Brachiopods of the Bois Blanc Formation in New York

GEOLOGICAL SURVEY PROFESSIONAL PAPER 584-B

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By A. J. BOUCOT *and* J. G. JOHNSON

STRATIGRAPHY AND PALEONTOLOGY OF THE BOIS BLANC FORMATION IN NEW YORK

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Lithofacies summary and paleogeography of Bois Blanc correlatives in eastern North America and description of silicified brachiopods from New York

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BRACHIOPODS OF THE BOIS BLANC FORMATION IN NEW YORK

By A. J. Boucot and J. G. Johnson [1]

ABSTRACT

Two localities in thin exposures of the Bois Blanc Formation of New York yielded silicified brachiopods comprising 25 articulate and one inarticulate species. One of these brachiopods, *Cloudothyris postovalis*, is proposed as a new genus and species. Bois Blanc brachiopods compose an assemblage indicating correlation with the Schoharie Formation of New York and its equivalents elsewhere in eastern North America. Correlation, based pimarily on acrospiriferid evolution, indicates a late Early Devonian (Emsian) age for Schoharie-Bois Blanc rocks in New York and for their correlatives with a similar brachiopod assemblage at distant localities.

Provinciality of Appalachian Lower Devonian brachiopod faunas is exemplified by the endemic rensselaeriid terebratulids whose evolutionary changes form the basis for some fundamental Lower Devonian correlations in the region. Four rensselaeriid zones that span the Lower Devonian interval from the base of the Coeymans and Manlius Limestones to the top of the Schoharie-Bois Blanc may be recognized. In ascending order, *Nanothyris* zone spans the Coeymans-New Scotland interval, the *Rensselaeria* zone spans the Becraft-Oriskany, the *Etymothyris* zone coincides with the Esopus Formation, and the *Amphigenia* zone coincides with the Schoharie-Bois Blanc interval.

The quartz-rich facies of Schoharie age consists of an almost continuous narrow belt of deposits from central Gaspé to Alabama. This belt is interpreted to have lain adjacent to an eastward land area which separated the quartz-rich facies from terrigenous rocks with a Rhenish fauna, preserved in the Annapolis Valley of Nova Scotia. West of the quartzose belt is a broad expanse characterized predominantly by limestone and chert deposition during Schoharie time. It extends from the James Bay Lowland, south of Hudson Bay, to central Texas and possibly as far southwest as Chihuahua city in northern Mexico. Between this area and the Cordilleran geosyncline to the west, there is a broad expanse where marine deposits of Schoharie age are unknown and which probably was above sea level during that time.

INTRODUCTION

Cooper (in Cooper, G. A., and others, 1942) in the correlation chart for the North American Devonian concluded that the Onondaga Limestone of New York is of late Early Devonian age. Assignment of the Onondaga by Cooper to the Lower Devonian was largely on the basis of the brachiopod faunas and, in particular, the range of the genus *Paraspirifer* (Cooper, G. A., and others, 1942, p. 1732). Oliver (1960, p. B174) recognized that the corals of the Edgecliff, Nedrow, and Moorehouse Members of the Onondaga are similar to Eifelian corals of western Europe and on this basis concluded that the Onondaga is entirely of Middle Devonian age, but he noted that the Bois Blanc (as Zone B) of New York may be distinguished from true Onondaga because of its different coral assemblage. Boucot (Boucot and Arndt, 1960; Boucot, 1961; Boucot and others, 1964) concluded that the Onondaga in a broad sense is of Early Emsian age because correlatives of the Bois Blanc, namely the Littleton and Tomhegan Formations of New Hampshire and Maine, contain spiriferids of Early Emsian type. Oliver's recognition that "Zone B" can be split off from the main mass of the Onondaga and assigned to the Bois Blanc now makes it possible to reconcile these conflicting views.

This paper consists of a descriptive section in which New York Bois Blanc brachiopods collected by W. A. Oliver, Jr., are described and figured, together with sections on the paleogeography and lithofacies relationships of Schoharie correlatives in eastern North America. The authors do not attempt to cope with the question of the apparently missing Late Emsian shelly faunas in eastern North America. The nonrecognition thus far of Late Emsian age faunas in eastern North America is very enigmatic; it may reflect our ignorance of either Late Emsian faunas or the evolutionary significance of morphologically recognizable changes in the Late Emsian-Early Eifelian faunas.

AGE AND CORRELATION

Throughout the Appalachian faunal province (Boucot, 1960) from Gaspé to Texas, a remarkably similar assemblage of brachiopods occurs in the upper Lower Devonian. Prominent among these shells are *Plicanoplia*, *Eodevonaria arcuata*, *Prionothyris*, and *Cloudo-*

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TABLE 1.—*Brachiopods of the Bois Blanc Formation and its correlatives in eastern North America*

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Schizophoria sp									cf									×		
Dalejina alsa	×	×		cf	×	cf			cf	cf			cf			cf				
D. musculosa solaris			×					×				cf						×	×	×
Platyorthis peloris		×																		
P. planoconvexa			×																	
Pentamerella arata	×	×			cf										cf	×				
Leptaena sp	×	×	×	×			×	×	×	×	×	×		×		×		×	×	
"Schuchertella" sp	×	×	×	×	×				×	×	×	×		×		×		×	×	×
Douvillina? sp		×																		
Strophonella ampla		×														×				
"Leptostrophia" magniventra																		×		
Amphistrophia cf. *alveata*								×												
Protoleptostrophia blainvillei			cf						cf	×	×	cf		×				×	cf	cf
P. perplana		×		cf							×					×				
Stropheodonta cf. *demissa*	×	×	×					×	×							cf		cf	×	
Megastrophia hemispherica		×	×							cf						×				
M. inaequiradiata		×								×										
Cymostrophia? patersoni		×			×											×				
Pholidostrophia sp																×				
"Chonetes" sp		×			×					×		×								
Anoplia nucleata			×	cf			×		cf	×	×	×		×				cf		
Plicanoplia fornacula	cf	×					cf	cf	cf	×					cf					
P. billingsi																		×		
Cyrtoniscus nectus																		×	×	×
Chonostrophia reversa			cf				cf	cf		×	×	×		×						
Eodevonaria arcuata	×	×	×	×			×		cf	×	×	×		×	cf			cf	×	×
Machaeraria carolina	×																		cf	
Cupularostrum sp	×		cf						cf	×					cf	×				
Costellirostra peculiaris										×		×								cf
Atrypa "reticularis"	×	×	×	×				×	×	×		×		×	cf	×	×	×	×	×
Coelospira camilla	×	cf													cf					
Leptocoelia flabellites				×			×	cf	×	×	×	cf	×	×						
Meristina nasuta	×	×	cf	cf		cf			cf	cf					cf	cf				
Pentagonia unisulcata		cf	×					×		×							×			
Charionella scitula																×				
Charionoides doris		×		cf														×	×	
Nucleospira sp	×	×							×											
Acrospirifer duodenaria	×	×	×	×	×	cf	cf		cf	×		×		×	×	×	×			
A. atlanticus																		×	×	×
"Acrospirifer" worthenanus										×	×	×								
"Brachyspirifer" perimele																			×	cf
"Howellella" gaspensis																		×		
"Mucrospirifer" macra	cf	×	×	cf	×			cf		cf					cf	cf		cf		
Mediospirifer hemicyclus										×	×	×				cf				
Megakozlowskiella raricosta	×	×																		
"Spirifer" grieri		×																		
"Costispirifer" unicus	×											×				×				
Costispirifer billingsianus																	×			
C. planicostatus					×															
Fimbrispirifer divaricatus	cf			cf				×	cf					cf		×	×			
Elytha fimbriata	cf	×	×	cf					cf	×		×			cf	cf	×			
Ambocoelia sp	×				×								×							
Plicoplasia sp		×																		
Metaplasia pyxidata						cf	cf			×		×								
M. paucicostata															cf				cf	
Cyrtina sp		×		×					×	×								×		
Cyrtinaella biplicata	×	×																		
Prionothyris sp				×				×	×	×		×						×		cf
Cloudothyris postovalis	×		×																cf	
Centronella glansfagea	×	×	cf					cf		×						×				
Amphigenia elongata	×	×	×					×								×	cf			
A. parva				cf		cf													×	×
A. curta					×					×	×	×		×						
A. chickasawensis									×											
Globithyris sp																		×	×	
Productella? sp									×											

thyris, small individuals of *Amphigenia*, *Platyorthis*, *Dalejina alsa*, and an abundance of *Fimbrispirifer divaricatus*. These assemblages have been referred to in the past as "Schoharie," "Camden Chert" (Cooper, G. A., and others, 1942, p. 1774, 1780) and "Zone B" (Oliver, 1954, p. 632; 1960, p. B173) faunas among other things. Where present, they may be underlain by the Esopus (*Etymothyris* zone) and Oriskany (*Rensselaeria* zone) or their correlatives and may be overlain by beds of Onondaga age and fauna with *Paraspirifer* as an important new element.

Most of the genera making up this assemblage are strictly indigenous to the Appalachian faunal province and therefore make the correlation of this faunal unit with units of similar age in other faunal provinces of the world very difficult. At present (1967) the most reliable brachiopods for correlating this fauna with the standard sequence in the Rhineland are the acrospiriferids. In the Silurian and Early Devonian there was an evolving sequence of delthyrid brachiopods, prominent among which is the acrospiriferid precursor *Howellella*. Ranging from Silurian to Middle Devonian, *Howellella* is present in the Appalachian province through Early Gedinnian (upper Keyser-Coeymans equivalents) time as relatively small forms. During Late Gedinnian time (Kalkberg-New Scotland equivalents) relatively large representatives (forms including *Howellella cycloptera*) appear and are also present in the earlier Siegenian (Becraft-Port Ewen equivalents). By Oriskany (later Siegenian) time these large representatives had given way to externally similar forms (*Acrospirifer murchisoni* types) which internally lack crural plates in the brachial valve; these plates are a key distinction between the genera *Howellella* and *Acrospirifer*. The pre-Emsian species of both genera are characterized by possessing relatively few lateral plications, commonly five to seven on each flank. During Early Emsian (Bois Blanc Formation, Schoharie Formation, Camden Chert, and their equivalents) time there appear species of *Acrospirifer* characterized by numerous lateral plications (*Acrospirifer hercyniae* types). The early ontogeny of *A. hercyniae* faithfully recapitulates *A. murchisoni*. *Acrospirifer hercyniae* is present in the Appalachian province, where it has been assigned to *A. hercyniae* var. *atlanticus*. The latter has been found in beds of Early Emsian age in Maine (Tomhegan Formation) and in the Matapedia Valley region of eastern Quebec (upper part of the York River Sandstone). The faunas of both the Tomhegan and the York River have much in common with those of the Schoharie, the Bois Blanc, and the Camden Chert and are correlated with them.

The following fossiliferous formations are at present considered to be of Schoharie, that is, "Zone B" age in the Appalachian province; Bois Blanc Formation of Michigan and New York, Bowmanstown Chert (of Swartz, 1939) of Pennsylvania, Camden Chert of Tennessee, Clear Creek Formation of Illinois, Frog Mountain Sandstone, in part, of Alabama, Huntersville Chert (of Price, 1929) of Virginia, basal part of the Jeffersonville Limestone of southern Indiana and northern Kentucky, Kanouse Sandstone of New York, Littleton Formation of New Hampshire (type area only), Penters Chert of Arkansas, Sallisaw Formation of Oklahoma, Schoharie Formation of New York, Springvale Sandstone of Ontario, Tomhegan Formation of Maine, unnamed limestone of central Texas, Wildcat Valley Sandstone of Virginia (upper part), Woodbury Creek Member (of Boucot, 1959b) of Esopus Formation of New York, and York River Sandstone (upper zone containing *Amphigenia*) of Gaspé, Quebec. Amsden (in Amsden and Ventress, 1963, p. 150–162) has already given an excellent summary of the basis for correlation of most of these formations. Table 1 gives an indication of the overall similarity shown by the brachiopods identified from these rock units. Table 2 shows the distribution of species from the two localities herein described.

Boucot (1959b, p. 737) proposed the "Esopus Stage" to include the *Etymothyris* zone of his Highland Mills or lower member of the Esopus Formation plus the zone of *Amphigenia preparva* which he reported from his upper or Woodbury Creek Member of the Esopus. Subsequently, it was found through the work of John Southard (written commun., 1966) that beds assigned to the

EXPLANATION FOR TABLE 1

A Bois Blanc Formation, New York (Boucot and Johnson, this report).
B Schoharie Formation, New York (Hall, 1867; Boucot, this report).
C Kanouse Sandstone and Woodbury Creek Member of Esopus Formation, New York (Boucot, 1959b, p. 735).
D Bowmanstown Chert of Swartz, Pennsylvania (Boucot, this report).
E Huntersville Chert of Price, Virginia (Cooper, B. N., 1944, p. 133, 134).
F Wildcat Valley Sandstone, Virginia, upper part (Miller and others, 1964, p. B52; Boucot, this report).
G Unnamed shale, Hawkins County, Tennessee (Boucot report to L. D. Harris, dated Dec. 11, 1953).
H Frog Mountain Sandstone, Alabama (part) (Boucot and Johnson, this report).
I Unnamed beds, Chickasaw County, Miss. (Boucot, this report).
J Camden Chert, Tennessee (Dunbar, 1919, p. 86, 87).
K Camden Chert, western Kentucky (Luttrell and Livesay, 1952, p. 10; J. T. Dutro, Jr., and W. A. Oliver, Jr., report to W. W. Olive, dated Mar. 11, 1964).
L Clear Creek Formation, Illinois (Amsden and Ventress, 1963, p. 159).
M Penters Chert, Arkansas (Kinney, 1946, p. 612).
N Sallisaw Formation, Oklahoma (Amsden and Ventress, 1963, p. 144).
O Unnamed limestone, central Texas (Boucot and Johnson, this report).
P Bois Blanc Formation, Michigan (Landes and others, 1945; Boucot, this report).
Q Unnamed beds, James Bay lowland, Ontario (Boucot and Johnson, this report).
R York River Sandstone, Gaspé, Quebec (part) (Boucot, this report).
S Tomhegan Formation, Maine (Boucot, this report).
T Littleton Formation, New Hampshire (Boucot and Arndt, 1960, p. 43).

NOTE.—Omitted from this list is *Paraspirifer* (sic *Spirifer acuminatus*) reported from the Camden Chert of Tennessee by Dunbar (1919, p. 87). *Paraspirifer* is unknown in beds equivalent in age to the Camden; it seemed advisable, therefore, to reexamine the specimens of Dunbar. Three Camden specimens, which appear to be the basis of Dunbar's report, were loaned to the authors by Dr. Copeland MacClintock from the collections of the Peabody Museum, Yale University. One of these, YPM 25659 from loc. 3427/5, can be dismissed as an indeterminate spiriferid. A second specimen, YPM 25660 from loc. 3427/4, is an internal mold with faint plications on the fold and may be a *Costispirifer* comparable to *C. planicostatus*, or possibly a *Fimbrispirifer*. The third specimen, YPM 25661 from loc. 3427/3, has the external form and fine plications of *Paraspirifer*, but no splitting of the plications can be seen. Assignment of this specimen to *Paraspirifer*, therefore, must also be regarded as doubtful.

Woodbury Creek Member of the Esopus Formation in the woods on the west side of the thruway, near Highland Mills, N.Y., belong, instead, to the lower or Highland Mills Member of the Esopus. Brachiopods collected at this locality and previously assigned to the Woodbury Creek Member include *Leptocoelia flabellites Cyrtina rostrata*, *Etymothyris* sp., and *Amphigenia preparva*. These fossils must therefore be added to the list of species from the Highland Mills Member; three of the four fossils had already been found in typical Highland Mills beds at the railroad cut at Highland Mills (Boucot, 1959b). *Amphigenia preparva* is the only one not previously recorded from the Highland Mills Member. With these four species removed, the fauna of Boucot's Woodbury Creek Member of the Esopus Formation and that of the Kanouse Sandstone do not differ greatly and both are here regarded as faunal equivalents of the Schoharie Formation. With *Amphigenia preparva* removed from the Woodbury Creek, the "Esopus Stage," envisioned by Boucot, has the value in effect of the *Etymothyris* zone and probably should be dropped as a suggested stage. The *Etymothyris* zone and the overlying Bois Blanc or Schoharie compose the Sawkill Stage of Rickard (1964).

Confirmation of Southard's reevaluation of the geology and the resulting addition of *Amphigenia preparva* to the *Etymothyris* zone fauna in eastern New York is found in the York River Sandstone of Gaspé where Boucot now has recognized *Etymothyris* (*E. gaspensis*) together with *Amphigenia preparva* and *Meganterella finksi* (pl. 8, figs. 16–21) in a fauna that includes *Dalejina* cf. *musculosa solaris*, *Platyorthis* sp., *Leptaena* sp., "*Leptostrophia*" *magniventra*, *Protoleptostrophia blainvillei*, "*Schuchertella*" sp., *Cyrtoniscus?* cf. *nectus*, *Eodevonaria gaspensis*, *Costellirostra* sp., *Atrypa "reticularis,"* *Leptocoelia flabellites*, *Acrospirifer* sp., "*Mucrospirifer*" sp., *Elytha* sp., and *Cyrtina* sp. underlying beds of Schoharie age which bear *Amphigenia parva* and other elements of the Schoharie-Bois Blanc fauna.

LOWER DEVONIAN RENSSELAERIID ZONATION

Rensselaeriid terebratulids compose a radially ribbed group with a cardinal plate supported by crural plates in the brachial valve. The group is typical and common in the Appalachian Lower Devonian, and its members are unknown beyond the Appalachian faunal province. The earliest members, in the form of small species of *Nanothyris*, appear first in the upper part of the Keyser Limestone and in the Coeymans Limestone (fig. 1). Above these occurrences, it is commonly possible to recognize somewhat larger species of *Nanothyris* in the New Scotland Limestone and its equivalents; the genus is also known to occur uncommonly in the Becraft-Oriskany interval. It is possible to recognize a *Nanothyris* zone inclusive of the occurrences below the top of the New Scotland Limestone in New York.

Above the New Scotland Limestone, the first true representative of *Rensselaeria*, derived from *Nanothyris*, occurs in the form of *R. aequiradiata*. Cloud (1942, p. 47) included *R. aequiradiata* in *Nanothyris*, but the size of the shell, the obsolescence of the dental lamellae, and the depth of the impression of the ventral musculature, in the authors' view, suggest inclusion in *Rensselaeria*.

TABLE 2.—*Bois Blanc brachiopods described in this report*

Brachiopods	4671–SD	4672–SD
Petrocrania sp		×
Dalejina alsa (Hall)		×
Pentamerella cf. *arata* (Conrad)		×
Leptaena sp		×
Stropheodonta cf. *demissa* (Conrad)		×
"Schuchertella" sp. A	×	×
"Schuchertella" sp. B	×	
Plicanoplia? sp		×
Eodevonaria arcuata (Hall)		×
Machaeraria carolina (Hall)		×
Cupularostrum? sp		×
Atrypa "reticularis" (Linnaeus)	×	×
Coelospira camilla (Hall)	×	×
Meristina nasuta (Conrad)		×
Nucleospira sp		×
Acrospirifer duodenaria (Hall)	×	×
Megakozlowskiella raricosta (Conrad)		×
"Costispirifer" unicus (Hall)		×
?Fimbrispirifer divaricatus (Hall)		×
Elytha sp		×
"Mucrospirifer" cf. *macra* (Hall)		×
Ambocoelia sp		×
Cyrtinaella biplicata (Hall)	×	×
Cloudothyris postovalis n. gen. and n. sp.		×
Centronella glansfagea (Hall)		×
Amphigenia elongata (Vanuxem)		×

Larger and more robust forms are characteristic elements of the Oriskany brachiopod fauna. A *Rensselaeria* zone, encompassing beds from the base of the Becraft Limestone to the top of the Oriskany Sandstone and their equivalents can be recognized over a wide area.

Overlying the Oriskany age beds with *Rensselaeria* are scattered occurrences of the closely allied genus *Etymothyris*, which evolved from *Rensselaeria* by development of long subparallel dental lamellae. *Etymothyris* occurs in the lower part of the York River Sandstone and in the upper part of the Grand Grève Limestone in Gaspé (Cloud, 1942, p. 59) and also in the lower or Highland Mills Member of the Esopus Formation near Highland Mills in eastern New York (Boucot, 1959b, p. 760). *Etymothyris* represents a small but distinct step in rensselaeriid evolution, and its occurrence signifies the *Etymothyris* zone.

Boucot was able to show earlier (1959b, p. 737) that *Etymothyris* gave rise to *Amphigenia* by coalescence of the long dental lamellae anteriorly to form a spon-

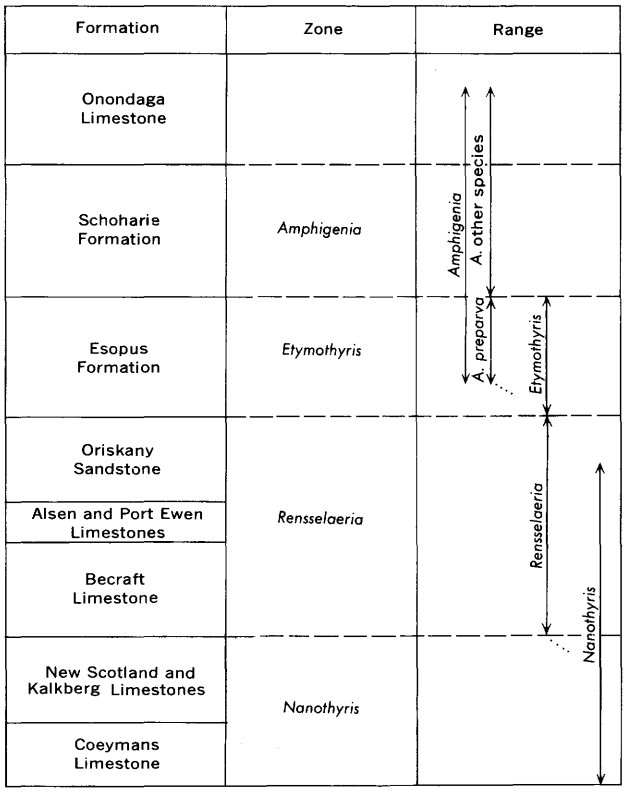

FIGURE 1.—Rensselaeriid zones in the Lower Devonian of eastern North America.

dylium. In addition, mystrochial plates support the dental lamellae posterolaterally (Boucot, 1959b, p. 762). The earliest known species of *Amphigenia*, *A. preparva*, occurs in Boucot's lower or Highland Mills Member of the Esopus Formation (*Etymothyris* zone) and in the *Etymothyris* zone of the lower York River Sandstone in Gaspé. Small *Amphigenia* including *A. elongata* Hall, *A. parva* Clarke, *A. curta* Meek and Worthen, and *A. chickasawensis* Boucot, with fully fused dental lamellae forming an elevated septum, occur in the Schoharie interval above the *Etymothyris* zone; larger specimens of *A. elongata* continue higher into the Moorehouse Member of the Onondaga (Oliver, 1960, p. B173). The *Amphigenia* zone as here used refers to pre-Edgecliff age rocks with *Amphigenia* and is equal to the Schoharie-Bois Blanc interval of this report. This coincides with the usage of Oliver (1954, p. 632; 1960).

PALEOGEOGRAPHY AND LITHOFACIES OF STRATA OF SCHOHARIE AGE

Enough information has now accumulated about strata of Schoharie age in eastern North America to make an attempt at a paleogeographic and lithofacies reconstruction fruitful (fig. 2). On the northeast, in Gaspé, there appears to be a transition from marine to nonmarine conditions affecting strata of Schoharie age between the Matapedia Valley region, where faunas of Schoharie age (*Amphigenia* zone) are abundant, and central to eastern Gaspé where *Etymothyris* zone faunas are succeeded by beds containing either plant debris or vertebrate fragments, or by globithyrid community faunas (Boucot, 1963) overlain by beds containing plants and vertebrates. It is probable that the Knoydart Formation of Nova Scotia and the oldest Devonian beds (above marine Silurian) of southeastern New Brunswick and adjacent Maine, all of which are characterized by vertebrate faunas, may extend into Schoharie time. In any event, it is reasonable to assume that nonmarine beds of Schoharie age occupied this area. If this premise be admitted, then it is reasonable to infer a shoreline between the marine strata in Gaspé and coastal Maine, New Brunswick, and adjacent Nova Scotia. The Annapolis Valley of southwestern Nova Scotia is occupied by marine strata of about Schoharie age in the upper part of the Torbrook Formation.

Southwest of Gaspé, the marine beds of the Tomhegan Formation, on the northwest side of the Moose River synclinorium, grade southeastward into strata characterized by a globithyrid community fauna suggesting proximity to a southeastern shoreline. To the southwest of northern Maine, faunas of Schoharie age occur in the Littleton Formation of northern New Hampshire. The southeastern shoreline inferred for northern Maine and Gaspé is extrapolated to northern New Hampshire. Similar logic leads to the prolongation of this same shoreline into the Green Pond outlier of New York and New Jersey, the outcrop belt of the Bowmanstown Chert of Swartz (a siliceous siltstone) of eastern Pennsylvania and the similar Huntersville Chert of Price of Virginia and adjacent West Virginia, and the Frog Mountain Sandstone of the Birmingham, Ala., region.

In the event that the extrapolation from the east side of the Connecticut River Valley to the Green Pond outlier is denied (the chief reason for such a denial would be the contention that the upper part of the Waits River Formation is a facies of the fossiliferous Schoharie age part of the Littleton Formation), it would then be appropriate to conclude that the shoreline in northern New Hampshire turned due south and paralleled the east side of the Connecticut River Valley, and that a northern termination for an island or peninsula would have to be inferred to have existed somewhat to the north of the Green Pond outlier. The extent and direction to the south of the shoreline in the Birmingham region cannot be inferred on the basis of presently available information.

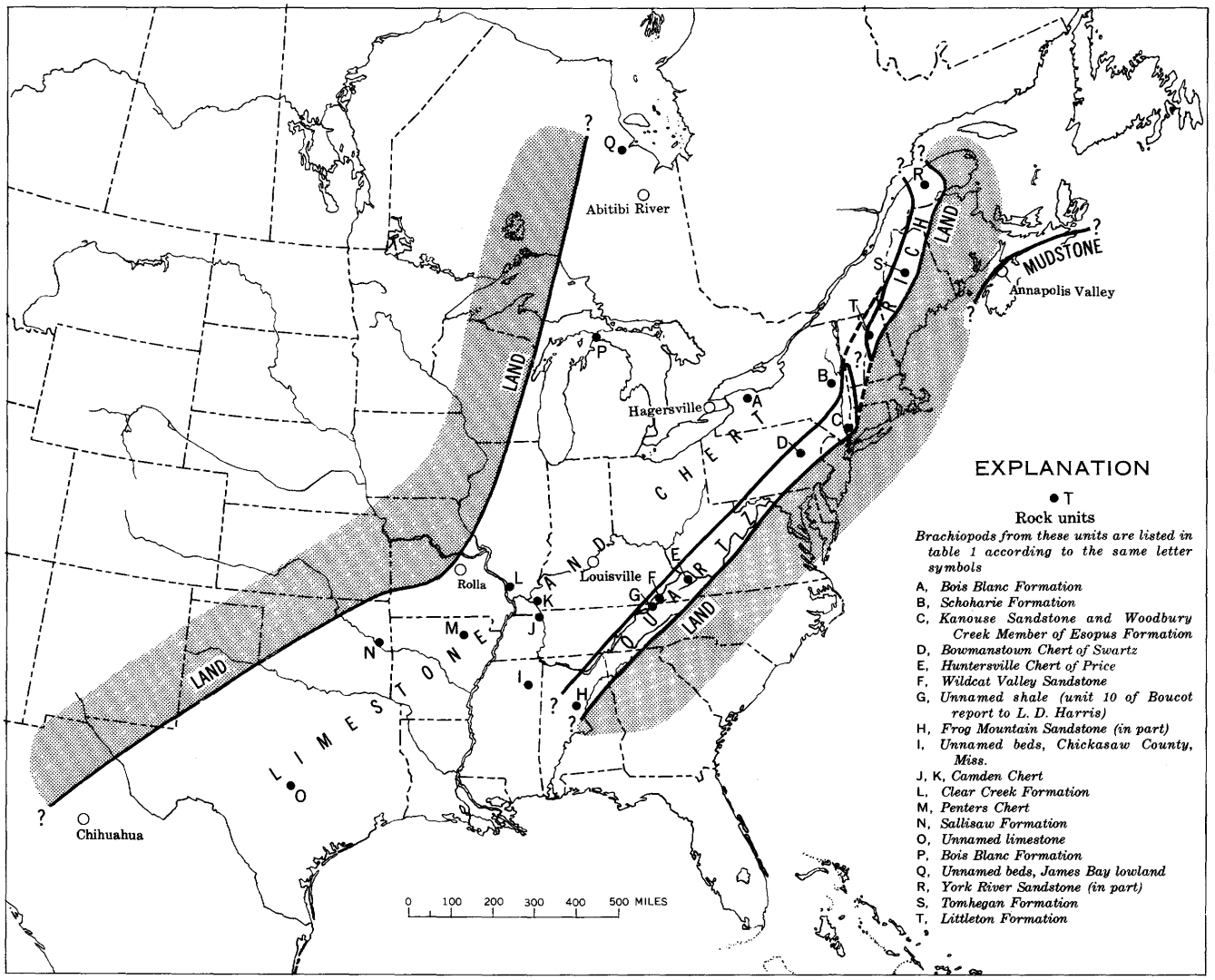

FIGURE 2.—Lithofacies map of Bois Blanc-Schoharie correlatives in eastern North America.

West of the clastic quartz-rich rocks extending in a relatively narrow belt, or belts from Gaspé to Birmingham, there occurs a carbonate-rich facies containing a large amount of light-colored chert in the Oklahoma, Illinois, western Tennessee, northern Mississippi region and less chert elsewhere. Limestone and chert are the predominant lithologies in this relatively wide region. In Gaspé there is reason to infer that carbonate rocks of Schoharie age occurred to the northwest of the Matapedia Valley, as one locality has been found where impure limestone of Grande Grève Limestone aspect has yielded a fauna of Schoharie age.

Absence of any well-defined belts of terriginous material on the west side of these deposits makes a reliable identification of the position of the original shoreline difficult, and the occurrence of quartzite of possible Schoharie age near Rolla, Mo. (Bridge and Charles, 1922), seems presently to be too isolated to be more than suggestive. Nevertheless, it is improbable that marine sediments were being deposited much farther west than the known outcrops. The contemporaneous fauna of the Great Basin is very different and has wholly different provincial affinities. It is probable that a broad area including the southern extension of the Canadian Shield was slightly above sea level, exposing Silurian carbonates which have been shown to be widely represented across that area and that may have completely covered it (Berry and Boucot, 1968). Thus, there is no reasonable expectation that a large remnant of a western terriginous belt will be found.

The Sylvania Sandstone of northwestern Ohio may include nearshore deposits of Bois Blanc age, since it overlies the Siegenian age Holland Quarry Shale of Carman (1960) with fish remains (Denison, 1960). If

future work should support this possibility, the marine seaway of Schoharie age was much more restricted than we have depicted in figure 2.

The Springvale Sandstone near Hagersville, Ontario (Stauffer, 1915, p. 77), also is of Bois Blanc age, according to Oliver who has recognized in it the distinctive Bois Blanc coral fauna (W. A. Oliver, Jr., oral commun., 1965).

In the western conterminous United States north of about the 41st Parallel, the Cordilleran geosyncline is bordered on the east by widespread nonmarine fish- and plant-bearing deposits of the Water Canyon and Beartooth Butte Formations (Sandberg, 1961). These deposits are slightly older (Early or Middle Siegenian, according to Denison, 1958, p. 500), indicating uplift in part of the postulated land area just before Schoharie time. In addition, Lower or Middle Devonian fossil plant remains are known from east-central Arizona (Teichert and Schopf, 1958). The remainder of the postulated western land area may have had limits that differed little from those indicated for late Helderberg to Oriskany time (Boucot and Johnson, 1964, fig. 1), but the broad area between the Great Basin marine deposits and the deposits of Schoharie age depicted on figure 2 lacks any known deposits, marine or nonmarine, of Schoharie age; the bordering Lower Devonian carbonates and sandstones are overlapped by rocks ranging in age from Givetian to Famennian and younger.

SYSTEMATIC PALEONTOLOGY

Material.—The brachiopods described below are relatively well-preserved silicified shells etched from limestone blocks collected at the two Bois Blanc localities of Oliver, noted above in table 2. (See Oliver, 1967, for locality descriptions.) Many species are represented by 5–10 specimens and few by as many as 20. The illustrated material is approximately half of what was available for study at the time the descriptive work was completed. For the rarer species, the illustrated specimens include all the available material.

Class INARTICULATA
Order NEOTREMATA Beecher
Superfamily CRANIACEA

Genus PETROCRANIA Raymond, 1911

Type species.—*Craniella meduanensis* Oehlert, 1888, p. 101, pl. 10, figs. 1–1g.

Petrocrania sp.

Plate 1, figures 1–10

Discussion.—There are two poorly preserved specimens of this genus from a single locality. The musculature is very poorly preserved owing to relatively crude silification, but the size and overall irregular shape and general layout of the muscle impressions serve to support the generic assignment.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147237, 147238.

Class ARTICULATA
Order ORTHIDA
Suborder DALMANELLOIDEA
Superfamily DALAMANELLACEA Schuchert
Family RHIPIDOMELLIDAE Schuchert
Subfamily RHIPIDOMELLINAE Schuchert

Genus DAJEJINA Havlíček, 1953

Type species.—*Dalejina hanusi* Havlíček, 1953, p. 5.

Dalejina alsa (Hall)

Plate 1, figures 11–27

Orthis alsus Hall, 1863, p. 33.
Rhipidomella alsa Hall, 1867, p. 36, pl. 4, figs. 2–7.

Exterior.—Pedicle valves are commonly subcircular with the maximum width very slightly exceeding the length. Brachial valves tend to be slightly transversely suboval. In lateral profile the valves are subequally biconvex, but the pedicle valve is commonly deeper posteriorly and the brachial valve is more evenly arched from posterior to anterior. Maximum width of the valves is generally near midlength. The hinge line is short and straight, and the interarea is low and triangular, equal in width to approximately half the maximum width of the valves or slightly less. The ventral interarea is slightly curved and apsacline. The dorsal interarea is nearly linear and anacline. The delthyrium is a broad, low triangular opening, rounded at the apex and enclosing an angle of close to 90°.

The radial ornament is very poorly preserved on the silicified specimens at hand, but apparently it consisted of numerous fine radial costellae, rather closely spaced and separated by narrow interspaces. A fold or sulcus is not developed.

Interior of pedicle valve.—There is a rather well-developed concave pedicle callist in the apex. The hinge teeth are blunt, semielliptical, and widely divergent and are supported basally by very short, stout, widely divergent dental lamellae that bound the posterior third of the muscle impression. Broad, shallow crural fossettes are present. Small shells bear a short and relatively narrower muscle impression bounded most of its length by low muscle bounding ridges that are slightly curved and convex laterally. In small shells flabellate muscle scars are not developed nor are adductors well impressed, and the diductors blend with the interior of

the shell anteriorly. The muscle impression in large specimens is large, flabellate, nearly circular, and commonly extends anterior to midlength. The adductor scars are well developed and suboval and are situated with their anterior edge at about the center of the muscle field. Generally, there is a thickening or elevation along the anterior edge of the adductor impressions that continues anteriorly as a myophragm dividing the enclosing diductor scars. The margins bear crenulations that are narrow and flat, some of which are longitudinally grooved on their inner faces.

Interior of brachial valve.—In moderate-sized specimens the brachiophores are stout and rounded in cross section and widely divergent with stout brachiophore plates attached almost the whole of their length. The sockets are formed between the brachiophore plates and the inner edge of the interarea. The cardinal process consists of a rounded curved shaft that extends from a slightly built-up notothyrial cavity. Muscle scars are not impressed on either small or large specimens. Large specimens appear to have the brachiophore supporting plates partly differentiated from the bases of the brachiophores approximately along the inner sides of the sockets so that a pair of shallow grooves separates them on their ventral faces. The brachiophores furthermore are somewhat swollen distally on the parts facing posterolaterally. The cardinal process is stout and projecting and subrhomboidal in cross section.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147239–147242.

Order PENTAMERIDA
Suborder PENTAMEROIDEA
Superfamily PENTAMERACEA M'Coy
Family GYPIDULIDAE Schubert and Le Vene
Subfamily GYPIDULINAE Schuchert and LeVene

Genus PENTAMERELLA Hall, 1867

Type species.—*Atrypa arata* Conrad, 1841, p. 55.

Pentamerella cf. arata (Conrad)

Plate 1, figures 28–36

Atrypa arata Conrad, 1841, p. 55.
Pentamerella arata Hall, 1867, p. 375, pl. 58, figs. 1–12.
Amsden, 1964, p. 233, pl. 40, figs. 9–15, text fig. 5.

Material.—Only three pedicle valves representing this species are available.

Exterior.—The valves are broadly pyriform in outline with width about equal to the length. The pedicle valves are deeply convex, almost hemispherical, with a short, strongly incurved beak. The hinge line is very narrow and rounded, and there is no interarea. The outline of the commissure is slightly transverse and evenly suboval. The posterolateral extremities flatten out very slightly, but otherwise do not appear much deflected from the overall convexity of the valve. A tangent to the shell at midline revolves about an angle of about 180° from the beak to the anterior commissure. There is no fold or sulcus medially, and the anterior commissure apparently was nearly rectimarginate. The ornament consists of a few low rounded plications, stronger on the midpart of the valves but nevertheless present on the lateral slopes as well, separated by shallow but well defined U-shaped interspaces. The plications give rise to new plications anteriorly in an irregular manner, apparently by bifurcation.

Pedicle valve interior.—The hinge teeth are very small and pointed and adjoin the inner edges of the delthyrium. A moderately deep spondylium of elongate rhomboidal outline beneath the delthyrium projects approximately half its length into the interior of the pedicle valve and parallel to the commissure. It is supported basally by a short, thin, median septum of a length equal to, or slightly less than, that of the spondylium. The interior is faintly crenulated by the impress of the plications.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147243, 147244.

Order STROPHOMENIDA
Suborder STROPHOMENOIDEA
Superfamily STROPHOMENACEA King
Family LEPTAENIDAE Hall and Clarke

Genus LEPTAENA Dalman, 1828

Type species.—*Leptaena rugosa* Dalman, 1828, pl. 1, fig. 1.

Leptaena sp.

Plate 2, figures 1–6

Discussion.—Two fragmentary pedicle valves are available, which suffice at best to document the presence of the genus in the collections under study. The valves are nearly semicircular, judging from the concentric rugose corrugations, and these are relatively well developed and prominent. The ventral muscle scar is subcircular in outline and is defined by strong, platelike muscle bounding ridges around it laterally and anteriorly. The diductor scars are divided medially by an elevated thick myophragm of square cross section and with parallel lateral sides. It extends from the adductor impressions in the posterior third of the muscle scar to its anterior boundary.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147245, 147246.

Family STROPHEODONTIDAE Caster

Genus STROPHEODONTA Hall, 1852

Type species.—*Strophomena demissa* Conrad, 1842, p. 258, pl. 14, fig. 14.

Stropheodonta cf. demissa (Conrad)

Plate 2, figures 7–16

Discussion.—Two relatively poorly preserved silicified brachial valves of this species are available for study. They are flatly concave to fairly strongly concave and bear bifurcating costae on the exterior. The hinge line is long and straight and is slightly less than the maximum width of the valves, which is found near midlength. On the interior the cardinalia are poorly preserved. The adductor muscle scar consists of two pairs of oval impressions comprising a pair of relatively widely set posterior adductors and a narrower, somewhat more triangular, pair of anterior adductors between them. The anterior part of the muscle scar is slightly elevated as a roughly trigonal platform which connects the anterior edges of the anterior adductors with a short, stout breviseptum at about midlength. Laterial to the breviseptum and originating at the junction between the posterior and anterior adductors, there is a pair of short but well-developed brachial ridges that are subparallel to the midline. The flatter of the two specimens bears a very faintly developed peripheral ridge. The other larger specimen lacks one.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147247, 147248.

Superfamily DAVIDSONIACEA King

(pro Orthotetacea of some authors)

Discussion.—The superfamily is based primarily on pseudopunctate Carboniferous-Permian brachiopods. However, Boucot (1959a, p. 25) and Williams (1956, p. 254) noted that many Silurian and Lower Devonian orthotetaceans lack pseudopunctate shells. G. A. Cooper (1962, p. 155) has commented on the problem of the absence of the pseudopunctae in certain early orthotetacean stocks. With these observations in mind, plus inability to discover any evidence of pseudopunctae in the specimens herein described, the authors do not attempt any classification at the family and subfamily levels.

Genus SCHUCHERTELLA Girty, 1904

Type species.—*Streptorhynchus lens* White, 1862, p. 28.

Discussion.—In the brachiopod volume of the "Treatise on Invertebrate Paleontology," Williams (1965, p. H408) reported that *Schuchertella* is impunctate. However, G. A. Cooper (written commun. to J. G. Johnson, dated Dec. 28, 1965) stated that *Schuchertella lens* is pseudopunctate. The authors have not detected pseudopunctae in the species described below and therefore have placed the genus name in quotation marks.

"Schuchertella" sp. A

Plate 2, figures 17–30

Exterior.—Six fragmentary specimens of a finely costate species are available. It is planoconvex with the pedicle valve only gently arched in the umbonal region. The remainder of the pedicle valve is also nearly flat. On the best preserved pedicle valve there are 10 costae in a space of 5 mm, measured along the midline at a distance of 10 mm from the beak. The ventral interarea is long, triangular, and flat, and is apsacline, nearly catacline. The delthyrium is covered by a strong, convex pseudodeltidium. The dorsal interarea is long and nearly linear, and is anacline and nearly catacline.

Interior of pedicle valve.—The hinge teeth are stout and subtriangular in cross section, and they project internally parallel to the surface of the interarea. Inside the delthyrium they form relatively ponderous ridges along the inner edges of the delthyrium, but dental lamellae are completely lacking. The muscle scars as a whole, are only faintly impressed, and the diductors are not clearly discernible on the specimens at hand; however, the adductor impressions compose a fairly well-marked cordate pair separated by a well-developed myophragm. The interior is smooth, except for the periphery which is crenulated.

Interior of brachial valve.—The sockets are widely set apart and diverge widely. They are defined posteriorly by the internal margins of the interarea and anteromedially by thick socket plates that converge posteriorly forming a nearly complete crescent-shaped posteriorly directed cardinal plate. Medially on the interior face of the cardinal plate there is a well-developed ridge, and posteriorly there is a small median groove and pair of adjoining ridges composing the site of diductor attachment. The dorsal edge of the whole structure is rimmed by a low arcuate chilidium. The adductor impressions are only poorly discernible.

Occurrence: Loc. 4671–SD, 4672–SD.
Figured specimens: USNM 147249–147251.

"Schuchertella" sp. B

Plate 2, figures 31–36

Discussion.—A single brachial valve of a second schuchertelloid species is available. It is distinguished from those described above as "*Schuchertella*" sp. A by

having considerably coarser costae. There are seven costae in a space of 5 mm, 10 mm anterior to the beak on the one available specimen. The shape is transverse subsemicircular, and the growth lines indicate that maximum width was at the hinge line in small specimens but moved anteriorly with growth. The length increases at a rate greater than width with increase in overall size. On the interior the sockets are very rudimentary and shallow. They are bounded anteromedially by thick straight socket ridges whose proximal ends coalesce posteriorly forming a thick multilobed cardinal plate. Brachiophores project ventrally from the socket ridges about at midlength. The posterior face of the cardinal plate has five lobes including a medial one that is produced somewhat further ventrally than the others and is relatively smooth. The four lateral ones, two on either side of the center, are roughened on their posterior faces, which probably indicates that they were the sites of diductor attachment. No chilidium is preserved on this specimen. The interior is relatively strongly crenulated by the impress of the costae.

Occurrence: Loc. 4671–SD.
Figured specimen: USNM 147252.

Suborder CHONETOIDEA
Superfamily CHONETACEA Bronn
Family CHONETIDAE Bronn
Subfamily ANOPLIINAE Muir-Wood

Genus PLICANOPLIA Boucot and Harper, 1968

Type species.—Chonetes fornacula Dunbar, 1920, p. 130.

Plicanoplia? sp.

Plate 3, figures 6–10

Discussion.—There is a single poorly preserved and fragmentary pedicle valve that is small in size and has a style of ribbing suggestive of *Plicanoplia.*

Occurrence: Loc. 4672–SD.
Figured specimen: USNM 147254.

Subfamily CHONETINAE Bronn

Genus EODEVONARIA Breger, 1906

Type species.—Chonetes arcuatus Hall, 1857, p. 116.

Eodevonaria arcuata (Hall)

Plate 3, figures 1–5

Chonetes arcuata Hall, 1857, p. 116; Hall, 1867, p. 119, pl. 20, fig. 7.
Eodevonaria arcuata Amsden *in* Amsden and Ventress, 1963, pl. 15, figs. 7–17.

Discussion.—The single specimen of *Eodevonaria arcuata* in the available collections is a free silicified pedicle valve. It is moderately strongly convex with a long straight hinge line that probably equaled the maximum width of the valves. The umbo is only very gently more convex than the posterolateral slopes of the valves and the beak is minute. The exterior bears a radial ornament of fine, low, rounded costae that uncommonly split anteriorly. The interarea is long, low, and nearly linear and is flat and orthocline with denticulations present along most of its length. The delthyrium is broad, low, and open. The muscle scars are not impressed, but there is a short, low median septum in the apex of the valve.

Occurrence: Loc. 4672–SD.
Figured specimen: USNM 147253.

Order RHYNCHONELLIDA
Suborder RHYNCHONELLOIDEA
Superfamily CAMAROTOECHIACEA Schuchert and LeVene
Family RHYNCHOTREMATIDAE Schuchert

Genus MACHAERARIA Cooper, 1955

Type species.—Rhynchonella formosa Hall, 1857, p. 76.

Discussion.—The known species of *Machaeraria,* in external form and internal morphology, have much in common with *Callipleura* G. A. Cooper (1942, p. 228). *Callipleura nobilis* (type species of the genus) is distinguished externally from *Machaeraria* by the presence of numerous closely-spaced concentric imbricating lamellae on the crests of the radial costae. The morphologic similarity taken in conjunction with the Hamilton age of *Callipleura* suggests derivation of that genus from the typically Lower Devonian *Machaeraria.*

Machaeraria carolina (Hall)

Plate 3, figures 11–20

Rhynchonella (Stenocisma) carolina Hall, 1867, p. 337, pl. 54, figs. 14–19.

Exterior.—The valves of this species are roughly trigonal in outline and strongly biconvex with the brachial valve somewhat deeper than the pedicle valve. The pedicle valve is relatively flat transversely across its posterolateral extremities, and the convexity from the umbo to the posterolateral extremities is slight and is only a little greater at the midline. The brachial valve is relatively strongly convex and domelike. The ventral beak is relatively short and stubby and is straight or nearly straight. There is a large apical foramen which is incomplete and thus open on its dorsal edge. There is no interarea, and the hinge line is short and curved. The posterolateral margins are straight and diverge for

some distance at an angle only slightly more than 90°. Maximum width is well anterior to midlength. There is a broad shallow sulcus in the pedicle valve and a poorly defined fold in the brachial valve. The sulcus is not sharply set off from the flanks because of its relatively shallow configuration, and there may or may not be a parietal costa present along its margin.

The ornament consists of well-developed angular radial costae which number 24 on the best preserved pedicle valve. Of these, nine are on each flank and five in the sulcus; a single parietal costa is present on one specimen. Concentric growth lines are not developed.

Interior of pedicle valve.—The hinge teeth are stubby and roughly pyriform in outline diverging anterolaterally at about right angles from one another, slightly less than the posterolateral margins. They are supported by short, stout, subparallel dental lamellae. The posterior part of the shell is moderately thickened by shell material making dental lamellae partly obsolescent and partly filling the narrow umbonal cavities. Between the dental lamellae the muscle impressions are elongate and relatively narrow with subparallel sides. They extend anteriorly approximately one-third the length of the valve and are divided medially by an indistinct low, rounded myophragm. The interior part of the valve is moderately strongly crenulated by the impress of the costae.

Interior of brachial valve.—The sockets are shallow, relatively short and broad, and are bounded posteriorly by the margins of the valve. The inner edges of the hinge plates are supported by stout crural plates that diverge somewhat laterally as they ascend toward the base of the valve. The notothyrial cavity between the crural plates is nearly completely filled with shell material forming a high notothyrial platform, but leaving a narrow slot with subparallel sides posteriorly. The slot bears a bladelike median septum. The anterior edge of the notothyrial platform is extended as a broad myophragm that bisects the posterior one-third to nearly one-half of the adductor muscle impressions. Muscle bounding ridges laterally enclose the posterior third of the adductor scars. The whole posterior part of the valve is relatively strongly thickened with secondary shell material. The adductor muscle impressions are roughly subcircular and blend moderately well with the interior of the valve anteriorly.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147255, 147256.

Family TRIGONIRHYNCHIIDAE Schmidt

Genus CUPULAROSTRUM Sartenaer, 1961

Type species.—*Cupularostrum recticostatum* Sartenaer, 1961, p. 6, pl. 1, figures. 1–7; pl. 2, figs. A–C.

Cupularostrum? sp.

Plate 3, figures 21–29

Exterior.—It is impossible to gain an accurate idea of the shape of the pedicle valves of this species because of inadequate material; however, the brachial valves are transversely oval and moderately deeply convex. The beak is moderately incurved on the pedicle valve. There is a triangular delthyrium. The position of a probable foramen is poorly preserved in the two pedicle valves available. The species is characterized by strong, narrow subangular costae on both valves separated by deep interspaces. The largest specimens available have 18 costae on the pedicle valve and 16 on the brachial valve. Of the latter, four costae are situated on a low fold.

Interior of pedicle valve.—The hinge teeth are small and narrow and diverge at an angle approaching 180°. The teeth are supported posteriorly by short, thin subparallel dental lamellae which enclose the poorly impressed muscle scars. The interior of the valve is moderately strongly crenulated throughout most of its length by the impress of the costae.

Interior of brachial valve.—The sockets are shallow, poorly defined, and widely divergent, and the hinge plates defining them are situated well above the base of the valve medially. The bases of the sockets are somewhat rough, but it is not possible to determine whether they are crenulated because the preservation is relatively crude. There is a well-developed median septum posteriorly that, however, is relatively low. It supports the posteromedial parts of the hinge plates by dividing medially, thus forming a rather stout septalium. The crura originate from the medial edges of the hinge plates. The crural flanges spread out medially forming triangular plates whose inner edges partly cover the septalium, but which extend well beyond the anterior end of the septalium. The distal ends of the crura that are preserved are ribbonlike and project anterolaterally. The interior is strongly crenulated by the impress of the costae.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147257, 147258.

Order SPIRIFERIDA
Suborder ATRYPOIDEA
Superfamily ATRYPACEA Gill
Family ATRYPIDAE Gill
Subfamily ATRYPINAE Gill

Genus ATRYPA Dalman, 1828

Type species.—*Anomia reticularis* Linnaeus, 1758, p. 702.

Atrypa "reticularis" (Linnaeus)

Plate 3, figures 30–49

Discussion.—The authors use the trivial name "*reticularis*" to include forms that are morphologically close to the type species of *Atrypa*. True *Atrypa* of this type constitutes an exceedingly common and widespread group, many forms of which have names that have been erected with little or no attention given to comparable forms. The authors, then, utilize *Atrypa* "*reticularis*" to indicate the genus *Atrypa* in the strict sense in order to distinguish the genus from the approximately 50 additional atrypoid genera.

Exterior.—The shells are elongate oval in outline and unequally biconvex in lateral profile with the brachial valve decidedly more strongly convex than the pedicle valve. Small pedicle valves are nearly oval with maximum width near midlength, but on larger specimens the maximum width occurs relatively closer to the posterior end at a distance about ¼–⅓ the length of the valves. Small specimens are nonsulcate, but the anterior part of larger pedicle valves becomes flattened and may be very gently sulcate. In the largest specimens the venter is extended anteriorly as a prominent tongue that presumably is accommodated by a broad, low fold in the brachial valve. No complete brachial valves, however, were available for examination. The beak of the pedicle valve is suberect. There is no interarea nor delthyrium. The pedicle passage evidently was defined at the apex of the beak of the pedicle valve by the adjacent posterior rim of the brachial valve.

The ornament consists of well-defined, rounded, radial costellae separated by narrow U-shaped interspaces. The costellae increase in number anteriorly by bifurcation which occurs most commonly on the pedicle valve and by intercalation which is more common on the brachial valve. There is, however, a general increase in size in the costellae from the beak to the anterior margin. Concentric growth lamellae are only moderately well defined posteriorly, but in medium to large size shells they become prominent and occur at irregular intervals. Growth lamellae become frilly and more numerous anteriorly.

Pedicle valve interior.—The hinge teeth are slightly crescent shaped in outline and are approximately parallel in their long dimension to the posterolateral margin of the valve. They are attached directly to the inner edge of the valve and are supported as well by short dental lamellae that have a somewhat shorter dimension measured anterolaterally than do the bases of the hinge teeth themselves. The articulated dorsal surfaces of the hinge teeth are grooved subparallel to the posterolateral margin of the valve and are deeply crenulated to accept the median crenulated ridge within the sockets of the brachial valve. The ventral muscle field is generally large and flabellate and moderately rounded-trigonal in outline. The adductors are situated medially in the posterior part of the muscle scar. They may be moderately impressed posterolaterally, but fade into the main part of the diductor field anteriorly. No myophragm dividing the adductors nor the diductors has been seen. The diductor scars are moderately well impressed laterally, but fade into the interior of the shell anteriorly. The shell surfaces lateral to the diductor impression are deeply pitted, and the unpitted parts of the shell, principally along the anterior half, are crenulated by the impress of the costellae.

Brachial valve interior.—The sockets are defined between the posterolateral edges of the valve and prominent, strongly curved hinge plates. Medially within each socket, there is an elevated longitudinal ridge that is strongly crenulated, and the crenulations extend medially from the ridge grooving the medial parts of the socket plates. Crural lobes are well developed as extensions of the hinge plates that recurve ventrally and then laterally to cover the inner edges of the posterior part of the sockets. Triangular crural bases are attached to the inner edges of the sockets and the crural lobes and project anteriorly and ventrally. The apex of the notothyrial cavity is longitudinally striate for diductor attachment. The adductor scars are divided into oval posterior and anterior pairs. The posterior pair is separated by a broad, low, flat area and a low V-shaped myophragm, and the adductor impressions themselves are radially grooved. The anterior pair of adductor impressions is set more closely together and is divided by a pair of thin myophragms medially.

Occurrence: Loc. 4671–SD, 4672–SD.
Figured specimens: USNM 147259–147262.

Superfamily **DAYIACEA** Waagen
Family **ANOPLOTHECIDAE** Schuchert
Subfamily **COELOSPIRINAE** Hall and Clarke

Genus COELOSPIRA Hall, 1863

Type species.—Leptocoelia concava Hall, 1857, p. 107.

Coelospira camilla Hall

Plate 4, figures 1–25

Coelospira camilla Hall, 1867, p. 329 (as *Coelospira concava*), pl. 52, figs. 13–19.

Exterior.—The shells of this species are small, transversely suboval to subrhomboidal in outline, and concavo-convex in lateral profile. Amongst the Devonian species the pedicle valve is relatively strongly convex. The brachial valve bears a shallow sulcus that broadens strongly anteriorly. The hinge line is short and rounded, and the beak angle is about 110°. The posterolateral edges of the pedicle valves are nearly straight to about midlength on small shells, but the anterolateral extremities are evenly rounded. The maximum width is slightly posterior to midlength on smaller shells and well to the posterior on the larger ones. The ventral beak is small and strongly incurved. There is no interarea. The pedicle valve is somewhat carinate posteriorly but is evenly rounded in transverse cross section anteriorly.

The ornament consists of rounded radial plications and shallow U-shaped interspaces of about the same width as the adjoining plications. The brachial valve bears a median plication that becomes relatively strongly flattened anteriorly and is bounded by two short plications that originate somewhat anterior to the beak. On each flank there are generally three lateral plications. The pedicle valve bears a pair of medial plications that are slightly larger than the adjoining lateral ones. The median interspace may be flat or commonly bears a narrow ridge. Four or five plications are common on each flank with the pair adjoining the median pair originating from them. Lateral plications uncommonly bifurcate anteriorly. On larger specimens there may be a more or less well-developed concentric growth line or two near the anterior.

Pedicle valve interior.—The hinge teeth are thin and platelike, diverging anterolaterally at a slightly smaller angle than the posterolateral extremities. They are attached directly to the interior margin of the valve. The median sides of the hinge teeth are deeply grooved by crural fossettes. The adductor muscle scars are obscure owing to poor preservation in the specimens available. The diductor impressions, however, constitute an elongate suboval pair divided medially by a strong high myophragm. The anterior margin of the diductor impressions is not notably elevated above the interior of the shell and blends with it without any strong line of demarcation. The interior is gently crenulate anteriorly by the impress of the plications.

Brachial valve interior.—The sockets are elongate pyriform and diverge anterolaterally. They are bounded posteriorly by the margin of the valve and medially by strongly curved socket plates that arise directly from the floor of the valve. The space between the socket plates posteriorly is almost completely filled with shell material and is somewhat extended posteriorly as a quadrilobate cardinal process. Anteriorly, the shell material is extended along the floor of the valve a short distance as a broad, low myophragm that narrows abruptly and extends about to midlength as a narrow rounded myophragm. The interior is only very faintly crenulated peripherally by the impress of the plications.

Occurrence: Loc. 4671–SD, 4672–SD.
Figured specimens: 147263–147269.

Suborder **ATHYRIDOIDEA** Boucot, Johnson, and Staton
Superfamily **ATHYRIDACEA** M'Coy
Family **MERISTELLIDAE** Waagen
Subfamily **MERISTELLINAE** Waagen

Genus MERISTINA Hall, 1867

Type species.—Meristella maria Hall, 1863, p. 212.

Meristina nasuta (Conrad)

Plate 4, figures 26–43

Atrypa nasuta Conrad, 1842, p. 265.
Meristella nasuta Hall, 1867, p. 299, pl. 48, figs. 1–25.

Exterior.—The shells of this species are unequally biconvex, with the pedicle valve two to three times as deep as the brachial valve. Most pedicle valves are elongate pyriform in outline, but the largest specimen is suboval with the length and width approximately equal. Maximum width is commonly anterior to midlength. Pedicle valves are for the most part strongly curved along their midline through their entire length, but brachial valves are most convex in their posterior half. The hinge line is very narrow and curved, and there is no ventral interarea. The delthyrium is broad and triangular, or may have rounded sides, and opens apically into a semicircular foramen. Anteriorly, there is a very faint sulcus on the pedicle valve, but it is modified by the development of a low, rounded, medial plication that effectively extends the anterior commissure into increasingly greater prolongation on the larger specimens, so that the whole anterior margin of the valve becomes a pointed tonguelike projection. Some shells bear an extremely faint pair of low, rounded plications within the sulcus lateral to the slightly more strongly developed medial one. The exterior of the valves is smooth, except

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for a few well-developed concentric growth lines that mark the anterior part of most specimens.

Interior of pedicle valve.—The hinge teeth are small, elongate-subpyriform projections that diverge anterolaterally with a somewhat smaller angle than do the adjoining margins of the valves. They are narrowest at their posteromedial tips which are drawn out and pointed. The hinge teeth are supported basally by thin, dental lamellae that converge somewhat toward the base of the valve, then diverge slightly laterally before they join it. Muscle scars are not preserved.

Interior of brachial valve.—The sockets are moderately shallow and U-shaped. They diverge anterolaterally at slightly smaller angles than the posterior margin of the valve and are elevated on hinge plates well above the base of the valve. Triangular crural lobes are well developed and extend from the inner edges of the hinge plates to the crural bases. Medially, the inner hinge plates join, forming a single concave septalium-like structure supported by a long, thin, median septum that reaches about halfway to the anterior margin. On several of the larger specimens there is a pair of plates or platelike ridges situated subparallel to the sockets and covering their posterior ends posterolaterally. These plates or ridges probably serve to articulate with the grooves between the teeth in the margins of the pedicle valve, and their posterior extremities effectively extend the beak of the brachial valve so as to partly close the delthyrium when the valves are articulated.

The adductor scars are elongate and extend out to the anterior end of the median septum, narrowing anteriorly as they go. They are bounded laterally by low ridges.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147270–147273.

Family NUCLEOSPIRIDAE Davidson

Genus NUCLEOSPIRA Hall, 1859

Type species.—*Spirifer ventricosa* Hall, 1857, p. 57.

Nucleospira sp.

Plate 5, figures 1–11

Discussion.—Several fragmentary brachial valves of *Nucleospira* are available. They have a low convexity and are transversely suboval in outline. Internally, the hinge plates are greatly extended in the ventral direction and join medially to form a cardinal plate of inverted U-shaped cross section. The distal third or perhaps two-fifths of the structure bends sharply posteriorly, narrows slightly, and is rounded on its distal end. There is a well-developed myophragm that extends from the notothyrial cavity to the anterior margin of the valve.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147274–147276.

Suborder SPIRIFEROIDEA
Superfamily DELTHYRIACEA Phillips
Family DELTHYRIDAE Phillips
Subfamily DELTHYRINAE Phillips

Genus ACROSPIRIFER Helmbrecht and Wedekind, 1923

Type species.—*Spirifer primaevus* Steininger, 1853, by subsequent designation of Wedekind, 1926, p. 202.

Acrospirifer duodenaria (Hall)

Plate 5, figures 12–39

Delthyris duodenaria Hall, 1843, p. 171, fig. 5.
Spirifer duodenaria Hall, 1867, p. 189, pls. 27, 28; Landes, Ehlers, and Stanley, 1945, pl. 12, fig. 4.
Hysterolites macrothyris Boucot, 1959b, p. 743, pl. 91, figs. 11–13, 15, 16.
Hysterolites (*Acrospirifer*) *worthenanus*? Amsden in Amsden and Ventress, 1963, p. 182, pl. 16, figs. 1–4, 6–8, 11–16, 5?, 9?, 10?.

Exterior.—The shells of this species are transversely subtrigonal to subsemicircular in outline and strongly biconvex in lateral profile with the pedicle valve commonly slightly more convex than the brachial valve. The relative width is considerably variable on the specimens at hand, ranging from about three to one for the most transversely extended specimens to about two to one for the more common forms. The hinge line is long and straight and is the place of maximum width. The interarea of the pedicle valve is long, low, triangular, slightly curved, and apsacline and lies anterior to a relatively short, stubby moderately incurved beak. It is cleft medially by a triangular open delthyrium encompassing an angle of about 70°–90°. Deltidial plates were not observed. The interarea is well developed all the way to the lateral extremities of the cardinal angles, and considering its relatively low height medially, it appears on some specimens to be almost ribbonlike. The dorsal interarea is long, flat, and ribbonlike, anacline on small specimens and nearly orthocline on the larger ones.

Commonly, five to eight relatively well defined, moderately elevated, rounded plications are on each flank of the pedicle valve. A small part of the posterolateral extremities is unplicated. Medially, the central pair of plications is slightly larger than the adjoining lateral ones, and these divide a U-shaped, commonly slightly flat-bottomed sulcus. The plications are separated by relatively deep U-shaped interspaces of slightly less width than the adjoining plications. The brachial valve bears a low, rounded fold of slightly less than twice the width of the adjoining plications and does not rise above the level of the adjacent plications on the flanks.

Pedicle valve interior.—The hinge teeth are stubby and suboval to slightly arcuate. The dental lamellae are short and widely divergent basally, and commonly are made obsolescent or nearly so by the thick development of secondary shell material in the umbonal cavities. Medially, there is a pyramidal pad of shell material that may be medially cleft or may appear to be a single solid structure that fills the apex of the shell and closes off the posterior part of the delthyrium. There may be a poorly developed or well-developed myophragm dividing the posterior margin of the ventral muscle impression. The diductor scars compose an elongate-suboval pair, generally separated throughout their length by a relatively faint myophragm, and they blend with the interior of the shell without any strong line of demarcation. Anteriorly, the diductor scars are commonly radially striate. The interior surface is strongly crenulated by the impress of the plications, except in the umbonal cavities which are smooth, owing to the development of thick shell material.

Brachial valve interior.—The sockets are relatively short, deep, and pyriform in outline. They diverge anterolaterally at a relatively high angle to the hinge line. Medially, the socket plates are thickened by the attachment of platelike crural bases, but no crural plates connect the inner edges of the sockets with the base of the valve. The notothyrial cavity may be slightly built up with a low mound of shell material and is generally longitudinally striate in the apex at the site of diductor attachment. The dorsal adductor impressions compose a relatively broad pair of elongate-oval scars that are impressed slightly posteriorly and posterolaterally and blend imperceptibly with the interior of the shell anteriorly. The interior surface is moderately strongly crenulated by the impress of the plications.

Discussion.—Specimens from the Kanouse Sandstone studied by Boucot (1959b, p. 743) were assigned to *Acrospirifer macrothyris* based on the belief that *A. duodenarius* represented the young of *A. macrothyris*. The present study convinces us, however, that *A. macrothyris* may be distinguished by its much lower plications and narrow shallow interspaces. The size difference between the two species is therefore probably real.

Occurrence: Loc. 4671–SD, 4672–SD.
Figured specimens: USNM 147277–147282.

Subfamily MUCROSPIRIFERINAE Boucot

Genus MUCROSPIRIFER Grabau, 1931

Type species.—*Delthyris mucronatus* Conrad, 1841, p. 54.

"Mucrospirifer" cf. macra (Hall)

Plate 6, figures 1–6

Material.—A single well-preserved silicified brachial valve of "*Mucrospirifer*" is available as a basis for the following description.

Exterior.—This specimen is decidedly transverse and subtrigonal in outline and gently convex in lateral profile. There are 15 well-defined narrow rounded plications on one flank of the valve separated by narrow U-shaped interspaces. The medial fold is moderately strongly elevated above the crests of the plications on the adjacent flanks and has a width equal to approximately three plications. The surface of the shell is covered with numerous frilly growth lamellae, but fine radial ornament, if present, was not preserved. The brachial valve interarea is relatively long and ribbonlike. It is approximately orthocline and flat laterally but concave medially.

Brachial valve interior.—The sockets are relatively deep and U-shaped and diverge fairly strongly anterolaterally. Their later edges are partly covered by the inner edges of the interarea. Medially, the inner edges of the socket plates are joined by the crural bases that are attached to the apex of the valve by a thickening of shell material. The ventral side of the shell material in the notothyrial cavity is deeply longitudinally striate at the site of diductor attachment. The impressions of the adductor muscles are not evident, but there is a thin myophragm extending about a centimeter anteriorly from the base of the shell material in the apex of the valve. The interior is fairly strongly crenulated by the impress of the plications.

Occurrence: Loc. 4672–SD.
Figured specimen: USNM 147283.

Subfamily KOZLOWSKIELLININAE Boucot
Genus KOZLOWSKIELLINA Boucot, 1958
(=KOZLOWSKIELLA Boucot, 1957)

Subgenus MEGAKOZLOWSKIELLA Boucot, 1957

Type species.—*Spirifer perlamellosus* Hall, 1857, p. 57.

Megakozlowskiella raricosta (Conrad)

Plate 6, figures 7–15

Delthyris raricosta Conrad, 1842, p. 262, pl. 14, fig. 18.
Spirifera raricosta Hall, 1867, p. 192, pl. 27, figs. 30–34; pl. 30, figs. 1–9.
Kozlowskiella (*Megakozlowskiella*) *raricosta* Boucot, 1957, pl. 3, figs. 18, 19.

Material.—Only a single pedicle valve and part of a single brachial valve are in our collection of silicified material, and it is therefore impossible to give an adequate description of the variation of the species.

Exterior.—The true outline is not discernible from the material, although it appears that the pedicle valve was approximately as wide as long and was probably more strongly convex that the brachial valve. The interarea on the pedicle valve is moderately incurved and apsacline and is transversely striate. The interarea on the brachial valve is short, flat, and anacline.

Three strong rounded plications are on each flank of the pedicle valve and two on each flank of the brachial valve. The interspaces between the plications are deep and U-shaped and are of about the same width as the adjoining plications. The pedicle valve bears a median sulcus, and the brachial valve bears a well-defined rounded and somewhat flattened median fold about twice as wide as the adjoining plications. The plications are crossed by relatively numerous frilly growth lamellae. Fine radial ornament is not preserved.

Pedicle valve interior.—A long, high, thin, median septum reaches well toward the anterior of the valve. The structures at the beak and umbo are not preserved. The interior is deeply corrugated by the impress of the plications.

Brachial valve interior.—The sockets are broad and shallow and diverge anterolaterally. Their posterolateral edges are partly covered beneath the inner edge of the interarea. Broad triangular platelike crural bases are attached to the inner edges of the socket plates and converge basally. The inner edges of the crural bases are joined apically by a thickening of shell material composed of a pair of posteriorly directed lobes that are deeply striate longitudinally for the attachment of the diductor muscles. The whole structure is made sessile apically by the presence of a medial thickening of shell material. The sites of adductor attachment are not evident, and the interior is strongly corrugated by the impress of the plications.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147284, 147285.

Subfamily COSTISPIRIFERINAE H. and G. Termier

Genus COSTISPIRIFER Cooper, 1942

Type species.—*Spirifer arenosus* var. *planicostatus* Swartz, 1929, p. 56, pl. 9, figs. 13–15.

"Costispirifer" unicus (Hall)

Plate 6, figures 16–31

Spirifera unica Hall, 1867, p. 203, pl. 30, fig. 21; Hall and Clarke, 1895, pl. 30, fig. 8.
Costispirifer unicus Landes, Ehlers, and Stanley, 1945, pl. 11, figs. 1, 2.

Discussion.—Since this species was first proposed it has been regarded as closely allied to *Costispirifer arenosus* and by that association as a *Costispirifer*. Hall erected the species on a single specimen, and it apparently is a rare one—only once again reported from New York (Oliver, 1954, p. 632) and beyond New York only from Tennessee (Dunbar, 1919, p. 87) and from Beaver Island, Lake Michigan (Landes, Ehlers, and Stanley, 1945, pl. 11). The specimens illustrated and herein described afford the first opportunity to evaluate their relation to *Costispirifer* and lead to the conclusion that they differ from *Costispirifer* s.s. in their narrower plications that do not flatten out anteriorly and in the presence of long recurving dental lamellae in the pedicle valve.

Our specimens appear to be more closely related to a form from the Tully Limestone assigned to "*Spirifer*" *mesastrialis* by G. A. Cooper and J. Stewart Williams (1935, pl. 57, figs. 23, 24).

Material.—Eight silicified pedicle valves were available for examination, but no brachial valves of the species have been seen.

Exterior.—The outline is roughly pentagonal. It is somewhat drawn out posteriorly at the beak and strongly rounded anterolaterally. The anterior commissure is slightly bilobate because of the deep convexity of the shell combining with a rather well-developed median sulcus. The specimens available are ragged and poorly preserved along their lateral edges, and growth lines are extremely poorly preserved; it is difficult therefore, to describe with certainty the true outline of the shell. However, it appears that maximum width may have been near midlength with the interarea being slightly less wide. The interarea is deeply apsacline, broad and triangular, and is only moderately incurved; however, the ventral beak is strongly incurved and projects pos-

teriorly well beyond the palintrope. The interarea is cleft medially by a triangular delthyrium, of about 90° or slightly less, that is closed off in its apical half by an externally convex chevron-shaped deltidium.

A relatively well-developed median sulcus begins at the posterior end of the umbo and is relatively narrow, well-defined, and U-shaped posteriorly. It broadens in the anterior part of the shell and becomes relatively deep, dividing strongly convex lateral parts and producing a bilobate transverse cross-sectional outline. The ornament consists of numerous low, rounded plications and relatively narrow interspaces on the flanks and in the sulcus. Generally, some size variation can be distinguished amongst the plications on the sulcus, and most of these are smaller than those on the flanks. It appears that there may be some splitting or intercalation of new plications within the sulcus, but the lateral plications are simple and do not increase in number anteriorly. The plications are crossed anteriorly on large specimens by a few poorly preserved concentric growth lines.

Pedicle valve interior.—The hinge teeth are triangular, relatively thin, and pointed, and they project dorsally. They are supported by long, thin dental lamellae that diverge from one another only slightly anteriorly. The dental lamellae bound an elongate elliptical pair of diductor muscle impressions laterally along their posterior half. Anteriorly, the lateral edges of the diductor impression may recurve slightly medially and be enclosed by low bounding ridges. Medially, there may be developed a low myophragm, and the diductor scars, especially anteriorly on large specimens, are dendritic. The umbonal cavities are not deeply filled with secondary shell material, but the central part, especially lateral to the anterior part of the diductor impressions, commonly is, and the interior is only faintly crenulated by the impress of the plications.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147286–147288.

Genus FIMBRISPIRIFER Cooper, 1942

Type species.—*Spirifer venustus* Hall, 1860 b, p., 82.

Fimbrispirifer divaricatus (Hall)?

Plate 6, figures 32–37

Spirifer divaricatus Hall, 1857, p. 133; Hall, 1867, p. 213, pl. 32, figs. 1, 9.
Fimbrispirifer divaricatus Cooper, 1944, p. 323, pl. 123, figs. 1, 2; Landes, Ehlers, and Stanley, 1945, pl. 11, figs. 3, 4.
Fimbrispirifer cf. *F. divaricatus* Amsden *in* Amsden and Ventress, 1963, p. 180, pl. 18, figs. 2–11.

Discussion.—Only a single pedicle valve of this species is available for study. In outline it is like typical specimens of *Fimbrispirifer divaricatus;* however, the plications are relatively fine owing to an initial splitting posteriorly, and in size and number of plications this form is much like *F. venustus* of the Hamilton. This is not surprising since Hall (1867, p. 213, 214) regarded the two species as synonyms. Our material is comparable to *F.* cf. *divaricatus* illustrated by Amsden (in Amsden and Ventress 1963, pl. 18).

Exterior of pedicle valve.—The specimen is transversely subtrigonal in outline with a long, straight hinge line and slightly rounded anterolateral edges. It is relatively strongly convex with a long, relatively low triangular interarea and a short, sharply incurved ventral beak. The delthyrium encompasses an angle of very slightly more than 90° and bears a pair of linear deltidial plates along its edges that are inclined approximately normal to the plane of the interarea. The hinge line is the place of maximum width. Medially, there is a shallow but somewhat angular sulcus that is not sharply set off from the lateral slopes but rather blends with them imperceptibly and forms a bilobed transverse cross-sectional outline.

The ornament consists of relatively fine rounded plications that number about 25 on each half. The plications on the flanks each split on the umbo at approximately the same distance from the beak to form pairs of rounded plications separated by well-defined narrow U-shaped interspaces. Medially, there is a pair of plications which are very slightly more strongly elevated than those on the lateral margin of the shell, at least on the umbo, and which may be recognized as dividing the shell into lateral and medial plication groups. The lateral plications. adjoining these bordering plications are parallel to them, but the median plications are laid out on a different plan. There is a single median plication, and each succeeding plication in the sulcus is parallel to it and splits off from the bordering plications further and further from the umbo on either side. The fine concentric and radial ornament was not preserved.

Interior of pedicle valve.—The hinge teeth are small and elliptical and diverge anterolaterally. They are continuous medially with the posterior parts of the dental lamellae that are relatively ponderous, thick, and converge medially. Basally, the dental lamellae become thin and platelike and diverge strongly laterally, defining an angle of slightly less than 90° between one another. The dental lamellae border a relatively large, circular, diductor muscle field posterolaterally. There is a faint, broad, low myophragm posteriorly, but the muscle impression, throughout most of its length, is divided only by the internal ridge corresponding to the median sulcus.. The diductor impressions blend anteriorly with the interior part of the shell without any

sharp line of demarcation. The interior of the shell is marked around its anterior half by the impress of the external plications.

Occurrence: Loc. 4672–SD.
Figured specimen: USNM 147289.

Family RETICULARIIDAE Waagen

Genus ELYTHA Fredericks, 1918

Type species.—Delthyris fimbriatus Conrad, 1842, p. 263.

Elytha sp.

Plate 7, figures 1–5

Discussion.—Two fragmentary pedicle valves of *Elytha* are available for study. They are recognized by their transverse oval shape, lack of plications on the posterior part (which is all that is present on the available material), the median sulcus, and the well-developed concentric growth lamellae. The hinge line is short, about half the maximum width, and the interarea is relatively low and apsacline and moderately incurved. Internally, short, moderately divergent, thin dental lamellae support the hinge teeth in the apex of the valve. Anterior to the distal edges of the bases of the dental lamellae there is a fairly well developed myophragm that extends a considerable length of the distance toward the anterior margin of the valve. The fine ornament is not preserved.

Occurrence: Loc. 4672–SD.
Figured specimen: USNM 147290.

Family AMBOCOELIIDAE George

Genus AMBOCOELIA Hall, 1860

Type species.—Orthis umbonata Conrad, 1842, p. 264, pl. 14, fig. 4.

Ambocoelia sp.

Plate 7, figures 6–10

Discussion.—A single pedicle valve of *Ambocoelia* was found in the collections studied. Its width, length, and depth dimensions are approximately equal, and it has a shallow but well-defined sulcus medially. The hinge line is short and somewhat less than the maximum width of the valve. The interarea is flat and nearly catacline above a short, stubby, gently incurved beak. It equals just a little more than half the maximum width of the valves. The delthyrium is open and triangular and encloses an angle of about 30°. No external ornament was observed. Internally, the specimen completely lacks dental lamellae, but the tracks of the teeth form relatively thin, long ridges on the interior, adjacent to the delthyrium. There is a well-developed myophragm in the umbo.

Occurrence: Loc. 4672–SD.
Figured specimen: USNM 147291.

Superfamily CYRTINACEA Fredericks
Family CYRTINIDAE Fredericks

Genus CYRTINAELLA Fredericks, 1916

Type species.—Cyrtia biplicata Hall, 1857, p. 165.

Cyrtinaella biplicata (Hall)

Plate 7, figures 11–17

Cyrtia biplicata Hall, 1857, p. 165.
Cyrtina biplicata Hall, 1867, p. 266, pl. 27, figs. 5–10.

Exterior.—The available material of this species is poor and consists of a single pedicle valve and a single brachial valve, each of which preserves in effect only the posterior parts, and thus an adequate description of the shape is not possible here. However, it is evident that the pedicle valve was approximately trigonal in outline with a high, nearly flat interarea and an elongate narrow delthyrium. The pedicle valve bears a median sulcus accentuated by a pair of bounding plications. In the brachial valve there is a low, rounded fold that is set off by a pair of shallow but well-defined furrows. The flanks appear to be unplicated.

Pedicle valve interior.—The hinge teeth are not preserved. Dental plates converge ventrally to form a spondylium attached to a relatively long, stout median septum. The median septum persists posteriorly into the base of the spondylium as a pair of plates that evidently formed the two sides of a tichorhinum.

Brachial valve interior.—The sockets are shallow and broad, and expand moderately strongly in a short distance anterolaterally. The bases of the sockets continue laterally as ridges on the inner edge of the valve parallel to a poorly developed interarea. The inner edges of the hinge plates extend medially as a transverse plate supported by a broad, transversely suboval, pillar-like base and bearing a bilobed cardinal process on its ventral side. A well-developed myophragm divides the area of adductor attachment anterior to the base of the cardinal plate.

Occurrence: Loc. 4671–SD, 4672–SD.
Figured specimens: USNM 147292, 147293.

Order TEREBRATULIDA
Suborder TEREBRATULOIDEA
Superfamily TEREBRATULACEA Menke
Family CENTRONELLIDAE Waagen
Subfamily EURYTHYRIDINAE Cloud

Genus CLOUDOTHYRIS Boucot and Johnson n. gen.

Type species.—*Cloudothyris postovalis* Boucot and Johnson n. sp.

Diagnosis.—Like *Prionothyris*, but with a ventrally extended stalklike cardinal process that is bifid posteroventrally.

Discussion.—The cardinal plate of *Prionothyris perovalis* (the type species of *Prionothyris*) bears an elevated cardinal process, but it is relatively much more stubby and bosslike. Moreover, it is basically trilobed on its ventral face with a well-developed median lobe dividing the serrated pits on either side. By contrast, *Cloudothyris* bears a considerably longer stalklike cardinal process that is ventrally and posteriorly bilobate. In addition, in the material at hand, the cardinal process seems to lack the serrations of the diductor attachment site, but rather bears a pair of lateral slitlike grooves that converge posteromedially forming a V that encloses the principal median groove. Cloud (1942, p. 66) thought that *Prionothyris* was derived directly out of *Beachia*, which would have been accomplished virtually by increasing the size and elevation of the cardinal process and introducing serration of the myophore. *Cloudothyris* appears to be the terminal form of this same lineage. It probably was derived out of *Prionothyris* by continued elongation and modification of the cardinal process.

Distribution: Maine and New York.

Cloudothyris postovalis Boucot and Johnson n. sp.

Plate 7, figures 26–42

"*Prionothyris*" sp. Boucot, 1959b, p. 761, pl. 100, figs. 1, 2.

Exterior.—Valves are subequally biconvex in lateral profile. Neither valve is strongly convex, and the overall lateral aspect is lenticular. In outline, the pedicle valve is suboval with the width and length approximately equal. The brachial valve may be slightly wider than long. The beak of the ventral valve is low and short and is suberect to erect. The hinge line is short and curved, but the palintrope is equal to approximately half the maximum width, and generally there is some suggestion of a ventral interarea. The latter is apsacline or nearly orthocline and is curved. There is an apical foramen that may or may not open anteriorly into the broad, low triangular delthyrium. The delthyrium is unmodified by deltidial plates. The brachial valve bears a poorly defined, short, flat orthocline interarea. It terminates laterally at the point where introversion of the lateral margins of the valve is initiated. Both valves have a somewhat rhomboidal lateral outline, and the posterior half of the lateral margins is introverted, but the anterior half is not. The exterior is smooth except for a few low, but well-marked growth lines—especially toward the anterior of the shell, although growth lines may appear at younger intervals.

Interior of pedicle valve.—The hinge teeth are triangular in horizontal section and are fairly prominent. They project dorsally, but are flattened on their dorsal faces which slope slightly posteriorly as well. The hinge teeth are supported by broad, thin, divergent, platelike dental lamellae that lie relatively close to the walls of the valve and define long, but thin, umbonal cavities. The dental lamellae do not extend anteriorly beyond the hinge teeth. Posteriorly, the dental lamellae enclose the muscle impression, but on specimens of moderate or large size at hand, the diductors are greatly elongated and narrow with nearly subparallel sides. The diductor tracks are impressed laterally and divided medially by a fairly well developed myophragm that may be rounded or rectangular in cross section. Anteriorly, the muscle scar merges without a rim with the interior of the valve.

Interior of brachial valve.—The sockets are shallow and only slightly indented into the base of the valve posteriorly. They are, however, defined on their outer edges by ridges along the inner edge of the dorsal interarea. Medially, they are bounded by the hinge plates which form the lateral portions of the cardinal plate. The sockets expand anterolaterally and fade virtually without a step or rim into the interior surface of the shell. The cardinal plate is roughly pentagonal with the crural bases supported by crural plates along the edges of the median third of the plate, and these are extended anteriorly as a pair of projections. On small specimens the posterior half of the cardinal plate is occupied by a stout stalklike cardinal process that is bilobate on its terminal end and on its posterior face. Larger specimens bear, in addition, a pair of lateral slits that converge posteromedially, forming a V that encloses the medial groove in the cardinal process. In larger specimens the crural plates are no longer clearly visible, and the cardinal plate is in effect sessile. In small specimens the adductor impressions consist of a pair of simple elongate tracks separated by a broad, low area medially. Larger specimens have elongate-oval adductor scars impressed posteriorly and slightly on their lateral edges as well. They are separated by a well-developed myophragm that is swollen at about midlength to extend somewhat laterally into the impressed area and that probably acted as divisions between the posterior and

anterior pair. The posterior pair, as they extend anteriorly, partly enclose the anterior adductors.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147298—147302, 126208A, 126218.

Subfamily CENTRONELLINAE Waagen

Genus CENTRONELLA Billings, 1859

Type species.—Rhynchonella glansfagea Hall 1857, p. 125, figs. 1–6.

Centronella glansfagea (Hall)

Plate 7, figures 18–25

Rhynchonella glansfagea Hall, 1857, p. 125, figs. 1–6.
Centronella glansfagea Hall, 1867, p. 399, pl. 61a, figs. 1–21, 25–26; Cloud, 1942, p. 75, pl. 8, figs. 18–25.

Exterior.—The pedicle valve is pyriform in outline, and the brachial valve is elongate suboval in large specimens. However, smaller brachial valves have length and width more nearly equal and have a slightly rhomboidal outline. The valves are unequally biconvex with the pedicle valve much deeper than the brachial valve and strongly incurved to the erect position at the beak. The pedicle valve is markedly carinate with the condition slightly more accentuated anteriorly where the shells have their maximum width. The brachial valve bears a well-develped, broad, shallow rounded sulcus most of its length which effectively gives it a bilobed cross section. The anterior commissure is bent toward the pedicle valve, reflecting the dorsal sulcus and a carinate condition of the pedicle valve. There is a mesothyrid to permesothyrid circular foramen apically in the pedicle valve. The interarea consists of a pair of ribbonlike strips of shell material inside the beak ridges that are separated by an open triangular delthyrium. Deltidial plates were not observed. The hinge line is short and curved.

No radial ornament is present, and the exterior is smooth except for a few distantly spaced growth lines that become slightly more numerous in the anterior portion of the shell.

Interior of pedicle valve.—The hinge teeth are relatively ponderous subpyriform lobes with their long axes lying roughly parallel to the posterolateral margins of the valve. They are connected basally to the interior of the shell without dental lamellae by slight thickenings of shell material in that position. Their posterior margins are delimited by relatively well defined grooves that receive the posterior edge of the brachial valve. The muscle scars are not strongly impressed, but are situated in the deep umbonal cavity and are decidedly elongate, merging imperceptibly anteriorly with the interior of the valve. They are separated medially by a low subangular myophragm. Separate adductor scars are not distinguishable. The remainder of the interior of the valve is smooth.

Interior of brachial valve.—The sockets are broad, shallow but well marked, and pyriform in outline with their width expanding anterolaterally. They are defined posterolaterally by the margin of the valve and on their inner edges by strong hinge plates that descend ventrally. Both sockets and hinge plates are situated on a posterior platform of thickened shell material that affects the whole width of the valve posteriorly. The inner edges of the hinge plates are thickened by the attachment of the crural bases. The medial part of the structure is attached to the base of the valve by what must have been crural plates, although the base of the cardinal plate is too greatly thickened to be certain of discrete structures. The inner edges of the crural bases or inner hinge plates are discrete and are separated by a long elliptical groove or slot medially. No cardinal process is developed. One specimen has remnants of the crura attached. They are flat and ribbonlike with their long dimension roughly perpendicular to the interior of the valve. The adductor muscle scars are relatively strongly impressed, especially posteriorly. They compose a slightly elongate suboval pair that are well defined laterally and are separated medially by a low, rounded myophragm that narrows and disappears anteriorly at about the anterior edge of the muscle impressions. The remainder of the interior of the valve is smooth.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147294–147297.

Subfamily AMPHIGENIINAE Cloud

Genus AMPHIGENIA Hall, 1867

Type species.—Pentamerus elongata Vanuxem, 1842, p. 132, fig. 1.

Amphigenia elongata (Vanuxem)

Plate 8, figures 1–13

Pentamerus elongata Vanuxem, 1842, p. 132, fig. 1.

Amphigenia elongata Hall, 1867, p. 383, pl. 58a, figs. 21–24, pl. 59, figs. 1–11; Hall and Clarke, 1895, pl. 73, figs. 16–20, pl. 74, figs. 1–8; Landes, Ehlers, and Stanley, 1945, pl. 11, figs. 5, 6; Boucot, 1959b, p. 762, pl. 100, figs. 8–13; pl. 101, fig. 10.

Exterior.—The material at hand consists of silicified free valves with their anterior parts not preserved, so it is not possible to discern accurately the outline of the largest specimens. The pedicle valves, judged from growth lines, tend to be somewhat elongate oval, slightly modified toward an elongate rhombodial out-

line. The outline of the brachial valves is more difficult to characterize, although they do appear at least in the earlier growth stages to have maximum width slightly posterior to midlength. Pedicle valves are strongly convex with a short, stubby, erect beak. Brachial valves are only gently convex. The delthyrium is wide and triangular and unmodified by any deltidial plates. It opens apically into a round foramen. The hinge line is short and rounded. The hinge line of the brachial valve is relatively longer and less curved. It also develops a broad, low, flat anacline interarea that equals about two-thirds of the maximum width of the valve. The pedicle valve is somewhat carinate, and the exterior is smooth, except for a few faintly developed concentric growth lines.

Interior of pedicle valve.—The hinge teeth are relatively small and wedge shaped and are directed posteromedially as well as toward the brachial valve. Their outer edges are attached by relatively thin plates directly to the interior edge of the valve, whereas their inner edges are supported by the "dental lamellae" that converge medially to form a long, relatively deep, rhomboidal spondylium. The spondylium is supported through almost its entire length by a thin median septum that continues anteriorly nearly to the anterior margin of the valves. The dental lamellae themselves are supported in the umbonal cavities by a pair of thin, oblique mystrochial plates.

Interior of brachial valve.—The sockets in the smallest specimens are slim, nearly conical, and very small. They diverge strongly laterally and are bounded posteriorly by the edge of the interarea, and internally by very shallow, thin, hinge plates that support the outer edges of the cardinal plates. Larger specimens have sockets that diverge less strongly laterally and are a little broader at their anterolateral edges. They are commonly overhung medially by the edges of the cardinal plate and posterolaterally by a ridge built up along the juncture between the sockets and the dorsal interarea. The cardinal plate is nearly pentagonal in outline with a long, slender, triangular foramen piercing it posteriorly. In the larger specimens the crural bases are drawn out to a pair of points along the edges of the median third of the cardinal plate which is then deeply indented medially and gives rise to a ventral projection at its anterior edge. The cardinal plate is supported by well-developed subparallel crural plates beneath the crural bases in the median-third of the cardinal plate. One of the larger specimens shows the posterior adductors impressed posteriorly and splaying anterolaterally. On some specimens the crural plates are greatly extended anteriorly beyond the overhanging edge of the cardinal plate, as is typical of the species.

Discussion.—Oliver (1954, p. 632) first listed *Amphigenia elongata* in the Zone B fauna, but the specimens later were referred to *Amphigenia* cf. *A. curta* by Boucot (*in* Oliver, 1960, p. B172)—the latter identifications being based principally on their small size.

It now appears that the species of *Amphigenia* can be split or grouped two different ways: *A. preparva* (pl. 8, figs. 14, 15) differs from all others in the absence of a median septum and in the presence of convergent dental lamellae that barely meet to form a spondylium (Boucot, 1959b, p. 765). As shown by Boucot, this split has considerable age significance with *A. preparva* marking the earliest *Amphigenia*-bearing beds of *Etymothyris* zone age. The second split may be made on convexity relations, grouping *A. curta* (Meek and Worthen) and *A. chickasawensis* Boucot together as subequally biconvex species; the former is strongly biconvex, and the latter is relatively lenticular. The remaining named species *A. elongata* (Vanuxem) and *A. parva* Clarke are unequally biconvex with the pedicle valve strongly convex, and the brachial valve gently convex or relatively flat (Boucot, 1959b, p. 764). This second split among the stratigraphically higher group seems to be a geographic one: unequally biconvex forms are restricted to New York and the northern Appalachians, and the subequally biconvex ones are dispersed to the central and southern part of North America.

Occurrence: Loc. 4672–SD.
Figured specimens: USNM 147303–147305.

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[Italic numbers indicate major references or fossil descriptions]

PLATES 1–8

PLATE 1

FIGURES 1–10. *Petrocrania* sp. (p. B7). USGS loc. 4672–SD.

1–7. Brachial valve. Exterior × 4; interior × 3; exterior × 3; four lateral views × 3. USNM 147237.

8–10. Brachial valve. Lateral and interior views × 3; exterior view × 4. USNM 147238.

11–27. *Dalejina alsa* (Hall) (p. B7). USGS loc. 4672–SD.

11–16. Pedicle valve. Interior and exterior × 1; interior × 2; anterior, posterior, and side views × 1. USNM 147239.

17–22. Pedicle valve. Interior × 3; exterior, interior, posterior, side, and anterior views × 2; USNM 147240.

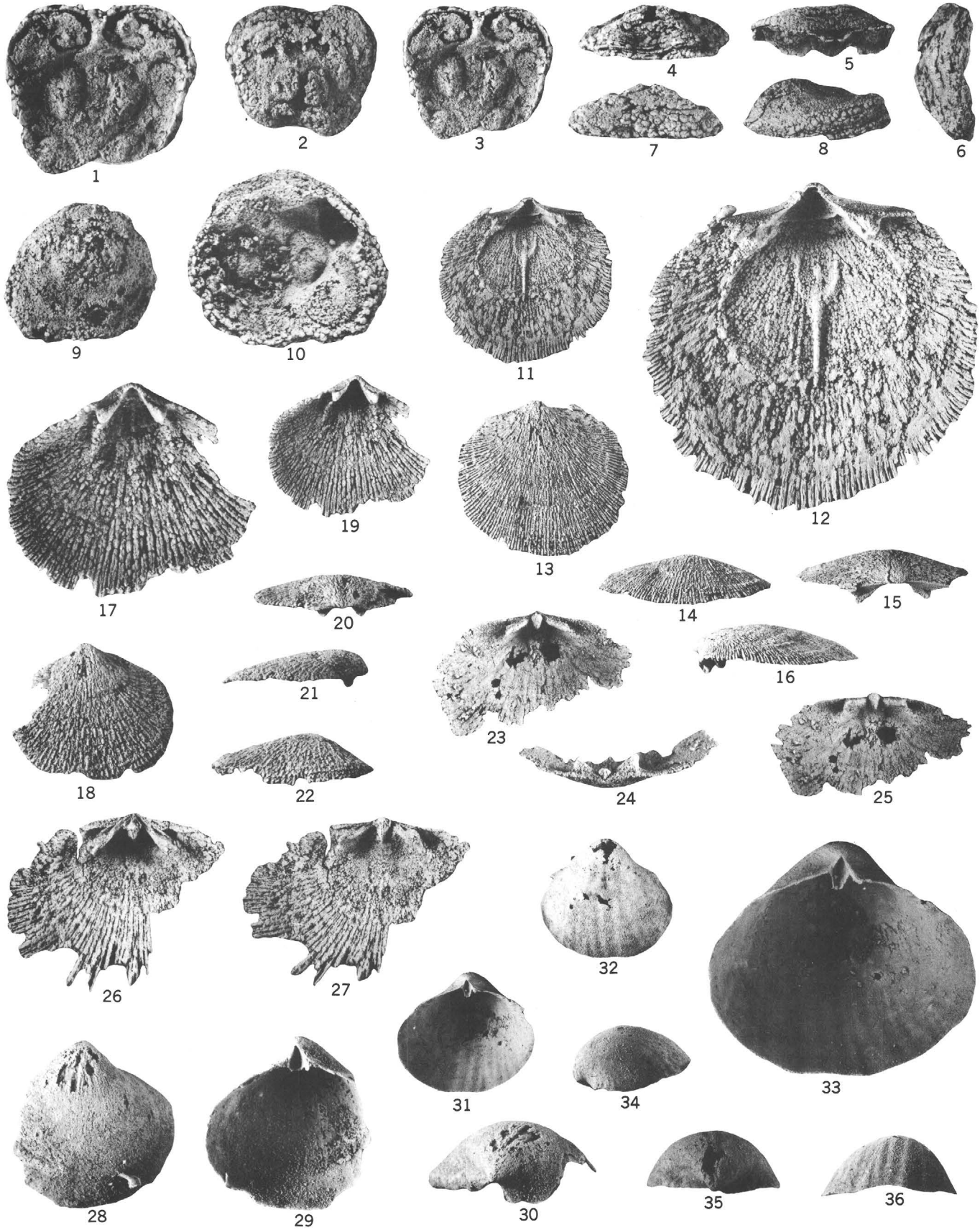
23–25. Brachial valve. Interior, posterior, and interior-oblique views × 2. USNM 147241.

26, 27. Brachial valve. Two views of interior × 1.5. USNM 147242.

28–36. *Pentamerella* cf. *arata* (Conrad) (p. B8). USGS loc. 4672–SD.

28–30. Pedicle valve. Exterior, interior, and posterior views × 2. USNM 147243.

31–36. Pedicle valve. Interior and exterior views × 1; interior × 2; side, posterior, and anterior views × 1. USNM 147244.



PETROCRANIA SP., *DALEJINA ALSA* (HALL), AND *PENTAMERELLA* CF. *ARATA* (CONRAD)

PLATE 2

FIGURES 1–6. *Leptaena* sp. (p. B8). USGS loc. 4672–SD.

1. Pedicle valve. Interior × 3. USNM 147245.

2–6. Ventral valve. Interior × 3; side, anterior, posterior, and ventral views × 2. USNM 147246.

7–16. *Stropheodonta* cf. *demissa* (Conrad) (p. B9). USGS loc. 4672–SD.

7–11. Brachial valve. Exterior × 3; anterior, interior, side, and posterior views × 2. USNM 147247.

12–16. Brachial valve. Posterior, side, dorsal, anterior, and interior views × 2. USNM 147248.

17–30. *"Schuchertella"* sp. A (p. B9). USGS loc. 4672–SD.

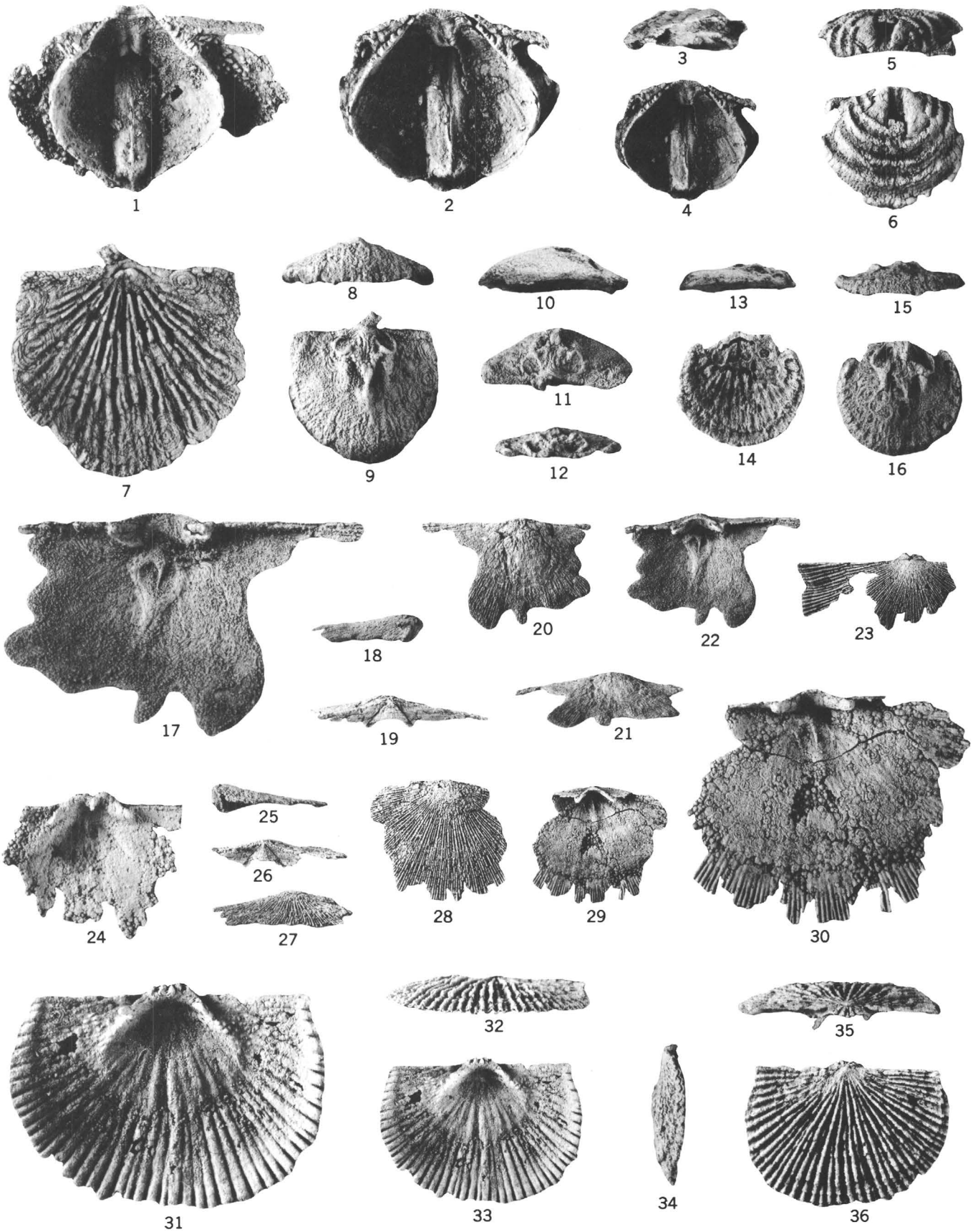
17–22. Ventral valve. Interior × 2; side, posterior, ventral, anterior, and interior views × 1. USNM 147249.

23–24. Brachial valve. Exterior × 1; interior × 2. USNM 147250.

25–30. Ventral valve. Side, posterior, anterior, ventral, and interior views × 1; interior view × 2. USNM 147251.

31–36. *"Schuchertella"* sp. B (p. B9). USGS loc. 4671–SD.

Brachial valve. Interior × 3; anterior, interior, side, posterior, and dorsal views × 2. USNM 147252.



LEPTAENA SP., *STROPHEODONTA* CF. *DEMISSA* (CONRAD)
"SCHUCHERTELLA" SP. A, AND *"SCHUCHERTELLA"* SP. B

PLATE 3

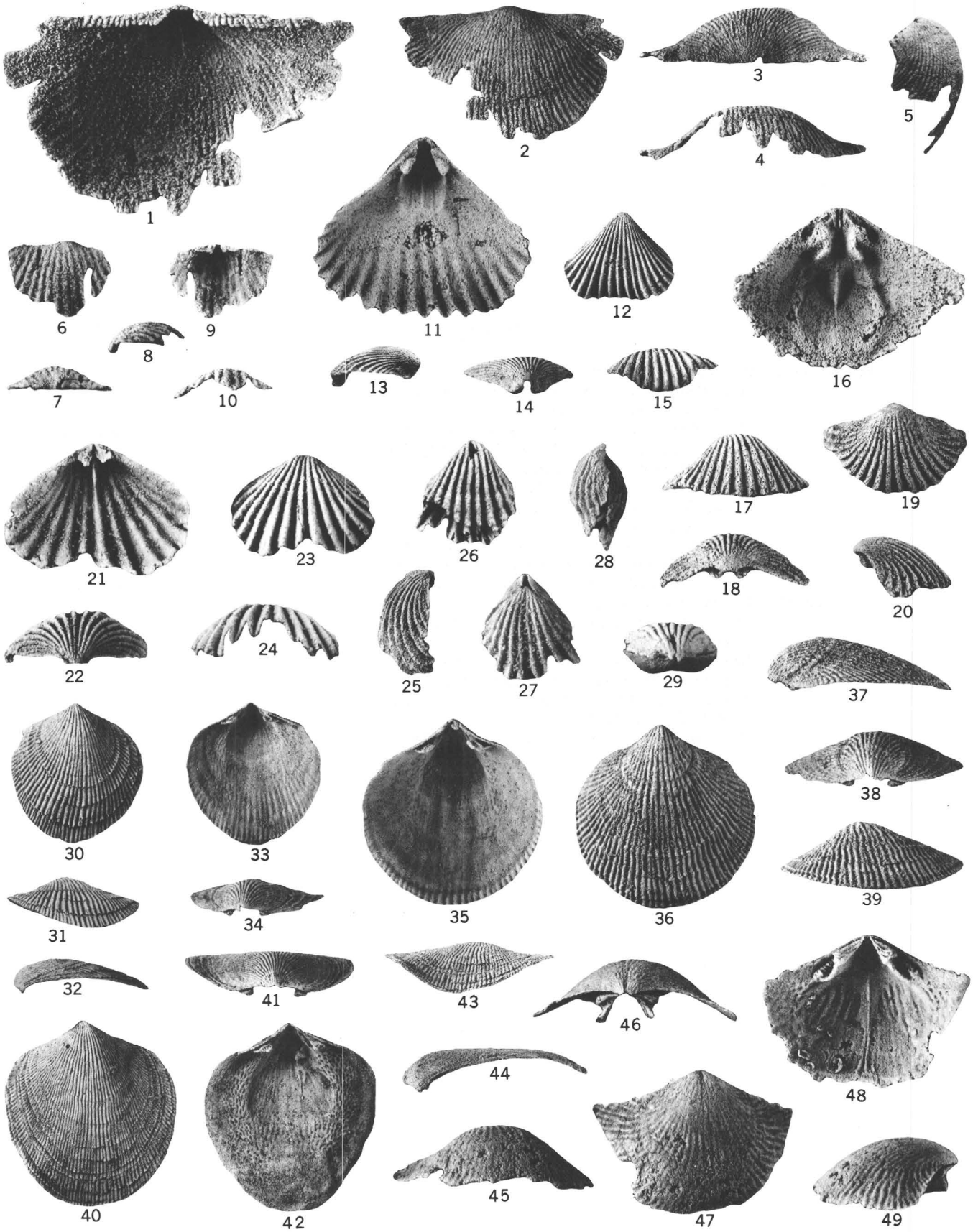
FIGURE 1–5. *Eodevonaria arcuata* (Hall) (p. B10).
Pedicle valve. Interior × 3; ventral, posterior, anterior, and side views × 2. USNM 147253, USGS loc. 4672–SD.

6–10. *Plicanoplia*? sp. (p. B10).
Pedicle valve. Ventral, posterior, side, interior, and anterior views × 3. USNM 147254, USGS loc. 4672–SD.

11–20. *Machaeraria carolina* (Hall) (p. B10). USGS loc. 4672–SD.
11–15. Pedicle valve. Interior × 2; exterior, side, posterior, and anterior views × 1. USNM 147255.
16–20. Brachial valve. Interior × 3; anterior, posterior, dorsal, and side views × 2. USNM 147256.

21–29. *Cupularostrum*? sp. (p. B11). USGS loc. 4672–SD.
21–25. Brachial valve. Interior × 4; posterior, dorsal, anterior, and side views × 3. USNM 147257.
26–29. Ventral, dorsal, side, and posterior views × 4. USNM 147258.

30–49. *Atrypa "reticularis"* (Linnaeus) (p. B12).
30–34. Pedicle valve. Ventral, anterior, side, interior, and posterior views × 1. USNM 147259, USGS loc. 4672–SD.
35–39. Pedicle valve. Interior, exterior, side, posterior, and anterior views × 2. USNM 147260, USGS loc. 4672–SD.
40–44. Pedicle valve. Ventral interior, anterior, and side views × 1. USNM 147261, USGS loc. 4671–SD.
45–49. Brachial valve. Interior, posterior, dorsal, interior, and side views × 2. USNM 147262, USGS loc. 4672–SD.



EODEVONARIA ARCUATA (HALL), *PLICANOPLIA*? SP., *MACHAERARIA CAROLINA* (HALL)
CUPULAROSTRUM? SP., AND *ATRYPA "RETICULARIS"* (LINNAEUS)

PLATE 4

FIGURE 1–25. *Coelospira camilla* (Hall) (p. B13).

1–5. Pedicle valve. Interior × 4; ventral, posterior, anterior, and side views × 3. USNM 147263, USGS loc. 4671–SD.

6–11. Pedicle valve. Side, interior, and ventral views × 3; interior view × 4; posterior and anterior views × 3. USNM 147264, USGS loc. 4672–SD.

12–16. Pedicle valve. Ventral view × 3; interior × 4; posterior, anterior, and side views × 3. USNM 147265, USGS loc. 4672–SD.

17–21. Ventral, posterior, dorsal, anterior, and side views × 3. USNM 147266, USGS loc. 4672–SD.

22. Brachial valve. Interior × 4. USNM 147267, USGS loc. 4672–SD.

23. Brachial valve. Interior × 3. USNM 147268, USGS loc. 4672–SD.

24, 25. Brachial valve. Dorsal and interior views × 3. USNM 147269, USGS loc. 4672–SD.

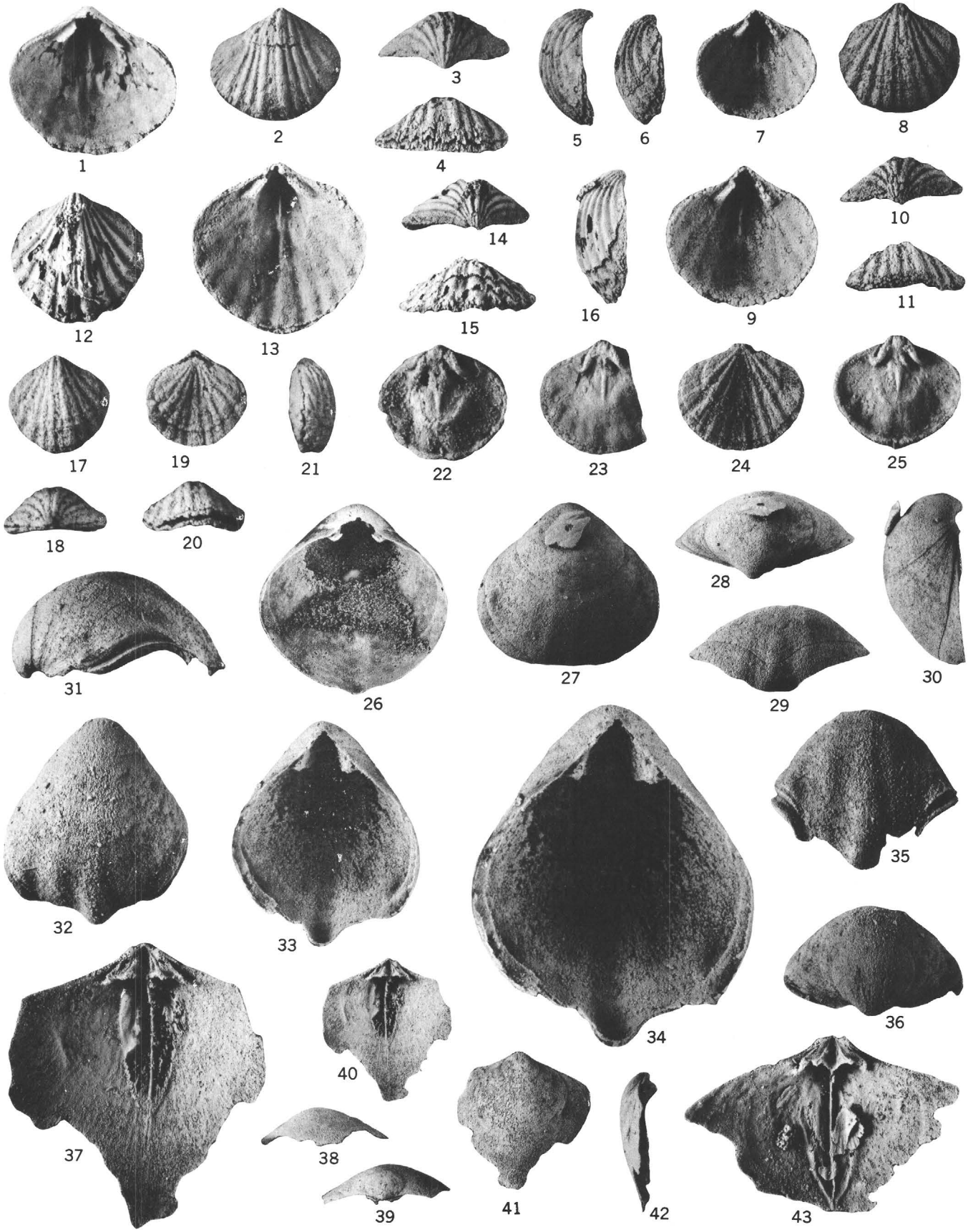
26–43. *Meristina nasuta* (Conrad) (p. B13). USGS loc. 4672–SD.

26–30. Pedicle valve. Interior, ventral, posterior, anterior, and side views × 1. USNM 147270.

31–36. Pedicle valve. Side, ventral, and interior views × 2; interior view × 3; anterior and posterior views × 2. USNM 147271.

37–42. Brachial valve. Interior × 2; anterior, posterior, interior, dorsal, and side views × 1. USNM 147272.

43. Brachial valve. Interior × 2. USNM 147273.



COELOSPIRA CAMILLA HALL AND *MERISTINA NASUTA* (CONRAD)

PLATE 5

FIGURE 1–11. *Nucleospira* sp. (p. B14). USGS loc. 4672–SD.

1– 5. Brachial valve. Interior × 3; dorsal, posterior, anterior, and side views × 2. USNM 147274.

6–10. Brachial valve. Posterior, side, dorsal, and anterior views × 2; interior view × 3. USNM 147275.

11. Pedicle valve. Interior × 3. USNM 147276.

12–39. *Acrospirifer duodenaria* (Hall) (p. B14).

12–17. Pedicle valve. Interior × 3; interior, ventral, side, anterior, and posterior views × 2. USNM 147277, USGS loc. 4671–SD.

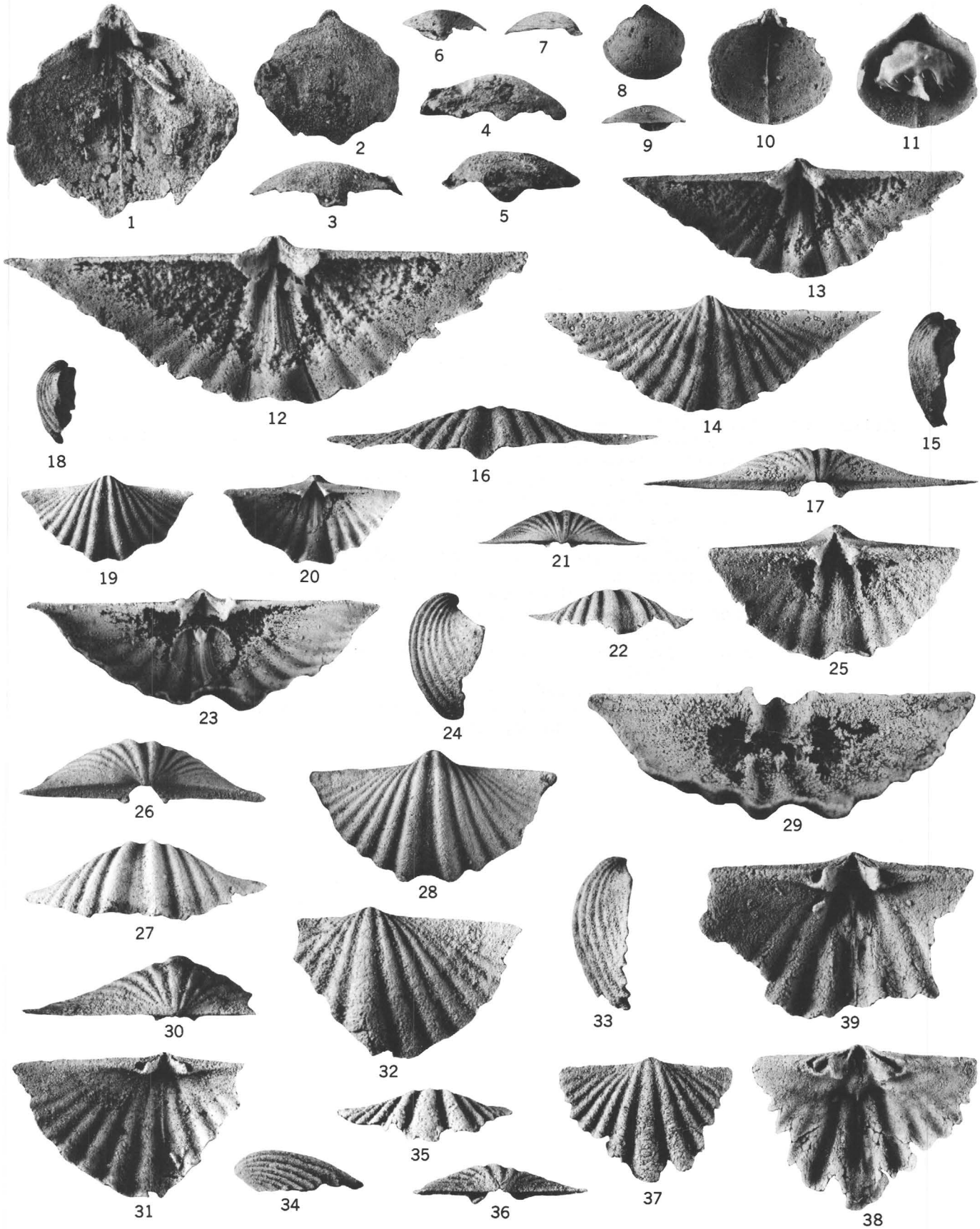
18–23. Pedicle valve. Side, ventral, interior, posterior, and anterior views × 1; anterior view of interior × 2. USNM 147278, USGS loc. 4672–SD.

24–29. Pedicle valve. Side, interior, posterior, anterior, and ventral views × 2; anterior view of interior × 3. USNM 147279, USGS loc. 4672–SD.

30–33. Brachial valve. Posterior, interior, dorsal, and side views × 2. USNM 147280, USGS loc. 4672–SD.

34–38. Brachial valve. Side, anterior, posterior, and dorsal views × 3; interior view × 4. USNM 147281, USGS loc. 4671–SD.

39. Brachial valve. Interior × 4. USNM 147282, USGS loc. 4672–SD.



NUCLEOSPIRA SP. AND *ACROSPIRIFER DUODENARIA* (HALL)

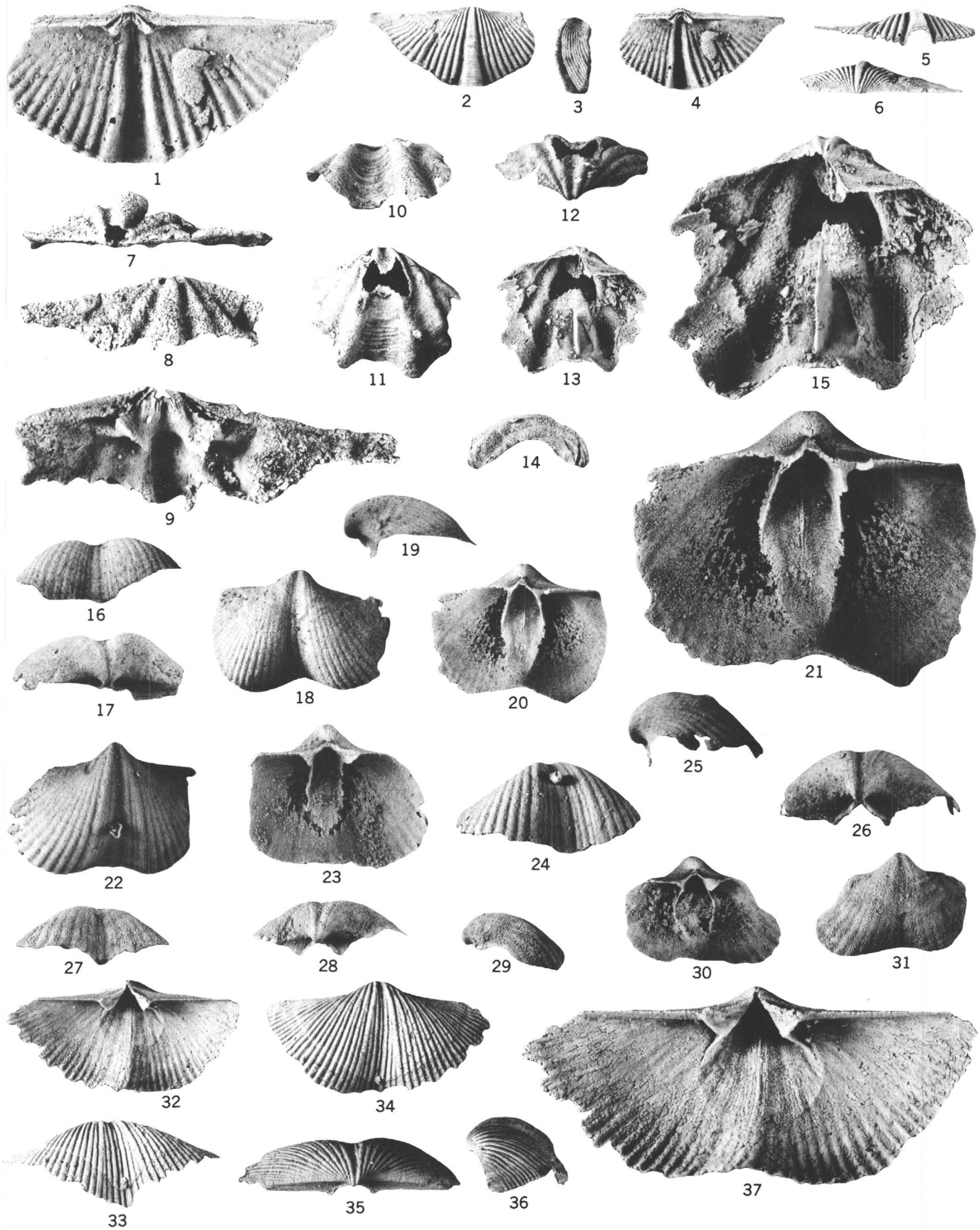
PLATE 6

FIGURE 1–6. *"Mucrospirifer"* cf. *macra* (Hall) (p. B15).
Brachial valve. Interior × 2; dorsal, side, interior, anterior, and posterior views × 1. USNM 147283, USGS loc. 4672–SD.

7–15. *Megakozlowskiella raricosta* (Conrad) (p. B16). USGS loc. 4672–SD.
7–9. Brachial valve. Posterior and dorsal views × 2; interior view × 3. USNM 147284.
10–15. Pedicle valve. Anterior, ventral, posterior, interior, and side views × 1; interior view × 2. USNM 147285.

16–31. *"Costispirifer" unicus* (Hall) (p. B16). USGS loc. 4672–SD.
16–21. Pedicle valve. Anterior, posterior, ventral, side, and interior views × 1; interior view × 2. USNM 147286.
22–26. Pedicle valve. Ventral, interior, anterior, side, and posterior views × 2. USNM 147287.
27–31. Pedicle valve. Anterior, posterior, side, interior, and ventral views × 1. USNM 147288.

32–37. *Fimbrispirifer divaricatus* (Hall)? (p. B17).
Pedicle valve. Interior, anterior, ventral, posterior, and side views × 1; interior view × 2. USNM 147289, USGS loc. 4672–SD.



"MUCROSPIRIFER" CF. *MACRA* (HALL), *MEGAKOZLOWSKIELLA RARICOSTA* (CONRAD)
"COSTISPIRIFER" UNICUS (HALL), AND *FIMBRISPIRIFER DIVARICATUS* (HALL)?

PLATE 7

FIGURE 1–5. *Elytha* sp. (p. B18).
Pedicle valve. Interior × 3, ventral, side, anterior, and posterior views × 2. USNM 147290, USGS loc. 4672–SD.

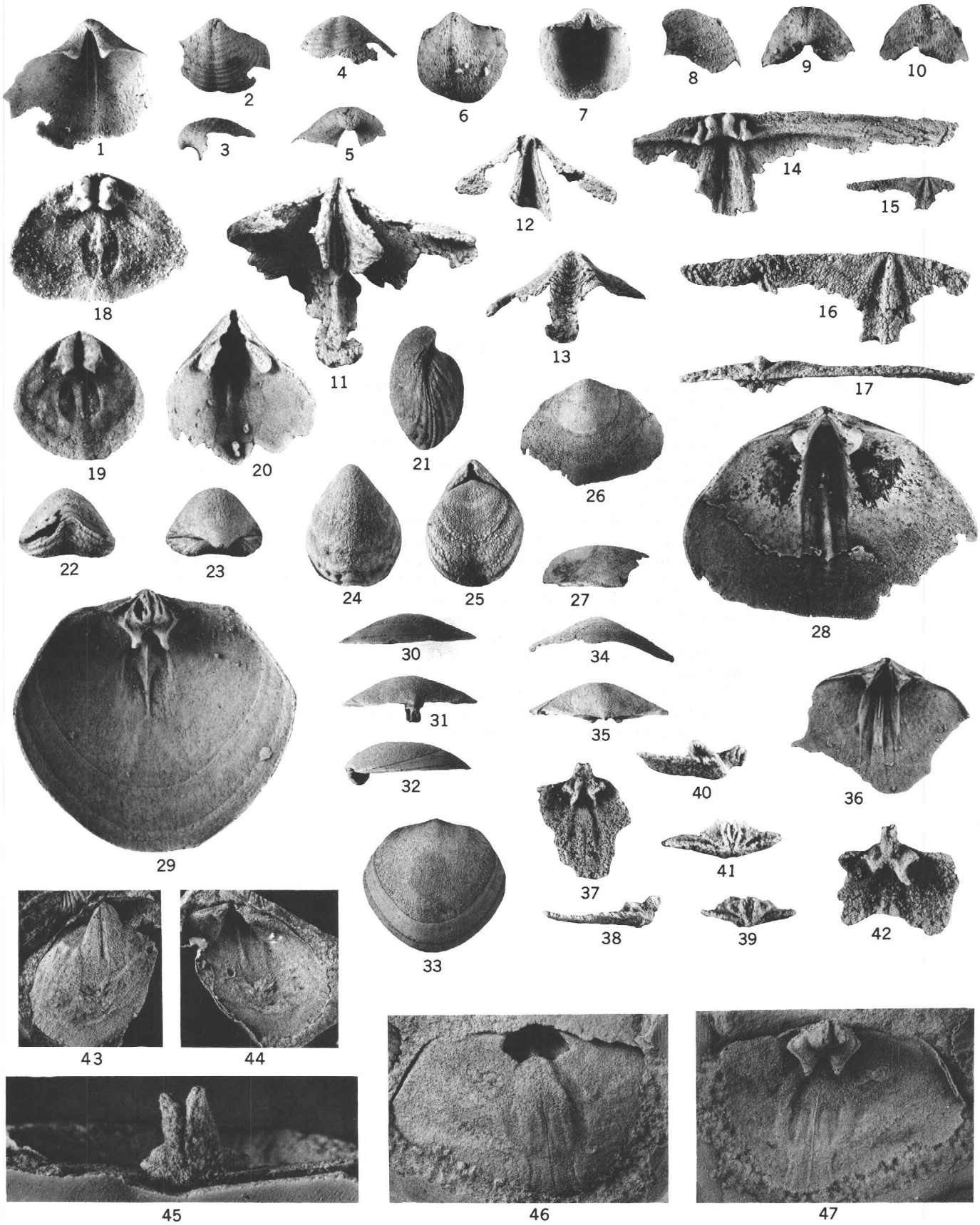
6–10. *Ambocoelia* sp. (p. B18).
Pedicle valve. Ventral, interior, side, posterior, and anterior views × 3. USNM 147291, USGS loc. 4672–SD.

11–17. *Cyrtinaella biplicata* (Hall) (p. B18).
11–13. Pedicle valve. Interior × 3; posterior and anterior views × 2. USNM 147292, USGS loc. 4672–SD.
14–17. Brachial valve. Anterior × 3; exterior × 1; dorsal and posterior views × 3. USNM 147293, USGS loc. 4671–SD.

18–25. *Centronella glansfagea* (Hall) (p. B20). USGS loc. 4672–SD.
18. Brachial valve. Interior × 3. USNM 147294.
19. Brachial valve. Interior × 3. USNM 147295.
20. Pedicle valve. Interior × 3. USNM 147296.
21–25. Side, anterior, posterior, ventral, and dorsal views × 2. USNM 147297.

26–42. *Cloudothyris postovalis* Boucot and Johnson n. gen., n. sp. (p. B19). USGS loc. 4672–SD.
26–28. Pedicle valve. Ventral and side views × 1; interior × 2. USNM 147298.
28–33. Brachial valve. Interior × 2; anterior, posterior, side, and dorsal views × 1. USNM 147299.
34–36. Pedicle valve. Interior and posterior views × 1; interior view × 1.5. USNM 147300.
37–39. Brachial valve. Interior, side, and posterior views × 3. USNM 147301.
40–42. Brachial valve. Side, posterior, and interior views × 4. USNM 147302.

43–47. *Cloudothyris* cf. *postovalis* Boucot and Johnson.
Tomhegan Formation, Brassua Lake quadrangle, Somerset County, Maine.
43–44. Internal mold of pedicle valve and rubber impression × 1. USNM 126208A, loc. SD–2750. Northeast ninth of Brassua Lake quadrangle, on end of Baker Brook Point. The actual outcrops are ledges located about 100 feet in from the point. Blocks have been moved from the outcrop to the shore, where much of the collection was made This is Clarke's (1909) localities 2454 and 3455. The fossils occur as scattered shells in subgraywacke. Many of the loose rocks have been moved from the ledges by ice push. Some of the material is closely enough packed to constitute a shell bed.
45–47. Rubber replica of cardinal process × 3; internal mold and rubber replica × 2. USNM 126218, loc. SD–3238. North ninth of Brassua Lake quadrangle, in float from the northwest end of Brassua Lake.



ELYTHA SP., *AMBOCOELIA* SP., *CYRTINAELLA BIPLICATA* (HALL), *CENTRONELLA GLANSFAGEA* (HALL), *CLOUDOTHYRIS POSTOVALIS* BOUCOT AND JOHNSON AND *CLOUDOTHYRIS* CF. *POSTOVALIS* BOUCOT AND JOHNSON

PLATE 8

FIGURE 1–13. *Amphigenia elongata* (Vanuxem) (p. B20). USGS loc. 4672–SD.

1–6. Pedicle valve. Interior × 3; side, interior, posterior, anterior, and ventral views × 2. USNM 147303.

7. Brachial valve. Interior × 3. USNM 147304.

8–13. Brachial valve. Side, posterior, anterior, and interior views × 2; interior view × 3; dorsal view × 2. USNM 147305.

14, 15. *Amphigenia preparva* Boucot.

York River Sandstone; north bank of Causapscal River about 1 mile upstream from its confluence with the outlet of Lake Frenette, Lagrange township, Matane County, Gaspé, 67°02′30″ W.; 48°32′04″ N. Collection of N. C. Ollerenshaw, 1961.

Posterior and ventral views of internal mold of pedicle valve × 1.5, P.R.M. (Redpath Mus., McGill Univ., Montreal) No. 10087.

16–21. *Meganterella finksi* Boucot.

York River Sandstone; discharge of lake Casault, Cuoq-Langis area, Gaspé, approx. 67°12′ W., 48°30.7″ N. Collection of C. R. Stearn, 1958, USNM loc. 11756.

16. Internal mold of brachial valve × 1. P.R.M. No. 10088.

17–19. Posterior and anterior views of rubber replica of brachial valve × 1.5; internal mold of brachial valve × 2. P.R.M. No. 10089A.

20–21. Rubber impression × 2; internal mold of brachial valve × 1.5. P.R.M. No. 10090A.

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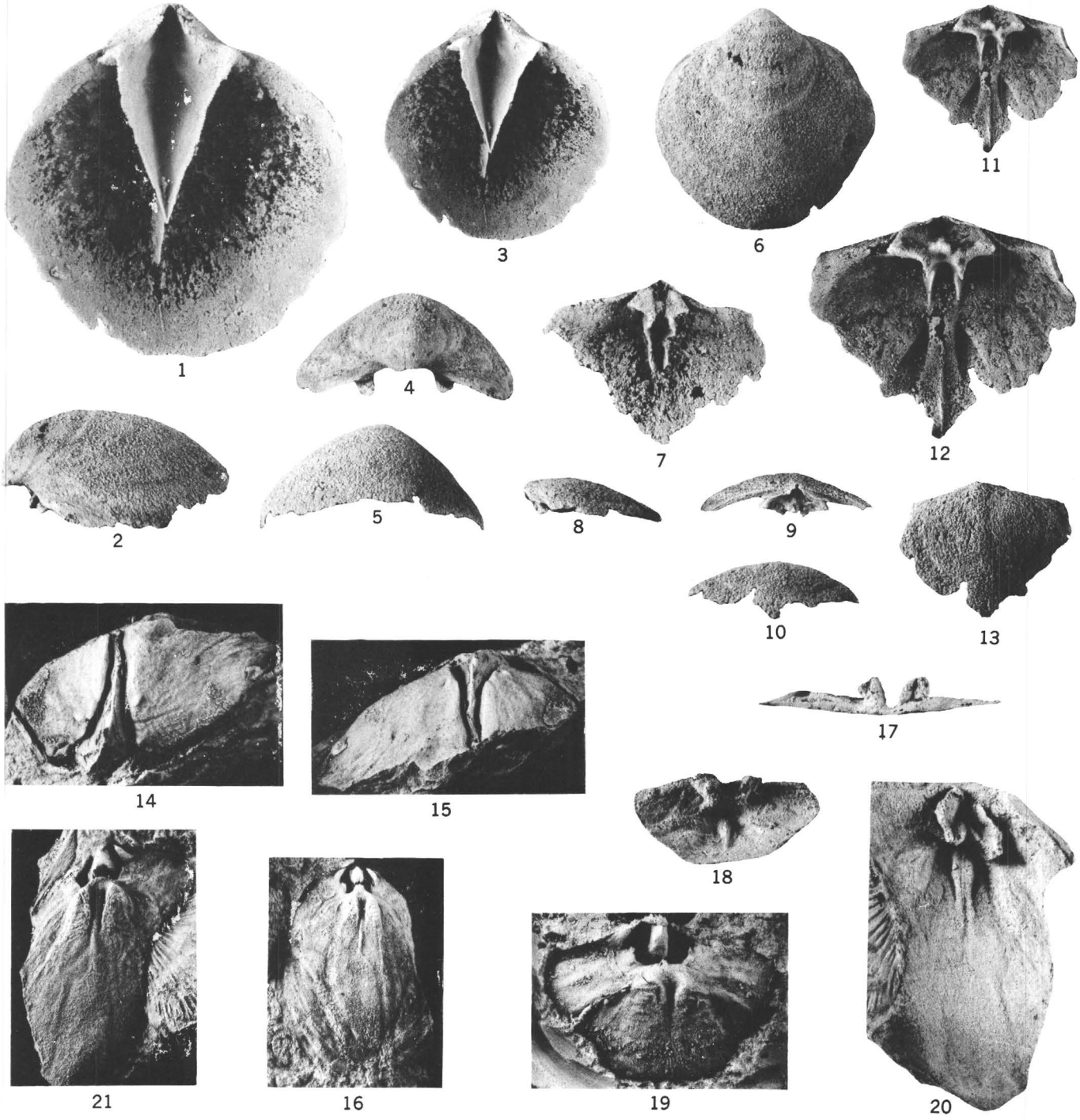

AMPHIGENIA ELONGATA (VANUXEM), *AMPHIGENIA PREPARVA* BOUCOT, AND *MEGANTERELLA FINKSI* BOUCOT