Key Foraminifera from Upper Oligocene to Lower Pleistocene Strata of the Central Atlantic Coastal Plain

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ABSTRACT

Biostratigraphically important planktonic and benthic foraminiferal species from strata of late Oligocene to early Pleistocene age in the central Atlantic Coastal Plain are described and illustrated. Thirty planktonic species are used, in conjunction with a few radiometric ages, to date the strata. The ages derived are: "Silverdale" beds of latest Oligocene age; Pungo River and Calvert formations of late early to early middle Miocene age; Choptank Formation of middle middle Miocene age; St. Marys Formation of late middle to early late Miocene age; "Virginia St. Marys" beds of late Miocene age; Yorktown Formation of early to late(?) Pliocene age; and uppermost "Yorktown," Croatan, and Waccamaw formations of late Pliocene and early Pleistocene age.

Thirty-seven species and subspecies of benthic Foraminifera important for regional correlation are described, and ranges are given for this area. New species described are *Bolivina pungoensis*, *Bolivinopsis fairhavenensis*, *Epistominella pungoensis*, *Cibicides cravenensis*, *C. croatanensis*, *C. pungoensis*, *Svratkina croatanensis*, *Nonion calvertensis*, *Florilus chesapeakensis*, and *Elphidium neocrespinae*. New subspecies described are *Nonion advenum pustulosum* and *Elphidium latispatium pontium*.

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Introduction

The age assignments of Cenozoic strata in the Atlantic Coastal Plain have been determined primarily from molluscan data. Although numerous molluscan groups, including the pectens, *Astarte*, and *Crassatella*, are valuable in correlation within the Atlantic Coastal Plain, the lack of molluscan species common to North America and Europe limits correlation with the European stratotype sections for the Oligocene, Miocene, Pliocene, and Pleistocene. Many benthic foraminiferal species are common to both areas, but species ranges generally are too long for the refined correlation desired.

This study used planktonic Foraminifera to correlate Atlantic Coastal Plain strata with intercontinental planktonic foraminiferal zones and the European stratotypes of Cenozoic stages. Gibson (1967), Akers (1972), and Hazel (1977) assigned some of the strata to planktonic zones. Strata ranging in age from late Oligocene to early Pleistocene and extending from Maryland to southern North Carolina were examined. Unfortunately, planktonic specimens are rare in many of the outcropping sections because of the shallow-water environment of deposition. This scarcity, combined with the cool-water nature of most of the assemblages, makes correlation difficult. The examination of large samples, however, produced rare but biostratigraphically important specimens in many of the formations. Radiometric ages supplement the foraminiferal data in some of the formations.

Key benthic species are proposed for correlation within the region and should prove valuable for dating subsurface sections. Thirty-seven benthic species that characterize one or more formations are discussed, and the range of each within the study area is given. Some of the species have greater ranges in other geographic and environmental areas. Species from well samples near the Atlantic Coast allow cross-indexing of the characteristic shallow-water species found in outcrops, and should serve as faunal links to assemblages found in strata on the Atlantic Continental Shelf.

Type specimens and all specimens illustrated here are deposited in the USNM collections of the National Museum of Natural History, Smithsonian Institution.

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Age of the Formations

Correlation with European Stages

The age placements by various authors for formations in the middle and late Tertiary show relative stability in the assignments of the older units, such as the Calvert Formation, and considerable, relatively recent changes in the placement of younger units, such as the Yorktown and Waccamaw formations. The correlation charts of Mansfield (1943) and Cooke, Gardner, and Woodring (1943) reflected the thinking at that time of many workers regarding the Atlantic Coastal Plain. In retrospect, however, the general stage of development of the invertebrate and vertebrate faunas appears to have been the only basis upon which these early workers correlated Atlantic Coastal Plain units with the European stages. Planktonic Foraminifera and nannoplankton were not used then, and radiometric dating was unavailable. Moreover, stages such as the Sarmatian and Pontian, with which the Yorktown Formation has been correlated (Mansfield, 1943) are represented by deposits formed in brackish to nonmarine environments in the eastern Mediterranean region. The type areas for these stages thus contain molluscan assemblages different from those found in the shallow-marine western Atlantic environments represented in the Yorktown Formation. Even within similar shallow marine environments, there are very few molluscan species common to both the Atlantic Coastal Plain and western Europe (Mongin, 1959:329).

The changes in age assignments made during the past 20 years include changes in interpretation of the age of the supposed later Miocene and younger formations. Although the recent use of planktonic groups has had a great effect on biostratigraphic studies, doubt about age assignments began because of the disparity in ages indicated by vertebrates and invertebrates. DuBar (1958:142) assigned a late Pleistocene age to the Caloosahatchee Formation of Florida, a unit that had been traditionally placed in the late Pliocene. His age assignment was based upon the occurrence of *Equus*, the modern horse, a genus considered indicative of a Pleistocene age. This change in age assignment disturbed those who studied invertebrates, because the large number of extinct molluscan species in the Caloosahatchee (as much as 50 percent, DuBar, 1958:137) suggested an older age. The resistance to accepting so many extinct species in Pleistocene strata probably is related to the Lyellian concept that less than 10 percent of the mollusks in the

Pleistocene are extinct. This resistance also appears to be related to the then accepted date of about one million years for the base of the Pleistocene, with the resultant rapid extinction of half of the assemblage. After DuBar's age assignment, common opinion among those who worked with invertebrates was as follows: If the Caloosahatchee were indeed Pleistocene in age, then the moderate similarity of its molluscan faunas to those of the Yorktown Formation would mean that the somewhat older Yorktown also must be interpreted as younger. Because the Yorktown Formation at that time was considered the "standard" unit of late Miocene age on the Atlantic Coastal Plain, a more recent date would indicate a Pliocene age. Although a Pleistocene age for the Caloosahatchee largely was discounted, the general result of this controversy was a new awareness of the uncertainties of previously accepted age assignments of Atlantic Coastal Plain Cenozoic strata.

Another opinion on the younger age of the Yorktown Formation resulted from the author's conversations with Remington Kellogg in the early 1960s concerning the age of a new baleen whale skeleton ("*Balaena*") found in the Yorktown Formation of Rice's Pit at Hampton Roads, Virginia. The baleen whale from the Yorktown Formation was similar to living baleen whales, and, in light of known rates of whale evolution, Kellogg could not resolve this similarity in terms of a late Miocene age for the Yorktown specimen. A possible explanation was that these beds in the upper half of the Yorktown Formation were younger than late Miocene.

The age significance of vertebrate specimens reported upon by Frank C. Whitmore, Jr. during the early 1960s also supported a post-late Miocene age for the Yorktown Formation. Whitmore (1965:A71) reported the following:

> Two mammalian fossils recently given to the Survey for identification have raised questions concerning the correspondence of age classifications of the coastal plain sediments based on vertebrate and on invertebrate fossils, respectively. A single lower horse molar, collected from the Yorktown Formation (upper Miocene) at Cobham Wharf, Va., has been identified by F.C. Whitmore, Jr., of the U.S. Geological Survey and M.F. Skinner, of the Frick Laboratory, American Museum of Natural History, as *Hipparion* cf. *H. eurystyle* Cope, of Clarendonian or early Hemphillian (early or early middle Pliocene) age. The possibility that part of the Yorktown may be of Pliocene age is further supported by the finding in 1960, at Hampton, Va., of a baleen whale of a type that seems too advanced for the Miocene.
>
> Part of a horse skull, found in the Caloosahatchee Formation in its type area near Labelle, Fla., has been identified by Whitmore as *Equus*, probably a mid-Pleistocene species. This find is of particular interest because the rich invertebrate fauna of the Caloosahatchee is generally regarded as being of Pliocene age.

Thus, most vertebrate evidence suggested that at least part of the Yorktown Formation was Pliocene in age. The tooth collected at Cobham Wharf, Virginia, however, was a float specimen from the modern beach rather than one collected in place from the Yorktown strata. Hence, doubt remained about whether it came from the fossiliferous Yorktown or from overlying sand units that tentatively were considered to be Pleistocene in age.

As a result of these questions concerning the age of the Yorktown Formation, the author examined planktonic Foraminifera from the Yorktown, because this group was being used to correlate with the European stages. On the basis of the sparse assemblages from the lower part of the Yorktown Formation, Gibson (1967:638) indicated a middle late Miocene age for these deposits. This age determination was based largely upon the identification of *Globorotalia mayeri* in the assemblages. On the basis of subsequent work on the "*Turborotalia*" lineages, particularly by Blow (1969), these specimens would now be placed in "*Turborotalia*" *acostaensis*, a group not widely recognized at that time. Even though the late Miocene age was applied to the lowermost part of the Yorktown, the age of the middle and upper part of the Yorktown Formation was considered unsettled at that time.

Therefore, pending additional concrete evidence for a Pliocene age for at least part of the Yorktown, the strata were questionably assigned a late Miocene age. This state of affairs was reflected in comments such as those in Gibson (1971:10):

With the occurrence of relatively large changes in the faunas, both macro and micro, in the overlying Yorktown beds, it is entirely possible that units placed in the upper Yorktown will range considerably into the Pliocene in age, but this reassignment will be dependent upon finding adequate planktonic assemblages.

Hazel (1971a) placed the youngest part of the Yorktown Formation in North Carolina, the beds along the Chowan River, into the early Pliocene. This was done on the assumption that the Yorktown Formation in Virginia was of late Miocene age, and that these younger beds along the Chowan (Mansfield, 1943) were, therefore, of early Pliocene age. How these beds correlated with the European stages of the upper Miocene and Pliocene was not demonstrated, except indirectly through strata in Florida. Hazel (1971a:8) stated:

Thus, it may be that the upper Miocene-lower Pliocene boundary in the Atlantic and Gulf Coastal Plain eventually will be revised further downward to include in the Pliocene more of the deposits that have been traditionally assigned to the upper Miocene.

Akers (1972) correlated the planktonic faunas from some Gulf and Atlantic Coastal Plain formations with planktonic zonations and stages in Europe. Akers (1972:32) concluded from the examination of a few assemblages from the Yorktown Formation that it was of Pliocene age, correlating with Blow's (1969) zones N19 and N20, and that the Waccamaw Formation in North Carolina, containing *Globorotalia truncatulinoides*, belonged to zone N22 of early Pleistocene age. Subsequent work by Akers and Koeppel (1973) on calcareous nannofossils supported a zone N20 date for the Yorktown Formation in Virginia and North Carolina. These age assignments also are supported by the present study.

The Waccamaw and Croatan formations are herein considered coeval with the Caloosahatchee Formation, and are all considered late Pliocene and early Pleistocene in age. The new age assignments for these formations, along with that for the Yorktown, bring into agreement, at least at the epoch level, the ages of the strata and are based on both the invertebrates and the vertebrates.

Planktonic Foraminiferal Zonation

Much of the current worldwide correlation with the European stratotypes is based upon the planktonic Foraminifera, although the use of calcareous nannoplankton, diatom, radiolarian, and dinoflagellate correlations is increasing rapidly. Zonations based upon planktonic Foraminifera have been established in several different regions, for example by Bolli (1957) for Trinidad, Blow (1959) for Venezuela, and Jenkins (1960) for New Zealand. A summary of the land-based distributions and some early Deep Sea Drilling Program samples were presented by Blow (1969), who then established a zonation that was based upon all available data. Blow named the zones, using diagnostic or important species of planktonic Foraminifera, and also placed them in a numbered series, using N numbers for the later Cenozoic or Neogene zones and P numbers for the older Cenozoic or Paleogene zones. Although Jenkins and Orr (1972:1063) criticized the use of numbered zones as "unacceptable to existing stratigraphic codes," the use of the N and P zones as a form of shorthand has become widespread, although far from universal. Studies in nontropical waters, such as those of Poore and Berggren (1975) in the high latitudes of the northern Atlantic and Kennett (1973) in the cool-subtropical southwest Pacific, and even some workers in tropical areas, such as Jenkins and Orr (1972), had difficulty in recognizing some or many of Blow's zones and developed their own zonal sequence. Some attempt, however, was usually made to correlate the zones with Blow's (1969) sequence.

The ranges of the stratigraphically important planktonic species generally are similar in the various oceanic and continental areas, but some relatively minor differences and a few major differences in the initial appearance or the extinction of species are found. The range discrepancies important to this study are noted under the species, where applicable.

Studies of the planktonic Foraminifera found in the stratotype sections of the later Cenozoic in Europe and in the JOIDES cores have refined the species ranges during the past 10 years. Some European stages containing good marine faunas including planktonic Foraminifera have been used as alternatives to more commonly used stages containing faunas of restricted environments. This is particularly true of the Sarmatian and Pontian stages, which were deposited in marginal marine to brackish water environments. Most authors now attempt correlations with other stages containing adequate marine invertebrate assemblages.

A better understanding of the ranges of planktonic Foraminifera has led to some changes in the stages to which zones are assigned. As a general rule, the zones have been shifted upward, either within the same stage or into a younger stage. An example of such a change, is the correlation of the Pungo River Formation of North Carolina. Gibson (1967) assigned these strata to the *Globigerinatella insueta* zone, then placed by Blow (1959:74) and Saito (1963, table 16) in the upper part of the Aquitanian. The present study supports the correlation of the Pungo River Formation with the *G. insueta* zone, but Berggren and Van Couvering (1974) placed this zone in the upper Burdigalian and lower Langhian stages. This study of the relationship of the planktonic zones to the stages in the later Cenozoic by Berggren and Van Couvering (1974), also integrated the radiometric dates with the sequence of planktonic foraminiferal zones, as shown in their figure 1.

The use of planktonic Foraminifera for correlation in the Miocene through Pleistocene strata of the Atlantic Coastal Plain is difficult, not only because planktonic specimens are extremely scarce (usually less than 1 percent), but also because most taxa that are present are cool-water species. Consequently it is difficult to recognize planktonic foraminiferal zones that are based on warm-water species. Most of the easternmost localities of the Coastal Plain are subsurface material or artificial exposures like those found in the Pungo River Formation in the Lee Creek Mine. In some of these easternmost localities, planktonic specimens are more common, composing 10 percent or more of the foraminiferal assemblage, reflecting deeper water environments. The clockwise circulation pattern of the North Atlantic does bring some warmer water faunal elements into the area, however, and a few specimens of important index species are found. Akers (1972) found two specimens of *Globorotalia truncatulinoides* in a large sample from Walkers Bluff in the Waccamaw Formation after 100 hours of examination. Most samples in this study present similar problems because the critical species may be represented by only one or several specimens at a locality. Although these low abundances are not desirable for biostratigraphic work, the use of rare specimens for zonation is the best means of interregional correlation at the present time. The scarcity of specimens and low reliability of correlation should be kept in mind when working with the placement of some of the strata in this area. An abundance of planktonic specimens at several localities yielded relatively large numbers of individuals belonging to critical species and thus provides fairly precise and reliable dates.

Important localities mentioned in the text are shown in Figure 1. The interpretations of the ages of the strata are given in Gibson's figure 2 (p. 38 herein). A summary of the assemblages from each formation and the resulting age assignments are as follows.

PUNGO RIVER FORMATION

The only known outcrop of this formation is an artificial one in the Lee Creek Mine of Texasgulf Inc. near Aurora, North Carolina (Figure 1, loc. 15). Additional faunas from the Pungo River Formation have been obtained from the Gatesville Well in northeastern North Carolina and the Moores Bridge well near Norfolk in southeastern Virginia (Figure 1, loc. 11).

In the Lee Creek Mine the Foraminifera are highly phosphatized in the phosphatic sands that are prevalent in the lower and middle part of the formation. Foraminifera and some mollusks, primarily calcitic pelecypods, are found in limy intervals in the upper 12 feet (3.7 m) of the formation.

Important planktonic foraminiferal species from the Pungo River strata in the Lee Creek Mine include the following: *Cassigerinella chipolensis* (Cushman and Ponton), *Globigerina euapertura* Jenkins, *G. woodi woodi* Jenkins, *Globigerina* species cf. *G. anguliofficinalis* Blow, *Globigerinoides altiaperturus* Bolli, *Globorotalia peripheroronda* Blow and Banner, *G. scitula praescitula* Blow, and "*Turborotalia*" *birnageae* (Blow).

The probable age for this assemblage is from the latter part of zone N7 to the latter part of zone N8 of Blow (1969) (Gibson's figure 2 on p. 38 herein). An age younger than N8 is not likely because of the presence of *Globigerina euapertura* and *Globigerinoides altiaperturus*, neither of which is known from strata younger than N8, and by the absence of *Orbulina* which is commonly regarded as marking the beginning of N9. The upper part of the Pungo River Formation in the Lee Creek Mine is thus considered to belong to planktonic zone N8, or latest early Miocene in age. The age of the underlying phosphatic sand units in the mine is unknown because of the poor preservation of the Foraminifera; the amount of time for and rapidity of deposition of the phosphatic sands and diatomaceous units is an intriguing, but presently unanswerable, question.

The northern limit of the Pungo River Formation occurs in the Norfolk, Virginia, Moores Bridge well area (Figure 1, loc. 11) drilled by the U.S. Geological Survey. The strata yielded a foraminiferal assemblage similar to that found at the Lee Creek Mine. In addition, rare specimens of *Globigerinatella insueta* were found at a depth of 581 feet (177 m). The age of these strata also is considered to be zone N8. At this locality, the Pungo River Formation rests directly upon Paleogene rocks, indicating that the oldest age of the formation in this area is late early Miocene (N8).

To the northeast of the Lee Creek Mine, Abbott and Ernissee (this volume) found strata containing diatoms; the lower part of the strata correlates with zone N8 or N9 and the upper part with zone N11, indicating deposition of the younger strata of the Pungo River Formation close to the area of the Lee Creek Mine. As the top of the Pungo River section in the Lee Creek Mine has an erosional surface (Gibson, 1967:636), it is possible that the younger part of the formation also was deposited there and later eroded.

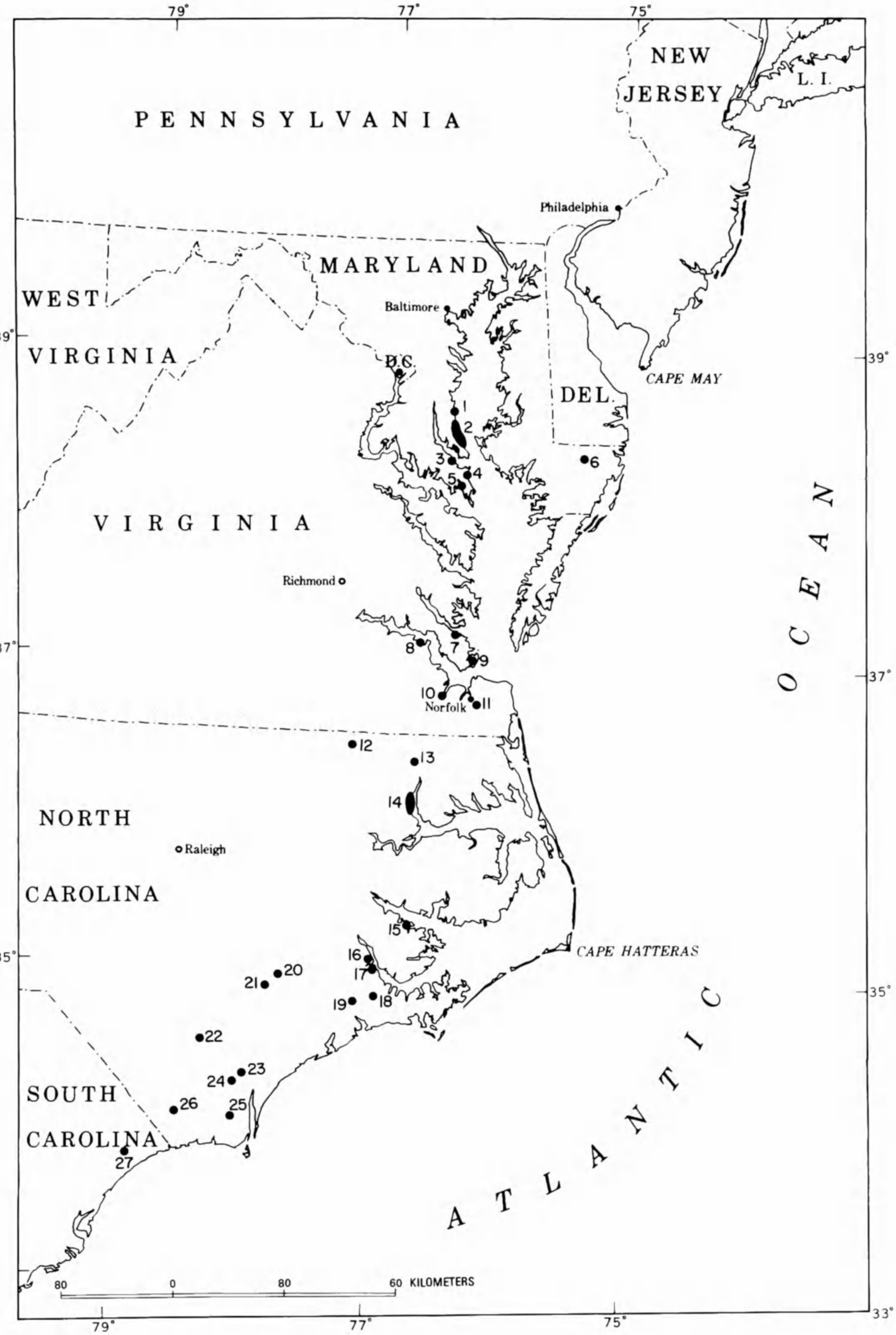
In summary, the distribution of strata assigned to the Pungo River Formation containing zone N8 planktonic Foraminifera is widespread, extending from south of the Neuse River in North Carolina northward to the area near Norfolk, Virginia. Strata with zone N11 planktonic assemblages are found in the central part of the Albemarle embayment in North Carolina. Strata of this age, however, may have been more extensive in the past, having been eroded in areas similar to the Lee Creek Mine and remaining unrecognized in other areas. Strata belonging to the intervening zones N9 and N10 have not been found.

Calvert Formation

The only diagnostic planktonic foraminiferal assemblages in the Calvert Formation come from beds 10 to 12 of Shattuck (1904) in the Calvert Cliffs along Chesapeake Bay in Maryland. The most abundant faunas come from bed 10, whereas beds 1 to 9, and the uppermost beds, 13 to 15, yielded few specimens. The following important species are found in bed 10 in the Calvert Cliffs: *Globigerina praebulloides pseudociperoensis* Blow, *Globigerinoides altiaperturus* Bolli, *G. sicanus* de Stefani, and *Praeorbulina glomerosa glomerosa* (Blow).

These species indicate an age of upper zone N8

FIGURE 1—Location of collecting localities mentioned in text (MARYLAND: 1 = Randle Cliffs, 2 = Calvert Cliffs, 3 = Jones Wharf, 4 = Langleys Bluff, 5 = St. Marys River, 6 = Hammond Well. VIRGINIA: 7 = Yorktown, 8 = Cobham Wharf, 9 = Rice's Pit, 10 = Suffolk, 11 = Moores Bridge Well, Norfolk. NORTH CAROLINA: 12 = Murfreesboro, 13 = Gatesville Well, 14 = Chowan River outcrops, 15 = Lee Creek Mine, 16 = New Bern, 17 = James City, 18 = Croatan National Forest, 19 = Long Point, 20 = Barwick Farm, 21 = Natural Well, 22 = Walkers Bluff, 23 = Neils Eddy Landing, 24 = Acme, 25 = Pierce Brothers Quarry, 26 = Old Dock. SOUTH CAROLINA: 27 = Tillys Lake).



PENNSYLVANIA
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MARYLAND
Baltimore
WEST VIRGINIA
D.C.
DEL.
CAPE MAY
VIRGINIA
Richmond
Norfolk
NORTH CAROLINA
Raleigh
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SOUTH CAROLINA
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to lower zone N9 for bed 10. The absence of *Orbulina* probably means an age of upper zone N8. As a large part of the *Orbulina* lineage is represented in the Calvert Cliffs, the absence of *Orbulina*, because of environmental causes, probably can be discounted. In beds 11 and 12 of the Calvert Formation, specimens belonging to *Praeorbulina glomerosa circularis* and *Orbulina suturalis* appear, indicating a probable lower zone N9 placement for these strata. Beds 13 to 15 at the top of the Calvert Formation and beds 1 to 9 at the base do not contain diagnostic planktonic species, but the general similarity in the stage of evolution of molluscan species suggests closeness in age to the adjacent dated beds.

In summary, the probable age for bed 10 of the Calvert Formation is zone N8, and that for the overlying beds 11 and 12 is probably of lower zone N9. The amount of time represented in the beds below bed 10, which includes a sequence of diatomaceous units 60 feet (18 m) thick, or more, is unknown at the present time.

Choptank Formation

Planktonic specimens are extremely rare in the Choptank Formation. The only specimens found to date belong to long-ranging species of *Globigerina*, and correlation with Blow's planktonic zonal sequence is not possible.

A tentative lower age limit for the formation was established on the following basis. The youngest age established for the Calvert Formation in Maryland is lower zone N9 for bed 12. There is disagreement as to whether a significant unconformity exists between the Calvert and Choptank formations (Gernant, 1970:7). The abrupt appearance in the basal Choptank Formation of several species of benthic Foraminifera that are absent in the uppermost part of the Calvert may indicate a time break (Gibson, 1962:13, 63). R.M. Forester (U.S. Geological Survey, pers. comm., 1976) also noticed that some lineages of ostracodes change significantly across the Calvert-Choptank boundary, indicating a possible hiatus. For the present, the contact is considered unconformable, and the basal beds of the Choptank are tentatively dated as belonging in zone N12.

Direct paleontological evidence is also inadequate to determine the age of the upper beds of the Choptank Formation. A K/Ar age determination of 12.0 ± 0.5 my from the overlying St. Marys Formation in Maryland was reported by Blackwelder and Ward (1976:5). This late middle Miocene date for the overlying St. Marys, if substantiated by further work, and the early middle Miocene date for the top of the underlying Calvert places the Choptank in approximately the middle part of the middle Miocene (Gibson's figure 2 on p. 38 herein).

St. Marys Formation

No diagnostic planktonic foraminiferal species have been recognized among the rare specimens found in the St. Marys Formation. A K/Ar date of 12.0 ± 0.5 my (Blackwelder and Ward, 1976:5) for beds along the St. Marys River in Maryland is the only evidence on the age of this unit. The radiometric date places these beds in the upper part of the middle Miocene. The stratigraphically higher parts of the formation along the St. Marys River show sufficient change in the molluscan fauna to suggest the possibility of a younger, early late Miocene age (Gibson, in prep.).

"Virginia St. Marys" Beds

Diagnostic planktonic foraminiferal species have not been found in the "Virginia St. Marys" beds of Mansfield (1943) (see Gibson, 1971). The late middle to possible early late Miocene age for the underlying St. Marys Formation in Maryland and the early Pliocene date (planktonic zone N19) for overlying zone 1 beds of the Yorktown of Mansfield (1943) bracket these strata and indicate a late Miocene age. A K/Ar date of 8.7 ± 0.4 my for the middle part of the "Virginia St. Marys" sequence, reported by Blackwelder and Ward (1976:5), supports this late Miocene age assignment. Changes in the molluscan faunas through these strata, particularly the pectens (Gibson, in prep.), indicate that a significant amount of late Miocene time may be represented.

Strata of the "Virginia St. Marys" sampled in northern North Carolina in a well near Gatesville in Gates County (Figure 1, loc. 13) contained moderately abundant planktonic specimens. Important species in the assemblage include *Globorotalia merotumida* Blow and Banner and *"Turborotalia" acostaensis acostaensis* Blow. Specimens approaching and within the range of variation of *Globorotalia plesiotumida* Blow and Banner occur, but specimens of *G. merotumida* dominate. These species indicate a probable placement in zone N17 for the upper beds of the "Virginia St. Marys" in North Carolina.

Yorktown Formation

The *Placopecten clintonius* zone or zone 1 of the Yorktown Formation of Mansfield (1943) contains a moderately abundant planktonic assemblage that includes some stratigraphically important species: *Globigerina apertura* Cushman, *Globoquadrina altispira altispira* (Cushman and Jarvis), *Globorotalia puncticulata* (Deshayes), *Globorotalia* species cf. *G. crassula* Cushman and Stewart, *Sphaerodinellopsis seminulina seminulina* (Schwager), *S. subdehiscens subdehiscens* (Blow), and "*Turborotalia*" *acostaensis humerosa* (Takayanagi and Saito).

The presence of *Globorotalia puncticulata* in these assemblages suggests a placement of zone N19 or later (see p. 373). The upper range of *Sphaerodinellopsis seminulina seminulina* in the Atlantic is considered to be the upper part of zone N20 (Poag, 1972b:492, 493, 499; Berggren and Amdurer, 1973:353, figs. 4, 7, 8). Blow (1969:338) reported an upper range of zone N20 in land-based sequences, but into lower zone N21 in deep-sea sequences. If these data are correct, this subspecies is indicative of zone N20, or older, age for the *Placopecten clintonius* zone of Mansfield (1943). Additional support comes from the occurrence of *Globigerina apertura*, which has a reported upper range of zone N20. *Globoquadrina altispira altispira* was considered by Blow (1969:339) to range into the lower part of zone N21 in oceanic deposits, but was probably not younger than lower zone N20 in land-based sequences. An upper range of lower zone N21 is commonly found for *Sphaerodinellopsis subdehiscens subdehiscens* also. The presence of "*Turborotalia*" *acostaensis* in the assemblage also indicates an early Pliocene age. Parker (1967:165) reported that species as ranging to the end of zone N18, but Jenkins and Orr (1972:1066, 1096) extended its range into zones N19/20, and Poag (1972b:485, 511) into zone N21. This assemblage appears to be indicative of an early Pliocene zone N19/20 age, and this is the age assigned to the *Placopecten clintonius* zone. A radiometric date of 4.4 ± 0.2 my was obtained from Yorktown strata immediately overlying this zone (Blackwelder and Ward, 1978:8), and this age closely corresponds to the planktonic foraminiferal assignment.

The overlying Yorktown strata of the *Turritella alticostata* zone or zone 2 of Mansfield (1943) and the Duplin Formation, the equivalent of the upper part of the Yorktown in southern North Carolina and southward, are younger. The correlation of these strata with Blow's zonation is difficult at present because of the scarcity of biostratigraphically diagnostic planktonic species. Most of the planktonic specimens in these strata belong to the long-ranging species *Globigerina bulloides*, *Globigerinoides trilobus*, and *G. ruber.* Among the few species that have shorter ranges is *Globigerina apertura*, which has a reported upper range through zone N20. The type area for this species is near Suffolk, Virginia, in the Yorktown deposits that Mansfield (1943) placed high in his zone 2. Subsequent work has supported this placement. *Globorotalia puncticulata*, which has an upper range of zone N21, also occurs in strata of Mansfield's zone 2. Specimens of *G. puncticulata* from zone 2 show characteristics transitional to those of "*Turborotalia*" *inflata*, but specimens of the latter species are absent from zone 2. "*Turborotalia*" *inflata* is indicative of zone 21 and younger ages. The occurrence of *G. puncticulata* and the absence of "*Turborotalia*" *inflata*, although meager evidence, could indicate a late zone N19/20 to early zone N21 age for the upper part of Mansfield's zone 2 of the Yorktown. Only the occurrence of *Globorotalia hirsuta hirsuta* in strata of zone 2 at the type area of the Yorktown Formation in the bluffs at Yorktown, Virginia, conflicts with this zonal assignment. This subspecies is usually considered characteristic of zone N22 and younger strata, but here occurs in strata tentatively assigned to late zone N20 to early zone N21. The specimens appear to fall well within the range of variation of this subspecies (Plate 3: figures 5–7).

Uppermost "Yorktown," Croatan, and Waccamaw Formations

The uppermost part of the "Yorktown" Formation, which is exposed along the Chowan River in northeastern North Carolina, the Croatan Formation at the Lee Creek Mine and southeast of New Bern, North Carolina, and the Waccamaw Formation in southern North Carolina and northern South Carolina appear to be of approximately equivalent age (Gibson's Figure 2, p. 38 herein). This correlation is based upon the stratigraphic distribution of pectens (Gibson, in prep.) and benthic Foraminifera (Figure 2). Planktonic Foraminifera are rare in these formations because of the very shallow water environment of deposition. Akers (1972:36, 38) reported rare specimens of "*Turborotalia*" *inflata* and *Globorotalia truncatulinoides* from the Waccamaw Formation at Walkers Bluff. The first appearance of *G. truncatulinoides* commonly is used to mark the base of the Pleistocene, although there is some controversy about how close to the boundary it occurs. In the upper part of the Croatan Formation at the Lee Creek Mine, a single specimen strongly resembling *G. truncatulinoides* was found. At least these parts of the formations apparently belong to the lower Pleistocene or zone N22.

Evidence that these deposits are no younger than zone N22 is the occurrence of *Globigerinoides obliquus* (Akers, 1972:34). Benthic foraminiferal species characteristic of zone 2 of the Yorktown Formation are found in the lower part of the Croatan Formation in the Lee Creek Mine, but they are not found in the upper part of the section. These faunal changes suggest that the lower part of the Croatan is somewhat older than the zone N22 assignment for the upper part. Because no specimens of *G. truncatulinoides* have been found in the lower beds, and in consideration of the changes in the benthic assemblages, the lower beds are placed in the upper Pliocene zone N21. Thus, the Croatan Formation and equivalent units appear to range in age from late Pliocene into early Pleistocene. The upper Pliocene strata may correlate with the Bear Bluff Formation of DuBar et al. (1974) as suggested by Hazel (1977:375). The younger strata, tentatively assigned to zone N22 of early Pleistocene age, on the basis of planktonic foraminiferal evidence, presently are recognized only in the upper part of the Croatan Formation in the Lee Creek Mine and in the Waccamaw Formation in southern North Carolina. Evidence from the pectens (Gibson, in prep.) indicates that the uppermost "Yorktown" beds at Mt. Gould along the Chowan River also may be included in this zone.

Key Benthic Species

Although benthic foraminiferal species generally have greater ranges and are more closely controlled environmentally than their planktonic counterparts, some benthic species were recognized by Gibson (1962) to be widespread throughout only one or several of the formations in this area. These species are useful guides, particularly in the subsurface where molluscan data are largely unavailable. Examination of several hundred samples in the Atlantic Coastal Plain from Maryland to North Carolina, both from outcrops and the subsurface, indicates that a number of benthic species are each characteristic of the upper Oligocene, Miocene, Pliocene, and lower Pleistocene formations in this area. Some diagnostic species are known only from the unit(s) in this area; others are found in coeval deposits in other areas in the Western Hemisphere or elsewhere; and still others have a restricted range here but broader ranges in other areas. The par-

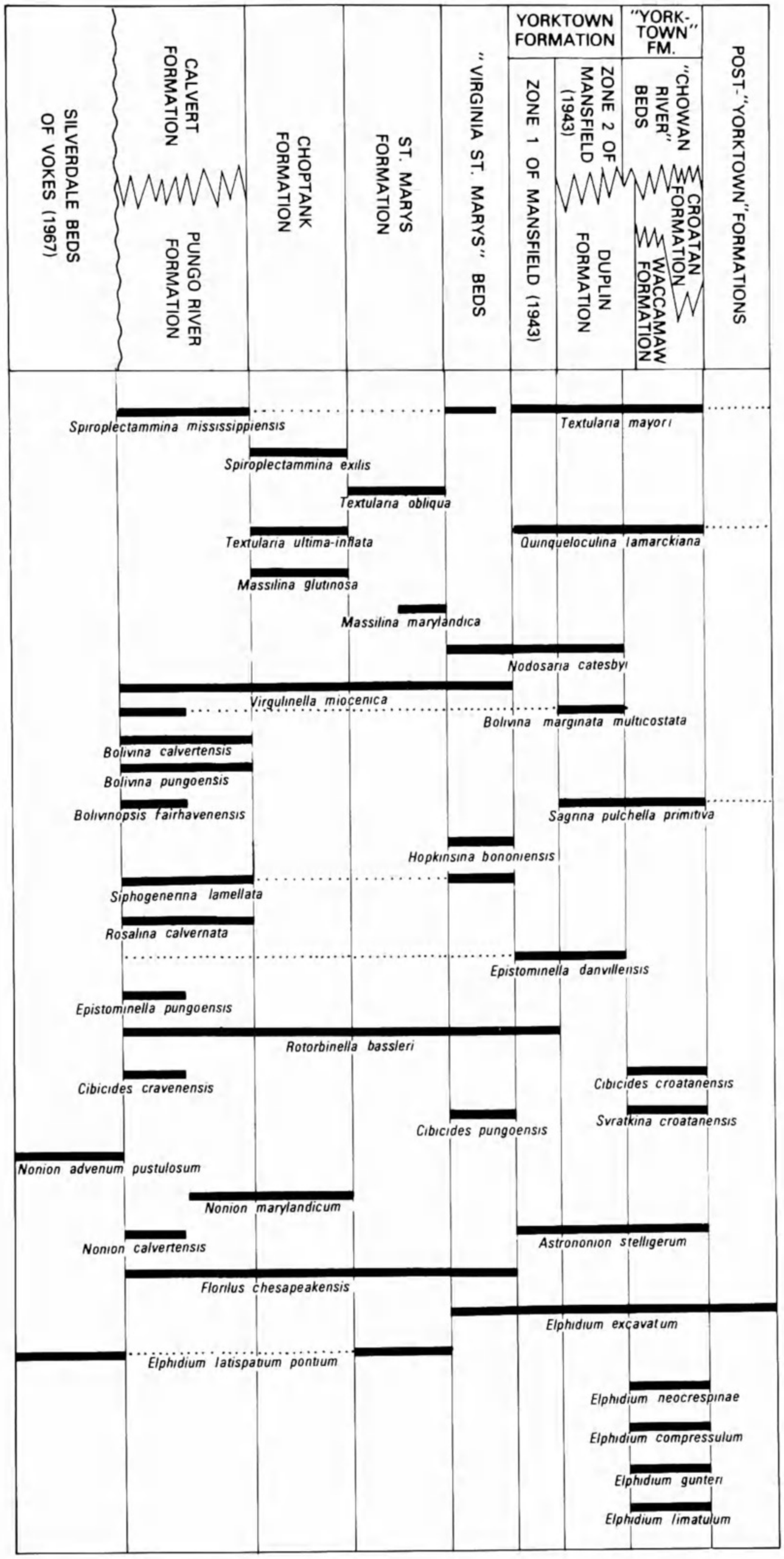

FIGURE 2.—Distribution of key benthic foraminiferal species in upper Oligocene through lower Pleistocene strata in the central Atlantic Coastal Plain.

ticular situation for each species is noted in the systematic section. Hazel (1977) noted the significant ostracodes for the Pliocene and early Pleistocene in this area.

Some species are present in both surface and subsurface samples, but others are found mostly only in one or the other. This results from the general eastward dip of the strata and increasing depth of deposition in the strata to the east. Thus the shallower water environments are generally found farther west in the outcrop belt. The general climatic pattern in the area was one of mild temperate conditions and some warmer fluctuations through the Miocene and earliest Pliocene. A general warming trend began in the early Pliocene and extended through late Pliocene and earliest Pleistocene time, when warm temperate to subtropical conditions were reached in southern North Carolina (Gibson, 1967:647; Hazel, 1971b:373). The warming trend allowed some species to make their first appearance at a later time in this area than in warmer areas to the south. Thus, some key species in this area have greater ranges in Florida and in other warm regions.

Many of the key species are relatively common in the assemblages, greater than 5 percent, but some are rare, making up less than 1 percent of the assemblage, as noted in the systematic section.

Some key species diagnostic of the deeper water environments of the formations in the subsurface of the Coastal Plain may aid in correlation with strata on the Continental Shelf, and serve as a bridge between the shallower water outcrop and deeper water offshore sections.

Species diagnostic of each formation or part thereof are shown in Figure 2. A general distribution is given (pp. 360–364), and detailed distributions are discussed in the systematics section.

Silverdale Beds of Vokes (1967)

These onshore strata represent very shallow marine environments, where a few species dominate the assemblages. Fortunately, the dominant species are diagnostic for this unit. They include the two new subspecies, *Nonion advenum pustulosum*, restricted to this unit, and *Elphidium latispatium pontium*, which occurs in this unit and again in the younger St. Marys Formation, and *Discorbitura dignata*, which is not found above this unit.

Calvert and Pungo River Formations

Because of the large geographic area covered by the two formations and the variety of environments represented, distributional patterns of the key species are variable. *Bolivina calvertensis, Bolivinopsis fairhavenensis,* new species, and *Epistominella pungoensis*, new species, are restricted to these two formations. *Spiroplectammina mississippiensis* occurs only in these two formations in this area, but is found in other regions. *Rosalina cavernata* and *Nonion calvertensis*, new species, are found only in the Calvert Formation. *Bolivina pungoensis*, new species, and *Cibicides cravenensis*, new species, are found only in the lower part of the Pungo River Formation. *Virgulinella miocenica, Rotorbinella bassleri,* and *Florilus chesapeakensis,* new species, range upwards from these formations, but serve to differentiate them from the underlying Oligocene units and, in those places where the Choptank and St. Marys formations are absent, from various parts of the overlying Yorktown Formation.

Choptank Formation

Because of the presently relatively restricted geographic distribution of this formation (Gibson, 1971) and generally similar shallow-water environments, the key species are found in most samples. They include *Spiroplectammina exilis, Textularia ultima-inflata, Massilina glutinosa,* and *Nonion marylandicum*, although the latter is also found rarely in the upper part of the Calvert.

St. Marys Formation

Most assemblages from the St. Marys Formation are composed of species that are found also in the underlying formations and in the lower part of the overlying Yorktown Formation, making it difficult to recognize this formation in the subsurface. However, the presence of *Textularia obliqua*, *Massilina marylandica*, and *Elphidium latispatium pontium*, new subspecies, and the absence of the common key species in the Choptank serve to identify the unit in most samples.

"Virginia St. Marys" Beds

One important subspecies that first appears in the "Virginia St. Marys" strata and still lives today is *Elphidium excavatum clavatum*. This subspecies appears abruptly and is so abundant (forming 20 to 40 percent of the assemblages) that it is a valuable guide for separating these strata from earlier ones. The co-occurrence of this species with *Virgulinella miocenica* marks the "Virginia St. Marys." *Hopkinsina bononiensis* and *Cibicides pungoensis*, new species, are only found in the "Virginia St. Marys" in the subsurface of northeastern North Carolina.

Yorktown Formation and Equivalents

This formation spans both considerable time and various environments, resulting in significant geographic changes in the benthic assemblages. Although some species are restricted stratigraphically to various parts of the formation, most appear in the underlying formations and are living today. Zone 1 of Mansfield (1943) is characterized by the first appearance of *Textularia mayori, Quinqueloculina lamarckiana, Nodosaria catesbyi, Epistominella danvillensis,* and *Astrononion stelligerium*, along with the co-occurrence of *Rotorbinella bassleri.* Zone 2 of Mansfield (1943) is marked by the restricted occurrence in this area of *Bolivina marginata multicostata*, the last appearance of *Nodosaria catesbyi* and *Epistominella danvillensis*, and the first occurrence of *Sagrina pulchella primitiva.* The youngest beds of the "Yorktown" along the Chowan River, as well as the coeval Croatan and Waccamaw formations to the south, contain a number of species restricted to those strata, including three new species, *Cibicides croatanensis, Svratkina croatanensis,* and *Elphidium neocrespinae*, and *Elphidium compressulum* and *E. limatulum*, all of which are found in these strata and in the Duplin Formation. *Elphidium gunteri* is restricted to these units, although it has a greater range in warmer environments.

Systematic Descriptions

Generic concepts as applied to planktonic Foraminifera are unsettled at this time. Some of the common generic names, such as *Globorotalia*, have been applied to several groups of species that occur at significantly different times in the fossil record and have no known connecting species; this leads one to doubt strongly any phylogenetic linkage between the groups. Other genera, such as *Turborotalia*, are used as morphologic types (usually on the basis of one or possibly several distinctive features) that occur at different times in a number of apparently separate lineages, which means that they are definitely polyphyletic. Even the commonest name, *Globigerina*, was considered by Fleisher (1974:1009, 1018) to include a number of polyphyletic units, which he discriminated largely on the basis of wall texture. Pending further study and revision, most of the generic names currently used can be considered convenient holding names for an uncertain number of species. Illuminating discussions on the generic problems are found in Fleisher (1974), Parker (1967), and Stainforth et al. (1975).

Placement of species of benthic Foraminifera here follows a classification of genera and families modified from Loeblich and Tappan (1964). The rigid application by Loeblich and Tappan of wall structure as the dominant character in higher level foraminiferal systematics has led to the placement of apparently closely related species in different genera and families. Towe and Cifelli (1967) showed the difficulties in applying optical studies of wall structure, such as those of Loeblich and Tappan, to electron microscope studies of the wall. Buzas (1965, 1966) found both granular and radial wall structure in species of *Elphidium*, as did Hansen (1972a) in *Turrilina* and Feyling-Hansen and Buzas (1976) in *Cassidulina*. Information from studies such as these indicates that groupings and separations based solely upon wall structure should be revised.

Order FORAMINIFERIDA Eichwald, 1830
  Superfamily GLOBIGERINACEA Carpenter, Parker, and Jones, 1862
    Family GLOBIGERINIDAE Carpenter, 1862
      Genus *Cassigerinella* Pokorný, 1955
      Genus *Globigerina* d'Orbigny, 1826
      Genus *Globigerinatella* Cushman and Stainforth, 1945
      Genus *Globigerinita* Bronnimann, 1951
      Genus *Globigerinoides* Cushman, 1927
      Genus *Globoquadrina* Finlay, 1947
      Genus *Globorotalia* Cushman, 1927
      Genus *Orbulina* d'Orbigny, 1839
      Genus *Praeorbulina* Olsson, 1964
      Genus *Pulleniatina* Cushman, 1927
      Genus *Sphaeroidinellopsis* Banner and Blow, 1959
    Family GLOBOROTALIIDAE Cushman, 1927
      Genus *Turborotalia* Cushman and Bermudez, 1949
  Superfamily LITUOLACEA de Blainville, 1825
    Family TEXTULARIIDAE Ehrenberg, 1838
      Genus *Spiroplectammina* Cushman, 1927
      Genus *Textularia* Defrance, 1824
      Genus *Bolivinopsis* Yakovlev, 1891
  Superfamily MILIOLACEA Ehrenberg, 1839
    Family MILIOLIDAE Ehrenberg, 1839
      Genus *Quinqueloculina* d'Orbigny, 1826
      Genus *Massilina* Schlumberger, 1893
  Superfamily NODOSARIACEA Ehrenberg, 1838
    Family NODOSARIIDAE Ehrenberg, 1838
      Genus *Nodosaria* Lamarck, 1812
  Superfamily BULIMINACEA Jones, 1875
    Family BOLIVINITIDAE Cushman, 1927
      Genus *Bolivina* d'Orbigny, 1839
    Family UVIGERINIDAE Haeckel, 1894
      Genus *Hopkinsina* Howe and Wallace, 1932
      Genus *Sagrina* d'Orbigny, 1839
      Genus *Siphogenerina* Schlumberger, 1882
  Superfamily DISCORBACEA Ehrenberg, 1838
    Family DISCORBIDAE Ehrenberg, 1838
      Genus *Rotorbinella* Bandy, 1944
      Genus *Epistominella* Husezima and Maruhasi, 1944
      Genus *Rosalina* d'Orbigny, 1826
      Genus *Cancris* Montfort, 1808
  Superfamily ROTALIACEA Ehrenberg, 1839
    Family ELPHIDIIDAE Galloway, 1933
      Genus *Elphidium* Montfort, 1808
  Superfamily ORBITOIDACEA Schwager, 1876
    Family CIBICIDIDAE Cushman, 1927
      Genus *Cibicides* Montfort, 1808
  Superfamily CASSIDULINACEA d'Orbigny, 1839
    Family CAUCASINIDAE Bykova, 1959
      Genus *Virgulinella* Cushman, 1932
    Family NONIONIDAE Schultze, 1854
      Genus *Astrononion* Cushman and Edwards, 1937
      Genus *Florilus* Montfort, 1808
      Genus *Nonion* Montfort, 1808
    Family ALABAMINIDAE Hofker, 1951
      Genus *Svratkina* Pokorný, 1956

Genus *Cassigerinella* Pokorný, 1955

Cassigerinella chipolensis (Cushman and Ponton)

PLATE 4: FIGURE 16

Cassidulina chipolensis Cushman and Ponton, 1932:98, pl. 15: figs. 2a–c.—Jenkins, 1971:73–74, pl. 1: fig. 30.

OCCURRENCE.—Rare specimens of this species are found in the upper beds of the Pungo River Formation in the Lee Creek Mine in North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:377) reported a relatively long range for this species, from zone P18 (early Oligocene) to zone N13 (middle Miocene).

Genus *Globigerina* d'Orbigny, 1826

REMARKS.—A large variety of species has been placed in this genus by various authors; the primary unifying characteristic is the umbilical position of the aperture. Fleisher (1974:1009–1012, 1018–1019) discussed the modification and splitting of this group. Fleisher's suggestions for different groups within those species assigned to *Globigerina* are based primarily, but not exclusively, upon the nature of the wall, which he felt reflected the phylogeny. Fleisher's concept of *Globigerina*, sensu stricto, would restrict the use of this genus to a fraction of the various species presently placed in the genus. Until more extensive studies are made, however, *Globigerina* will be used for those species that have an umbilical aperture and have traditionally been placed in this genus.

Globigerina apertura Cushman

PLATE 1: FIGURE 10

Globigerina apertura Cushman, 1918:57, pl. 12: figs. 8a–c.—Zachariasse, 1975:119–120, pl. 16: figs. 1–2.

Globigerina bulloides apertura Cushman.—Blow, 1969:317, pl. 12: fig. 8.

REMARKS.—*Globigerina apertura* is distinguished from *G. bulloides* by a larger, rimmed aperture that is more centrally umbilicate, and by having more appressed chambers and a coarsely cancellate wall (Fleisher, 1974:1019; Zachariasse, 1975). The species was originally described from the Yorktown Formation in Virginia.

OCCURRENCE.—Rare in the Yorktown Formation in outcrops near Suffolk, Virginia, the type area for the species; in the upper part of the sequence exposed along the Meherrin River near Murfreesboro, North Carolina; and in the Norfolk, Virginia, Moores Bridge Well core at a depth of 113 feet (34.4 m). Akers (1972:30) reported it from the Yorktown Formation at Rice's Pit, Hampton, Virginia, and Copeland (1964:281) reported it from Natural Well and Barwick Farm in the Duplin Formation in North Carolina (Figure 1, loc. 9, 20, 21).

STRATIGRAPHIC RANGE.—Blow (1969:317) reported a range from zone N16 to zone N19. Jenkins and Orr (1972:1086) recorded it from the equivalent of zone N18 to the upper part of zone N20.

Globigerina euapertura Jenkins

PLATE 4: FIGURE 15

Globigerina euapertura Jenkins, 1960:351, pl. 1: figs. 8a–c; 1971:147, pl. 15: figs. 457–461: pl. 16, fig. 462.—Jenkins and Orr, 1972:1088, pl. 9: figs. 1–6.
Turborotalia (Turborotalia) euapertura (Jenkins).—Fleisher, 1974:1035.

OCCURRENCE.—Rare in the Pungo River Formation in the Lee Creek Mine, North Carolina.

STRATIGRAPHIC RANGE.—Jenkins and Orr (1972:1088) recorded a range for this species corresponding to zone P18 to zone N3, and smaller specimens (*G.* cf. *euapertura*) extending to the equivalent of zone N6. Fleisher (1974) reported this species from zone P22 to zone N7–N8; the upper limit is similar to the age of the present occurrence.

Globigerina praebulloides pseudociperoensis Blow

PLATE 1: FIGURES 7–9

Globigerina praebulloides pseudociperoensis Blow, 1969:381–382, pl. 17: figs. 8–9.

OCCURRENCE.—Rare to common in bed 10 of the Calvert Formation at Plum Point, Maryland.

STRATIGRAPHIC RANGE.—Blow (1969:321) reported a range from zone N7 to zone N12.

Globigerina woodi woodi Jenkins

PLATE 4: FIGURES 9–11

Globigerina woodi Jenkins, 1960:352, pl. 2: figs. 2a–c.
Globigerina (Globigerina) woodi woodi Jenkins.—Jenkins, 1971: 159–160, pl. 18: figs. 548–550.

OCCURRENCE.—Rare in the upper part of the Pungo River Formation in the Lee Creek Mine, North Carolina.

STRATIGRAPHIC RANGE.—Jenkins and Orr (1972:1090) reported a range equivalent to zone N4 to zone N17. Kennett (1973:578, 583, 584, 588) recorded its upper limit in the lower Pleistocene, N22.

Globigerina species cf. *G. anguliofficinalis* Blow

PLATE 4: FIGURES 13, 14

REMARKS.—Specimens from the Pungo River Formation are similar to *G. anguliofficinalis* Blow, 1969, in having 4½ chambers in the last whorl, incised intercameral sutures, and a similar appearance of the wall. Pungo River specimens differ in having a narrower and shallower umbilicus and a lower arched aperture. In view of these differences between the Pungo River specimens and those illustrated by Blow, the specimens from the Pungo River are not included within the species, although there appears to be a close relationship.

OCCURRENCE.—Rare in the upper beds of the Pungo River Formation in the Lee Creek Mine, North Carolina.

STRATIGRAPHIC RANGE.—The specimens from

the Pungo River Formation occur in rocks that are assigned to zone N8 on the basis of the co-occurrence of other planktonic species. *G. anguliofficinalis*, according to Blow (1969:315), has a range from zone P17 to zone N2 and is thus restricted to the Oligocene.

Genus *Globigerinatella* Cushman and Stainforth, 1945

Globigerinatella insueta Cushman and Stainforth

PLATE 6: FIGURE 17

Globigerinatella insueta Cushman and Stainforth, 1945:69, pl. 13: figs. 7–9.—Blow, 1969:330, pl. 26: figs. 1–7.

REMARKS.—Only a single specimen was found. It has a series of separated bullae and appears to fit within the range of variation described by Brönnimann (1950). It is very similar to the specimen illustrated by Brönnimann and Resig (1971, pl. 21: fig. 1).

OCCURRENCE.—The single specimen was found in the Pungo River Formation in the Norfolk, Virginia, Moores Bridge Well, at a depth of 581 feet (177 m).

STRATIGRAPHIC RANGE.—Blow (1969:330) reported a range from the beginning of zone N6 to the lower part of zone N9.

Genus *Globigerinita* Brönnimann, 1951

Globigerinita glutinata ambitacrena (Loeblich and Tappan)

PLATE 1: FIGURES 11–13

Tinophodella ambitacrena Loeblich and Tappan, 1957:114, figs. 2a–3c.

Globigerinita glutinata ambitacrena (Loeblich and Tappan).—Fleisher, 1974:1022, pl. 9: fig. 3.

REMARKS.—Following the usage of Fleisher (1974), which is compatible with my observations on limited material of Miocene to Holocene age, forms with a simple bulla are placed in the "subspecies" *G. glutinata ambitacrena*.

OCCURRENCE.—Rare in the upper part of the Pungo River Formation in the Lee Creek Mine and in the Yorktown Formation in North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:327) reported a range of zone N5 to zone N23.

Genus *Globigerinoides* Cushman, 1927

Globigerinoides altiaperturus Bolli

PLATE 1: FIGURES 1, 2; PLATE 4: FIGURES 7, 8

Globigerinoides triloba altiapertura Bolli, 1957:113, pl. 25: figs. 7a–8.

Globigerinoides altiaperturus Bolli.—Jenkins, 1971:174–175, pl. 20: figs. 604–606.

OCCURRENCE.—Rare in the upper part of the Pungo River Formation in the Lee Creek Mine, North Carolina, and in bed 10 of the Calvert Formation, Plum Point, Maryland.

STRATIGRAPHIC RANGE.—Blow (1969:325) reported a range from zone N5 to the lower parts of zone N7. Brönnimann and Resig (1971:1441) recorded a range from zone N4 to zones N7/8, and it appears from this and other works (Fleisher, 1974:1023) that this species ranges into zone N8. The occurrence in bed 10 of the Calvert Formation indicates a range into upper zone N8 or lower zone N9 in this area.

Globigerinoides sicanus de Stefani

PLATE 1: FIGURES 4, 5

Globigerinoides conglobata (Brady).—Cushman and Stainforth, 1945:68, pl. 13: fig. 6.

Globigerinoides sicana de Stefani, 1952:9.—Fleisher, 1974:1024, pl. 9: fig. 10.

Globigerinoides bispherica Todd, 1954:681, pl. 1: figs. 1a–c.

Globigerinoides sicanus de Stefani.—Blow, 1969:326.

OCCURRENCE.—Rare in bed 10 of the Calvert Formation at Plum Point, Maryland.

STRATIGRAPHIC RANGE.—Blow (1969:327) reported that the range was from the beginning of zone N8 to within the lower part of zone N9. Brönnimann and Resig (1971:1251, 1441) recorded it as low as the top of zone N6 in some cores in the Pacific Ocean.

Globigerinoides trilobus trilobus (Reuss)

PLATE 4: FIGURE 12

Globigerina triloba Reuss, 1850:374, pl. 47: figs. 11a–d.
Globigerinoides triloba triloba (Reuss).—Bolli, 1957:112–113, pl. 25: figs. 2a–c.
Globigerinoides trilobus trilobus (Reuss).—Jenkins, 1971:180–182, pl. 19: figs. 571–581.

OCCURRENCE.—Rare to common in the Calvert Formation in Maryland, the Pungo River Formation in Virginia and North Carolina, the Yorktown Formation in Virginia and North Carolina, and the Waccamaw and Croatan formations in North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:326) reported a range from zone N6 to zone N23.

Genus *Globoquadrina* Finlay, 1947

Globoquadrina altispira altispira (Cushman and Jarvis)

PLATE 2: FIGURES 4, 7, 8

Globigerina altispira Cushman and Jarvis, 1936:5, pl. 1: figs. 13a–c, 14.
Globoquadrina altispira altispira (Cushman and Jarvis).—Bolli, 1957:111, pl. 24: figs. 7a–8b.—Stainforth et al., 1975:245, fig. 100.

OCCURRENCE.—Rare in bed 10 of the Calvert Formation in Maryland, and in the lower part of the Yorktown Formation along the bluffs of the Meherrin River near Murfreesboro, North Carolina. Dorsey (1948:313, fig. 28) reported rare occurrences in beds 10 to 12 of the Calvert Formation and bed 16 of the Choptank Formation in Maryland.

STRATIGRAPHIC RANGE.—Blow (1969:339) reported a range from zone N4 to the lower part of zone N20 and a probable range in deep oceanic areas into part of zone N21. Upon examination of many land-based sequences, Blow (1969:255) considered this species to have become extinct in the lower part of zone N20 during shallow-water sequences found on the continents. In the deep-ocean sequences sampled by JOIDES, later extinction horizons than early N20 have been found, as mentioned by Blow. In the Pacific, Brönnimann and Resig (1971:1437) recorded this species from the middle of zone N20, Parker (1967:165) and Jenkins and Orr (1972:1094), the lower part of N21, and Kennett (1973:578, 580, 583, 584, 589, 596), the top of N21. In the North Atlantic, Poag (1972b:504, 514) found this species into the lower part of N21.

Genus *Globorotalia* Cushman, 1927

As discussed by Fleisher (1974:1009–1012, 1025–1026), the genus *Globorotalia* has been used to include a diverse multitude of forms. The general usage of Fleisher is followed here, but not the subgeneric groupings, as there is still a need for lineage studies to demarcate the different stocks clearly.

Globorotalia hirsuta hirsuta (d'Orbigny)

PLATE 3: FIGURES 5–7; PLATE 5: FIGURES 9, 10

Rotalina hirsuta d'Orbigny, 1839b:131, pl. 1: figs. 37–39.
Globorotalia hirsuta hirsuta (d'Orbigny).—Blow, 1969: 398–400, pl. 8: figs. 1–3, pl. 43: figs. 1–2.

OCCURRENCE.—Rare in the Yorktown Formation in the type area at the cliffs at Yorktown, Virginia, and in the Croatan Formation in the Lee Creek Mine.

STRATIGRAPHIC RANGE.—Blow (1969:363) reported a range from zone N22 to zone N23, and Brönnimann and Resig (1971:1433) recorded this species from the middle of zone N22 into the Holocene. Most other records of older ranges, such as Parker's (1967:178), from the middle of N20 upward, and Jenkins' and Orr's (1972:1099), from N19/20 upward, have to be studied with caution as these authors did not differentiate the subspecies proposed by Blow (1969:398–402).

Globorotalia menardii (Parker, Jones, and Brady)

PLATE 3: FIGURES 1–3

Rotalia (Rotalie) menardii d'Orbigny, 1826:273, model no. 10 [nomen nudum].
Rotalia menardii Parker, Jones, and Brady, 1865:20, pl. 3: fig. 81.—Banner and Blow, 1960:31–33, pl. 6: figs. 2a–c.

Globorotalia menardii (Parker, Jones, and Brady).—Jenkins, 1971:90, pl. 6: figs. 135–137.

REMARKS.—The illustrated specimen and others from this area closely resemble *G. menardii* form 5 of Tjalsma (1971:60, pl. 6, figs. 3a–5c), particularly those specimens referred to this taxon by Zachariasse (1975, pls. 3, 4), although the proximal ends of the intercameral sutures are perpendicular or slightly acute to the spiral suture rather than slightly oblique.

OCCURRENCE.—Rare in the Yorktown Formation in Virginia and North Carolina and in the Duplin Formation in North and South Carolina. Akers (1972:36) reported it from the Waccamaw Formation at Walkers Bluff, North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:359) reported a range from zone N14 to zone N23.

Globorotalia merotumida Blow and Banner

PLATE 6: FIGURES 1–13

Globorotalia (Globorotalia) merotumida Blow and Banner, in Banner and Blow, 1965:1352, fig. 1a–c.

REMARKS.—Most specimens in the assemblages have the relatively slow increase in whorl height and uniformly enlarging chambers characteristic of *G. merotumida.* Some specimens, however, have a much greater increase in whorl height and likely fall within the range of variation of *G. plesiotumida.*

OCCURRENCE.—Common to rare in the "Virginia St. Marys" at depths from 131.5 to 138 feet (40 to 42 m) in the Gatesville Well, North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:364) reported a range from just above the base of zone N16 to within zone N18.

Globorotalia minima Akers

PLATE 6: FIGURES 14–16

Globorotalia carariensis (d'Orbigny) var. *minima* Akers, 1955: 659, pl. 65: fig. 3a–d.

Globorotalia minima Akers.—Blow, 1959:217–218, pl. 19: figs. 122a–c.

OCCURRENCE.—Common to rare in the Pungo River Formation at depths from 131.5 to 138 feet (40 to 42 m) in the Gatesville Well, North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:352) reported a range from the middle of zone N7 to within zone N13. Brönnimann and Resig (1971:1433, 1441) recorded this species from the lower part of zone N6 to within zone N13.

Globorotalia peripheroronda Blow and Banner

PLATE 5: FIGURES 5, 6

Globorotalia (Turborotalia) peripheroronda Blow and Banner, 1966:294, pl. 1: fig. 1a–c, pl. 2: figs. 1–3.

OCCURRENCE. Rare to common in the upper beds of the Pungo River Formation in the Lee Creek Mine in North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:354) reported a range from within zone N6 to within zone N11. Brönnimann and Resig (1971:1441) recorded the species as early as zone N5.

Globorotalia puncticulata (Deshayes)

PLATE 3: FIGURES 9–11; PLATE 5: FIGURES 11, 12

Globigerina puncticulata Deshayes, 1832:170.—Banner and Blow, 1960:15–17, pl. 5: fig. 7a–c.

Globorotalia puncticulata (Deshayes).—Zachariasse, 1975:114–115, pl. 14: fig. 2a–c.

REMARKS.—The specimens from the lower part of the Yorktown Formation (zone 1 of Mansfield) are well-developed members of this species, as illustrated in Plates 3 and 5. Specimens from the middle part of the Yorktown Formation (zone 2 of Mansfield) approach *Turborotalia inflata* in chamber arrangement and outline of the periphery.

OCCURRENCE.—Specimens occur in the lower part of the Yorktown Formation (zone 1 of Mansfield) along the Meherrin River near Murfreesboro, North Carolina, and in the Lee Creek Mine, North Carolina, and in the middle and upper parts of the Yorktown Formation in Virginia and North Carolina. The species also occurs in the

Duplin and Waccamaw formations in North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:354) reported a range from the upper part of zone N19 through zone N23. However, most later authors found the first appearance essentially at the base of zone N19 (Berggren, 1972:970, 973; Cita and Gartner, 1973:530, 533, 536; Kennett, 1973:587; Gradstein, 1974:68, 99; Zacharriasse, 1975:30–31, 37; Poore and Berggren, 1975:273, 278, 282). The upper limit of the species is uncertain. In the Mediterranean region it disappears within zone N20 (Gradstein, 1974:68, 99; Zacharriasse, 1975:30–31, 37). Kennett (1973:587) marked its extinction in the middle of zone N21 in the Pacific Ocean sequences. Berggren and Amdurer (1973, fig. 10) and Blow (1969:354) found it through zone N23. Poore and Berggren (1975:273, 278) showed an upper limit in the latest Pliocene or earliest Pleistocene (probably equivalent to uppermost N21 or lower N22). Cifelli (pers. comm., 1975) noted that *G. puncticulata*, in the form recognized by the above authors, does not occur today in the plankton in the North Atlantic Ocean, and that forms previosuly placed under that name belong to what is now called *G. crassiformis*. If *G. puncticulata* did become extinct sometime during the Pliocene or early Pleistocene as stated by various authors, then the occurrence of the type suite of Deshayes and d'Orbigny at Rimini (Banner and Blow, 1960:15) requires reclassification of fossil specimens.

Globorotalia scitula praescitula Blow

PLATE 5: FIGURES 1–4

Globorotalia scitula praescitula Blow, 1959:221, pl. 19: figs. 128a–c.

Globorotalia (Turborotalia) scitula praescitula Blow.—Blow, 1969:356, pl. 4: figs. 21–23, pl. 39: fig. 9.

OCCURRENCE.—Rare to common in the upper part of the Pungo River Formation in the Lee Creek Mine, North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:356) reported the range as zone N5 to near the end of zone N9.

Globorotalia species cf. *G. crassula* Cushman and Stewart

PLATE 3: FIGURES 4, 8, 12

REMARKS.—A single specimen has more chambers in the final whorl than most individuals of *G. crassula*, although Berggren and Amdurer (1973, pl. 30: fig. 9) illustrated *G. crassula* with 4½ chambers in the final whorl. Specimens similar to the one from the Yorktown Formation were figured by Lamb and Beard (1972, pl. 2, figs. 10–12; pl. 20, figs 3–7) as *G. crassacrotonensis* Conato and Follador, a form placed in *G. crassula*, sensu lato, by Berggren and Amdurer (1973:367). Probably the most similar form was illustrated by Rögl (1974, pl. 5, figs. 1–9, 13–15) as *Globorotalia crassaformis* cf. *viola* Blow, 1969. Rögl did not assign his specimens to *G. crassula* because they lack the moderately strong-keel development found in this species.

OCCURRENCE.—A single specimen was found in the lower part of the Yorktown Formation (*Placopecten clintonius* zone of Mansfield) in the bluffs along the Meherrin River near Murfreesboro, North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:361, 362) reported a range from zone N18 to zone N23 for *G. crassula crassula* and *G. crassula viola*.

Globorotalia species cf. *G. truncatulinoides truncatulinoides* (d'Orbigny)

PLATE 5: FIGURES 13–15

REMARKS.—Only a single specimen was found. Blow (1969:405) distinguishes *G. truncatulinoides* from *G. tosaensis* by the presence in the former "of the peripheral carina, no matter where or to what extent it is developed." Blow (1969:395) recognizes *G. truncatulinoides truncatulinoides* "at the first appearance of an 'imperforate' carina regardless of the extent or position of the true carina." Rögl (1974) illustrates transitional forms. By using these criteria, the specimen from the Lee Creek Mine would fall into the range of *G. truncatulinoides truncatulinoides*. The umbilicus is less open than those of well-developed specimens of *G. truncatulinoides*, and this specimen seems to be an early form of the species. Because only one atypical specimen is known, it is placed in an uncertain status.

OCCURRENCE.—A single specimen was found in the upper part of the Croatan Formation in the Lee Creek Mine, North Carolina. *G. truncatulinoides* was reported by Akers (1972:36) from the Waccamaw Formation at Walkers Bluff, North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:370), Brönnimann and Resig (1971:1248), and Kennett (1973:587 reported a range from the base of zone N22 through zone N23.

Genus *Orbulina* d'Orbigny, 1839

Orbulina universa d'Orbigny

PLATE 5: FIGURE 8

Orbulina universa d'Orbigny, 1839a:3, pl. 1. fig. 1.—Blow, 1956:66, fig. 2, nos. 8–9.—Jenkins, 1971:193–194, pl. 23: fig. 660.—Stainforth et al., 1975:328–330, fig. 150.
Orbulina cornwallisi McLean, 1956:365, pl. 53: figs. 3a–b.

REMARKS.—Examination of McLean's type material and additional topotypic material showed no difference in surface appearance between *O. cornwallisi* and *O. universa*.

OCCURRENCE.—Common in the "Virginia St. Marys" beds in the Gatesville Well in North Carolina in the interval from 131.5 to 138 feet (40 to 42 m). Specimens are rare in the Yorktown Formation in Virginia and North Carolina, and in the Duplin and Waccamaw formations in North Carolina. Dorsey (1948:314) found a single specimen in bed 17 of the Choptank Formation in Maryland; examination indicates this specimen should be referred to *O. suturalis*.

STRATIGRAPHIC RANGE.—Blow (1969:334) reported a range from within the lower part of zone N9, through zone N23.

Genus *Praeorbulina* Olsson, 1964

Praeorbulina glomerosa glomerosa (Blow)

PLATE 1: FIGURES 3, 6

Globigerinoides glomerosa glomerosa Blow, 1956:65, fig. 1: nos. 15–19, fig. 2: nos. 1, 2.
Praeorbulina glomerosa glomerosa (Blow).—Jenkins, 1971:198, pl. 23: fig. 668.
Praeorbulina glomerosa (Blow).—Postuma, 1971:376.—Stainforth et al., 1975:281, fig. 121.

REMARKS.—Stainforth et al. (1975) accepted Postuma's (1971:376) combining of the various subspecies of *P. glomerosa* into one taxon. The relatively few specimens of *Praeorbulina* found in this area indicate that the time of initial appearance of the subspecies is consistent with that found in warmer areas by Blow and that there is a transition upward through the various subspecies similar to that described by Blow.

OCCURRENCE.—A single specimen was found in bed 10 of the Calvert Formation at Plum Point, Maryland. Dorsey (1948:314) reported rare occurrences of *Candorbulina universa* Jedlitschka from beds 11 and 12 of the Calvert Formation in Maryland. Examination of the material indicates that two of the specimens from bed 11 belong in this subspecies, but one from bed 11 and two from bed 12 belong to *P. glomerosa circularis*.

STRATIGRAPHIC RANGE.—Blow (1969:333) reported a range from the middle part of zone N8 to the basal part of zone N9.

Praeorbulina glomerosa circularis (Blow)

PLATE 10: FIGURE 9

Globigerinoides glomerosa circularis Blow, 1956:65, fig. 2, nos. 3, 4.
Praeorbulina glomerosa circularis (Blow).—Jenkins, 1971:196–197, pl. 23: fig. 665.

REMARKS.—As noted under *P. glomerosa glomerosa*, the lineage proposed by Blow has been questioned. The few specimens found in the Calvert Formation support Blow's interpretation. Bed 10 contains *Globigerinoides sicanus* and *P. glomerosa glomerosa*, bed 11 contains *P. glomerosa glomerosa* and *P. glomerosa circularis*, and bed 12 contains *P. glomerosa circularis*. Although there is overlap in the occurrences, the over-all trend is consistent with Blow's description.

OCCURRENCE.—One specimen was found in bed 11 and two in bed 12 from the collections made by Dorsey from the Calvert Formation in Maryland.

STRATIGRAPHIC RANGE.—Blow (1969:333) reported that its range is from the upper part of zone N8 to near the top of zone N9.

Genus *Pulleniatina* Cushman, 1927

Pulleniatina obliquiloculata obliquiloculata (Parker and Jones)

PLATE 2: FIGURES 5, 6, 9

Pullenia obliquiloculata Parker and Jones, 1865:365, pl. 19: figs. 4a,b.
Pulleniatina obliquiloculata obliquiloculata (Parker and Jones).—Banner and Blow, 1967:137–139, pl. 3: figs. 4a–c.
Pulleniatina obliquiloculata (Parker and Jones).—Stainforth et al., 1975:385, figs. 186, 187.

REMARKS.—Although these specimens are consistent with the subspecies concept used by Blow in Pliocene and Pleistocene assemblages, they differ slightly from living specimens found in plankton tows and may warrant a separate taxonomic designation to signify their biostratigraphic importance.

OCCURRENCE.—Rare in the uppermost part of the "Yorktown" Formation along the western shore of the Chowan River, at Colerain Landing, Mt. Gould Landing, and Black Rock Landing in Bertie County, North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:376) reported a range from within zone N19 through zone N23, as did Parker (1967:172). Earlier first occurrences are from the beginning of zone N20 (Brönnimann and Resig, 1971:1435) and from zone N22 onward (Kennett, 1973:587).

Genus *Sphaeroidinellopsis* Banner and Blow, 1959

Sphaeroidinellopsis seminulina seminulina (Schwager)

PLATE 2: FIGURES 10–12; PLATE 5: FIGURE 7

Globigerina seminulina Schwager, 1866:256, pl. 7: fig. 112.—Banner and Blow, 1960:24, pl. 7: figs. 2a, b.
Sphaeroidinella seminulina (Schwager).—Parker, 1967:161–162, pl. 23: figs. 1–5.

OCCURRENCE.—Rare in the "Virginia St. Marys" beds in the Gatesville Well, North Carolina, at a depth of 131.5 feet (40 m) and in the lower part of the Yorktown Formation (*Placopecten clintonius* zone of Mansfield) along the bluffs of the Meherrin River near Murfreesboro, North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:338) reported a range from zone N6 to near the zones N19/N20 boundary in most localities, with a range possibly as high as the lower part of zone N21 in the deep sea sequences. The youngest range, as indicated by Blow, is variable, depending apparently upon the location and environment. A range to uppermost zone N20 was given by Poag (1972b:492, 493, 499) and Berggren and Amdurer (1973:353, figs. 4, 7, 8) in the Atlantic. A range to the lower part of zone N21 was given by Parker (1967:161), to the latter part of zone N21 by Kennett (1973:587, 591, 594), and into the lower part of zone N22 by Brönnimann and Resig (1971:1435). Berggren and Van Couvering (1974:31) placed the extinction datum in the lowest part of zone N21.

Sphaeroidinellopsis subdehiscens subdehiscens (Blow)

PLATE 2: FIGURES 13–15

Sphaeroidinella dehiscens subdehiscens Blow, 1959:195–196, pl. 12: fig. 71a–c, 72.
Sphaeroidinellopsis subdehiscens subdehiscens (Blow).—Blow, 1969:338, pl. 30: figs. 1–3, 6.

OCCURRENCE.—A single specimen was found in the lower part of the Yorktown Formation in the *Placopecten clintonius* zone of Mansfield along the bluffs of the Meherrin River near Murfreesboro, North Carolina. Akers (1972:32) reported this species from the Yorktown Formation at Rice's Pit, Virginia.

STRATIGRAPHIC RANGE.—Blow (1969:338) reported a range from the base of zone N13 to within zone N19. Some workers (e.g., Parker, 1967:160) had a similar latest occurrence, but most recent work shows considerably later occurrences for this species: the top of N19/N20 (Ujiié and Oki, 1974:44), the top of N20 (Brönnimann and Resig, 1971:1435), the lower part of N21 (Poag, 1972b:515; Berggren and Van Couvering, 1974:67), and as recent as the lowest part of N22 (Kennett, 1973:587, 588).

Genus *Turborotalia* Cushman and Bermudez, 1949

In addition to the type-species *Globorotalia centralis* Cushman and Bermudez and other related species that also occur in Eocene strata, a wide variety of species from Miocene and younger ages have been placed in this genus or subgenus. A problem with Blow's (1969) concept of this genus is that species from several different lineages, which possess characteristics of "*Turborotalia*" during some stage of the lineage development, are placed together, making the genus recognizably polyphyletic. This problem was discussed by Fleisher (1974). Although many workers have used *Turborotalia* for species occurring in Miocene and younger strata, it appears that this name should be restricted to the Eocene lineages, because the phylogenetic gap between these two groups is large. This restriction leaves a large number of younger species without a generic name. *Neogloboquadrina* has been used for "*Turborotalia*" *dutertrei* and its related forms. In this study, species possessing a rounded periphery without an imperforate carina are temporarily placed in "*Turborotalia*" pending resolution of the problem.

"*Turborotalia*" *birnageae* (Blow), new combination

PLATE 4: FIGURES 1–6

Globorotalia birnageae Blow, 1959:210–211, pl. 17: fig. 108a–c.
Globorotalia (turborotalia) birnageae Blow.—Blow, 1969:346, pl. 34: figs. 7, 8.

REMARKS.—The number of chambers in the last whorl varies from approximately 4½ to 5½. The aperture varies in position, becoming more extraumbilical in some specimens, and ranges from a very low slit (Plate 4: figures 2 and 3, and to a lesser degree Plate 4: figure 4) to a somewhat arched aperture (Plate 4: figure 5). The wall texture is coarsely cancellate.

OCCURRENCE.—Rare to common in the upper beds of the Pungo River Formation in the Lee Creek Mine, North Carolina, and rare in the 581 to 618 foot (177 to 188 m) interval in the Norfolk, Virginia, Moores Bridge Well.

STRATIGRAPHIC RANGE.—Blow (1969:346) reported a range from within zone N7 to within the later part of zone N9. Brönnimann and Resig (1971:1441) recorded the species as early as zone N6, with specimens of *G.* aff. *birnageae* specimens in zone N4.

"*Turborotalia*" *acostaensis humerosa* (Takayanagi and Saito), new combination

PLATE 2: FIGURES 1–3

Globorotalia humerosa Takayanagi and Saito, 1962:78, pl. 28: figs, 1–2.—Stainforth et al., 1975:357–360, fig. 170.
Globorotalia (Turborotalia) acostaensis humerosa Takayanagi and Saito.—Blow, 1969:345–346, pl. 33: figs. 4, 5, 7–9, pl. 34: figs. 1–3.

OCCURRENCE.—Rare to common in the lower part of the Yorktown Formation in the *Placopecten clintonius* zone along the bluffs of the Meherrin River near Murfreesboro, North Carolina. Akers (1972:32) reported this species from the Yorktown Formation in Rice's Pit in Virginia and the basal part of the section (*Placopecten clintonius* zone) in the Lee Creek Mine, North Carolina, and in the Waccamaw Formation at Walkers Bluff and Old Dock in North Carolina.

STRATIGRAPHIC RANGE.—Blow (1969:345) reported a range from the latest part of zone N16 through N23. The ranges reported in most subsequent studies generally indicate a later origin and an earlier extinction. Parker (1967:169) gave a range from lower N18 to the top of N21; Brönnimann and Resig (1971:1433) recorded it from the middle of N17 into N23; Jenkins and Orr (1972:1099) had a range from N17 to N22; Poag (1972b:485) recorded it from N19 to the end of N21; and Kennett (1973:580, 583, 584, 588, 591) had a range from the base of N19 to N22.

"*Turborotalia*" *inflata* (d'Orbigny), new combination

PLATE 3: FIGURES 13–15

Globigerina inflata d'Orbigny, 1839b:134, pl. 2: figs. 7–9.
Globorotalia (Turborotalia) inflata (d'Orbigny).—Banner and Blow, 1967:145–146, pl. 4: figs. 1a–c, 11.
Globorotalia inflata (d'Orbigny).—Zachariasse, 1975:116, pl. 14: fig. 3a–c.—Stainforth et al., 1975:360, fig. 171.

OCCURRENCE.—A single specimen that undoubtedly belongs to this species was obtained from the Waccamaw Formation at Walkers Bluff on the Cape Fear River, North Carolina. Several specimens placed in *G. puncticulata*, although they show strong transitional characteristics to *G. inflata*, were found in the upper part of the Yorktown and Duplin formations in North Carolina. Akers (1972:36, 42) reported this species from Walkers Bluff and Old Dock in the Waccamaw Formation in North Carolina.

STRATIGRAPHIC RANGE.—Although Blow (1969:350) reported a range from zones N17 through N23, most subsequent work has shown a considerably later initial appearance of the species. Boltovskoy (1974:678, 706) reported *G. inflata* from sediments as old as late Miocene in the Indian Ocean, but, judging from his ensuing discussion, it appears that these were confused with *G. crassaformis*. Bolli (1970:581, 614) and Kennett (1973:587) indicated a range from the equivalent of upper N20 through N23, and Parker (1967:179), Ujiié and Oki (1974:39, 44), and Zachariasse (1975:30–31, 39, 79) had the first occurrence at the base of N21. It seems that an earliest occurrence of uppermost N20 to lower N21 is best documented.

Genus *Spiroplectammina* Cushman, 1927

Spiroplectammina mississippiensis (Cushman)

PLATE 9: FIGURES 5, 9; PLATE 16: FIGURES 1–3

Textularia mississippiensis Cushman, 1922b:90, pl. 14: fig. 4.
Spiroplectammina mississippiensis (Cushman).—Dorsey, 1948: 275–276, pl. 27: figs. 3a–4b.
Spiroplectammina spinosa Dorsey, 1948:276, pl. 27: figs. 5a, 6b.

DESCRIPTION.—Test elongate, varying in width from 1½ to 3 times as long as wide, tapering uniformly towards the initial end; periphery acute, usually keeled, and keel development, if present, varying from slight to very wide in different populations; chambers planispirally coiled in early portion, consisting of 5 or 6 chambers, later part of test biserial; chambers compressed, with little, if any, increase in inflation of chambers throughout ontogeny; sutures distinct, slightly depressed, varying from straight to slightly curved downward, sutural areas filled with clear shell material that is variable in development from a slight line along the suture to broad bands covering as much as half of the surface of the test; wall finely arenaceous with much cement, giving a smooth finish; aperture a moderately low slit at the base of the inner margin of the last-formed chamber.

REMARKS.—This species is variable, as noted in the description. *S. spinosa* Dorsey was distinguished by its straight, horizontal sutures and spinose projections at the peripheral margin. Spinose projections can be seen on many specimens of *S. mississippiensis* as either the thicker parts of a broken peripheral keel or as the incipient parts of a poorly developed keel. Although the holotype of *S. spinosa* has horizontal sutures, as do specimens in some populations of *S. mississippiensis*, the paratypes have slightly curved sutures. Dorsey reported both *S. spinosa* and *S. mississippiensis* in the same samples, and it seems clear that *S. spinosa* is just an extreme variation within a population of *S. mississippiensis.*

Spiroplectammina mississippiensis can be distinguished from *S. exilis* Dorsey, which occurs in the Choptank Formation, because the latter has a more inflated test with a nonkeeled periphery, the sutures are more strongly curved downwards, and it has a longer and narrower shape.

Occurrence.—Rare to common throughout most of the Calvert Formation in Maryland, ranging from beds 3 to 14, and rare in the Pungo River Formation in the Lee Creek Mine and in the "Virginia St. Marys" beds in the Gatesville Well in North Carolina at a depth of 138 feet (42 m).

Stratigraphic Range.—The first appearance of this species is in strata of Eocene age, ranging geographically from Texas to Virginia. It is common in the Oligocene and questionable in the lowermost Miocene strata of the Gulf Coast region. The occurrences in the Miocene Calvert and Pungo River formations and "Virginia St. Marys" beds are probably the most recent records.

Spiroplectammina exilis Dorsey

Plate 10: figures 1, 2; Plate 16: figures 4, 5

Spiroplectammina gracilis Cushman and Cahill, 1933:6, pl. 1: figs. 6, 7.
Spiroplectammina exilis Dorsey, 1948:275, pl. 27: figs. 1, 2.

Description.—Test elongate, about 2½ times as long as wide, tapering uniformly towards the initial end; moderately inflated test with subacute to narrowly rounded periphery; chambers planispirally coiled in initial stage, numbering 4 or 5, composing small part of test, later part of test biserial consisting of 16 to 20 chambers; chambers compressed with only slight increase in inflation during ontogeny; sutures distinct, slightly depressed, varying from straight to slightly curved downward, meeting periphery at approximately a 45 degree angle; wall finely arenaceous and containing much cement, giving a smooth finish; aperture a low, narrow slit at base of inner margin of last-formed chamber.

Remarks.—This species is distinguished from *S. mississippiensis* (Cushman) by its more inflated cross-section, nonkeeled periphery, more curved sutures, and generally more elongated shape.

Occurrence.—This species is characteristic of the Choptank Formation in Maryland and northern Virginia. Dorsey (1948) reported an occurrence in bed 24 of the St. Marys Formation along the St. Marys River, but extensive collecting by the author has not yielded any specimens belonging to this genus in those strata.

Stratigraphic Range.—The age range is restricted to the middle Miocene.

Genus *Textularia* Defrance, 1824

Textularia obliqua Dorsey

Plate 16: figures 8, 9

Textularia obliqua Dorsey, 1948:279, pl. 28: figs. 6, 7.

Description.—Test broadly elongate, about 1½ times as long as broad, widest part may be at last pair of chambers or at earlier stage, early portion strongly tapering, later portion almost parallel; test moderately inflated, periphery broadly rounded; 7 to 8 pairs of chambers biserially arranged, early chambers much longer than high, later ones increasing in height; sutures distinct, straight, slightly depressed, forming an angle of approximately 30 degrees with horizontal; wall coarsely arenaceous, smoothly finished; aperture an arched slit at base of inner margin of last formed chamber.

Occurrence.—This species is rare throughout beds 22 to 24 of the St. Marys Formation in Maryland and also is found at one locality in the overlying "Virginia St. Marys."

Stratigraphic Range.—The range is from upper middle to probable lower upper Miocene.

Textularia mayori Cushman

Plate 16: figures 11, 12

Textularia mayori Cushman, 1922a: 23, pl. 2: fig. 3.—McLean, 1956:320, pl. 36: figs. 1–3.

Description.—Test broadly elongate, almost as broad as long, widest part at last pair of chambers, uniformly tapering toward initial end; test moderately compressed throughout, periphery strongly angled with variable number of spines projecting from chamber margins; 7 to 8 pairs of chambers biserially arranged, early chambers longer than high, later ones gradually becoming higher; sutures indistinct, later ones slightly depressed, straight to slightly curved downward; wall finely arenaceous with relatively smooth finish; aperture a low slit at base of indented inner margin of last formed chamber.

REMARKS.—Spinosity ranges from complete absence of spines to long projecting spines. This species is similar to *T. gramen* d'Orbigny, and it is probable that the specimens from the Choptank and St. Marys formations placed in *T. mayori* by Dorsey (1948:278) belong to *T. gramen. Textularia gramen* does not have spines and differs from nonspinose forms of *T. mayori* by having a shorter, broader test, which is more inflated in cross-section.

OCCURRENCE.—Rare to very common throughout the Yorktown Formation in Virginia and North Carolina and in the Waccamaw Formation in North Carolina.

STRATIGRAPHIC RANGE.—From zone N19 to present off the southeastern coast of the United States.

Textularia ultima-inflata Dorsey

PLATE 16: FIGURES 6, 7

Textularia ultima-inflata Dorsey, 1948:279, pl. 28: fig. 8a–c.

DESCRIPTION.—Test broadly elongate, about 1½ times as long as broad, widest part at last pair of chambers, strongly tapering toward initial part throughout test; test compressed in early portion, inflated in later; periphery subacute in early portion, broadly rounded in later portion; 7 to 8 pairs of chambers biserially arranged, early chambers much longer than high, later ones gradually becoming higher until last pair is about as high as wide; sutures indistinct, not depressed, curved slightly downward; wall finely to coarsely arenaceous; aperture a low slit at indented base of inner margin of last formed chamber.

OCCURRENCE.—Only in beds 17 to 19 of the Choptank Formation in Maryland.

STRATIGRAPHIC RANGE.—The range is restricted to the middle Miocene.

Genus *Bolivinopsis* Yakovlev, 1891

Bolivinopsis fairhavenensis, new species

PLATE 20: FIGURES 1–4

Bolivinopsis curta Cushman, 1948:220 [not *Spiroplectoides curta* Cushman, 1933]

DESCRIPTION.—Test small, about 3 times as long as broad, early planispiral stage moderately compressed, becoming less compressed through growth with later biserial portion only slightly compressed, being oval in cross-section and having a rounded periphery; sides of test nearly parallel with biserial portion having approximately the same width as planispiral; biserial stage usually straight, but may be slightly to moderately curved; chambers distinct in both stages; 7 to 8 chambers in planispiral stage, usually 3 to 4 slightly inflated chambers of equal height and width in each row of biserial stage; sutures distinct, slightly depressed, forming approximately a 45 degree angle with periphery; wall calcareous, radial, finely perforate, smooth, highly translucent to transparent; an elongate oval aperture in the terminal face extending to the inner margin.

REMARKS.—*Bolivinopsis* is most common in Cretaceous to Eocene rocks; *B. fairhavenensis* is one of the youngest species of the genus. The nature of the wall structure within the genus, as typified by the Russian type-species, remains uncertain. Some species placed in *Bolivinopsis* clearly look agglutinated, while others, including the present species, clearly appear to be perforate calcareous. Some species in the USNM collections that are placed in *Spiroplectammina* Cushman, 1927, also appear to be calcareous perforate. This problem of the generic wall structure is discussed in Loeblich and Tappan (1964:251). Examination of the species in the USNM collections shows three groups of species that apparently have the same pattern of chamber arrangement. One group has a clearly agglutinated structure, ranging from coarse- to fine-grained; one has clearly calcareous perforate structure and one may be finely agglutinated or calcareous perforate. This last group will have to be sectioned to determine the wall structure. If the type-species of *Bolivinopsis*, *B. capitata* Yakovlev, does prove to have a calcareous perforate wall, as has been suggested, then the calcareous perforate group does have a name. If this species proves to be agglutinated, then it probably should be the senior synonym of *Spiroplectammina*, and the perforate group will need a new generic name.

Bolivinopsis curta (Cushman) differs from *B. fairhavenensis* in that it has a broader and more inflated test (about twice as thick) containing more inflated chambers throughout and a more roughened or granular wall texture.

Bolivinopsis attenuata (Cushman) from the Eocene of the Atlantic shelf differs by having a broad planispiral stage followed by a narrow biserial stage with compressed chambers, a subacute periphery, and limbate sutures.

OCCURRENCE.—Restricted in outcrop occurrence in Maryland to the top of bed 3 of the Fairhaven Member of the Calvert Formation in Calvert County. The abundance may be as high as 4 percent. Cushman (1948) found it in the lower 100 feet (30 m) of the Calvert Formation in the Hammond Well on the Eastern Shore of Maryland. It also was recorded in the upper 10 feet (3 m) of the Eocene in this well, but this probably represents down-hole contamination. In a continuous core hole at the site of the Baltimore Gas and Electric Company's nuclear power plant near St. Leonards, Calvert County, Maryland, this species occurs from within 8 feet (2.4 m) of the base of the Calvert Formation to the top of bed 3, an interval of 108 feet (33 m). In Maryland, this species is characteristic of the lower part of the Calvert Formation, the Fairhaven Member. The species was found in one sample in the Pungo River Formation in the Lee Creek Mine, North Carolina.

STRATIGRAPHIC RANGE.—The occurrences in Maryland are in the lower part of the Calvert Formation, below the beds assigned to the latest part of planktonic zone N8 or N9. The North Carolina occurrence is in beds dated as probably late N8. Thus, the upper age limit of the species in this area is latest N8 (late early Miocene). Although the lower part of the Calvert Formation appears to be somewhere in zone N8, it has not been dated with certainty; therefore the lower range of this species is still uncertain.

TYPE LOCALITY.—The type locality for the holotype, figured paratypes, and unfigured paratypes is Randle Cliffs on the western shore of Chesapeake Bay, Calvert County, Maryland, in the upper part of bed 3 of the Calvert Formation.

TYPES.—The holotype is USNM 252518; figured paratypes are USNM 252519 and 252520; all from USGS 25981.

Genus *Quinqueloculina* d'Orbigny, 1826

Quinqueloculina lamarckiana d'Orbigny

PLATE 17: FIGURES 1, 2, 6

Quinqueloculina lamarckiana d'Orbigny, 1839a:189, pl. 11: figs. 14, 15.—Cushman, 1929:26, pl. 2: fig. 6.
Quinqueloculina venusta? Cushman, 1918:70, pl. 29: fig. 3a–c.
Quinqueloculina cuvieriana Cushman, 1919:69.
Quinqueloculina seminulangulata McLean, 1956:322, pl. 37: fig. 8a, b.

DESCRIPTION.—Test about 1½ times as long as wide, triangular in cross-section, periphery acute to subacute; chambers broad and flattened, middle chamber large, projecting, having distinct acute edge, other chambers visible as narrow band; sutures distinct, slightly depressed; surface smooth, polished, covered with few low costae that are parallel to slightly oblique to periphery; aperture oval, having a slightly thickened rim and a short, stout tooth.

REMARKS.—The degree of acuteness of the periphery varies from strongly angulated to subangulated. The strength of the ornamentation varies from barely visible on the early chambers to well developed on all chambers. These characters vary with latitude in living populations along the Atlantic Coast of the United States. Specimens with a more rounded periphery and less-developed costae occur in the northern part of the range in coastal waters off North Carolina, whereas forms having a more angular periphery and more strongly developed costae are more abundant in populations off Florida. A similar north-to-south pattern in the variation is seen in the Yorktown and Waccamaw formations; the more southern localities have more strongly angulated and ornamented specimens.

OCCURRENCE.—Rare to common throughout the Yorktown Formation in Virginia and North Carolina and in the Waccamaw Formation in North and South Carolina.

STRATIGRAPHIC RANGE.—The range in this area is from lower Pliocene strata (zone N19) into the living fauna. In South America, the West Indies, and the southern United States, reports extend its range to the Eocene.

Genus *Massilina* Schlumberger, 1893

Massilina glutinosa Cushman and Cahill

PLATE 17: FIGURES 3, 4, 7

Massilina glutinosa Cushman and Cahill, 1933:10, pl. 2: fig. 10a–c.—Dorsey, 1948:281, pl. 29: fig. 6a–c.

DESCRIPTION.—Test strongly compressed with parallel sides, periphery broadly rounded, test oval in outline, apertural end not projecting; chambers of uniform width, later chambers nearly circular in cross-section; sutures distinct, slightly depressed; wall agglutinated with much cement; aperture circular and has slightly thickened lip, containing bifid tooth that may be thin and elongated or short and stout.

OCCURRENCE.—Known from beds 16 through 20 of the Choptank Formation in Maryland and northern Virginia.

STRATIGRAPHIC RANGE.—Restricted to the middle Miocene.

Massilina marylandica Cushman and Cahill

PLATE 16: FIGURES 10, 13, 14

Massilina marylandica Cushman and Cahill, 1933:10, pl. 2: fig. 9a–c.

DESCRIPTION.—Test strongly compressed, periphery rounded, test oval in outline, apertural end not projecting; chambers distinct, later ones increasing considerably in width; sutures distinct, slightly depressed; wall has well-developed longitudinal costae crossing chamber at slight angle to the periphery; aperture circular, containing thickened bifid tooth.

OCCURRENCE.—Found only in the upper part of the St. Marys Formation at Langley's Bluff and Chancellor Point, Maryland.

STRATIGRAPHIC RANGE.—Middle to lower upper Miocene.

Genus *Nodosaria* Lamarck, 1812

Nodosaria catesbyi d'Orbigny

PLATE 11: FIGURES 5, 6; PLATE 17: FIGURE 11

Nodosaria catesbyi d'Orbigny, 1839a:16, pl. 11: figs. 8–10.—McLean, 1956:329, pl. 39: figs. 1–4.

DESCRIPTION.—Test elongate, varying from slightly tapering to slightly expanding; initial end blunt and rounded, some specimens have an apical spine; chambers vary in number from 2 to 4; sutures distinct, depressed; wall ornamented by 12 to 16, high, sharp, longitudinal costae, continuous across the sutures; aperture terminal, radiate on short to medium neck; wall calcareous, finely perforate.

REMARKS.—Originally characterized by d'Orbigny as composed of two chambers; specimens having three or four chambers occur in the present material. The later chambers may be as large or larger than the earlier, or considerably smaller in size. The costae vary in development from strong to very faint or absent on the last chamber. The costae may continue onto the neck where they are twisted.

OCCURRENCE.—Lower and middle parts of the Yorktown Formation in Virginia and northern North Carolina.

STRATIGRAPHIC RANGE.—The occurrences in this area are restricted to the lower and middle Pliocene parts of the Yorktown Formation, although the species is found in upper Oligocene and Pliocene strata in other areas.

Genus *Bolivina* d'Orbigny, 1839

REMARKS.—Loeblich and Tappan (1964:549) confine the usage of *Bolivina* to those forms having the test "somewhat compressed . . . basal margins of chambers with retral processes or backward directed chamber overlap . . . . Species without chamber overlaps, commonly keeled and strongly compressed, are placed by us in *Brizalina*."

These distinctions have not been uniformly applied by subsequent authors. *Bolivina pungoensis*, new species, undoubtedly belong to the genus *Bolivina* under these concepts, but the placement of *B. calvertensis* would be more difficult as it is transitional between the groups. The gradational nature of the large number of species belonging to the *Bolivina-Brizalina* complex as interpreted by Loeblich and Tappan makes placement of the species difficult.

Bolivina calvertensis Dorsey

PLATE 9: FIGURES 1–4

Bolivina calvertensis Dorsey, 1948:306, pl. 36: fig. 17a–c.

DESCRIPTION.—Test elongate, from 2 to 3 times as long as broad, gently tapering toward both ends and having greatest width at or slightly anterior to mid-point of test; somewhat compressed test that has subacute periphery in earlier stages, becoming more inflated with more rounded periphery in later stages; chambers in later part moderately distinct, slightly inflated; sutures somewhat distinct with inner part being curved and later straight, forming angle of about 30 to 45 degrees with the horizontal; in earlier part, chambers and sutures largely obscured by ornamentation; wall moderately perforate; surface of all but the last 2 or 3 chambers prominently ornamented by closely spaced longitudinal costae, varying in strength from fine to moderately coarse between specimens, numbering approximately 12 to 20, costae may bifurcate and shortly rejoin; aperture moderately narrow, an elongate oval, opening above the base of last formed chamber, sometimes with slight lip.

REMARKS.—Dorsey compared this species to *B. marginata multicostata* Cushman; the latter differs in being much larger, having a more compressed test with a keel, and having fewer costae that are straighter and cover less of the test.

OCCURRENCE.—Dorsey reported the species as rare in beds 6 through 14 in the Calvert Formation in Maryland. Additional collecting by the author also yielded few specimens in bed 5, giving a range from the middle to upper parts of the Calvert Formation. Occurrence is rare to common in the upper part of the Pungo River Formation in the Lee Creek Mine.

STRATIGRAPHIC RANGE.—Found only in those parts of the Calvert and Pungo River formations regarded as equivalent to zones N8–lower N9.

Bolivina pungoensis, new species

PLATE 8

DESCRIPTION.—Test elongate, about 2 to 2½ times as long as broad, gently tapering toward both ends, greatest width near anterior end, usually across base of shoulders of last two chambers; moderately compressed test with subacute periphery in early part, becoming more inflated with more rounded periphery in later two-thirds to one-half of test; chambers distinct, moderately compressed in early stages, becoming more inflated in later part, chambers in early portion low and broad, later increasing considerably in height, inner basal part of chambers extending as a lobe over earlier chambers and the lobular projections becoming very pronounced in later chambers; sutures distinct, depressed, curved near periphery at 50 to 60 degree angle to the horizontal; wall distinctly perforate except for areas surrounding the apertural face; imperforate areas around aperture generally only partially covered by succeeding chambers in earlier part of the test, more commonly completely overlapped in later parts; aperture narrow, elongate, opening on or near the base of the inner margin of the last-formed chamber, usually with tooth plate exposed.

REMARKS.—The apertural face and surrounding area is imperforate, and during ontogeny the amount of imperforate area covered by succeeding chambers varies. In the earlier parts of the test much of the imperforate area remains visible after succeeding chambers are formed (Plate 8: figure 5), whereas during later stages of ontogeny the amount of imperforate area exposed becomes considerably reduced (Plate 8: figure 4), and in the latest stages, only very thin areas, if any, are visible (Plate 8: figure 3).

The grain size within the imperforate area is coarsest in the early stages (Plate 8: figure 9) and becomes increasingly finer in the later stages (Plate 8: figures 7, 8). This appears to be a result of the organism's activity and not of diagenetic alteration, as the same pattern of changing grain size is observable on all specimens. Diagenetic alteration should affect the areas equally as far as regrowth of crystal size is concerned.

A group of species of *Bolivina* appears in the early and lower middle Miocene that seems to be morphologically related, and occurs over much of North America. Although some of the species are apparently restricted stratigraphically, others range well into and through the later parts of the Miocene strata. This group includes *B. pungoensis*, new species, and the following three closely related species, among others.

Bolivina advena Cushman (1925:29), described from the Monterey shale of California, differs from *B. pungoensis* by having the lobular extensions not as strongly developed, and by lacking the imperforate areas in the earlier chambers.

Bolivina floridana Cushman (1918:49), described from the Choctawhatchee Formation in Florida, is longer and narrower (specimens being 3 to 4 times as long as wide), has the inflation of the chambers beginning much earlier, has a more rounded periphery in the later chambers, has multiple lobular extensions, and lacks the imperforate areas on earlier chambers. *B. floridana imporcata* Cushman and Renz and *B. floridana regularis* Cushman and Renz, from the Miocene of Venezuela, are similar to *B. pungoensis* in the overall shape of the test, but differ in the presence of multiple lobular extensions.

Bolivina plicatella mera Cushman and Ponton (1932:82), from the Oak Grove Formation in Florida, differs in having the greatest width at the apertural end, giving a square appearance, having a more compressed test, and lacking the imperforate areas.

OCCURRENCE.—*Bolivina pungoensis* comprises about 3 percent of the foraminiferal assemblages in most samples of the Pungo River Formation in the Lee Creek Mine. It is found also in the Pungo River Formation in the 581 to 616 foot (177 to 187.7 m) interval of the Norfolk, Virginia, Moores Bridge Well.

STRATIGRAPHIC RANGE.—Found only in the parts of the Pungo River Formation that are assigned to planktonic zone N8 of Blow (1969:289) of late early Miocene age.

TYPE-LOCALITY.—The locality for the holotype and figured paratypes is the Lee Creek Mine, North Carolina, in the upper part of the Pungo River Formation. Unfigured paratypes are from the Moores Bridge Well, Norfolk, Virginia, at depths of 581 and 610 feet (177 and 186 m).

TYPES.—The holotype is USNM 240134 from USGS locality 26013; figured paratypes are USNM 240135 from USGS locality 26014 and USNM 240136 from USGS locality 26013. Unfigured paratypes are USNM 240151 from USGS locality 26002 and USNM 240152 from USGS locality 26003.

Bolivina marginata multicostata Cushman

PLATE 11: FIGURES 1, 2; PLATE 17: FIGURES 5, 8

Bolivina aenariensis var. *multicostata* Cushman, 1918:48, pl. 10: fig. 2.

Bolivina marginata var. *multicostata* Cushman.—Cushman, 1937:87, pl. 10: figs. 71–10.

Bolivina marginata multicostata Cushman.—Puri, 1953:121, pl. 22: figs. 3–6.

DESCRIPTION.—Test elongate, about 2½ times as long as broad, uniformly tapering toward initial end, very compressed, variable development of keel on periphery ranging from prominent to almost absent, commonly absent on last several chambers; approximately 18 to 20 compressed chambers, early ones low and broad, later ones increasing in relative height; sutures distinct, slightly limbate and curved, intersecting margin at 45 to 60 degree angle; ornamented by a series of longitudinal costae, approximately 6 in number, which vary in strength and extent; may have short basal spine; aperture narrow, elongate, opening at inner margin of base of last formed chamber; wall moderately perforate.

REMARKS.—This species is variable in development of the keel and costae and in the shape of the sutures. The keel may extend along the entire periphery, most of the periphery except for the last two pairs of chambers, or a lesser distance. The costae vary in their length and strength, and in some specimens the central costae may be enlarged to form a median ridge. The shape of the sutures varies from strongly arched to straight. Although both this subspecies and *B. marginata marginata* Cushman occur in the same strata in Florida (Puri, 1953), *B. marginata multicostata* is by far the more common of the two in Virginia and North Carolina.

OCCURRENCE.—Rare in the middle part of the Yorktown Formation in Virginia and North Carolina and at Barwick Farm in the Duplin Formation in North Carolina. Cushman (1937) reported this subspecies from the Calvert Formation in Maryland, but none were found in outcrops of the Calvert Formation during this study. Specimens are found, however, in the subsurface strata of the Pungo River Formation in the Moores Bridge Well at 610 feet (186 m), Norfolk, Virginia.

STRATIGRAPHIC RANGE.—The range in this study area is from uppermost lower Miocene (equivalent to zone N8) to probable middle Pliocene.

Genus *Hopkinsina* Howe and Wallace, 1932

Hopkinsina bononiensis (Fornasini)

PLATE 11: FIGURES 3, 4

Uvigerina bononiensis Fornasini, 1888:48, pl. 3: figs. 12–12a.
Hopkinsina bononiensis (Fornasini).—Marks, 1952:288, pl. 1: fig. 25.

DESCRIPTION.—Test elongate, fusiform, initial end rounded; slightly inflated chambers arranged triserially in early stages, later becoming biserial; chambers have lobulate projections over earlier chambers; sutures distinct, depressed; approximately 20 costae of medium strength on each chamber, some bifurcating, others discontinuous, costae do not extend over the sutures; aperture terminal, rounded, on short, relatively broad neck containing slight lip and internal tooth plate; wall calcareous, finely perforate.

REMARKS.—The occurrence in the Pungo River Formation in North Carolina is the first report of this species in North America. The species is widespread in middle Miocene through Pliocene strata of Europe and North Africa, particularly in the Mediterranean region.

Several varieties and subspecies of *H. bononiensis* have been described, but comparative material is lacking in the USNM collections and some of the original illustrations are inadequate for subspecific discrimination of the North Carolina material. The North Carolina specimens appear to be most similar to the original material of Fornasini.

The only species similar to *H. bononiensis* is *H. quasistriata* Krasheninnikov, 1961, from the middle Miocene of Russia, which differs in having barely discernible, very fine longitudinal striae.

OCCURRENCE.—Only in the younger, subsurface part of the "Virginia St. Marys" beds in the Gatesville Well, North Carolina, at a depth of 131.5 to 132 feet (40.1 to 40.2 m).

STRATIGRAPHIC RANGE.—The known range in this area is restricted to the upper Miocene.

Genus *Sagrina* d'Orbigny, 1839

Sagrina pulchella primitiva (Cushman), new combination

PLATE 17: FIGURES 9, 10

Bolivina pulchella var. *primitiva* Cushman, 1930:47, pl. 8: figs. 12a–b.
Bolivina pulchella primitiva Cushman.—Puri, 1953:122, pl. 21: figs. 11–12.

DESCRIPTION.—Test about 1½ times as long as broad, greatest breadth formed by last pair of chambers, periphery broadly rounded, lobulate; chambers distinct, inflated, increasing gradually in size, early and middle stages of test triserial, only last 3 chambers biserial; sutures distinct, depressed, straight, making angle of 20 to 30 degrees with horizontal; test ornamented by short, strong, longitudinal costae, usually not crossing sutures; aperture an elongate oval with distinct lip; wall coarsely perforate.

OCCURRENCE.—Rare in the Waccamaw Formation in southern North Carolina. Its distribution elsewhere includes the Pliocene, Pleistocene, and Holocene of Florida and adjacent areas.

STRATIGRAPHIC RANGE.—In the study area the species has a range of upper Pliocene to lower Pleistocene, although it ranges from lower Pliocene into the Holocene in Florida and other southern areas.

Genus *Siphogenerina* Schlumberger, 1882

Siphogenerina lamellata Cushman

PLATE 9: FIGURES 6, 10–16; PLATE 17: FIGURE 13

Siphogenerina lamellata Cushman, 1918:55–56, pl. 12: fig. 3.—Dorsey, 1948:309, pl. 36: figs. 13a, b.
Siphogenerina spinosa (Bagg).—Cushman, 1926:10.—Dorsey, 1948:309, pl. 36: figs. 14a, b.

DESCRIPTION.—Test elongate, about 3 to 4 times as long as wide, greatest width at or near apertural end, tapering gradually toward initial end and tapering to broadly rounded at apertural end; early portion triserial, later and greater portion of test uniserial, commonly with 6 to 8 uniserial chambers; chambers distinct, increasing very gradually in size as added, slightly inflated; ornamentation consisting of longitudinal costae, ranging in number from approximately 7 to 9, equally spaced, varying in strength from slightly raised to broadly flanged, and extending the length of the uniserial stage and commonly onto the initial chambers where they may project as basal spines, additional costae seldom added by intercalation; sutures distinct, flush to strongly depressed with a U-shaped pattern, being strongly curved downwards at the costae and arched upwards between costae; aperture terminal with a short cylindrical neck and lip.

REMARKS.—This species appears to have relatively consistent variations over its broad geographic range. The test usually expands toward the apertural end where the greatest width occurs. Less frequently the greatest width may be about two-thirds of the distance from the initial end, with a gradual taper towards the apertural end similar to the shape of *S. collomi* Cushman. A few specimens in the Caribbean region may have additional costae added in the later stages of the test by intercalation (the holotype from Florida has a very slight added costa over the last several chambers), but this characteristic is rare in this species in contrast to other species of *Siphogenerina*.

Basal spines are commonly found in a small to moderate proportion of the population in various geographical areas. The spines are a result of the projection of the basal portion of the costae beyond the initial chambers of the test.

The only other reported species of *Siphogenerina* from the Miocene of the middle Atlantic Coastal Plain is *S. spinosa* (Bagg), originally described from the Choptank Formation at Jones Wharf, Maryland. The type material of this species is not in the Cushman Collection at the Smithsonian and its whereabouts is unknown. The type illustration of *S. spinosa* does not show the basal spines that are discussed in the description and indicated by the species name [although Bagg (1904:480) mentioned distal spines, he probably meant spines at the basal or proximal end]. Basal spines are prominent in specimens such as Dorsey's from the Calvert Formation and in some specimens from the type area in the Red Bay Formation of Puri and Vernon (1964) in western Florida, and are probably just part of the range of variation within *S. lamellata*. The prominent intercalated costae shown in the type illustration of *S. spinosa* distinguish it from most specimens of *S. lamellata*, but it is probable that both taxa are variants of one species. If so, *S. spinosa* has priority. No other specimens of *Siphogenerina* have been reported from the Choptank Formation, including samples from Jones Wharf examined by Dorsey (1948) and Gibson (1962). Because of the absence of any type material of *S. spinosa*, the two species are not placed in synonymy.

Several related species are found in Miocene strata in Florida, the Caribbean region, and California. Among the most closely related are the following species.

Siphogenerina transversa Cushman is very similar to *S. lamellata*, but differs in having a less tapered test; more inflated later chambers, which may give a slightly nodular appearance; more costae (11 to 12 being common); and intercalation and bifurcation of the costae.

Siphogenerina reedi Cushman is broader; not as tapered toward the initial end, and has more costae (13), which are more closely spaced and not as strongly developed.

Some specimens of *S. senni* Cushman and Renz closely approach *S. lamellata*, but the former typically differs in having 9 costae that become less strongly developed during ontogeny; commonly having intercalation of costae, a spinose projection at the base of the test (typically better developed than in *S. lamellata*), sutures not as strongly recurved, and very little taper toward the initial end.

Siphogenerina collomi Cushman differs in commonly having intercalated costae half-way up the side of the test, having more costae (12–14), and in tapering anteriorly. Broken specimens more closely resemble *S. lamellata*, but have more costae that are not as strongly developed.

Occurrence.—Rare in the Calvert Formation in Maryland in beds 9 to 13; rare in the upper beds of the Pungo River Formation in the Lee Creek Mine, and rare to common in the Norfolk, Virginia, Moores Bridge Well at a depth of 610 feet (186 m) and in the "Virginia St. Marys" beds in the Gatesville Well, North Carolina, at 131.5 feet (40 m). McLean (1956:350) reported one specimen which he attributed to reworking in the Yorktown Formation in Virginia.

Stratigraphic Range.—Specimens are found in the Calvert and Pungo River formations in levels assigned to zones N8 to N11. In the middle Atlantic Coastal Plain this species appears to be useful as an index to strata of this age. Younger ages for this species are reported in other areas. In Florida, the species occurs only in the *Arca* zone (Cushman and Ponton, 1932:86), which provisionally has been placed by Akers (1972:5, 14) in zone N17. Blow (1959:153) found the species to range throughout the Miocene section in Venezuela, which in that area included a range from zone N5 into zone N17; Blow (1959:153) cited the local environment as a possible causal factor for the upper range.

Other closely related species, particularly those found in California, occur through approximately the same time range as *S. lamellata* in North Carolina to Maryland. *Siphogenerina collomi* and *S. reedi* have ranges of zones N8–N9 in California (Kleinpell, 1938:300, 304; Berggren and Van Couvering, 1974, fig. 1), with *S. transversa* being found earlier in approximately zones N1 to N7, and thus being a likely forerunner of this group. In Venezuela, Blow (1959:153) reported a time range of zones N6 to N12 for *S. senni* and zones N6 to N10 for *S. transversa*.

Siphogenerina species

Plate 9: figures 7, 8

Remarks.—Some specimens from the upper beds of the Pungo River Formation in the Lee Creek Mine differ from *S. lamellata* in having almost horizontal sutures and in having twelve moderately developed costae. These specimens probably represent a new species because none of the other described species of *Siphogenerina* includes such forms.

OCCURRENCE.—Rare in the upper part of the Pungo River Formation in the Lee Creek Mine, North Carolina.

STRATIGRAPHIC RANGE.—The only occurrence of this species is in beds assigned to zone N8.

Genus *Rotorbinella* Bandy, 1944

Rotorbinella bassleri (Cushman and Cahill), new combination

PLATE 18: FIGURES 4–6

Rotalia bassleri Cushman and Cahill, 1933:30, pl. 10, fig. 7a–c.—Dorsey, 1948:312, pl. 37: fig. 8a–c.

DESCRIPTION.—Test trochoid, planoconvex, spiral side moderately convex with thickening of shell material at apex, umbilical side varies from slightly convex to slightly concave, outline circular; last several chambers may be lobulate; periphery subacute and limbate; umbilicus depressed with stout plug of clear shell material; 3½ whorls, 20 to 25 chambers, 6 to 7 chambers in last whorl, increasing gradually in size; sutures distinct, strongly recurved and slightly limbate on spiral side, moderately recurved and depressed on umbilical side; aperture an elongate slit with slight lip, extending from near periphery to umbilical plug, apertural slits on last 2 to 4 chambers may be visible; wall coarsely perforate.

REMARKS.—The convexity of the test is variable. The spiral side is usually moderately convex, but the umbilical side can vary from concave to convex. In some specimens the last chamber is strongly inflated. This species is similar to *R. colliculus* Bandy and *R. campanulata* (Galloway and Wissler) and clearly belongs to *Rotorbinella* as emended by Douglass and Sliter (1965).

OCCURRENCE.—Rare throughout the Calvert, Choptank, and St. Marys formations in Maryland. A single specimen was found in the lower part of the Yorktown Formation in Virginia.

STRATIGRAPHIC RANGE.—The range is from uppermost lower Miocene (zone N8) to lower Pliocene (zone N19); however, all occurrences except for one specimen are pre-Pliocene.

Genus *Epistominella* Husezima and Maruhasi, 1944

Epistominella danvillensis (Howe and Wallace)

PLATE 20: FIGURES 10–12; PLATE 21: FIGURES 9–13

Pulvinulinella danvillensis Howe and Wallace, 1932:71, pl. 13: fig. 7a–c.
Epistominella pontoni sensu Schnitker, 1970:72–73, pl. 6: fig. 5a–c.

DESCRIPTION.—Test trochospiral, small, approximately equally biconvex with spiral side usually more convex, circular in outline, very slightly lobulate, periphery rounded, umbilical area not depressed, but small clear shell area present where sutures converge in center; 2½ whorls, 20 to 26 chambers, 8 to 10 in last whorl, chambers slightly inflated, gradually increasing in size, last chamber may project above general umbilical surface; sutures distinct, straight to slightly curved and strongly oblique to periphery and slightly limbate on spiral side, umbilical sutures radial to slightly recurved in later chambers, essentially radial in earlier chambers and slightly limbate; aperture a narrow opening parallel to the periphery of the test; wall finely perforate with pores located in center of surface granules.

REMARKS.—This species was described from upper Eocene strata in Louisiana. Subsequent records in Eocene strata are from Georgia (McBean Formation) and Virginia (Chickahominy Formation). *Epistominella danvillensis* is reported from Oligocene and lower Miocene strata of Europe; but the illustrations show specimens differing from the paratypes of *E. danvillensis*, and it is doubtful that they are conspecific. Four paratypes of *E. danvillensis* are in the USNM collections, and the present material from the Yorktown and Pungo River formations falls well within the range of morphologic variation of these specimens.

Epistominella pontoni (Cushman) is a similar species from strata of Miocene and Pliocene age in northwestern Florida (Plate 21: figures 7, 8). It is characterized by having 6 to 7 inflated chambers in the last whorl, depressed, nonlimbate sutures on both the spiral and umbilical sides, lobulate periphery, and a depressed umbilicus. *Epistominella danvillensis* has less convexity on the umbilical side; lacks a depressed umbilicus; has more limbate sutures on the umbilical side and undepressed sutures on the spiral side; has fewer and more compressed chambers in the last whorl; and a less lobulate periphery.

Epistominella danvillensis differs from *E. pungoensis*, new species, by having more chambers in the last whorl, a less lobulate periphery, less limbate sutures, and an imperforate umbilical area.

OCCURRENCE.—This species composes less than 1 percent of the assemblage in the lower and middle parts of the Yorktown Formation in Virginia and North Carolina and in one sample from the Pungo River Formation in North Carolina; however, in the Yorktown Formation in the Lee Creek Mine in North Carolina it composes as much as 9 percent of the assemblage. The occurrences appear to be in strata and areas representing greater water depths in the Yorktown and Pungo River formations.

STRATIGRAPHIC RANGE.—The occurrences in the Pungo River and lower and middle parts of the Yorktown formations give a documented range of upper lower Miocene (zone N8) to possibly middle Pliocene (zones N20–N21), in addition to the Eocene range of the species in the Gulf Coast.

Epistominella pungoensis, new species

PLATE 20: FIGURES 13–15; PLATE 21: FIGURES 1–6

DESCRIPTION.—Test trochospiral, small, biconvex with spiral side slightly to considerably more convex, circular to slightly oval in outline, slightly to moderately lobulate, periphery rounded, umbilical area flush to slightly depressed, containing moderate to large area of imperforate clear shell material from coalescing of limbate sutures; 3 whorls, 22 to 26 chambers, 6 to 7 in last whorl, chamber slightly inflated, gradually increasing in size; sutures distinct, slightly limbate and straight to slightly curved and strongly oblique to periphery on spiral side, radial and moderately to strongly limbate on umbilical side; aperture a moderately wide slit parallel to the periphery of the test; wall coarsely perforate.

REMARKS.—This species is characterized by having 6 to 7 chambers in the last whorl and moderately to strongly limbate sutures on the umbilical side with a large area of imperforate shell material in the umbilical region.

Epistominella pungoensis differs from *E. danvillensis* (Howe and Wallace) by having fewer and wider chambers in the last whorl (6 to 7 compared with 8 to 10), a more lobulate periphery, more strongly limbate sutures on the umbilical side, a larger area of imperforate shell material in the umbilical region, and possibly a slightly depressed umbilicus.

Epistominella pontoni (Cushman) differs in having more inflated chambers, less limbate sutures on the umbilical side, and lacking the imperforate shell material in the umbilical area.

OCCURRENCE.—The species is common (approximately 8 percent) in the Pungo River Formation in southeastern Virginia in the Norfolk Moores Bridge Well at depths of 581 to 616 feet (177 to 187.7 m) and in the upper part of bed 3 of the Fairhaven Member of the Calvert Formation at Randle Cliffs, Maryland, along the Chesapeake Bay.

STRATIGRAPHIC RANGE.—The range is uppermost lower Miocene (zone N8) to lower middle Miocene (zone N9).

TYPE-LOCALITY.—The type-locality for the holotype and figured and unfigured paratypes is from a core sample at 610 foot (186 m) depth in the Norfolk, Virginia, Moores Bridge Well.

TYPES.—The holotype is USNM 252521; figured paratypes are USNM 252522–252525; 10 unfigured paratypes are USNM 252526; all of which are from USGS locality 26003.

Genus *Rosalina* d'Orbigny, 1826

Rosalina cavernata (Dorsey)

PLATE 10: FIGURE 4; PLATE 17: FIGURES 14–16

Discorbis cavernata Dorsey, 1948:311, pl. 37: fig. 2a–c.

DESCRIPTION.—Test planoconvex, spiral side of low convexity with all chambers visible, umbilical side with large cavernous depression containing large bulbous growths on broad chamber flaps, test oval in outline, periphery narrowly rounded; 5 to 6 chambers in last whorl, increasing rapidly in size; sutures distinct, slightly depressed, strongly recurved on spiral side, less recurved and slightly limbate on umbilical side; aperture a low slit under plate-like extension of last chamber, extending to periphery, previous apertures sometimes visible; wall coarsely perforate with a brown chitinous inner lining.

DISCUSSION.—The presence of a relatively open umbilicus, broad chamber flaps, and occasional remnants of earlier apertures places this species in *Rosalina* d'Orbigny as interpreted by Loeblich and Tappan (1964:584).

OCCURRENCE.—Rare throughout the Plum Point Marl Member of the Calvert Formation in Maryland and in the lower part of the Calvert Formation in the Hammond Well on the Eastern Shore of Maryland.

STRATIGRAPHIC RANGE.—The range is uppermost lower to lower middle Miocene (zones N8 to N9).

Genus *Cancris* Montfort, 1808

Cancris sagra (d'Orbigny)

PLATE 18: FIGURES 1–3

Rotalina sagra d'Orbigny, 1839a:77, pl. 5: figs. 13–15.
Cancris sagra (d'Orbigny).—McLean, 1956:359, pl. 48: figs. 3–5, 7.

DESCRIPTION.—Test trochospiral, biconvex, moderately elongated to almost oval in outline; 6 to 7 chambers in last whorl, moderately compressed to highly inflated, rapidly enlarging; periphery broadly rounded to moderately compressed with keel, entire or lobulate; umbilical aperture a low slit under broad lip, which may extend over much of umbilicus; wall finely perforate.

OCCURRENCE.—This species is common to rare in most samples of the Yorktown, Duplin, and Waccamaw formations in Virginia and North Carolina.

STRATIGRAPHIC RANGE.—The range is lowest Pliocene, zone N19, into the modern fauna.

Genus *Elphidium* Montfort, 1808

REMARKS.—Because of the presence of areal openings on the septal face, several workers suggested that the following new species be placed in *Cribroelphidium*. The other features of the test, however, show a close relationship to the type-species and related species of *Elphidium*. In addition, examination of another species of *Elphidium* from the Croatan Formation in the Lee Creek Mine reveals that specimens of undoubtedly a single species range from forms with a row of 3 or 4 openings at the base of the septal face to forms having both basal and areal openings. The character of the aperture alone, therefore, is not considered sufficient justification to place such closely related species in different genera. This view is also stated in Loeblich and Tappan (1964:637): "Some species previously placed in *Cribroelphidium* by reason of the presence of a multiple areal aperture belong to *Elphidium*, as shown by the presence of retral processes and a complex canal system. . . ." In addition, Loeblich and Tappan (1964:632), in the description of *Elphidium*, stated that the "aperture consist[s] of row of pores at base of septal face, earlier septa may also have areal foramina due to resorption." The illustrated specimens in the following species have a broken last chamber, exposing the previous septal face, and this may be the cause for the exposed face showing areal apertures.

Elphidium neocrespinae, new species

PLATES 7, 19: FIGURES 3, 4

DESCRIPTION.—Test free, planispiral, involute, much compressed, sides flattened, nearly parallel; periphery subacute with a broadly rounded keel; umbilical regions flattened, not excavated, containing a variable number of small bosses; chambers usually distinct, although in earlier parts of last whorl sutures may be partially obscured by development of retral processes; number of chambers in final whorl variable from about 10 to 15, chambers relatively narrow and curved; sutures distinct, slightly elevated, strongly curved; retral processes distinct, numbering 11 to 15 in the later chambers, covering much of the surface of the chamber, extent variable from almost entirely across the chamber in some specimens to less than halfway in others; retral processes contain spines on their sides, extending to considerable depths into the canal region, but none on the top; low, rounded papillae common on the chamber surface; apertural face roughly triangular, slightly concave with numerous low, rounded papillae; aperture consists of a varying number of small rounded openings, both at the base of the apertural face, usually 3 in number, and as areal openings above the base, from 3 to 10; apertural openings have a complete raised rim, which may be accompanied by low papillae on the sides; wall calcareous, radial, finely perforate.

REMARKS.—*Elphidium crespinae* Cushman, known from middle Oligocene to middle Miocene strata in Australia, differs from *E. neocrespinae* in having more chambers in the last whorl (16 to 18), narrower chambers, more strongly biconvex shape with a more acute periphery and a stronger keel, in having a depressed umbilicus in most specimens, and commonly a more lobulate periphery. The morphologic variation of most characters within a population sample of *E. crespinae* is considerably greater than in samples of *E. neocrespinae*. The wide range of morphology in *E. crespinae* places the extreme specimens of that species very close to those of *E. neocrespinae*.

Elphidium subplanatum Cushman, described from the upper Oligocene to lower Miocene of Germany, differs in having more chambers, about 20 to 22 in the final whorl, and a wider area of more conspicuous bosses in the umbilical region. The probable continuation of the lineage in the Australasian area is through *E. crassatum* Cushman, described from middle Miocene to middle Pliocene strata in Australia, which differs in having more chambers in the last whorl, about 20, a slightly depressed umbilicus containing a low umbo, and a more biconvex test with a more acute periphery. Species morphologically similar to *E. neocrespinae* are found among later Cenozoic faunas in widely distributed areas. Species described include: *E. novo-zealandicum* Cushman, known from late Miocene to Holocene faunas in New Zealand and a likely continuum of the lineage in the Australasian area, which differs from *E. neocrespinae* in having 20 or more chambers in the final whorl and a more biconvex test with a depressed umbilical region containing reticulate ornamentation; *E. jenseni* (Cushman), from living assemblages in Samoa and from Pliocene and Pleistocene strata of Japan (Asano, 1938) which differs in having more chambers and a more acute and keeled periphery; *E. pustulosum* Cushman and McCullock, from the Holocene of the west coast of North and South America, which differs in having more inflated later chambers, a stronger and sharper keel, and less well-developed retral processes; and *E. earlandi* Cushman, from the Atlantic Ocean off the coast of Spain, which differs in having fewer chambers and much less-developed retral processes.

The entire group of species of *Elphidium* with strong retral process development, including the above discussed species and numerous others in the *E. macellum–E. crispum* complex, have a wide geographic and stratigraphic distribution. Although Cushman (1939) states that the Eocene species of *Elphidium* have poorly developed retral processes, subsequent descriptions have shown specimens in the Pacific area from Eocene strata with well-developed retral processes. This group possibly originates with *E. hampdenense* Finlay, from the upper lower Eocene of New Zealand,

and continues in geographic range through slightly younger *E. aguafrescaense* Todd and Kniker and *E. skyringense* Todd and Kniker, from the middle Eocene of Chile. The above three species are strongly biconvex; among the first species with a compressed test are the middle to late Oligocene forms, including *E. crespinae* from Australia and *E. subplanatum* from Germany, indicating a spread into Europe. The development of species with strong retral processes continued, but the geographic extent, as in the earlier species, is mainly in the Pacific region, including the west coast of North America and through the Mediterranean area into the Atlantic coast of Europe or Africa. The species of *Elphidium* in Eocene and Oligocene strata in the Atlantic Coast of the United States generally have poorly developed retral processes, and the *E. macellum–E. crispum* complex does not make an appearance in this area, even in the Holocene, except for a distant relative, *E. advenum* (Cushman) [or *E. fimbriatulum* (Cushman)], which is found in Pliocene and younger strata and *E. neocrespinae*. The ancestral form of *E. neocrespinae* does not occur in the Atlantic Coast area of North America as far as can be determined from the earlier species of *Elphidium*. Although *E. neocrespinae* is found during an interval in the late Pliocene to early Pleistocene, it is absent from the later Pleistocene and Holocene deposits of the Atlantic Coast. This relatively short time range for the species makes it useful for correlation.

Faujasina compressa Margerel (1971) is similar in many morphologic features to *E. neocrespinae*, such as canal system and sutural arrangement, apertural characteristics, and general surface ornamentation, but differs in being slightly plano-convex with a spiral side. The group of three species of *Faujasina* discussed by Margerel appears in the Pliocene and Pleistocene deposits of northern Europe, close in time to the appearance of *E. neocrespinae* in the eastern United States.

OCCURRENCE.—Moderately rare throughout the area, composing up to 2 percent of the foraminiferal assemblages, but it is found in most samples and, with its relatively large size, is a conspicuous member of the fauna. Specimens are found in the following units: the Croatan Formation at the Lee Creek Mine, North Carolina; the Waccamaw Formation in southern North Carolina at Walkers Bluff and Neils Eddy Landing on the Cape Fear River, an outcrop 1 mile (1.6 km) east of Neils Eddy Landing, a marl pit at Acme, marl pits at Old Dock, and the Pierce Brothers Quarry 8 miles (12.8 km) southwest of Wilmington; the Waccamaw Formation in South Carolina at Tillys Lake; the James City Formation of DuBar and Solliday (1963) at James City, North Carolina; and the uppermost part of the "Yorktown" Formation along the Chowan River, North Carolina at Colerain Landing, Mt. Gould Landing, one-half mile (0.8 km) south of Mt. Gould Landing, and Black Rock Landing.

STRATIGRAPHIC RANGE.—Based upon the ranges of the co-occurring planktonic Foraminifera, E. *neocrespinae* has a probable range of zones N21 (upper Pliocene) and N22 (lower Pleistocene). *Elphidium neocrespinae* is absent from the many samples examined from the Duplin Formation in North and South Carolina and the Yorktown Formation in North Carolina and Virginia, most of which are dated as belonging to zones N19/N20 and probably lower N21. The species is also absent from the upper Pleistocene strata in North Carolina, such as exposed at Flanners Beach and Terra Ceia, from upper Pleistocene deposits in Virginia and Maryland (Langleys Bluff and Cornfield Harbor), and from the living faunas off the coast.

TYPE-LOCALITY.—The locality for the holotype and figured paratypes is the Lee Creek Mine, North Carolina, in the Croatan Formation. Unfigured paratypes are from the Waccamaw Formation at Old Dock and Walkers Bluff, North Carolina, and from the "Yorktown" Formation one-half mile (0.8 km) below Mt. Gould Landing on the Chowan River, North Carolina.

TYPES.—The holotype is USNM 240133; figured paratypes are USNM 240130, USNM 240131, and USNM 240132; all of which are from USGS locality 25997. Unfigured paratypes are USNM 240148 from USGS locality 26021, USNM 240149 from USGS locality 25926, and USNM 240150 from USGS locality 25927.

Elphidium compressulum Copeland

PLATE 19: FIGURES 5, 6; PLATE 21: FIGURES 14, 15

Elphidium compressulum Copeland, 1964:262–263, pl. 37: figs. 3a,b.

DESCRIPTION.—Test planispiral, involute, strongly compressed; outline an elongate oval, not lobulate in early portion but may be slightly to moderately so in later portions; periphery narrowly rounded; umbilical region may be slightly depressed, commonly containing one small boss or may be completely filled with clear shell material flush with chamber walls; chambers compressed in early portion of final whorl, later becoming slightly inflated; 9 to 12 chambers in last whorl; sutures distinct, slightly depressed to flush with surface, may be thickened, slightly to moderately recurved; short retral processes well developed; aperture composed of small rounded openings at base of apertural face as well as areal openings; wall moderately coarsely perforate.

DISCUSSION.—The extreme compression of the test, the presence of short and broad, but well-defined retral processes, thickened sutures below the retral processes, and coarse wall porosity characterize this species. Some specimens from the Waccamaw and Croatan formations are less compressed and have an umbilical umbo projecting above the chamber surface.

OCCURRENCE.—The initial description of this species was from the Duplin Formation in southern North Carolina, and is most widely found there, in abundances up to 3 percent. It is fairly widespread in abundances of less than 1 percent in the Waccamaw and Croatan formations in central and southern North Carolina. The species occurs at some localities in the upper part of the Yorktown Formation, particularly those near Suffolk in southeastern Virginia.

STRATIGRAPHIC RANGE.—The known range of this species is from the upper part of the Yorktown and Duplin formations (probably middle Pliocene) to the lower Pleistocene strata of the Croatan and Waccamaw formations.

Elphidium gunteri Cole

PLATE 19: FIGURES 7, 10

Elphidium gunteri Cole, 1931:34, pl. 4: figs. 9, 10.—Cushman, 1939:49, pl. 13: fig. 10.—Copeland, 1964:263, pl. 37: fig. 4a,b.

DESCRIPTION.—Test free, planispiral, involute, slightly compressed; periphery broadly rounded, not lobulate; umbilical regions usually filled with a series of large pustules, as many as 15, occasionally containing only a single large boss or entirely lacking any filling; chambers distinct, 12 to 15 in last whorl; sutures usually radial, sometimes slightly recurved, well marked by retral processes; retral processes well developed along entire sutural area, may be raised above chamber surface; wall rather coarsely perforate; aperture composed of rounded openings at base of apertural face.

DISCUSSION.—Test shape, type of umbilical filling, and development of the retral processes vary in *E. gunteri*. The test varies from a very broad oval shape with almost parallel sides and a broadly rounded periphery to a more compressed shape that tapers from the umbilical region toward the more narrowly rounded periphery. The most common type of umbilical filling is a series of about 10 moderate-sized clear pustules; however, in some specimens there may be several pustules or just one large pustule or boss, or in smaller specimens nothing in the umbilical area. The retral processes vary in development; they may be very strong and extend across much of the chamber and have a rounded shape that is raised above the chamber surface or be considerably shorter and have a flattened shape that is flush with the chamber surface.

OCCURRENCE.—This species is commonly found in low frequencies, up to 3 percent, in most of the samples from the Croatan Formation in the Lee Creek Mine, the Duplin and Waccamaw formations in southern North Carolina, and the uppermost part of the "Yorktown" Formation in the beds along the Chowan River in northeastern North Carolina.

STRATIGRAPHIC RANGE.—In addition to its range from the middle Pliocene (Duplin) to the lower Pleistocene (Croatan, Waccamaw) in North Carolina, the species is known from the Caloosahatchee Formation (upper Pliocene and lower Pleistocene) in Florida and also is found living in the Gulf of Mexico. The range for the southeastern United States would be from middle Pliocene to Holocene.

Elphidium latispatium latispatium Poag, new status

PLATE 22: FIGURES 3, 11, 12, 15, 16

Elphidium latispatium Poag, 1966:415, pl. 7: figs. 3, 4.
Elphidium cf. *E. poeyanum* (d'Orbigny).—Cushman and McGlamery, 1938:106, pl. 25: figs. 5, 7.

DESCRIPTION.—Test planispiral, involute, moderately compressed; periphery broadly rounded, slightly lobulate; umbilical regions flush to slightly depressed, commonly containing 3 or 4 irregular bosses; chambers distinct, increasing slowly in size, 10 to 12 in last whorl; sutures incised, slightly recurved; retral processes well developed along most of suture except for periphery; processes relatively short, may have slight inflation at proximal end giving bulbous appearance; aperture composed of small, rounded openings at base of apertural face; wall calcareous, finely perforate.

REMARKS.—A comparison was made between Cushman and McGlamery's specimens and other specimens from the Chickasawhay Formation at Choctaw Bluff and a topotypic population sample of *E. latispatium latispatium*, described from the overlying Paynes Hammock Formation. There is a close similarity in most characteristics, except that the specimens from the Chickasawhay at Choctaw Bluff generally have slightly shorter retral processes and a more bulbous shape (Plate 22: figures 11, 12, 15). This subspecies has shorter retral processes than those found in *E. latispatium pontium*.

OCCURRENCE.—Poag (1966) recorded this form from the Chickasawhay Formation in Mississippi, the Paynes Hammock Formation in Alabama and Mississippi, and the Tampa Limestone in Florida. The subspecies is also found in Cushman and McGlamery's material from the Chickasawhay Formation in Alabama. Examination of the Smithsonian collections yielded specimens identified as *Elphidium* species from the Frio Clay in Texas, which also belong to this taxon. The specimens are from a depth of 5805 to 5810 feet (1769 to 1770.8 m), described as 600 feet (182.8 m) below the top of the Frio in Magnolia Petroleum Company's Corpus Christi Bank #2, Plymouth Field, San Patricio County, Texas. A note on the back of the slide states that this form is found throughout the Frio. This form has not been recognized in the Atlantic Coast.

STRATIGRAPHIC RANGE.—This subspecies ranges through the Chickasawhay and Paynes Hammock formations, which were dated by Poag (1972a:266) as late Oligocene in age, equivalent to zones N2–N3.

Elphidium latispatium pontium, new subspecies

PLATE 12: FIGURES 15, 16; PLATE 13: FIGURES 8, 9; Plate 19: FIGURES 8, 9; PLATE 22: FIGURES 9, 10, 13, 14

Elphidium poeyanum d'Orbigny.—Dorsey, 1948:302, pl. 35: figs. 7a, 8b.

DESCRIPTION.—Test planispiral, involute, slightly to moderately compressed; periphery broadly rounded, slightly lobulate; umbilical regions flush to slightly depressed, commonly contain 3 or 4 irregular bosses; chambers distinct, increasing slowly in size, 10 to 12 in last whorl; sutures incised, usually radial to slightly recurved in later chambers, slightly to moderately recurved in earlier; retral processes well developed along entire sutural area, bridges vary in width from moderately thin to broad; aperture composed of small, rounded openings at base of apertural face; wall finely perforate, calcareous, optically radial.

REMARKS.—This species is the oldest *Elphidium* in the Oligocene and Miocene of the central Atlantic region, and is followed by a number of species in the uppermost Miocene and Pliocene of Virginia and North Carolina.

This subspecies differs from *E. latispatium latispatium* by having longer retral processes that continue across the periphery, and by the later sutures being less recurved to radial. The population from the Silverdale beds of Vokes (1969), although belonging to *E. latispatium pontium*, has individuals with short retral processes approaching those found in *E. latispatium latispatium*.

Dorsey (1948) and Cushman and McGlamery (1938) incorrectly placed this subspecies in *E. poeyanum*. *Elphidium poeyanum* differs in having fewer chambers (7 to 9) in the last whorl, a more coarsely perforate wall, a more depressed umbilicus, a more elongate test outline, and more recurved sutures in the later part of the test.

Several species described from the Oligocene and Miocene of Europe have characters similar to this species. They include *Elphidium antoninum* (d'Orbigny), *E. listerii* (d'Orbigny), *E. hauerinum* (d'Orbigny), *E. rugosum* (d'Orbigny), *E. minutum* (Reuss), *E. latidorsatum* (Reuss), and *E. articulatum* (d'Orbigny). These species all differ from *E. latispatium* in variable combinations of characters, but do belong in a closely related grouping. Twelve specimens on a slide in the Smithsonian USNM collections, labeled only "*E. rugosum* d'Orbigny, Sarmat," do not belong to that species but do belong to *E. latispatium pontium*, confirming the European connection of this group.

Elphidium gunteri Cole differs in having longer and stronger retral processes, a more inflated test shape, and generally more umbilical bosses.

Elphidium excavatum (Terquem) includes 5 subspecies (Feyling-Hanssen, 1972). In addition to the nominate form, they are *E. excavatum clavatum* Cushman, *E. excavatum selseyensis* (Heron-Allen and Earland), *E. excavatum alba* Feyling-Hanssen, and *E. excavatum lidoensis* Cushman. Although these taxa show considerable variation among themselves, they differ as a group from *E. latispatium* by having poorly developed retral processes, fewer chambers, papillae in umbilical, apertural, and sutural areas, more convexity of test in umbilical regions, and generally either a large boss or many small bosses in the umbilicus.

OCCURRENCE.—This subspecies occurs in the Silverdale beds of Vokes (1967) in Jones, Carteret, Craven, and parts of adjacent counties in the central part of eastern North Carolina, and in the lower and middle parts of the St. Marys Formation in Calvert and St. Marys counties, Maryland.

STRATIGRAPHIC RANGE.—The range of this subspecies is from the upper Oligocene and lower Miocene (zones N3–N4), to probable middle Miocene (post-zone N11).

TYPE-LOCALITY.—The type locality for the holotype and some of the figured and unfigured paratypes is Langley's Bluff on the western shore of Chesapeake Bay, St. Marys County, Maryland, in the St. Marys Formation. The other figured and unfigured paratypes are from the Silverdale beds of Vokes (1967) southeast of Maysville, Jones County, North Carolina, on the Long Point Road to the White Oak River.

TYPES.—The holotype is USNM 252571 from USGS locality 25955; figured paratypes are USNM 252572 and 252573 from USGS locality 25955, and USNM 252574 and 252575 from USGS locality 22294. Unfigured paratypes are USNM 252576 from USGS locality 25955, and USNM 252577 from USGS locality 22294.

Elphidium limatulum Copeland

PLATE 11: FIGURES 9–12

Elphidium limatulum Copeland, 1964:263–264, pl. 37: fig. 5a–b.

DESCRIPTION.—Test free, planispiral, involute, moderately compressed; periphery broadly rounded; umbilical regions slightly to moderately depressed, containing 20 to 40 pustules of varying sizes; chambers increasing gradually in size, numbering 9 to 11 in last whorl; sutures deeply incised, moderately recurved; retral process development varies from the presence of 4 to 6 short, broad processes in the later chambers of larger specimens to the total absence in medium to small specimens; aperture composed of small, rounded openings at the base of the apertural face; wall glossy, finely perforate.

REMARKS.—The development of the retral processes is variable in this species. Large adult specimens usually have short, broad retral processes, particularly near the umbilicus in the later chambers (Plate 11: figure 11), but many medium- to small-sized individuals lack them completely (Plate 11: figure 9). The glossy wall, large number of umbilical pustules, and weak development of retral processes characterize the species.

OCCURRENCE.—Rare to common throughout the Croatan Formation in the Lee Creek Mine, the Waccamaw and Duplin formations in southern North Carolina, and in the uppermost part of the "Yorktown" Formation as exposed along the Chowan River in North Carolina.

STRATIGRAPHIC RANGE.—The known range of this species is from the Duplin Formation (probably middle to upper Pliocene) to the lower Pleistocene (Croatan and Waccamaw formations).

Genus *Cibicides* Montfort, 1808

REMARKS.—During studies of the species of *Cibicides* on the scanning electron microscope, the presence of structures in the large pores was noted, first in *C. pungoensis*, new species, and subsequently in the other species as they were examined. The structures in the pores are sieve-like in appearance. The pore pattern in the sieve plate is generally consistent within each of the species, although it differs among the species. The sieve plates are most readily visible on the umbilical side, particularly on the last several chambers. They are less prominent on the spiral side, also occurring most noticeably in the last several chambers, probably because the sieve plates are near the surface in the last two or three chambers, but are more deeply recessed in the earlier chambers in the whorl.

The arrangement of the pores in the sieve plates differs among species. In *C. pungoensis*, new species, the pores are small and numerous, as many as 20 to 25, mostly round with some elongate, and some of the interpore areas are considerably raised (Plate 13: figures 3, 10). In *C. cravenensis*, new species, the pores are large and few in number, from 1 to 4, mostly irregular in shape, and have a raised collar around the outside of the wall pore (Plate 14: figures 5, 7, 9). In *C. croatanensis*, new species, the sieve pore pattern is more variable, particularly between the spiral and umbilical sides. Some specimens have 8 to 10 medium-sized rounded sieve pores with raised ridges between (most commonly on the umbilical side), and others have a thin, flat plate with several irregular openings (most commonly on the spiral side) (Plate 10: figures 8, 10).

Several descriptions of structures within the pores of Foraminifera have been made, including the "foraminal plugs" in *Elphidium crispum* (Jepps, 1942:625–627), "bouchons" in *Planorbulina mediterranensis* (Le Calvez, 1938:236, 1947), "dark disks" in *Discorbis erecta* (Le Calvez, 1947), "sieve plates" in several species (Jahn, 1953), "pore plugs" in *Discorbinopsis aguayo* (Arnold, 1954a, 1954b), and "sieve plates" in *Amphistegina* (Hansen, 1972b). The reported pore structures vary in position and shape, and include structures with similarity to the presently figured ones; however, all the previously described pore structures are of organic composition and thus differ from the present ones, which are largely calcareous.

It is not known at present whether calcareous "sieve plates" are widespread in species of *Cibicides* or restricted to this group of species from the Oligocene through lower Pleistocene in the Atlantic Coastal Plain.

Cibicides cravenensis, new species

PLATE 14

DESCRIPTION.—Test trochospiral, biconvex, spiral side slightly to moderately convex, umbilical side moderately to strongly convex; broad, prominent umbo on umbilical side; periphery very slightly lobulate, keeled, acute; chambers compressed, increasing gradually in size, 11 to 13 in last whorl; sutures strongly recurved on both sides, moderately limbate and raised on both sides; aperture a narrow slit along inner margin of spiral side of final chamber and extending as an arch onto umbilical side, with thickened rim; wall calcareous, optically indistinctly radial, coarsely perforate on both sides, pores on both sides commonly containing "sieve plates" with 1 to 5 irregular openings, pores commonly surrounded by raised collar.

REMARKS.—The distinguishing characters of this species are the broad umbo on the spiral side, convex umbilical side, limbate, raised, curved sutures on the umbilical and spiral sides, keel throughout, and coarse pores on both sides.

Cibicides cravenensis, new species, and *C. pungoensis*, new species, differ by the latter having a strongly lobulate and irregular adult form with nonlimbate, depressed sutures on the umbilical side and a flat spiral side that has more strongly limbate and raised sutures. *Cibicides elomoensis* Rau differs in being smaller in size and having a less conspicuous keel. *Cibicides cravenensis* is distinguished from *C. falconensis* Renz by having a stronger umbo and more limbate sutures on the umbilical side and a more convex spiral side. *Cibicides cravenensis* is similar to *C. floridanus* (Cushman), but has a stronger keel, broader and more highly raised sutures on both sides, and is more coarsely perforate on the umbilical side.

OCCURRENCE.—This species is abundant in the subsurface in the limey facies of the Pungo River Formation in the Croatan National Forest area between New Bern and Morehead City, North Carolina.

STRATIGRAPHIC RANGE.—The range is upper lower Miocene (zone N8), with a possibility of a slightly lower limit in the lower Miocene.

TYPE-LOCALITY.—The holotype and figured and unfigured paratypes are from a well core at a depth of 48.5 to 49.5 feet (14.7 to 15.0 m) near Great Lake in Craven County, North Carolina.

TYPES.—The holotype is USNM 252527, figured paratypes are USNM 252528 through 252532, 10 unfigured paratypes are USNM 252533; all of which are from USGS locality 26018.

Cibicides croatanensis, new species

PLATE 10: FIGURES 5–8, 10; PLATE 20: FIGURES 5–9

DESCRIPTION.—Test trochospiral, plano-convex with umbilical side moderately convex, spiral side commonly has undulating surface consisting of depressions at sutures and strong overgrowths on early chambers; small umbo on umbilical side, more pronounced in early stages; periphery slightly to moderately lobulate, subacute, slight keel throughout; chambers compressed, increasing gradually in size, 9 to 10 in last whorl, later chambers sometimes irregular in shape; sutures strongly recurved on spiral side, less recurved on umbilical side; moderately limbate on both sides in early stages, becoming slightly limbate and depressed in later stages; aperture a narrow slit along inner margin of spiral side of final chamber and extending as a broad arch with thickened rim onto umbilical side; wall calcareous, optically indistinctly radial, coarsely perforate on both sides, pores deeply set in wall with thickened ridges between pores, thickening of wall in earlier chambers of last whorl covers many of the pores and is more prevalent on umbilical side, pores on both sides commonly containing sieve plates; on umbilical side, most sieve plates have as many as 10 rounded openings with raised ridges inbetween, on spiral side plates have as many as 5 irregular openings in a generally flat plate.

REMARKS.—This species is characterized by having coarse pores, deeply set in thickened wall on both sides, a flat spiral side with thickened surface over early chambers, and a moderately convex umbilical side with recurved limbate sutures.

Cibicides croatanensis differs from *C. altamiraensis* Kleinpell in having coarser pores and more strongly limbate and raised sutures on the umbilical side. *Cibicides croatanensis* is distinguished from *C. ornatus* (Cushman) by having fewer chambers in the last whorl, coarser pores, and lacking pustules on inner chambers on the spiral side.

OCCURRENCE.—Rare to common (as much as 4.5 percent) in the Croatan Formation in the Lee Creek Mine. It also occurs in abundances of less than 1 percent in scattered localities in the Waccamaw Formation in southern North Carolina, including Acme and Old Dock, and in the uppermost beds of the "Yorktown" Formation along the Chowan River in northeastern North Carolina at Mt. Gould Landing and Black Rock Landing.

STRATIGRAPHIC RANGE.—Upper Pliocene to lower Pleistocene (zones N21–N22).

TYPE-LOCALITY.—The holotype and figured and unfigured paratypes are from the Lee Creek Mine, North Carolina, in the Croatan Formation.

TYPES.—The holotype is USNM 252534, figured paratypes are USNM 252535 to 252539, 10 unfigured paratypes are USNM 252540; all of which are from USGS locality 25997.

Cibicides pungoensis, new species

PLATE 13: FIGURES 1–7, 10

DESCRIPTION.—Test medium to large, trochospiral, spiral side flat to strongly concave, umbilical side slightly to strongly convex, becoming partially evolute in later chambers; strongly projecting umbo on umbilical side; in early stages periphery subrounded, slightly lobulate with keel, becoming strongly lobulate and acute with less-developed keel in later stages; chambers increasing gradually in size, 9 to 11 in last whorl, later chambers irregular in shape; sutures strongly recurved on spiral and umbilical sides, limbate and raised in early stages on umbilical side, gradually becoming nonlimbate and moderately depressed in later stages on both sides; aperture a narrow slit along inner margin of spiral side of final chamber and extending as an arch onto umbilical side, with thickened rim; wall calcareous, optically indistinctly radial, coarsely perforate on both sides, pores on both sides containing sieve plates that have small circular to oval pores, as many as 25, and raised ridges between pores.

REMARKS.—This species is characterized by the prominent umbo, strongly limbate and raised sutures in the early stages, which become nonlimbate and depressed in the later stages on the umbilical side; a circular and slightly lobulate early shape, which becomes highly lobulate and somewhat evolute in the later stages, and coarse pores on both sides. The test may have a strongly concave spiral side, a shape attributed in *C. lobatulus* (Walker and Jacob) to attachment to seaweed during growth.

The change in outline during growth from circular to irregular and strongly lobulate also is similar to that found in *C. lobatulus* by Nyholm (1961). *Cibicides pungoensis* differs in having a strongly developed umbo and limbate sutures, and generally is more coarsely perforate, especially on the umbilical side. *Cibicides pungoensis* differs from *C. cravenenisis* in its more lobulate adult shape and a flat to concave spiral side with less limbate and raised sutures.

OCCURRENCE.—Rare to common in the "Virginia St. Marys" beds in the Gatesville Well, North Carolina, at depths of 131 to 138 feet (39.9 to 42.0 m).

STRATIGRAPHIC RANGE.—Upper Miocene.

TYPE-LOCALITY.—The holotype and figured and unfigured paratypes are from the Gatesville Well, North Carolina, at a depth of 131.5–132 feet (40.0 to 40.2 m) in the "Virginia St. Marys" beds.

TYPES.—The holotype is USNM 252541, figured paratypes are USNM 252542 to 252544, 10 unfigured paratypes are USNM 252545; all of which are from USGS locality 25992.

Genus *Virgulinella* Cushman, 1932

Virgulinella miocenica (Cushman and Ponton), new combination

PLATE 10: FIGURE 3; PLATE 17: FIGURES 12, 17, 18

Virgulina miocenica Cushman and Ponton, 1931:32, pl. 4: figs. 14–16.

Virgulina (*Virgulinella*) *miocenica* Cushman and Ponton.—Cushman, 1937:35, pl. 5: figs. 15–16.—Dorsey, 1948:305, pl. 36: fig. 12.

DESCRIPTION.—Test elongate, about 3 times as long as wide, tapering toward both ends; early part of test may be straight or curved; chambers inflated, distinct, with numerous arcuate projections to previous chambers; sutures distinct, with arcuate pattern; aperture elongate, narrow, straight to slightly curved, extending from base of final chamber nearly to apex, with toothplate; wall smooth, glassy, finely perforate.

OCCURRENCE.—Rare to common throughout the Calvert, Choptank, and St. Marys formations in Maryland and northern Virginia, the Pungo River Formation in North Carolina, and through the "Virginia St. Marys" in Virginia.

STRATIGRAPHIC RANGE.—The range in the central Atlantic Coastal Plain is from uppermost lower Miocene (zone N8) to the top of the upper Miocene (probably near the end of zone N17).

Genus *Astrononion* Cushman and Edwards, 1937

Astrononion stelligerum (d'Orbigny)

PLATE 11: FIGURES 13–16; PLATE 12: FIGURES 1, 2

Nonionina stelligera d'Orbigny, 1839:128, pl. 3: figs. 1, 2.
Astrononion stelligerum (d'Orbigny).—Cushman and Edwards, 1937:31, pl. 3: fig. 7a,b.—Hornibrook, 1964:334, pl. 1: figs. 5–9, 14, 15.—Le Calvez, 1974:37–38, pl. 9: figs. 1–4.

DESCRIPTION.—Test free, relatively small, planispiral, involute, moderately to strongly compressed; periphery rounded, umbilical regions slightly depressed; chambers increasing gradually in size, 7 to 9 in last whorl; sutures distinctly incised, slightly recurved; in early part of last whorl relatively narrow tubes are present along sutures, extending from umbilicus about one-third of way along the sutures with outer ends of tubes opening into sutures; in later part of last whorl tubes are modified into flattened essentially triangular plates that are attached to chamber on anterior side and open down outermost part of posterior side; plates join in umbilical region forming large plate over area; aperture is low, simple, rimmed, arched slit at base of final chamber.

REMARKS.—A neotype for this species has been selected by both Hornibrook (1964) and Le Calvez (1974). Each noted that the type specimen had "disintegrated." Topotypic material from Teneriffe Island was not available to Hornibrook, so he picked a specimen from the nearby island of Las Palmas as the neotype. As all the conditions for the establishment of a neotype appear to have been met by Hornibrook, his designation of the neotype would stand even though Le Calvez subsequently designated a specimen from the d'Orbigny collection from Teneriffe as neotype. A comparison of the illustrations of each neotype shows that both appear to be well within the variation of the species.

The specimens in the present material generally have fewer chambers, ranging from 7 to 9 in comparison to 10, and a more pronounced umbilicus than those illustrated by Hornibrook and Le Calvez.

OCCURRENCE.—Except for one specimen found in the lower Pliocene part of the Yorktown Formation in Virginia, this species is rare in the Croatan Formation in North Carolina (upper Pliocene and lower Pleistocene).

STRATIGRAPHIC RANGE.—Although found in the Pliocene and Pleistocene of the Atlantic Coastal Plain, this species has been recorded from lower Miocene strata in Europe and New Zealand, and continues into the modern fauna.

Genus *Florilus* Montfort, 1808

Florilus chesapeakensis, new species

PLATE 11: FIGURES 7, 8; PLATE 18: FIGURES 7, 8, 11, 12

Nonion medio-costatum sensu Dorsey, 1948:300, pl. 35: fig. 4a–c.

DESCRIPTION.—Test relatively large, planispiral to slightly asymmetrical, longer than broad, with width increasing rapidly in later stages, periphery subrounded to subacute, umbilical regions slightly to moderately depressed, containing slight to moderate amount of pustulose material, which may extend onto apertural face; chambers distinct, about 13 in last whorl, much higher than wide, increasing abruptly in width as seen in apertural face, marked by slightly to sharply raised areas between sutures, raised areas extend from the umbilicus to about halfway to the periphery; sutures distinct, slightly depressed, moderately to strongly limbate, especially in earlier chambers in last whorl, moderately recurved, containing single row of pustules extending as far as halfway to periphery; apertural face broadly heart-shaped, aperture a low, curved slit at base of apertural face; wall calcareous, finely perforate.

REMARKS.—This species is characterized by the slightly to sharply raised areas between the inner parts of the sutures, the limbate sutures, and the abrupt increase in width of the heart-shaped apertural face. It differs from *Florilus medio-costatum* (Cushman) by having generally stronger raised areas between the sutures with the raised areas being found earlier in the last whorl, by more strongly limbate sutures, and in having a much more flaring test in the later chambers with the apertural face almost twice as wide. *Florilus costiferus* (Cushman) differs in having more chambers in the last whorl (approximately 20), lacking the raised chamber areas, and having more strongly limbate sutures. *Florilus incisa* (Cushman) is similar except for the absence of the raised areas between the sutures.

OCCURRENCE.—Rare to common in samples from the Calvert, Choptank, and St. Marys formations in Maryland and Virginia, and the Pungo River Formation in North Carolina.

STRATIGRAPHIC RANGE.—This species first occurs in beds placed in the uppermost lower Miocene (zone N8) and continues into upper Miocene strata.

TYPE-LOCALITY.—The holotype is from Windmill Point on the St. Marys River, Maryland, in the St. Marys Formation. Figured paratypes are from the Calvert Formation at Governors Run, Maryland, and figured and unfigured paratypes are from the "Virginia St. Marys" beds in the Gatesville Well in North Carolina. Unfigured paratypes are from the Choptank Formation at Flag Pond, Maryland.

TYPES.—The holotype is USNM 252565 from USGS locality 25992; figured paratypes are USNM 252566 from USGS locality 25983, and USNM 252567 from USGS locality 25969; unfigured paratypes are 5 specimens, USNM 252568 from USGS locality 25992 and 5 specimens, USNM 252569 from USGS locality 25962.

Genus *Nonion* Montfort, 1808

Nonion advenum pustulosum, new subspecies

PLATE 22: FIGURES 1, 2, 4–6

DESCRIPTION.—Test planispiral, circular to oval in side view, moderately compressed; periphery broadly rounded, slightly lobulate; umbilical region not depressed, filled with a small to occasionally moderate-sized boss and moderate to large amount of small pustules, with pustules extending onto excavated sutures and apertural face; 10 to 13 chambers in last whorl; sutures deeply incised on chamber sides, slightly so on periphery, with deep excavation near boss, moderately recurved; aperture composed of small, rounded openings at the base of the apertural face; wall calcareous, optically granular, finely perforate.

DISCUSSION.—This subspecies is characterized by a generally small umbilical boss, abundant pustulose material, excavated sutures, and 10 to 13 chambers in the last whorl.

Populations of *Nonion advenum advenum* (Cushman) differ in generally having a larger umbilical boss, a more discoid shape with a subacute periphery, more extensive excavated sutures, and less pustulose material. A specimen from the Chickasawhay Formation at Choctaw Bluff on the Alabama River is illustrated (Plate 22: figures 7, 8). Some specimens of *N. advenum pustulosum* in the populations from North Carolina have a larger umbilical boss and less pustulose material and approach the minimum development of those characters in specimens of *N. advenum advenum* from Alabama.

Nonion advenum pustulosum is larger than *N. calvertensis*, new species, and has more chambers in the last whorl, a smaller boss, and more pustulose material.

Nonion inexcavatum (Cushman and Applin) differs in having a more compressed test with a subacute periphery, a larger umbilical boss, and the absence of excavated sutures in the umbilical area.

OCCURRENCE.—This subspecies occurs in the "Silverdale-age" beds on the central Atlantic Coastal Plain area of North Carolina, particularly exposures in Onslow, Craven, and Carteret counties. The subspecies is usually abundant, composing more than 50 percent of the total assemblage in some samples.

STRATIGRAPHIC RANGE.—The subspecies is restricted to the upper Oligocene Silverdale beds of Vokes (1967) (probably zones N2–N3). It is not found in the overlying uppermost lower Miocene Pungo River Formation (zones N8–N10).

TYPE-LOCALITY.—The type-locality for the holotype, figured paratypes, and unfigured paratypes is near Long Point on the White Oak River, Carteret County, North Carolina.

TYPES.—The holotype is USNM 252561, figured paratypes are USNM 252562 and 252563, and 10 unfigured paratypes are USNM 252564, all of which are from USGS locality 22294.

Nonion calvertensis, new species

PLATE 12: FIGURES 3–8; PLATE 19: FIGURES 1, 2

Nonion advenum sensu Dorsey, 1948:299–300, pl. 35: fig. 1a–c.

DESCRIPTION.—Test planispiral, small, nearly circular in side view, moderately compressed; periphery broadly rounded; umbilical region filled with a large clear boss that may be even in height with sides of chambers or project well beyond them; the boss is joined to the chamber sides in the earlier chambers of the last whorl, but not in the last 3 or 4 chambers; a small amount of pustulose material is found in the umbilicus, extending up the sutures and onto the apertural face; chambers increasing gradually in size, numbering 8 to 10 in the last whorl; sutures deeply incised on chamber sides, not on periphery, with deep excavation nearing boss, moderately recurved; aperture composed of small, rounded openings at the base of the apertural face; wall finely perforate, calcareous, optically granular.

DISCUSSION.—This subspecies is characterized by its small size and circular shape with a rounded periphery, 8 to 10 chambers in the last whorl, a prominent umbilical boss in most specimens and having the inner part of the sutures excavated and containing a small amount of pustulose material. *Nonion advenum advenum* (Cushman), found in Eocene and Oligocene strata in the southeastern United States, shows considerable variation both within and between populations, but generally differs by being larger, as much as twice as large, having more chambers in the last whorl, 10 to commonly 15, and by having a more discoid-shaped test with a subacute periphery.

Nonion advenum pustulosum, new subspecies, from the upper Oligocene of North Carolina differs by being larger in size, having more chambers in the last whorl, 10 to 13, by largely lacking a prominent boss, and by having a larger amount of pustulose material in the umbilical, sutural, and apertural areas.

OCCURRENCE.—The distribution is limited to the lower and middle part of the Calvert Formation in Maryland, from beds 3 to 10 of Shattuck. The highest frequencies are found in the lower beds, reaching a peak of 14 percent in bed 8, and the lowest, less than 1 percent, in bed 10.

STRATIGRAPHIC RANGE.—Upper part of bed 3 (probably zone N8) through bed 10 (zone N9) of Calvert Formation.

TYPE-LOCALITY.—The type-locality is Randle Cliffs on the western shore of Chesapeake Bay, Calvert County, Maryland, in bed 6 of the Calvert Formation.

TYPES.—The holotype is USNM 252554; figured paratypes are USNM 252555–252558; all of which are from USGS locality 25980 in bed 6. Unfigured paratypes are USNM 252559 from USGS locality 25980 in beds 5 and 6, and USNM 252560 from USGS locality 26022.

Nonion marylandicum Dorsey

PLATE 12: FIGURES 9–14; PLATE 18: FIGURES 9, 10

Nonion marylandicum Dorsey, 1948:301, pl. 35: fig. 2a–c.

DESCRIPTION.—Test planispiral, involute, moderately compressed; periphery broadly rounded;

umbilical regions slightly depressed, filled with small pustules that also extend outward along the sutural areas; chambers may increase gradually in size in last whorl or in large specimens may have a relatively constant size; 7 to 9 chambers in last whorl; sutures deeply incised, moderately recurved; aperture a narrow slit at base of apertural face; wall finely perforate.

REMARKS.—This species is variable in the size and shape of chambers in the last whorl, largely dependent upon the size of the individual. Smaller specimens have 7 relatively compressed chambers with increasing chamber size and a small to moderate amount of pustulose material (Plate 12: figures 11, 13). Large specimens have 8 or 9 more inflated and fairly equal-sized chambers in the last whorl, and a large amount of pustulose material in the umbilical area (Plate 12: figure 9).

OCCURRENCE.—Rare throughout the upper part of the Calvert Formation in Maryland and the Choptank Formation in Maryland and Virginia. Dorsey (1948) also reported this species in the overlying St. Marys Formation in Maryland. None of her specimens from the St. Marys Formation could be found in the Smithsonian collections, but specimens collected by the author from the same localities include two species that could have been misidentified as *N. marylandicum.* One is a species of *Nonion*, represented by only a few specimens, which differs from *N. marylandicum* in having very few umbilical pustules. The other, represented by more specimens, is a species of *Anomalinoides*, characterized by a low trochospiral coiling and small amount of pustulose material in the umbilical region.

STRATIGRAPHIC RANGE.—The range is from bed 10 of the Calvert Formation upward through the Choptank Formation, which gives a middle Miocene age, ranging from uppermost zone N8 to lowermost N9 to later than zone N11.

Genus *Svratkina* Pokorný, 1956

REMARKS.—The only previously known occurrences of this genus in the New World are of *S. lajollaensis* Sliter from the Upper Cretaceous of southern California and the living *S. decorata* (Phleger and Parker) from the Gulf of Mexico.

Three new occurrences of this genus in North America were found: *S. croatanensis*, new species from the upper Pliocene part of the Croatan Formation of North Carolina and Virginia, an as yet undescribed species from upper Oligocene strata in North Carolina, and *S. crassicoria* (Poag) from the Paynes Hammock Formation (upper Oligocene) of Alabama and Mississippi.

The depth distribution of the living species within this genus is variable; *S. tuberculata* Balkwill and Wright is found in shelf waters and *S. decorata* is characteristic of depths from 1300 to 3550 m.

Four species were placed in *Svratkina* by Pokorný (1956). One of these, *Discorbina turris* Karrer, 1868, does not appear to belong to this genus based upon examination of a topotype specimen in the Smithsonian USNM collections and comparison with the original illustration. In *D. turris*, the suture pattern is radial on both sides and the aperture is round and umbilical in position, characteristics not consistent with the generic concept of *Svratkina. D. turris* probably belongs in *Glabratella* Dorreen, 1948.

Svratkina croatanensis, new species

PLATE 15

DESCRIPTION.—Test free, trochospiral, oval in outline; about 7 chambers in last whorl; all chambers visible on the spiral side, only those of the last formed whorl visible on the umbilical side; both left and right coiled specimens; sutures moderately curved on spiral side, radial to slightly curved on umbilical side; spiral side varies from essentially planar to moderately convex, umbilical side from slightly to moderately convex; periphery broadly rounded to subrounded; aperture a long narrow opening of variable height and distinctness, extending from near the umbilicus to near the periphery, without lip, but having funnel-like projection into previous chamber; wall calcareous, spiral side coarsely perforate, pores with thickened rims opening on top of low tubular necks; size of pores variable, long slits common, probably as a result of connection of a series of pores; pores scattered over most of spiral surface except for early chambers, with linear concentrations sometimes found along sutures; umbilical side largely imperforate, but some large pores are occasionally found near the periphery.

REMARKS.—This species is distinguished by the large pores that commonly coalesce into slit-like openings on the spiral side, and few pores on the umbilical side. *Svratkina tuberculata* (Balkwill and Wright) is distinguished by having strongly elevated tubercles over much of the umbilical surface. *Svratkina australiensis* (Chapman, Parr, and Collins) differs in having more pores on the umbilical side; even, moderate-sized pores on the spiral side; a very convex spiral side; even, moderate-sized pores on the spiral side; a very convex spiral side; and more chambers (9) in the last whorl. *Svratkina decorata* (Phleger and Parker) differs in having few, scattered fine tubercles. *Svratkina perlata* (Andreae) is the most similar species, but has finer pores, which also cover much of the umbilical side. Also, a lesser degree of alignment of pores is seen along the sutural areas on the spiral side.

OCCURRENCE.—Abundances of less than 1 percent in the lower part of the Croatan Formation in the Lee Creek Mine and at depths between 112.5 and 113 feet (34 and 34.4 m) in the Norfolk, Virginia, Moores Bridge Well.

STRATIGRAPHIC RANGE.—The species is restricted to the Croatan Formation and uppermost part of the "Yorktown" Formation, indicating a late Pliocene and early Pleistocene age.

TYPE-LOCALITY.—The locality for the holotype and some of the figured paratypes is the Lee Creek Mine, in the lower part of the Croatan Formation. Additional figured paratypes are from the Norfolk, Virginia, Moores Bridge Well at a depth between 112.5 and 113 feet (34 and 34.4 m).

TYPES.—The holotype is USNM 252546 from USGS locality 25997; figured paratypes are USNM 252547 and 252548 from USGS locality 25997 and USNM 252549–252553 from USGS locality 26001.

Register of USGS Localities

(Each locality is listed in the following order: number of locality, formation, location and description of collection site, collector, and date of collection.)

22294. Silverdale beds of Vokes (1967). Few inches (cm) of outcrop in bottom of gully south of Long Point Road about 0.5 miles (0.8 km) west of intersection with Haywood Landing Road; in Croatan National Forest, Jones County, North Carolina. P.M. Brown, Druid Wilson, and Alan Rubin, 17 November 1959.

25921. Chickasawhay Formation. Marl above hard limestone, Choctaw Bluff, Alabama River, Alabama (from Cushman Foraminifera Collection).

25922. Choctawhatchee Formation. Alice Creek, near N.E. corner of SE ¼ Sec. 8, T. 1N, R. 19W about 1 mile (1.6 km) NE of Old Parmenter Place, Walton County, Florida (from Cushman Foraminifera Collection).

25923. Duplin Formation. Natural Well, 2 miles (3.2 km) west of Magnolia, Duplin County, North Carolina. Four feet (122 cm) of bluish clayey sand exposed, sample 3 feet (91 cm) above base. T. Gibson, 1959.

25924. Duplin Formation. Marl pit on Barwick Farm southwest of Kenansville, Duplin County, North Carolina. Four feet (122 cm) of yellow clayey sand exposed, sample 3 feet (91 cm) above base. T. Gibson, 1959.

25925. Waccamaw Formation. Walker's Bluff on southern bank of Cape Fear River 9 miles (14.5 km) below Elizabethtown, Bladen County, North Carolina. Five feet (1.5 m) exposed; lowermost 2 feet (61 cm) of clayey sand with large pelecypods, upper 3 feet (91 cm) of yellow sand contains much shell hash: Sample 1 foot (30 cm) above base of section. T. Gibson, 1959.

25926. (same formation/location as 25925); sample 4 feet (122 cm) above base of section. T. Gibson, 1959.

25927. "Yorktown" Formation. Bluff at Mt. Gould on western bank of Chowan River in Bertie County, North Carolina. Five feet (1.5 m) of yellow clayey sand are exposed in upper part of bluff; sample 3 feet (91 cm) above base. T. Gibson, 1959.

25929. "Yorktown" Formation. Bluff on western side of Chowan River at Black Rock Landing in Bertie County, North Carolina, 1 mile (1.6 km) north of Highway 17 bridge. 9-foot (2.7-m) section exposed; sample 1½ feet (46 cm) above base of 3-foot (91-cm) unit of yellow fossiliferous sand that extends from 5 to 8 feet (1.5 to 2.4 m) above base of section. T. Gibson, 1959.

25930. (same formation/location as 25929); sample in middle of 2-foot (61-cm) bluish clayey sand unit that extends from 3 to 5 feet (0.9 to 1.5 m) above base of section. T. Gibson, 1959.

25933. Yorktown Formation. South bank of Yorktown River about 1 mile (1.6 km) downstream from Yorktown at base of Moore House bluff in James County, Virginia. 24 feet (7.3 m) of section exposed: sample 1 foot (30 cm) above base of 3-foot (91-cm)fossiliferous gray sand unit, which extends from 6 to 9 feet (1.8 to 2.7 m) above base of section, T. Gibson, 1959.

25934. (same formation/location as 25933); sample 2 feet (61 cm) above base of 4-foot (122-cm) brown sand unit, which extends from 2 to 6 feet (0.6 to 1.8 m) above base of section and contains few fossils. T. Gibson, 1959.

25937. Yorktown Formation. Bluff at Morgart's Beach on south bank of James River, 5 miles (8 km) north of Smithfield, Isle of Wight County, Virginia. 21.5 feet (6.6 m) of section exposed; sample 1.5 feet (46 cm) above base of 4-foot (122-cm) yellow sandy shell hash unit, which extends from 17.5 to 21.5 feet (5.3 to 6.6 m) above base of section. T. Gibson, 1959.

25941. Yorktown Formation. Bluff on western bank of Nansemond River 1½ miles (2.4 km) NE of Highway 258 bridge in the northern part of Suffolk, Nansemond County, Virginia. 13 feet (4 m) of yellow clayey sand exposed; lowermost 2 feet (61 cm) sparingly fossiliferous and upper 11 feet (3.4 m) very fossiliferous; sample 7 feet (2.1 m) above base of section. T. Gibson, 1959.

25942. (same formation/location as 25941): sample 8 feet (2.4 m) above base of section in *Mulinia congesta* bed. T. Gibson, 1959.

25948. Yorktown Formation. Maddry's Bluff on south bank of the Meherrin River 1 mile (1.6 km) downstream from Highway 258 bridge, 1 mile (1.6 km) northeast of Murfreesboro, Hertford County, North Carolina. 37 feet (11.3 m) of section exposed; sample 1 foot (30 cm) above base of 3-foot (91-cm) bluish clayey sand unit at base of section. T. Gibson, 1959.

25950. St. Marys Formation. Bluff ¼ mile (1.2 km) south of Little Cove Point on western shore of Chesapeake Bay, Calvert County, Maryland. 46 feet (14 m) of section exposed; sample 1 foot (30 cm) above base of 5-foot (1.5-m) bluish sandy clay unit that extends from 11 to 16 feet (3.4 to 4.9 m) above base of section. T. Gibson, 1959.

25955. St. Marys Formation. Langleys Bluff, 5½ miles (8.8 km) south of Cedar Point on western shore of Chesapeake Bay, St. Marys County, Maryland. 2½ feet (76 cm) of section exposed; lowest 6 inches (15 cm) of bluish sandy clay contains scattered fossils, upper 2 feet (61 cm) of yellow sandy clay contains concentrated fossil bands; sample 2½ feet (76 cm) above beach. T. Gibson, 1959.

25957. St. Marys Formation. Small bluff ¼ mile (0.4 km) SE of Chancellor Point, St. Marys River, St. Marys County, Maryland. 7.5 (2.3 m) feet of section exposed; sample 6 inches (15 cm) above base of 2-foot (61-cm) bluish sandy clay unit, which is at base of section. T. Gibson, 1959.

25960. Choptank Formation. Bluff ½ mile (0.8 km) south of Flag Pond on western shore of Chesapeake Bay, Calvert County, Maryland. 105 feet (32 m) of section exposed; sample 2 feet (61 cm) above base of 15-foot (4.6-m) unit of fossiliferous sand (zone 19), which extends from 17 to 32 feet (5.2 to 9.8 m) above base of section. T. Gibson, 1959.

25962. (same formation/location as 25960); sample 1 foot (30 cm) above base of 2 feet (61 cm) of bluish green sand exposed to base of section at beach level (zone 17). T. Gibson, 1959.

25965. Choptank Formation. Nomini Cliffs, 12.5 miles (2.4 km) west of eastern end of cliffs, on Potomac River, Westmoreland County, Virginia. 70 feet (21 m) of section exposed; sample 25 feet (7.6 m) above base of 30-feet (9.1-m) unit of bluish sandy clay which is at base of section. T. Gibson, 1959.

25966. Paynes Hammock Formation. Stop 6, 1975 GCAGS Guidebook. Exposure along western bank of Chickasawhay River, about 200 feet (61 m) north of U.S. Highway 84 bridge about 2.5 miles (4 km) west of center of downtown Waynesboro, Mississippi; sample in bed 12 of measured section, about 3.5 feet (1.1 m) above the contact with the underlying Chickasawhay Formation. L. Bybell, R. Christopher, and C. Smith, 25 October 1975.

25969. Calvert Formation. Bluff ¼ mile (0.4 km) south of Governor's Run on western shore of Chesapeake Bay in Calvert County, Maryland. 26.5 feet (8.1 m) of section exposed; sample 1.5 feet (46 cm) above base of 3.5-foot (1.1-m) unit of bluish sandy clay, which is at base of section. T. Gibson, 1959.

25971. Calvert Formation. Bluff ½ mile (0.8 km) south of Parker Creek on western shore of Chesapeake Bay, Calvert County, Maryland. 30 feet (9.1 m) of section exposed; sample in middle of 1-foot (30-cm) unit of blue sandy clay, fossiliferous, which extends from 4 to 5 feet (122–152 cm) above base of section (zone 12). T. Gibson, 1959.

25972. (same formation/location as 25971); sample 2.5 feet (76 cm) above base of 4-foot (122-cm) blue clay unit at base of section (zone 11). T. Gibson, 1959.

25974. Calvert Formation. Bluff 1 mile (1.6 km) south of

Plum Point on western shore of Chesapeake Bay, Calvert County, Maryland: sample 2 feet (61 cm) above beach level in 7 feet (2.1 m) of greenish fossiliferous sand of zone 10. T. Gibson, 1959.

25975. Calvert Formation. Bluff 1 mile (1.6 km) north of Plum Point on western shore of Chesapeake Bay, Calvert County, Maryland. 28.5 feet (8.7 m) of section exposed: sample 1 foot (30 cm) above base of 10-foot (3-m) unit of fossiliferous sand (zone 10), which extends 18.5 to 28.5 feet (5.6 to 8.7 m) above base of section. T. Gibson, 1959.

25977. (same formation/location as 25975); sample 6 feet (1.8 m) above base of 10-foot (3-m) unit of bluish green clayey sand (zone 8), which extends from 6 to 16 feet (1.8 to 4.9 m) above base of section. T. Gibson, 1959.

25980. Calvert Formation. Bluff south of Chesapeake Beach at Randle Cliffs Community Association Church, western shore of Chesapeake Bay, Calvert County, Maryland: sample 8 feet (2.4 m) above *Ostrea percrassa* bed (zone 4), 1 foot (30 cm) above base of thickly packed *Corbula* bed 3 feet (91 cm) thick. T. Gibson, J. Ayres, 1 July 1963.

25981. (same formation/location as 25980); sample in diatomaceous sediments, 4 feet (122 cm) below *Ostrea percrassa* bed. T. Gibson, J. Ayres, 1 July 1963.

25982. Calvert Formation. Bluffs about 1.5 miles (2.4 km) south of Plum Point on western shore of Chesapeake Bay, Calvert County, Maryland. 2 feet (61 cm) of bed 10 exposed above beach level: sample 1 foot (30 cm) below top of bed 10. T. Gibson, J. Ayres, 1 July 1963.

25983. St. Marys Formation. Bluff at Windmill Point on west side of St. Marys River, St. Marys County, Maryland. 5 feet (1.5 m) of section exposed in bank; sample 1 foot (30 cm) above base of 4-foot (122-cm) blue clayey sand unit, which is at base of section. T. Gibson, J. Ayres, 1 July 1963.

25985. Choptank Formation. Section at step area at Baltimore Gas and Electric Company Nuclear Power Plant site south of St. Leonards, Calvert County, Maryland, on western shore of Chesapeake Bay. Sample taken 1 foot (30 cm) below top of zone 17. T. Gibson, 1969.

25989. Waccamaw Formation. Pierce Bros. marl pit, about 3 miles (4.8 km) west of Town Creek on road to Winnabow, Brunswick County, North Carolina. 6.5 feet (2 m) of section exposed; sample 1 foot (30 cm) below top of 3-foot (91-cm) blue sand unit, which extends to water level. T. Gibson, D. Wilson, 22 June 1963.

25992. Pungo River Formation. Gatesville Well, North Carolina; hole located on south end of Gatesville, Gates County: sample at 131.5 feet (40.1 m) below well collar. T. Gibson and others, 1967.

25993. (same formation/location as 25992); sample 138.0 feet (42.1 m) below well collar. T. Gibson and others, 1967.

25995. "Yorktown" Formation. Texasgulf Inc. Lee Creek Mine; NW wall of test pit, Beaufort County, North Carolina. 21 feet (6.4 m) of section at top of pit; sample 1 foot (30 cm) below top of 3- to 4-foot (92-122-cm) greenish blue clayey sand unit which is 2 feet (61 cm) below top of section; top of section marked by brown cross-bedded sand. T. Gibson, 5 December 1963.

25997. (same formation/location as 25995); sample 5 feet (1.5 m) below top of 6- to 7-foot (1.8–2.1-m) blue clayey sand unit, which extends from 7 to 14 feet (2.1 to 4.3 m) below top of section. T. Gibson, 5 December 1963.

26001. "Yorktown" Formation. Moores Bridge Well, Moores Bridge Pumping Station, Norfolk, Virginia; sample 112.5 feet (34.3 m) below collar, blue-green clayey fine sand, fossiliferous. T. Gibson, 1967.

26002. Pungo River Formation. (same location as 26001); sample 581 feet (177.1 m) below collar, dark olive-green silty clay. T. Gibson, 1967.

26003. (same formation/location as 26002); sample 610 feet (239.3 m) below collar, olive-green phosphatic sand. T. Gibson, 1967.

26009. Yorktown Formation. Texasgulf Inc. Lee Creek Mine, NW wall of test pit, Beaufort County, North Carolina; sample 6 feet (1.8 m) below top of 10-foot (3-m) unit of blue clayey sand which extends from 1 to 11 feet (0.3 to 3.4 m) above base of Yorktown Formation. T. Gibson, 1963.

26010. (same formation/location as 26009); sample 9 inches (22.9 cm) below top of 1-foot (30-cm) blue sand unit containing *Placopecten clintonius*, which is lowest unit of Yorktown Formation. T. Gibson, 1963.

26012. Pungo River Formation. (same location as 26009); sample 5 feet (1.5 m) below top of 6-foot (1.8-m) yellow-green shell hash and phosphatic sand unit, which is at top of Pungo River Formation. T. Gibson, 1963.

26013. (same formation/location as 26012); sample at base of 6-foot (1.8-m) yellow-green shell hash and phosphatic sand unit, which is at top of Pungo River Formation. T. Gibson, 1963.

26014. (same formation/location as 26012); sample at top of 3-foot (91-cm) unit of interbedded limestone and phosphatic sand beds that extend from 9 to 12 feet (2.3 to 3.7 m) below the top of the Pungo River Formation. T. Gibson, 1963.

26018. Pungo River Formation. Well C181, near Great Lake, Craven County, North Carolina; 48.5 feet (12.6 m) below collar; in unit of 6.5 feet (2 m) of yellow-green sandy shell hash. T. Gibson and others, 1967.

26019. Choptank Formation, Bartein's Landing, Maryland. From interior of molluscan shells in Smithsonian USNM collections.

26020. Calvert Formation. Well core at Baltimore Gas and Electric Company Calvert Cliffs Nuclear Power Plant south of St. Leonards, Calvert County, Maryland; sample 43 at 165′10″–166′1″ below (50.5–50.6 m) collar. T. Gibson and F. Whitmore, September 1967.

26021. Waccamaw Formation. Marl pit ½ mile (0.8 km) north of Old Dock, Columbus County, North Carolina; sediment is largely coarse quartz sand; megafossils fairly common. T. Gibson, 1959.

26022. Calvert Formation. Bluff south of Chesapeake Beach at Randle Cliffs Community Association Church, western shore of Chesapeake Bay, Calvert County, Maryland; sample in 7-foot (2.1-m) unit with bands of *Corbula* more common near top; this unit immediately above *Ostrea percrassa* bed and corresponds to zone 5; sample 1 foot (30 cm) above base. T. Gibson, J. Ayres, July 1, 1963.

26023. Calvert Formation. 1 mile (1.6 km) south of Plum Point, Calvert County, Maryland: zone 12. A. Dorsey.

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PLATE 1

1, 2. *Globigerinoides altiapertwus* Bolli, Calvert Formation, Plum Point, Maryland, USNM 240082, USGS 25975: 1, spiral view; 2, apertural view. Both × 93.

3, 6. *Praeorbulina glomerosa glomerosa* (Blow), Calvert Formation, Plum Point, Maryland, USNM 240083, USGS 25974: 3, spiral view; 6, side view. Both × 93.

4, 5. *Globigerinoides sicanus* de Stefani, Calvert Formation, Parker Creek, Maryland, USNM 240084, USGS 25972: 4, umbilical view; 5, spiral view. Both × 148.

7–9. *Globigerina praebulloides pseudociperoensis* Blow, Calvert Formation, Plum Point, Maryland, USNM 240086, USGS 25975: 7, umbilical view; 8, edge view; 9, spiral view. All × 93.

10. *Globigerina apertura* Cushman, Yorktown Formation, Suffolk, Virginia, USNM 240085, USGS 25941: umbilical view, × 150.

11–13. *Globigerinita glutinata ambitacrena* (Loeblich and Tappan), Yorktown Formation, near Murfreesboro, North Carolina, USNM 240087, USGS 25948: 11, spiral view; 12, umbilical view; 13, side view. All × 93.

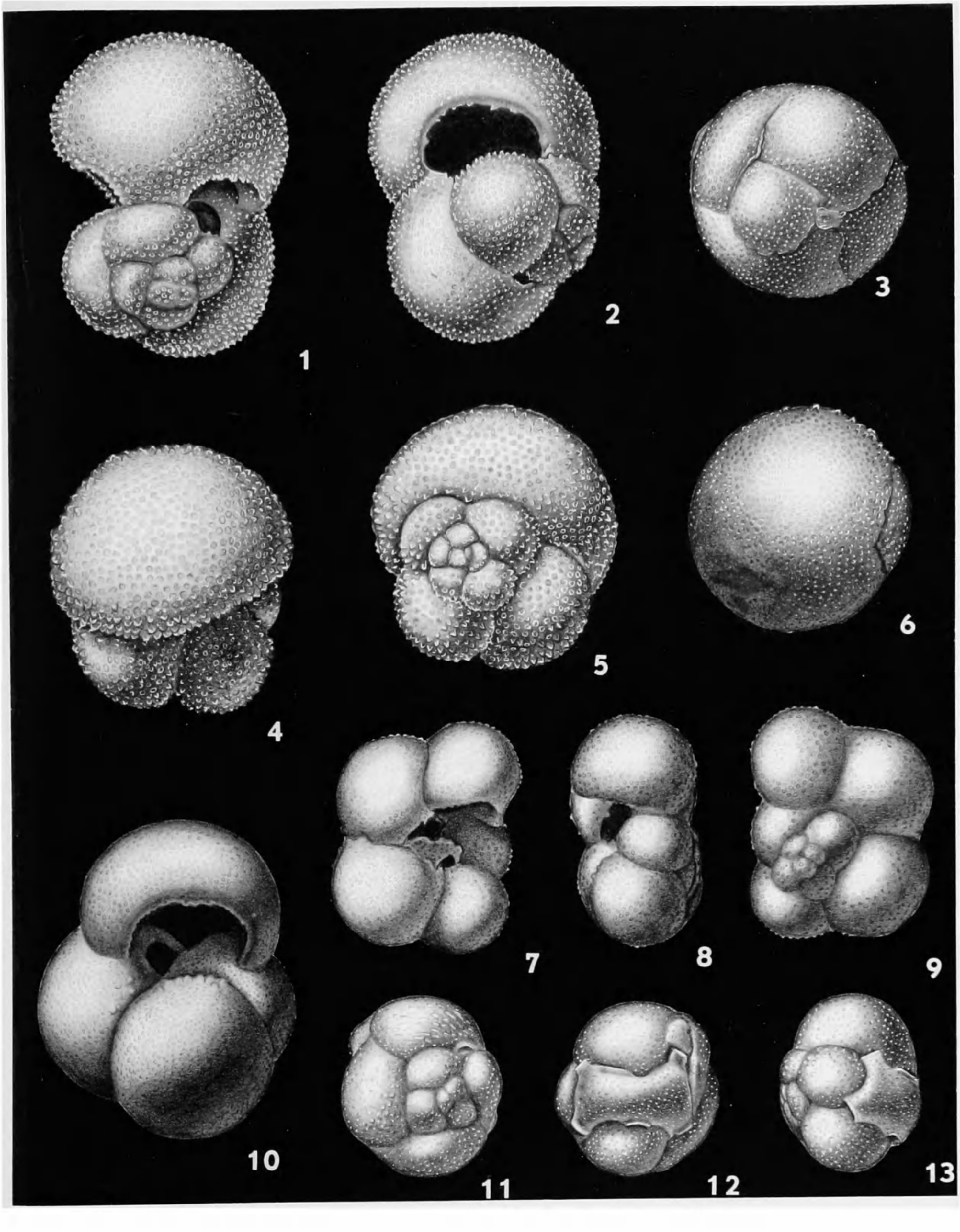
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PLATE 2

1–3. "*Turborotalia*" *acostaensis humerosa* (Takayanagi and Saito), Yorktown Formation, near Murfreesboro, North Carolina, USNM 240088, USGS 25948: 1, spiral view; 2, edge view; 3, umbilical view. All × 93.

4, 7, 8. *Globoquadrina altispira altispira* (Cushman and Jarvis), Yorktown Formation, near Murfreesboro, North Carolina, USNM 240089, USGS 25948: 4, spiral view; 7, edge view; 8, umbilical view. All × 93.

5, 6, 9. *Pulleniatina obliquiloculata obliquiloculata* (Parker and Jones), Yorktown Formation, Black Rock Landing, Bertie County, North Carolina, USNM 240090, USGS 25929: 5, umbilical view; 6, edge view; 9, spiral view. All × 93.

10–12. *Sphaeroidinellopsis seminulina seminulina* (Schwager), Yorktown Formation, near Murfreesboro, North Carolina, USNM 240091, USGS 25948: 10, umbilical view; 11, edge view; 12, spiral view. All × 93.

13–15. *Sphaeroidinellopsis subdehiscens subdehiscens* (Blow), Yorktown Formation, near Murfreesboro, North Carolina, USNM 240092, USGS 25948: 13, umbilical view; 14, edge view; 15, spiral view. All × 93.

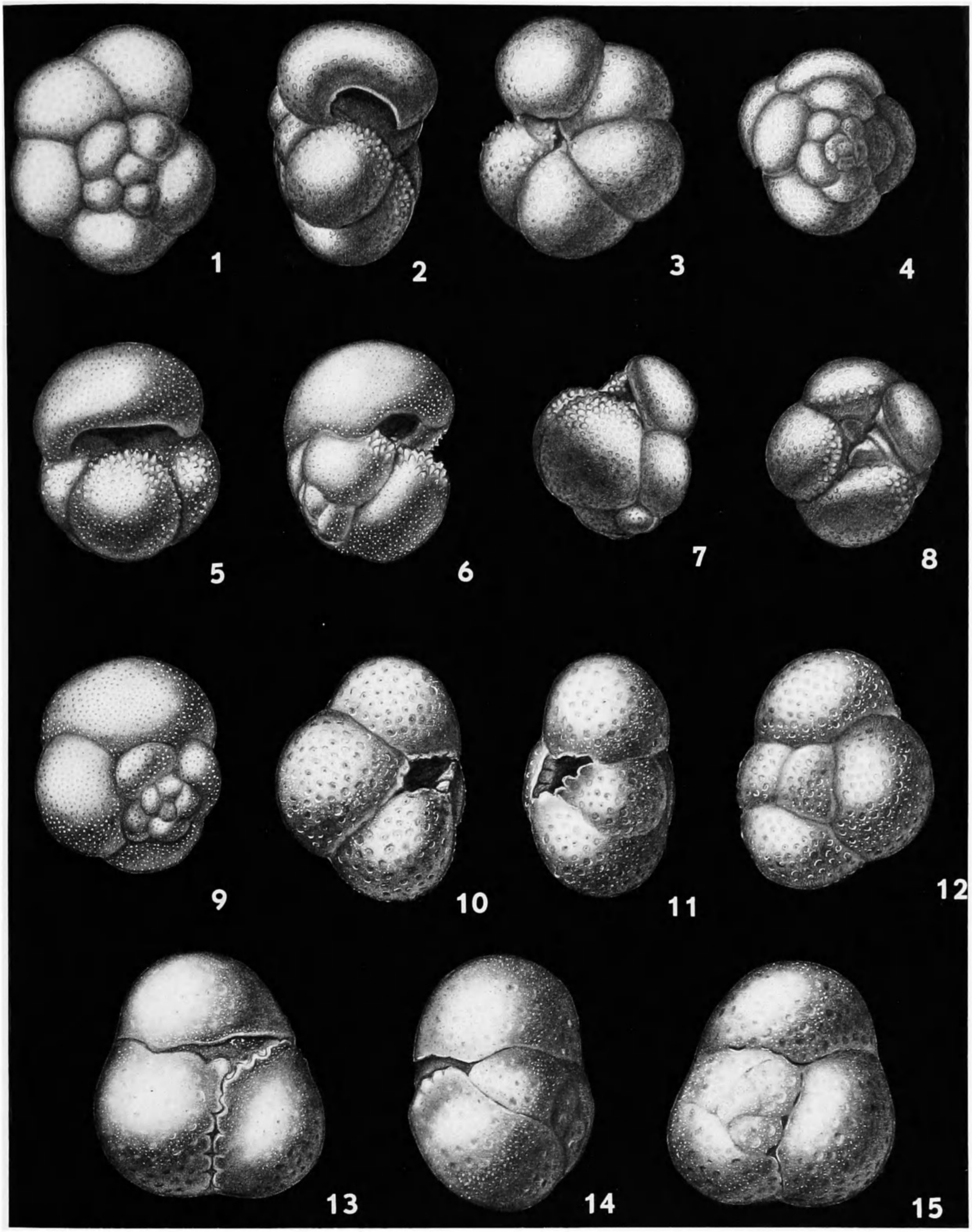
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PLATE 3

1–3. *Globorotalia menardii* (Parker, Jones, and Brady), Yorktown Formation, Suffolk, Virginia, USNM 240093, USGS 25941: 1, spiral view; 2, edge view; 3, umbilical view. All × 93.

4, 8, 12. *Globorotalia* species cf. *G. crassula* Cushman and Stewart, Yorktown Formation, near Murfreesboro, North Carolina, USNM 240094, USGS 25948: 4, spiral view; 8, edge view; 12, umbilical view. All × 93.

5–7. *Globorotalia hirsuta hirsuta* (d'Orbigny), Yorktown Formation, Yorktown, Virginia, USNM 240095, USGS 25934: 5, spiral view; 6, edge view; 7, umbilical view. All × 93.

9–11. *Globorotalia puncticulata* (Deshayes), Yorktown Formation, near Murfreesboro, North Carolina, USNM 240096, USGS 25948: 9, spiral view; 10, edge view; 11, umbilical view. All × 93.

13–15. "*Turborotalia*" *inflata* (d'Orbigny), Waccamaw Formation, Walker's Bluff, North Carolina, USNM 240097, USGS 25925: 13, spiral view; 14, edge view; 15, umbilical view. All × 93.

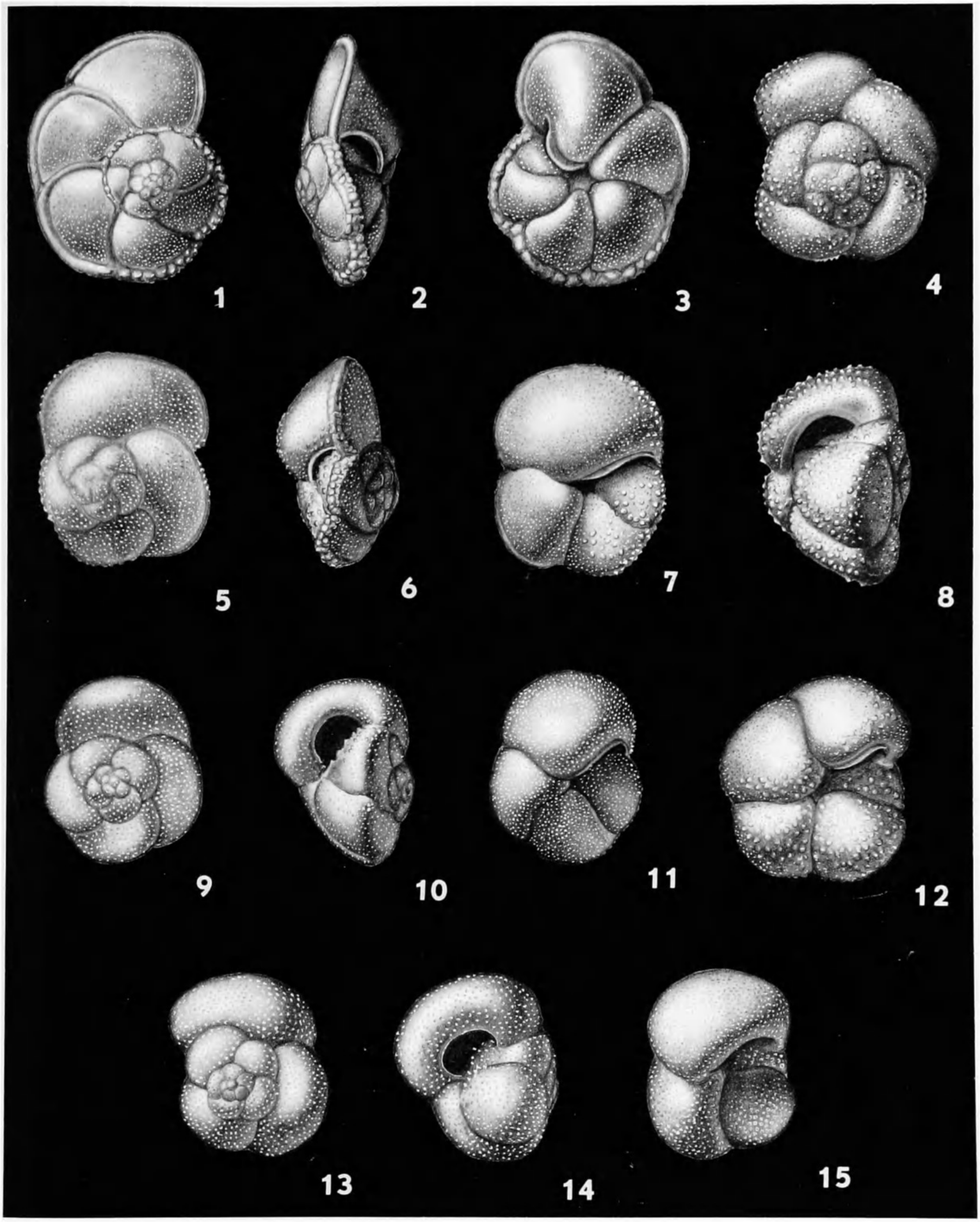
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PLATE 4

1–6. "*Turborotalia*" *birnageae* (Blow), Pungo River Formation, Lee Creek Mine, North Carolina: 1, USNM 240098, USGS 26013, umbilical view, × 440; 2, USNM 240099, USGS 26013, umbilical view, × 400; 3, USNM 240100, USGS 26012; umbilical view, × 300; 4, USNM 240101, USGS 26013, umbilical view, × 300; 5, USNM 240102, USGS 26012, edge view, × 450; 6, USNM 240102, USGS 26012, umbilical view, × 410.

7, 8. *Globigerinoides altiaperturus* Bolli, Pungo River Formation, Lee Creek Mine, North Carolina: 7, USNM 240103, USGS 26012, umbilical view, × 290; 8, USNM 240104, USGS 26013, umbilical view, × 290.

9–11. *Globigerina woodi woodi* Jenkins, Pungo River Formation, Lee Creek Mine, North Carolina, USGS 26013: 9, USNM 240105, umbilical view; 10, USNM 240105, edge view; 11, USNM 240106, umbilical view. All × 300.

12. *Globigerinoides trilobus trilobus* (Reuss), Pungo River Formation, Lee Creek Mine, North Carolina, USNM 240107, USGS 26012, umbilical view, × 240.

13, 14. *Globigerina* species cf. *G. anguliofficinalis* Blow, Pungo River Formation, Lee Creek Mine, North Carolina: 13, USNM 240108, USGS 26012, umbilical view, × 300; 14, USNM 240109, USGS 26013, umbilical view, × 300.

15. *Globigerina euapertura* Jenkins, Pungo River Formation, Lee Creek Mine, North Carolina, USNM 240110, USGS 26012, umbilical view, × 300.

16. *Cassigerinella chipolensis* (Cushman and Ponton), Pungo River Formation, Lee Creek Mine, North Carolina, USNM 240111, USGS 26013, side view, × 400.

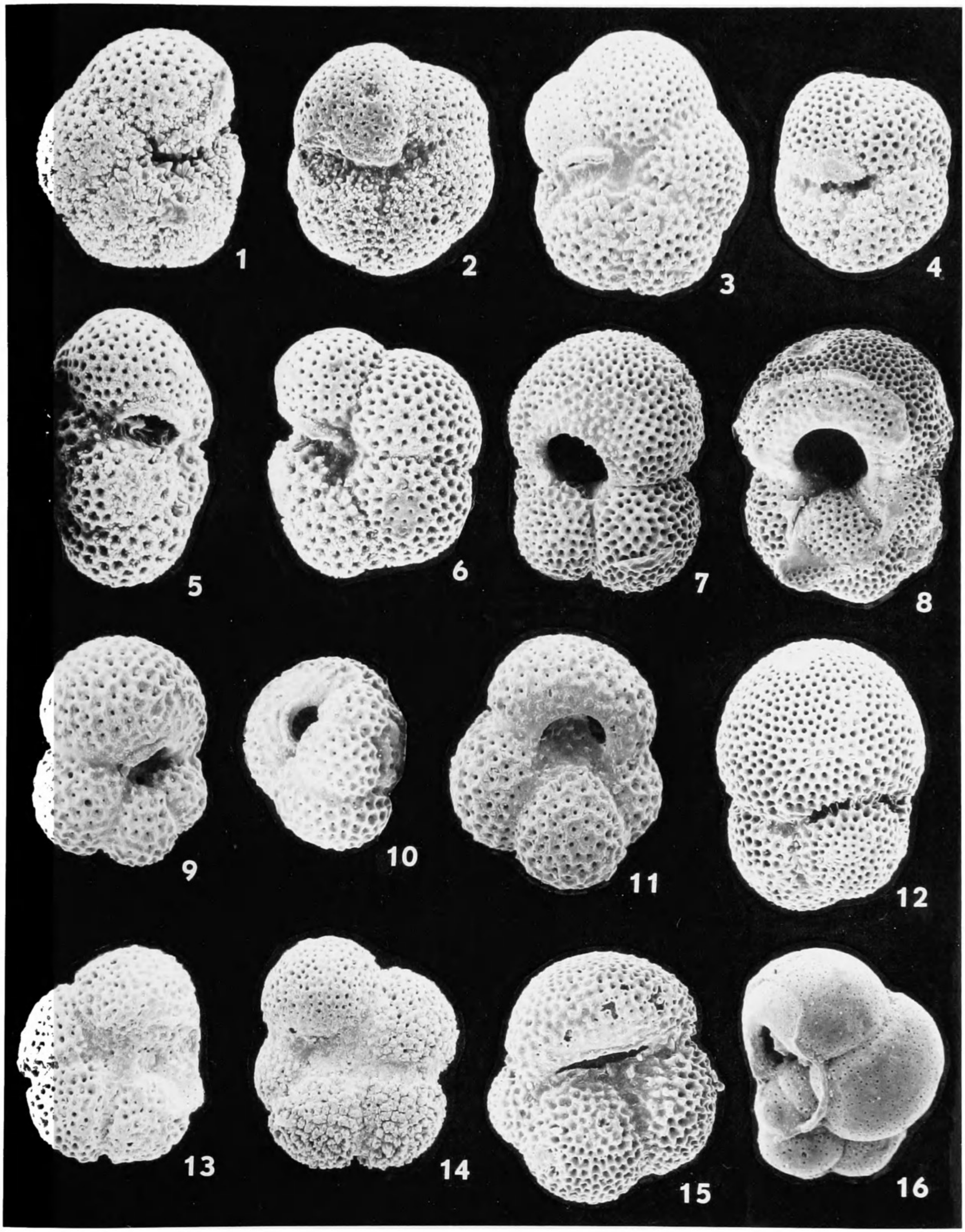

PLATE 5

1, 2. *Globorotalia scitula praescitula* Blow, Pungo River Formation, Lee Creek Mine, North Carolina, USNM 240112, USGS 26012: 1, side view, × 420; 2, umbilical view, × 410.

3, 4. *Globorotalia scitula praescitula* Blow, Pungo River Formation, Lee Creek Mine, North Carolina, USNM 240113, USGS 26012: 3, umbilical view, × 330; 4, side view, × 360.

5, 6. *Globorotalia peripheroronda* Blow and Banner, Pungo River Formation, Lee Creek Mine, North Carolina, USNM 240114, USGS 26012: 5, umbilical view, × 410; 6, side view, × 450.

7. *Sphaeroidinellopsis seminulina seminulina* (Schwager), Pungo River Formation, Gatesville, North Carolina well core, USNM 240115, USGS 25992, umibilical view, × 170.

8. *Orbulina universa* d'Orbigny, Pungo River Formation, Gatesville, North Carolina well core, USNM 240116, USGS 25992, × 77.

9–10. *Globorotalia hirsuta hirsuta* (d'Orbigny), Croatan Formation, Lee Creek Mine, North Carolina, USNM 240117, USGS 25995: 9, umbilical view; 10, side view. Both × 300.

11, 12. *Globorotalia puncticulata* (Deshayes), Yorktown Formation, Lee Creek Mine, North Carolina, USNM 240118, USGS 26009: 11, umbilical view; 12, side view. Both × 270.

13–15. *Globorotalia* species cf. *G. truncatulinoides truncatulinoides* (d'Orbigny), Croatan Formation, Lee Creek Mine, North Carolina, USNM 240119, USGS 25995: 13, umbilical view, × 300; 14, side view, × 300; 15, close-up of periphery, × 1375.

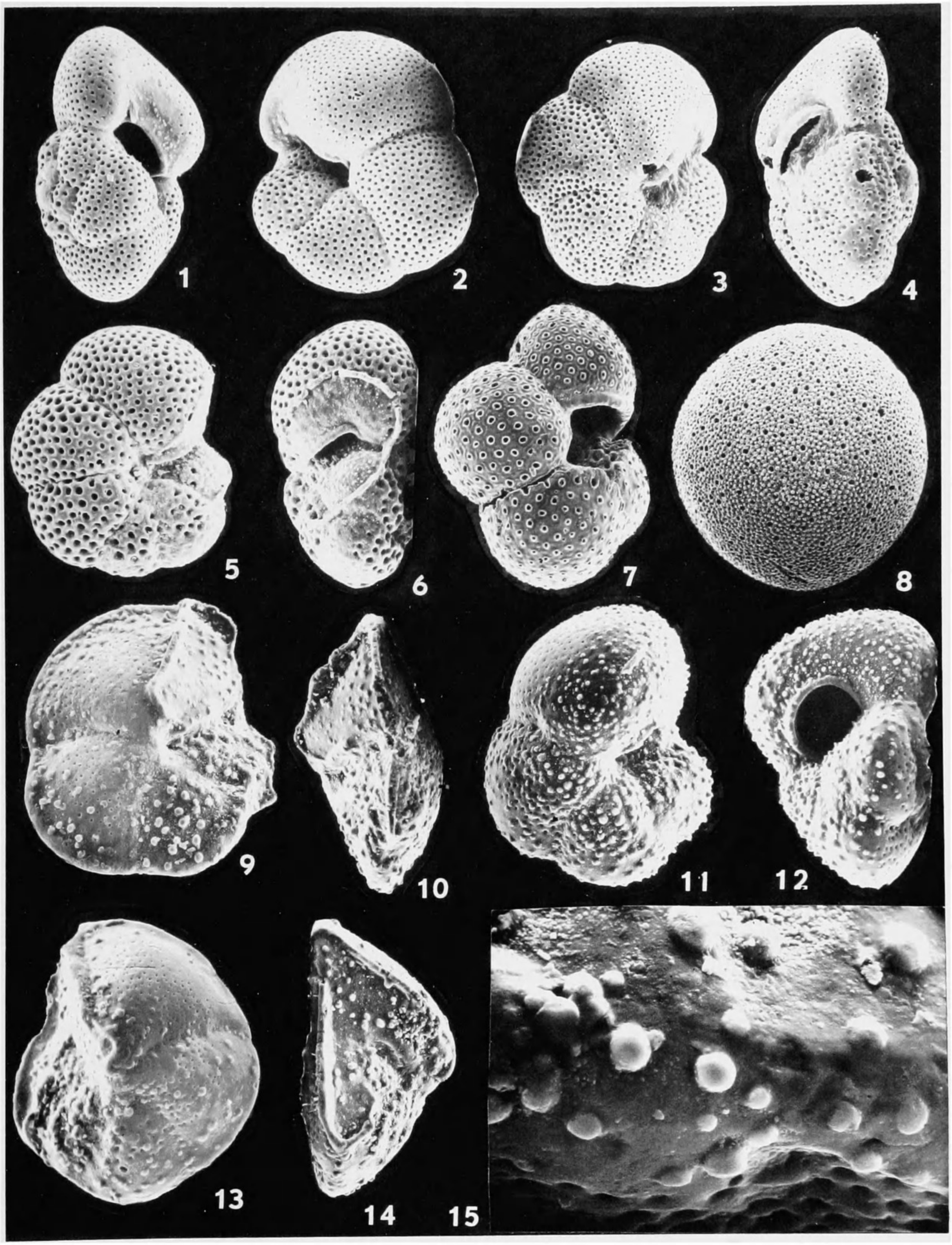
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PLATE 6

1–13. *Globorotalia merotumida* Blow and Banner, "Virginia St. Marys" beds, Gatesville Well, North Carolina, USGS 25992: 1, USNM 240120, spiral view, × 260; 2, USNM 240120, side view, × 250; 3, USNM 240121, side view, × 250; 4, USNM 240121, umbilical view, × 250; 5, USNM 240122, spiral view, × 190; 6, USNM 240122, close-up of spiral side, × 490; 7, USNM 240122, side view, × 240; 8, USNM 240123, spiral view, × 250; 9, USNM 240124, umbilical view, × 190; 10, USNM 240124, side view, × 200; 11, USNM 240125, spiral view, × 170; 12, USNM 240125, side view, × 170; 13, USNM 240126, spiral view, × 170.

14, 15. *Globorotalia minima* Akers, "Virginia St. Marys" beds, Gatesville, North Carolina, well core, USNM 240127, USGS 25992: 14, umbilical view, × 340; 15, side view; × 340.

16. *Globorotalia minima* Akers, "Virginia St. Marys" beds, Gatesville, North Carolina, well core, USNM 240128, USGS 25992, umbilical view, × 340.

17. *Globigerinatella insueta* Cushman and Stainforth, Pungo River Formation, Norfolk, Virginia, Moores Bridge Well, USNM 240129, USGS 26002, umbilical view, × 220.

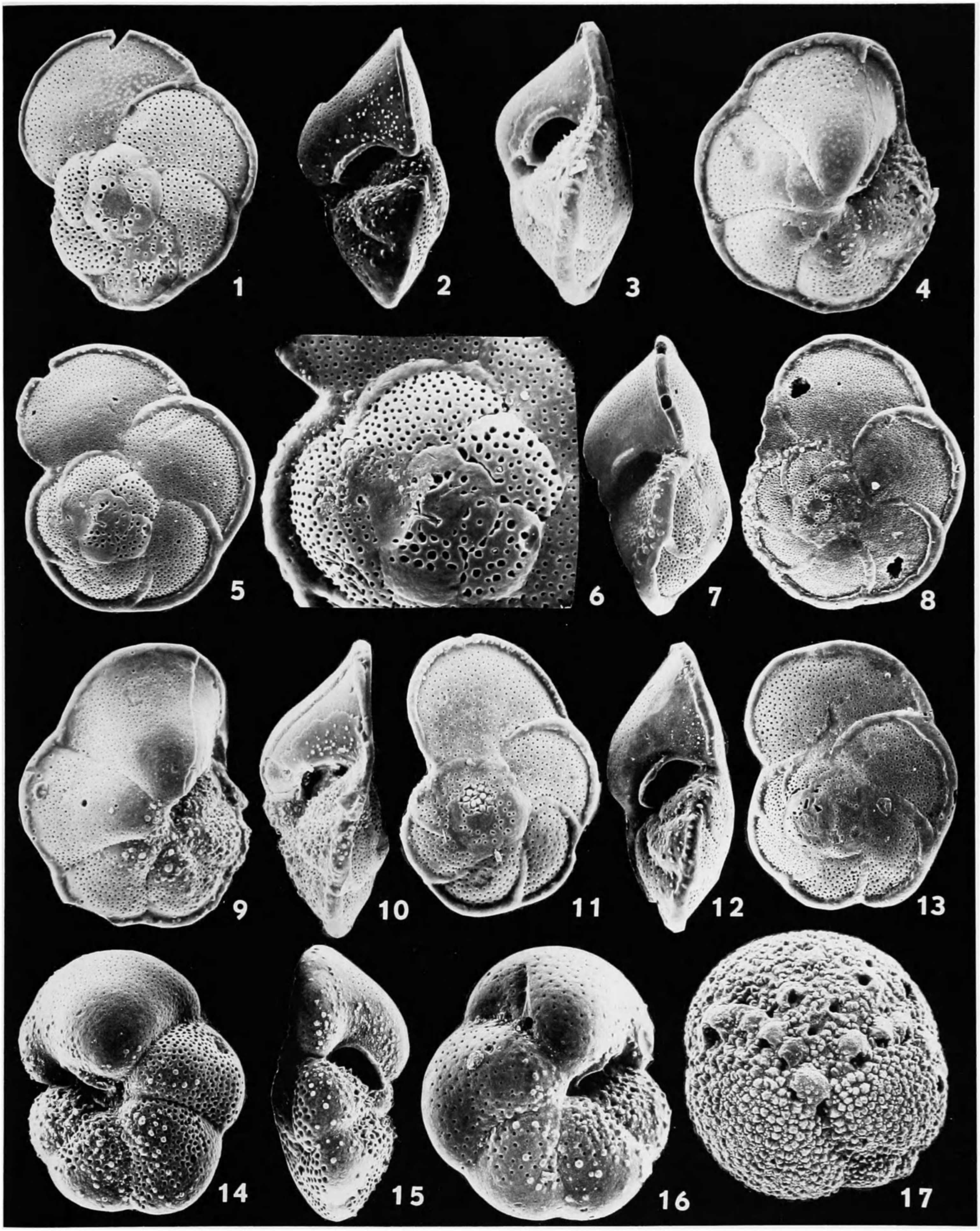
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PLATE 7

Elphidium neocrespinae, new species, Croatan Formation, Lee Creek Mine, North Carolina, USGS 25997

1, 2. Paratype, USNM 240130: 1, side view; 2, apertural view. Both × 190.
3, 4. Paratype, USNM 240131: 3, side view; 4, apertural view. Both × 160.
5, 6. Paratype, USNM 240132: 5, side view; 6, apertural view. Both × 150.
7–11. Holotype, USNM 240133: 7, apertural view, × 150; 8, side view, × 140; 9, close-up of apertural face, × 1200; 10, close-up of canal in penultimate chamber, × 6000; 11, close-up of penultimate chamber, × 1000.

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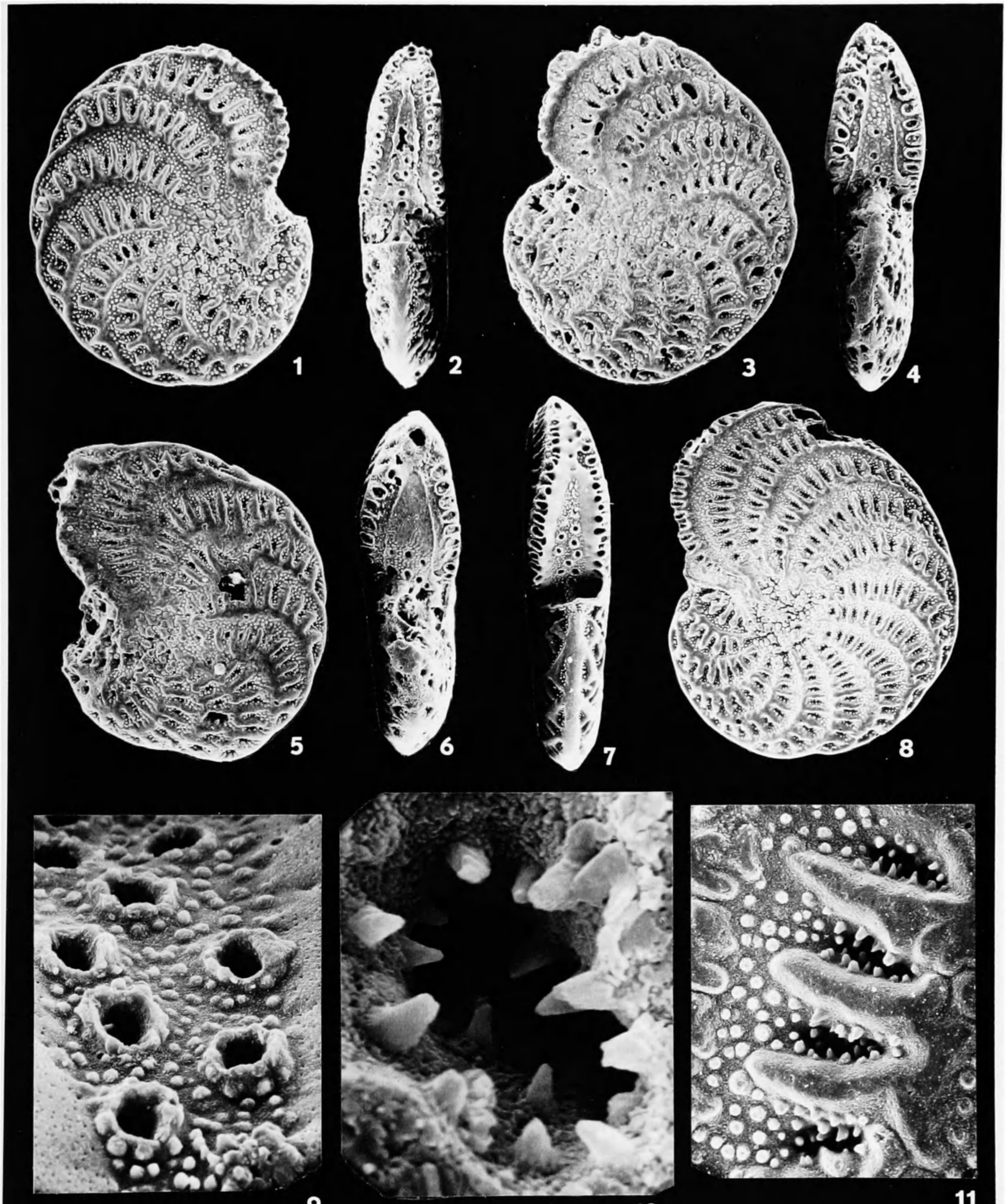
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PLATE 8

Bolivina pungoensis, new species, Pungo River Formation, Lee Creek mine, North Carolina

1–5. Holotype, USNM 240134, USGS 26013: 1, apertural view, × 435; 2, side view, × 150; 3, upper right part of specimen, × 600; 4, lower center part of specimen, × 600; 5, initial part of specimen, × 750.

6–10. Paratype, USNM 240135, USGS 26014: 6, side view, × 200; 7, close-up of apertural face, × 6000; 8, imperforate area of third last chamber, × 6000; 9, imperforate area in fourth chamber of test, × 6000; 10, apertural view, × 410.

11. Paratype, USNM 240136, USGS 26013, side view, × 160.

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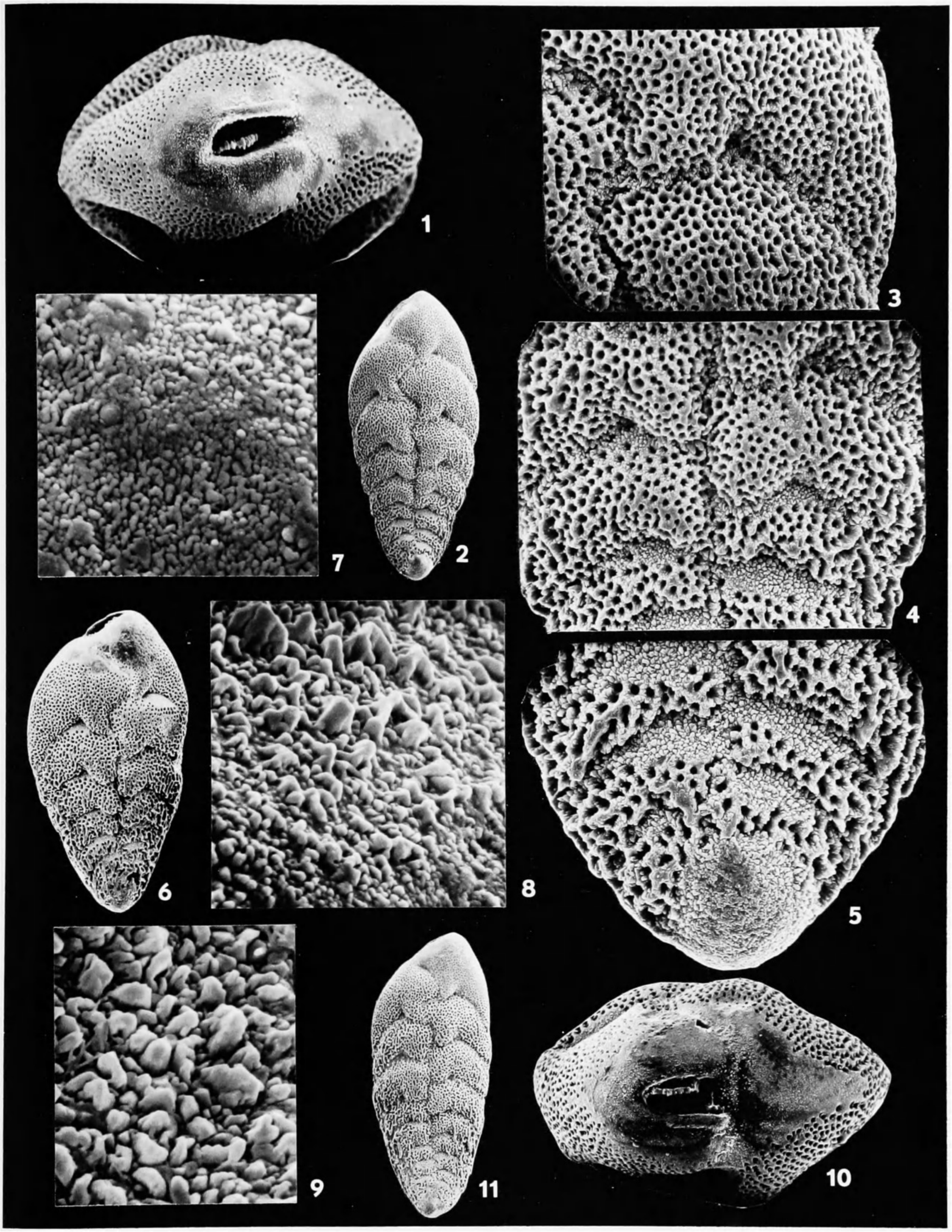
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PLATE 9

1–4. *Bolivina calvertensis* Dorsey, Pungo River Formation, Lee Creek Mine, North Carolina: 1, USNM 240137, USGS 26014, side view, × 140; 2, USNM 240137, USGS 26014, apertural view, × 500; 3, USNM 240138, USGS 26013, side view, × 220; 4, USNM 240139, USGS 26014, side view, × 200.

5, 9. *Spiroplectammina mississippiensis* (Cushman), "Virginia St. Marys" beds, Gatesville Well, North Carolina, USNM 240140, USGS 25992: 5, apertural view, × 75; 9, side view, × 50.

6. *Siphogenerina lamellata* Cushman, Pungo River Formation, USNM 240141, USGS 26013, side view, × 220.

7, 8. *Siphogenerina* sp., Pungo River Formation, Lee Creek Mine, North Carolina, USNM 240142, USGS 26014: 7, side view, × 110; 8, apertural view, × 245.

10–16. *Siphogenerina lamellata* Cushman, Pungo River Formation, USGS 26003: 10, USNM 240143, side view, × 110; 11, USNM 240144, side view, × 100; 12, USNM 240145, side view, × 115; 13, USNM 240146, side view, × 75; 14, USNM 240147, apertural view, × 130; 15, USNM 240145, apical view, × 225; 16, USNM 240146, apical view, × 310.

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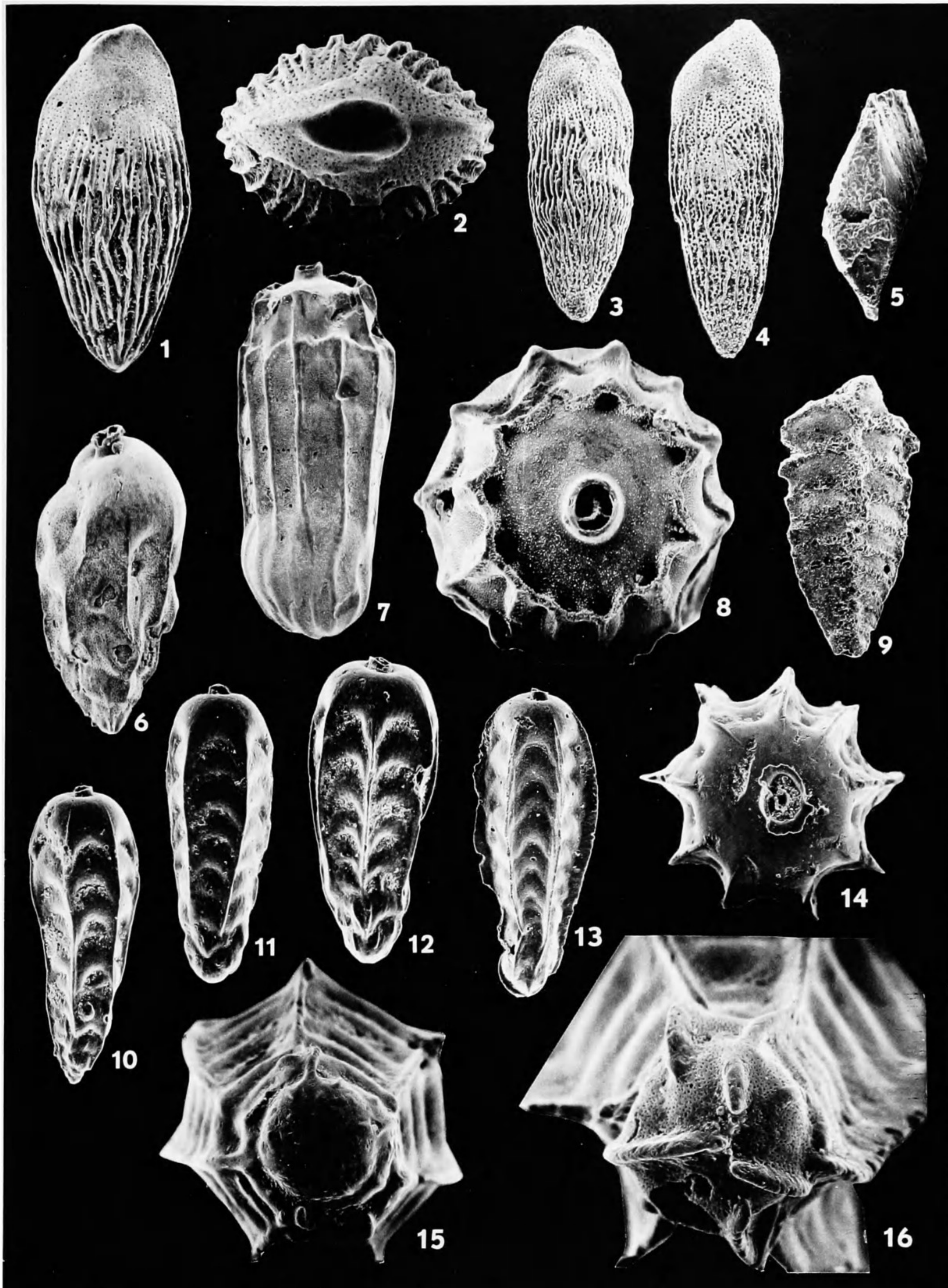
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PLATE 10

1, 2. *Spiroplectammina exilis* Dorsey, Choptank Formation, Flag Pond, Maryland, USNM 252578, USGS 25985: 1, side view, × 55; 2, apertural view, × 115.

3. *Virgulinella miocenica* (Cushman and Ponton), Pungo River Formation, Lee Creek Mine, North Carolina, USNM 252579, USGS 26013, side view, × 115.

4. *Rosalina cavernata* (Dorsey), Calvert Formation, Baltimore Gas and Electric Company core hole, Calvert County, Maryland, USNM 252580, USGS 26020, umbilical view, × 190.

5, 6, 8. *Cibicides croatanensis*, new species, Croatan Formation, Lee Creek Mine, North Carolina, holotype, USNM 252534, USGS 25997: 5, umbilical view, × 115; 6, side view, × 110; 8, close-up of last chamber on umbilical side, × 800.

7, 10. *Cibicides croatanensis*, new species, Croatan Formation, Lee Creek Mine, North Carolina, paratype, USNM 252535, USGS 25997: 7, spiral view, × 80; 10, close-up of last chamber on spiral side, × 1100.

9. *Praeorbulina glomerosa circularis* (Blow), Calvert Formation Calvert Cliffs, Maryland, USNM 252581, USGS 26023, apical view, × 115.

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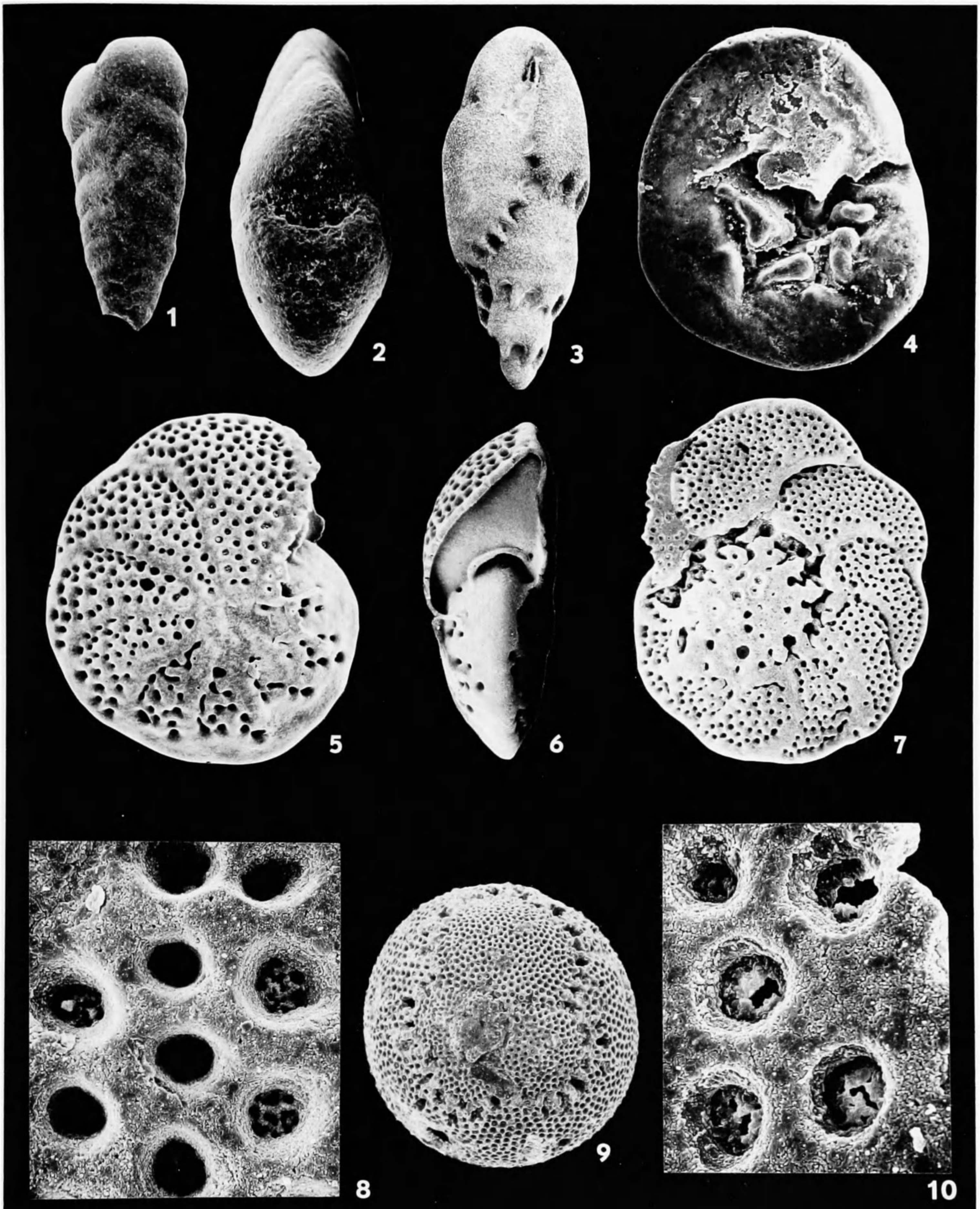
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PLATE 11

1, 2. *Bolivina marginata multicostata* Cushman, Pungo River Formation, Moores Bridge Well, Norfolk, Virginia, USNM 252582, USGS 26003: 1, apertural view, × 225; 2, side view, × 85.

3, 4. *Hopkinsina bononiensis* (Fornasini), "Virginia St. Marys" beds, Gatesville Well, North Carolina, USNM 252583, USGS 25992: 3, side view, × 90; 4, apertural view, × 265.

5, 6. *Nodosaria catesbyi* d'Orbigny, "Virginia St. Marys" beds, Gatesville Well, North Carolina, USNM 252584, USGS 25992: 5, side view, × 75; 6, apertural view, × 260.

7, 8. *Florilus chesapeakensis*, new species, "Virginia St. Marys" beds, Gatesville Well, North Carolina, holotype, USNM 252565, USGS 25992: 7, side view, × 95; 8, apertural view, × 95.

9–12. *Elphidium limatulum* Copeland, Croatan Formation, Lee Creek Mine, North Carolina, USGS 25997: 9, USNM 252586, side view, × 140; 10, USNM 252586, apertural view, × 140; 11, USNM 252587, side view, × 90; 12, USNM 252587, apertural view, × 80.

13–16. *Astrononion stelligerum* (d'Orbigny), Croatan Formation, Lee Creek Mine, North Carolina, USGS 25997: 13, USNM 252588, side view, × 180; 14, USNM 252589, apertural view, × 230; 15, USNM 252590, apertural view, × 210; 16, USNM 252590, side view, × 320.

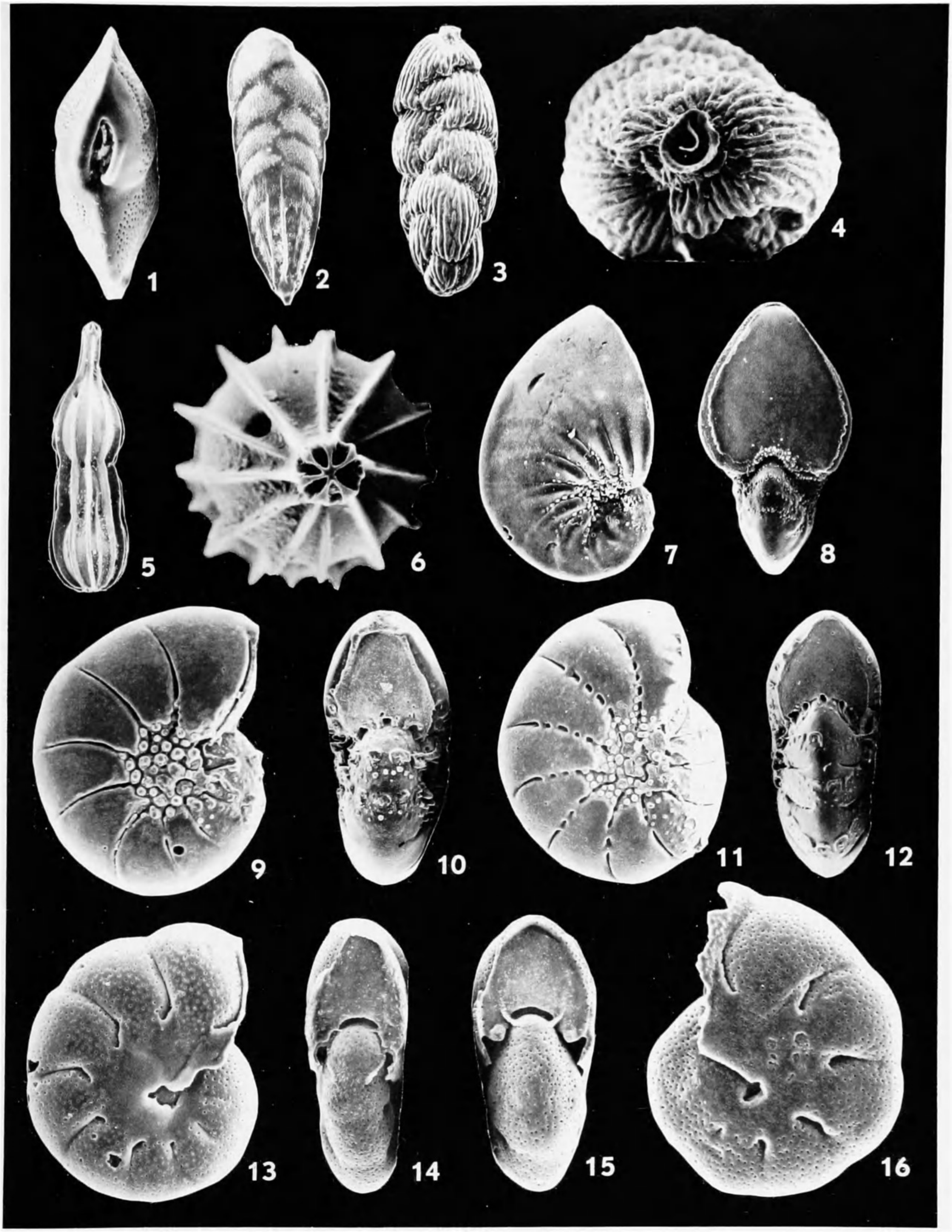
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PLATE 12

1, 2. *Astrononiom stelligerum* (d'Orbigny), Croatan Formation, Lee Creek Mine, North Carolina, USNM 252591, USGS 25997: 1, side view, × 155; 2, apertural view, × 155.

3, 4. *Nonion calvertensis*, new species, Calvert Formation, Randle Cliffs, Maryland, holotype, USNM 252554, USGS 25980: 3, side view, × 170; 4, apertural view, × 170.

5–7. *Nonion calvertensis*, new species, Calvert Formation, Randle Cliffs, Maryland, paratypes, USGS 25980: 5, USNM 252555, side view, × 170; 6, USNM 252556, apertural view, × 170; 7, USNM 252557, apertural view, × 170; 8, USNM 252557, side view, × 170.

9–14. *Nonion marylandicum* Dorsey, Choptank Formation, Flag Pond, Maryland, USGS 25985: 9, USNM 252592, side view, × 130; 10, USNM 252592, apertural view, × 130; 11, USNM 252593, side view, × 195; 12, USNM 252593, apertural view, × 195; 13, USNM 252594, side view, × 150; 14, USNM 252594, apertural view, × 130.

15, 16. *Elphidium latispatium pontium*, new subspecies, St. Marys Formation, Langley's Bluff, Maryland, holotype, USNM 252571, USGS 25955: 15, side view, × 110; 16, apertural view, × 110.

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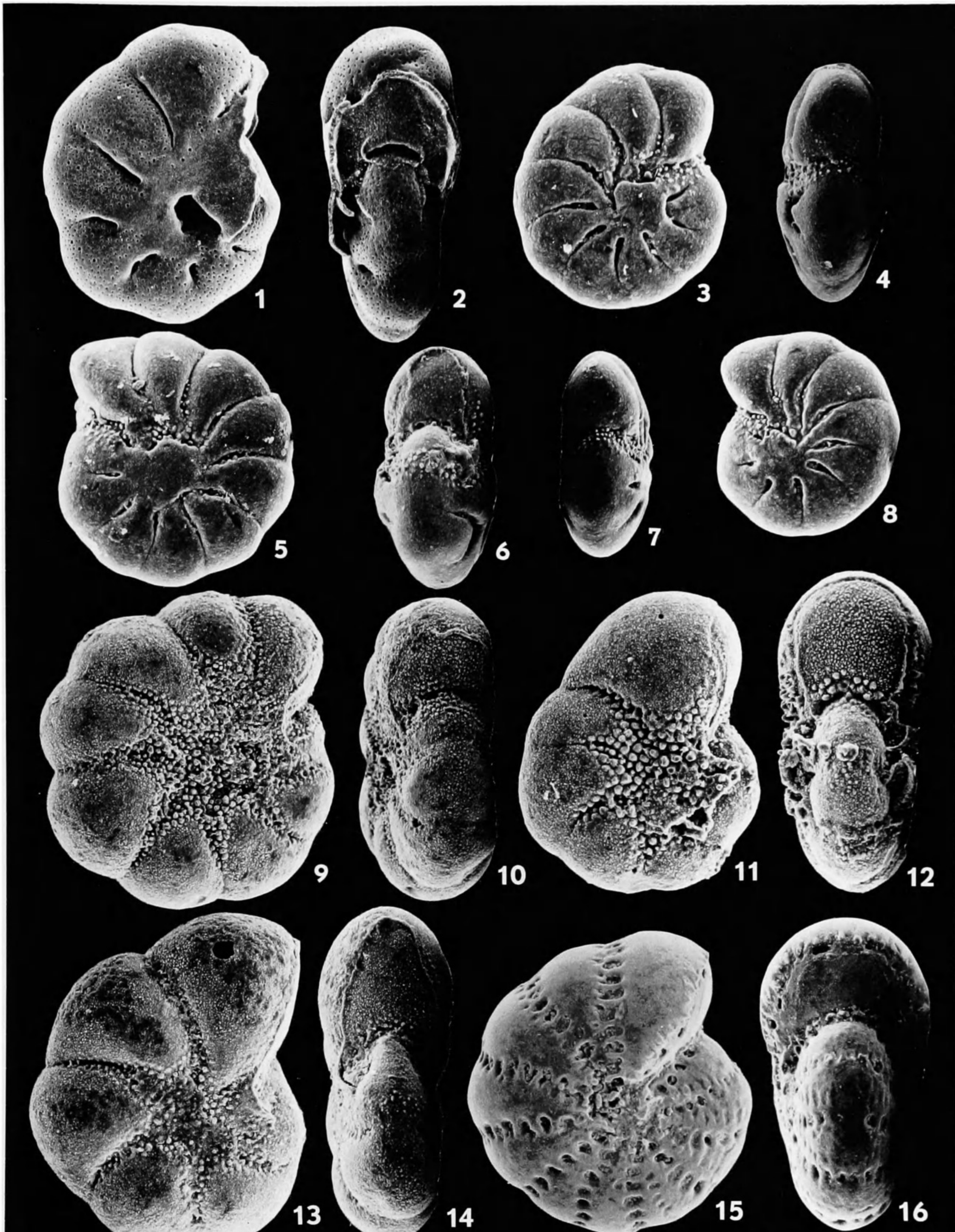
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PLATE 13

1–5. *Cibicides pungoensis*, new species, "Virginia St. Marys" beds, Gatesville Well, North Carolina, paratypes, USGS 25993: 1, USNM 252542, edge view, × 130; 2, USNM 252542, umbilical view, × 130; 3, USNM 252542, close-up of umbilical side, × 975; 4, USNM 252543, spiral view, × 65; 5, USNM 252544, edge view, × 115.

6, 7, 10. *Cibicides pungoensis*, new species, "Virginia St. Marys" beds, Gatesville Well, North Carolina, holotype, USNM 252541, USGS 25993: 6, umbilical view, × 65; 7, edge view, × 65; 10, close-up of umbilical surface, × 975.

8, 9. *Elphidium latispatium pontium*, new subspecies, St. Marys Formation, Langley's Bluff, Maryland, paratype, USNM 252572, USGS 25955: 8, side view, × 130; 9, apertural view, × 145.

Micrographs reduced to 72½% for publication.

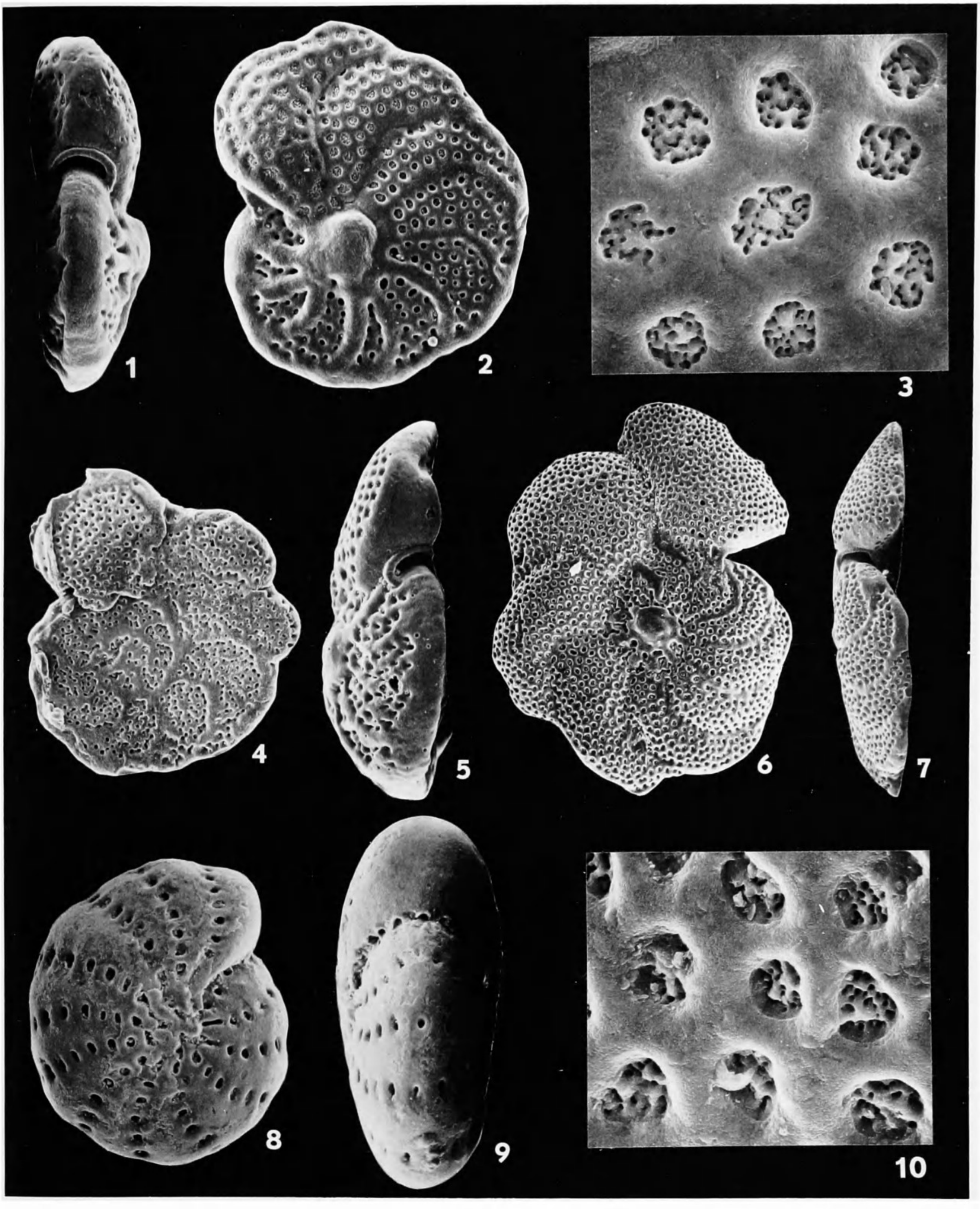
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PLATE 14

Cibicides cravenensis, new species, Pungo River Formation, Great Lake core hole, North Carolina, USGS 26018

1, 2, 5. Paratype, USNM 252528: 1, spiral view, × 90; 2, edge view, × 90; 5, close-up of last chamber on spiral side, × 900.

3, 4, 7. Holotype, USNM 252527: 3, edge view, × 115; 4, umbilical view, × 115; 7, close-up of umbilical side, × 1950.

6. Paratype, USNM 252529, umbilical view, × 65.

8, 9. Paratype, USNM 252530: 8, umbilical view, × 130; 9, close-up of umbilical surface, × 975.

10, 12. Paratype, USNM 252531: 10, edge view; 12, spiral view; both × 65.

11. Paratype, USNM 252532, edge view, × 65.

Micrographs reduced to 67½% for publication

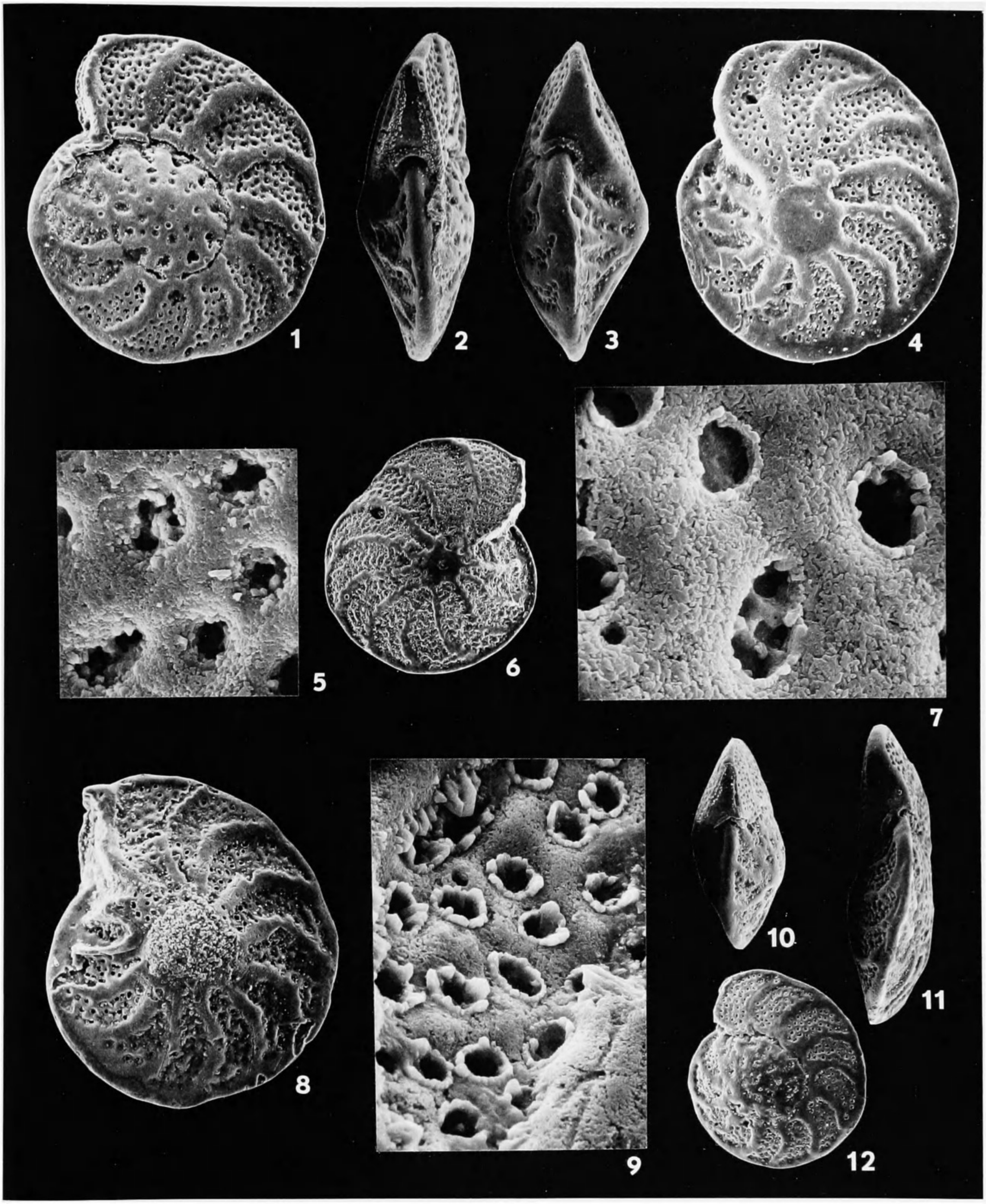
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PLATE 15

Svratkina croatanensis, new species, Croatan and Yorktown Formations, North Carolina and Virginia

1, 2. Holotype, USNM 252546, USGS 25997: 1, spiral view; 2, edge view. Both × 225.
3, 4. Paratype, USNM 252547, USGS 25997: 3, edge view; 4, umbilical view. Both × 225.
5, 6. Paratype, USNM 252549, USGS 26001: 5, umbilical view; 6, edge view. Both × 195.
7, 8. Paratype, USNM 252550, USGS 26001: 7, umbilical view; 8, edge view. Both × 130.
9, 12. Paratype, USNM 252548, USGS 25997: 9, spiral view; 12, edge view. Both × 215.
10, 13. Paratype, USNM 252551, USGS 26001: 10, spiral view, × 170; 13, close-up of spiral surface, × 1430.
11. Paratype, USNM 252552, USGS 26001, spiral view, × 160.
14. Paratype, USNM 252553, USGS 26001, edge view, × 175.

Micrographs reduced to 68½% for publication.

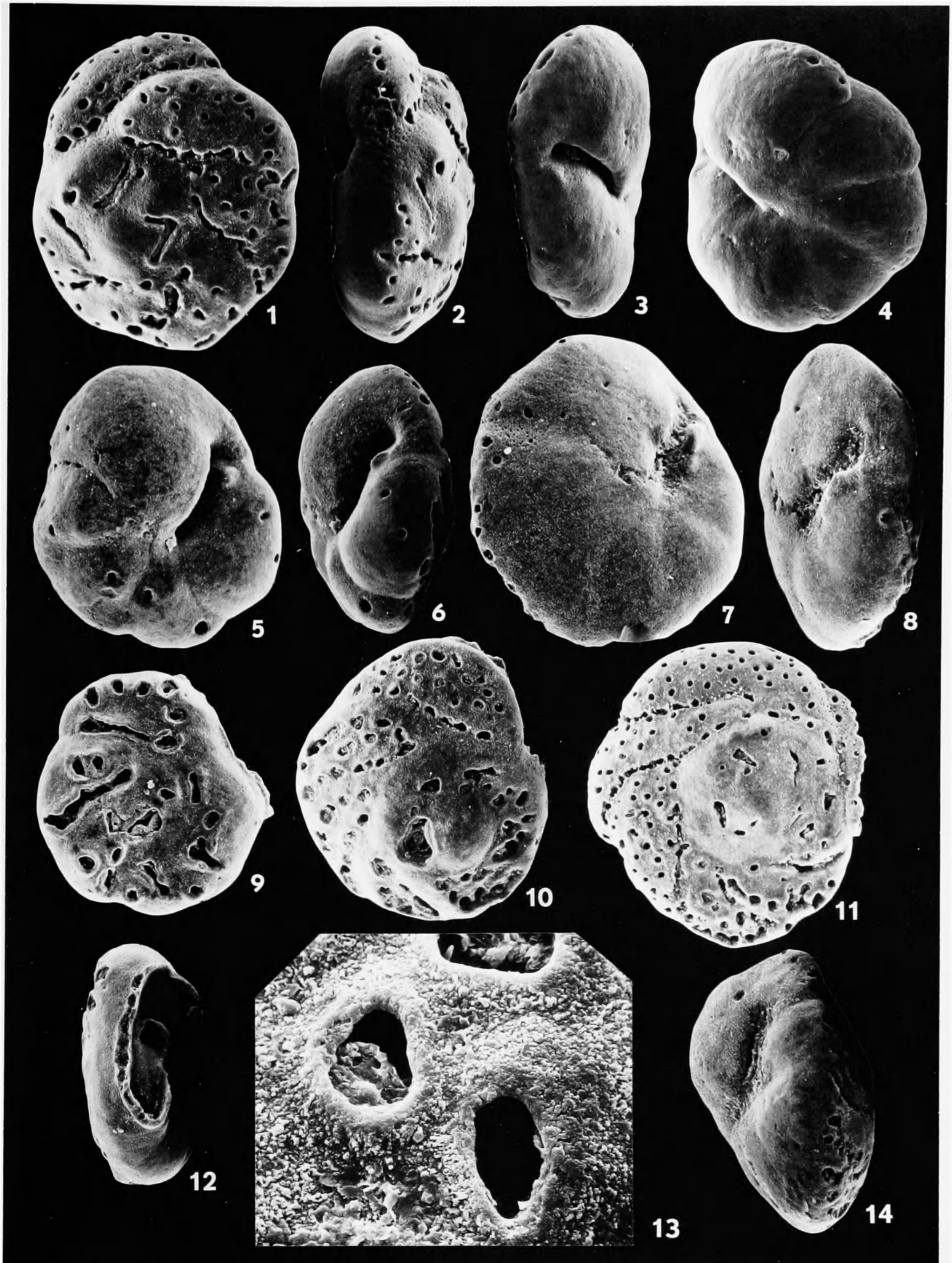
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PLATE 16

1–3. *Spiroplectammina mississippiensis* (Cushman), Calvert Formation, Parker Creek, Maryland: 1, USNM 252595, USGS 25972, side view, × 88; 2, USNM 252596, USGS 25971, side view, × 88; 3, USNM 252596, USGS 25971, apertural view, × 88.

4, 5. *Spiroplectammina exilis* Dorsey, Choptank Formation, Nomini Cliffs, Virginia, USGS 25965: 4, USNM 252597, apertural view, × 112; 5, USNM 252598, side view, × 56.

6, 7. *Textularia ultima-inflata* Dorsey, Choptank Formation, Bartein's Landing, Maryland, USNM 252599, USGS 26019: 6, side view, × 66; 7, apertural view, × 66.

8, 9. *Textularia obliqua* Dorsey, St. Marys Formation, Chancellor Point, Maryland, USNM 252600, USGS 25957: 8, apertural view, × 56; 9, side view, × 56.

10, 13, 14. *Massilina marylandica* Cushman and Cahill, St. Marys Formation, Chancellor Point, Maryland, USNM 252601, USGS 25957: 10, apertural view, × 66; 13, side view, × 66; 14, side view, × 66.

11, 12. *Textularia mayori* Cushman, Yorktown Formation, Suffolk, Virginia, USNM 252602, USGS 25942: 11, apertural view, × 44; 12, side view, × 44.

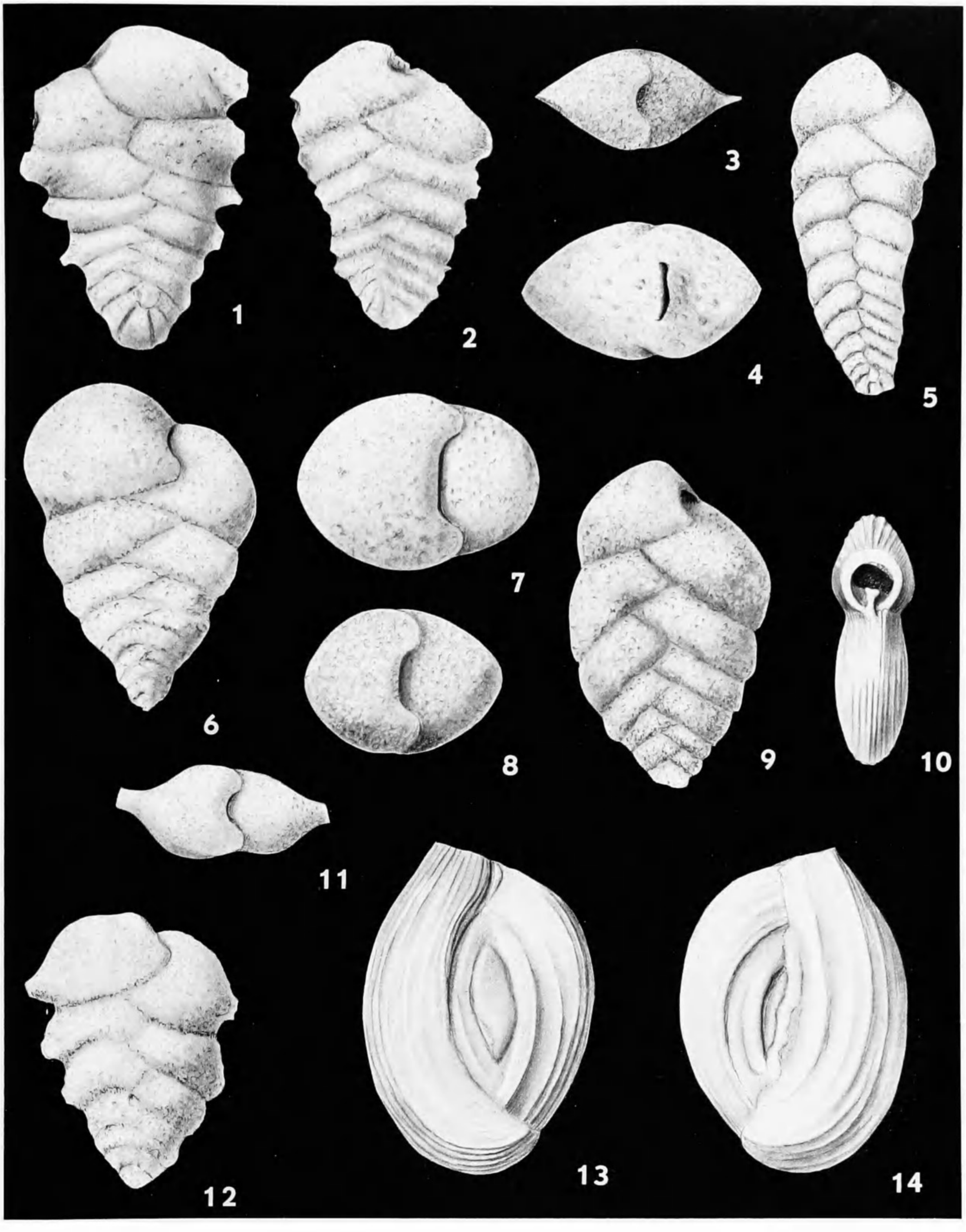

PLATE 17

1, 2, 6. *Quinqueloculina lamarckiana* d'Orbigny, Waccamaw Formation, near Town Creek, North Carolina, USNM 252603, USGS 25989: 1, side view; 2, side view; 6, apertural view. All × 88.

3, 4, 7. *Massilina glutinosa* Cushman and Cahill, Choptank Formation, Flag Pond, Maryland, USNM 252604, USGS 25962: 3, apertural view; 4, side view; 7, side view. All × 56.

5, 8. *Bolivina marginata multicostata* Cushman, Yorktown Formation, Yorktown, Virginia, USNM 252605, USGS 25933: 5, apertural view; 8, side view. Both × 112.

9, 10. *Sagrina pulchella primitiva* (Cushman), Waccamaw Formation, Walker's Bluff, North Carolina, USNM 252606, USGS 25926: 9, apertural view; 10, side view. Both × 140.

11. *Nodosaria catesbyi* d'Orbigny, Yorktown Formation, near Murfreesboro, North Carolina, USNM 252607, USGS 25948, side view, × 56.

12. *Virgulinella miocenica* (Cushman and Ponton), Choptank Formation, Nomini Cliffs, Virginia, USNM 252608, USGS 25965, side view, × 88.

13. *Siphogenerina lamellata* Cushman, Calvert Formation, Plum Point, Maryland, USNM 252610, USGS 25982, side view, × 148.

14–16. *Rosalina cavernata* (Dorsey), Calvert Formation, Plum Point, Maryland, USNM 252611, USGS 25977: 14, spiral view; 15, umbilical view; 16, end view. All × 88.

17, 18. *Virgulinella miocenica* (Cushman and ponton), St. Marys Formation, Windmill Point, Maryland, USNM 252609, USGS 25983: 17, front view; 18 back view. Both × 112.

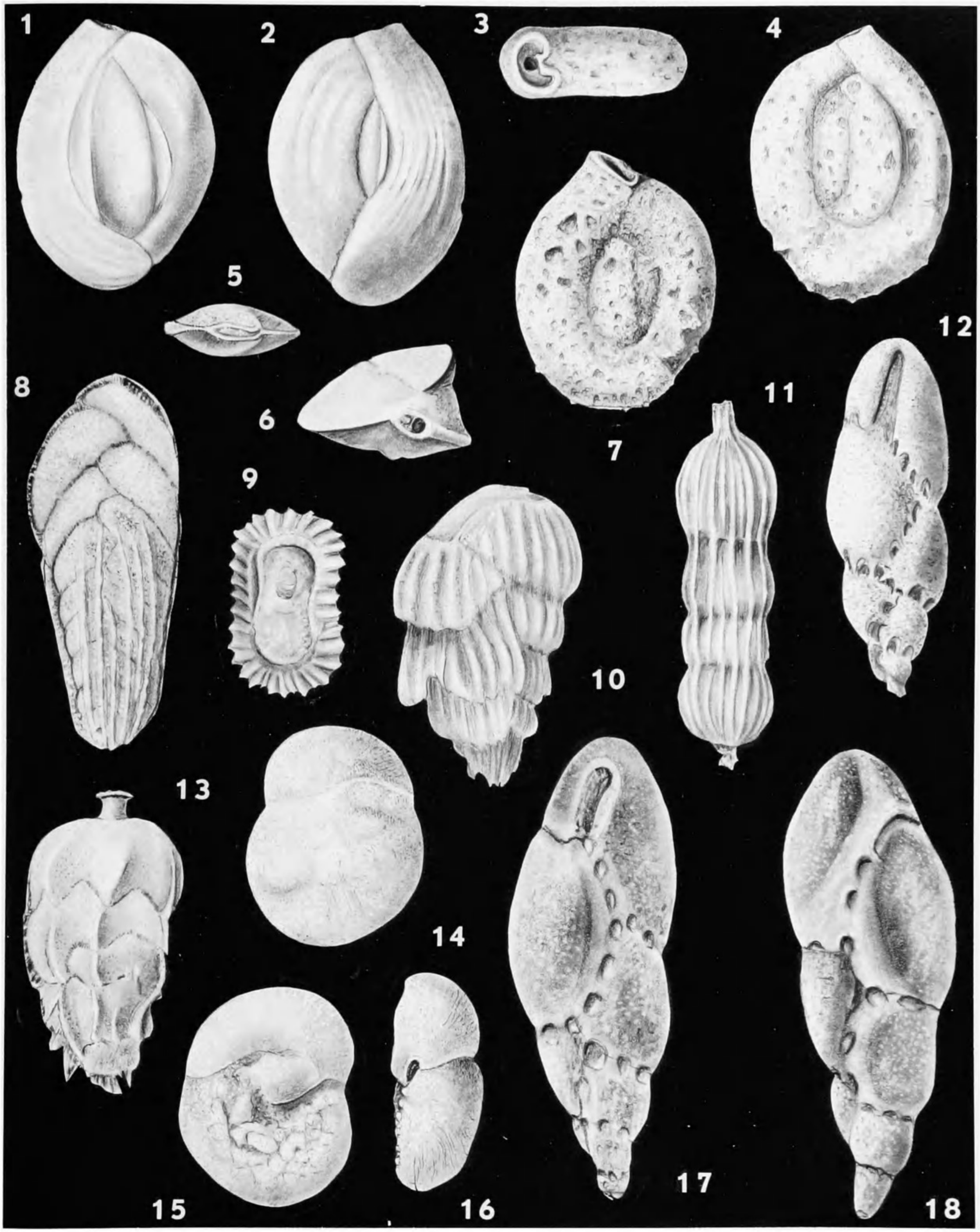
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PLATE 18

1–3. *Cancris sagra* (d'Orbigny), Yorktown Formation, Suffolk, Virginia, USNM 252612, USGS 25941: 1, spiral view; 2, umbilical view; 3, edge view. All × 88.

4–6. *Rotorbinella bassleri* (Cushman and Cahill), Calvert Formation, Governors Run, Maryland, USNM 252613, USGS 25969: 4, spiral view; 5, umbilical view; 6, edge view. All × 112.

7, 8, 12. *Florilus chesapeakensis*, new species, St. Marys Formation, Windmill Point, Maryland, paratypes, USNM 25266, USGS 25983: 7, spiral view; 8, umbilical view; 12, apertural view. All × 93.

9, 10. *Nonion marylandicum* Dorsey, Choptank Formation, Flag Pond, Maryland, USNM 252614, USGS 25960: 9, side view; 10, apertural view. Both × 112.

11. *Florilus chesapeakensis*, new species, Calvert Formation, Governors Run, Maryland, paratype, USNM 252567, USGS 25969, apertural view, × 88.

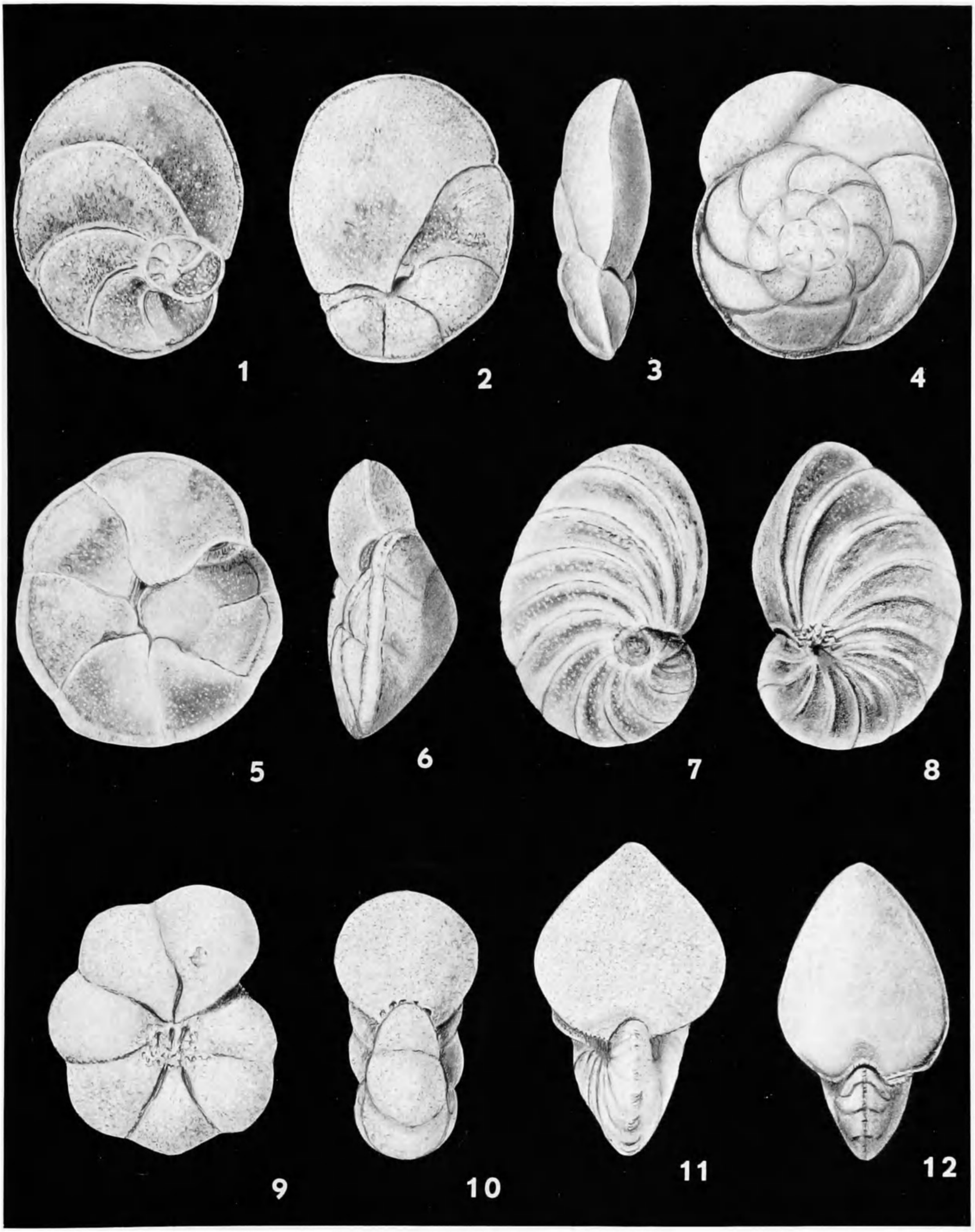
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PLATE 19

1, 2. *Nonion calvertensis*, new species, Calvert Formation, Randle Cliffs, Maryland, paratype, USNM 252558, USGS 25980: 1, side view; 2, apertural view. Both × 194.

3, 4. *Elphidium neocrespinae*, new species, Yorktown Formation, Black Rock Landing, Bertie County, North Carolina, paratype, USNM 252570, USGS 25930: 3, side view; 4, apertural view. Both × 88.

5, 6. *Elphidium compressulum* Copeland, Duplin Formation, near Kenansville, North Carolina, USNM 252615, USGS 25924: 5, apertural view; 6, side view. Both × 112.

7, 10. *Elphidium gunteri* Cole, Yorktown Formation, Mt. Gould Landing, North Carolina, USNM 252616, USGS 25927: 7, side view; 10, apertural view. Both × 88.

8, 9. *Elphidium latispatium pontium,* new subspecies, St. Marys Formation, Little Cove Point, Maryland, paratype, USNM 252573, USGS 25950: 8, apertural view; 9, side view. Both × 88.

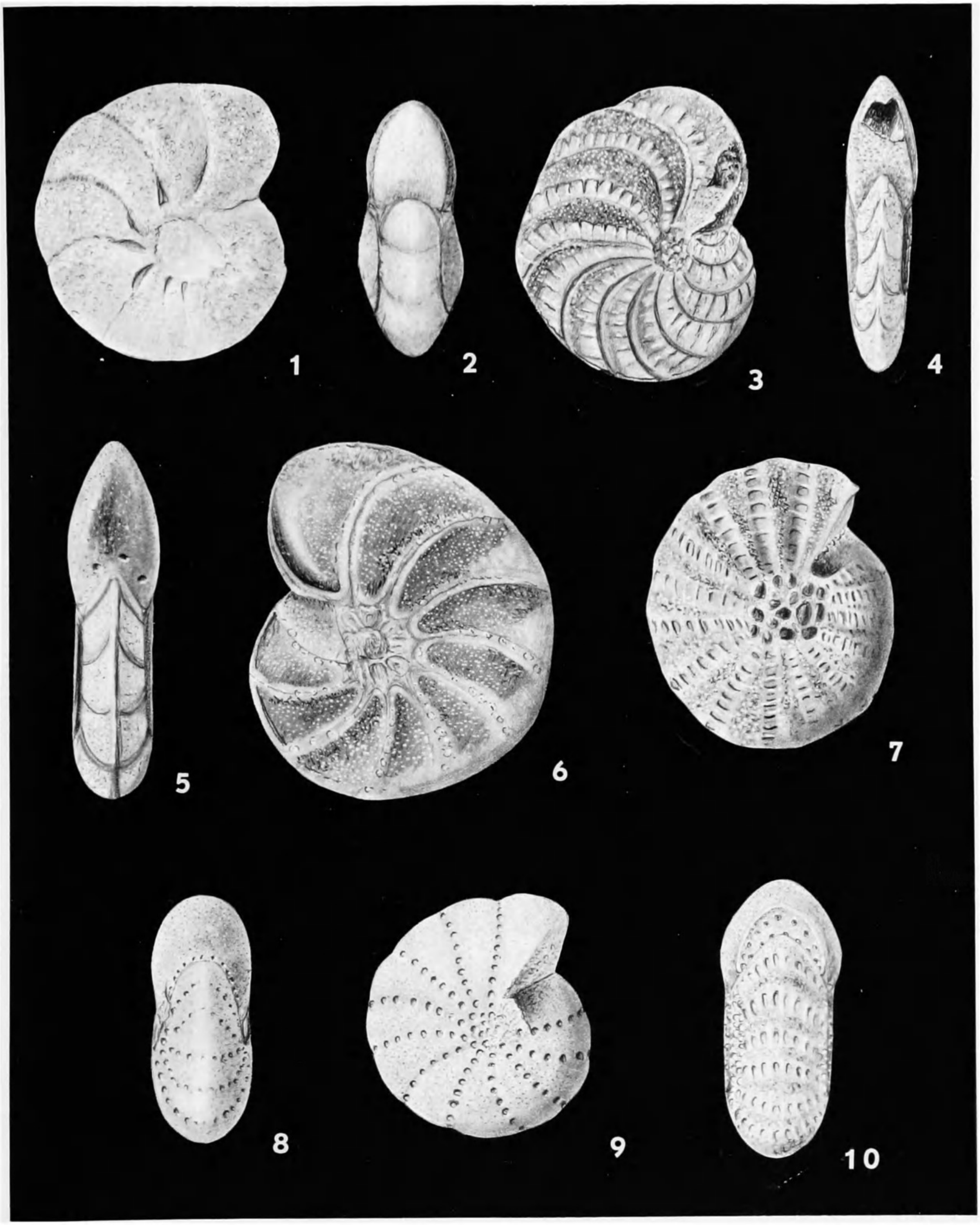
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PLATE 20

1–4. *Bolivinopsis fairhavenensis*, new species, Calvert Formation, Randle Cliffs, Maryland, USGS 25981: 1. paratype, USNM 252519, side view, × 300; 2, holotype, USNM 252518, side view, × 300; 3, holotype, USNM 252518, apertural view, × 660; 4, paratype, USNM 252520, side view, × 340.

5–9. *Cibicides croatanensis*, new species, Croatan Formation, Lee Creek Mine, North Carolina, USGS 25997: 5. Paratype, USNM 252536, spiral view, × 120; 6, paratype, USNM 252537, umbilical view, × 210; 7, paratype, USNM 252537, edge view, × 210; 8. paratype, USNM 252538, umbilical view, × 100; 9. paratype, USNM 252539, umbilical view, × 130.

10–12. *Epistominella danvillensis* (Howe and Wallace), Yorktown Formation, Morgart's Beach, Virginia, USNM 252617, USGS 25937: 10, umbilical view; 11, edge view; 12, spiral view. All × 194.

13–15. *Epistominella pungoensis*, new species, Pungo River Formation, Moores Bridge Well, Norfolk, Virginia, holotype, USNM 252521, USGS 26003: 13, umbilical view; 14, edge view; 15, spiral view. All × 200.

Micrographs reduced to 97½% for publication.

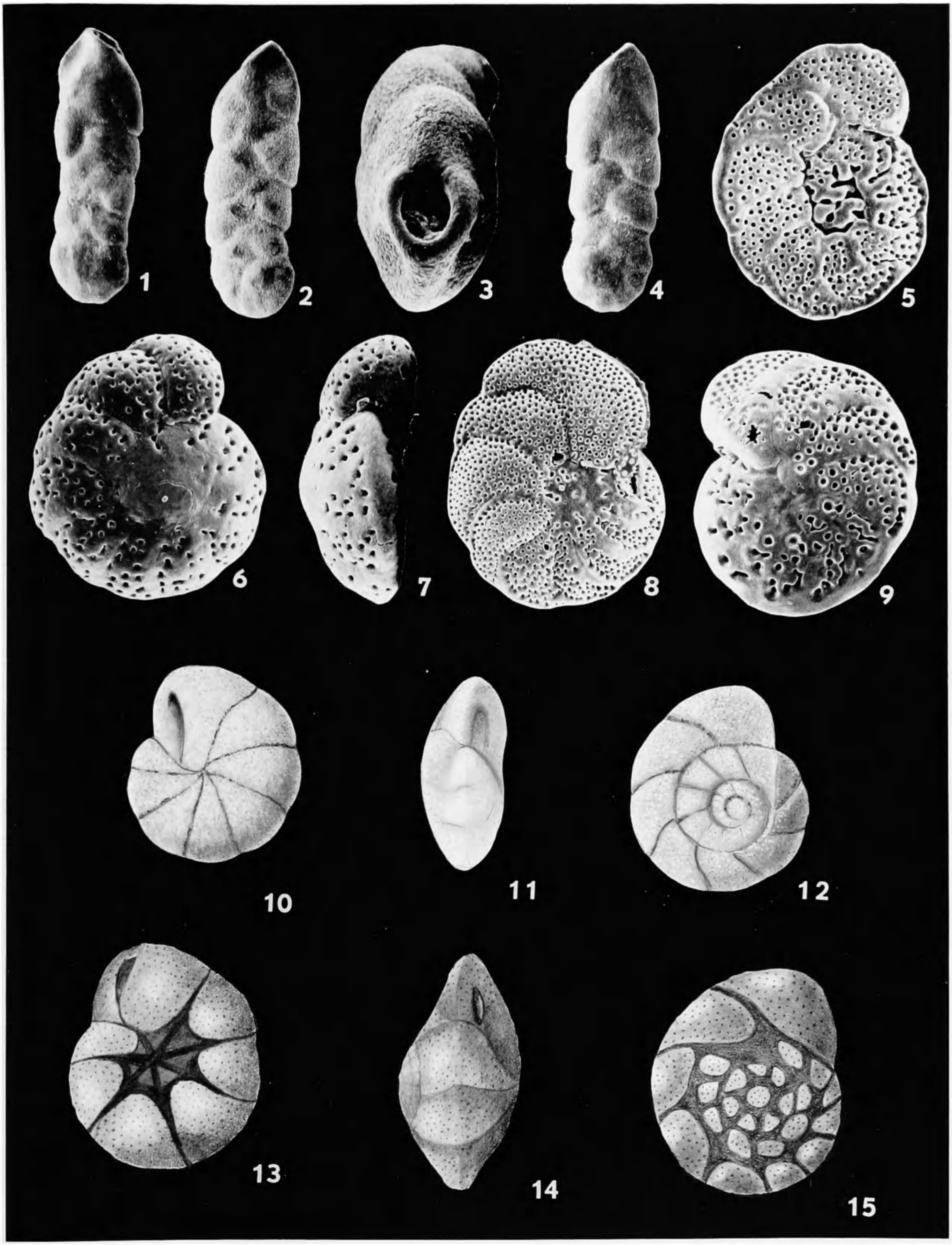
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PLATE 21

1–6. *Epistominella pungoensis*, new species, Pungo River Formation, Moores Bridge Well, Norfolk, Virginia, paratypes, USGS 26003: 1, USNM 252522, umbilical view, × 400; 2, USNM 252522, edge view, × 400; 3, USNM 252523, edge view, × 500; 4, USNM 252523, umbilical view, × 500; 5, USNM 252524, spiral view, × 300; 6, USNM 252525, spiral view, × 340.

7, 8. *Epistominella pontoni* (Cushman), Choctawhatchee Formation, Alice Creek, Florida, USNM 252618, USGS 25922: 7, edge view, × 300; 8, umbilical view, × 300.

9–13. *Epistominella danvillensis* (Howe and Wallace), Yorktown Formation, Lee Creek Mine, North Carolina, USGS 26010: 9, USNM 252619, umbilical view; 10, USNM 252619, edge view; 11, USNM 252620, spiral view; 12, USNM 252621, umbilical view; 13, USNM 252621, edge view. All × 500.

14, 15. *Elphidium compressulum* Copeland, Duplin Formation, Natural Well, North Carolina, USNM 252622, USGS 25923: 14, side view, × 200; 15, apertural view, × 200.

Micrographs reduced to 94% for publication.

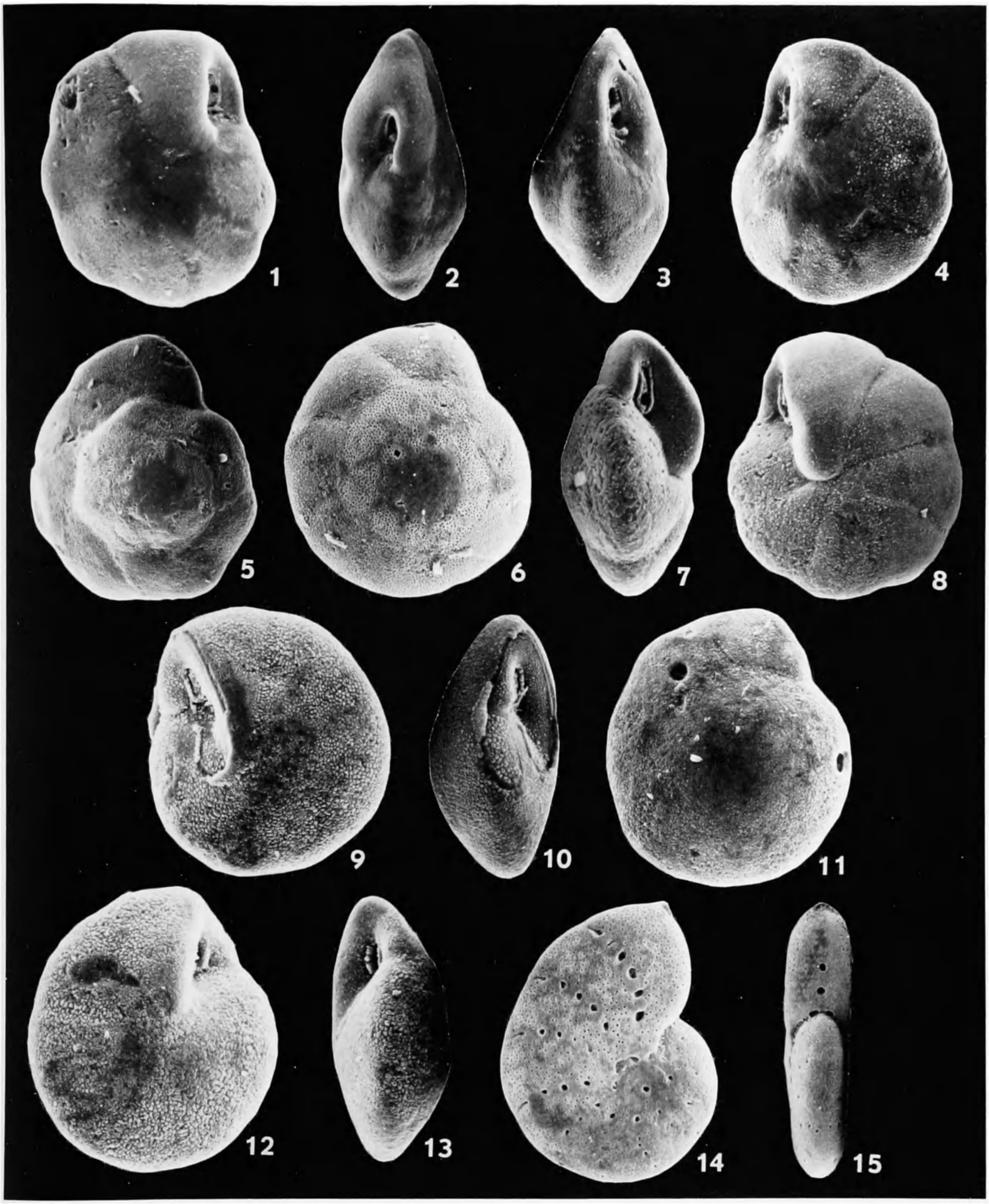
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PLATE 22

1, 2. *Nonion advenum pustulosum*, new subspecies, Silverdale beds of Vokes (1967), near Long Point, North Carolina, holotype, USNM 252561, USGS 22294: 1, side view; 2, apertural view. Both × 160.

3, 11–12. *Elphidium latispatium latispatium* Poag, Chickasawhay Formation, Choctaw Bluff, Alabama, USGS 25921: 3, USNM 252623, apertural view; 11, USNM 252624, side view; 12, USNM 252623, side view. All × 200.

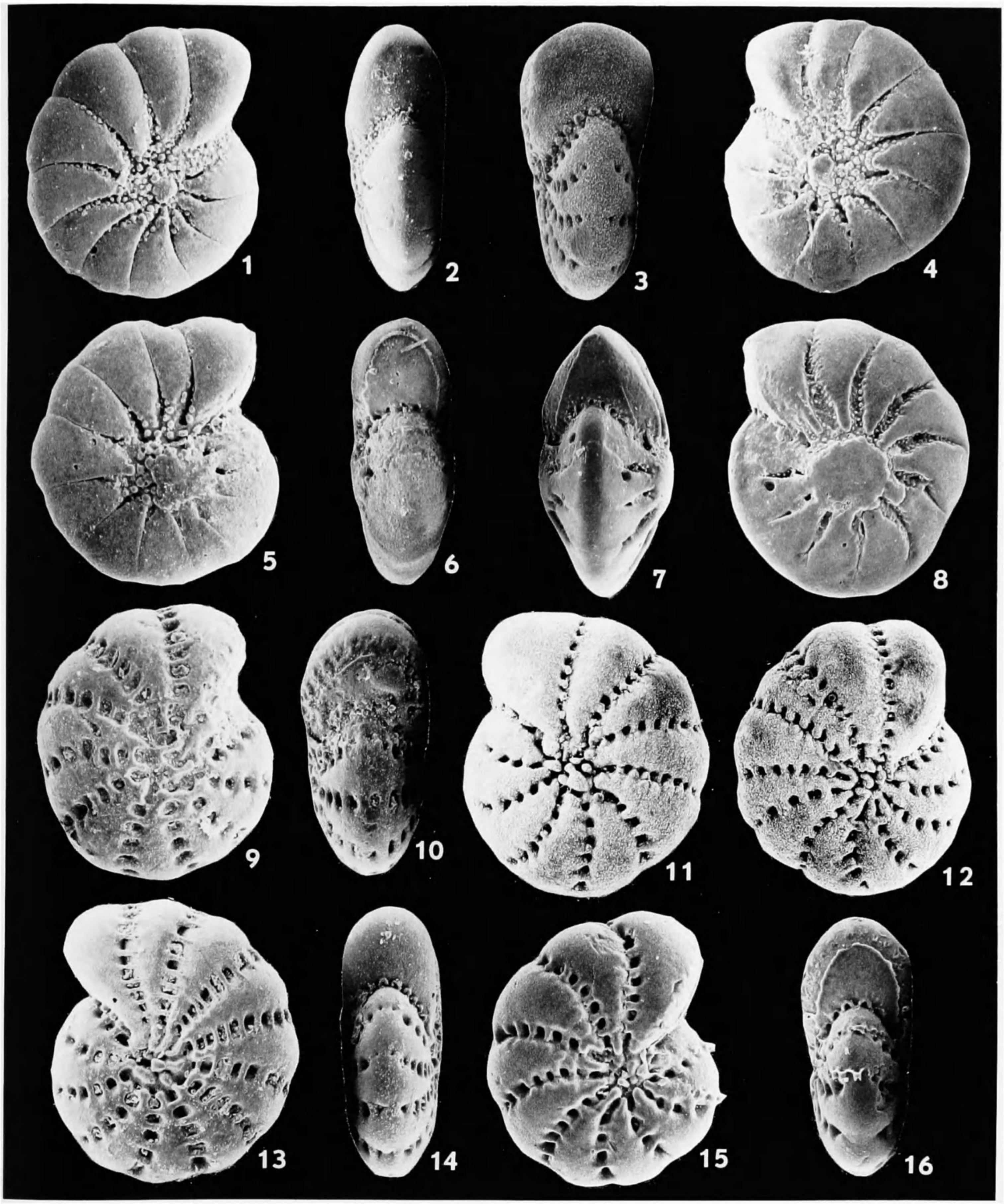
4–6. *Nonion advenum pustulosum*, new subspecies, Silverdale beds of Vokes (1967), near Long Point, North Carolina, paratypes, USGS 22294: 4, USNM 252562, side view, × 160; 5, USNM 252563, side view, × 180; 6, USNM 252563, apertural view, × 180.

7, 8. *Nonion advenum advenum* (Cushman), Chickasawhay Formation, Choctaw Bluff, Alabama, USNM 252626, USGS 25921: 7, apertural view; 8, side view. Both × 200.

9, 10, 13, 14. *Elphidium latispatium pontium*, new subspecies, Silverdale beds of Vokes (1967), near Long Point, North Carolina, paratypes, USGS 22294: 9, USNM 252574, side view, × 200; 10, USNM 252574, apertural view, × 200; 13, USNM 252575, side view, × 160; 14, USNM 252575, apertural view, × 160.

15, 16. *Elphidium latispatium latispatium* Poag, Paynes Hammock Formation, near Waynesboro, Mississippi, USNM 252625, USGS 25966: 15, side view; 16, apertural view. Both × 240.

Micrographs reduced to 93% for publication.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