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BRACHIOPODA AND STRATIGRAPHY OF THE RONDOUT FORMATION IN THE ROSENDALE QUADRANGLE, SOUTHEASTERN NEW YORK

FLORENCE GROSVENOR HOAR AND ZEDDIE PAUL BOWEN

Shenandoah National Park, Luray, Virginia, and University of Rochester, Rochester, New York

ABSTRACT—Study of the stratigraphy and paleontology of the Rondout Formation in the type area, the Rosendale and Rhinebeck quadrangles in southeastern New York, suggests that the formation was deposited in very shallow water with periodic emergence on a broad, carbonate mud flat sloping toward the west and southwest. The sequence represents accumulation in shifting subtidal, intertidal, and supratidal environments. Fossiliferous limestones were deposited in very shallow water on an offshore bar and/or a near shore bank; while at the same time, unfossiliferous, laminated carbonates, now dolomites, were deposited in quieter and slightly deeper water between the limestone areas. A thin, stromatoporoid bioherm in the Glasco Member apparently developed on an offshore bar. Mudcracks in the laminated dolomites of the Whiteport Member indicate frequent subaerial desiccation and suggest pencon-temporaneous dolomitization of these beds in a shifting subtidal to supratidal environment similar to that recently described in Florida and the Bahamas.

Thirty-five stratigraphic sections were studied; twenty were measured in detail. Polished, stained and etched rock specimens were examined from each section, but thin sections were not made. Type sections are proposed for the Wilbur and Rosendale Members, and a reference section for the Glasco Member in the Rosendale quadrangle is suggested.

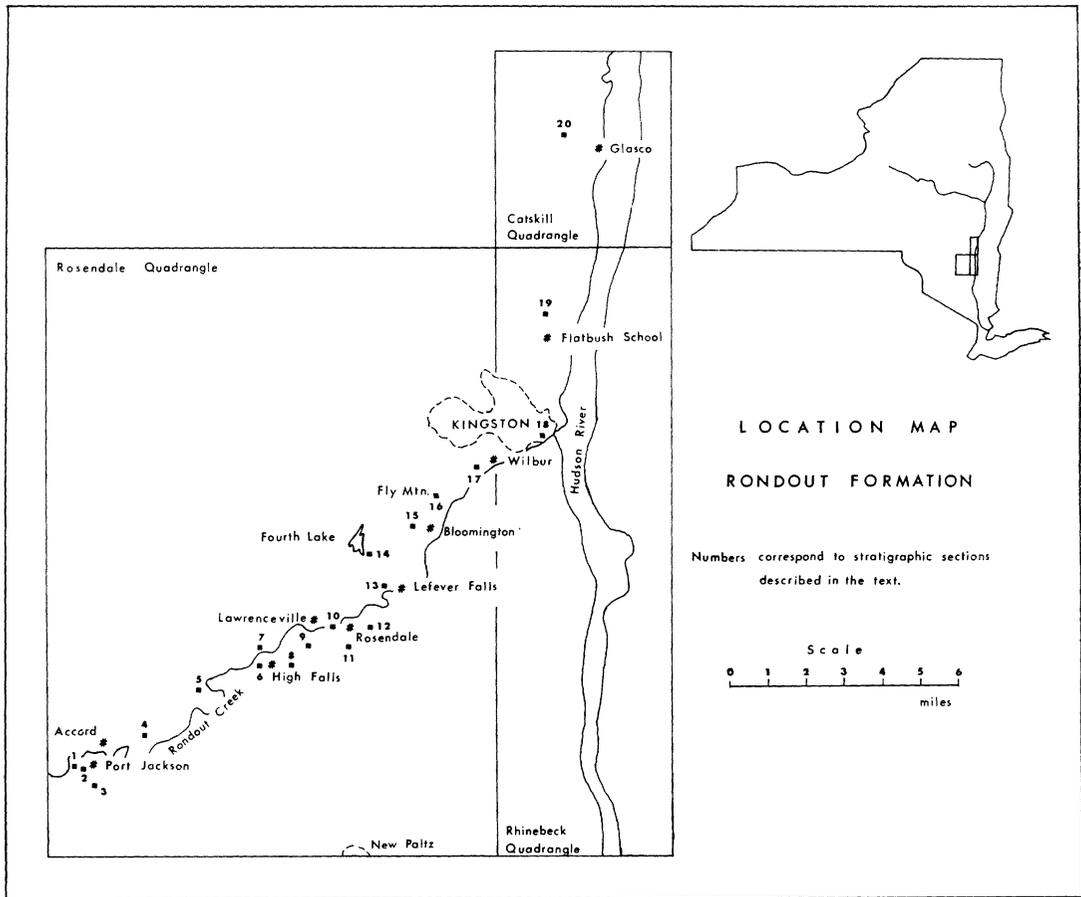
Fourteen brachiopods, one colonial coral, and one bryozoan species are described. On the basis of these fossils, the Rondout Formation is correlated with the Decker Formation of New Jersey, the Cobleskill Formation of central New York, and the *Eccentricosta jerseyensis* Zone of the Keyser Limestone of Maryland, West Virginia, and Pennsylvania, and the Rondout is judged to be Late Silurian in age.

INTRODUCTION

THE Rondout Formation of New York is composed of argillaceous and silty carbonates and calcareous sandstones of Late Silurian age cropping out in two belts across New York State, an east-west belt from Albany to Seneca Falls, and a northeast-southwest belt from Albany to Port Jervis on the New Jersey border. Both lithologically and faunally these belts are dissimilar and represent two broad facies complexes: west of Albany the Rondout consists of unfossiliferous dolomite beds, the Chrysler Member of Rickard (1962), whereas southwest of Albany the formation contains several variable limestone, dolomite, and sandstone members and a rich and varied fauna.

The stratigraphy of the Rondout has been studied by a number of other workers in varying detail since 1843, most recently by Rickard (1962), but no systematic paleontological study has been made. The present work was undertaken to describe the stratigraphy of the Rondout Formation in the type area near Rondout, New York, to describe and illustrate some of the fossils, especially the brachiopods, and to discuss the environmental conditions under which these animals lived and the rocks were deposited. The area of study extends from Glasco, in the Catskill quadrangle, to Port Jackson, in the Rosendale quadrangle, as shown in text-figure 1.

Field work was done during the summer of 1964. Thirty-five sections were examined, and of



TEXT-FIG. 1—Map showing locations of stratigraphic sections of the Rondout Formation from which fossils were collected.

these, twenty were measured in detail. Fossils, where present, and rock specimens were collected from each unit at each of the localities. The rock specimens were cut, polished, and stained with cupric nitrate, according to the method described by Rodgers (1940), to determine textures and to distinguish between calcite and dolomite. The specimens were also etched with a 10 percent hydrochloric acid solution to permit rapid visual estimation of the percent of argillaceous material present. All but two of the stratigraphic sections listed have been measured by previous workers, but all were remeasured and redescribed for this study.

This work was begun as a Master of Science dissertation project by Hoar under the direction of Bowen at the University of Rochester. In the present paper, the original report has been revised and enlarged upon by Bowen. Descriptions of each of the measured sections can be found in Mrs. Hoar's thesis.

We are grateful for support of the field work by an honorarium from the State of New York and by a grant from the Society of Sigma Xi. We also thank Dr. Lawrence V. Rickard, Senior Paleontologist, New York State Museum, for information about Rondout exposures, and Drs. Robert G. Sutton and Lawrence W. Lundgren of the University of Rochester for helpful suggestions which improved the manuscript. Mrs. Hoar also thanks Mr. and Mrs. G. Gordon Connally for providing food and lodging during the completion of the field work and Leigh D. Hoar, Jr. for help in collecting rock specimens.

STRATIGRAPHY

The name Rondout was proposed by Clarke & Schuchert (1899) for rocks exposed in the vicinity of the town of Rondout in southeastern New York. In this region, the Rondout has been subdivided into four members, which are, from bottom to top: the Wilbur Limestone, the Rosen-

dale Dolomite, the Glasco Limestone, and the Whiteport Dolomite. A fifth member, the Fuyk Sandstone, interfingers with the carbonate members in the northern and central parts of the Catskill quadrangle but is not exposed in the area studied. The formation is overlain conformably throughout eastern New York by the Thacher Member of the Manlius Formation. It overlies highly deformed Ordovician siltstones and shales in the northeastern part of the area at Flatbush School (text-fig. 1, loc. 19) and Rondout (loc. 18), the Binnewater Formation from Wilbur (loc. 17) to High Falls (loc. 7), and the Bossardville? Formation at the southwestern edge of the area at Port Jackson (loc. 1).

Binnewater Formation

The Binnewater Formation underlies the Rondout throughout most of the Rosendale quadrangle. It is a thin- to medium-bedded, gray, red, or green, dolomitic sandstone unit which is easily distinguished by its high sand content from the overlying Rondout carbonates. Cross-bedding and ripple marks are prominent throughout all but the upper 3 feet of the formation, and mudcracks are present on some beds. The uppermost 3 feet differ in character from the beds below, in that they show little cross-bedding and contain the few fossils, fragments of cup corals and stromatoporoids, that have been found in the formation. Interbedded with the sandstone are irregular fragments or thin, discontinuous layers of argillaceous dolomite up to 3 inches thick. At Wilbur (loc. 17), the argillaceous dolomite is present only as abundant, angular fragments within the sandstone beds; but to the southwest, thicker and more persistent beds are present. At Fourth Lake (loc. 14), the individual dolomite beds are from 2 to 10 feet long and over 1 inch thick. At the southwesternmost exposure of the Binnewater, at High Falls (loc. 7), the upper 14 feet of the formation consist of alternating layers of thinly laminated, argillaceous dolomite and dolomitic sandstone.

The Binnewater reaches a maximum thickness of 35 feet at High Falls, thins to the northeast to 11 feet at Wilbur, and pinches out near Kingston. The boundary between the Binnewater and Rondout Formations is sharp at all localities; between Wilbur (loc. 17) and Coxing Kill (loc. 9), it is an erosional surface, but at High Falls, where the upper part of the Binnewater consists of alternating sandstone and dolomite, no evidence of erosion was found, and the formations are conformable. Farther southwest, the sandstone disappears, apparently completely replaced by dolomite, the Bossardville? Formation, at Port Jackson (locs. 1 and 3).

Bossardville? Formation

The Rondout in the Port Jackson area (loc. 1 and 3) is underlain by an extremely fine-grained and thinly laminated dolomite unit with alternating light and dark laminae. Included within some of the laminae is silt sized quartz, and in some beds, fragments of the laminae appear to have been torn up and rotated. A 1- to 2-inch thick layer of grayish black shale marks the boundary between the Rondout and this dolomite unit, which is distinctly different from the Rondout in its extremely fine grain size. Wanless (1921 unpublished M.A. thesis, Princeton Univ.) suggested that these beds are the northern equivalent of the Bossardville Limestone of New Jersey. The Bossardville Limestone at the old Nearpass Quarries in New Jersey, where it underlies the Decker Formation, is a "compact, fine-grained, bluish grey, banded limestone," (Weller, 1903, p. 61). Wanless' correlation is accepted here but queried because the only evidence to support it is the correlation of the overlying Rondout and Decker Formations as discussed later in this paper.

Manlius Formation, Thacher Member

The Thacher Member of the Manlius Formation conformably overlies the Rondout in eastern New York, and the boundary between the two is sharp. Only the lower two units of the Thacher were measured in this study, the lower "curly beds," and the overlying "*Leperditia* limestone." These are local names used to refer to the lower part of the Manlius in the Rosendale-Rondout area (Rickard, 1962). The curly beds are fissile, laminated, fine-grained, gray, calcareous shales, which in some localities contain impressions of ostracods. The *Leperditia* limestone is very fossiliferous and consists of interbedded argillaceous limestone, dolomite, and shale. The combined thickness of the two units varies from 2 to 6 feet, but both are present and recognizable throughout the outcrop area. Rickard (1962) defined the boundary between the Thacher and the Rondout as the bottom of the curly beds, and those beds are easily distinguished from the nonfissile, laminated dolomites and limestones of the upper Rondout.

Rondout Formation

The rocks referred to in this report as the Rondout Formation have had a long and confusing nomenclatorial history starting with Hall in 1893. The problem of the nomenclature has been summarized recently by Rickard (1962, p. 29-31, fig. 4). Much of the confusion arose because, in keeping with stratigraphic procedure of the day, a specific type section was not designated by

Clarke & Schuchert (1899) when they proposed the name Rondout for rocks cropping out in the vicinity of Rondout, New York. Furthermore, the exposures at Rondout, where the rocks are quarried extensively, are not representative because the formation is much thinner than in adjacent areas, and the Glasco Member is only between 0.6 and 2.0 feet thick. To clarify the meaning of the name, Rickard (1962, p. 30) suggested that the section at Wilbur (loc. 17) be established as the standard section of the Rondout Formation; and since all of the carbonate members of the formation, as well as the upper and lower boundaries, are exposed at that section, its use should eliminate any further confusion in the stratigraphic nomenclature. In this report, Rickard's definition of the Rondout, which differs somewhat from that of other authors, is used, but some of the members are redefined.

The character and distribution of the rock types found in the Rondout are shown in text-figure 2. The distribution of the fossils is shown in text-figure 3, and table 1.

Wilbur Limestone Member.—The Wilbur Limestone Member is the lowermost member of the Rondout Formation between Wilbur and Glasco. Hartnagel (1903) named it after a section near the town of Wilbur, measured and described by Mather in 1843. The original section cannot be located; therefore, the exposure at Wilbur (loc. 17), the standard reference section for the Rondout Formation, is here designated as the type section. The member is a highly variable unit, both faunally and lithologically; and nearly every fossil species found in the Rondout is represented in it (see table 1), although the assemblage varies from one section to another.

The Wilbur Member consists of a variety of limestone types. At Wilbur (loc. 17) and Glasco (loc. 20), it is a fossiliferous, thinly bedded, silty, fine- to medium-grained limestone. Thin shale beds and shaly partings are present, and small-scale cross-lamination is common. At Wilbur, both the lower and upper contacts with the Rosendale are gradational and marked by mottled limestone. In contrast, the Wilbur Member at Rondout (loc. 18) is a medium-bedded, extremely fossiliferous, coarse-grained limestone, with thin to medium interbeds of silty limestone, and with fossils composing nearly 90 percent of the rock. Cabbage-shaped stromatoporoids and favositid corals occur in life position, with smaller fossils, fossil fragments, and silt concentrated in the pods between them. Brachiopods are common and diverse in these biostromal beds. At Flatbush School (loc. 19), fossils are also extremely abundant, but the stromatoporoids are absent. The rock there is a thin- to me-

dium-bedded, medium- to coarse-grained limestone.

The thickness of the Wilbur varies from 4 feet at Wilbur to 12 feet at Flatbush School. It inter-fingers with the Rosendale at Wilbur, where it is both underlain and overlain by tongues of Rosendale dolomite, as shown in text-figure 2, and discussed below. North of Wilbur, it oversteps the underlying tongue of the Rosendale and rests with angular unconformity on highly deformed Ordovician siltstones and shales.

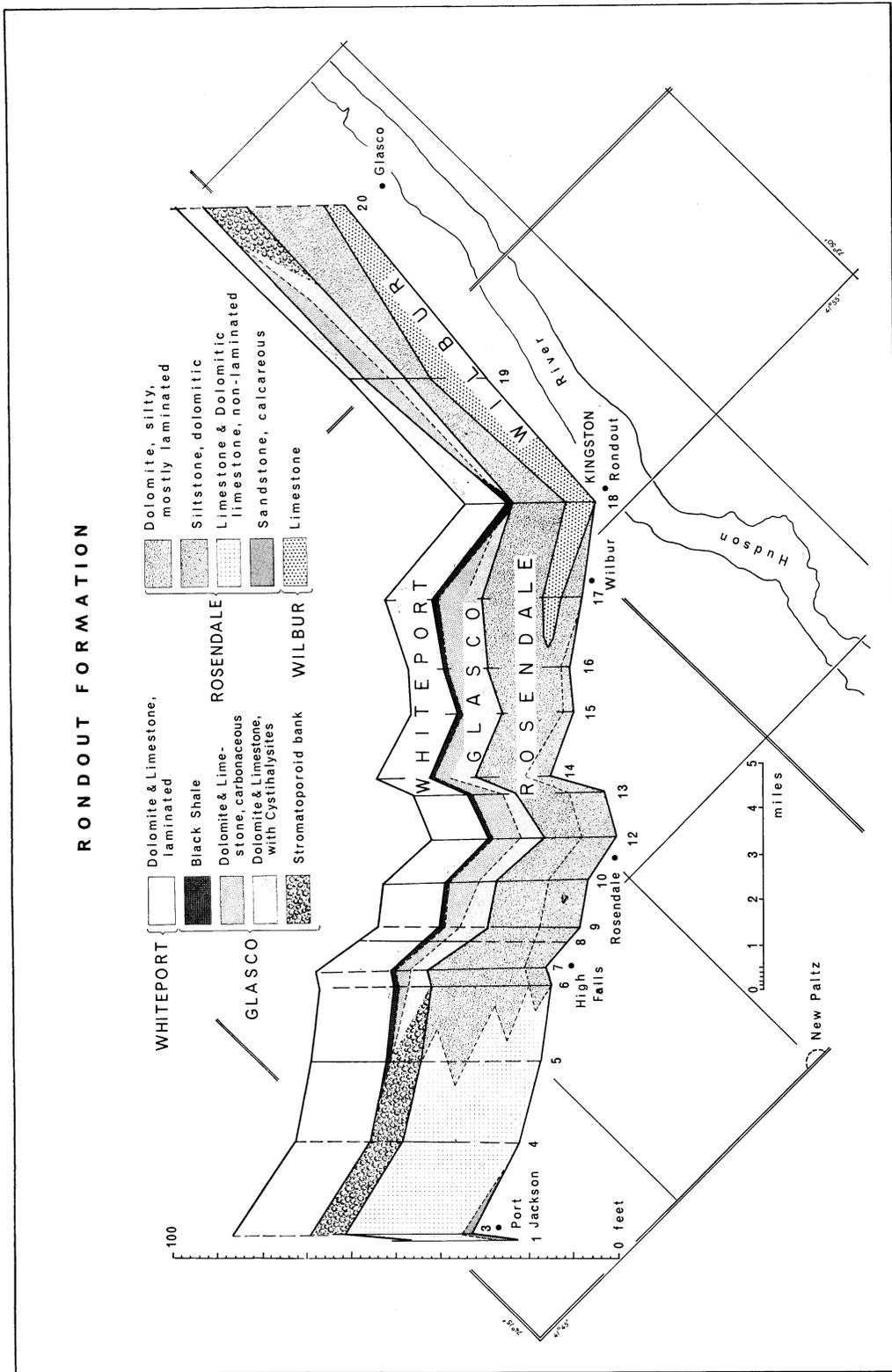
Rosendale Dolomite Member.—The Rosendale Dolomite Member is the lowermost member of the Rondout Formation southwest of Rondout (loc. 18). It was named by Hartnagel in 1905 (p. 356), who reintroduced Hall's (1893) term Rosendale for the "lower cement" in Ulster and adjacent counties. Hall (1893, p. 159) used the term, in a different sense, for cement rocks quarried at Rosendale, but neither Hall nor Hartnagel designated a type section. The section at Fourth Lake (loc. 14) is here designated as the type section of the member so that it will not be confused with the Rosendale of Hall.

The Rosendale Member is thickest, 27 feet, in the southern part of the area between Port Jackson (locs. 1 and 3) and High Falls (loc. 7). It thins to the northeast, where it is, in part, replaced by the Wilbur Member and is reduced to a thickness of 6 feet at Flatbush School (loc. 19).

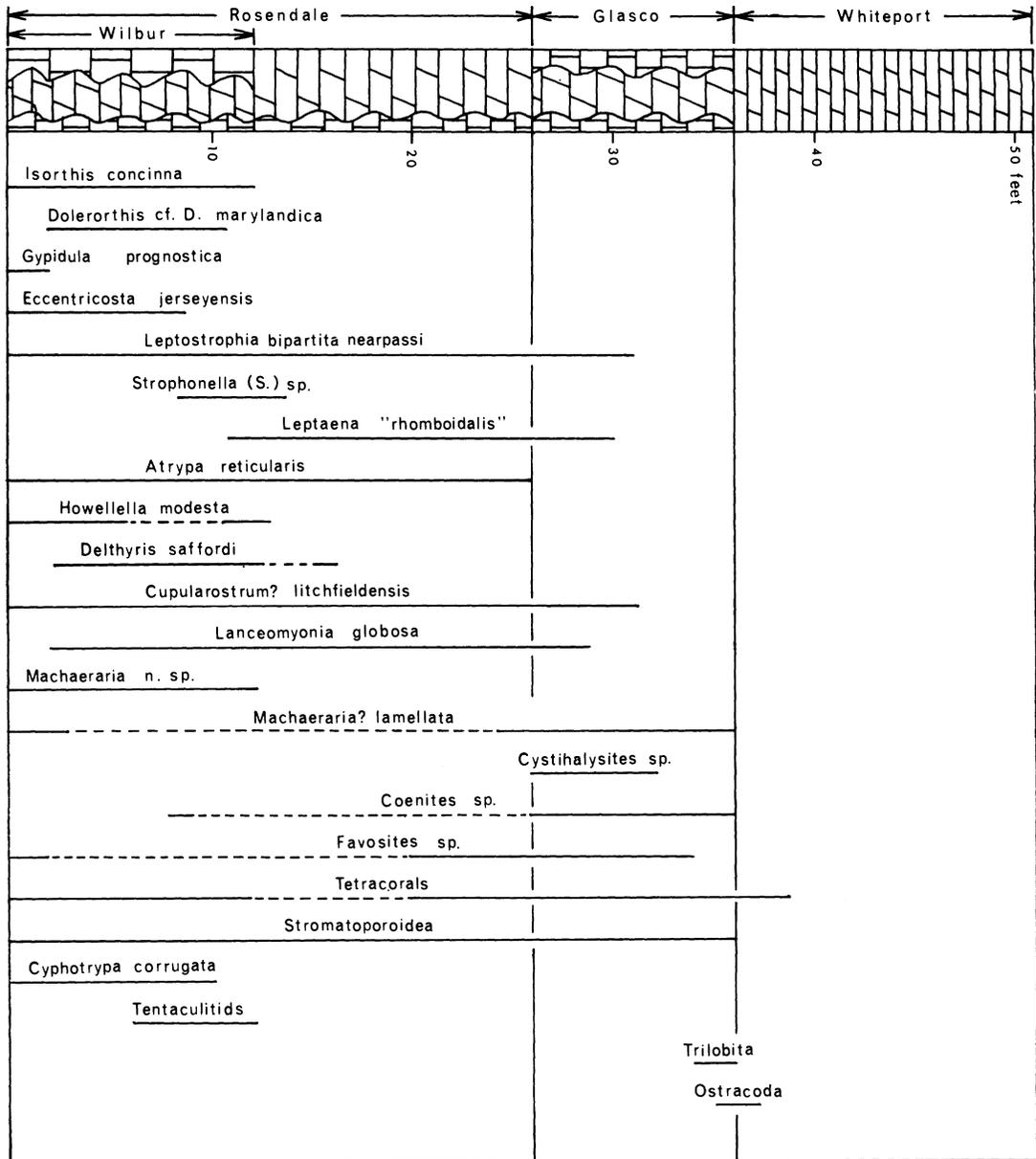
It can be divided into two major facies, a dolomitic facies northeast of the High Falls area and a calcareous facies to the southwest (see text-fig. 2). These facies grade into each other near High Falls.

In the dolomitic facies northeast of High Falls two units are recognized: a dolomitic siltstone at the base and a silty dolomite above. The basal dolomitic siltstone unit is irregularly laminated and micro-cross-laminated to thin-bedded, with many discontinuous laminae, disrupted around worn burrows. The unit is fine-grained, and rounded interclasts of argillaceous dolomite are present. Fossils are rare and many are silicified. Many small, unidentifiable fossil fragments, mostly of echinoderms and brachiopods, are present in some beds. *Atrypa reticularis* is common in some sections. The siltstone pinches out north of Fly Mountain (loc. 16). It increases in thickness from 2 feet at Fly Mountain to 9 feet at Coxing Kill (loc. 9). With the southwestward increase in thickness, there is also an increase in the silt content, in the thickness of the laminae, and in the abundance of fossils, and a decrease in the amount of dolomite. It grades first into calcareous siltstone, then into limestone and calcareous sandstone in the calcareous facies.

Gradationally overlying the dolomitic siltstone is a silty dolomite unit differentiated from



TEXT-FIG. 2—Fence diagram showing the stratigraphic relationships of the members of the Rondout Formation.



TEXT-FIG. 3—Stratigraphic distribution of fossils in the Rondout Formation in southeastern New York.

the underlying strata by its lower silt content, thicker shale partings and almost complete lack of fossils. It is fine-grained, thinly laminated, micro-cross-laminated, and breaks with a conchoidal fracture. The bedding is disturbed and disrupted, more so than in the unit below. Most of the fossils consist of echinoderm and brachiopod fragments, commonly occurring in "clumps." The few identifiable fossils found are abraded, fragmented, and randomly oriented.

To the northeast, this upper unit of the Rosen-

dale oversteps the lower dolomitic siltstone and rests directly on the Binnewater Formation (see text-fig. 2). Farther northeast, at Wilbur (loc. 17) a medium- to coarse-grained limestone inter-fingers with it. Rickard (1962, p. 130) included both this limestone and the dolomite underlying it in the Wilbur Limestone Member. As originally described (Hartnagel, 1903), the Wilbur is a limestone unit; therefore, the dolomite beds underlying the limestone at Wilbur, which are lithologically like the Rosendale, are here

TABLE 1.—Distribution of species and groups in the members and rock types of the Rondout Formation
r=rare, only a few specimens; c=common, many tens of specimens; a=abundant, innumerable specimens

	Wilbur	Rosendale	Glasco	Whiteport		Dolomitic siltstone	Calcareous siltstone	Silty, finely crystalline dolomite	Medium crystalline dolomite	Argillaceous limestone	Silty, carbonaceous dolomite and limestone	N2 calcareous and dolomitic shale	(Biogenic) limestone	Clayey, finely crystalline dolomite	Calcareous sandstone
Stromatoporoids	c	c	a			r		r	a	c	c	c	a		
Flat		c	a			r		r	a		c				
Cabbage	c	r	a					r		c		c	a		
<i>Cystihalysites</i> sp.			a						a				r		
<i>Coenites</i> sp.	c		a						c		a		c		
Cup corals	c	c	c	r				r	c	c	c	c	r		r
"Favosites"	c	r	a			r			a	r			c		r
Bryozoa	r	r	c						c				c		
" <i>Orthoceras</i> "		r					r			r					
<i>Cupularostrum?</i> <i>lilchfeldensis</i>	r	a	r			r	a	r	r	a			r		r
<i>Howellella modesta</i>	r	c				r	r			c					
<i>Gypidula prognostica</i>		r													a
<i>Machaeraria</i> n.sp.		a								a					
<i>M.?</i> <i>lamellata</i>	r		c							r		c	c		
<i>Delthyris saffordi?</i>		c				r	r	r		c					
<i>Eccentricosta jerseyensis</i>		a								a					r
<i>Leptaena</i> " <i>rhomboidalis</i> "	r	a	r							a			r		
<i>Strophonella</i> (S.) sp.		a								a					
<i>Leptostrophia bipartita nearpassi</i>	c	a					c			a					r
<i>Atrypa reticularis</i>	c	a				r	c	r		a					c
<i>Isorthis concinna</i>		c								c					r
<i>Dolerorthis</i> cf. <i>D. marylandica</i>		r					r			r					
<i>Lanceomyonia globosa</i>	r	c	r							c			r		
<i>Cyphotrypa?</i> <i>corrugata</i>		a					c			a					r
Pelecypoda		r	r							r	r	r			
Gastropoda	c	r					r			c	r				
Trilobita			r									r			
Ostracoda			r	a								r		a	
Crinoid columnals	a	a	a			c	c	r	a	a	c	c	a		

referred to the Rosendale Member instead of the Wilbur, and the two members interfinger at this locality. Northeast of Wilbur the lower tongue of the Rosendale pinches out, and the Wilbur rests directly on Ordovician strata.

The upper silty dolomite unit of the Rosendale is thickest at Fly Mountain, being 17 feet thick, but thins gradually to the southwest to a minimum of 8 feet at High Falls (see text-fig. 2). Toward the southwest, it grades into limestone and dolomitic limestone of the calcareous facies, fossils are greater in abundance, and "garden

patches" of cabbage-shaped stromatoporoids occur in life position where the two facies intergrade.

The section at High Falls (loc. 7) is transitional between the northern dolomitic facies and the southern calcareous facies. Both the upper and lower units of the dolomitic facies can be recognized, but the siltstone at the base is calcareous and abundantly fossiliferous. Many fossils are whole and articulated, but concentrated in thin shell beds separated by beds containing only small, unidentifiable fossil fragments. The en-

crusting bryozoan *Cyphotrypa? corrugata* is one of the few species which occur in living position, and it commonly encrusts shells of *A. reticularis*, forming laterally expanded colonies with thin edges extending into the sediment beyond the *Atrypa* shells.

From High Falls south to Port Jackson (locs. 1-4), the Rosendale Member consists of argillaceous, silty limestone and dolomitic limestone with abundant fossils. In this calcareous facies, the bedding is thin to medium, but not laminated nor micro-cross-laminated. Fossils are fragmented, abraded and size-sorted in some beds but well preserved in others. *Atrypa reticularis* with a pronounced notothyrial deposit occurs in poorly sorted calcarenites in some localities, but specimens with a well developed fringe or geniculation and lacking a notothyrial deposit are found at others. *Eccentricosta jerseyensis* is abundant but found only in thin, shell beds. *Strophonella (Strophonella)* sp. and *Leptostrophia bipartita nearpassi* are common and often found at random orientation to the bedding. Most of the fossils reported from the Rosendale Member are found in these calcareous strata.

At Port Jackson the lowermost unit of the member is a thin calcareous sandstone, with prominent cross-bedding. The quartz grains are well rounded and of coarse sand to granule size. Rounded fragments of argillaceous dolomite are also present. This sandstone does not occur in the Rosendale Member northeast of Port Jackson. It differs from the Binnewater Formation underlying the Rosendale to the northeast by being abundantly fossiliferous, medium gray, and in having calcite cement. Fossils in the sandstone are fragmented, abraded, valve sorted and oriented parallel to the bedding. Pedicle valves of the brachiopod *Gypidula prognostica?* are abundant.

The total thickness of the Rosendale in this region is 27 feet. From High Falls to Port Jackson, the complete thickness is revealed in only two exposures, but two other outcrops expose the upper 18 feet. The most favorable localities in which to examine this facies of the Rosendale are the sections at Stony Kill (loc. 1) and in the abandoned railroad cut (loc. 3) near Port Jackson.

The uppermost 0.5 to 1.5 feet of the Rosendale Member are lithologically intermediate between the Rosendale and the overlying Glasco and contain abundant specimens of flat stromatopoids. However, they do not contain the coral *Cystihalysites* characteristic of the Glasco Member.

Glasco Limestone Member.—The Glasco Member consists of highly fossiliferous and variable limestones and dolomites characterized by abun-

dant corals, especially halysitids, and stromatoporoids. The fossils are silicified throughout most of the outcrop area in the Rosendale quadrangle and weather out in relief to give the member a distinctive appearance.

The type section is in an isolated 10-foot thick ledge at Glasco (loc. 20) in the Catskill quadrangle (Chadwick, 1944), where the Glasco consists of medium gray, thin- to medium-bedded, fossiliferous, fine- to medium-grained, silty limestone, with abundant, large, cabbage-shaped stromatoporoids. Neither the overlying Whiteport nor the underlying Rosendale are exposed at the type section, and the member is lithologically different from the Glasco exposed to the south in the Rosendale quadrangle. For these reasons, it is suggested that the section at Fourth Lake (loc. 14) be used as a reference section for the Glasco Member in the Rosendale quadrangle. The type section of the Whiteport Member and the Rosendale Member, as designated in this paper, also occur at this locality.

In the Rosendale quadrangle, from Wilbur (loc. 17) to Coxing Kill (loc. 8), the Glasco Member can be divided into 3 units (see text-fig. 2). The lowermost of these units is composed of gray, thin- to medium-bedded, medium-grained, argillaceous limestone and dolomite, with abundant flat stromatoporoids, *Cystihalysites* sp., and cup corals. It varies between 3 and 6 feet in thickness. The middle unit is thin-bedded to laminated and contains small flat stromatoporoids and abundant *Coenites* sp., but *Cystihalysites* sp. is absent. This unit is 4 to 8 feet thick and is darker and less fossiliferous than the unit below. The upper unit is a very fossiliferous, black, calcareous shale, varying from 0.2 to 2 feet in thickness, with thin interbeds of very dark limestone.

The lower unit changes both lithologically and faunally from northeast to southwest. Between Fly Mountain (loc. 16) and High Falls (loc. 7), it is abundantly fossiliferous, medium-grained, crystalline, argillaceous dolomite containing abundant specimens of *Cystihalysites* sp., favositids and flat stromatoporoids. Many of the *Cystihalysites* specimens in the lower part of this unit are still in living position, but most of those in the upper part of the unit are broken, disrupted, and turned over. Intraclasts and fossil debris are associated with, and interbedded with, the *Cystihalysites* and flat stromatoporoids. These species are very abundant but do not form a solid framework. To the north, from Fly Mountain to Glasco, and to the south, from High Falls to Port Jackson, the unit is composed of limestone. South of High Falls (loc. 5), *Cystihalysites* is absent, and cabbage-shaped stromatoporoids compose most of the rock. The

stromatoporoids are in living position, forming a solid framework, with smaller fragments and fossils concentrated in voids between them. Algal structures? which resemble those figured by Lowenstam (1950, p. 442), are present between some of the stromatoporoid heads. The colonial corals usually associated with the flat stromatoporoids in the Glasco are only rarely found in the cabbage-shaped stromatoporoid bioherm. This reef-like deposit of stromatoporoids was built on a coquina deposit at the top of the Rosendale Member composed of brachiopod, echinoderm, coral, and stromatoporoid debris.

The middle unit of the Glasco is a carbonaceous, finely crystalline, argillaceous dolomite between Fly Mountain and Lawrenceville (loc. 10). These rocks are thin- to medium-bedded and, in some cases, laminated. The unit pinches out southwest of Lawrenceville and is absent at High Falls (loc. 5). Northeast of Fly Mountain, it grades into argillaceous limestones. *Coenites* sp., very small, flat stromatoporoids, and crinoid columnals are found in both the thin-bedded carbonaceous dolomites and the limestones, with the specimens of *Coenites* aligned parallel to bedding, and clumps of fossil fragments common in areas of disrupted bedding.

The upper unit of the Glasco Member is a grayish black, calcareous and dolomitic shale, interbedded with very thin beds of dark limestone. The fauna is abundant and diverse, and differs somewhat from the fauna of the rest of the Rondout Formation. Trilobites are present, although flattened, and ostracods are common. Scattered, large, cabbage-shaped stromatoporoids occur in living position and are "veneered" by shale. Only one brachiopod species, *Mach-aeraria? lamellata*, was found in these beds. This unit varies irregularly in thickness throughout the quadrangle, but it is unfossiliferous only at Tillson (loc. 12), where it consists of grayish black, arenaceous limestone. It pinches out in the north and south against the more massive rocks below.

The base of the Glasco in the Rosendale quadrangle, from Wilbur to High Falls, is here considered to be the base of the *Cystihalysites* unit. In some localities, the upper few inches to 2 feet of the Rosendale Member contain a fauna similar to that of the Glasco, and at High Falls, small, "cabbage-head" stromatoporoids are abundant throughout the upper Rosendale; however, *Cystihalysites* is not present in these beds. Previous writers have considered the base of the Glasco to be the base of the fossiliferous limestones in the Rondout Formation, including the fossiliferous, but *Cystihalysites*-free, beds in the Glasco Member. The boundary as redefined here is simply a clarification of the older defini-

tion, and it is convenient and easily recognized in the field. The *Cystihalysites* unit is also present north of the Rosendale quadrangle at Flatbush School, and the base of the Glasco Member is placed at the bottom of that unit.

Southwest of High Falls, the contact between the Glasco and the Rosendale is more difficult to define. The total thickness of the Glasco is not exposed in that area, and both the Glasco and the Rosendale Members are composed of fossiliferous limestone. Furthermore, *Cystihalysites* is not present in the Glasco in the southwest and cannot be used to separate the two members. At Accord (loc. 4), and Port Jackson (locs. 1-3), the base of the Glasco is considered to be the base of a 2- to 4-inch bed of coral, brachiopod, echinoderm, and stromatoporoid debris underlying a massive stromatoporoid bed, the top of which is not exposed.

The Glasco Member changes very little in overall thickness in the area, being between 10 and 13 feet thick, except at Rondout (loc. 18). At Rondout the member is less than 2 feet thick and consists of grayish black, fossiliferous limestone. The boundary with the Rosendale Member there is uncertain.

Whiteport Dolomite Member.—The Whiteport Dolomite Member was named and defined by Rickard (1962) as "buff-weathering, argillaceous dolomites and thin calcitic dolomites between the underlying Glasco Limestone and the overlying Manlius Formation. Both contacts are gradational. . . ." At the type section, at Fourth Lake (loc. 14), Rickard gave the thickness as 14 feet and divided it into two units, a lower "argillaceous buff dolomite, and one laminated dark grey limestone. . . ."

The Whiteport consists of thinly laminated and micro-cross-laminated, very fine-grained dolomite and limestone, containing shaly partings which result in a thin- to medium-bedded appearance. The laminae are very irregular throughout the unit and can be traced for only a few inches. Intraclasts of clayey dolomite and fine quartz sand occur in the lower 0.5 feet. Mud-cracks were observed in the upper and lower few feet and have been reported throughout the member by others. At Lawrenceville (loc. 10), the Whiteport Member is a clayey, very fine-grained dolomite. Southwest of Lawrenceville it was observed at only two localities: Coxing Kill (loc. 8) and High Falls (loc. 5). At both of these, the lower 4 to 8 feet are fine-grained, laminated, clayey limestone and dolomitic limestone, containing ostracods and cup corals. These are overlain by interbedded, unfossiliferous, clayey, laminated dolomite and thin beds of laminated limestone. Northeast of Fourth Lake, the type locality, the Whiteport Member consists of

interbedded clayey, laminated, fossiliferous limestones, unfossiliferous dolomites, and dolomitic limestones.

In some respects the Whiteport resembles the thinly laminated and micro-cross-laminated beds of the Rosendale Member, but the argillaceous material in the Whiteport is much finer grained than that of the Rosendale, and the Whiteport is much lighter in color. They also differ in their fauna, that of the Rosendale being mainly brachiopod and echinoderm debris and that of the Whiteport being ostracods and cup corals.

The ostracods of the Whiteport, *Leperditia* sp., are abundant in the lower 1 to 2 feet of the thinly laminated dolomites; and the specimens are all nearly the same size, and most are disarticulated and oriented with the convex side of the valve up. Toward the southwest, the lower part of the member grades into fine-grained, laminated limestone, and cup corals are found with the ostracods.

The Whiteport Member increases in thickness toward the southwest; it is 4 feet thick in the Catskill quadrangle (loc. 19), 10 feet at Wilbur, 12 feet at the type section at Fourth Lake, and 16 feet at High Falls (loc. 5).

The contact between the Glasco and Whiteport Members was not defined by Rickard (1962) or Chadwick (1944). In this paper it is understood to be the top of the grayish black, laminated, calcareous shale and argillaceous limestone seen at Fly Mountain (loc. 16), Bloomington (loc. 15), and Coxing Kill (loc. 8). This shale unit is traceable from Wilbur to Coxing Kill; and although there are changes in the lithology of the beds above it, they are regarded as Whiteport. Northeast of Wilbur, the calcareous shale is not identifiable, and there is some question as to where the boundary should be placed.

PALEOENVIRONMENTAL INTERPRETATION

The faunal and lithologic data collected from the Rondout Formation in southeastern New York suggest that these sediments accumulated in very shallow water with frequent emergence on a broad carbonate mud flat sloping toward the west or southwest. The sequence represents accumulation in a regime of shifting subtidal, intertidal, and supratidal environments initiated in pre-Rondout time with the deposition of the Binnewater sandstones and the Bossardville? dolomites. Rich fossil assemblages are found in limestone facies judged to represent deposition in shallow, agitated water on an offshore bar and a nearshore bank of very low relief, whereas virtually no fossils are found in laminated dolo-

mite facies apparently deposited in somewhat restricted, quiet, perhaps deeper, water. The axis of the basin of deposition and the shore line during the Late Silurian appears to have been approximately north-south (Rickard, 1962; Alling & Briggs, 1960). The exposures of the Rondout fall along an irregular line which runs toward the basin axis at a low angle both north and south of Kingston, New York.

The Bossardville? dolomites and Binnewater sandstones underlying the Rondout are judged to represent contemporaneous offshore and beach facies which thinned and lapped onto a land area of deformed Ordovician sediments to the east. In the east, where the Binnewater is thin, mudcracked surfaces indicate periodic exposure to subaerial desiccation; and the presence of irregular fragments of dolomite, from once more extensive beds, suggests short periods of accumulation of fine-grained carbonates punctuated by erosion, fragmentation, and redeposition of the dolomite in cross-bedded, coarse-grained sandstone layers. These features indicate accumulation in repeatedly shifting subtidal, beach, and supratidal environments. The westward increase in thickness of the sandstone, and the increasing number of more continuous interbeds of dolomite, indicate longer and more frequent periods of carbonate accumulation. This may not indicate appreciably deeper water but merely shorter exposure to subaerial desiccation and shallow water erosion during which the dolomite beds might be dried and "cracked" into fragments, then reworked or destroyed by waves. The alternation of these laminated, fine-grained dolomite beds with layers of cross-bedded and ripple-marked sandstone indicates rapid and frequent change from very quiet water to strongly agitated water conditions. Mudcracks in some of the dolomite beds testify to occasional desiccation even in the western exposures of the Binnewater. The absence of the Binnewater sands in the Port Jackson area and their apparent gradation into dolomites near High Falls is interpreted as a gradation into a more stable, quiet water realm.

The virtual absence of fossils from both the sandstone and the dolomite layers suggests that these beds accumulated in a somewhat restricted, perhaps hypersaline, environment.

In the eastern part of the area, the contact between the two formations is a sharp and irregular surface indicating the Binnewater was exposed and subjected to erosion there before deposition of the Rondout. In the west there is no evidence of erosion at the end of Binnewater time for the surface is smooth and conformable.

The succeeding Rondout deposits overstepped both the Bossardville? and Binnewater and

transgressed onto the area of eroded Ordovician sediments in the east. During the early stages of Rondout deposition, three main facies developed: (1) a short-lived, biostromal limestone facies, the Wilbur Member, containing abundant cabbage-shaped stromatoporoids and favositid corals; (2) a fine-grained dolomite facies with laminated and micro-cross-laminated beds but few fossils, the dolomitic facies of the Rosendale Member; and (3) a medium- to thin-bedded limestone facies with an abundant and diverse fauna, the calcareous facies of the Rosendale Member.

The biostromal Wilbur Limestone Member is judged to represent deposition in shallow water where turbulence was, at least occasionally, great. In addition to containing abundant cabbage-shaped stromatoporoids and favositid corals in life position, it also contains large, broken and transported fragments of these and other fossils, and a diverse assemblage of brachiopods in a matrix of fossil fragmental debris, all suggesting deposition in strongly agitated water. These beds grade laterally into thin, irregularly-bedded, argillaceous limestones which probably represent the finer grained debris shed from the turbulent area into quieter water.

The fossiliferous Wilbur limestones inter-tongue to the west with the fine-grained dolomitic facies of the Rosendale Member which contains few fossils. Laminar bedding and micro-cross-lamination, so common in these fine-grained dolomite beds, suggest accumulation in a low energy environment with weak, irregular currents shifting and sorting the sediments, before depositing them in thin laminated layers. Infrequent, stronger agitation is indicated by thin beds of poorly sorted, fossil fragmental calcarenites.

The paucity of fossils in this facies is judged to be an original feature reflecting unfavorable environmental conditions; it probably is not due to destruction or nonpreservation, because the fossil fragments and rare, whole fossils that do occur are well preserved.

Late in Rosendale deposition, the dolomitic facies overlapped the biostromal facies of the Wilbur Member. To the west, the dolomitic facies of the Rosendale Member grades through an intermediate zone of mixed dolomites, dolomitic limestones and limestones, into the fossiliferous limestone facies. This calcareous facies contrasts sharply with the dolomitic facies in that it lacks thinly laminated and micro-cross-laminated bedding; it is coarser grained and has a more abundant and diverse fauna. Stronger, although intermittent, wave or current activity is indicated for it by coarse sandstone and calcarenite beds. The cross-bedded sandstone at the

base of the Rosendale at Port Jackson has abundant, fragmented, size and valve sorted fossils and indicates deposition in agitated water. The coarse-grained calcarenites—especially the one at the top of the member near Port Jackson composed of coral, brachiopod, echinoderm and stromatoporoid debris—also indicate a turbulent environment. In addition, shell beds, such as those in which only large specimens of *Eccentricostea jerseyensis* are found, show that the currents were periodically strong enough to sort particles of fairly large size. The random orientation of forms such as *Strophonella* (*S.*) sp. and *Leptostrophia bipartita* indicate rapid transportation and deposition. Transported and fragmented specimens of cabbage-shaped stromatoporoids, as well as small patches of specimens in living position, occur in this facies indicating at least local currents strong enough to move large objects.

These features suggest that the calcareous facies of the Rosendale was deposited mostly in agitated, therefore probably shallow, water at or well above wave base. This facies is interpreted as an offshore carbonate bank or bar separated from the shore by a deeper, more quiet water environment in which the laminated dolomitic facies accumulated. The unfossiliferous dolomitic facies thus appears to reflect an originally uninhabitable environment for shelly invertebrates lying between two densely populated environments.

The Glasco Member overlying the Rosendale is interpreted as a reef complex, composed of a reef-bank or bioherm developed on the offshore carbonate bar facies of the Rosendale, and a back-reef facies of fossiliferous dolomite and limestone which pinches out eastward or shoreward. The reef-bank is formed by the cabbage-shaped stromatoporoid deposit found near Port Jackson, and it probably extended parallel to the shoreline to near Glasco. Initial growth of the bioherm began with flat stromatoporoids encrusting and binding debris of favositid and cup corals, echinoderms, brachiopods, and stromatoporoids at the top of the limestone facies on the offshore bar. On this foundation, large, cabbage-shaped stromatoporoids built a structural framework which extended above the surrounding area forming a reef about 10 feet thick.

The early back-reef facies appears to have been deposited before the reef-bank strongly controlled back-reef conditions. It consists of dolomitized calcarenite and calcisiltite with abundant halysitid corals, cup corals, flat stromatoporoids, and some small cabbage-shaped stromatoporoids. Many of these fossils occur in life position in the lower part but are overturned and broken in the upper part of the early back-

reef deposits, indicating some turbulence of the water.

The late back-reef facies appears to have been deposited in a more restricted, less agitated, environment. It is very carbonaceous, black, and foul smelling when broken; and it is finer grained and contains fewer fossils than the early back-reef beds. Of the fossils found, few occur in life position, and some may have been washed in from the reef area. A thin, black shale 2 feet thick caps the back-reef sequence.

The thinly laminated and micro-cross-laminated dolomites and limestones of the overlying Whiteport Member suggest a return throughout the area to deposition in a low energy environment, below wave base. Mudcracks throughout this member, however, indicate frequent periods

of exposure and desiccation in the supratidal zone so that the water in which the carbonate mud accumulated was probably quite shallow.

The rarity of fossils in the Whiteport Member may reflect an originally uninhabitable environment for most shelly invertebrates.

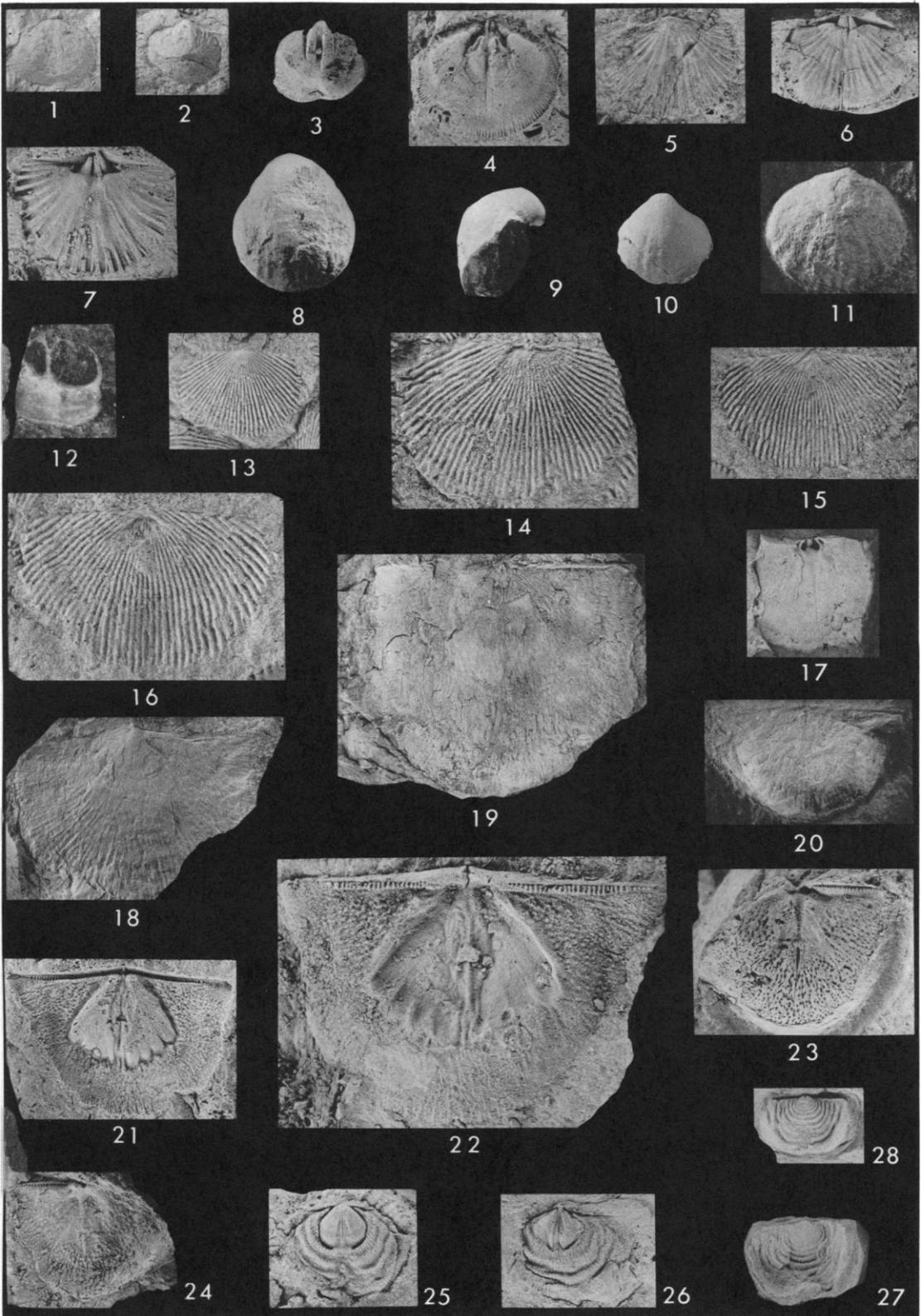
Recent work by Shinn and others (1964) on carbonate deposits in Florida and the Bahamas indicates that dolomite is presently forming on exposed lime mud flats where wetting by extreme high tides or storm flooding is followed by many days of subaerial exposure, and dolomite is penecontemporaneously replacing calcium carbonate. A similar origin seems likely for the dolomites in the Whiteport.

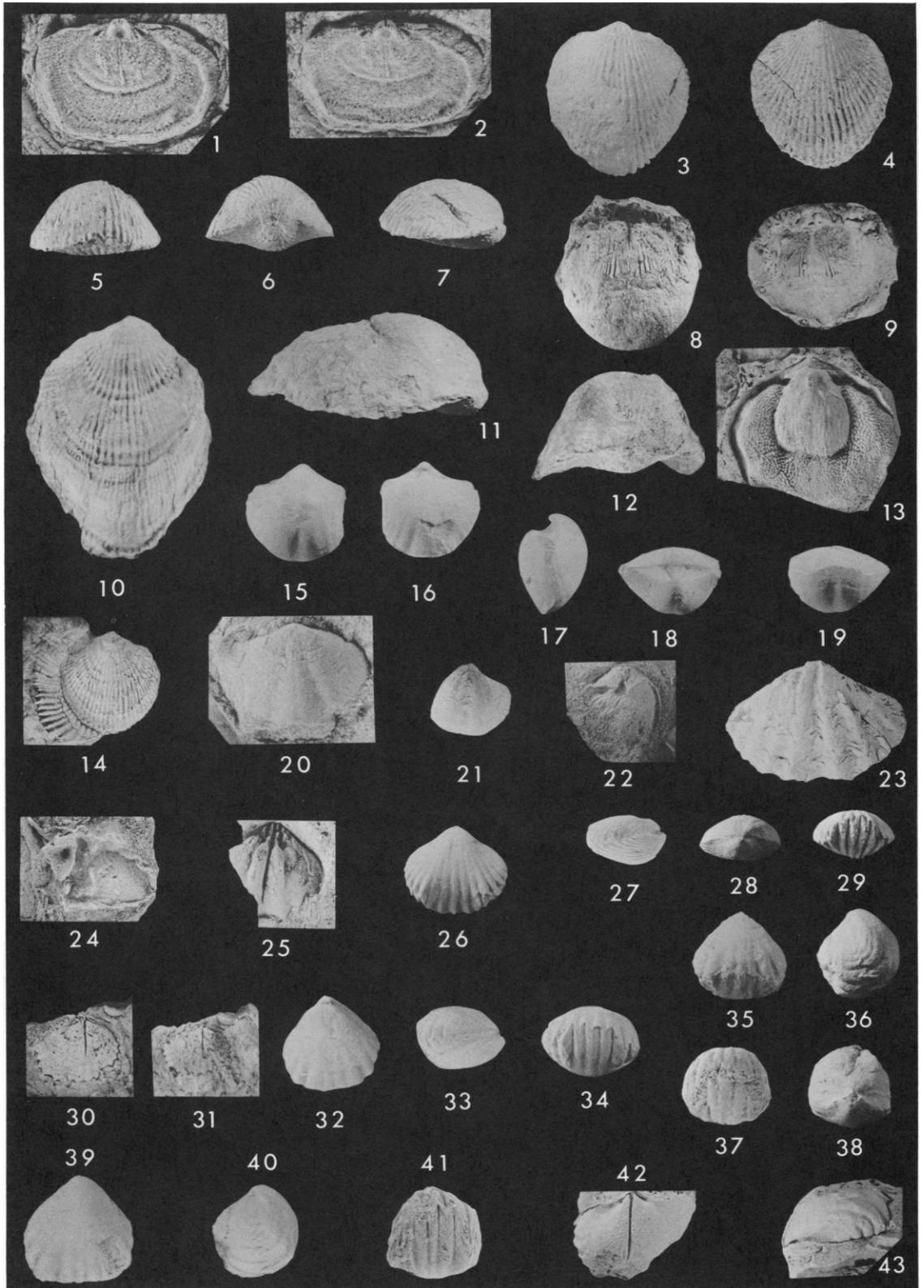
Similar origins also have been suggested by Laporte (1964) for dolomite horizons in the

EXPLANATION OF PLATE 1

(NYSM = New York State Museum)

- FIGS. 1-4—*Isorthis concinna* (Hall, 1859). Loc. 4, Accord, Rosendale Member, 0-4.6'. 1, Brachial exterior, $\times 1$, NYSM 12569; 2, pedicle exterior, $\times 1$, NYSM 12570; 3, impression of the pedicle interior; note the broad adductor muscle platform and the lateral ridges which bound the muscle field, $\times 1.2$, NYSM 12571; 4, impression of the brachial interior; note the impressions of the fulcral plates, $\times 2$, NYSM 12572.
- 5-7—*Dolerorthis* cf. *D. marylandica* (Maynard, 1913). Loc. 6, High Falls, Rosendale Member, 0-4.6'. 5, Brachial exterior, $\times 1$, NYSM 12573. Loc. 4, Accord, Rosendale Member, 0-4.6'. 6, Impression of the brachial interior, $\times 1$, NYSM 12574; 7, impression of the brachial interior; note the plate-like cardinal process, $\times 2$, NYSM 12575.
- 8-12—*Gypidula prognostica* (Maynard, 1913). Loc. 3, Port Jackson, Rosendale Member, 9.2-11.3'. 8, Pedicle exterior; note faint marginal plications, $\times 1$, NYSM 12576; 9, 10, lateral and pedicle views of another specimen, $\times 1.2$, NYSM 12577; 11, brachial exterior, $\times 1$, NYSM 12578; 12, section through a pedicle interior showing the posterior part of the spondylium duplex supported by the median septum, $\times 1$, NYSM 12579.
- 13-16—*Eccentricosta jerseyensis* (Weller, 1900). Loc. 4, Accord, Rosendale Member, 0-4.6'. 13, Pedicle exterior; faint spines on the hinge line diverge laterally at an angle of approximately 85 degrees, $\times 1.5$, NYSM 12580; 14, brachial interior; note cardinalia, $\times 2$, NYSM 12581; 15, impression of the pedicle interior, $\times 2$, NYSM 12582; 16, latex cast of the specimen shown in figure 15; a faint median septum is present, $\times 1.5$, NYSM 12583.
- 17-19—*Leptostrophia bipartita nearpassi* (Barrett, 1878). Loc. 4, Accord, Rosendale Member, 0-4.6'. 17, Partial impression of a brachial interior. The bilobed cardinal process is bounded laterally by socket plates, and the median ridge divides the muscle field; note the denticulate hinge line, $\times 1$, NYSM 12584; 18, partial pedicle exterior; note the curved postero-lateral costellae, $\times 1$, NYSM 12585; 19, partial pedicle interior; the ventral process has a central depression, $\times 0.8$; NYSM 12586.
- 20-24—*Strophonella* (*Strophonella*) sp. Loc. 4, Accord, Rosendale Member, 0-4.6'. 20, Partial brachial exterior, $\times 1$, NYSM 12587. Loc. 3, Port Jackson, Rosendale Member, 16.4-20.4'. 21, Impression of the pedicle interior, $\times 1$, NYSM 12588; 22, enlargement of a latex cast of the specimen shown in figure 21. The hinge line is completely denticulate. The large, flabellate diductor muscle scar is bisected by a low diductor platform, which is divided by a narrow median ridge. The interarea is wide; the delthyrium is partially closed by a pseudodeltidium, $\times 2$, NYSM 12589; 23, impression of the brachial interior, $\times 1.5$, NYSM 12590; 24, latex cast of the specimen shown in figure 23. The stout bilobed cardinal process is supported by the notothyrial platform, which extends anteriorly as the median ridge, and separates the muscle scars, $\times 1$, NYSM 12591.
- 25-28—*Leptaena* cf. *L. "rhomboidalis"* (Wilkins, 1769). Loc. 19, Flatbush School, Wilbur Member, 0-5.3'. 25, Impression of the pedicle interior, $\times 1.5$, NYSM 12592; 26, impression of the pedicle interior; note filling in the pedicle opening?, $\times 1.5$, NYSM 12592; 27, partial brachial exterior, $\times 1$, NYSM 12593; 28, pedicle exterior; note the small, apical foramen, $\times 1$, NYSM 12594.





Manlius Formation of New York, and by Gwinn & Clack (1964) for dolomites in the Tonoloway and Wills Creek Formation in Pennsylvania. The similar associations of thin laminations, mudcracks, micro-cross-laminations, and the lack of fossils, both in the modern and the ancient sediments, suggest similar origins of all.

CORRELATION
New Jersey

Hartnagel (1905) examined the outcrops of the Rosendale and Glasco Members of the Rondout Formation at Port Jackson and Accord and suggested the correlation of these, and more typical Rondout to the northeast, with the Decker Formation in New Jersey. The faunal similarity between these units is great, as can be

seen by comparing our text-figure 3 with text-figure 2 of Swartz & Whitmore (1956), and there can be little doubt of this correlation. Of the 14 brachiopod species described here from the Rondout, 9 are present in the more fossiliferous Decker Formation, and these include the most characteristic species of both units such as *Eccentricosta jerseyensis*, *Howellella modesta*, *Leptostrophia bipartita*, *Machaeraria? lamellata*, *Lanceomyonia globosa*, and *Cupularostrum litchfieldensis*. In addition, both contain abundant halysitid corals, *Coenites* and *Cyphotrypa corrugata*. The 39 feet of nearly barren strata overlying the Decker Formation which were called Rondout by Weller (1903, p. 76) and Swartz & Whitmore (1956, p. 1033-1034) apparently correlate with only the thinner Whiteport Mem-

EXPLANATION OF PLATE 2

- FIGS. 1,2—*Leptaena* cf. *L. "rhomboidalis"* (Wilkins, 1769). Loc. 19, Flatbush School, Wilbur Member, 0-5.3'. 1, Brachial interior; note the fused? cardinal process lobes, $\times 2$, NYSM 12595; 2, Postero-ventral view of the specimen shown in figure 1, $\times 2$, NYSM 12596.
- 3-14—*Atrypa reticularis* (Linnaeus, 1758). Loc. 3, Port Jackson, Rosendale Member, 9.2-32.6'. 3-7, Brachial, pedicle, anterior, posterior, and lateral views of a single specimen; 3,4 $\times 1$, 5-7 $\times 0.8$, NYSM 12597. Loc. 3, Port Jackson, Rosendale Member, 21-27'. 8, Posterior view of an impression of the brachial interior, $\times 1.3$, NYSM 12598; 9, Latex cast of the specimen shown in figure 8. The large notothyrial deposit is supported in the posterior by a short septum; note the median groove in the process?, $\times 1$, NYSM 12599. Loc. 1, Port Jackson, Rosendale Member, 7.5-17.7'. 10-12, Pedicle, lateral, and posterior views of a geniculate specimen, $\times 1$, NYSM 12600. Loc. 3, Port Jackson, Rosendale Member, 11.3-21.5'. 14, Pedicle view of a fringed specimen, $\times 1$, NYSM 12602. Loc. 4, Accord, Rosendale Member, 8.8-16.3'. 13, Impression of the pedicle interior; note the deposit in the delthyrium, the deeply impressed muscle area, and faint pallial trunks which converge with the antero-lateral edges of the muscle area, $\times 1.2$, NYSM 12601.
- 15-22—*Howellella modesta* (Hall, 1857). Loc. 3, Port Jackson, Rosendale Member, 15.3-16.7'. 15-19, Pedicle, brachial, lateral, posterior, and anterior views of a single specimen; note the faint lateral plications on either side of the fold and sulcus, $\times 1$, NYSM 12603; 20, brachial exterior. Faint spines? may be seen projecting anteriorly from each of the concentric growth lamellae, $\times 2.2$, NYSM 12604; 21, pedicle view of a more transverse specimen, showing lateral plications, $\times 1.5$, NYSM 12606; 22, Partial pedicle interior. The open, triangular delthyrium is bordered by deltidial plates which are perpendicular to the margin of the delthyrium, $\times 1.5$, NYSM 12605.
- 23-25—*Delthyris saffordi?* (Hall, 1859). Loc. 4, Accord, Rosendale Member, 0-4.6'. 23, Pedicle exterior, $\times 1.3$, NYSM 12607. Loc. 6, High Falls, Rosendale Member, 4.6-18.4'. 24, Partial brachial and pedicle interiors. The teeth are supported by stout dental lamellae; note the crural plates, $\times 1.2$, NYSM 12608. Loc. 1, Port Jackson, Rosendale Member, 7.5-17.7'. 25, Partial impression of the pedicle interior; note the strong median septum and dental lamellae, $\times 1$, NYSM 12609.
- 26-31—*Cupularostrum? litchfieldensis* (Schuchert, 1903). Loc. 3, Port Jackson, Rosendale Member, 9.2-32.6'. 26-29, Pedicle, lateral, posterior, and anterior views of a single specimen, $\times 1.8$, NYSM 12610. Loc. 2, Port Jackson, Rosendale Member, 0-16.5'. 30, Impression of the brachial interior, $\times 1.5$, NYSM 12611; 31, posterior view of the specimen shown in figure 30, $\times 1$, NYSM 12612.
- 32-43—*Lanceomyonia globosa* (Weller, 1903). Loc. 4, Accord, Rosendale Member, 0-15.9'. 32-34, Pedicle, lateral, and anterior views of a single specimen. Plications are present only on the anterior one-third of the shell; note the prominent concentric growth lines, $\times 2$, NYSM 12613. Loc. 20, Glasco, Glasco Member, 22-24'. 35-38, Pedicle, lateral, anterior, and posterior views of a more globose specimen, $\times 2$, NYSM 12614. Loc. 3, Port Jackson, Rosendale Member, 15.9-32.6'. 39-41, Pedicle, lateral, and anterior views of a single specimen; note the ridges at the anterior margins of the plications, 39 $\times 2$, 40-41 $\times 1.8$, NYSM 12615. Loc. 4, Accord, Rosendale Member, 0-15.9'. 42,43, Brachial and lateral views of an impression of the brachial interior; note bifurcating pallial trunks. The median septum extends to midlength. $\times 2$, NYSM 12616.

ber of the Rondout to the northeast (Rickard, 1962).

It is assumed here that the Rosendale and Glasco correlate with the full Decker interval because of the lack of contrary evidence and because they are of approximately the same thickness. As discussed earlier, the laminated dolomite underlying the Rosendale Member at Port Jackson perhaps correlates with the Bossardville Formation underlying the Decker Formation, as suggested by Wanless (1921, unpublished M.A. thesis, Princeton University). Hartnagel (1905), however, firmly stated that the laminated dolomites at Port Jackson are not the Bossardville but are part of the Poxono Island Formation. There is too little evidence at present to support either argument, and the dolomites at Port Jackson may even correlate with the lower part of the Decker.

Central New York

Rickard (1962, p. 29–31) has recently discussed the nomenclature of the Upper Silurian and Lower Devonian rocks of central New York and reviewed the correlations suggested by previous workers between these rocks and those of southeastern New York. The paleontologic evidence from the present study suggests that the Rosendale-Wilbur-Glasco interval correlates with the thinner Cobleskill Formation of central New York. The Cobleskill contains a small but varied fauna including the following brachiopods cited by Berdan (1964, p. B15):

"Schellwienella" interstriata (Hall)
Leptostrophia bipartita (Hall)
Eccentricosta jerseyensis (Weller)
Cupularostrum litchfieldensis (Schuchert)
Machaeraria? lamellata (Hall)
Lanceomyonia? sp.
Protathyris nucleolata (Hall)
Protathyris sulcata (Vanuxem)
Howellella corallinensis (Grabau)
Howellella eriensis (Grabau)

Of these brachiopods *L. bipartita*, *E. jerseyensis*, *C.? litchfieldensis*, and *M.? lamellata* occur in the Rosendale-Wilbur-Glasco interval of the Rondout. In addition, *H. corallinensis* and *H. eriensis* are very likely synonymous with *H. modesta* in the Rondout. The Cobleskill also contains *Cystihalysites* sp. On the basis of this faunal similarity, the Cobleskill appears to correlate with the Rosendale, Wilbur, and Glasco Members of the Rondout.

In central New York the Chrysler Member of the Rondout Formation overlying the Cobleskill is nearly unfossiliferous, containing *Howellella vanuxemi* and eurypterid fragments but little else (Rickard, 1962, p. 39). There appears to be no paleontologic evidence for correlating it with the Rondout of southeastern New York.

Pennsylvania, Maryland, and
West Virginia

The fossils found in the Rosendale, Wilbur, and Glasco Members of the Rondout Formation of southeastern New York closely resemble those of the *Eccentricosta jerseyensis* Zone of the Keyser Limestone in Pennsylvania, Maryland, and West Virginia. The Rondout fauna is not as diverse as that of the Keyser, but only 3 of the 14 brachiopod species described here from the Rondout were not found by Bowen (in press) in the thicker *E. jerseyensis* Zone of the Keyser. *Lanceomyonia globosa*, *Delthyris saffordi?*, and *Strophonella* (*S.*) sp. were not found in the Keyser, but the latter two are closely related to Keyser species. The brachiopods in common between the Rondout and the Keyser are species characteristic of the *E. jerseyensis* Zone, and they are most abundant in the middle and upper part of that zone (Bowen, in press, fig. 2). Some of them, such as *E. jerseyensis* and *Howellella modesta*, have not been found in rocks known to be older or younger than the *E. jerseyensis* Zone. In addition, *Cystihalysites* sp., *Cyphotrypa? corrugata*, and *Coenites* sp., which are common in the Rondout, are found in the *E. jerseyensis* Zone but rarely, or not at all, in the overlying *Meristella praenuntia* Zone of the Keyser. The stromatoporoids are the only fossils common between the Rondout and the Keyser which are more abundant in the *M. praenuntia* Zone than in the *E. jerseyensis* Zone.

On the bases of these faunal similarities, the Rosendale, Wilbur, and Glasco Members of the Rondout are correlated with the *E. jerseyensis* Zone of the Keyser Limestone. Since the *E. jerseyensis* Zone is between 100 and 150 feet thick in most places, the thinner Rondout probably corresponds only to the middle or upper part.

If this correlation is correct, then the unfossiliferous Whiteport Member may correlate with part of the upper Keyser, *Meristella praenuntia* Zone. The Binnewater and Bossardville? Formations, which appear to have been deposited in the same oscillating transgressive regime as the Rondout, without a prolonged time gap between them, may correlate with the lower part of the Keyser Limestone. However, no fossil evidence was found to support either of these correlations.

Age of the Rondout Formation

Bowen (in press), in discussing the age of the Keyser Limestone, concluded that the lower zone, the *E. jerseyensis* Zone, is Silurian in age because of the presence of *Cystihalysites* sp. No halysitid corals have yet been found in known

Devonian rocks. The upper Keyser zone, the *M. praenuntia* Zone, was concluded to be Devonian in age because it contains several brachiopods (*Meristella*, *Kozłowskiellina* (*Megakozłowskiella*), *Nanothyris*, and *Cyrtina*) which are characteristically found only in post-Silurian rocks.

Using the same line of reasoning, the Rondout Formation, at least the Rosendale, Wilbur, and Glasco Members, are considered to be Silurian because the Glasco contains *Cystihalysites*, and none of the other fossils present in the formation are found exclusively, or even more commonly, in Devonian rocks of other regions.

Nevertheless, more caution is necessary in establishing the age of the Rondout. Because of its stratigraphic position below the Helderberg Group and the Manlius Formation, and its apparent correlation with the Keyser Limestone, the Rondout undoubtedly lies near the Siluro-Devonian boundary. However, variations in the environment appear to have had a much greater effect on both the geographic and stratigraphic ranges of the fossils than did the temporal changes. The brachiopods are found in the limestone facies of the Rosendale and Wilbur Members and are rare or absent elsewhere. The halysitid corals are especially limited in their distribution, being confined to the thin, early back-reef facies of the Glasco. The presence or absence of fossils in such rapidly changing facies is due more to environmental factors than to time, and they cannot be used to distinguish with reliability the uppermost Silurian from the lowermost Devonian.

SYSTEMATIC PALEONTOLOGY

Phylum BRACHIOPODA

Superfamily ENTELETACEA Waagen, 1884

Family DALMANELLIDAE Schuchert, 1913

Genus ISORTHIS Kozłowski, 1929.

Type species: *Dalmanella* (*Isorthis*) *szajnochai* Kozłowski, 1929.

ISORTHIS CONCINNA (Hall, 1859)

Pl. 1, figs. 1-4

Orthis concinna HALL, 1859, p. 172, pl. 10a, figs. 1-3.
Dalmanella concinna MAYNARD, 1913, p. 301-302, pl. 54, figs. 11-13.

Description.—Outline subquadrate to semi-circular; width greater than length; greatest width approximately at midlength, or slightly posterior to midlength. Biconvex, pedicle valve more convex than brachial valve. Pedicle beak erect to slightly incurved, interarea apsacline, delthyrial opening triangular, unmodified. Brachial interarea orthocline to anacline, no opening observed; beak small. Cardinal margins diverge at 120-160 degrees. Brachial valve with a shallow sulcus, pedicle valve with a poorly de-

finied fold, anterior margin slightly sulcate. Surface finely costellate, and marked by a prominent growth line one-half to one-third the length of the shell. Shell punctate.

Brachial interior: Brachiophores blunt, diverge at 70 to 80 degrees; bases continue anteriorly as low ridges, bounding the postero-lateral part of the muscle field. Fulcral plates present. Cardinal process blade-like, continues anteriorly to merge with a low ridge, which extends for three-fourths of the length of the shell, bisecting the muscle field. Myophore with chevron grooves. Muscle field bisected transversely by a low ridge, and bounded anterolaterally by a low, discontinuous ridge.

Pedicle interior: Teeth blunt, supported by dental lamellae, and separated from the shell margin by narrow accessory sockets. Dental lamellae diverge from the posterior, but at one-third shell length become parallel and continue, to midlength. Diductor muscle scars bilobed, narrow, elongate, and deeply impressed, separated by a short, broad, median ridge which begins in the anterior part of the delthyrial cavity and continues to midlength. Anterior margin finely crenulate. No pallial markings observed.

Measurements (in mm).—

Length	Width	Length	Width
11	16	10	11
12	14	10	10
11	14	9	10
10	13	9	10
11	12	7	9

Discussion.—*Isorthis* is distinguished by its biconvex lateral profile and low fold and sulcus. Narrow, elongate diductor scars are present in the pedicle valve and are separated by a low elevated adductor track. Plate-like brachiophores with fulcral plates are present in the brachial valve. *Levenea* Schuchert & Cooper, 1931, is a very similar genus, but has a pentagonal pedicle muscle field, and appears to lack fulcral plates.

Type specimens of Hall's *Orthis concinna* (1859), from the Keyser Formation in Maryland, were examined and found to be similar in all characters to these shells. Hall's specimens were observed to have fulcral plates, a broad, poorly defined pedicle fold, a shallow brachial sulcus, and divergent dental lamellae extend anteriorly to define the lateral edges of the narrow, elongate diductor scars. The diductor scars are bilobed and divided by a broad, low, platform.

Hall (1982) assigned *I. concinna* to the genus *Dalmanella*, and this assignment was later continued by Maynard (1913), who described specimens in the Keyser Limestone of Maryland, West Virginia, and Pennsylvania. The species was placed in the genus *Levenea* by Schuchert & Cooper (1932, p. 123), although they queried the

assignment. Bowen (in press, pl. 1, figs. 1-8) assigned Keyser specimens to the genus *Isorthis* on the basis of the fulcral plates. Bowen's Keyser specimens were re-examined, and the fulcral plates are present on nearly all. Also present are the distinctive pedicle musculature, and the plate-like brachiophores. The Rondout specimens are identical to Bowen's specimens and to Hall's types from the Keyser Formation in Maryland.

I. concinna differs from *I. perelegans* (Hall, 1857, p. 44; 1859, p. 171, pl. 13, figs. 4-12) in that the dental plates and the ridges from the dental plates in *I. perelegans* converge anteriorly around the ventral muscle scars, whereas in *I. concinna*, they diverge at the posterior, then continue parallel toward the anterior.

I. arcuaria (Hall & Clarke, 1892), described by Amsden (1951, p. 76-77, pl. 15, figs. 39-44), from the Henryhouse and Brownsport Formations in Oklahoma, is more biconvex, and has shorter pedicle muscle scars than *I. concinna*.

I. pygmaea (Dunbar, 1919) from the Haragan Formation of Oklahoma (Amsden, 1958, p. 62-64, pl. 11, figs. 5-14) is much smaller than *I. concinna*, and the pedicle interarea is anacline, rather than apsacline, as in *I. concinna*.

Dalmanella (Isorthis) szajnochia Kozłowski (1929, p. 75-79, pl. 2, figs. 24-41) is more strongly biconvex than *I. concinna*, and the beaks are more rounded and pronounced. In the brachial valve, the transverse ridge bisecting the muscle field is stronger, and in the pedicle valve, the median ridge which divides the diductors bifurcates, and borders the adductor scars.

Occurrence.—Loc. 1, Rosendale, 5.4-17.7'; loc. 2, Rosendale, 0-6.9'; loc. 3, Rosendale, 9.2-22.1'; loc. 4, Rosendale, 0-4.6'.

Superfamily ORTHACEA Woodward, 1852

Family DOLERORTHIDAE Öpik, 1934

Subfamily DOLERORTHINAE Öpik, 1934

Genus DOLERORTSIS Schuchert &

Cooper, 1931

Type species: *Orthis interplicata* Foerste, 1909.

DOLERORTSIS cf. D. MARYLANDICA

(Maynard, 1913)

Pl. 1, figs. 5-7

Schuchertella marylandica MAYNARD, 1913, p. 332-333, pl. 61, figs. 5-9

Description.—Outline subquadrate to semi-circular. Width greater than length; greatest width near midlength. Brachial valve depressed-convex, more convex at umbo. Pedicle valve high but not curved in the posterior, flattened anteriorly and laterally, giving a wedge-shaped appearance in side view. Brachial interarea low, anacline; notothyrial opening wide and V-shaped. Pedicle interarea high, apsacline to

nearly catacline, delthyrial opening narrower than notothyrial opening. Brachial valve with a shallow sulcus beginning at the beak and broadening anteriorly. Surface ornamented with 14 to 18 primary costae, which begin near the beak, and continue undivided for one-third to one-half shell length. Each of these primary costae bifurcates or trifurcates at approximately one-half to one-third shell length. Each of the two primary costae which borders the brachial sulcus divides more posteriorly than the others, and these branches are directed toward the sulcus. The secondary costellae divide near the anterior margin. The largest of the eight specimens available for description was 21 mm wide and 16 mm long.

Brachial interior: Plate-like brachiophores supported posteriorly by the interarea marginal to the notothyrial cavity, and supported beneath in the posterior by deposits from the floor of the valve. The brachiophores diverge at approximately 90 degrees, and are slightly concave toward the midline. Sockets deep and wide. A blade-like cardinal process divides the raised floor of the notothyrial cavity, and extends slightly anterior to the brachiophores on the floor of the valve, to merge with a broad, low, median ridge, which extends slightly anterior to midlength. Interior costate.

Pedicle interior: None observed.

Discussion.—The external characteristics of the genus *Dolerorthis* are a high, apsacline pedicle interarea, open delthyrium and notothyrium, and multicostellate surface with unequally branching ribs marked by fine concentric filae. In the pedicle valve the teeth are stout, dental plates are short, and the muscle field is suboval. In the brachial valve blade-like brachiophores border a raised notothyrial cavity which is bisected by a single plate-like cardinal process.

Dolerorthis can be distinguished from *Schizoramma* Foerste, 1909 because the latter genus has accessory ridges lateral to the cardinal process and lacks concentric filae on the external surface (Boucot, 1960, p. 294).

Hesperorthis Schuchert & Cooper, 1931, differs from *Dolerorthis* in being more plano-convex to gently concavo-convex, in lacking concentric filae, in lacking the unequal rib branching pattern of *Dolerorthis*, and in having an apical plate in the delthyrium.

The Rondout specimens studied include molds of the interior of two brachial valves, seven specimens showing the brachial exterior and one good pedicle exterior. No specimens showing the internal features of the pedicle valve were found. The shell material is partially exfoliated on all the specimens collected so that concentric filae are not preserved. The generic assignment is based on the shape of the shells, angle of the

interareas, rib branching pattern, and brachial cardinalia.

The Rondout specimens appear to be identical to the type specimen of *D. marylandica* (Maynard, 1913, p. 332-333, pl. 61, figs. 5-9) and to specimens of *D. marylandica* described by Bowen (in press) from the Keyser Limestone in Maryland. They also appear to be conspecific with *D. fissiplica* (Roemer) from the Brownsport Formation of Tennessee (Amsden, 1949, p. 45, pl. 1, figs. 22-25). These two species are probably synonyms, but the Rondout and Keyser material is too poorly preserved to make this certain.

Dolerorthis cf. *D. marylandica* from the Rondout differs from "*D.*" *flabellites* (Foerste, 1889) from the Osgood Formation of Indiana (Foerste, 1909, p. 74-75, pl. 3, fig. 43) in the character of the costae. The costae of "*D.*" *flabellites* bifurcate in the posterior part of the shell, but not at the anterior edge, while in in the Rondout species they bifurcate into secondary and tertiary costae, which become much finer toward the anterior. "*D.*" *flabellites* has no brachial sulcus.

D. interplicata (Foerste, 1909, p. 76, pl. 3, fig. 44) has more primary costae, is somewhat more biconvex than the Rondout species and lacks the brachial sulcus.

Specimens identified as *D. flabellites* were described by Weller (1903, p. 231-232, pl. 20, fig. 20) from the Decker formation of New Jersey. The specimen illustrated, however, shows that there is a well-developed, although shallow, brachial sulcus, and the plications appear to be fewer in number and more irregularly added than in *D. flabellites*. It is possible that when the Decker Formation is re-examined, the species will prove to be conspecific with *D. marylandica*.

D. hami Amsden (1951, p. 77, pl. 16, figs. 1-8) is also quite similar to the Rondout species, but *D. hami* can be distinguished by its more strongly biconvex profile, longer pedicle interarea, and thicker costellae.

Occurrence.—Loc. 1, Rosendale, 7.5-16.2'; loc. 4, Rosendale, 0-4.6'; loc. 6, Rosendale, 0-4.6'.

Superfamily PENTAMERACEA M'Coy, 1844

Family PENTAMERIDAE M'Coy, 1844

Subfamily GYPIDULINAE Schuchert
& LeVene, 1929

Genus GYPIDULA Hall, 1867

Type species: *Gypidula typicalis* Amsden, 1953 (pro *Pentamerus occidentalis* Hall, 1858, non Hall, 1852).

GYPIDULA PROGNOSTICA (Maynard,
1913)

Pl. 1, figs. 8-12

Description.—Outline subcircular to suboval, width approximately equal to length. Biconvex,

pedicle valve much more convex than brachial valve. Pedicle beak incurved, brachial beak not seen. Palintrope high, apsacline; delthyrium not seen. Pedicle valve with a weak fold, developed only in the anterior half of the shell. Four to 7 weak plications present on the medial part of the anterior one-half to three-quarters of each valve. Plications absent laterally and posteriorly. Concentric growth lines present on both valves.

Brachial interior: Not seen.

Pedicle interior: Spondylium duplex joined laterally and posteriorly to the valve wall. Spondylium joined to median septum only in the posterior; anterior part free. Median ridge continues anteriorly to midlength.

The largest complete pedicle valve studied is 22 mm long and 21 mm wide.

Discussion.—Most of the material at hand is fragmentary. Two complete pedicle valves and one brachial valve were obtained. The pedicle interior was studied from transverse sections through rock and fossils.

Gypidula is distinguished by its galeatiform outline, strong spondylium duplex, and the strongly convex profile of the pedicle valve. It has a faint fold on the pedicle valve. Septal plates in the brachial valve unite with the valve floor.

The Rondout specimens appear to belong to the species *G. prognostica* (Maynard, 1913) from the Keyser Limestone. *G. prognostica* was designated as a variety of *G. coeymanensis* by Maynard (1913, pl. 344-345, p. 62, figs. 9-11) who distinguished them by the feebly developed fold and sulcus, indistinct plications, and the small size of *G. prognostica*. Bowen (in press) elevated *G. prognostica* to specific rank on the basis of the same characters and the fact that in *G. coeymanensis* the median plications extend nearly to the beak on both valves.

Although the interior of the brachial valve was not seen in these specimens, they so closely resemble Keyser Limestone shells, which have all the typical features of *Gypidula* including the septal plates of the brachial valve, that they are assigned to the genus *Gypidula* without a query.

The Rondout specimens are distinguished from *G. coeymanensis* (Schuchert, 1913, p. 342-345, pl. 62, figs. 4-7) in that the Rondout specimens have a weakly developed pedicle fold, indistinct plications on both the brachial valve and the pedicle valve which do not extend to the beak, and obsolete lateral plications.

G. circularis (Weller, 1903, p. 233, pl. 20, figs. 17-19) from the Decker Formation of New Jersey has a smooth surface, lacking fold and plications. A spondylium and median septum are present.

Occurrence.—Loc. 1, Rosendale, 7.5-9.5'; loc. 3, Rosendale, 9.2-11.2'.

Superfamily CHONETACEA Bronn, 1862
 Family CHONETIDAE Bronn, 1862
 Subfamily DEVONCHONETINAE
 Muir-Wood, 1962
 Genus ECCENTRICOSTA Berdan, 1963

Type species: *Chonetes jerseyensis* Weller, 1900.

ECCENTRICOSTA JERSEYENSIS
 (Weller, 1900)

Pl. 1, figs. 13–16

Chonetes jerseyensis WELLER, 1900, p. 8; 1903, p. 230–231, pl. 20, figs. 12,15,16; MAYNARD, 1913, p. 338–339, pl. 41, figs. 18,19; SWARTZ, F. M., 1939, pl. 2, fig. 2a,b.

Chonetes jerseyensis var. *nondivergens* SWARTZ & WHITMORE, 1956, p. 1090.

Eccentricosta jerseyensis BERDAN, 1963, p. 254–256, text-figs. 1a–c.

Description.—Profile plano-convex or concavo-convex; wider than long; greatest width at midlength or slightly posterior to midlength. Seven to 12 (average 9) costellae per 5 mm ornament the exterior. The median costellae radiate from the beak, but the lateral and postero-lateral costellae originate at the hinge line. In some specimens, the lateral costellae are markedly curved toward the anterior margin, but in other specimens of the same size, there is a complete gradation from straight to curved costellae. The costellae increase by bifurcation and intercalation. Fine concentric lines cross both the costellae and the interspaces. Each side of the pedicle hinge line is ornamented with 6 to 9 spines, which are postero-laterally directed at a high angle; those closer to the margins are more laterally directed. The beak and interarea on both valves are small and inconspicuous. Very fine striae on the interareas, perpendicular to the hinge line, are preserved on a few specimens.

Brachial interior: Cardinal process bilobed; posterior portion not observed. The lateral margins of the cardinal process are bordered by socket plates, which extend nearly parallel to the hinge line. Two narrow, short septa diverge at approximately 30 degrees from the anterior edge of the cardinal process and extend one-fourth the length of the shell or less. A smaller, median ridge extends to nearly one-fourth the shell length. Small pits in the posterior portion of the shell are interpreted as impressions of pseudopunctae. These are distributed radially, between the costellae.

Pedicle interior: Teeth stout, not supported by dental plates, rarely preserved. In the posterior, a thickened platform is present, which fills the posterior part of the pedicle valve between the teeth. In two specimens, this thickened portion extends anteriorly as a short median ridge. Two ridges or septa diverge at approximately 90 degrees from just anterior to the teeth. In some

specimens, these ridges are thickened and border a depression which may have been the area of attachment of the diductor muscles. A pair of smaller, shorter ridges is present within this depressed area.

Measurements (in mm).—

Length	Width	Number of ribs per 5 mm*	Number of spines, beak to margin
Pedicle valve			
17	23	9	8
13	22	10	9
14	20	9	8
12	19	10	10
13	8	10	7
9	16	10	5
10	14	11	5
10	13	11	7
10	12	10	7
9	11	10	6
7	8	12	5
Brachial valve			
17	26	9	
13	22	10	
14	21	9	
10	18	11	
11	14	11	
11	14	9	
10	12	9	
6	8	14	
7	8	13	

* Measured at the anterior.

Discussion.—*Eccentricosta jerseyensis* from the Rondout Formation is in no way different from *Chonetes* (= *Eccentricosta*) *jerseyensis* Weller (1900, p. 8; 1903, p. 230–231, pl. XX, figs. 12–16) from the Decker Formation of New Jersey. Weller included forms with straight lateral ribs and those with curved lateral ribs in the species, suggesting that because all gradations existed between the two forms, there seemed no immediate justification for putting them into separate species. Swartz & Whitmore (1956, p. 1090), also studying specimens from the Decker Formation, described assemblages including forms with straight and with curved lateral costellae and designated the form with straight lateral costellae as *Chonetes* (= *Eccentricosta*) *jerseyensis* var. *nondivergens*. Bowen (in press, pl. 2, figs. 7–8,11–12) gave *E. nondivergens* specific rank, in specimens from the Keyser Formation of Maryland, Virginia, West Virginia, and Pennsylvania. In the Keyser, *E. jerseyensis* is distinguished from *E. nondivergens* by the character and number of the costellae, by the angle at which the spines project from the hinge line of the pedicle valve, and by the fact that the two species usually are not found together.

The two forms, which are also present in the Rondout Formation, can be separated only by the differences in the curvature of the costellae, and this character shows a complete gradation

within specimens of the same size. Both forms, and gradations between them, are found on the same bedding planes. Following Weller, both are considered to be *Eccentricosta jerseyensis*.

Eccentricosta? jerseyensis var. *spinus* (Maynard, 1913, p. 339, pl. XLI, fig. 20) may be a variant form of *E. jerseyensis*. Maynard distinguished it from *E. jerseyensis* by its slightly more convex character, more marginal spines on each side of the beak, and coarser, more nodose costellae.

Occurrence.—Loc. 1, Rosendale, 5.4-14.5'; loc. 3, Rosendale, 9.2-20.0'; loc. 4, Rosendale, 0-3.7'.

Superfamily STROPHOMENACEA King, 1846

Family STROPHEODONTIDAE Caster, 1939

Genus LEPTOSTROPHIA Hall & Clarke,
1892, emended Williams, 1953

Type species: *Stropheodonta magnifica* Hall, 1857.

LEPTOSTROPHIA BIPARTITA NEARPASSI

(Barrett, 1878)

Pl. 1, figs. 17-19

Stropheodonta nearpassi BARRETT, 1878, p. 372.

Stropheodonta bipartita WELLER, 1903, p. 226, pl. 20, figs. 1-5.

Stropheodonta (Leptostrophia) bipartita MAYNARD, 1913, p. 316, pl. 57, figs. 17, 18.

Stropheodonta (Leptostrophia) bipartita var. *nearpassi* PROUTY & SWARTZ, 1923, p. 426, pl. 18, fig. 4

Description.—Outline subquadrate; profile concavo-convex to plano-convex; greatest width at the straight hinge line. Mucronate extensions preserved on some specimens. Parvi-costellate; spaces between the costellae approximately 5 times the width of a costella. Costellae spaced further apart at the margins, and curve toward the posterior. They increase by intercalation, adding from 1 to 3 new costellae at a time. Pedicle interarea apsacline, brachial interarea anacline. Beaks small and inconspicuous. Concentric filae present on well-preserved specimens. On very small specimens, 1 cm or less, these filae are prominent, but costellae are present only on specimens larger than 1 cm. Hinge line denticulate the full length, or nearly so. Pseudopunctae in rows between the costellae.

Brachial interior: Cardinal process bilobed; myophores directed postero-laterally. A median ridge extends from the base of the cardinal process, broad at the posterior, becoming narrower at the anterior end, near midlength. Lobes of the cardinal process bounded laterally by short socket plates. Median ridge separates oval adductor muscle scars. Muscle scars bounded by short, straight, narrow, lateral ridges.

Pedicle interior: Triangular diductor scars are bounded laterally by ridges, which diverge at approximately 80 degrees from the beak. Process pits deep. Ventral process platform-like, with

central depression. The process extends anteriorly as a narrow, low, median ridge, which separates the adductor scars. Diductor field divided by 3 or 4 accessory lateral ridges; not strongly papillose. Anterior and lateral portions of the shell strongly papillose.

Measurements (in mm).—

Width	Length
52	43
46	36
45	42
39	38
38	30
34	30
27	22
27	22
26	27
11	8
7	6

Discussion.—The genus *Leptostrophia* Hall & Clarke (1892), which was redescribed by Williams (1953), is similar to the genus *Protopleptostrophia* Caster (1939), except for the presence of socket plates in *Leptostrophia*. Specimens from the Rondout Formation are assigned to the genus *Leptostrophia* because socket plates are present.

Leptostrophia nearpassi (Barrett, 1878, p. 372) described from specimens from the Decker Formation at the Nearpass Quarry, New Jersey, was illustrated by reference to Hall's species *Leptaena* sp., *Leptaena bipartita*, and *Stropheodonta textilis* (1852, p. 326-328, pl. 74, figs. 3a,b, 4,5,6a-d) from the Cobleskill Formation of New York. According to Barrett, the only difference between those species and *L. nearpassi* was that in *L. nearpassi*, "the postero-lateral radiate striae are more arcuate," whereas those of Hall's species are straight. Weller (1903, p. 226, pl. 20, figs. 1-5) placed Barrett's *L. nearpassi* in synonymy with Hall's species and designated all four as *Stropheodonta bipartita*. The specimens Weller (1903) found in the Nearpass Quarries had curved costellae like those found by Barrett. *Stropheodonta (Leptostrophia) bipartita* described by Maynard (1913) from specimens from the Keyser Limestone were considered to be conspecific with *Leptostrophia bipartita* described by Weller (1903) because of the presence of the curving costellae. Prouty & Swartz (1923, p. 426, pl. 18, fig. 4), in describing specimens from the Tonoloway Formation in West Virginia, felt that the specimens with the curved costellae differed so constantly from Hall's specimens with straight costellae that they should be given standing as a "variety" of *Stropheodonta (Leptostrophia) bipartita*, namely, *S. (L.) bipartita* var. *nearpassi*. Bowen (in press, pl. 3, figs. 8-10; pl. 4, figs. 1-2) gave similar specimens from the Keyser Formation subspecific rank as *L. bipartita nearpassi*.

Specimens from the Rondout Formation are referred to the subspecies *L. bipartita nearpassi* on the basis of the curved costellae.

Occurrence.—Loc. 1, Rosendale, 5.4–34.8'; loc. 2, Rosendale, 0–20.5'; loc. 3, Rosendale, 9.2–39.6'; loc. 4, Rosendale, 0–19.4'; loc. 6, Rosendale, 0–4.6'; loc. 7, Rosendale, 27.0–31.6'; loc. 19, Wilbur, 0–6.7'.

Genus STROPHONELLA Hall, 1879,
emended Williams, 1953

Subgenus STROPHONELLA (STROPHONELLA)
Hall, 1859, emended Williams, 1953

Type species: *Strophodonta semifasciata* Hall, 1863.

STROPHONELLA (STROPHONELLA) sp.
Pl. 1, figs. 20–24

Description.—Outline subquadrate to semi-circular; brachial valve concave in the posterior, geniculate at an angle of approximately 60 degrees slightly beyond midlength. Pedicle valve convex in the posterior, and near midlength bends away from the brachial valve in a long trail. Degree of curvature at the geniculation varies among specimens. Greatest width at the hinge line, which projects beyond the rest of the shell into short mucronate extensions. Brachial interarea anacline, pedicle interarea apsacline. Delthyrium partially covered in the posterior half by a pseudodeltidium. Beaks small, but project slightly beyond the hinge line. Surface ornamented with very fine rounded costellae, 22 per 5 mm at the geniculation, which increase by bifurcation, trifurcation, and intercalation. Extremely fine concentric lines cross the costellae. Faint concentric rugae are observable in the posterior of some specimens. Pseudopunctae in radial rows between the costellae. Hinge line denticulate nearly the whole length.

Brachial interior: Cardinal process bilobed, with postero-ventrally projecting faces. Process supported at the base by a callus swelling, which extends anteriorly as a low, median ridge, to midlength, and continues to the anterior as a poorly defined ridge. Thin, short, socket plates laterally closely bound the process. Round muscle attachment area deeply impressed in the posterior, and defined postero-laterally by ridges which diverge at approximately 110 degrees from the cardinal process support, then curve anteriorly. The adductor scars are divided by the median ridge.

Pedicle interior: A triangular platform or ventral process with a median groove is present in the posterior part of the valve, and extends anteriorly to midlength, to form a low, narrow ridge, which bisects the muscle field. Process pits are deep. A large, subtriangular, posteriorly

deeply impressed muscle field is bordered postero-laterally by broad ridges or callus deposits, which diverge at approximately 80 degrees from from posterior to the ventral process. Antero-laterally, the muscle scar is bounded by a petaloid ridge, and further subdivided by accessory lateral ridges or myophragms. The adductor scars are lenticular, raised on a low platform, and well-defined, both anteriorly and posteriorly by low, narrow, curved ridges, which are continuous with the lateral edges of the ventral process. The postero-lateral part of the valve is closely papillose.

Measurements (in mm).—

	Width	Length to geniculation	Length beyond geniculation* (or trail)
Brachial valve			
	32	18	11
	32	13	8
	31	18	9
	31	16	8
	30	15	11
	29	17	—
	29	16	10
	27	16	10
	24	16	8
Pedicle valve			
	34	18	8
	34	16	—
	32	15	—
	31	18	—
	31	17	9
	30	18	—
	30	16	9
	26	16	9

* Length measured from geniculation to anterior margin.

Discussion.—This species was placed in the genus *Strophonella* because of the presence of the stout ventral process, pedicle median ridge, and large pedicle muscle area bounded anteriorly by a ridge with a petaloid appearance. It has short socket plates in the brachial valve. It was placed in the subgenus *Strophonella* (*Strophonella*) because of the absence of dental plates. It is different from "typical" *Strophonella* in that the pedicle muscle area is sub-triangular rather than quadrate, and the hinge line is nearly completely denticulate, while the hinge line of *Strophonella* typically is denticulate one-half its length. The pedicle adductor scar is raised above the diductor scar on a low platform, and is defined by low ridges.

Strophonella (*Strophonella*) sp. from the Rondout is distinguished from the other species of the genus discussed below by having denticles along nearly the entire hinge line, whereas most of the others have denticles along less than one-half the length of the hinge line. In addition, they can be distinguished as follows.

S. semifasciata (Hall, 1879, p. 153–154) from the Lockport Formation, has a less impressed, smaller pedicle valve muscle attachment area. The cardinal process is more conjunct and has longer myophores, and the brachial median ridge is not well-developed.

S. leavenworthana (Hall, 1859, p. 189–190, pl. 21, figs. 5–7; pl. 23, figs. 1–3), from the lower Helderberg Group in the Helderbergs, is similar in size, shape, ornamentation, and presence of a well-developed brachial median ridge, but the brachial muscle area is elongate, whereas that of these specimens is round. The pedicle muscle scar is subquadrate.

S. alterniradiata Amsden (1951, p. 80, pl. 18, figs. 45–51) from the Henryhouse Formation, Oklahoma, is much smaller than the Rondout specimens. The radial ornamentation consists of two distinct sizes of costellae.

S. prolongata Foerste (1903, p. 711) from the Brownsport Formation, Tennessee, is approximately the same size as the Rondout specimens, but the ornamentation is coarser in *S. prolongata*, and the brachial interior has a reduced median ridge which is flanked by two well-developed lateral ridges in the central part of the valve.

S. laxiplicata Foerste (1903, p. 711) from the Brownsport Formation, has two alternating sizes of costellae, and the ornamentation is more coarse. The brachial median ridge is shorter and more poorly developed.

S. loeblichii Amsden (1951, p. 81–82, pl. 20, figs. 36–41), from the Henryhouse Formation, Oklahoma, is very similar to these specimens, but the ornamentation is more coarse, and is of the alternating type. The pedicle muscle area is smaller, and has a straight transverse ridge, rather than a petaloid one.

S. roemerii Foerste (1903, p. 711) from the Brownsport Formation is much larger and more coarsely ornamented and is triangular in outline.

S. dixoni Foerste (1909) from the Henryhouse Formation is much smaller and more alate (Amsden, 1949, p. 51–52, pl. 5, figs. 6,7).

S. (Strophonella) bransoni Amsden (1958, p. 70–73, pl. 4, figs. 15–21) from the Haragan Formation, Oklahoma, is more coarsely costellate.

S. geniculata (Hall, 1859, p. 483, pl. 23, figs. 6a–c) from the Keyser Formation in Maryland has a pedicle fold and a brachial sulcus.

S. (S.) sp., figured by Williams (1953, pl. 13) from the Birdsong Shale, Tennessee, and *S. (S.)* sp., described by Bowen (in press, pl. 2, figs. 13–16), from the Keyser Formation, have a more quadrate pedicle muscle scar.

S. (S.) cavumbona (Hall, 1859) and *S. (S.) punctulifera* (Conrad, 1838), both from the lower

Helderberg Group of New York, are similar in many features to the Rondout species. The differences between these two older species are unclear and several writers (Hall, 1892; Schuchert, 1913) have suggested that they be placed in synonymy. Berdan (1949, unpublished Ph.D. thesis, Yale University) has pointed out that there are differences in the type specimens which warrant retaining both species. The bifurcation and trifurcation of costellae in *S. (S.)* sp. distinguish it from Hall's *S. (S.) cavumbona* in which costellae are added by implantation. *S. (S.) punctulifera* has denticles along less than one-half of the length of the hinge line, and by this characteristic it can be distinguished from the Rondout species.

Occurrence.—Loc. 1, Rosendale, 12.9–17.7'; loc. 2, Rosendale, 0–2.9'; loc. 3, Rosendale, 16.4–20.4'; loc. 4, Rosendale, 0–4.6'.

Family LEPTAENIDAE Hall
and Clarke, 1894

Genus LEPTAENA Dalman, 1828

Type species: *Leptaena rugosa* Dalman, 1828.

LEPTAENA cf. L. "RHOMBOIDALIS"
(Wilckens, 1769)

Pl. 1, figs. 25–28; pl. 2, figs. 1, 2

Description.—Outline subquadrate; concavo-convex to plano-convex; greatest width at hinge line. Pedicle hinge line slightly alate, brachial hinge line straight, projected into short mucronate extensions which are not often preserved. Pedicle valve geniculate, at nearly a 90 degree angle, at approximately three-fourths of the length of the shell. Brachial valve parallel to the pedicle valve anterior to the geniculation. Beaks reduced and inconspicuous. A round, epithyrid foramen was seen in two specimens. Brachial interarea anacline, pedicle, apsacline. Posterior portions of both valves marked by 7 to 12 coarse concentric rugae. Anterior to the geniculation, there is no concentric ornamentation. Costellae (14 to 21 per 5 mm; average 17) cross both the rugae and the interspaces. Pseudopunctae occur in radial rows between the costellae. Costellae increase by bifurcation, trifurcation, and intercalation.

Brachial interior: Stout, bilobed cardinal process present; the lobes are fused but separated at the posterior by a central groove. Cardinal process lobes diverge at approximately 50 degrees, and have flat, postero-ventrally projecting myophores. Each lobe of the process is postero-laterally supported by a callus-swelling, which also forms one side of each dental socket. These swellings extend anteriorly, surrounding the circular muscle field, and end as two narrow, anteriorly-projecting ridges, near mid-length. The

muscle field is bisected by a narrow ridge which originates just anterior to the cardinal process, and extends to slightly beyond midlength. Dental sockets are oval and elongate, and are bounded in the posterior by the hinge line.

Pedicle interior: Teeth are supported by dental plates, which diverge and surround the muscle field. Diductor muscle field deeply impressed, circular to oval, divided by a median ridge which extends to the geniculation. Elongate adductor scars situated on a low platform, which is wider in the anterior.

Measurements (in mm).—

Width	Length*	Costellae	Number of
Brachial valve		per 5 mm†	rugae
26	18	14	11
22	17	17	12
21	15	14	12
19	9	15	9
18	10	14	8
17	11	18	8
16	10	15	10
15	11	—	9
Pedicle valve			
20	14	21	7
18	12	16	10
18	11	15	7
17	12	18	10
17	12	18	8
16	12	17	9
15	9	—	11
14	9	17	10
14	10	—	7
13	10	17	9
12	10	18	8
9	6	24	7

* Length measured to geniculation.

† Costellae measured at the geniculation.

Discussion.—*L. "rhomboidalis"* from the Rondout Formation differs from *L. cf. L. "rhomboidalis"* described by Bowen (in press, pl. 4, figs. 3–5) from the Keyser Formation in that the lobes of the cardinal process are fused in the Rondout specimens but are not in the Keyser specimens.

L. rhomboidalis described by Weller (1903, p. 228, pl. 20, fig. 10) from the Decker Formation of New Jersey may be conspecific with the Rondout specimens. However, Weller points out that all the specimens he found were "smaller than usual, with proportionately coarser concentric wrinkles."

Occurrence.—Loc. 1, Rosendale, 16.2–27.3'; loc. 2, Rosendale, 6.9–20.5'; loc. 3, Rosendale, 28.5–39.6'; loc. 4, Rosendale, 10.6–15.9'; loc. 18, Wilbur, 0–7.1'; loc. 19, Wilbur, 0–5.3'; loc. 20, Glasco, 22–24'.

Superfamily ATRYPACEA Gill, 1871
 Family ATRYPIDAE Gill, 1871
 Subfamily ATRYPINAE Gill, 1871
 Genus ATRYPA Dalman, 1828

Type species: *Anomia reticularis* Linnaeus, 1758.

ATRYPA RETICULARIS (Linnaeus, 1758)

Pl. 2, figs. 3–14

Description.—Outline semicircular to subcircular or elongately suboval; width greater than, equal to, or less than length; greatest width between posterior margin and mid-length. Hinge line short, usually less than or equal to one-half the width of the shell. Profile biconvex; brachial valve more convex than pedicle valve. Pedicle valve convex at umbo, straight to concave at lateral and anterior margins. Some specimens much more biconvex than others. Pedicle beak suberect to erect, closely pressed against suberect brachial beak. Brachial fold and pedicle sulcus variably developed, from non-existent to strong on anterior third of large shells. On some specimens, the anterior and lateral margins are produced into a thin fringe, which may be one-third or more of the length of the shell. On other specimens, anterior part of the brachial valve strongly geniculate toward the pedicle valve, with a smooth curve, the pedicle valve bending away from it in a trail. On those specimens with a fringe or trail, the fold and sulcus are poorly developed or lacking, while on the non-fringed, less geniculate specimens, the fold and sulcus are more commonly present. Fold and sulcus not present on small shells. Surface ornamented by 5 to 9 rounded costellae per 5 mm (average 7), measured 10 mm anterior to the beak, which increased by bifurcation. Concentric growth lamellae cross both costellae and interspaces, but are stronger on the costellae, sometimes flaring to form spine-like projections. Growth lamellae more strongly developed toward the anterior.

Brachial interior: Large hinge plates diverge anteriorly, are inclined laterally, joining with the convex inner socket walls. Crural plates slightly thickened on the underside. A small secondary deposit is present in the posterior of the notothyrial floor. In three specimens, there is a large, subtriangular cardinal process, formed by the medial junction of the crural plates. The process has a ventral face with a median ridge, and an anterior face with a median groove (pl. 2, fig. 9). Sockets are wide, with a median ridge which articulates with a complementary groove lateral to the teeth in the pedicle valve. Muscle scars semicircular, lightly impressed, separated by a short, low, median myophragm, which begins slightly anterior to the umbo, and reaches nearly to midlength. In the specimens which have a cardinal process, the muscle scars are deeply impressed. A pair of small, oval adductors is raised on a low platform, surrounded by the more deeply impressed diductor scars. Muscle

Measurements (in mm).—

Length	Width	Thickness	Number of costellae per 5 mm*	Fold, Sulcus	Fringe, or geniculation†
36	31	15	5	weak	—
32	26	24	7	pronounced	—
31	30	17	6	—	geniculate†
31	28	16	7	—	—
31	30	9	7	—	geniculate†
29	28	9	5	weak	geniculate
29	27	19	8	weak	—
29	30	— (b.v.)	7	weak	fringe (11)‡
29	28	— (b.v.)	5	weak	fringe
28	30	13	7	—	fringe
28	30	10	5	—	fringe
28	28	16	7	weak	—
28	26	10	6	—	fringe
27	26	13	7	—	fringe (10)
27	26	9	7	weak	geniculate
25	25	9	7	weak	geniculate
22	26	6	5	—	fringe (10)
21	20	11	8	weak	—
19	19	11	8	—	fringe (8)
18	18	10	6	—	geniculate
17	16	11	9	weak	—
13	14	— (b.v.)	7	—	—
12	14	4	5	—	fringe (3)
8	7	3	—	—	—

* Measured 10 mm anterior to the beak.

† Geniculation included in length measurement.

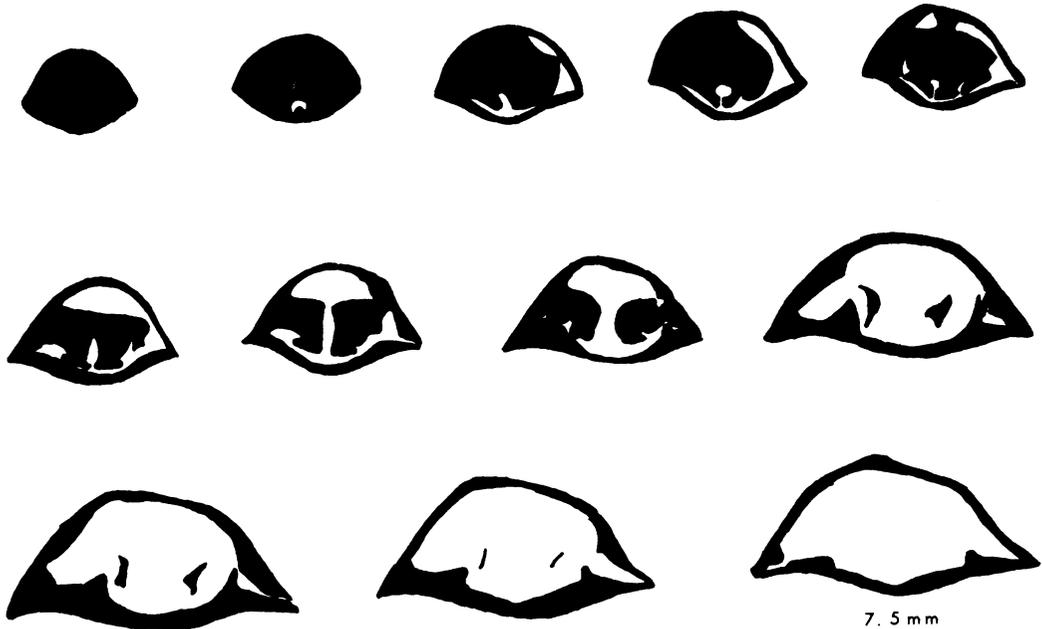
‡ Fringe measured where possible; not measured, but presence noted, where broken.

b.v. = brachial valve.

scars are divided by low, radiating myophragms, and surrounded by ridges which are the anterior continuations of low deposits on the floor of the valve beneath the crura. Genital? markings are confined to muscle scar margins in the posterior and lateral parts of the shell. Apices of the spires are directed toward the brachial valve.

Pedicle interior: Large teeth are attached to the shell walls, and separated from the edges of the shell by accessory sockets. The teeth are supported on the inner edges by plates which descend to the floor of the valve, defining narrow, shallow, umbonal cavities. In some specimens, a pedicle callist fills the posterior of the delthyrial cavity. The muscle area is suboval. In specimens with the pedicle callist, the muscle field is deeply impressed, and surrounded laterally and antero-laterally by a ridge, which is continuous with the teeth supports. In the anterior, the ridge is lower. The adductor scars are suboval, and raised on a low platform which is bisected by a deep median groove. The groove is continuous with the more deeply impressed diductor scars. The diductor scars are divided by radiating myophragms. The interior of the shell outside of the muscle scar areas is papillose. Vascular impressions consist of two main trunks which merge with the antero-lateral margins of the diductor scars. Each main trunk bifurcates into two main branches, one of which is directed laterally, the other, anteriorly.

Discussion.—Specimens of *Atrypa reticularis* bearing a massive deposit filling the notothyrial cavity have been described and discussed by Bowen (1964; 1966; in press) from the Keyser Formation of West Virginia, Virginia, Maryland, and Pennsylvania. Bowen noted that all the specimens he collected of the species were similar externally, and all possessed features typical of *Atrypa reticularis*. The specimens which have a massive deposit in the notothyrial cavity, however, were found primarily in deposits suggesting a turbulent environment of deposition, while the specimens with normal cardinalia were found primarily in deposits suggesting a non-turbulent environment of deposition. Fossils from the Rondout Formation must be studied exclusively by internal molds and by serial sections, and time did not allow for an intensive study such as that done by Bowen. However, the deposits in which the *Atrypa reticularis* are found are medium grained, argillaceous limestones and dolomites, with many fragmental fossils, suggesting that a somewhat turbulent environment existed at the time of disposition. Four brachial interiors were studied, three of which have the massive deposit in the notothyrium. The other brachial interior contained small, but not extensive secondary deposits. Three pedicle interiors were studied, one of which was normal.



TEXT-FIG. 4—Serial sections of *Atrypa reticularis*, $\times 3$, approximately equal intervals.

Other features of this species are also suggestive of environmental control such as the wide variation in relative convexity of the valves, the variability in the development of a marginal fringe and of the fold and sulcus, and the geniculation of many of the specimens from the Rosendale Member.

Occurrence.—Loc. 1, Rosendale, 5.4–27.3'; loc. 2, Rosendale, 0–18.1'; loc. 3, Rosendale, 9.2–32.6'; loc. 4, Rosendale, 0–15.9'; loc. 6, Rosendale, 0–12.6'; loc. 7, Rosendale, 27.0–41.3'; loc. 9, Rosendale, 11.6–28.8'; loc. 10, Rosendale, 0–8.7'; loc. 13, Rosendale, 24.4–32.6'; loc. 15, Rosendale, 0–1.9'; loc. 16, Rosendale, 12–30.6'; loc. 17, Wilbur, Rosendale, 11.4–30.9'; loc. 19, Wilbur, Rosendale, 0–6.9'; loc. 18, Wilbur, 0–7.1'.

Superfamily DELTHYRIDACEA Phillips, 1841

Family DELTHYRIDIDAE Phillips, 1841

Subfamily DELTHYRIDINAE Phillips, 1841

Genus HOWELLELLA Kozłowski,
1946 (= CRISPELLA Kozłowski, 1929)

Type species: *Terebratulata crispa* Hisinger, 1826.

HOWELLELLA MODESTA (Hall, 1857)

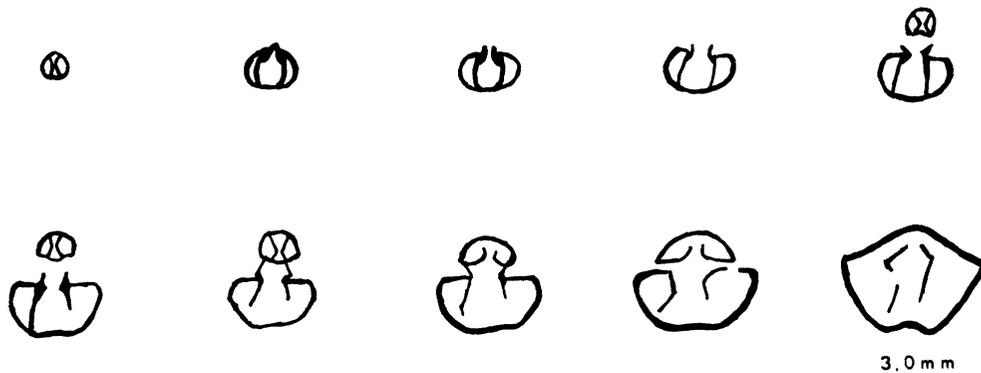
Pl. 2, figs. 15–22

Spirifer modesta HALL, 1857, p. 61.

Spirifer modestus HALL, 1859, p. 203, pl. 8, figs. 1 a–f;
MAYNARD, 1913, p. 339–400, pl. 68, figs. 17–22;
SWARTZ, F. M., 1929, p. 56, pl. 6, figs. 16, 17.

Spirifer modestus var. *plicatus* MAYNARD, 1913, p. 400–401, pl. 68, figs. 23, 24; SWARTZ, F. M., 1929, p. 56, pl. 6, figs. 18, 19.

Description.—Outline semicircular to transversely oval. Width usually greater than length, but may be equal to, or less than, length. Greatest width at hinge line. Lateral and anterior margins strongly rounded. Biconvex, pedicle valve much more convex than brachial valve. Pedicle beak prominent, erect to slightly incurved. Pedicle interarea apsacline, one-half to three-quarters the width of the shell, concave, wide, longitudinally striated. Brachial interarea narrow, shorter than pedicle interarea, anacline. Delthyrium wider than high; bordered by narrow deltidial plates which are at an angle of approximately 50 degrees to the interarea, which coalesce at the top of the delthyrium. Pedicle valve with a sulcus, brachial valve with a fold, beginning slightly anterior to the beaks, more pronounced at the anterior margin. Both variable in intensity, but with U-shaped cross sections, always present. Lateral crenulations or plications present on several specimens, most prominent at the anterior, beginning near mid-length, but also variable in intensity: some very



TEXT-FIG. 5—Serial sections of *Howellella modesta*, $\times 2.5$, approximately equal intervals.

faint. Faint, concentric, evenly-spaced growth lines present, becoming more pronounced near the anterior. Radial flae present, projecting as spines at each growth lamella. Sulcus projecting as a slight, rounded tongue into the fold on some specimens. Fold usually with a median groove, originating at the beak and continuing to the anterior.

Brachial interior: Well-developed crural plates bordering large sockets. Crural plates convex toward the midline, reaching the floor of the valve only in the posterior, and diverging anteriorly to one-fourth the length of the shell. No muscle scars or median myophragm observed.

Pedicle interior: Small teeth supported by anteriorly divergent dental lamellae, which define wide but short umbonal cavities, extending one-fourth the length of the shell. Dental lamellae continuing anteriorly as low ridges to beyond midlength. Deltidial plates joined to the dental lamellae approximately half-way to the floor of the valve, and continuous with them, and with

the teeth, to the posterior of the shell (text-fig. 5, sections 2-5).

Discussion.—*Howellella* can be distinguished internally from *Delthyris* by the absence of a pedicle median septum, which is pronounced in *Delthyris*.

In the original description of *Howellella modesta*, from specimens from the lower Helderberg Group in Maryland, Hall (1857, p. 61) made no mention of lateral plications. The type specimens were examined and were found to be well-weathered and poorly preserved; no lateral plications were present. On one specimen, however, the growth lamellae near the anterior were 'scalloped,' indicating the possible presence of lateral plications. A median groove on the fold is present.

Maynard (1913, p. 400-401, pl. 68, figs. 23,24) described specimens of *Howellella modesta* with lateral plications from the Keyser Limestone in West Virginia and Maryland. He gave these specimens a separate varietal name, *H. m.* var.

Measurements (in mm).—

Length	Width	Thickness	Length	Width	Thickness
17	15	11*	11	17	—* b.v.
16	19	10*	11	13	—* p.v.
15	18	— b.v.	10	14	7*
14	18	—* p.v.	10	14	—* p.v.
14	14	10	9	14	18*
13	17	— p.v.	9	13	— p.v.
13	15	10*	9	12	— b.v.
13	15	— p.v.	9	10	— p.v.
12	14	— p.v.	8	12	7*
12	14	10*	7	10	6
12	13	— p.v.	7	8	5
12	12	9			

b.v., p.v., indicates valve measured.

* Indicates plicate specimens.

plicata. He distinguished this form from the 'typical' form by the more transverse character, better developed fold and sulcus, and the more pronounced lateral plications. Specimens from the Rondout Formation show all gradations between plicate and non-plicate forms and are thus all considered to be *Howellella modesta*.

Rondout specimens differ from *H. modesta* from the Keyser Limestone by having a mesial groove or depression in the brachial fold, which, according to Bowen (in press), is infrequently developed in the Keyser specimens.

Howellella corallinensis (Grabau, 1900, p. 352) is similar to *H. modesta*. Berdan (1949, p. 217 unpublished Ph.D. thesis, Yale University) noted the similarity between these but distinguished *H. corallinensis* in the Cobleskill of New York, from *H. modesta* from the Keyser Formation in Maryland, by the less well-developed fold and sulcus in *H. modesta*, the more erect pedicle beak, and the less transverse character. Since there is a great deal of variability in these characters in both species, it is possible that they are synonymous.

Occurrence.—Loc. 1, Rosendale, 7.5–17.7'; loc. 3, Rosendale, 15.3–16.7'; loc. 4, Rosendale, 0–4.6'; loc. 6, Rosendale, 0–4.6'; loc. 9, Rosendale, 20.5–28.2'; loc. 10, Rosendale, 0–8.7'.

Subfamily DELTHYRIDINAE Phillips, 1841

Genus DELTHYRIS Dalman, 1828,

emended Boucot, 1957

Type species: *Delthyris elevata* Dalman, 1828.

DELTHYRIS SAFFORDI? (Hall, 1859)

Pl. 2, figs. 23–25

Spirifer saffordi HALL, 1859, p. 203, pl. 28, fig. 2a–f.

Description.—Laterally elongate, greatest width at hinge line or slightly anterior to the hinge line. Length between one-half and three-fourths width. Biconvex, pedicle valve more convex than brachial valve. Brachial valve with a well-developed fold, with a rounded cross-section. No median groove present. Pedicle valve with a well-developed sulcus. Exterior of brachial valve marked by 4 lateral plications on each side of the fold; pedicle valve marked 4 to 5 lateral plications on each side. A sixth plication is sometimes present, on larger specimens, but is poorly developed. Exterior of both valves marked by non-frilly growth lamellae. No spines observed. The cross-sections of the plications and the spaces between them are V-shaped. Brachial beak small, suberect to erect. Pedicle beak erect. Brachial interarea narrow, orthocline pedicle interarea wide, concave, apsacline, and laterally striated. Delthyrium open, higher than wide; no deltidial plates observed. Posterior margin includes an angle of 110–140 degrees.

Brachial interior: Crural plates are divergent at an angle of approximately 30 degrees and supported by the socket walls. Crural plates extend to the floor of the valve, forming a V-shaped depression at the posterior. A faint median myophragm is present. Interior strongly plicate.

Pedicle interior: Teeth stout, supported by dental lamellae which extend approximately one-fourth of the length of the valve. Dental lamellae are convex toward the midline, diverge laterally, toward the anterior, and continue as ridges to three-fourths shell length, bounding the muscle area. Diductor muscle field deeply impressed, elongately oval, bisected by a well-developed, narrow, median septum, which extends nearly to midlength, then abruptly tapers off. Interior strongly plicate.

Measurements (in mm).—

Width	Length	Thickness	Lateral plications	
			Brachial valve	Pedicle valve
31	20	—	—	5
29	18	—	—	5*
28	—	15	—	4
28	18	—	—	5
27	17	—	—	4
26	18	—	—	4*
26	16	14	4*	4*
26	14	—	—	4
24	15	11	4	4*
20	11	8	—	4
14	10	—	—	4
14	9	—	—	4

* Indicates one additional poorly developed lateral plication present.

Discussion.—*Delthyris* is characterized by non-frilly growth lamellae, a pedicle median septum, and well-developed dental lamellae in the pedicle valve. It has short crural plates in the brachial valve.

Delthyris saffordi? from the Rondout Formation has 4 or 5 plications on each lateral slope of the pedicle valve and 4 on the brachial valve, and it differs from other species placed in the genus as follows:

Spirifer (Delthyris) magnus Kozłowski (1929, p. 188–189, pl. 10, figs. 4–9) from Podolia has 6 or more lateral plications, and a groove in the brachial fold, with a corresponding small plication in the pedicle sulcus.

Delthyris kozłowskii Amsden (1951, p. 91–92, pl. 18, figs. 32–38), from the Henryhouse Formation, Oklahoma, has the same number of plications as *D. saffordi*, but the width more closely equals the length, and the dental lamellae are not as well developed as in *D. saffordi?*.

Topotype material of *D. hyndmanensis* Bowen (in press, pl. 6, figs. 34–43) was examined, and

found to have 2 lateral plications on the brachial valve and 3 on the pedicle valve.

The specific assignment is queried, because only two good brachial valves were found, and the range of variations of the number of plications on the lateral slopes cannot be determined.

Occurrence.—Loc. 1, Rosendale, 7.5–17.7'; loc. 2, Rosendale, 0–2.9'; loc. 3, Rosendale, 5.2–20.5'; loc. 4, Rosendale, 0–4.6'; loc. 6, Rosendale, 4.6–18.4'; loc. 7, Rosendale, 31.6–42.1'; loc. 9, Rosendale, 11.6–17.2'; loc. 10, Rosendale, 0–8.7'; loc. 14, Rosendale, 32.2–48.7'; loc. 15, Rosendale, 0–1.9'; loc. 16, Rosendale, 12–30.6'; loc. 17, Rosendale, 11.4–20.7'; loc. 19, Rosendale, 0–5.3'.

Superfamily RHYNCHONELLACEA Gray, 1848

Family TRIGONIRHYNCHIIDAE Schmidt, 1965

Genus CUPULAROSTRUM Sartenaer, 1961

Type species: *Cupularostrum recticostatum* Sartenaer, 1961.

CUPULAROSTRUM? LITCHFIELDENSIS

(Schuchert, 1903)

Pl. 2, figs. 26–31

Rhynchonella? litchfieldensis SCHUCHERT, 1903, p. 167.

Rhynchonella agglomerata WELLER, 1903, p. 234–235, pl. 21, figs. 5–11.

Camarotoechia litchfieldensis MAYNARD, 1913, p. 353, pl. 63, figs. 11–14; SWARTZ, 1929, p. 54, pl. 6, figs. 3, 5.

Description.—Shell small, outline sub-triangular; biconvex, convexity of valves nearly equal. Greatest width near anterior. Width slightly greater than, or equal to, length. Thickness greater than one-half width. Postero-lateral margins straight, lateral and antero-lateral margins curved; anterior margin straight or gently curved. Commissure crenulate, uniplicate. Pedicle beak suberect, extending beyond brachial beak, with a round, apical foramen. Posterior angle 80 to 100 degrees. Surface ornamented by 16–23 simple, angular plications which originate at the beak. Fold on brachial valve with 4, sometimes 5, plications; sulcus on pedicle valve with 3, sometimes 4 or 5, plications. Fold and sulcus originate near midlength, but are most prominent at the anterior. Fine growth lines observable near the anterior on some specimens. Deltidial plates not observed. Interiors determined from serial sections of one specimen, and from two brachial and two pedicle internal molds.

Brachial interior: Septalium with a cover plate present. Cover plate convex in the posterior, flat near the middle, and concave at the anterior. Sockets long and narrow, not crenulated. Hinge plates supported medially by the lateral edges of the septalium, and attached to inner socket walls. Hinge plates inclined medially, and the inner edges are raised as ridges along the

margins of the cover plate of the septalium. Median septum extends nearly to midlength. Crura attached to the inner edges of the hinge plates, and curved ventrally. Muscle scars not observed.

Pedicle interior: Teeth small, supported by short dental lamellae which diverge at approximately 60 degrees, and define narrow umbonal cavities. Dental lamellae do not continue anteriorly as ridges. Muscle scars not observed.

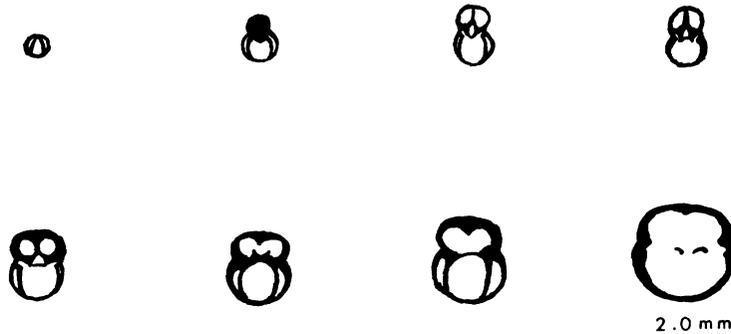
Measurements (in mm).—

Length	Width	Thick- ness	Plications		Total plications	
			Fold	Sulcus	Bra- chial valve	Ped- icle valve
9	10	6	5	5	19	21
8	9	6	4	3	18	17
8	9	5	4	3	17	18
8	8	4	4	4	22	20
7	8	5	5	5	19	20
7	8	5	5	4	20	17
7	8	5	4	3	17	18
7	7	4	4	3	21	20
7	7	4	5	4	24	21
7	7	5	6	5	21	23
7	7	4	4	3	19	20
6	7	4	4	3	19	16
6	6	4	4	3	19	19
6	6	4	4	3	23	20
4	4	3	4	3	19	18

Discussion.—The genus *Cupularostrum* is distinguished externally by its small size, anterior development of the fold and sulcus, and simple, angular plications. Dental plates are present in the pedicle valve, and in the brachial valve a covered septalium is supported by a septum which extends to half the shell length.

The Rondout specimens are assigned to *Cupularostrum* because they more closely resemble that genus than any other known to the authors. There are, however, several differences between these specimens and the type species of *Cupularostrum*. The cover plate over the septalium in *Cupularostrum* is arched and bears a median longitudinal ridge on the ventral surface. In the Rondout specimens this structure is convex in the posterior, flat near the middle and concave at the anterior. No median ridge is present. The sockets of the Rondout specimens lack a crenulated ridge. In *Cupularostrum* the sockets contain a ridge which articulates with a groove in each tooth of the pedicle valve (Sartenaer, personal communication, 1966). This feature can be seen only in the serial sections of type specimens of *Cupularostrum*. Because the taxonomic importance of these characters is not known at present, but may indicate that they belong to different genera, the identification is queried.

Camarotoechia Hall & Clarke, 1893, emended Sartenaer, 1961a, includes species which have an uncovered septalium, rounded, more irregular



TEXT-FIG. 6—Serial sections of *Cupularostrum? litchfieldensis*, $\times 3$, approximately equal intervals.

plications, which increase by bifurcation, a fold and sulcus beginning close to the beak, and a variable outline.

Cupularostrum? litchfieldensis differs from "*Rhynchonella? neglecta* (Hall, 1852, p. 274–275, pl. 57, fig. 1 a–p), from the Rochester Shale of New York, and from "*Rhynchonella? transversa* Hall (1859, p. 234, pl. 34, figs. 9–16) from the New Scotland Formation of New York, in having less pronounced growth lines at the anterior and more plications.

C.? litchfieldensis from the Rondout Formation is similar to *C.? litchfieldensis* from the Cobleskill Formation, described by Berdan (1949, p. 190–193, pl. 1, figs. 19–24, unpublished Ph.D. thesis, Yale University), but differs from those from the Keyser Formation (Bowen, 1963, p. 199–206, p. 7, figs. 28–33) in being less variable in the ratio of length to width.

Occurrence.—Loc. 1, Rosendale, 5.4–27.3'; loc. 2, Rosendale, Glasco, 0–20.5'; loc. 3, Rosendale, 9.2–32.6'; loc. 4, Rosendale, 0–15.9'; loc. 6, Rosendale, 0–18.4'; loc. 7, Rosendale, 27–41.3'; loc. 9, Rosendale, 6–28.8'; loc. 10, Rosendale, 0–8.7'; loc. 17, Wilbur, 16.6–20.7'; loc. 19, Wilbur, 0–6.7'.

Family UNCINULIDAE
Rzonsnitskaya, 1956

Subfamily HEBETOECHEINAE
Havlíček, 1960

Genus LANCEOMYONIA Havlíček, 1960

Type species: *Terebratula tarda* Barrande, 1847.

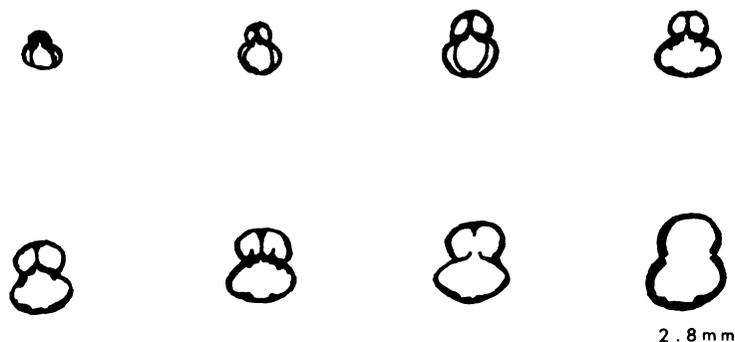
LANCEOMYONIA GLOBOSA (Weller, 1903)
Pl. 2, figs. 32–43

Wilsonia globosa WELLER, 1903, p. 235, pl. 21, figs. 5–11; MAYNARD, 1913, p. 369, 370, pl. 56, figs. 15–17.

Description.—Shell small, outline subcircular to subtriangular; greatest width between midlength and anterior margin. Width slightly greater than, or equal to, length. Biconvex, brachial valve much inflated. Pedicle valve flattened. Beaks small, pointed; pedicle beak suberect, pressed tightly against brachial beak. Brachial beak suberect to erect, enters delthyrium. Postero-lateral margins slightly rounded, diverging at approximately 85 to 100 degrees. Lateral and anterior margins rounded, anterior face nearly vertical. An indistinct pedicle sulcus and brachial fold begin in the anterior third of the shell and are prominent at the anterior margin, where the commissure is strongly uniplicate. The pedicle sulcus extends as a tongue into the brachial fold. Surface ornamented with 12 to 18 (average 14) rounded plications beginning anterior to midlength, which are flattened and split into prongs near the anterior margin, each bifurcation being produced into a spine which articulates with a groove in the opposite valve. Pedicle sulcus with 3 plications, brachial fold with 4. Faint concentric growth lines ornament the posterior one-half to two-thirds of the shell, becoming stronger anteriorly, crossing the plications and interspaces, producing a zigzag effect.

Brachial interior: Hinge plates supported medially by a strong median septum, and joined to inner socket walls, forming a small septalium. No cover plate was observed. Crura crescent-shaped in cross-section, convex medially, attached to the inner margins of the hinge plates. Median septum reaches nearly to midlength. Muscle field broad, subcircular, lightly impressed.

Pedicle interior: Stout teeth supported by short, thin, dental lamellae which define somewhat narrow umbonal cavities. Dental lamellae



TEXT-FIG. 7—Serial sections of *Lanceomyonia globosa*, $\times 2.8$, approximately equal intervals.

continue anteriorly as low ridges, to approximately one-fourth shell length, bordering the narrow muscle field, as shown in text-figure 7, sections 4 through 8.

Measurements in (mm).—

Length	Width	Thick- ness	Plications		Plica- tions per valve
			Fold	Sulcus	
12	12	11	6	5	18
11	12	9	4	3	14
11	12	8	4	3	14
10	12	9	5	5	16
9	9	9	4	3	12
9	9	7	4	3	12
8	9	7	4	3	16
7	7	6	4	3	12
7	8	7	4	3	14

Discussion.—The genus *Lanceomyonia* Havlíček, 1960 is distinguished by its subcircular to sub-pentagonal outline, fold and sulcus developed only at the anterior, and nearly vertical anterior face. The pedicle interior has well-developed dental lamellae; the brachial interior has a septalium without a cover plate, supported by a median septum. Plications are developed only in the anterior half of the valves. It is distinguished from *Hebetoechia* Havlíček, 1959, in the character of the cardinalia, which in *Hebetoechia* consist of a separated septalium with a bilobed cardinal process, while *Lanceomyonia* has no cardinal process.

In *Lanceomyonia*, the narrow ventral muscle field is bordered on both sides by a narrow but distinct marginal ridge, while in *Hebetoechia* the ventral muscle impressions are faint, and no marginal ridge is present.

Havlíček distinguished *Lanceomyonia* from *Sphaerirhynchia* Cooper & Muir-Wood, 1951,

by the absence of dental lamellae in *Sphaerirhynchia*, the presence of plications over the entire surface of the valves, and the wide ventral muscle field. In *Lanceomyonia*, there are well-developed dental lamellae, a narrow ventral muscle field, and the posterior portion of the valves is not plicate.

Cupularostrum Sartenaer, 1961b, differs from *Lanceomyonia* in the presence of a cover plate over the septalium and of plications which begin at the beak.

A distinct cover plate over the septalium does not appear to be present in the specimens at hand. The hinge plates approach each other closely over the anterior part of the cruralium but do not touch. Serial sections were made of one specimen, and internal molds of one brachial and one pedicle valve were available for study. Eight complete specimens were found. It is certain, however, that plications do not exist on the posterior half of the valves, and that well-developed dental lamellae are present. The pedicle muscle field is narrow and bordered by ridges. For those reasons the specimens were assigned to the genus *Lanceomyonia*.

Several American and European species of *Lanceomyonia* have formerly been assigned to the genus *Sphaerirhynchia* Cooper and Muir-Wood (1951) (= *Wilsonella* Nikiforova, 1937, = *Wilsonia* Kayser, 1871). The interior of the type species of *Sphaerirhynchia*, *Terebratula wilsoni* Sowerby from the Silurian of Britain, has apparently never been described, and from this fact stems a great deal of confusion. Davidson (1852, pl. 13, figs. 12–14) illustrated internal molds of the brachial and pedicle interiors, as well as the brachial exterior of specimens which he identified as *Terebratula wilsoni*, from the

Silurian of Britain. The figures of these specimens show the brachial median septum, the wide pedicle muscle field, and entirely plicate surface of the brachial valve. Dental lamellae are absent. Kozłowski (1929, p. 159–160, pl. 7, figs. 27–34), however, described a species, *Camarotoechia* (*Wilsonia*) *wilsoni* from Podolia which he considered to be the same as the type species of *Sphaerirhynchia*. This species has dental plates confined to the umbonal region, a strong median septum supporting a septalium partially closed in the anterior by the junction of the hinge plates, and plications which begin at the beak. He also described a species which he felt to belong to the same genus, *Camarotoechia* (*Wilsonia*) *tarda*, which is now the type species of *Lanceomyonia*. That species differs from *Sphaerirhynchia wiltoni* in that the plications begin in the anterior half of the valve. It has a narrow ventral muscle field, which is limited laterally by weak ridges, and divided by a weak median ridge.

Nikiforova (1937, p. 74) described a "variety" of a species which she believed to be the same as the type species of *Sphaerirhynchia* from the Isfara beds of the Central Asiatic region of the U.S.S.R. This species, *Wilsonella* (= *Sphaerirhynchia*) *wiltoni* var. *ivorica*, has well-developed dental lamellae, plications which begin in the anterior half of the shell, and a median septum supporting a divided hinge plate. She differentiated it from "typical" *W. wiltoni* by the plicae beginning in the anterior half of the valves, whereas the plicae of typical specimens of *W. wiltoni* begin at the beak. It is probable that this "variety" belongs to the genus *Lanceomyonia*.

Lanceomyonia globosa, as described by Weller (1903, p. 235–236, pl. 21, figs. 12–22) from specimens from the Decker Formation of New Jersey has well-developed dental lamellae, narrow ventral muscle scars with ridges as extensions from the dental lamellae bounding them, and with only the anterior half of the shell plicate. Specimens from the Rondout Formation are identical with those from the Decker Formation.

Berdan (1949, unpublished Ph.D. thesis, Yale University) described two species from the Cobleskill Formation of New York, which she assigned to the genus *Sphaerirhynchia*: both have well-developed dental lamellae, and only the anterior half of the shells are plicate. These two species probably belong to the genus *Lanceomyonia*. Her species *L. dunbari* (p. 198–200, pl. 1, figs. 1–5) and *L. cobleskillensis* (p. 201–202, pl. 1, figs. 6–10) differ from specimens from the Rondout Formation in having a median ridge in the pedicle valve, and the dental lamellae do not continue anteriorly as low ridges. Externally, *L.*

cobleskillensis has fewer plications than the Rondout specimens.

Occurrence.—Loc. 1, Rosendale, 7.5–27.3'; loc. 2, Rosendale, 5.5–20.5'; loc. 3, Rosendale, 15.9–32.6'; loc. 4, Rosendale, 0–15.9'; loc. 6, Rosendale, 0–4.6'; loc. 19, Wilbur, 0–5.3'; loc. 20, Glasco, 22–24'.

Family RHYNCHOTREMATIDAE Schuchert, 1913
Subfamily ORTHORHYNCHULINAE Cooper, 1956
Genus MACHAERARIA Cooper, 1955

Type species: *Rhynchonella formosa* Hall, 1859.

MACHAERARIA n. sp. (Bowen, in press)
Pl. 3, figs. 1–8

Description.—Outline subtriangular to transversely suboval; width greater than length. Greatest width at midlength or slightly anterior to midlength. Biconvex, brachial valve more convex than pedicle valve. Lateral margins smoothly curved; anterior margin straight or curved. Posterior includes an angle of 110 to 140 degrees. Pedicle beak nearly straight to suberect, extended posterior to brachial beak, with a round permesothryd foramen. Conjunct deltidial plates at apex of delthyrium. Prominent fold on brachial valve; sulcus on pedicle valve extended as a tongue into the fold. Surface ornamented by 17 to 23 simple angular plications, which originate at the beak. Fold with 3 to 4 plications; sulcus with 2 to 3.

Brachial interior: Hinge plates attach laterally to inner socket walls. Sockets long and narrow. Inner socket wall convex toward midline. Hinge plates approach each other very closely in the posterior, and diverge toward the anterior. Crura crescent-shaped in cross-section, and are attached to inner edge of the hinge plates, continuing posteriorly as a ridge beneath each plate, to join the floor of the valve; they continue anteriorly for a short distance as low ridges. A narrow blade-like cardinal process is present, which is slightly expanded into a ventral face; and it continues as a low, narrow ridge, to one-fourth shell length. Sockets not crenulated.

Pedicle interior: Small teeth, supported by dental lamellae which define short, narrow, umbonal cavities. No pedicle median septum or ridge. Deltidial plates interiorly constrict pedicle opening.

Discussion.—These specimens are placed in the genus *Machaeraria* on the basis of the presence of discrete hinge plates, dental lamellae, a blade-like cardinal process, and crura which extend posteriorly as ridges under the edges of the hinge plates. The specimens are dissimilar to *Machaeraria*, as described by Cooper (1955), in the presence of conjunct, rather than disjunct,

Measurements (in mm).—

Length	Width	Thick- ness	Plications		Total/ Valve
			Fold	Sulcus	
14	17	11	3	2	21
13	18	11	4	3	23
13	16	7	3	2	18
13	15	9	4	3	22
12	17	—	3	—	17
11	14	9	3	2	23
11	13	7	4	3	18
11	12	6	3	2	19
10	15	7	3	2	19
10	12	6	4	3	20
10	11	5	4	3	18
10	11	5	3	2	17
10	10	8	4	3	20
10	10	4	3	2	17
9	9	6	3	2	21

deltidial plates, which constrict the pedicle opening, and the presence of a permesothyrid foramen.

M. formosa (Hall, 1859, p. 236–237, pl. 35, figs. 6a–y) lacks a permesothyrid foramen, and has disjunct deltidial plates. Hall's figures show that the species has forms with 2 plications in the sulcus and 3 on the fold, as well as those with 3 plications in the sulcus and 4 on the fold.

The specimens from the Rondout Formation are conspecific with a new species of *Machaeraria* described by Bowen (in press) from the Keyser Limestone. The Rondout specimens differ from those from the Keyser only in the variability of the number of plications in the sulcus and on the fold. Thirty topotype specimens of the Keyser species were examined, and it was found that there are consistently 3 plications on the fold, and 2 on the sulcus; only one specimen was seen on which there were 4 on the fold and 3 in the sulcus. Rondout specimens include both these forms, in approximately equal proportions, and specimens from these formations are otherwise alike.

Rhynchotrema formosa (Hall), described by Weller (1903, p. 309, pl. 36, figs. 12–15), from the Becraft and New Scotland Formations in New Jersey, is probably a species of *Machaeraria*, but it has fewer plications than the Rondout specimens. The position of the foramen is not mentioned, and it does not show in the figures specimens.

Rhynchonella deckerensis Weller (1903, p. 234, pl. 21, figs. 1–4) also may belong to *Machaeraria*; it has a similar number of plications to this species but the position of the foramen is not mentioned, and does not show on the figured specimens.

Occurrence.—Loc. 1, Rosendale, 5.4–17.7'; loc. 2, Rosendale, Glasco, 0–20.5'; loc. 3, Rosendale, 9.2–38.1'; loc. 4, Rosendale, Glasco, 0–19.4'; loc. 6, Rosendale, 0–4.6'.

MACHAERARIA? LAMELLATA (HALL, 1852)

Pl. 3, figs. 9–13

Description.—Shell small, outline subpentagonal to semicircular; width greater than length. Postero-lateral margins straight, meeting at an angle of 140 to 170 degrees. Profile biconvex, brachial valve slightly more convex than pedicle valve. Pedicle beak erect to slightly incurved, closely pressed over brachial beak; brachial beak suberect. Brachial fold and pedicle sulcus begin slightly anterior to the umbos, becoming pronounced anteriorly. The pedicle sulcus extends as a tongue into the brachial fold. The surface is ornamented with from 10 to 15 rounded plications. Three, sometimes two or four, plications are found on the fold, and from one to four in the sulcus. The lateral plications originate at the beak, but the plications on the fold and in the sulcus increase by bifurcation or intercalation from the 1 or 2 plications which originate at the beak. Strong concentric growth lamellae cross both plications and interspaces.

Brachial interior: Triangular hinge plates discrete, supported laterally by inner socket walls, and diverge anteriorly at an angle of approximately 45 degrees. Sockets long and narrow. A low, narrow, ridge-like cardinal process divides the floor of the notothyrium on one specimen, but is absent on others. A low median ridge begins slightly anterior to the notothyrial cavity, and extends to midlength, broad in the posterior, but narrower in the anterior. The median ridge and cardinal process are separated. Large transversely suboval diductor scars faintly impressed, divided by the median ridge. Adductor scars not seen. Crura crescent-shaped in cross-section, concave medially; they diverge anteriorly, and curve toward the pedicle valve.

Pedicle interior: Teeth small, supported by short, thin dental lamellae which diverge at an angle of 45 to 50 degrees, and define shallow umbonal cavities. Muscle scars not observed.

Discussion.—These small specimens appear to be conspecific with those first described by Hall (1852, p. 329) as *Atrypa lamellata* from the Cobleskill Formation. The species also occurs in the Tonoloway Limestone (Prouty & Swartz, 1923, p. 434, pl. 20, figs. 1–7) and the Keyser Limestone (Maynard, 1913, p. 352) in Maryland and West Virginia, and in the Decker Formation in New Jersey (Weller, 1903, p. 237, pl. 21, figs. 23–29). The Tonoloway and Keyser Limestone specimens differ consistently from those in the Decker, Rondout, and Cobleskill Formations by having only one plication in the sulcus and two on the fold of most specimens. All of the specimens, however, are characterized by the lamellose growth lines for which the species is named.

Measurements (in mm).—

Length	Width	Thick- ness	Number of plications		Total plications per valve
			Fold	Sulcus	
10	13	—	3	—	15
10	12	—	3	—	15
9	6	—	3	—	11
9	12	—	3	—	15
9	11	—	—	3	15
9	10	—	—	3	11
8	14	—	3	—	13
8	12	—	4	—	12
8	10	—	4	—	12
7	10	—	—	3	12
7	10	—	—	1	11
7	8	5	3	2	14
7	5	—	—	1	11
6	10	3	3	2	12
6	7	4	3	4	12
6	7	—	3	—	12
5	6	—	3	—	13
4	5	3	2	1	10
4	4	—	—	3	11
3	3	—	—	3	13

The interiors of the Rondout specimens were studied from serial sections of two specimens, from three internal molds (one of the pedicle valve and two of the brachial valve), and from one brachial interior.

This species is assigned, with considerable uncertainty, to the genus *Machaeraria* because it has many of the external and internal features of that genus. The assignment is queried because the material at hand is not well-preserved, the plate-like cardinal process, a characteristic of *Machaeraria*, is preserved on only one specimen, and, unlike other species of *Machaeraria*, this species has strongly developed growth lamellae and plications which are added anterior to the beaks. In the last two characters it resembles lamellose species of *Atrypa*; but the sectioned specimens show no trace of a spirulum and the specimens are otherwise rhynchonelloid in appearance.

Occurrence.—Loc. 2, Rosendale, 15.9–19.4'; loc. 3, Rosendale, 32.6–39.6'; loc. 15, Glasco, 25.6–27.8'; loc. 16, Glasco, 39.2–40.2'; loc. 18, Glasco, 17.6–18.5'; loc. 19, Wilbur, 6.7–11.8'; loc. 20, Glasco, 22–26'.

Phylum COELENTERATA
Class ANTHOZOA
Order TABULATA
Family HALYSITIDAE Milne-Edwards
and Haime, 1850
Genus CYSTIHALYSITES Tchernychev,
1941, emended Sutton, 1964

Type species: *Cystihalysites mirabilis* Tchernychev, 1941.

CYSTIHALYSITES sp.
Pl. 3, figs. 16–18

Description.—Corallum large; largest one observed 140 mm wide, 80 mm high. Chains formed of 8 to 15 corallites; chains divide and anastomose to form irregularly oval fenestrules.

Transverse section: Autocorallites and mesocorallites alternate. Autocorallites oval, and measure an average of 2.0 mm long, and 1.8 mm wide, on the inside dimension, the longest dimension being along the length of the chain. Mesocorallites quadrangular, one-third to one-half the size of the autocorallites. Outer walls of autocorallites average 0.2 mm in thickness. No septal spines seen.

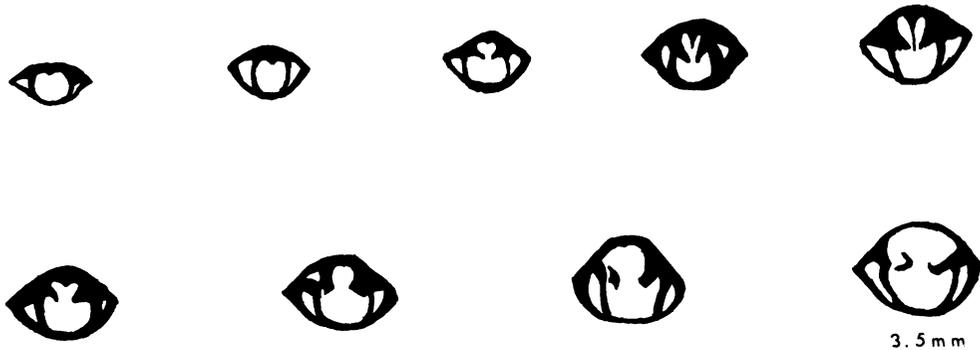
Longitudinal section: Tabulae of the autocorallites complete, horizontal or slightly concave toward the base. The average separation of the tabulae is 0.85 mm. The tabulae of the mesocorallites are vesicular, and form the walls between the autocorallites and the mesocorallites. No true wall is present. Septal spines not seen.

Discussion.—The genus *Cystihalysites* is distinguished by the long dimorphic corallites, which join laterally and divide to form anastomosing networks of chains. Oval autocorallites and quadrangular mesocorallites are present. The tabulae in the mesocorallites are vesicular or highly convex upward. *Cystihalysites* differs from the genus *Halysites* Fischer von Waldheim (1828), which has horizontal tabulae in the mesocorallites, and from *Catenipora* Lamarck (1816), which lacks mesocorallites (Duncan, 1956, p. 222, pl. 27, figs. 1a-e; 2a-c; 3a-f).

Weller (1903, p. 222, pl. 17, figs. 6–8) described specimens from the Decker Formation of New Jersey which he referred to the species *Halysites catenularia*. The figures of his specimens show highly convex tabulae in the mesocorallites. It is probable that they belong to the genus *Cystihalysites*. They differ from specimens from the Rondout Formation, in that the septa in the mesocorallites are less vesicular in those described by Weller.

Cystihalysites catenularia brownsportensis (Amsden, 1949, p. 94–95, pl. 18, figs. 1–3) from the Brownsport Formation of western Tennessee has vesicular tabulae in the autocorallites, whereas the species from the Rondout does not.

Occurrence.—Loc. 6, Glasco, 28.7–30.3'; loc. 7, Glasco, 51.9–53.4'; loc. 8, Glasco, 2.8–7.8'; loc. 10, Glasco, 21.2–21.7'; loc. 11, Glasco, 15.6–17.6'; loc. 12, Glasco, 43.4–44.6'; loc. 13, Glasco, 44.2–47.0'; loc. 14, Glasco, 48.7–54.5'; loc. 15, Glasco, 16.1–20.1'; loc. 16, Glasco, 30.6–33.9'; loc. 17, Glasco, 30.9–35.0'; loc. 19, Glasco, 18.0–22.1'; loc. 20, Glasco, 22–26'.



TEXT-FIG. 8—Serial sections of *Machaeraria* n. sp. (Bowen, in press), $\times 2.8$, approximately equal intervals.

Phylum BRYOZOA

Order TREPOSTOMATA Ulrich, 1882

Suborder AMALGAMATA Ulrich &
Bassler, 1904

Family HETEROTRYPIDAE Ulrich,
1890

Genus CYPHOTRYPA Ulrich & Bassler,
1904

Type species: *Leptotrypa acervulosa* Ulrich,
1893.

CYPHOTRYPA? CORRUGATA (Weller,
1903)

Pl. 3, figs. 14, 15

Monotrypa corrugata WELLER, 1903, p. 223–224, pl. 18,
figs. 1–5.

Cyphotrypa corrugata SCHUCHERT, 1913, p. 269–270,
pl. 42, figs. 5–9; pl. 44, fig. 4; pl. 52, figs. 1, 2;
SWARTZ, F. M., 1929, p. 53, pl. 6; 1939, Table X.

Description.—Zoarium massive, hemisphaerical, encrusting. Maculae circular, depressed slightly below the surface of the zoarium. Largest zoarium found: 55 mm in diameter, 20 mm high.

Tangential section: Zoecial apertures polygonal in outline. Larger zoecia concentrated in groups, irregularly spaced, indicating the position of the maculae. No mesopores present. Acanthopores few in number, irregularly distributed, confined to the zoecial corners. Thin-walled; walls amalgamate.

Longitudinal section: Zoecial walls irregularly undulating in both the ephebic and the neanic zones. Acanthopores not common. Wall structure not observable.

Discussion.—The genus *Cyphotrypa* is characterized by its thin walls, and absence of mesopores. Acanthopores are well-developed. The

genus cannot be distinguished from *Trachytoechus* Duncan, 1939, emended Boardman, 1960, because the wall structures are not visible in the specimens at hand.

The species shows a tendency to grow on shells of *Atrypa reticularis*.

C.? *corrugata* from the Rondout Formation is identical with *C. corrugata* from the Keyser Formation from West Virginia and Maryland, described by Schuchert (1913, p. 269–270, pl. 42, figs. 5–9; pl. 44, fig. 4; pl. 52, figs. 1–2).

C. corrugata (Weller, 1903) from the Decker Formation of New Jersey strongly resembles *C. expanda* Bassler (1923, p. 407, pl. 13, figs. 5–9) from the Tonoloway Formation in West Virginia, except in the shape of the colony. *C. expanda* has a thin, lamellar zoarium, whereas *C. corrugata* is found in large, hemisphaeric masses. *C. expanda* has been assigned to the genus *Trachytoechus* Duncan (1939, emended Boardman, 1960) by Boardman (1960, p. 49) on the basis of the wall structures, and the presence of heterophragms. It is possible that *C. corrugata* also belongs to the genus *Trachytoechus*, but the wall structure and presence or absence of heterophragms could not be observed in the specimens at hand.

Occurrence.—Loc. 1, Rosendale, 5.4–17.7'; loc. 2, Rosendale, 0–2.9'; loc. 3, Rosendale, 9.2–21.7'; loc. 4, Rosendale, 0–4.6'.

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EXPLANATION OF PLATE 3

- FIGS. 1-8—*Machaeraria* n. sp. (Bowen, in press). Loc. 4, Accord, Rosendale Member, 0-19.4'. 1-4, Pedicle, lateral, anterior, and posterior views of a single specimen, $\times 1$, NYSM 12617. Loc. 3, Port Jackson, Rosendale Member, 9.1-38.1'. 5-7, Brachial, anterior, and posterior views of a specimen with 4 plications on the fold and 3 on the sulcus; note the permesothyrid foramen, $\times 1.2$, NYSM 12618. Loc. 1, Port Jackson, Rosendale Member, 5.4-17.7'. 8, Posterior view of an impression of the brachial interior; a blade-like cardinal process divides the floor of the delthyrium, $\times 1$, NYSM 12619.
- 9-13—*Machaeraria? lamellata* (Hall, 1852); Loc. 2, Port Jackson, Glasco Member, 18.1-20.5'. 9, 10, Pedicle and lateral views of a single specimen, $\times 2$, NYSM 12620; 11, pedicle exterior; only the median plication in the sulcus originates at the beak, $\times 1$, NYSM 12621; 12, impression of the brachial interior; note the small, blade-like cardinal process, $\times 2$, NYSM 12622; 13, impression of the pedicle interior; short dental lamellae define shallow umbonal cavities, $\times 1$, NYSM 12623.
- 14, 15—*Cyphotrypa corrugata* (Weller, 1903); Loc. 6, High Falls, Rosendale Member, 0-4.6'. 14, Transverse section, $\times 12$, NYSM 12624; 15, longitudinal section, showing wall structure, $\times 12$, NYSM 12625.
- 16-18—*Cystihalysites* sp.; Loc. 14, Fourth Lake, Glasco Member, 48.7-54.5'. 16, Transverse section, etched, showing autocorallites and mesocorallites, $\times 2$, NYSM 12626; 17, transverse section, $\times 2$, NYSM 12627; 18, longitudinal section; note the vesicular tabulae of the mesocorallites, $\times 2$, NYSM 12628.

