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SPECIAL PUBLICATION 3

UPPER MIOCENE FORAMINIFERA FROM NEAR GRIMESLAND, PITT COUNTY, NORTH CAROLINA

By

Detmar Schnitker

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UPPER MIOCENE FORAMINIFERA FROM NEAR GRIMESLAND, PITT COUNTY, NORTH CAROLINA

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ABSTRACT

From a vertical sequence of ten samples taken from an outcrop of the Upper Miocene Yorktown Formation near Grimesland, Pitt County, North Carolina, eighty-seven species of foraminifera belonging to thirty-nine genera have been identified, described and figured.

One new genus, Ventrostoma, and three new species, Lagena torsicollis, Cibicides primulus, and Globocassidulina bifurcata are described.

The faunas indicate a normal marine, shallow, semiprotected environment. A closer ecologic affinity to the Upper Miocene Yorktown Formation of Virginia than to the Upper Miocene Duplin Formation of North Carolina is apparent.

The vertical sequence at Grimesland is divided into three environmental zones that reflect conditions of deposition. These are, from top to bottom:

zone 3 Turritella zone, silty and clayey sand, more than 7% of planktonic foraminifera, deposited in warm water, 20-35 meters deep.

zone 2 Dosinia-Mercenaria zone, sandy and clayey silt, up to 73% of Elphidium clavatum, deposited in cool water, less than 20 meters deep.

zone 1 Pecten zone, plastic clayey and sandy silt, more than 8% of planktonic foraminifera, deposited in warm water, 20-35 meters deep.

All three zones were deposited in a quiet environment. Their ecologic difference is thought to be related to a shift in the location of confluence of two oceanic current systems of different temperatures.

INTRODUCTION

Purpose of the Study

The primary objective of the study is the identification, description, and illustration of foraminifera from the Upper Miocene Yorktown Formation near Grimesland, Pitt County, North Carolina. A second purpose is the interpretation of the faunal and sedimentary data with regard to the ecological conditions of deposition. The third objective is consideration of the biostratigraphic relationship of the Upper Miocene (Yorktown) sediments from Grimesland to those of similar age from other parts of the Southeastern United States.

One locality was sampled and its foraminiferal faunas and sediments analyzed. A superficial field check of other outcrops in the Grimesland vicinity was made. Associated outcrops exhibit the same general lithology and macrofossils as the Grimesland site.

Description of the Collection Site

Material for study was collected from an outcrop near Grimesland, Pitt County, North Carolina, one mile northeast of the intersection of U.S.

Highway 264 with Pitt County Road 1565.

There are 10 to 15 foot bluffs along the southern bank of the Tar River. They are overgrown with vegetation and are inaccessible in most places. Under the bridge across the Tar River on Pitt County Road 1565, which connects Grimesland with North Carolina Highway 33, is a good bare exposure.

Five to seven feet of unfossiliferous yellow-brown to rust colored sand of probable Pleistocene age (Richards, 1950, p. 36) overlie the fossiliferous Yorktown Formation. The fossiliferous deposits are divisible into three environmental zones. These are, from top to bottom:

		Thickness
zone 3	grey to yellow-brown silty and clayey sand, with abundance of the gastropod Turritella	2 feet
zone 2	light grey-brown arenaceous and clayey silt, lenticular in structure, characterized by the pelecypods Dosinia and Mercenaria	5 feet
zone 1	plastic, bluish-grey, slightly clayey and sandy silt, with abundance of the pelecypod Pecten	2 feet
	Total	9 feet

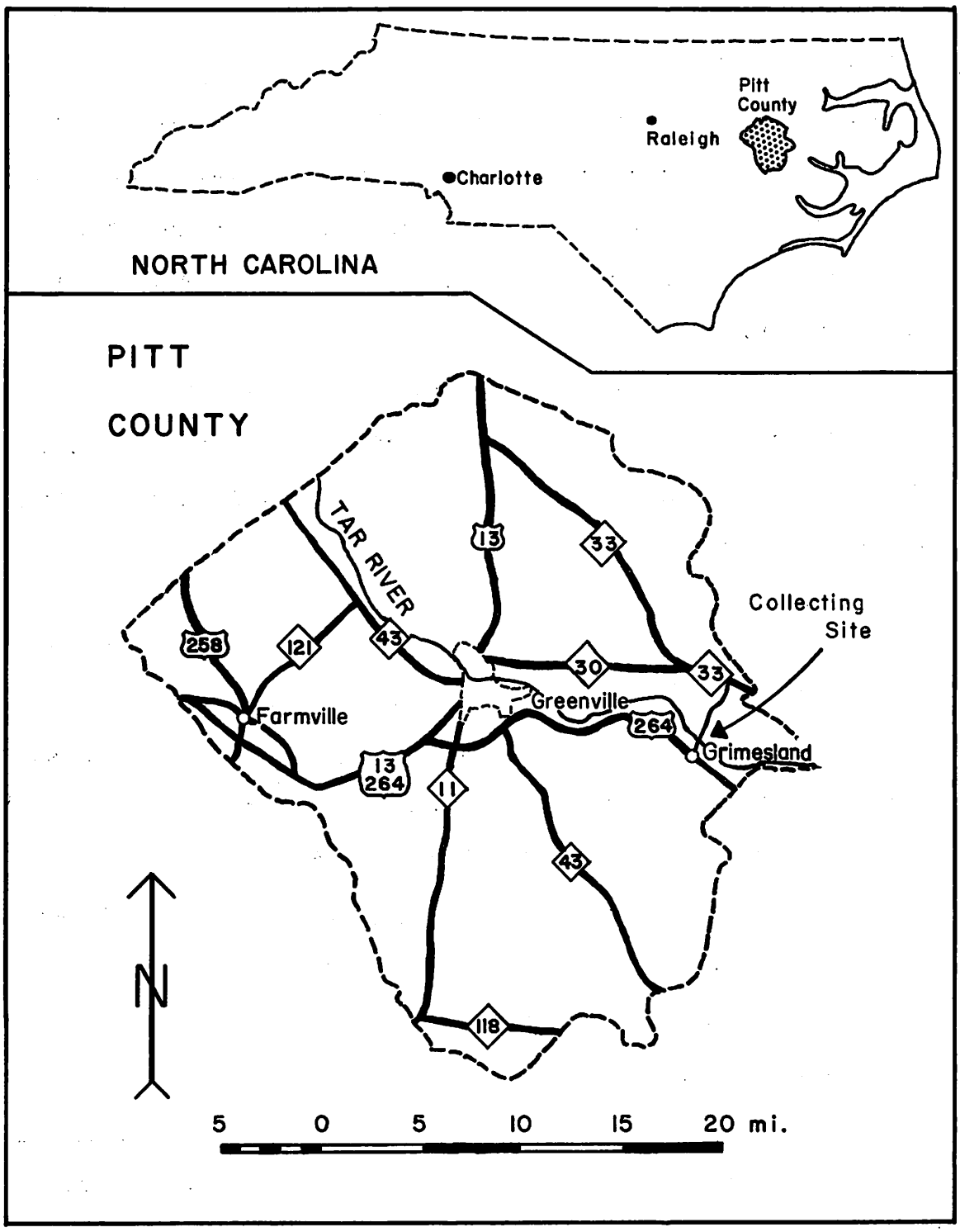


Figure 1

Index Map of Collection Site

Previous Investigations

Mansfield collected material in 1928 from the "right bank of Tar River at Boyd Bridge, about one mile north of Grimesland, Pitt County, North Carolina," (Cushman and Cahill, 1933, p. 4). Whether or not Mansfield's locality is identical to my collection site is uncertain, but it must have been near by. Cushman and Cahill (1933) described 12 species of foraminifera from Mansfield's material. Gardner (1943, 1948) incorporated molluscs from Mansfield's samples into her work on Miocene molluscs. Dawson (1958) described the molluscan fauna from Grimesland in a comparative study with a fauna from the Duplin Formation in Duplin County, North Carolina.

Acknowledgements

I thank Doctors Joseph St. Jean, Jr., Walter H. Wheeler from the Department of Geology and Doctor Alan E. Stiven from the Department of Zoology at the University of North Carolina at Chapel Hill for discussing problems and constructive criticism.

TECHNIQUES OF INVESTIGATION

Sampling

To avoid contamination and to secure fresh material, a vertical section, one foot wide on the face of the outcrop, was cleared from all loose and weathered material. The first sample was taken immediately below the contact with the overlying barren sand. Consecutive samples, each of about 500 grams were taken at one foot intervals. The spacing assured that each environmental zone, as indicated by sediments and macrofossils, was represented by at least two samples. In this manner 9 samples were recovered,

the tenth sample had to be extracted from beneath the water level.

Paleontological Techniques

Each sample was split and 50 grams set aside for sediment analysis. Four hundred grams of sediment were washed down in a "Curtin" sediment washer to separate the clay and silt from the coarse fraction. The dried residue was sieved through a number 12 mesh sieve, with 1.4 mm openings, to remove large debris and shell fragments. The foraminifera were floated off from the resulting residue with carbon-tetrachloride.

From each sample 400 specimens were picked at random from a reticulated picking tray and secured on faunal slides for a determination of the relative abundance of the species. Identification was made from these faunal slides and the number of specimens for each species recorded. Repeated counts of 100 and 200 specimens showed significant variation in species percentages, repeated counts of 400 specimens yielded nearly identical percentages. Next, each sample concentrate was carefully searched for species which had not been found among the previously extracted 400 specimens.

For preliminary identification the foraminifera were first compared with illustrations in the pertinent literature. These preliminary identifications were then compared with the type descriptions and figures. Most of the species were checked against type material deposited in the U.S. National Museum, Washington, D.C.

Sedimentary Techniques

Sedimentary data from analysis of all ten samples supplement the paleontological data. Fifty grams of air-dried material were soaked for 12 hours in water to which "Calgon" had been added as a dispersing agent. The disintegrated sample was stirred intensively in a milk shaker to dis-

perse the clay. The resulting slurry was washed into one liter cylinders. Clay content was determined by the pipette method. The sediment was then washed on a 250 mesh screen to separate the coarse fraction from the silt and clay. The coarse fraction was dried and weighed. The amount of silt was determined by subtracting the weight of the coarse fraction and the weight of the clay from the weight of the total sample. The dried coarse fraction was run through a series of sieves according to the Wentworth grade scale. Residues of the sediment insoluble in hydrochloric acid were used for the determination of the sand-silt-clay ratios.

Methods of Illustration

For all illustrations a "Wild" stereo microscope was used. Outlines and structures are camera lucida tracings, the shading was done with soft pencil and paper stubs.

DISCUSSION

Extent of the Yorktown Formation

The Yorktown Formation is known from outcrops in southeastern Virginia and northeastern North Carolina. Its greatest thickness in surface sections is attained in Virginia, where 125 feet have been measured (Clark and Miller, 1912, p. 159). Surface sections in North Carolina are thinner, where updip, towards the west, the Yorktown Formation wedges out against the Piedmont. Downdip the thickest surface sections do not exceed 50 feet (Mansfield, 1943, p. 11). In Virginia the Yorktown Formation is unconformably underlain by the St. Mary's Formation (Middle Miocene) (Mansfield, 1943, p. 7), in North Carolina it rests unconformably upon various deposits of Eocene and Upper Cretaceous

age (Richards, 1950, p. 22-23). Upper Miocene deposits south of the Neuse River are referred to as the Duplin Formation.

History of Previous Investigations

The name Yorktown Formation was first applied by Dana (1863, p. 287) to all Miocene and Pliocene deposits of the Atlantic Coastal Plain. Clark and Miller (1906, p. 19-20) defined the Yorktown Formation as it is presently understood. The bluffs along the York River near Yorktown, Virginia, are the type locality of the formation. Miller (1912, p. 229) described the Yorktown Formation in North Carolina, where Miocene strata had previously not been differentiated. The lower beds at Murfreesboro, North Carolina, are the type locality for a Murfreesboro stage, defined by Olsson (1917, p. 155-163). However, the name is preoccupied by the Paleozoic Murfreesboro Formation in Tennessee (Mansfield, 1943, p. 8). Mansfield (1943, p. 8-10) subdivided the Yorktown Formation into two zones. The lower zone, or Zone I, is characterized by the presence of a suite of molluscs with Pecten clintonius as an index. Zone II comprises the upper portion of the Yorktown Formation and is characterized by the gastropod Turritella alticostata and its suite. Part of the Murfreesboro is included in Zone I by Mansfield. Zone II is further subdivided by him into three parts and up to five beds locally.

In this study the term "zone" has been used in an entirely informal sense.

Discussion of Sediments of the Yorktown Formation at Grimesland

The basal two feet of sediment, zone 1 in the outcrop, are composed of bluish-grey, slightly plastic clayey and sandy silts, showing hardly any

induration. The sand is mainly fine to very fine-grained. The calcium carbonate content is high (25.5% in sample 1, 24% in sample 2), contributed by mostly fragmented remains of invertebrates. This kind of sediment points to a low energy environment, little introduction of coarse material, and protection from strong currents that would tend to sort out the clay and other fine material. Occasional storm waves succeeded in partially fracturing the invertebrate remains.

Overyling zone 1 are 5 feet of zone 2 sediments, which are poorly indurated, light grey-brown clayey and arenaceous siltstones. Its irregular structure consists of lenses and ill-defined bedding. The sediment composition is variable between the individual lenses and beds. The sand fraction in zone 2 is mostly fine to very fine-grained. Sand increases by 14% on the average, with a comparable decrease in silt and clay. The calcium carbonate content averages 13%, contributed by mostly fragmented remains of invertebrates. This type of sediment still represents a low energy environment of deposition, but differs from the sediment of zone 1 either in a higher rate of introduction of sand, perhaps because of closeness to the shore with supply from the continent, or else in a more shallow situation with a corresponding loss of the very fine size fraction through wave and current action.

The top 2 feet of sediment, zone 3 in the outcrop, do not differ much from the underlying zone 2 in induration, color, and structure. They differ, however, in composition. The fine sand content of zone 3 increases by as much as 15% over zone 2, clay increases by 5%, and the amount of calcium carbonate in the form of invertebrate remains increases by 25%.

SEDIMENT DISTRIBUTION

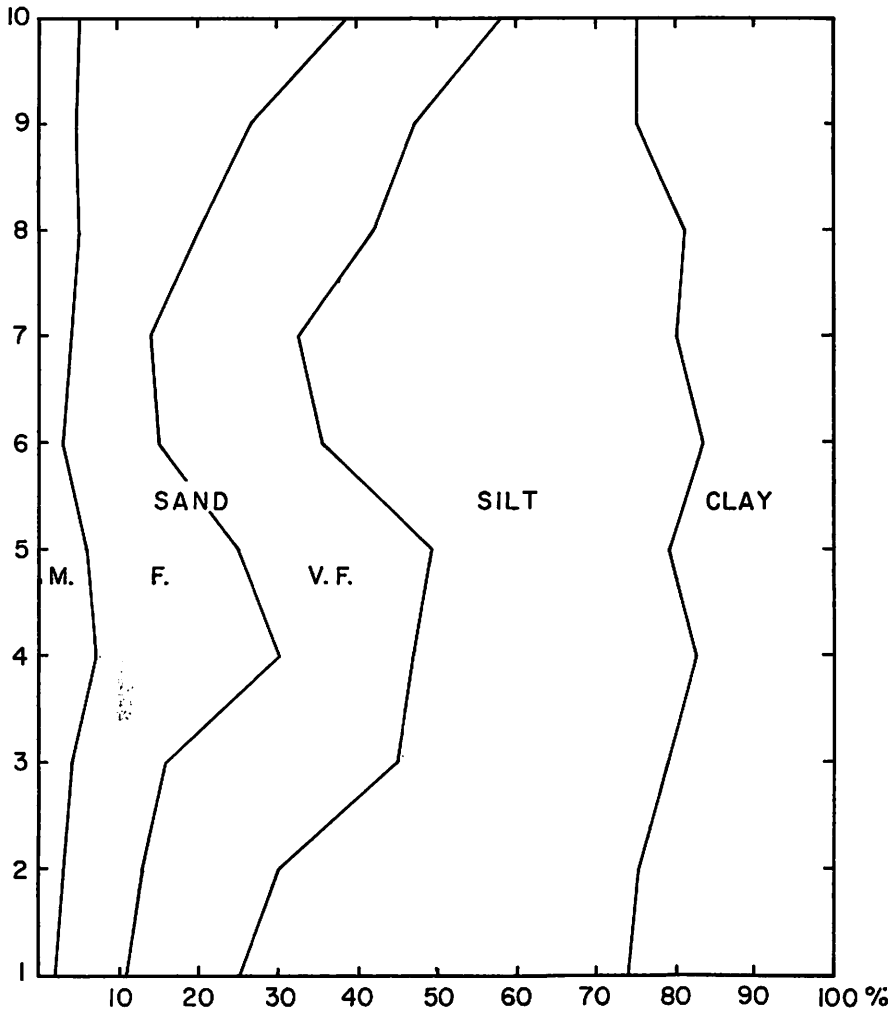


Figure 2. Sediment distribution in vertical sequence

Aspects of Fauna

The foraminifera of the Grimesland area are excellently preserved, and rarely show signs of abrasion or leaching. Infiltration was not observed. The foraminifera are not abundant in any of the samples, comprising 0.1% to 0.4% of the sediment by volume. Since a few species make up most of the faunas, large samples had to be processed to assure the recovery of the minor

faunal elements.

Eighty-seven species of foraminifera were recovered. One genus, Ventrostoma, and three species, Lagena torsicollis, Cibicides primulus, Globocassidulina bifurcata are new. Benthonic genera comprise the largest portion of the faunas. Planktonic foraminifera were present throughout the samples with low relative frequencies. Most previously described species found in the Grimesland area are also known from Middle and Upper Tertiary deposits and from modern seas of the eastern United States. Most species are cosmopolitan. Table 1 (p. 19-23) shows the distribution and the relative abundance of each species in the samples.

Paleoecology

Most of the abundant benthonic species of the Grimesland faunas are still living and serve as guides to the interpretation of past environments.

The most common species in the fauna is Elphidium clavatum which occurs in relative frequencies of 14% to 73% of the total faunas. This species is common in shallow coastal waters of northern Europe and North America: it occurs in semiprotected bays and occasionally in transitional environments to the open sea in the Long Island area (Parker, 1952, p. 448). The species is abundant, up to 90% of the fauna on nearshore areas at depths of less than 15 meters in the Long Island Sound (Buzas, 1965, table 3).

Elphidium subarcticumm ranks second in abundance, with relative frequencies of 2% to 25%. Known from northern waters only, this species occurs generally in the same area as E. clavatum, but ranges to slightly greater depths (Phleger, 1952, p. 330; Parker, 1952, p. 449; Buzas, 1965, table 3).

Buccella frigida, third in abundance with relative frequencies of 6%

to 16%, is known to occur in the open water environments of the Long Island Sound, reaching its maximum abundance at greater depths than either E. clavatum or E. subarcticum (Parker, 1952, p. 449; Buzas, 1965).

Rosalina floridana occurs in temperate to warm water in the Gulf of Mexico at depths between 10 and 30 meters (Phleger, 1965, p. 1). It ranges from 18% to less than 1% of the Grimesland faunas.

Buliminella elegantissima is known from warm to cold water, being more common at shallow depths in warm water in the Gulf of Mexico (Phleger, 1951, p. 45, 55), and on the Pacific coast of Mexico (Walton, 1955, p. 985). It favors open water over enclosed bays or estuarine conditions. B. elegantissima occurs with relative frequencies of 14% to less than 1% in the Grimesland faunas.

Other species for which ecologic information is available are Bolivina subaenariensis, Bulimina aculeata, B. marginata, Patellina corrugata, Cibicides lobatulus, Fursenkoina fusiformis, F. pontoni, Nonionella miocenica stella, and Elphidium poeyanum. Because of their rare and sporadic occurrences throughout the ten samples, less reliance is placed upon them as ecological indicators. Mostly they are indicative of either cool shallow water or warm shallow water.

Combining the known depth ranges, it appears that the Grimesland faunas are indicative of inshore deposition, ranging from sublittoral depth to depths of 20 to 35 meters. When the occurrences and abundances of the species are plotted against the stratigraphic position of the samples, the plot shows that forms indicative of warm water are most common in the lowest and topmost samples (zone 1 and zone 3). Cool water forms are most abundant in the intermediate section (zone 2). Therefore, at the beginning of deposition represented in the sampled exposure, the climate was similar to

presently existing climates along the coasts of Georgia and Florida. During deposition of sediments in zone 2 the water temperatures were lower, similar to those of the Northeastern United States. After deposition of the sediments found in zone 2, the water temperatures were higher again, similar to those of the first period of deposition.

Planktonic foraminifera reached their greatest abundance and species diversity in zone 1 and zone 3. Planktonic foraminifera are not known to inhabit shallow water. Therefore, deposition of the exposed sediments began at depths of 20 to 35 meters, a depth at which Bandy (1954, p. 136) reports the first noteworthy appearance of planktonic species on the shelf of the Gulf of Mexico. This was followed by a period of deposition in depths of no more than 20 meters, when planktonic species were largely excluded. The planktonic foraminifera reappear again in the top zone (zone 3), indicating deepening of the water.

The sequence of deep-shallow-deep water deposition relates to the changes from warm to cool and back to warm water faunas and is supported to some degree by the sediment composition.

Faunal Diversity

E.P. Odum (1959, p. 281) gives a summary definition of faunal diversity: "Of the total number of species in a trophic component, or in a community as a whole, a relatively small per cent are usually abundant (represented by large numbers of individuals) and a large per cent are rare (represented by a small number of individuals). The ratio between the number of species and the number of individuals is the diversity index. Either strong physico-chemical limiting factors or intense interspecific competion tends to reduce the diversity within a community."

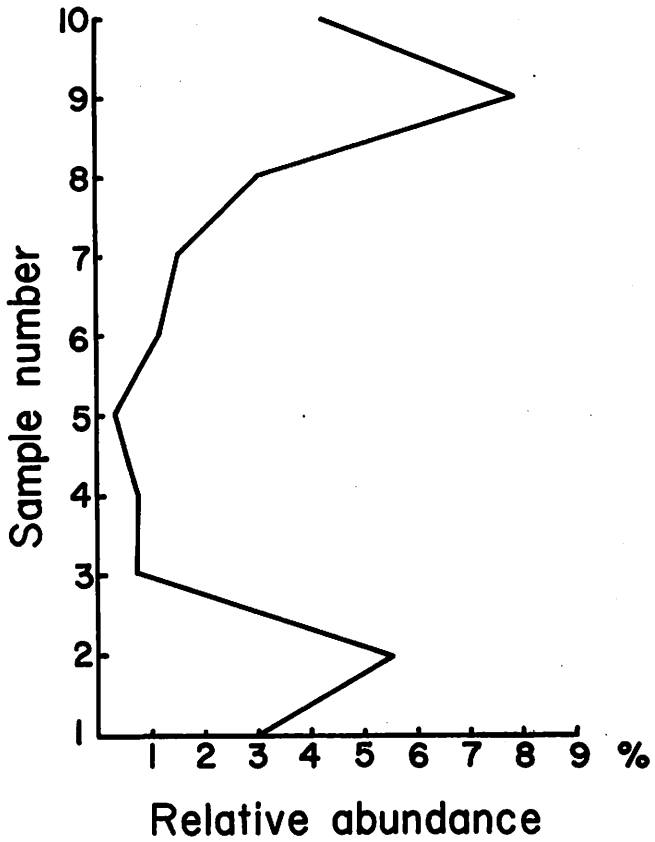


Figure 3

Relative abundance of planktonic Foraminifera in vertical sequence

The diversity of the foraminiferal faunas of the ten samples has been expressed in two ways, by numerical index and graphically. The diversity indices were calculated, using the formula given by E.H. Simpson (1949, p. 688):

$$\sum \frac{n(n-1)}{N(N-1)}$$

However, the numerator and denominator were exchanged (as used by Williams, 1954, p. 9) to make the indices directly proportional to the diversity. N represents the number of individuals in the population, n is the number of individuals in a species within that population. Graphically, the diversity is illustrated by a plot of the cumulative percentage of specimens against

the number of species on a semilog graph. The slope of the resulting curve is a measure of the faunal diversity. However, the total number of species present in each sample is to some extent distorted by the method of recording which was employed in this study. In the frequency counts species with an abundance of less than 1% were merely listed as "present" and additional rare species were extracted from the sample concentrate and also tabulated as "present". These rare species make up the "tail" of the curves, which were therefore terminated at about the 5% level. Figure 4 shows the species diversity curves for each of the ten samples. The curves fall into three categories, which correspond to the three zones which were discussed previously. Curves one and two are of moderate steepness, curves three to eight are fairly flat, and curves nine and ten are very steep. This change in faunal diversity is shown even more drastically when the numerical indices of diversity are plotted against the samples in their stratigraphical sequence. Zone 1 has a fauna of medium diversity, with indices slightly higher than 6, zone 2 has a fauna of very low diversity, with indices ranging from 3.3 to 1.84. Zone 3 has the most diverse fauna of the entire section with indices of 10.38 and 12.16.

The drastic changes of faunal diversity suggest that the environment at the time of deposition underwent sharp changes during the transition from zone 1 to zone 2 and again from zone 2 to zone 3. The environment probably became most restrictive during the time of depositon of zone 2, when only a few species, rich in individuals, were successful. During deposition of zone 1 and especially of zone 3, the environment was less restrictive, i.e. the number of ecologic niches increased and with it the number of species to exploit them.

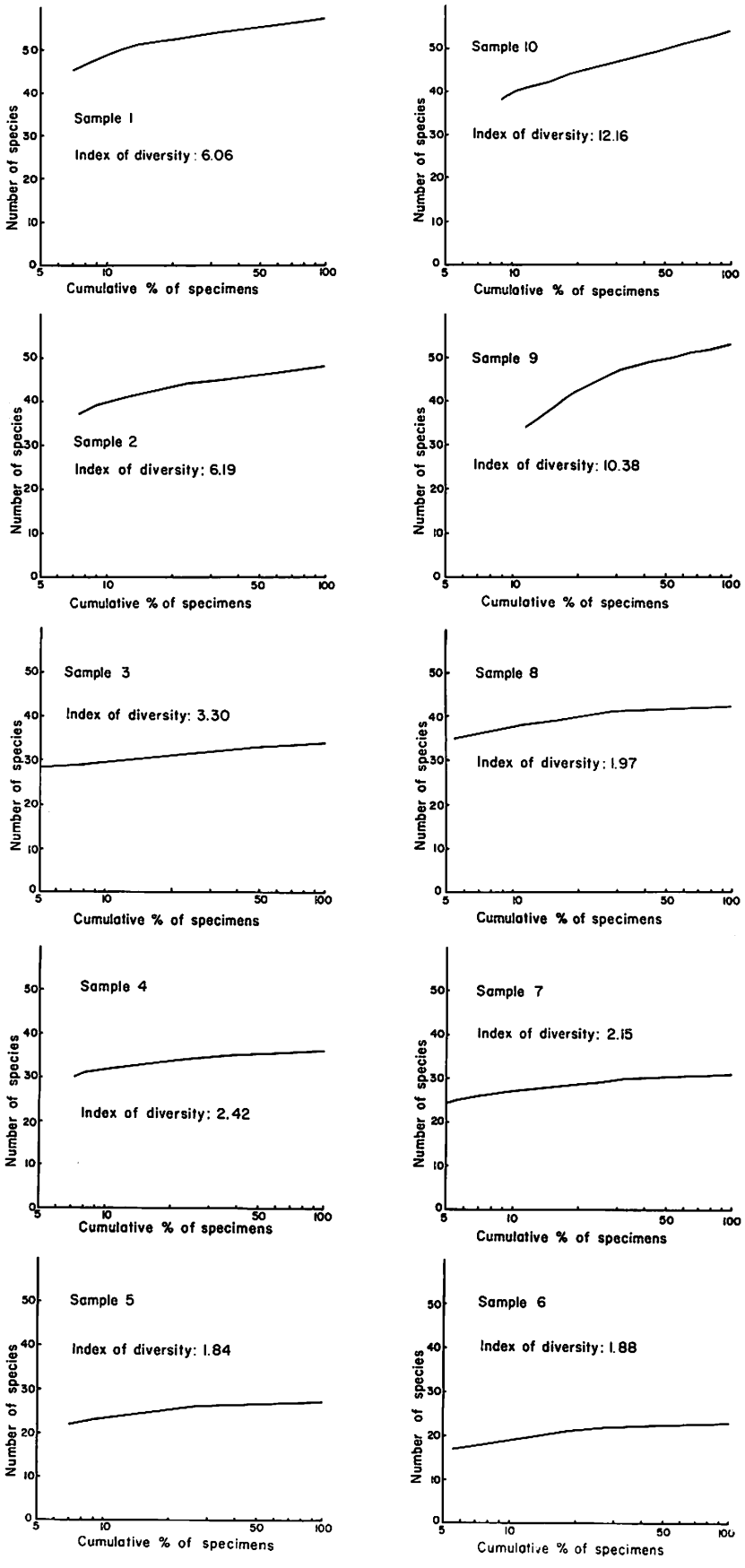


Figure 4. Species diversity curves for ten samples.

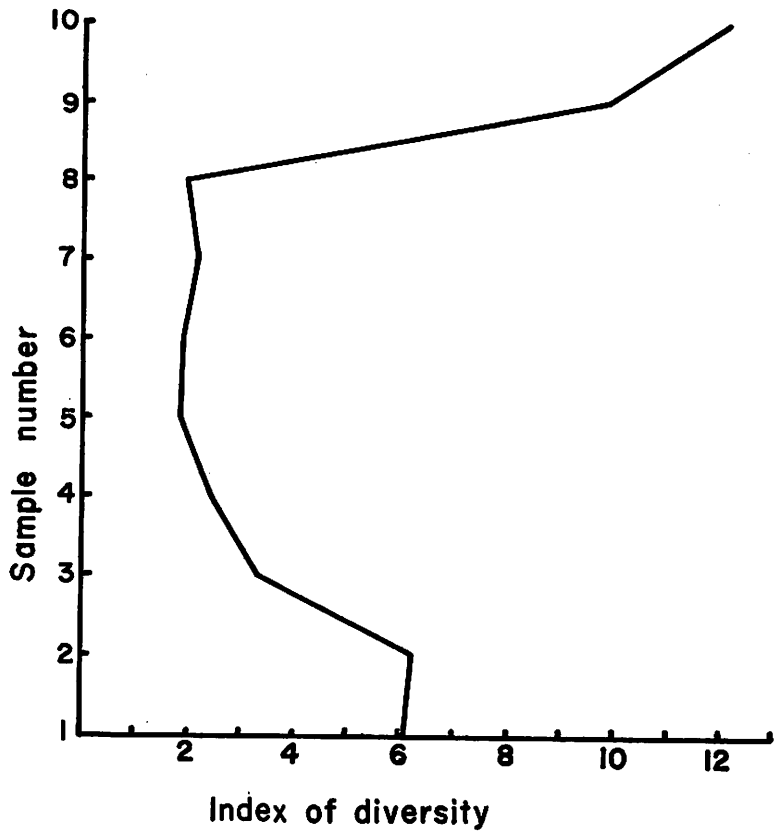


Figure 5

These statistical indicators do not succeed to define the nature of the changes which took place, but help to substantiate the deductions made previously on the basis of other faunal characteristics.

There is no evidence for assuming a major time break between the deposition of the three zones of the Yorktown Formation. The transition from one sediment type to the other, though taking place within a few centimeters, is gradational. No abrupt evolutionary changes in the microfauna indicate the presence of diastems, nor are there any planar sedimentary breaks. Faunal and sedimentary differences reflect different environments of deposition.

The peristence of smaller numbers of indicative species for the warm and deep water environment in the cool and shallow water deposits, and vice versa, suggests that this area was the site of faunal mixing, in which at

times the one or the other type of conditions dominated.

The most probable mechanism for the temperature changes can be found in the present oceanic current pattern along the coast of North Carolina, where the warm Gulf Stream from the south meets a weaker but cold current from the north in the vicinity of Cape Hatteras. Fluctuations in the location of confluence of a similar current system and a changing coastline configuration during Upper Miocene time may have brought the area of the Grimesland deposits alternatingly under the influence of either the warm or the cold current respectively.

Embedded in the matrix of the sediment is a fauna of molluscs, corals, bryozoa, and echinoid remains. The molluscs consist mostly of fragments, but complete specimens are common, some bivalves have left and right valves still fitted together. The lack of abrasion on these fossils excludes significant amounts of transport or reworking, but frequent fragmentation and dislocation of the fragments indicates that the sea floor was within the reach of storm waves. That no constant reworking took place is also indicated by the sediment composition and by the preservation of the foraminifera and their size distribution. Minute fragile specimens occur together with larger and robust ones in a beautiful state of preservation.

Considering this evidence, a large open bay is suggested as the site of deposition. This site was freely connected with the open ocean and normal marine conditions prevailed as is indicated by animal groups which do not tolerate sub-or hypersaline conditions. The geographic extent of the Upper Miocene bay cannot be determined without regional studies.

Stratigraphic Correlation

Correlative Upper Miocene formations in the Southeastern United States are the Yorktown Formation in Virginia, Maryland, and Delaware, the Duplin

Formation in the Carolinas and Georgia, and the Choctawhatchee Formation in Florida.

Unfortunately, McLean (1956), and Puri (1953) do not present data on the abundance of their species, which would have led to a more precise correlation.

The Grimesland faunas have 24 species in common with the Choctawhatchee Formation in Florida (all four facies of Puri, 1953), 17 species are in common with the Duplin Formation in North Carolina (Copeland, 1964), and 21 species are in common with the Yorktown Formation in Virginia (McLean, 1956). McLean (1956, p. 267-268) and Sabol (1960, p. 214-215) question the validity of Mansfield's Yorktown zones I and II as time stratigraphic units and assert that these are merely due to ecologic differences. In the Grimesland outcrop, Mansfield's zone I seems to be represented by the lower two feet of sediment from which the samples 1 and 2 have been collected. The overlying 8 feet of sediment would consequently represent Mansfield's Zone II, which can be subdivided into two more units. Detailed faunal studies over a larger geographical extent would help to clarify the problem of the validity and persistence of these zones and furnish definite criteria for their recognition.

TABLE 1

Abundance and vertical distribution of foraminiferal species within the section

	bottom									top
Sample number:	1	2	3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%	%	%
Textularia deltoidea	1		-	-	-					
Lagena dorseyae	-		-	-	-	-	-	-	-	
L. laevis	-		-	-	-		-	-		-
L. pseudosulcata	-		-	-						-
L. torsicollis	-	-	-	-	-		-	-		-
Lenticulina americana americana	-		-	-	-	-			-	-
L. americana spinosa	-	-								
L. glabrata			-							
Polymorphina subdilatata										-
Guttulina austriaca				-						
Guttulina sp., cf. G. leprosa					-					
Guttulina sp.	-									
Pseudopolymorphina sp.				-						
Laryngosigma williamsoni	-			-					-	-
Oolina sp., cf. O. hexagona	-				-					
O. striatopunctata	-									
Fissurina aequilabialis	-							-		-
F. cucurbitasema								-	-	-
F. lucida	-		-	-	-					

TABLE 1.--Continued

	bottom									top
Sample number:	1	2	3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%	%	%
Fissurina lacunata	-		-				-		-	-
F. pseudoglobosa	-		-						-	-
Parafissurina arata								-	-	
Ventrostoma fovigera	-			-			-		-	-
Buliminella elegantissima	2	4	4	-	-	-	1	1.5	7	14
Bolivina compacta		-							-	
B. directa		-							-	
Bolivina floridana	-	-				-	-	-	-	-
B. lafayetti							-	-	-	-
Bolivina marginata multicostata	-									
B. paula	-	-	-	-	-	-	-	-	1.5	3.5
Bolivina plicatella	-	-	-	-	-	-	-	-	1	2
Bolivina subaenariensis	-									
Bulimina aculeata	-	-		-	-				-	-
Bulimina sp.										-
Bulimina marginata	-	-								
Reussella pulchra		-								
Uvigerina attenuata									-	
U. juncea		-						-	-	-
U. modeloensis		-							-	-
U. subperegrina	-	-		-				-	-	-
Trifarina occidentalis	-	-				-	-	-	-	-

TABLE 1.--Continued

	bottom									top
Sample number:	1	2	3	44	5	6	7	8	9	10
	%	%	%	%	%	%	%	%	%	%
Buccella anderseni		-			-			-	-	
B. depressa	6	1	2	2	2.5	2.5	3	1.5	2	2
B. frigida	13.5	16	12	7	8	10	6	8	11	8
B. inusitata	1	4	1	-	1	2	-	-	1	5
B. mansfieldi		-		-				-	-	-
B. vicksburgensis	6.5	29	6	3	6	5	8	5	11	12
Epistominella pontoni	-	-	-	-	-	-	1.5	-	2.5	8
Rosalina floridana	8	12	6	5	2	1	-	2.5	18	7
R. floridensis		-							-	
R. opima	-	-	-	-				-	-	
?R. posidonicola	-	-		-			-	-	-	-
Cancris communis	-	-							-	-
Patellina corrugata		-	-		-	-		-	2	-
Elphidium clavatum	27	19	50	62	73	72	67	70.5	17	14
E. selseyense	-		-				-			-
E. subarcticum	25	2	18	15	4	3	9	5	1	4
Cribroelphidium poeyanum	-		-	-	--				-	-
Globorotalia menardii										-
Turborotalia obesa	-	-	-				-	-	-	
T. oscitans	-	-								
Globigerina angustiumbilicata	-	-		-		-		-	-	-
G. apertura	-									
G. bulloides	-	2				-	-	-	3	2
G. concinna	-	-								

TABLE 1.--Continued

Sample number:	bottom 1	2	3	4	5	6	7	8	9	top 10
	%	%	%	%	%	%	%	%	%	%
Globigerina pachyderma										
G. quinqueloba		-						-	-	
G. trilocularis	-	-								
Globigerinoides rubra	-	3	-	-	-	-	-	-	5	2
Orbulina sp., cf. O. universa	-							-		-
Globigerinita incrusta			-	-		-	-	-		
Cibicides altamiraensis							-	-		
C. crassiseptus			-							
C. celebrus										-
C. lobatulus		-								
C. ornatus	-	-	-	-					-	-
C. primulus	-	-		-	-				-	-
C. sublobus	-	-		-		-	-	-	-	-
Dyocibicides sp., cf. D. biserialis		-							-	-
Fursenkoina fusiformis										-
F. pontoni	-							-	-	-
Globocassidulina bifurcata	-					-			-	-
Nonion pauperatum	-	-	-	-	-	-	-	2	2	6
Florilus pizarrensis								-	-	-
Nonionella auris	1.5	-	-	-	-		-		-	-
N. miocenica stella	-	-	-				-	-	-	-
Hanzawaia concentrica		-					-	-	-	-
	-	-	-					-		

Note: percentages are based on 400 randomly picked specimens from each sample.
"-" species is present in sample, but with less than 1% relative abundance.

TABLE 2

Stratigraphic ranges of previously described Foraminifera from the Yorktown Formation

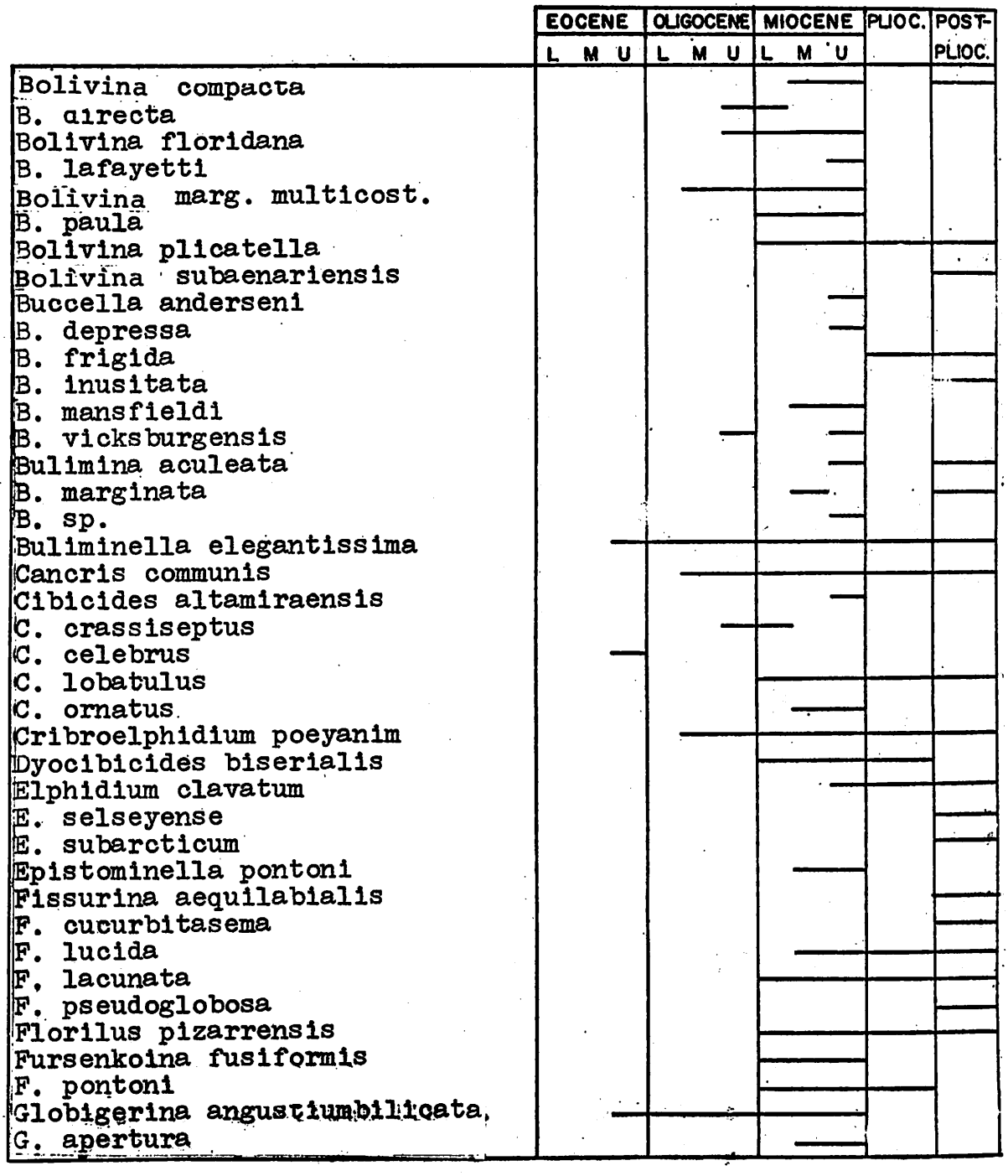
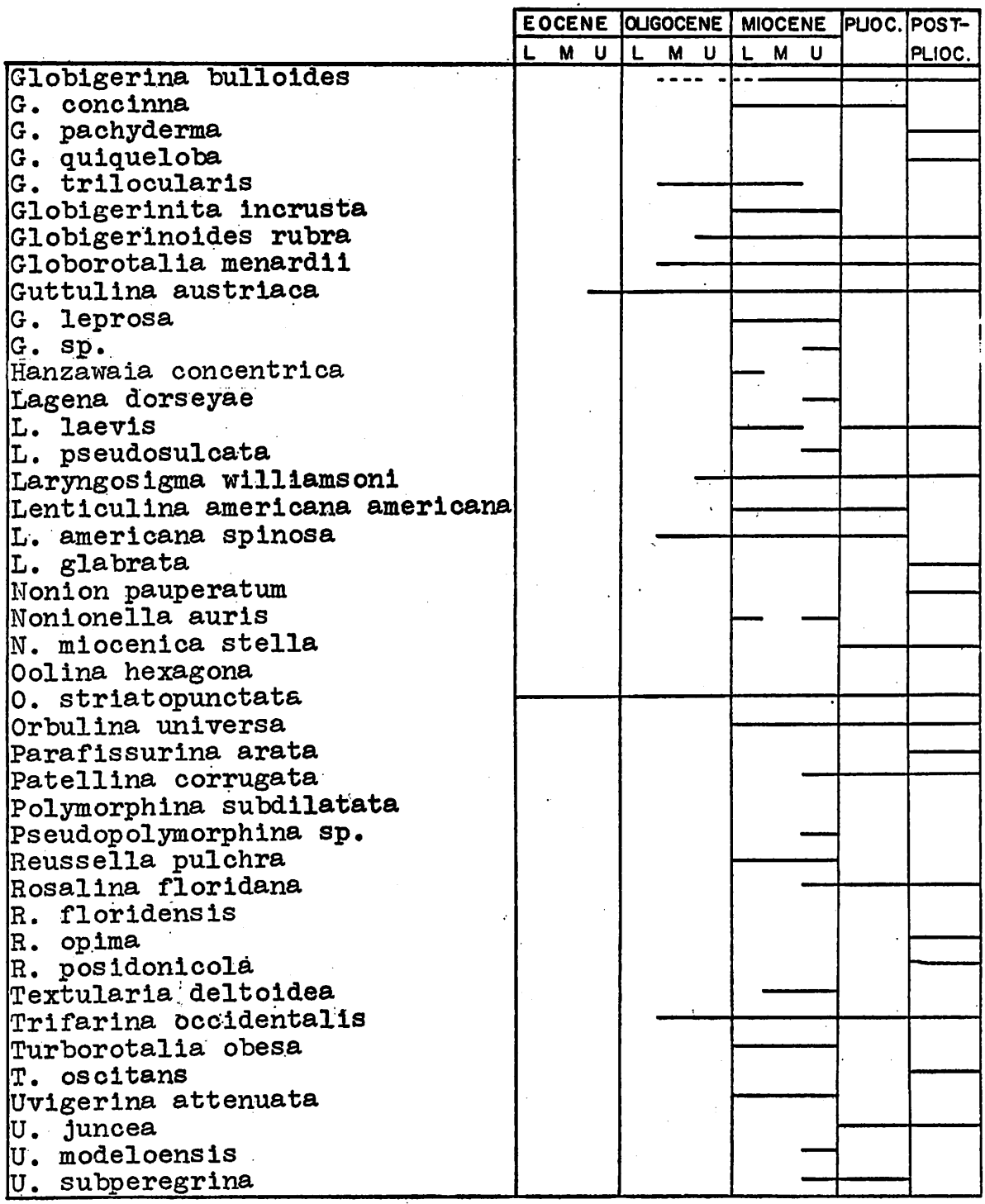


TABLE 2.--Continued



Systematic Paleontology

All of the foraminiferal material studied for this report has been deposited in the Paleontology Laboratory of the University of North Carolina, Department of Geology.

The genera are arranged according to the classification given by Loeblich and Tappan in the Treatise on Invertebrate Paleontology, Part C, Protista 2.

Suborder Textulariina Delage and Hérouard, 1896

Superfamily Lituolacea de Blainville, 1825

Family Textulariidae Ehrenberg, 1838

Subfamily Textularinae Ehrenberg, 1838

Genus Textularia Defrance, 1824

Textularia deltoidea Reuss

Pl. 1, figs. 1a-b

Textularia deltoidea Reuss, 1850, K. Akad. Wiss., Math. Nat. Cl., Denkschr., Bd. 1, p. 381, pl. 49, figs. 4a-c.

Test small, triangular in side view, expanding rapidly from a blunt initial end to the broad apertural end; periphery subacute; chambers indistinct, low, about eight to ten comprising the test, increasing rapidly in size as added; sutures indistinct, slightly depressed, slightly curved; wall medium coarsely arenaceous; aperture a low, straight and broad slit on the flat apertural end of the test, at the base of the inner margin

of the ultimate chamber. Length 0.30 mm, width 0.34 mm, thickness 0.22 mm.

Rare to common. Occurs in the Dosinia - Mercenaria zone and the Pecten zone. Present in the samples 3,4, and 5. Common in sample 1 (1%).

In general, the Grimesland specimens compare favorably with Reuss's description and figures. In top view, however, they display some variation, mostly, the peripheral angle is not as acute as in the type figure.

Textularia cuyleri Davis and T. renzi Becker and Dusenbury, are very similar forms, the former differs in being too oval in top view, the latter one is separated primarily by its size and strongly oblique sutures.

Hypotype.-- U.N.C. Cat. No. 3795.

Suborder Rotaliina Delage and Hérouard, 1896

Superfamily Nodosariacea Ehrenberg, 1838

Family Nodosariidae Ehrenberg, 1838

Subfamily Nodosariinae Ehrenberg, 1838

Genus Lagena Walker and Jakob, 1798

Lagena dorseyae McLean

Pl. 1, figs. 2a-b

Lagena sp. D., Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 291, pl. 31, figs. 19-21, (not figs. 22, 23).

Lagena dorseyae McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 330, pl. 39, figs. 8a-b.

Test of normal size for the genus, nearly globular, somewhat elongate, round in apertural view; chamber ornamented with numerous fine longitudinal striations, about 40 in number, most of which extend from the base to the neck, some are discontinuous; neck long, slender, somewhat tapering,

ornamented with irregular rugosities; aperture terminal, simple and round. Total length 0.48 mm, length of chamber 0.32 mm, diameter 0.26 mm.

Rare. Occurs in all three zones, in the samples 1, 3, 4, 5, 6, 7, 8, and 9.

This form has been reported from the Miocene of the Coastal Plain of the eastern United States, from Maryland to North Carolina.

Hypotype. -- U.N.C. Cat. No. 3796.

Lagena laevis (Montagu)

Pl. 1, figs. 3a-b

Serpula (Lagena) laevis ovalis Walker and Boys, 1784, Test. Min., p. 3, pl. 1, fig. 9.

Vermiculum laeve Montagu, 1803, Testacea Britannica, p. 524.

Lagena laevis Williamson, 1848, Annal. Mag. Nat. Hist., ser. 3, vol. 1, p. 12, pl. 1, figs. 1, 2. --- Brady, 1884, Challenger Rept., Zool., vol. 9, p. 455, pl. 56, figs. 7-9, (not 10-14, 30). --- Cushman, 1933, U.S. Nat. Mus., Bull. 161, pt. 2, p. 19, pl. 4, fig. 5. --- Cushman, 1935, U.S. Geol. Survey, Prof. Paper 181, p. 22, pl. 9, figs. 3,4. --- Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 289, pl. 31, figs. 9, 10. -- Buchner, 1940, Nova Acta Leopoldina; Abh. K. Leop. Carol. Deutsch. Akad. Naturf.; Neue Folge, Bd. 9, No. 62, p. 418, pl. 3, figs. 34-38, (not 39-46).

Test small, club or flask shaped, circular in apertural view; largest diameter below the midline, tapering gradually into a long, cylindrical neck, basal end rounded; wall hyaline, smooth, finely perforated; aperture terminal, bordered by a narrow lip, round. Length 38 mm, diameter

.12mm.

Rare. Occurs in all three zones, present in the samples 1, 3,4, 5,7,8, and 10.

Some degree of variation is displayed by this species. The zone of greatest diameter may be narrow, or, in elongated specimens, give rise to a mid-section with nearly parallel sides. According to Buchner (1942, p. 420-421), this species grades into forms which carry faint costae at their basal end and along the apertural neck. Two specimens in this material have been found, which show faint costae along the neck. They are for the present time retained in this species, but not regarded as being typical.

Hypotype. -- U.N.C. Cat. No. 3797.

Lagena pseudosulcata McLean

Pl. 1, figs. 4a-b

Lagena acuticosta Brady, 1884, (not Reuss, 1862),

Challenger Rept., Zool., vol. 9, pl. 57, fig. 31, (not fig. 32, pl. 58, figs. 20, 21.).

Lagena pseudosulcata McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 332, pl. 39, figs. 11a, b.

Test ovate to slightly pyriform, apertural end tapering, basal end rounded, with a circular basal ring of clear shell material; apertural process formed by massive clear shell material which forms a stout cone capping the chamber proper, transversed lengthwise by a narrow capillary from the chamber to the round aperture; wall hyaline, thick, finely perforate, ornamented with about fourteen broad, heavy longitudinal costae. Length 0.37 mm, diameter 0.26 mm.

Rare. Occurs in all three zones, in the samples 1,3,4, and 10.

Lagena acuticosta of authors (not Reuss), and L. elegantissima (Bornemann) (1855, Deutsch. Geol. Ges. Zeitschr., Berlin, Bd. 7, Heft 2, p. 316, pl. 12, figs. 1a-c.) are species which closely resemble L. pseudosulcata with regard to their heavy longitudinal ornamentation. They differ, however, in the lack of the stout apertural process of L. pseudosulcata.

Hypotype. -- U.N.C. Cat. No. 3798.

Lagena torsicollis n. sp.

Pl. 1, figs. 5a-b

Test small, elongate oval to pyriform in side view, circular in apertural view, basal end broadly rounded, with a small circular scar, apertural end tapering into the long slender neck which is ornamented with seven to eight narrow and faint costae, twisting around the neck in about one-half volution in a high spire; wall hyaline, finely perforate, smooth, glossy in well-preserved specimens, without ornamentation, neck not perforate; aperture terminal, simple, round or constricted. Total length 0.30 mm, length of chamber 0.22 mm, diameter 0.15 mm.

Rare. Occurs in all zones, in the samples 1, 2, 3, 4, 5, 7, 8 and 10.

This form has some similarity with Lagena striaticollis (d'Orbigny), (1839, Voyage dans l'Amérique Méridionale; Foraminifères, vol. 5, pt. 5, p. 21, pl. 5, fig. 14.) and L. howei Bergquist, (1942, Miss. Geol. Survey, Bull. 49, p. 50, pl. 5, fig. 19.) with respect to the high spired costae on the apertural neck, but differs in lacking the basal striations, and/or spines of these forms. It differs from L. laevis (Montagu) in the possession of the completely costate neck.

Holotype. -- U.N.C. Cat. No. 3799.

Paratype. -- U.N.C. Cat. No. 3800.

Genus Lenticulina Lamarck, 1804

Lenticulina americana americana (Cushman)

Pl. 1, figs. 6a-b

Cristellaria americana Cushman, 1918, U.S. Geol. Survey Bull. 676, p. 50, pl. 10, figs. 5-6.

Robulus americanus Cushman, 1930, Florida Geol. Survey Bull. 4, p. 24, pl. 3, fig. 7. --- Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 12, pl. 3, fig. 6. --- Renz, 1948, Geol. Soc, America Mem. 32, p. 157, pl. 12, fig. 3.

Test lenticular, nearly circular, umbonal areas raised; periphery acute, provided with a thin, sharp keel; chambers appressed, about eight in the last whorl, embracing toward the umbilicus, enlarging gradually in size as added; sutures distinct, slightly curved, flush with the surface, strongly limbate, umbonal region covered with deposits of clear shell material; wall smooth, hyaline, finely perforate; aperture at the peripheral angle of the apertural face of the last chamber, elongate, radiate, earlier apertures can be distinguished in the angle of the limbate sutures and the peripheral keel. Diameter 0.74 mm, thickness 0.37 mm.

Rare. Occurs in all three zones, present in the samples 1, 3, 4, 5, 6, 9,and 10.

Among completely developed specimens, a number of juvenile forms have been found. These typically consist of a large proloculus with any number, from one to five or six additional chambers. Because of the

characteristics of their aperture and the absence of spines, (compare with the following, Lenticulina americana spinosa), these immature forms have been included in this species.

Hypotype. -- U.N.C. Cat. No. 3801.

Lenticulina americana spinosa (Cushman)

Pl. 1, figs. 7a-b

Cristellaria americana spinosa Cushman, 1918, U.S. Geol. Survey Bull. 676, p. 51, pl. 10, fig. 7.

Robulus americanus spinosus Cushman, 1930, Florida Geol. Survey Bull. 4, p. 24, pl. 3, figs. 8a, b.

--- Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 12, pl. 3, fig. 7.

--- Renz, 1948, Geol. Soc. America Mem. 32, p. 157, pl. 12, fig. 4. ---- Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. no. 25, p. 120, pl. 6, figs. 55,56.

Variety differing from the typical form in the addition of spines at the periphery, which are confined mostly to the first portion of the outer whorl. Diameter 0.76 mm, thickness 0.30 mm.

Rare. Occurs in the Pecten zone only, present in the samples 1 and 2.

As with L . americana americana a number of immature specimens have been found among the adult forms. Several growth stages are present, which exhibit the short spines which are characteristic for this subspecies. It is noteworthy, that the spines are present even on the proloculus of specimens with less than one complete whorl.

Hypotype. -- U.N.C. Cat. No. 3802.

Lenticulina glabrata (Cushman)

Pl. 1, figs. 8a-b

Cristellaria occidentalis glabrata Cushman, 1923, U.S. Natl. Mus. Bull. 104, p. 103, pl. 25, fig. 3.

Robulus occidentalis glabratus Cushman and Todd, 1945 Cushman Lab. Foram. Res., Spec. Publ. no. 15, pl. 2, fig. 15.

Test subcircular in outline, lenticular, much higher than wide; periphery acute, with a narrow, sharp keel; about eight chambers in the last whorl, appressed, embracing toward the umbilicus, increasing gradually in size as added; sutures distinct, flush with the surface, strongly limbate, curved, umbonal region covered with clear, transparent shell material; wall hyaline, finely perforate, aperture a narrow, vertical slit at the peripheral angle of the apertural face of the last chamber, reaching on to the periphery, where it is strongly radiate, radiations of previous apertures can be observed in the angle formed by the limbate sutures and the peripheral keel. Diameter 0.89 mm, thickness 0.37 mm.

Rare. Occurs in the Dosinia-Mercenaria zone only, present in sample 3.

Lenticulina glabrata is considered here to represent a species distinct from L. occidentalis. The degree of uncoiling and the type of aperture being different to such an extent, that it is doubtful, whether they are congeneric.

Hypotype. -- U.N.C. Cat. No. 3803.

Family Polymorphinidae d'Orbigny, 1839

Subfamily Polymorphininae d'Orbigny, 1839

Genus Polymorphina d'Orbigny, 1826

Polymorphina subdilatata Egger

Pl. 1, figs. 9a-c

Polymorphina subdilatata Egger, 1857, Neues Jahrbuch, Min. Geogn. Geol. Petref. - Kunde, p. 286, pl. 13, figs. 30-33.

Test small, ovate in side view, compressed equally on both sides, sides nearly parallel in edge view; periphery rounded; chambers distinct, about five visible on each side, added in a slightly twisted series, appressed, rapidly enlarging as added; sutures distinct, slightly depressed, much more oblique to the axis on one side than on the other; wall hyaline, finely perforate; aperture terminal, slightly produced, simple, radiate. Length 0.26 mm, width 0.15 mm, thickness 0.08 mm.

Rare. Occurs in the Turritella zone, present in sample 10 only.

Hypotype. -- U.N.C. Cat. No. 3804.

Genus Guttulina d'Orbigny, 1839

Guttulina austriaca d'Orbigny

Pl. 2, figs. 1a-b

Guttulina austriaca d'Orbigny, 1846, Foram. Foss. Basin Tertiaire, Vienne, p. 223, pl. 12, figs. 23-25. --- Cushman and Ozawa, 1930, U.S. Natl. Mus. Proc. vol. 77, art. 6, p. 29, pl. 4, figs. 3,4, (not figs. 5a-c). --- Cushman and Cahill, 1933, U.S. Geol. Survey

Prof. Paper 175-A, p. 17, pl. 6, figs. 3, (?) 4. --- Dorsey, 1948, Maryland, Dept. Geol., Mines, Water Res., Bull. 2, p. 291, pl. 31, figs. 25a, b, 26. --- McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 333, pl. 40, figs. 1-3.

Test small, fusiform to pyriform, elongate, basal end somewhat rounded, apertural end pointed, greatest width through the middle; chambers elongate, slightly inflated, embracing, arranged in a twisted polymorphine series, each succeeding chamber farther from the base, three to four visible on each side; sutures distinct, somewhat depressed; wall smooth, finely perforate, hyaline; aperture terminal, produced, radiate, large and round. Diameter 0.45 mm, width 0.22 mm.

Rare. Occurs in the Mercenaria-Dosinia zone only, in sample 4.

Since Cushman and Ozawa (1930) regarded Guttulina oblonga (d'Orbigny) as synonymous with G. austriaca, very large, elongated forms have been identified in the literature as G. austriaca. Here, only specimens which, instead of flaring towards the apertural end, retain their fusiform shape were included in G. austriaca.

Hypotype. -- U.N.C. Cat. No. 3805.

Guttulina sp. cf. G. leprosa (Reuss)

Pl. 2, figs. 2a-b

Polymorphina leprosa Reuss, 1867, Sitzungsber., K. Akad. Wiss., vol. 55, pt. 1, p. 89, pl. 4, figs. 3a-c.

Test oval in side view, broadly rounded at the basal end, apertural end bluntly pointed, slightly compressed, subtriangular in apertural view; five chambers visible, appressed except for the last one which is inflated, failing to reach the basal end; sutures distinct, slightly depressed; wall hyaline, finely perforate, ornamented with irregular fine tubercles which

tend to align themselves into ill-defined longitudinal rows near the apertural end; aperture terminal, somewhat produced, round, radiate. Length 0.44 mm, width 0.33 mm, thickness 0.29 mm.

Rare. Occurs in the Mercenaria-Dosinia zone only, present in sample 5.

The present specimen differs from the type-figure of Guttulina leprosa (Reuss) in exhibiting more elongated chambers in the early stages. Also, five chambers are present instead of only three as in the type. Though the final chamber is inflated, it does not show the radial symmetry and circular outline of the type.

Cushman and Ozawa, 1930 put G. leprosa into synonymy with Globulina caribaea d'Orbigny. This practice is not followed here. G. caribaea has a more produced final chamber and, as d'Orbigny illustrates and especially stated in his description, a non-radiate aperture!

Hypotype. -- U.N.C. Cat. No. 3806.

Guttulina sp.

Pl. 2, figs. 4a-b.

Guttulina lactea earlandi Cushman, 1930, (not Cushman and Ozawa, 1930), Florida Geol. Survey Bull. 4, p. 34, pl. 5, fig. 19.

Test minute, oval in outline, much compressed, two distinct stages of growth observed. Earlier portion of regular polymorphine growth, oval and compressed, chambers distinct, elongate, unequally embracing, reaching from the basal end far over the apical end, three visible on one side, four on the other; juvenarial apertures not observed. Last chamber embracing almost completely the earlier portion of the test, horseshoe-shaped, compressed; suture distinct, slightly depressed in the basal portion, deeply incised

between the proximal portion of the polymorphine stage and the final chamber; no sign of an aperture on the last chamber; wall hyaline, thin, smooth, finely to moderately perforate. Length 0.24 mm, width 0.19 mm, thickness 0.08 mm.

Rare. Occurs in the Pecten zone only, in sample 1.

In their description of Guttulina lactea earlandi, Cushman and Ozawa do not say, whether the rim around the regular portion of the test is a keel, test fragments or a regular, embracing chamber, though the type figure, a side view only, shows an irregularly sculptured flange, completely surrounding the polymorphine test. The identity of either this specimen or the one figured by Cushman in 1930 (Florida Geol. Survey Bull. 4.) with the type figure of G. lactea earlandi is doubtful and can be established only after a better description of the holotype is available.

Unfortunately the only specimen found at Grimesland was lost during the final checking of the manuscript.

Hypotype. -- U.N.C. Cat. No. 3807.

Genus Pseudopolymorphina Cushman and Ozawa, 1928

Pseudopolymorphina sp.

Pl. 2, figs. 3a-b

Test large, elongate slender fusiform, somewhat compressed, widest in about the middle of the test, basal end blunt, periphery rounded; chambers large, elongate, slightly inflated, arranged in a clockwise twisting polymorphine series, each chamber considerably larger than the preceding one, removed farther from the base, about seven chambers visible on each

side; sutures distinct, depressed in early portion, later flush with the surface; wall hyaline, smooth, finely perforate; aperture very large, radiate, at the end of the long, tapering ultimate chamber; remnants of the former apertures can be seen occasionally in the sutures of earlier chambers as fine striations from the radii. Length 1.52 mm, width 0.57 mm.

Rare. Occurs in the Mercenaria-Dosinia zone only, present in sample 4.

The present specimens compare with the larger specimens (figs. 6, 7) of Guttulina palmerae McLean (1956, p. 333, pl. 40, figs. 4-7) which are probably the end members of a growth series. These larger specimens are, however, true Pseudopolymorphina.

Hypotype. -- U.N.C. Cat. No. 3808.

Family Glandulinidae Reuss, 1860

Subfamily Glandulininae Reuss, 1860

Genus Laryngosigma Loeblich and Tappan, 1953

Laryngosigma williamsoni (Terquem)

Pl. 2, figs. 5a-b

Polymorphina lactea oblonga Williamson, 1858, (not P. oblonga Roemer, 1838, nor P. oblonga d'Orbigny, 1846), Rec. Foram. Great Britain, p. 71, pl. 6, figs. 149, 149a.

Polymorphina williamsoni Terquem, 1878, Soc. Géol. France, Mém., ser. 3, vol. 1, no. 3, p. 37.

Sigmomorphina williamsoni Cushman and Ozawa, 1930, U.S. Natl. Mus. Proc., vol. 77, art. 6, p. 138, pl. 38, figs. 3,4. -- McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 338, pl. 42,

figs. 1-4.

Larygosigma williamsoni Loeblich and Tappan, 1953, Smithsonian Inst., Misc. Coll., vol. 121, no. 7, p. 83.

Test small, elongated, basal and apertural end broadly rounded, compressed in apertural view, periphery rounded; chambers few, distinct, arranged in a slightly sigmoid series, elongate; sutures distinct, slightly depressed, nearly straight at the lower part, curving strongly toward the oral end; wall hyaline, thin, transparent, finely perforate; aperture terminal, a narrow, elongate opening, radiate, provided with a short entosolenian tube. Length 0.44 mm, width 0.19 mm, thickness 0.11 mm.

Rare. Occurs in all three zones, present in the samples 1, 4, 9, and 10.

Only a few adult specimens were found, which display the typical characteristics. Some specimens have altered tests, rendering them opaque, so that the entosolenian tube is not observable. Several small specimens were found also, which seem to be juvenile forms of this species, though their relative width is slightly greater than in the adult forms.

Hypotype. -- U.N.C. Cat. No. 3809.

Subfamily Oolininae Loeblich and Tappan, 1961

Genus Oolina d'Orbigny, 1839

Oolina sp. cf. O. hexagona (Williamson)

Pl. 2, figs. 6a-b

Entosolenia squamosa hexagona Williamson, 1848, Ann. and Mag. Nat. Hist., ser. 2, vol. 1, pl. 2, fig. 23.

Lagena hexagona Brady, 1884, Challenger Rept., Zoology, vol. 9, pl. 58, figs. 32, 33. --- Cushman, 1930. Florida Geol. Survey, Bull. 4, p. 30, pl. 5, figs. 11a-b. --- Cushman and Cahill, 1933, U.S. Geol.

Survey, Prof. Paper 175-A, p. 15, pl. 5, figs. 8a-b.

Test small, egg shaped in side view, circular in apertural view, basal end rounded with a small, central scar, apertural end tapering into a blunt point or into a small flat apertural surface; wall calcareous, hyaline, finely perforate, covered with numerous shallow hexagonal pits which are more or less aligned into longitudinal rows, the symmetry of the rows is best developed near the midline of the test, but disorderly near the basal and apertural end; aperture a small round opening in a slight depression with an entosolenian tube extending straight down into the chamber for one third of its length. Diameter 0.14 mm, length 0.20 mm.

Rare. Occurs in the Mercenaria-Dosinia zone and in the Pecten zone, samples 1 and 5.

Only three specimens were recovered, one of which was broken to ascertain the character of the entosolenian tube.

The present specimens differ from the typical O. hexagona in that their hexagonal pits are much more numerous, smaller in size in relation to the size of the entire test and also have these pits aligned into more or less regular rows. The identity of these specimens with the type is questionable. However, more material is needed to decide whether these forms here present are part of a distinct new species, or fall within the range of variation of O. hexagona.

Hypotype. -- U.N.C. Cat. No. 3810.

Oolina striatopunctata (Parker and Jones)

Pl. 2, figs. 7a-b

Lagena sulcata striatopunctata Parker and Jones, 1865, Roy. Soc. London, Philos. Trans., vol. 155, p. 350, pl. 13, figs. 25-27.

Lagena striatopunctata Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 468, pl. 58, figs. 37, 40. --- Cushman, 1923, U.S. Natl. Mus. Bull. 104, pt. 4, p. 55, pl. 10, fig. 10. ---Cushman, 1948, Cushman Lab. Foram. Res., Spec. Publ. no. 23, p. 47, pl. 5, fig. 10.

Test small, pyriform in side view, circular in apertural view, basal end rounded, apertural end elongate, tapering; ornamented with about fifteen stout longitudinal costae which are perforated by large distinct pores located on the costae proper near the basal end of test and on the sides of the costae near the apertural end; wall hyaline, aperture terminal, a simple round opening without neck, costae fuse near the aperture, surrounding it with massive shell material, probably with entosolenian tube. Length 0.22 mm, diameter 0.15 mm.

Rare. Occurs in the Pecten zone only, present in sample 1.

The character of the aperture was not definitely determined because only one specimen was found. The wetted specimen in transmitted light suggests the presence of an entosolenian tube.

Hypotype. -- U.N.C. Cat. No. 3811.

Genus Fissurina Reuss, 1850

Fissurina aequilabialis (Buchner)

Pl. 2, figs. 8a-c

Lagena aequilabialis Buchner, 1940, K. Leop. - Carol. Deutsch, Akad. Naturf., Abh. (Nova Acta), n.s., vol. 9, no. 62, p. 513, pl. 21, figs. 440-444.

Test minute, broadly oval in side view, moderately compressed in edge view; periphery subrounded, with a faint keel, basal end slightly

produced in some specimens; wall hyaline, finely perforate, perforation more dense near the periphery than in the central portions; aperture produced, terminal, lying between a pair of equal sized lips as a narrow, elongated slit, the entosolenian tube is free for the first portion, becoming attached to the dorsal chamber wall above the middle of the test, reaching almost to the bottom of the chamber, where it ends in a flange. Height 0.20 mm, width 0.15 mm, thickness 0.13 mm.

Rare. Occurs in all three zones, in samples 1, 8, and 10.

Fissurina aequilabialis falls between the genera Fissurina and Parafissurina. The asymmetric and attached position of the lower portion of the entosolenian tube is typical for Parafissurina, however, the lack of an apertural hood and the equal size of the lips, the truly terminal aperture together with the central and free position of the proximal end of the entosolenian tube puts this species into the genus Fissurina.

Hypotype. --- U.N.C. Cat. No. 3812.

Fissurina cucurbitasema Loeblich and Tappan

Pl. 2, figs. 9a-c

Fissurina cucurbitasema Loeblich and Tappan, 1953, Smithsonian Inst., Misc. Coll., vol. 121, no. 7, (publ. 4105), p. 76, pl. 14, figs. 10, 11.

Test small, elongate ovate, moderately compressed; periphery with a thin marginal keel which is much reduced near the central portion of the test, basal end slightly produced, in some specimens with a thickened projection; aperture terminal, an oval slit between a pair of thick lips, drawn out into a free entosolenian tube which extends about halfway down

into the test; wall hyaline, finely perforate. Height 0.20 mm, width 0.09 mm, thickness 0.075 mm.

Rare. Occurs in the Turritella zone, samples 9 and 10, and in the Mercenaria-Dosinia zone, sample 8.

Hypotype. -- U.N.C. Cat. No. 3813.

Fissurina lucida (Williamson)

Pl. 2, figs. 10a-c

Entosolenia marginata lucida Williamson, 1848, Ann. Mag. Nat. Hist., ser. 2, vol. 1, p. 17, pl. 2, fig. 17.

Entosolenia lucida Cushman and Cole, 1930, Cushman Lab. Foram. Res., Contr. vol. 6, p. 98, pl. 13, figs. 11, 12. --- Cole, 1931, Florida Geol. Survey Bull. 6, p. 40, pl. 7, figs. 5,6. --- Cushman and Gray, 1946, Cushman Lab. Foram. Res., Spec. Publ. no. 19, p. 30, pl. 5, figs. 16-18. --- Cushman and Todd, ibid., Spec. Publ. no. 21, p. 20, pl. 3, fig. 11. --- Cushman, 1948, ibid., Spec. Publ. no. 23, p. 63, pl. 7, fig. 2. --- Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res. Bull. 2, p. 304, pl. 36, figs. 8a, b.

Entosolenia cf. lucida Cushman, 1941, Cushman Lab. Foram. Res., Contr. vol. 17, p. 36, pl. 9, fig. 12.

Lagena lucida Cushman, 1923, U.S. Natl. Mus., Bull. 104, pt. 4, p. 33, pl. 6, figs. 1,2.

Test minute, ovate and compressed; periphery round, not carinate, somewhat produced at the base; wall in central portion and along the margins hyaline and clear, very finely perforate, separated by a broad, horseshoe shaped band of white opaque wall material, which is partially or completely divided by a clear section immediately above the basal projection in some

of the specimens; aperture a narrow slit between a pair of thin lips, continuing into a free entosolenian tube which extends inward into the test for about one quarter to one third of its length. Height 0.22 mm, width 0.15 mm, thickness 0.12 mm.

Rare. Occurs in the Mercenaria-Dosinia and Pecten zones, samples 1, 3, 4, and 5.

The characteristic white horseshow shaped band makes this species conspicuous. If it were not for this particular characteristic, the species would be difficult to identify, for the variation of the size ratios is considerable.

Hypotype. -- U.N.C. Cat. No. 3814.

Fissurina lacunata (Burrows and Holland)

Pl. 2, figs. 11a-c

Lagena castrensis Brady, 1884, (not Schwager), Challenger Rept., Zoology, vol. 9, p. 485, pl. 60, figs. 1, 2.

Lagena lacunata Burrows and Holland, in: Jones, 1895, Foram. Crag, p. 205, pl. 7, figs. 12a, b.

Lagena orbignyana lacunata Cushman, 1913, U.S. Natl. Mus. Bull. 71, pt. 3, p. 43, pl. 20, fig. 1. -- Cushman, 1930, Florida Geol. Survey Bull. 4, p. 32, pl. 5, figs. 13a, b. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 16, pl. 5, figs. 12a, b.

Fissurina orbignyana lacunata Puri, 1953, Florida Geol. Survey Bull. 36, p. 115, pl. 26, figs. 2,3.

Test minute, oval, compressed in varying degrees; periphery carinate, three distinct keels surrounding the test, the central one may be quite reduced, on each side of the lateral keels thre is a slightly raised rim, surrounding the chamber surface proper; wall finely perforate,

on the chamber sides ornamented with small round pits; aperture terminal, a narrow oval between a pair of narrow lips, continuing into an entosolenian tube for about one-half of the chamber length. Length 0.26 mm, width 0.22 mm, thickness 0. 13 mm.

Rare. Occurs in all three zones, in samples 1, 3, 7, 9, and 10.

Specimens previously illustrated from Recent material show the three marginal keels very prominently and sharply. Specimens from Tertiary deposits (Cushman, 1930; Cushman and Cahill, 1933), including specimens of this fauna, show keels which are rather low and rounded. Whether this represents a constant morphological character or is due to preservation cannot be determined.

Hypotype. -- U.N.C. Cat. No. 3815.

Fissurina pseudoglobosa (Buchner)

Pl. 3, figs. 1a-c

Lagena pseudoglobosa Buchner, 1940, k. Leop. - Carol. Deutsch. Akad. Naturf., Abh. (Nova Acta), n.s., vol. 9, no. 62, p. 463, pl. 11, figs. 169-172 (not 167, 168).

Test minute, variable, smooth, broadly oval in side view, compressed in edge view, rarely inflated; periphery rounded, not carinate, basal end slightly produced; wall hyaline, thin, finely perforate; aperture terminal, somewhat produced, elongate oval, an entosolenian tube extends downward from the aperture for about one-fourth the length of the chamber, inclined to the wall but not attached to it. Length 0.26 mm, width 0.18 mm, thickness 0.09 mm.

Rare. Occurs in all three zones, in samples 1,3, 9, and 10.

In his original description Buchner states that the species is a variable one. This variability is also expressed by his type figures. A

similar range of variation of shapes was found in the present material, however, it seems doubtful that specimens which possess definite lips, as fig. 167 and 168 of Buchner, actually belong into this species. They have not been included here.

Hypotype. -- U.N.C. Cat. No. 3816.

Genus Parafissurina Parr, 1947

Parafissurina arata (Buchner)

Pl. 3, figs. 2a-b

Lagena arata Buchner, 1940, K. Leop. - Carol. Deutsch. Akad. Naturf., Abh. (Nova Acta), n.s., vol. 9, no. 62, p. 532, pl. 26, figs. 562-565.

Test minute, suboval in outline, compressed; periphery acute, not keeled through the central part, but a keel develops at the lower third of test, with a slight furrow on each side in which the wall appears opaque; aperture covered by a well developed hood, leaving a low arched apertural opening, the lateral ends of the hood extending down the sides of the test, but fading out before they reach the middle; a prominent siphon extends along the dorsal side of the chamber wall, down to the lowest part of the test and reaches part way up the ventral side where it terminates in a flare, the siphon is attached to the chamber wall so that the test wall forms one side of the tube; wall hyaline, very finely perforate. Length 0.15 mm, thickness 0.09 mm, width 0.13 mm.

Rare. Occurs in the Turritella zone and the Dosinia-Mercenaria zone. Present in the samples 8 and 9.

A few specimens have been found in the Grimesland fauna which are identical except for the lack of a basal keel. They have tentatively been retained in this species.

Hypotype. -- U.N.C. Cat. No. 3817.

Genus Ventrostoma, new genus

Type species: Ventrostoma fovigera (Buchner), 1940

Test free, unilocular, ellipsoid or ovate in ventral view, somewhat compressed in side view, dorsal side convex, ventral side concave, wall calcareous, hyaline, finely perforate, smooth, periphery rounded mostly, may be slightly keeled, aperture a rounded opening in a depression on the ventral side, variously situated in the anterior portion of the ventral side to central in position, continuing into an entosolenian tube which extends into the chamber, may be attached to the dorsal wall and extending towards the posterior end.

Remarks: In 1947, Parr erected the genus Parafissurina and described this genus as Fissurina-like, in which the aperture is asymmetrically shifted to the ventral side, one of the unequally developed lips overhanging the aperture in a hood-like fashion.

The genus Ventrostoma is the consequent development of a tendency to shift the apertural position downward. The aperture in Ventrostoma is separated from the periphery and the lips or a hood are no longer present. Some previously described species which can be assigned to Ventrostoma are:

Ellipsolagena cor Wiesner

Lagena cordiformis Buchner

Lagena cymbula Heron-Allen and Earland

Lagena removens Buchner

Lagena reniformis Sidebottom

Lagena tympanigera Buchner

Lagena curvans Buchner can be regarded as a form which is intermediate in position between Parafissurina and Ventrostoma.

Ventrostoma fovigera (Buchner)

Pl. 3, figs. 3a-c

Lagena fovigera Buchner, 1940, Nova Acta Leopoldina; Abh. K. Leop. Carol. Deutsch. Akad. Naturf.; Neue Folge, Bd. 9, no. 62, p. 541, pl. 29, figs. 627-629.

Test minute, egg-shaped to ovate in front view, compressed in side view; periphery angular to subrounded, bearing thickened shell material, separating sharply the convex dorsal side from the slightly concave ventral side; aperture a simple round opening situated in a slight depression on the anterior third of the ventral side, an entosolenian tube extends from the aperture backwards to the dorsal chamber wall, where it becomes attached and continues posteriorly towards the basal end; wall hyaline, transparent, very thin, finely perforate, in well preserved specimens the pores tend to be concentrated near the periphery; a basal scar appears as an opaque spot, a little removed from the base on the dorsal side of the chamber. Length 0.20 mm, width 0.16 mm.

Rare. Occurs in all three zones, present in the samples 1, 4, 7, 9, and 10.

Hypotype. -- U.N.C. Cat. No. 3818.

Superfamily Buliminacea Jones, 1875

Family Turrilinidae Cushman, 1927

Subfamily Turrilininae Cushman, 1927

Genus Buliminella Cushman, 1911

Bulminella elegantissima (d'Orbigny)

Pl. 3, figs. 4a-b

Bulimina elegantissima d'Orbigny, 1839, Voyage dans l'Amérique Méridionale, tome 5, pt. 5, Foraminifères, p. 51, pl. 7, figs. 13, 14. ---Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 402, pl. 50, figs. 20-22. Buliminella elegantissima Cushman, 1911, U.S. Natl. Mus. Bull. 71, pt. 2, p. 89. ---Cushman, 1925, Contr. Cushman Lab. Foram. Res., vol. 1, p. 40, pl. 6, figs. 5a, b. ---Cushman, 1930, Florida Geol. Survey Bull. 4, p. 42, pl. 8, figs. 2,3. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 23, pl. 7, figs. 13, 14.

Test small, elongate, about two and one-half times as long as wide, pointed at the initial end, subparallel sides for most of the test; chambers elongated, arranged in a high spire, standing oblique to the axis of coiling, about three volutions forming the spire, with about ten chambers in the last whorl; sutures distinct, slightly depressed, curved; wall smooth, hyaline, finely perforate; aperture an elongate opening in a depression high on the apertural face. Length 0.37 mm, diameter 0.11 mm.

Rare to abundant. Present in all samples, common or abundant in the following samples: 1 (2%), 2 (4%), 3 (4%), 7 (1%), 8 (1.5%), 9 (7%), and 10 (14%).

A large percentage of the specimens in the Grimesland material are smaller than most of those previously described. In the Grimesland specimens the average remains less than 0.30 mm in length.

Hypotype. --U.N.C. Cat. No. 3819.

Family Bolivinitidae Cushman, 1927

Genus Bolivina d'Orbigny

Bolivina floridana Cushman

Pl. 3, figs. 7a-b

Bolivina floridana Cushman, 1918, U.S. Geol. Survey, Bull. 676, p. 49, pl. 10, fig. 4. ---Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 46, pl. 8, figs. 15a, b. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 26, pl. 8, figs. 11a, b. ---Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. no. 9, p. 85, pl. 10, figs. 2,3. ---Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 306, pl. 36, figs. 15a, b. ---Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. no. 25, p. 190, pl. 12, fig. 37.

Test elongate, about two and one-half times as long as broad, tapering gradually, greatest width across the last formed pair of chambers; slightly compressed, periphery broadly rounded; chambers numerous, indistinct, last chamber weakly inflated in some specimens; sutures moderately depressed, obscure in early portions, distinct in later stages, lower chamber margins lobular, lobulations poorly aligned, producing irregular longitudinal raised areas and intermediate depressed areas; wall hyaline, coarsely per-

forate; aperture an elongated slit, equal to the height of the apertural face. Length 0.37 mm, width 0.15 mm, thickness 0.09 mm.

Rare. Occurs in the Turritella zone, sample 9, 10, the Mercenaria-Dosinia zone, sample 6,7,8, and the Pecten zone, sample 1, 2.

The type figure of this species, as published in 1918, does not correspond very well with the holotype. However, the holotype was refigured by Cushman with much more accuracy in 1937.

Hypotype. --U.N.C. Cat. No. 3822.

Bolivina lafayetti McLean

Pl. 3, figs. 8a-b

Bolivina lafayetti McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 346, pl. 45, figs. 6a, b, 8a, b.

Test small, elongate, about two times as long as broad, tapering from the initial end toward the apertural end, widest across the last formed pair of chambers in young forms, sides subparallel in the late stages of adult specimens, slightly compressed, periphery rounded, irregular in outline; chambers numerous, only slightly inflated, last few chambers more strongly inflated, indistinct, curved, broader than high, irregular in outline, marked by an elevated process and a downward projecting lobe close to the center of each chamber which form two discontinuous ridges on each side of the test; sutures moderately distinct, slightly depressed, especially between the last formed chambers; wall hyaline, coarsely perforate; aperture high arched, widest at the base of the apertural face. Length 0.30 mm, width 0.15 mm, thickness 0.07 mm.

Rare. Occurs in the Turritella zone, sample 9, 10, and the Mercenaria-Dosinia zone, sample 7, 8.

The forms here present are smaller than the types from the upper Miocene from Virginia. However, they possess the same proportions and characteristics and are believed to be young forms. Megalospheric as well as microspheric forms are represented in the fauna which differ from each other in the size of the proloculus and the degree of pointing at the initial end. The megaspheric tests are more blunt.

Hypotype. -- U.N.C. Cat. No. 3823.

Bolivina plicatella Cushman

Pl. 4, figs. 1a, b

Bolivina plicatella Cushman, 1930, Florida Geol. Survey Bull. 4, p. 46, pl. 8, figs. 10a, b. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 26, pl. 8, figs. 12a, b. ---Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. no. 9, p. 89, pl. 11, figs. 3,4.

Test small, about twice as long as broad, widest near the apertural end, moderately compressed, periphery rounded, irregular in outline; chambers, except for the last pair, indistinct in the more ornate forms, obscured by the surface ornamentation; sutures indistinct in the first portion of the test, partially obliterated by ornamentation, distinct and slightly depressed in the last portion; lower margins of the chambers lobate, lobes aligned into two or three irregular longitudinal rounded to sharp costae on each side, leaving between them distinct grooves of varying deepness, short, transverse ridges connect the longitudinal costae and extend from them laterally at irregular intervals, giving the surface a strongly re-

ticulate appearance; wall hyaline, coarsely perforate; aperture a high arch at the inner margin of the last chamber, with an indication of a narrow lip. Length 0.30 mm, width 0.16 mm, thickness 0.07 mm.

Rare to common. Occurs in all samples, common in the Turritella zone, sample 9 (1%) and sample 10 (2%).

This species was inadequately illustrated in 1930 and again in 1933. In 1937, the holotype was refigured in the Cushman Lab. Foram. Res., Spec. Publ. no. 9, pl. 11, fig. 3, showing the accurate form in great detail. Grimesland specimens display some degree of variation, mainly in respect to their surface ornamentation. The ridges are more sharply defined, but their spacing ranges from very irregular pattern to a high degree of symmetry, in the latter case they approach B. thalmanni Renz, from the lower Miocene of Venezuela.

Hypotype. -- U.N.C. Cat. No. 3826.

Bolivina compacta (Sidebottom)

Pl. 3, figs. 5a-b

Bolivina robusta Brady var. compacta Sidebottom, 1905, Mem. Proc. Manchester Lit. Philos. Soc., vol. 49, no. 5, p. 15, pl. 3, figs. 7a, b.

Bolivina compacta Cushman, 1937, Cushman Lab. Foram. Res., Spec. Res., Spec. Publ. no. 9, p. 135, pl. 17, figs. 22-24. ---Cushman and Todd, 1945, ibid., Spec. Publ. no. 15, p. 44, pl. 7, fig. 5.

Test small, elongate, about two and one-half times as long as broad, tapering, initial end bluntly pointed, rounded periphery, moderately

compressed, oval in transverse section, five to seven pairs of chambers present, the last three pairs making up two-thirds of the test; sutures slightly depressed, indistinct; wall hyaline, coarsely perforate so as to make the surface appear pitted; aperture elongate, reaching the full length of the apertural face. Length 0.35 mm, width 0.15 mm, thickness 0.10 mm.

Rare. Occurs in the Turritella zone, sample 9, and the Pecten zone, sample 2.

Hypotype. --- U.N.C. Cat. No. 3820.

Bolivina directa (Cushman)

Pl. 3, figs. 6a-b

Bolivina directa Cushman, 1936, Cushman Lab. Foram. Res., Spec. Publ. No. 6, p. 54, pl. 7, figs. 22a, b. ---Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. no. 9, p. 95, pl. 12, fig. 14.

Test elongate, narrow, about three times as long as broad, tapering gradually from the apertural end to the initial end, widest near the last formed chambers, moderately compressed, rounded periphery; chambers numerous, ten and more pairs, very distinct, low crescent shaped in early portions, becoming higher arched in later stages, slightly inflated toward the apertural end; sutures very distinct, slightly depressed in early stages, more so in later portions, development of a small, pointed lobe at the inner margin of the chambers increasing with age; wall hyaline, smooth, finely perforate; aperture an oval slit reaching over the whole length of the apertural face. Length 0.27 mm, width 0.12 mm.

Rare. Occurs in the Turritella zone, sample 9, and the Pecten zone, sample 9, and the Pecten zone, sample 2.

Most of the specimen from Grimesland appear to be juvenile forms.

Hypotype. --- U.N.C. Cat. No. 3821.

Bolivina sp. cf. B. marginata multicostata Cushman

Pl. 3, figs. 9a-b

Bolivina aenariensis multicostata Cushman, 1918, U.S. Geol. Survey, Bull. 676, p. 48, pl. 10, fig. 2.

Bolivina marginata multicostata Cushman, 1930, Florida Geol. Survey, Bull. 4, p. 46, pl. 8, figs. 13, 14. ---Cushman and Cahill, 1933, U.S. Geol. Survey, Prof. Paper 175-A, p. 25, pl. 8, figs. 10a, b. ---Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. no. 9, p. 87, pl. 10, figs. 7-10.

Test elongate, about two and one-half times as long as wide, widest near the apertural end, tapering gradually toward the initial end, much compressed; periphery acute, carinate throughout, width of carina diminishing from apical toward apertural end; chambers distinct, numerous, curved, increasing gradually in size as added, last chambers slightly inflated; sutures distinct, curved, slightly limbate, slightly depressed; wall hyaline, medium perforate, surface ornamented with a few low longitudinal costae, strongest near the basal end, diminishing towards the middle where they disappear; aperture an elongate opening extending over nearly the entire inner margin of the last chamber. Length 0.35 mm, width 0.14 mm.

Rare. Occurs in the Pecten zone only, present in sample 1.

In the present specimens the costae are not as numerous and strongly developed as is seen in the illustration of the holotype nor do they extend as far anteriorly. As Cushman notes (1937, p. 87), this variation of

the development of costae seems to be normal for this species.

In the Grimesland specimens the chambers are higher arched than illustrated in the figure of the holotype, a feature which is also shown in B. marginata multicostata Cushman, 1937, pl. 10, fig. 10.

Hypotype. --- U.N.C. Cat. No. 3824.

Bolivina paula (Cushman and Cahill)

Pl. 3, figs. 10a-b

Bolivina paula Cushman and Cahill, 1932, in Cushman and Ponton, Florida Geol. Survey Bull. 9, p. 84, pl. 12, figs. 6a, b. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 26, pl. 8, figs. 14a, b. ---Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. no. 9, p. 91, pl. 11, figs. 9a, b. ---Cushman and McGlamery, 1938, U.S. Geol. Survey Prof. Paper 189-D, p. 107, pl. 25, figs. 14, 18, 19. ---Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 307, pl. 36, figs. 20a, b.

Test small, elongate,compressed, periphery rounded, sides tapering in early portions, later two-thirds nearly parallel; chambers numerous, seven to thirteen pairs, nine being the most common, increasing in height as added; sutures distinct, slightly limbate, flush in early stages, later depressed slightly, curving strongly near the central portion, later almost straight, meeting the periphery at an oblique angle; wall hyaline, smooth, finely perforate; aperture a high arch, extending over the whole height of the apertural face. Length 0.32 mm, width 0.11 mm, thickness 0.07 mm.

Rare to common. Occurs in all samples, common in sample 9 (1.5%) and 10 (3.5%).

Hypotype. --- U.N.C. Cat. No. 3825.

Bolivina subaenariensis (Cushman)

Pl. 4, figs. 2a-b

Bolivina subaenariensis Cushman, 1922, U.S. Natl. Mus. Bull. 104, pt. 3, p. 46, pl. 7, fig. 6. --- Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. no. 9. p. 155, pl. 18, figs. 26-28.

Test small, elongate, about two times as long as broad, widest at the apertural end, tapering gradually toward the blunt, broadly rounded initial end, much compressed; periphery acute, carinate throughout; chambers distinct, numerous, highest near the center; sutures distinct, flush with the surface, limbate, curved, meeting the periphery at an oblique angle; wall hyaline, distinctly perforate, surface ornamented with longitudinal costae, of which the two on each side of the median line are the most prominent, lateral costae shorter, and fail to reach the proloculus, apex provided with a small spine; aperture an elongated opening extending to the full height of the apertural face, slightly produced by the bifurcating peripheral carina. Length 0.37 mm, width 0.16 mm, thickness 0.07 mm.

Rare. Occurs in the Pecten zone only, sample 1.

Hypotype. -- U.N.C. Cat. No. 3827.

Family Buliminidae Jones, 1875

Subfamily Bulimininae Jones, 1874

Genus Bulimina d'Orbigny, 1826

Bulimina aculeata d'Orbigny

Pl. 4, figs. 3a-b

Bulimina aculeate d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 269. ---Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 406, pl. 51, figs. 7-9. ---Fornasini, 1902, Mem. Acad. Sci. Instit. Bologna, ser. 5a, vol. 9, p. 373, text-fig. 4. ---Cushman, 1922, U.S. Natl. Mus., Bull. 104, pt. 3, p. 96, pl. 22, figs. 1, 2. ---Cushman and Parker, 1938, Contr. Cushman Lab. Foram. Res., vol. 14, pt. 4, p. 92, pl. 16, figs. 7a, b. 8-10. ---Cushman, 1944, Cushman Lab. Foram. Res., Special Publ. no. 12, p. 28, pl. 3, fig. 47.

Test of medium size, tapering moderately, widest in the upper portion of the test; chambers distinct, inflated, globular in the later stages, triserial; sutures indistinct in the early portion, later strongly depressed; wall smooth, perforate; apical end with three distinct, short prolocular spines, spines also at the base of several of the earlier chambers; aperture an oval elongate opening at the base of the ultimate chamber. Length 0.40 mm, diameter 0.24 mm.

Rare. Occurs in all three zones, present in the samples 1, 2,4,5,9, and 10.

The size, number, and appearance of basal spines are variable. There may be few stout spines, or many slender spines of varying length. Some of the larger specimens found show an aberrantly oriented ultimate chamber.

Hypotype. -- U.N.C. Cat. No. 3828.

Bulimina sp.

Pl. 4, figs. 4a-b

Test small, elongate, slender, tapering in the early portion of the test, of uniform diameter for most of its length; chambers distinct, somewhat inflated and globular, arranged in a high triserial spiral; sutures distinct,

depressed; wall calcareous, finely to medium perforate; aperture slightly comma shaped, relatively broad at the base, extending from the base of the apertural face.

Length 0.33 mm, diameter 0.15 mm.

Rare. Occurs in the Turritella zone only, sample 10.

Hypotype. -- U.N.C. Cat. No. 3829.

Bulimina marginata d'Orbigny

Pl. 4, figs. 5a-b

Bulimina marginata d'Orbigny, 1826, Ann. Sci. Nat., sér. 1, tome 7, pl. 12, figs. 10-12. --- Brady, 1884, Challenger Rept., Zoology, vol, 9, p. 405, pl. 51, figs. 3-5. ---Cushman, 1922, U.S. Natl. Mus. Bull. 104, pt. 3, p. 91, pl. 21, figs. 4,5. ---Cushman and Ponton, 1932, Florida Geol. Survey Bull. 9, p. 77, pl. 11, fig. 12. ---Cushman and Todd, 1945, Cushman Lab. Foram. Res., Special Publ. no. 15, p. 39, pl. 6, fig. 8. ---Bermudez, 1949, Cushman Lab. Foram. Res., Special Publ. no. 25, p. 182, pl. 12, fig. 11.

Test small to medium sized, nearly as wide as long, tapering, widest through the last formed chambers; chambers distinct and inflated, except for the initial end, arranged in a regular triserial spiral, lower margin of chambers protruding from the preceding chambers at nearly right angles, thus forming a rim which is characterized by numerous small spines or crenulations; sutures distinct, depressed; wall smooth, hyaline, finely perforate; aperture comma shaped, much higher than wide in most specimens, lying in a depressed area on the apertural face, in well preserved specimens a slight border or lip lines the aperture on one side. Length 0.31 mm, diameter 0.20 mm.

Rare. Occurs in the Pecten zone only, sample 1 and sample 2.

Hypotype. -- U.N.C. Cat. No. 3830.

Subfamily Pavonininae Eimer and Fickert, 1899

Genus Reussella Galloway, 1933

Reussella pulchra Cushman

Pl. 4, figs. 6a-b

Reussella pulchra Cushman, 1945, Cushman Lab. Foram. Res., Contr. vol. 21, p. 34, pl. 6, figs. 11, 12.

Test of medium size, in shape of a three-sided pyramid, widest near the apertural end, about one and one-half times as long as broad; periphery acute, slightly carinate, spinose; chambers distinct, especially in later portion of test, three to a whorl, five whorls composing the test; sutures distinct, strongly limbate, raised, may be slightly irregular, curved, meeting the periphery at an oblique angle, protruding over the periphery to form short, irregular flanges; wall calcareous, coarsely perforate; aperture a medium arch at the inner margin of the ultimate chamber. Length 0.37 mm, diameter 0.22 mm.

Rare. Occurs in the Pecten zone only, in sample 2.

Only one specimen was recovered of which the aperture was partially damaged. The character of the complete aperture, however, can be inferred from the intact marginal portions.

Hypotype. -- U.N.C. Cat. No. 3831.

Family Uvigerinidae Haeckel, 1894

Genus Uvigerina d'Orbigny, 1826

Uvigerina attenuata Cushman and Renz

Pl. 4, figs. 7a-b

Uvigerina auberiana attenuata Cushman and Renz, 1941, Cushman Lab. Foram. Res., Contr. vol. 17, p. 21, pl. 3, figs. 17a, b. ---Renz, 1948, Geol. Soc. America Mem. 32, p. 173, pl. 7, figs. 20a, b.

Test elongate, slender, fusiform, tapering rapidly at initial end, and gradually at the apertural end; periphery lobulate; chambers distinct, about three to a whorl in the early portion, inflated, appressed and compact, becoming strongly inflated and more high spired in later part, the axial side of the last two chambers concave; sutures distinct, deeply depressed; wall calcareous, perforate, initial end coarsely spinose, apertural end finely spinose; aperture at the end of a long neck, round. Length 0.41 mm, diameter 0.15 mm.

Rare. Occurs in the Turritella zone only, present in the sample 9.

The only specimen present in this material differs from the typical in its more slender and elongate test. This differentiation is brought about by the addition of one or two more chambers beyond the growth stage of the holotype. Uvigerina attenuata differs from U. auberiana in the character of the terminal chamber which in U. attenuata is kidney shaped in cross section, and in having the apertural neck at the concave inner margin of the last chamber.

Hypotype. -- U.N.C. Cat. No. 3832.

Uvigerina juncea Cushman and Todd

Pl. 4, figs. 8a-b

Uvigerina juncea Cushman and Todd, 1941, Cushman Lab. Foram. Res.,

Contr. vol. 17, p. 78, pl. 20, figs. 4-11. ---Cushman and Gray, 1946, ibid., Spec. Publ. no. 19, p. 36, pl. 6, figs. 10-12.

Test elongate, slender, fusiform, tapering about equally at both ends; periphery lobulate; chambers distinct, numerous, much inflated, about three to a whorl in the early portion of the test, later becoming very high spired, the axial side of the last chamber is concave, bearing the trace of the internal apertural neck; sutures distinct, deeply depressed; wall hyaline, perforate, ornamented in the early portion by low, narrow costae, the intercoastal space wider than costae, about ten to a chamber, the costae of each chamber are not continuous from chamber to chamber, diminishing toward the apertural end where the wall becomes finely pustulose or even spinose; aperture terminal, at the end of a short neck, with a narrow lip. Length 0.45 mm, diameter 0.22 mm.

Rare. Occurs in all three zones, present in the samples 2,8, 9 and 10.

The paratypes of this species display in general a variation towards larger size than the holotype. This trend is reversed in the Grimesland material, where the largest specimens scarcely reach the size of the holotype. The general proportions, however, and the surface ornamentations are identical.

Hypotype. -- U.N.C. Cat. No. 3833.

Uvigerina modeloensis Cushman and Kleinpell

Pl. 4, figs. 9a-b

Uvigerina modeloensis Cushman and Kleinpell, 1934, Cushman Lab. Foram. Res., Contr. vol. 10, pt. 1, p. 12, pl. 2, figs. 8a-b.

Test elongate, slender, fusiform; periphery lobulate; chambers distinct, much inflated, large and high, arranged in a high spire, about two and one-half chambers to a whorl, the axial side of the last chamber concave;

sutures distinct, deeply depressed; wall hyaline, thin, finely perforate, with faint ornamentation of pustules and costae on some specimens, especially near the basal end; aperture terminal, round, at the end of a short neck which arises at the axial margin of the last chamber, trace of internal apertural neck marked on the inner, concave side of the chamber. Length 0.42 mm, diameter 0.15 mm.

Rare. Occurs in the Turritella zone and in the Pecten zone, present in the samples 2, 9, and 10.

Both, the figure and the type description fail to indicate, that there exists some very faint surface ornamentation on most specimens of this species. Pustules or fine spine bases are present on the whole test with varying degrees of prominence. Faint costae are visible under favorable light conditions, mainly near the basal end of the test.

Hypotype. -- U.N.C. Cat. No. 3834.

Uvigerina subperegrina Cushman and Kleinpell

Pl. 4, figs. 10a-b

Uvigerina subperegrina Cushman and Kleinpell, 1934, Cushman Lab. Foram. Res., Contr. vol. 10, pt. 1, p. 12, pl. 2, figs. 9-11. ---Cushman and Todd, 1941, ibid., Contr. vol. 17, pt. 2, p. 52, pl. 14, figs. 19-23. ---Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 308, pl. 36, fig. 22.

Test elongate, fusiform, tapering gradually at initial end, rapidly at apertural end, widest above the middle; periphery lobulate; chambers distinct, inflated, about five whorls forming the test, axial margin of the last chambers concave; sutures distinct, depressed; wall hyaline, perforate, ornamented with low, fine costae, between eight and fourteen per chamber,

discontinuous at chamber boundaries, diminishing in height toward the apertural end; aperture terminal, round, at the end of a short neck which arises at the concave margin of the last chamber. Length 0.38 mm, diameter 0.20 mm.

Rare. Occurs in all three zones, present in the samples 1, 2, 4, 8, 9 and 10.

Uvigerina subperegrina has a general resemblance to U. juncea with regard to its surface ornamentation of discontinuous costae and the apertural characteristics. The difference lies mainly in its proportions. U. subperegrina is more rapidly expanding from the initial end and remains much shorter and broader than U. juncea. Also, the wall does not become pustulose or spinose on the last chambers.

Hypotype. -- U.N.C. Cat. No. 3835.

Genus Trifarina Cushman, 1923

The assignment of Angulogerina as a junior synonym of Trifarina by Loeblich and Tappan (1964) is followed here, but it poses a problem of interpretation.

Both have in common a triserial early portion and a uniserial later portion, and, as Hofker (1951) demonstrates, the arrangement of the apertural tooth plates in the uniserial portion still follows the triserial 120° rotation. Both genera differ in the degree of chamber organization and symmetry of the test.

In Angulogerina the triserial stage comprises the largest portion of the test, rarely more than 2 chambers are uniserially arranged. Carinae are developed on individual chambers but rarely are continuous over the several chambers.

Trifarina has the triserial stage much less developed, the greatest portion of the test is uniserial. The triangular chambers are well aligned, continuous carinae extending along the length of the test.

Study of more extensive material should show, whether these differences are extensive and persistent enough to be of generic significance or not.

Trifarina occidentalis (Cushman)

Pl. 4, figs. 11a-b

Uvigerina angulosa Cushman, 1922 (not Williamson), Carnegie Inst. Washington, Pub. 311, p. 34, pl. 5, figs. 3,4.

Uvigerina occidentalis Cushman, 1923, U.S. Nat. Mus. Bull. 104, pt. 4, p. 169. Angulogerina occidentalis (Cushman), 1930, Florida Geol. Survey Bull. 4, p. 50, pl. 9, figs. 8, 9. ---Cushman and Laiming, 1931, Jour. Paleontology, vol. 5, p. 112, pl. 12, figs. 15a, b, 16. ---Cushman, 1932, Contr. Cushman Lab. Foram. Res., vol. 8, p. 46, pl. 6, figs. 15, 16. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 28, pl. 9, figs. 8a, b. ---Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. no. 25, p. 218, pl. 13, fig. 57.

Test small, elongate, triangular in transverse section, periphery lobulate; chambers distinct, inflated, triserial, progressively higher spired; surface ornamented with longitudinal costae which diminish towards the apertural end; sutures distinct, depressed; wall hyaline, finely perforate; aperture terminal, round, at the end of a short neck with a phialine lip. Length 0.29 mm, width 0.15 mm.

Rare. Occurs in the Turritella zone, sample 9, 10, the Mercenaria-Dosinia zone, sample 6,7,8, and the Pecten zone, sample 1, 2.

The Grimesland specimens are generally smaller than the holotype and paratypes, averaging about two-thirds of their size. Megalospheric juvenile forms occur frequently, which are shorter and broader than the microspheric forms.

Hypotype. -- U.N.C. Cat. No. 3836.

Superfamily Discorbacea Ehrenberg, 1838

Family Discorbidae Ehrenberg, 1838

Subfamily Discorbinae Ehrenberg, 1838

Genus Buccella Andersen, 1952

Buccella anderseni McLean

Pl. 5, figs. 5a-c

Buccella anderseni McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 354, pl. 50, figs. 1a-c, pl. 51, figs. 1a-c, 4a-c.

Test of medium size, trochoid, unequally to equally biconvex, ventral side mostly the more convex side; periphery slightly angular and keeled, but without strongly developed flange; dorsal side evolute; wall hyaline, smooth, finely perforate in well preserved specimens; sutures flush, limbate and curved obliquely towards the periphery; ventral side involute, umbilical area largely covered with opaque, pustulose material, extending into the sutures almost to the periphery, the ventral sutures are radial, curved to nearly straight, depressed; aperture not visible on complete, unweathered specimens; about nine chambers per whorl, about three whorls visible on the dorsal side. Diameter 0.56 mm, thickness 0.26 mm.

Rare. Occurs in all three zones, present in the samples 2,5,8, and 9.

All of the specimens of Buccella anderseni from Grimesland have a slightly angular and limbate periphery. Though McLean 1956, describes the periphery as being, "rounded to slightly angular." he does not mention the keel, but illustrates a narrow keel in figs. 1c of pl. 50 and in fig. 1a of pl. 51. Some specimens were found which differ from the typical form in their unusually high convex ventral sides.

Hypotype. -- U.N.C. Cat. No. 3841.

Buccella depressa Andersen

Pl. 5, figs. 6a-c

Eponides peruvians Cushman and Parker, 1931, (not d'Orbigny), U.S. Natl. Mus. Proc. vol. 80, art. 3, no. 2903, p. 19.

Buccella depressa Andersen, 1952, Washington Acad. Sci. Jour. vol. 42, no. 5, p. 145, figs. 7a, b, 8. --- McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 355, pl. 50, figs. 2-4.

Test small, trochoid, subequally biconvex, periphery subrounded, moderately lobulate; dorsal side evolute, smooth, ventral side involute; umbilical area deeply depressed, covered with opaque pustulose shell material, which extends into the depressed ventral sutures; sutures flush and limbate dorsally, slightly depressed in the last one-half whorl, curved slightly; two and one-half to three whorls visible on the dorsal side, seven to eight chambers in the last whorl, chambers inflated ventrally; wall hyaline, finely perforate; aperture covered by the pustulose material. In weathered specimens, supplementary apertures are exposed in the ventral sutural margins of each chamber near the periphery. Diameter 0.26 mm, thickness 0.12 mm.

Common to abundant. Occurs in all three zones, present in the samples 1 (6%), 2 (1%), 3 (2%), 4 (2%), 5 (2.5%), 6 (2.5%), 7 (3%), 8 (1.5%), 9 (2%), and 10 (2%).

Buccella depressa is very similar to B. frigida and it appears, that intermediate forms exist, of which the assignment to either species can be equally justified. Typical forms of B. depressa have more chambers per whorl, less pustulose material on the ventral side and in the sutures, and have a much more depressed umbilical region as well as depressed ventral sutures and a depressed dorsal spiral suture. Very small specimens of B. depressa show some resemblance to B. bella Bandy and Arnal, but do not possess the strongly limbate dorsal sutures and the apertural pores of B. bella.

Hypotype. -- U.N.C. Cat. No. 3842.

Buccella frigida (Cushman)

Pl. 6, figs. 1a-c

Pulvinulina frigida Cushman, 1922, Contr. Canadian Biol. (1921), no. 9, p. 144.

Eponides frigida Cushman, 1931, (part), U.S. Nat. Mus., Bull. 104, pt. 8, p. 45.

Eponides frigidus Cushman, 1941, Contr. Cushman Lab. Foram. Res., vol. 17, p. 37, pl. 9, figs. 16, 17.

Eponides frigida calida Cushman and Cole, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, p. 98, pl. 13, figs. 13a-b. ---Cushman, 1931, U.S. Nat. Mus., Bull. 104, pt. 8, p. 47, pl. 10, figs. 3,4. ---Cushman, 1944, Cushman Lab. Foram. Res., Spec. Publ. 12, p. 34, pl. 4, figs. 19, 20.

Buccella frigida Andersen, 1952, Washington Acad. Sci., Jour., vol. 42, no. 5, p. 144, text figs. 4-6.

Test small, trochoid, biconvex, periphery subrounded, slightly lobulate; dorsal side evolute, with smooth surface and narrow, slightly curved and limbate sutures which meet the periphery at a strongly oblique angle. Ventral side involute, sutures slightly curved, radial, umbilical area and sutures slightly depressed and filled with a coating of opaque pustulose material, forming a broad band to the periphery; two and one-half whorls visible dorsally, about six chambers forming the last whorl; wall hyaline, finely to medium perforate; aperture covered by the pustulose material, on weathered specimens exposed as openings on the base of the apertural face and in the ventral sutural margins of the chambers near the periphery. Diameter 0.28 mm, thickness 0.13 mm.

Abundant. Occurs in all three zones, present in the samples 1 (13.5%), 2 (16%), 3 (12%), 4 (7%), 5 (8%), 6 (10%), 7 (6%), 8 (8%), 9 (11%), and 10 (8%).

The basis of distinction of B. frigida from B. depressa have been mentioned under the discussion of that species. B. frigida differs from B. vicksburgensis (Cushman and Ellisor) in its slightly greater number of chambers per whorl and in the possession of a round periphery instead of a limbate and subangular periphery.

Hypotype. --- U.N.C. Cat. No. 3843.

Buccella inusitata Andersen

Pl. 6, figs. 2a-c

Eponides frigidus Cushman and Todd, 1947, (not Pulvinulina frigida Cushman, 1922) Cushman Lab. Foram. Res., Spec. Publ. no. 21, p. 21, pl. 3, figs. 20a-b. ---Cushman, 1948, ibid., no. 23, p. 71, pl. 8, fig. 7.

Eponides peruvianus Cushman and Kellet, 1929, (not d'Orbigny), U.S. Nat. Mus., Proc. vol. 75, art. 25, p. 10, pl. 4, figs. 5a-c.

Buccella inusitata Andersen, 1952, Washington Acad. Sci., Jour., vol. 42, no. 5, p. 148, text figs. 10-11.

Test medium sized, trochoid, unequally biconvex, nearly biconvex in microspheric forms, megalospheric forms with high dorsal side and flattened ventral side; periphery angular, weakly carinate, lobate in the last two or three chambers; dorsal side evolute, with smooth surface and slightly curved limbate sutures which meet the periphery at a strongly oblique angle. Ventral side involute, with depressed, gently curved or straight radial sutures, umbilical area depressed; pustulose opaque material covering the umbilical area and extending into the sutures, imparting a petaliferous pattern; three whorls visible dorsally, with about eight chambers forming the last whorl; wall hyaline, finely to medium perforate; aperture usually covered by the pustulose material, weathered specimens expose small pores in the ventral sutural margins of the chambers near the periphery. Diameter 0.33 mm, thickness 0.16 mm.

Rare, common and abundant. Occurs in all zones, present in the samples 1 (1%), 2 (4%), 3 (1%), 4, 5 (1%), 6 (2%), 7,8,9 (1%), and 10 (5%).

Buccella inusitata closely resembles B. hannai. It can be separated from that species on the basis of its lobulate periphery, less pustulose material on the ventral side and the very low, oblique chambers on the dorsal side of the test. Assignment of juvenile specimens to either species was not possible.

Hypotype. --- U.N.C. Cat. No. 3844.

Buccella mansfieldi (Cushman)

Pl. 6, figs. 3a-c

Eponides mansfieldi Cushman, 1930, Florida Geol. Survey, Bull. no. 4, p. 54, pl. 11, figs. 1a-c. ---Cushman and Cahill, 1933, U.S. Geol. Survey, Prof. Paper 175-A, p. 31, pl. 10, figs. 8a-c. ---Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 311, pl. 37, figs. 7a-c.

Buccella mansfieldi Andersen, 1952, Washington Acad. Sci., Jour., vol. 42, no. 5, p. 148, text figs. 12a-b, 13a-c.

Test large, trochoid, unequally biconvex; periphery angular, limbate, slightly lobulate; dorsal side evolute, smooth surface with broadly raised sutural limbations which are slightly curving and meet the periphery at an oblique angle, confluent with the limbate periphery. Ventral side involute, chambers slightly inflated, umbilical area shallow, sutures strongly depressed, straight, coarse pustulose material covering the umbilical area, extending into the sutures to the periphery, especially heavy at the base of the apertural face; about two whorls visible dorsally, with about ten chambers forming the last whorl; wall hyaline, finely perforate on dorsal side, medium perforate on ventral side; aperture concealed by cover of pustules, not exposed upon weathering. Diameter 0.71 mm, thickness 0.31 mm.

Rare. Occurs in all three zones, present in the samples 2,4,8,9, and 10.

The type figure of B. mansfieldi shows an inaccuracy in its apertural or edge view. In actuality, the peripheral keel is not offset but continues as raised spiral sutural limbation on the dorsal side which can be seen in the illustration of the dorsal side. Unfortunately, Andersen, 1952, does not refigure the holotype.

B. mansfieldi is separated from all other species of this genus primarily by its large size and the extremely raised limbate sutures of the

dorsal side.

Hypotype. -- U.N.C. Cat. No. 3845.

Buccella vicksburgensis (Cushman and Ellisor)

Pl. 6, figs. 4a-c

Eponides vicksburgensis Cushman and Ellisor, 1931, Cushman Lab. Foram. Res., Contr. vol. 7, pt. 3, p. 56, pl. 7, figs. 8a-c.

Eponides alabamensis Cushman and McGlamery, 1938, U.S. Geol. Survey Prof. Paper 189-D, p. 110, pl. 27, fig. 2.

Buccella vicksburgensis Andersen, 1952, Wash. Acad. Sci. Jour. vol. 42, no. 5, p. 150, text-figs. 1a-c, 2a-c.

Test small, trochoid, unequally biconvex; periphery angular, limbate and slightly lobulate; dorsal side evolute, smooth surface with narrowly limbate, flush and curved sutures which meet the periphery at an oblique angle; ventral side involute; sutures slightly depressed and slightly curved, pustulose material covering the umbilical area, extending into the sutures to the periphery, especially at the base of the apertural face; two and one-half whorls visible dorsally, seven chambers typically forming the last whorl; wall hyaline, finely perforate; aperture concealed by pustulose material. Diameter 0.30 mm, thickness 0.15 mm.

Common, abundant, and very abundant. Occurs in all three zones, present in the samples 1 (6.5%), 2 (29%), 3 (6%), 4 (3%), 5 (6%), 6(5%) 7(8%) 8 (5%), 9 (11%), and 10 (12%).

Buccella vicksburgensis most closely resembles B. frigida. Characters for distinction between the two species are variable and not very useful in many cases. The amount of pustulose material covering the ventral side is subject to considerable variation. The number of chambers per

whorl is typically six for B.frigida and seven for B. vicksburgensis. But the number of chambers per whorl is not constant and overlap occurs frequently. The only reliable distinguishing character is the angular periphery of B. vicksburgensis. Therefore, to be able to recognize this species, I have chosen, not to include B. choctawensis (Cushman and McGlamery) into the synonymy because of its rounded rather than angular periphery. Though it may be closer to B. vicksburgensis than the type figure illustrates, it does not have an angular periphery and may, possibly be B. frigida.

Hypotype. -- U.N.C. Cat. No. 3846.

Genus Epistominella Husezima and Maruhasi, 1944

Epistominella pontoni (Cushman)

Pl. 6, figs. 5a-c

Pulvinulinella pontoni Cushman, 1930, Florida Geol. Survey Bull. 4, p. 57, pl. 11, figs. 2a-c. -- Cushman and Ponton, 1932, ibid. Bull 9, p. 97.

Epistominella pontoni Puri, 1953, Florida Geol. Survey, Bull. 36, p. 135, pl. 27, figs. 9-11.

Test minute, trochoid and biconvex; periphery subangular, entire, slightly lobulate at the last few chambers of a few specimens; chambers distinct, between eight and ten in the last formed whorl, the most common being nine, about two and one-half to three whorls visible dorsally, chambers increasing gradually in size as added; sutures distinct, slightly limbate on the dorsal side, flush, curved and oblique to the periphery, on the ventral side radial and flush, slightly depressed in a few cases;

wall hyaline, smooth, finely perforate; aperture a narrow, high arched, nearly vertical slit in a depression, extending from the base to about half the height of the apertural face. Diameter 0.15 mm, thickness 0.08 mm.

Rare to common to abundant. Occurs in all zones and samples. Common in sample 7 (1.5%), 9 (2.5%), abundant in sample 10 (8%).

As figured and described by Cushman (1930), this species has a high and narrow aperture. Specimens having such an aperture are present in this material, however, they seem to represent one extreme of a range of variation. Generally the aperture is lower and wider than in the type.

Hypotype. -- U.N.Č. Cat. No. 3847.

Genus Rosalina d'Orbigny, 1826

Rosalina floridana (Cushman)

Pl. 5, figs. 1a-c

Discorbis floridana Cushman, 1922, Carnegie Instit. Washington, Publ. 311, p. 39, pl. 5, figs. 11, 12. ---Cushman, 1931, U.S. Natl. Mus. Bull. 104, pt. 8, p. 21, pl. 4, figs. 7, 8. --Cushman and Ponton, 1932, Florida Geol. Survey Bull. 9, p. 88, pl. 13, figs. 2a-c. ---McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 351, pl. 46, figs. 9-12, 15.

Discorbis candeiana Cushman and Ponton, (not d'Orbigny). 1932, Florida Geol. Survey Bull. 9, p. 88, pl. 13, figs. 4a-c. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 29, pl. 10, figs. 3a-c.

Test concavo-convex, dorsal side convex, evolute with about two and one-half to three whorls visible, ventral side concave, flattened in some specimens, involute, slightly umbilicate in some cases; periphery subangular to subrounded, slightly lobulate in the last few chambers; chambers distinct, about six in the last whorl, last ones slightly inflated, increasing rapidly in size as added, last ones may be slightly elongated; dorsal sutures distinct, curved, slightly limbate, flush in the early portion, later slightly depressed; ventral sutures curved, depressed; wall hyaline, with medium coarse pores dorsally, medium perforate near the periphery and few, if any, pores in the portion on the ventral side; aperture on the ventral side, a low arched opening with a slight lip, reaching from the periphery to the umbilical area, extending under an umbilical valve. Diameter 0.30 mm, thickness 0.11 mm.

Rare to abundant. Occurs in all samples, common in sample 1 (8%), 3 (6%), 4 (5%), 5 (2%), 6 (1%), 8 (2.5%), 10 (7%). Abundant in samples 2 (12%), 9 (18%).

For the material here present, a wide range of variation was allowed in the definition of the species. This was done mainly to accomodate specimens which display all the characteristics of the typical forms but have their last chamber or chambers deformed. Irregularity of the last chambers is also reflected in the incomplete development of the umbilical valves. Partially involute forms were not included into this species, as was done by Cushman and Cahill, (1933, U.S. Geol. Survey Prof. Paper 175-A, p. 29, pl. 9, figs. 12, 13).

Hypotype. -- U.N.C. Cat. No. 3837.

Rosalina floridensis (Cushman)

Pl. 5, figs. 2a-c

Discorbis bertheloti floridensis Cushman, 1930, Jour. Paleontology, vol. 4, p. 364, pl. 33, figs. 13a-c. ---Cushman, 1931, U.S. Natl. Mus., Bull. 104, pt. 8, p. 17, pl. 3, figs. 3-5. ---Cushman and Todd, 1945, Cushman Lab. Foram. Res., Spec. Publ. no. 15, p. 56, pl. 8, figs. 15, 16. ---Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. no. 25, p. 238, pl. 15, figs. 19-21.

Test small, ovate in axial view, strongly compressed dorso-ventrally, concavo-convex in side view, rotaloid, dorsal side evolute and convex, ventral side concave; periphery angular, carinate, entire; chambers distinct, four or five in final whorl, increasing rapidly in size as added, final chamber very broad, embracing at least one-third of circumference, extending into umbilical region ventrally with a valvelike extension; sutures distinct, limbate, flush with the surface, to very slightly depressed between last chambers, curved, meeting the periphery at an oblique angle; wall hyaline, smooth, finely perforate; aperture a low arched slit on the ventral side at the base of the last chamber, extending from the periphery to the umbilical area under an umbilical valve. Diameter 0.23 mm, thickness 0.06 mm.

Rare. Occurs in the Pecten zone and Turritella zone only, samples 2 and 9.

Only a few, small specimens have been found, one of which differs slightly in its ventral aspect. Instead of having one umbilical valve, it possesses two lobelike extensions of lesser size.

Hypotype. -- U.N.C. Cat. No. 3838.

Rosalina opima (Cushman)

Pl. 5, figs. 3a-c

Discorbis opima Cushman, 1933, Contr. Cushman Lab. Foram. Res., vol. 9, pt. 9, no. 137, p. 88, pl. 9, figs. 3a-c.

Test medium sized, thick, rotaloid, dorsal side evolute with about two and one-half whorls visible, slightly convex, ventral side flattened to slightly concave, umbilicate; periphery broadly rounded, lobulate; chambers distinct, about five in the last whorl, increasing rapidly in size as added, inflated, becoming elongated in the latter chambers; sutures distinct, depressed and curved; wall hyaline, coarsely perforate; aperture a low arched opening on the ventral side, reaching from near the periphery to the umbilicus; umbilical valves at the base of each chamber are mostly transformed into irregular knoblike projections of massive shell material, covering most of the umbilical area. Diameter 0.45 mm, thickness 0.15 mm.

Rare. Occurs in all zones, in samples 1, 2,3,4, 8, 9.

Hypotype. -- U.N.C. Cat. No. 3839.

? Rosalina posidonicola (Colom)

Pl. 5, fig. 4

Discorbis posidonicola Colom, 1942, Inst. Espanol Oceanogr., Notas y Resum., ser. 2, no. 108, p. 37, pl. 7, figs. 149, 150, 152, 153, 155-157, 161.

Discorbis rhederi McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160. p. 353, pl. 46, figs. 13, 14.

Test probably attached, irregular in shape, generally plano-convex to concavo-convex, rotaloid, dorsal side evolute with conical central part and flattened peripheral chambers, ventral side flattened to concave, umbilicate; periphery subangular, irregular and lobulate; chambers distinct and regular in the first portion, about six per whorl, later chambers becoming erratic,

totally embracing ventrally, partially embracing dorsally; sutures distinct, slightly limbate and curved obliquely in conical central part on dorsal side, depressed, very oblique or irregular on the rest of the test; wall hyaline, coarsely perforate; aperture a low arch to curved slit, reaching from near the periphery to an umbilical valve on the ventral side, in most cases obscured by the irregular growth of the last chambers. Diameter 0.47 mm, thickness 0.15 mm.

Rare. Present in all zones, in samples 1, 2,4,7, 8, 9, 10.

Hypotype. --U.N.C. Cat. No. 3840.

Subfamily Baggininae Cushman, 1927

Genus Cancris de Montfort, 1808

Cancris communis Cushman and Todd

Pl. 6, figs. 6a-c

Pulvinulina sagra Cushman, 1918, (not d'Orbigny), U.S. Geol. Survey Bull. 676, p. 65, pl. 22, fig. 3, pl. 23, fig. 1.

Cancris sagra Cushman, 1930, Florida Geol. Survey Bull. 4, p. 56, pl. 11, figs. 4a-c. ---Cushman and Ponton, 1932, ibid., Bull. 9, p. 94, pl. 14, figs. 3a-c. ---Ellisor, 1940, Am. Assoc. Petroleum Geologists Bull. 24, p. 474, pl. 6, fig. 6.

Cancris sagra communis Cushman and Todd, 1942, Contr. Cushman Lab. Foram. Res., vol. 18, p. 79, pl. 19, figs. 8-11, pl. 20, figs. 1a-c. ---Dorsey, 1948, Maryland Dept. Geol., Mines, Water Res., Bull. 2, p. 312, pl. 37, figs. 10a-c.

Test higher than wide, unequally biconvex; periphery acute, tending to be slightly lobulate in the last two chambers; chambers few, about six to seven in the last whorl, increasing rapidly in size as added, last chamber nearly one-third the size of the entire test, inflated on the ventral side; sutures gently curved, slightly depressed on dorsal side, much depressed on ventral side; wall smooth, calcareous, finely perforate with a clear imperforate area immediately above aperture; aperture a low arch under the umbilical flap of the last chamber, extending to the periphery. Height 0.35 mm, width 0.25 mm, thickness 0.11 mm.

Rare. Occurs in the Turritella zone, samples 9 and 10, and in the Pecten zone, samples 1 and 2.

Hypotype. ---U.N.C. Cat. No. 3848.

Superfamily Spirillinacea Reuss, 1862

Family Spirillinidae Reuss, 1862

Subfamily Patellininae Rhumbler, 1906

Genus Patellina Williamson, 1858

Patellina corrugata Williamson

Pl. 7, figs. 1a-c

Patellina corrugata Williamson, 1858, Recent. Foram. Gt. Britain, p. 46, pl. 3, figs. 86-89. --- Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 633, pl. 86, figs. 1-7. --- Cushman, 1932, Florida Geol. Survey Bull. 9, p. 87, pl. 13, figs. 1a-b.

Test minute,conical in side view, circular in top view; periphery sharply angular; chambers in early portion arranged in a spiral, later be-

coming elongated, tending to become more embracing to semiannular in large specimens; chambers partially divided by internal septa which extend radially inward, short and long septa alternating; ventral side concave, filled with thin irregular shell material; umbilical surface wrinkled; sutures distinct, flush; walls hyaline, finely perforate, very thin, translucent; aperture an elongated slit at the inner margin of the last chamber. Diameter 0.22 mm, thickness 0.075 mm.

Rare to common, occurs in all three zones. Present in the samples 2, 3, 5, 6, 8, and 10. Common in sample 9 with 2%.

Hypotype. -- U.N.C. Cat. No. 3849.

Superfamily Rotaliacea Ehrenberg, 1839

Family Elphidiidae Galloway, 1933

Subfamily Elphidiinae Galloway, 1933

Genus Elphidium de Montfort, 1808

Elphidium clavatum Cushman

Pl. 7, figs. 2a-b

Elphidium incertum clavatum Cushman, 1930, U.S. Natl. Mus. Bull. 104, pt. 7, p. 20, pl. 7, fig. 10. ---Cushman and Cole, 1930, Contr. Cushman Lab. Foram. Res., vol. 6, p. 96, pl. 13, figs. 8?, 9. ---Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 57, pl. 16, figs. 1,2. ---Cushman, 1944, Cushman Lab. Foram. Res., Spec. Publ. no. 12, p. 25, pl. 3, figs. 32, 33. ---Cushman, 1948, Cushman Lab. Foram. Res., Spec. Publ. no. 23, p. 57, pl. 6, fig. 8.

Elphidium clavatum Loeblich and Tappan, 1953, Smithsonian Inst., Misc. Coll., vol. 121, no. 7, (Publ. 4105), p. 98, pl. 19, figs. 8-10.

Elphidium johnstonae McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 343, pl. 42, figs. 9, 18, pl. 44, figs. 3-5, 7.

Test of medium size, planispiral, biumbonate, umbilical boss areas projecting in some specimens; periphery broadly rounded, entire in early portion of the whorl, later slightly lobulate; chambers distinct, about twelve in the last whorl, increasing gradually in size as added, last ones slightly inflated; sutures distinct, gently curved, depressed, with rows of pores and three to five irregularly developed retral bridges which increase in distinctiveness toward the last portion of the test; wall hyaline, distinctly perfororate, umbilical areas ornamented with a slightly elevated boss of clear shell material which may be present as irregular umbilical granulations in some forms; aperture a row of few small pores at the base of the apertural face, somewhat obscured by granular deposits. Diameter 0.45 mm, thickness 0.22 mm.

Abundant, occurs in all samples: 1 (27%), 2 (19%), 3 (50%), 4 (62%), 5 (73%), 6 (72%), 7 (67%), 8 (70.5%), 9 (17%), and 10 (14%).

Specimens with much raised umbilical areas as figured by Loeblich and Tappan (1953, fig. 8b) are present in this material. The majority of specimens, however, have a much less pronounced thickening of the umbilical areas, and thus correspond more closely to the type figure of Cushman (1930, fig. 10b). Difficulties may be encountered in recognizing the faint retral bridges of juvenile forms.

Hypotype. ---U.N.C. Cat. No. 3850.

Elphidium selseyense (Heron-Allen and Earland)

Pl. 7, figs. 3a-b

Polystomella striatopunctata (Fichtel and Moll). Heron-Allen and Earland, 1909, Jour. Roy. Micr. Soc., p. 695, pl. 21, figs. 2a, c, (not 2b).

Polystomella striatopunctata selseyensis Heron-Allen and Earland, 1911, Jour. Roy. Micr. Soc., p. 448.

Elphidium incertum selseyensis Brand, 1941, Senckenbergiana, vol. 23, no. 1-3, p. 66.

Test of medium size, planispiral; periphery becoming increasingly lobulate toward the ultimate chamber; chambers distinct, about nine in the last whorl, increasing gradually in size as added, increasingly inflated toward the distal end, the last ones failing to reach the umbilicus; sutures distinct, depressed, gently curved, sutural bridges indistinct, between six and eight in the last sutures on one side, best developed in the last few sutures; wall hyaline, perforate, depressed umbilical area partially covered by finely granular test material; aperture a row of pores at the base of the apertural face. Diameter 0.48 mm, thickness 0.19 mm.

Rare. Occurs in all three zones, in samples 1, 3, 7, and 10.

Hypotype. ---U.N.C. Cat. No. 3851.

Elphidium subarcticum Cushman

Pl. 7, figs. 4a-b

Elphidium subarcticum Cushman, 1944, Cushman Lab. Foram. Res., Spec. Publ. no. 12, p. 27, pl. 3, figs. 34, 35. ---Cushman, ibid., Spec. Publ. no. 23, p. 58, pl. 6, fig. 12.

Nonion pauciloculum Cushman, 1944, Cushman Lab. Foram. Res., Spec. Publ. no. 12, p. 24, pl. 3, figs. 25a, b.

Test of medium size, planispiral, compressed,sides appearing parallel in edge view; periphery rounded, slightly lobulate; chambers distinct, about eight to ten in the last whorl, increasing gradually in size as added, last ones somewhat inflated, wedge shaped toward the umbilical region; sutures distinct, depressed, slightly curved, about six retral processes in the last suture on one side, small, broad, often appearing in the last sutures only; umbilical area, as well as bands along the suture lines are composed of a white opaque, slightly granular material; wall hyaline, medium perforate; aperture tends to be indistinct, concealed by the white granular and opaque wall material, if ultimate chamber is broken away, a low slit is visible at the base of the apertural face of the penultimate chamber. Diameter 0.42 mm, thickness 0.17 mm.

Common to abundant. Samples 1 (25%), 2 (2%), 3 (18%), 4 (15%), 5 (4%), 6 (3%), 7 (9%), 8 (5%), 9 (1%), and 10 (4%).

Small specimens of this form are in many cases difficult to distinguish from a Nonion, for the retral processes are so ill-defined in the early stages as to be observable only under the most favorable light conditions. Sutural pores are in general covered by opaque shell material, but may become visible in slightly leached specimens.

Hypotype. ---U.N.C. Cat. No. 3852.

Genus Cribroelphidium Cushman and Brönnimann, 1948

Cribroelphidium poeyanum (d'Orbigny)

Pl. 7, figs. 5a-b

Polystomella poeyana d'Orbigny, 1839, in: de la Sagra, Histoire physique et naturelle de l'Ile de Cuba, Foraminifères, p. 55, pl. 6, figs. 25, 26.

Elphidium poeyanum Cushman, 1929, U.S. Natl Mus. Bull. 104, pt. 7, p. 25, pl. 10, figs. 4, 5. ---Cushman, 1930, Florida Geol. Survey Bull. 4, p. 39, pl. 7, figs. 3?, 4. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 21, pl. 7, figs. 7a, b. ---Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 54, pl. 14, figs. 25, 26. ---Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. no. 25, p. 171, pl. 11, fig. 27.

Cribroelphidium poeyanum Loeblich and Tappan, 1964, Treatise on Invertebrate Paleontology, Pt. C, Protista 2, vol. 2, p. 635, fig. 508, 3,4.

Test small, compressed, planispiral; periphery slightly lobulate, rounded, the umbilical areas somewhat depressed; chambers distinct, about eleven in the last whorl, slightly inflated in the last portion; sutures distinct, slightly depressed with very distinct, short septal bridges, about ten visible on one side; wall hyaline, smooth, medium perforate; aperture a number of small, low pores near the base of the apertural face. Diameter 0.53 mm, thickness 0.20 mm.

Rare. Present in all zones, in samples 1, 3,4, 5, 9, and 10.

Elphidium poeyanum is figured in the literature as having straight as well as gently curved sutures and being slightly evolute with some granulose material in the umbilical areas or being tightly involute. The present material shows just such a variation, however, more confidence in the correctness of the identification is placed into tightly involute forms with straight sutures.

Hypotype. --- U.N.C. Cat. No. 3853.

Superfamily Globigerinacea Carpenter,

Parker and Jones, 1862

Family Globorotaliidae Cushman, 1927

Subfamily Globorotaliinae Cushman, 1927

Genus Globorotalia Cushman, 1927

Globorotalia menardii (d'Orbigny)

Pl. 7, figs. 6a-c

Rotalia menardii d'Orbigny, 1826, Ann. Sci. Nat., ser. 1, vol. 7, p. 273, model 10.

Pulvinulina menardii Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 690, pl. 103, figs. 1, 2.

Pulvinulina tumida Brady, ibid., p. 692, pl. 103, figs. 4-6.

Globorotalia menardii Cushman, 1930, Florida Geol. Survey Bull. 4, p. 60, pl. 12, figs. 1a-c. ---Cole and Ponton, 1932, Florida Geol. Survey Bull. no. 5, p. 45, pl. 11, figs. 4,5. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 34, pl. 12, figs. 5a-c. ---Bermudez, 1949, Cushman Lab. Foram, Res., Spec. Publ. no. 25, p. 286, pl. 22, figs. 9-11. ---Bolli, 1957, U.S. Natl. Mus. Bull. 215, p. 120, pl. 29, figs. 6a-10b. ---Bé, 1959, Micropaleontology, vol. 5, no. 1, p. 83, pl. 1, figs. 1-3. ---Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 215, pl. 18, figs. 119a-c, 120a-c.

Test small, unequally biconvex, dorsal side moderately convex to nearly flat, ventral side convex; periphery angular with a definite keel, slightly lobulate in outline; chambers distinct, flattened on the dorsal side, inflated on the ventral side, about nine in total number, which are arranged in one and one-half whorls, five chambers in the last whorl; sutures distinct, on the dorsal side strongly curved and limbate, slightly raised; ventral

sutures deeply depressed, radial, and straight; wall hyaline, medium perforate, smooth; aperture at the base of the last formed chamber, about one-fourth the height of the chamber, extending from the umbilicus to the periphery. Diameter 0.27 mm, thickness 0.11 mm.

Rare. Occurs in the Turritella zone only, in the sample 10.

Hypotype. ---U.N.C. Cat. No. 3854.

Genus Turborotalia Cushman and Bermudez, 1949

Turborotalia obesa (Bolli)

Pl. 7, figs. 7a-c

Globorotalia obesa Bolli, 1957, U.S. Natl. Mus. Bull. 215, p. 119, pl. 29, figs. 2a-c, 3. ---Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 218, pl. 19, figs. 124a-c.

Test small, trochoid, wider than high, dorsal side low convex, evolute, ventral side concave, umbilicate; periphery broadly rounded, strongly lobulate; chambers distinct, much inflated, nearly spherical, increasing rapidly in size as added, nine to ten in total number, arranged in about two whorls, four and one-half chambers comprising the final whorl; sutures distinct, deeply incised, radial; wall calcareous, perforate, finely spinose and pitted; aperture a moderately high arch with a narrow rim at the base of the apertural face of the ultimate chamber, between umbilical region and periphery; umbilicus deep, fairly large. Diameter 0.22 mm, thickness 0.11 mm.

Rare. Occurs in all three zones, present in the samples 1, 2,3,7, 8, and 9.

There are specimens of Turborotalia obesa in this fauna which have only four chambers in the final whorl, and their aperture tends to be in a

more umbilical position.

Hypotype. -- U.N.C. Cat. No. 3855.

Turborotalia oscitans (Todd)

Pl. 7, figs. 8a-c

Globorotalia oscitans Todd, 1958, Swedish Deep-Sea Exped. 1947-1948, Repts., vol. 8, fasc. 2, no. 3, p. 201, pl. 1, figs. 23a-c.

Test minute, trochoid, dorsal side slightly convex to flat, ventral side highly convex; periphery subrounded, slightly lobulate, nearly quadrangular in outline; chambers obscured on the dorsal side, few in number, increasing rapidly as added, distinct on the ventral side, appressed, slightly inflated, four chambers comprising the last whorl; sutures slightly depressed, curved and oblique to the periphery on the dorsal side, radial and straight on the ventral side; wall calcareous, perforate, spinose; aperture a high arched opening at the base of the apertural face of the ultimate chamber, between the periphery and umbilicus, rimmed by a narrow lip. Diameter 0.22 mm, thickness 0.12 mm.

Rare. Occurs in the Pecten zone only, in the samples 1 and 2.

Hypotype. ---U.N.C. Cat. No. 3856.

Family Globigerinidae Carpenter, Parker and Jones, 1862

Subfamily Globigerininae Carpenter,

Parker and Jones, 1862

Genus Globigerina d'Orbigny, 1826

Globigerina angustiumbilicata Bolli

Pl. 7, figs. 9a-c

Globigerina ciperoensis angustiumbilicata Bolli, 1957, U.S. Natl. Mus. Bull. 215, p. 109, pl. 22, figs. 12a-c, 13a-c. ---Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, pl. 7, figs. 33a-c, 34. ---Banner and Blow, 1962, in: Eames, F.E., Banner, F.T., Blow, W.H., and Clarke, W.J., Fundamentals of Mid-Tertiary stratigraphical paleontology, Pt. 2, Cambridge University Press, p. 85, pl. 19, figs. x-z, tf. 9, (IV), 16 (VI, VII).

Test small, trochoid, dorsal side low convex, nearly flat, spiral coil well developed, but low spired, ventral side concave, umbilicate; periphery broadly rounded, strongly lobulate; chambers distinct, much inflated, nearly spherical, about twelve in total, forming about two and one-half whorls, four and one-half chambers comprising the last whorl, increasing rapidly in size as added; sutures distinct, depressed and radial; wall calcareous, perforate, surface finely but distinctly pitted; aperture moderately high arched, at the base of the ultimate chamber, opening into the umbilicus, extending part way to the periphery, provided with a definite lip. Diameter 0.24 mm, thickness 0.15 mm.

Rare. Occurs in all three zones, in the samples 1,2, 4, 6, 8, 9, and 10.

Hypotype. ---U.N.C. Cat. No. 3857.

Globigerina apertura Cushman

Pl. 8, figs. 1a-c

Globigerina apertura Cushman, 1918, U.S. Geol. Survey Bull. 676, p. 57, pl. 12, figs. 8a-c. ---Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 172, pl. 8, figs. 35a-b.

Test of medium size, trochoid, dorsal side moderately convex, ventral side concave, umbilicate; periphery broadly rounded, lobulate; chambers distinct, inflated, nearly spherical, later ones slightly appressed, about ten in total number, arranged in a low trochoid spire, four composing the last whorl, increasing rapidly in size as added; sutures deeply depressed, radial; wall calcareous, perforate, pores in the center of large distinct pits; aperture a large, high arched opening in the umbilicus, provided with a narrow lip. Diameter 0.34 mm, thickness 0.22 mm.

Rare. Occurs in the Pecten zone only, sample 1.

Only two specimens of this species have been found. One corresponds closely to the holotype, whereas the other seems to be an aberrant form in that the aperture is not in the usual umbilical position but is asymmetrical and extend nearly to the periphery.

Hypotype. --- U.N.C. Cat. No. 3858.

Globigerina bulloides d'Orbigny

Pl. 8, figs. 2a-c

Globigerina bulloides d'Orbigny, 1826, Ann. Sci. Nat., Paris, sér. 1, tome 7, p. 277, Modèles no. 17, 76. ---d; Orbigny, 1839, Foraminifères, in: Barker-Webb et Berthelot, Hist. Nat. Iles Canaries, pl. 2, figs. 1-3, 28. ---Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 593, pl. 79, figs. 7a-c, (not figs. 3,4, 5a-b, 6a-b). ---Cushman, 1941, Cushman Lab. Foram. Res., Contr., vol. 17, p. 38, pl. 10, figs. 3-7. --- Bolli, Loeblich and Tappan, 1957, U.S. Natl. Mus. Bull. 215, p. 31, pl. 4, figs. 1a-c. ---Bé, 1959, Micropaleontology, vol. 5, no. 1, p. 83, pl. 1,

figs. 15-17. ---Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 175, pl. 9, figs. 38a-c.

Globigerina apertura Copeland, 1964, Bull. Am. Paleontology, vol. 47, no. 215, p. 281, pl. 41, figs. 4a-c.

Test of medium size, trochoid, dorsal side slightly convex, ventral side concave, umbilicate; periphery broadly rounded, lobulate; chambers distinct, about ten in total number, four in the last whorl, much inflated, nearly spherical, increasing rapidly in size as added; sutures distinct, depressed, radial on both sides; wall calcareous, perforate, distinctly pitted and spinose; aperture a high arched opening at the base of the last chamber, attaining about one-fourth to one-third the height of the chamber, opening into the small, deep umbilicus. Diameter 0.35 mm, thickness 0.26 mm.

Rare. Occurs in all zones, in samples 1, 2 (2%), 6,7, 8, 9 (3%), and 10 (2%).

Only forms which possess four chambers in the last whorl and have the aperture opening into the umbilicus are here included into this species. These characteristics are also displayed by the similar Globigerina ampliapertura Bolli, and G. praebulloides Blow. G. bulloides differs from the first in its less compressed chambers and more deeply incised sutures and from the latter in being less elongate, in its more spherical chambers and less restricted aperture.

Hypotype. --- U.N.C. Cat. No. 3859.

Globigerina concinna Reuss

Pl. 8, figs. 3a-c

Globigerina concinna Reuss, 1850, K. Akad. Wiss. Wien, Math.-Nat. Cl., Denkschr., Bd. 1, p. 373, pl. 47, figs. 8a-b. ---Cushman, 1946, Contr. Cushman Lab. Foram. Res., vol. 22, p. 20, pl. 3, figs. 10a-b, pl. 4, figs. 11-13. ---Marks, 1951, Contr. Cushman Lab. Foram. Res., vol. 2, pt. 2, p. 70, pl. 8, fig. 6.

Test of medium size, trochoid, dorsal side low convex, ventral side concave, wider than high, umbilicate; periphery broadly rounded, very lobulate; chambers distinct, much inflated, nearly spherical, about thirteen in total number, forming two and one-half whorls, five chambers comprising the last whorl, increasing rapidly in size as added; sutures distinct, depressed and radial; wall calcareous, perforate, finely hispid and pitted; aperture umbilical, a medium high arched opening, apertures of the last three chambers visible in the deep and wide umbilicus. Diameter 0.33 mm, thickness 0.15 mm.

Rare. Occurs in the Pecten zone only, in the samples 1 and 2.

Only two specimens of this species were found in the present material. One seems to be very typical, the other specimen is poorly preserved and has a partially filled umbilicus. There is a possibility that the latter is a deformed G. bulloides.

Hypotype. ---U.N.C. Cat. No. 3860.

Globigerina pachyderma (Ehrenberg)

Pl. 8, figs. 4a-c

Aristerospira pachyderma Ehrenberg, 1861, K. Preuss. Akad. Wiss., Monatsber., pp. 276, 277, 303. ---Ehrenberg, 1873, K. Akad. Wiss., Abh., Jahrg. 1872, pl. 1, fig. 4.

Globigerina bulloides Brady, 1878, Ann. Mag. Nat. Hist., ser. 5, vol. 1, p. 435, pl. 21, figs. 10a-c.

Globigerina bulloides borealis Brady, 1881, Ann. Mag. Nat. Hist., ser. 5, vol. 8, no. 48, p. 412.

Globigerina pachyderma Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 600, pl. 114, figs. 19a-c, 20. ---Heron-Allen and Earland, 1932, Discovery Repts., vol. 4, p. 401, pl. 13, figs. 9-13. ---Bé, 1959, Micropaleontology, vol. 5, no. 1, p. 83, pl. 1, figs. 23, 24. ---Galloway and Heminway, 1941, N.Y. Acad. Sci., vol. 3, pt. 4, p. 413, pl. 29, figs. 5a-c.

Test of medium size, trochoid, compact, convex dorsally, ventrally flat to slightly concave; periphery broadly rounded and moderately lobulate; chambers indistinct in the earliest portions, later distinct, subequal, inflated, somewhat appressed, arranged in a low trochoid spiral, four composing the last whorl, increasing gradually in size as added; sutures slightly depressed dorsally, distinctly depressed on the ventral side, radial; wall calcareous, thick, perforate and distinctly pitted; aperture a variously low opening, extending from the umbilicus up to two-thirds of the way to the periphery, with or without a low lip. Diameter 0.22 mm, thickness 0.15 mm.

Rare. Occurs in all three zones, in the samples 2, 8 and 9.

Hypotype. --U.N.C. Cat. No. 3861.

Globigerina quinqueloba Natland

Pl. 8, figs. 5a-c

Globigerina quinqueloba Natland, 1938, California, Univ., Scripps Inst. Oceanogr., Bull., Tech. Ser., vol. 4, no. 5, p. 149, pl. 6, figs. 7a-c.

Test small, trochoid, dorsal side convex, ventral side slightly convex, slightly higher than wide; periphery broadly rounded, lobulate; chambers distinct, inflated, nearly spherical, about twelve in total number, arranged in two and one-half whorls, the last whorl comprised of five rapidly expanding chambers; sutures distinct, depressed and radial on both sides; wall calcareous, perforate, surface rough in appearance, finely but distinctly pitted; aperture an elongated slit on the umbilical side under a large valve, covering nearly all of the umbilical area. Diameter 0.26 mm, thickness 0.15 mm.

Rare. Occurs in the Pecten zone only, in the samples 1 and 2.

The present forms seem to be typical, with the exception of a slightly higher spire and a lobulate rather than a flat valve.

Hypotype. --- U.N.C. Cat. No. 3862.

Globigerina trilocularis d'Orbigny

Pl. 8, figs. 6a-c

Globigerina trilocularis d'Orbigny, 1826, Ann. Sci. Nat., vol. 7, p. 277, (nomen nudum). ---d'Orbigny, 1832, in: Deshayes, Encyclopédie Méthodique; Hist. nat. des vers. Paris, France, Mme. v. Agasse, vol. 2, pt. 2, p. 2, p. 170. ---Fornasini, 1897, Rend. R. Accad. Sci. Inst., Bologna, new ser., vol. 2, fasc. 1, pl. 1, figs. 6, 7a-b; p. 12, text fig. ---Galloway and Morrey, 1929, Bull. Am. Paleontology, vol. 15, no. 55, p. 10, pl. 3, figs. 9.

Globigerina sp., cf. G. trilocularis Bolli, 1957, U.S. Natl. Mus. Bull. 215, p. 110, pl. 22, figs. 9a-c, (not figs. 8a-c). ---Bolli, 1957, ibid., p. 163, pl. 36, figs. 3a-b.

Globigerina pseudotriloba Galloway and Heminway, 1941, (not White, 1928)

N.Y. Acad. Sci., vol. 3, pt. 4, p. 413, pl. 29, figs. 6a-b.

Test small, trochoid, dorsal side convex, ventral side concave, umbilicate, wider than high; periphery broadly rounded, strongly lobulate, roughly trigonal in outline; chambers distinct, inflated, spherical, about seven to eight in total number, arranged in two and one-half whorls, three and one-half chambers composing the last whorl, increasing rapidly in size, the last chamber about a third as large as the remainder of the test; suture distinct, depressed; wall calcareous, perforate, finely hispid and pitted; aperture a low arch with a slight lip, opening into the umbilicus. Diameter 0.30 mm, thickness 0.21 mm.

Rare to common. Occurs in all zones and samples. Common in the Turritella and Pecten zones, in the samples 2 (3%), 9 (5%), and 10 (2%).

Bolli's specimens are here included in synonymy, though they approach G. bulloides in having a slightly higher than normal aperture and a fairly wide umbilicus.

Hypotype. --- U.N.C. Cat. No. 3863.

Genus Globigerinoides Cushman, 1927

Globigerinoides rubra (d'Orbigny)

Pl. 9, figs. 1a-c

Globigerina rubra d'Orbigny, 1839, in: De la Sagra, Hist. Phys. Nat. Cuba, Foraminifères, p. 82, pl. 4, figs. 12-14, ---Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 592, pl. 79, figs. 11-16.

Globigerinoides rubra Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. no. 25, p. 281, pl. 21, figs. 52.

---Loeblich, Tappan and Bolli, 1957, U.S. Natl. Mus. Bull. 215, p. 32, pl. 4, figs. 2a-c. ---Bolli, ibid., p. 113, pl. 25, figs. 12a-13b. ---Bé, 1959, Micropaleontology, vol. 5, no. 1, p. 83, pl. 2, figs. 16, 17. ---Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 192, pl. 11, fig. 70, pl. 13, figs. 69a-b. ---Belford, 1962, Commonwealth of Australia, Dept. Natl. Devel. Bur. Min. Res., Geology and Geophysics, Bull. 62-1, p. 19, pl. 5, figs. 1-6.

Test small, trochoid, higher than wide; periphery broadly rounded, lobulate, trigonal in outline; chambers inflated, nearly spherical, loosely appressed, indistinct in the earliest portion, later ones very distinct, increasing rapidly in size as added, about seven to nine in total number, three chambers forming the last whorl; sutures distinct, depressed, radial; wall calcareous, perforate, distinctly spinose; primary aperture a high arched large umbilical opening, several secondary openings on the dorsal side within the sutures between adjacent chambers. Diameter 0.20 mm, thickness 0.17 mm.

Rare. Occurs in all zones, in samples 1, 8 and 10.

Most specimens of Globigerinoides rubra of this fauna are low spired forms, like the hypotype here figured. High spired forms, similar to Brady's figures 11, 13-15, are also present, but in fewer numbers.

Hypotype. --- U.N.C. Cat. No. 3864.

Subfamily Orbulininae Schultze, 1854

Genus Orbulina d'Orbigny, 1839

Orbulina sp. cf. O. universa d'Orbigny

Pl. 9, fig. 2

Orbulina universa d'Orbigny, 1839, Foraminifères, in: De la Sagra, Hist.

Phys. et Nat. de l'Ile de Cuba, p. 2, vol. 8, pl. 1, fig. 1. ---Blow, 1956, Micropaleontology, vol. 2, no. 1, p. 66, text-fig. 2, no. 8, 9. ---Bolli, Loeblich and Tappan, 1957, U.S. Natl. Mus. Bull. 215, p. 35, pl. 7, fig. 3. ---Belford, 1962, Commonwealth of Australia, Dept. Natl. Devel. Bur. Min. Res., Geology and Geophysics, Bull. 62-1, p. 6, pl. 1, figs. 1-3, 8, 9.

Test minute, perfectly spherical, composed of a single chamber; wall hyaline, thin, highly polished in appearance, perforate, with pores either equidimensional and very fine, or of two distinct sizes; no enclosed Globigerina stage visible. Diameter 0.15 mm.

Rare. Occurs in the Dosinia-Mercenaria zone only. Present in the samples 3,4,6,7, and 8.

The specimens found at Grimesland are exceptional with regard to their minute size.

Hypotype. --- U.N.C. Cat. No. 3865.

Subfamily Catapsydracinae Bolli,
Loeblich and Tappan, 1957
Genus Globigerinita Brönnimann, 1951

Globigerinita incrusta Akers
Pl. 9, figs. 4a-c

Globirerinita incrusta Akers, 1955, Jour. Paleontology, vol. 29, no. 4, p. 655, pl. 65, figs. 2a-d.

Globigerinita naparimaensis incrusta Blow, 1959, Bull. Am. Paleontology, vol. 39, no. 178, p. 206, pl. 15, figs. 100-101.

Test minute, trochoid, dorsal side very low convex, ventral side flat to slightly convex, not umbilicate, wider than high; periphery broadly rounded, lobulate, nearly trigonal in outline; chambers indistinct in the juvenarium inflated and distinct in the last whorl and a half, nearly spherical, about nine in total number, four forming the last regular whorl, increasing rapidly in size as added, an irregular bulla covers the umbilicus and extends far toward the periphery over the sutures of the last whorl; sutures distinct, depressed; wall calcareous, perforate, finely pitted; aperture consists of multiple openings at the end of the branches of the bulla, in line with the sutures of the primary chambers, previous apertures not visible. Diameter 0.22 mm, thickness 0.15 mm.

Rare. Occurs in the Mercenaria-Dosinia zone only, in the samples 7 and 8.

Blow's (1959) decision, to regard Globigerinita incrusta as a variety of G. naparimaensis Brönnimann, is not followed here, because no specimens were found in this material, which had apertures along the contact suture of the bulla with the previous chambers, which is typical for G. naparimaensis.

Hypotype. -- U.N.C. Cat. No. 3866.

Superfamily Orbitoidea Schwager, 1876

Family Cibicidae Cushman, 1927

Subfamily Cibicidinae Cushman, 1927

Genus Cibicides de Montfort, 1808

Cibicides altamiraensis Kleinpell

Pl. 9, figs. 4a-c

Cibicides altamiraensis Kleinpell, 1938, Am. Assoc. Petroleum Geologists Bull., p. 351, pl. 19, figs. 4,5,8.

Test small, plano-convex, moderately convex on involute side, flat on the evolute side; periphery abruptly rounded, slightly lobular in outline; chambers distinct, about nine in the last whorl, first chambers of outer whorl tend to be appressed, later chambers more distinct and slightly inflated; sutures indistinct and flush with the surface in the first portion of the test, sutures of the last two-thirds of the test are distinct and depressed, slightly sigmoid in the last three chambers, spiral suture on evolute side depressed and broad, becoming obscure after one volution, outlining a low boss of shell material; wall calcareous with abnormally large pores on the evolute side; aperture a low arched opening at the base of the last chamber, peripheral, extending on to the evolute side along the base of the last three chambers. Diameter 0.35 mm, thickness 0.13 mm.

Rare. Occurs in the Mercenaria-Dosinia zone only. Sample 3.

Only one specimen of this species was recorded and this is in a very poor state of preservation. However, the general shape and the presence of the umbilical boss, and also the large pores on the evolute side are evidence for identification of this species.

Hypotype. --- U.N.C. Cat. No. 3867.

Cibicides crassiseptus Cushman and Laiming

Pl. 9, figs. 5a-c

Cibicides americanus (Cushman), var. crassiseptus Cushman and Laiming, 1931, Jour. Paleontology, vol. 5, p. 119, pl. 14, figs. 7a-c.

Test plano-convex, evolute side flat, involute side moderately convex; periphery acute, limbate and entire; chambers distinct, about ten in the last whorl, increasing gradually in size as added, wider than high throughout; sutures distinct, strongly limbate, broad and raised on both sides of the test, but more so on the involute side, curved; wall calcareous, smooth, finely perforate; aperture peripheral, at the base of the ultimate chamber, extending on to the evolute side for the length of two or three chambers. Diameter 0.31 mm, thickness 0.11 mm.

Rare. Occurs in the Turritella zone only, sample 10.

Hypotype. -- U.N.C. Cat. No. 3868.

Cibicides celebrus Bandy

Pl. 9, figs. 6a-c

Cibicides celebrus Bandy, 1944, Jour. Paleontology, vol. 18, p. 374, pl. 61, figs. 8a-c.

Test plano-convex, evolute side flat, involute side moderately convex; periphery acute and entire except for the last few chambers where it becomes subrounded and somewhat lobulate; chambers distinct, about nine in the last whorl, increasing gradually in size as added, the last few chambers slightly inflated and distorted, extending to the periphery of the umbilical plug; sutures distinct, gently curved backward, limbate in the first portion, later becoming somewhat depressed, irregular umbo of clear, coarsely perforate shell material on evolute side; umbilical plug of clear shell material present on the involute side; wall smooth, hyaline and coarsely perforate; aperture a low arch in peripheral position at the base of the ultimate chamber with a strong lip, extending on to the evolute side between the last two

whorls for the length of three to four chambers, apertural lip does not continue on the evolute side. Diameter 0.37 mm, thickness 0.11 mm.

Rare. Occurs in the Pecten zone only, sample 2.

In contrast to Bandy's type figure, the limbation of the sutures is more promiment on the involute side than on the evolute side. This and the slightly smaller dimensions being the only deviations from the type figure.

Hypotype. --- U.N.C. Cat. No. 3869.

Cibicides lobatulus (Walker and Jacob)

Pl. 9, figs. 7a-c

Nautilus lobatulus Walker and Jacob, 1798, Adam's Essays on the microscope, Kenmacher's ed., p. 642, pl. 14, fig. 36.

Truncatulina lobatula Brady, 1884, Challenger Rept., Zoology, vol. 9, p. 660, pl. 92, fig. 10, pl. 93, figs. 1, 4. ---Cushman, 1918, U.S. Geol. Survey, Bull. 676, p. 60, pl. 17, figs. 1-3.

Cibicides lobatulus Cushman, 1931, U.S. Natl. Mus. Bull. 104, pt. 8, p. 118, pl. 21, figs. 3a-c. ---Cushman, 1939, Cushman Lab. Foram. Res., Contr. vol. 15, p. 76, pl. 12, fig. 25, ---LeRoy, 1941, Colorado School of Mines, Quart. vol. 36, no. 1, pt. 1, p. 47, pl. 2, figs. 120-122; pt. 3, p. 119, pl. 1, figs. 12-14. ---Cushman, 1945, Cushman Lab. Foram. Res., Spec. Publ. no. 13, p. 27, pl. 6, figs. 13-15. ---Cushman, 1948, Cushman Lab. Foram. Res., Spec. Publ. no. 23, p. 78, pl. 8, fig. 14. ---Bermudez, 1949, Cushman Lab. Foram. Res. Spec. Publ. no. 25, p. 301, pl. 25, figs. 46-48.

Test plano-convex, flattened on the evolute side, slightly concave in some specimens, involute side moderately cinvex; periphery subacute, slight-

ly limbate, entire for most of the whorl,last portion becoming lobulate; chambers distinct, about seven to eight in the last formed whorl, increasing rapidly in size as added, the last ones being usually somewhat inflated on the involute side; sutures distinct, gently curved and depressed on the involute side, curved strongly and limbate on the evolute side; wall smooth and coarsely perforate, translucent in many specimens; aperture peripheral at the base of the last formed chamber, extending on the evolute side at the lower margin of the last three or more chambers, rimmed by a narrow lip on the involute side. Diameter 0.41 mm, thickness 0.14 mm.

Rare. Present in all three zones, in the samples 1, 2,3,4,9, and 10.

Most of the specimens seem to be normal, maintaining their characteristics throughout their growth stages. Two specimens were found in which the last two or three chambers are distorted, they are elongated and divert from the plane of coiling.

Hypotype. ---U.N.C. Cat. No. 3870.

Cibicides ornatus (Cushman)

Pl. 10, figs. 1a-c

Truncatulina lobatula ornata Cushman, 1918, U.S. Geol. Survey Bull. 676, p. 61, pl. 18, fig. 1, 2.

Cibicides floridanus Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 34, pl. 13, figs. 1a-c.

Test small, plano-convex, flattened on the evolute side, convex on the involute side; periphery subacute, slightly limbate, entire for the most of the whorl, the last few chambers may be lobulate; chambers distinct, about

nine in the last formed whorl, increasing rapidly in size as added, the last ones usually become somewhat irregular in shape and mode of attachment; sutures distinct, curved, strongly limbate, depressed slightly between the last formed chambers on the involute side; wall calcareous, hyaline with large pores; aperture peripheral, at the base of the ultimate chamber, with a narrow lip, extending onto the evolute side for one to three chambers. Diameter 0.39 mm, thickness 0.15 mm.

Rare, present in all three zones, in the samples 1, 2, 4,5,9, and 10.

The Grimesland specimens are identical to the type. However, since their sutures are opaque instead of clear, their ornamentation is not as obvious as in the type. Cibicides lobatulus ornatus Cushman and Cahill, 1933, does not seem to belong into this species in that the aperture is modified and the slight degree of asymmetry indicates that it is an Anomalina.

Hypotype. --- U.N.C. Cat. No. 3871.

Cibicides primulus, new species

Pl. 10, figs. 2a-c

Test small, subcircular to oval in side view, planoconvex, moderately convex on involute side, with an umbo of clear shell material, evolute side flat to very slightly concave, showing about two and one quarter whorls, covered by a coating of glassy shell material; periphery acute, slightly limbate on involute side, entire; chambers distinct, about eight in the last formed whorl, closely appressed, increasing evenly and gradually in size as added; sutures distinct, flush with the surface, limbate, gently curved on involute side, more curved on evolute side; wall hyaline, coarsely

perforate, smooth; aperture a medium wide slit at the base of the apertural face near the periphery, extending along the spiral suture line on the evolute side for a distance of one to one and one-half chambers, rimmed by a narrow lip on the involute side. Diameter 0.37 mm, thickness 0.15 mm.

Rare. Occurs in all three zones, in the samples 1, 2, 4, 6, 7, 8, 9, and 10.

Cibicides primulus closely resembles C. tallahattensis Bandy (1949, Bull. Am. Paleontology, vol. 32), the main difference being the narrower and higher chambers.

Holotype. ---U.N.C. Cat. No. 3872.

Paratype. ---U.N.C. Cat. No. 3873.

Cibicides sublobus (Cushman)

Pl. 10, figs. 3a-c

Truncatulina subloba Cushman, 1918, U.S. Geol. Survey, Bull. 676, p. 62, pl. 19, figs. 1a-c.

Cibicides sublobus McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 367, pl. 49, figs. 1-3.

Test large, probably attached, irregular in shape, generally plano-convex; periphery angular, limbate, strongly lobulate and irregular; involute side convex, evolute side flattened, showing the regular early stage for about one and one-third volutions, successive chambers are added in an irregular fashion, increasing rapidly in size as added, about seven in the last whorl; sutures distinct, limbate and curved on the evolute side, radial on the involute side; wall hyaline, coarsely perforate; aperture a medium high slit on the base of the apertural face, with a definite lip, extending along the basal margin on the evolute side for one-half the length of the chamber.

Diameter 0.95 mm, thickness 0.42 mm.

Rare. Present in the Pecten zone and the Turritella zone, occurs in the samples 2, 9, and 10.

Grimesland specimens of this species are quite variable, their shape was probably determined by the shape of the substrate to which they were attached. The specimens of C. sublobus are similar to those of C. lobatulus but differ from the latter in having at least one whorl of irregular chambers. Few specimens of C. lobatulus showed irregular chamber development and then only in the last two or three chambers. Intermediate forms were not found.

Hypotype. ---U.N.C. Cat. No. 3874.

Genus Dyocibicides Cushman and Valentine, 1930

Dyocibicides sp. cf. D. biserialis Cushman and Valentine

Pl. 10, figs. 4a-c

Dyocibicides biserialis Cushman and Valentine, 1930, Contr. Dept. Geol. Stanford Univ., vol. I, no. 1, p. 31, pl. 10, figs. 1, 2a-b. ---Cushman, 1931, U.S. Natl. Mus. Bull. 104, pt. 8, p. 126, pl. 24, fig. 2. ---Cushman, 1930, Florida Geol. Survey Bull. 4, p. 62, pl. 12, figs. 6a-b. ---Cushman and Todd, 1945, Cushman Lab. Foram. Res., Spec. Publ. no. 15, p. 72, pl. 12, fig. 10. ---Cushman and Gray, 1946, Cushman Lab. Foram. Res., Spec. Publ. no. 19, p. 46, pl. 8, figs. 18, 19. ---McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 368, pl. 49, figs. 7a-b.

Test small, early portion coiled, later becoming uncoiled, plano-convex, evolute side probably attached, flattened, involute side convex; chambers distinct, six or seven visible in the last whorl, becoming biserial and much enlarged in the uncoiled portion where they are distinctly inflated on the involute side, flat on the evolute side; sutures flush and curved in

the coiled portion, becoming depressed and irregular in the biserial portion; wall hyaline, finely perforate in the coiled portion, coarsely perforate in the uncoiled portion; aperture a medium high arch with a slight but distinct lip at the base of the apertural face of the last chamber. Length 0.24 mm, thickness 0.08 mm, diameter of coil 0.08 mm.

Rare. Present in the Turritella zone only, sample 10.

The present specimen is smaller than the holotype and has fewer chambers in the uncoiled portion of the test. It also resembles D. diminuta Tinoco but lacks the carinate periphery of that species.

Hypotype. --U.N.C. Cat. No. 3875.

Superfamily Cassidulinacea d'Orbigny, 1839

Family Caucasinidae Bykova, 1959

Subfamily Fursenkoininae Loeblich and Tappan, 1961

Genus Fursenkoina Loeblich and Tappan, 1961

Fursenkoina fusiformis (Cushman)

Pl. 10, figs. 5a-b

Virgulina fusiformis Cushman, 1930, Florida Geol. Survey Bull. 4, p. 45, pl. 8, figs. 8a-b. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 25, pl. 8, figs. 7a-b. ---Cushman, 1936, Geol. Soc. America Bull. vol. 47, p. 429, pl. 5, figs. 6, 7. ---Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. no. 9, p. 18, pl. 2, figs. 20a-b.

Test small, about twice as long as broad, roughly fusiform, greatest width near the middle, tapering towards both ends, compressed in edge view; periphery broadly rounded, lobulate; chambers distinct, few in

number, initially triserial, becoming twisted biserial for most of the test, inflated, much higher than wide; sutures depressed; wall hyaline, finely perforate, smooth; aperture terminal, slightly produced, small, broadly comma-shaped, extending to the inner margin of the chamber. Length 0.30 mm, width 0.15 mm.

Rare. Occurs in the Turritella zone and the Pecten zone, present in the samples 1, 9, and 10.

Hypotype. ---U.N.C. Cat. No. 3876.

Fursenkoina pontoni (Cushman)

Pl. 10, figs. 6a-b

Virgulina floridana Cushman and Laiming, 1931, Jour. Paleontology, vol. 5, p. 109, pl. 12, figs. 3a-b.
(not V. floridana Cushman, 1920).

Virgulina pontoni Cushman, 1932, Cushman Lab. Foram. Res., Contr. vol. 8, p. 17, pl. 8, fig. 7. ---Cushman and Ponton, 1932, Florida Geol. Survey, Bull. 9, p. 80, pl. 12, figs. 10, 11. ---Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. no. 9, p. 19, pl. 2, figs. 26-28. ---Cushman and Todd, 1945, ibid., Spec. Publ. no. 15, p. 42, pl. 6, fig. 23.

Test small, elongate, fusiform, about two and one-half times as long as wide, tapering on both ends, widest above the middle, slightly compressed, twisted; periphery broadly rounded, slightly lobulate; chambers distinct, slightly inflated, higher than wide, triserial in the initial portion, biserial and twisted in the rest of the test; sutures distinct, depressed; wall hyaline, perforate, smooth; aperture wide comma-shaped, terminal. Length 0.33 mm, width 0.15 mm.

Rare. Occurs in all three zones, present in the samples 1, 6, 9, and 10.

Fursenkoina pontoni differs from F. fusiformis in its greater length, more numerous and less inflated chambers. Juvenile forms of both species are difficult, if not impossible to separate.

Hypotype. --U.N.C. Cat. No. 3877.

Family Cassidulinidae d'Orbigny, 1839

Genus Globocassidulina Voloshinova, 1960

Globocassidulina bifurcata, new species

Pl. 10, figs. 7a-d, (holotype)

Pl. 11, figs. 1a-d, (paratype)

Test minute, subcircular to broadly oval in side view, somewhat compressed, biumbilicate; periphery narrowly rounded for the first third of the last whorl, becoming broadly rounded in the last portion, entire to slightly lobulate in the last chambers; chambers distinct, slightly inflated, four and one-half to five pairs making up the last whorl, increasing gradually in size and rapidly in thickness as added, only a small triangular portion of each set of chambers showing on the opposite side near the periphery; sutures distinct, slightly depressed, straight; wall hyaline, finely perforate, smooth; aperture in a depression of the inner side of the last chamber, in an asymmetrical Y-shape, the lower branch elongate, running along the suture with the penultimate chamber, the upper inward branch much reduced in size. Max. diameter of holotype 0.19 mm, min. diameter of holotype 0.17 mm, thickness 0.12 mm.

Rare to common. Present in all samples, common in the Turritella zone, samples 8 (2%), 9 (2%), and 10 (6%).

A virguline or comma-shaped aperture is normally attributed to this genus. Globocassidulina bifurcata deviates from this, but in all other aspects is a Globocassidulina. The slight apertural difference is not considered of sufficient importance to warrant the erection of a new genus. This species differs from G. islandica norvangi (Thalman) (1952, Cushman Found. Foram. Res., contr. vol. 3, pt. 2, p. 83) in the shape of the aperture, from G. subglobosa subcalifornica (Drooger) (1953, Cushman Found. Foram. Res., Contr. vol. 4, pt. 4, p. 140, pl. 22, figs. 8-9) in being about one-half or less the size of that species and in the shape of the aperture.

Holotype. -- U.N.C. Cat. No. 3878.

Paratype. -- U.N.C. Cat. No. 3879.

Family Nonionidae Schultze, 1854

Subfamily Nonioninae Schultze, 1854

Genus Nonion de Montfort, 1808

Nonion pauperatum (Balkwill and Wright)

Pl. 11, figs. 2a-b

Nonionina pauperata Balkwill and Wright, 1885, Roy. Irish Acad. Trans., vol. 28, Sci., p. 353, pl. 13, figs. 25, 26.

Nonion pauperatum Cushman, 1930, U.S. Natl. Mus. Bull. 104, pt. 7, p. 13, pl. 5, figs. 4,5,7. ---Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 24, pl. 6, figs. 21-23.

Test small, planispiral, involute, compressed, higher than wide; periphery angular, lobulate; about seven to nine chambers in the last whorl, distinct, increasing gradually in size as added, somewhat inflated, the last chamber

elongated on both sides, reaching below and past the anterior side of the umbilicus; sutures distinct, depressed, curved and meeting the periphery at an oblique angle; wall hyaline, finely perforate, smooth; aperture a low slit at the base of the apertural face, apertural face heartshaped in front view. Diameter 0.20 mm, thickness 0.09 mm.

Rare. Occurs in the Turritella zone and the Dosinia-Mercenaria zone, present in the samples 8, 9, and 10.

Nonion pauperatum from the Grimesland material is less wide through the umbilici than illustrated by the type-figure. In all other respects, the present forms seem to be identical.

Hypotype. -- U.N.C. Cat. No. 3880.

Genus Florilus de Montfort, 1808

Florilus pizarrensis (Berry)

Pl. 11, figs. 3a-c

Nonion pizarrensis Berry, 1928, Jour. Paleontology, vol. 1, p. 269, text fig. 1, figs. 1-3. ---Cushman, 1930, Florida Geol. Survey Bull. 4, p. 37, pl. 6, figs. 7,8.

Nonion pizarrense Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 20, pl. 7, figs. 2a-b. ---Cushman, 1939, ibid., Prof. Paper 191, p. 24, pl. 6, fig. 27, 28. ---Dorsey, 1948, Maryland Dept. Geology, Mines, Water Res., Bull. 2, p. 300, pl. 35, figs. 6a-c. ---McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 340, figs. 6,8,10, 12.

Test planispiral, higher than wide, asymmetrical, slightly evolute; periphery broadly rounded, entire, umbilici depressed; chambers distinct, about twelve in the last whorl, closely appressed, increasing rapidly in size as added, the last few chambers slightly inflated; sutures distinct, gently curved, somewhat

depressed in last part of the whorl; wall hyaline, finely perforate, smooth, pustulose material deposited in the umbilical region on one side only; aperture a low arched opening at the base of the apertural face. Diameter 0.59 mm, thickness 0.36 mm.

Rare to common. Occurs in all three zones, present in the samples 2,3,4, 5,7,9, and 10. Common in sample 1 (1.5%).

In the literature cited above, Florilus pizarrensis appears in some degree of variation, some doubt exists as to the true identity of those identifications. This doubt applies especially to Cushman's (1930, pl. 6, fig. 7.) Specimen which shows moderately inflated chambers.

Hypotype. -- U.N.C. Cat. No. 3881.

Genus Nonionella Cushman, 1926

Nonionella auris (d'Orbigny)

Pl. 11, figs. 4a-c

Valvulina auris d'Orbigny, 1839, Voyage dans l'Amérique Méridionale, vol. 5, pt. 5, Foraminifères, p. 47, pl. 2, figs. 15-17.

Nonionina auris Cushman, 1925, Cushman Lab. Foram. Res. Contr. vol. 1, pt. 2, pl. 7, figs. 3a-c.

Nonionella auris Cushman, 1930, Florida Geol. Survey Bull. 4, p. 38, pl. 7, figs. 1a-c. ---Cushman and Cahill, 1933, U.S. Geol. Survey Prof. Paper 175-A, p. 21, pl. 7, figs. 6a-b. ---Cushman, 1939, ibid. Prof. Paper 191, p. 33, pl. 9, fig. 4. ---Dorsey, 1948, Maryland, Dept. Geol., Mines, Water Res., Bull. 2, p. 301, pl. 35, figs. 3a-c. ---McLean, 1956, Bull. Am. Paleontology, vol. 36, no. 160, p. 341, pl. 43, figs. 1,4.

Test small, higher than wide, asymmetrical, slightly trochoid; periphery broadly rounded, entire to slightly lobulate; not completely evolute on the dorsal side; chambers distinct, elongate, about nine in the last formed whorl, increasing rapidly in size as added, the last chamber slightly inflated, extending over the umbilicus on the ventral side; sutures distinct, depressed near the umbilici, flush near the periphery, gently curved; wall calcareous, hyaline, finely perforate, smooth; aperture a low slit at the base of the apertural face, extending a little over onto the ventral side. Diameter 0.48 mm, thickness 0.22 mm.

Rare. Occurs in all three zones, present in the samples 1, 2,3,7,8,9, and 10.

The type-figure of d'Orbigny shows a very lobulate periphery. In many of the subsequent publications specimens with much less lobulate periphery have been illustrated, which also exhibit a greater thickness. In the present material, specimens with moderately inflated chambers and slightly lobulate periphery are most common.

Hypotype. ---U.N.C. Cat. No. 3882.

Nonionella miocenica stella Cushman and Moyer

Pl. 11, figs. 5a-c

Nonionella miocenica stella Cushman and Moyer, 1930, Cushman Lab. Foram. Res., Contr. vol. 6, p. 56, pl. 7, figs. 17a-c. ---Cushman, 1939, U.S. Geol. Survey Prof. Paper 191, p. 34, pl. 9, fig. 10.

Test compressed, higher than wide, slightly trochoid, asymmetrical; periphery broadly rounded to slightly lobulate; evolute on the dorsal side, involute on the ventral side; chambers distinct, elongate, about eight in the last whorl, increasing rapidly in size as added, the last chamber slightly inflated, enlarged on the ventral side, reaching over the umbilicus where it becomes

digitate with small, short processes extending into the sutures; sutures distinct, slightly depressed between the last few chambers and near the umbilical region, flush near the periphery, gently curved; wall calcareous, hyaline, finely perforate, smooth; aperture a low, narrow slit at the base of the apertural face. Diameter 0.45 mm, thickness 0.19 mm.

Rare. Occurs in all three zones, present in the samples 2, 7, 8, 9 and 10.

Due to poor preservation and small size of part of the material, some of the specimens cannot definitely be assigned to this species. There remains the possibility, that some are specimens of Nonionella pulchella Hada.

Hypotype. --- U.N.C. Cat. No. 3883.

Family Anomalinidae Cushman, 1927

Subfamily Anomalininae Cushman, 1927

Genus Hanzawaia Asano, 1944

? Hanzawaia concentrica (Cushman)

Pl. 11, figs. 6a-c

Cibicides concentrica Cushman, 1918, U.S. Geol. Survey Bull. 676, p. 64, pl. 21, fig. 3.

Test plano-convex to slightly biconvex, evolute side nearly flat, involute side moderately convex; periphery sharply rounded, entire; chambers distinct, about nine in the last whorl, increasing rapidly in size as added, in the largest specimens the last few chambers may be somewhat inflated on the ventral side, a band of shell material joins the proximal part of the chambers on the dorsal side; sutures distinct, curved, somewhat limbate and flush in the first part, the last ones may be slightly depressed on the involute side, the sutures of the evolute

side, terminate in a small pit near the concentric band of shell material; wall smooth, medium perforate; aperture on the periphery at the base of the last formed chamber, a low arch with a small lip, extending on to the evolute side under the band of shell material into the umbilicus. Diameter 0.30 mm, thickness 0.10 mm.

Rare. Occurs in the Mercenaria-Dosinia zone and in the Pecten zone, present in the samples 1, 2,3, and 8.

The sutures of these specimens are not as limbate as in the type illustration, also the periphery is more sharply angled.

The assignment of this species to the genus Hanzawaia is somewhat doubtful. The band of shell material on the proximal ends of the chambers on the evolute side may represent the fused umbilical flaps, characteristic for the genus Hanzawaia.

Hypotype. --- U.N.C. Cat. No. 3884.

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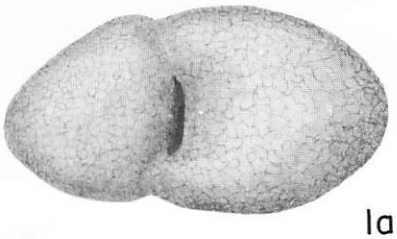

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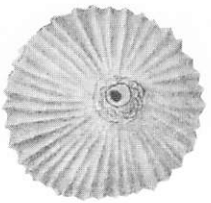

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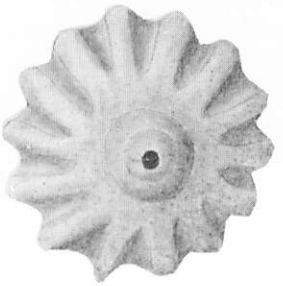

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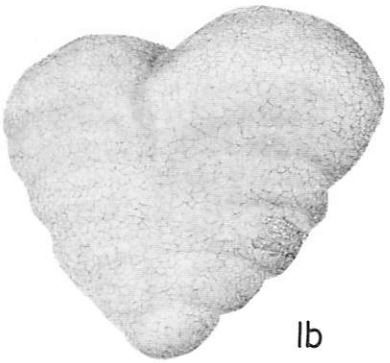

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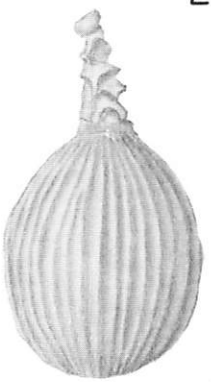

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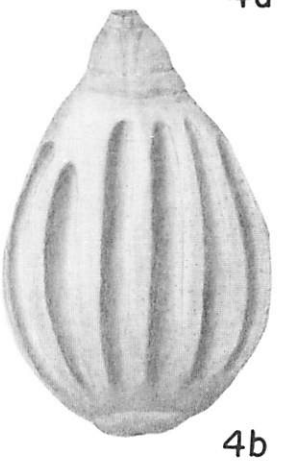

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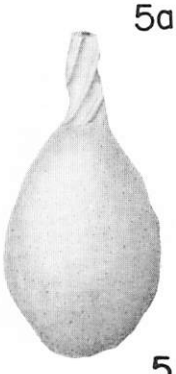

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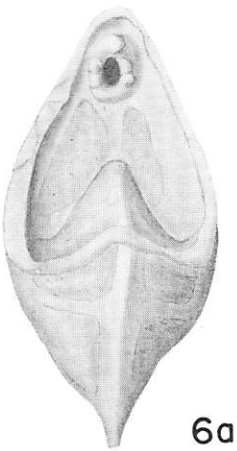

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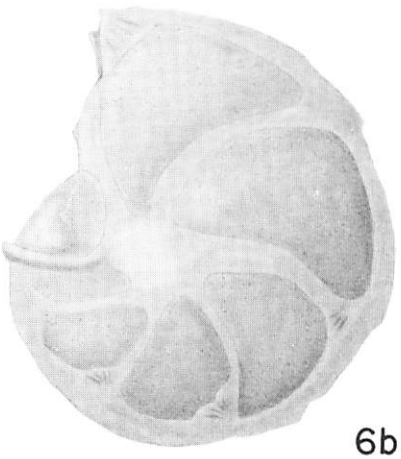

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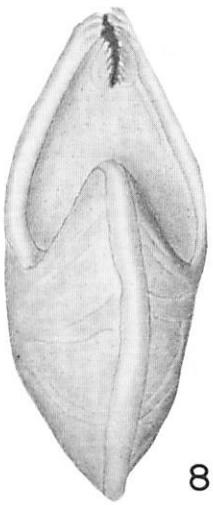

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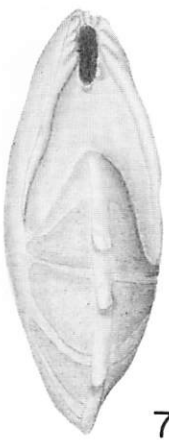

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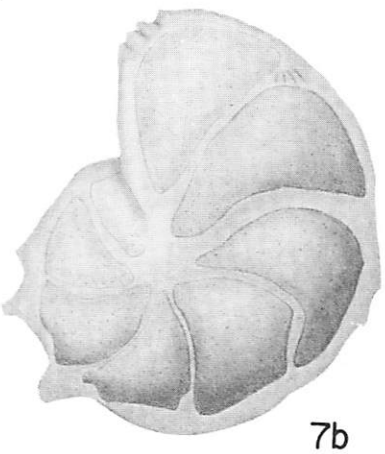

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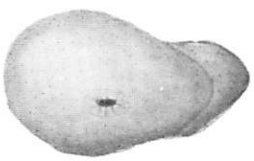

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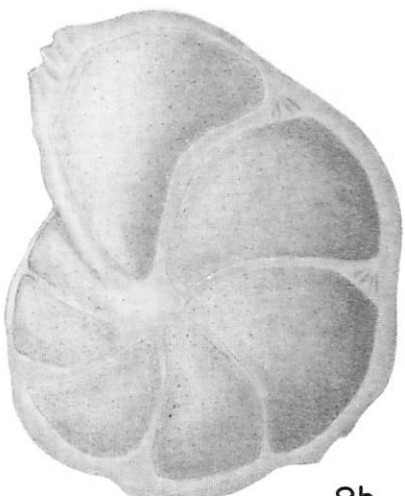

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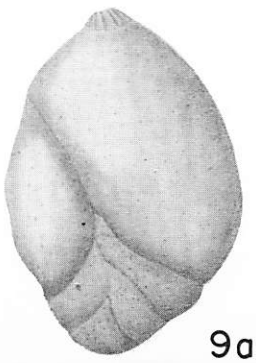

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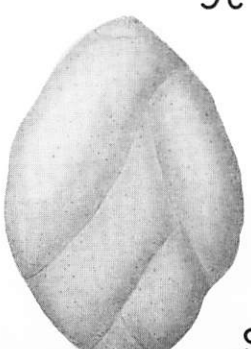

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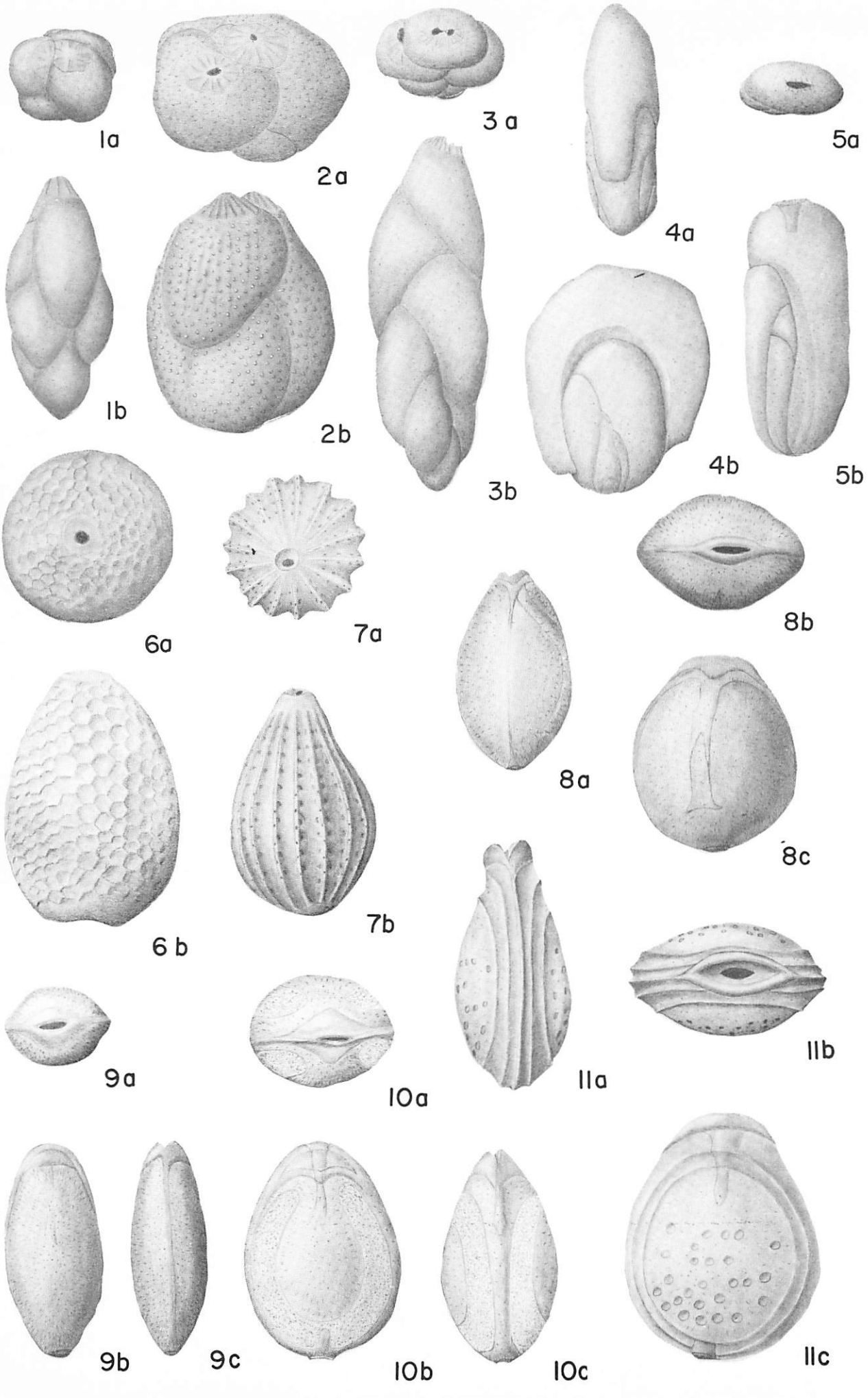
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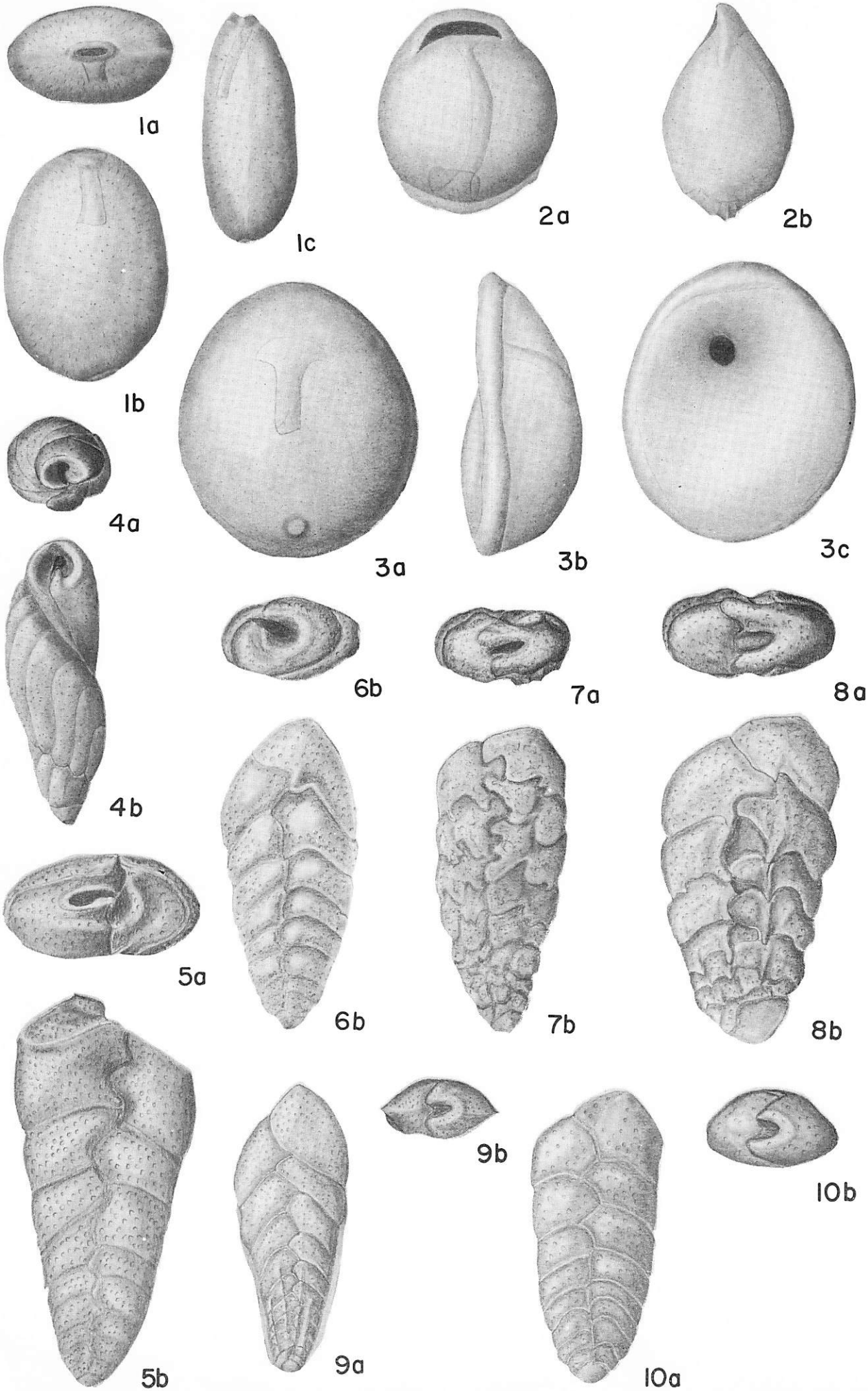
Explanation of Plate 3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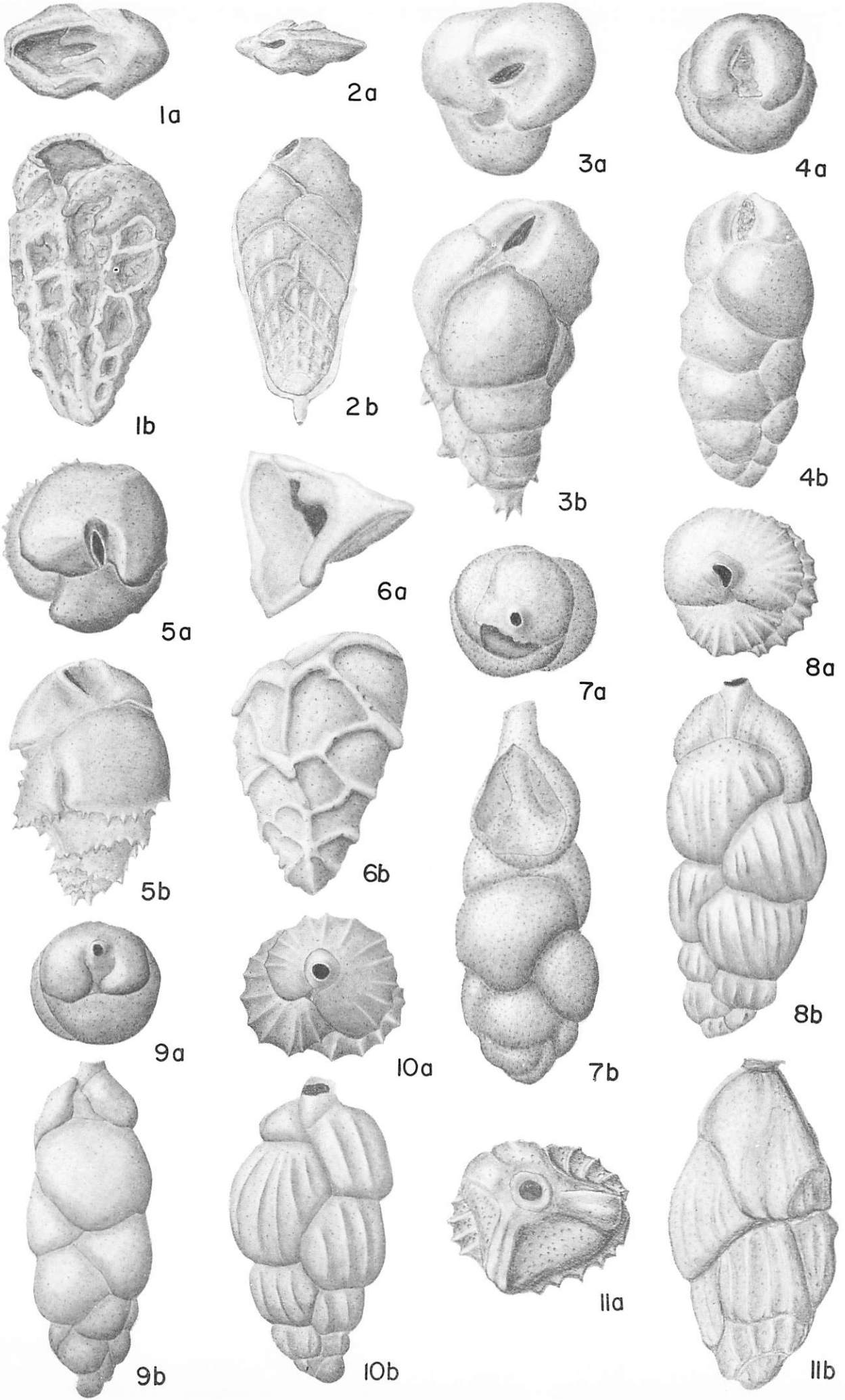
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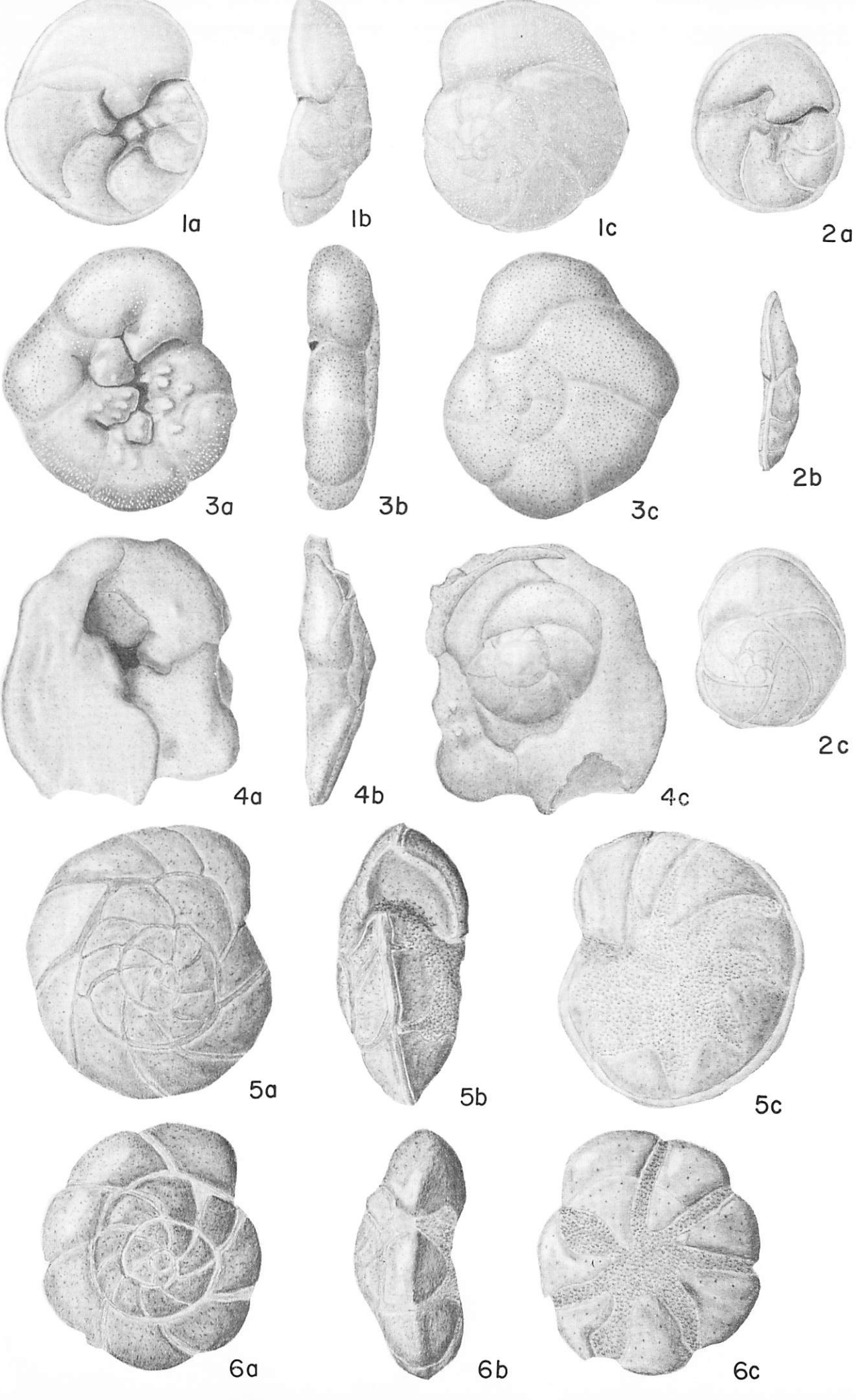
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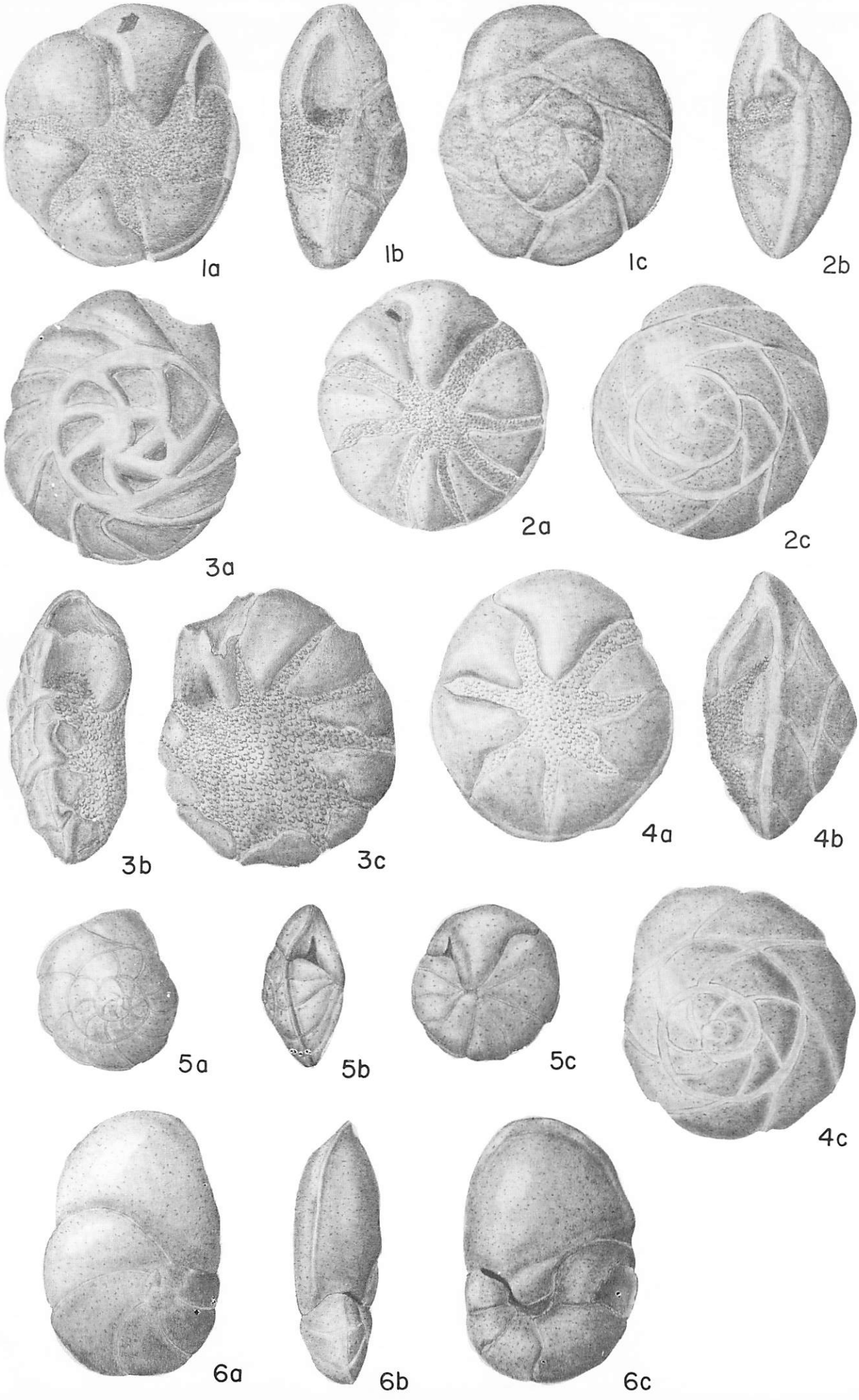
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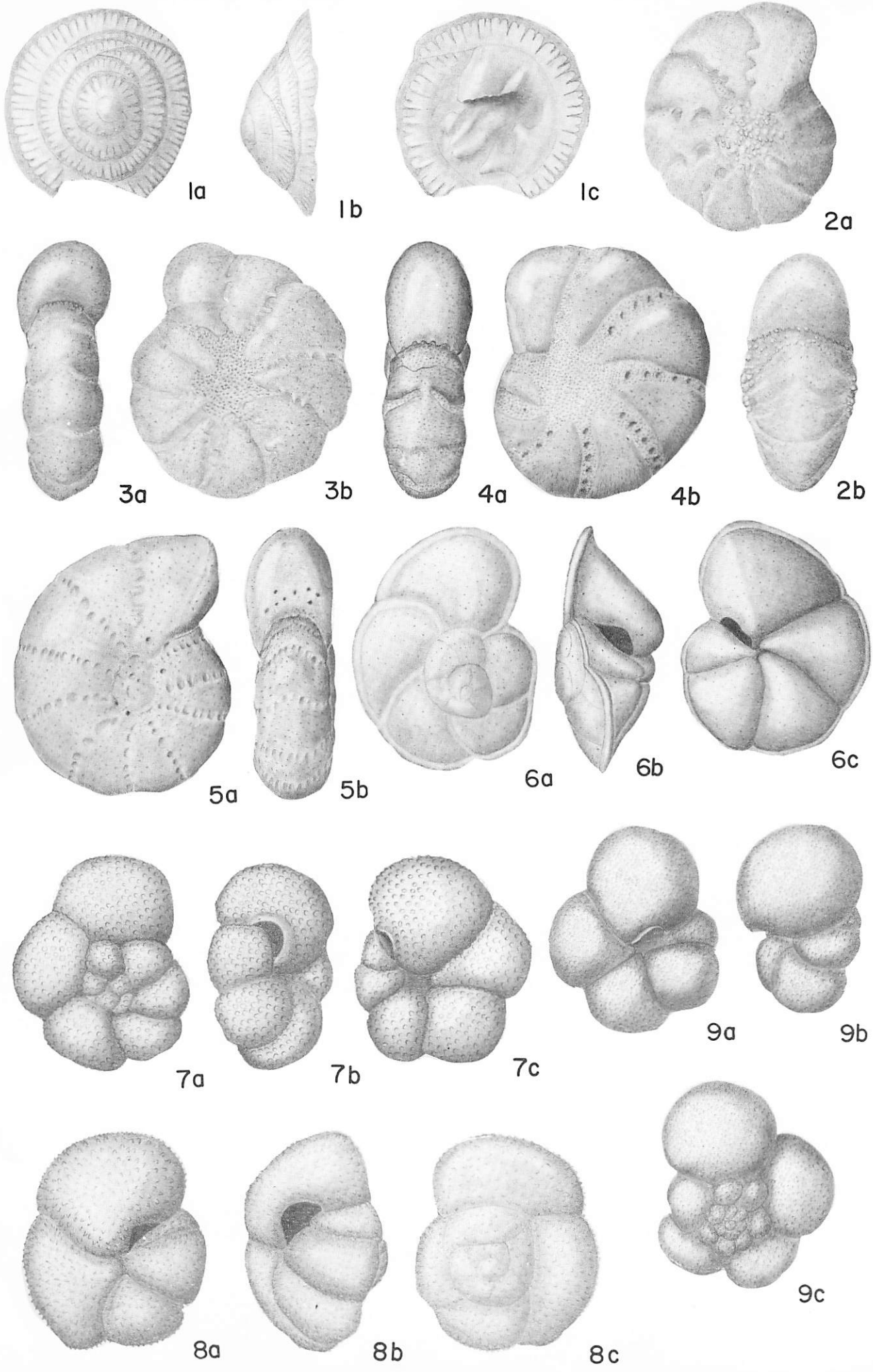
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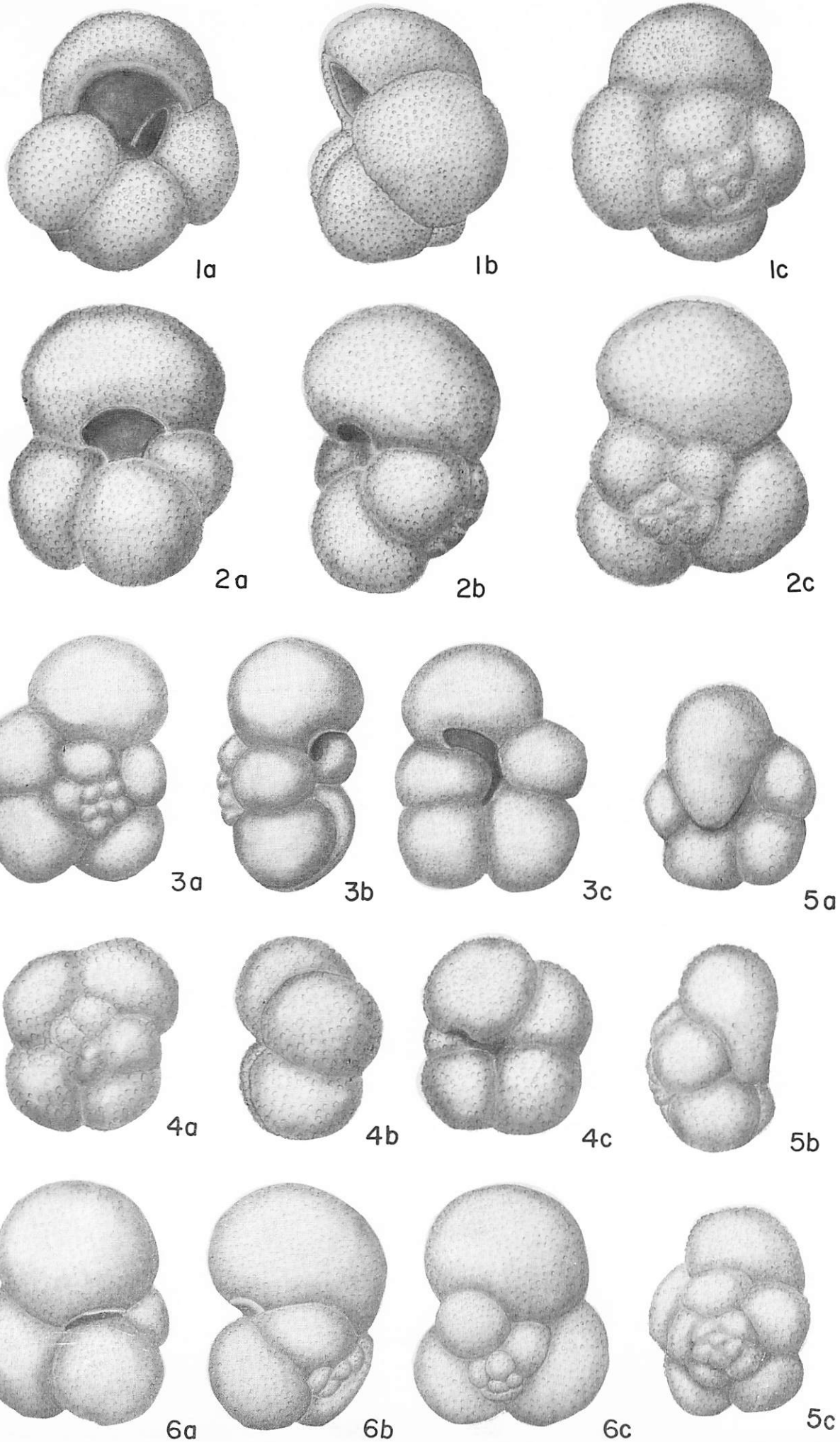
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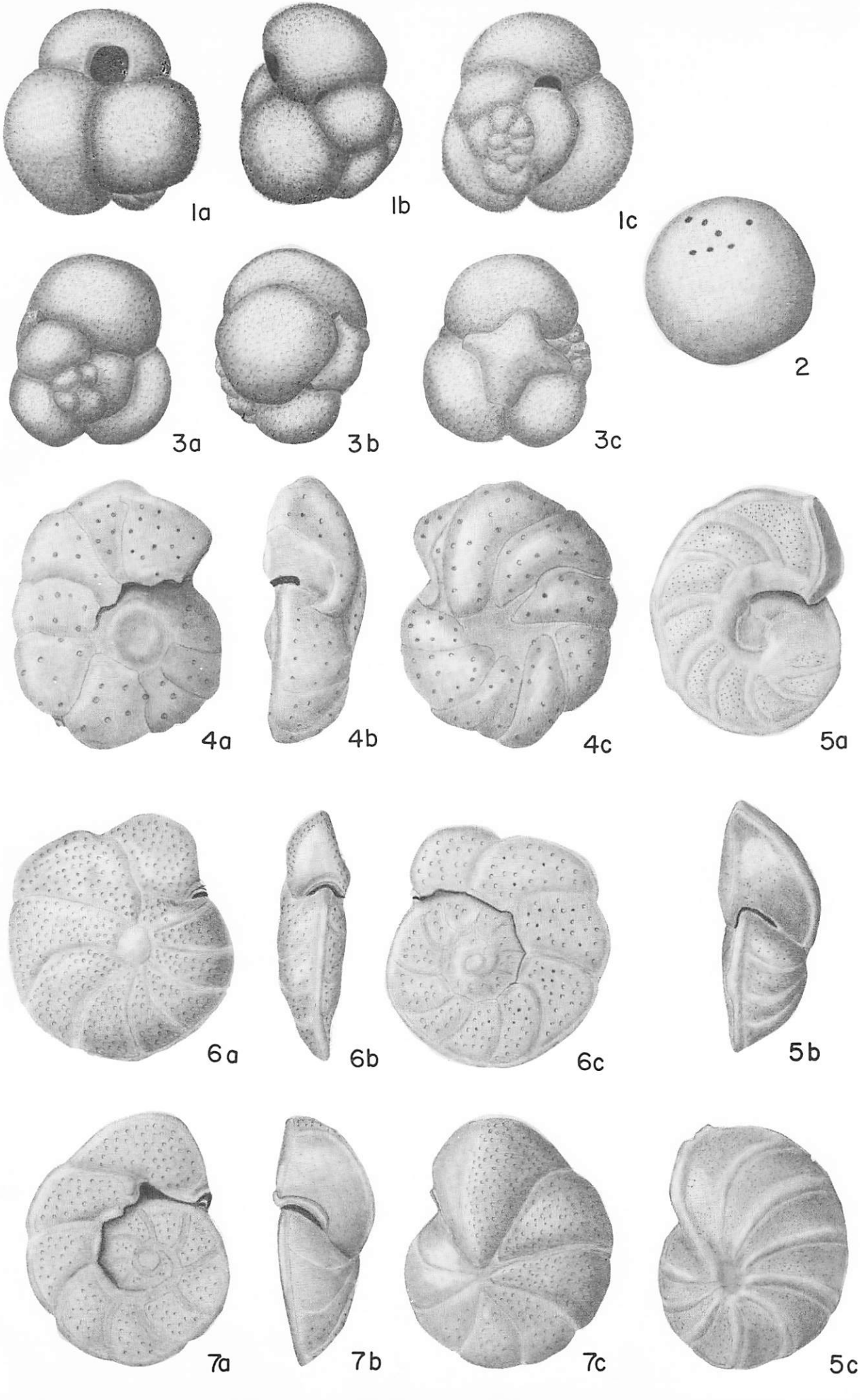
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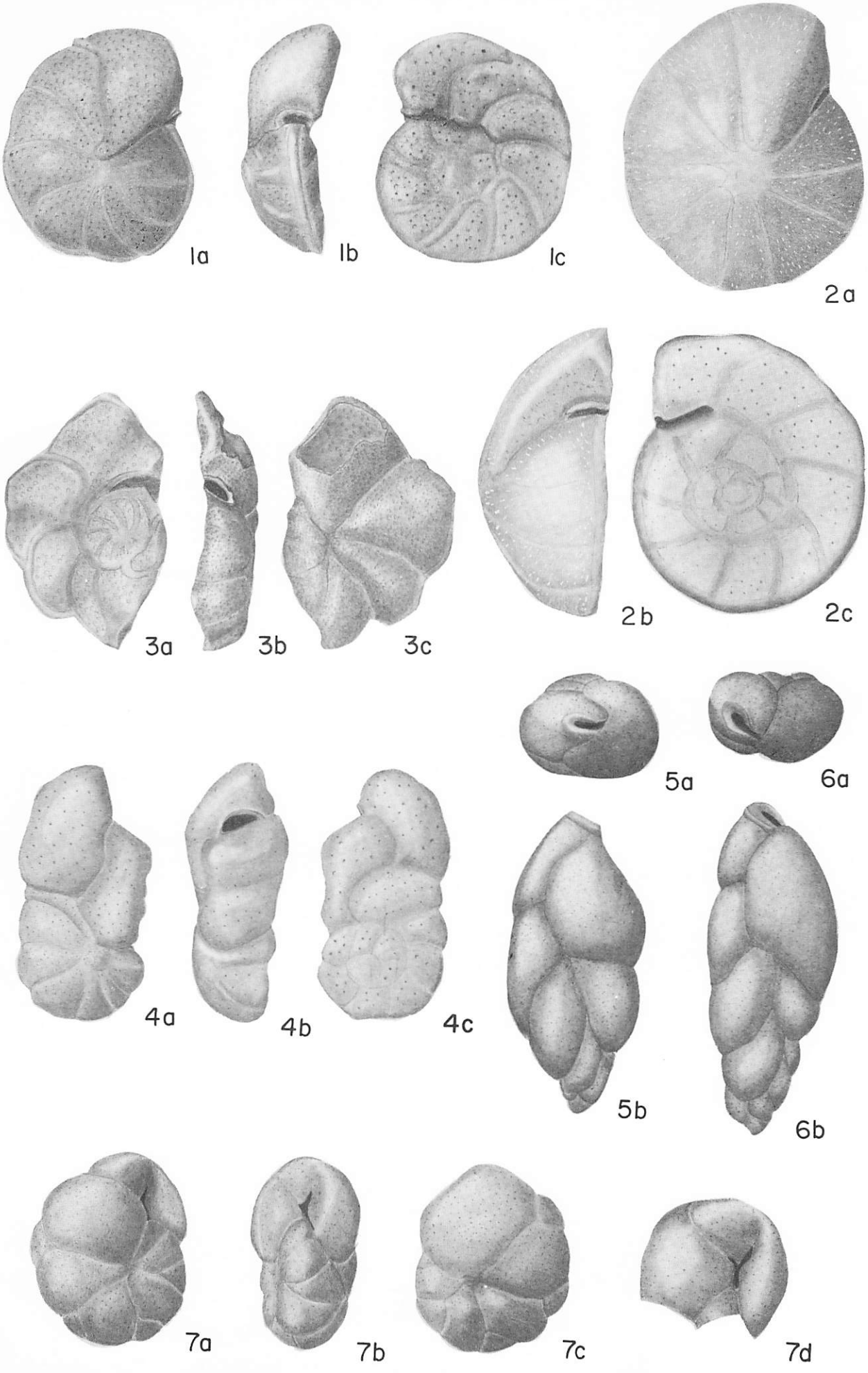
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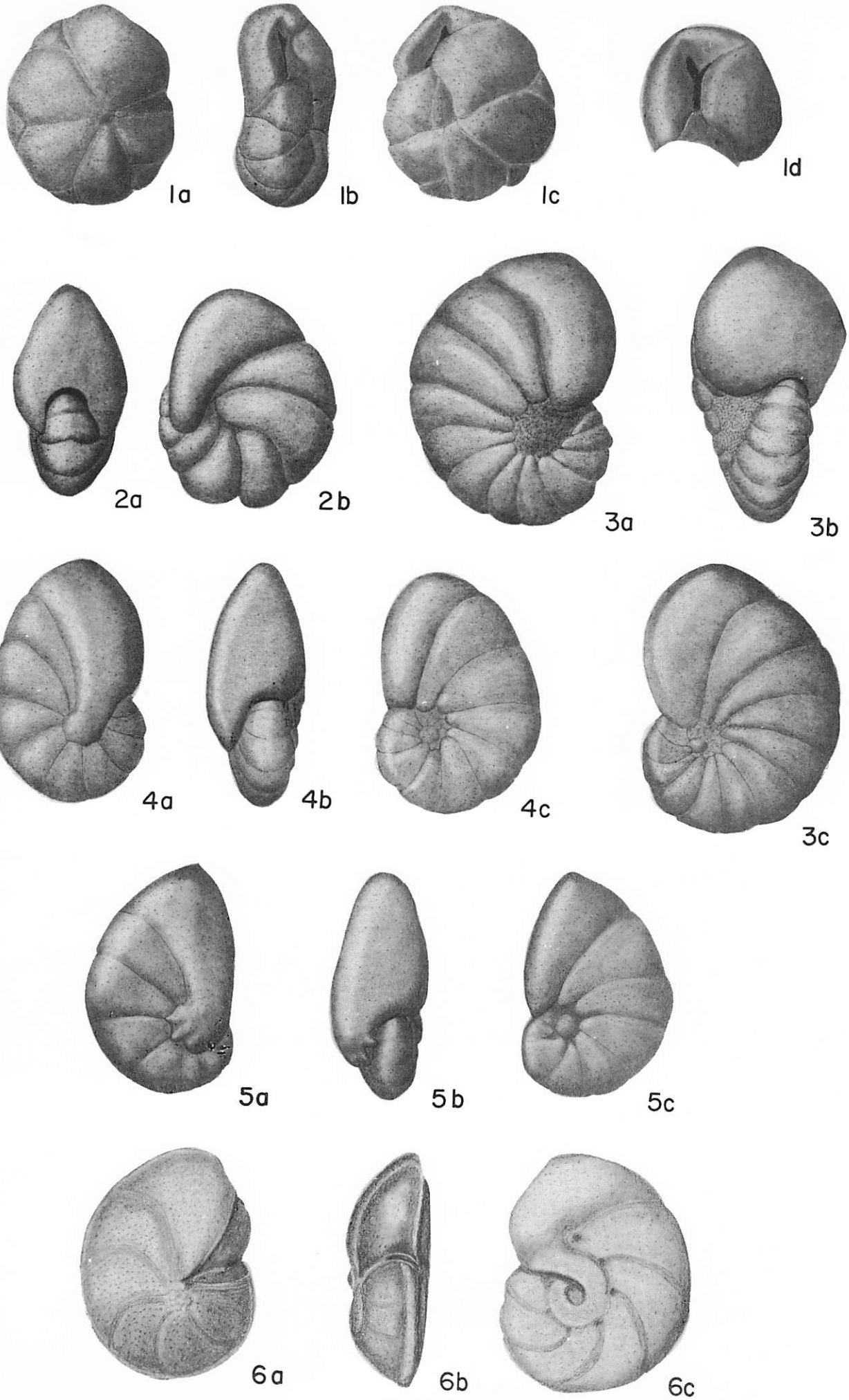
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