the velar ridge, appear to converge anteriorly in *T. paeneteichus*, whereas they are less prominent and have less convergence in *T. quaternarius*.

*Occurrence.*—Known only from the Dock Street Clay Member of the Four Mile Dam Formation in Michigan.

*Types.*—All from loc. 1. Holotype UMMP 64936, female carapace. Paratypes 64935, 64937, 64938, 64963, and 64964.

## Family HOLLINIDAE Swartz 1936

*Diagnosis.*—Dimorphism involving simple dolonal antrum within incurved frill in female valve; if broad, frill terminating below or ahead of L3 and strongly incurved and, if narrow, continuing behind L3 as a low tapering ridge and less strongly incurved.

Subfamily Hollininae Swartz 1936

*Diagnosis.*—Female valve with strongly incurved frill in valves, the dolonal antrum forming a large elongate "false pouch" in closed carapace. Dimorphic structure of male consisting only of ventral tips of L1 and L3. Lobation involving most or all of valve.

Genus *Hollina* Ulrich and Bassler 1908

*Type species.*—*Ctenobolbina insolens* Ulrich, 1900, p. 182,183, pl. 8, figs. 10,11, by subsequent designation of Ulrich and Bassler, 1908, p. 315.

*Diagnosis.*—Complexly quadrilobate, with L1 and L3 elongate and extending to ventral border in the male and to the frill in the female, L2 a distinct node, and L4 a well-defined lobule. Male with subpointed tip of L1 and rounded ventral end of L3 projecting below free border of valve.

*Hollina pyxidata* Kesling

Pl. 68, figs. 3–13

*Hollina pyxidata* Kesling, 1952c, p. 49,50, pl. 1, figs. 24–31. [Ferron Point Formation. Holotype UMMP 28036, male carapace.]

*H. pyxidata* Kesling, 1953a, p. 209, pl. 1, figs. 1–3.

*H. pyxidata* Bless and Jordan, 1971, pl. 878.

*Diagnosis.*—L2 distinctly separated from L1 and anteroventral lobe. Dimorphic tips of L1 and L3 relatively small. L3 divided into dorsal bulb and inclined posteroventral lobule. Carapace boxlike, subquadrate in end view.

*Remarks.*—This species, perhaps the youngest of the genus, differs from the type species in the complete isolation of L2, the smaller dimorphic structures of the male, and in the more subquadrate shape of the carapace, as well as in details of the lobation.

*Occurrence.*—Bell Shale, Ferron Point Formation, and Gravel Point Formation of Michigan, and the Arkona Shale of Ontario.

*Illustrated specimens.*—Holotype UMMP 28036 (Ferron Point Formation, loc. 3). UMMP 64644–64646 (Arkona Shale, loc. 1); and 64770 (Gravel Point Formation, loc. 1); and 30849, 30851 (Ferron Point Formation, loc. 3).

Subfamily HANAITINAE n. subfam.

*Diagnosis.*—Female valve with long, slightly incurved frill and male with narrower non-curved or concave frill. Lobation dominated by S2 and long ventral lobe.

*Remarks.*—The genus *Hanaites* differs from other Hollinidae as well as from genera of the Hollinellidae. Bless and Jordan (1971, p. 879) elected to place it in the subfamily Falsipollicinae with question. Unlike *Falsipollex*, however, the male does not express dimorphism as spurs; in addition, *Falsipollex* is quadrilobate with a bulbous L3 and at least fairly well developed L2.

The unusual genus *Gortanella* seems to be intermediate in its expression of dimorphism; both male and female have spurs adjoined to a frill, with the frill wider in the female. Because *Gortanella* has lobation like that of *Falsipollex* and *Parabolbinella*, we would retain it in the subfamily Falsipollicinae.

Thus, the subfamily Hanaitinae would be monogeneric at this time.

Genus *Hanaites* Pokorny 1950

= *Proplectrum* Kesling and McMillan, 1951, pl. 64; type species, *P. platum* Kesling and McMillan, 1951, p. 64,65, pl. 1, figs. 1,2.

*Type species.*—By original designation of Pokorný, 1950, p. 599, *Halliella* (*Hanaites*) *givetiana* Pokorný, 1950, p. 599–601, pl. 2, fig. 5; pl. 5, figs. 12,13. Subgenus elevated to generic rank by Stover, 1956, p. 1105.

*Diagnosis.*—Anterior palmate spur (? adventral) present in both male and female. L3 reduced to, at most, a protuberance extending above hinge line. Marginal or submarginal structure developed as a broad thin tubulous frill-like keel in posterior half of each valve.

*Remarks.*—Kesling and McMillan (1951) were unaware of Pokorný's recognition of these ostracods as a new supraspecific taxon in the previous year when they proposed the genus *Proplectrum*. With only the type species and *H. platus* known, it is difficult to decide what characters should constitute the diagnosis of the genus.

*Hanaites platus* (Kesling and McMillan)

Pl. 27, figs. 1–18

*Proplectrum platum* Kesling and McMillan, 1951, p. 64,65, pl. 1, figs. 1,2; pl. 7, fig. 2. [Bell Shale. Holotype UMMP 26686, incomplete male left valve.]

*Hanaites platus* Stover, 1956, p. 1105, 1106, pl. 112, figs. 10–14.

*H. platus* Bless and Jordan, 1971, p. 880.

*H. platus* Kesling and Chilman, 1978, p. 62, pl. 35, figs. 12–20; pl. 119, fig. 6.

*Diagnosis.*—L3 developed as a subconical protuberance inclined slightly posteriorly, set rather high on valve and projecting above hinge line. S2 geniculate and directed posteroventrally. Ventral lobe very long and prominent. Keel well developed posteriorly. Anterior spur distally flared out, palmate.

*Remarks.*—The descriptions and figures of Pokorný (1950) seem to be based on worn or damaged specimens. It is quite impossible to interpret if any keel was originally present or the nature of the anterior spur. However, it would appear that the L3 in his *Hanaites givetianus* is poorly developed if at all and that the S2 is considerably shorter than that of *H. platus*.

*Hanaites platus* is rare and most specimens show appreciable distortion by compression. We suppose that the shell wall was thin; the lack of strong lobation may also have contributed to the poor preservation. The most

fragile part of the valves is the keel, which is so thin that it is seldom seen entire or nearly so except where it is backed onto matrix.

*Occurrence.*—Silica Shale of Ohio and southeastern Michigan. Bell Shale, (?) Rockport Quarry Limestone, Genshaw Formation, and Four Mile Dam Formation of northern Michigan. Hungry Hollow Formation of Ontario. Centerfield Formation and Windom Shale of western New York.

*Illustrated specimens.*—UMMP 30968 and 30970 (basal Rockport Quarry Limestone or uppermost Bell Shale, loc. 3); 64763–64765 (Bell Shale, loc. 4); 64766 and 64769 (Windom Shale, loc. 1); and 64767 and 64768 (Hungry Hollow Formation, loc. 3).

## Subfamily Falsipollicinae Bless and Jordan 1971

*Diagnosis.*—Dimorphism involving incurved frill in female valve and an anteroventral and a ventral to posteroventral spur in the male. Lobation well developed, with L3 large and bulbiform and L2 a distinct preadductorial node. No anterior or anteroventral spurlike projection in either dimorph.

*Remarks.*—In addition to *Falsipollex*, Bless and Jordan (1971, p. 879, 880) included *Gortanella*, *Parabolbinella*, and *Thuringobolbina*, all three of which appear to be European genera.

## Genus *Falsipollex* Kesling and McMillan 1951

*Type species.*—By original designation, *Falsipollex altituberculatus* Kesling and McMillan, 1951, p. 69, 69, pl. 3, figs. 1-3.

*Diagnosis.*—L3 developed as a bulb, L2 usually distinct around all its periphery, L1 nodelike to lobate, L4 low and confluent with ventral lobe. Female valve with strongly incurved frill extending from anterior corner to below L3; frill may be shorter and separated from a velar posteroventral spur. Male valve with two spurs, usually prominent and may be expanded.

*Remarks.*—None of the female valves found in the Great Lakes region appear to have the short anterior frill and posteroventral (set behind L3) spur that are typical of *Parabolbinella*. However, no distinctive character has been reported to separate male valves of *Falsipollex* from those of *Parabolbinella*, except perhaps the more posterior location of the rear spur. Hence, we are not certain whether some of the male specimens that are not associated with females in the same sample are all *Falsipollex*, and we must consider the possibility that some of them may be *Parabolbinella*.

*Falsipollex* is not rare in the Middle Devonian formations of the Great Lakes region, and at least eight species can be distinguished. In particular, *F. lativelatus*, *F. laxivelatus*, and *F. valgus* are common and have an extended range both stratigraphically and geographically.

*Falsipollex altituberculatus* Kesling and McMillan
Pl. 49, figs. 1–3
*Falsipollex altituberculatus* Kesling and McMillan, 1951, p. 68,69, pl. 3, figs. 1–3. [Bell Shale. Holotype UMMP 26636, male left valve.]

*Diagnosis.*—Female valve about 1.1 mm long. Female frill entire, reaching posteroventral part of valve and not followed by a spur, its junction with the ventral lobe marked by a shallow groove; frill covered with strongly developed papillae. Male spurs large, curved backward, apparently circular in cross section, covered with papillae. Valves of male and female slightly tapered posteriorly, with only gentle curvature of the posteroventral border. Papillae large and irregular in both size and spacing.

*Remarks.*—Specimens are rare and many are impregnated with pyrite crystals, which obscure details of ornamentation. Nevertheless, this, the type species of *Falsipollex*, can scarcely be confused with other species of the genus. The extension of papillae onto the spurs of the male is unique.

*Occurrence.*—Known only from the Bell Shale (few specimens) and Genshaw Formation (one specimen) of northern Michigan.

*Illustrated specimens.*—Holotype UMMP 26636 (Bell Shale, loc. 2). UMMP 65002 (Bell Shale, loc. 8), and 65027 (Genshaw Formation, loc. 4).

***Falsipollex ampliatus*** n. sp.
Pl. 50, figs. 16–21; pl. 54, figs. 6–18; pl. 58, figs. 1,2; pl. 70, fig. 1

*Derivatio nominis.*—From the Latin *ampliatus* ("made larger, wider"), referring to the very large anteroventral width of the frill.

*Description.*—Carapace of male about twice as long as high; female carapace about 1.6 mm long. Hinge line long and straight; anterior corner with small forwardly directed sharp projection and posterior corner with very small rounded projection directed posterodorsally. Valves quadrilobate, with L3 more or less bulbous, but better defined dorsally than ventrally; L2 anteriorly tending to blend with L1; L4 large and evenly convex; and ventral lobe long and confluent with L4 and L1. S2 deep and curved around posteroventral edge of L2. Valves rather robust, except for the delicate frill of the female, fairly wide.

Female valve with exceptional development of frill. Frill long, extending from anterior corner to rear border of L3, especially broad in anteroventral part. Frill very delicate and thin, but reinforced with anteroventral and posterior spurlike thickenings; anteroventral thickening tapered distally, curved with convex edge anterior, protruding slightly beyond rest of frill. Posterior spurlike termination of frill very thick and directed outward. Where well preserved, frill displaying denticulate edge;

KEY TO SPECIES OF *FALSIPOLLEX*

1. Carapace small for the genus, female valve slightly less than 1.0 mm long; papillae on lateral surface small and low; L3 very large and bulbous, in some specimens reaching diameter equal to one-third the length of the valve; L1 prominent and extending above the hinge line; L2 small but fairly distinct around most of its periphery; frill of female valve narrow ..... * *F. minimus*

   Carapace appreciably longer than 1.0 mm; papillae on lateral surface prominent; L3 never reaching diameter equal to one-third the length; L1 rarely extending above hinge line; L2 less well defined than the above, tending to be confluent (in at least part of its periphery) with L1; frill of female valve relatively wide ..... 2

2. Valve ornamented with papillae varying greatly in size, the largest sometimes described as tubercles, but some sharp-tipped; frill of female reinforced anteroventrally by spur-like thickening, projecting slightly beyond rest of frill; frill terminating near posteroventral spur but definitely separated from it; L1 and L2 with low relief, the latter scarcely defined ..... 3

   Valve ornamented with papillae equal or only slightly unequal in size and elevation, none approaching size that could be described as tubercles; frill of female in anteroventral region of equal thickness and without projecting tip; frill may or may not be separated from posteroventral spur; L1 and L2 with more relief and better definition than the above (although adjoined in part) ..... 4

3. Adult carapace about 1.2 mm long; frill immediately behind anteroventral thickening not appreciably wider than rest of frill ..... *F. simplilobatus*

   Adult carapace about 1.5 mm long; frill very broad at anteroventral thickening, tapering posteriorly ..... *F. ampliatus*

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* Additional specimens are needed to determine if those with exceptionally large and bulbous L3 should be recognized as a separate species — *F. bulbosus*.

denticles apparently marking internal tubules of frill. Male with two spurs in each valve, widely separated, the anteroventral one below L1 and the posterior one about aligned with rear edge of L3.

Valves ornamented with coarse and irregularly spaced papillae except for sulcus and frill, with coarsest papillae on major parts of lobes. Marginal ridge composed of papillae.

*Remarks.*—Like the smaller *Falsipollex simplilobatus*, this species has the surface studded with large papillae, the spurs of the male are distantly placed, and the frill of the female incorporates a spurlike anteroventral thickening and a posteroventral spur. Unlike *F. simplilobatus*, however, the new species has a much wider frill anteroventrally, its spurlike thickening there is more prominent and longer, and its L2 is slightly better defined.

The frills in both *F. ampliatus* and *F. simplilobatus* are much longer than those in most species of *Falsipollex*. Whether they actually incorporate the posterior spur in all specimens is questionable; the frill tapers posteriorly behind the anteroventral thickening, and, in some specimens which seem to be better preserved, appears to reach the spur, but in others it may almost reach the spur but be separated from it.

In specimens of female valves which are worn and do not preserve the full anteroventral width of the frill, *F. ampliatus* is distinctly larger than *F. simplilobatus*, being about 0.3 to 0.4 mm longer.

4. Female valve with frill shortened posteriorly and separated from a prominent posteroventral spur; papillae notably regular and very distinct ..... *F. valgus*

   Female valve with frill reaching posteroventral area, no posteroventral spur; papillae either lower and less pronounced than above, or somewhat irregular ..... 5

5. Carapace large, over 1.5 mm long (some female valves reaching 1.6 mm); frill wide and smooth to granulose, in contrast to papillose lateral surface; male valve elongate, exclusive of spurs having length about twice the height ..... *F. lativelatus*

   Carapace less than 1.5 mm long (but more than 1.1 mm); frill either narrow or ornamented with papillae; male valve not particularly elongate, exclusive of spurs seldom exceeding length/height ratio of 1.75 ..... 6

6. Carapace over 1.3 mm long, female valves commonly reaching 1.4 mm; male spurs very strongly flared outward (similar to those in *F. valgus*) ..... *F. laxivelatus*

   Carapace less than 1.3 mm long; male spurs not strongly flared out ..... 7

7. Valve posteriorly tapered (but not strongly), its posteroventral border only slightly curved; papillae somewhat irregular, particularly in spacing; male spurs slightly flared ..... *F. altituberculatus*

   Valve without much taper, its posteroventral border well rounded; papillae very regular in size and spacing; male spurs nearly vertical ..... *F. equipapillatus*

*Occurrence.*—Known only from the Kashong Shale of western New York.

*Types.*—Holotype UMMP 65032, female right valve (loc. 1). Paratypes 65030, 65033, 65034, and 65043 (loc. 1); and 65031 and 65037–65039 (loc. 3).

*Falsipollex equipapillatus* Kesling and Weiss
Pl. 49, figs. 4–8
*Falsipollex equipapillatus* Kesling and Weiss, 1953, pl. 44,45, pl. 1, figs. 1–13. [Norway Point Formation. Holotype UMMP 27327, female right valve.]
*F. equipapillatus* Bless and Jordan, 1971, p. 879.

*Diagnosis.*—Valve not much tapered posteriorly, its posteroventral border rounded. Male valve about 1.1 mm long. Lateral surface ornamented with papillae of equal size and very regular spacing. Frill of female valve very long, papillose, without posterior spur or anteroventral expansion or thickening; frill and adjoined L1 rounded above hinge line. Male spurs flat and distally expanded, papillose, directed nearly vertically. L3 a bulb less than one-third the length of the valve.

*Remarks.*—This species is intermediate in size between *F. minimus* and *F. altituberculatus* and such larger species as *F. lativelatus* and *F. laxivelatus*; it is about the same length as *F. valgus*.

The equal size of the papillae, the lack of posterior taper, and the flattened shape of the male spurs distinguish it from *F. altituberculatus*. The lack of a prominent posteroventral spur behind the female frill separates it from *F. valgus*.

*Occurrence.*—Norway Point Formation and (rare) Petoskey Formation of northern Michigan.

*Illustrated specimens.*—All from the Norway Point Formation at loc. 1. Holotype UMMP 27327. Paratypes 27329, 27335, and 27338.

*Falsipollex lativelatus* (Kesling and McMillan)
Pl. 58, figs. 3–16; pl. 70, figs. 8–16
*Hollinella lativelata* Kesling and McMillan 1951, p. 58–60, pl. 5, figs. 1–5. [Bell Shale. Holotype UMMP 26689, a complete male carapace].
*Hollinella* (*Keslingella*) *lativelata* Bless and Jordan, 1971, p. 883.

*H. (K.) lativelata* Bless and Jordan, 1972, p. 53.
*Falsipollex lativelatus* Kesling and Chilman, 1978, p. 60,61, pl. 21, figs. 14–22; pl. 22, figs. 8–19; pl. 23, figs. 1–10; pl. 25, figs. 10–16, and others.

*Diagnosis.*—Large, male valve over 1.5 mm long and female valve reaching 1.6 mm. Frill of female valve long, posteriorly ending in thickened spurlike structure, smooth to finely granulose, rather wide where completely preserved. Spurs of male smooth with anteroventral and posterior ones flared outward and distally expanded and flattened; unique small anterior spur in addition to normal two. L3 fairly small. Marginal ridge low, provided with row of small papillae. Papillae of lateral surface small and even.

*Remarks.*—This is the only known species of *Falsipollex* in which the male valve has an anterior spur in addition to the normal two. The valve in the male is elongate, exclusive of the spurs having a length about twice the height.

The species definitely belongs in *Falsipollex* rather than *Hollinella*. The adult male, of about the same length as the female, has spurs intead of a flared-outward frill and has no smooth antrum. It can be separated from *F. laxivelatus* by its greater elongation, larger valves, smooth frill in the female, and the even papillae of the marginal ridge.

*Occurrence.*—Silica Shale of Ohio and southern Michigan. Bell Shale, Ferron Point Formation, and (rare) Norway Point Formation of northern Michigan. Arkona Shale and Widder Formation of Ontario. Wanakah Shale and Kashong Shale of western New York.

*Illustrated specimens.*—Widder Formation: UMMP 65014–65017 (loc. 1); and 65018–65021 (loc. 4). Ferron Point Formation (loc. 3): 30760, 30764, and 30766. Silica Shale (loc. 1): 30762 and 30765.

### *Falsipollex laxivelatus* Kesling

Pl. 47, figs. 11–19; pl. 49, figs. 23–34; pl. 50, figs. 1–10; pl. 53, figs. 1–7; pl. 70, figs. 2–7; pl. 72, fig. 18

*Falsipollex laxivelatus* Kesling, 1952c, p. 51, pl. 2, figs. 1–9. [Ferron Point Formation. Holotype UMMP 28040, female carapace.]
*Hollinella senticosta* Kesling, 1953a, pl. 211,212, pl. 3, figs. 22,23.
*Falsipollex laxivelatus* Kesling and Chilman, 1978, p. 62, pl. 22, figs. 1–7; pl. 24, figs. 5–18; pl. 25, figs. 1–10; pl. 26, figs. 10–16, and others.

*Diagnosis.*—Adult carapace 1.3 to 1.4 mm long, with length/height seldom more than 1.5. Male with flattened spurs flared outward, papillose. Female frill wide, strongly incurved and posteriorly terminating in a thickening and with its distal tip pointing backward and acutely tapered, papillose. L3 large and bulbous, L2 small and vertically elongate, and L1 and adjoined frill dorsally rounded and protuberant above hinge line. Marginal ridge provided with spinelets, particularly long in anteroventral part in male valve.

*Remarks.*—This species can be distinguished from *F. lativelatus* by its smaller size, more compact valves, papillose frill in the female, lack of an anterior spur in the male valve, and coarser papillae on the lateral surface. The extreme development of curved spinelets on the anteroventral part of the marginal ridge, delicate and often broken, is unique among known *Falsipollex* species.

Its shape is reminiscent of *Falsipollex valgus*, but the male has somewhat coarser papillae and the frill of the female is not separated from a posteroventral spur.

The young of *F. laxivelatus* have more prominent and irregular papillae than the adult male. The marginal ridge in these juveniles bears papillae or low spinelets, which are even and not elongated in the anteroventral part.

*Occurrence.*—Silica Shale of Ohio and southern Michigan. Bell Shale, Ferron Point, and (rare) Norway Point Formation of northern Michigan. Arkona Shale, (?) Hungry Hollow Formation, and Widder Formation of Ontario.

*Illustrated specimens.*—All from the Ferron Point Formation at loc. 3. Holotype UMMP 28040. Paratypes 28041 and 28042. UMMP 30776-30778, 65003–65013, 65041, and 65042.

### *Falsipollex minimus* Kesling and Tabor

Pl. 47, figs. 1–10; pl. 49, figs. 9–22

*Falsipollex minimus* Kesling and Tabor, 1953, p. 92, pl. 2, figs. 5–10. [Genshaw Formation. Holotype UMMP 28069, male carapace.]
*? F. bulbosus* Kesling and Tabor, 1953, p. 93, pl. 2, figs. 11–17. [Genshaw Formation. Holotype UMMP 28075, male carapace.]

*Diagnosis.*—Carapace small for the genus; female valve slightly less than 1.0 mm long. Papillae small and low on lateral surface. L3 large and bulbous, variable in size, the largest with diameter exceeding one-third the length of the valve. L1 prominent and protruding above hinge line. L2 small. Frill of female valve narrow.

*Remarks.*—Without additional specimens, we find it impossible to define a clear distinction between *F. minimus* and *F. bulbosus*, both from the Genshaw Formation. Some specimens have a modest L3, about one-third the height of the valve, whereas others have an exceedingly large L3, exceeding half the height of the valve. We have noted some specimens with intermediate size of the L3, so that we herein include all the small *Falsipollex* in the one species. The male spurs, like those of *F. valgus*, are distally wide and flat, unlike the subconical spurs of such species as *F. ampliatus* and *F. lativelatus*.

*Occurrence.*—Genshaw Formation of northern Michigan.

*Illustrated specimens.*—All from loc. 6. Holotype UMMP 28069. Paratype 28070. UMMP 28075 (holotype of *F. bulbosus*). UMMP 64994–65001.

### *Falsipollex simplilobatus* Stover

Pl. 50, figs. 11–15; pl. 55, fig. 46; pl. 61, figs. 14–22; pl. 62, figs. 1–3

*Falsipollex simplilobatus* Stover, 1956, p. 1102,1103, pl. 12, figs. 1–3. [Windom Shale. Holotype NYSM 10833, male carapace.]

*F. simplilobatus* Bless and Jordan, 1971, p. 879.

*Diagnosis.*—Adult valve about 1.2 mm long. Lateral surface ornamented with irregular large papillae or tubercles, some sharp-tipped. Frill of female valve reinforced with anteroventral spurlike thickening and terminating in or nearby at a posteroventral spur, about the same width throughout and not exceptionally wide anteroventrally. L1 not much if any above hinge line, tending to fuse with L2. L3 not particularly large.

*Remarks.*—This species is a smaller version of *Falsipollex ampliatus* without the exaggerated expansion of the female frill anteroventrally and with a less conspicuous spurlike thickening anteroventrally. Both species appear to be characteristic of western New York, although *F. simplilobatus* has been found in the Ipperwash Limestone of Ontario.

*Occurrence.*—Wanakah Shale, Kashong Shale, and Windom Shale of western New York. Rare in Ipperwash Limestone of Ontario.

*Illustrated specimens.*—UMMP 65022–65026 (Wanakah Shale, loc. 6) and 65028 (Wanakah Shale, loc. 4); 64992 (Kashong Shale, loc. 2); 65029 (Windom Shale, loc. 1); and 64978 and 64979 (Ipperwash limestone, loc. 1).

### *Falsipollex valgus* Kesling

Pl. 47, figs. 20–32; pl. 53, figs. 11–19; pl. 54, figs. 1–5; pl. 70, figs. 17,18

*Falsipollex valgus* Kesling, 1952c, p. 52, pl. 2, figs. 19–26. [Ferron Point Formation. Holotype UMMP 28049, female right valve.]

*F. valgus* Kesling, 1953a, p. 212,213, pl. 3, figs. 24–28

*F. valgus* Kesling, 1954b, p. 18, pl. 2, fig. 24.

*Diagnosis.*—Adult male about 1.1 mm long. Valves rather short but with distinct swing. L3 very bulbous but not exceptionally large. Female with short frill, in most specimens terminating below L2 and in very few extending as far as L3, strongly incurved and nearly contacting the frill of the opposite valve in a closed carapace, its junction with the lateral surface marked only by a slightly depressed area, papillae continuous with those of lateral surface but distally decreasing in size; spur behind and aligned with frill, seldom joined to it in any way. Male with large, flat, distally expanded spurs, the anterior one very strongly flared outward. Marginal ridge of even papillae, somewhat larger than the adjacent ones of the ventral surface.

*Remarks.*—The separation of the short incurved frill from the posterior spur in the female is the outstanding character of this species. It further differs from *F. laxivelatus* in its smaller and more regularly spaced papillae. The flare of the anterior spurs in the male carapace is also outstanding.

A few specimens of this species preserve small patchs of what appears to be an exterior lamina outside the papillae. Kesling (1954b, p. 18) called attention to this feature, which is a reticulation of tiny punctae. Perhaps this and other species of *Falsipollex* actually had a thin fragile outer layer of shell, and the papillae seen in nearly all specimens are the supporting pillars, just as has been noted in *Ctenoloculina*.

*Occurrence.*—Silica Shale of Ohio and southern Michigan. Bell Shale, Ferron Point Formation, and (rare) Norway Point Formation of northern Michigan. Arkona Shale and Widder Formation of Ontario.

*Illustrated specimens.*—UMMP 30987, 64980–64984, and 65040 (Arkona Shale, loc. 2); 64987 (Arkona Shale, loc. 3); 64985 (Arkona Shale, loc. 4); 64986 and 64989–64991 (Arkona Shale, loc. 7); and 64988 (Norway Point Formation, loc. 1).

## Genus *Parabolbinella Adamczak* 1968

*Type species.*—By original designation, *Parabolbinella postaculeata* Adamczak, 1968, p. 53–55, pl. 4, fig. 2; pl. 15, figs. 1,3,4; pl. 16, fig. 2, pl. 17, figs. 1–3; pl. 21, fig. 4; text-figs. 15,37. [Skaly beds, Poland. Holotype GIO 1319 (Museum of the Institute of Geology of the University of Stockholm), female carapace.]

*Diagnosis.*—Lobation dominated by S2, with L1 and L2 essentially fused but L3 bulbous. Frill of female valve restricted to anterior half, separated from posteroventral to ventral spur. Male velar structures consisting of two smooth spurs, the anteroventral one the larger and wider.

*Remarks.*—Except for the restriction of the female frill, which may terminate below L2, this genus has essentially the features of *Falsipollex*. According to the original description (Adamczak, 1968, p. 55), the female narrow frill is flared outward and separated from the marginal structure by a smooth antrum.

We find no identifying character listed which would distinguish males of *Parabolbinella* from those of *Falsipollex*. Whereas we recognize the possibility that certain rather large male forms from samples which yield no female specimens may indeed belong in *Parabolbinella*, we have no proof that they do. Hence, for the present, we decline to classify them at all.

## Family Hollinellidae Bless and Jordan 1971

*Diagnosis.*—Dimorphism involving differential development of frill or velar ridge in male and female. Female

valve with frill narrower than that of male and slightly incurved only in anteroventral part, separated from marginal ridge by ornamented area of valve. Male valve with wider frill, not incurved and usually flared outward, separated from margin by a smooth antrum. Frill of both dimorphs usually reinforced by a spurlike thickening at posterior end.

### Genus *Adelphobolbina Stover* 1956

*Type species.*—*Ctenobolbina papillosa* Ulrich, 1891, pl. 186, pl. 15, figs. 8a–8e, by subsequent designation of Stover, 1956, p. 1103.

*Diagnosis.*—Carapace large and robust. L3 large and strongly inflated but not bulbous, dorsally forming a hump above the hinge line, posteriorly with distinct boundary, and ventrally confluent with ventral lobe. S2 long, its dorsal half deep and vertical, its ventral half shallow, curved anteroventrally, and fading out before reaching the frill. L1 and L2 completely fused to form a large pre-adductorial lobe. L4 low and rather narrow, crescent-shaped. Frills well developed in both dimorphs. Surface papillose, often coarsely so.

### *Adelphobolbina medialis* Stover

Pl. 16, figs. 1–8; pl. 17, figs. 1–9; pl. 18, figs. 1–12; pl. 19, figs. 1–9; pl. 20, figs. 9–12; pl. 63, figs. 5,6; pl. 67, figs. 5–7

*Ctenobolbina papillosa* Coryell and Malkin, 1936, p. 3, fig. 6; *non C. papillosa* Ulrich, 1891.

*Adelphobolbina medialis* Stover, 1956, p. 1104, 1105, pl. 112, figs.4–9. [Windom Shale. Holotype NYSM 10835, male carapace.]

*Diagnosis.*—Carapace large, female reaching 1.8 mm long. Surface, except for sulcus and frill, studded with rather coarse tubercles or large papillae, somewhat irregular in size and distribution. Anterior corner also ornamented. Frill of female valve rather wide but uniform in width, ventrally exposing ornamented area between it and margin. Frill of male valve especially wide anteriorly, separated from margin by deep concave and uniform smooth antrum.

*Remarks.*—This is the largest species of *Adelphobolbina* found in the Great Lakes region. It is readily distinguished from the somewhat smaller *A. trilobata* by its rather irregular ornamentation and its lack of a smooth "shoulder" area adjacent to the anterior corner.

*Occurrence.*—Centerfield Formation, Ledyard Shale, Wanakah Shale, Kashong Shale, and Windom Shale of western New York. Hungry Hollow Formation and (?) Widder Formation of Ontario. Not found in Michigan.

*Illustrated specimens.*—UMMP 58758 (Hungry Hollow Formation, loc. 1); 60130–60132, 60157–60160, 60162, and 60167 (Ledyard Shale, loc. 1); 60133 and 60163–60165 (Wanakah Shale, loc. 4); and 60166 (Kashong Shale, loc. 1).

### *Adelphobolbina megalia* (Kesling and Tabor)

Pl. 46, figs. 1–5

*Ctenobolbina megalia* Kesling and Tabor, 1952, p. 761,762, pl. 111, figs. 15–19. [Genshaw Formation. Holotype UMMP 27783, female carapace.]

*C. megalia* Kesling and Tabor, 1953, p. 87,88, pl. 3, figs. 18–25.

*Adelphobolbina megalia* Stover, 1956, p. 1104.

*A. megalia* Bless and Jordan, 1971, p. 884.

*Diagnosis.*—Lateral surface, except for sulcus and frill, ornamented with papillae of two distinct sizes, the larger very regularly distributed among the smaller. Female carapace about 1.1 mm long, rather narrow, its width less than half the length.

*Remarks.*—This is one of the smaller species of *Adelphobolbina*. It bears some resemblance to *A. trilobata* in having papillae of two distinct sizes, but it is appreciably smaller and lacks the smooth "shoulder" area of the latter. The regularity of its ornamentation serves to distinguish *A. megalia* from the irregular spinose ornament of *A. spicata*.

*Occurrence.*—Genshaw Formation and (?) Petoskey Formation of Michigan.

*Illustrated specimens.*—UMMP 30872 and 30873 (Genshaw Formation, loc. 5).

### *Adelphobolbina trilobata* Stewart

Pl. 20, figs. 1–4; pl. 46, figs. 6–14; pl. 53, figs. 8–10; pl. 72, fig. 23

*Ctenobolbina trilobata* Stewart, 1936, p. 749, pl. 100, figs. 25–27. [Silica Formation. Syntypes OSU 18181.]

*C. trilobata* Warthin, 1937, card 70, figs. 25–27.

*Ctenobolbina pinguis* Kesling and McMillan, 1951, p. 53,54, pl. 4, figs. 7,8.

*Adelphobolbina trilobata* Stover, 1956, p. 1104.

*A. trilobata* Kesling and Chilman, 1978, p. 66, pl. 1, figs. 2–12; pl. 2, figs. 2–12; pl. 3, figs. 2–12; pl. 4, figs. 1–4; pl. 38, figs. 8,9; and others.

*Diagnosis.*—Adults about 1.6 mm long. Surface of valve, except sulcus, frill, and "shoulder" adjacent to anterior corner ornamented with papillae of two sizes, the larger of an even size and elevation (about three times the diameter of the smaller) evenly distributed among the smaller. Frill of female valve narrow, unornamented, the two frills of carapace slightly convergent in anteroventral region.

*Remarks.*—This species is intermediate in size between the smaller *Adelphobolbina megalia* and the larger *A. medialis*. It is the only species to have a smooth, slightly elevated "shoulder" on L1, and this feature alone is sufficient to separate it from other known species of the genus.

*Occurrence.*—Bell Shale, Ferron Point Formation, and Genshaw Formation of Michigan. Silica Shale of

KEY TO SPECIES OF *ADELPHOBOLBINA*

1. Carapace large, 1.5 mm or longer ..... 2

   Carapace less than 1.5 mm long ..... 3

2. Surface (except S2, frill, and anterior corner) ornamented with papillae of two sizes, the larger of an even size and elevation (about three times the diameter of the smaller), scattered among the field of the smaller; anterior corner area nearly smooth or slightly granulose, somewhat elevated and forming a conspicuous "shoulder" on the valve; frill of female valve narrow; adult carapaces averaging about 1.6 mm long ..... *A. trilobata*

   Surface (except S2 and frill) ornamented with rather coarse tubercles or irregular large papillae; no smooth spot at anterior corner; frill of female valve rather wide, especially anteriorly; adult carapaces averaging about 1.8 mm long ..... *A. medialis*

3. Surface (except S2 and frill) ornamented with papillae of two sizes, the larger regularly scattered among the smaller; female carapace rather narrow, its width less than half the length ..... *A. megalia*

   Surface (except S2 and frill) ornamented with numerous large blunt spines, somewhat irregular in size, scattered among fine papillae; female carapace with width appreciably more than half (about 0.6) the length ..... *A. spicata*

Ohio and southern Michigan. Wanakah Shale of western New York. Arkona Shale and Widder Formation of Ontario.

*Illustrated specimens.*—UMMP 64776 (Widder Formation, loc. 1); 64781–64783, and 64823 (Ferron Point Formation, loc. 1); and 30865, 64780, and 64784 (Ferron Point, loc. 3).

*Adelphobolbina spicata* (Kesling and McMillan)

Pl. 20, figs. 5–8

*Ctenobolbina spicata* Kesling and McMillan, 1951, p. 52,53, pl. 4, figs. 1–6. [Bell Shale. Holotype UMMP 26640, male left valve.]

*Adelphobolbina spicata* Bless and Jordan, 1971, p. 884.

*A. spicata* Kesling and Chilman, 1978, p. 66, pl. 1, fig. 1; pl. 2, fig. 1; pl. 111, fig. 1.

*Diagnosis.*—Male valve about 1.2 mm long. Surface of valve, except sulcus and frill, ornamented with numerous large blunt spines, somewhat irregular in size, scattered among fine papillae and dominating the surface. Carapace width more than half the length.

*Remarks.*—The spinosity of the ornamentation readily identifies this species. It is one of the smaller species of the genus, much smaller than *Adelphobolbina medialis* or *A. trilobata.*

*Occurrence.*—Bell Shale of northern Michigan and the Silica Shale of Ohio and southeastern Michigan. Unknown in Ontario or western New York. Rare at all localities.

*Illustrated specimens.*—Both from the Bell Shale at loc. 2. UMMP 64778 and 64779.

Genus ***Bisphenella*** n. gen.

*Type species.*—Herein designated, *Bisphenella rana* Weiss n. sp.

*Derivatio nominis.*—From the Latin *bi-*("two") and the Greek *sphenos* ("wedge"), referring to the postero-ventral projections behind the S2 sulci in a complete carapace as viewed ventrally.

*Description.*—Carapace small in known species, less than 1.0 mm long. Valve distinctly quadrilobate in both dimorphs, with L3 bulbous and L2 fairly well defined. S2 very long and S-shaped, its dorsal half deep and its ventral half shallow, curved forward, down, and then slightly backward. Ventral lobe behind S2 extending outward to a posterior protuberant tip, sharply set off from posterior part of valve, sloping forward toward shallow end of S2.

Dimorphism in the form of fairly narrow frills in adults. Juveniles without any velar structures. Frill of female valve very narrow, extending almost straight

downward. Frill of male only slightly wider but flared outward. Frill of each dimorph located between protuberant ventral lobe and margin. Ornamentation of lateral surface small.

*Remarks.*—This new genus has the same general form of dimorphism as that found in *Hollinella*, but the peculiar lobation in the ventral half of the valve, the elongate sinuous S2, and the lack of any velar structures in the juvenile valve readily distinguish it. Juveniles, unlike those of late instars of *Flaccivelum*, have a long S2.

*Bisphenella deminuta* (Kesling and Tabor)

Pl. 60, figs. 26–31; pl. 61, figs. 4–6; pl. 72, figs. 10,11

*Winchellatia deminuta* Kesling and Tabor, 1953, p. 91,92, pl. 2, figs. 20–23. [Genshaw Formation, Holotype UMMP 28077, juvenile carapace.]

*Diagnosis.*—Anterior segment of ventral lobe low. L1 dorsally rounded, extending very little above the hinge line. Posteroventral border very gently rounded, giving valve decided swing. L3 horizontally elongate. Adults unknown.

*Remarks.*—This small species, insofar as juvenile specimens are concerned, is very rare. Only four specimens are known, which include no adults although the well-defined lobation would appear to indicate they are late instars. The horizontal elongation of the bulbous L3 is unlike the more spherical L3 of *Bisphenella rana* and we regard them as different species.

The ostracods described by Kesling and Tabor (1953, p. 90,91, pl. 2, figs. 24–29) as *Winchellatia deliquiata* are of uncertain affinities. They have a long and sinuous S2 reaching the ventral border and a ventral lobe tapering to a posterior rounded tip, but the L3 is very small and inconspicuous. Possibly they are juveniles of *Flaccivelum teleutaeum*, which occurs in the same strata; if so, the ontogeny of *F. teleutaeum* involves expansion of L3 and eradication of the ventral part of S2. One thing is certain—they are not *Bisphenella deminuta*.

*Occurrence.*—Known from the Genshaw Formation at loc. 6, in the shale known informally as the *Cyrtina umbonata alpenensis* zone, and from the Petoskey Formation.

*Illustrated specimens.*—Holotype UMMP 28077 (Genshaw Formation, loc. 6). Paratype 28078 (Genshaw Formation, loc. 6). UMMP 30930, 64819 and 64820 (Genshaw Formation, loc. 6); 64822 (Petoskey Formation, loc. 3).

*Bisphenella cf. B. deminuta* (Kesling and Tabor)

*Remarks.*—One specimen, UMMP 64822, from the Petoskey Formation at loc. 3 has an L3 smaller and less horizontally elongate and the ventral lobe behind S2 ends in a tubercle. Otherwise, it agrees with the types and other specimens of *B. deminuta*.

***Bisphenella rana*** Weiss n. sp.

Pl. 60, figs. 32–49; pl. 61, figs. 7–13

*Derivatio nominis.*—From the Latin *rana* ("frog"), referring to the superficial resemblance of the carapace in dorsal view to a squatting frog, with the protruding ventral lobes serving as the rear legs.

*Authorship.*—In his unpublished doctoral dissertation of 1954, Martin Weiss recognized this as a distinct species, although he assigned it to the genus *Hollinella*. We here credit him as author.

*Description.*—Carapace subpyriform to elongate oval in lateral view. Rather small, adult valves about 0.9 mm long. Hinge line long and straight, anterior and posterior borders subround, and posteroventral border gently curved. Well-preserved specimens with protruding small tubercle at posterior corner.

Quadrilobate. Each valve with L3 a sharply delineated bulb, spherical, about one-third the height of the valve. L1 a small inclined lobe extending slightly above hinge line, set parallel to anterodorsal border and separated from the anterior segment of the ventral lobe by a shallow groove. L2 a small well-defined node placed well below the hinge line and separated from ventral lobe by a narrow groove. L4 low and inconspicuous. Anterior segment of ventral lobe enlarged but not nodelike; posterior segment expanded posteriorly and rounded at its abrupt posterior termination, there declining sharply to the L4 at position below middle of L3. S2 dorsally confluent with S1 above L2, its dorsal half very wide and its ventral half shallower and directed anteroventrally to split the ventral lobe into segments.

Frill of male wider than that of female, each extending well behind L3. Frill of male concave but not sharply set off from lateral surface, set well out from the marginal ridge and separated from it by a shallow smooth antrum. Frill of female valve narrow and nearly vertical, set closer to the marginal ridge than that of male.

Marginal ridge very low. Surface, except for sulcus, ornamented with very low even papillae, producing a fine "pebble grained" texture.

*Remarks.*—Although small, this is a robust species, and most specimens are complete carapaces showing little if any distortion. The spherical shape of L3 distinguishes it from *Bisphenella deminuta* and the lack of a distinct node upon the anterior segment of the ventral lobe separates it from *B. nodosa*.

*Occurrence.*—Known only from the Gravel Point Formation of northern Michigan.

*Types.*—Holotype UMMP 30944, female carapace (loc. 10). Paratypes 30943, 30944 and 38876 (loc. 10); 38872 (loc. 3); and 64533–64562 (loc. 1).

KEY TO SPECIES OF *BISPHENELLA*

1. Anterior segment of ventral lobe bearing a distinct node anteroventral to L2; L1 strongly tapered and protuberant above hinge line at the anterodorsal corner ..... *B. nodosa*

   Anterior segment of ventral lobe low, without node; L1 extending only a little above the hinge line if at all ..... 2

2. Adults unknown, but specimens 0.8 mm long juvenile, without frills; L1 more or less a continuation of anterior segment of ventral lobe, dorsally about even with hinge line and rounded; posteroventral border very gently convex, giving valve decided swing; L3 horizontally elongate ..... *B. deminuta*

   Adult specimens, with dimorphic narrow frills, about 0.8 mm long; L1 low but distinct, extending above hinge line; posteroventral border rounded, valves with little swing; L3 evenly rounded, not notably elongate horizontally ..... *B. rana*

***Bisphenella nodosa*** n. sp.

Pl. 61, figs. 1-3

*Derivatio nominis.*—From the Latin *nodosus* ("provided with nodes, knobs, or knots"), referring to the small discrete tubercle upon the anterior segment of the ventral lobe as well as the nodelike L1, L2, and L3.

*Description.*—Adult female carapace about 0.9 mm long. Valves elongate, about twice as long as high, subelliptical with rounded ends, straight hinge line, and gently curved ventral border. Distinctly quadrilobate. L1 nodelike, extending well above hinge line, ventrally decreasing in height to merge with low inflation of anterior segment of ventral lobe. Anterior segment bearing a tubercle-like discrete node below shallow S1. L2 small, very discrete, outlined by shallow groove-like descent onto rest of valve. L3 a bulb extending well above the hinge line and separated from L2 by rather wide part of S2. L4 low and gently arched. S2 fairly shallow but wide in dorsal half; its ventral half still shallower and serving to separate the two segments of the ventral lobe but not sharply defined, located well forward from the dorsal part to give the sulcus a modified zig-zag shape. Prominent rear segment of ventral lobe expanding laterally from sulcus to abrupt termination below L3.

Female with modest frill in each valve, not clearly defined from lateral surface, and directed downward, separated from marginal ridge by narrow flat strip of venter. Frill extending from anterior corner well behind L3. Marginal ridge with spaced very low papillae. Surface ornamented with very fine and very low papillae, practically granulose.

*Remarks.*—As seen in dorsal and ventral views, the nodes on the anterior segment of the ventral lobes are acuminate and directed outward, and the wedge-shaped inflations of the posterior segment of the ventral lobe extend outward nearly as far as the L3 lobes. In addition, the nodelike development of L1 at the anterior corner and the isolated L2 emphasize the trivial term of the name.

*Occurrence.*—The holotype and only specimen is from the Petoskey Formation of northern Michigan at loc. 2.

*Type.*—Holotype UMMP 30942, a female carapace.

Genus *Flaccivelum* Kesling and Peterson 1958

*Type species.*—*Winchellatia teleutaea* Kesling and Tabor, 1952, p. 762, pl. 111, figs. 20-23, by subsequent designation of Kesling and Peterson, 1958, p. 139.

*Diagnosis.*—L3 large and inflated, dorsally forming hump above hinge line but ventrally blending into rest of valve. Lobation dominated by S2. L2 rather indistinct, practically fused with L1. Ventral lobe prominent, extending behind L3, rather abruptly terminating in rounded tip, not set off from frill in any way. Frill of female narrow, essentially a velar ridge, with slightly concave antrum; as viewed anteriorly, anterodorsal part of frill close to marginal ridge, angled with rest of frill flaring outward. Frill of male strongly convex, laterally continuous with lateral surface of valve, wide and in some specimens distally separated from the frill of the opposite valve by short interval in closed carapace.

*Remarks.*—The identification of male and female is questionable, inasmuch as the more incurved frill in most hollinids is that of the female. Juveniles have no frill at all,

nor even a velar ridge. They have the extended posterior part of the ventral lobe much like that of *Bisphenella*. The chief characteristic of *Flaccivelum* is the complete absence of demarcation between the lateral surface of the valve and the velar structure.

*Flaccivelum teleutaeum* (Kesling and Tabor)

Pl. 57, figs. 1–4; pl. 59, figs. 1–12; pl. 62, figs. 21–26; pl. 71, figs. 1–5

*Winchellatia teleutaea* Kesling and Tabor, 1952, p. 762, pl. 111, figs. 20–23. [Genshaw Formation. Holotype UMMP 27785, female right valve.]

*Winchellatia teleutaea* Kesling and Tabor, 1953, p. 90, pl. 2, figs. 30–35.

*? Winchellatia deliquiata* Kesling and Tabor, 1953, p. 90,91, pl. 2, figs. 24–29.

*Flaccivelum teleutaeum* Kesling and Peterson, 1958, p. 139.

*? F. deliquiatum* Kesling and Peterson, 1958, p. 139.

*F. teleutaeum* Bless and Jordan, 1971, p. 884.

*Diagnosis.*—Valve smooth to finely granulose. L2 rather poorly defined, without a ventral groove to mark its boundary.

*Remarks.*—The questionable species described by Kesling and Tabor (1953, p. 90,91) as *Winchellatia deliquiata* appears to be immature. It has a smaller L3 than those in late instars of *Flaccivelum teleutaeum* from the same strata, but it has a ventral continuation of S2 more like that in *Bisphenella*. The whole of the ontogeny in *Flaccivelum* is not known, so that we here include *deliquiatum* in the species *F. teleutaeum* with some question.

*Flaccivelum teleutaeum* is readily distinguished from *F. papillosum* by its poor ventral delineation of L2 and by its nearly smooth surface.

*Occurrence.*—Known only from northern Michigan in the Bell Shale, Genshaw Formation, Gravel Point Formation, and Petoskey Formation. Most specimens from the Genshaw Formation.

*Illustrated specimens.*—All from the Genshaw Formation at loc. 6. Holotype UMMP 27785. Paratype 27784. UMMP 28079–28081, 30925, 30932, 60257, 64821, 64830, 64965, and 64966.

***Flaccivelum papillosum*** n. sp.

Pl. 57, figs. 5–12; pl. 67, figs. 8–11; pl. 71, fig. 6

*Derivatio nominis.*—From the Latin *papilla* ("pimple, nipple") and *-osus* ("full of, replete with"), referring to the prominent ornamentation of papillae.

*Description.*—Valve of adult about 1.2 mm long, with length about half again the height. Valve subpyriform but not strongly tapered to posterior corner. Male valve with anterior border rounded with center of curvature near base of L2, anteroventral and ventral borders very evenly round with center of curvature in S2, posteroventral border gently convex, and posterior corner area acutely rounded. Female valve much more gently rounded ventrally.

L3 forming dorsal hump extending above the hinge line but ventrally blending into rest of valve. L2 poorly defined but with ventral end marked by shallow groove extending forward from S2, its anterior part confluent with L1. L4 low and gently convex. S2 fairly wide, dominating the dorsal half of the lobation. Ventral lobe confluent with L1 anterodorsally and with velar structure ventrally, definitely convex but not protruding at its distal edge, posteriorly terminanting abruptly in a distal, backward-directed tip; that of the male with a distinct constriction or upward offset near the end, producing a parallel-sided end section extending out over part of L4 and concealing the concave end of the lobe.

Velar structure fused with ventral lobe and L1, with no line of demarcation, bearing a distal smooth rim, and continuing to the end of the ventral lobe. Male valve with extensive incurved frill overhanging the free edge and separated from the marginal ridge by a smooth antrum (hidden in lateral view); as viewed ventrally, male frill well set off from anterior part of marginal ridge and continuing back parallel to it to a point near its posterior end, there with a sharp-angled offset onto the distal edge of the spurlike end section of the ventral lobe. Female valve with very narrow frill or velar ridge, anteriorly set close to marginal ridge, in anteroventral region flaring outward along distal edge of ventral lobe, without any offset near its posterior end, enclosing a papillose, posteriorly expanding section of flat venter. Juveniles with no velar structure whatsoever.

Surface, except for sulcus and distal rim of ventral lobe, ornamented with evenly distributed small papillae. Marginal ridge low.

*Remarks.*—This species has the general shape of *Flaccivelum teleutaeum* but is smaller and has distinctive papillose ornamentation. It could scarcely be confused with the smaller, very elongate, papillose *F. excertum*, with its flat-sided, strongly protuberant ventral lobe.

*Occurrence.*—Known only from the Bell Shale in northern Michigan.

*Types.*—Holotype UMMP 60254, female left valve (loc. 4). Paratypes 30965, 60252, and 60253 (loc. 4); and 60256 (loc. 8).

***Flaccivelum excertum*** n. sp.

Pl. 57, figs. 13–19; pl. 59, figs. 20–23

*Derivatio nominis.*—From the Latin *excertus* ("projecting, prominent, protruding"), referring to the exceptional lateral extent of the ventral lobe.

*Description.*—Presumed male valve only about 0.85 mm long. Valves very elongate, strongly tapered to posterior corner, with posteroventral border long and nearly straight. Anterior cardinal angle measured between hinge and free edge nearly a right angle; posterior

KEY TO SPECIES OF *FLACCIVELUM*

1. Adult valve less than 1.0 mm long, with length twice the height or more, very strongly acuminate to posterior corner, its posterior border long and almost straight, forming notably acute cardinal angle at rear corner; ventral lobe extremely protuberant, shaped like a triangular pyramid, its upper side flat and set at an angle to the dorsal half of the valve, its lower side flat and forming an elongate triangular venter bearing papillae, and its posterior end produced into a sharp tip separated from the L4 surface by a concavity; frill or velar ridge much abbreviated, confined to the anterior border and terminating below the poorly defined L2; L3 small, inconspicuous, not protruding much if any above the hinge line but dorsally slightly inflated ..... *F. excertum*

   Adult valve more than 1.0 mm long, with length considerably less than twice the height, not strongly acuminate posteriorly, its posterior border gently round; ventral lobe convex but not strongly protuberant, bearing the velar structure to its end; L3 rather large and forming a hump extending above the hinge line, fairly distinct except ventrally ..... 2

2. Female valve about 1.4 mm long; surface smooth to finely granulose; L2 poorly defined, without a ventral groove to mark its extent; posterior end not sharply set off from rest of ventral lobe, even in male valve ..... *F. teleutaeum*

   Female valve about 1.2 mm long; surface, except for sulcus and smooth narrow rim along distal edge of velar structure, covered with regularly distributed, distinct, small papillae; L2 tending to be defined ventrally by a shallow groove curving forward from base of S2; posterior end set off from rest of ventral lobe by constriction, leaving a parallel-sided end section in the male valve, more or less a confluent flattened spur ..... *F. papillosum*

cardinal angle very acute. Anterior border rounded, in the male confluent with the slightly less curved ventral border; ventral border terminating at rear tip of ventral lobe. Ventral lobe extremely protuberant, its dorsal half nearly flat and sloping sharply outward to the distal edge, its ventral side nearly flat and horizontal, bearing papillae; lobe having the shape of a triangular pyramid, its posterior end produced into a sharp tip extended out over and partly concealing in lateral view a concavity connecting it to L4. L1 more or less fused with L2, not inflated strongly and not above hinge line, evenly confluent with rest of anterior surface and, in some specimens, joining ventral lobe with an outward bend. L2 poorly defined but set at about midheight. L3 small, inconspicuous, not protruding much above hinge line if at all, ventrally undefined with posterocentral area continuing down to abrupt junction with protruding ventral lobe. L4 low, a slightly convex elongate triangle. S2 ending a little above middle of the valve, rather wide.

Velar structure very abbreviated, consisting of a narrow frill or sharp velar ridge curved around anterior end of valve and, in male valve, concealing the free border by its overhang; velar structure ending in anteroventral area, joined near (but not at) its end to a narrow rim along distal edge of ventral lobe. Narrow frill of female little more than a ridge, set alongside submarginal ridge and practically meeting it at the anteroventral corner (pl. 59, fig. 21); that of male more developed and definitely separated from submarginal ridge by a shallow antrum (pl. 59, fig. 23).

Surface evenly papillose, with all papillae of about equal size and prominence. Marginal ridge low, apparently without much ornament.

*Remarks.*—The strongly protuberant ventral lobe,

extending outward to the distal edge as an alate structure, combined with the greatly restricted velar structure, could be regarded as sufficient for the erection of a new genus. Herein, we are satisfied to place it in *Flaccivelum*, awaiting the discovery of additional forms with similar morphology. The specimens assigned here cannot be juveniles of the distinctly larger *F. papillosum* from the same formation, inasmuch as they display definite dimorphism and must be considered adults.

*Occurrence.*—Known only from the Bell Shale of northern Michigan.

*Types.*—Holotype UMMP 64815, a female left valve (loc. 8). Paratypes 60255 and 64816 (loc. 8); and 64817 and 64818 (loc. 4).

## Genus *Hollinella* Coryell 1928

*Type species.*—By original designation, *Hollinella dentata* Coryell, 1928, p. 377,378, pl. 51, fig. 1; emended by Kellett, 1929, p. 196–200.

*Diagnosis.*—S2 terminating near middle of valve. L3 developed as a clearly defined bulb. Long frill in both dimorphs; that of the female tending to be flared outward and separated from marginal ridge by a smooth antrum with parallel sides, and that of the male somewhat narrower, separated from the marginal ridge by a nearly flat papillose venter and convergent toward marginal ridge in anteroventral region, in some species slightly incurved. Frill rather thin, may show tubules. Surface papillose to finely granulose.

*Remarks.*—*Hollinella* is one of the common genera of Middle Devonian ostracods and ranges from Silurian to Permian, possibly (*fide* Bless and Jordan, 1971, p. 880) into lowermost Triassic. It contains many species, with a considerable range in adult size. Bless and Jordan separated it into three subgenera: *Hollinella*, *Praehollinella*, and *Keslingella*, based on the development of the velar structures in the juveniles.

### Subgenus *Keslingella* Bless and Jordan 1970

*Type species.*—*Hollinella pumila* Kesling, 1952c, p. 48,49, pl. 1, figs. 16–23, by subsequent designation of Bless and Jordan, 1970, p. 84.

*Diagnosis.*—Velar structures of juveniles consisting of two spurs in each valve. Adults with well-developed tubulous frills.

#### *Hollinella (Keslingella) acutilobata* Weiss

Pl. 29, figs. 1–21; pl. 30, figs. 1–11; pl. 71, figs. 17–20

*Hollinella kolmodini* (Jones), Kesling and McMillan, 1951, p. 55, pl. 1, fig. 10; *non Beyrichia kolmodini* Jones, 1890, p. 538, pl. 20, fig. 6; *non Hollina kolmodini* Ulrich and Bassler, 1908, p. 315, pl. 42, figs. 5–7; *non Hollinella kolmodini* Bassler and Kellett, 1934, p. 333.

*Hollinella acutilobata* Weiss *in* Melik, 1966, p. 224,225, pl. 22, figs. 1–8, 11–18.

*H. (Keslingella) acutilobata* Bless and Jordan, 1971, p. 882.

*H. (K.) acutilobata* Bless and Jordan, 1972, p. 46,47.

*Diagnosis.*—L2 set very low, at about the middle of the domicilium, completely isolated; three front lobes tending to bear vertical ridge or crest each, those of L1 and L3 particularly prominent. Frill of each dimorph distinctly set off from lateral surface by a groove, extending from anterior corner to position below L3, there suddenly decreasing in height and either separated from very prominent posteroventral spur or connected to it by only a faint ridge; spur evidently part of velar structure and aligned with frill. The female frill especially wide anteroventrally, incurved, separated from margin by a smooth antrum. Adult valve about 1.0 mm long.

*Remarks.*—The strong relief of lobes and the sharp vertical ridges on L1 and L3 readily separate this species of *Hollinella* from all others. Some show a vertical crest on L2 as well. The very low position of L2 further distinguishes it from *H. (K.) tendilobata*, *H. (K.) vegrandis*, *H. (K.) productilobata*, *H. (K.) pumila*, *H. (K.) bullata*, *H. (K.) ampulla*, *H. (K.) magnilobata*, *H. (K.) auroriradiata*, and *H. (K.) plauta.*

*Occurrence.*—Known only from the Bell Shale of northern Michigan.

*Illustrated specimens.*—Paratypes UMMP 30905 and 30907 (loc. 6). UMMP 64754–64762 (loc. 4); and 47593 and 47595 (loc. 6).

#### ***Hollinella (Keslingella) alpenensis*** Weiss n. sp.

Pl. 33, figs. 1–4

*Derivatio nominis.*—From the occurrence of the only known specimens in the Alpena Limestone in Alpena, Michigan.

*Authorship.*—In his unpublished doctoral dissertation of 1954, Martin Weiss recognized this as a distinct species. We here present his description (slightly modified) and credit him as author.

*Description.*—Carapace subelliptical in lateral view, sublanceolate in dorsal and ventral views. Hinge line straight. Anterior border round, posterior border subround, and ventral border a gentle curve. L1 wide, occupying about one-fourth the length of the valve from anterior border, ventrally confluent with ventral lobe. L2 vertically elongate. L3 a large bulb, extending very little above the hinge line, slightly compressed laterally and horizontally elongate. L4 a slight swelling at posterodorsal corner. S1 vertical, narrow, separating L1 and L2; dorsally confluent with S2 and occupying about half the height of the valve. S2 wider than S1, vertical in dorsal two-thirds, slanting anteroventrally in ventral one-third where confluent with sulcus ventral to L2, the latter thus completely isolated. Ventral lobe convex, confluent with L1 dorsally, about half the height of the valve below L2, its posterior half expanded upward to be separated from

KEY TO SPECIES OF *HOLLINELLA (KESLINGELLA)*

1. Adult carapace over 1.7 mm long ..... 2

   Adult carapace less than 1.7 mm long ..... 5

2. Surface papillose; shallow groove from S2 sulcus to frill ..... *H. (K.) ampla*

   Surface not papillose, granulose with or without larger papillae or tubercles; valve may or may not have groove between S2 and frill ..... 3

3. L2 prominent, completely isolated be S1, S2, and their connections; distinct groove extending from S2 forward and down below L2, reaching the frill; posterior margin with rather dense zone of tubercles, may be separated from L4 by shallow groove; surface granulose but with numerous scattered tubercles on ventral lobe and, in some specimens, on other lobes ..... *H. (K.) sella*

   L2 not prominent, joined to L1 or separated from it by at most a shallow groove; if present, groove below S2 very shallow; no posterior marginal zone of tubercles, not set off from L4; surface granulose, tubercles, if present, few and scattered ..... 4

4. L1 hemispherical, prominent, extending above hinge line; ventral lobe tending to connect ventral ends of L1, L2, and L3; no trace of any groove below S2; no tubercles on lateral surface of any kind ..... *H. (K.) tricollina*

   L1 low, not inflated; ventral lobe definitely separated from L3; at most, a very shallow, indistinct depression below S2; a few scattered tubercles may be present on L4 and posterior part of the ventral lobe ..... *H. (K.) magnambitata*

5. Valve strongly acuminate to posterior corner ..... 6

   Valve not acuminate, posterior end rounded ..... 7

6. Adult carapace about 1.25 mm long in Bell Shale specimens, reaching 1.45 mm in younger strata; numerous strongly developed tapered papillae or blunt spinelets scattered on lobes, especially on middle of ventral lobe ..... *H. (K.) devoniana*

   Adult carapace only about 1.0 mm long; no strongly developed papillae or spinelets on lobes ..... *H. (K.) epakra*

7. Adult carapace 1.4 to 1.7 mm long ..... 8

   Adult carapace less than 1.4 mm long ..... 11

8. Surface ornamented with numerous large papillae or blunt spinelets in addition to granules or fine papillae ..... 22

   Surface smooth to granulose, few or no large papillae or spinelets except, in some specimens, one atop L3 ..... 9

9. Valve elongate, length about twice the height; L3 not very well defined ventrally, tending to slope into ventral lobe .... *H. (K.) porrecta*

   Length/height rarely exceeding 1.7, never approaching 2.0; L3 clearly defined and separated from ventral lobe by semisulcus ..... 10

10. Valve very finely granulose, notably smooth and lacking conspicuous papillae or spinelets of any kind ..... *H. (K.) horologiina*

    Valve granulose and bearing in addition small but distinct papillae; some specimens with dorsal spinelet atop L3; extremely variable development of L3 ..... *H. (K.) antespinosa*

11. Adult carapace 1.2 to 1.4 mm long ..... 12

    Adult carapace less than 1.2 mm long ..... 14

12. Ventral lobe confluent with L1 and expanded below L3, terminating abruptly just behind L3; lobes with low relief; L3 wider than high, separated from ventral lobe by a narrow but deep horizontal groove, making it appear truncated ..... *H. (K.) alpenensis*

    Ventral lobe not expanded below L3 and not abruptly terminated; lobes with moderate to strong relief; L3 at least as high as wide, oval to circular in lateral view, not truncated below ..... 13

13. L2 tending to be completely separated from L1 and ventral lobe by a shallow groove; L3 extending little if any above hinge line; frill narrow; ventrally expanded end of S2 inclined very little if at all ..... *H. (K.) angustivelata*

    L2 tending to be incompletely separated from L1; L3 extending above hinge line; frill moderately broad; ventrally expanded end of S2 strongly inclined anteroventrally; similar to *H. (K.) antespinosa*, this species is consistently much smaller and appears to be distinct ..... *H. (K.) inclinisulcata*

14. No demarcation of frill from lateral surface of valve; large knoblike posteroventral process even with end of frill but apparently not connected to it; ventral lobe bearing irregular low nodose areas and distinct but shallow punctae .. *H. (K.) nodiventricula*

    Proximal limit of frill distinct; no large knoblike posteroventral process; no nodose areas or punctae on ventral lobe ..... 15

15. L2 set very low, near middle of domicilium, completely isolated from all other lobes; lobes tending to be crested or ridged, with a long vertical ridge on L1 and a shorter vertical ridge on L3; frill of female very broad at about middle of anterior border, gradually tapered above and below ..... *H. (K.) acutilobata*

    L2 with its center above the middle of the domicilium; lobes lacking crests or ridges; female frill not expanded anteriorly ..... 16

16. L3 broader than high, extending little if any above hinge line ..... 17

    L3 at least as high as broad, extending above hinge line ..... 18

17. Groove between L3 and ventral lobe nearly horizontal; lobes with rather low relief; expanded base of S2 nearly horizontal, not inclined anteroventrally ..... *H. (K.) tendilobata*

    Groove between L3 and ventral lobe strongly inclined anteroventrally to give L3 a peculiar tilted appearance; lobes with moderate relief; expanded base of S2 strongly inclined ..... *H. (K.) vegrandis*

18. Surface finely papillose (papillae spaced 0.02 mm or farther apart) with a few interspersed larger papillae; frill very narrow and sharply set off from lateral surface ..... 19

    Surface granulose (granules, if discernible, spaced much closer than 0.02 mm) with or without scattered papillae or small tubercles; frill bounded proximally by a shallow groove, making its precise junction with the lateral surface somewhat obscure ..... 20

19. Posterior corner rather rounded; greatest height median, approximately at front edge of L3; S2 narrow, not much expanded at ventral end, only about 5% of length between L2 and L3 ..... *H. (K.) productilobata*

    Posterior corner rather sharply angular; greatest height anterior, approximately through L2; S2 fairly wide and ventrally expanded, about 7% or more of length between L2 and L3 ..... *H. (K.) pumila*

20. Granulose surface with numerous scattered tapered papillae or small tubercles, even on L3 and alongside hinge line; valve elongate, nearly twice as long as high ..... *H. (K.) bullata*

    Granulose surface with few if any papillae, never with large papillae; length/height of valve rarely over 1.75 ..... 21

21. S2 fairly wide, its ventral end expanded below L2 and L3 and sloping anteroventrally; L2 fairly large, nearly half the area of L3 in lateral view ..... *H. (K.) ampulla*

    S2 relatively narrow, its ventral end not greatly enlarged; L2 smaller than in *H. (K.) ampulla*, about one-third the area of L3 in lateral view ..... *H. (K.) magnilobata*

22. Larger papillae high, irregularly distributed, many developed as blunt spinelets; valves not exceptionally elongate, length only about 1.5 times the height ..... *H. (K.) auroriradiata*

    Larger papillae rather low and only slightly above level of smaller papillae, fairly evenly dispersed among them, all papillae with rounded distal ends; valves elongate, length about twice the height ..... *H. (K.) plauta*

L3 by a very narrow groove, and terminated at a sharp, more or less vertical declivity behind L3.

Frill of female very narrow, separated from marginal ridge by a rather narrow antrum, extending along distal edge of ventral lobe nearly or quite to its end. Velar structure of male reduced to a very inconspicuous ridge.

Surface very finely granulose, practically smooth. Marginal ridge low. Dimensions of holotype: length 1.38 mm, and height 0.80 mm.

*Remarks.*—No other Middle Devonian *Hollinella* from the Great Lakes region has such narrow sulci outlining L2 and L3 nor such a smoothly convex and abruptly terminated ventral lobe. The posteriorly expanded ventral lobe separates this species from *H. (K.) angustivelata* and *H. (K.) inclinisulcata*, which are about the same size.

*Occurrence.*—Known only from a one-foot shale layer near the middle of the Alpena Limestone. This unit was well exposed when the quarry was operated by the Michigan Alkali Company, which practised selective quarrying. Later it passed into ownership of the Huron Portland Cement Company, and the entire face of the formation is now blasted at once; presently, even scraps of the shale unit cannot be identified in the rubble with certainty. Quarry located on east edge of Alpena, exposing strata between the uppermost Genshaw Formation and the Dock Street Clay Member of the Four Mile Dam Formation, W1/2 sec 13, T31N, R8E, Alpena

County Michigan.

*Types.*—Holotype UMMP 30883, male left valve. Paratype 30884, female left valve.

*Hollinella (Keslingella) ampla* Kesling and Weiss

Pl. 45, fig. 13; pl. 71, figs. 13,14

*Hollinella ampla* Kesling and Weiss, 1953, p. 38,39, pl. 2, fig. 27. [Norway Point Formation. Holotype UMMP 27355, male left valve.]

*H. (Keslingella) ampla* Bless and Jordan, 1971. p. 882.

*Diagnosis.*—Adult carapace long, over 1.7 mm. Surface papillose in even pattern over valve, except on sulcus and frill. L3 knoblike rather than bulblike; L2 low but rather well defined except ventrally. Valve rather high, with length not more than half again the height. S2 relatively shallow, with groove leading from it to the frill and dividing extensive ventral lobe into two parts.

*Remarks.*—Although only few specimens are known, we have no doubt that this exceptionally large species is distinct. Only *Hollinella (K.) sella*, *H. (K.) tricollina*, and *H. (K.) magnambitata* are about its size, and they have a basic granulose ornamentation, with a few scattered tubercles in all but *H. (K.) tricollina*.

The female has a very wide frill ending at the rear edge of L3 in a thickened spurlike thickening. The frill of the male is only slightly narrower where completely preserved, and is not strongly convergent toward the marginal ridge anteroventrally.

*Occurrence.*—Found only in the Norway Point Formation at loc. 1 and (two specimens) in the Gravel Point Formation at loc. 9.

*Illustrated specimen.*—Holotype 27355 (Norway Point Formation).

*Hollinella (Keslingella) ampulla* Stover

*Hollinella ampulla* Stover, 1956, p. 1101,1102, pl. 111, fig. 12. [Windom Shale. Holotype NYSM 10825, a female left valve.]

*H. (Keslingella) ampulla* Bless and Jordan, 1971, p. 882.

52H. (*Keslingella*) *ampulla* Bless and Jordan, 1972, p. 47.

*Diagnosis.*—Male valve about 1.1 mm long and 0.7 mm high. Surface granulose with few if any papillae, never with large papillae. S2 fairly wide, its ventral end expanded below L2 and L3, the expansions sloping anteroventrally. L2 large, nearly half the size of L3, elliptical, elongate vertically, set near middle of domicilium. Frill long, extending behind L3, not strongly thickened at its posterior end.

*Remarks.*—Bless and Jordan (1972) believe that this species is synonymous with *H. (K.) epakra* Stover, also from the Windom Shale. We prefer to recognize them as separate species, with the latter distinguished by its smaller and more circular L2, less inclination of its ventral extensions of S2, and more acuminate posterior end.

*Occurrence.*—Windom Shale. Our samples of this formation have yielded no specimens of this species, and we base our diagnosis on the types described and illustrated by Stover.

*Hollinella (Keslingella) angustivelata* Weiss n. sp.

Pl. 33, figs. 13–21

*Derivatio nominis.*—From the Latin *angustus* ("narrow") and *velum* ("curtain, frill"), referring to the rather narrow frill in both dimorphs.

*Authorship.*—In his unpublished doctoral dissertation in 1954, Martin Weiss recognized this as a distinct species. We here present his description (slightly modified) and credit him as author.

*Description.*—Carapace elongate, subelliptical. Dorsal border straight, anterior border acutely round, posterior border subround, ventral border gently curved, almost straight in the center. S2 deep, extending from dorsal border to below middle of valve, below L2 and L3. S1 narrow, shallow, dorsally confluent with S2. L1 low, gently arched, large. L1 and L4 confluent with the ventral lobe, forming a U-shaped continuous raised surface, becoming lower posteriorly and sloping gently to the free border. L3 a large bulb, extending slightly above the hinge line, somewhat horizontally compressed.

Frill narrow, extending more than three-fourths of the distance around the free border from the anterior corner. Frill of male valve slightly convergent toward the margin anteroventrally; that of female about the same width but subparallel to marginal ridge and separated from it by a rather narrow antrum.

Surface granulose except for smoother sulci and frill. Marginal structure low and papillose. Measurements of holotype, a female carapace: length 1.23 mm; height 0.63 mm; and width 0.65 mm.

*Remarks.*—As in *Hollinella (K.) alpenensis*, the L2 is very well defined around its entire periphery, but *H. (K.) angustivelata* lacks the posterior expansion and abrupt termination of the ventral lobe. It is readily distinguished from *H. (K.) inclinisulcata* by the U-shaped continuation of the sulcus around the ventral end of L2 and by the much narrower frill. This species is larger than *H. (K.) acutilobata* and *H. (K.) vegrandis*.

*Occurrence.*—Known only from northern Michigan in the Gravel Point Formation and in the basal Rockport Quarry Limestone or the uppermost Bell Shale.

*Types.*—Holotype UMMP 64777, a male carapace (Gravel Point Formation, loc. 1). Paratypes 64773–64776 (Gravel Point Formation, loc. 1). Illustrated specimen 30918, thought to belong to this species (uppermost Bell Shale or basal Rockport Quarry Limestone, loc. 3).

*Hollinella (Keslingella) antespinosa* (Ulrich)

Pl. 34, figs. 11–20; pl. 35, figs. 1–12; pl. 67, fig. 4

*Ctenobolbina (? Bollia) antespinosa* Ulrich, 1891, p. 187, pl. 15, figs. 9a-c.

*Hollina antespinosa* Ulrich and Bassler, 1908, p. 315.

*H. antispinosa* [*sic*!] Grabau and Shimer, 1910, p. 367, figs. 1660y-y".

*Hollinella antispinosa* [*sic*!] Kellett, 1929, p. 200.

*H. hamiltonensis* [*pars*] Warthin, 1937, card 74, figs. 9a-c.

*H. subcircularis* Turner, 1939, p. 17, pl. 1, fig. 20.

*H. amplilobata* Kesling and Tabor, 1953, p. 84, pl. 1, figs. 9–17.

*H. cuspibulbata* Kesling and Tabor, 1953, p. 85,86, pl. 2, figs. 1–4.

*H. antespinosa* Kesling and Peterson, 1958, p. 141,142, pl. 2, figs. 39–42.

*H. subcircularis* Stumm and Wright, 1958, p. 123.

*H. antri* Adamczak, 1968, p. 58,59, figs. 16,39A, 40; pl. 17, figs. 4,5; pl. 18, figs. 4,5.

*H. antespinosa* Bless and Jordan, 1971, p. 882.

*H. (Keslingella) antespinosa* Bless and Jordan, 1972, p. 47–49, pl. 18, fig. 2.

*Diagnosis.*—Adults about 1.5 mm to 1.6 long. Posterior end rounded, not acuminate. Valve with length/height ratio about 1.7, always much less than 2.0. L3 clearly defined and separated from ventral lobe by a semisulcus, in some populations bearing a dorsal tip or spinelet, very variable in shape. Lateral surface, except for sulci and frill, granulose but bearing additional distinct papillae, their number and concentraion varying according to population.

*Remarks.*—Of all species of *Hollinella* (*Keslingella*), this is undoubtedly the one with greatest variation. We have here followed the synonymy of Bless and Jordan (1972), and still contain some anxiety about the identity of all species here included. Unlike most species of Middle Devonian age, this one has a long stratigraphic record and wide geographic range. According to Bless and Jordan (1972), the species described as *Hollinella antri* by Adamczak (1968), from the Skaly beds in the Holy Cross Mountains of Poland, should be assigned to this species; whereas it is somewhat more papillose than most, we would agree that it is conspecific with the North American species. This would make a correlative tie of the Skaly beds with the Hamilton and Traverse Groups of the Great Lakes region.

*Occurrence.*—All formations of the Great Lakes region except the Ipperwash Formation of Ontario and the Potter Farm Formation of Michigan.

*Illustrated specimens.*—UMMP 64771 and 64772 (Centerfield Formation, loc. 2); 64787 and 64788 (Genshaw Formation, loc. 6); 64789 (Gravel Point Formation, loc. 1); 64790 (Norway Point Formation, loc. 1); 64791–64793 (Widder Formation, loc. 1); 64794 and 64795 (Petoskey Formation, loc. 3); and 64796 (Ledyard Shale, loc. 1).

*Hollinella (Keslingella) auroriradiata* Kesling and McMillan

Pl. 63, figs. 1–4; pl. 67, figs. 1–3

*Hollinella auroriradiata* Kesling and McMillan, 1951, p. 56,57, pl. 6, figs. 3,4. [Bell Shale. Holotype UMMP 26647, a presumed male left valve.]

*H. (Keslingella) auroriradiata* Bless and Jordan, 1971, p. 882.

*H. (Keslingella) auroriradiata* Bless and Jordan, 1972, p, 49.

*Diagnosis.*—Adult valve about 1.3 mm long. Posterior end rounded, not acuminate. L3 knoblike rather than bulbous. S2 fairly wide and shallow, anteroventrally curved around base of L2. Surface granulose to finely papillose with scattered larger papillae, the latter high and irregularly distributed, many developed as blunt spinelets; dorsal border tending to have small, low spinelet in anterior half and others behind S2 and at the corners. Length not more than half again the height. Frill wide, showing traces of tubules.

*Remarks.*—The dimorphism is difficult to ascertain in this species. The presumed female has a very wide but incurved frill partly concealing a smooth antrum. The presumed male has a slightly narrower frill, flared slightly outward, but not convergent anteroventrally toward the margin. The occurrence of low spinelets along the dorsal border is unusual in the genus. The species is less elongate than *H.* (*K.*) *plauta* and has higher large papillae or spinelets.

*Occurrence.*—Known only from northern Michigan. Not many specimens found, most in the Bell Shale, but a few (some of them broken) in the Ferron Point, Genshaw, Norway Point, Potter Farm, Gravel Point, and Petoskey formations.

*Illustrated specimens.*—Holotype UMMP 26647 (Bell Shale, loc. 2). Paratype 26716 (Bell Shale, loc. 2). UMMP 64785 (Bell Shale, loc. 4); and 64786 (Petoskey Formation, loc. 3).

*Hollinella (Keslingella) bullata* Kesling and McMillan

Pl. 31, figs. 11–13

*Hollinella bullata* Kesling and McMillan, 1951, p. 58, pl. 1, figs. 8,9. [Bell Shale. Holotype UMMP 26725, male right valve.]

*H. (Keslingella) auroriradiata* [*pars*] Bless and Jordan, 1972, p. 49.

*Diagnosis.*—Male valve about 0.9 mm long, elongate with length/ height ratio at least 2. L3 relatively small for genus, extending very little above hinge line. L2 nearly fused with L1, vertically elongate. S2 particularly wide, its ventral end curved anteroventrally below L2. L1 low and inconspicuous. Surface granulose with scattered tapered papillae or small tubercles, with high tapered papillae on L3 and along dorsal border. Frill long, extending behind L3, ending in a strong spinelike thickening directed slightly outward.

*Remarks.*—This species, which Bless and Jordan (1972) made synonymous with *H.* (*K.*) *auroriradiata*, is smaller and more elongate than the latter. It also has a much wider S2 and a narrower frill. Its large tapered papillae or blunt spinelets serve to separate it from *H.* (*K.*) *ampulla* and *H.* (*K.*) *magnilobata.*

*Occurrence.*—Known only from the Bell Shale of northern Michigan.

*Illustrated specimens.*—Holotype UMMP 26725 (loc. 2). Paratype 26726 (loc. 2). UMMP 47578 (loc. 4).

### *Hollinella (Keslingella) devoniana* Van Pelt

Pl. 28, figs. 1–12; pl. 30, figs. 12–21

*Hollinella devoniana* Van Pelt, 1933, p. 327, pl. 39, figs. 33–36.

*H. devoniana* Warthin, 1937, card 73, figs. 33–36.

*Hollinella devoniana* Kesling, 1954, p. 17, pl. 2, figs. 13–16.

*H. devoniana* Melik, 1966, p. 222,223, pl. 2, figs. 1–6; pl. 9, figs. 15–21; pl. 10, figs. 1–20; pl. 11, figs. 1–8; pl. 20, figs. 1–8, 10–15.

*H.* (*Keslingella*) *devoniana* Bless and Jordan, 1971, p. 882.

*H.* (*K.*) *devoniana* Bless and Jordan, 1972, p. 50,51, pl. 18, figs. 3,5–8.

*Diagnosis.*—Valve elongate, very strongly tapered posteriorly to rear corner. Adult valve from about 1.25 mm to 1.45 mm long, according to population. L3 inflated but not bulbous, extending only slightly above hinge line. L1 a slanting lobe at the anterior corner, not fully confluent with rest of lateral surface. L2 vertically elongate, anteroventrally joined to ventral lobe but distinct around rest of perimeter. Ventral lobe not strongly inflated, posteriorly meeting base of L3 along shallow groove and ventrally meeting frill along long shallow groove, without distinct boundary. L4 very long with nearly straight posteroventral border. S2 dorsally wide and confluent with S1, deep, terminating at midheight against ventral lobe. Surface granulose with scattered high subconical papillae variously concentrated on the ventral lobe, L2, and L3; papillae varying in same population from very few to numerous, rarely on L4. Frill poorly defined proximally, wide and slightly incurved in female and very narrow in male. Marginal ridge bearing pointed papillae or spinelets in anteroventral section.

*Remarks.*—The exaggerated swing of the valve and the lobation and associated large papillae are distinctive. Unlike most other species of the subgenus, the frill gradually decreases posteriorly below L3 rather than terminating with a prominent protuberant spurlike thickening. The species most closely resembling *H.* (*K.*) *devoniana* is *H.* (*K.*) *epakra*, which differs in its smaller size, lack of papillae, and less elongate L2.

*Occurrence.*—Bell Shale of Michigan and (rare) Wanakah Shale of western New York.

*Illustrated specimens.*—All from the Bell Shale in Calcite Quarry of Michigan Limestone Division of United States Steel Corporation near Rogers City, Michigan. UMMP 31027, 31203, 31205, and 31210–31213 (loc. 2); 47586 and 47587 (loc. 6); and 64797–64801 (loc. 4).

### *Hollinella (Keslingella) epakra* Stover

*Hollinella epakra* Stover, 1956, p. 1100, 1101, pl. 111, figs. 9–11.

[Windom Shale. Holotype NYSM 10823, male right valve.]

*H.* (*Keslingella*) *ampulla* [*pars*] Bless and Jordan, 1972, p. 47; *non Hollinella ampulla* Stover, 1956, p. 1101,1102.

*Diagnosis.*—Valve elongate, rather strongly tapered to posterior corner with long posteroventral border below L4. L3 bulbous and L2 well defined with S2 and S1 practically joined at midheight below it. Ventral extensions from S2, below adjacent lobes, inclined. Frill separated from lateral surface along groove, its proximal boundary indistinct in lateral view. Adult valve little more than 1.0 mm long.

*Remarks.*—This species differs from *H.* (*K.*) *devoniana* in its slightly smaller size, less elongation and higher placement of L2, and lack of protuberant large papillae. Its L3 is also better defined ventrally.

Whereas Bless and Jordan (1972) regarded this species as a synonym of *H.* (*K.*) *ampulla* from the same formation, we note differences. The latter species has a much more elongate L2, more inclined extensions of S2 below adjacent lobes, and much less swing with the posteroventral border more rounded. Its length/height ratio is also less than that of *H.* (*K.*) *epakra.*

*Occurrence.*—Known only from the types described from the Windom Shale in western New York. Our samples of this and other formations have yielded no specimens which could be assigned to the species.

### *Hollinella (Keslingella) horologiina* Weiss

Pl. 64, figs. 15–21; pl. 72, figs. 19–22

*Hollinella horologiina* Weiss *in* Melik, 1966, p. 219,220, pl. 3, figs. 15,16; pl. 11, figs. 9–22, 35,36; pl. 19, figs. 1–4; pl. 21, figs. 10,11. [Gravel Point Formation. Holotype UMMP 30922, male left valve.]

*H.* (*Keslingella*) *horologiina* Bless and Jordan, 1971, p. 883.

*H.* (*K.*) *horologiina* Bless and Jordan, 1972, p. 52.

*Diagnosis.*—Valve with length/height about 1.7, never approaching 2.0. L3 bulbous but not extending above hinge line, large, its diameter exceeding half the height of the domicilium, separated from ventral lobe by a semisulcus. S2 deep and conspicuous, dorsally expanded above L2 and ventrally below L2 and L3, making an hour-glass shape. Frill long, extending far behind L3, ending in spinelike thickening. Valve very finely granulose, practically smooth, never bearing papillae.

*Remarks.*—Although distinctive by its fine ornament and sulcation, this species is known from few specimens. It is most similar to *H.* (*K.*) *antespinosa*, although the latter has some papillae and stronger expression of L3.

*Occurrence.*—Gravel Point Formation and (rare) Potter Farm Formation of Michigan. Unknown in Ontario and western New York.

*Illustrated specimens.*—All from the Gravel Point Formation of Michigan. Holotype UMMP 30922 ("Upper Blue Shale" unit, loc. 9). Paratypes UMMP 30919, 30920, 30923, 30933, and 38850 ("Upper Blue Shale" unit, loc. 9). UMMP 47580 and 47581 ("Lower Blue Shale" unit, loc. 1).

*Hollinella (Keslingella) inclinisulcata* Kesling and Weiss

Pl. 31, figs. 1–10; pl. 72, fig. 17

*Hollinella inclinisulcata* Kesling and Weiss, 1953, p. 40,41, pl. 2, figs. 5–8. [Norway Point Formation. Holotype UMMP 27357, male left valve.]

*H.* (*Keslingella*) *antespinosa* [*pars*] Bless and Jordan, 1972, p. 47,48; *non H.* (*K.*) *antespinosa* Ulrich, 1891, p. 187.

*Diagnosis.*—Lobes with moderate to strong relief, with L3 nearly circular in outline and extending above hinge line. Ventral lobe not terminated abruptly. L2 partly fused with L1. Ventrally expanded end of S2 strongly inclined anteroventrally. Frill moderately broad, with moderate thickening at its posterior end; that of male more sharply set off from ventral lobe and much narrower than that of female.

*Remarks.*—Bless and Jordan (1972) made this a synonymn of *H.* (*K.*) *antespinosa*, but in our view this species is consistently smaller and has a distinctive combination of lobation and sulcation. Its inclined ventral extension of S2 is like that of *Hollinella amplilobata* erected in 1953 by Kesling and Tabor and here included in *H.* (*K.*) *antespinosoa*; but *amplilobata* has a much larger L3, which bears a dorsal papilla or tip, and adult valves are larger than those of *H.* (*K.*) *inclinisulcata*. This species has lobation similar to that of *H.* (*K.*) *plauta*, but the latter is larger, more elongate, and has an ornamentation of distinct small papillae forming a background for the slightly larger ones.

*Occurrence.*—Norway Point Formation and (rare) Petoskey Formation of northern Michigan.

*Illustrated specimens.*—Holotype UMMP 27357 (Norway Point, loc. 1). Paratypes 27356, 23758, and 27362 (Norway Point, loc. 1). UMMP 30856 and 30940 (Petoskey, loc. 1); and 30941 (Petoskey, loc. 2).

***Hollinella (Keslingella) magnambitata*** Weiss n. sp.

Pl. 31, figs. 14–17; pl. 33, figs. 5–7

*Derivatio nominis.*—From the Latin *magnus* ("large") and *ambitus* ("periphery, distance around"), referring to the large size of the carapace.

*Authorship.*—In his unpublished doctoral dissertation of 1954, Martin Weiss recognized this as a distinct species. We here present his description (slightly modified) and credit him as author.

*Description.*—Adult valve large, 1.8 to 1.9 mm long, subelliptical. Dorsal border straight, anterior and posterior borders curved, and ventral border gently round. L1 low, broad, extending about three-fourths the height of the valve. L2 low, vertically elongate, separated from L1 by a very shallow S1. L3 a prominent hemispherical bulb, sharply delineated, extending above hinge line only by a dorsal blunt, short spine. L4 low, sloping gently to ventral lobe. S2 a large deep depression in the dorsocentral part of valve, extending about three-fifths the height of the valve; the ventral part of S2 expanded laterally below adjacent lobes, the anteroventral extension sloping below L2. S3 a shallow depression, vertically elongate.

Frill long in each dimorph, extending far behind L3, with a long groove marking its junction with the domicilium. Frill of female fairly wide, separated from marginal ridge by a parallel-sided smooth antrum, weakly convex with its distal edge nearly vertical. Frill of male slightly narrower, without deep antrum, not strongly convergent toward marginal ridge anteroventrally. Frill end thickened, protuberant.

Surface finely granulose with a few scattered low papillae. Marginal ridge with tubercles.

*Remarks.*—This is the largest species we know of *Hollinella* (*Keslingella*), slightly exceeding *H.* (*K.*) *sella*. It differs from *H.* (*K.*) *ampla* in lacking a basic papillose ornamentation and in having no ventral extension of S2 through the ventral lobe; it is also more elongate. It differs from *H.* (*K.*) *sella* in having a less well defined and lower L2 and a more restricted S2, which does not cross the ventral lobe even as a shallow groove. It is unlike the species described as *Hollinella tricollina* (Ulrich) by Stover (1956) in being more elongate, with a less inflated L1, a ventral lobe which does not turn upward to the base of L3, and a narrower frill.

*Occurrence.*—Known only from the Petoskey Formation of northern Michigan at loc. 2.

*Types.*—Holotype UMMP 30915, a female carapace. Paratypes 30913, 30914, and 30989.

*Hollinella (Keslingella) magnilobata* Kesling and McMillan

Pl. 34, figs. 1,2

*Hollinella magnilobata* Kesling and McMillan, 1951, p. 60,61, pl. 1, figs. 11–13. [Bell Shale. Holotype UMMP 26644, female left valve.]

*H.* (*Keslingella*) *auroriradiata* [*pars*] Bless and Jordan, 1972, p. 49.

*Diagnosis.*—Adult valve about 0.8 to 0.9 mm long. S2 relatively narrow, its ventral end not much expanded. L2 centered above middle of domicilium, about one-third the

area of L3 in lateral view, confluent with ventral lobe only anteroventrally if at all. L3 nearly spherical, only very slightly wider than high. Ventral lobe with very shallow depression below S2. Frill long, bounded proximally by shallow groove and without distinct line of junction with domicilium, its posterior end not much thickened. Surface granulose to very finely papillose, without larger papillae.

*Remarks.*—Whereas Bless and Jordan (1972) placed this species in synonymy with *H.* (*K.*) *auroriradiata*, we find that the latter differs in its larger size (adult valve about 1.3 mm long), large conspicuous papillae scattered on lateral surface, and a strong protuberant spinelike thickening of the frill end.

The species is probably more like *H.* (*K.*) *ampulla* than any other hollinellid in the Great Lakes region. However, the New York state *H.* (*K.*) *ampulla* has a significantly wider S2 and a larger L2 that is more elongate and placed lower on the domicilium.

*Occurrence.*—Known only from the Bell Shale of northern Michigan.

*Illustrated specimens.*—Both from Loc. 2. Holotype UMMP 26644. Paratype 26645.

*Hollinella (Keslingella) nodiventriculata* Weiss

*Hollinella nodiventriculata* Weiss *in* Melik, 1966, p. 220–222, pl. 2, figs. 10–12; pl. 11, figs. 23–30; pl. 18, figs. 7,8; pl. 19, fig. 13. [Gravel Point Formation. Holotype UMMP 30908, female left valve.]

*H.* (*Keslingella*) *nodiventriculata* Bless and Jordan, 1972, p. 53.

*Diagnosis.*—Adult valve about 1.0 to 1.1 mm long, oval to subpyriform in lateral view. L3 developed as a prominent bulb. L2 set near middle of domicilium, narrowly connected to ventral lobe anteroventrally. L1 and ventral lobe confluent, rounded, overhanging frill and antrum of male and bearing a narrow ventral crest; ventral lobe reaching greatest prominence near or at posterior end of frill. L4 an elongate lobe along posterior border.

*Remarks.*—Bless and Jordan (1972) correctly compared this species with those of *Flaccivelum*, in which the frill is continuous with the lateral surface. We here believe that the lobation is that of a *Hollinella*, with the L3 having a distinct ventral border, rather than that of a *Flaccivelum*, with the base of L3 confluent with the lateral surface of the valve. In any case, the combination of a bulbous L3 and a ventral lobe combined with the frill and overhanging the antrum of the male is unique.

*Hollinella (Keslingella) nodiventriculata nodiventriculata* Weiss

Pl. 34, fig. 10; pl. 72, figs. 4–6

*Diagnosis.*—A subspecies of *Hollinella* (*Keslingella*) *nodiventriculata* in which the ventral lobe has low nodulous elevations and a few coarse punctae in addition to the basic granulose to very finely papillose ornamentation. Each valve has a very prominent node at the end of the ventral lobe, projecting outward in some specimens as far as the L3, near the end of the crest of the combined ventral lobe-frill but not directly connected with it.

*Occurrence.*—Known only from the "Upper Blue Shale" of the Gravel Point Formation in northern Michigan.

*Illustrated specimen.*—Holotype UMMP 30908 (loc. 9). Paratypes UMMP 30909 and 30910 (loc. 9), and 47577 (loc. 4).

***Hollinella (Keslingella) nodiventriculata incompta*** n. subsp.

Pl. 34, figs. 5–9

*Derivatio nominis.*—From the Latin *incomptus* ("unadorned"), referring to the lack of a prominent node at the end of the ventral lobe, as well as the lack of nodulous elevations and punctae on the ventral lobe.

*Diagnosis.*—A subspecies of *Hollinella* (*Keslingella*) *nodiventriculata* in which the ventral lobe reaches greatest prominence at its posterior end but bears there no prominent node. The basic ornamentation of coarse granules or very fine papillae continues across the ventral lobe without any nodulous elevations or coarse punctae.

*Remarks*—As in *H.* (*K.*) *nodiventriculata nodiventriculata*, the ventral lobe overhangs the antrum of the male, and is combined with the frill. The crest along its edge is probably the protruding remnant of the frill.

*Occurrence.*—Known only from the Potter Farm Formation of northern Michigan at loc. 1.

*Types.*—Holotype UMMP 64805, a male left valve. Paratypes 64806 and 64807.

*Hollinella (Keslingella) plauta* Kesling and Tabor

Pl. 32, figs. 2–15; pl. 33, figs. 8–12

*Hollinella plauta* Kesling and Tabor, 1953, p. 86,87, pl. 2, figs. 1–4. [Genshaw Formation. Holotype UMMP 28061, female carapace.]

*H. plauta* Stover, 1956, p. 1102, pl. 111, fig. 14.

*? Parabolbina hypercala* Kesling and Tabor, 1953, p. 88,89, pl. 3, figs. 1–7.

*? P. oxypages* Kesling and Tabor, 1953, p. 89, pl. 3, figs. 8–15.

*Hollinella* (*Keslingella*) *antespinosa* [*pars*] Bless and Jordan, 1973, pl. 48.

*Diagnosis.*—Adult valve about 1.4 mm long, with length/height about 1.9 to 2.0. L3 clearly defined ventrally, subspherical, tending to have dorsal tubercle above hinge line. S2 fairly wide, with anteroventral extension below vertically elongate L2. Frill very long, extending well behind L3, rather broad and joining lateral

surface along narrow groove, ending in flared thickening; frill of male flared outward from wide smooth antrum. Surface ornamented with field of small distinct papillae and scattered slightly larger papillae, the latter low and only slightly above level of the former.

*Remarks.*—As suggested by Bless and Jordan (1972, p. 48), the ostracods described by Kesling and Tabor (1953) as *Parabolbina hypercala* and *P. oxypages* may indeed be juveniles of this species. They are of about the proper shape and ornamentation, and bear two widely separated spurs in each valve, of which the anterior is much closer to the marginal ridge and the posterior is flared outward. In the smaller specimens ("*Parabolbina oxypages*"), the ornamentation is nearly all the same size papillae and L3 is not so well developed; hence, this could be an immature form of a different species of *Hollinella* (*Keslingella*).

This species is similar to *H.* (*K.*) *auroriradiata*, but it is more elongate and has very little difference between the two sizes of papillae.

*Occurrence.*—Genshaw Formation of Michigan; Centerfield Formation, Ledyard Shale, and Windom Shale of western New York.

*Illustrated specimens.*—Holotype UMMP 28061 (Genshaw Formation, loc. 6). Paratype 28060 (Genshaw Formation, loc. 6). UMMP 64084 (Ledyard Shale, loc. 1); 64808–64811 (Centerfield Formation, loc. 2).

*Hollinella (Keslingella) porrecta* Kesling and McMillan

Pl. 32, fig. 1

*Hollinella porrecta* Kesling and McMillan, 1951, p. 61,62, pl. 6, figs. 1,2. [Bell Shale, Holotype UMMP 26727, male carapace.]

*H.* (*Keslingella*) *porrecta* Bless and Jordan, 1971, p. 883.

*H.* (*K.*) *porrecta* Bless and Jordan, 1972, p. 54.

*Diagnosis.*—Male carapace about 1.6 mm long, length about twice the height. L3 not well defined ventrally, merging into ventral lobe. Ends rounded. S2 fairly wide and well defined. L2 tending to fuse with L1, its boundary only a shallow groove. L1 joined to long large ventral lobe, decreasing behind L3. L4 rather low and gently convex. Frill relatively narrow but long, extending well behind L3. Surface granulose to very finely papillose.

*Remarks.*—The shape of L3 and its ventral confluence with the ventral lobe is as much like that of the genus *Adelphobolbina* as it is like *Hollinella*. Because S2 is confined to the dorsal half of the domicilium and L2 is present (although poorly defined anteriorly,) we retain this species in *Hollinella* (*Keslingella*).

*Hollinella* (*Keslingella*) *porrecta* is more elongate than *H.* (*K.*) *horologiina* and less ornamented than *H.* (*K.*) *antespinosa*, and its L3 is larger and less defined ventrally than in either of them.

*Occurrence.*—Known only in the Bell Shale of Michigan. Rare.

*Illustrated specimens.*—Holotype UMMP 26727 (Bell Shale, loc. 2).

*Hollinella (Keslingella) productilobata* Kesling and McMillan

Pl. 34, figs. 3,4

*Hollinella productilobata* Kesling and McMillan, 1951, p. 62,63, pl. 3, figs. 4,5. [Bell Shale. Holotype UMMP 26649, female carapace.]

*H.* (*Keslingella*) *productilobata* Bless and Jordan, 1971, p. 883.

*H.* (*K.*) *productilobata* Bless and Jordan, 1972, p. 54.

*Diagnosis.*—Female valve about 1.1 mm long, subelliptical. L3 bulbous and rather well defined. S2 narrow, not much expanded at its ventral end. L2 verticaly elongate, separated from L1 by a shallow groove. L1, the ventral lobe, and L4 adjoined, not much inflated. Frill narrow, ending shortly behind L3. Lateral surface finely papillose, the papillae high and well defined though small, with only a very few (if any) very slightly and inconspicuously larger; frill granulose.

*Remarks.*—The ornamention and simple lobation distinguish this species. Its S2 is much narrower than in most others of the subgenus, including *H.* (*K.*) *pumila.*

*Occurrence.*—Known only from the Bell Shale of Michigan at locs. 2 and 11.

*Illustrated specimens.*—All from loc. 2. Holotype UMMP 26649. Paratype 26651. UMMP 30902.

*Hollinella (Keslingella) pumila* Kesling

Pl. 27, figs. 19–23; pl. 28, figs. 13–23

*Hollinella pumila* Kesling, 1952c, p. 48,49, pl. 1, figs. 16–23. [Ferron Point Formation. Holotype UMMP 28032, female carapace.]

*H. pumila* Kesling, 1953b, p. 211, pl. 3, figs. 1–21.

*H.* (*Keslingella*) *pumila* Bless and Jordan, 1970, p. 84.

*H.* (*K.*) *pumila* Bless and Jordan, 1971, p. 883.

*H.* (*K.*) *pumila* Bless and Jordan, 1972, p. 46.

*H.* (*K.*) *pumila* Kesling and Chilman, 1978, p. 64, pl. 13, figs. 11–24; pl. 14, figs. 1–3; pl. 15, figs. 1–7; pl. 16, figs. 7–19; pl. 109, figs. 1,2.

*Diagnosis.*—Adult valve 1.0 to 1.1 mm long, oval in lateral view. L3 bulbous and well defined, extending above hinge line. Greatest height anterior, about through L2; valve with slight swing. S2 fairly wide, expanded ventrally. L2 indistinctly defined anteriorly, vertically elongate. L1 smoothly confluent with ventral lobe, not much inflated, practically confluent with L4. Frill unornamented, narrow. Female frill separated from marginal ridge by wide antrum, nearly disappearing posteriorly before ending in flared spurlike thickening; male frill about same width throughout, as viewed ventrally convergent anteriorly toward marginal ridge. Surface finely but distinctly papillose with very few (if any) larger papillae present.

*Remarks.*—This, the type species of the subgenus *Keslingella*, is both abundant and stratigraphically dispersed. It is much like *H.* (*K.*) *productilobata* but has a

more distinct posterior cardinal angle, a wider S2, and more anterior position of greatest height.

*Occurrence.*—Silica Shale of Ohio and southern Michigan; Arkona Shale of Ontario; and the Ferron Point Formation, Norway Point Formation, and Gravel Point Formation of northern Michigan.

*Illustrated specimens.*—Holotype UMMP 28032 (Ferron Point Formation, loc. 3). Paratypes 28033 and 28035 (Ferron Point, loc. 3). UMMP 28982 and 28990 (Arkona Shale, loc. 3); and 64812–64814 (Arkona Shale, loc. 6).

### *Hollinella (Keslingella) sella* Stover

Pl. 45, figs. 1–12; pl. 51, figs. 20–23; pl. 52, figs. 1–4; pl. 63, figs. 10–16; pl. 71, figs. 15,16 *Hollinella sella* Stover, 1956, p. 1096,1098,1099, pl. 111, figs. 1–6. [Windom Shale. Holotype NYSM 10817, male carapace.]

*H.* (*Keslingella*) *sella* Bless and Jordan, 1971, p. 883.

*H.* (*K.*) *sella* Bless and Jordan, 1972, p. 56.

*Diagnosis.*—Carapace large, adult valves from 1.7 to 1.8 mm long, length about 1.8 times the height. L3 bulbous but not much above the hinge line, may be separated from L4 by shallow groove. L2 vertically elongate, isolated from L1 by deep S1 groove and from ventral lobe by a connection of S1 and S2; shallow depression leading anteroventrally from base of L2 to frill. S2 well developed, fairly wide. Ventral lobe large, separated from L4 by only a shallow depression. Surface ornamented with a basic field of coarse granules or very fine papillae, with larger and higher even and rounded papillae scattered on ventral lobe and L4, and particularly concentrated along posterior margin of valve. Frill long and fairly wide; male frill narrower than that of female, flared outward, not much convergent anteroventrally if at all, separated from marginal ridge by ornamented venter. Female frill incurved, separated from marginal ridge by a smooth antrum.

*Remarks.*—Of the other large species of *Hollinella* in the Great Lakes region, *H.* (*K.*) *ampla* is covered with an even papillose ornament, *H.* (*K.*) *tricollina* and *H.* (*K.*) *magnambitata* have L2 practically joined to L1 and lack a concentration of larger papillae along the posterior margin, and *H.* (*K.*) *tricollina* has a prominent hemispherical L1 extending above the hinge line.

*Occurrence.*—Known only in western New York from the Centerfield Formation, Wanakah Shale, Kashong Shale, and the Windom Shale.

*Illustrated specimens.*—UMMP 64920 (Centerfield Formation, loc. 2); 64546, 64547, 64548, 64580, 64916, and 64917 (Wanakah Shale, loc. 3); 64848 (Wanakah Shale, loc. 6) and 64849, 64915, and 64924 (Kashong Shale, loc. 1).

### *Hollinella (Keslingella) tendilobata* Kesling and Weiss

Pl. 35, figs. 13–16; pl. 72, figs. 8,9

*Hollinella tendilobata* Kesling and Weiss, 1953, p. 39,40, pl. 2, figs. 23–26. [Norway Point Formation. Holotype UMMP 27379, male left valve.]

*H.* (*Keslingella*) *tendilobata* Bless and Jordan, 1971, p. 883.

*H.* (*K.*) *tendilobata* Bless and Joordan, 1972, p. 58.

*Diagnosis.*—Adult valve about 1.1 mm long, elliptical. L3 a horizontally elongate bulb separated from ventral lobe by horizontal groove. Lobes with low relief. L2 a vertically elongate node, anteroventrally joined to ventral lobe. L1 and ventral lobe continuous; ventral lobe with greatest width and height below S2, separated by only shallow depression from L4. Frill narrow but long. Surface finely granulose, with no papillae.

*Remarks.*—This species most closely resembles *H.* (*K.*) *vegrandis*, from which it differs in having the groove between L3 and the ventral lobe nearly horizontal instead of inclined, and in having less relief of the lobation.

*Occurrence.*—Found only in northern Michigan from the Rockport Quarry Limestone (Bell Shale), Ferron Point Formation, Norway Point Formation, Gravel Point Formation, and the Petoskey Formation.

*Illustrated specimens.*—Holotype UMMP 27379 (Norway Point Formation, loc. 1). Paratype 27380 (Norway Point, loc. 1). UMMP 64918 and 64919 (Ferron Point Formation, loc. 3); and 30887 and 30890 (uppermost Bell Shale or basal Rockport Quarry Limestone, loc. 3).

### *Hollinella (Keslingella) vegrandis* Kesling and Tabor

Pl. 36, figs. 11–13; pl. 63, figs. 7–9

*Hollinella vegrandis* Kesling and Tabor, 1953, p. 84,85, pl. 1, figs. 23–27. [Genshaw Formation. Holotype UMMP 28062, male carapace.]

*H.* (*Keslingella*) *vegrandis* Bless and Jordan, 1971, p. 883.

*H.* (*K.*) *vegrandis* Bless and Jordan, 1972, p. 59.

*Diagnosis.*—Adult valve about 1.0 mm long, suboval in lateral view. Lobes with only moderate relief. L3 anteroventrally elongate, separated from ventral lobe by an inclined groove. S2 large, with anteroventral elongation below L2. L2 vertically elongate, joined to ventral lobe only at its anteroventral edge. L1 confluent with long ventral lobe, the latter separated from L4 by only a shallow depression. Frill narrow, extending behind L3, not reinforced at its posterior end. Surface finely granulose, without papillae.

*Remarks.*—This species most closely resembles *H.* (*K.*) *tendilobata*, differing only in its slightly stronger lobation, inclination of the elongate L3, greater extension of S2, and slightly greater swing.

*Occurrence.*—Known only in northern Michigan from the Genshaw Formation, Four Mile Dam Formation, Potter Farm Formation, and Petoskey Formation.

*Illustrated specimens.*—Paratypes UMMP 28063 and 28064 (Genshaw Formation, loc. 6). UMMP 38868 (Petoskey Formation, loc. 2); 64925 (Dock Street Clay Member of Four Mile Dam Formation, loc. 1); and 64926 (Genshaw Formation, loc. 6).

### ***Labrosavelum*** n. gen.

*Derivatio nominis.*—From the Latin *labrum* ("lip") and *velum* ("curtain, frill"), referring to the long inflated nature of the frill.

*Type species.*—Herein designated, *Hollinella labrosa* Kesling and Weiss, 1953, p. 35,38, pl. 2, figs. 1–4.

*Description.*—S2 very long, slanting anteroventrally, truncating ventral lobe. L2 fused with anterior segment of ventral lobe to form very long slanting lobe reaching to frill. L1 isolated from L2 by very long S1. L3 large, bulbous, extending to or above hinge line. Frill large and exceptionally thick, terminating posteriorly in large spurlike thickening. Ventral lobe tapering below L3, separated from L4. L4 a curved ridge parallel to posterior border. Dimorphism hollinellid.

*Remarks.*—The lobation is unlike that of species here included in *Hollinella* (*Keslingella*), resembling them only in the bulbous L3. The exceptional thickening of the frill effectively conceals any external indication of tubules.

### *Labrosavelum labrosum* (Kesling and Weiss)

Pl. 37, figs. 1–4

*Hollinella labrosa* Kesling and Weiss, 1953, p. 35,38, pl. 2, figs. 1–4. [Norway Point Formation. Holotype UMMP 27371, female right valve.]

*H. labrosa* Melik, 1966, p. 223,224, pl. 21, figs. 1–6.

*H.* (*Keslingella*) *labrosa* Bless and Jordan, 1971, p. 883.

*H.* (*K.*) *labrosa* Bless and Jordan, 1972, p. 52,53.

*Diagnosis.*—Frill exceptionally thick, nearly 0.1 mm in an adult valve 1.5 mm long. L3 spherical to slightly ovate, not more than half the height of the valve. L2 somewhat sinuous and slightly expanded anteroventrally. L4 rather well developed, ridgelike. Surface rather irregular, papillose where well preserved, without any larger papillae or tubercles.

*Remarks.*—Bless and Jordan (1972, p. 53) referred to the lobation of this species as "rather baroque"—which could apply to all known species of the new genus. The ventral lobe in this species tends to be subelliptical rather than subtriangular as in *L. retusilobatum*. It also differs from *L. retusilobatum* in having a higher expression of L4, a larger L1, and less expansion of the frill anteroventrally. *Labrosavelum labrosum*, unlike other species of the genus, has no large papillae associated with L4 and the ventral lobe. It differs further from *L. pyriforme* in the ovate to spherical L3, which shows little if any taper upward.

*Occurrence.*—Known only in northern Michigan from the Bell Shale, Norway Point Formation, and the Gravel Point Formation.

*Illustrated specimens.*—UMMP 64517–64519 (Norway Point Formation, loc. 1); and 64520 (Bell Shale, loc. 4).

### ***Labrosavelum sphaericum*** n. sp.

Pl. 38, figs. 6–11

*Hollinella* (*Keslingella*) *labrosa* [*pars*] Kesling and Chilman, pl. 14, figs. 10,11. [Silica Shale.]

*Derivatio nominis.*—From the Greek and Latin *sphaericus* ("globular, spherical"), referring to the huge spherical L3.

*Description.*—Valve elongate elliptical, with rounded ends and very little swing. Adult female carapace about 1.6 mm long. 0.8 mm high, and 1.0 mm wide. Lobation very clearly expressed but lobes not strongly protuberant. L1 large, tapering anteroventrally. L2 with dorsal part nearly vertical, thence with an abrupt bend or geniculation and, in some valves, with a slight constriction, the ventral part expanded anteroventrally. L3 extremely large, over half the height of the valve, not projecting much above hinge line. Ventral lobe with greatest height below S2, tapering strongly below and around ventral side of L3, separated from L4 by only a short groove. L4 a curved ridge parallel to posterior border. All sulci well defined.

Frill of male valve relatively narrow as seen laterally, extending from anterior corner to position below rear edge of L3, only slightly thickened at its posterior end. Frill of male valve as viewed from below separated from marginal ridge by a rather wide granulose venter, with indentation toward marginal ridge only in anteroventral part.

Surface granulose, with a few large but low papillae or tubercles associated with L4 and posterior part of ventral lobe. Slightly smaller papillae along posterior edge of valve in some specimens. Marginal ridge bearing papillae.

*Remarks.*—This species is distinguished from others of the genus by its extremely large L3, which despite its size does not project far out from the rest of the valve. The papillae or tubercles on L4 and the ventral lobe are low and inconspicuous. Its frill is not nearly as thick as that of *Labrosavelum labrosum*.

*Occurrence.*—Silica Shale of northwestern Ohio and southeastern Michigan. Hungry Hollow and Widder Formations of Ontario. Not found in northern Michigan or western New York.

*Types.*—Holotype UMMP 30874, female carapace (Widder Formation, loc. 1). Paratypes 58730 and 64537 (Widder Formation, loc. 1); and 58781 (Hungry Hollow Formation, loc. 4).

KEY TO SPECIES OF *LABROSAVELUM*

1. L3 very large, subspherical, its diameter over half the height of the valve; ventral lobe strongly tapered posteriorly and greatly constricted below L3 ..... *L. sphaericum*

   L3 not exceeding in diameter half the height of the valve; ventral lobe moderately tapered posteriorly, may not extend below L3 ..... 2

2. L3 spherical; L1 small and low; L2 strongly expanded anteroventrally; L4 low; ventral lobe tending to be subtriangular; anterior part of frill very wide, convex ..... *L. retusilobatum*

   L3 ovate to some degree; L1 well developed; L2 slightly expanded anteroventrally if at all; L4 rather well developed; ventral lobe tending to be subelliptical; frill about same width throughout ..... 3

3. L3 slightly ovate; L2 somewhat sinuous and slightly expanded anteroventrally; L4 rather well developed; frill very thick; ornamentation irregular but without large papillae ..... *L. labrosa*

   L3 tapered upward, pyriform; L2 with subparallel sides; L4 narrow but distinctly elevated; frill only moderately thick, the anterior part tapered to the distal edge; ornamentation even, valves with low, fine, and even papillae and a few large papillae or spinelets associated with S3 and posterior part of valve ..... *L. pyriforme*

***Labrosavelum pyriforme*** n. sp.

Pl. 36, figs. 7–10; pl. 37, figs. 5–10; pl. 39, figs. 1–7; pl. 40, figs. 8–12; pl. 41, figs. 1–8; pl. 42, figs. 1–11; pl. 43, figs. 1–5; pl. 51, fig. 19; pl. 59, fig. 13

*Hollinella* (*Keslingella*) *labrosa* [*pars*] Kesling and Chilman, 1978, pl. 12, figs. 1–10; pl. 14, figs. 4–9.

*Derivatio nominis.*—From the Latin *pyrum* ("pear") and *forma* ("shape, appearance, nature"), referring to the distinctive shape of L3, which is tapered upward.

*Description.*—Valve elongate oval, adult valve about 1.8 mm long and 0.9 mm wide, with distinct swing. Posterior end more narrowly rounded than anterior end. Lobation clearly expressed. L1 an elongate lobe, ridgelike, reaching at least to midheight of valve. L2 long, its sides nearly parallel, inclined. L3 large, pyriform, its tapered dorsal end extending above the hinge line. L4 rather narrow, curved, parallel to posterior border. Ventral lobe tapering posteriorly, its upper border nearly horizontal and separated from L3 by a shallow groove, its posterior end aligned with that of L3 and widely separated from L4.

Frill only moderately thick, its anterior part tapering out to the distal edge, posterior end turned upward and tip flared outward (where preserved). Frill of female rather wide but not sharply defined proximally, incurved, separated from marginal ridge by a smooth antrum. Frill of male slightly narrower and less incurved, separated from marginal ridge by a papillose venter. Marginal ridge exceptionally wide, especially ventrally, composed of fused denticles.

Surface ornamented with fine and very even papillae, with a few very large papillae or tubercles, most of them concentrated along the ventral edge of the ventral lobe.

*Remarks.*—The lobes extend outward about equally, with L3 only slightly more protuberant than the others. The development of the marginal ridge is outstanding, much wider than in other hollinids seen. S3 is particularly wide, extending between the L4 and the L3 and ventral lobe. This large species also shows the hingement to advantage.

This species is readily identified by the shape of L3. It differs from *Labrosavelum labrosum* also in its nearly straight L2, narrower L4, and more even field of ornamentation with large papillae, tubercles, or spinelets associated with the ventral lobe and, occasionally, with L4. It differs fom *L. retusilobatum* in lacking a ventral expansion of L2 and by the close juxtaposition of its tapered ventral lobe and the base of L3.

*Occurrence.*—Widder Formation and Ipperwash Formation of Ontario. Bell Shale, Ferron Point Formation, Genshaw Formation, Potter Farm Formation, and Petoskey Formation of northern Michigan. Not found in Ohio, southeastern Michigan, or western New York.

*Types.*—Holotype UMMP 59666, male right valve

(Potter Farm Formation, loc. 1; illustrated by Kesling and Chilman, 1978, pl. 12, figs. 8–10). Paratypes from Potter Farm Formation at loc. 1: 30881, 59664 (see Kesling and Chilman, 1978, pl. 14, figs. 4,5), 59665 (see Kesling and Chilman, 1978, pl. 14, figs. 6,7), 59667 (see Kesling and Chilman, 1978, pl. 12, figs. 5–7), 59668 (see Kesling and Chilman, 1978, pl. 12, figs. 1–4), and 64527–64532; from Bell Shale at loc. 4: 64521; from Genshaw Formation: 64522 (loc. 1), 64523 (loc. 2), and 64524–64526 (loc. 3); from Petoskey Formation: 30879 and 64539 (loc. 1) and 64540-64542 (loc. 2); from Hungry Hollow Formation: 64533 and 64534 (loc. 4) and 64535 and 64536 (loc. 3); and Widder Formation at loc. 1: 64538.

*Labrosavelum retusilobatum* (Stover)

Pl. 38, figs. 1–5; pl. 40, figs. 1–7

*Hollinella retusilobata* Stover, 1956, p. 1099, 1100, pl. 111, figs. 7,8. [Windom Shale. Holotype NYSM 10820, female left valve.]

*H. (Keslingella) retusilobata* Bless and Jordan, 1971, p. 883.

*H. (K.) retusilobata* Bless and Jordan, 1972, p. 56, pl. 35, fig. 16.

*Diagnosis.*—Carapace large, adult valve 1.9 to 2.0 mm long and about 1.0 mm high, oval in lateral view. L1 distinctly low and only slightly inflated. L2 with constriction and geniculation at base of dorsal one-third. L3 spherical, not much above hinge line if at all. L4 isolated. Ventral lobe tending to be subtriangular, tapered posteriorly. Anterior part of frill very wide, convex.

*Remarks.*—The ornamentation of closely packed granules gives the surface a finely pebbled appearance. Large papillae are concentrated along the posterior margin and scattered on the posterior and posteroventral parts of the valve. The outstanding character of this species is the very wide anteroventral section of the frill. Specimens display considerable variation in the form of the ventral lobe and in the number of papillae associated with the posteroventral part of the valve. The size and shape of L3 distinguishes this species from *L. sphaericum* (with much larger L3) and *L. pyriforme* (with dorsally tapered L3).

*Occurrence.*—Known only with certainty in western New York from the Centerfield Formation, Wanakah Shale, and Windom Shale. Specimens from the Silica Shale illustrated by Kesling and Chilman (1978) may also belong to this species, despite their smaller size: UMMP 58980 (K. and C., pl. 14, fig. 12), 58982 (K. and C., pl. 14, fig. 13), 60049 (K. and C., pl. 10, fig. 19), and 60050 (K. and C., pl. 10, fig. 18).

*Illustrated specimens.*—UMMP 64543–64545 (Centerfield Formation, loc. 2); and 64921–64923 (Windom Shale, loc. 1).

***Physcocalyptra*** n. gen.

*Derivatio nominis.*—From the Greek *physke* ("blister, sausage") and *calyptra* ("veil"), referring to the long inflated section of the frill in the female.

*Type species.*—*Physcocalyptra pomphosa* n. sp.

*Diagnosis.*—Genus of Hollinellidae in which the female frill is thin and broad, with a sausage-shaped inflation anteroventrally, extending posteriorly as far as rear edge of L3. L3 large and bulbous, its ventral border clearly defined. S2 terminating near middle of valve.

*Description.*—Same as that of *Physcocalyptra pomphosa*, the only known species.

*Remarks.*—This distinctive genus is distinguished from *Hollinella* (*Keslingella*) by its wider frill and, particularly, by the sausage-shaped inflation of the anteroventral part of the frill in the female. The frill in the adult male is not interrupted, which serves to distinguish it further from *Ruptivelum*. *Physcocalyptra* has the S2 terminating near the middle of the valve, whereas that in *Labrosavelum* and *Bisphenella* extends ventrally to the frill; in addition, the frill of *Labrosavelum* is much thicker, and the ventral lobe of the much smaller *Bisphenella* is posteriorly protuberant.

*Occurrence.*—Known only from the Hungry Hollow Formation of Ontario.

***Physcocalyptra pomphosa*** n. sp

Pl. 21, figs. 1–12; pl. 67, figs. 12–15

*Derivatio nominis.*—From the Greek *pomphos* ("blister"), referring to the inflated section of the frill.

*Description.*—Shell, including frill, very thin and easily broken or deformed. Male valve about 1.6 mm long and 1.0 mm high, elongate oval. Female valve with anterior end more broadly rounded than the posterior. Dorsal border straight except for projecting spinelets and dorsal part of L3. Lobation distinct. L3 spherical, its diameter about one-third the height of the valve. S2 broad but not deep. L2 a vertically elongate node, fairly small, close to L1. L1 reduced to an arcuate ridge set close to L2 and leaving large area in anterior part of valve not involved in lobation, not reaching dorsal border, ventrally separated from ventral lobe by a short groove. Ventral lobe elongate, set rather high and not extending to frill, terminating below L3, in male valve with an angular bend along its crest. L4 low, very gently convex.

Frill of female with inflated part occupying large part of anteroventral region of valve, elongate, its proximal border nearly straight, extending from middle of anterior margin to position below front edge of L3, not in contact with the reduced ventral lobe. Female frill above inflated section narrow, with an extended tip above the hinge line; part of frill behind inflated section also narrow, not incurved, terminating in a spinelike thickening projecting far out from the lateral surface and rather sharply acuminate. Frill of male wide where preserved, beginning

at anterior corner with a projecting tip or spinelet and curved around free border to posterior spurlike thickening, not incurved appreciably, and not in contact with the reduced ventral lobe.

Surface ornamented with scattered spinelets, distributed over dorsal margin (there projecting above the hinge line), the anterior part of the valve ahead of L1, L3, L4, and the area below the ventral lobe. Rest of valve surface with a basic coverage of coarse but even granules. Some specimens showing projecting tip at posterior corner (may be spinelet). L1, L2, and ventral lobe apparently free of spinelets. Frill of female thin and showing external traces of tubules. Inflated section of female frill ornamented with large elongate granules forming discontinuous ridging parallel to the direction of elongation. Distal edge of inflated section of frill not bearing a rim. Juvenile specimen with very small L3 and velar ridge fading out below L3, ornamented with granules and spinelets like those of adults.

*Remarks.*—This is the only species of the exotic genus, and many of the types are badly deformed or broken. However, the "false pouch" formed by the inflated section of the female frill is observed in several specimens, so it is not an abnormality. Its function is not known. However, the very strong incurving of this part of the frill suggests to us that the designation of the more incurved frills of *Hollinella* (*Keslingella*) as female characters is probably correct.

The ontogeny of *Physcocalyptra pomphosa*, insofar as known, involves velar ridges in the juvenile instars. In this regard, the genus is more like *Hollinella* (*Hollinella*), *Hollinella* (*Praehollinella*), *Jordanites*, and *Gortanella* than it is like *Parabolbina*, *Subligaculum*, *Triemilomatella*, *Parabolbinella*, *Ruptivelum*, or *Hollinella* (*Keslingella*), all of which have the velar structure of the juveniles reduced to two spurs in each valve.

*Occurrence.*—Known only in Ontario from the Hungry Hollow Formation.

*Types.*—Holotype UMMP 64507, female left valve (loc. 1). Paratypes 64508, 64509, 64512–64515, and 64928 (loc. 1); and 64510, 64511, and 64516 (loc. 4).

## Genus *Ruptivelum Kesling and Weiss 1953*

*Type species.*—By original designation, *Ruptivelum bacculatum* Kesling and Weiss, 1953, p. 47.

*Diagnosis.*—Lobation distinct with well-developed L1 L2, and L3. S2 limited to dorsal half of valve. Male with interrupted frill, the two segments corresponding to spurs in other genera of hollinellids. Female with frill entire.

*Remarks.*—The lobation is exactly like that of most *Hollinella* species, with the separate lobes expressed in the dorsal half of the valve and the ventral half occupied by a ventral lobe. The bizarre expression of dimorphism is sufficient to separate these ostracods as a distinct genus.

### *Ruptivelum bacculatum* Kesling and Weiss

Pl. 51, figs. 1–18; pl. 68, figs. 17–23; pl. 71, figs. 11,12; pl. 72, figs. 12,13

*Hollinella* sp., Kesling, 1951, pl. 14, figs. 1,2.

*Ruptivelum bacculatum* Kesling and Weiss, 1953, p. 47,48, pl. 1, figs. 22–30. [Norway Point Formation. Holotype UMMP 27346, male left valve.]

*? Hollinella* sp. A Kesling and Weiss, 1953, p. 41, pl. 1, figs. 19,20.

*Ruptivelum bacculatum* Melik, 1966, p. 226, pl. 2, figs. 20–22; pl. 11, figs. 31–34; pl. 12, figs. 1–6; pl. 19, figs. 11,12; pl. 20, fig. 9.

*R. bacculatum* Bless and Jordan, 1971, p. 885.

*R. bacculatum* Bless and Jordan, 1972, p. 76, pl. 35, fig. 17.

*Diagnosis.*—Female valve about 1.2 mm long, elongate oval. L1 a prominent lobe at the anterior corner, projecting above the hinge line as a small hump and ventrally confluent with the frill in the adult. L2 a small node isolated except ventrally. L3 a large bulb set rather far forward, ahead of low arched L4. Ventral lobe not much inflated. Surface granulose. Frill of male interrupted below S2. Frill of female wide, extending slightly behind L3, rather flat and only slightly incurved.

*Remarks.*—The juveniles appear to be specimens with spurs anteroventrally and posteroventrally, the latter flared outward slightly. The lobation differs from that of the adults in the less conspicuous L1 and proportionally smaller L3.

The dimorphic form of the frill has the wider and more incurved designated as the female, and the interrupted less incurved designated as the male. As in the case of *Physcocalyptra*, this casts doubt on the correctness of the designation of the narrower and less incurved frill as that of the female in *Hollinella* species.

*Occurrence.*—Known only in northern Michigan from the Bell Shale, Norway Point Formation, Gravel Point Formation, and Petoskey Formation. A female carapace illustrated by Melik (1966, pl. 2, figs. 20–22) from the Widder Formation was destroyed by sectioning it to study the hingement and contact margin, and the peels were shown by Melik in his pl. 11, figs. 31–34, 37, and pl. 12, figs. 1–6. It differed from *Ruptivelum bacculatum* in having a reticulate rather than granulose ornamentation and less confluence of L1 and the frill. It is the only known specimen of its kind, and may belong to an undescribed species of *Ruptivelum*; our searches of Widder Formation washings did not disclose any specimens like it. Bless and Jordan (1972, p. 76) cited the Widder Formation as an occurrence of *R. bacculatum*, but we disbelieve the conspecificity of Melik's specimen with those herein included.

*Illustrated specimens.*—Holotype UMMP 27346 (Norway Point Formation, loc. 1). Paratypes 27344, 27345, 27347, and 27348 (Norway Point, loc. 1). UMMP 64971 and 64977 (Bell Shale, loc. 1); 64993 (Bell Shale,

loc. 8); 64973 and 64976 (Gravel Point Formation, loc. 1); 30788 and 64975 (Norway Point, loc. 1); and 64972 (Petoskey Formation, loc. 2).

## DISTRIBUTION OF SPECIES

The numbers of species found in each area are compared for pre-Centerfield, Centerfield and younger, and all Middle Devonian strata. In the tables (Tables 2–8), "endemic" is used to mean species occurring only in a particular area during the time stated; some species which are thus "endemic" for pre-Centerfield time later migrated to other areas, so that species such as *Hollinella (Keslingella) devoniana* and *Subligaculum laciniosum*, which occur only in Michigan in pre-Centerfield time and only in New York in post-Centerfield time, are counted as endemics for each state in the particular interval. "Ubiquitous" is used to mean species which occur in all four areas.

Table 2—Distribution of ostracod species of Great Lakes region occurring in pre-Centerfield formations. Ohio=northwestern Ohio and southeastern Michigan; Mich.=northern Michigan; Ont.=western Ontario.

| Area | Present | Absent | Endemic | Ubiquitous | Other shared | Species shared with Ohio | Mich. | Ont. |
|---|---|---|---|---|---|---|---|---|
| Ohio | 17 | 41 | 2 | 10 | 5 | | 15 | 10 |
| Mich. | 51 | 7 | 31 | 10 | 10 | 15 | | 15 |
| Ont. | 20 | 38 | 5 | 10 | 5 | 10 | 15 | |

Table 3—Distribution of ostracod species of Great Lakes region occurring in Centerfield and younger formations. Mich.=northern Michigan; Ont.=western Ontario; N.Y.=western New York.

| Area | Present | Absent | Endemic | Ubiquitous | Other shared | Species shared with Mich. | Ont. | N.Y. |
|---|---|---|---|---|---|---|---|---|
| Mich. | 42 | 23 | 24 | 11 | 7 | | 17 | 12 |
| Ont. | 24 | 41 | 3 | 11 | 9 | 17 | | 14 |
| N.Y. | 31 | 34 | 17 | 11 | 4 | 12 | 14 | |

Table 4—Distribution of ostracod species of Great Lakes region occurring in all Middle Devonian formations. Ohio=northwestern Ohio and southeastern Michigan; Mich.=northern Michigan; Ont.=western Ontario; N.Y.=western New York.

| Area | Present | Absent | Endemic | Ubiquitous | Other shared | Species shared with Ohio | Mich. | Ont. | N.Y. |
|---|---|---|---|---|---|---|---|---|---|
| Ohio | 17 | 76 | 1 | 9 | 7 | | 15 | 14 | 9 |
| Mich. | 67 | 26 | 42 | 9 | 16 | 15 | | 19 | 14 |
| Ont. | 29 | 64 | 7 | 9 | 14 | 14 | 19 | | 14 |
| N.Y. | 32 | 61 | 15 | 9 | 8 | 9 | 14 | 14 | |

Table 5—Faunal indices of ostracod species occurring in more than one area of Great Lakes region. Ohio=northwestern Ohio and southeastern Michigan; Mich.=northern Michigan; Ont.=western Ontario; N.Y.=western New York.

| Area | Pre-Centerfield | | | Centerfield and later | | | All Middle Devonian | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ohio | Mich. | Ont. | Mich. | Ont. | N.Y. | Ohio | Mich. | Ont. | N.Y. |
| Ohio | | 88 | 59 | | | | | 88 | 82 | 53 |
| Mich. | 88 | | 75 | | 74 | 39 | 88 | | 66 | 48 |
| Ont. | 59 | 75 | | 74 | | 57 | 82 | 66 | | 48 |
| N.Y. | | | | 39 | 57 | | 53 | 48 | 48 | |

Table 6—Indices of provincality (number of endemics/number of shared species).

| Area | Pre-Centerfield | Centerfield and younger | All Middle Devonian |
|---|---|---|---|
| Ohio | .13 | | .06 |
| Mich. | 1.55 | 1.33 | 1.68 |
| Ont. | .33 | .20 | .30 |
| N.Y. | | 1.13 | .88 |

Table 7—Per cent of endemic species in time intervals found in each area.

| Area | Pre-Centerfield | Centerfield and younger | All Middle Devonian |
|---|---|---|---|
| Ohio | 5% | | 2% |
| Mich. | 82% | 53% | 64% |
| Ont. | 13% | 9% | 11% |
| N.Y. | | 38% | 23% |
| Total | 100% | 100% | 100% |

Table 8—Number of endemic species confined to a particular area throughout Middle Devonian time, by genera. Ohio=southeastern Michigan and northwestern Ohio; Mich.=northern Michigan; Ont.=western Ontario; N.Y.=western New York.

| Genus | Ohio | Mich. | Ont. | N.Y. |
|---|---|---|---|---|
| *Abditoloculina* | | 1 | | 1 |
| *Adelphobolbina* | | 1 | | |
| *Bisphenella* | | 3 | | |
| *Ctenoloculina* | | 2 | 4 | 2 |
| *Falsipollex* | | 3 | | 1 |
| *Flaccivelum* | | 3 | | |
| *Hercynobolbina* | | 1 | | |
| *Hollinella (K.)* | | 15 | | 3 |
| *Labrosavelum* | | 1 | | 1 |
| *Leprestola* | | | | 1 |
| *Phlyctiscapha* | | 2 | | 1 |
| *Physcocalyptra* | | | 1 | |
| *Ruptivelum* | | 1 | | |
| *Subligaculum* | 1 | 4 | 1 | 2 |
| *Sulcicuneus* | | 3 | | |
| *Tetrasacculus* | | 1 | | 1 |
| *Treposella* | | | | 1 |
| *Welleria* | | 1 | | 1 |
| Total | 1 | 42 | 6 | 15 |

The tabulations reveal that during Middle Devonian time (Tables 4, 6, 7), northern Michigan was the major locus of speciation. More endemics are found there than in any other area; in fact, the fauna contains more species which are confined to that area than species which are shared with all other areas (Table 6). The second most significant locus of speciation was western New York, although it appears to have spawned less than half as many new taxa as did northern Michigan (Table 4). Contrary to expectations, western Ontario, situated between northern Michigan and western New York, did not produce many endemics; most of its fauna was shared with other areas, with 19 of its 22 shared species found in common with northern Michigan and 12 of the 22 in common with western New York. The area of southeastern Michigan-northwestern Ohio was faunally apparently a depleted continuation of the northern Michigan area; as might have been anticipated, it shared only a few (nine) long-lived species with western New York (Table 4).

During Centerfield and later Middle Devonian time, both northern Michigan and western New York were dominated by local faunas; in both areas, the endemics were more numerous than the shared species (Table 6). As a result, both contain larger Centerfield-and-younger faunas than the intervening Ontario area (Table 3). During this interval, the Ontario area shared six species with northern Michigan which were not shared with New York, but only two species with New York which were not also shared with Michigan. Again, this confirms the stronger faunal relationship of the Ontario area with northern Michigan than with New York.

Certain areas were the homelands of species which were endemic and unsuccessful elsewhere during Middle Devonian time. In particular, northern Michigan yielded 15 species of *Hollinella (Keslingella)* which did not thrive outside the area (Table 8). It is the only area where the genera *Bisphenella*, *Flaccivelum*, *Hercynobolbina*, and *Ruptivelum* occur. Ohio, on the other hand, developed only one species, *Subligaculum bifidum*, which remained isolated there. Ontario, although not a place where many new species evolved, did yield five endemic species of *Ctenoloculina*—more than any other area; it is also the only area where the distinctive genus *Physcocalyptra* has been discovered. New York was the only area in which species of the beyrichiids *Leprestola* and *Treposella* have been found.

Of all endemic beyrichiacean, primitiopsacean, and hollinacean ostracods in the Great Lakes region during the Middle Devonian, nearly two-thirds were in northern Michigan (Table 7), with more evolving in pre-Centerfield than in later time. The remaining third was mostly in New York, which produced nearly twice as many endemic species as did Ontario and northwestern Ohio combined.

## PALEOECOLOGY

In seeking to explain the exceptionally large fauna and the numerous endemic species centered in northern Michigan, we are impressed by the numerous alternations of limestones and shales there, particularly as compared to Ontario.

The stratigraphic column of Middle Devonian rocks in northern Michigan contains over 550 feet of strata, divided into ten formations. Clearly this area repeatedly changed from quiet water of moderate depth (clay shales) to very shallow nearshore depths or even tidal flats (limestones). The environments of deposition in Michigan and Ontario contrast sharply in pre-Centerfield time. Traverse strata of that age in northeastern Michigan consist of some 80 feet of Bell Shale (soft uniform clay shale), 43 feet of Rockport Quarry Limestone (biostromal stromatoporoid-coral limestone with bituminous residues), 42 feet of Ferron Point Formation (mostly shales, alternating in the lower half with thin beds of impure limestone or calcareous shale), 116 feet of Genshaw Formation (mostly limestone units alternating with thinner shales), 25 feet of Newton Creek Formation (sterile lagoonal impure limestone), and 80 feet of Alpena Limestone (limestone with reefs and one thin shale unit about 20 feet above the base, probably interreefal). On the other hand, the same time interval in Ontario is represented by about 30 feet of Arkona Shale (nearly all shale, some units somewhat calcareous, and a few very thin lenses of argillaceous limestone). Thus, northern Michigan was near enough to the shoreline to experience very shallow depths during times of regression, whereas Ontario had few times when water was shallow or

turbulent. The only exposed pre-Centerfield strata in northwestern Michigan belong to the Gravel Point Formation, a series of alternating limestones of varying argillaceous content, with two shale units near the top.

As interpreted by Kesling, Johnson, and Sorensen (1976, p. 95–100), during Centerfield time northern Michigan was a Middle Devonian analogue of the present Andros Island: on the east (Alpena and Presque Isle counties) reefs developed in the windward Four Mile Dam Formation, in the middle (Afton-Onaway area) no rocks of that age are present, and on the west (Charlevoix and Emmet counties) the leeward Charlevoix Formation contains crossbedded oolitic limestone. Hence, across this part of Michigan at that time, the central part was an emergent island. Shallower water also was present during Centerfield time in Ontario, represented by six feet of argillaceous limestone and shale with numerous corals in the upper half.

In Middle Devonian post-Centerfield time, northeastern Michigan again alternated between moderately deep and quiet water and shallow more turbulent water. Strata there are divided into the 50 feet thick Norway Point Formation (mostly uniform shale), the 162 feet of Potter Farm Formation (alternating limestones of varying argillaceous content), and the 16 feet of Thunder Bay Limestone (limestone with a few thin units of shaly limestone). Strata of this age in Ontario contain about 60 feet of Widder Formation (mostly uniform impure shale) and perhaps 10 feet of Ipperwash Limestone. Probably, the Ipperwash is equivalent to the Thunder Bay Limestone; in that case, the limy units of the Potter Farm Formation in northern Michigan are nearshore facies of the deeper-water Widder Formation in Ontario.

Perhaps because northern Michigan was the site of frequent changes in depth and sediment, it yielded the large fauna and the numerous endemic species which were unable to extend their range into the deeper water covering western Ontario during the Middle Devonian.

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PHOTOGRAPHS

In the listing, the plate number is followed by a virgule (/) and then by the figure numbers.

EXPLANATION OF PLATE 1

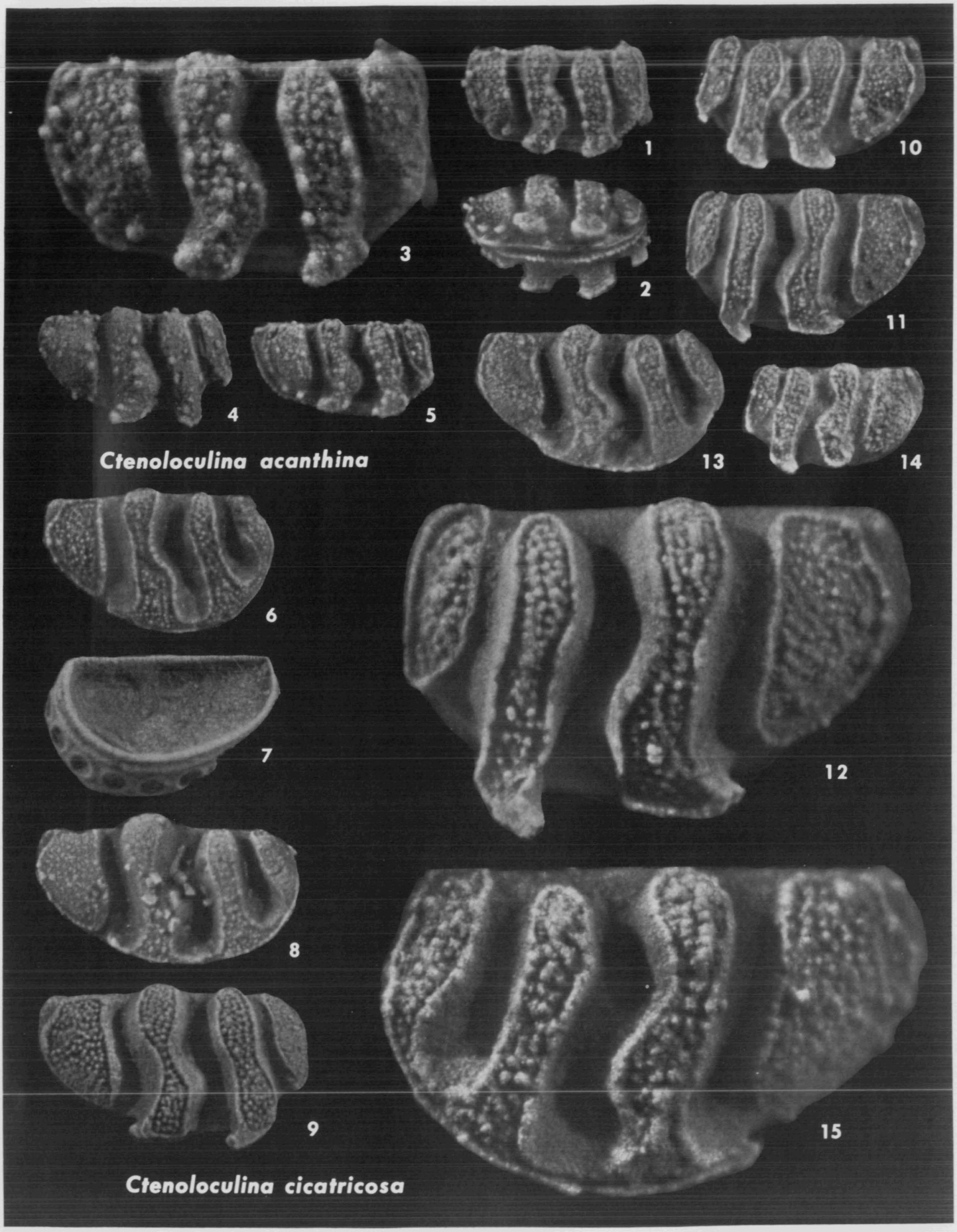
Figures x 40 except as noted

*Ctenoloculina acanthina*

All specimens from Arkona Shale

FIGS. 1–5—1–3, right lateral and inclined ventral views of male carapace, UMMP 64622, Loc. 6; note flared spurs. 4, lateral view of male right valve, 28944, Loc. 1. 5, right lateral view of male carapace, 64621, Loc. 6.

*Ctenoloculina cicatricosa* FIGS. 6–15—6,7, lateral and interior views of female right valve, 58171, Ipperwash Limestone, Loc. 2. 8, lateral view of female right valve, 58151, Silica Shale, Loc. 1; note crystals of pyrite protruding from S2 and L3. 9, lateral view of male right valve, 60299, Arkona Shale, Loc. 1; note blunt ventral termination of L3 and recurved spur of L2. 10, lateral view of male left valve, 60301, Petoskey Formation, Loc. 1. 11,12, lateral views of male left valve, 58421, Ferron Point Formation, Loc. 3; 12, about x 80; note typical ventral terminations of L2 and L3. 13, lateral view of female right valve, 58160, Silica Shale, Loc. 1. 14, lateral view of immature left valve, 58407, Norway Point Formation, Loc. 1 (topotype locality). 15, lateral view of female left valve, 64640, Dock Street Clay Member of Four Mile Dam Formation, Loc. 1, about x 80.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Ctenoloculina acanthina
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Ctenoloculina cicatricosa

EXPLANATION OF PLATE 2

Figures x 40 except as noted

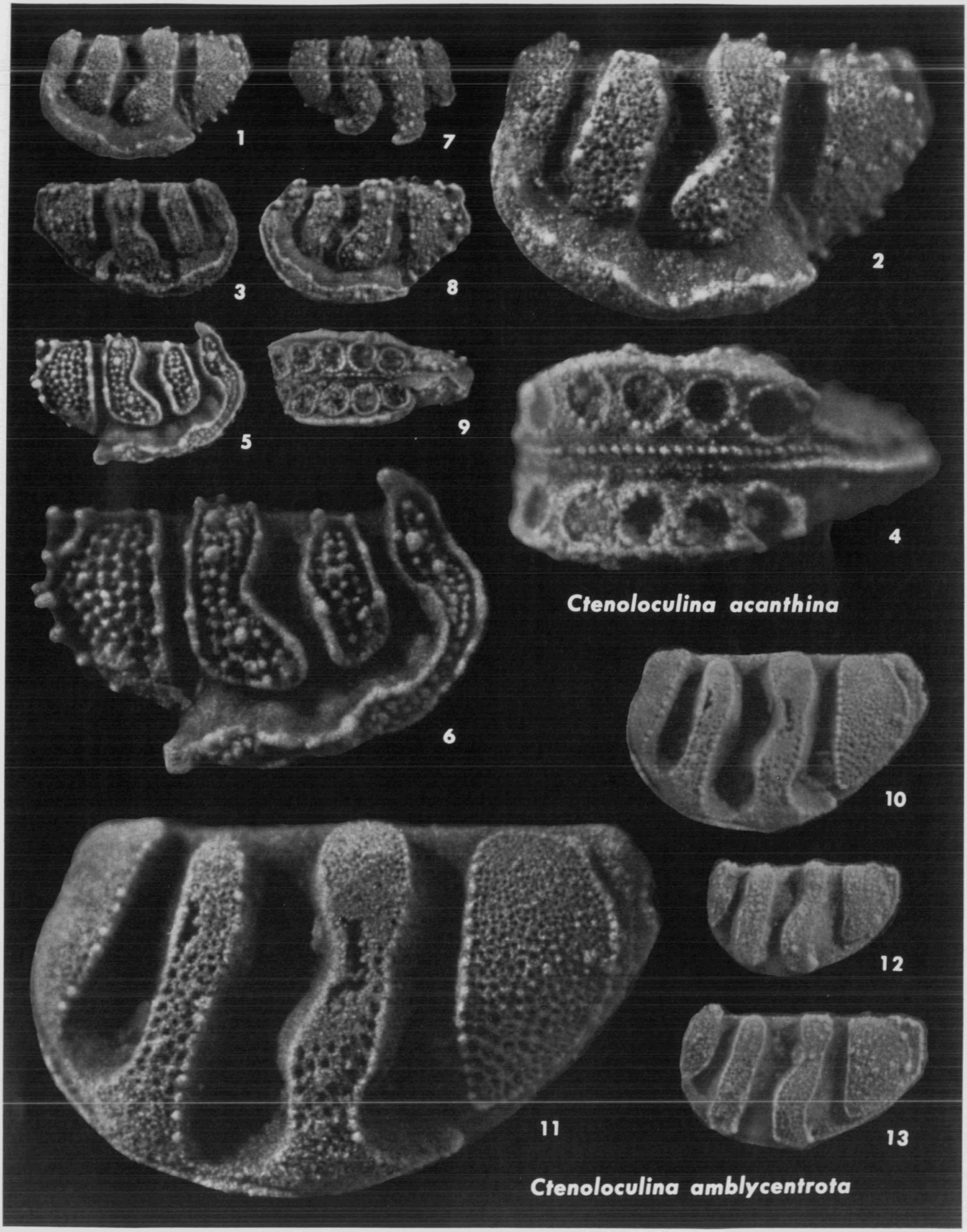
*Ctenoloculina acanthina*

FIGS. 1–9—1,2, lateral views of female left valve, UMMP 58387, Arkona Shale, Loc. 10; 2, about x 80; note preservation of outer lamella in ornamented area of L4 and compare with Fig. 6. 3,4, right lateral and ventral views of female carapace, 64624, Arkona Shale, Loc. 9; 4, about x 80. 5,6, lateral views of female right valve, 58401, Widder Formation, Loc. 3; 6, about x 80; note removal by weathering and/or corrosion of most of thin ornamented lamella on all lobes. 7, lateral view of male or late instar right valve, 58398, Arkona Shale, Loc. 10; note recurved spurs on L2 and L3. 8,9, left lateral and ventral views of female carapace, 60295, Centerfield Formation, Loc. 1.

*Ctenoloculina amblycentrota*

All specimens from Kashong Shale

FIGS, 10–13—10,11, left lateral views of female carapace, paratype 60292, Loc. 2; 11, about x 80; note fine reticulation on much of ornamented areas of lobes. 12, left lateral view of immature (A–2) carapace, paratype 60290, Loc. 3. 13, left lateral view of ultimate immature (A–1) carapace, paratype 60289, Loc. 2.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EXPLANATION OF PLATE 3

Figures x 40 except as noted

*Ctenoloculina acrolobata*

All specimens from Arkona Shale

FIGS. 1–10—1–4, lateral, interior, and inclined interior views of female right valve, paratype UMMP 60282, Loc. 6; 4, about x 80. 5-7, right lateral, ventral, and inclined anterior views of female carapace, paratype 60284, Loc. 6. 8, lateral view of female right valve, paratype 58397, Loc. 10; lobes retain original layer of ornamentation. 9, lateral view of female right valve, holotype 60283, Loc. 6. 10, lateral view of female right valve, paratype 58392, Loc. 10.

*Ctenoloculina didyma*

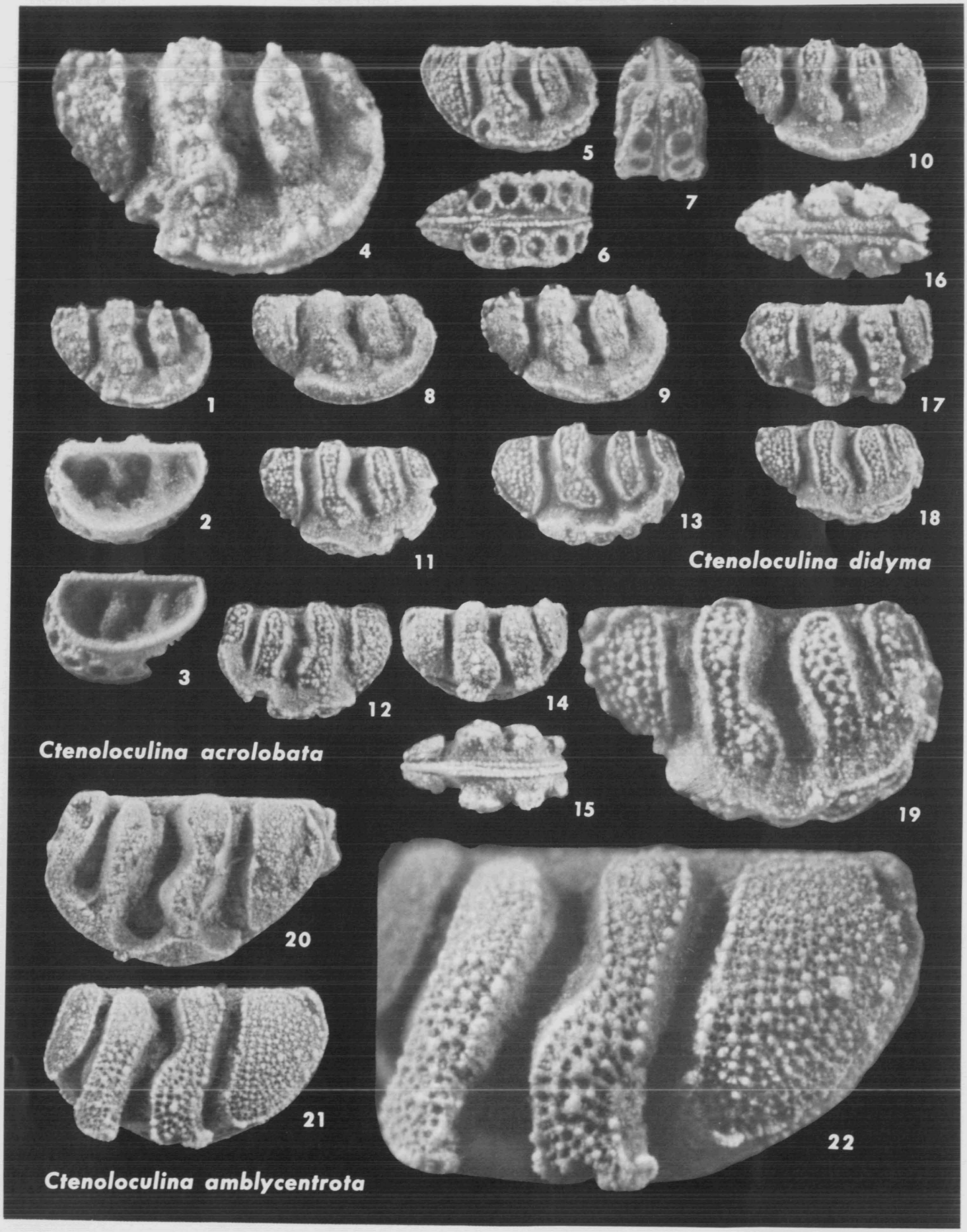
All specimens from Arkona Shale, Locality 3

FIGS. 11–19—11, lateral view of female right valve, paratype 60263. 12, lateral view of female left valve, paratype 60262. 13, lateral view of female right valve, paratype 60279. 14,15, right lateral and ventral views of male or late instar carapace, paratype 60280. 16,17, dorsal and right lateral views of male carapace, paratype 64636. 18,19, lateral views of female right valve, paratype 60266; 19, about x 80.

*Ctenoloculina amblycentrota*

Both specimens from Kashong Shale

FIGS. 20–22—20, left lateral view of female carapace, paratype 60291, Loc. 3. 21,22, left lateral views of male carapace, holotype 60293, Loc. 2.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Ctenoloculina didyma
Ctenoloculina acrolobata
Ctenoloculina amblycentrota

EXPLANATION OF PLATE 4

Figures x 40 except as noted

*Ctenoloculina myurilobata*

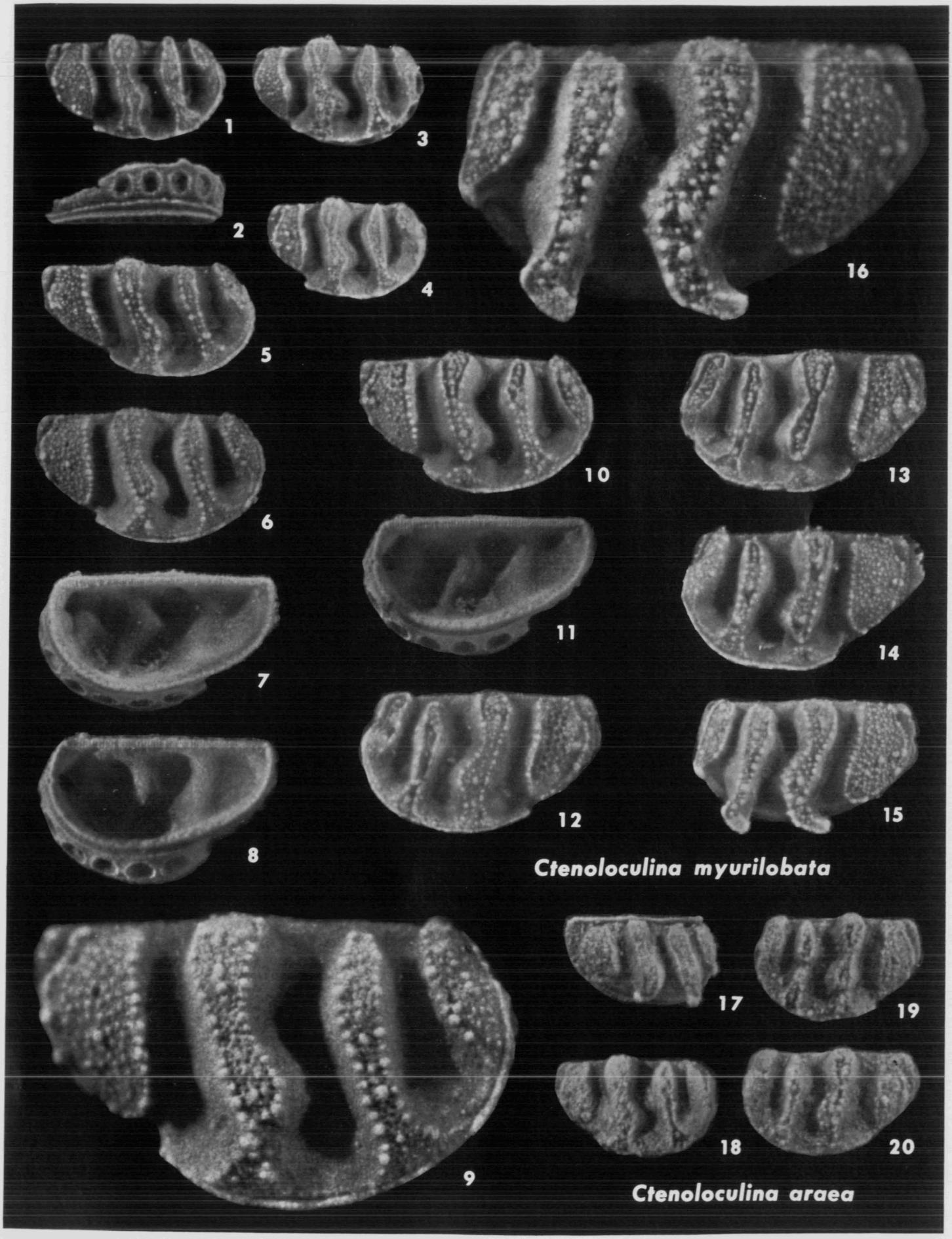
All specimens from Widder Formation

FIGS. 1–16—1,2, lateral and ventral views of female right valve, UMMP 58538, Loc. 3. 3, lateral view of female right valve, 58529, Loc. 1. 4, lateral view of small female right valve, 58540, Loc. 3. 5, lateral view of female right valve, Loc. 3. 6–9, lateral, interior, and inclined interior views of female right valve, 58515, Loc. 1; 9, about x 80. 10,11, lateral and interior views of female right valve, 58518, Loc. 1. 12, lateral view of female left valve, 58511, Loc. 1. 13, lateral view of female left valve, 58487, Loc. 1; note extreme weathering of L4, removing much of thin ornamented outer lamella. 14, lateral view of female left valve, 60237, Loc. 1. 15, 16, lateral view of male left valve, 60238, Loc. 1; note thin spur on L3; 16, about x 80.

*Ctenoloculina araea*

All specimens from Norway Point Formation, Locality 1

FIGS. 17–20—17, right lateral view of male carapace, paratype 60288. 18, lateral view of female right valve, paratype 60285. 19, lateral view of female left valve, holotype 60286. 20, lateral view of female left valve, paratype 60287. Note narrow and (in holotype, especially) constricted L2 and L3, containing little ornamentation. This is the smallest species of the genus.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Ctenoloculina myurilobata
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Ctenoloculina araea

EXPLANATION OF PLATE 5

Figures x 40 except as noted

*Ctenoloculina eurybathrota*

FIGS. 1-11—1-3, right lateral and inclined ventral views of female carapace, UMMP 60246, Wanakah Formation, Loc. 1; 3, about x 80. 4,5, left lateral and inclined ventral views of female carapace, 60245, Centerfield Formation, Loc. 2. 6,7, left lateral views of male carapace, 58478, Arkona Shale, Loc. 1; 7, about x 80. 8,9, right lateral and ventral views of carapace of immature instar, 64641, Arkona Shale, Loc. 1. 10, left lateral view of carapace of immature (probably A-1) instar, 64643, Arkona Shale, Loc. 1. 11, left lateral view of male carapace, 58479, Arkona Shale, Loc. 1.

*Ctenoloculina cicatricosa*

FIGS. 12,13—12, lateral view of female left valve, 64640, Dock Street Clay Member of Four Mile Dam Formation, Loc. 1. 13, lateral view of left valve of immature (probably A-1) instar, 58409, Norway Point Formation, Loc. 1.

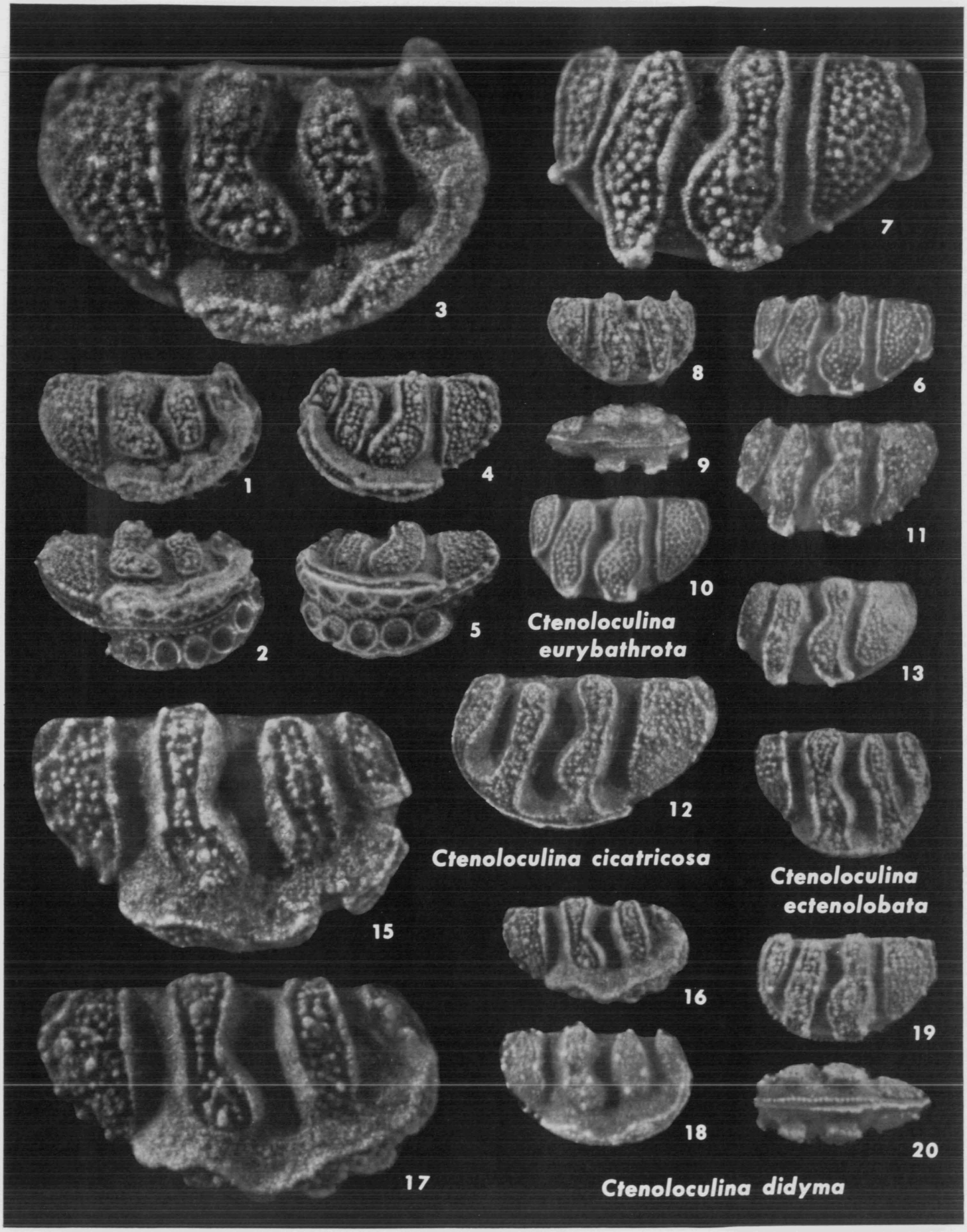
*Ctenoloculina ectenolobata*

FIGS. 14—Lateral view of female right valve, holotype 60265, Wanakah Formation, Loc. 6.

*Ctenoloculina didyma*

All specimens from Arkona Shale, Locality 3

FIGS. 15-20—15, lateral view of female right valve, paratype 60263. 16,17, lateral views of female right valve, holotype 60281, 17, about x 80. 18, lateral view of female right valve, paratype 64635; note original ornamentation (unaltered by weathering) on lobes. 19,20, left lateral and ventral views of male carapace, paratype 64634.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Ctenoloculina eurybathrota
Ctenoloculina cicatricosa
Ctenoloculina ectenolobata
Ctenoloculina didyma

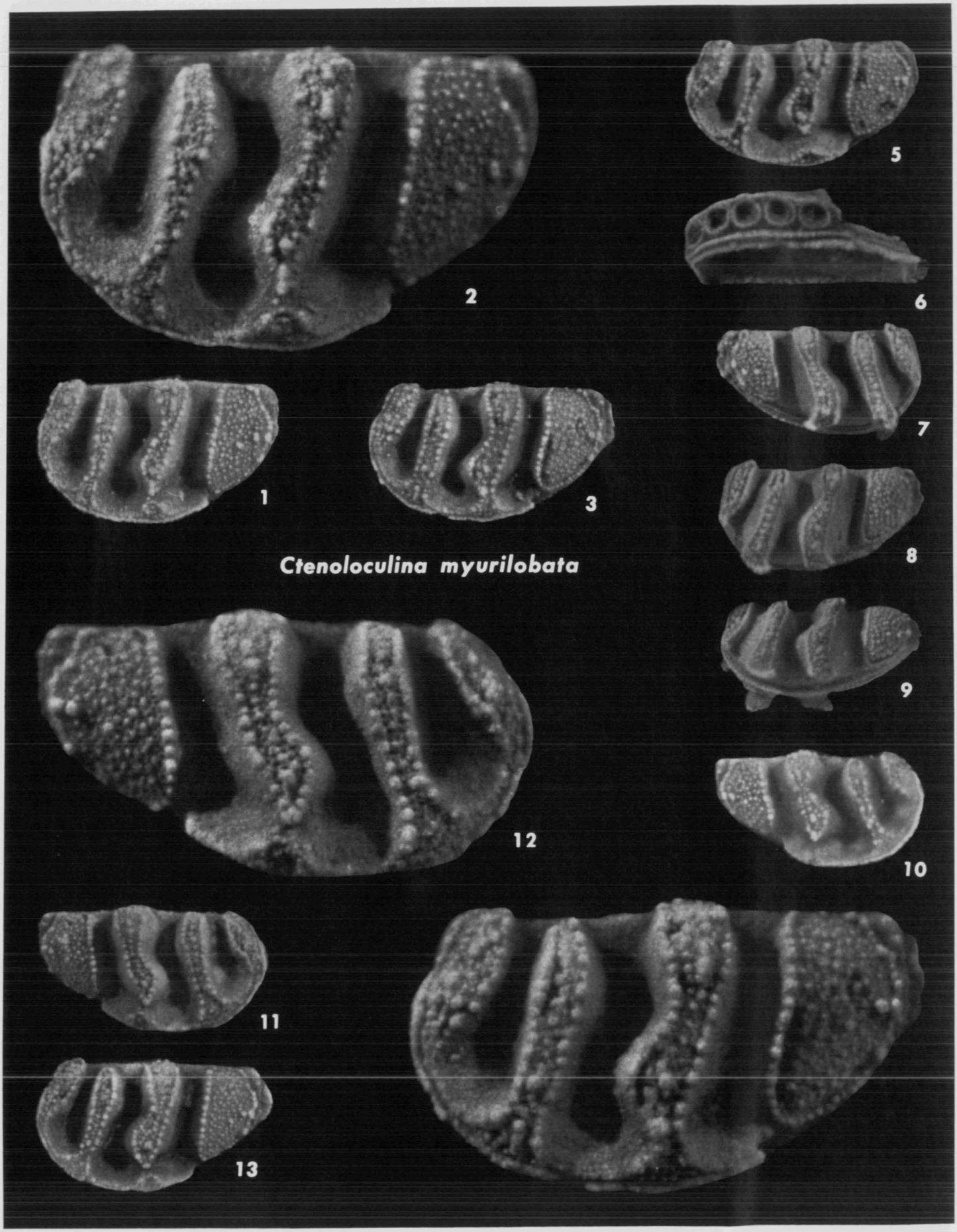
EXPLANATION OF PLATE 6

Figures x 40 except as noted

*Ctenoloculina myurilobata*

All specimens from Widder Formation, Locality 1

FIGS. 1–13—1,2, lateral views of female left valve, UMMP 58493; 2, about x 80. 3,4, lateral views of female left valve, 58501; 4, about x 80. 5,6, lateral and inclined ventral views of female left valve, 58502; note wide interruption of ornamented area on L3. 7-9, right lateral, left lateral, and inclined ventral views of male carapace, 60239. 10, lateral view of female right valve, 58527; note very narrow ornamented area on L2 and acuminate termination of that on L3. 11,12, lateral views of female right valve, 58528; 12, about x 80; note ventral constriction of L3 at its junction with the frill. 13, lateral view of female left valve, 58488; note remnants of flange at posterior end.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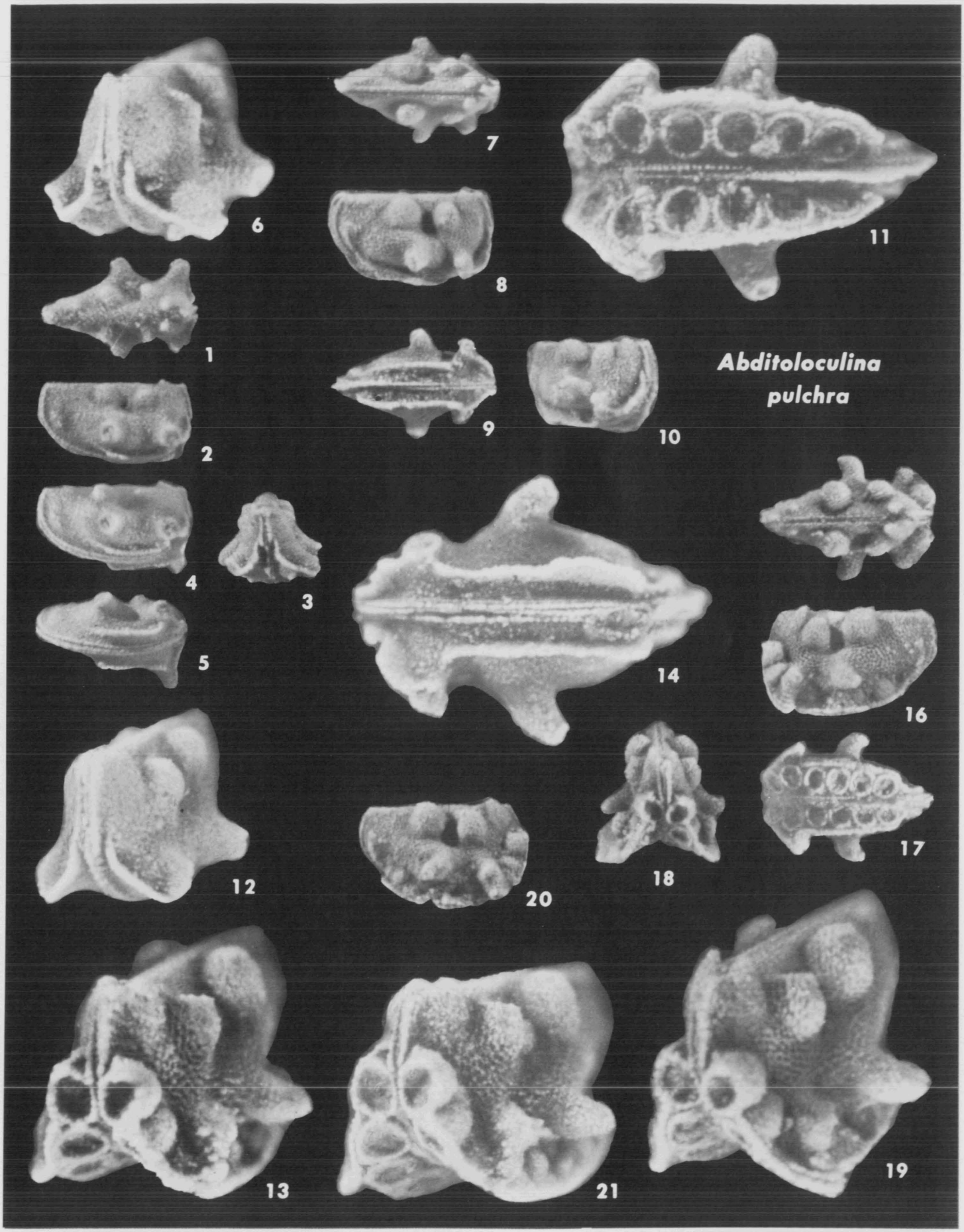
EXPLANATION OF PLATE 7

Figures x 40 except as noted

*Abditoloculina pulchra*

All specimens from Centerfield Formation, Locality 2

FIGS. 1–21—1–6, dorsal, right lateral, anterior, right inclined, ventral inclined, and anterior inclined views of male carapace, UMMP 60273, 6, about x 80. 7–10, dorsal, right lateral, ventral, and anterolateral views of male carapace, 60276. 11, ventral view of female carapace, 60136, about x 80. 12, inclined anterior view of male carapace, paratype 30500, about x 80. 13, inclined anterior view of female carapace, paratype 30487, about x 80. 14, ventral view of male carapace, 60135, about x 80. 15–19, dorsal, left lateral, ventral, anterodorsal, and inclined anterior views of female carapace, 60274; 19, about x 80. 20, right lateral view of female carapace, 60275. 21, inclined anterior view of female carapace, holotype 30497, about x 80.


Abditoloculina
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EXPLANATION OF PLATE 8

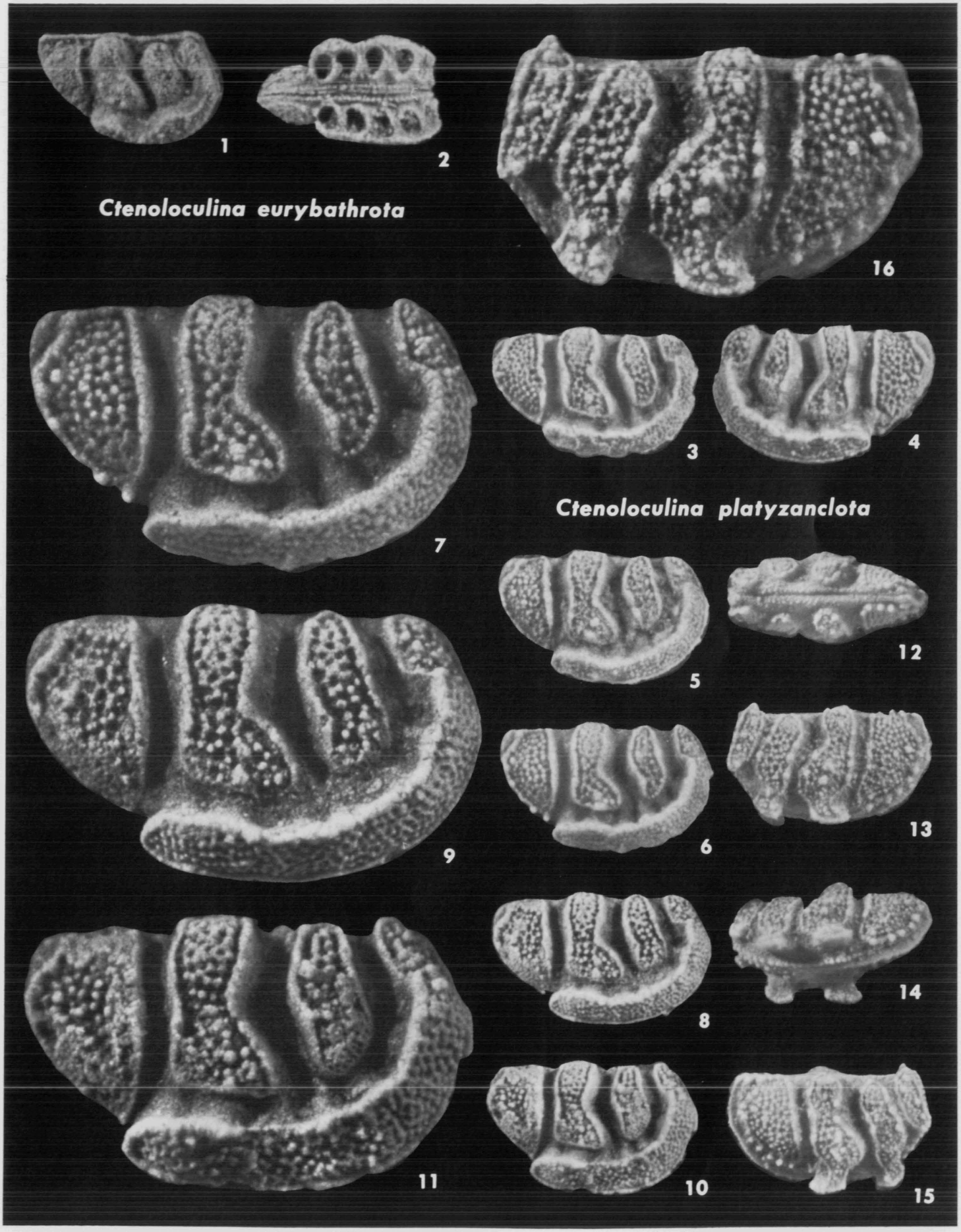
Figures x 40 except as noted

*Ctenoloculina eurybathrota*

FIGS. 1,2—right lateral and ventral views of female carapace, 60169, Ferron Point Formation, Loc. 3.

*Ctenoloculina platyzanclota*

FIGS. 3–16—3, lateral view of female right valve, 58567, Arkona Shale, Loc. 1. 4, lateral view of female left valve, 58550, Arkona Shale, Loc. 1. 5, lateral view of female right valve, 58573, Arkona Shale, Loc. 1. 6,7, lateral views of female right valve, 60277, Arkona Shale, Loc. 7; 7, about x 80. 8,9, lateral views of female right valve, 60241, Arkona Shale, Loc. 1; 9, about x 80. 10,11, lateral views of female right valve, 58589, Arkona Shale, Loc. 5; 11, about x 80. 12–16, dorsal, left lateral, inclined ventral, and right lateral views of male carapace, 60243, Ferron Point Formation, Loc. 3; 16, about x 80.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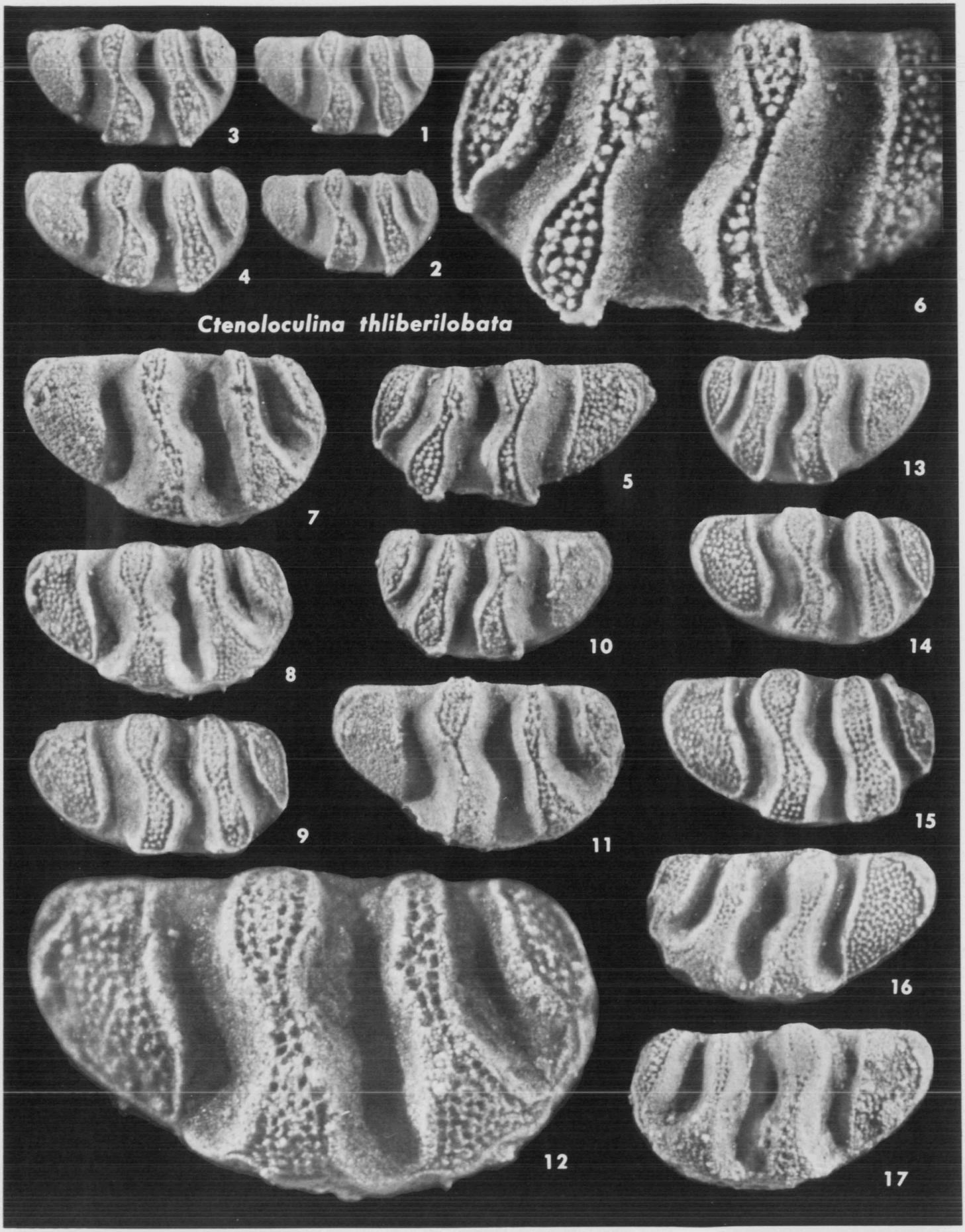
EXPLANATION OF PLATE 9

Figures x 40 except as noted

*Ctenoloculina thliberilobata*

All specimens from Arkona Shale, Locality 1

FIGS. 1–17—1,2, lateral views of penultimate instar (A–2) right valves, UMMP 58017 and 58016. 3,4, lateral views of ultimate instar (A–1) right valves, 58089 and 58088; note median constriction of L3 and ventral expansion of L2. 5,6, lateral views of male left valve, 58063; 6, about x 80; note median constrictions of L2 and L3. 7,8, lateral views of two female right valves, 58020 and 58052; note constrictions of L3 and ventral expansions of L2, with ornamented areas of both extending to ventral border. 9, lateral view of male right valve, 58099. 10, lateral view of ultimate instar (A–1) left valve, 58072. 11, lateral view of female right valve, 58029; note median reduction of L3 to a slit. 12, lateral view of female right valve, 58052, about x 80. 13,14, lateral views of ultimate instar (A–1) left and right valves, 58071 and 58095. 15, lateral view of male right valve, 58083. 16, lateral view of female left valve, 58008. 17, lateral view of female left valve, 57998; note ornamented areas of L2 and L3 nearly interrupted by median constrictions.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Ctenoloculina thliberilobata
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EXPLANATION OF PLATE 10

Figures x 40 except as noted

*Ctenoloculina platyzanclota*

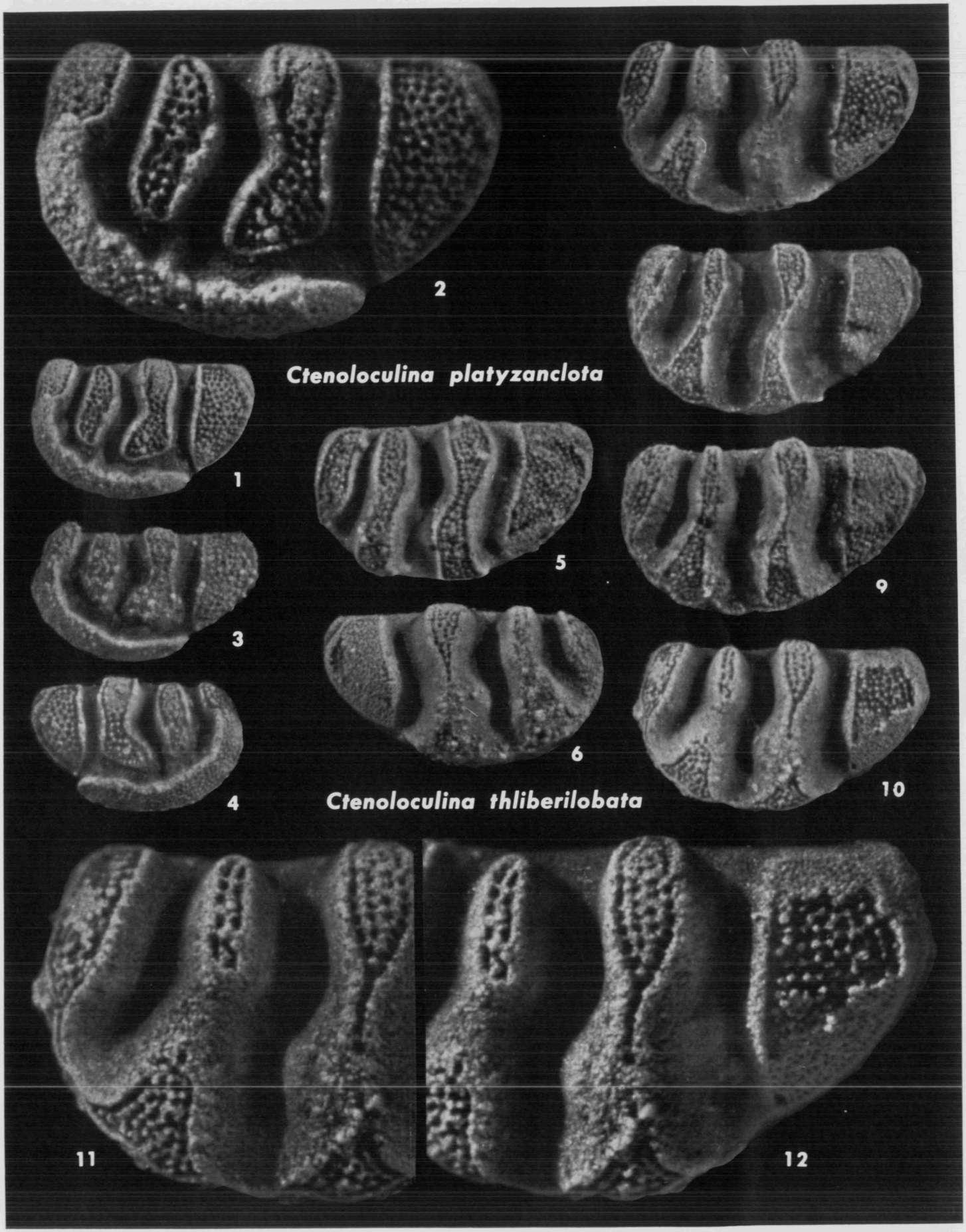
All specimens from Arkona Shale

FIGS. 1–4—1,2, lateral views of female left valve, UMMP 58583, Loc. 5; 2, about x 80; note wide ornamented area of frill. 3, lateral view of female left valve, 58557, Loc. 1. 4, lateral view of female right valve, 60278, Loc. 7.

*Ctenoloculina thliberilobata*

All specimens from Arkona Shale, Locality 1

FIGS. 5–12—5, lateral view of male left valve, 58078. 6, lateral view of female right valve, 58033. 7, lateral view of female left valve, 58006; note effacement of ornamentation on large areas of L2 and L3. 8,9, lateral views of two female left valves, 58009 and 58014. 10–12, lateral views of female left valve, 58012; 11,12, about x 80; note median interruption of ornamented area of L2 and reduction of ornamented area of L3 to a slit; L4 retains marginal areas of exterior ornamentation.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Ctenoloculina thliberilobata
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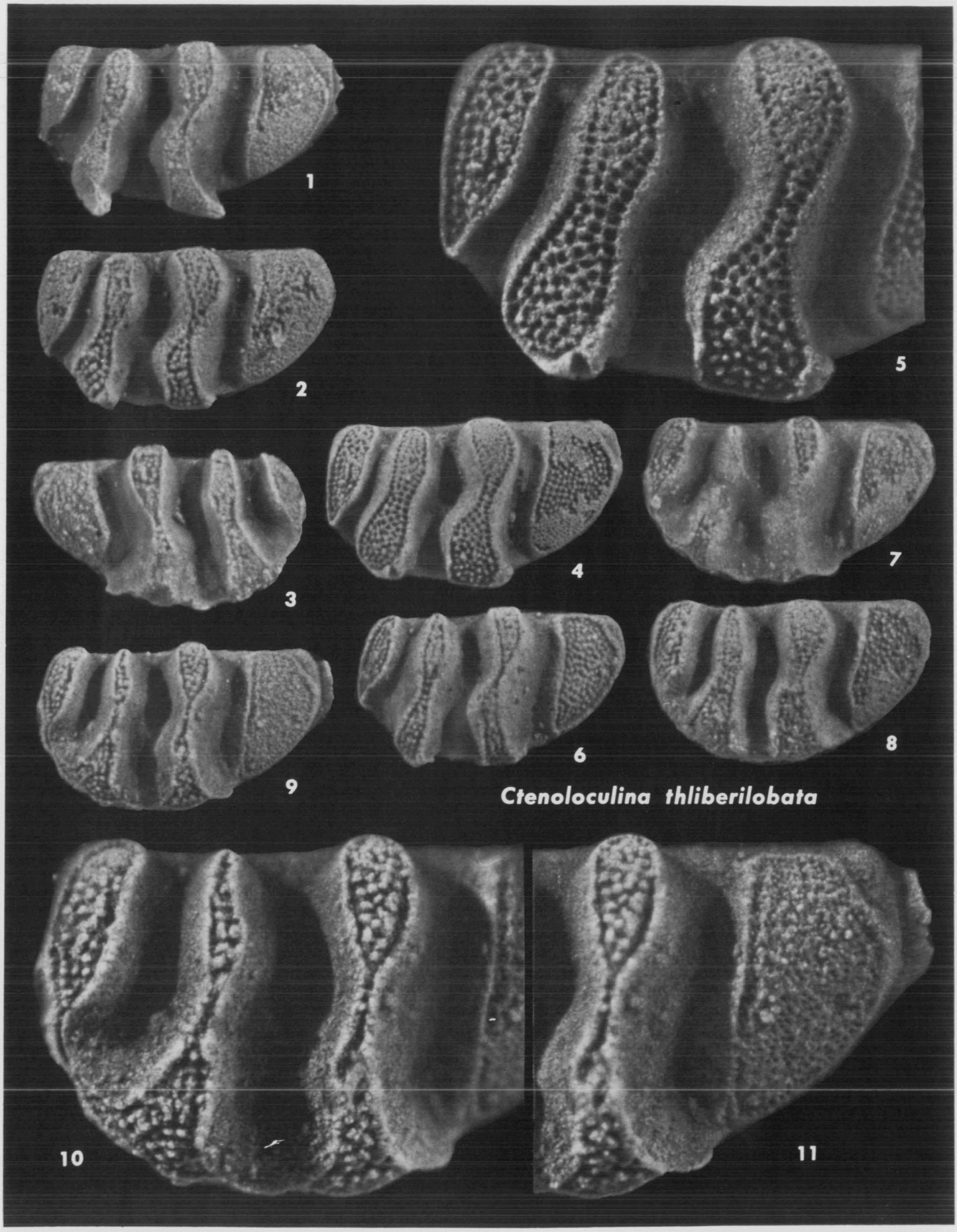
EXPLANATION OF PLATE 11

Figures x 40 except as noted

*Ctenoloculina thliberilobata*

All specimens from Arkona Shale, Locality 1

FIGS. 1-11—1,2, lateral views of two male left valves, UMMP 58061 and 58054. 3, lateral view of female right valve, 58051. 4,5, lateral views of male left valve, 58057; 5, about x 80. 6, lateral view of male left valve, 58068. 7, lateral views of female left valve, 58002; note effacement of large areas of ornamentation on L2 and L3. 8, lateral view of female left valve, 58019. 9-11, lateral views of female left valve, 58007; 10,11, about x 80; note remnant of flange on posterior end of valve.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Ctenoloculina thliberilobata

EXPLANATION OF PLATE 12

Figures x 40 except as noted

*Ctenoloculina platyzanclota*

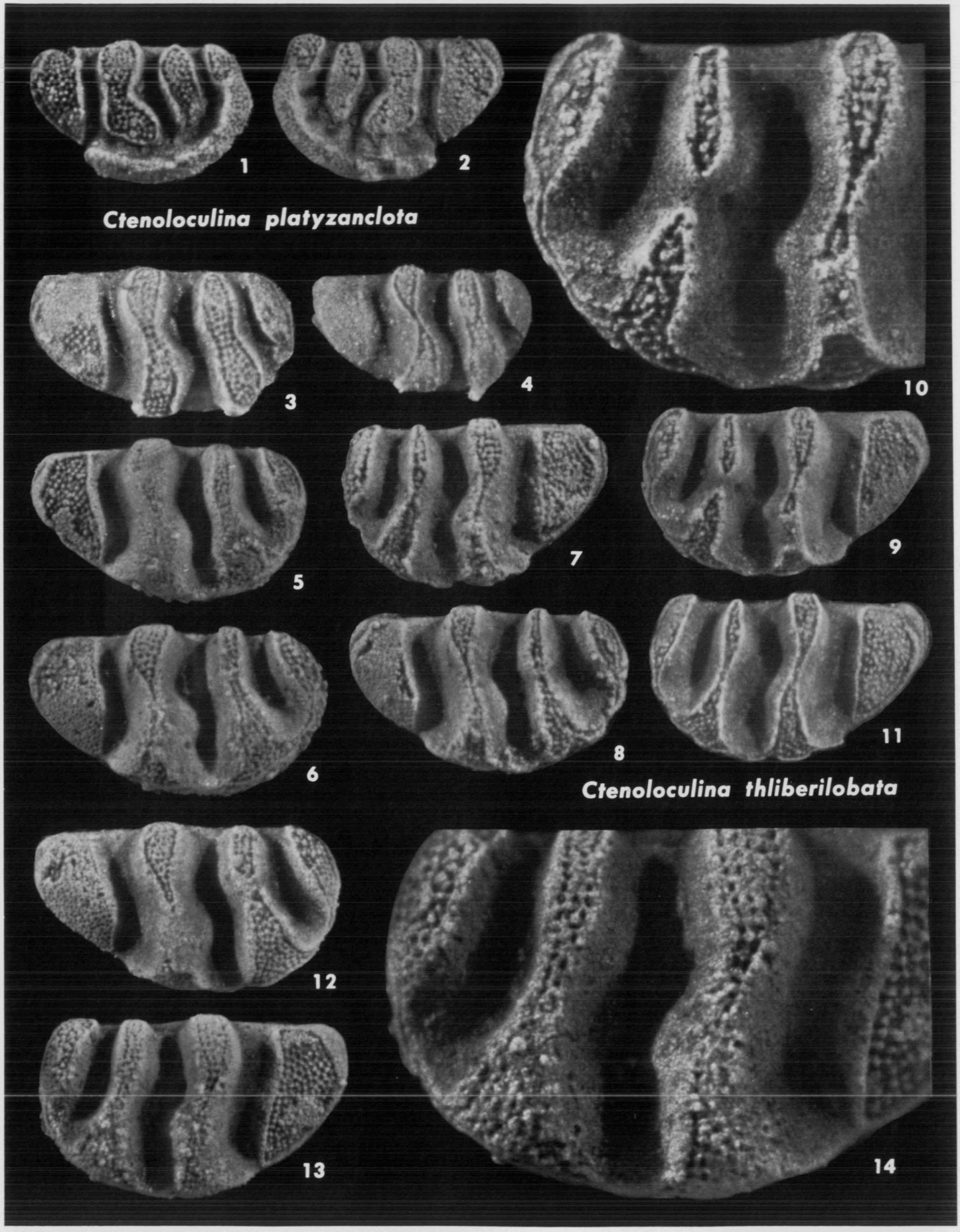
Both specimens from Arkona Shale

FIGS. 1,2—1, lateral view of female right valve, UMMP 58592, Loc. 5. 2, lateral view of female left valve, 58558, Loc. 1.

*Ctenoloculina thliberilobata*

All specimens from Arkona Shale, Locality 1

FIGS. 3–14—3, lateral view of male right valve, 58111. 4, lateral view of immature (A–1) right valve, 58104. 5, lateral view of female right valve, 58025. 6, lateral view of female right valve, 58044. 7, lateral view of female left valve, 57994. 8, lateral view of female right valve, 58026. 9,10, lateral views of female left valve, 58022; 10, about x 80; note complete interruption of ornamented area on L2. 11, lateral view of female left valve, 58011. 12, lateral view of female right valve, 60248; note complete interruption of ornamented area on L3. 13,14, lateral views of female left valve, 57993.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EXPLANATION OF PLATE 13

Figures x 40 except as noted

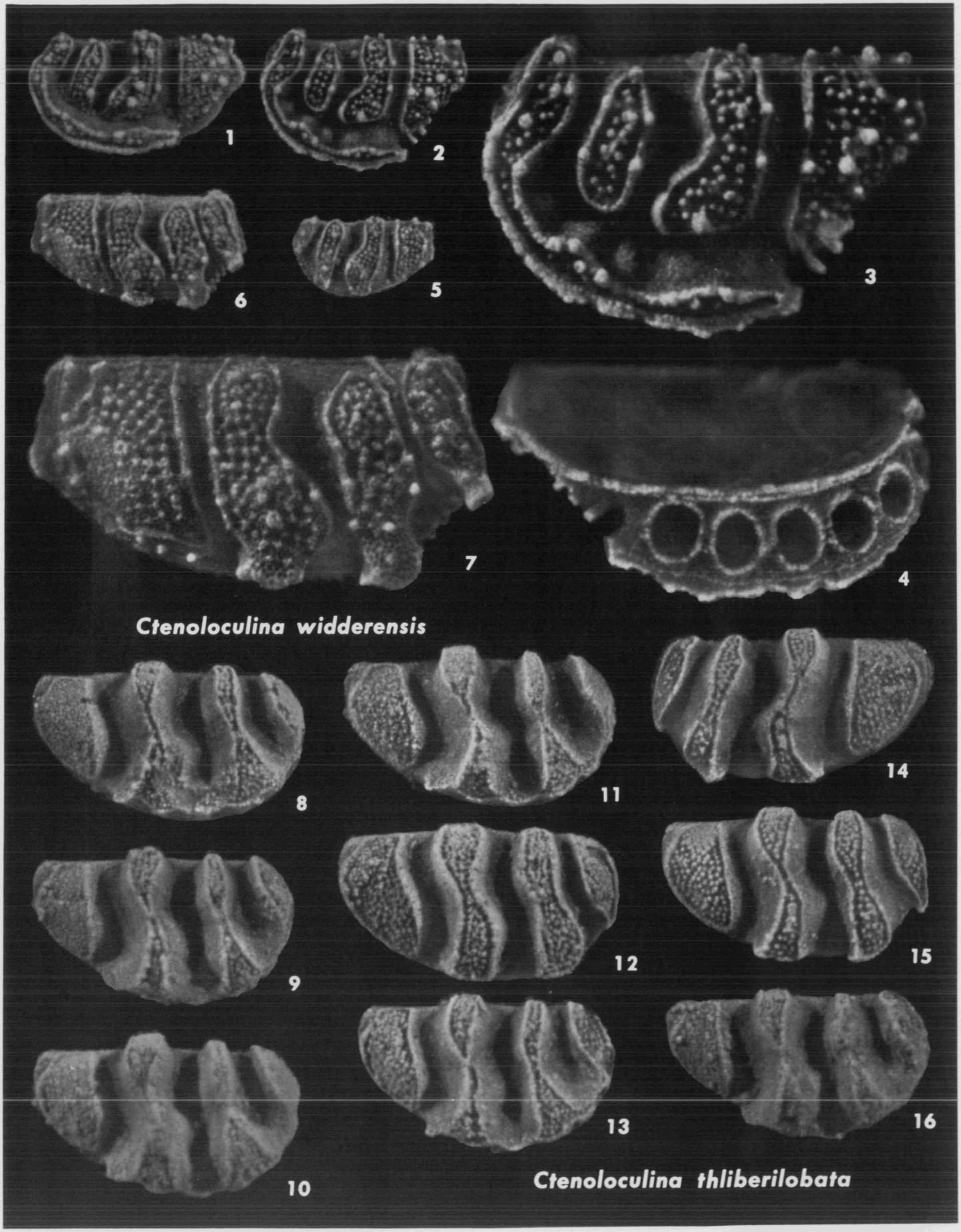
*Ctenoloculina widderensis*

FIGS. 1–7—1, left lateral view of female carapace, paratype UMMP 64632, Wanakah Formation, Loc. 1. 2–4, lateral and inclined ventral views of female left valve, paratype 58400, Widder Formation, Loc. 3; 3,4, about x 80. 5, left lateral view of immature carapace, paratype 64633, Wanakah Formation, Loc. 1. 6,7, right lateral views of male carapace, holotype 64627, Widder Formation, Loc. 1; note constrictions near ventral ends of lobes.

*Ctenoloculina thliberilobata*

All specimens from Arkona Shale

FIGS. 8–16—8–10, lateral views of three female right valves, 58038, 58039, and 58036, Loc. 1. 11, lateral view of female right valve, 58043, Loc. 1. 12, lateral view of male right valve, 58012, Loc. 1. 13, lateral view of female right valve, 58027, Loc. 1. 14, lateral view of male left valve, 58067, Loc. 1. 15, lateral view of male right valve, 60249, Loc. 7. 16, lateral view of female right valve, 58046. Note variable median constrictions of L2 and L3.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Ctenoloculina widderensis
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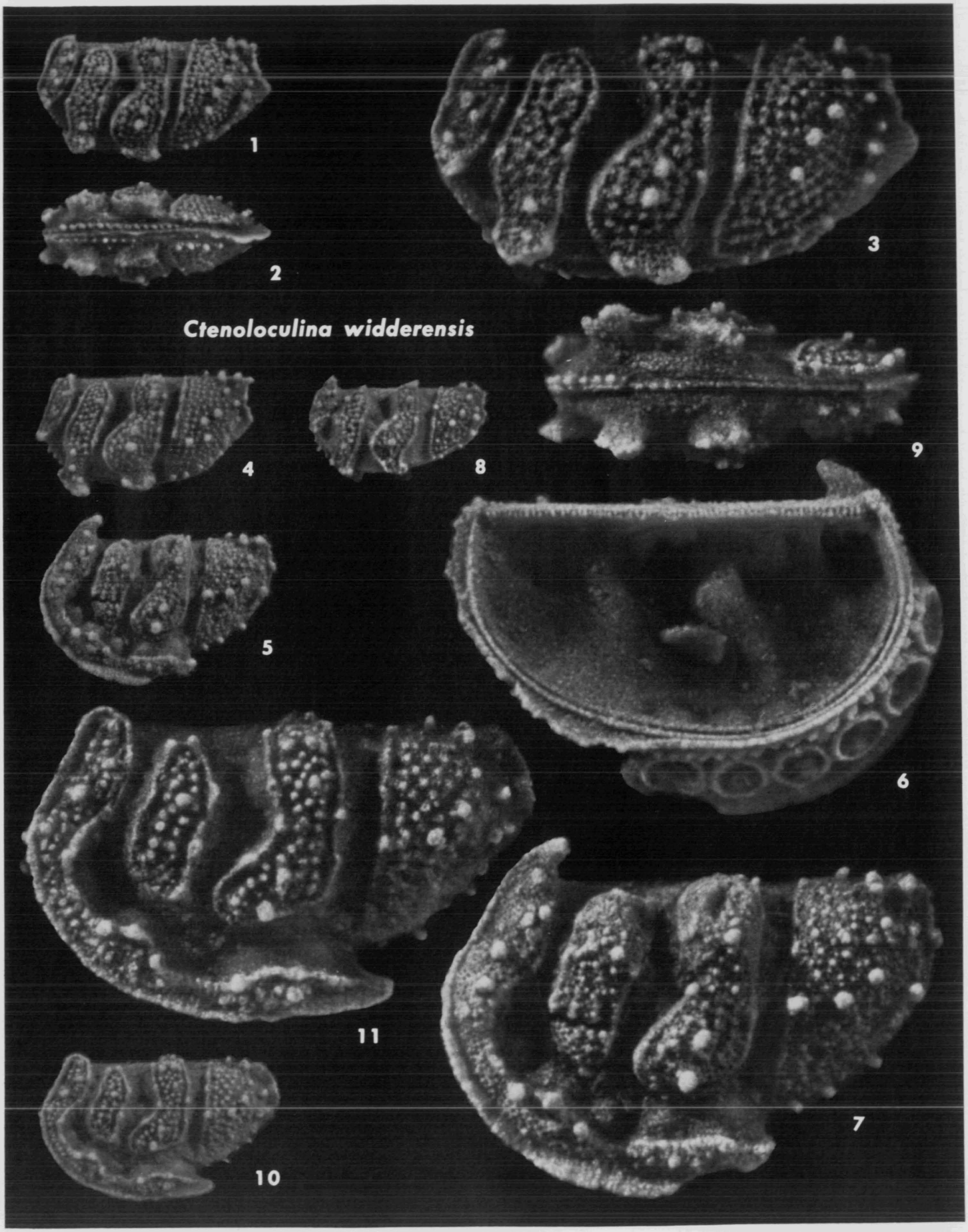
Ctenoloculina thliberilobata

EXPLANATION OF PLATE 14

Figures x 40 except as noted

*Ctenoloculina widderensis*

FIGS. 1–11—1–3, left lateral and ventral views of male carapace, paratype UMMP 64631, Wanakah Formation, Loc. 1; 3, about x 80. 4, left lateral view of male carapace, paratype 64626, Widder Formation, Loc. 1. 5–7, lateral and interior views of female left valve, paratype 64630, Wanakah Formation, Loc. 1; 6,7, about x 80; note flange developed alongside closing edge in posterior half of valve. 8,9, left lateral and ventral views of immature (A–1) carapace, paratype 64628, Widder Formation, Loc. 1. 10,11, lateral views of female left valve, paratype 64625, Widder Formation, Loc. 1; 11, about x 80; note fairly consistent pattern of large papillae or blunt spinelets on ornamented parts of lobes; compare with Fig. 7.


Ctenoloculina widderensis
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EXPLANATION OF PLATE 15

Figures x 40 except as noted

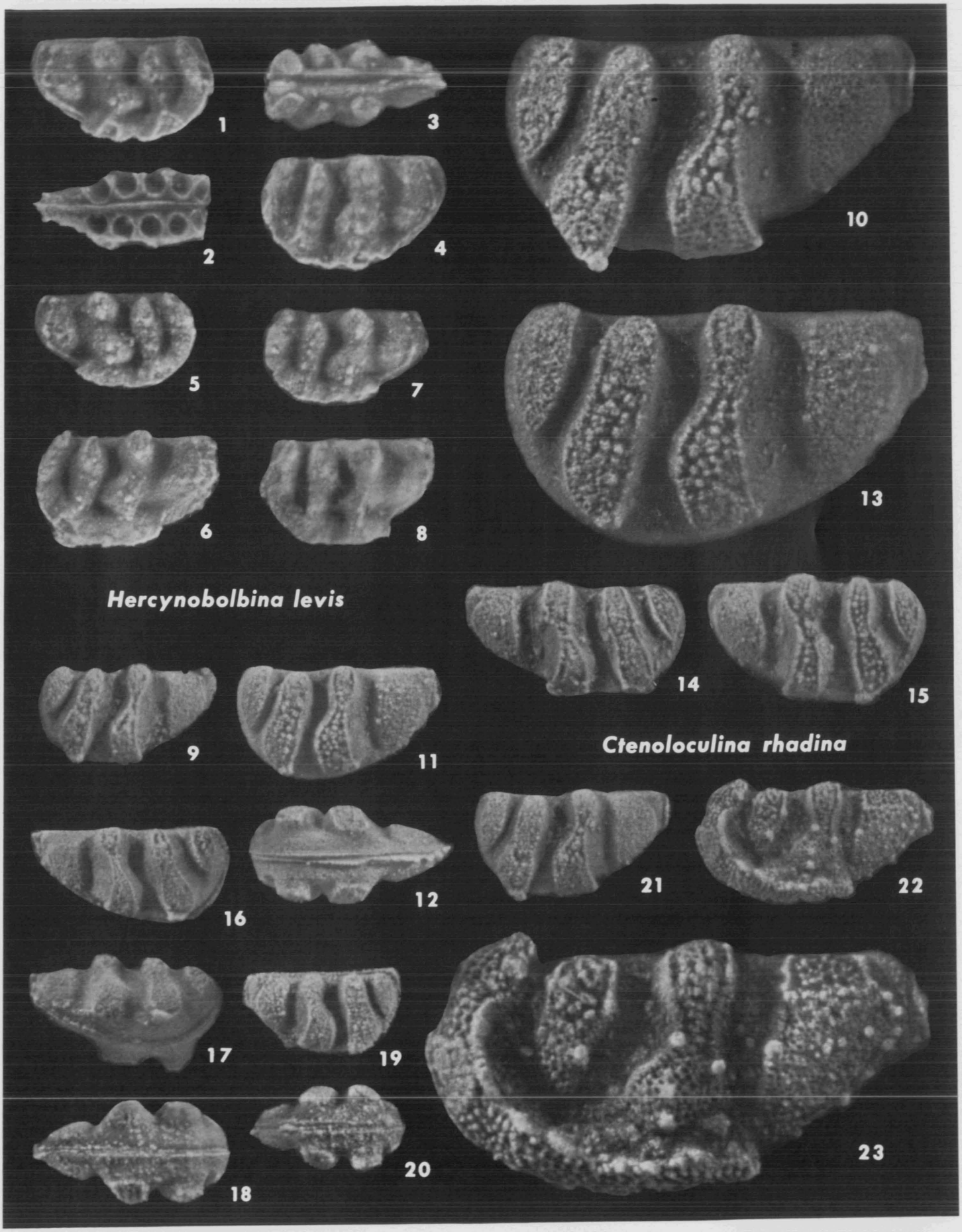
*Hercynobolbina levis*

FIGS. 1–8—1,2, right lateral and ventral views of female carapace, UMMP paratype 64752, Potter Farm Formation, Loc. 1. 3,4, dorsal and left lateral views of female carapace, paratype 64650, Norway Point Formation, Loc. 1. 5, lateral view of small female right valve, paratype 64751, Norway Point Formation, Loc. 1. 6, lateral view of female left valve, paratype 64753, Petoskey Formation, Loc. 3; note faint indications of ornamentation on L2 and L3, reminiscent of *Ctenoloculina*. 7, left lateral view of female carapace, paratype 64649, Norway Point Formation, Loc. 1. 8, lateral view of female left valve, holotype 38843, Petoskey Formation, Loc. 2.

*Ctenoloculina rhadina*

All specimens from Arkona Shale

FIGS. 9–23—9, lateral view of male left valve, paratype 60269, Loc. 5. 11–13, left lateral and ventral views of male carapace, paratype 60296, Loc. 4; 13, about x 80. 14,15, lateral views of two male right valves, holotype 60270, and paratype 60271, Loc. 5. 16–18, right lateral and ventral views of immature (A–1?) carapace, paratype 60267, Loc. 5. 10,21, lateral views of male left valve, paratype 64629, Loc. 5; 10, about x 80. 22,23, lateral views of female left valve, paratype 60272, Loc. 5; 23, about x 80.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Ctenoloculina rhadina
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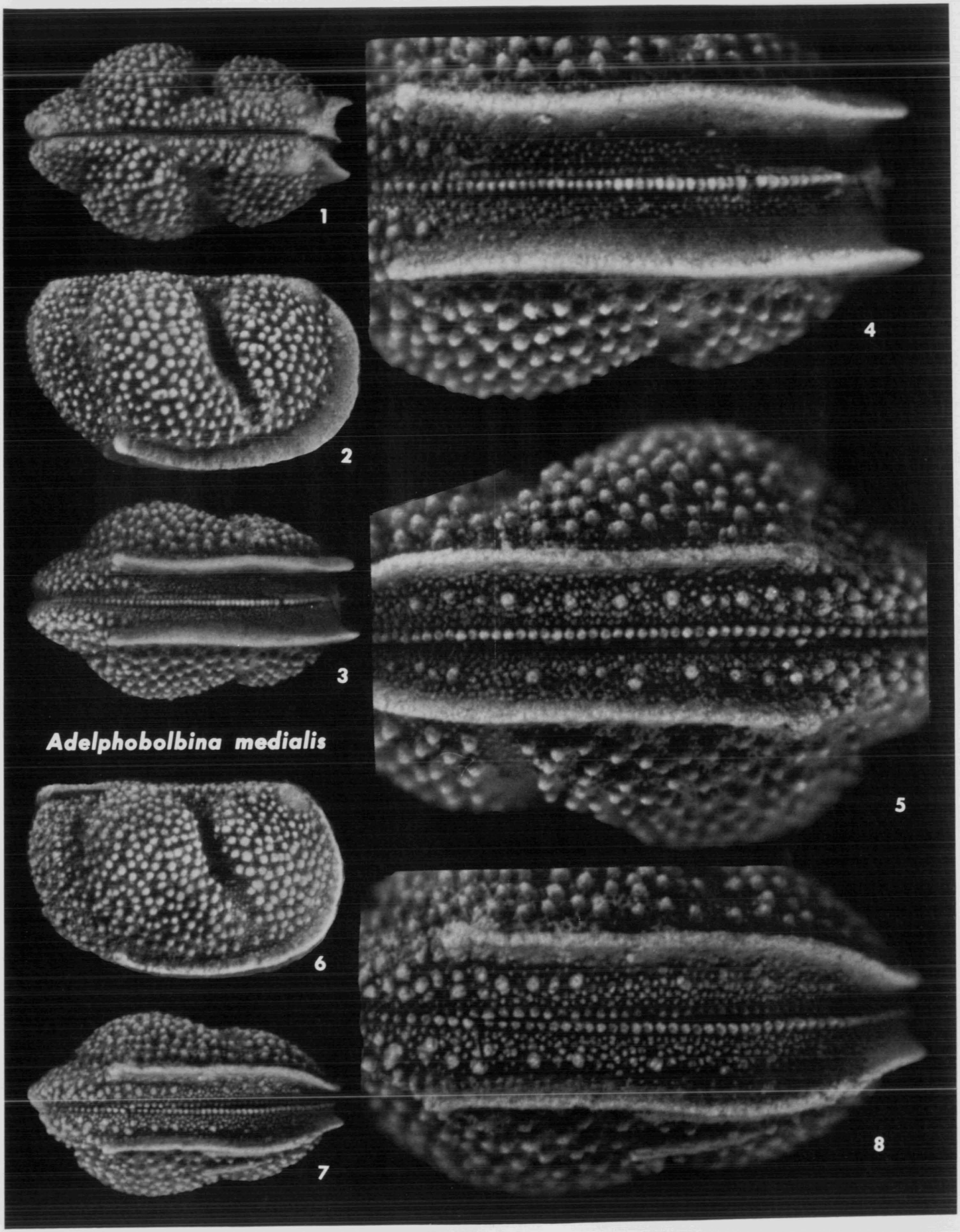
EXPLANATION OF PLATE 16

Figures x 40 except as noted

*Adelphobolbina medialis*

All specimens from Ledyard Shale, Locality 1

FIGS. 1–8—1–4, dorsal, right lateral, and ventral views of female carapace, UMMP 60130; 4, about x 80; note wide and nearly smooth anteroventral sections of antra. 5, ventral view of male carapace, 60158, about x 80. 6–8, right lateral and ventral views of male carapace, 60157; 8, about x 80; note ornamented and constricted anteroventral sections of antra.



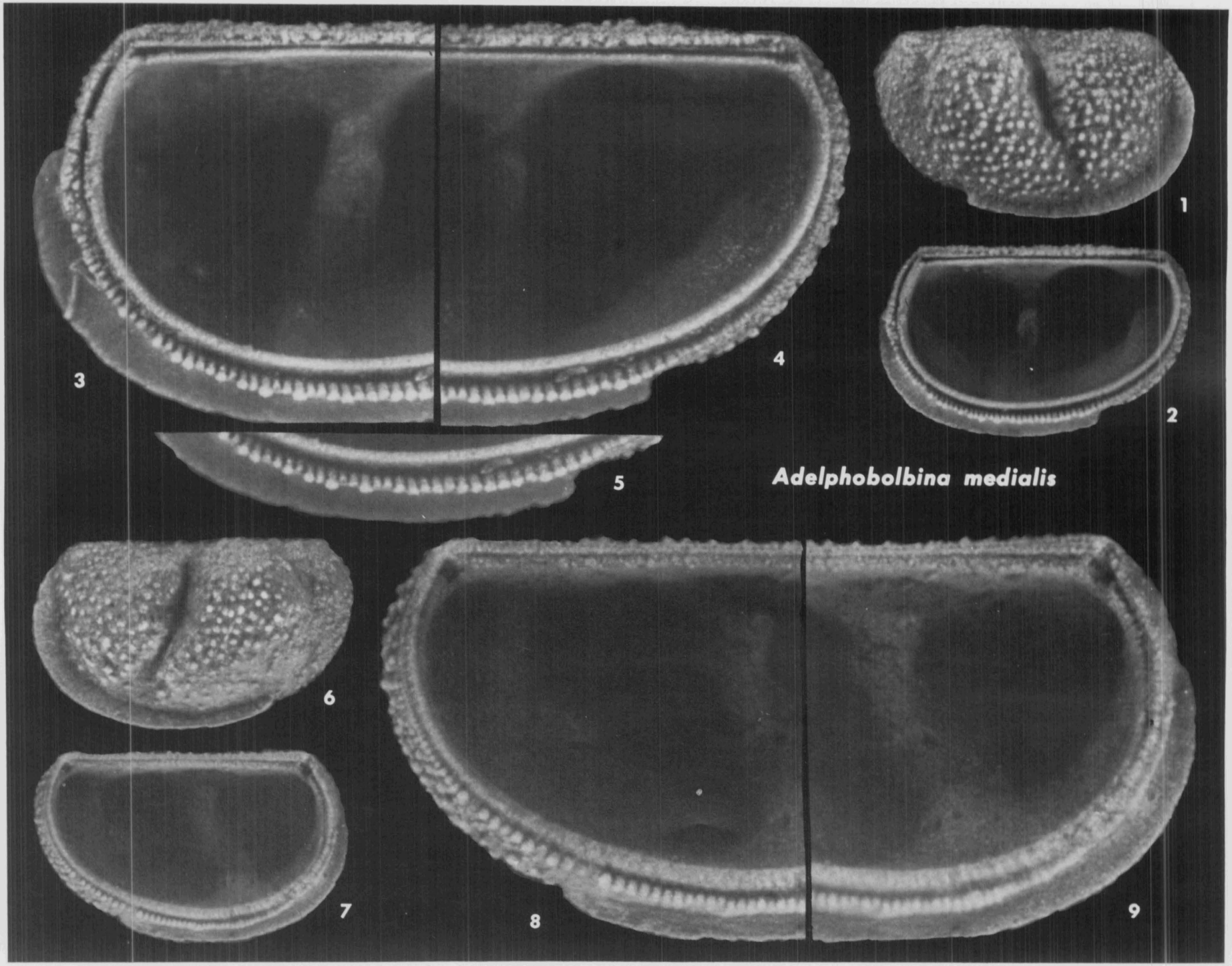

*Adelphobolbina medialis*

EXPLANATION OF PLATE 17

All figures x 40 except as noted

*Adelphobolbina medialis*

FIGS. 1-9—1-5, lateral and interior views of male right valve, UMMP 60133, Wanakah Shale, Loc. 4; 3-5, about x 80. 6-9, lateral and inclined views of left valve, 60160, Ledyard Shale, Loc. 1; 8,9, about x 80. Note how edge of right valve fits into groove of the left. The scar left by the adductor muscles can be faintly seen in Fig. 9. The function of the closely spaced marginal denticles is not fully substantiated, but they may have served as interlocking structures in the closure of the carapace.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Adelphobolbina medialis
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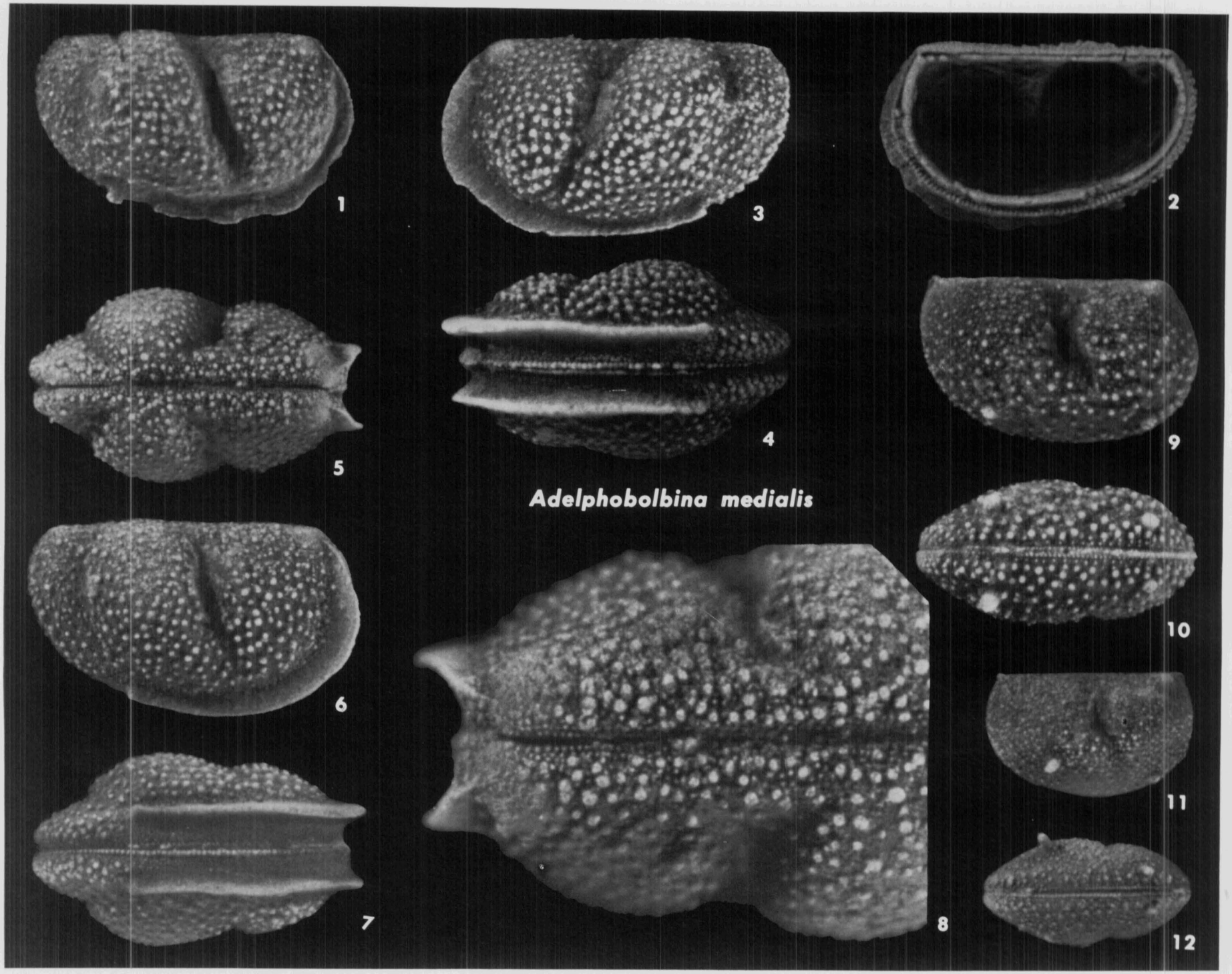
EXPLANATION OF PLATE 18

Figures x 40 except as noted

*Adelphobolbina medialis*

FIGS. 1–12—1,2, lateral and interior views of right valve, UMMP 60163, Wanakah Formation, Loc. 4. 3,4, left lateral and ventral views of female carapace, 60167, Ledyard Shale, Loc. 1; note nearly smooth antra. 5–8, dorsal, right lateral, and ventral views of female carapace, 60159, Ledyard Shale, Loc. 1; 8, about x 80; note pattern of papillae comprising the ornamentation. 9,10, right lateral and ventral views of immature (A–1) carapace, 60166, Kashong Shale, Loc. 1. 11,12, right lateral and ventral views of immature (A–2) carapace, 60165, Wanakah Formation, Loc. 4; note prominent spurs and ornamentation finer than that of the adult.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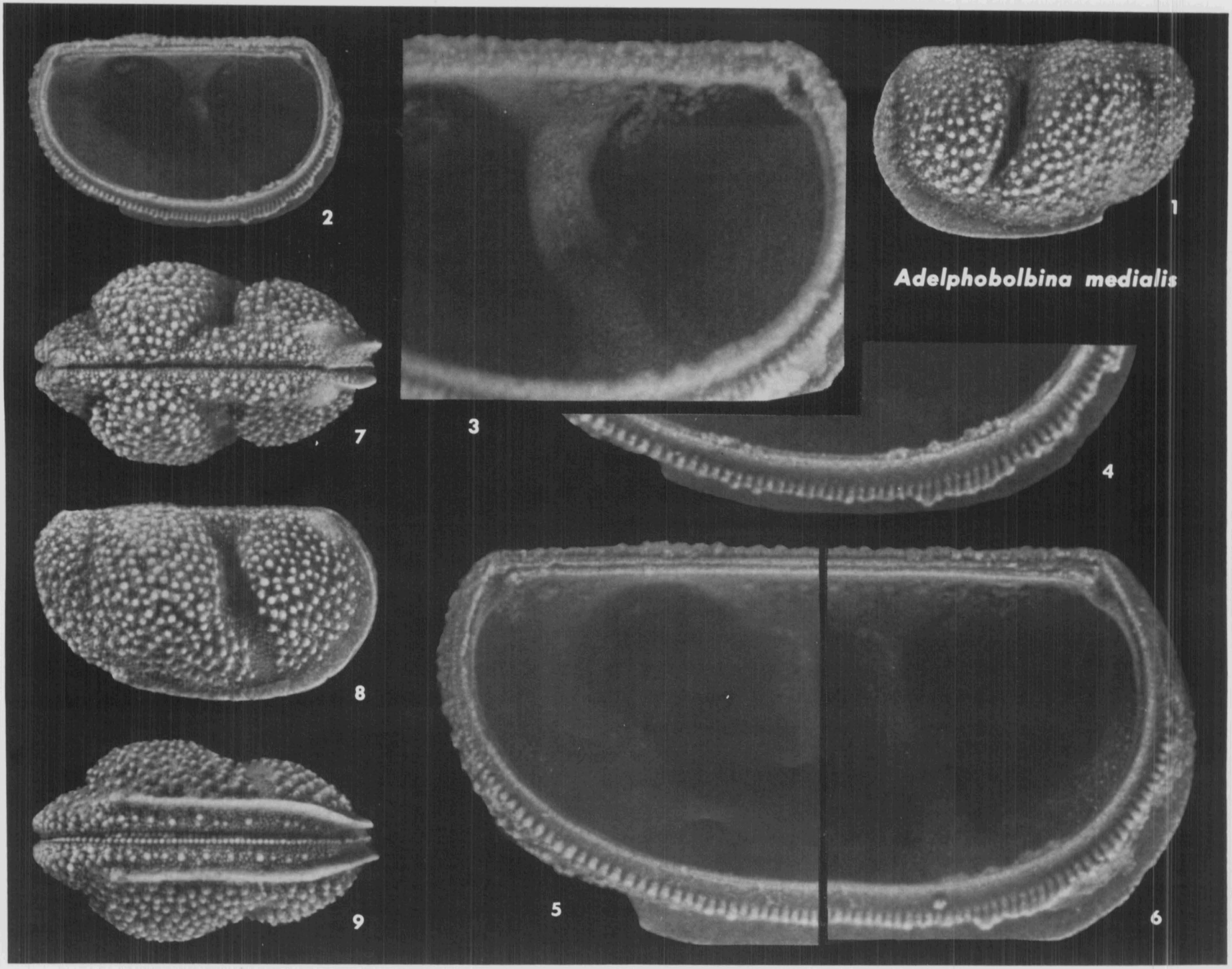
EXPLANATION OF PLATE 19

Figures x 40 except as noted

*Adelphobolbina medialis*

Both specimens from Ledyard Shale, Locality 1

FIGS. 1-9—1-6, lateral and interior views of left valve, UMMP 60132; 3-6, about x 80; Fig. 3 focused on adductor muscle scar field, containing depressed circlets; Figs. 4-6 showing hingement and closely spaced marginal denticles, the latter delicate and partly broken off. 7-9, dorsal, right lateral, and ventral views of male carapace, 60158; note antra are ornamented and anteroventrally constricted.


Adelphobolbina medialis
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EXPLANATION OF PLATE 20

Figures x 40 except as noted

*Adelphobolbina trilobata*

Both specimens from Ferron Point Formation

FIGS. 1–4—1,2, left lateral and ventral views of male carapace, UMMP 64780, Loc. 3. 3,4, right lateral and ventral views of immature (A–1) carapace, 64782, Loc. 1. Note finer ornamentation in this species than in *A. spicata* or *A. medialis.*

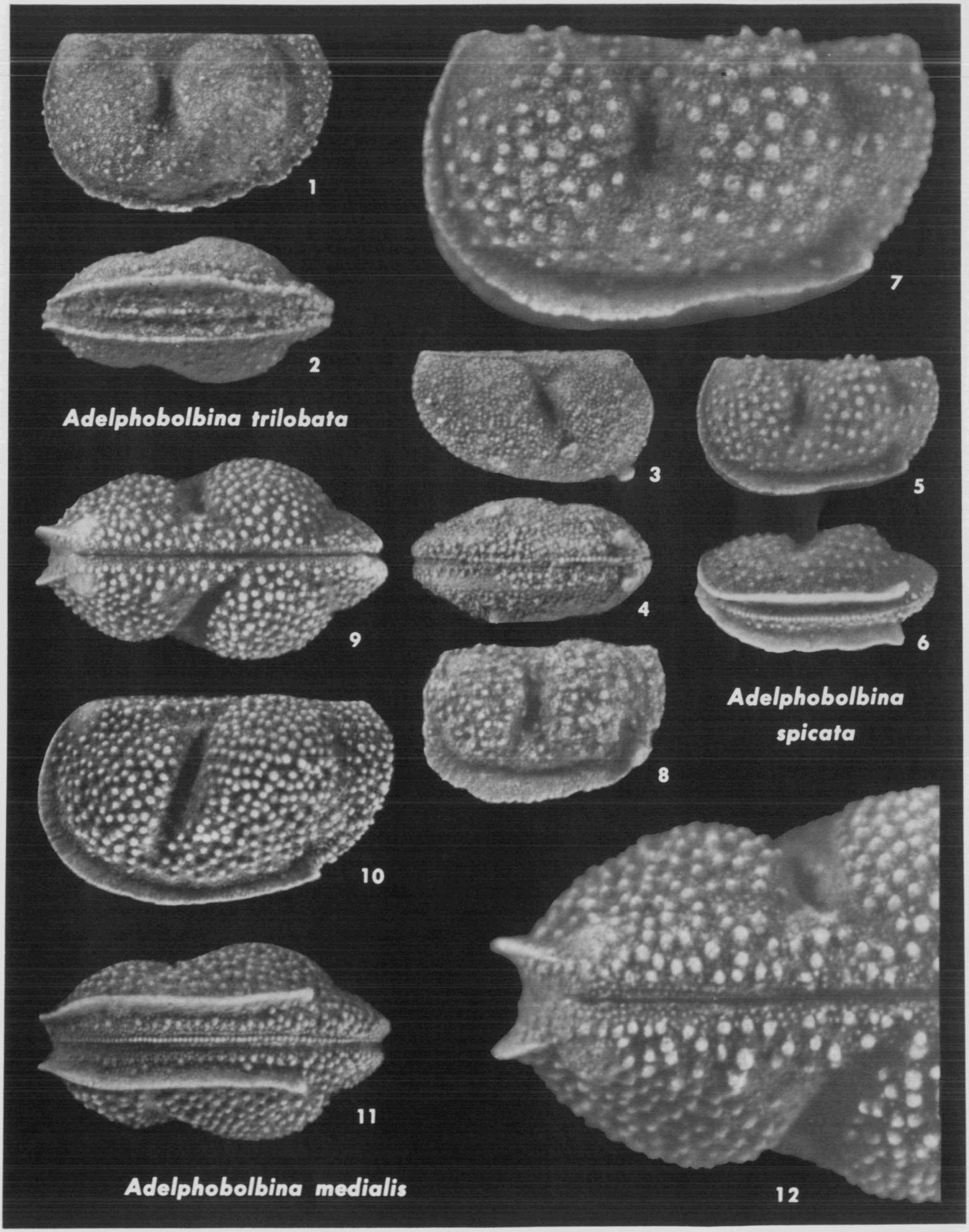
*Adelphobolbina spicata*

Both specimens from Bell Shale, Locality 2

FIGS. 5–8—5–7, left lateral and inclined ventral views of male carapace, 64779; 7, about x 80; note height of larger papillae or spinelets. 8, lateral view of female left valve, 64778.

*Adelphobolbina medialis*

FIGS. 9–12—dorsal, left lateral, and ventral views of male carapace, 60131, Ledyard Shale, Loc. 1; 12, about x 80. Note larger papillae are lower and more closely spaced than those of *A. spicata.*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Adelphobolbina medialis

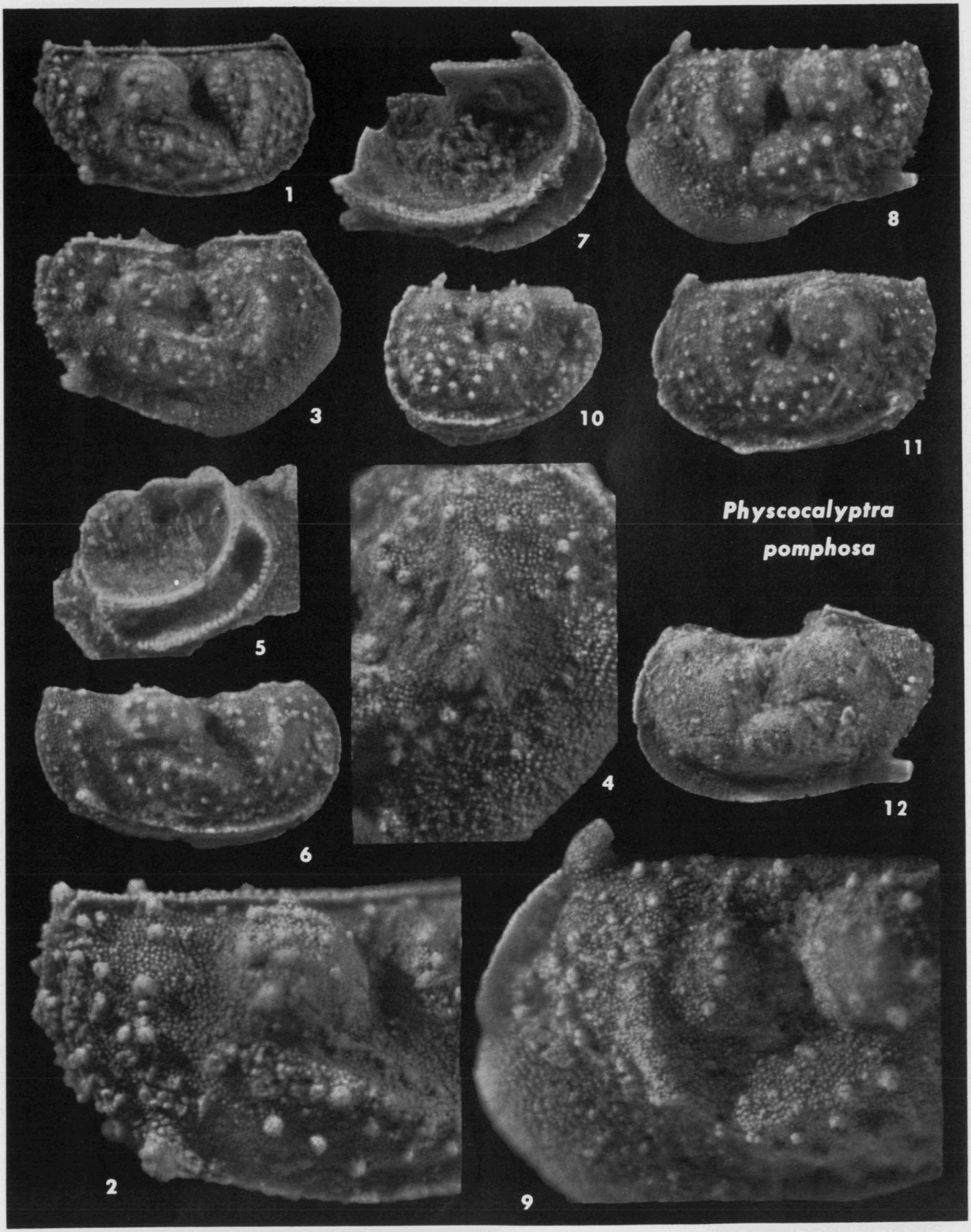
EXPLANATION OF PLATE 21

Figures x 40 except as noted

*Physcocalpytra pomphosa*

All specimens from Hungry Hollow Formation

FIGS. 1–12—1,2, lateral views of male right valve, paratype UMMP 64514, Loc. 1; 2, about x 80, showing ornamentation of scattered spinelets in a field of papillae. 3,4, lateral views of female right valve, paratype 64509, Loc. 1; 4, about x 80. 5, interior view of incomplete female left valve attached to fragment of shell, paratype 64516, Loc. 4. 6, lateral view of male right valve, paratype 64510, Loc. 4; dorsal border slightly caved downward. 7, interior view of incomplete female left valve, paratype 64515, Loc. 1, showing spine at anterodorsal corner and blisterlike enlargement of frill to form false pouch. 8,9, lateral views of female left valve, holotype 64507, Loc. 1; this is the only female valve complete and undistorted among many specimens found, most being small fragments of the thin delicate shell; 9, about x 80. 10, left lateral view of crushed immature carapace, paratype 64513, Loc. 1. 11, lateral view of male left valve, paratype 64508, Loc. 1. 12, lateral view of male left valve with posterior fragment of right valve attached but twisted from normal position, paratype 64512, Loc. 1; this preserves the very thin and long spur on the posterior end of the frill.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Physcocalyptra
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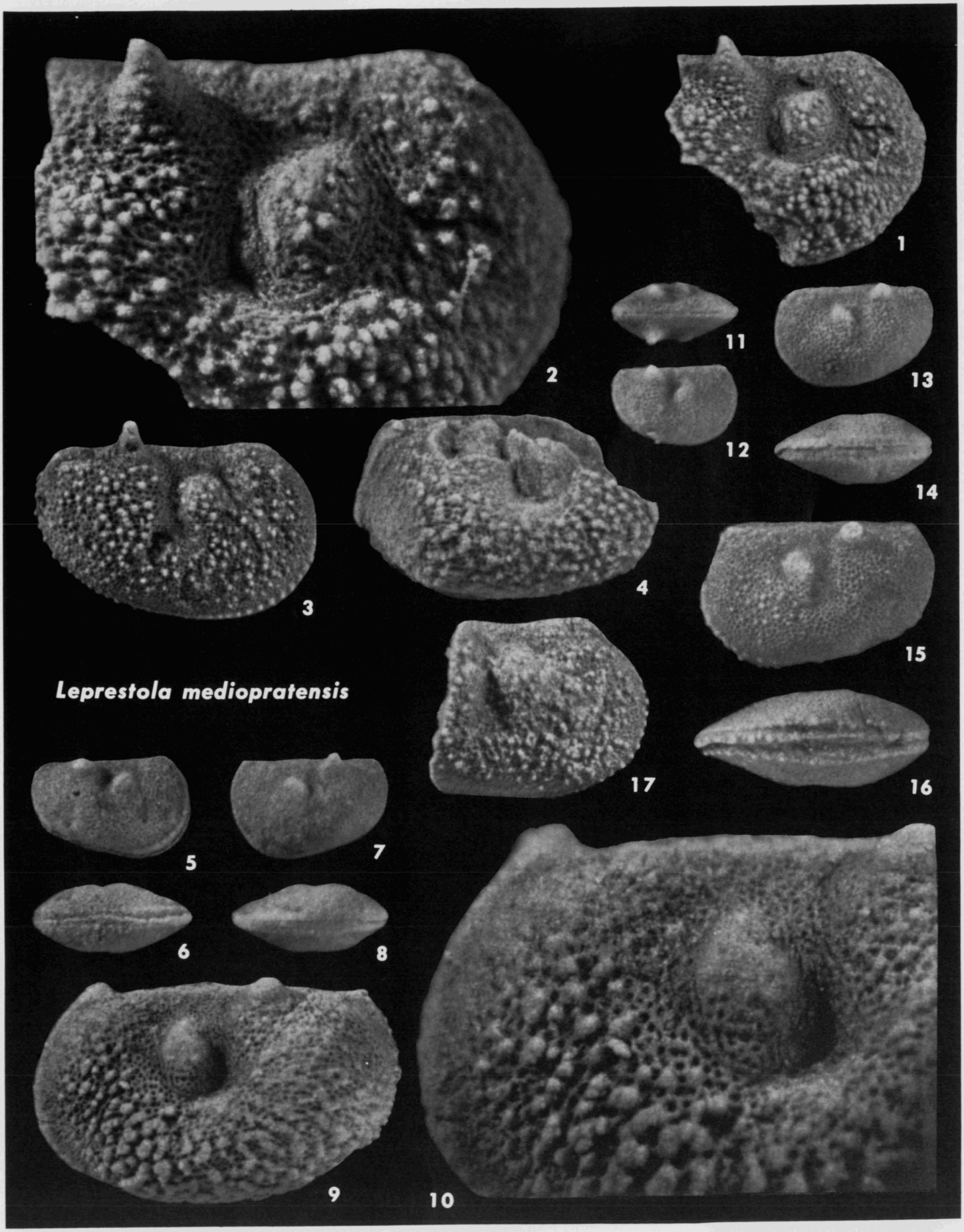
EXPLANATION OF PLATE 22

Figures x 40 except as noted

*Leprestola mediopratensis*

All specimens from Centerfield Formation

FIGS. 1–17—1,2, lateral view of incomplete female right valve, paratype UMMP 64551, Loc. 1; 2, about x 80, showing the protuberances of various sizes and distribution on a field of reticulation. 3, lateral view of ultimate immature (A–1) right valve, paratype 64550, Loc. 1; marginal tubercles visible along free border; larger elements of ornamentation consisting of tubercles rather than irregular protuberances, as in adult. 4, lateral view of incomplete female right valve, paratype 60232, Loc. 2; the poorly defined crumina extends ventrally to obscure the free border. 5,6, right lateral and ventral views of immature (A–4) carapace, paratype 60207, Loc. 2; the ornamentation in such young instars lacks the papillae and protuberances of older instars. 7,8, left lateral and ventral views of immature (A–4) carapace, paratype 60208, Loc. 2. 9,10, lateral views of female left valve, holotype 60231, Loc. 1; 10, about x 80, showing typical nodular protuberances of adult. 11,12, dorsal and right lateral views of immature (A–5) carapace, paratype 60209, Loc. 2. 13,14, left lateral and ventral views of immature (A–4) carapace, paratype 60205, Loc. 1. 15,16, left lateral and ventral views of penultimate immature (A–2) carapace, paratype 60206, Loc. 2; ornamentation beginning to display tubercles in the field of reticulation. 17, lateral view of incomplete right valve, probably ultimate immature (A–1) instar, paratype 64647, Loc. 1.


Leprestola mediopratensis
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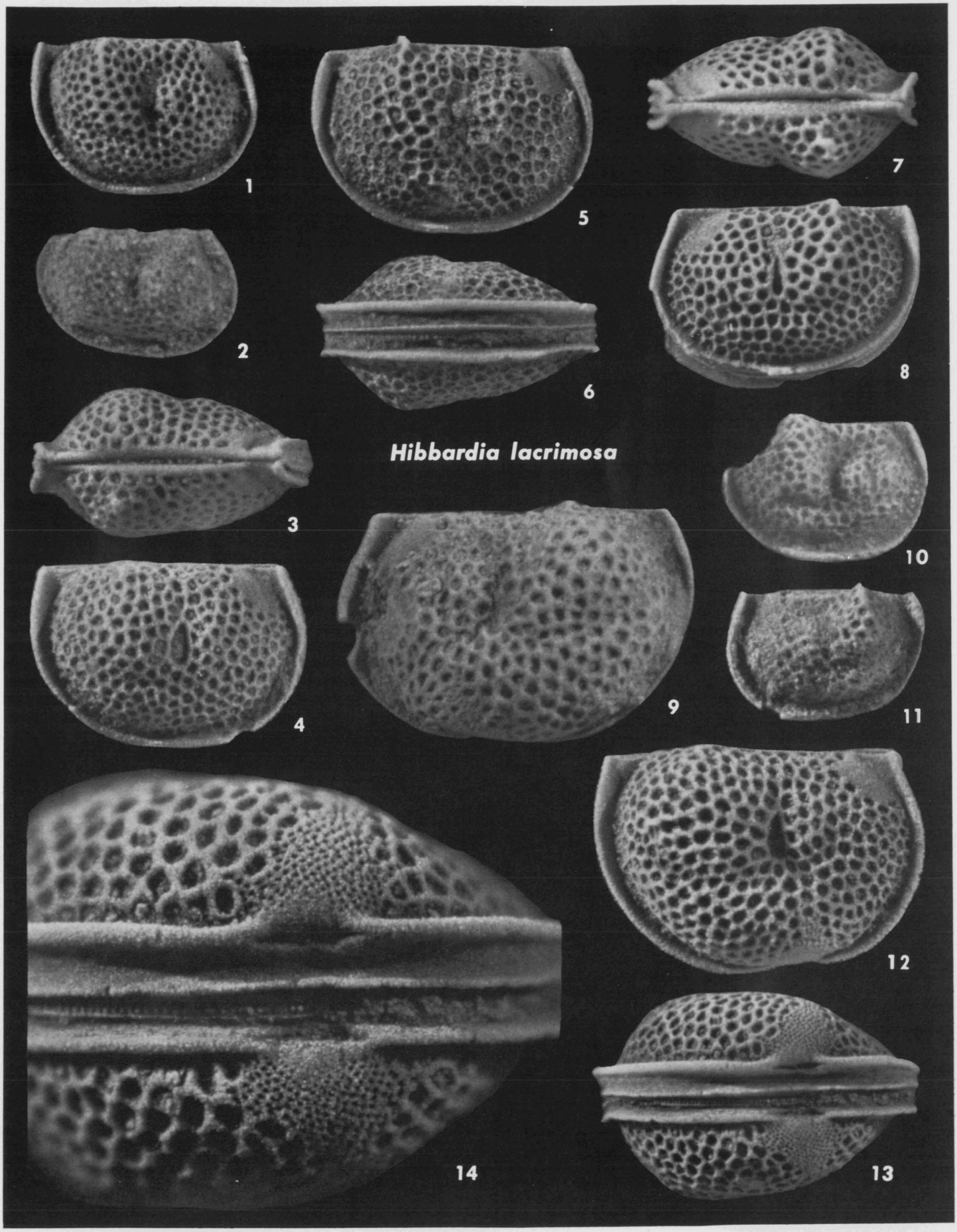
EXPLANATION OF PLATE 23

Figures x 40 except as noted

*Hibbardia lacrimosa*

FIGS. 1–14—1, lateral view of penultimate immature (A–2) right valve, UMMP 64580, Windom Shale, Loc. 1. 2, lateral view of penultimate immature (A–2) right valve, 64581, Gravel Point Formation, Loc. 5; specimens are rare and poorly preserved in this formation. 3,4, dorsal and right lateral views of ultimate immature (A–1) carapace, 64573, Wanakah Formation, Loc. 5. 5,6, right lateral and ventral views of ultimate immature (A–1) carapace, 64570, Wanakah Formation, Loc. 3. 7,8, dorsal and left lateral views of ultimate immature (A–1) carapace, 64577, Kashong Shale, Loc. 1. 9, lateral view of female left valve, 64568, Wanakah Formation, Loc. 3. 10, lateral view of immature (A–2) right valve, 64576, Petoskey Formation, Loc. 1. 11, lateral view of immature (A–2) left valve, 64578, Kashong Shale, Loc. 1. 12–14, right lateral and ventral views of female carapace, 64567, Wanakah Formation, Loc. 3; 14, about x 80, showing areas of fine reticulation outside the front borders of cruminae.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Hibbardia lacrimosa
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EXPLANATION OF PLATE 24

Figures x 40 except as noted

*Hibbardia lacrimosa*

FIGS. 1–10—1, lateral view of ultimate immature (A–1) right valve, UMMP 64571, Centerfield Formation, Loc. 2. 2, right lateral view of penultimate immature (A–2) carapace, 64579, Windom Shale, Loc. 1. 3,4, dorsal and right lateral views of immature (A–4) carapace, 64569, Wanakah Shale, Loc. 3. 5,6, dorsal and right lateral views of immature (A–6) carapace, 64574, Wanakah Shale, Loc. 5. 7, lateral view of immature (A–3) right valve, 64582, Gravel Point Formation, Loc. 5. 8, lateral view of immature (A–4) left valve attached to shell fragment, 64575, Bell Shale, Loc. 4. 9,10, dorsal and left lateral views of immature (A–4) carapace, 64572, Wanakah Shale, Loc. 5.

*Welleria aftonensis*

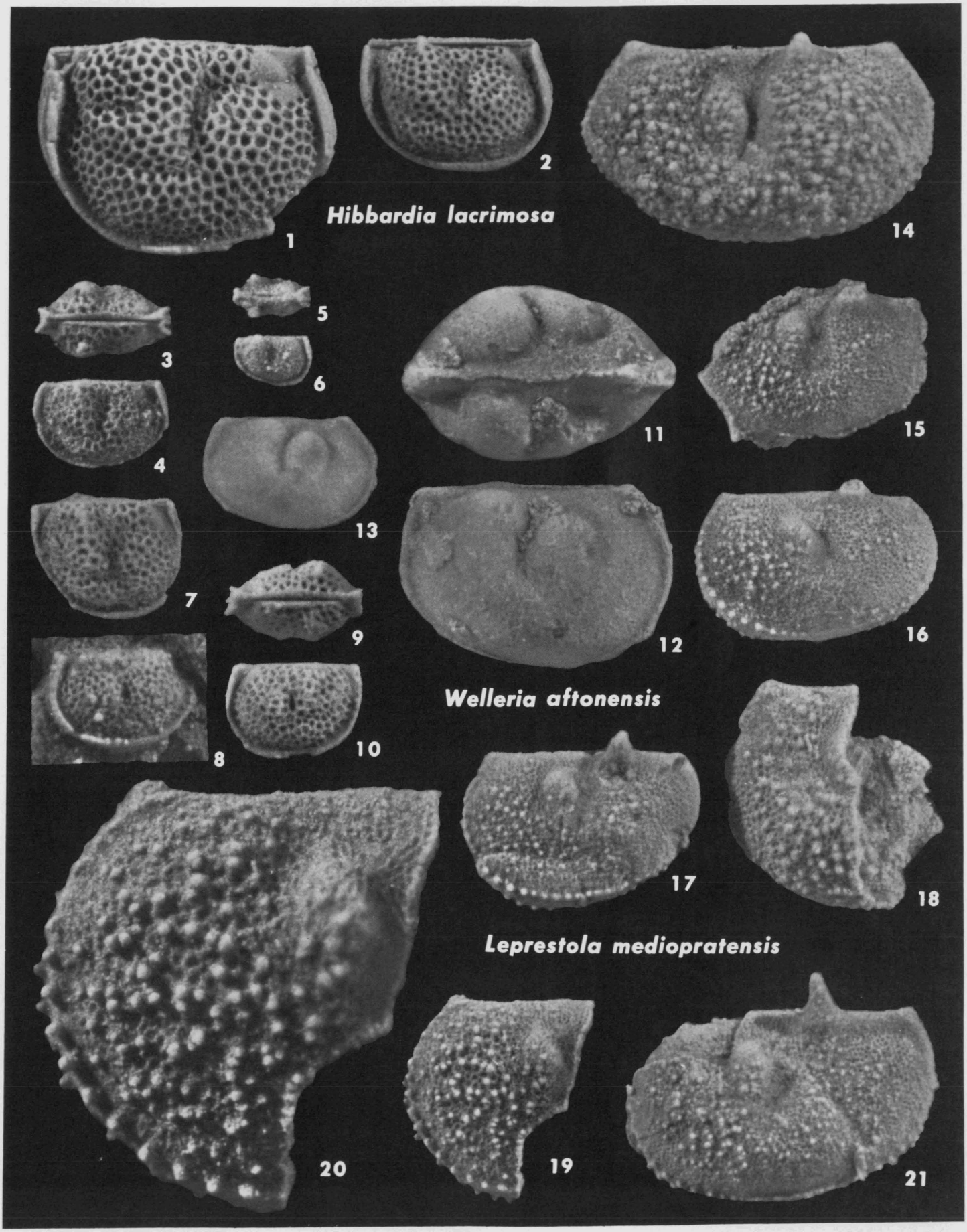
Both specimens from Gravel Point Formation, Locality 8

FIGS. 11–13—11,12, dorsal and right lateral views of male carapace, 33721. 13, right lateral view of immature (A–2) carapace, 33694.

*Leprestola mediopratensis*

All specimens from Centerfield Formation

FIGS. 14–21—14, lateral view of slightly distorted female left valve, paratype 60233, Loc. 2. 15, lateral view of incomplete immature (probably A–2) left valve, paratype 64549, Loc. 1. 16, lateral view of imature (A–2) left valve, paratype 64548, Loc. 1. 17, lateral view of immature (A–2) left valve, paratype 60234, Loc. 1. 18, anterior fragment of female left valve, paratype 64552, Loc. 1. 19,20, anterior fragment of immature (A–1) left valve, paratype 64552, Loc. 1; 20, about x 80. 21, lateral view of immature (A–1) left valve, paratype 60230, Loc. 2; this valve retains the large dorsal spine intact.


Hibbardia lacrimosa
Welleria aftonensis
Leprestola mediopratensis
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EXPLANATION OF PLATE 25

Figures x 40 except as noted

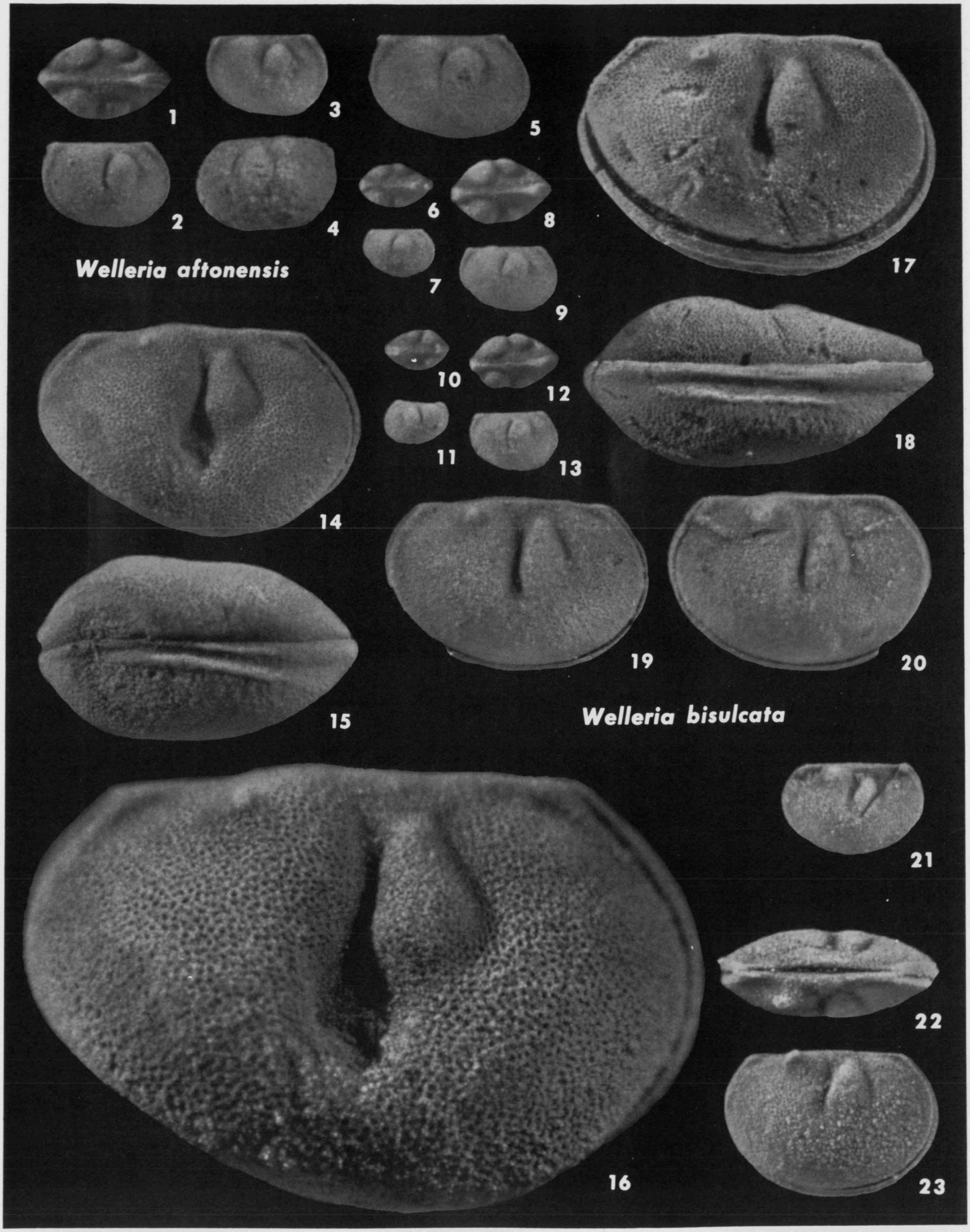
*Welleria aftonensis*

All specimens from Gravel Point Formation

FIGS. 1–13—1,2, dorsal and right lateral views of immature (A–3) carapace, UMMP 33681, Loc. 8. 3, right lateral view of immature (A–3) carapace, 33702, Loc. 8. 4, left lateral view of worn specimen, an immature (A–3) carapace, 64591, Loc. 4. 5, right lateral view of immature (A–2) carapace, 33685, Loc. 8. 6,7, dorsal and right lateral views of immature (A–6) carapace, 33679, Loc. 8. 8,9, dorsal and right lateral views of immature (A–4) carapace, 33712, Loc. 8. 10,11, dorsal and left lateral views of immature (A–6) carapace, 33677, Loc. 8. 12,13, dorsal and right lateral views of immature (A–5) carapace, 33700, Loc. 8.

*Welleria bisulcata*

FIGS. 14–23—14–16, right lateral and ventral views of female carapace, 64584, Wanakah Shale, Loc. 4; 16, about x 80, showing fine reticulation. 17,18, right lateral and ventral views of male carapace, 64585, Wanakah Shale, Loc. 4. 19, right lateral view of ultimate immature (A–1) carapace, 64586, Wanakah Shale, Loc. 4. 20, right lateral view of ultimate immature (A–1) carapace, 64583, Windom Shale, Loc. 3. 21, right lateral view of immature (A–4) carapace, 64590, Wanakah Shale, loc. 3. 22,23, dorsal and right lateral views of immature (A–2) carapace, 64587, Wanakah Shale, Loc. 4; note spinelike tip is present on L3 only in right valve.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Welleria aftonensis
Welleria bisulcata

EXPLANATION OF PLATE 26

All figures x 40 except as noted

*Welleria aftonensis*

All specimens from Gravel Point Formation, Locality 8

FIGS. 1–11—1,2, dorsal and right lateral views of male carapace, UMMP 33717. 3,4, right lateral and ventral views of female carapace with valves slightly agape, 33676. 5–7, dorsal, right lateral, and ventral views of male carpace, 33718. 8,9, dorsal and right lateral views of female carapace with valves widely gaping, 33689. 10,11, right lateral views of two ultimate immature (A–1) carapaces, 33704 and 33714.

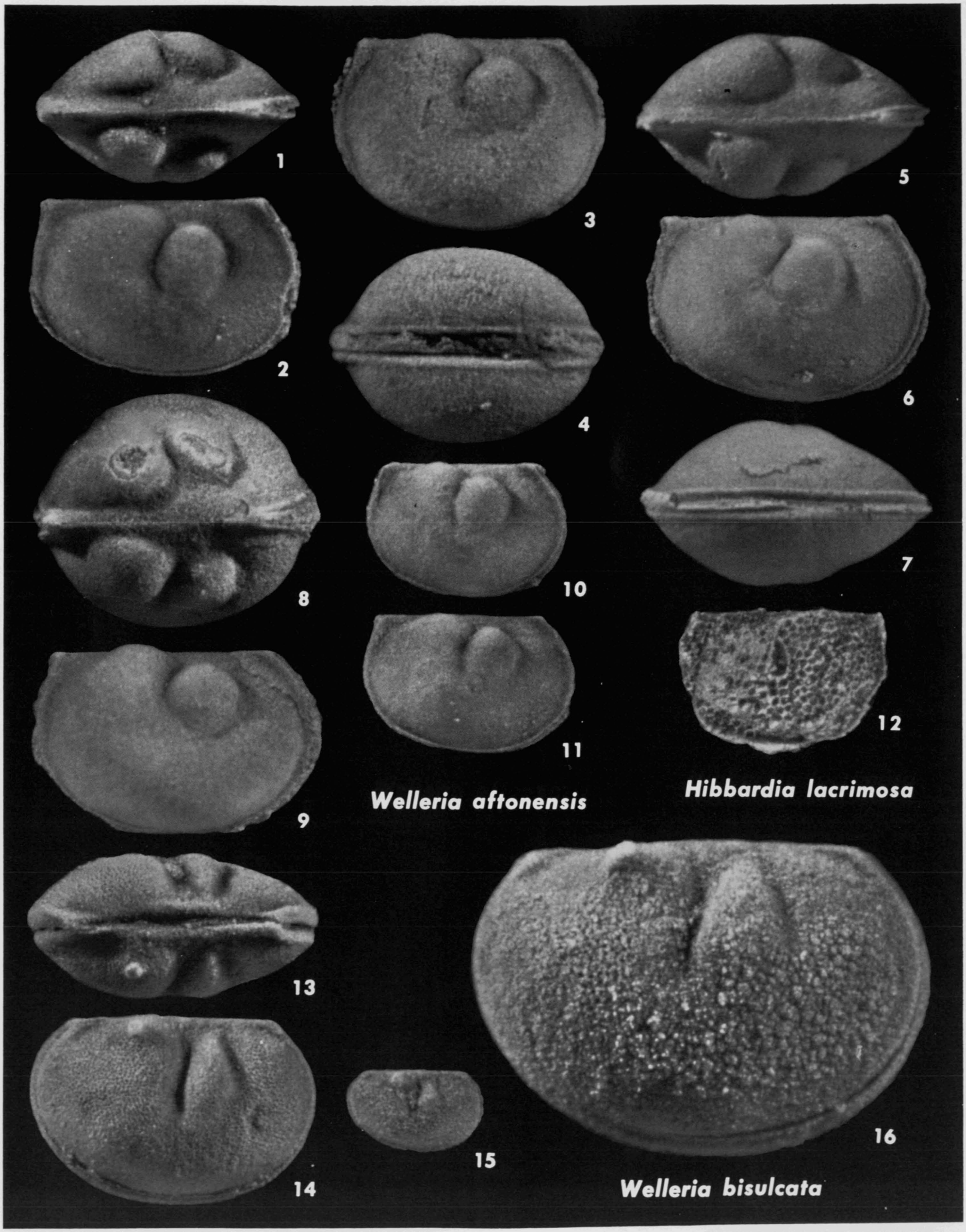
*Hibbardia lacrimosa*

FIG. 12—lateral view of immature left valve, 64648, Bell Shale, Loc. 4; this worn specimen is one of the few found in this formation; most are from younger formations.

*Welleria bisulcata*

All specimens from Wanakah Shale

FIGS. 13–16—13,14, dorsal and right lateral views of ultimate immature (A–1) carapace, 64588, Loc. 6; dorsal view shows tubercle or blunt spine of L3 only on the right valve. 15, right lateral view of immature (A–4) carapace, 64589, Loc. 1. 16, right lateral view of immature (A–2) carapace, 64587, Loc. 4, about x 80; see also Pl. 25, figs. 22,23.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Welleria aftonensis
Hibbardia lacrimosa
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Welleria bisulcata

EXPLANATION OF PLATE 27

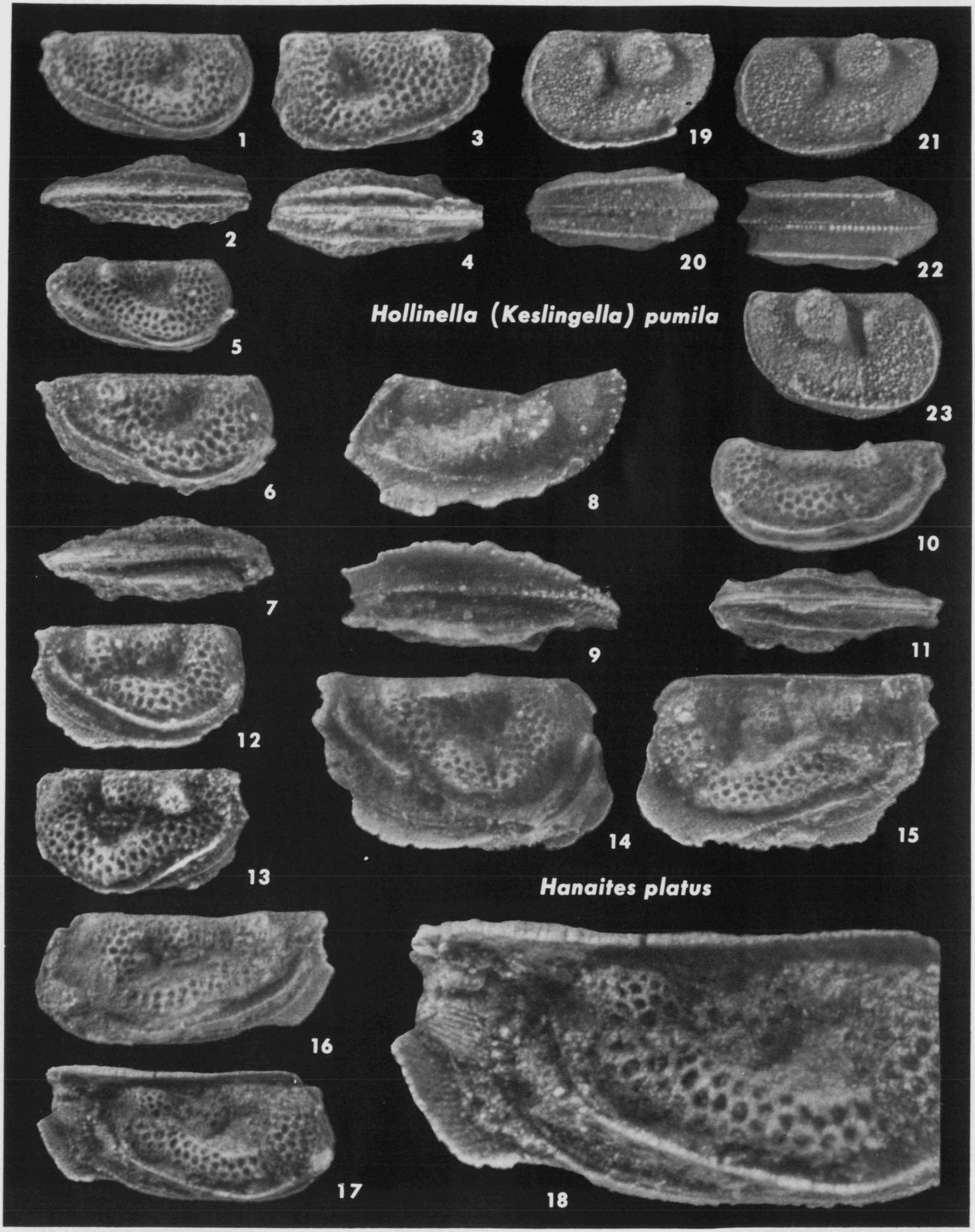
Figures x 40 except as noted

*Hanaites platus*

FIGS. 1–18—1,2, right lateral and ventral views of immature (A–1) carapace, UMMP 30970, basal Rockport Quarry Limestone or uppermost Bell Shale, Loc. 3. 3,4, left lateral and ventral views of immature (A–1) carapace, 30968, basal Rockport Quarry Limestone or uppermost Bell Shale, Loc. 3. 5, right lateral view of immature (A–2) carapace, 64769, Windom Shale, Loc. 1. 6,7, right lateral and ventral views of immature (A–1) carapace, 64763, Bell Shale, Loc. 4. 8,9, left lateral and ventral views of crushed adult male (?) carapace, 64764, Bell Shale, Loc. 4. 10,11, left lateral and ventral views of immature (A–1) carapace, 64766, Windom Shale, Loc. 1. 12,13, right and left lateral views of immature (A–1) carapace, 64765, Bell Shale, Loc. 4. 14,15, right and left lateral views of adult male (?) carapace, 64768, Hungry Hollow Formation, Loc. 3. 16–18, left and two right lateral views of adult female (?) carapace, 64767, Hungry Hollow Formation, Loc. 3; 18, about x 80, showing fragments of delicate tubulose keel.

*Hollinella (Keslingella) pumila*

FIGS. 19–23—19,20, left lateral and ventral views of male carapace, paratype (allotype) 28033, Ferron Point Formation, Loc. 3. 21,22, left lateral and ventral views of female carapace, 28982, Arkona Shale, Loc. 3. 23, right lateral view of female carapace, 64813, Arkona Shale, Loc. 6.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Hollinella (Keslingella) pumila
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Hanaites platus
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EXPLANATION OF PLATE 28

Figures x 40 except as noted

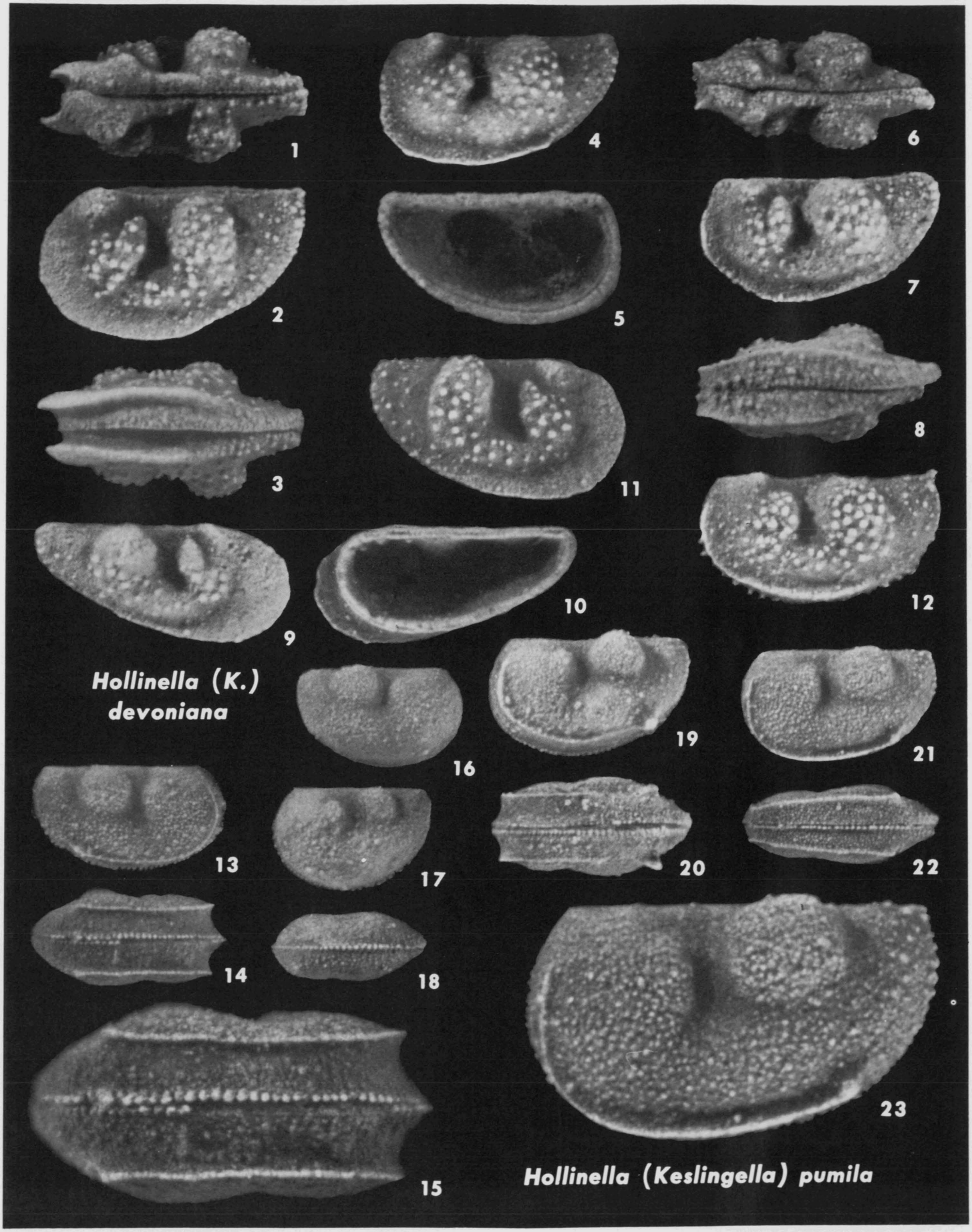
*Hollinella* (*Keslingella*) *devoniana*

All specimens from Bell Shale

FIGS. 1–12—1–3, dorsal, left lateral, and ventral views of female carapace, UMMP 64798, Loc. 4. 4,5, lateral and interior views of male left valve, 31211, Loc. 2. 6–8, dorsal, left lateral, and ventral views of male carapace, 64797, Loc. 4. 9,10, lateral and interior views of elongate female right valve, 64800, Loc. 4. 11, lateral view of female right valve, 64801, Loc. 4. 12, left lateral view of male carapace, 64799, Loc. 4; this specimen atypically rounded anteroventrally.

*Hollinella* (*Keslingella*) *pumila*

FIGS. 13–23—13–15, right lateral and ventral views of female carapace, 64812, Arkona Shale, Loc. 6; 15, about x 80, showing wide antra and marginal denticles. 16, right lateral view of immature (A–1) carapace, 28990, Arkona Shale, Loc. 3. 17,18, left lateral and ventral views of immature (A–1) carapace, 64814, Arkona Shale, Loc. 6; note small spurs as only velar structures developed. 19,20, left lateral and ventral views of female carapace, holotype 28032, Ferron Point Formation, Loc. 3. 21–23, left lateral and ventral views of male carapace, paratype 28035, Ferron Point Formation, Loc. 3; 23, about x 80.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Hollinella (K.)
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Hollinella (Keslingella) pumila

EXPLANATION OF PLATE 29

Figures x 40 except as noted

*Hollinella* (*Keslingella*) *acutilobata*

All specimens from Bell Shale

FIGS. 1–21—1–3, lateral, ventral, and interior views of right valve, paratype UMMP 47595, Loc. 6. 4,5, lateral and ventral views of right valve, paratype 47593, Loc. 6. 6–8, two lateral and one interior views of left valve, 64762, Loc. 4; 8, about x 80, showing preserved posterodorsal spine. 9–11, two lateral and one ventral views of right valve, 64761, Loc. 4; 11, about x 80. 12–14, dorsal, lateral, and ventral views of right valve, paratype 30907, Loc. 6. 15,16, lateral and interior views of right valve, 64760, Loc. 4. 17,18, lateral and ventral views of left valve, paratype (allotype) 30905, Loc. 6. 19–21, dorsal and two lateral views of right valve, 64757, Loc. 4; 21, about x 80.


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Hollinella (Keslingella) acutilobata
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EXPLANATION OF PLATE 30

All figures x 40

*Hollinella* (*Keslingella*) *acutilobata*

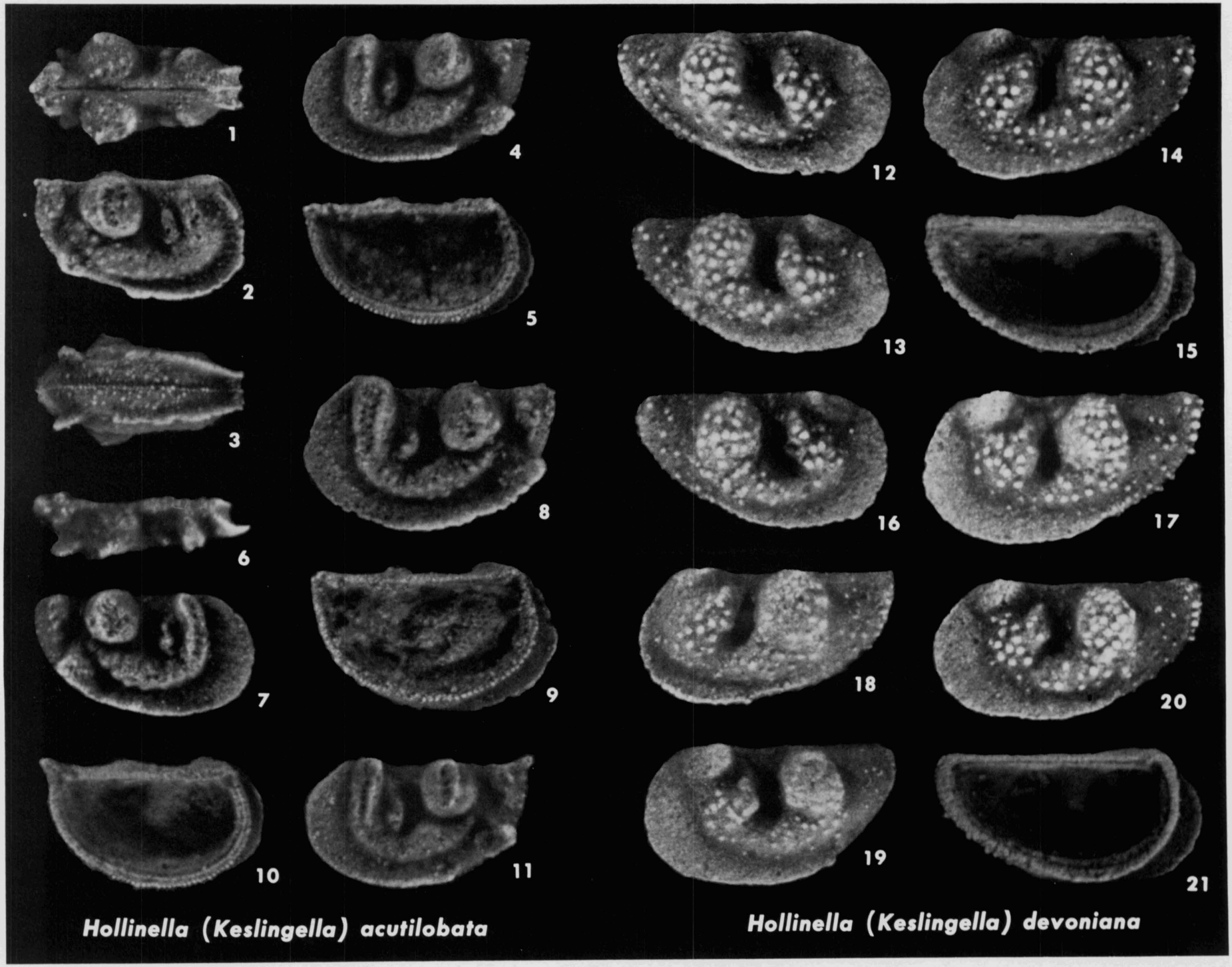
All specimens from Bell Shale, Locality 4

FIGS. 1-11—1-3, dorsal, right lateral, and ventral views of male carapace, UMMP 64758; this is the only complete carapace found. 4,5, lateral and interior views of female left valve, 64759. 6,7, dorsal and lateral views of female right valve, 64756. 8,9, lateral and interior views of female left valve, 64754. 10,11, interior and lateral views of female left valve, 64755, preserving spine at posterodorsal corner.

*Hollinella* (*Keslingella*) *devoniana*

All specimens from Bell Shale

FIGS. 12-21—12, lateral view of female right valve, 47586, Loc. 6. 13, lateral view of female right valve, 31203, Loc. 2. 14,15, lateral and interior views of female left valve, 31212, Loc. 2. 16, lateral view of female right valve, 31027, Loc. 2. 17, lateral view of female left valve, 31213, Loc. 2. 18, lateral view of male left valve, 31210, Loc. 2. 19, lateral view of female left valve, 31205, Loc. 2. 20,21, lateral and interior views of female left valve, 47587, Loc. 6.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Hollinella (Keslingella) acutilobata
Hollinella (Keslingella) devoniana

EXPLANATION OF PLATE 31

Figures x 40 except as noted

*Hollinella* (*Keslingella*) *inclinisulcata*

FIGS. 1–10—1,2, lateral and interior views of male right valve, paratype (allotype) UMMP 27356, Norway Point Formation, Loc. 1. 3,4, lateral and ventral views of female left valve, paratype 27358, Norway Point Formation, Loc. 1. 5,6, lateral and ventral views of female right valve, paratype 27362, Norway Point Formation, Loc. 1. 7, lateral view of female right valve, 30941, Petoskey Formation, Loc. 2. 8, lateral view of female right valve, 30940, Petoskey Formation, Loc. 1. 9,10, lateral and ventral views of male left valve, holotype 27357, Norway Point Formation, Loc. 1.

*Hollinella* (*Keslingella*) *bullata*

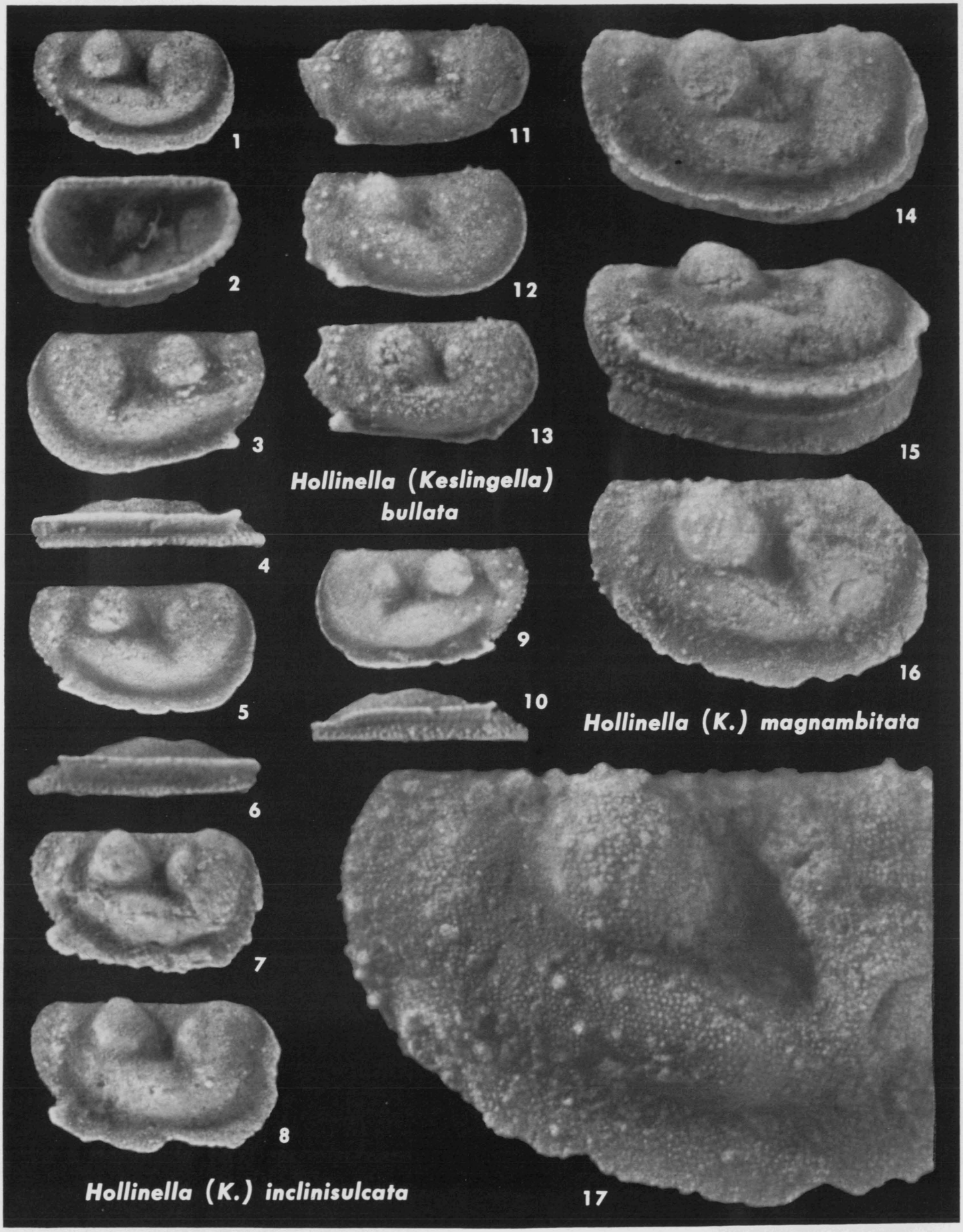
All specimens from Bell Shale, Locality 2

FIGS. 11–13—11, lateral view of male right valve, holotype 26725. 12, lateral view of female right valve, paratype (allotype) 26726. 13, lateral view of female right valve, 47578.

*Hollinella* (*Keslingella*) *magnambitata*

Both specimens from Petoskey Formation, Locality 2

FIGS. 14–17—14,15, right lateral and inclined ventral views of female carapace, paratype (allotype) 30913. 16,17, lateral views of male right valve, paratype 30914; 17, about x 80.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Hollinella (K.) inclinisulcata
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Hollinella (Keslingella) bullata
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Hollinella (K.) magnambitata
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EXPLANATION OF PLATE 32

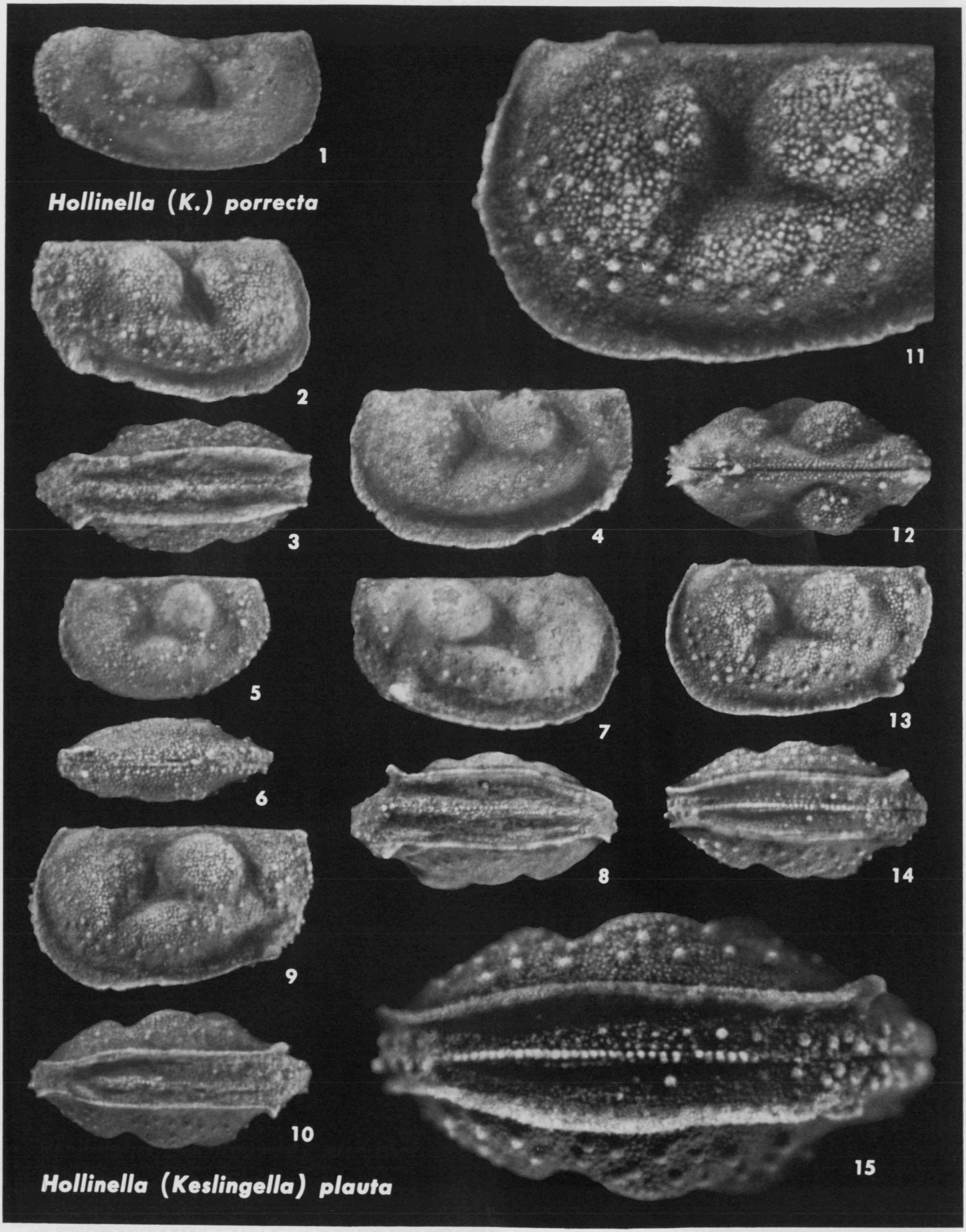
Figures x 40 except as noted

*Hollinella* (*Keslingella*) *porrecta*

FIG. 1—right lateral view of adult (male ?) carapace, holotype UMMP 26727, Bell Shale, Loc. 2.

*Hollinella* (*Keslingella*) *plauta*

FIGS. 2–15—2,3, right lateral and ventral views of female carapace, 64811, Centerfield Formation, Loc. 2. 4, left lateral view of female carapace, paratype 28060, Genshaw Formation, Loc. 6. 5,6, lateral and ventral views of ultimate immature (A-1) carapace, 64810, Centerfield Formation, Loc. 2. 7,8, right lateral and ventral views of male carapace, 64804, Ledyard Shale, Loc. 1. 9,10, left lateral and ventral views of male carapace, 64808, Centerfield Formation, Loc. 2. 11–15, dorsal, two left lateral, and two ventral views of male carapace, 64809, Centerfield Formation, Loc. 2; 11,15, about x 80, showing strong ornamentation of papillae.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Hollinella (Keslingella) plauta

EXPLANATION OF PLATE 33

All figures x 40

*Hollinella* (*Keslingella*) *alpenensis*

Both specimens from Alpena Limestone, Huron Portland Cement Quarry

FIGS. 1-4—1,2, lateral and ventral views of female left valve, holotype UMMP 30883. 3,4, lateral and ventral views of male left valve, paratype (allotype) 30884.

*Hollinella* (*Keslingella*) *magnambitata*

Both specimens from Petoskey Formation, Locality 2

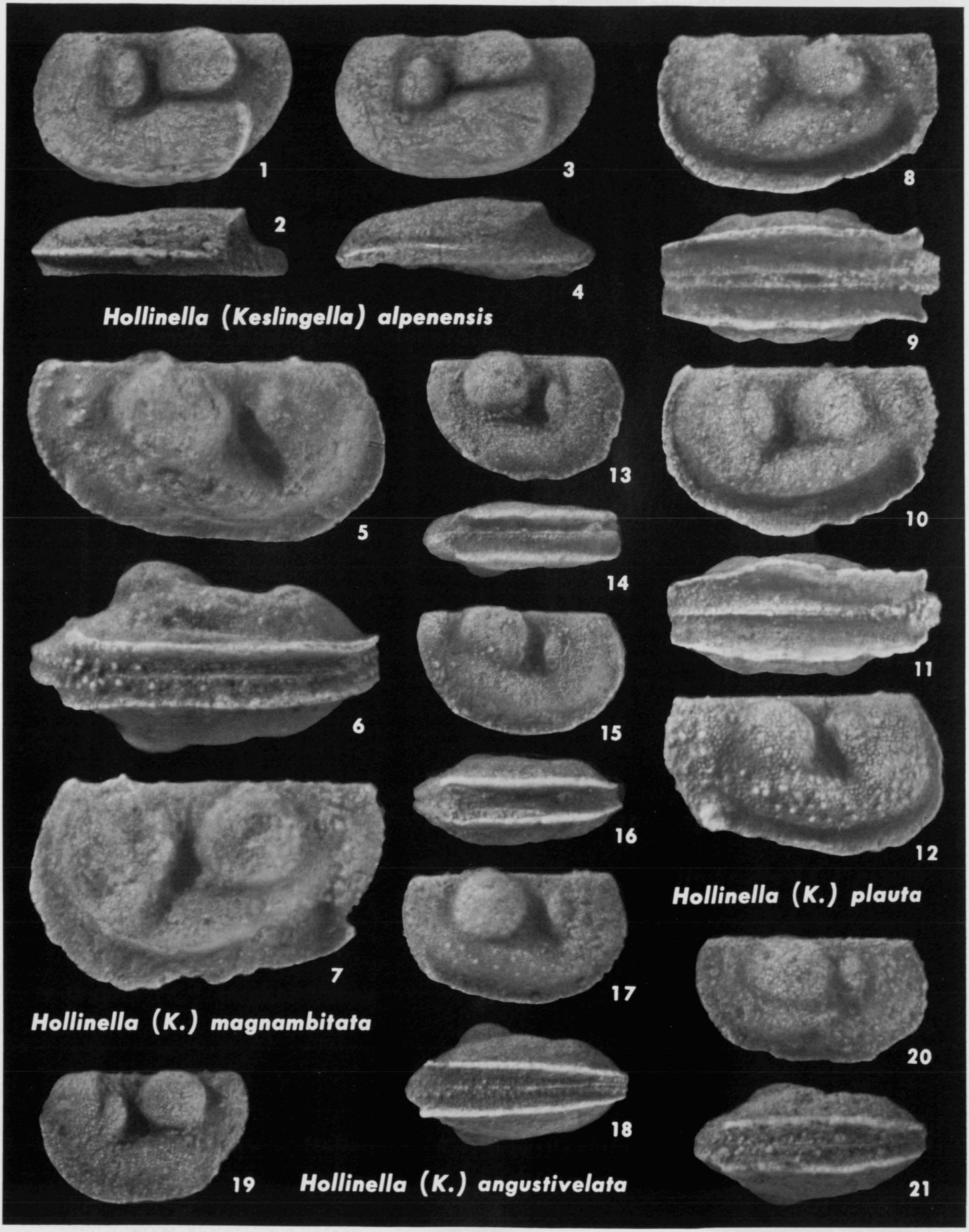
FIGS. 5-7—5,6, right lateral and ventral views of male carapace, holotype 30915. 7, lateral view of female left valve, paratype 30989.

*Hollinella* (*Keslingella*) *plauta*

FIGS. 8-12—8,9, left lateral and ventral views of female carapace, paratype 28060, Genshaw Formation, Loc. 6. 10,11, left lateral and ventral views of female carapace, holotype 28061, Genshaw Formation, Loc. 6. 12, right lateral view of female carapace, 64811, Centerfield Formation, Loc. 2.

*Hollinella* (*Keslingella*) *angustivelata*

FIGS. 13-21—13,14, right lateral and ventral views of female carapace, paratype (allotype) 64773, Gravel Point Formation, Loc. 1. 15,16, right lateral and ventral views of male carapace, paratype 64774, Gravel Point Formation, Loc. 1. 17,18, right lateral and ventral views of male carapace, holotype 64777, Gravel Point Formation, Loc. 1. 19, left lateral view of female carapace, paratype 64775, Gravel Point Formation, Loc. 1. 20,21, right lateral anad ventral views of male carapace, 30918, Bell Shale or basal Rockport Quarry Limestone, Loc. 3; although this poorly preserved specimen has its L3 covering an exceptionally large area in lateral view, it agrees in other respects with the other specimens illustrated herein.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Hollinella (Keslingella) alpenensis
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Hollinella (K.) plauta
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Hollinella (K.) magnambitata
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Hollinella (K.) angustivelata
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EXPLANATION OF PLATE 34

Figures x 40 except as noted

*Hollinella* (*Keslingella*) *magnilobata*

Both specimens from Bell Shale, Locality 2

FIGS. 1,2—1, left lateral view of female carapace with valves askew, holotype UMMP 26644. 2, lateral view of male left valve, paratype (allotype) 26645.

*Hollinella* (*Keslingella*) *productilobata*

Both specimens from Bell Shale, Locality 2

FIGS. 3,4—3, left lateral view of female carapace, paratype 26651. 4, left lateral view of female carapace, holotype 26649.

*Hollinella* (*Keslingella*) *nodiventriculata incompta*

All specimens from Potter Farm Formation, Locality 1

FIGS. 5-9—5,6, lateral and ventral views of female right valve, paratype 64807. 7,8, lateral and ventral views of female left valve, holotype 64805. 9, lateral view of female right valve, paratype 64806.

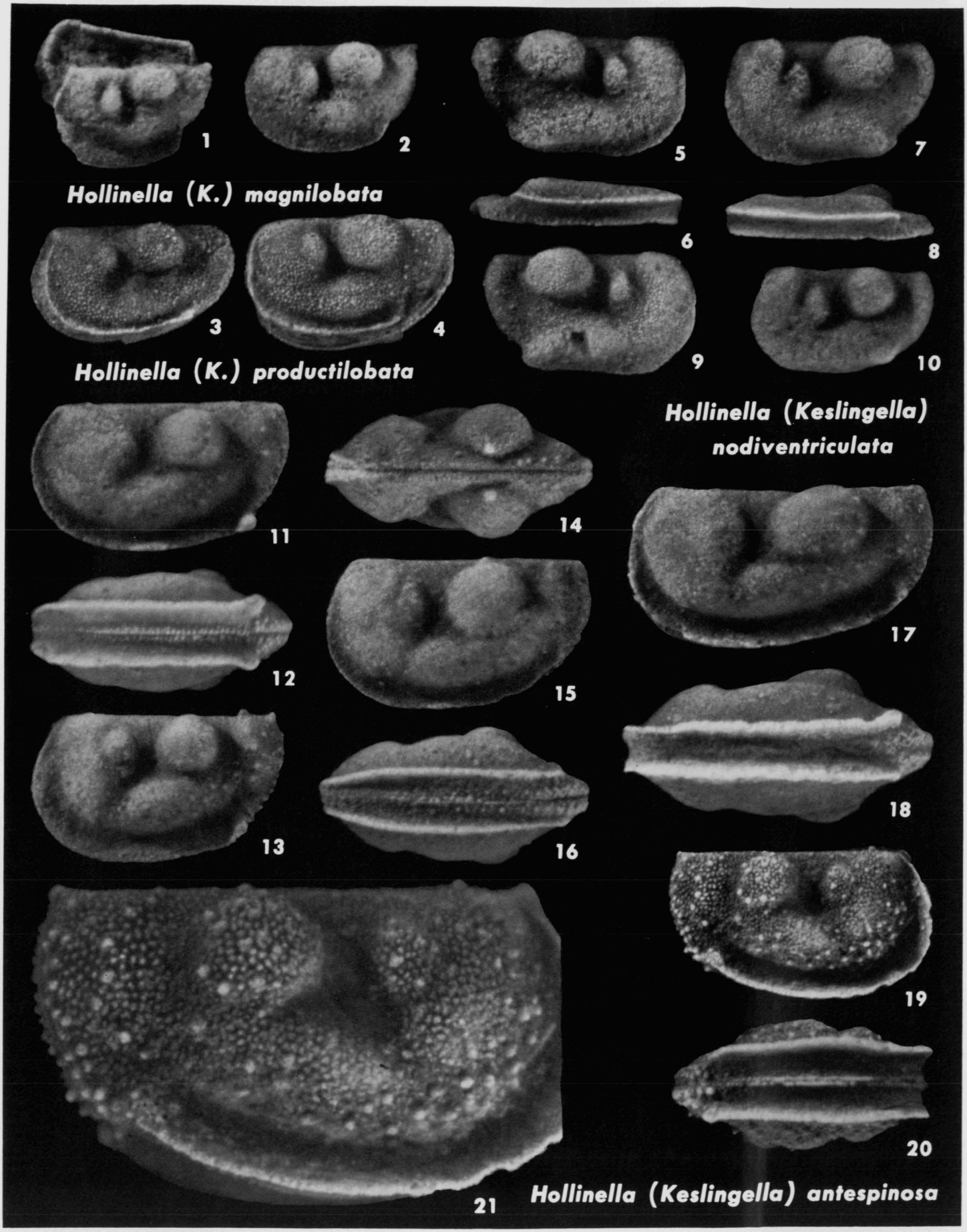
*Hollinella* (*Keslingella*) *n. nodiventriculata*

FIG. 10—lateral view of left valve, 47577, Gravel Point Formation, Loc. 4.

*Hollinella* (*Keslingella*) *antespinosa*

Illustrated specimens show range of size and ornamentation in this widespread and variable species

FIGS. 11-21—11,12, left lateral and ventral views of female carapace, 64791, Widder Formation, Loc. 1. 13, lateral view of left valve, 64794, Petoskey Formation, Loc. 3. 14-16, dorsal, left lateral, and ventral views of male carapace, 64788, Genshaw Formation, Loc. 6. 17,18, left lateral and ventral views of female carapace, 64789, Gravel Point Formation, Loc. 1. 19-21, two right lateral and one ventral views of female carapace, 64772, Centerfield Formation, Loc. 2; 21, about x 80.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Hollinella (K.) magnilobata
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Hollinella (Keslingella) nodiventriculata
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Hollinella (Keslingella) antespinosa

EXPLANATION OF PLATE 35

All figures x 40

*Hollinella* (*Keslingella*) *antespinosa*

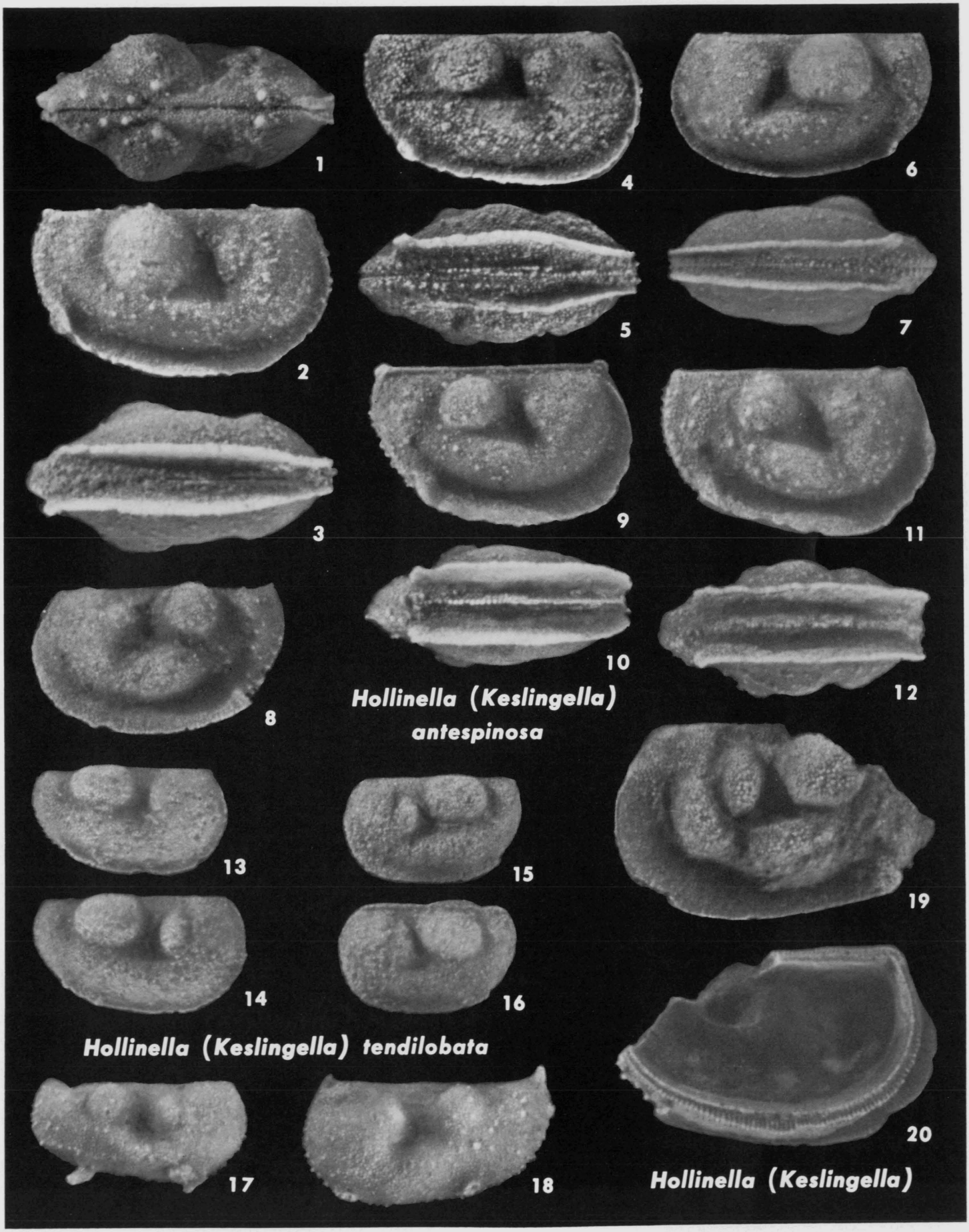
FIGS. 1–12—1–3, dorsal, right lateral, and ventral views of male carapace, UMMP 64787, Genshaw Formation, Loc. 6. 4,5, right lateral and ventral views of male carapace, 64771, Centerfield Formation, Loc. 2. 6,7, left lateral and ventral views of male carapace, 64793, Widder Formation, Loc. 1. 8, lateral view of left valve, 64795, Petoskey Formation, Loc. 3. 9,10, right lateral and ventral views of female carapace, 64792, Widder Formation, Loc. 1. 11,12, right lateral and ventral views of female carapace, 64796, Ledyard Shale, Loc. 1.

*Hollinella* (*Keslingella*) *tendilobata*

FIGS. 13–16—13, lateral view of right valve, 64918, Ferron Point Formation, Loc. 3. 14, lateral view of right valve, 64919, Ferron Point Formation, Loc. 3. 15, lateral view of male left valve, holotype 27379, Norway Point Formation, Loc. 1. 16, lateral view of female left valve, paratype (allotype) 27380, Norway Point Formation, Loc. 1.

*Hollinella* (*Keslingella*) spp.

FIGS. 17–20—17, lateral view of juvenile right valve, 64832, Gravel Point Formation, Loc. 6. 18, lateral view of juvenile left valve, 64831, Gravel Point Formation, Loc. 6. 19,20, lateral and interior views of left valve, 64927, Windom Shale, Loc. 1.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Hollinella (Keslingella)
antespinosa
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Hollinella (Keslingella) tendilobata
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Hollinella (Keslingella)

EXPLANATION OF PLATE 36

Figures x 40 except as noted

*Treposella stellata*

All specimens from Centerfield Formation

FIGS. 1–6—1, lateral view of immature (A–1) right valve, 30502, Loc. 2.; unlike hollinids, immature instars of this genus have a well-developed frill. 2,3, lateral views of immature (A–2) left valve, 64563, Loc. 2; 3, about x 80. 4, lateral view of incomplete immature (A–1) right valve, 64566, Loc. 1. 5, lateral view of immature (A–1 ?) left valve, 64565, Loc. 1. 6, lateral view of incomplete female right valve, 64564, Loc. 1.

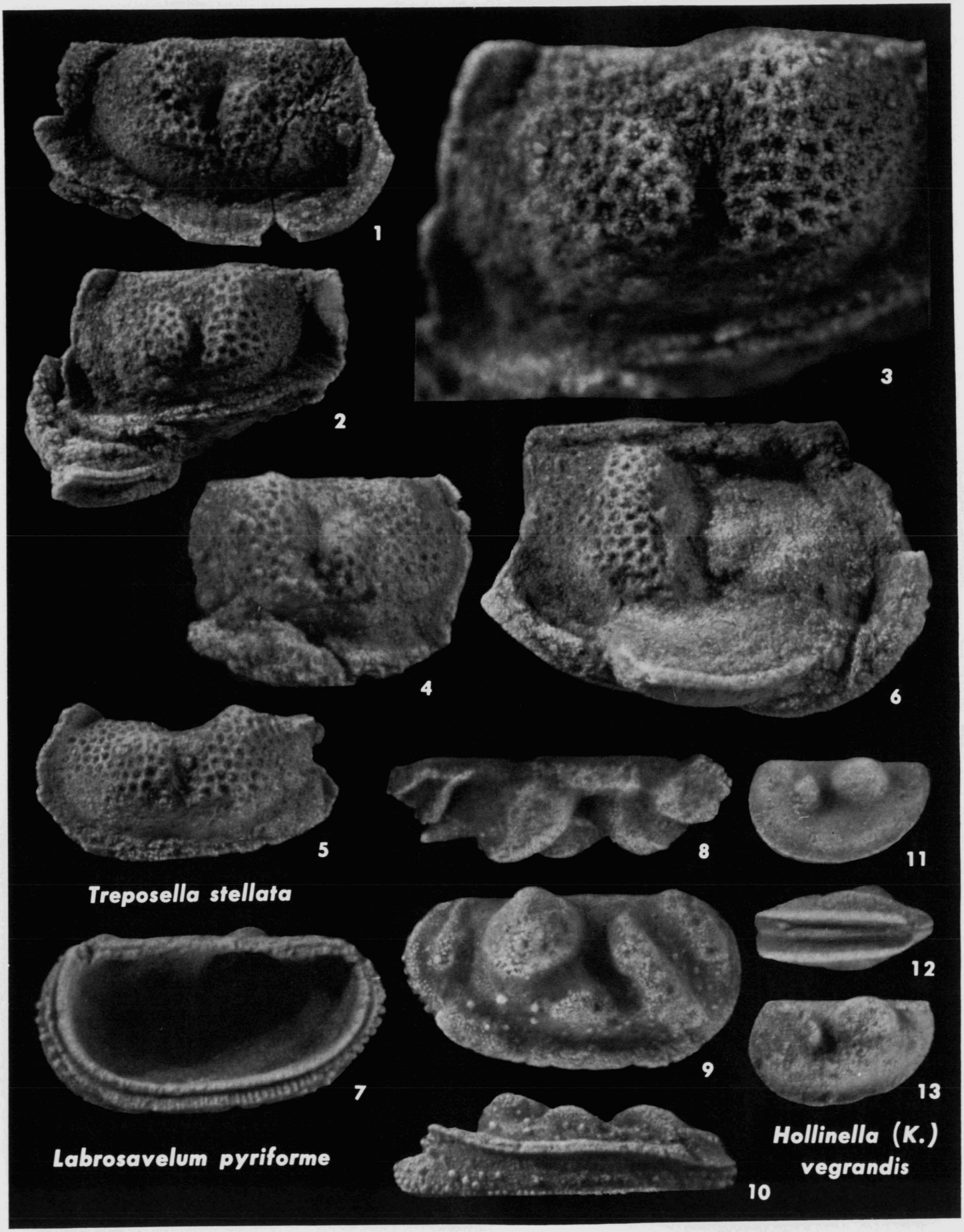
*Labrosavelum pyriforme*

FIGS. 7–10—interior, dorsal, lateral, and ventral views of male right valve, paratype 64527, Potter Farm Formation, Loc. 1.

*Hollinella (Keslingella) venrandis*

Both specimens from Genshaw Formation, Locality 6

FIGS. 11–13—11,12, left lateral and ventral views of female carapace, 64926. 13, left lateral view of male carapace, paratype 28063.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Treposella stellata
Labrosavelum pyriforme
Hollinella (K.) vegrandis

EXPLANATION OF PLATE 37

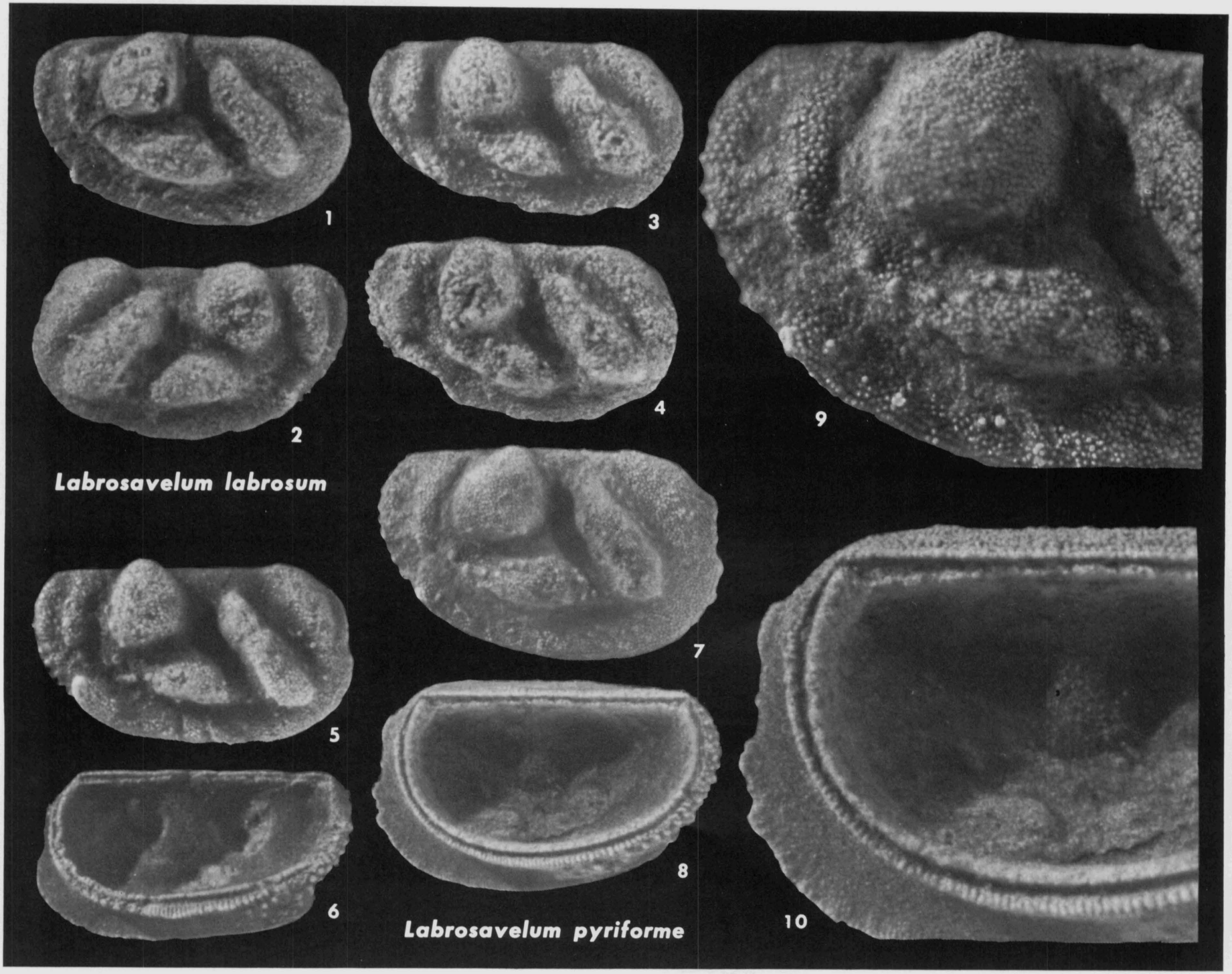
Figures x 40 except as noted

*Labrosavelum labrosum*

FIGS. 1–4—1, lateral view of right valve, UMMP 64520, Bell Shale, Loc. 4. 2, lateral view of left valve, 64519, Norway Point Formation, Loc. 1. 3, lateral view of right valve, 64517, Norway Point Formation, Loc. 1. 4, lateral view of right valve, 64518, Norway Point Formation, Loc. 1.

*Labrosavelum pyriforme*

FIGS. 5–10—5,6, lateral and interior views of right valve, paratype 64528, Potter Farm Formation, Loc. 1. 7–10, two lateral and two interior views of right valve, paratype 64535, Hungry Hollow Formation, Loc. 3; 9,10, about x 80.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Labrosavelum labrosum
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Labrosavelum pyriforme

EXPLANATION OF PLATE 38

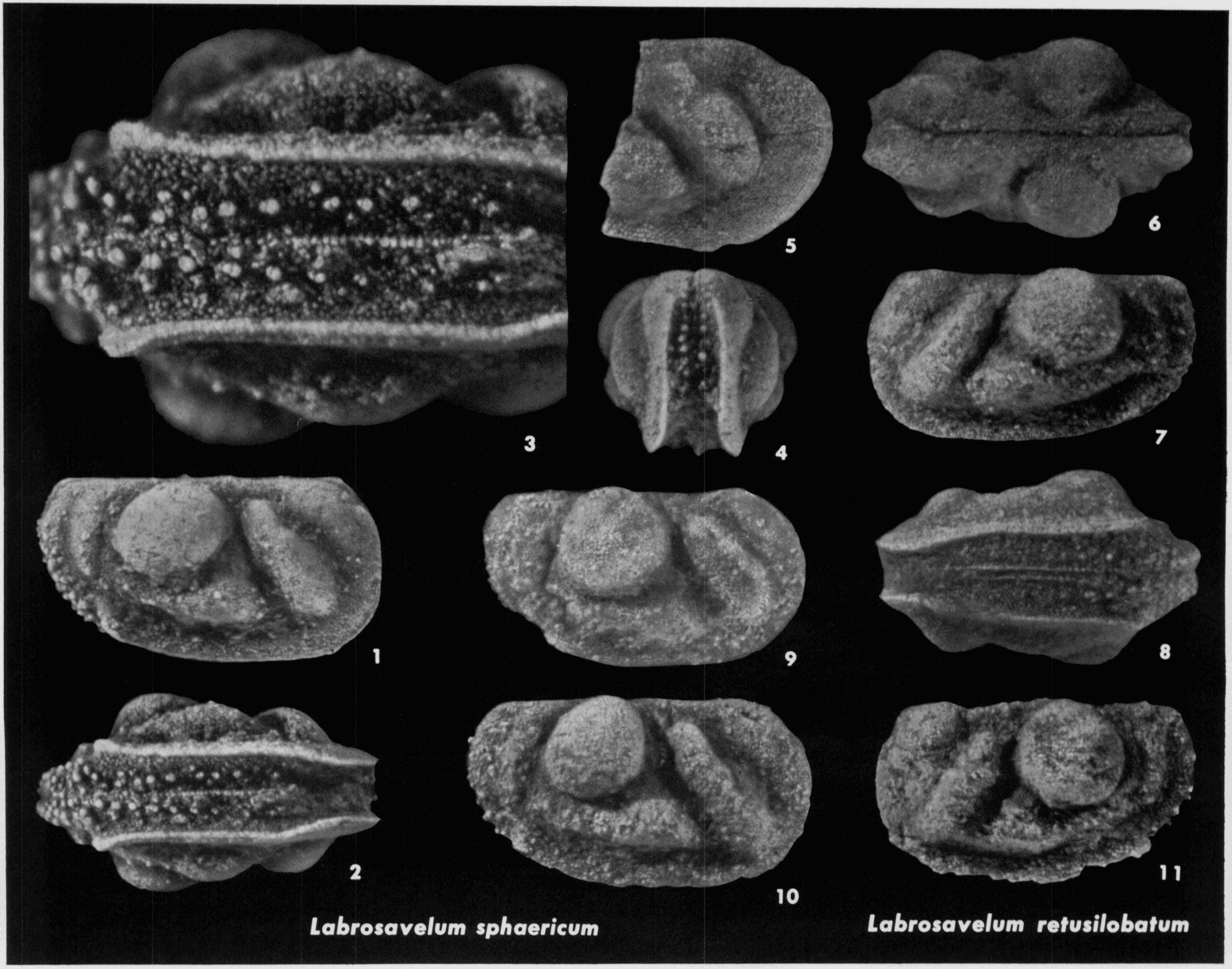
Figures x 40 except as noted

*Labrosavelum retusilobatum*

FIGS. 1–5—1–4, right lateral, ventral, and anterior views of adult (male ?) carapace, UMMP 64545, Centerfield Formation, Loc. 2; 3, about x 80. 5, anterior fragment of male right valve, 64922, showing exceptionally wide frill, Windom Shale, Loc. 1.

*Labrosavelum sphaericum*

FIGS. 6–11—6–8, dorsal, left lateral, and two ventral views of male carapace, holotype 30874, Widder Formation, Loc. 1. 9, lateral view of right valve, paratype 58730, Widder Formation, Loc. 1. 10, lateral view of right valve, paratype 58781, Hungry Hollow Formation, Loc. 4. 11, lateral view of left valve, paratype 64537, Widder Formation, Loc. 1.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Labrosavelum sphaericum
Labrosavelum retusilobatum

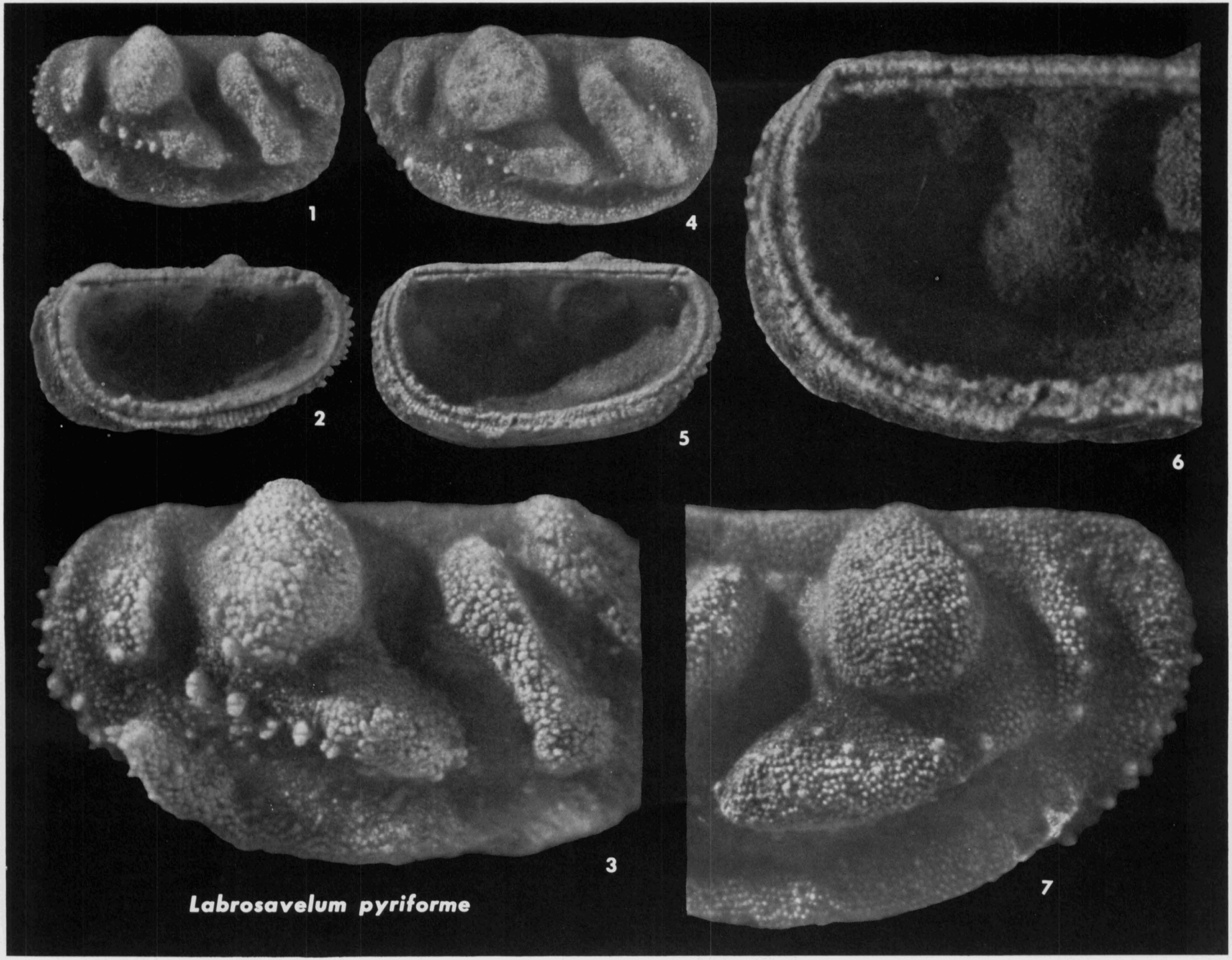
EXPLANATION OF PLATE 39

Figures x 40 except as noted

*Labrosavelum pyriforme*

All specimens from Potter Farm Formation, Locality 1

FIGS. 1–7—1–3, two lateral and an interior views of right valve, paratype UMMP 64529; 3, about x 80; note peculiar "doubled" large papillae on ventral lobe below L3. 4–6, lateral and two interior views of right valve, paratype 64531; 6, about x 80. 7, lateral view of left valve, paratype 64529, about x 80, showing unusual "double" spinelets along posterior part of ventral lobe; such spinelets also occur on certain other areas, but rarely.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Labrosavelum pyriforme

EXPLANATION OF PLATE 40

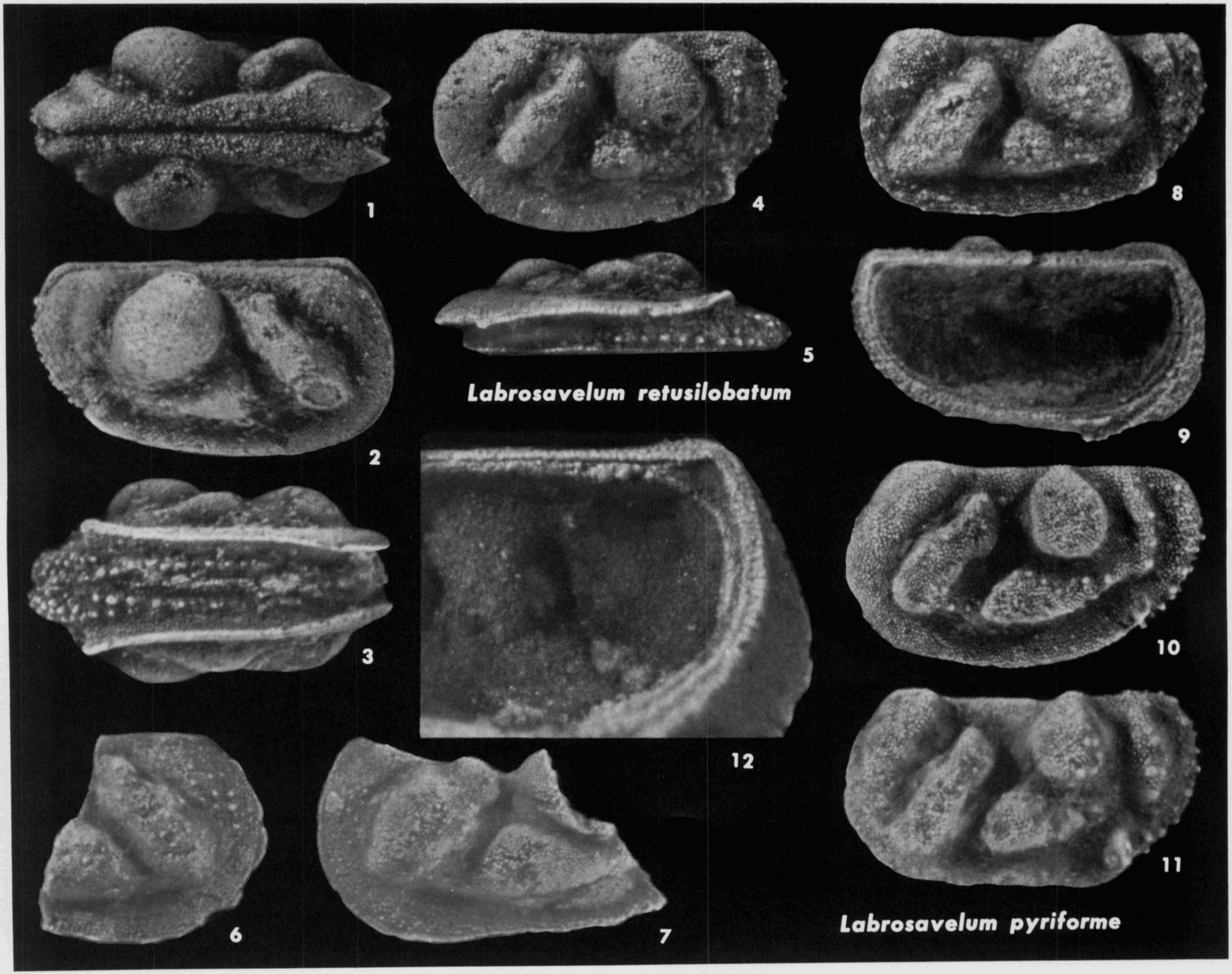
Figures x 40 except as noted

*Labrosavelum retusilobatum*

FIGS. 1–7—1–3, dorsal, right lateral, and ventral views of adult (male ?) carapace, UMMP 64543, Centerfield Formation, Loc. 1. 4,5, lateral and ventral views of adult (male ?) left valve, 64544, Centerfield Formation, Loc. 1. 6, lateral view of anterior fragment of right valve, 64923, Windom Shale, Loc. 1. 7, lateral view of incomplete left valve, 64921, Windom Shale, Loc. 1.

*Labrosavelum pyriforme*

FIGS. 8–12—8,9, lateral and interior views of female left valve, paratype 64526, Genshaw Formation, Loc. 3. 10, lateral view of male left valve, paratype 64533, Hungry Hollow Formation, Loc. 4. 11, lateral view of adult left valve, paratype 64541, Petoskey Formation, Loc. 2. 12, interior view of anterior part of left valve, paratype 64530, Potter Farm Formation, Loc. 1; about x 80, showing hinge structure; see also Plate 41, figs. 1–4.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Labrosavelum retusilobatum
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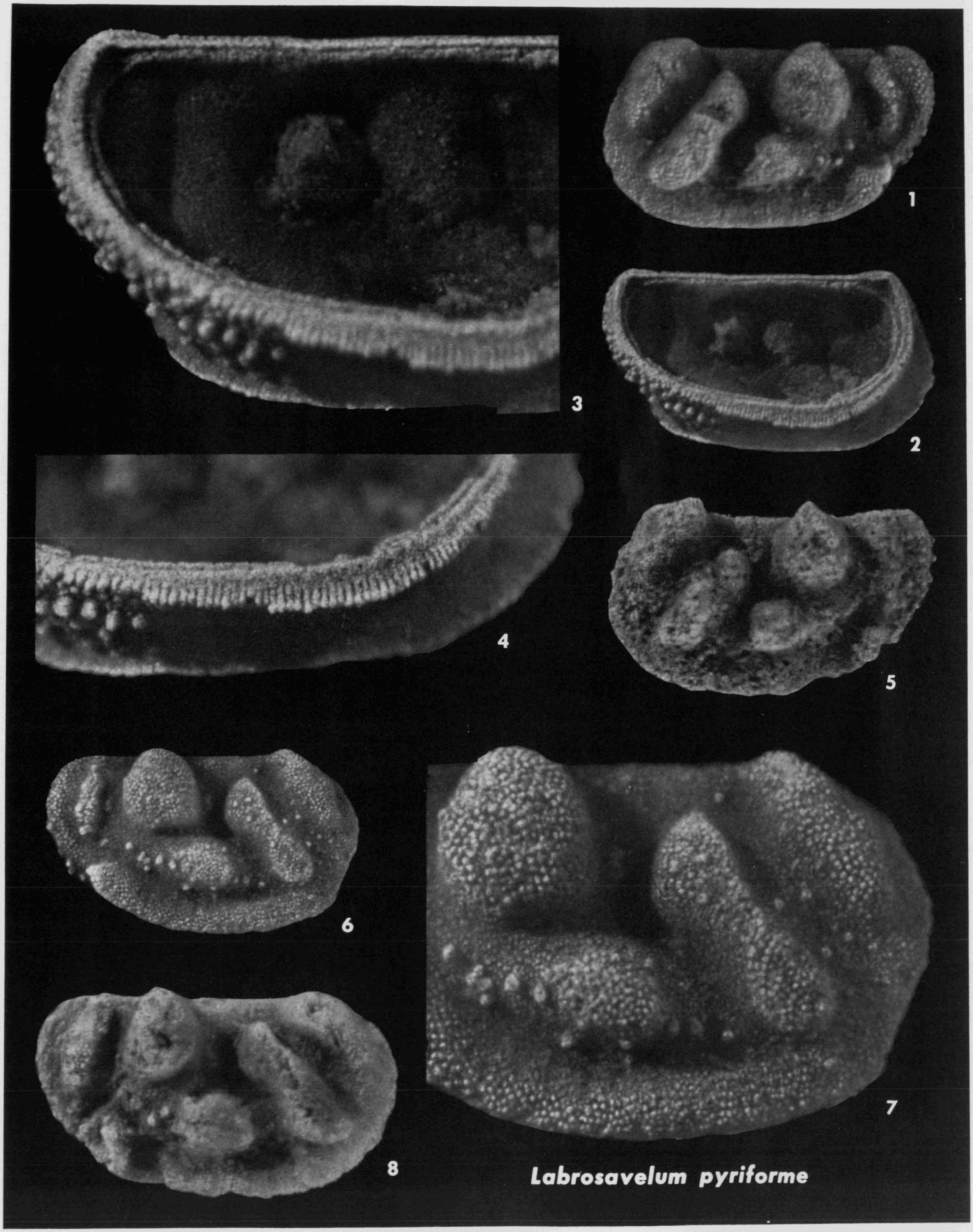
Labrosavelum pyriforme

EXPLANATION OF PLATE 41

Figures x 40 except as noted

*Labrosavelum pyriforme*

FIGS. 1–8—1–4, lateral and three interior views of adult left valve, paratype UMMP 64530, Potter Farm Formation, Loc. 1; 3,4, about x 80; see also Plate 40, fig. 12. 5, lateral view of adult left valve, paratype 64523, Genshaw Formation, Loc. 2; specimen badly worn. 6,7, lateral views of adult right valve, paratype 64532, Potter Farm Formation, Loc. 1; 7, about x 80. 8, lateral view of adult (male ?) right valve, paratype 64542, Petoskey Formation, Loc. 2; this specimen, which reveals few areas with papillae, may retain the thin and fragile outer layer of shell.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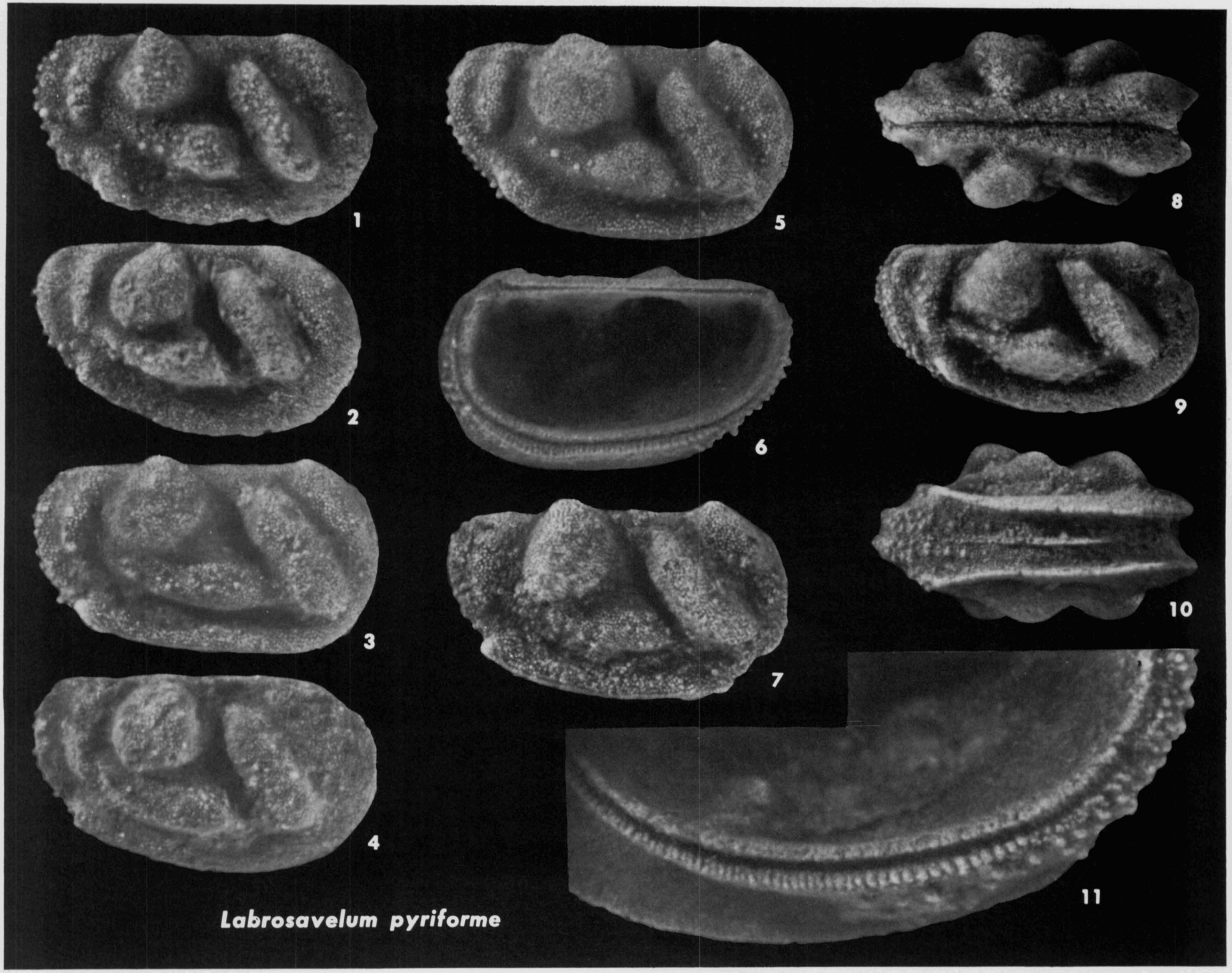
Labrosavelum pyriforme

EXPLANATION OF PLATE 42

Figures x 40 except as noted

*Labrosavelum pyriforme*

FIGS. 1–11—1, lateral view of right valve, partype UMMP 64539, Petoskey Formation, Loc. 1. 2, lateral view of right valve, paratype 64536, Hungry Hollow Formation, Loc. 3. 3, lateral view of right valve, paratype 30879, Petoskey Formation, Loc. 1. 4, lateral view of right valve, paratype 64521, Bell Shale, Loc. 4. 5,6, lateral and interior views of right valve, paratype 30881, Potter Farm Formation, Loc. 1. 7, lateral view of right valve, paratype 64525, Genshaw Formation, Loc. 3. 8–10, dorsal, right lateral, and ventral views of carapace, paratype 64538, Widder Formation, Loc. 1. 11, interior view of posteroventral part of right valve, paratype 64535, Hungry Hollow Formation, Loc. 3, about x 80; see also Plate 43, figs. 4,5.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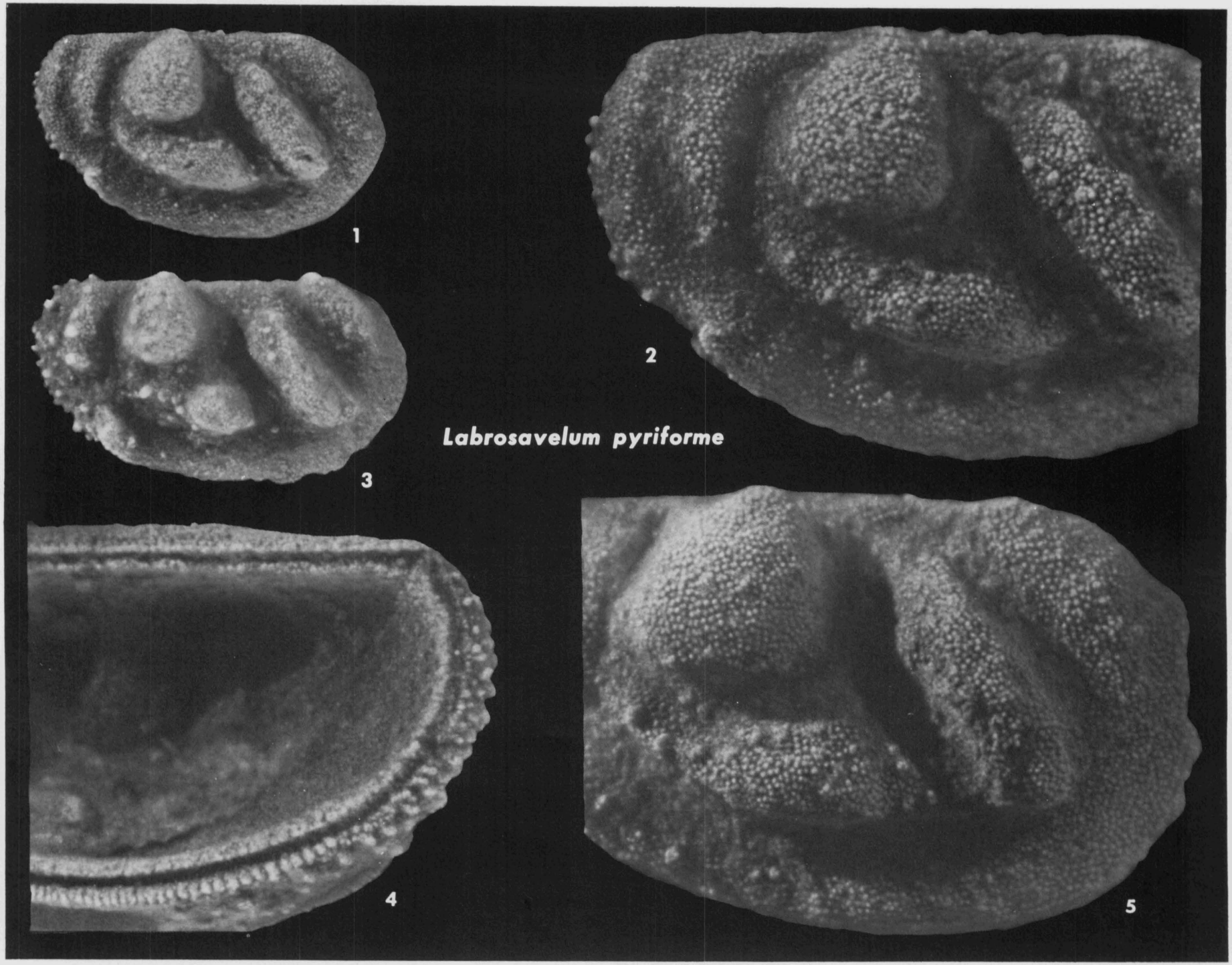
Labrosavelum pyriforme

EXPLANATION OF PLATE 43

Figures x 40 except as noted

*Labrosavelum pyriforme*

FIGS. 1–5—1,2, lateral views of adult right valve, paratype UMMP 64534, Hungry Hollow Formation, Loc. 4; 2, about x 80. 3, lateral view of adult right valve, paratype 64540, Petoskey Formation, Loc. 2. 4,5, interior and lateral views of parts of adult right valve, paratype 64535, Hungry Hollow Formation, Loc. 3, both about x 80; see also Plate 42, fig. 11.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Labrosavelum pyriforme
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EXPLANATION OF PLATE 44

All figures x 40

*Tetrasacculus paeneloculatus*

Specimens from Arkona Shale, Locality 4, except as noted

FIGS. 1–27—1–3, right lateral, ventral, and inclined ventral views of female carapace, 64826. 4,5, left lateral and ventral views of female carapace, 64958. 6–8, dorsal, left lateral, and ventral views of male carapace, 64825. 9, right lateral view of female carapace, 64952, Gravel Point Formation, Loc. 1. 10,11, right lateral and ventral views of male carapace, 64959. 12,13, right lateral and ventral views of female carapace, 64955. 14,15, lateral and interior views of female left valve, 64824. 16–18, dorsal, right lateral, and ventral views of male carapace, 64829. 19,20, right lateral and ventral views of male carapace, 64827. 21,22, right lateral and ventral views of female carapace, 64954, Ipperwash Formation, Loc. 1. 23, right lateral view of female carapace, 64828. 24,25, right lateral and ventral views of female carapace, 64957. 26,27, right lateral and ventral views of male carapace, 64951, Gravel Point Formation, Loc. 1.

*Tetrasacculus quaternarius*

All specimens from Dock Street Clay Member of Four Mile Dam Formation, Locality 1

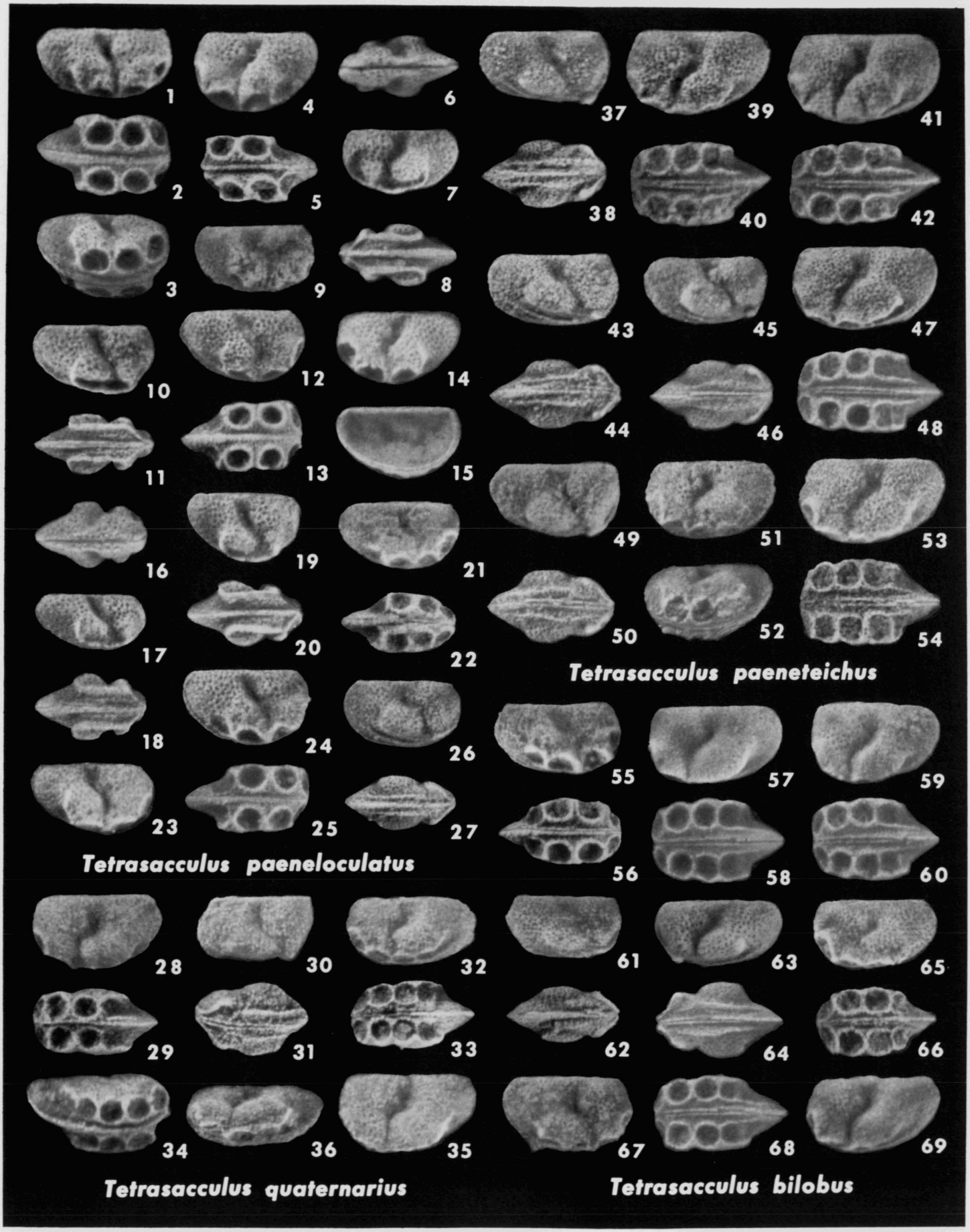
FIGS. 28–36—28,29, left lateral and ventral views of female carapace, paratype 64935. 30,31, left lateral and ventral views of male carapace, paratype 64938. 32,33, left lateral and ventral views of female carapace, holotype 64936. 34, inclined view of female carapace, paratype 64937. 35,36, lateral and inclined views of female left valve, paratype 64963.

*Tetrasacculus paeneteichus*

FIGS. 37–54—37,38, right lateral and ventral views of male carapace, 64948, Kashong Shale, Loc. 1. 39–42, left lateral and ventral views of two female carapaces, 64945 and 64939, Kashong Shale, Locs. 1 and 6. 43,44, right lateral and ventral views of male carapace, 64947, Kashong Shale, Loc. 1. 45,46, right lateral and ventral views of male carapace, 64943, Windom Shale, Loc. 2. 47,48, left lateral and ventral views of female carapace, 64944, Kashong Shale, Loc. 1. 49,50, right lateral and ventral views of male carapace, 64946, Kashong Shale, Loc. 1. 51,52, left lateral and ventral views of female carapace, 64941, Wanakah Shale, Loc. 1. 53,54, left lateral and ventral views of female carapace, 64970, Kashong Shale, Loc. 1.

*Tetrasacculus bilobus*

FIGS. 55–69—55,56, right lateral and ventral views of female carapace, 64960, Genshaw Formation, Loc. 2. 57–60, left lateral and ventral views of two female carapaces, 64931 and 64929, Widder Formation, Loc. 1. 61,62, right lateral and ventral views of male carapace, 64950, Gravel Point Formation, Loc. 1. 63,64, left lateral and ventral views of male carapace, 64932, Widder Formation, Loc. 1. 65,66, left lateral and ventral views of female carapace, 64961, Genshaw Formation, Loc. 2. 67, right lateral view of female carapace, 64949, Gravel Point Formation, Loc. 1. 68,69, left lateral and ventral views of female carapace, 64930, Widder Formation, Loc. 1.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Tetrasacculus paeneloculatus
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Tetrasacculus paeneteichus
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Tetrasacculus quaternarius
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Tetrasacculus bilobus

EXPLANATION OF PLATE 45

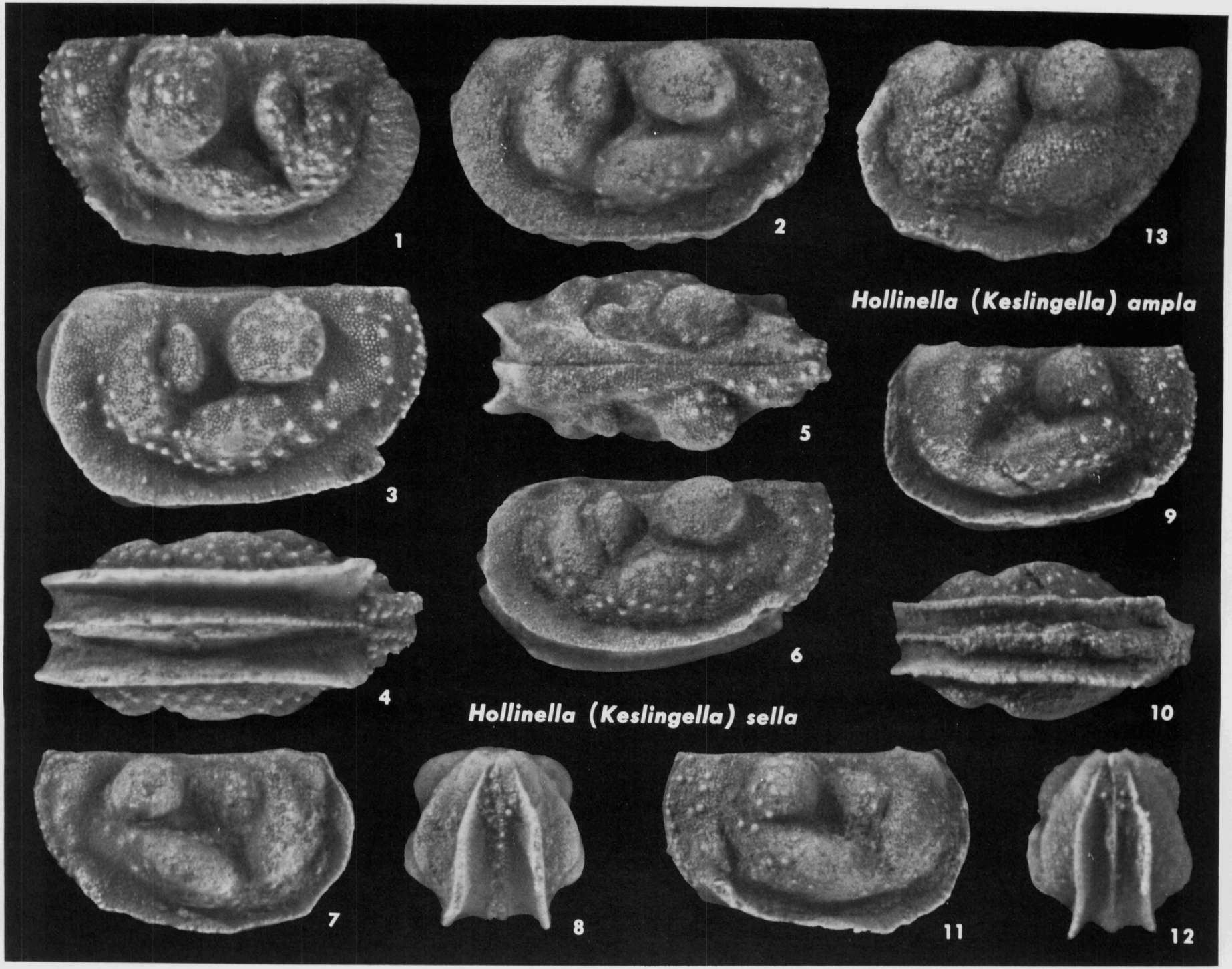
All figures x 40

*Hollinella* (*Keslingella*) *sella*

FIGS. 1–12—1, lateral view of male right valve, UMMP 64920, Centerfield Formation, Loc. 1. 2, lateral view of male left valve, 64915, Kashong Shale, Loc. 1. 3,4, left lateral and ventral views of female carapace, 64848, Wanakah Shale, Loc. 6. 5,6, dorsal and left lateral views of female carapace, 64916, Wanakah Shale, Loc. 3. 7,8, right lateral and anterior views of female carapace, 64546, Wanakah Shale, Loc. 6. 9–12, left lateral, ventral, right lateral, and anterior views of female carapace, 64547, Wanakah Shale, Loc. 3; this specimen is appreciably smaller than UMMP 64916 (figs. 5,6) from the same locality, but shows similar features.

*Hollinella* (*Keslingella*) *ampla*

FIG. 13—lateral view of male left valve, holotype 27355, Norway Point Formation, Loc. 1.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Hollinella (Keslingella) ampla
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Hollinella (Keslingella) sella
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EXPLANATION OF PLATE 46

Figures x 40 except as noted

*Adelphobolbina megalia*

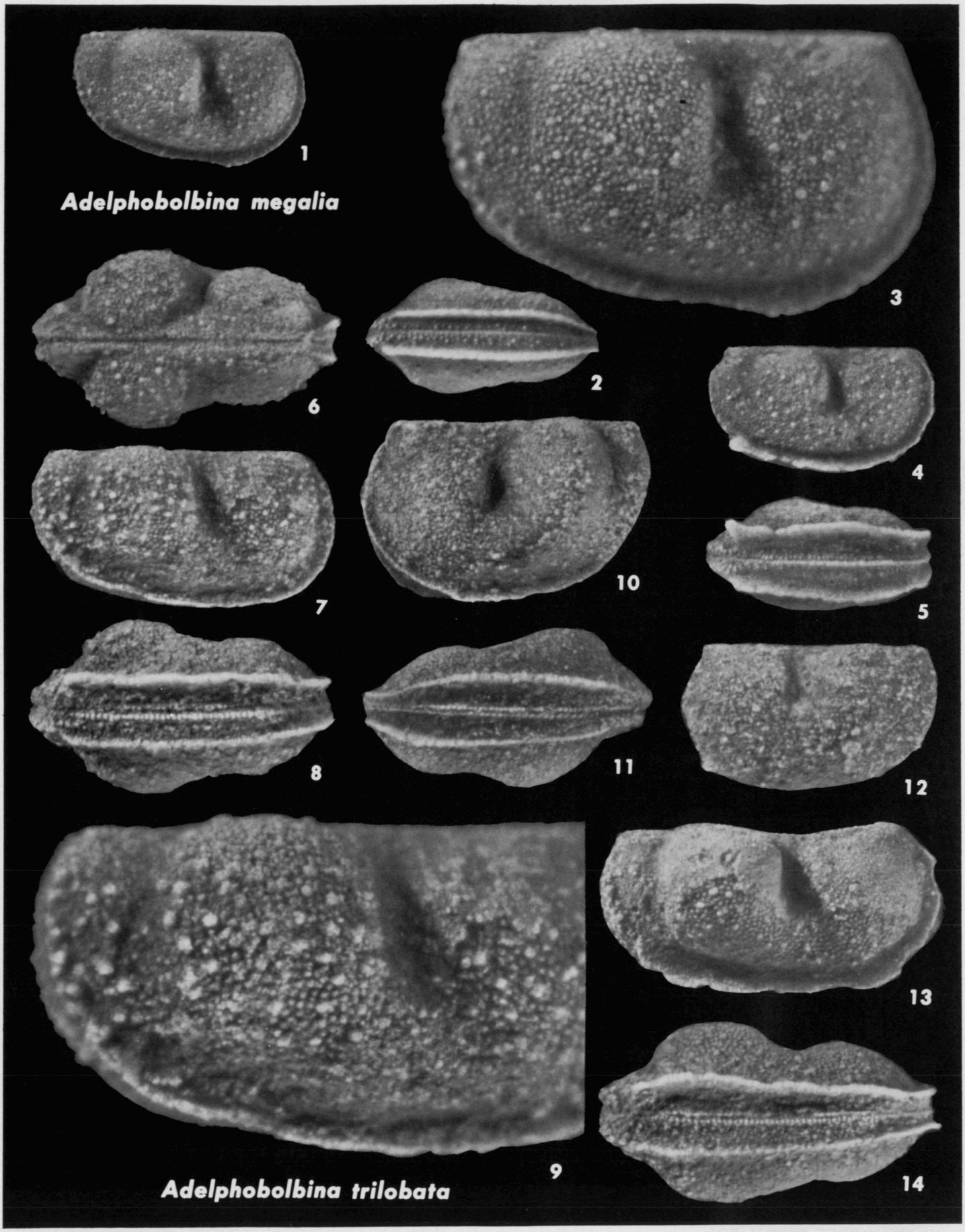
Both specimens from Genshaw Formation, Locality 5

FIGS. 1-5—1-3, right lateral and ventral views of male carapace, UMMP 30873; 3, about x 80. 4,5, right lateral and ventral views of female carapace, 30872.

*Adelphobolbina trilobata*

All specimens from Ferron Point Formation

FIGS. 6-14—6-9, dorsal, right lateral, and ventral views of male carapace, 64783, Loc. 1; 9, about x 80. 10,11, left lateral and ventral views of distorted male carapace, 64781, Loc. 1. 12, left lateral view of ultimate immature (A-1) carapace, 64784, Loc. 3. 13,14, right lateral and ventral views of male carapace, 64823, Loc. 1; specimen apparently retains dorsally parts of fragile outermost shell layer bearing a finely pebbled texture, and displays ventrally the typical fine papillae and scattered larger papillae.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Adelphobolbina megalia
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Adelphobolbina trilobata
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EXPLANATION OF PLATE 47

All figures x 40

*Falsipollex minimus*

All specimens from Genshaw Formation, Locality 6

FIGS. 1–10—1, lateral view of female right valve, holotype UMMP 28069. 2, lateral view of male right valve, paratype 28070. 3–5, dorsal, left lateral, and ventral views of female carapace, 64996. 6–8, dorsal, right lateral, and ventral views of female carapace, 64995. 9,10, right lateral and ventral views of female carapace, 64994.

*Falsipollex laxivelatus*

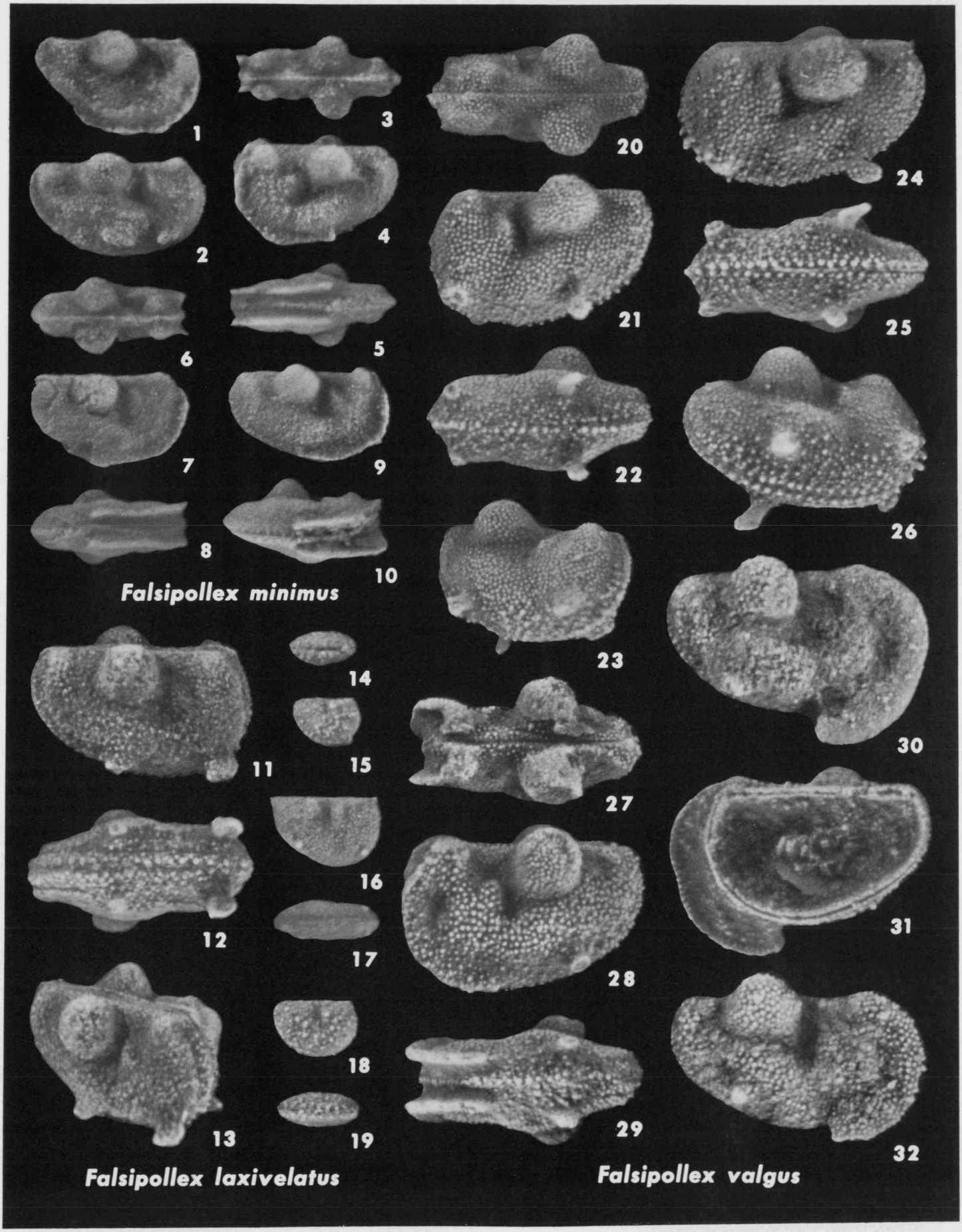
All specimens from Ferron Point Formation, Locality 3

FIGS. 11–19—11–13, right lateral, ventral, and inclined views of male carapace, 65005. 14,15, dorsal and right lateral views of immature (A–5) carapace, 65012. 16–17, right lateral and ventral views of immature (A–3) carapace, 65011. 18,19, right lateral and ventral views of immature (A–4) carapace, 65013.

*Falsipollex valgus*

All specimens from Arkona Shale

FIGS. 20–32—20–23, dorsal, left lateral, ventral, and inclined anteroventral views of male carapace, 64991, Loc. 7. 24–26, left lateral, ventral, and inclined posteroventral views of male carapace, 64986, Loc. 7. 27–29, dorsal, left lateral, and ventral views of female carapace, 64990, Loc. 7. 30,31, lateral and interior views of female right valve, 64984, Loc. 2. 32, lateral view of female right valve, 64983, Loc. 2.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Falsipollex minimus
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Falsipollex laxivelatus
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Falsipollex valgus

EXPLANATION OF PLATE 48

Figures x 40 except as noted

*Tetrasacculus paeneteichus*

All figures about x 80

FIGs. 1–4—1, inclined ventral view of male carapace, UMMP 64946, Kashong Shale, Loc. 1. 2, inclined ventral view of male carapace, 64947, Kashong Shale, Loc. 1. 3, ventral view of male carapace, 64943, Windom Shale, Loc. 2. 4, inclined ventral view of female carapace, 64942, Windom Shale, Loc. 2.

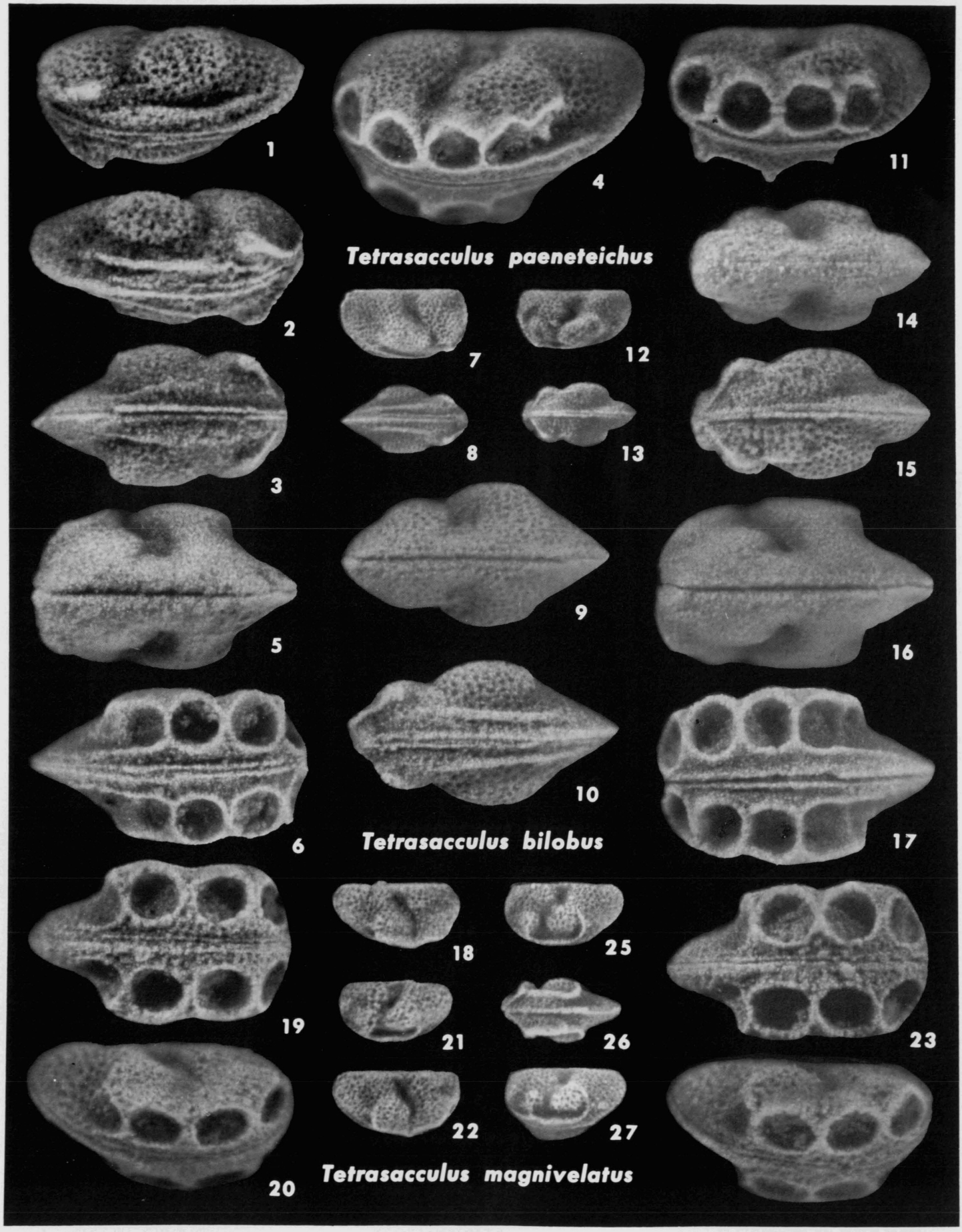
*Tetrasacculus bilobus*

FIGS. 5–17—5, dorsal view of female carapace, 64929, Widder Formation, Loc. 1, about x 80. 6, ventral view of female carapace, 64930, Widder Formation, Loc. 1, about x 80. 7–10, right lateral, ventral (2), and dorsal views of male carapace, 64933, Widder Formation, Loc. 1; 9,10, about x 80. 11, inclined ventral view of female carapace, 64960, Genshaw Formation, Loc. 6, about x 80. 12–15, left lateral, ventral (2), and dorsal views of male carapace, 64962, Genshaw Formation, Loc. 6; 14,15, about x 80. 16,17, dorsal and ventral views of female carapace, 64931, Widder Formation, Loc. 1, both about x 80.

*Tetrasacculus magnivelatus*

All specimens from Arkona Shale

FIGS. 18–27—18–20, right lateral, ventral, and inclined ventral views of female carapace, 64968, Loc. 4; 19,20, about x 80. 21, left lateral view of male carapace, 64967, Loc. 4. 22–24, right lateral, ventral, and inclined ventral views of female carapace, 64969, Loc. 4; 23,24, about x 80. 25–27, left lateral, ventral, and inclined ventral views of male carapace, 30957, Loc. 3.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Tetrasacculus paeneteichus
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Tetrasacculus bilobus
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Tetrasacculus magnivelatus

EXPLANATION OF PLATE 49

All figures x 40

*Falsipollex altituberculatus*

FIGS. 1-3—1, lateral view of female right valve, UMMP 65027, Genshaw Formation, Loc. 4. 2, lateral view of female right valve, 65002, Bell Shale, Loc. 8. 3, lateral view of male left valve, holotype 26636, Bell Shale, Loc. 2.

*Falsipollex equipapillatus*

All specimens from Norway Point Formation, Locality 1

FIGS. 4-8—4, lateral view of female right valve, paratype 27329. 5, lateral view of female right valve, holotype 27327. 6, lateral view of female left valve, paratype 27335. 7,8, lateral and interior views of female right valve, paratype 27338.

*Falsipollex minimus*

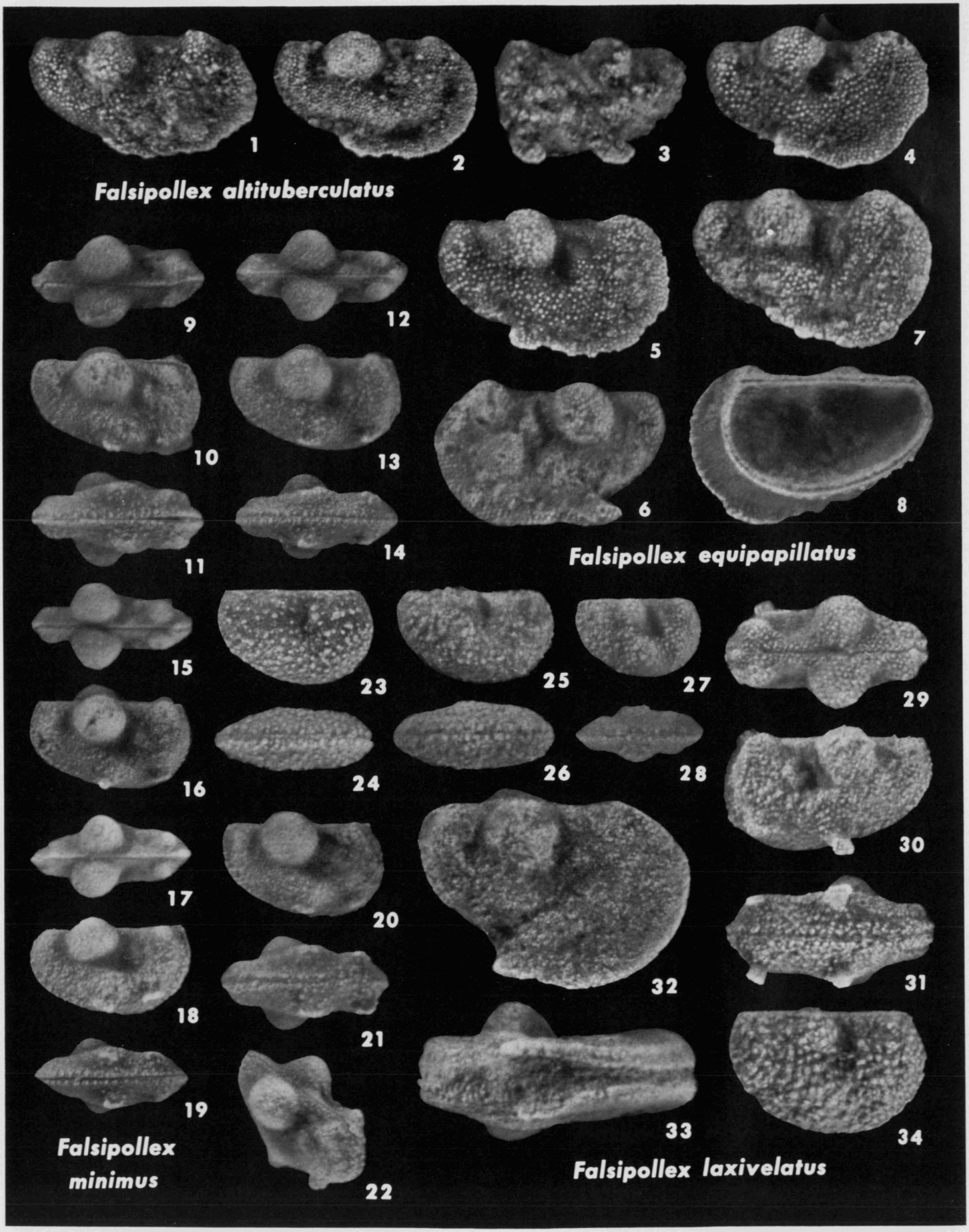
All specimens from Genshaw Formation, Locality 6

FIGS. 9-22—9-11, dorsal, right lateral, and ventral views of male carapace, 65000. 12-14, dorsal, right lateral, and ventral views of male carapace, 64998. 15,16, dorsal and right lateral views of male carapace, 64997. 17-19, dorsal, right lateral, and ventral views of male carapace, 64999. 20-22, right lateral, ventral, and inclined views of male carapace, 28075 (holotype of *Falsipollex bulbosus*, now placed in synonymy).

*Falsipollex laxivelatus*

All specimens from Ferron Point Formation, Locality 3

FIGS. 23-34—23-28, right lateral and ventral views of three juvenile carapaces, 65007, 65008, and 65009. 29-31, dorsal, left lateral, and ventral views of male carapace, paratype 28042. 32,33, right lateral and ventral views of female carapace, holotype 28040. 34, right lateral view of immature (A-1) carapace, 65010.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Falsipollex altituberculatus
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Falsipollex minimus
Falsipollex laxivelatus

EXPLANATION OF PLATE 50

All figures x 40

*Falsipollex laxivelatus*

All specimens from Ferron Point Formation, Locality 3

FIGS. 1–10—1–3, right lateral, ventral, and inclined views of female carapace, UMMP 65004. 4,5, right lateral and ventral views of juvenile carapace, 65009. 6,7, left lateral and ventral views of male carapace, paratype (allotype) 28041. 8–10, dorsal, left lateral, and ventral views of male carapace, 65042.

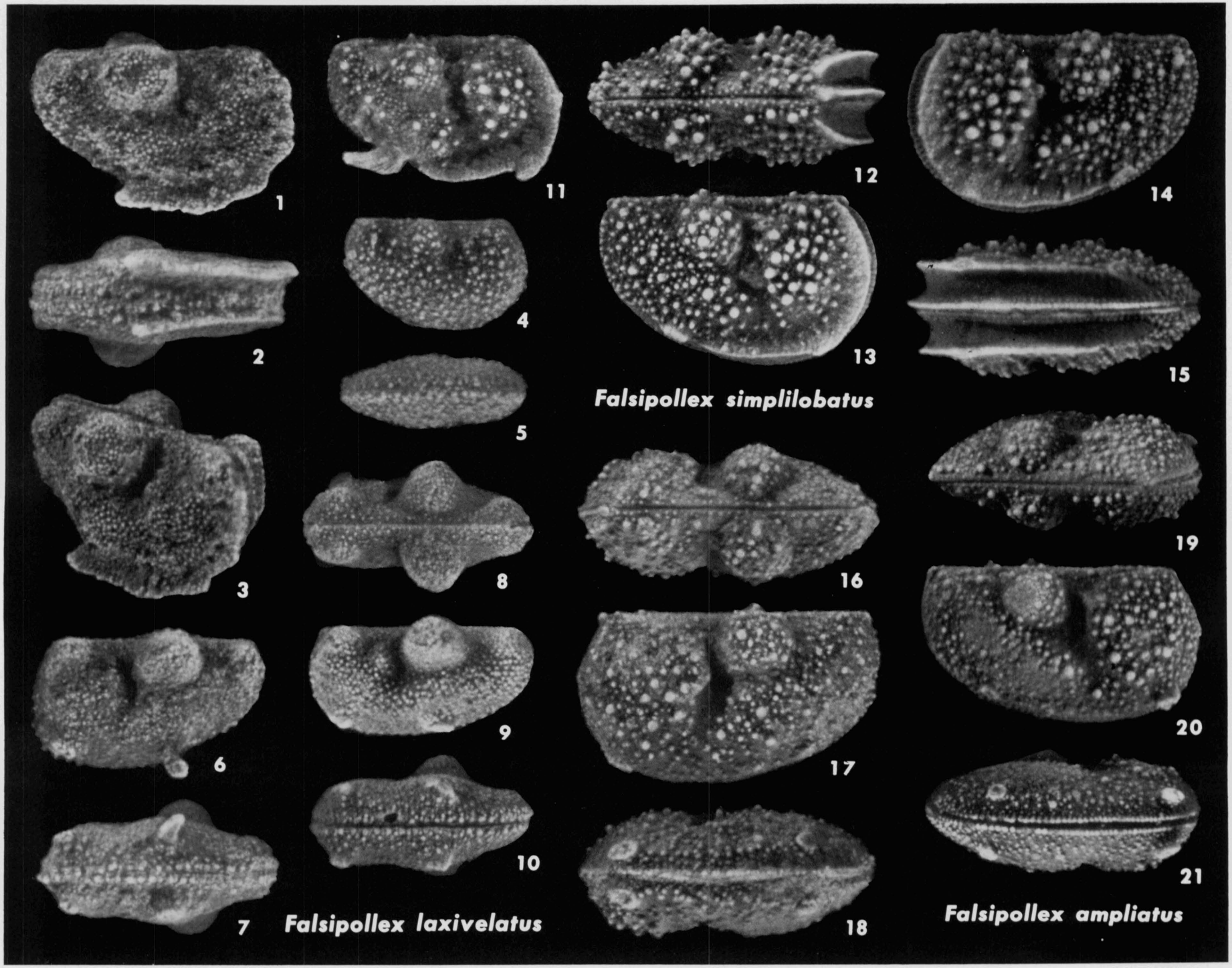
*Falsipollex simplilobatus*

FIGS. 11–15—11, right lateral view of female carapace, 65029, Windom Shale, Loc. 1. 12–15, dorsal, right lateral, left lateral, and ventral views of female carapace, 64992, Kashong Shale, Loc. 2.

*Falsipollex ampliatus*

Both specimens from Kashong Shale, Locality 2

FIGS. 16–21—16–18, dorsal, left lateral, and ventral views of male carapace, paratype 65038. 19–21, dorsal, right lateral, and ventral views of male carapace, paratype 65039.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Falsipollex laxivelatus
Falsipollex simplilobatus
Falsipollex ampliatus

EXPLANATION OF PLATE 51

All figures x 40

*Ruptivelum bacculatum*

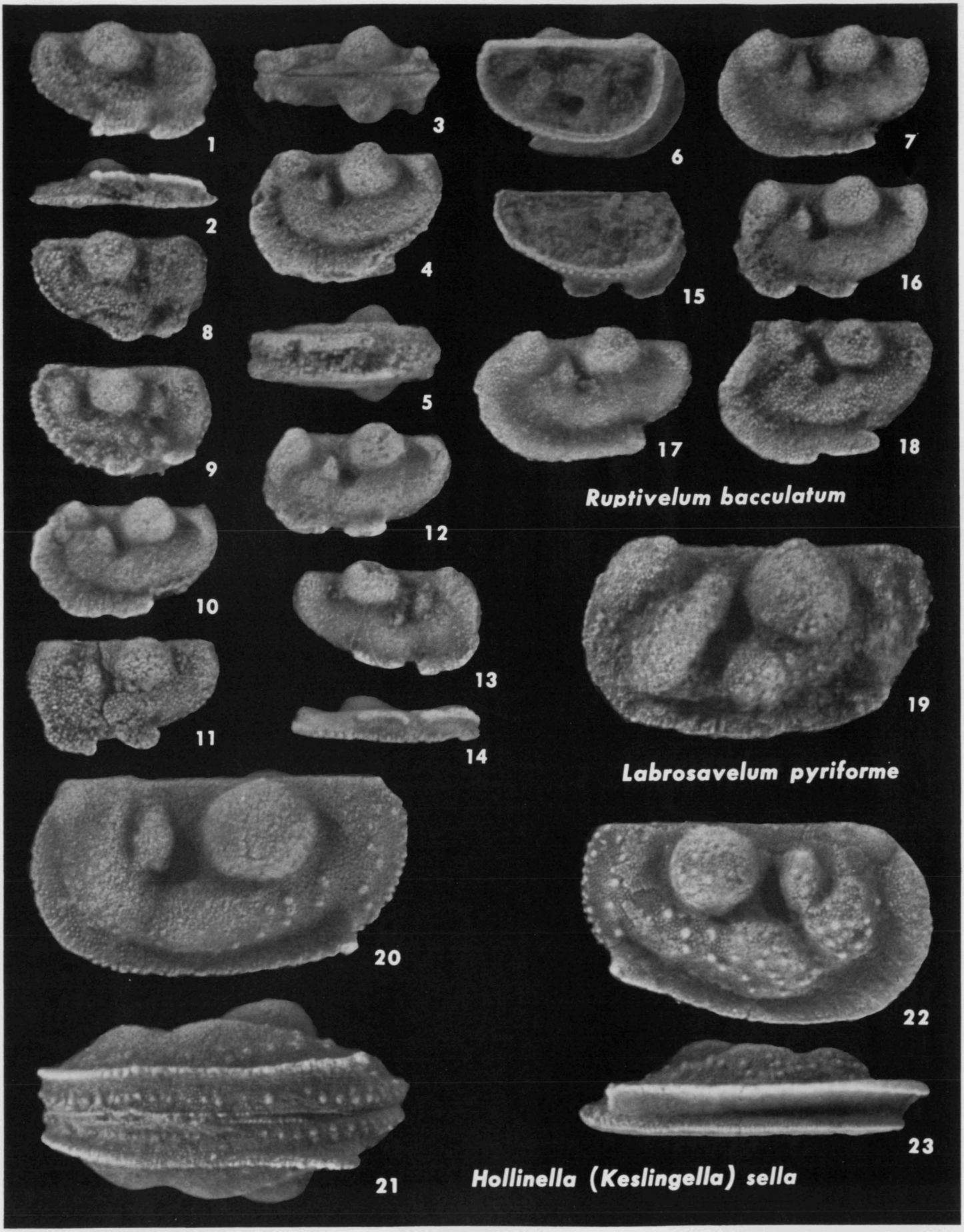
FIGS. 1–18—1,2, lateral and ventral views of male right valve, UMMP 64972, Petoskey Formation, Loc. 2. 3–5, dorsal, left lateral, and ventral views of female carapace, 64976, Gravel Point Formation, Loc. 1. 6,7,15,16, interior and lateral views of two female valves, paratype (allotype) 27344 and paratype 27347, both from Norway Point Formation, Loc. 1. 8,9, lateral views of two male valves, 64971 and 64977, Bell Shale, Loc. 1. 10, lateral view of female left valve, 64973, Gravel Point Formation, Loc. 1. 11, lateral view of male left valve, 64975, Norway Point Formation, Loc. 1. 12, lateral view of male left valve, holotype 27346, Norway Point Formation, Loc. 1. 13,14, lateral and ventral views of male right valve, paratype 27348, Norway Point Formation, Loc. 1. 17, lateral view of female left valve, paratype 27345, Norway Point Formation, Loc. 1. 18, lateral view of female left valve, 64993, Bell Shale, Loc. 8.

*Labrosavelum pyriforme*

FIG. 19—lateral view of left valve, paratype 64522, Genshaw Formation, Loc. 1.

*Hollinella (Keslingella) sella*

FIGS. 20–23—20,21, left lateral and ventral views of adult (male ?) carapace, 64849, Kashong Shale, Loc. 1. 22,23, lateral and ventral views of adult female right valve, 64850, Wanakah, Shale, Loc. 3.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Ruptivelum bacculatum
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Labrosavelum pyriforme
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Hollinella (Keslingella) sella

EXPLANATION OF PLATE 52

Figures x 40 except as noted

*Hollinella* (*Keslingella*) *sella*

FIGS. 1–4—1,2, left lateral and ventral views of male carapace, UMMP 64917, Wanakah Shale, Loc. 3. 3,4, dorsal and left lateral views of carapace, 64924, Kashong Shale, Loc. 1.

*Tetrasacculus paeneteichus*

FIGS. 5–13—5,10,11, ventral (2) and left lateral views of female carapace, 64940, Kashong Shale, Loc. 6; 5, about x 80. 6-9, left lateral, ventral (2), and inclined ventral views of male carapace, 64942, Windom Shale, Loc. 2; 9, about x 80. 12, inclined ventral view of male carapace, 64944, Kashong Shale, Loc. 1, about x 80. 13, inclined ventral view of female carapace, 64948, Kashong Shale, Loc. 1.

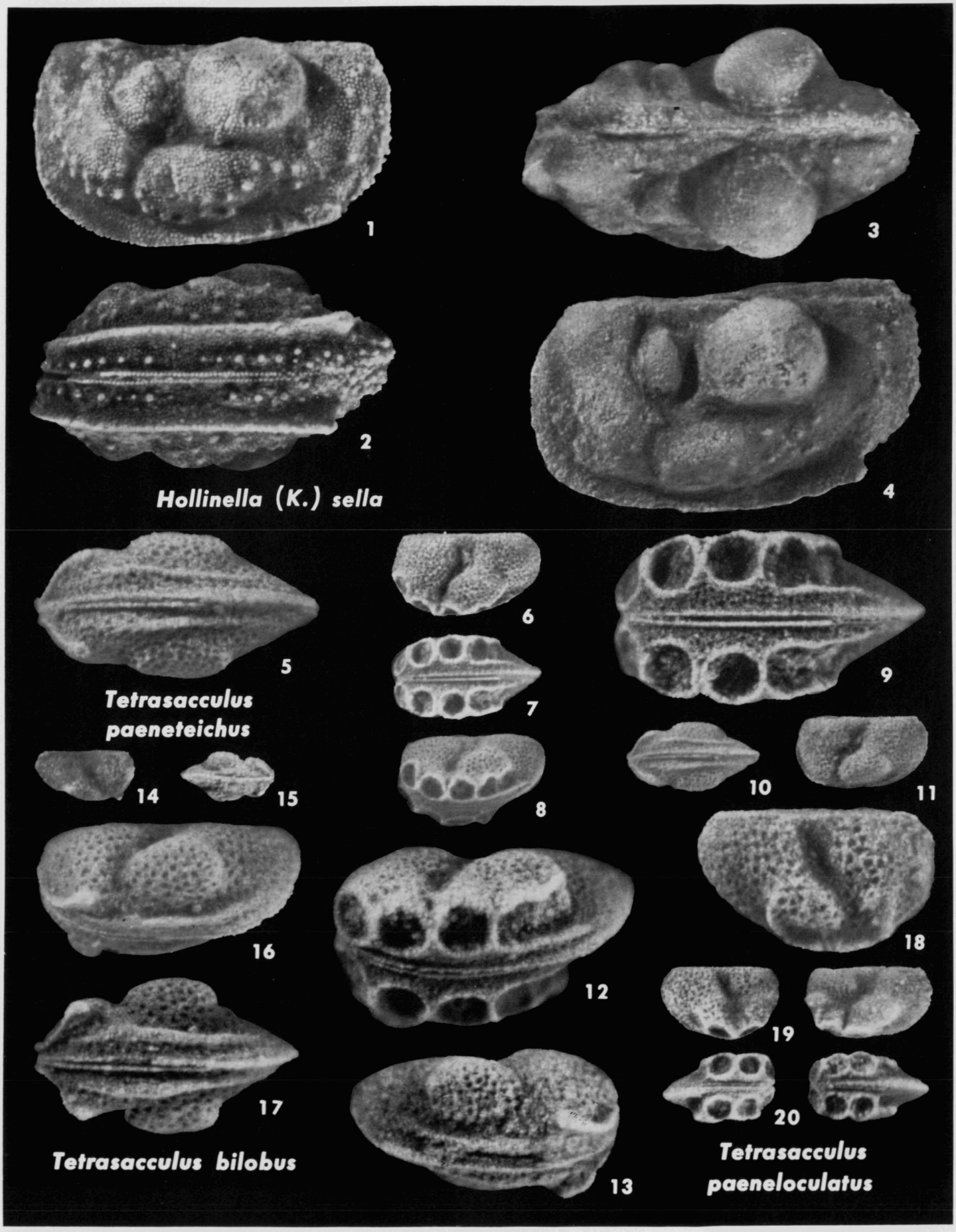
*Tetrasacculus bilobus*

Both specimens from Widder Formation, Locality 1

FIGS. 14–17—14,15, right lateral and ventral views of male carapace, 64934. 16,17, inclined ventral and ventral views of male carapace, 64932, both figures about x 80.

*Tetrasacculus paeneloculatus*

FIGS. 18–22—18, right lateral view of male carapace, 64827, Arkona Shale, Loc. 4, about x 80. 19,20, right lateral and ventral views of female carapace, 64956, Arkona Shale, Loc. 4. 21,22, left lateral and ventral views of female carapace, 64953, Gravel Point Formation, Loc. 1.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Hollinella (K.) sella
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Tetrasacculus paeneteichus
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Tetrasacculus bilobus
Tetrasacculus paeneloculatus

EXPLANATION OF PLATE 53

All figures x 40

*Falsipollex laxivelatus*

All specimens from Ferron Point Formation, Locality 3

FIGS. 1-7—1-3, right lateral, ventral, and inclined anterior views of female carapace, UMMP 65003. 4,5, right lateral and ventral views of immature (A-1) carapace, 65006. 6,7, right lateral and inclined anterior views of female carapace, 65041.

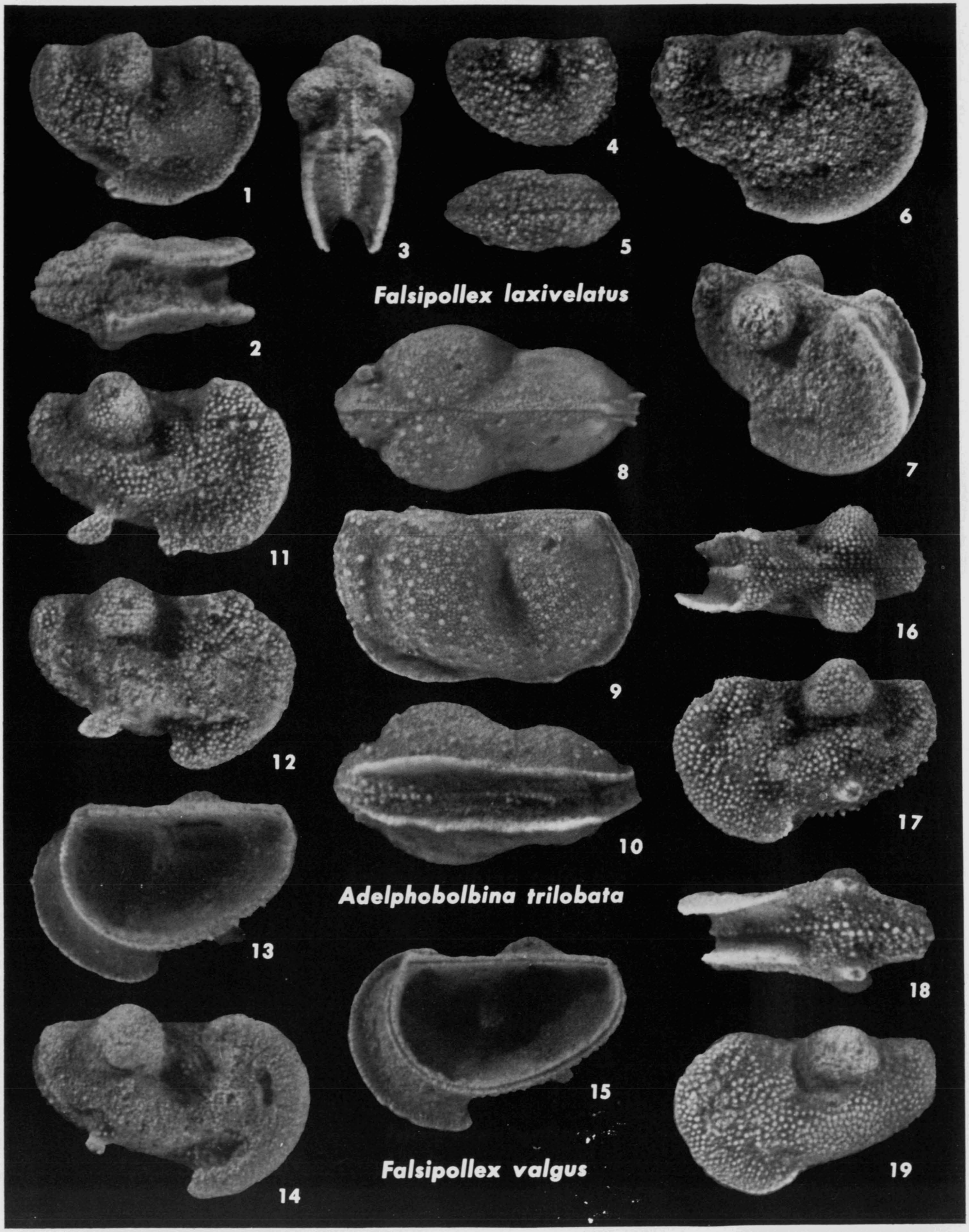
*Adelphobolbina trilobata*

FIGS. 8-10—dorsal, right lateral, and ventral views of male carapace, 64776, Widder Formation, Loc. 1.

*Falsipollex valgus*

All specimens from Arkona Shale

FIGS. 11-19—11, lateral view of female right valve, 65040, Loc. 2. 12,13, lateral and interior views of female right valve, 64987, Loc. 3. 14,15, lateral and interior views of female right valve, 64985, Loc. 4. 16-18, dorsal, left lateral, and ventral views of female carapace, 64989, Loc. 7. 19, left lateral view of female carapace, 64980, Loc. 2.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Falsipollex laxivelatus
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Adelphobolbina trilobata
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Falsipollex valgus
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EXPLANATION OF PLATE 54

All figures x 40

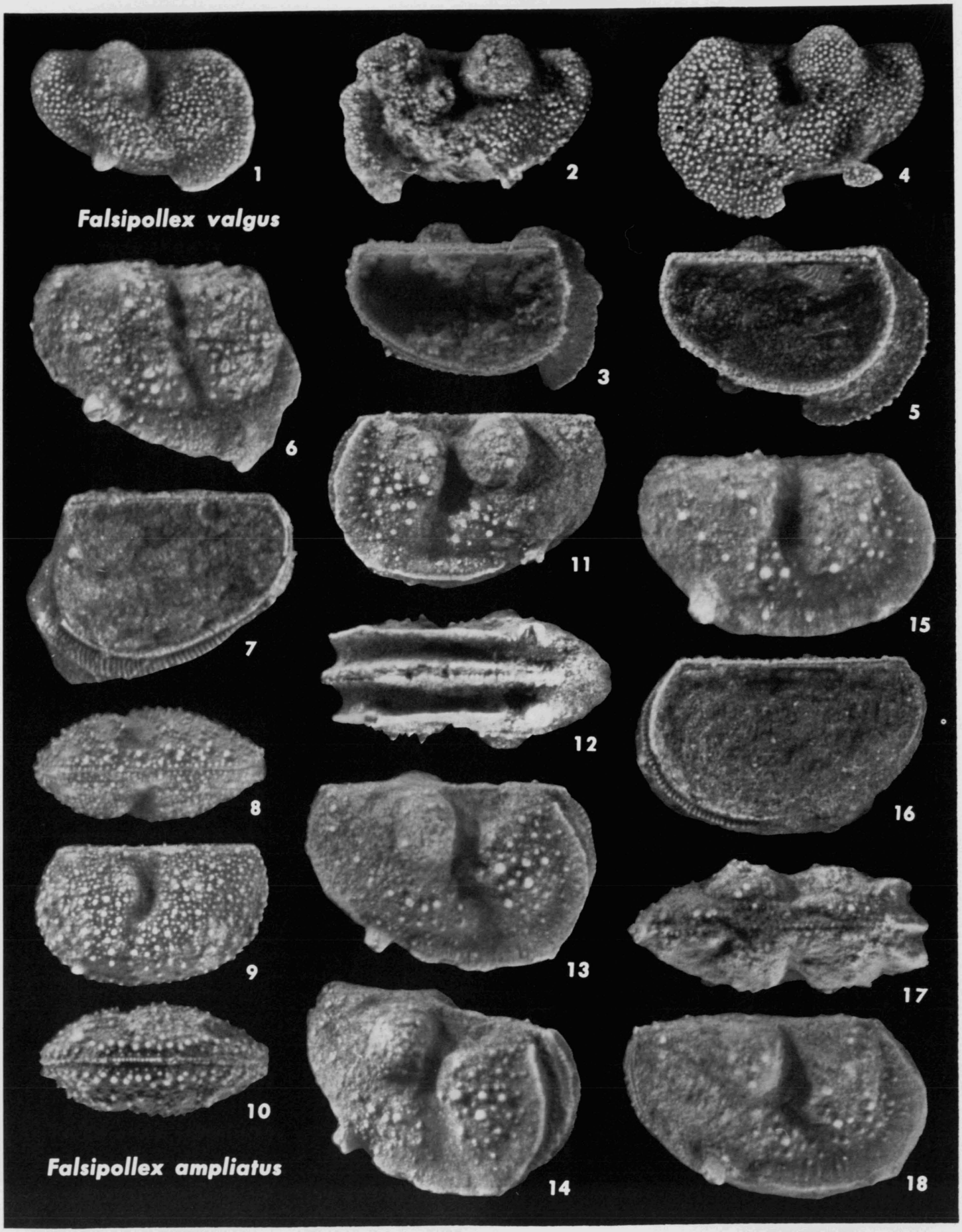
*Falsipollex valgus*

FIGS. 1–5—1, right lateral view of female carapace, UMMP 64981, Arkona Shale, Loc. 2. 2,3, lateral and interior views of female left valve, 64988, Norway Point Formation, Loc. 2. 4,5, lateral and interior views of female left valve, 64982, Arkona Shale, Loc. 2.

*Falsipollex ampliatus*

All specimens from Kashong Shale

FIGS. 6–18—6,7, lateral and interior views of female right valve, holotype 65032, Loc. 1. 8–10, dorsal, left lateral, and ventral views of male carapace, paratype 65037, Loc. 3. 11–14, left lateral, ventral, right lateral, and inclined views of female carapace, paratype 65031, Loc. 3. 15,16, lateral and interior views of female right valve, paratype 65033, Loc. 1. 17,18, dorsal and right lateral views of female carapace, paratype 65034, Loc. 1.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Falsipollex valgus
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Falsipollex ampliatus

EXPLANATION OF PLATE 55

Figures x 40 except as noted

*Subligaculum scrobiculatum*

All specimens from Bell Shale, Locality 2

FIGS. 1–8—1–3, lateral (2) and interior views of male right valve, holotype UMMP 26638; 3, about x 80. 4–6, lateral (2) and interior views of female right valve, paratype (allotype) 26639; 6, about x 80. 7,8, lateral and interior views of female left valve, paratype 26785.

*Subligaculum bifidum*

All specimens from Silica Shale

FIGS. 9–14—9,10, right lateral and ventral views of female carapace, 30974, Loc. 1. 11,12, right lateral and ventral views of female carapace, 59006, Loc. 2. 13,14, left lateral and ventral views of female carapace, 30973, Loc. 1.

*Subligaculum calcaratum*

FIGS. 15–28—15,16, lateral and interior views of female right valve, 65047, Arkona Shale, Loc. 5. 17,18, right lateral and inclined ventral views of female carapace, 65053, Arkona Shale, Loc. 7. 19,20, right lateral and ventral views of immature carapace, 65045, Widder Formation, Loc. 1. 21,22, right lateral and ventral views of male carapace, 65049, Widder Formation, Loc. 1. 23,24, left lateral and ventral views of female carapace, 48950, Widder Formation, Loc. 1. 25,26, left lateral and ventral views of female carapace, 65054, Arkona Shale, Loc. 7. 27,28, left lateral and ventral views of female carapace, 65050, Arkona Shale, Loc. 5.

*Subligaculum laciniosum*

All specimens from Ferron Point Formation, Locality 3

FIGS. 29–40—29,30, left lateral and ventral views of female carapace, holotype 28047. 31,32, left lateral and ventral views of female carapace, 65066. 33, right lateral view of crushed female carapace, paratype 28048. 34,35, right lateral and ventral views of female carapace, 30946. 36,37, right lateral and ventral views of immature (A–3) carapace, 65068. 38, left lateral view of male carapace, 65069. 39,40, left lateral and ventral views of immature (A–1) carapace, 65067.

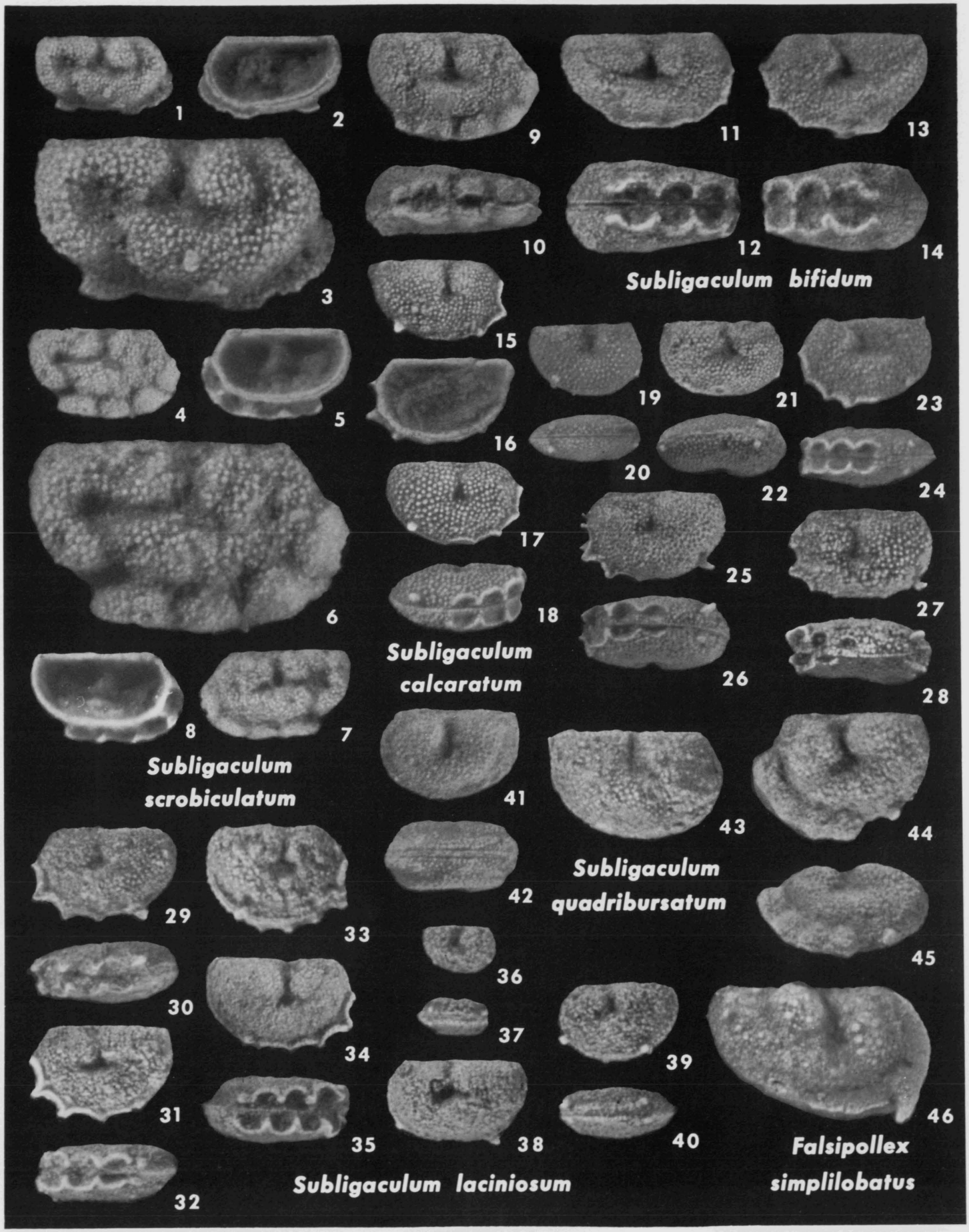
*Subligaculum quadribursatum*

All specimens from Kashong Shale

FIGS. 41–45—41,42, left lateral and ventral views of male carapace, paratype 65060, Loc. 4. 43, right lateral view of exceptionally large male carapace, paratype 65062, Loc. 1. 44,45, left lateral and inclined ventral views of female carapace, paratype 65061, Loc. 1.

*Falsipollex simplilobatus*

FIG. 46—lateral view of female right valve, 64979, Ipperwash Formation, Loc. 1.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Subligaculum scrobiculatum
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Subligaculum calcaratum
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Subligaculum bifidum
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Subligaculum quadribursatum
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Subligaculum laciniosum
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Falsipollex simplilobatus

EXPLANATION OF PLATE 56

All figures x 40

*Subligaculum biorthogonium*

FIGS. 1–7—1, lateral view of female right valve, paratype UMMP 30980, Petoskey Formation, Loc. 2. 2, lateral view of female left valve, 30947, Norway Point Formation, Loc. 1. 3, lateral view of female left valve, paratype 27389, Norway Point Formation, Loc. 1. 4,5, lateral and interior views of female left valve, holotype 27390, Norway Point Formation, Loc. 1. 6,7, lateral and interior views of female left valve, 30981, Gravel Point Formation, Loc. 9.

*Subligaculum proclivisulcatum*

Both specimens from Genshaw Formation, Locality 6

FIGS. 8–11—8,9, right lateral and inclined ventral views of female carapace, holotype 28053. 10,11, lateral and interior views of female right valve, 30963.

*Subligaculum aculeatum*

All specimens from Windom Shale, Locality 1

FIGS. 12–14—12, lateral view of female right valve, 65064. 13, lateral view of female right valve (incomplete), 65065. 14, lateral view of female left valve, 65063.

*Subligaculum calcaratum*

FIGS. 15–22—15,16, right lateral and ventral views of female carapace, 65051, Arkona Shale, Loc. 2. 17,18, lateral and interior views of female right valve, 65052, Arkona Shale, Loc. 2. 19,20, right lateral and ventral views of male carapace, paratype (allotype) 28975, Arkona Shale, Loc. 1. 21,22, left lateral and ventral views of female carapace, 65044, Widder Formation, Loc. 1.

*Subligaculum tribursatum*

FIGS. 23–28—23, right lateral view of female carapace, 65056, Wanakah Shale, Loc. 1. 24–26, left lateral, ventral, and right lateral views of female carapace, 65055, Wanakah Shale, Loc. 1. 27,28, lateral and interior views of female right valve, holotype 28046, Ferron Point Formation, Loc. 3. Note that the New York Wanakah specimens are much larger than the holotype from the Michigan Ferron Point Formation, although they agree with respect to the frill structure.

*Subligaculum scrobiculatum*

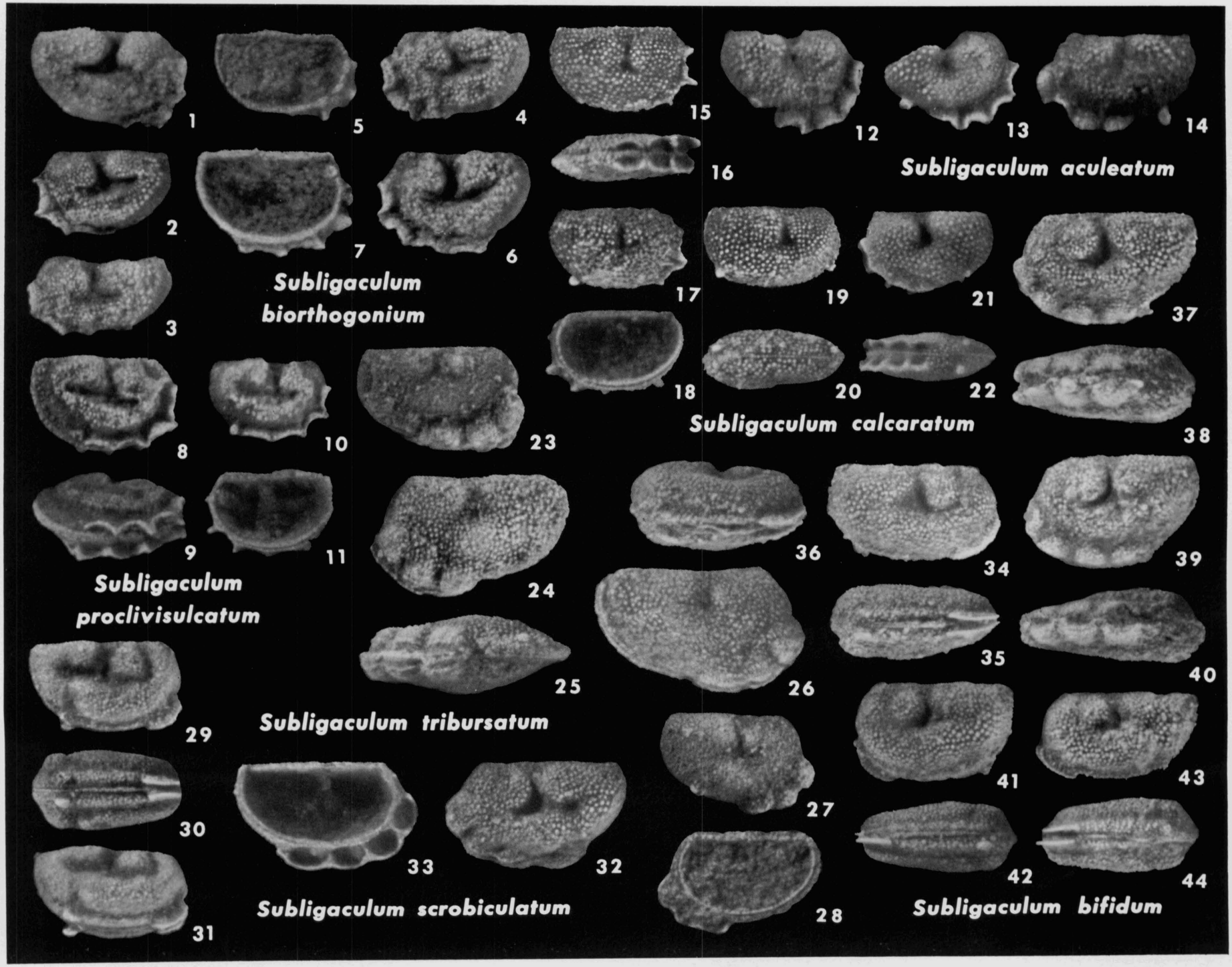
Both specimens from Silica Shale, Locality 1

FIGS. 29–33—29–31, right lateral, ventral, and inclined views of male carapace, 65070. 32,33, lateral and interior views of female left valve, 65071.

*Subligacululm bifidum*

All specimens from Silica Shale

FIGS. 34–44—34–36, right lateral, ventral, and inclined ventral views of male carapace, 65073, Loc. 2. 37,38, left lateral and ventral views of female carapace, 59002, Loc. 2. 39,40, left lateral and ventral views of female carapace, 59004, Loc. 1. 41,42, left lateral and ventral views of male carapace, 59005, Loc.2. 43,44, left lateral and ventral views of male carapace, 65072, Loc. 2.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Subligaculum aculeatum
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Subligaculum biorthogonium
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Subligaculum calcaratum
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Subligaculum proclivisulcatum
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Subligaculum tribursatum
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Subligaculum scrobiculatum
Subligaculum bifidum

EXPLANATION OF PLATE 57

Figures x 40 except as noted

*Flaccivelum teleutaeum*

Both specimens from Genshaw Formation, Locality 6

FIGS. 1–4—1, lateral view of female right valve, holotype UMMP 27785. 2–4, dorsal, left lateral, and ventral views of male carapace, 64821.

*Flaccivelum papillosum*

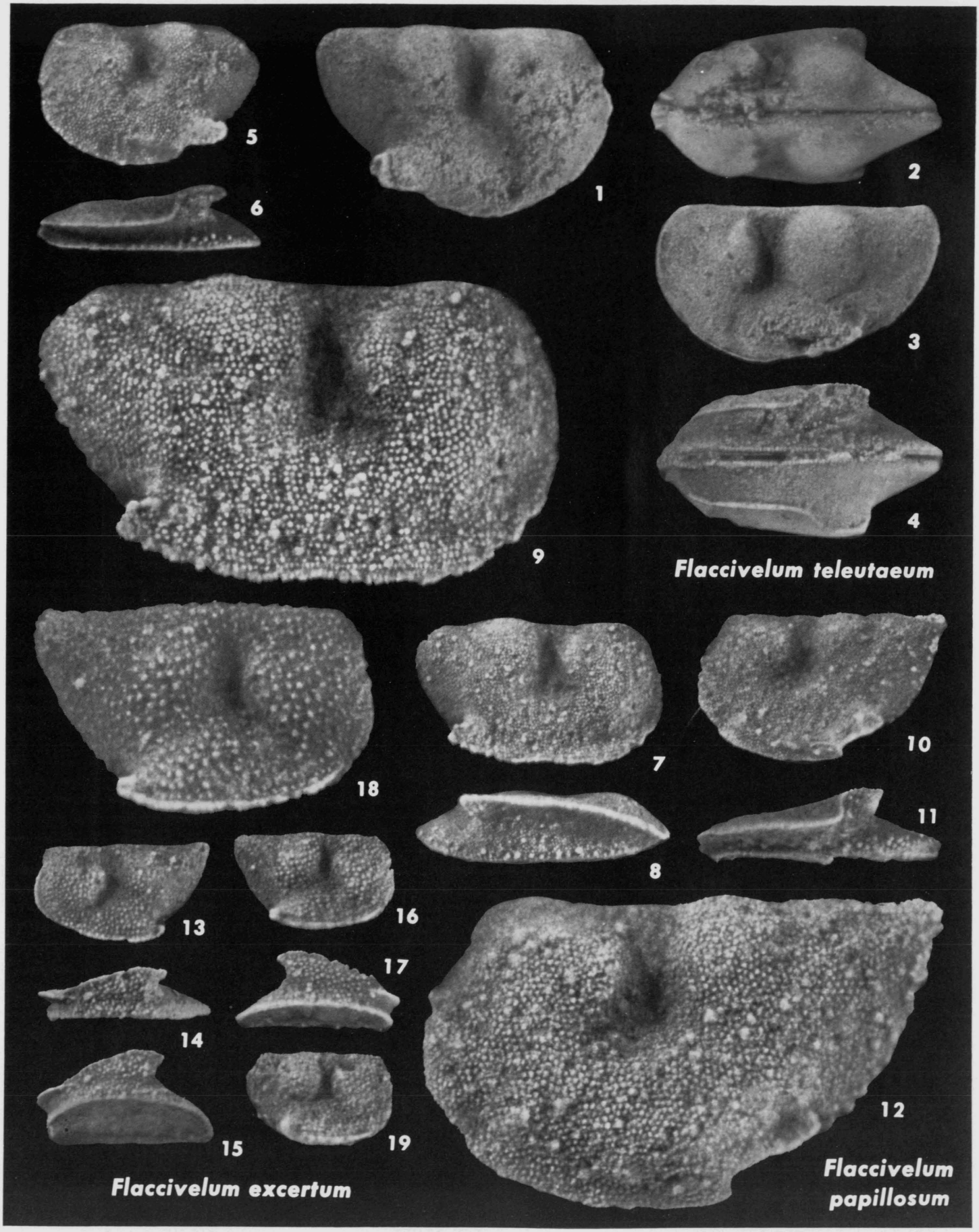
All specimens from Bell Shale

FIGS. 5–12—5,6, lateral and ventral views of female left valve, paratype 60252, Loc. 4. 7–9, lateral (2) and ventral views of male left valve, paratype 60256, Loc. 8; 9, about x 80. 10–12, lateral (2) and ventral views of female left valve, holotype 60254, Loc. 4; 12, about x 80.

*Flaccivelum excertum*

All specimens from Bell Shale

FIGS. 13–19—13–15, lateral, ventral, and inclined views of female left valve, holotype 64815, Loc. 8. 16–18, lateral (2) and ventral views of female right valve, paratype 60255, Loc. 8. 19, lateral view of female right valve, paratype 64817, Loc. 4.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Flaccivelum teleutaeum
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Flaccivelum excertum
Flaccivelum papillosum

EXPLANATION OF PLATE 58

All figures x 40

*Falsipollex ampliatus*

FIGS. 1,2—left lateral and ventral views of immature (A-1) carapace, paratype UMMP 65043, Kashong Shale, Loc. 1.

*Falsipollex lativelatus*

All specimens from Widder Formation

FIGS. 3-16—3-6, right lateral, ventral, left lateral, and inclined dorsal views of female carapace, 65014, Loc. 1. 7,8, lateral and interior views of female right valve, 65018, Loc. 4. 9,10, lateral and interior views of female left valve, 65019, Loc. 4. 11,12, left lateral and ventral views of compressed female carapace, 65015, Loc. 1. 13,14, left lateral and ventral views of compressed male carapace, 65016, Loc. 1. 15,16, lateral and interior views of anterior fragment of female left valve, 65020, Loc. 4.

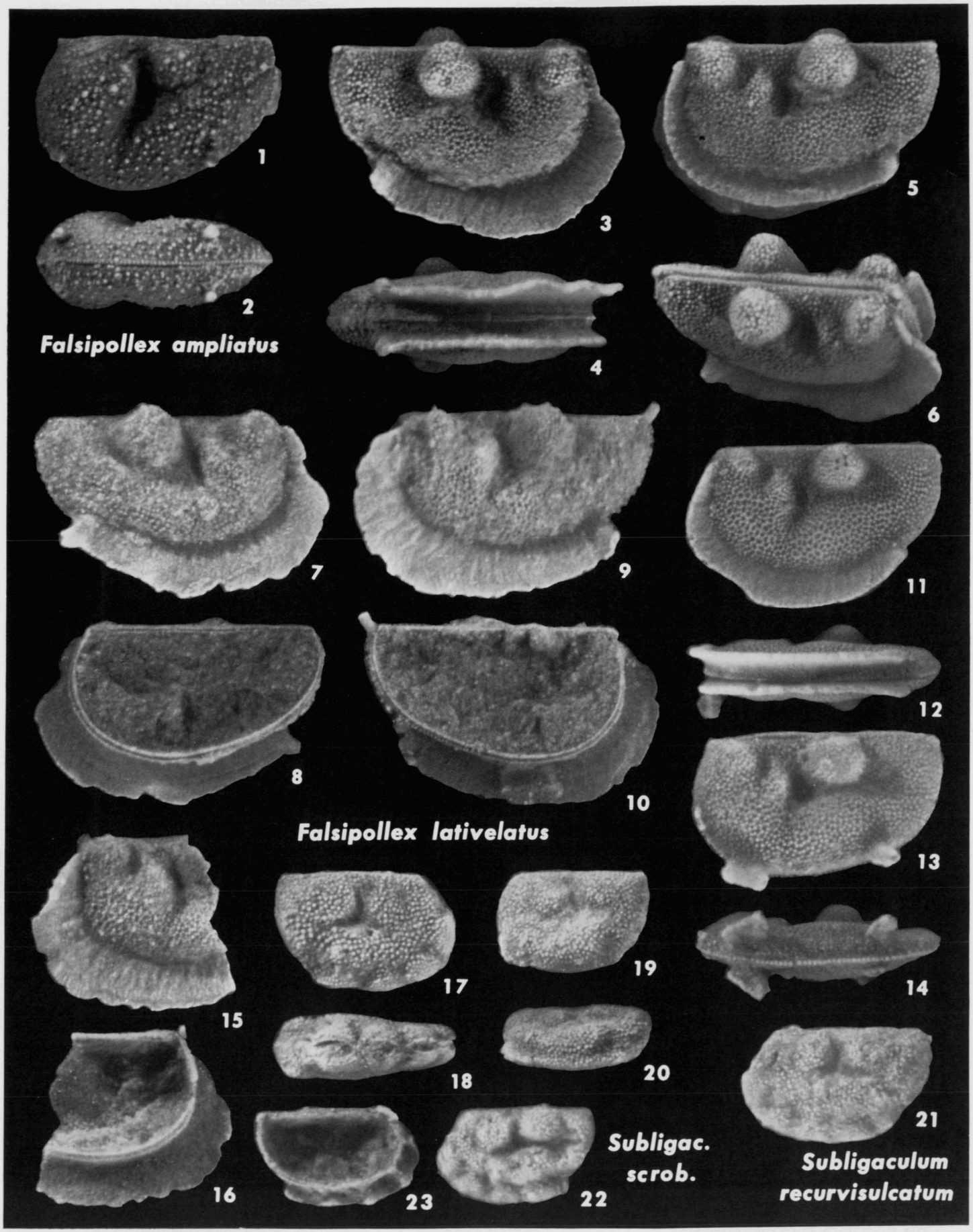
*Subligaculum recurvisulcatum*

All specimens from Bell Shale, Locality 2

FIGS. 17-21—17,18, right lateral and ventral views of female carapace, paratype (allotype) 26682. 19,20, left lateral and inclined ventral views of male carapace, paratype 26696. 21, lateral view of female left valve, paratype 26683.

*Subligaculum scrobiculatum*

FIGS. 22,23—lateral and interior views of female left valve, paratype 26784, Bell Shale, Loc. 2.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Falsipollex ampliatus
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Falsipollex lativelatus
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Subligac. scrob.
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Subligaculum recurvisulcatum

EXPLANATION OF PLATE 59

All figures x 40

*Flaccivelum teleutaeum*

All specimens from Genshaw Formation, Locality 6

FIGS. 1–12—1,2, lateral and ventral views of male right valve, paratype (allotype) UMMP 27784. 3,4, left lateral and ventral views of immature (A–1) damaged carapace, 64830. 5,6, lateral and ventral views of female right valve, holotype 27785. 7–9, right lateral, ventral, and inclined views of immature (A–2) carapace, 64966. 10–12, dorsal, left lateral, and ventral views of male carapace, 60257.

*Labrosavelum pyriforme*

FIG. 13—lateral view of right valve, paratype 64524, Genshaw Formation, Loc. 3.

*Falsipollex simplilobatus*

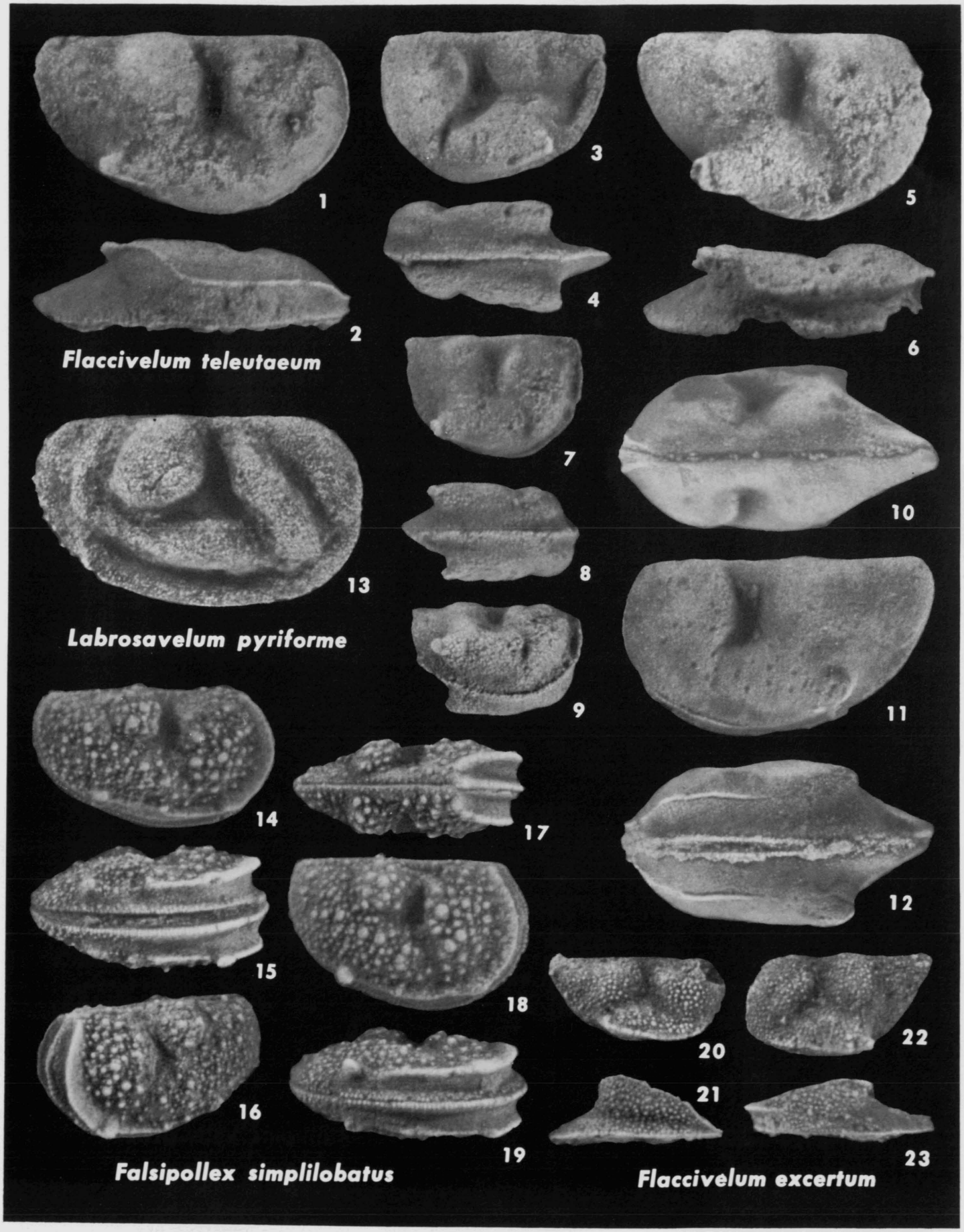
Both specimens from Wanakah Shale, Locality 6

FIGS. 14–19—14–16, right lateral, ventral, and inclined left views of female carapace, 65022. 17–19, dorsal, right lateral, and ventral views of female carapace, 65023.

*Flaccivelum excertum*

Both specimens from Bell Shale

FIGS. 20–23—20,21, lateral and ventral views of male right valve, paratype 64816, Loc. 8. 22,23, lateral and ventral views of female left valve, paratype 64818, Loc. 4. Note sexual differences in venters.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Flaccivelum teleutaeum
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Labrosavelum pyriforme
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Falsipollex simplilobatus
Flaccivelum excertum

EXPLANATION OF PLATE 60

All figures x 40

*Sulcicuneus latus*

FIGS. 1–15—1,2, right lateral and ventral views of female carapace, holotype 38891, Petoskey Formation, Loc. 2. 3,4, right lateral and ventral views of male carapace, paratype 60119, Genshaw Formation, Loc. 6. 5–7, dorsal, right lateral, and ventral views of female carapace, paratype 60332, Gravel Point Formation, Loc. 1. 8, left lateral view of female carapace, paratype 60260, Gravel Point Formation, Loc. 1. 9,10, right lateral and ventral views of male carapace, paratype 60188, Gravel Point Formation, Loc. 2. 11,12, left lateral and ventral views of female carapace, paratype 60261, Gravel Point Formation, Loc. 1. 13, right lateral view of male carapace, paratype 60331, Gravel Point Formation, Loc. 1. 14,15, right lateral and ventral views of male carapace, paratype 60802, Gravel Point Formation, Loc. 1.

*Sulcicuneus minutus*

FIGS. 16,17—lateral and ventral views of female right valve, holotype 60235, Norway Point Formation, Loc. 1.

*Sulcicuneus porrectinatius*

All specimens from Bell Shale

FIGS. 18–25—18–20, dorsal, right lateral, and ventral views of female carapace, 60258, Loc. 4. 21, lateral view of female left valve, 60259, Loc. 4. 22,23, left lateral and inclined ventral views of female carapace, 60326, Loc. 4. 24,25, lateral and interior views of female left valve, 60325, Loc. 8.

*Bisphenella deminuta*

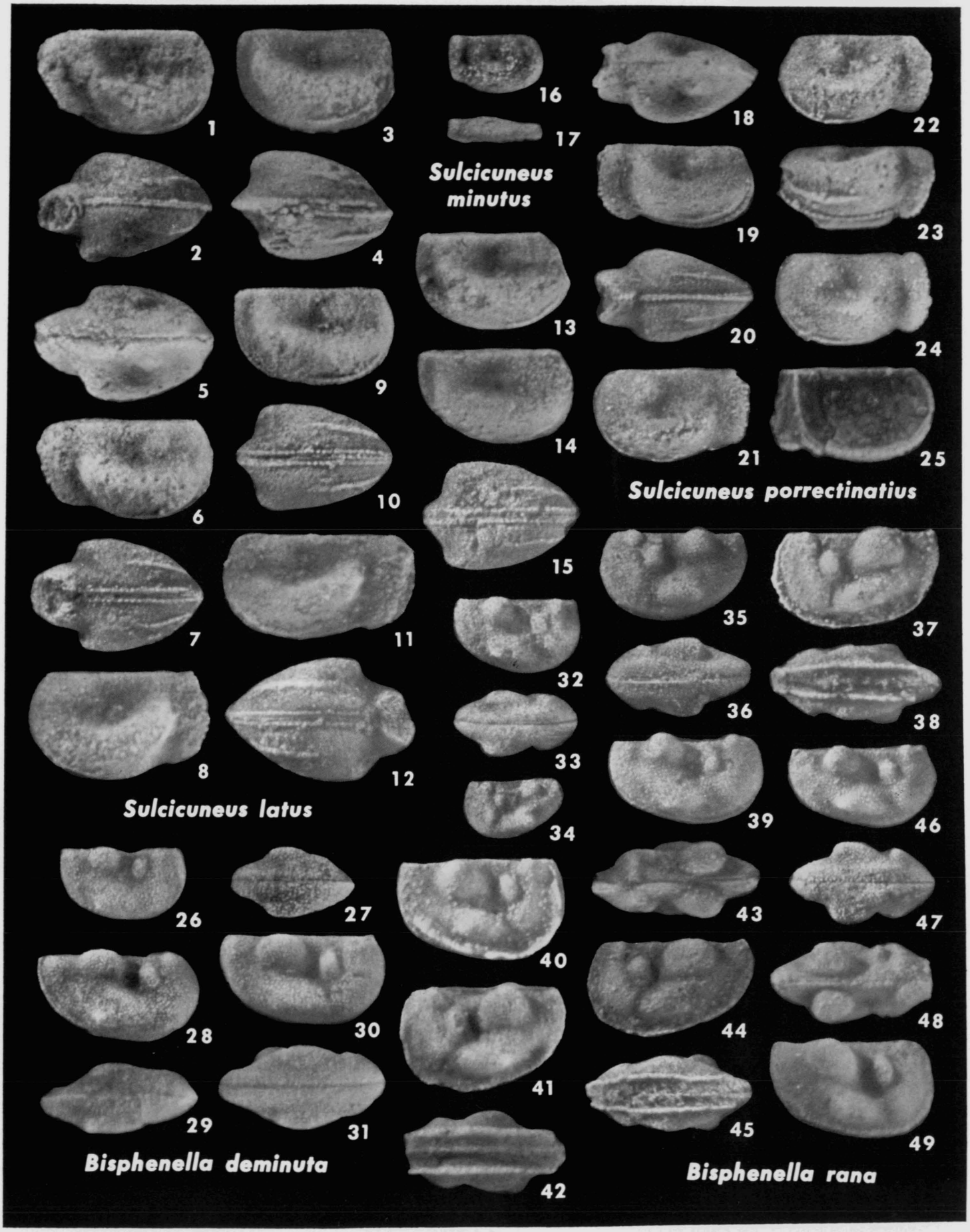
All specimens from Genshaw Formation, Locality 6

FIGS. 26–31—26,27, right lateral and ventral views of juvenile carapace, 64819. 28,29, right lateral and ventral views of male carapace, paratype 28078. 30,31, right lateral and ventral views of male carapace, 64820.

*Bisphenella rana*

All specimens paratypes from Gravel Point Formation

FIGS. 32–49—32,33, right lateral and ventral views of juvenile carapace, 64561, Loc. 1. 34, left lateral view of juvenile carapace, 64559, Loc. 1. 35,36, left lateral and ventral views of male or late juvenile carapace 64558, Loc. 1. 37,38, left lateral and ventral views of female carapace, 64555, Loc. 1. 39, right lateral view of male carapace, 64554, Loc. 1. 40, right lateral view of female carapace, 64562, Loc. 1. 41,42, left lateral and ventral views of female carapace, 38876, Loc. 10. 43–45, dorsal, left lateral, and ventral views of female carapace, 64556, Loc. 1. 46–47, right lateral and ventral views of male carapace, 64553, Loc. 1. 48,49, dorsal and right lateral views of female carapace, 38872, Loc. 3.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Sulcicuneus minutus
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Sulcicuneus porrectinatius
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Sulcicuneus latus
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Bisphenella deminuta
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Bisphenella rana

EXPLANATION OF PLATE 61

Figures x 40 except as noted

*Bisphenella nodosa*

FIGS. 1–3—dorsal, right lateral, and ventral views of female carapace, holotype UMMP 30942, Petoskey Formation, Loc. 2.

*Bisphenella deminuta*

FIGS. 4–6—4, right lateral view of juvenile carapace, holotype 28077, Genshaw Formation, Loc. 6. 5,6, right lateral and ventral views of immature carapace, 64822, Petoskey Formation, Loc. 3.

*Bisphenella rana*

All specimens from Gravel Point Formation

FIGS. 7–13—7, right lateral view of female carapace, paratype 30943, Loc. 10. 8, right lateral view of juvenile carapace, paratype 64560, Loc. 1. 9,10, right lateral and ventral views of female carapace, paratype 64557, Loc. 1. 11–13, right lateral (2) and ventral views of female carapace, holotype 30944, Loc. 10; 13, about x 80.

*Falsipollex simplilobatus*

FIGS. 14–22—14–16, right lateral, ventral, and inclined ventral views of female carapace, 65026, Wanakah Shale, Loc. 4. 17, left lateral view of female carapace, 64978, Ipperwash Limestone, Loc. 1. 18–20, inclined lateral, right lateral, and ventral views of female carapace, 65024, Wanakah Shale, Loc. 4. 21,22, lateral and interior views of female left valve, 65025, Wanakah Shale, Loc. 4.

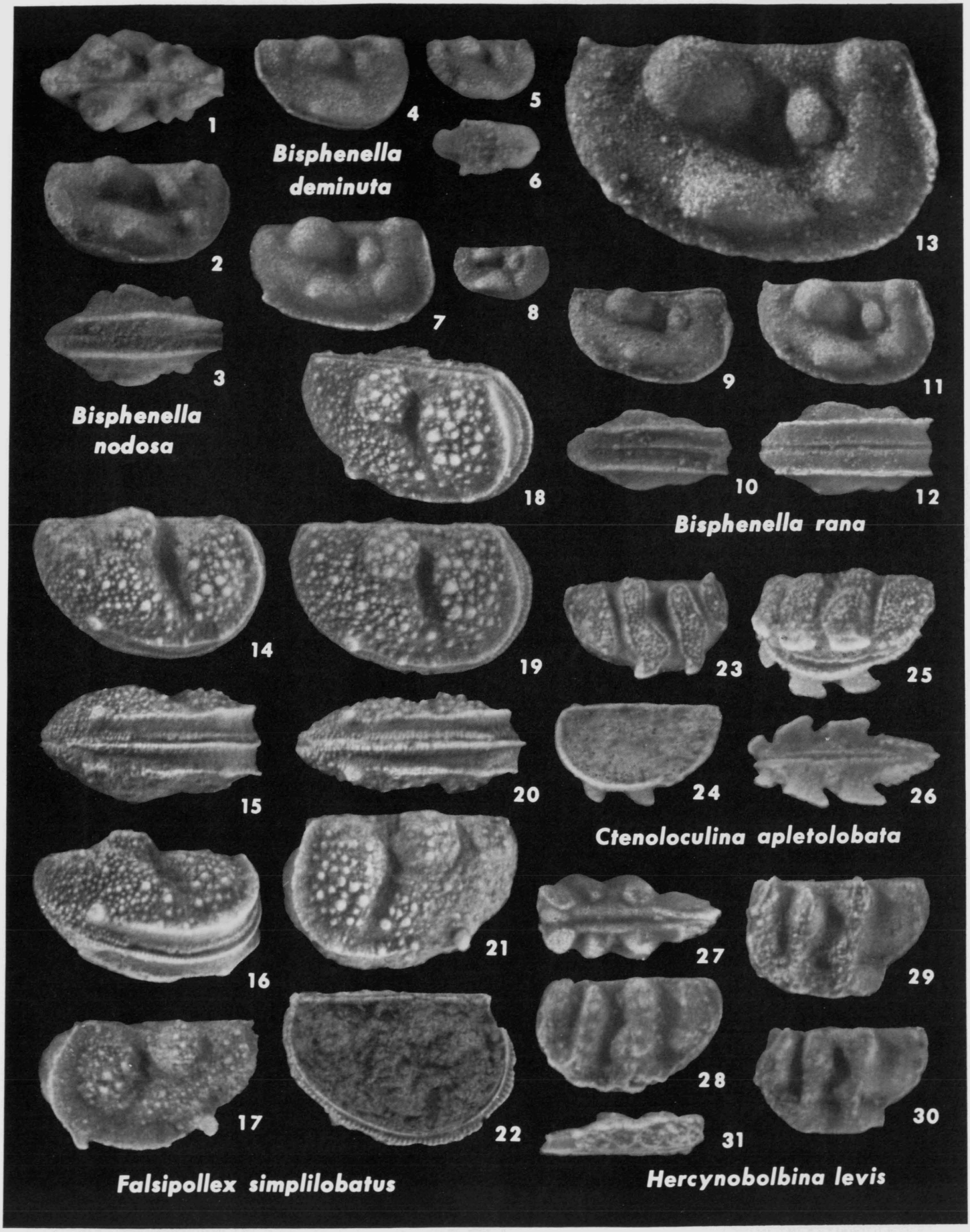
*Ctenoloculina apletolobata*

Both specimens from Ferron Point Formation, Locality 3

FIGS. 23–26—23,24, lateral and interior views of juvenile (A-1) right valve, paratype 65081. 25,26, inclined left lateral and ventral views of male carapace, 65076.

*Hercynobolbina levis*

FIGS. 27–31—27,28, dorsal and left lateral views of female carapace, paratype 64650, Norway Point Formation, Loc. 1. 29, lateral view of female left valve, paratype 38842, Petoskey Formation, Loc. 2. 30, lateral view of female left valve, holotype 38843, Petoskey Formation, Loc. 2. 31, ventral view of female right valve, paratype 30835, Petoskey Formation, Loc. 2.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Bisphenella nodosa
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Bisphenella deminuta
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Bisphenella rana
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Falsipollex simplilobatus
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Ctenoloculina apletolobata
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Hercynobolbina levis

EXPLANATION OF PLATE 62

Figures x 40 except as noted

*Falsipollex simplilobatus*

FIGS. 1–3—dorsal, left lateral, and ventral views of female carapace, UMMP 65028, Wanakah Shale, Loc. 4.

*Falsipollex* sp.

FIGS. 4,5—right lateral and ventral views of immature carapace, 65036, Kashong Shale, Loc. 1.

*Abditoloculina pulchra*

FIGS. 6–17—6–8, right lateral, ventral, and inclined left anterior views of male carapace, 60135, Centerfield Formation, Loc. 2; 8, about x 80. 9-11, left lateral, ventral, and inclined left anterior views of female carapace, 60136, Centerfield Formation, Loc. 2; 11, about x 80. 12,13, two right lateral views of male carapace, 60251, Windom Shale, Loc. 1; 13, about x 80. 14–16, right lateral, ventral, and inclined left anterior views of immature (A-1) carapace, 60134, Centerfield Formation, Loc. 2; 16, about x 80. 17, inclined left anterior view of female carapace, 30497, Centerfield Formation, Loc. 2, about x 80.

*Abditoloculina insolita*

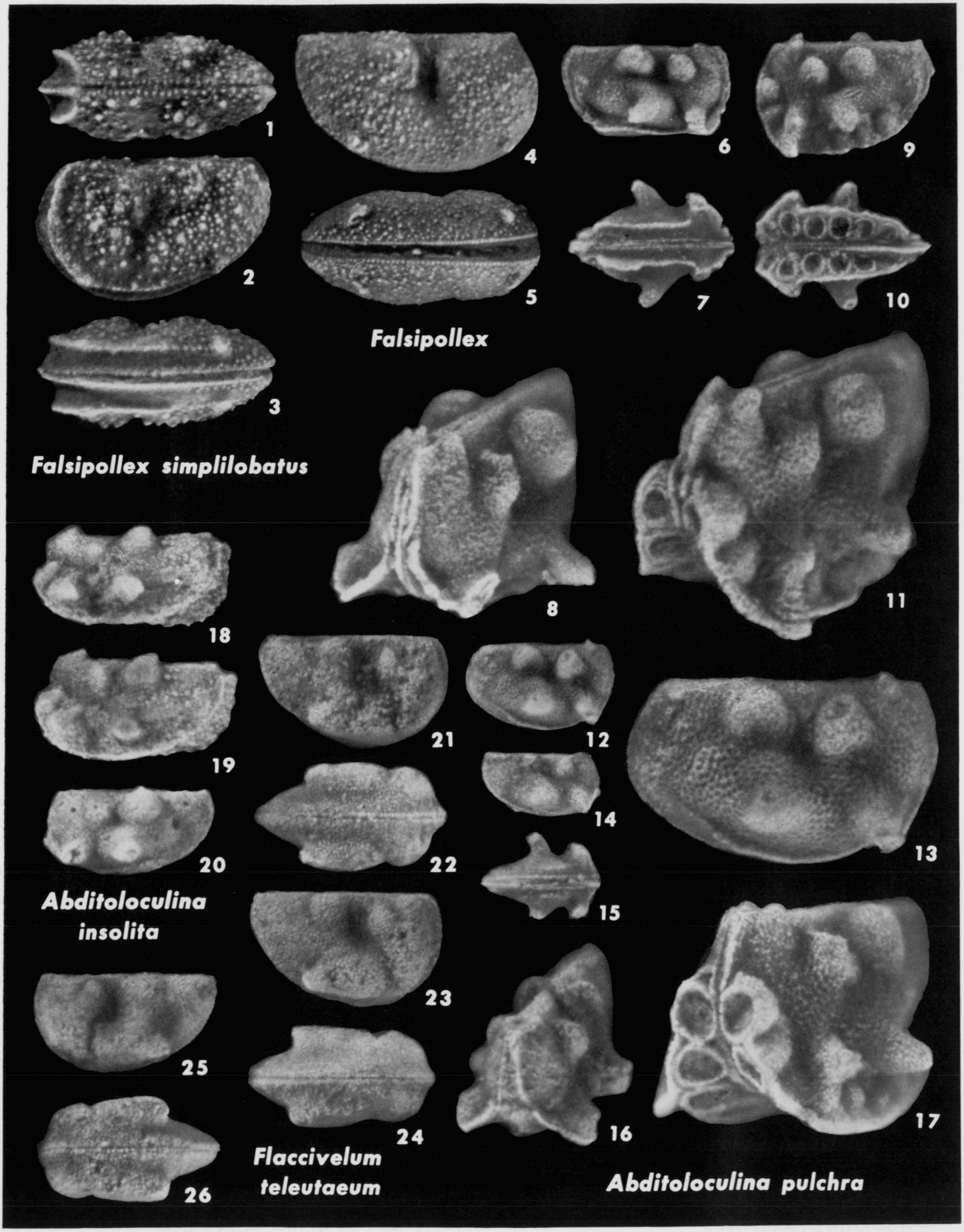
Both specimens from Gravel Point Formation, Locality 3

FIGS. 18–20—18,19, left lateral and slightly inclined views of male carapace, 30840. 20, left lateral view of male carapace, 30843.

*Flaccivelum teleutaeum*

All specimens juvenile carapaces from Genshaw Formation, Locality 6

FIGS. 21–26—21–24, right lateral and ventral views of two carapaces, 28079 and 28081. 25,26, left lateral and ventral views of carapace, 28080.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Falsipollex
Falsipollex simplilobatus
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Abditoloculina insolita
Flaccivelum teleutaeum
Abditoloculina pulchra

EXPLANATION OF PLATE 63

All figures x 40

*Hollinella* (*Keslingella*) *auroriradiata*

FIGS. 1–4—1,2, lateral and interior views of male right valve, paratype (allotype) 26716, Bell Shale, Loc. 2. 3,4, lateral and ventral views of male left valve, 64786, Petoskey Formation, Loc. 3.

*Adelphobolbina medialis*

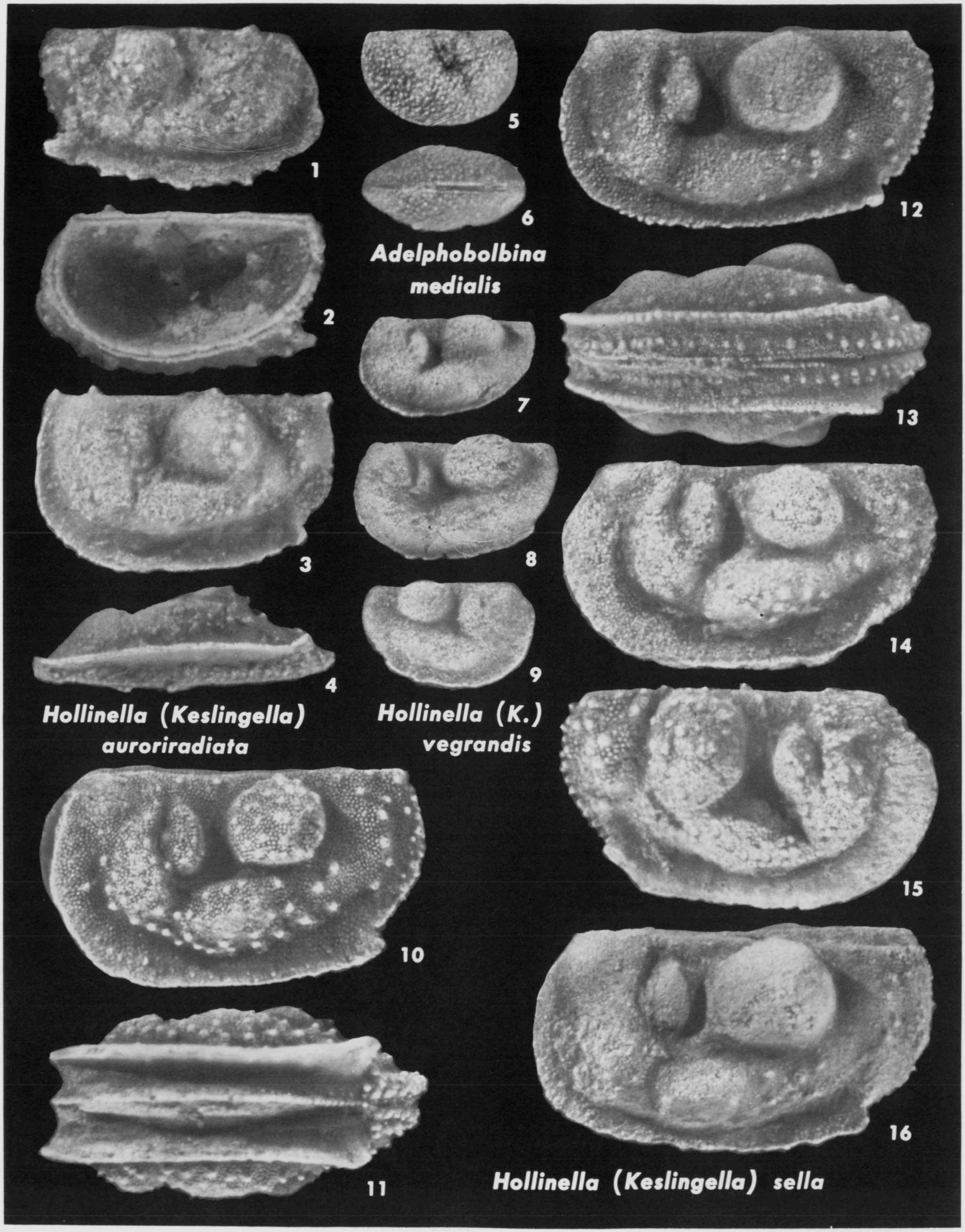
FIGS. 5,6—right lateral and ventral views of juvenile carapace, 60164, Wanakah Shale, Loc. 4.

*Hollinella* (*Keslingella*) *vegrandis*

FIGS. 7–9—7, left lateral view of adult carapace, paratype 28064, Genshaw Formation, Loc. 6. 8, lateral view of adult left valve, 38868, Petoskey Formation, Loc. 2. 9, lateral view of adult right valve, 64925, Dock Street Clay Member of Four Mile Dam Formation, Loc. 1.

*Hollinella* (*Keslingella*) *sella*

FIGS. 10–16—10,11, left lateral and ventral views of female carapace, 64848, Wanakah Shale, Loc. 3. 12,13, left lateral and ventral views of male carapace, 64849, Kashong Shale, Loc. 1. 14, lateral view of male left valve, 64915, Kashong Shale, Loc. 1. 15, lateral view of male right valve, 64920, Centerfield Formation, Loc. 1. 16, left lateral view of adult carapace, 64924, Kashong Shale, Loc. 1.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Hollinella (Keslingella) auroriradiata
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Adelphobolbina medialis
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Hollinella (K.) vegrandis
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Hollinella (Keslingella) sella

EXPLANATION OF PLATE 64

All figures x 40

*Phlyctiscapha apleta*

FIGS. 1–5—1,2, left lateral and inclined ventral views of female carapace, holotype UMMP 30842, Ferron Point Formation, Loc. 3. 3, right lateral view of immature (A–1) carapace, 58740, Widder Formation, Loc. 3. 4,5, left lateral and ventral views of male carapace, 64610, Gravel Point Formation, Loc. 5.

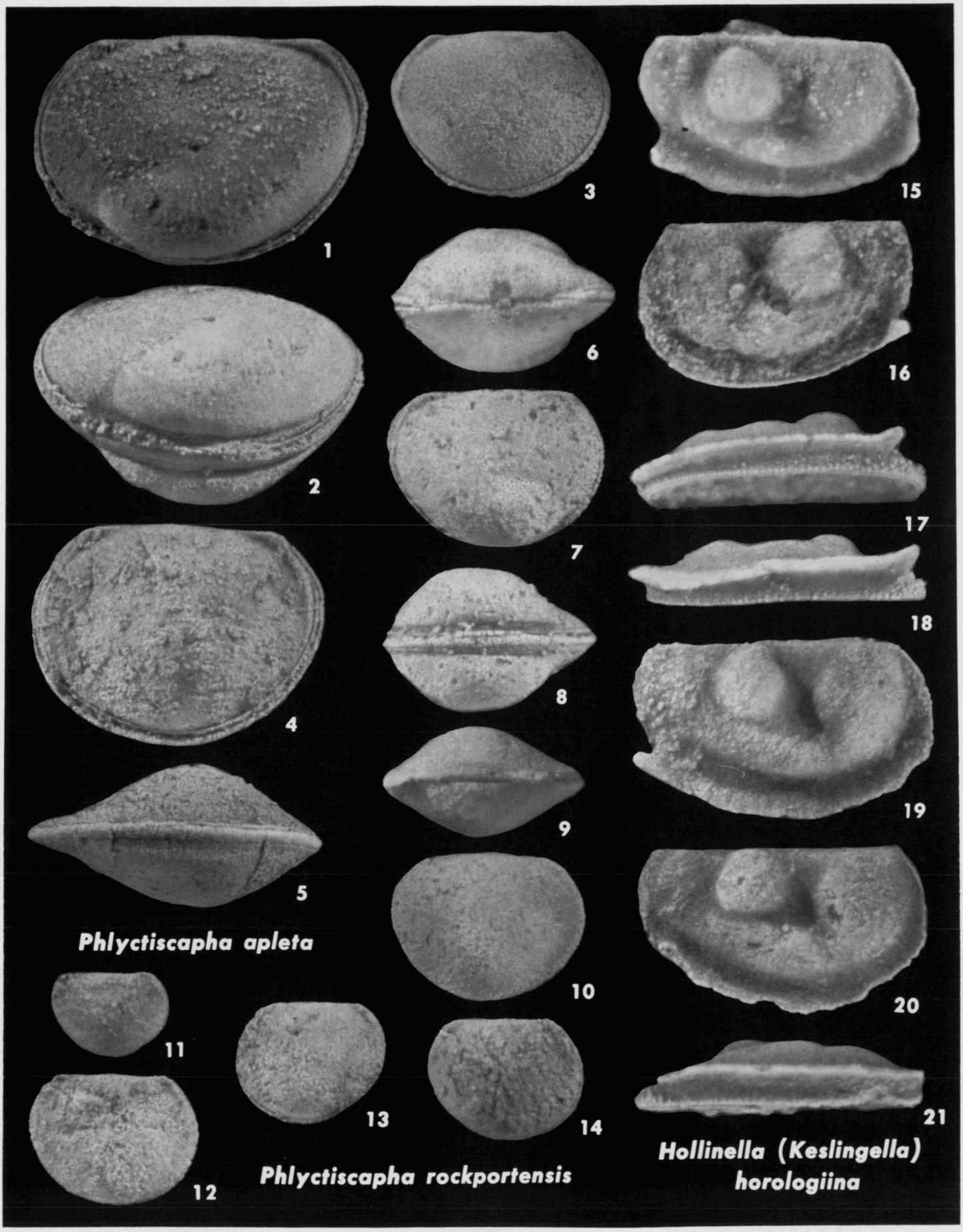
*Phlyctiscapha rockportensis*

FIGS. 6–14—6–8, dorsal, right lateral, and ventral views of female carapace, 64592, uppermost Bell Shale or basal Rockport Quarry Limestone, Loc. 3. 9,10, dorsal and right lateral views of male or ultimate immature carapace, 64593, Genshaw Formation, Loc. 6. 11, right lateral view of immature (A–2) carapace, 64597, uppermost Bell Shale or basal Rockport Quarry Limestone, Loc. 3. 12, right lateral view of immature (A–1) carapace, 64596, Genshaw Formation, Loc. 6. 13, left lateral view of immature (A–1) carapace, 64595, Genshaw Formation, Loc. 6. 14, right lateral view of immature (A-1) carapace, 64594, Genshaw Formation, Loc. 6.

*Hollinella* (*Keslingella*) *horologiina*

All specimens from Gravel Point Formation

FIGS. 15–21—15, inclined right view of carapace, 30923, Loc. 1. 16, lateral view of left valve, paratype 47581, Loc.1. 17,18, inclined ventral and ventral views of two left valves, holotype 30922 and paratype 30920, Loc. 9. 19, lateral view of right valve, 38850, Loc. 9. 20,21, lateral and ventral views of female (?) right valve, paratype 47580, Loc. 1.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Phlyctiscapha apleta
Phlyctiscapha rockportensis
Hollinella (Keslingella) horologiina

EXPLANATION OF PLATE 65

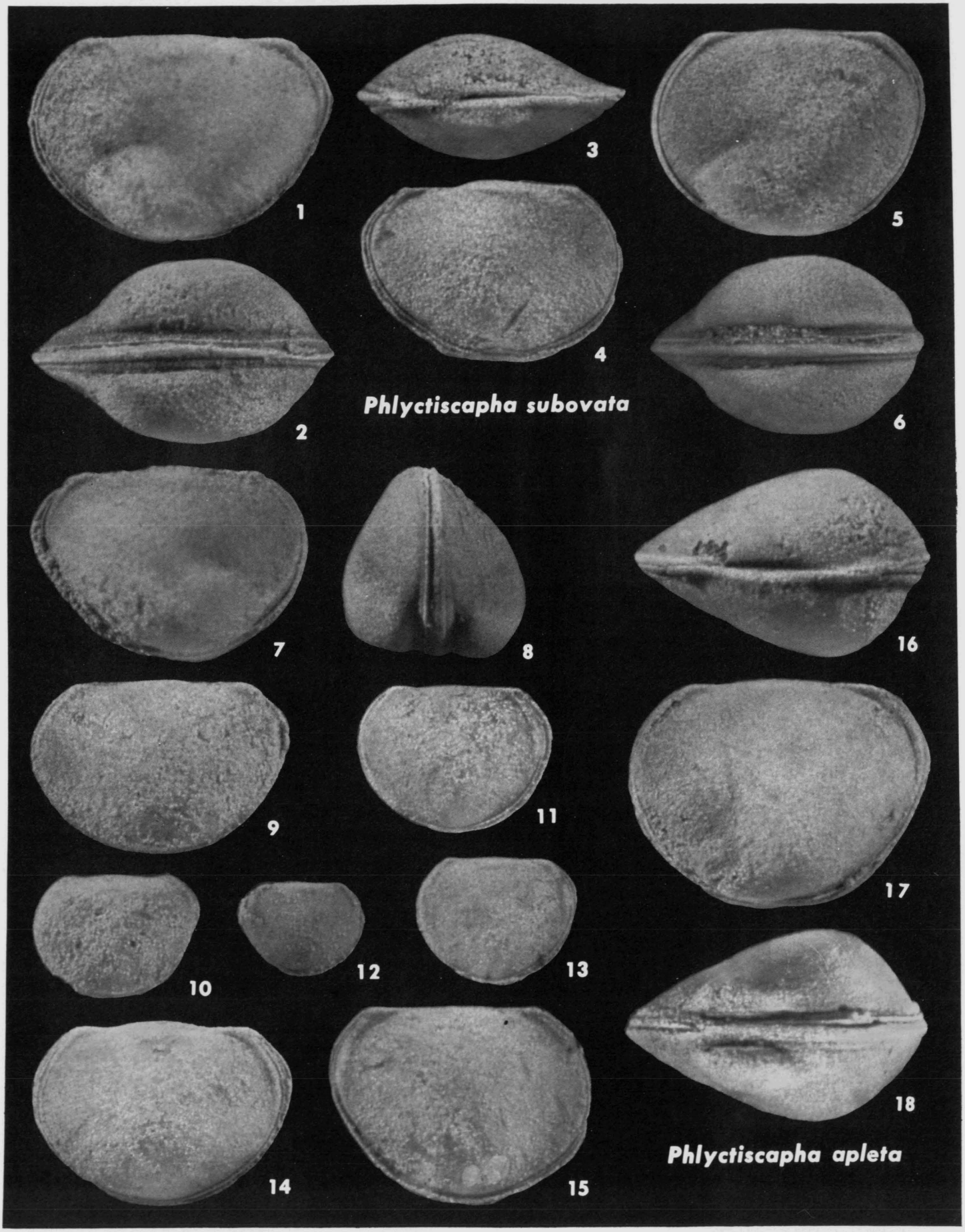
All figures x 40

*Phlyctiscapha subovata*

FIGS. 1–10—1,2, left lateral and ventral views of female carapace, UMMP 64601, Centerfield Formation, Loc. 2. 3,4, dorsal and right lateral views of male carapace, 64600, Wanakah Shale, Loc. 3. 5,6, left lateral and ventral views of female carapace, 64599, Wanakah Shale, Loc. 1. 7,8, right lateral and anterior views of female carapace, 64598, Wanakah Shale, Loc. 3. 9, left lateral view of male carapace, 64602, Centerfield Formation, Loc. 2. 10, left lateral view of immature (A–2) carapace, 64603, Windom Shale, Loc. 3.

*Phlyctiscapha apleta*

FIGS. 11–18—11, left lateral view of immature (A–2) carapace, 64608, Gravel Point Formation, Loc. 5. 12, right lateral view of immature (A–4) carapace, 64611, Gravel Point Formation, Loc. 5. 13, left lateral view of immature (A–3) carapace, 64607, Gravel Point Formation, Loc. 2. 14, left lateral view of ultimate immature (A–1) carapace, 64606, Gravel Point Formation, Loc. 2. 15, right lateral view of ultimate immature (A–1) carapace, 64605, Ferron Point Formation, Loc. 3. 16–18, dorsal, left lateral, and ventral views of female carapace, 64604, Gravel Point Formation, Loc. 2.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Phlyctiscapha subovata
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Phlyctiscapha apleta

EXPLANATION OF PLATE 66

All figures x 40

*Phlyctiscapha rockportensis*

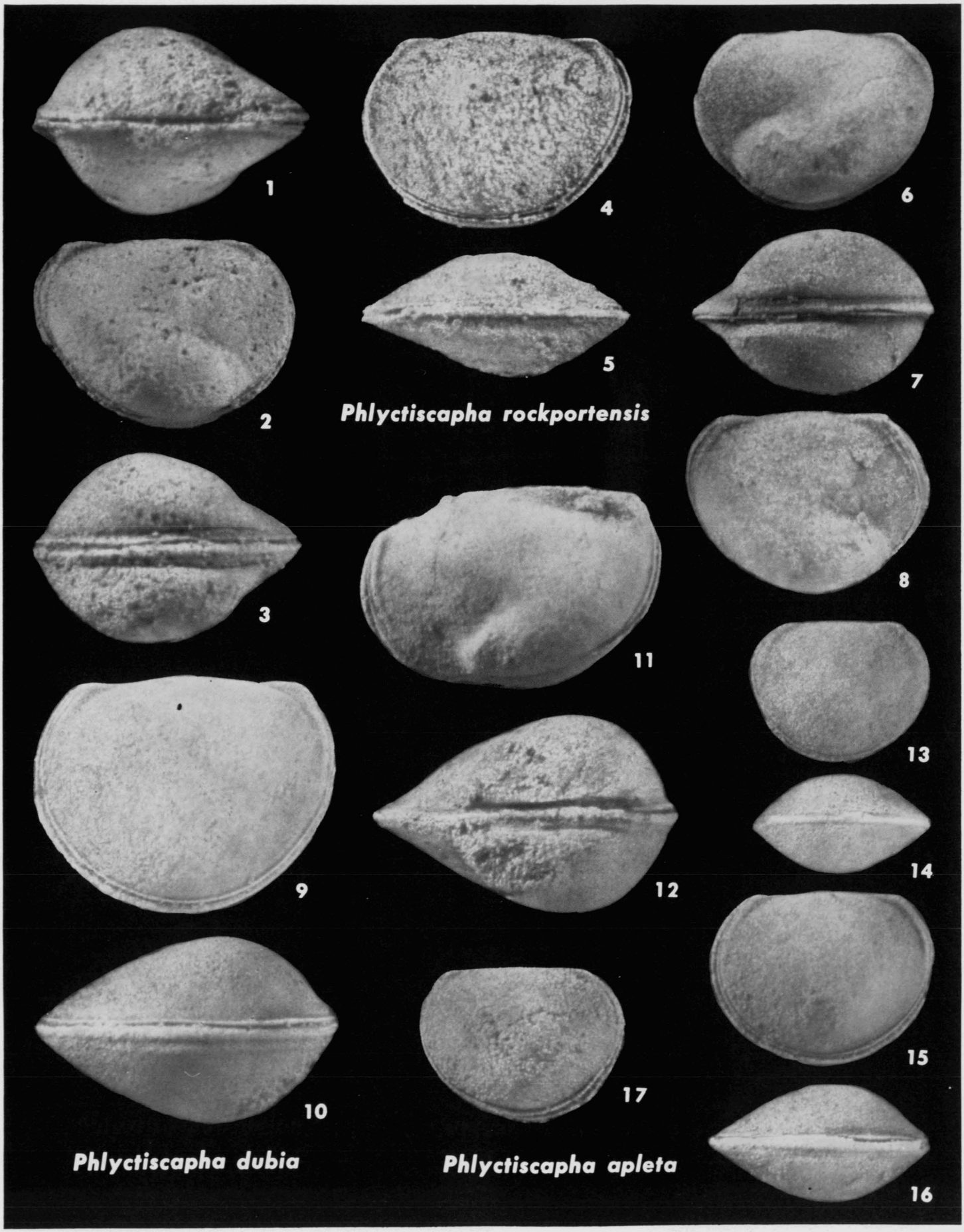
FIGS. 1–8—1–3, dorsal, right lateral, and ventral views of female carapace, holotype UMMP 29603, uppermost Bell Shale or basal Rockport Quarry Limestone, Loc. 3. 4,5, left lateral and ventral views of male carapace, paratype 29610, same locality. 6–8, left lateral, ventral, and right lateral views of female carapace, 64612, Gravel Point Formation, Loc. 4.

*Phlyctiscapha dubia*

FIGS. 9–16—9,10, left lateral and ventral views of male carapace, paratype 39027, Gravel Point Formation, Loc. 1. 11,12, left lateral and ventral views of female carapace, holotype 39033, Petoskey Formation, Loc. 2; anterior corner pinched off and ventral surfaces of crumina corroded. 13,14, right lateral and ventral views of immature (A–2) carapace, paratype 39039, Gravel Point Formation, Loc. 5. 15,16, left lateral and ventral views of ultimate immature (A–1) carapace, paratype 39025, Gravel Point Formation, Loc. 5.

*Phlyctiscapha apleta*

FIG. 17—right lateral view of immature (A–2) carapace, 64609, Gravel Point Formation, Loc. 5.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Phlyctiscapha rockportensis
Phlyctiscapha dubia
Phlyctiscapha apleta

EXPLANATION OF PLATE 67

Figures x 40 except as noted

*Hollinella* (*Keslingella*) *auroriradiata*

Both specimens from Bell Shale

FIGS. 1-3—1,2, lateral and ventral views of left valve, UMMP 64785, Loc. 4. 3, interior view of female (?) left valve, holotype 26647, Loc. 2.

*Hollinella* (*Keslingella*) *antespinosa*

FIG. 4—lateral view of right valve, 64790, Norway Point Formation, Loc. 1.

*Adelphobolbina medialis*

FIGS. 5-7—5,6, lateral and interior views of left valve, 60162, Ledyard Shale, Loc. 1. 7, lateral view of left valve, 58758, Hungry Hollow Formation, Loc. 1.

*Flaccivelum papillosum*

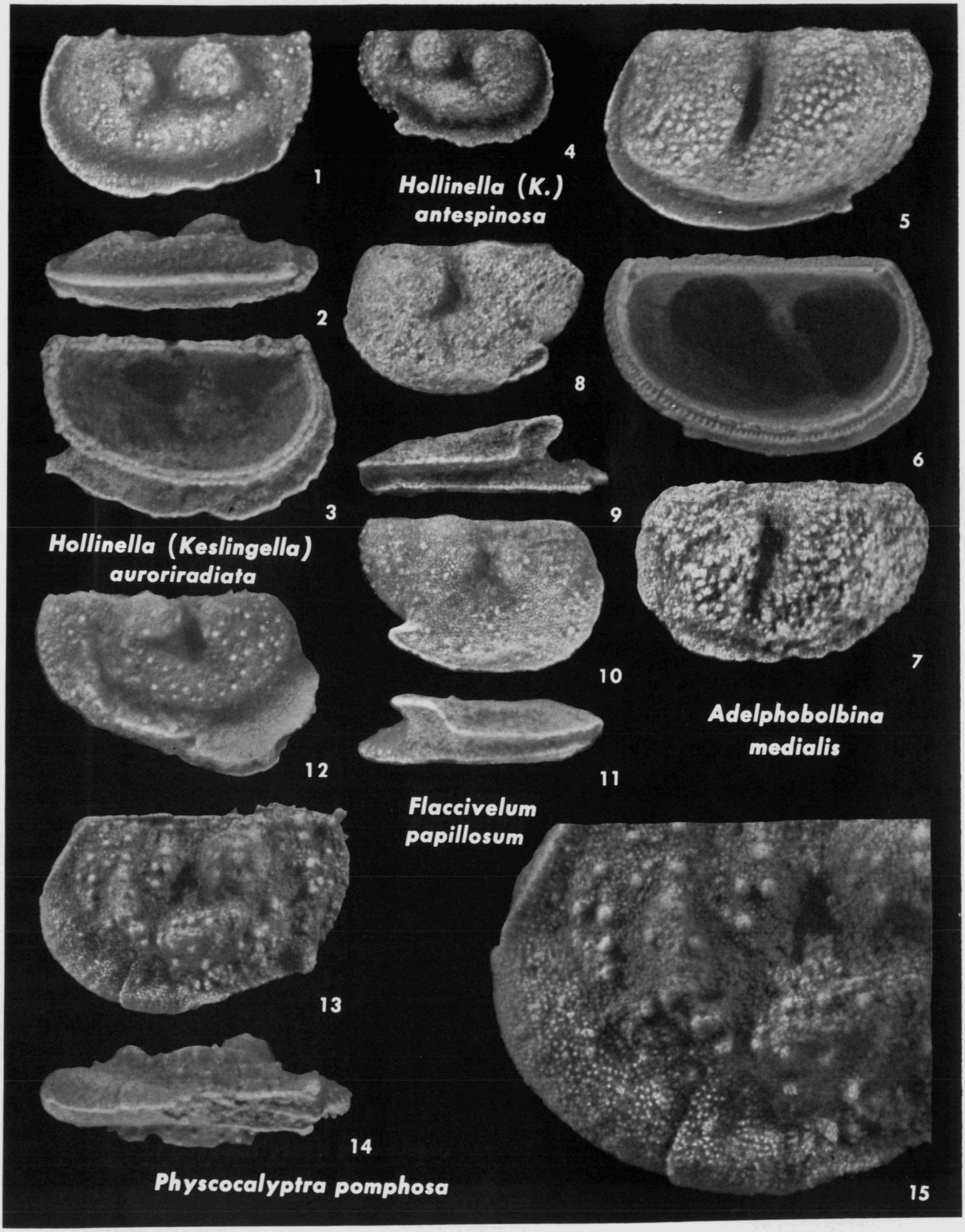
Both specimens from Bell Shale, Locality 4

FIGS. 8-11—8,9, lateral and ventral views of female left valve, paratype 60253. 10,11, lateral and ventral views of female right valve, paratype 30965.

*Physcocalyptra pomphosa*

Both specimens from Hungry Hollow Formation

FIGS. 12-15—12, right lateral view of female carapace, paratype 64928, Loc. 1; delicate margin of frill broken. 13-15, left lateral (2) and ventral views of female carapace, paratype 64511, Loc. 4; 15, about x 80, showing ornamentation.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Hollinella (K.)
antespinosa
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Hollinella (Keslingella)
auroriradiata
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Adelphobolbina
medialis
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Flaccivelum
papillosum
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14
Physcocalyptra pomphosa
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EXPLANATION OF PLATE 68

All figures x 40

*Phlyctiscapha dubia*

FIGS. 1,2—right lateral and ventral views of male carapace, paratype UMMP 30929, Gravel Point Formation, Loc. 2.

*Hollina pyxidata*

FIGS. 3–13—3,4, lateral and interior views of female left valve, 64644, Arkona Shale, Loc. 1. 5, lateral views of immature (A–3) right valve, 64770, Gravel Point Formation, Loc. 1. 6, lateral view of male right valve, 64645, Arkona Shale, Loc. 1. 7,8, right lateral and ventral views of male carapace, holotype 28036, Ferron Point Formation, Loc. 3. 9,10, left lateral and ventral views of ultimate immature (A–1) carapace, 38049, Ferron Point Formation, Loc. 3. 11,12, right lateral and inclined ventral views of immature (?) crushed carapace, 30851, Ferron Point Formation, Loc. 3. 13, lateral view of incomplete female right valve, 64646, Arkona Shale, Loc. 1.

*Abditoloculina insolita*

Both specimens from Gravel Point Formation, Locality 3

FIGS. 14–16—14,15, left lateral and slightly inclined left lateral views of male carapace, 30840; the delicate expanded "flange" at the posterior end not well perserved. 16, left lateral view of male carapace, 30843; tips of spurlike processes broken off.

*Ruptivelum bacculatum*

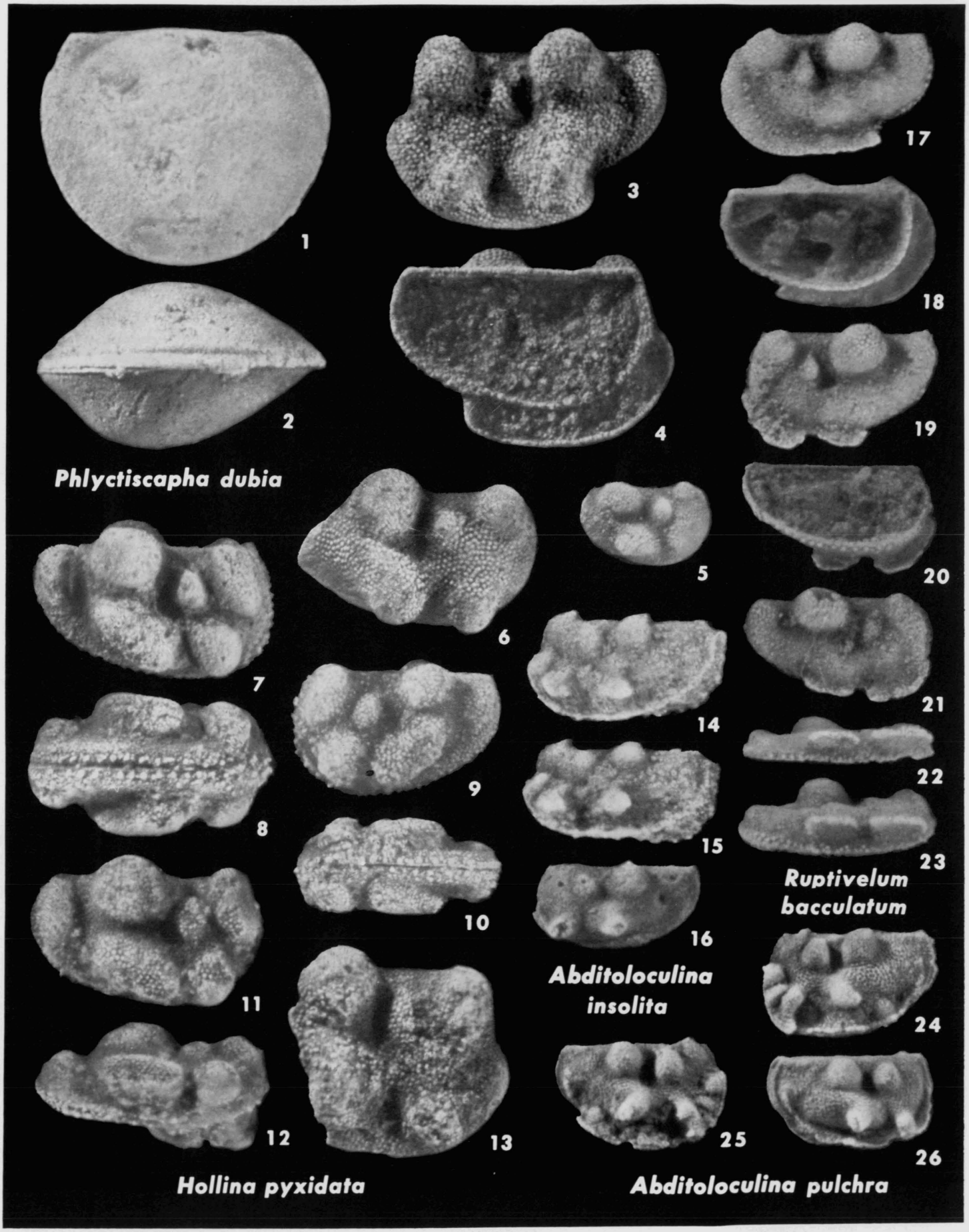
All specimens from Norway Point Formation, Locality 1

FIGS. 17–23—17,18, lateral and interior views of female left valve, paratype (allotype) 27344. 19,20, lateral and inclined interior views of male left valve, paratype 27347. 21,22, lateral and ventral views of male right valve, paratype 27348. 23, inclined ventral view of male right valve, 30788.

*Abditoloculina pulchra*

All specimens from Centerfield Formation, Locality 2

FIGS. 24–26—24, lateral view of female left valve, 60274. 25, lateral view of female right valve, 60275. 26, lateral view of male right valve, 60276.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Phlyctiscapha dubia
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Hollina pyxidata
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Abditoloculina insolita
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Ruptivelum bacculatum
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Abditoloculina pulchra

EXPLANATION OF PLATE 69

All figures x 40

*Subligaculum quadribursatum*

FIGS. 1–5—1,2, lateral and interior views of female right valve, paratype 65057, Wanakah Shale, Loc. 4. 3,4, lateral and inclined views of female left valve, holotype 65058, Kashong Shale, Loc. 1. 5, lateral view of female left valve, paratype 65059, Kashong Shale, Loc. 3.

*Subligaculum recurvisulcatum*

Both specimens from Bell Shale, Locality 2

FIGS. 6–8—6,7, right lateral and ventral views of male carapace, paratype 26700. 8, lateral view of female left valve, paratype 26684.

*Subligaculum trullatum*

All specimens from Norway Point Formation, Locality 1

FIGS. 9–13—9, lateral view of female left valve, 65046. 10,11, lateral and interior views of male left valve, holotype 27367. 12,13, lateral and interior views of male right valve, 30964.

*Subligaculum scrobiculatum*

All specimens from Bell Shale, Locality 2

FIGS. 14–16—14, lateral view of female right valve, paratype 26655. 15, lateral view of female left valve, paratype 26783. 16, lateral view of female left valve, paratype 26688.

*Subligaculum calcaratum*

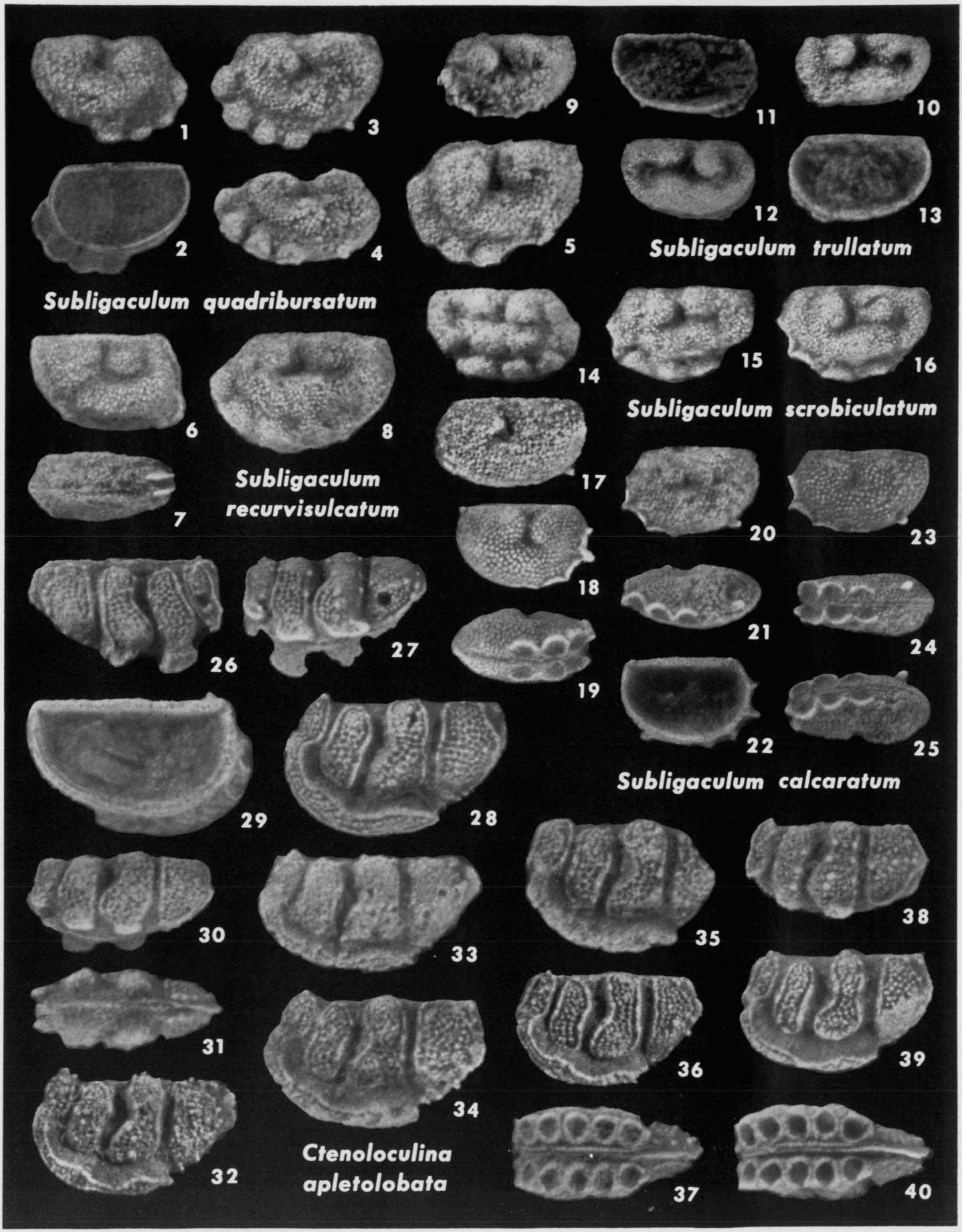
All specimens from Arkona Shale

FIGS. 17–25—17, left lateral view of male carapace, 65048, Loc. 5. 18,19, right lateral and inclined ventral views of female carapace, holotype 28935, Loc. 3. 20–22, lateral, inclined ventral, and interior views of female left valve, paratype 28936, Loc. 3. 23–25, left lateral, ventral, and inclined views of female carapace, paratype 28937, Loc. 3.

*Ctenoloculina apletolobata*

All specimens from Ferron Point Formation, Locality 3

FIGS. 26–40—26,27, right lateral and inclined left views of male carapace, paratype 65075. 28,29, lateral and interior views of female left valve, paratype 60244. 30,31, inclined left lateral and ventral views of male carapace, paratype 65077. 32, lateral view of female left valve, paratype 58402. 33, lateral view of female left valve, paratype 65082. 34, lateral view of female left valve, 65078. 35, lateral view of damaged female left valve, 65079. 36,37, left lateral and ventral views of female carapace, holotype 60264. 38, lateral view of female left valve, paratype 65080. 39,40, left lateral and ventral views of female carapace, paratype 65074.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Subligaculum trullatum
Subligaculum quadribursatum
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Subligaculum scrobiculatum
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Subligaculum recurvisulcatum
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Subligaculum calcaratum
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Ctenoloculina apletolobata
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EXPLANATION OF PLATE 70

All figures x 40

*Falsipollex ampliatus*

FIG. 1—left lateral view of female carapace, paratype UMMP 65030, Kashong Shale, Loc. 1.

*Falsipollex laxivelatus*

All specimens from Ferron Point Formation, Locality 3

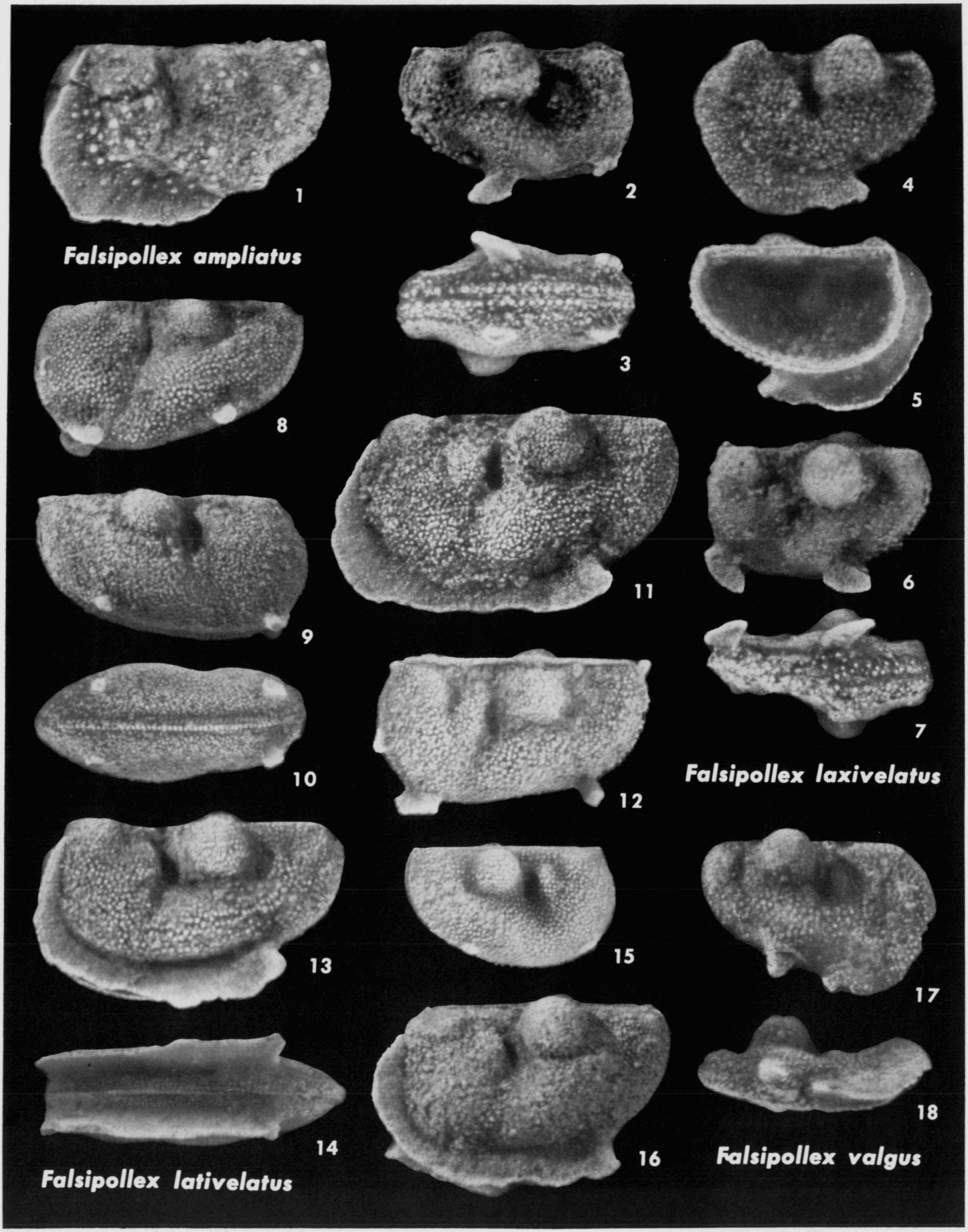
FIGS. 2-7—2,3, right lateral and ventral views of male carapace, 30776. 4,5, lateral and interior views of female left valve, 30778. 6,7, left lateral and ventral views of damaged male carapace, 30777.

*Falsipollex lativelatus*

FIGS. 8-16—8, left lateral view of male carapace, 30762, Silica Shale, Loc. 1. 9,10, right lateral and ventral views of male carapace, 30760, Ferron Point Formation, Loc. 3. 11, lateral view of female left valve, 30766, Ferron Point Formation, Loc. 3. 12, left lateral view of male carapace, 65021, Widder Formation, Loc. 4. 13,14, left lateral and ventral views of female carapace, 30765, Silica Shale, Loc. 1. 15, left lateral view of immature (A-1) carapace 65017, Widder Formation, Loc. 1. 16, lateral view of female left valve, 30764, Ferron Point Formation, Loc. 3.

*Falsipollex valgus*

FIGS. 17,18—lateral and inclined ventral views of female right valve, 30987, Arkona Shale, Loc. 2.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Falsipollex ampliatus
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Falsipollex laxivelatus
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Falsipollex lativelatus
Falsipollex valgus

EXPLANATION OF PLATE 71

All figures x 40

*Flaccivelum teleutaeum*

Both specimens from Genshaw Formation, Locality 6

FIGS. 1–5—1,2, left lateral and ventral views of immature (A–2) carapace, 30932. 3, lateral view of female left valve, 30925. 4,5, left lateral and ventral views of ultimate immature (A–1) carapace, 64965.

*Flaccivelum papillosum*

FIG. 6—lateral view of female right valve, 30965, Bell Shale, Loc. 4.

*Hercynobolbina levis*

FIGS. 7–10—7, ventral view of female carapace, paratype 38842, Petoskey Formation, Loc. 2. 8, ventral view of female carapace, paratype 30836, Petoskey Formation, Loc. 2. 9, ventral view of female carapace, paratype 64752, Potter Farm Formation, Loc. 1. 10, lateral view of female left valve, paratype 38842, Petoskey Formation, Loc. 2.

*Ruptivelum bacculatum*

FIGS. 11,12—11, lateral view of female left valve, 64973, Gravel Point Formation, Loc. 1. 12, lateral view of male left valve, holotype 27346, Norway Point Formation, Loc. 1.

*Hollinella* (*Keslingella*) *ampla*

FIGS. 13,14—lateral and ventral views of female left valve, holotype 27355, Norway Point Formation, Loc. 1.

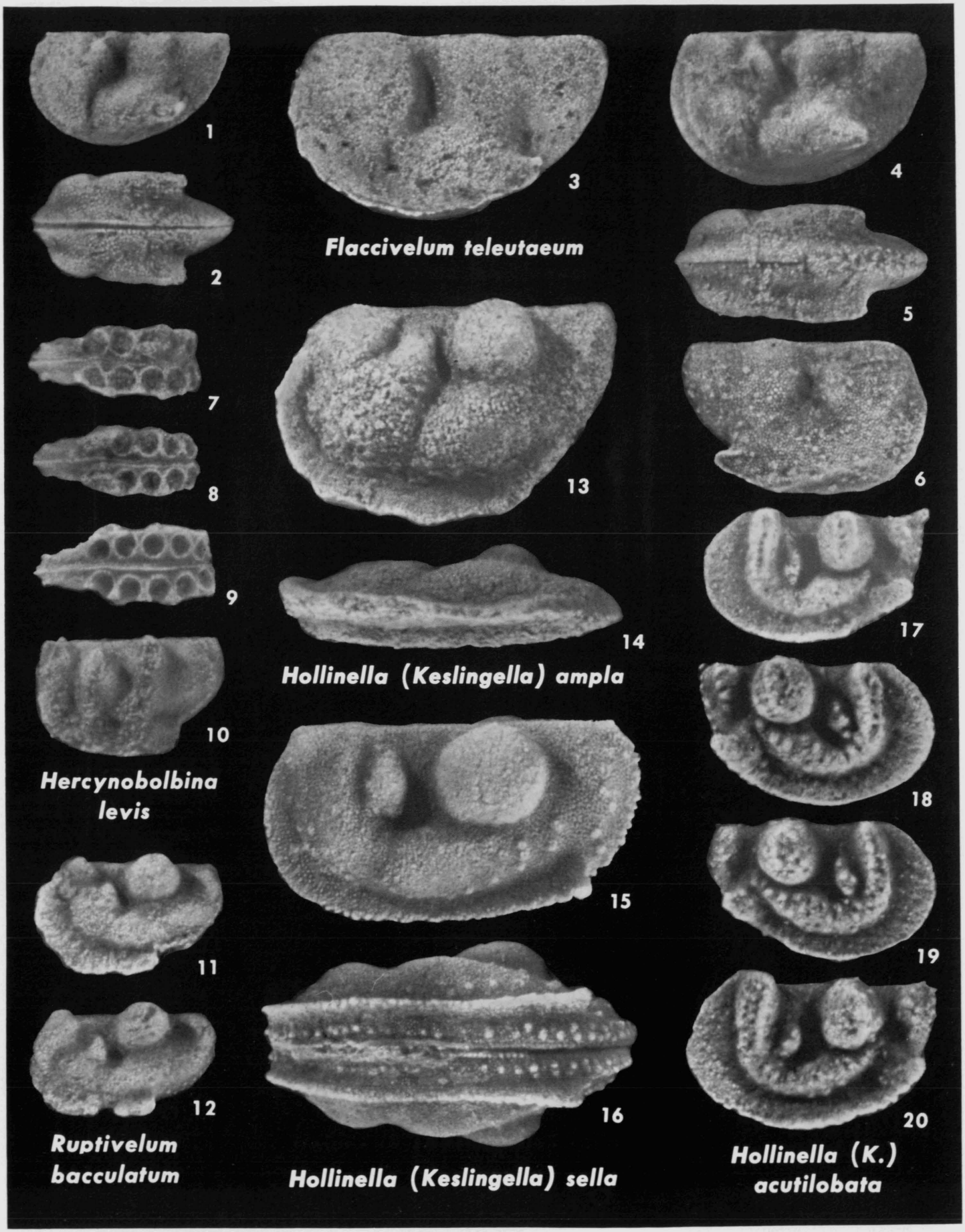
*Hollinella* (*Keslingella*) *sella*

FIGS. 15,16—left lateral and ventral views of adult carapace, 64849, Kashong Shale, Loc. 1.

*Hollinella* (*Keslingella*) *acutilobata*

All specimens from Bell Shale, Locality 4

FIGS. 17–20—17, lateral view of female (?) left valve, paratype 64755. 18, lateral view of female (?) right valve, paratype 64757. 19, lateral view of female (?) right valve, paratype 64761. 20, lateral view of left valve, paratype 64754.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Flaccivelum teleutaeum
Hollinella (Keslingella) ampla
Hercynobolbina levis
Ruptivelum bacculatum
Hollinella (Keslingella) sella
Hollinella (K.) acutilobata

EXPLANATION OF PLATE 72

All figures x 40

*Ctenoloculina acanthina*

Both specimens from Ferron Point Formation, Locality 3

FIGS. 1,2—1, lateral view of male right valve, 30821. 2, lateral view of female left valve, 30822.

*Ctenoloculina cicatricosa*

FIG. 3—lateral view of immature right valve, 30813, Norway Point Formation, Loc. 1.

*Hollinella (Keslingella) nodiventriculata nodiventriculata*

All specimens from Gravel Point Formation, Locality 9

FIGS. 4-6—4,5, lateral views of two left valves, paratype 30909 and holotype 30908. 6, lateral view of right valve, paratype 30910.

*Hollinella (Keslingella) productilobata*

FIG. 7—lateral view of right valve, 30902, Bell Shale, Loc. 2.

*Hollinella (Keslingella) tendilobata*

Both specimens from uppermost Bell Shale or basal Rockport Quarry Limestone, Locality 3

FIGS. 8,9—lateral views of two right valves, 30887 and 30890.

*Bisphenella deminuta*

Both specimens from Genshaw Formation, Locality 6

FIGS. 10,11—right lateral views of two carapaces, 30930 and 64820.

*Ruptivelum bacculatum*

Both specimens from Norway Point Formation, Locality 1

FIGS. 12,13—12, lateral view of male right valve, 30788. 13, ventral view of male right valve, paratype 27348.

*Hercynobolbina levis*

All specimens from Petoskey Formation, Locality 2

FIGS. 14-16—14, lateral view of female right valve, 30835. 15, lateral view of female left valve, 30836. 16, lateral view of female left valve, 30833.

*Hollinella (Keslingella) inclinisulcata*

FIG. 17—lateral view of left valve, 30856, Petoskey Formation, Loc. 1.

*Falsipollex laxivelatus*

FIG. 18—lateral view of female left valve, 30778, Ferron Point Formation, Loc. 3.

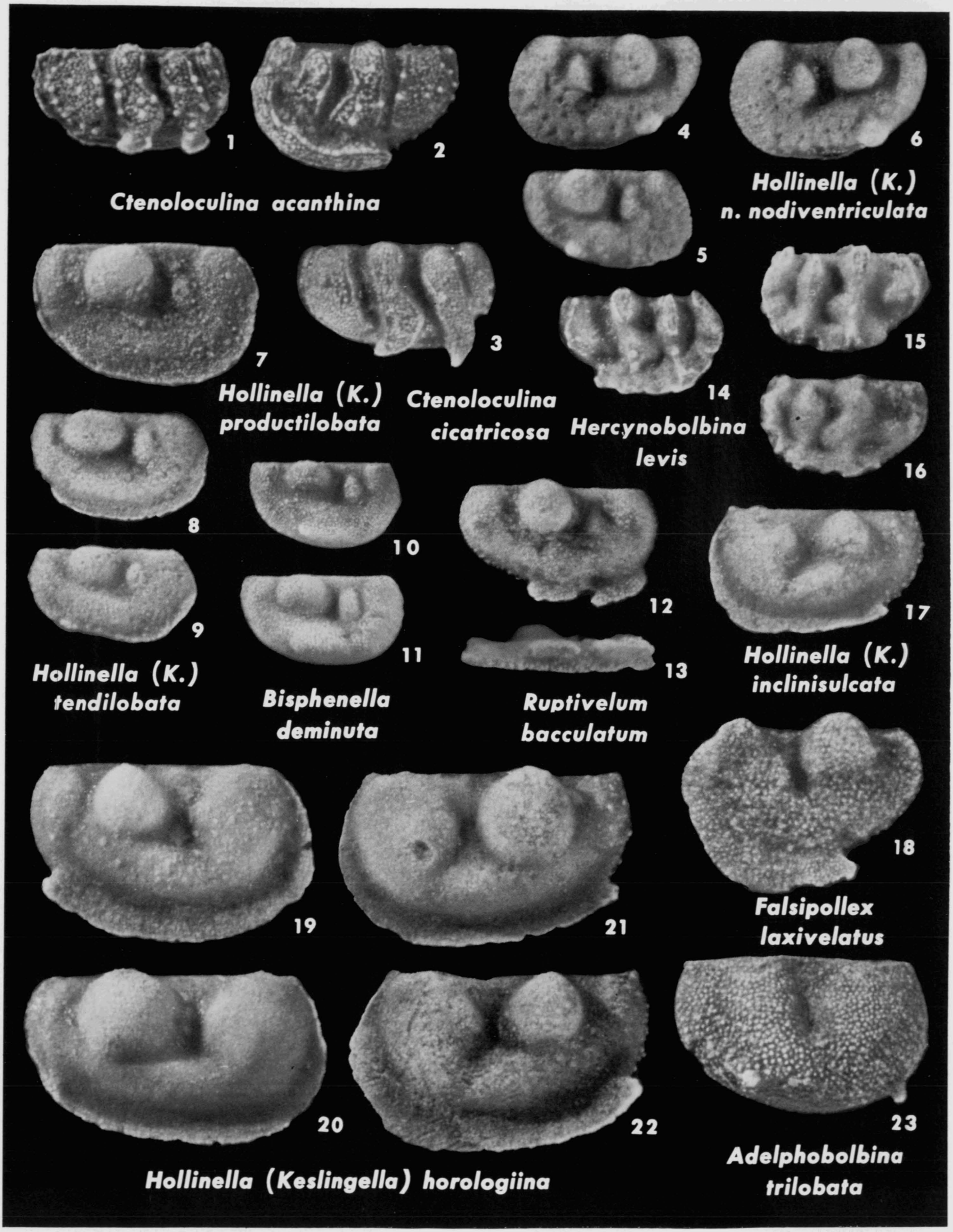
*Hollinella (Keslingella) horologiina*

All specimens from Gravel Point Formation, Locality 9

FIGS. 19-22—19,20, lateral views of two right valves, paratypes 30923 and 30919. 21,22, lateral views of two left valves, holotype 30922 and paratype 30920.

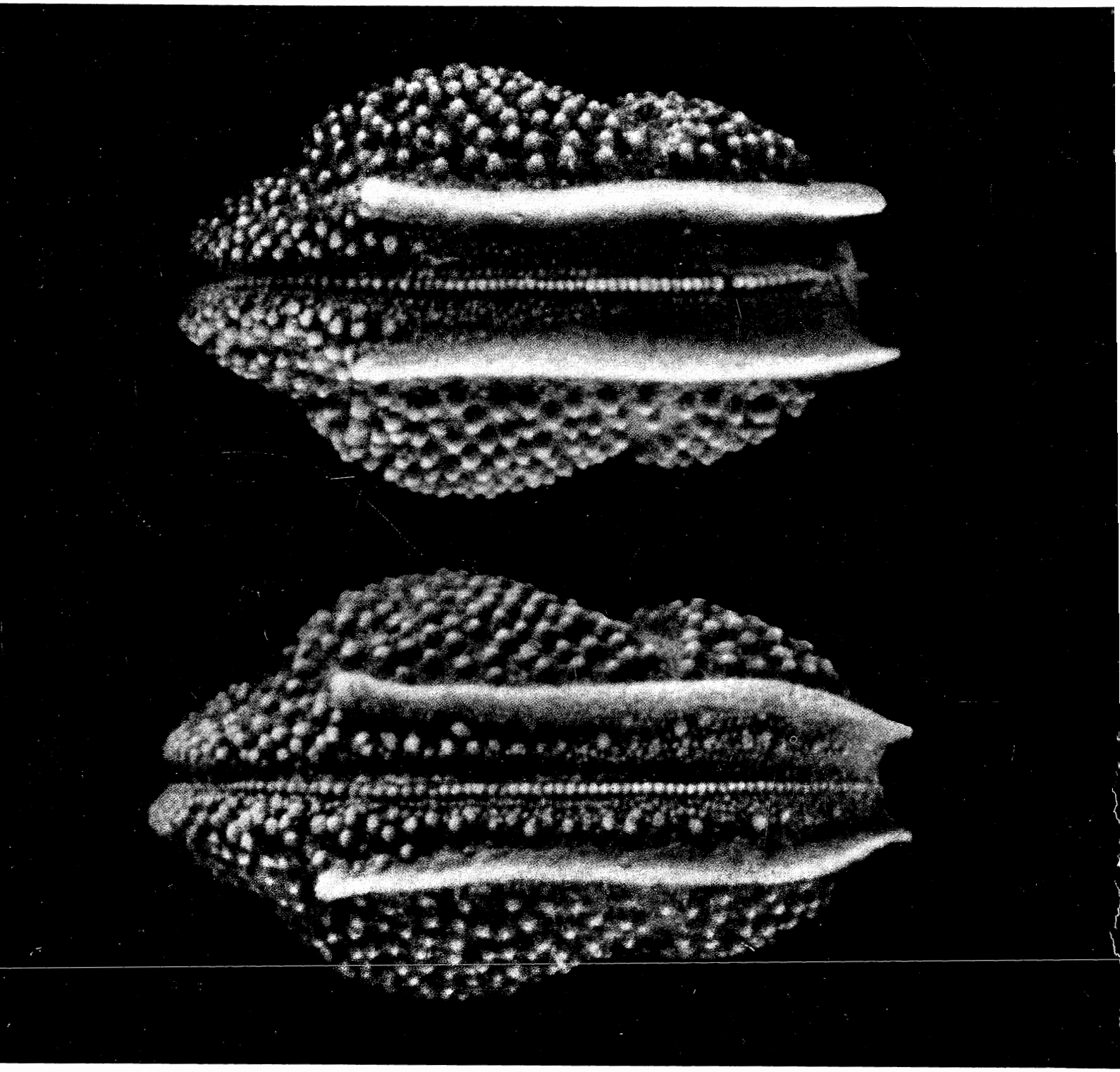
*Adelphobolbina trilobata*

FIG. 23—lateral view of immature right valve, 30865, Ferron Point Formation, Loc. 3.


1
2
Ctenoloculina acanthina
4
6
Hollinella (K.) n. nodiventriculata
5
7
3
Hollinella (K.) productilobata
Ctenoloculina cicatricosa
14
15
Hercynobolbina levis
16
8
10
12
17
9
11
13
Hollinella (K.) tendilobata
Bisphenella deminuta
Ruptivelum bacculatum
Hollinella (K.) inclinisulcata
18
19
21
Falsipollex laxivelatus
20
22
23
Hollinella (Keslingella) horologiina
Adelphobolbina trilobata

BACK COVER: *Adelphobolbina medialis*, UMMP 60130 (above) and 60131 (below), from the Ledyard Shale of western New York; ventral views of presumed male (above) and presumed female (below) carapaces, × 80, showing the dimorphism in the venter of this species.

# Dimorphic Middle Devonian Paleocopan Ostracoda of the Great Lakes Region



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