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JOSEPH T. SINGEWALD, JR., *Director*
Bulletin 3

EOCENE STRATIGRAPHY AND FORAMINIFERA OF THE AQUIA FORMATION

BY
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PREFACE

The stratigraphic and paleontologic investigations of the ditch samples and cores from the deep test wells for oil and gas that were drilled on the Eastern Shore in 1943 to 1946, the results of which are published in Bulletin 2 of the Department of Geology, Mines and Water Resources, disclosed that the strata correlated as Eocene in this subsurface study represented portions of Eocene time that were not represented in the outcrop strata described in the Eocene systematic report of the Maryland Geological Survey published in 1901.

The 1901 Eocene report was published before micropaleontology had been developed as an important means of stratigraphic correlation. Only a very limited use of microfossils was made in that study. The subsurface results from the Eastern Shore wells raised the question whether the time intervals represented by the outcropping strata were different from the time intervals represented by the subsurface strata, or whether the discrepancies were due to an incomplete knowledge of the time intervals represented by the outcrop strata.

To answer this question, Dr. Elaine Shifflett systematically sampled the Lower Eocene outcrops at the type locality in Virginia and at other exposures in Virginia and Southern Maryland, and utilized the samples from water wells in Southern Maryland and on the Eastern Shore that penetrated the Eocene strata. These samples were secured by the Department of Geology, Mines and Water Resources through the 1945 well control law. A comprehensive investigation of the Foraminifera in these Eocene sections was made and the results compared with the correlations of the Eocene strata in the deep test wells farther east on the Eastern Shore.

The investigation was carried out in the Geological Laboratory of The Johns Hopkins University under the guidance of Professor Harold E. Vokes and with much assistance from Dr. Robert M. Overbeck, Ground Water Geologist of the Department of Geology, Mines, and Water Resources.

This report is an important addition to the knowledge of geologic history during Eocene time in the region of Southern Maryland and the southern part of the Eastern Shore. It reveals the migrations of the shore line and areas of deposition during Paleocene and Eocene times and shows that the time intervals represented by the Eocene strata in the subsurface of the Eastern Shore are different from the time intervals represented by the Eocene strata which outcrop in Maryland and Virginia.

JOSEPH T. SINGEWALD, JR., *Director.*

PURPOSE AND SCOPE OF THE REPORT

The age of the Eocene formations of Maryland and Virginia in the outcrop has been referred to the Wilcox and Claiborne, Eocene, of the Gulf Coastal Plain on the basis of both megafossils (Cooke, Gardner and Woodring, 1943) and microfossils (Cushman, 1944b, p. 17). No beds of Wilcox age and no beds of definite Claiborne age were recognized, however, by Cushman, on the basis of foraminiferal studies, in the Ohio Oil Company's Larry G. Hammond well[1] near Salisbury, Maryland, some 50 to 60 miles southeast of the outcrop of the Eocene which trends northeast-southwest across Maryland. Strata of Paleocene and Jackson, Upper Eocene, age were found in this well.

This suggested the possibilities that the outcrop had not been sufficiently searched for faunas of Paleocene and Jackson age, or that the history of the Eocene of Maryland in the subsurface was very different from that of the Eocene of the outcrop in Maryland and Virginia. If the latter proved to be the case, the questions would remain whether facies changes were responsible for the different faunas of the outcrop and the subsurface, or whether deposition occurred in different areas in the course of Eocene times.

A systematic study of the Foraminifera of the Lower Eocene, Aquia formation, from the outcrop in Maryland and Virginia and from water well samples in Maryland was made to interpret the history of the Lower Eocene in Maryland. The foraminiferal fauna of the Aquia formation is described, and the extent and position of the Aquia beds in the subsurface in southern Maryland are determined.

Another aspect of the investigation involved a distinctive foraminiferal fauna found in the Buchheister water well at Upper Marlboro, Prince George's County, Maryland, determined by Cushman as Paleocene in age. This raised the question whether this fauna underlies the typical Aquia Eocene fauna, or whether it is a facies fauna of the Aquia and the beds containing it a time equivalent of the Aquia. The Buchheister well Paleocene fauna proves to be an older fauna than the Aquia fauna.

[1] Maryland Department of Geology, Mines and Water Resources, Bulletin 2, 1948.

ACKNOWLEDGMENTS

The investigation was suggested by Professor Harold E. Vokes of the Department of Geology of The Johns Hopkins University and carried out both in the field and in the laboratory under his guidance. Field and laboratory assistance was also rendered by Dr. Robert M. Overbeck, Groundwater Geologist of the Maryland Department of Geology, Mines and Water Resources, and by Dr. J. L. Anderson, Associate Professor of Geology of The Johns Hopkins University. Miss Ruth Schmidt of the United States Geological Survey showed the author the fossiliferous locality at Friendly, Maryland where the Eocene-Cretaceous contact is exposed and furnished samples from zones 8 and 9 of the Aquia formation at Aquia Creek, Virginia.

The samples from Maryland water wells were collected through the cooperative groundwater investigations of the Maryland Department of Geology, Mines and Water Resources and the United States Geological Survey. Miss Claire Richardson aided in making these well records accessible.

All of the facilities of the Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts, were available for use during the investigations. Dr. Joseph A. Cushman very kindly checked the identifications of the Foraminifera from the outcrop of the Aquia formation at Aquia and Potomac Creeks, Virginia, and Miss Ruth Todd aided greatly in giving access to the collections.

The cooperation of the staffs of the Department of Geology of The Johns Hopkins University, the Maryland Department of Geology, Mines and Water Resources, the Baltimore Field Office of the Ground Water Division of the United States Geological Survey and the Cushman Laboratory for Foraminiferal Research is much appreciated.

HISTORICAL SUMMARY

Previous Work on Foraminifera

The Atlantic Coastal Plain has received much attention from geologists during the past two centuries, and the formations which are so easily accessible because of the extensive waterways have been the subject of many geological papers and discussions. A summary of the early work in stratigraphy and paleontology of the Atlantic and Gulf Coast region is given by Clark (1891 pp. 17–37), and summaries of the work in Maryland and Virginia are given by Clark and Martin (1901, pp. 24–31) and by Gildersleeve (1942, pp. 4–6).

Since the first important paleontological studies of the American Tertiary by T. A. Conrad (1832) the macrofauna of the Eocene of the Middle Atlantic Slope has been studied by numerous paleontologists. The microfauna of the Eocene of Maryland and Virginia, however, has received relatively little study.

In 1845 J. W. Bailey figured two "Rotaline" casts, one of which was from "the greensand of Fort Washington, Maryland." This was probably a foraminifer from an Eocene horizon. In Otto Meyer's report on Upper Tertiary invertebrates from the west side of Chesapeake Bay (1888, pp. 170–171), Anthony Woodward mentioned three species of Foraminifera, one of which Bagg later recorded as Eocene in age.

The early records and descriptions of Foraminifera in Maryland and Virginia were by R. M. Bagg, Jr. As early as 1895 (in Clark, 1895, p. 6) he gave a list of twenty-three species from the Eocene from localities at Woodstock and Pamunkey River, Virginia and Sunnyside, Maryland. This list was republished a year later in Clark's report (1896a, pp. 91–92) with no additions. Twenty-five Eocene species from the Middle Atlantic Slope were described and figured by Bagg in 1898. They included a number of species which had been identified in greensand samples from artesian well borings at Norfolk, Virginia, and Crisfield, Maryland. In the Maryland Eocene volume Bagg recorded thirty-three species mainly from Eocene localities at Upper Marlboro and Seat Pleasant, Maryland, and Woodstock, Virginia. The figures in this publication as well as the ones in the preceding publication are rather conventionalized, and the references are not included in the synonymies in this paper although they are mentioned in some cases in the remarks concerning various species. In 1912 (Clark and Miller, pp. 123–124), Foraminifera were recorded from the Aquia formation from three localities, 1 mile northeast of Piscataway and 1 mile southeast of Mason Springs in Maryland, and 2 miles below Potomac Creek in Virginia. Woodstock, Virginia, and a locality on Pope's Creek, Maryland, yielded seventeen species of Foraminifera from the Nanjemoy formation.

The study of Eocene Foraminifera of Maryland or Virginia was not resumed after Bagg's work until 1944 when Dr. Joseph A. Cushman studied samples from the Aquia formation from Marlboro Point between the mouths of Potomac and Aquia Creeks on the Potomac River, Stafford County, Virginia, from Fairview Beach, King George County, Virginia, and from a locality ½ mile southeast of Stafford Court House, Stafford County, Virginia. The first locality is probably the same as Gildersleeve's Section 2 and is very near the type locality of the Aquia formation from which the samples for the present study were taken. Cushman records forty-four species, most of which are again recorded here.

DIVISIONS OF THE EOCENE OF MARYLAND AND VIRGINIA

The term "Eocene" was first used in reference to the American Lower Tertiary deposits by Lea (1833) in a discussion of the stratigraphy of the Atlantic Coastal Plain. The name "Pamunkey formation" was applied to the Eocene deposits of the Middle Atlantic Slope by Darton in 1891 (p. 432).

The present divisions of the Pamunkey are as follows:

Pamunkey Group
- Nanjemoy formation
  - Woodstock member or substage
  - Potapaco member or substage
- Aquia formation
  - Paspotansa member or substage
  - Piscataway member or substage

Clark (1895, p. 3) previously recognized two stages of the Pamunkey and designated them the "Aquia Creek stage" and the "Woodstock stage", the names being taken from localities on the Virginia bank of the Potomac River. Subsequently Clark and Martin (1901, p. 58), who further divided the Pamunkey into substages, used the name Woodstock as a substage name and the Nanjemoy as the name of the upper formation.

The Pamunkey Group has been divided into seventeen zones (Clark, 1896a, pp. 41–43; 1896b, pp. 367–69). The Aquia formation comprises zones 1–9 described by Clark from the type locality in the bluffs at Aquia Creek, Stafford County, and at Potomac Creek, King George County, Virginia. These zones were later redefined by Clark and Martin and distinguished on the bases of lithology and contained macrofossils.

Zones 1–7 are included in the Piscataway substage. The name is taken from Piscataway Creek which empties into the Potomac River on the Maryland bank about ten miles below Washington, D. C. In the Eocene volume of the Maryland Geological Survey, a list of nineteen macrofossils restricted to this

horizon is given. The Paspotansa substage, named from Paspotansa Creek, which empties into the Potomac from the Virginia side a mile below Potomac Creek, includes zones 8 and 9. A list of seventy-four macrofossils restricted to the Paspotansa substage is given. The division of the Aquia formation into two faunal substages is substantiated by the study of the microfauna of the outcrop.

OUTCROP LOCALITIES

Figure 1 is a map showing the locations of the outcrop sections and the wells involved in this study.

From the outcrop material of the Aquia formation, seventy-eight species and five varieties of Foraminifera are recorded, including six new species and one new variety.

The Aquia formation is not fully exposed in any single section, although the bluffs at the type locality of the formation at Aquia Creek, Virginia, exhibit a section complete except for zone 1 and probably the lower portion of zone 2. For this reason and for reasons of accessibility a composite section of the formation was obtained by sampling three localities. These were at Aquia and Potomac creeks in Virginia and at Friendly, Maryland. Since two of the localities, Aquia Creek and Potomac Creek, were those first described by Clark, the samples were taken with reference to the nine zones enumerated by him. As recognized by Gildersleeve, Schmidt and others who have worked in the area these zones cannot always be traced laterally over much distance. That Clark himself realized this is indicated by his statement (1896a, p. 39) that

"the deposits may be locally separated into clearly defined lithological zones, which sometimes admit of recognition in adjoining regions."

A complete vertical section of the formation was obtained by taking samples systematically from the bluffs. Samples representing an interval of $\frac{1}{2}$ foot were taken at Aquia Creek and Potomac Creek and an interval of 1 foot at the Friendly locality. In the vertical distribution charts the species from alternate samples only are recorded.

Outcrop locality No. 1—Small stream bed near Friendly, Prince George's County, Maryland. "U. S. Geol. Survey Anacostia, Md.-D. C. quad., 1:31,-680, 1945. (Also on Washington and Vicinity, Md.-Va.-D. C. quad.) Southwest corner of map; stream south of road leading west from Friendly, Maryland. Aquia formation crops out 0.5 mile west of Friendly; Monmouth formation farther downstream. . .".[2] Here the Cretaceous and Eocene are exposed in contact with one another. This locality was chosen as it was known to contain a fairly abundant foraminiferal fauna, whereas the section described by Clark and Martin at Glymont, Maryland, where the Cretaceous-Eocene contact is exposed is practically barren of Foraminifera.

A sample was taken below the contact so that the Cretaceous and Eocene microfaunas could be compared, and fifty feet of Eocene beds above the contact were sampled, a sample being taken for every foot. As the entire section

[2] Schmidt, Ruth A. M., Journ. Pal., vol. 22, 1948, p. 399.

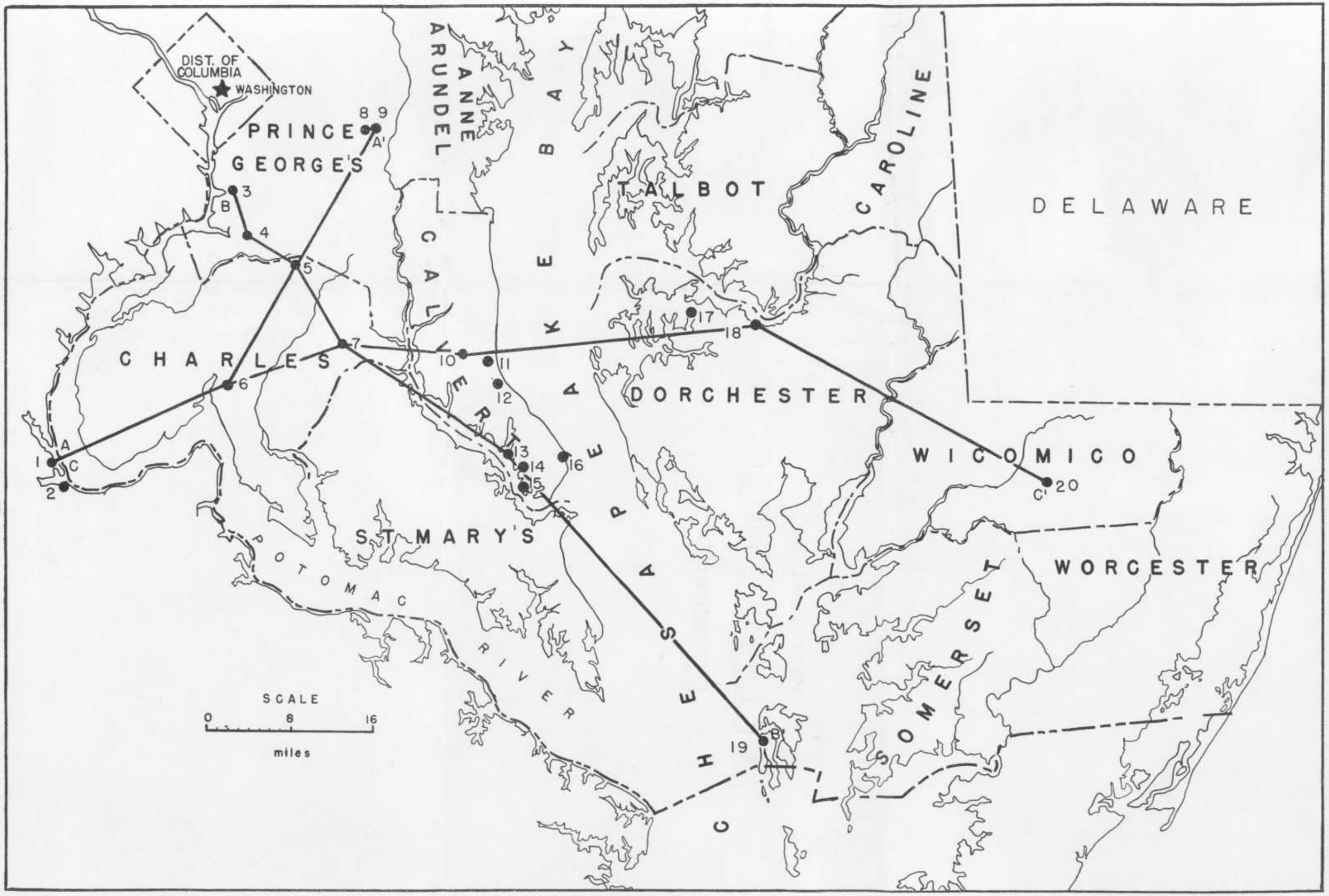


FIGURE 1—Sample Localities. Outcrops: 1. Aquia Creek, Virginia. 2. Potomac Creek, Virginia. 3. Friendly, Maryland. Water wells: 4. Kierstead. 5. Maryland State Police. 6. Southern Maryland Cleaners. 7. Southern Maryland Electric Cooperative. 8. Gardner. 9. Buchheister. 10. Goldstein. 11. Gravatt. 12. Trueman. 13. Duke Adams. 14. Richardson. 15. Dowell. 16. Michitoff. 17. Linthicum. 18. Dorchester Water Company. 19. Bradshaw. 20. Ohio Oil Company Larry G. Hammond well. A-A, B-B′, C-C′ lines of section shown in figures 19–21.

here was not exposed in a single vertical section, samples were taken from successively higher exposures upstream by means of a Locke level traverse.

The microfaunas above and below the contact indicate clearly the difference in age. Three species belonging to the genera *Textularia*, *Valvulineria* and *Lamarckina* are characteristic of the Cretaceous here and were easily recognized in the Cretaceous samples from some of the well sections.

The beds above and below the contact are very similar lithologically, and the contact would not be apparent except for the obvious change in the macrofaunas. Within two inches of the contact typical Cretaceous fossils including a *Baculites* with the nacreous shell material still preserved were recognized. Above the contact typical Eocene species of *Venericardia* and other Eocene fossils were found. The preservation of the fossils is similar to that at Aquia Creek and Potomac Creek where the fossils are very soft and crumbly and are difficult to remove in a whole condition. This is due to the solubility of the shells when subjected to the groundwaters circulating through the porous greensands.

The lithologic section sampled at Friendly beginning with the younger beds is as follows:

	Thickness in Feet
Light buff-colored, iron-stained, glauconitic quartz sand and shell fragments	2
Light buff-colored, indurated ledges composed of glauconitic quartz sand, much calcareous cement and shell fragments, alternating with less indurated layers of the same composition, the layers each being about a foot in thickness	7
Yellowish weathered greensand and shell fragments	2
Greensand composed of glauconite, quartz and shell fragments	4
Gray, indurated ledge of glauconitic quartz sand with calcareous cement and shell fragments. Somewhat weathered and iron-stained in the upper portion	3
Greenish gray, glauconitic quartz sand, calcareous clay and shell fragments. Somewhat indurated and slightly weathered in part	6
Indurated layer of glauconitic quartz sand, calcareous cement and shells	2
Gray glauconitic quartz sand, calcareous clay and shell fragments	1
Indurated layer	3
Gray sand	1
Greensand composed of glauconite, quartz and a little clay	1
Indurated glauconitic quartz sand, calcareous cement and shell fragments	5
Gray glauconitic quartz sand and shell fragments	2
Greensand composed of quartz and glauconite and shell fragments in the upper portion	4
Not exposed	3
Greenish gray to yellowish glauconitic quartz sand, calcareous clay and shell fragments	4
Cretaceous-Eocene contact	
Gray glauconitic quartz sand, some mica, calcareous clay and shell fragments just below the contact	

In summary the lithology may be described as a homogeneous series of glauconitic quartz sands. The color varies according to the amount of iron

due to weathering, and the induration varies according to the amount of calcareous cement. The absence of mica is striking in comparison with the amount of mica in the beds at Aquia Creek and Potomac Creek.

The Foraminifera were recovered from the indurated beds by boiling the samples in a sodium peroxide solution before washing. The amount of foraminiferal material recovered did not seem to be a function of the degree of induration as some of the indurated layers yielded very poor microfaunas whereas the upper indurated layers contained numerous species.

Figure 2 is a vertical distribution chart showing the species recorded from this locality and their range. Eleven species were found here which were not found at Aquia Creek or Potomac Creek in Virginia. They are the following:

Gaudryina sp.
Vaginulina plumoides Plummer
Lagena hexagona (Williamson)
Gümbelina wilcoxensis Cushman and Ponton
Eouvigerina excavata Cushman
Ellipsonodosaria (?) sp.
Discorbis amicus Shifflett, n. sp.
Valvulineria sp.
Globigerina compressa Plummer
Cibicides marylandicus Shifflett, n. sp.
Cibicides neelyi Jennings

Correlation of the Friendly section with the Piscataway substage of Aquia Creek is discussed in a subsequent part of this report. The Friendly section probably includes zones 1 and 2, although lithologic correlation with the local zones at Aquia Creek is impossible.

Outcrop locality No. 2—Section of southwestern portion of bluff southeast of Brents Point at Aquia Creek, Stafford County, Virginia. War Department, Corps of Engineers, U. S. Army Widewater, Va.-Md. quad., 1:31,680, 1944. This is the type locality of the Aquia formation originally described by Clark (1896a, p. 40).

Figure 3 gives a general columnar section, compiled from the information of Clark and Martin, showing the lithology and most important megafossils of the zones at Aquia Creek. The lithology is typical Eocene greensand composed of glauconite, quartz, calcareous clay and a large amount of mica. The clay acts as a cement in the indurated ledges.

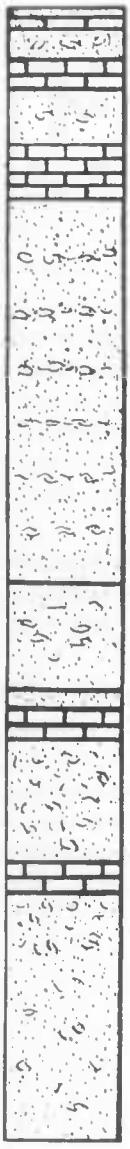
Figure 4 is a vertical distribution chart showing the range of the species in the sections from Potomac and Aquia creeks. Zones 2–9 of the Aquia formation are exposed at Aquia Creek. Zones 2–7 and the lower 5 feet of zone 8 were sampled systematically every half foot at Aquia Creek, and the remaining portion of zone 8 was systematically sampled at Potomac Creek. A check list of the few species found higher in zone 8 in a 10-foot channel sample at Aquia Creek is given for comparison with the species found in zone 8 at Potomac

	49–50′	47–48′	45–46′	43–44′	41–42′	39–40′	37–38′	35–36′	33–34′	31–32′	29–30′	26–27′	25–26′	24–25′	21–22′	19–20′	17–18′	15–16′	13–14′	11–12′	9–10′	7–8′	3–4′	1–2′	2″–1′	0–2″
Haplophragmoides sphaericulum Cushman																								x		
Spiroplectammina wilcoxensis Cushman & Ponton		x	x	x	x	x	x			x	x									x				x	x	x
Gaudryina sp.																									x	
Robulus midwayensis (Plummer), var. *virginianus* Shifflett, n. var.			x									x								x			x	x	x	
Dentalina communis d'Orbigny	x	x	x	x	x	x	x	x	x	x	x	x				x				x				x	x	x
Dentalina virginiana Cushman	x	x	x		x	x	x		x	x	x	x								x			x			
Dentalina wilcoxensis Cushman	x		x			x	x	x		x	x									x						
Nodosaria sp.											x															
Vaginulina plumoides Plummer						x																				
Lagena clavata d'Orbigny							x			x																
Lagena costata (Williamson)	x						x			x	x		x							x				x	x	x
Lagena hexagona (Williamson)							x	x																		
Lagena laevis (Montagu)	x			x			x	x	x	x														x	x	x
Guttulina irregularis d'Orbigny	x	x	x	x	x	x	x	x		x										x						
Guttulina problema d'Orbigny	x	x	x	x	x	x	x	x	x	x		x	x			x			x	x		x	x	x	x	x
Guttulina wilcoxensis Cushman & Ponton	x	x	x			x	x	x	x	x	x	x								x				x	x	x
Globulina cf. *gibba* d'Orbigny						x					x															
Globulina inaequalis Reuss	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x		x	x		x	x	x	x	x
Globulina minuta (Roemer)								x			x															
Globulina münsteri (Reuss)	x		x																					x	x	
Glandulina abbreviata (Neugeboren)							x				x									x				x	x	x
Glandulina laevigata d'Orbigny																									x	
Pseudopolymorphina decora (Reuss)			x																							
Pseudopolymorphina wilcoxensis Cushman & Ponton		x	x			x	x	x		x	x	x								x			x	x	x	x
Sigmomorphina semitecta (Reuss)	x				x	x		x			x									x				x		
Sigmomorphina semitecta (Reuss), var. *terquemiana* (Fornasini)	x	x	x	x	x	x	x	x	x	x	x	x				x				x				x	x	x
Polymorphina advena Cushman, var. *nuda* Howe & Walla·e						x																				
Polymorphina sp.	x		x			x	x	x		x	x	x				x		x		x						
Nonion planatum Cushman & Thomas						x					x	x	x						x	x			x	x	x	x
Nonionella insecta (Schwager)			x			x																				
Gümbelina wilcoxensis Cushman & Ponton					x			x		x																
Eouvigerina excavata Cushman	x	x	x		x	x	x	x		x														x		
Bulimina ovata d'Orbigny							x																			
Entosolenia cf. *marginata* (Walker & Jacob)		x		x	x	x		x		x																
Entosolenia oslatus Shifflett, n. sp.		x		x		x	x	x	x	x	x									x						
Virgulina wilcoxensis Cushman & Ponton			x			x	x	x		x																
Angulogerina parvula (Cushman & Thomas)																									x	
Angulogerina virginiana Cushman	x		x		x	x	x	x	x	x														x	x	x
Angulogerina wilcoxensis Cushman & Ponton																				x						
Ellipsonodosaria (?) sp.			x					x		x										x						
Discorbis amicus Shifflett, n. sp.	x		x		x	x	x			x														x	x	x
Discorbis calypira Shifflett, n. sp.	x	x	x		x	x	x	x		x	x	x								x		x	x			x
Lamarckina wilcoxensis Cushman	x										x		x		x	x	x				x		x	x		x
Valvulineria scrobiculata (Schwager)	x	x	x	x	x	x	x	x	x	x	x	x		x	x		x	x								
Valvulineria wilcoxensis Cushman & Ponton	x	x	x	x	x	x	x	x	x	x	x															
Valvulineria sp.							x	x		x																
Gyroidina soldanii d'Orbigny, var. *octocamerata* Cushman & G. D. Hanna	x																			x						
Eponides labiomargus Shifflett, n. sp.	x	x	x	x	x	x	x	x	x	x	x	x		x	x					x			x			x
Eponides lotus (Schwager)																							x		x	
Pulvinulinella danvillensis Howe & Wallace				x	x	x	x	x		x													x			
Alabamina wilcoxensis Toulmin	x	x	x		x	x	x	x		x	x	x			x					x			x	x	x	x
Globigerina compressa Plummer	x			x						x										x						
Globigerina cf. *ouachitaensis* Howe & Wallace	x	x	x	x	x	x	x	x	x	x	x				x					x			x		x	x
Globigerina cf. *pseudo-bulloides* Plummer	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x		x	x			x	x	x	x
***Globigerina triloculinoides* Plummer**	x		x	x	x	x	x	x	x	x	x				x					x				x	x	x
Globorotalia cf. *angulata* (White)				x			x			x																
Globorotalia membranacea (Ehrenberg)									x	x	x															
Globorotalia wilcoxensis Cushman & Ponton						x																				x
Globorotalia wilcoxensis Cushman & Ponton, var. *acuta* Toulmin	x		x	x	x	x	x			x																
Anomalina umbonifera (Schwager)	x	x	x	x	x	x	x	x	x	x	x	x			x					x			x	x	x	x
Cibicides howelli Toulmin	x	x	x	x	x	x	x	x	x	x	x	x			x		x			x			x		x	x
Cibicides marylandicus Shifflett, n. sp.			x				x			x										x			x	x		x
Cibicides neelyi Jennings																				x					x	
Cibicides praecursorius (Schwager)			x			x					x									x						x

Eocene

Cretaceous

FIGURE 2—*Vertical Distribution Chart of Foraminifera from the Outcrop, Aquia Formation, Piscataway Substage, Friendly, Maryland*



Thickness		Zone
12′	Thick-bedded arenaceous and glauconitic limestone interstratified with layers of weathered greensand, the indurated strata largely composed of the shells of *Turritella mortoni*	9
25′	Greensand bed, much weathered in its upper portions, containing *Turritella mortoni* in several thick layers; also *T. humerosa*, *Cucullaea gigantea*, *Crassatellites alaeformis*, *Ostrea compressirostra* and many other species	8
7′	Dark-colored greensand containing broken shells of *Meretrix ovata*, var. *pyga* and *Crassatellites alaeformis*	7
1′	Dark-colored greensand containing same forms as zone 7 in	
2′	whole condition	6
	Indurated layer of light-colored greensand containing same forms as zone 4	5
8′	Greensand marl containing *Turritella mortoni*, *T. humerosa*, *Crassatellites alaeformis*, *Dosiniopsis lenticularis*, *Meretrix ovata*, var. *pyga*, *Panopea elongata*, *Pholadomya*	
2′	*marylandica*	4
	Indurated layer of dark-colored greensand containing same forms as zone 2	3
16′	Greensand marl containing *Dosiniopsis lenticularis*, *Meretrix ovata*, var. *pyga* and *Crassatellites alaeformis*	2

FIGURE 3—*Section Showing Lithology and Major Megafossils at Aquia Creek and Potomac Creek, Virginia*

Creek. A list of species found in a sample from zone 9 at Aquia Creek is also given. The latter two samples were furnished by Ruth Schmidt of the United States Geological Survey.

The check list of Foraminifera from a field sample channeled for 10 feet from zone 8, Aquia Creek "collected from 3 shelly zones and areas between where fossils are leached out"[3] is:

Haplophragmoides sphaeriloculum Cushman
Spiroplectammina wilcoxensis Cushman and Ponton
Robulus midwayensis (Plummer), var. *virginianus* Shifflett, n. var.
Globulina inaequalis Reuss
Globigerina triloculinoides Plummer
Anomalina umbonifera (Schwager)
Stichocibicides cerviculus Shifflett, n. sp.

The check list of Foraminifera from a field sample from zone 9, Aquia Creek "taken from top of cliff—some loose material between indurated areas"[3] is:

Robulus wilcoxensis Cushman and Ponton
Globulina inaequalis Reuss
Angulogerina wilcoxensis Cushman and Ponton
Globigerina triloculinoides Plummer
Anomalina umbonifera (Schwager)

Outcrop locality No. 3—Section of center of southern bluff opposite Marlboro Point at Potomac Creek, King George County, Virginia. War Department, Corps of Engineers, U. S. Army Passapatanzy, Va.-Md. quad., 1:31,680, 1944. This is the section originally described by Clark (1896a, p. 40).

Figure 3 shows the typical Eocene greensand lithology of this section. The formation is considerably weathered, and the color of the outcrop is yellowish brown due to the resulting iron oxide.

Zones 8 and 9 of the Aquia formation and the lower part of the overlying Nanjemoy formation are exposed. Zone 8 was systematically sampled, and the vertical range of the species recorded is shown in Figure 4. The non-indurated portions of zone 9 and the lower portion of the Nanjemoy formation were sampled, but they yielded no fossils.

[3] Miss Schmidt's labels.

SUBSTAGES OF THE AQUIA

The division of the Aquia formation into two substages, a lower, Piscataway substage, and an overlying, Paspotansa substage, originally made on the basis of the macrofauna, is substantiated by the distribution of the foraminiferal fauna. Twenty-five species occur in the Piscataway substage at the type locality of the Aquia formation at Aquia Creek which are not present in the outcrop material of the Paspotansa. An additional eleven species were found in the Piscataway substage represented in the section at Friendly, Maryland. Eight species found in the Paspotansa at Potomac Creek are not present in the Piscataway substage.

The following species are restricted to the Piscataway substage in the outcrop material at Aquia Creek, Virginia, and Friendly, Maryland, and are not present in the outcrop material of the Paspotansa substage:

Ammobaculites sp.
Gaudryina sp.
Quinqueloculina cf. *harrisi* Howe and Roberts
Marginulina toulmini Cushman
Dentalina cf. *hexacostata* Howe
Dentalina virginiana Cushman
Dentalina wilcoxensis Cushman
Vaginulina plumoides Plummer
Lagena hexagona (Williamson)
Lagena laevis (Montagu)
Pyrulina sp.
Glandulina abbreviata (Neugeboren)
Glandulina laevigata d'Orbigny
Pseudopolymorphina wilcoxensis Cushman and Ponton
Sigmomorphina semitecta (Reuss)
Polymorphina advena Cushman, var. *nuda* Howe & Wallace
Nonionella insecta (Schwager)
Gümbelina wilcoxensis Cushman and Ponton
Eouvigerina excavata Cushman
Entosolenia cf. *laevigata* (Reuss)
Entosolenia cf. *marginata* (Walker and Jacob)
Entosolenia oslatus Shifflett, new species
Virgulina wilcoxensis Cushman and Ponton
Angulogerina parvula (Cushman and Thomas)
Angulogerina virginiana Cushman
Ellipsonodosaria (?) sp.
Discorbis amicus Shifflett, new species
Valvulineria scrobiculata (Schwager)
Valvulineria wilcoxensis Cushman and Ponton
Valvulineria sp.
Eponides labiomargus Shifflett, new species

Pulvinulinella danvillensis Howe and Wallace
Globigerina compressa Plummer
Globorotalia cf. *angulata* (White)
Cibicides marylandicus Shifflett, new species
Cibicides neelyi Jennings

The following species are restricted in the outcrop material to the Paspotansa substage:

Ammodiscus incertus d'Orbigny
Cyclammina sp.
Trochammina exigua Cushman and Applin
Trochammina howei Cushman
Trochammina sp.
Robulus knighti Toulmin
Eponides sp.
Stichocibicides cerviculus Shifflett, new species

The following species are found predominantly in the Paspotansa substage with a few specimens present in the Piscataway substage at Friendly. They were not found in the Piscataway at Aquia Creek:

Angulogerina wilcoxensis Cushman
Gyroidina soldanii d'Orbigny, var. *octocamerata* Cushman and G. D. Hanna

CORRELATION OF THE SUBSTAGES OF THE AQUIA

Correlation of Friendly and Aquia Creek Sections

The correlation of the section at Friendly, Maryland, with that at Aquia Creek, Virginia, presents a rather difficult problem. The presence of the following species limits the Friendly section to the Piscataway substage of the Aquia according to the foraminiferal fauna at Aquia Creek.

Dentalina virginiana Cushman
Dentalina wilcoxensis Cushman
Lagena laevis (Montagu)
Glandulina abbreviata (Neugeboren)
Glandulina laevigata d'Orbigny
Pseudopolymorphina wilcoxensis Cushman and Ponton
Sigmomorphina semitecta (Reuss)
Nonionella insecta (Schwager)
Entosolenia cf. *marginata* (Walker and Jacob)
Entasolenia oslatus Shifflett, new species
Virgulina wilcaxensis Cushman and Ponton
Angulogerina parvula (Cushman and Thomas)
Angulogerina virginiana Cushman
Valvulineria scrobiculata (Schwager)
Valvulineria wilcoxensis Cushman
Eponides labiomargus Shifflett, new species
Pulvinulinella danvillensis Howe and Wallace
Globorotalia cf. *angulata* (White)

The section at Friendly should include zone 1 of Clark, the basal zone of the Aquia above the Cretaceous-Eocene contact, and should overlap the section at Aquia Creek. Zone 1 is recorded (Clark and Martin, 1901, p. 68) as having a thickness of 8 feet at Glymont, Maryland, and a thickness of 18 feet two miles up Aquia Creek.

Of the eighteen species which restrict the section at Friendly to the Piscataway substage only three occur in sufficient abundance and in significant zonal arrangement in both sections to form a basis for correlation. They are *Pseudopolymorphina wilcoxensis* Cushman and Ponton, *Valvulineria scrobiculata* (Schwager) and *Valvulineria wilcoxensis* Cushman and Ponton.

Arbitrary limits were chosen to classify the occurrence of a species in a sample as rare, common or abundant. The intervals in which a species is common or abundant were then used to correlate the sections at Friendly and Aquia Creek. They are shown on Figure 5. Above and below the limits of the intervals used the species is rare.

On the basis of the occurrence of *Pseudopolymorphina wilcoxensis* the lower 24 feet of the Friendly section are below the section at Aquia Creek. This is

the most useful species as it occurs abundantly within this narrow zone 4 to $4\frac{1}{2}$ feet thick at both localities. On the basis of the occurrence of *Valvulineria scrobiculata* 19 feet of the Friendly section are below the Aquia Creek section, and on the basis of the occurrence of *Valvulineria wilcoxensis* 20 feet of the Friendly section are below the Aquia Creek section. Thus the section at Friendly includes between 19 feet and 24 feet of section stratigraphically lower

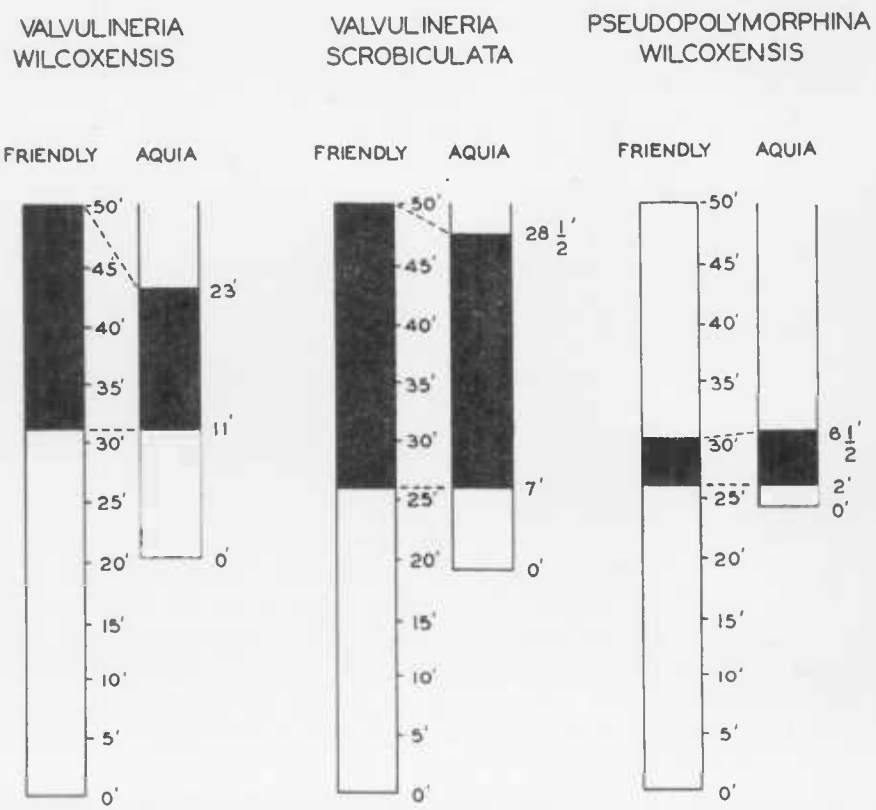


FIGURE 5—*Sections showing the species used in the correlation of the Aquia Creek, Virginia and Friendly, Maryland sections*

than the Aquia Creek section. More restricted correlation is not practical on the basis of the Foraminifera, and lithologic correlation with the zones of Clark is impossible. The 50 feet sampled at Friendly probably include the time equivalents of zones 1 and 2 at least.

SUBSURFACE CORRELATION

Many of the species listed here as restricted to one substage or the other are represented by only a few specimens and cannot be used in correlation. Some

of the species restricted in the outcrop to one substage were found to have a wider range in the subsurface. General faunal assemblages must be used in the distinction of the two substages in the subsurface.

The Piscataway substage is characterized by a considerably larger fauna than the Paspotansa substage. This is apparent from Figure 4 and the lists of species restricted to the substages in the outcrop. This condition persists in the subsurface, and the two substages were easily distinguished in the three wells from Charles County, Maryland, and in two of the three wells from Prince George's County, Maryland.

The eight species restricted to the Paspotansa in the outcrop cannot be used in correlation as specimens of them are found rarely or not at all in the subsurface.

The Piscataway substage can be recognized immediately by the greater abundance of species. Only one species was found to be absolutely restricted to this substage in the subsurface, but four other species are of use in correlation.

Dentalina virginiana Cushman is restricted to the Piscataway substage in both outcrop and subsurface. It is not present in abundance but is of use in correlation as it makes its first appearance at the top of the Piscataway. It was not found in the Gardner well.

The following comments on species used in correlation apply to the wells in Charles County and Prince George's County with the exception of the Buchheister well in which the Paspotansa substage of the Aquia could not be recognized. An explanation of its absence is suggested in the discussion of the Buchheister well.

Valvulineria scrobiculata (Schwager) comes in abundantly in all the wells at the top of the Piscataway. It is restricted to the Piscataway except in the Southern Maryland Cleaners well and Southern Maryland Electric Cooperative well where a few specimens occur higher in the section.

Eponides labiomargus Shifflett, new species is practically restricted to the Piscataway and occurs abundantly in it. In three of the wells scattered specimens were found higher in the section.

Cibicides neelyi Jennings comes in rather abundantly at the top of the Piscataway in four of the wells and seems to be characteristic of this substage. In the Maryland State Police well the species is rare and occurs in two samples in the Nanjemoy part of the section.

Alabamina wilcoxensis Toulmin is markedly more abundant in the Piscataway substage, although specimens are found higher in the section in all the wells except the Southern Maryland Cleaners well.

The occurrence of these species in some abundance together with the first appearance in the section of a considerable number of species usually mark the top of the Piscataway substage quite definitely.

DIFFERENTIATION OF THE NANJEMOY AND THE AQUIA

In general the Nanjemoy fauna contains fewer species than the Aquia fauna, and specimens are never so numerous in the Nanjemoy as in the Aquia. No species were found in the Nanjemoy which were not present in the Aquia. The only species which is of use in differentiating the two formations is *Spiroplectammina wilcoxensis* Cushman and Ponton. In two of the five wells which contain both the Nanjemoy and Aquia formations this species is absolutely restricted to the Aquia. In the other three wells the species comes in abundantly at the top of the Aquia although specimens range up into the Nanjemoy. In the wells in which the pink clay that marks the base of the Nanjemoy is present, this species appears abundantly immediately below the clay or within a few feet below it. Specimens occurring above the pink clay are rare and scattered.

The pink clay at the base of the Nanjemoy is the Marlboro clay. Darton recently called attention to its stratigraphic persistency (N. H. Darton, Economic Geology, vol. 43, 1948, pp. 154–155).

CORRELATION OF THE AQUIA FORMATION WITH THE STAGES OF THE GULF COAST AND EUROPE

The Aquia formation has long been recognized as belonging in the lower Eocene and is now considered equivalent to the lower Wilcox of the Gulf Coast and to the Ypresian of Europe.

W. H. Dall (1898) early divided the Eocene of the United States as follows:

Jacksonian
Claibornian
Chickasawan
Midwayan

Clark and Martin (1901, p. 87) believed that the fauna of the Aquia is probably Lower Chickasawan in age and that the formation is approximately equivalent to the Tuscahoma sand, Greggs Landing and Nanafalia substages, as differentiated in Alabama and Mississippi.

In later usage the name Wilcox has been adopted for the Chickasawan, and the Midwayan is referred to the Paleocene.

Vaughan (1924) placed the Aquia in the middle Wilcox and the Nanjemoy formation overlying the Aquia in the upper Wilcox and lower Claiborne. Woodring and Gazin (1933) and Cooke (1936, p. 40) also placed the Aquia in the middle Wilcox.

Cooke, Gardner and Woodring (1943) more recently correlate the Wilcox of the United States with the Ypresian and Cuisian of Europe and consider the Aquia formation equivalent to the lower Wilcox or Ypresian. Equivalents in Mississippi and Alabama are the Ackerman formation, the Nanafalia formation and the Salt Mountain limestone. The Hornerstown marl and the overlying Vincentown sand of New Jersey are also equivalent to the Aquia formation.

The Foraminifera indicate definitely the Wilcox age of the formation (Cushman, 1944b, p. 17). Many species recorded here from the Aquia are present in the Salt Mountain limestone and in the Tuscahoma sand, Bashi formation and Hatchetigbee formation of Alabama. On the correlation chart of Cooke, Gardner and Woodring, the latter three are indicated as upper Wilcox or Cuisian in age. The Aquia formation shows definite affinities with these three formations and may include the time equivalents of these supposedly slightly younger formations. If this is the case, the Aquia formation would include essentially all of the Wilcox except the uppermost part and would be equivalent to the Ypresian and part of the Cuisian of Europe.

WATER WELL SECTIONS

A number of water well sections were studied in an effort to determine the thickness and extent of the Aquia formation in southern Maryland. The results of this study have suggested an explanation of the fact that the Eocene of the outcrop of Maryland and Virginia is Wilcox-Claiborne in age, whereas the section found in the Larry G. Hammond well drilled by the Ohio Oil Company near Salisbury, Maryland, includes Paleocene, Jackson Eocene and questionable Claiborne but no Wilcox. The locations of the wells are shown in Figure 1.

Eight wells were carefully examined and the foraminiferal fauna recorded from each sample. These wells are located in Charles and Prince George's counties on the Western Shore of Maryland, in Dorchester County on the Eastern Shore, and on Smith Island in Chesapeake Bay in Somerset County. All of these wells go through the Eocene section except the Gardner well in Prince George's County which stops in the Eocene at a depth of 310 feet.

In addition samples from seven wells in Calvert County on the Western Shore were examined to determine the age of the upper part of the Eocene section in an effort to learn whether or not the Jackson Eocene is present in the Western Shore of Maryland. The wells in Calvert County usually penetrate only about 50 feet into the upper part of the Eocene which is the principal aquifer in that region. Specimens were scarce in the few samples available, and faunal lists were not compiled.

Samples from the Linthicum well at Cornersville, Dorchester County, west of the Dorchester Water Company well, were examined to determine the age of the Eocene in that section.

The Eocene-Miocene contact is usually easily distinguished as the Miocene foraminiferal fauna in all the wells is distinctive. The presence of a diatomaceous bed at the base of the Miocene is also of great use in drawing the Eocene-Miocene contact as the diatoms can be readily observed under the microscope on a slide prepared by mixing a very small amount of the sample with water.

Wells in Charles County

Southern Maryland Cleaners well, at Spring Hill, approximately three miles southeast of La Plata, Charles County, Maryland state coordinates 804–240, elevation 165 feet, depth 462 feet. The section penetrated by this well is geographically the nearest available fossiliferous well section to the type locality of the Aquia formation at Aquia Creek, Virginia. Samples from the Sullivan well, south of Liverpool Point on the Maryland bank of the Potomac River contain no fossils.

Miocene forms	*Spiroplectammina wilcoxensis* Cushman & Ponton	*Robulus midwayensis* (Plummer)	*Robulus wilcoxensis* Cushman & Ponton	*Dentalina communis* d'Orbigny	*Dentalina* cf. *virginiana* Cushman	*Lagena clavata* d'Orbigny	*Guttulina irregularis* d'Orbigny	*Guttulina problema* d'Orbigny	*Globulina inequalis* Reuss	*Globulina minuta* (Roemer)	*Globulina münsteri* Reuss	*Sigmomorphina semitecta* (Reuss), var. *terquemiana* (Fornasini)	*Nonion planatum* Cushman & Thomas	*Nonionella insecta* (Schwager)	*Bolivinopsis* sp.	*Eouvigerina excavata* Cushman	*Bulimina* cf. *cacumenata* Cushman & Parker	*Loxostomum* cf. *wilcoxensis* Cushman & Ponton	*Angulogerina virginiana* Cushman	*Angulogerina wilcoxensis* Cushman & Ponton	*Discorbis amicus* Shifflett, n. sp.	*Discorbis calyptra* Shifflett, n. sp.	*Lamarckina wilcoxensis* Cushman	*Valvulineria scrobiculata* (Schwager)	*Gyroidina* cf. *depressa* Plummer	*Gyroidina soldanii* d'Orbigny, var. *octocamerata* Cushman & G. D. Hanna	*Eponides labiomargus* Shifflett, n. sp.	*Eponides lotus* (Schwager)	*Siphonina wilcoxensis* Cushman	*Pulvinulinella danvillensis* Howe & Wallace	*Alabamina wilcoxensis* Toulmin	*Globigerina* cf. *ouachitaensis* Howe & Wallace	*Globigerina* cf. *pseudo-bulloides* Plummer	*Globigerina triloculinoides* Plummer	*Globorotalia* cf. *angulata* (White)	*Globorotalia wilcoxensis* Cushman & Ponton	*Globorotalia wilcoxensis* Cushman & Ponton, var. *acuta* Toulmin	*Anomalina umbonifera* (Schwager)	*Cibicides howelli* Toulmin	*Cibicides marylandicus* Shifflett, n. sp.	*Cibicides neelyi* Jennings				
x																																										90–100′			MIOCENE
																																										100–110′		Nanjemoy	EOCENE
																																										110–120′			
																																		x								120–130′			
																							x											x								130–140′			
																										x		x							x								140–150′			
																																		x								150–160′			
							x											x																								160–166′			
	x								x									x								x		x	x					x								166–173′			
	x								x																									x								173–180′			
									x																																	180–190′			
	x																																									190–200′			
																																										200–210′			
	x	x	x				x		x								x	x	x					x	x	x		x	x										x			210–220′			
	x	x							x				x				x	x						x															x			220–230′			
	x																	x						x														x	x			230–240			
	x	x		x					x			x	x				x	x	x					x				x	x	x				x								240–248′			
	x	x							x				x	x			x	x						x			x	x	x									x				248–255′			
	x																x	x						x						x												255–260′			
	x																	x	x					x					x	x									x			260–267′			
	x												x				x	x										x	x					x			x					267–274′			
	x	x											x						x					x					x	x												274–282′	Paspotansa	Aquia	
		x											x				x	x						x				x		x					x			x				282–290′			
																																										290–302′			
	x			x	x			x	x				x		x	x	x		x					x		x	x			x	x	x	x		x			x	x	x	x	302–314′	Piscataway		
									x										x					x			x	x					x	x					x		x	314–323′			
				x				x	x				x				x	x	x				x	x			x			x			x	x					x		x	323–328′			
	x			x					x			x			x	x						x	x	x		x	x		x	x	x		x	x			x	x	x	x	x	328–331′			
	x			x				x	x		x					x				x			x				x				x		x	x		x			x		x	331–340′			
									x							x		x						x			x						x						x		x	340–350′			
	x	x		x					x				x			x			x		x		x				x			x	x					x		x	x	x	x	350–360′			
	x								x				x											x			x			x	x		x				x		x		x	360–375′			
	x	x				x	x	x	x						x	x	x						x	x		x				x	x		x					x	x	x	x	375–390′			
									x	x																	x				x		x			x		x	x			390–401′			
	x	x							x				x											x			x	x					x			x		x	x	x	x	401–410′			
																																										410–462′			CRETACEOUS

FIGURE 6—*Distribution Chart of the Foraminifera, Southern Maryland Cleaners Well, Charles County, Maryland, Elevation 165′*

The section penetrated includes Cretaceous, Eocene, Miocene and Pleistocene. The Eocene is 310 feet thick and includes the Aquia and Nanjemoy formations. The foraminiferal fauna of the Aquia is essentially the same as that of the outcrop in Virginia and Maryland. The formation is 136 feet thick and includes the Piscataway substage, 108 feet thick, and the Paspotansa substage, 28 feet thick. Only twelve species of Foraminifera were recorded from the Paspotansa, whereas thirty-eight species were found in the Piscataway.

The bottom of the basal pink clay of the Nanjemoy formation occurs in this well at 274 feet depth, and the Aquia-Nanjemoy contact is drawn at this point. The clay is 30 feet thick in this section. *Spiroplectammina wilcoxensis*, as noted above, is more characteristic of the Aquia than of the Nanjemoy and occurs abundantly in the sample immediately below the clay. The species is rare in much of the Nanjemoy portion of the section which is 174 feet thick.

The lithology changes at a depth of 410 feet from typical Eocene greensand to a light brown clay with lignite and siderite which is characteristic of the Cretaceous of this area. No Foraminifera occur below this depth.

Figure 6 shows the distribution of the Foraminifera in this well.

Maryland State Police well (Waldorf Barracks), approximately ½ mile west of Mattawoman, Charles County, Maryland state coordinates 834–299, elevation 215 feet, depth 448 feet.

The section, as in the Southern Maryland Cleaners well, includes Cretaceous, Eocene, Miocene and Pleistocene. The Eocene is represented by the Aquia and Nanjemoy formations. The Aquia has a thickness of 170 feet and consists of the Piscataway substage, 140 feet thick, and the Paspotansa substage, 30 feet thick. The fauna in the Paspotansa is represented by only five species whereas the Piscataway substage contains thirty-three species.

The Aquia-Nanjemoy contact is drawn, primarily on the basis of lithology, at the base of the pink clay which is present from 220–240 feet. *Spiroplectammina wilcoxensis* occurs much more abundantly in the Aquia portion of the well than in the Nanjemoy portion. The thickness of the Nanjemoy is 120 feet in this well section.

The lithology changes abruptly at a depth of 410 feet from glauconitic sand to a typical Cretaceous quartz sand. No Foraminifera were observed below 410 feet. The Cretaceous-Eocene contact is accordingly drawn at this point.

Figure 7 shows the distribution of the Foraminifera in this well.

Southern Maryland Electric Cooperative well, Hughesville, Charles County, Maryland state coordinates 862–255, elevation 179 feet, depth 545 feet.

Paleocene, Eocene, Miocene and Pleistocene are included in this well section. The Aquia portion of the Eocene is 88 feet thick and includes 47 feet of Piscataway and 41 feet of Paspotansa. Eighteen species of Foraminifera are present in the Paspotansa, whereas forty-six species are present in the Piscataway.

The base of the Nanjemoy pink clay is at 445 feet depth, and *Spiroplectam-*

	MIOCENE	EOCENE																																CRETACEOUS
		Nanjemoy								Aquia																								
										Paspotansa	Piscataway																							
	120–130′	130–140	140–150	180–190	190–200	200–210	210–220	220–230	230–240	250–260	270–280	280–290	300–310	310–320	330–340	340–350	360–370	370–380	400–410	410–448													
Spiroplectammina wilcoxensis Cushman & Ponton							x		x		x		x					x															
Quinqueloculina harrisi Howe & Roberts												x																					
Robulus midwayensis (Plummer), var. *virginianus* Shillett, n. var.						x	x	x	x		x	x	x	x	x			x															
Robulus wilcoxensis Cushman & Ponton					x																												
Dentalina communis d'Orbigny										x	x	x	x	x	x	x	x	x															
Dentalina virginiana Cushman											x							x															
Lagena costata (Williamson)						x																											
Guttulina irregularis d'Orbigny			x		x	x					x		x			x		x														
Globulina inaequalis Reuss						x					x		x	x		x	x	x														
Stigmomorphina semiteeta (Reuss), var. *terquemiana* (Fornasini)											x																						
Polymorphina sp.																																	
Bouligerina excavata Cushman												x																					
Virgulina wilcoxensis Cushman & Ponton														x																			
Loxostoma cf. *wilcoxensis* Cushman & Ponton						x	x	x								x	x																
Angulogerina gravida (Cushman & Thomas)											x		x						x														
Discorbis amicus Shillett, n. sp.														x		x			x														
Discorbis calyphra Shillett, n. sp.											x		x		x		x																
Lamarckina wilcoxensis Cushman											x	x		x				x															
Valvulineria scrobiculata (Schwager)											x	x	x	x	x	x	x	x															
Valvulineria wilcoxensis Cushman											x																						
Gyroidina soldanii d'Orbigny, var. *octocamerata* Cushman & G. D. Hanna						x						x		x		x																
Eponides labiomargus Shillett, n. sp.						x	x				x	x		x		x	x	x														
Eponides lotus (Schwager)			x	x	x	x	x	x	x		x	x	x	x		x		x															
Siphonina wilcoxensis Cushman												x																					
Pulvinulinella danvillensis Howe & Wallace	x					x	x	x					x			x																	
Alabamina wilcoxensis Toulmin										x	x	x	x	x	x	x	x	x	x														
Globigerina quachitaensis Howe & Wallace																			x														
Globigerina cf. *pseudo-bulloides* Plummer						x	x	x	x	x		x		x		x	x	x															
Globigerina triloculinoides Plummer		x			x						x	x		x				x															
Globorotalia wilcoxensis Cushman & Ponton, var. *acuta* Toulmin						x	x					x					x																
Anomalina umbonifera (Schwager)		x			x	x			x	x	x	x	x			x	x	x															
Cibicides howelli Toulmin						x	x	x	x	x	x	x	x	x	x	x	x	x															
Cibicides marylandicus Shillett, n. sp.											x			x	x		x		x														
Cibicides nealyi Jennings			x		x							x		x																			
Cibicides praecursorius (Schwager)											x				x				x														

FIGURE 7.—*Distribution Chart of the Foraminifera, Maryland State Police Well, Charles County, Maryland, Elevation 215′*

mina wilcoxensis occurs in marked abundance below this depth. The Aquia-Nanjemoy contact is thus placed definitely at a depth of 445 feet. The Nanjemoy is approximately 239 feet thick.

From 535 feet to 545 feet many large well-preserved specimens of *Nodosaria affinis* Reuss and several rather worn specimens of a large *Robulus* were found. These are characteristic of the Paleocene in the Buchheister well in Prince George's County. The lithology changes at 527 feet from a medium- to fine-grained, olive green, glauconitic sand with calcareous cement to an iron-stained, coarse, quartz sand and some reddish brown glauconite. The change in lithology together with the appearance of these Foraminifera is quite indicative that the Paleocene is present here.

The section is different, therefore, from the other two Charles County wells in that the Aquia is underlain by Paleocene rather than by the Cretaceous. The thickness of the Aquia section is considerably reduced from its average thickness in the subsurface in Charles County; and, as will be pointed out later, deposition was apparently near the old shoreline of the basin of deposition of the Aquia.

Figure 8 shows the distribution of the Foraminifera in this well section.

WELLS IN PRINCE GEORGE'S COUNTY

Kierstead well, approximately 1 mile southeast of Piscataway, Prince George's County, Maryland state coordinates 813–316, elevation 50 feet, depth 166 feet.

The section in this well goes directly from Pleistocene into the Nanjemoy formation of the Eocene. The base of the Nanjemoy, drawn at the bottom of the pink clay, is at a depth of 32 feet.

The Aquia section is 98 feet thick including the Piscataway substage, 75 feet thick, and the Paspotansa substage, 23 feet thick. Nine species of Foraminifera are present in the Paspotansa substage and thirty-five are present in the Piscataway substage. However, in most of the samples specimens are not numerous.

The Cretaceous Foraminifera first occur in the sample representing the interval from 137 feet to 145 feet depth. These are the same Cretaceous forms which are found in the Cretaceous samples from Friendly, Maryland. On the basis of lithology, the Cretaceous-Eocene contact is at a depth of 130 feet at which point the Eocene glauconitic sand passes into a Cretaceous brownish gray quartz sand.

Figure 9 shows the vertical distribution of the Foraminifera in this well.

Buchheister well, east of Upper Marlboro, Prince George's County, approximate Maryland state coordinates 878–366, elevation 130 feet, depth 334 feet.

This section includes Cretaceous, Paleocene, Eocene, Miocene and Pleistocene. The Eocene is 200 feet thick and consists of the Aquia and Nanjemoy

	EOCENE														CRETACEOUS	
	Nanjemoy		Aquia													
			Paspotansa		Piscataway											
	20–28′	28–32	32–37	37–45	55–62	62–70	70–75	75–80	80–86	86–94	100–104	109–113	113–120	128–137	146–151	158–166
Spiroplectammina wilcoxensis Cushman & Ponto n			x		x	x	x					x				
Robulus knighti Toulmin						x	x				x					
Robulus midwayensis (Plummer), var. *virginianus* Shifflett, n. var.			x	x	x							x				
Dentalina communis d'Orbigny			x		x	x		x	x							
Dentalina virginiana Cushman					x	x			x							
Lagena hexagona (Williamson)			x		x											
Guttulina irregularis d'Orbigny						x										
Guttulina problema d'Orbigny						x										
Globulina inaequalis Reuss					x	x	x	x	x	x		x		x		
Pseudopolymorphina wilcoxensis Cushman & Ponton									x							
Sigmomorphina semitecta (Reuss), var. *terquemiana* (Fornasini)									x		x					
Polymorphina sp.						x										
Eouvigerina excavata Cushman					x	x	x	x	x							
Entosolenia oslatus Shifflett, n. sp.						x										
Virgulina wilcoxensis Cushman & Ponton									x							
Angulogerina parvula (Cushman & Thomas)					x	x										
Angulogerina virginiana Cushman				x	x	x										
Angulogerina wilcoxensis Cushman & Ponton						x										
Discorbis calyptra Shifflett, n. sp.					x	x	x	x	x							
Lamarckina wilcoxensis Cushman					x	x	x	x	x		x	x				
Valvulineria scrobiculata (Schwager)					x	x	x	x	x	x		x	x			
Eponides labiomargus Shifflett, n. sp.					x	x			x	x						
Eponides lotus (Schwager)					x	x										
Pulvinulinella danvillensis Howe & Wallace	x			x					x							
Alabamina wilcoxensis Toulmin			x		x	x	x	x	x	x		x	x	x		
Globigerina cf. *pseudo-bulloides* Plummer					x		x	x	x	x	x	x	x	x		
Globigerina triloculinoides Plummer		x			x	x	x		x							
Globorotalia cf. *angulata* (White)					x	x										
Globorotalia wilcoxensis Cushman & Ponton						x	x									
Globorotalia wilcoxensis Cushman & Ponton, var. *acuta* Toulmin						x										
Anomalina umbonifera (Schwager)		x	x	x	x	x	x	x	x							
Cibicides howelli Toulmin					x	x	x	x	x	x	x	x		x		
Cibicides marylandicus Shifflett, n. sp.						x	x		x							
Cibicides praecursorius (Schwager)					x						x					
Cibicides neelyi Jennings							x		x			x				

FIGURE 9—*Distribution Chart of the Foraminifera, Kierstead Well, Prince George's County, Maryland, Elevation 50*

FIGURE 10—*Distribution Chart of the Foraminifera, Buchheister Well, Prince George's County, Maryland, Elevation 130'*

	50–60′	60–70′	70–80′	80–90′	90–100′	100–110′	110–120′	120–130′	130–140′	140–150′	150–160′	160–170′	170–180′	180–190′	190–200′	200–210′	210–220′	220–230′	230–240′	240–250′	250–260′	260–270′	270–280′	280–290′	290–300′	300–310′	310–320′	324–334′
Spiroplectammina wilcoxensis Cushman & Ponton				x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x		
Textularia sp.																x	x	x	x							x		
Robulus midwayensis (Plummer), var. *virginianus* Shifflett, n. var.	x	x	x	x									x		x	x	x	x				x	x	x	x	x	x	
Robulus wilcoxensis Cushman & Ponton					x									x									x	x	x			
Robulus cf. *pilulifer*us Cushman															x				x			x	x	x	x	x	x	
Dentalina communis d'Orbigny	x			x	x	x	x		x		x	x	x	x		x	x		x	x		x	x	x	x	x	x	
Dentalina hexacostata Howe				x							x	x																
Dentalina virginiana Cushman				x	x		x				x	x		x			x											
Dentalina sp.																					x	x	x	x	x	x	x	
Nodosaria affinis Reuss																					x	x	x	x	x	x	x	
Lagena clavata d'Orbigny		x												x		x								x	x	x		
Lagena costata (Williamson)		x																			x				x			
Lagena hexagona (Williamson)	x			x							x					x												
Lagena laevis (Montagu)							x					x																
Lagena sp.																					x	x	x	x	x	x	x	
Guttulina irregularis d'Orbigny	x		x	x	x	x	x		x		x	x	x	x		x	x		x	x		x	x	x	x	x		
Guttulina problema d'Orbigny			x	x	x	x	x				x		x			x	x		x			x	x	x	x			
Guttulina wilcoxensis Cushman & Ponton									x		x	x		x														
Globulina cf. *gibba* d'Orbigny					x						x		x															
Globulina inaequalis Reuss	x		x	x	x	x	x			x		x	x	x		x	x	x	x	x		x	x	x	x	x		
Globulina minuta (Roemer)												x				x	x									x		
Globulina münsteri (Reuss)														x		x	x					x						
Pyrulina sp.																								x		x		
Glandulina abbreviata (Neugeboren)																x												
Pseudopolymorphina wilcoxensis Cushman & Ponton				x			x				x		x			x			x			x	x					
Sigmomorphina semitecta (Reuss)																								x				
Sigmomorphina semitecta (Reuss), var. *terquemiana* (Fornasini)				x	x	x	x				x	x	x	x								x						
Polymorphina advena Cushman, var. *nuda* Howe & Wallace				x								x																
Polymorphina sp.				x									x	x	x					x						x		
Gümbelina wilcoxensis Cushman & Ponton					x																							
Eouvigerina excavata Cushman														x					x									
Entosolenia cf. *marginata* (Walker & Jacob)					x	x	x						x	x						x								
Entosolenia oslatus Shifflett, n. sp.					x	x	x					x		x														
Loxostoma cf. *wilcoxensis* Cushman & Ponton		x			x	x	x				x	x	x	x														
Angulogerina parvula (Cushman & Thomas)				x			x					x																
Angulogerina virginiana Cushman							x					x	x															
Angulogerina wilcoxensis Cushman & Ponton												x																
Angulogerina sp.																												
Discorbis amicus Shifflett, n. sp.									x																			
Discorbis calpytra Shifflett, n. sp.				x	x	x	x		x		x	x	x	x			x											
Discorbis sp.																												
Lamarckina wilcoxensis Cushman				x	x	x	x		x		x			x														
Valvulineria scrobiculata (Schwager)				x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x								
Valvulineria wilcoxensis Cushman & Ponton	x								x					x														
Gyroidina soldanii d'Orbigny, var. *octocamerata* Cushman & G D. Hanna											x			x														
Eponides labiomargus Shifflett, n. sp.	x			x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x								
Eponides lotus (Schwager)	x	x		x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x								
Siphonina wilcoxensis Cushman	x	x												x		x	x	x										
Ceratobulimina sp.							x				x	x																
Pulvinulinella danvillensis Howe & Wallace							x					x		x		x	x											
Alabamina wilcoxensis Toulmin					x	x	x				x	x	x	x	x	x	x	x	x	x								
Globigerina compressa Plummer																												
Globigerina cf. *ouachitaensis* Howe & Wallace												x	x	x		x	x	x										
Globigerina cf. *pseudo-bulloides* Plummer	x		x	x	x	x	x		x		x	x	x	x	x	x	x	x		x		x	x	x	x	x		
Globigerina triloculinoides Plummer	x	x	x				x					x	x	x		x	x	x				x	x	x	x	x		
Globorotalia cf. *angulata* (White)				x																								
Globorotalia membranacea (Ehrenberg)														x														
Globorotalia wilcoxensis Cushman & Pnnton						x						x						x										
Globorotalia wilcoxensis Cushman & Ponton, var. *acuta* Toulmin				x	x	x					x		x	x	x		x		x									
Anomalina umbonifera (Schwager)	x				x		x	x	x	x	x	x	x	x		x	x	x	x									
Cibicides howelli Toulmin	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								
Cibicides marylandicus Shifflett, n. sp.				x	x	x		x		x	x	x																
Cibicides neelyi Jennings	x	x	x										x	x	x	x	x	x	x	x								
Cibicides praecursorius (Schwager)																												

				50–60′	
				60–70′	
			Nanjemoy	70–80′	
				80–90′	
				90–100′	
				100–110′	
				110–120′	
				120–130′	
				130–140′	
				140–150′	
				150–160′	
			Aquia	160–170′	
				170–180′	
				180–190′	
				190–200′	
				200–210′	
				210–220′	
				220–230′	
				230–240′	
				240–250′	
				250–260′	
				260–270′	
				270–280′	
				280–290′	
				290–300′	
				300–310′	
				310–320′	
				324–334′	
	MIOCENE	EOCENE		PALEOCENE	CRETACEOUS

formations. The Aquia-Nanjemoy contact is placed at a depth of 80 feet on the basis of the first occurrence of *Spiroplectammina wilcoxensis* which occurs abundantly from 80 feet on throughout the Aquia portion of the section. This species also occurs in some samples from the Paleocene part of the section.

The 40-foot to 50-foot sample contains Miocene diatoms, and the Eocene-Miocene contact is placed at 50 feet depth. Thus the Nanjemoy formation is only 30 feet thick here.

The Aquia is 170 feet thick and is well delimited by the Nanjemoy above and the Paleocene below. The numerous species present and the abundant appearance of the five species previously cited as characteristic of the Piscataway suggest that the section passes directly from the Nanjemoy into the Piscataway substage rather than into the Paspotansa substage. In the Gardner well, approximately one mile west of the Buchheister well, the Piscataway has a thickness of at least 180 feet, and it does not seem unreasonable that the 170 feet of Aquia present in this well may represent only this substage. It is suggested that the Paspotansa may have been eroded away in the region of this well during the post-Aquia erosional interval, although it is possible that the Paspotansa was never deposited in this immediate area. However, the latter is the more improbable of the two explanations.

At a depth of 250 feet the section passes from a glauconitic sand with some micaceous clay into a brownish micaceous clay with very little sand and glauconite and containing a distinctive fauna of Paleocene age. Large megalospheric and microspheric specimens of *Nodosaria affinis* Reuss, numerous specimens of a large *Robulus*, and species of *Dentalina*, *Lagena* and *Discorbis* are characteristic of the fauna. The *Robulus* is ornamented with a central raised boss and limbate raised sutures which are continuous from the periphery to the umbonal region in some specimens but are discontinuous near the inner end and broken into bead-like masses in other specimens. This very characteristic species somewhat resembles *Robulus pseudomamilligerus* (Plummer) but even more closely resembles *R. piluliferus* Cushman, described from the Paleocene of Arkansas (Contr. Cushman Lab. Foram. Res., vol. 23, 1947, p. 83, pl. 18, fig. 4) and may, in fact, be identical with this species. Thirty of the thirty-eight species in the Paleocene part of the section occur also in the Aquia.

At 320 feet depth the lithology changes from a brown sandy clay to a mixture of fine and coarse grayish white sand and gravel and some whitish clay. This quartzitic sand is undoubtedly Cretaceous in age. From 324 feet to 334 feet pyrite and lignite are present.

Figure 10 shows the vertical distribution of the Foraminifera in this well section.

Gardner well, northeast of Upper Marlboro, Prince George's County, approximate Maryland state coordinates 872–366, elevation 150 feet, depth 310 feet.

This well section contains only Eocene and Pleistocene. The section from

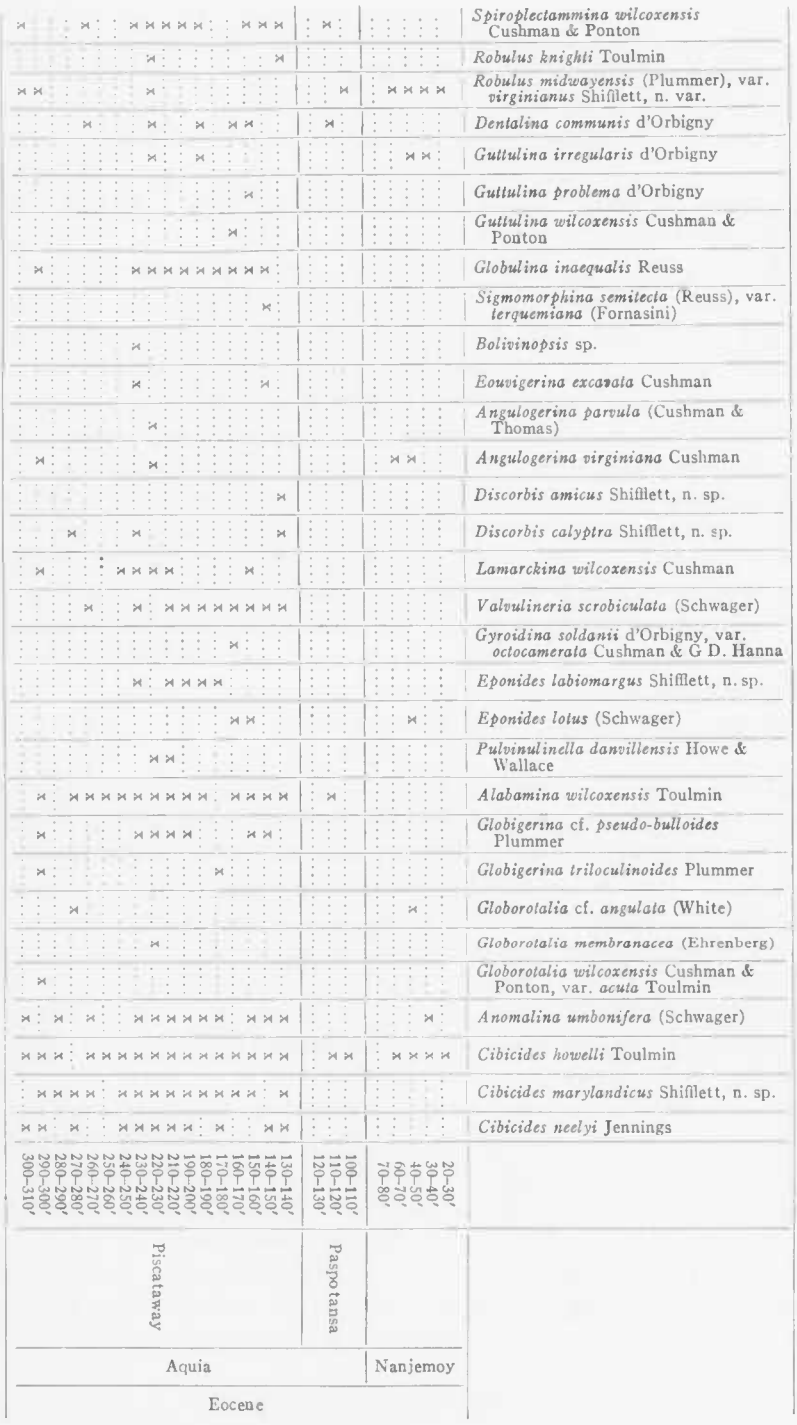


FIGURE 11—*Distribution Chart of the Foraminifera, Gardner Well, Prince George's County, Maryland, Elevation 150′*

20 feet to 100 feet is Nanjemoy with the pink clay 20 feet thick at the base. *Spiroplectammina wilcoxensis* is not present in the Nanjemoy but is common in most of the samples from the Aquia portion.

From 100 feet depth to the bottom of the well at 310 feet depth the section is in the Aquia formation. The Paspotansa substage is 30 feet thick and contains only five species of Foraminifera. The Piscataway is 180 feet thick, and the fauna is represented by twenty-nine species.

The proximity of this well to the Buchheister well would lead to the expectation that the Paleocene fauna in that well should occur in the Gardner well. The samples were carefully examined, but no trace of the species characteristic of the Paleocene in the Buchheister well was observed. The entire foraminiferal fauna in this well is not abundant. Many occurrences are represented

	Thickness			Elevation of Top of the Aquia
	Piscataway	Paspotansa	Total	
Charles County				
Southern Maryland Cleaners well	108 Feet	28 Feet	136 Feet	−109 Feet
Maryland State Police well	140	30	170	−25
Southern Maryland Electric Coop well	47	41	88	−266
Prince George's County				
Kierstead well	75	23	98	18
Buchheister well	170	absent?	170	50
Gardner well	180	30	210	50

FIGURE 12—*Table Showing Data on Aquia Formation in Well Sections, Charles and Prince George's Counties, Maryland*

by only one specimen in a sample. Whether this is because conditions were unfavorable for the Foraminifera at the time of deposition or because of subsequent removal due to leaching by groundwater is impossible to say.

Figure 11 shows the vertical distribution of the Foraminifera in this well section.

Figure 12 is a table showing the data on the Aquia in the Charles County and Prince George's County wells.

WELLS IN DORCHESTER COUNTY

Dorchester Water Company well, Cambridge, Dorchester County, Maryland state coordinates 1063–270, elevation 16 feet, depth 940 feet.

Cretaceous, Paleocene, Eocene, Miocene and Pleistocene are present in this well section.

The Eocene is not the typical Aquia-Nanjemoy of Wilcox-Claiborne age found in the Western Shore but is Jackson in age. It has a thickness of 240 feet between depths of 350 feet and 590 feet. The first Jackson Foraminifera occur at 450 feet depth. The fauna to this point is represented by a few Miocene forms in each sample. The last occurrence of Miocene diatoms and the first occurrence of glauconite in the section, however, are at a depth of 350 feet. The Eocene-Miocene contact is accordingly placed at this point.

The presence of Claiborne beds in this well cannot be established definitely on the basis of the fauna recorded from the samples. Three Claiborne species occur. They are *Uvigerina russelli* Howe, *Loxostoma claibornensis* Cushman and *Cibicides westi* Howe. The first two occur in a few scattered samples, and *Cibicides westi* occurs in the portion of the section which seems to be definitely Paleocene in age.

The first appearance of definite Paleocene Foraminifera is at a depth of 590 feet. Here *Marginulina subaculeata* (Cushman), var. *tuberculata* (Plummer) and other forms occur for the first time in the section. At this depth there is also a slight change in the lithology from a medium coarse quartz sand with large dark green grains of glauconite to a sand with finer grains of olive green glauconite. The Paleocene-Eocene contact is accordingly placed at 590 feet.

The Paleocene has a thickness of 170 feet in this well and continues down to a depth of 760 feet at which point twenty-one species of Cretaceous Foraminifera and seven other species which could not be specifically identified make their first appearance in the section. The lithologic change is hardly noticeable, although the amount of glauconite is somewhat reduced, and the color of the sample from 760 feet to 770 feet is light gray rather than greenish gray. The Cretaceous-Paleocene contact is definitely at a depth of 760 feet according to the foraminiferal fauna.

Figure 13 is a chart showing the vertical distribution of the Foraminifera in this well section.

Linthicum well, Cornersville, Dorchester County, Maryland state coordinates 1026–279, elevation 4 feet, depth 520 feet.

Specimens were extremely rare in this well, but the 300 foot, 360 foot, 400 foot and 420 foot samples contained a few Jackson Eocene Foraminifera. From 420 feet to 510 feet no Foraminifera were observed. At approximately 400 feet depth the lithology changes from yellowish glauconitic sand to dark greensand and gray clay. The 510 feet and 520 feet samples contained the Paleocene form *Marginulina subaculeata* (Cushman), var. *tuberculata* (Plummer).

WELL IN SOMERSET COUNTY

Bradshaw well, Ewell, Smith Island, Somerset County, Maryland state coordinates 1079–060, elevation 5 feet, depth 840 feet.

This section includes Cretaceous, Paleocene, Eocene and Miocene. The

Eocene is Jackson in age, and there is no evidence of Wilcox or Claiborne Eocene in the section. The Eocene-Miocene contact is at a depth of 590 feet. The last occurrence of Miocene diatoms is at 580 feet, and the first occurrence of Jackson Foraminifera is at 600 feet; but the sharp lithologic change is at 590 feet, at which point the lithology changes from the typical fine gray to buff-colored sandy clay of the Miocene to a coarse gray quartz sand with some glauconite.

The samples from this well have been examined by Dr. Joseph A. Cushman and by Doris S. Malkin of the Shell Oil Company. Dr. Cushman places the Paleocene-Eocene contact at 640 feet, whereas Miss Malkin suggests that the contact is at a depth of 740 feet. The author places the contact at 680 feet. Jackson species of Foraminifera start at 600 feet and appear in the section down to 680 feet. *Dentalina bevani* Cushman and Cederstrom, a very easily recognized Jackson species, occurs abundantly in the section down to 680 feet depth, below which it is absent. The first appearance of *Nodosaria affinis* Reuss is at 690 feet. This species seems to be characteristic of the Paleocene material studied, although Bagg records it from beds as young as the Nanjemoy. The lithology changes at 680 feet from a gray clay and some glauconite to a greensand. If the Paleocene-Eocene contact is correctly placed at 680 feet, the thickness of the Eocene is 90 feet.

The Cretaceous-Paleocene contact is at a depth of 800 feet, at which point the lithology changes from a coarse dark greensand to a light gray almost pure quartz sand. No Foraminifera occur below 800 feet. The Paleocene is thus 120 feet thick.

Figure 14 shows the vertical distribution of the Foraminifera in this well section.

WELLS IN CALVERT COUNTY

Trueman well, 2¼ miles east of Mutual, Calvert County, Maryland state coordinates 941–233, elevation 109 feet, depth 340 feet.

The Eocene-Miocene contact in this well is at a depth of 284 feet. Nothing suggestive of Jackson Eocene was observed in samples below this depth. The section is apparently Nanjemoy in age. *Robulus midwayensis* (Plummer), var. *virginianus* Shifflett, *Entosolenia oslatus* Shifflett, one specimen of *Spiroplectammina wilcoxensis* Cushman and Ponton, and numerous specimens of *Globulina inaequalis* Reuss and *Globigerina* sp. were observed.

Goldstein well, Prince Frederick, Calvert County, Maryland state coordinates 921–258, elevation 147 feet, depth 555 feet.

The Eocene of this well is typical Aquia-Nanjemoy, and there is nothing in the fauna to suggest Jackson Eocene. The Eocene-Miocene contact is at approximately 260 feet depth. Below this point species typical of the Aquia-Nanjemoy such as *Valvulineria scrobiculata* (Schwager), *Eponides lotus* (Schwa-

FIGURE 14.—*Distribution Chart of the Foraminifera, Bradshaw Well, Somerset County, Maryland, Elevation 5'*

ger), *Alabamina wilcoxensis* Toulmin, *Robulus midwayensis* (Plummer), var. *virginianus* Shifflett and *Spiroplectammina wilcoxensis* Cushman and Ponton occur. Specimens are very rare below 324 feet depth, however. The Nanjemoy pink clay occurs from 471 feet to 481 feet approximately. There is no suggestion of Paleocene in the section.

Gravatt well, Scientists Cliffs, approximately 1 mile northeast of Governor Run, Calvert County, Maryland state coordinates 839–247, elevation 96 feet, depth 360 feet.

The Eocene-Miocene contact in this well is at 350 feet. The 350 foot to 360 foot sample contained very few specimens. *Sigmoidella plummerae* Cushman and Ozawa and *Siphonina jacksonensis* (Cushman) were present. These species are found in the Eastern Shore material and not in the Aquia-Nanjemoy Eocene, but such rare specimens could scarcely justify the suggestion of a Jackson age for this sample.

Dowell well, at Point Patience, Calvert County, Maryland state coordinates 851–184, elevation 19 feet, depth 290 feet.

Quite a few species in the Eocene portion of this well from 210 feet to 290 feet suggest an affinity with the Eocene of the Eastern Shore of Maryland but do not definitely indicate Jackson age. These include *Valvulineria* sp., *Sigmoidella plummerae* Cushman and Ozawa, *Lagena acuticostata* Reuss, *Cibicides lobatulus* (Walker and Jacob) and *Spiroplectammina mississippiensis* (Cushman). All of these are found in the Jackson Eocene of the Eastern Shore but are not present in the Aquia-Nanjemoy Eocene.

Michitoff well, Cove Point, Calvert County, Maryland state coordinates 872-199, elevation 5 feet, depth 320 feet.

The Eocene-Miocene contact is questionably placed at a depth of 252 feet in this well. The foraminiferal fauna does not appear to be typical Aquia-Nanjemoy, and the species present indicate an affinity with the Eastern Shore Eocene; however, the specimens are rare, and nothing conclusive can be said about the age of the Eocene here. Species observed include *Valvulineria* sp., *Cibicides lobatulus* (Walker and Jacob), *Dentalina bevani* Cushman and Cederstrom, *Spiroplectammina mississippiensis* (Cushman), *Sigmoidella plummerae* Cushman and Ozawa and *Lagena orbignyana* (Sequenza).

Richardson well, Appeal, Calvert County, Maryland state coordinates 952-194, elevation 25 feet, depth 325 feet.

The Eocene-Miocene contact in this well section is at a depth of 273 feet. Specimens in the Eocene portion are not numerous, but an affinity with the Eastern Shore material is suggested by the presence of *Spiroplectammina mississippiensis* (Cushman), *Uvigerina dumblei* Cushman and Applin, *Guttulina spicaeformis* (Roemer), *Sigmoidella plummerae* Cushman and Ozawa, *Valvulineria* sp., and *Globorotalia crassata* (Cushman), var. *aequa* Cushman and Renz.

Duke Adams well, Sollers, Calvert County, Maryland state coordinates 844-203, elevation 28 feet, depth 310 feet.

The Eocene-Miocene contact in this section is at an approximate depth of 220 feet. A species of *Valvulineria*, present throughout the Paleocene-Eocene section in the Eastern Shore, occurs abundantly in the Eocene portion of this well indicating a definite affinity with the Eastern Shore section. The presence of *Eponides cocoaensis* Cushman, *Siphonina jacksonensis* (Cushman) and *Sigmoidella plummerae* Cushman and Ozawa suggests a Jackson age for this part of the section. A few forms were observed which are present also in the Aquia or Nanjemoy. These included *Eponides lotus* (Schwager) and *Globigerina triloculinoides* Plummer. A great many specimens of a Globigerina which could not be specifically identified were found.

SUMMARY OF THE STUDY OF THE AQUIA FORMATION

The information on the Aquia formation revealed in this study may be summarized in a number of points.

(1) The outcrop of the Aquia formation in Maryland and at the type locality on Aquia Creek and at Potomac Creek in Virginia has yielded a foraminiferal fauna of seventy-eight species and five varieties including six new species and one new variety. In addition, six species were found in subsurface material in Maryland which were not found in the outcrop material.

(2) The foraminiferal fauna of the Aquia definitely indicates a Wilcox, Eocene, age for the formation. This conclusion is in agreement with the determination of the age on the basis of the megafossils.

(3) Two substages of the Aquia formation, the lower, Piscataway, substage and the overlying, Paspotansa, substage, previously differentiated on the basis of the contained megafossils, can be distinguished on the basis of the foraminiferal fauna. Thirty-six species occur in the Piscataway substage in the Maryland and Virginia outcrop material which are not found in the outcrop of the Paspotansa substage. Eight species were found to be restricted to the Paspotansa in the outcrop material of the Aquia.

(4) The Aquia formation is present in the wells studied from Charles County and Prince George's County on the Western Shore of Maryland. In all these wells except one, the Piscataway and Paspotansa substages can be differentiated. In the Buchheister well only the Piscataway substage appears to be represented in the Aquia portion of the well section, and it is suggested that the overlying Paspotansa was eroded away during the post-Aquia erosion interval.

(5) In the Charles County and Prince George's County wells, the Aquia formation is everywhere overlain by the Nanjemoy formation, supposedly of uppermost Wilcox and Claiborne, Eocene, age. Thus the Eocene of the Western Shore of Maryland is Wilcox-Claiborne in age. The lithology is characteristically greensands and glauconitic marls, and the Eocene can usually be differentiated from the overlying and underlying beds on this lithologic basis.

(6) There is no Oligocene present in Maryland, and the Eocene is everywhere overlain by the Miocene. There is usually a lithologic break at the contact and a corresponding change in the foraminiferal fauna. The presence of a diatomaceous bed, referred to as the Fairhaven bed, at the base of the Miocene is also of great aid in the determination of the Eocene-Miocene contact.

(7) In three of the wells studied from Charles County and Prince George's County, the Southern Maryland Cleaners well, the Maryland State Police well

and the Kierstead well, the Aquia formation is underlain by Cretaceous beds. The Cretaceous-Eocene contact is marked by a lithologic break in all three cases. Typical Cretaceous Foraminifera were observed in the Kierstead well, but no specimens were found in the Cretaceous portions of the other two wells.

(8) In the Buchheister and Southern Maryland Electric Cooperative wells the Aquia formation is underlain by the Paleocene. The lithologic change at the contact is sharp, and the Paleocene fauna, especially characterized by large specimens of *Nodosaria affinis* Reuss and *Robulus* cf. *piluliferus* Cushman, is distinctive, although it includes many of the species which range up into the Eocene. When this fauna was first discovered in the Buchheister well, it was suggested that it might be a facies fauna of the Aquia and a time equivalent of it. However, careful study of the samples from the well has shown that these Paleocene beds are overlain by beds containing a typical and abundant Aquia foraminiferal fauna. The possibility that the two faunas are facies faunas of equivalent age is thus eliminated. This is the first record of the presence of Paleocene beds in the Western Shore of Maryland.

DISCUSSION AND SUMMARY OF THE HISTORY OF THE MARYLAND EOCENE

The results of this investigation permit a number of conclusions and suggestions concerning the history of the Maryland Eocene.

In the Ohio Oil Company's Larry G. Hammond No. 1 well, drilled in 1944–45 to a depth of 5568 feet, near Salisbury, Wicomico County, on the Eastern Shore of Maryland, the Eocene was determined by Dr. Joseph A. Cushman as Jackson in age. Some Claiborne Foraminifera were recorded, and beds of this age are possibly present, but their actual presence in the area could not be definitely confirmed. There was no indication whatsoever of beds of Wilcox age, and Paleocene underlies the Jackson in this well. In the Socony-Vacuum Oil Company's James D. Bethards No. 1 well, drilled in 1945 near Berlin, eleven miles southeast of the Hammond well, Worcester County, Maryland, Jackson Eocene is recorded, with no indication of Wilcox or Claiborne. In the Standard Oil Company of New Jersey's Maryland Esso No. 1 well, drilled in 1946 approximately $4\frac{1}{2}$ miles north of Ocean City, Worcester County, the Eocene was found to be Jackson in age, with no Wilcox or Claiborne.

An interesting problem was thus brought to light, since the Eocene of the outcrop in Virginia and in the Western Shore of Maryland had for many years been designated as Wilcox-Claiborne in age. The question was whether the Eocene of the Western Shore had a very different history from that of the Eastern Shore or whether the outcrop material from Virginia and Maryland had not been searched sufficiently for evidence of Jackson beds.

The study of the Eocene foraminiferal material of Charles County and Prince George's County on the Western Shore has shown that the Miocene is always underlain by the Nanjemoy and Aquia formations, and there is no indication of Jackson beds in this area. Of the 100 species recorded by Cushman from the Paleocene and Jackson Eocene of the Hammond well only ten were found in the Aquia material, and these are common and widely ranging species which have known ranges throughout the Eocene or throughout the Tertiary.

The next problem was to determine the extent of the Jackson in the subsurface westward from the Hammond well. The samples from the Dorchester Water Company well at Cambridge, Dorchester County, 940 feet deep, yielded faunas of Cretaceous, Paleocene and Eocene age. The Eocene is definitely Jackson in age and contains many of the species which were recorded from the Hammond well. A few Claiborne forms were found, but no definite interval in the well section can be assigned to this age. Samples from the Linthicum well at Cornersville, Dorchester County, west of the Dorchester Water Company well, contain a few Jackson Eocene Foraminifera, although specimens

are scarce. Wells in the southern part of Calvert County on the Western Shore usually penetrate into the upper part of the Eocene section which is the aquifer of the region. The Eocene samples from four wells in this area yielded Foraminifera which definitely indicate an affinity with the Jackson Eocene of the Eastern Shore rather than with the Aquia-Nanjemoy of Charles County and Prince George's County. The Bradshaw well on Smith Island, Somerset County, contains definite Jackson and no indication of Wilcox or Claiborne beds. On the basis of these occurrences a map showing the known extent of the Jackson Eocene in the subsurface of Maryland has been prepared (Figure 15). The occurrence of Upper Eocene has been observed also in the subsurface of Virginia and is recorded by Cederstrom (1945) and will be described in Virginia Geological Survey Bulletin 67 (in press) by J. A. Cushman and D. J. Cederstrom entitled "An Upper Eocene Foraminiferal Fauna from Deep Wells in York County, Virginia". The fauna in the latter paper is described from the Chickahominy formation, probably of Jackson age.

In the well sections which pass through the Eocene, the Jackson formation is found to rest on the Paleocene. The possible exception would be in the Hammond well where some Claiborne, Eocene, is suggested. Paleocene is present in this well below the Eocene portion of the section. The present extent of the Paleocene in Maryland, as indicated by its occurrence in these sections and in the Buchheister and Southern Maryland Electric Cooperative wells, is indicated in Figure 16. As the Paleocene in the Buchheister well is 70 feet thick, it must extend considerably west of this location toward the old shoreline.

The presence of only Wilcox-Claiborne Eocene in most of the Western Shore and the presence of only Jackson and some possible Claiborne underlain by Paleocene in the Eastern Shore raises the question whether the Wilcox was deposited in the Eastern Shore area and subsequently removed by post-Wilcox erosion or whether the area was one of non-deposition during Wilcox time.

On the basis of nine points from the subsurface and one from the outcrop an isopach map of the Aquia formation was compiled. This is shown in Figure 17. Five of the subsurface thicknesses are from the wells for which the complete faunal lists were compiled. In the Upper Marlboro area, the Aquia thickness recorded in the Gardner well rather than that found in the Buchheister well was used, since it was the maximum thickness and definitely includes both substages of the Aquia. The thicknesses of the Aquia in the I. and P. Paint Company and the La Plata wells in Charles County are from information furnished by Dr. R. M. Overbeck of the Maryland Department of Geology, Mines and Water Resources, and the thicknesses in the Dahlgren and Washington's Birthplace wells in Virginia were calculated from the lithologic logs given by Cederstrom (1945, pp. 15, 16). Apparent on this map is a local basin of deposition with its axis trending approximately northeast-southwest, parallel with the trend of the outcrop to the west. The deepest part of the basin is in the

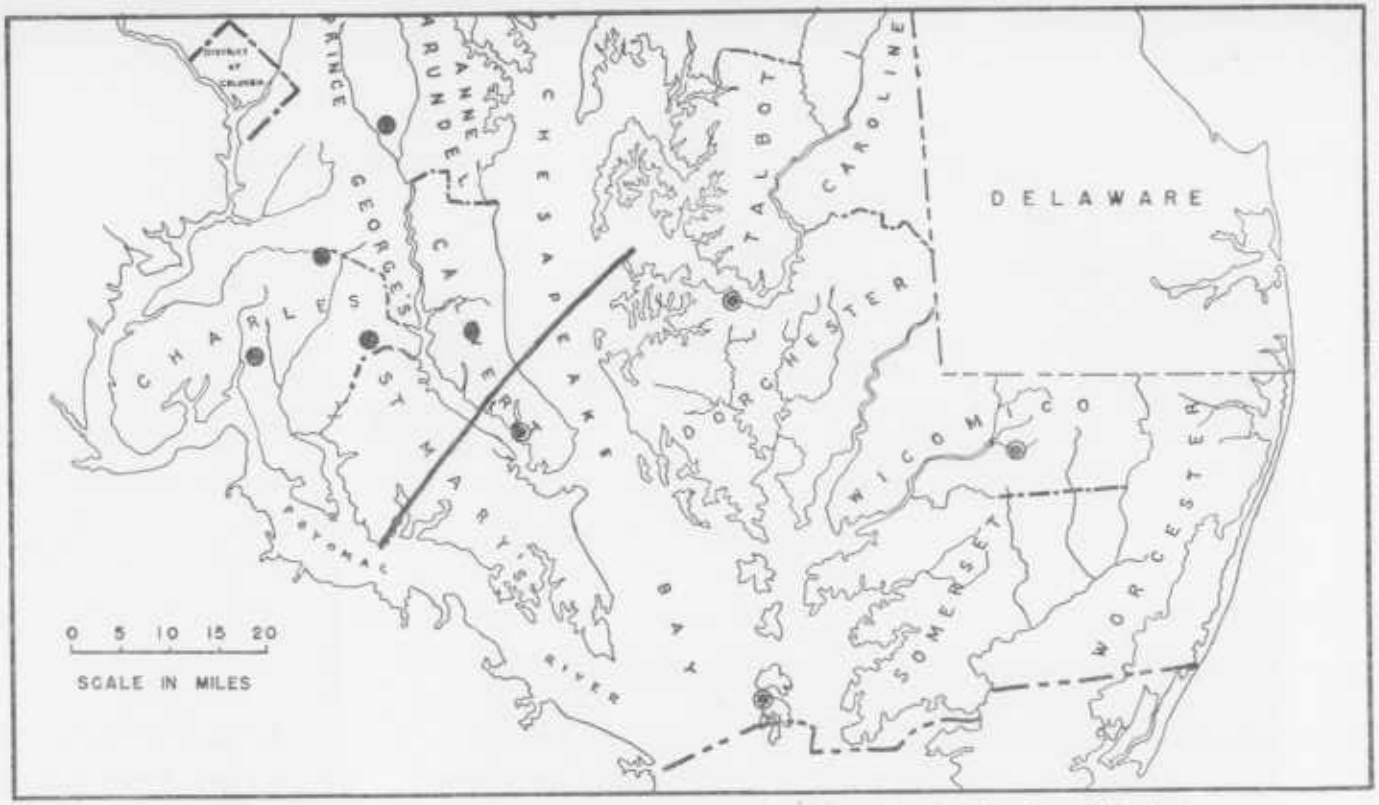


FIGURE 15—*Map Showing the Known Distribution of Jackson Eocene in the Subsurface of Maryland*

- Miocene underlain by Nanjemoy
- Miocene underlain by Jackson Eocene
- Extent of Jackson sea

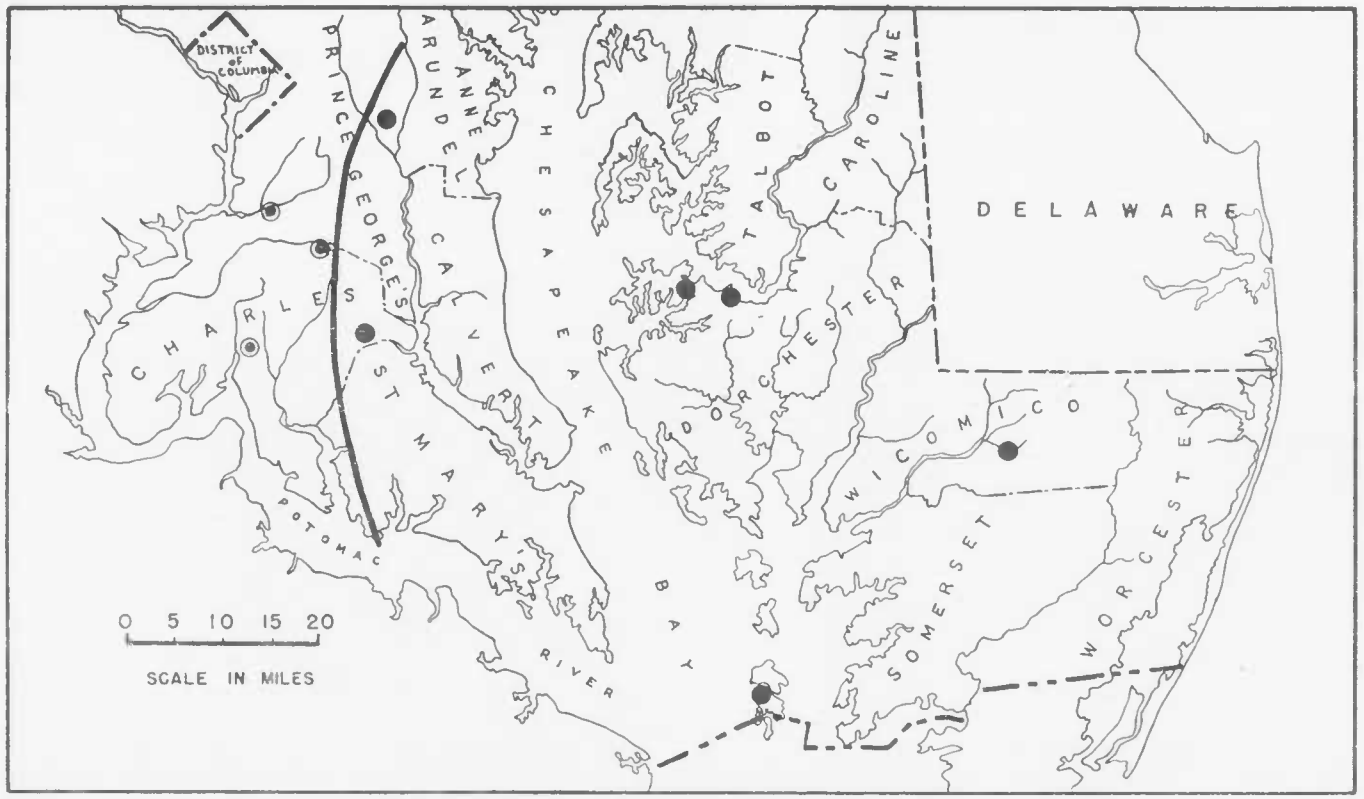


FIGURE 16—*Map Showing the Known Distribution of Paleocene in the Subsurface of Maryland*

- Eocene underlain by Paleocene
- Eocene underlain by Cretaceous
- Extent of Paleocene sea

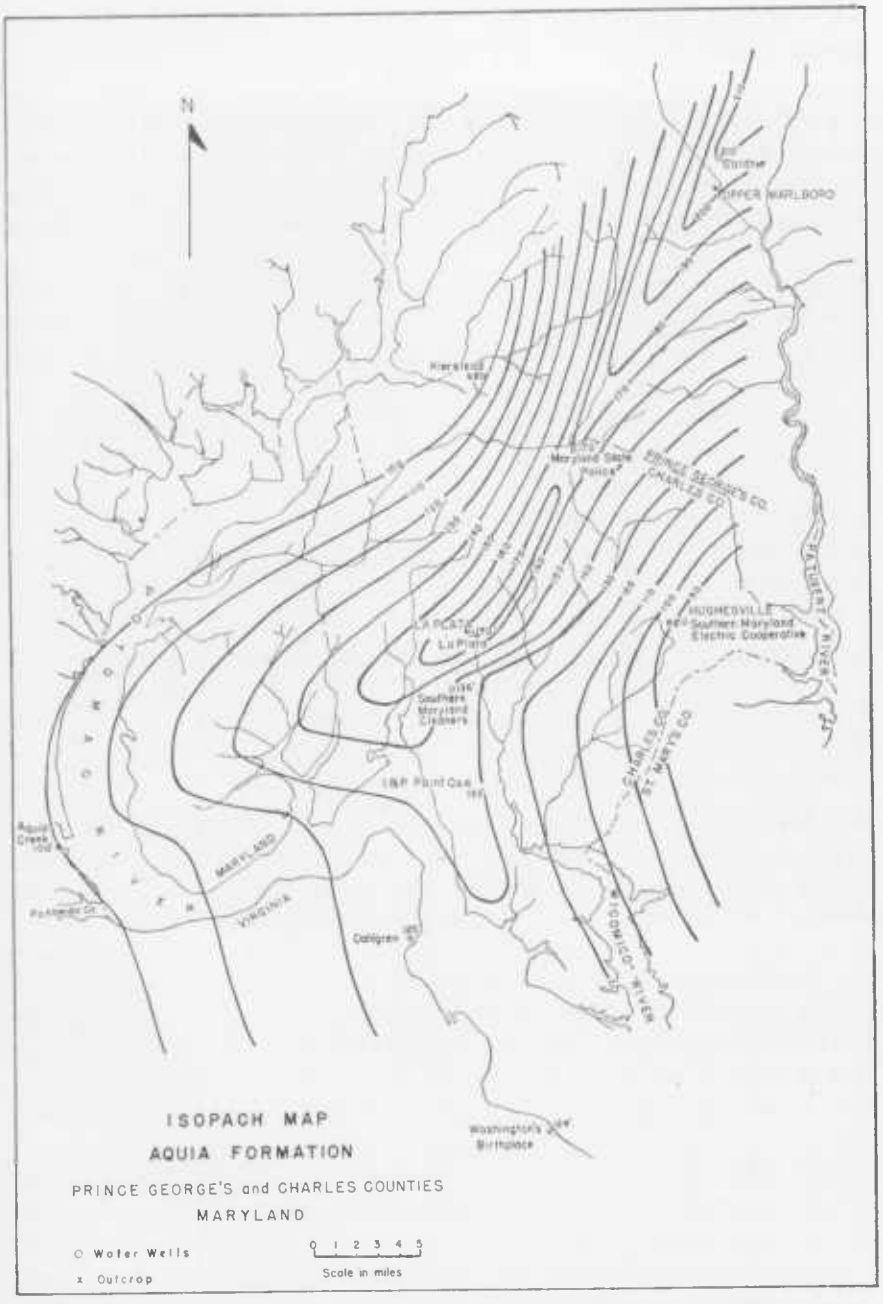


FIGURE 17—*Isopach map of the Aquia formation, Prince George's and Charles counties, Maryland.*

center of Charles County and Prince George's County, and the basin becomes more shallow in the west toward the outcrop and in the east toward the region of the Eastern Shore.

The Eocene rests disconformably on the Cretaceous except in the two easternmost wells where it rests on the Paleocene. The Aquia formation was apparently deposited in an elongated shallow depression in the old erosion surface. The Aquia increases in thickness from the Kierstead well in the west to the axis of the basin at the Maryland State Police well at a rate of approximately 14 feet per mile, and from the Southern Maryland Electric Cooperative well in the east to the axis of the basin at a rate of approximately $8\frac{1}{2}$ feet per mile. The greater amount of variation in thickness is in the Piscataway, the lower substage of the Aquia. The thickness of this substage ranges from 47 feet to 180 feet. The Paspotansa substage, on the other hand, varies from 23 feet to 41 feet maintaining a general thickness of about 30 feet over the area. This suggests that the basin was largely filled by the deposition of the Piscataway and that the Paspotansa must have been deposited in a basin which was rather shallow throughout the area. The extent of post-Paspotansa erosion cannot be estimated.

Clark and Martin (1901, p. 62) suggest that zone 7 of the Aquia represents

"an unconformity between the Piscataway and Paspotansa members"

since

"there are physical indications of more disturbed conditions of sedimentation than are usual in these formations at the very point where the faunal change occurs."

With reference to the same zone Ruth Schmidt (Op. cit., p 401) also states that an old erosion surface can be seen in this formation and that the groundwater table and the topography may be reflected by an irregular leached zone of shells preserved at different levels in the formation. In the well sections a slight color change between the two substages of the Aquia is sometimes observed, but no other lithologic change is noticeable. In the opinion of the present author any erosion interval which may have occurred between the two substages was of little magnitude. The only changes between the foraminiferal faunas of the two substages are the addition of a very few species in the outcrop of the Paspotansa and a marked decrease in the general fauna present in that substage.

Figure 18 is a structure contour map on the top of the Aquia. The southeast dip of the surface of the Aquia formation is very gentle, averaging about 15 feet per mile or less than 1°.

From the evidence thus shown on the isopach and structure contour maps, it is postulated that the Aquia formation was deposited in a narrow elongated basin of local extent in the region of eastern Virginia and the Western Shore of Maryland. This basin apparently did not extend to the area of the Eastern

Shore of Maryland, and no deposition was taking place there during Wilcox time. The area was probably merely above the profile of equilibrium so that deposition did not occur there. No coarse clastics were found in the Eocene

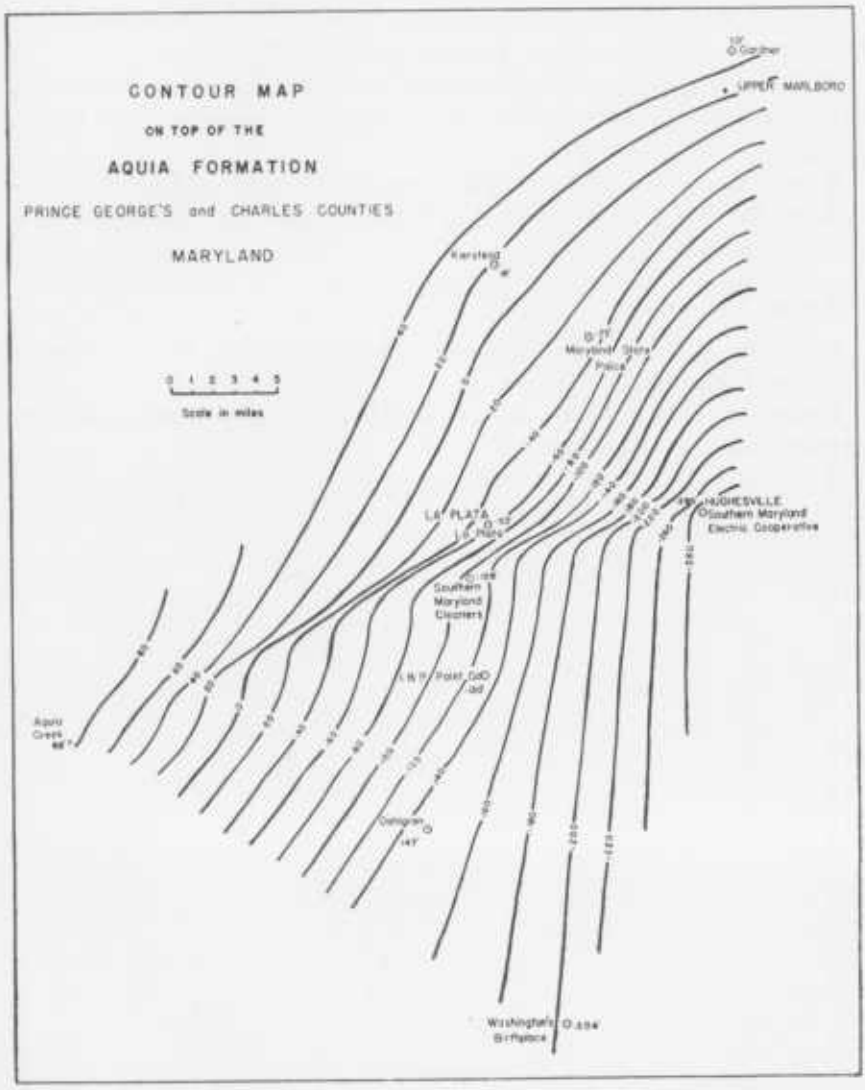


FIGURE 18—*Contour map on top of the Aquia formation, Prince George's and Charles counties, Maryland.*

section in the possible Claiborne or Jackson of the Eastern Shore such as would be expected if the region had been subjected to subaerial erosion during Wilcox time.

The probable sequence of events during the Paleocene and Eocene history of Maryland could be summarized as follows:

Eocene

Jackson: Deposition in the region of the Eastern Shore of Maryland and as far west into the Western Shore as shown on Figure 15.

Claiborne: Deposition of the Nanjemoy formation in eastern Virginia and the Western Shore of Maryland and possible Claiborne deposition in the Eastern Shore.

Wilcox: Deposition of the Aquia formation in eastern Virginia and the Western Shore of Maryland in a local basin of deposition. No deposition in the Eastern Shore.

Paleocene

Deposition in the Eastern Shore and as far west into the Western Shore as shown on Figure 16.

Figures 19 to 21 are cross sections showing the probable relations of the Tertiary horizons in Maryland.

CONDITIONS OF SEDIMENTATION OF THE AQUIA

A few statements may be made concerning the probable conditions of sedimentation of the Aquia formation. Both the lithology and foraminiferal content furnish clues.

Regarding this problem Clark (1895, p. 3) remarks in very general terms

"that the position of accumulation was in the vicinity of a coast reached by no large rivers bearing sediment, while at the same time sufficiently removed from the coast line to be unaffected by shore conditions."

The Aquia formation is predominantly glauconitic, and Clark's idea corresponds rather well with the current ideas concerning the origin of glauconite. Hadding (1932, pp. 149–60) states that glauconite is

"as a rule formed under decreased deposition of detritus"

and is

"always sublittoral, . . . a shallow sea formation".

Regarding the temperature and depth of formation of glauconite, he states that

"glauconite is to a large extent deposited where relatively cold currents occur"

and that

"the bulk of the mineral . . . is found at a depth of 100–400 m, and somewhere in or in the neighborhood of these depths the formation of glauconite takes place."

With regard to the foraminiferal fauna of the Aquia, Cushman (1944b, p. 17) believes that

"the fauna as a whole indicates that it lived in waters of considerable depth."

The family Miliolidae is represented by only two specimens in the material studied. As this family is virtually confined to shallow warm waters its absence from the Aquia is significant. The presence of fifteen species of the family Lagenidae is indicative also. Cushman (1913, p. 2) states

"the best development of the Lagenidae takes place in waters from 50 to 500 fathoms in depth. *Lagena* is found in perhaps greater numbers between 1,000 and 2,000 fathoms as far as the North Pacific material shows. Warmer waters are necessary for the best development of *Cristellaria* [*Robulus*], *Nodosaria*, etc."

At the time this statement was made the taxonomy of the family Lagenidae included the subfamilies Lageninae, Polymorphininae and others. These notes on depths would apply, therefore, to the Polymorphinidae of which there are

seventeen species in the Aquia material. Some species of *Lagena* occur in the Aquia which have been found in depths as great as 2,250 fathoms.

Probably the rather deep water aspect of the Aquia fauna is a result of the moderately low temperature of the Aquia sea rather than great depths. Glaessner (1945, p. 190) states

> "The depth- and temperature-ranges of living foraminifera should be used as palaeoecologic indicators only in conjunction with confirmatory evidence obtained either from the study of complete fossil faunas or sequences of faunas, or from lithological or other geological observations.
>
> "It has become clear to students of foraminiferal ecology that the most important factor controlling the distribution of living foraminifera is not depth but temperature."

The presence of thirteen species of arenaceous forms, in spite of the fact that some are represented by only a few specimens, probably indicates a cool water environment. The probable cool shallow water origin of the glauconite supplements this assumption.

From the evidence thus furnished by the lithology and the Foraminifera, the Aquia was probably deposited in fairly shallow cool water at a depth of at least 50 fathoms.

SYSTEMATIC DESCRIPTION OF THE FORAMINIFERA

Phylum PROTOZOA

Class SARCODINA

Order FORAMINIFERA

Family SACCAMMINIDAE

Genus PROTEONINA Williamson, 1858

PROTEONINA DIFFLUGIFORMIS H. B. Brady

(Pl. 1, fig. 1)

Reophax difflugiformis H. B. Brady, Quart. Journ. Micr. Sci., vol. 19, 1879, p. 51, pl. 4, figs. 3a, b.

Saccammina difflugiformis Eimer and Fickert, Zeitschr. Wiss. Zool., vol. 65, 1899, p. 671.

Proteonina difflugiformis Rhumbler, Arch. Prot., vol. 3, 1903, p. 245, figs. 80a, b (in text).—Cushman, Bull. 71, U. S. Nat. Mus., pt. 1, 1910, p. 42, figs. 40, 41 (in text).

Proteonina difflugiformis (H. B. Brady) Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 1, 1939, p. 39, pl. 1, fig. 5 (See this reference for further synonymy).—Howe, La. Dept. Conserv., Geol. Bull. No. 14, 1939, p. 29, pl. 1, figs. 9, 10.—Cushman and Ellisor, Journ. Pal., vol. 19, no. 6, 1945, p. 545, pl. 71, fig. 1.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 11, pl. 3, fig. 1.—Cushman, U. S. Geol. Surv. Prof. Paper 206, 1946, p. 15, pl. 1, figs. 7, 8.—Cushman and Todd, Spec. Publ. No. 21, Cushman Lab. Foram. Res., 1947, p. 3, pl. 1, fig. 4.—Hoglund, Zoologiska Bidrag fran Uppsala, vol. 26, 1947, p. 53, pl. 4, fig. 18.

Description.—"Test free, consisting of a single elongate oval or pyriform chamber with a more or less distinct tubular neck usually tapering gradually from the body of the chamber, undivided; wall fairly thick, of sand grains of variable size, firmly cemented or in small specimens with an excess of cement and fairly smooth; aperture circular, simple, terminal." (Cushman and McCulloch, 1939)

Occurrence.—This species is present in the Aquia material only from the outcrops at Aquia Creek and Potomac Creek. It is represented by only a few specimens.

Remarks.—This species occurs in the present oceans and also as a fossil. It has been found in the Claiborne Eocene of Louisiana and Alabama.

Family REOPHACIDAE

Genus REOPHAX Montfort, 1808

REOPHAX CURTUS Cushman

(Pl. 1, fig. 2)

Reophax scorpiurus Göes (part) (not *R. scorpiurus* Montfort), Kongl. Svensk. Vet. Akad. Handl., vol. 25, no. 9, 1898, p. 24, pl. 5, figs. 160–163.

Reophax curtus Cushman, Bull. 104, U. S. Nat. Mus., pt. 2, 1920, p. 8, pl. 2, figs. 2, 3; Contr. Canadian Biol., 1921 (1922), p. 139.—Hada, Sci. Rep't Tohoku Imp. Univ., ser. 4, Biol., vol. 6, 1931, p. 57, text fig. 8.—Earland, *Discovery* Rep'ts, vol. 10, 1934, p. 79; vol. 13, 1936, p. 30.—Cushman and McCulloch, Allan Hancock Pacific Exped., vol. 6, no. 1, 1939, p. 58, pl. 2, figs. 12.—Cushman, Spec. Publ. No. 12, Cushman Lab. Foram. Res., 1944, p. 10, pl. 1, figs. 15, 16.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 18, pl. 3, fig. 21.

Description.—"Test short and thick, composed typically of three chambers, increasing rapidly in size as added, last-formed chamber making up a large proportion of the test, fusiform or elliptic, axis of the test straight or more often slightly curved; wall composed of angular quartz sand grains with a considerable amount of gray cement between; apertural end slightly tapering, without a definite neck, the aperture being an opening between three or more sand grains at the end of the chamber. Length up to 2 mm." (Cushman, 1920)

Occurrence.—This species like the preceding was found in the outcrop at Aquia and Potomac creeks but does not occur in the subsurface material. Only three specimens were found.

Remarks.—The chambers of the specimens are not distinctly delineated, but the early portion is much smaller than the later portion, and it is apparent that the test is not single-chambered.

This species which has been recorded from both the Atlantic and Pacific oceans has been found as a fossil form only in the Aquia formation.

REOPHAX sp.

(Pl. 1, fig. 3)

Two incomplete specimens like the one figured were present in the Aquia formation at Aquia Creek, Virginia. They are rather coarsely arenaceous, and two or three chambers are visible.

Family AMMODISCIDAE

Genus AMMODISCUS Reuss, 1861

AMMODISCUS INCERTUS d'Orbigny

(Pl. 1, fig. 4)

Operculina incerta d'Orbigny, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, 1839, "Foraminiferes," p. 49, pl. 6, figs. 16, 17; Spanish Edit., 1840, p. 71, pl. 6, figs. 16, 17.

Ammodiscus incertus H. B. Brady, Rep. Voy. *Challenger*, Zoology, vol. 9, 1884, p. 330, pl. 38, figs. 1–3.—Cushman, Bull. 104, U. S. Nat. Mus., pt. 1, 1918, p. 95, pl. 39 (See this reference for further synonymy); l. c., Bull. 100, vol. 4, 1921, p. 62, pl. 5, figs. 1, 2.—Howe, La. Dept. Conserv., Geol. Bull. No. 14, 1939, p. 29, pl. 1, fig. 8.—LeRoy, Nat. Tijdschr. Nederl.-Indie, vol. XCIX, pt. 6, 1939, p. 226, pl. 9, figs. 17, 18.—Staesche and Hiltermann, Abhandl. Reichs Bodenforschung, n. ser., 1940.—Gallitelli, Atti Soc. Toscana Sci. Nat., Mem., vol. 52, 1943, p. 8, pl. 1, figs. 5, 6.—Franklin, Journ. Pal., vol. 18, no. 4, 1944, p. 304, pl. 44, fig. 1.—LeRoy, Colo. Sch. Mines Quart., vol. 39, no. 3, pt. 1, 1944, p. 13, pl. 4, figs. 46, 47.—ten Dam, Med. Geol. Stichting, ser. C-V, no. 3, 1944, p. 76, pl. 1, fig. 10.—Colom, Num. 2 Estudios Geologicos, Instit. Invest. Geol., 1945, p. 7, pl. 1, figs. 12–13.—Cushman and Stainforth, Spec. Publ. No. 14, Cushman Lab. Foram. Res., 1945, p. 14, pl. 1, figs. 10, 11.

Description.—"Test spiral, discoidal, thin; peripheral edge rounded; consisting of numerous narrow convolutions on one plane of a non-septate tube of slightly increasing diameter. Aperture usually formed of the open unconstricted end of the tube. Texture very finely arenaceous, exterior smooth, colour (of recent specimens) ruddy brown." (Brady, 1884)

Occurrence.—The only two specimens found were in the sample immediately below the lower indurated ledge of zone 9 of Clark at Potomac Creek, Virginia.

Remarks.—This species, which has a widespread occurrence throughout the world from the Cretaceous to the Recent, is recorded in the Claiborne, Eocene, Cook Mountain formation, of Louisiana. It occurs also in the Paleocene and Eocene of the Netherlands.

Family LITUOLIDAE

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES SPHAERILOCULUM Cushman

(Pl. 1, figs. 5a, b)

Haplophragmoides sphaeriloculum Cushman, Bull. 71, U. S. Nat. Mus., pt. 1, 1910, p. 107, fig. 165; Proc. U. S. Nat. Mus., vol. 51, 1917, p. 652; Bull. 104, U. S. Nat. Mus., pt. 2, 1920, p. 44, pl. 8, fig. 3; l. c., Bull. 100, vol. 4, 1921, p. 83, pl. 15, fig. 3; Publ. 342, Carnegie Instit., 1924, p. 11, pl. 1, fig. 2; Bull. Scripps Instit. Oceanography, Tech. Ser., vol. 1, no. 10, 1929, p. 134.—Wiesner, Deutsche Sud-Polar-Exped., vol. XX Zool., 1931, p. 96, pl. 12, fig. 142.—Heron-Allen and Earland, *Discovery* Rep'ts, vol. IV., 1932, p. 340. —Earland, l. c., vol. VII, 1933, p. 78; l. c., vol. X, 1934, p. 87; l. c., vol. XIII, 1936, p. 34, pl. 1, figs. 17, 18.—Chapman and Parr, Australasian Antarctic Exped., ser. C, vol. 1, pt. 2, 1937, p. 141.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 19, pl. 3, fig. 24.

Description.—"Test free, planospiral, consisting of five chambers in the last-formed coil, partially involute, periphery deeply lobulated; chambers inflated, nearly as broad as high, sutures depressed; wall finely arenaceous, with much cement, surface smooth; aperture a short, narrow slit at the base of the final chamber; color usually yellowish brown. Diameter up to 1 mm." (Cushman, 1910)

Occurrence.—Quite a number of specimens were found at Aquia and Potomac creeks in Virginia, and a few were found at Friendly, Maryland.

Remarks.—The five-chambered last coil, lobulated periphery and smoothly arenaceous test are typical of this species.

The occurrence in the Aquia is the only fossil record for this species. It was first described from off Japan and has numerous Atlantic Ocean records.

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES sp.

(Pl. 1, fig. 6)

The figured specimen was the only one found. It occurred in the Aquia formation at Aquia Creek, Virginia. This is not the same species as *Ammobaculites* sp. figured by Cushman from the Aquia (Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 19, pl. 3, fig. 25). The latter is more delicate and more finely arenaceous with a much smaller early-coiled portion which is followed by several chambers in a linear series. The coiled portion of the specimen from Aquia Creek is followed by only two chambers in a linear series with a large round aperture at the terminal end.

Genus CYCLAMMINA H. B. Brady, 1876

CYCLAMMINA sp.

(Pl. 1, fig. 7)

The figured specimen was found at Potomac Creek, Virginia, in the sample immediately below the lower indurated ledge of zone 9 of Clark. The specimen is involute and full-bodied with a finely arenaceous wall.

Family TEXTULARIIDAE

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA WILCOXENSIS Cushman and Ponton

(Pl. 1, figs. 8, 9)

Spiroplectammina wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 51, pl. 7, fig. 1.—Cushman and Garrett, l. c., vol. 15, 1939, p. 78, pl. 13, figs. 1, 2.—Toulmin, Journ. Pal., vol. 15, 1941, p. 571, pl. 78, fig. 1.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 8, pl. 1, figs. 1, 2; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 19, pl. 3, figs. 26, 27; l. c., p. 29, pl. 5, fig. 1.

Description.—"Test broad, compressed, periphery subacute, early chambers coiled; chambers distinct, low and broad in the early portion, gradually and rather regularly increasing in height as added, slightly over-lapping, later ones slightly inflated; sutures distinct, slightly depressed especially in the later portion, gently curved making a very slight angle with the horizontal; wall arenaceous but rather smoothly finished; aperture a low curved opening at the base of the apertural face. Length of holotype 0.45 mm.; breadth 0.25 mm.; thickness 0.12 mm." (Cushman and Ponton, 1932)

Occurrence.—This species occurs in the outcrop material from Virginia and Maryland and in all the water wells examined from Charles and Prince George's counties, Maryland.

Remarks.—Both megalospheric and microspheric forms of the species were found, the megalospheric in greater abundance. The latter has a broad rounded initial end, and the width of the test increases only slightly toward the apertural end. The larger microspheric form has a pointed initial end, and the test increases rapidly in width for about $\frac{1}{5}$ of its length and then tapers off very slightly to the blunt apertural end.

In the Maryland water wells this species is useful in differentiating the lower Eocene, Aquia formation, from the overlying Eocene formation, the Nanjemoy. A few broken specimens were observed in the Nanjemoy portion of the wells, but the species appears in abundance only in the Aquia portion.

Spiroplecta clarki Bagg described from the Nanjemoy formation (Bull. Amer. Pal., No. 10, 1898, p. 20, pl. 1, fig. 1; Maryland Eocene volume, 1901, p. 235, pl. LXII, fig. 4) is probably this species.

This species is common in the Wilcox Eocene and is characteristic of it. It was described from the Tuscahoma sand of Alabama. It has also been recorded from the Bashi formation and the Salt Mountain limestone of Wilcox age and from the Paleocene, Coal Bluff marl member of the Naheola formation, of Alabama.

Genus TEXTULARIA Defrance, 1824

TEXTULARIA sp.

Specimens of a rather large *Textularia* occur in a few samples in the Buchheister water well, Prince George's County, Maryland.

Family VERNEUILINIDAE

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA sp.

Rare specimens of this genus were found in one sample from the outcrop at Friendly, Maryland.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA cf. HARRISI Howe and Roberts

(Pl. 1, figs. 10a, b)

The figured specimen was found at Aquia Creek, Virginia. A specimen was also found in the Maryland State Police well, Charles County, Maryland. The species was first described by Howe from the Claiborne Eocene, Cook Mountain formation, of Louisiana (La. Geol. Survey, Geol. Bull. No. 14, 1939). The early chambers are raised above the inner margin of the later chambers so that the test is sub-triangular in cross section.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA EXIGUA Cushman and Applin

(Pl. 1, figs. 11a, b)

Trochammina exigua Cushman and Applin, Contr. Cushman Lab. Foram. Res., vol. 22, 1946, p. 75, pl. 13, fig. 8.

Description.—"Test small, strongly convex on the ventral side, dorsal side less convex, periphery broadly rounded, ventral side umbilicate; chambers 5 or 6 in the final whorl, strongly inflated on the ventral side, only slightly so on the dorsal side, increasing gradually in size as added; sutures deeply depressed ventrally, slightly so dorsally, slightly curved dorsally, ventrally slightly curved to nearly radiate; wall distinctly arenaceous but the surface smoothly finished; aperture an elongate, slightly arched opening on the umbilical portion of the last-formed chamber. Diameter 0.25–0.28 mm.; thickness 0.15 mm."

Occurrence.—Rare specimens of this species were found in the outcrop material from Potomac Creek, Virginia.

Remarks.—This species was described from the Upper Cretaceous, Woodbine formation, of Texas.

TROCHAMMINA HOWEI Cushman

(Pl. 1, figs. 12a, b)

Trochammina howei Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 20, pl. 3 fig. 28.

Description.—"Test small, dorsal side slightly convex, ventral side less convex, somewhat umbilicate, periphery broadly rounded, composed of about three whorls; chambers four to the whorl, gradually increasing in size, those of the adult whorl increasing only slightly, somewhat inflated, especially on the ventral side; sutures nearly straight, slightly depressed on the dorsal side, nearly radial and strongly depressed on the ventral side; wall distinctly arenaceous but smoothly finished; aperture on the ventral side of the last-formed chamber, elongate, slightly arched, with a slightly developed, overhanging lip. Length 0.30–0.38 mm.; breadth 0.24–0.30 mm.; thickness 0.07–0.09 mm."

Occurrence.—This species which was first described from the Aquia formation, *Turritella* beds, at Fairview Beach, King George County, Virginia occurs at Potomac Creek, Virginia in the upper 5 feet of zone 8 of Clark.

Remarks.—This species is easily recognized from the ventral side which shows four chambers, the last-formed larger than the other three and separated from them by a distinct transverse suture.

TROCHAMMINA sp.

(Pl. 1, figs. 13a, b)

The figured specimen was found in the Paspotansa substage of the Aquia formation at Potomac Creek, Virginia. Specific identification was not possible.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

ROBULUS KNIGHTI Toulmin

(Pl. 1, fig. 14)

Robulus knighti Toulmin, Journ. Pal., vol. 15, 1941, p. 578, pl. 78, fig. 21; text fig. 2C.

Description.—"Test full-bodied, the thickness being about two-thirds the diameter, close coiled, periphery angled, with a very indistinct blunt keel; chambers about six in the last-formed coil, increasing rapidly in size as added; sutures indistinct, flush with the surface, very strongly curved; wall smooth; apertural face broad, aperture at the outer peripheral angle of the last-formed chamber, radiate with a supplementary robuline slit in the apertural face. Average diameter 1.2 mm.; average thickness 0.7 mm."

Occurrence.—A few specimens of this species were found at Potomac Creek, Virginia. Rare specimens were also recorded from the Gardner and Kierstead wells, Prince George's County, Maryland.

Remarks.—This species shows very little compression. This character together with the rather translucent test and indistinct sutures are distinctive of the species.

This species was described from the Wilcox, Salt Mountain limestone, of Alabama.

ROBULUS MIDWAYENSIS (Plummer),

var. VIRGINIANUS Shifflett, n. var.

(Pl. 1, figs. 15, 16)

Description.—Variety differing from the typical in that the adults have 6 to 8 chambers rather than 10 to 12, and the sutures are not as markedly raised. The last suture may even be depressed rather than raised. The angle of the junction of the sutures with the umbo varies from 90° to tangential, and the sutures vary in amount of elevation. The variations are great in the sutures, but the central raised boss, bluntly angular peripheral margin and broad indented nature of the apertural face are constant characters.

Holotype (Cushman Coll. No. 57601) from the Eocene, Aquia formation, at Potomac Creek, King George County, Virginia, from zone 8 of Clark.

Occurrence.—The species occurs in all the Aquia material studied from both the outcrop and the subsurface. The specimens in the Southern Maryland Cleaners well, Charles County, more closely resemble the typical form of the species than the variety.

Remarks.—Aquia specimens were compared with specimens furnished by Mrs. Plummer to the Cushman Laboratory. The species was first described from the Midway of Texas (Univ. of Texas, Bull. 2644, 1926).

ROBULUS WILCOXENSIS Cushman and Ponton

(Pl. 1, figs. 17, 18)

Robulus wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 52, pl. 7, fig. 3.—Toulmin, Journ. Pal., vol. 15, 1941, p. 579, pl. 78, figs. 24, 25, text fig. 2H.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 27, pl. 5,

fig. 7.—Bergquist, Bull. 49, Miss. State Geol. Surv., 1942, p. 32, pl. 3, figs. 1, 3.—Kline, Bull. 53, Miss. State Geol. Surv., 1943, p. 20, pl. 7, fig. 27.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 20, pl. 3, figs. 29, 30.

Description.—"Test compressed, close coiled except in the oldest portion where 1 or 2 chambers may become uncoiled, periphery in the earlier portion with a narrow blunt keel, in the adult chambers with the keel becoming obsolescent and the periphery rounded in the last chambers; chambers numerous, 9 or 10 in the last-formed coil of the adult, later ones slightly inflated and uncoiling, early ones of uniform shape, gradually increasing in size as added; sutures distinct, rather strongly curved, in the early portion limbate and raised, then becoming flush with the surface and in the adult slightly depressed; wall smooth except for the early raised sutures; aperture terminal, radiate in the adult, in the earlier chambers at the outer peripheral angle. Length 1.00–1.15 mm.; breadth 0.75–0.80 mm.; thickness 0.25–0.30 mm." (Cushman and Ponton, 1932)

Occurrence.—This species was not found in abundance in any of the samples. It occurs in the outcrop material from Virginia, in the Maryland State Police well in Charles County, and in the Buchheister well in Prince George's County, Maryland.

Remarks.—This *Robulus* is easily distinguished from *Robulus midwayensis* (Plummer), var. *virginianus* Shifflett. The latter is close-coiled and rounded in outline and possesses a distinct central boss and indented apertural face, while *Robulus wilcoxensis* tends to uncoil in the later portions, shows no central boss and has a smoothly rounded apertural face.

This species was described from the Tuscahoma sand of Wilcox age of Alabama. It is recorded from the Wilcox, Salt Mountain limestone of Alabama also. Paleocene occurrences are in the upper Midway limestone of Fort Gaines, Alabama, the Naheola formation of Alabama and the Porters Creek clay of Mississippi. It is also recorded from the Jackson, Eocene, Yazoo clay of Mississippi.

Genus DARBYELLA Howe and Wallace, 1933

DARBYELLA sp.

A few specimens which clearly belong to this genus were found in outcrop in Virginia.

Genus MARGINULINA d'Orbigny, 1826

MARGINULINA TOULMINI Cushman

(Pl. 2, fig. 1)

Vaginulinopsis brantlyi Toulmin (not *Hemicristellaria brantlyi* Garrett), Journ. Pal., vol. 15, 1941, p. 583, pl. 79, figs. 8–10.
Marginulina sp. Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 21, pl. 4, fig. 4.
Marginulina toulmini Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 34, pl. 5, fig. 16.

Description.—"Test elongate, compressed, the early portion close coiled, later adult portion uncoiled, periphery in the adult becoming nearly straight; chambers distinct, 6 to 8 in the coiled portion, rapidly increasing in size, the adult uncoiled portion consisting of 3 or 4 chambers increasing gradually in height but not in width; sutures distinct, slightly curved, raised, with a row of small tubercles of clear shell material increasing in number in the uncoiled portion; wall mostly smooth except for the sutural beading, the last one or two chambers in the adult occasionally with a few, small, slightly elongate tubercles; aperture radiate, at the outer peripheral angle, in the adult with a slight neck. Length of holotype, 1.00 mm.; breadth 0.37 mm.; thickness 0.25 mm." (Cushman, 1944)

Occurrence.—This species occurs at Aquia Creek, Virginia, in a restricted vertical range of about 5 feet above and below the indurated ledge known as zone 5 of Clark. The species is

markedly absent from the subsurface material and occurs in only one sample from the Southern Maryland Electric Cooperative well, Charles County, Maryland.

Remarks.—The test of this species is smaller than *Hemicristellaria brantlyi* Garrett and is not keeled. The last chamber of the Aquia specimens frequently tapers up to the apertural end and shows only a slight neck, but others have the typical projecting neck. The amount of ornamentation varies slightly.

The types of this species are from the Paleocene, Coal Bluff marl member of the Naheola formation, of Alabama. It has been recorded also from the Salt Mountain limestone of Wilcox Eocene age from Alabama and has been previously recorded from the Aquia formation at Marlboro Point between the mouths of Potomac and Aquia creeks on the Potomac River, Stafford County, Virginia.

Genus DENTALINA d'Orbigny, 1826

DENTALINA COMMUNIS d'Orbigny

(Pl. 2, fig. 2)

Nodosaria (*Dentalina*) *communis* d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 254.—Cushman, Bull. 71, U. S. Nat. Mus., pt. 3, 1913, p. 54, pl. 28, figs. 1, 2.

Dentalina communis Van den Broeck, Ann. Soc. Belge Micr., vol. 2, 1876, p. 91, pl. 2, fig. 5.—Cushman and Todd, Spec. Publ. No. 15, Cushman Lab. Foram. Res., 1945, p. 20, pl. 3, fig. 13 (See this reference for further synonymy).

Description.—"Test elongate, slender, tapering, straight or more often slightly curved, composed of numerous chambers, slightly inflated toward the apical end but later ones becoming more inflated; sutures oblique; aperture radiate somewhat eccentric, elongate somewhat; surface smooth. Length up to 3 mm." (Cushman, 1913)

Occurrence.—This species occurs in the Maryland and Virginia outcrop material and in all the wells studied in Charles County and Prince George's County, Maryland.

Remarks.—This species was described from the Recent but also has numerous fossil records.

DENTALINA cf. HEXACOSTATA Howe

(Pl. 2, fig. 3)

The figured specimen from Aquia Creek which was the only one found in outcrop material seems to be identical with this species which was first described by Howe from the Claiborne Eocene, Cook Mountain formation, of Louisiana (La. Dept. Conserv., Geol. Bull. No. 14, 1939). A few specimens were recorded in the Buchheister water well, Prince George's County, Maryland.

The specimens are young ones and show only two chambers, but the six longitudinal costae are typical.

DENTALINA VIRGINIANA Cushman

(Pl. 2, fig. 4)

Dentalina virginiana Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 22, pl. 4, figs. 8, 9.

Description.—"Test small, consisting of 4 or 5 chambers, initial end with a short spine, apertural end slightly projecting; chambers nearly uniform in size, somewhat inflated; sutures slightly depressed, usually more so on one side than the other; wall ornamented with longitudinal costae, 7 or 8 in number, continuous over the sutures, typically somewhat spiral in position, the last chamber often smooth; aperture terminal, radiate, slightly projecting. Length 0.75–0.85 mm.; diameter 0.18 mm."

Occurrence.—This species, which has been recorded only from the Aquia formation, occurs in the outcrop material from Aquia Creek, Virginia, and Friendly, Maryland and was found in all the wells studied on the Western Shore of Maryland except the Gardner well in Prince George's County.

Remarks.—The species is of use in differentiating the substages of the Aquia formation as it is apparently restricted in both outcrop and subsurface to the lower substage, the Piscataway. It is a distinctive species and easily recognized.

Marginulina costata (Batsch) recorded by Bagg (Maryland Eocene volume, 1901, p. 240, pl. LXIII, figs. 2, 3) is probably this species newly recorded and described by Cushman.

DENTALINA WILCOXENSIS Cushman

(Pl. 2, fig. 5)

Dentalina sp. Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 30, pl. 5, fig. 20.

Dentalina wilcoxensis Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 8, pl. 1, figs. 5, 6; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 22, pl. 4, fig. 10; l. c., p. 36, pl. 5, figs. 22–24.

Description.—"Test small, elongate, of nearly uniform diameter throughout, circular or slightly compressed in transverse section, rounded at the initial end; chambers few, slightly if at all inflated, increasing only slightly in height as added; sutures distinct but not depressed, strongly oblique; wall smooth; aperture terminal, rounded, with the border finely toothed. Length 0.50 mm., diameter 0.10–0.12 mm." (Cushman, 1944)

Occurrence.—In outcrop the species was found at Aquia Creek, Virginia, and Friendly, Maryland and is restricted to the Piscataway substage. It was not found, however, in any of the subsurface material.

Remarks.—In outcrop material this species has approximately the same range as *D. virginiana* Cushman, with *D. communis* d'Orbigny also common in the assemblage. *D. virginiana* is larger than this species and exhibits longitudinal costae. *D. wilcoxensis* usually has a translucent test and is distinguished by the oblique sutures. Some of the Aquia specimens are slightly pointed at the initial end rather than rounded.

This species was first described from the Wilcox Eocene, Bashi formation, near Yellow Bluff, Alahama. It has also been recorded from the Paleocene, Naheola formation, of Alabama.

Genus NODOSARIA Lamarck, 1812

NODOSARIA sp.

(Pl. 2, fig. 6)

Broken specimens of this genus like the one figured are rare at Aquia Creek and at Friendly, Maryland. They are probably *Nodosaria affinis* Reuss.

Genus VAGINULINA d'Orbigny, 1826

VAGINULINA PLUMOIDES Plummer

(Pl. 2, fig. 7)

Vaginulina plumoides Plummer, Univ. Texas Bull. 2644, 1927, p. 113, pl. 6, fig. 6.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 16, 1940, p. 61, pl. 9, fig. 26.—Cushman and Renz, l. c., vol. 18, 1942, p. 6, pl. 1, fig. 6.—Cushman and Todd, l. c., vol. 22, 1946, p. 55, pl. 9, fig. 20.

Description.—"Test very thin, wing shaped, acuminate posteriorly and anteriorly, spreading rapidly upward; chambers very oblique and somewhat curved, ornamented by very fine

delicate striae parallel to the direction of growth; aperture protruding. Length up to .8 mm." (Plummer, 1927)

Occurrence.—The only specimen found was in the outcrop at Friendly, Maryland.

Remarks.—This species has been recorded from the Paleocene of Texas, Arkansas, Alabama and Trinidad. Cushman has previously described a variety of the species from the Aquia formation from Marlboro Point, Virginia.

Genus LAGENA Walker and Jacob, 1798

LAGENA CLAVATA (d'Orbigny)

(Pl. 2, fig. 8)

Oolina clavata d'Orbigny, For. Foss. Vienne, 1846, p. 24, pl. 1, fig. 2.
Lagena clavata Mackie, Recreative Science, vol. 1, 1859, p. 148, fig. 13.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 9, pl. 2, fig. 3 (See this reference for further synonymy).—Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 60, pl. 7, figs. 23a, b.—Cushman, l. c., vol. 20, 1944, p. 23, pl. 4, fig. 12.

Description.—"Test elongate, elavate or fusiform, with a long neck at the oral end and an elongation of the test somewhat variable in length at the aboral end, surface smooth, cross section nearly circular, wall thin and transparent, aperture nearly circular, at the end of the neck, often with a phialine lip. Length up to 1 mm." (Cushman, 1913)

Occurrence.—In outcrop the species was found in both the Virginia and Maryland material. In the subsurface it was found in the Southern Maryland Electric Cooperative, Southern Maryland Cleaners and Buchheister wells.

Remarks.—In the Aquia specimens the neck and phialine lip are very characteristic.

This species has been recorded as both fossil and Recent. In the Wilcox Eocene it has previously been found at Ozark, Alabama.

LAGENA COSTATA (Williamson)

(Pl. 2, fig. 9)

Entosolenia costata Williamson, Rec. For. Great Britain, 1858, p. 9, pl. 1, fig. 18.
Lagena costata Reuss, Sitz. Akad. Wiss. Wien., vol. 46, pt. 1, 1862 (1863), p. 329, pl. 4, fig. 54.—Cushman, U. S. Nat. Mus., Bull. 71, pt. 3, 1913, p. 21, pl. 9, fig. 6; pl. 10, fig. 1; pl. 12, fig. 1.

Description.—"Test subglobular, ornamented with a few rather remote ribs or costae running nearly the length of the test, frequently not reaching the apex, but ending in a ring of spinose projections, aperture small and rounded; costae most often rounded. Length 0.25 to 0.50 mm." (Cushman, 1913)

Occurrence.—This species is present in outcrop in Virginia and Maryland and occurs in the Maryland State Police, Southern Maryland Electric Cooperative, and Buchheister wells.

Remarks.—This common and easily recognized species has been recorded as fossil and Recent. In the Wilcox Eocene it occurs at Ozark and Woods Bluff, Alabama.

LAGENA HEXAGONA (Williamson)

(Pl. 2, fig. 11)

Entosolenia squammosa Montagu var. *hexagona* Williamson, Annals and Mag. Nat. Hist., 2nd ser., vol. 1, 1848, p. 20, pl. 2, fig. 23; Recent Foraminifera of Great Britain, 1858, p. 13, pl. 1, fig. 31.
Lagena hexagona (Williamson) Siddall, Catalogue of Rec. Brit. Foram., 1879, p. 6.—Cushman, U. S. Geol. Survey, Prof. Paper 129, 1922, p. 129, pl. 29, fig. 12.—Howe and Wallace, La. Dept. Conserv., Geol. Bull. No. 2, 1932, p. 28, pl. 6, fig. 14.—Howe, La. Dept. Conserv.,

Geol. Bull. No. 14, 1939, p. 50, pl. 6, fig. 16.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 3, pl. 1, fig. 7.

Description.—"Test subglobular, broadly rounded at the apical end, bluntly pointed at the apertural end, surface ornamentation consisting of a reticulate pattern, the areoles of which are hexagonal, either arranged in vertical rows or irregular. Length 0.5 mm." (Cushman, 1922)

Occurrence.—In outcrop material this species was found at Friendly, Maryland, but not in Virginia. In the subsurface it is present in the Kierstead and Buchheister wells.

Remarks.—This species also has both fossil and Recent records and is present throughout the Eocene.

LAGENA LAEVIS (Montagu)

(Pl. 2, fig. 10)

"*Serpula* (*Lagena*) *laevis ovalis*" Walker and Boys, Test. Min., 1784, p. 3, pl. 1, fig. 9.
Vermiculum laeve Montagu, Test. Brit., 1803, p. 524.
Lagena laevis Cushman, U. S. Nat. Mus. Bull. 71, 1913, pt. 3, p. 5, pl. 1, fig. 3; pl. 38, fig. 5 (See this reference for further synonymy).—Howe, La. Dept. Conserv., Geol. Bull. No. 14, 1939, p. 50, pl. 6, fig. 12.—Toulmin, Journ. Pal., vol. 15, 1941, p. 593, pl. 80, fig. 7.

Description.—"Test globular to ellipsoid, circular in transverse section, with long slender neck and phialine lip; wall without ornamentation; aperture a round opening at the end of the long neck. Length up to 0.6 mm.; diameter up to 0.35 mm." (Cushman, 1913)

Occurrence.—Specimens of this species were not abundant but were found in outcrop material from Aquia Creek, Virginia and Friendly, Maryland and in the subsurface in the Southern Maryland Electric Cooperative and Buchheister water wells.

Remarks.—This species is distinguished from *L. clavata* d'Orbigny by its smaller size and more slender neck.

It has both fossil and Recent records and has been recorded from Alabama from the Salt Mountain limestone of Wilcox age.

Family POLYMORPHINIDAE

Genus GUTTULINA d'Orbigny, 1826

GUTTULINA IRREGULARIS (d'Orbigny)

(Pl. 2, figs. 12, 13)

Globulina irregularis d'Orbigny, Foram. Foss. Bass. Tert. Vienne, 1846, p. 226, pl. 13, figs. 9, 10.
Guttulina irregularis Cushman and Thomas, Journ. Pal., vol. 3, 1929, p. 177, pl. 23, fig. 2.—Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 25, pl. 3, figs. 4, 5, pl. 7, figs. 1, 2.—Cushman, Spec. Publ. No. 16, Cushman Lab. Foram. Res., 1946, p. 18, pl. 4, fig. 12 (See this reference for further synonymy).—U. S. Geol. Surv., Prof. Paper 210-A, 1946, p. 5.

Description.—"Test oval to subdeltoidal, equilaterally triangular with rounded sides and angles, excepting the acute apertural end; chambers more or less angular, elongated, arranged in a clockwise, quinqueloculine series, each succeeding chamber excepting the last one or two chambers in full grown specimens coming down to the base; sutures depressed, distinct; wall smooth, but in full-grown specimens often having the last small chamber with spines or covered with fistulose tubes; aperture radiate. Length, 0.45–1.40 mm.; breadth, 0.30–1.20 mm.; thickness, 0.20–0.75 mm." (Cushman and Ozawa, 1930)

Occurrence.—This is a common form in all the outcrop and subsurface material examined.

Remarks.—The Aquia specimens are all triangular in shape and are distinguished easily by

this character from *G. problema*. Many immature specimens consisting of only three or four chambers were found.

The range of this widely distributed species is from the Eocene to the Recent.

GUTTULINA PROBLEMA d'Orbigny

(Pl. 2, figs. 14, 15)

Guttulina problema d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 266, No. 14, Modeles No. 61, 1826.—Cushman and Schenck, Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 17, 1928, p. 310, pl. 43, figs. 9–11.—Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 19, pl. 2, figs. 1–6; pl. 3, fig. 1 (See this reference for further synonymy).—Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 61, pl. 8, figs. 3, 4.

Description.—"Test broadly fusiform, acute at the apertural end, more or less rounded at the initial end in the megalospheric form, rather rounded at the base in the microspheric form; chambers elongated, more or less inflated, arranged in a clockwise, quinqueloculine series, each succeeding chamber slightly removed from the base; sutures depressed, very distinct; wall rather thick, smooth; aperture radiate. Length, 0.50–1.25 mm.; breadth, 0.40–1.25 mm.; thickness 0.28–0.70 mm." (Cushman and Ozawa, 1930)

Occurrence.—This species occurs in all the material examined, both outcrop and subsurface.

Remarks.—Specimens were found in all stages of growth, some having only three chambers while others were completely adult showing a number of chambers in typical quinqueloculine arrangement.

This is a widely distributed form, both geographically and geologically, and it has many Eocene records, being in the Tertiary deposits throughout the Atlantic and Gulf Coastal areas.

GUTTULINA WILCOXENSIS Cushman and Ponton

(Pl. 2, figs. 16a, b)

Guttulina wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 60, pl. 8, figs. 1, 2.—Cushman and Garrett, l. c., vol. 15, 1939, p. 80, pl. 14, figs. 8, 9.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 9, pl. 1, fig. 8; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 23; l. c., vol. 20, 1944, p. 39, pl. 6, fig. 18.

Description.—"Test elongate, fusiform, composed of comparatively few chambers, distinctly inflated, elongate, usually 2 or 3 times as long as wide, each chamber added in the adult only reaching to about $\frac{1}{2}$ or $\frac{2}{3}$ of the way to the base of the preceding chamber; sutures distinct, depressed; wall smooth, finely perforate; aperture radiate, terminal. Length 0.60–0.75 mm.; diameter 0.20–0.25 mm." (Cushman and Ponton, 1932)

Occurrence.—This species occurs in the Virginia and Maryland outcrop material and in three of the wells in Charles County and Prince George's County.

Remarks.—The specimens vary somewhat in their elongation and in the character of the wall, some being translucent, others opaque.

This species was described from the Wilcox Eocene of Alabama and has been recorded in the Bashi formation of that state. It occurs also in the Paleocene, Coal Bluff marl member of the Naheola formation, of Alabama.

Genus GLOBULINA d'Orbigny, 1839

GLOBULINA cf. GIBBA d'Orbigny

(Pl. 2, fig. 17)

Several specimens found at Potomac Creek, Virginia, and Friendly, Maryland, and in the Buchheister water well seem to be attached forms of this species. They are identical with

the form figured by Cushman from the Aquia formation from Virginia (Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 23, pl. 4, fig. 18). These attached forms are slightly embedded in a calcareous platform roughly circular in outline. Portions of three chambers are usually visible.

This widely ranging species has been recorded from the Jurassic to Recent, although Cushman and Ozawa separate the Mesozoic Globulinas with more or less globular tests from the Tertiary *Globulina gibba* (Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 61).

GLOBULINA INAEQUALIS Reuss

(Pl. 2, fig. 18)

Globulina inaequalis Reuss, Denkschr. Akad. Wiss. Wien., vol. 1, 1850, p. 377, pl. 48, fig. 9.—Cushman, Bull. 4, Florida State Geol. Survey, 1930, p. 35, pl. 5, fig. 22.—Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 73, pl. 18, figs. 2–4.—Cushman and Ponton, Bull. 9, Florida State Geol. Survey, 1932, p. 66, pl. 10, fig. 1.—Cushman and Cahill, U. S. Geol. Survey, Prof. Paper 175-A, 1933, p. 18, pl. 6, figs. 7, 8.—Cushman, Prof. Paper 181, 1935, p. 26, pl. 9, fig. 22 (See this reference for further synonymy).—Bermudez, Mem. Soc. Cubana Hist. Nat., vol. 12, 1938, p. 11.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 60, pl. 10, fig. 36.—Cushman and McGlamery, U. S. Geol. Survey, Prof. Paper 197-B, 1942, p. 68, pl. 4, fig. 33.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 4, pl. 1, fig. 10.—Cushman and Ellisor, Journ. Pal., vol. 19, no. 6, 1945, p. 559, pl. 74, fig. 18.—van Bellen, Med. Geol. Stichting, ser. C-V, no. 4, 1946, p. 39, pl. 3, fig. 8.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 22, 1946, p. 87.—Cushman and Gray, Spec. Publ. No. 19, Cushman Lab. Foram. Res., 1946, p. 23, pl. 4, figs. 23, 24.

Description.—"Test ovate, more or less compressed, broadly rounded at the base, tapering toward the apex; chambers few, inflated, much overlapping, arranged in a nearly triserial series; sutures very slightly if at all depressed, distinct; wall smooth, translucent; aperture radiate. Length, 0.50–0.85 mm.; breadth, 0.45–0.85 mm.; thickness, 0.25–0.50 mm." (Cushman and Ozawa, 1930)

Occurrence.—This species occurs abundantly in all the Aquia material examined.

Remarks.—The Aquia specimens vary considerably in size and degree of compression, but as all gradations were observed no specific separations were feasible.

GLOBULINA MINUTA (Roemer)

(Pl. 2, fig. 19)

Polymorphina minuta Roemer, Neues Jahrb. fur Min., 1838, p. 386, pl. 3, fig. 35.
Globulina minuta Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 83, pl. 20, figs. 3, 4.—Cushman, U. S. Geol. Survey, Prof. Paper 181, 1935, p. 27, pl. 9, fig. 23. (See this reference for further synonymy).—Howe, La. Dept. Conserv., Geol. Bull. No. 14, 1939, p. 54, pl. 7, figs. 15, 16.—Cushman and Herrick, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 60, pl. 10, fig. 2.—Cushman and Todd, l. c., vol. 21, 1945, p. 89, pl. 14, fig. 16.

Description.—"Test fusiform, pointed at both ends, circular to elliptical in section; chambers few, elongate, each some distance from the base; sutures distinct, not depressed; wall smooth; aperture radiate, pointed. Length 0.50–0.70 mm.; breadth 0.20–0.35 mm.; thickness 0.20–0.35 mm." (Cushman and Ozawa, 1930)

Occurrence.—*Globulina minuta* is of rare occurrence in the Aquia Creek and Potomac Creek sections in Virginia and at Friendly, Maryland. It was also found in the Buchheister well.

Remarks.—This species ranges throughout the Tertiary and Recent; it has been recorded from the Claiborne and Jackson Eocene of the Coastal Plain.

GLOBULINA MÜNSTERI (Reuss)

(Pl. 2, fig. 22)

Polymorphina munsteri Reuss, Sitz. Akad. Wiss. Wien, vol. 18, 1855 (1856), p. 249, pl. 8, fig. 80.
Polymorphina ovulum Reuss, l. c., p. 250, pl. 8, fig. 83.
Polymorphina amygdaloides Reuss, l. c., p. 250, pl. 8, fig. 84.—Burrows and Holland, Proc. Geol. Assoc., vol. 15, 1897, p. 46, pl. 2, fig. 18.
Polymorphina communis d'Orbigny var. *etrusca* Fornasini, Mem. Accad. Sci. Instit. Bologna, ser. 5, vol. 9, 1900–1902, p. 70, fig. 23 (in text).
Polymorphina obtusa d'Orbigny, Ann. Sci. Nat., vol. 7, 1826, p. 265, No. 1.—Fornasini, Boll. Soc. Geol. Ital., vol. 19, 1900, p. 146, fig. 4 (in text).
Polymorphina gibba Burrows, Sherborn, and Bailey, Journ. Roy. Micr. Soc., 1890, p. 561, pl. 11, fig. 13.
Globulina münsteri Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 85, pl. 22, figs. 3a–c.—Cushman, U. S. Geol. Survey, Prof. Paper 181, 1935, p. 27, pl. 9, fig. 25; Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 61, pl. 10, fig. 38; l. c., vol. 21, 1945, p. 4, pl. 1, fig. 11.—Cushman and Herrick, l. c., vol. 21, 1945, p. 60, pl. 10, fig. 1.

Description.—"Test ovate to oval, more or less compressed, rounded at the base; chambers rather elongated, embracing, arranged in a nearly overlapping, triserial series; sutures not depressed, generally distinct; wall smooth, often with fistulose tubes; aperture radiate. Length 0.45–0.70 mm.; breadth 0.25–0.50 mm.; thickness 0.18–0.38 mm." (Cushman and Ozawa, 1930)

Occurrence.—In outcrop this species occurs in Virginia and Maryland and in subsurface in the Buchheister and Southern Maryland Cleaners wells.

Remarks.—The Aquia specimens are rather large. They sometimes resemble *Polymorphina* sp. recorded in this paper but can be distinguished by their more irregular outline. The *Polymorphina* sp. has a test which tapers gently from the base to a bluntly pointed apertural end.

This species has a range from Eocene to Miocene. It is recorded from the Jackson Eocene of Alabama and Georgia and from the Claiborne Eocene, McBean formation, of Georgia. It was also noted in submarine cores taken off the eastern coast of North America which penetrated sediments of Eocene age.

Genus PYRULINA d'Orbigny, 1839

PYRULINA sp.

(Pl. 2, fig. 23)

Rare specimens belonging to this genus occur in outcrop material from Aquia Creek, Virginia, and in the Buchheister well in Prince George's County, Maryland.

Genus GLANDULINA d'Orbigny, 1826

GLANDULINA ABBREVIATA Neugeboren

(Pl. 2, fig. 20)

Glandulina abbreviata Neugeboren, Verh. Mitth. siebenbürg. Ver. Nat., Jahrb. 1, 1850, p. 48, pl. 1, figs. 1a, b.
Nodosaria (Glandulina) abbreviata Sherborn and Chapman, Journ. Roy. Micr. Soc., ser. 2, vol. 6, 1886, p. 745, pl. 14, figs. 20a, b.
Glandulina abbreviata Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 64, pl. 8, figs. 9a, b.—Cushman and Garrett, l. c., vol. 15, 1939, p. 81, pl. 14, fig. 10; Toulmin, Journ. Pal., vol. 15, 1941, p. 594, pl. 80, fig. 11; Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 40, pl. 7, fig. 1.

Description.—"Test short, broad; chambers biserially arranged in the early portion of the test, uniserial in the later portion, increasing rapidly in size as added, inflated; sutures distinct, depressed; wall smooth; aperture terminal. Length 0.45 mm., diameter 0.3 mm." (Toulmin, 1941)

Occurrence.—This species occurs rarely at Aquia Creek, Virginia, and Friendly, Maryland, and in the Buchheister well.

Remarks.—In the Wilcox Eocene this species is recorded from Ozark and Woods Bluff, Alabama and from the Salt Mountain limestone of that state. In the Paleocene of Alabama it occurs in the Coal Bluff marl member of the Naheola formation. It is also present in the London clay of England.

GLANDULINA LAEVIGATA d'Orbigny

(Pl. 2, fig. 21)

Glandulina laevigata d'Orbigny, Foram. Foss. Bass. Tert. Vienne, 1846, p. 29, pl. 1, figs. 4. 5.—Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 143, pl. 40, fig. 1.—Cushman and Todd, Spec. Publ. No. 15, Cushman Lab. Foram. Res., 1945, p. 34, pl. 5, fig. 19 (See this reference for further synonymy).—Colom, Institt. Invest. Geol., Estudios Geologicos, Num. 3, 1946, p. 75, pl. 10, fig. 235.

Description.—"Test fusiform, the initial end very acute and often with spine in the microspheric form, obtuse in the megalospheric form, circular in cross section; chambers inflated, much overlapping, arranged at first in a biserial series, abruptly becoming uniserial in the microspheric form, entirely uniserial in the megalospheric form; sutures not depressed, distinct; wall smooth, rather thick; aperture radiate." (Cushman and Ozawa, 1930)

Occurrence.—Rare specimens of this species were found at Aquia Creek, Virginia, and Friendly, Maryland. It was not present in any of the subsurface material examined.

Remarks.—This species is easily distinguished from *G. abbreviata* by the acute initial end and depressed sutures.

It ranges from the Eocene to the Pliocene.

Genus PSEUDOPOLYMORPHINA Cushman and Ozawa, 1928

PSEUDOPOLYMORPHINA DECORA (Reuss)

(Pl. 2, figs. 24a, b)

Polymorphina decora Reuss, Bull. Acad. roy. sci. Belgique, ser. 2, vol. 15, 1863, p. 152, pl. 3, fig. 41.

Polymorphina texana Cushman and Applin, Bull. Am. Assoc. Petr. Geol., vol. 10, 1926, p. 173, pl. 9, figs. 1, 2.

Pseudopolymorphina decora Cushman and Ozawa, U. S. Nat. Mus. Proc., vol. 77, 1930, Art. 6, p. 96, pl. 24, figs. 6–8.—Cushman, U. S. Geol. Survey, Prof. Paper 181, 1935, p. 29, pl. 10, figs. 11, 12.—Toulmin, Journ. Pal., vol. 15, 1941, p. 595, pl. 80, fig. 14.

Description.—"Test elongate, somewhat compressed, periphery rounded; chambers distinct, longer than wide, not inflated, early chambers guttuline, later chambers alternating; sutures distinct, not depressed; wall smooth; aperture radiate. Length 1.41 mm.; width 0.62 mm.; thickness 0.42 mm." (Cushman and Ozawa, 1930)

Occurrence.—Rare specimens of this species were found in the outcrop from Aquia Creek, Virginia, and Friendly, Maryland.

Remarks.—This species ranges from the Eocene to the Pliocene; it has been recorded from the Salt Mountain limestone of Wilcox Eocene age in Alabama.

PSEUDOPOLYMORPHINA WILCOXENSIS Cushman and Ponton

(Pl. 3, figs. 1a, b)

Pseudopolymorphina wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 61, pl. 8, figs. 5, 6.—Cushman and Garrett, l. c., vol. 15, 1939, p. 81, pl. 14, fig. 11.—Cushman, l. c., vol. 20, 1944, p. 23, pl. 4, fig. 19; l. c., p. 41, pl. 7, fig. 2.

Description.—"Test somewhat compressed, only slightly longer than broad, periphery broadly rounded, apertural end slightly produced, early chambers irregularly spiral, later ones becoming biserial; chambers distinct, slightly inflated; sutures distinct, very slightly if at all depressed in the early stages, slightly so in the adult; wall thick, opaque, ornamented with definite, short, slightly raised, somewhat elongate papillae arranged generally lengthwise of the test but irregularly placed; aperture fairly large, radiate, terminal, slightly projecting. Length 0.60–0.75 mm.; breadth 0.55–0.60 mm.; thickness 0.30–0.35 mm." (Cushman and Ponton, 1932)

Occurrence.—Apparently restricted to the Piscataway substage, this species is present in the outcrop at Aquia Creek, Virginia, where it occurs in marked abundance in a zone about 4½ feet thick near the base of the section sampled. It occurs in the Friendly, Maryland, section in a similar zone and in the Kierstead and Buchheister wells in scattered samples.

Remarks.—The broad test and papillate surface make this an easily distinguished species.

This species was described from beds of Wilcox age at Ozark, Alabama, and it has since been recorded from the Wilcox at Woods Bluff, Alabama. In the Paleocene it occurs in the Coal Bluff marl member of the Naheola formation of Alabama.

Genus SIGMOMORPHINA Cushman and Ozawa, 1928

SIGMOMORPHINA SEMITECTA (Reuss)

(Pl. 3, fig. 2)

Polymorphina semitecta Reuss, Sitz. Akad. Wiss. Wien, vol. 55, pt. 1, 1867, p. 91, pl. 3, fig. 10
Sigmomorphina semitecta Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 129, pl. 33, figs. 6, 7.—Howe and Wallace, La. Dept. Conserv., Geol. Bull. No. 2, 1932, p. 50, pl. 8, figs. 4a–c.—Howe, l. c., Geol. Bull. No. 14, 1939, p. 55, pl. 7, figs. 9, 10.—Cushman and Applin, Contr. Cushman Lab. Foram. Res., vol. 19, 1943, p. 36, pl. 7, fig. 22.

Description.—"Test compressed, oval to ovate, broadly rounded at the base, tapering toward the aperture; chambers elongate, arranged in a clockwise sigmoid series, all extending down to the base, but not involute; sutures scarcely depressed, distinct; wall smooth, the apertural end often with fistulose tubes; aperture radiate. Length 0.40 mm.; breadth 0.25 mm." (Cushman and Ozawa, 1930)

Occurrence.—The outcrop material from Aquia Creek, Virginia, and Friendly, Maryland, contains this form, which occurs also in the Buchheister well.

Remarks.—Specimens are comparatively rare in the Aquia material. The species ranges from Eocene to Miocene.

SIGMOMORPHINA SEMITECTA (Reuss),

var. TERQUEMIANA (Fornasini)

(Pl. 3, figs. 3a, b)

Polymorphina amygdaloides Terquem (not Reuss), Mem. Soc. geol. France, ser. 3, vol. 2, 1882, p. 141, pl. 14 (22), figs. 30, 31.
Polymorphina amygaloides Reuss, var. *terquemiana* Fornasini, Mem. Accad. Sci. Instit. Bologna, ser. 5, vol. 9, 1900–1902 (1902), p. 72, text fig. 25.

Sigmomorphina semilecta (Reuss), var. *terquemiana* Cushman and Ozawa, Proc. U. S. Nat. Mus., vol. 77, Art. 6, 1930, p. 129, pl. 33, figs. 4, 5; pl. 34, figs. 2, 3; pl. 35, fig. 1.—Cushman, Spec. Publ. No. 16, Cushman Lab. Foram. Res., 1946, p. 20, pl. 4, fig. 18 (See this reference for further synonymy).—van Bellen, Med. Geol. Stichting, ser. C-V, no. 4, 1946, p. 42, pl. 3, fig. 20.—Cushman, U. S. Geol. Survey, Prof. Paper 206, 1946, p. 98, pl. 41, fig. 13.—Cushman and Renz, Spec. Publ. No. 18, Cushman Lab. Foram. Res., 1946, p. 35, pl. 5, fig. 26; l. c., Contr. Cushman Lab. Foram. Res., vol. 23, 1947, p. 44.

Description.—"Variety differing from the typical in its more elongate lanceolate test consisting of elongated chambers and more acute initial end." (Cushman and Ozawa, 1930)

Occurrence.—This common species is prescnt in all the Aquia material studied, both outcrop and subsurface.

Remarks.—The range of this species is from the Eocenc to the Recent; it is present in the Eocenc of nearly all of the Gulf Coast states.

Genus POLYMORPHINA d'Orbigny, 1826

POLYMORPHINA ADVENA Cushman,

var. NUDA Howe and Roberts

(Pl. 3, fig. 4)

Polymorphina advena Cushman, var. *nuda* Howe and Roberts, in Howe, La. Dept. Conserv., Geol. Bull. No. 14, 1939, p. 56, pl. 7, fig. 4.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 91, pl. 14, fig. 21.

Description.—"This variety differs from *P. advena* in the absence of any type of ornamentation and in being much smaller." (Howe, 1939)

Occurrence.—Several specimens of this variety occur in the outcrop at Aquia Creek, Virginia, and at Friendly, Maryland, and in the subsurface in the Buchheister, Southern Maryland Electric Coopcrative and Maryland State Police wells.

Remarks.—The Aquia specimens are extremely compressed and clearly show the biserial arrangement of the chambers.

The other recorded occurrences of this variety are from the Claiborne, Eocene, Cook Mountain formation, of Louisiana and the Moodys Marl member of the Jackson Eocene of Mississippi.

POLYMORPHINA sp.

(Pl. 3, figs. 5a, b)

A number of specimens of this rather large species occur in the Virginia and Maryland outcrops and in the Kierstead, Buchheister and Maryland State Police wells. The initial end is broadly rounded, and the test tapers to a rather acute initial end. Most of the specimens found consisted of three or four chambers and were not mature.

Family NONIONIDAE

Genus NONION Montfort, 1808

NONION PLANATUM Cushman and Thomas

(Pl. 3, fig. 6)

Nonion planatum Cushman and Thomas, Journ. Pal., vol. 4, 1930, p. 37, pl. 3, figs. 5a, b.—Cushman and Dusenbury, Contr. Cushman Lab. Foram. Res., vol. 10, 1934, p. 60, pl. 8, figs. 6a, b.—Cushman and Garrett, l. c., vol. 15, 1939, p. 81, pl. 14, figs. 12, 13.—Howe, La. Dept. Conserv., Geol. Bull. No. 14, 1939, p. 58, pl. 7, figs. 24, 25.—Cushman, U. S. Geol. Survey, Prof. Paper 191, 1939, p. 4, pl. 1, figs. 15a, b.—Cushman and Applin, Contr.

Cushman Lab. Foram. Res., vol. 19, 1943, p. 37, pl. 7, fig. 24.—Bandy, Journ. Pal., vol. 18, 1944, p. 370, pl. 60, fig. 15.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 15, pl. 3, fig. 29;—Cushman and Herrick, l. c., vol. 21, 1945, p. 61, pl. 10, fig. 8; Cushman and Todd, l. c., vol. 21, 1945, p. 92, pl. 15, fig. 2.—Cushman, Spec. Publ. No. 16, Cushman Lab. Foram. Res., 1946, p. 21, pl. 4, fig. 24.

Description.—"Test planispiral, close-coiled, compressed, bilaterally symmetrical, biumbilicate, periphery rounded; chambers distinct, but not inflated, about ten in the last-formed coil, which is almost completely involute, peripheral face of the last chamber convex; sutures distinct, earlier ones flush with the surface, later ones very slightly depressed, ending in a thickened ring with slight inward projections about the umbilici; wall smooth, finely perforate; aperture a crescent-like slit at the base of the last-formed chamber. Diameter 0.25–0.35 mm.; thickness 0.10–0.12 mm." (Cushman and Thomas, 1930)

Occurrence.—This species is present in all the outcrop material from Virginia and Maryland and in the subsurface in the Southern Maryland Electric Cooperative and Southern Maryland Cleaners wells.

Remarks.—The Aquia specimens vary somewhat in size, but the number of chambers in the last-formed whorl and the character of the chambers, sutures, etc. remain constant.

Genus NONIONELLA Cushman, 1926

NONIONELLA INSECTA (Schwager)

(Pl. 3, fig. 7)

Anomalina insecta Schwager, Palaeontographica, vol. 30, 1883, Pal. Theil, p. 128, pl. 28 (5), figs. 1, 2.

Nonionella insecta Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 65, pl. 8, figs. 13, 14.—Glaessner, Problems of Paleontology, Moscow Univ., vols. 2–3, 1937, p. 368.—Cushman, U. S. Geol. Survey, Prof. Paper 191, 1939, p. 29, pl. 8, fig. 1.—Toulmin, Journ. Pal., vol. 15, 1941, p. 597, pl. 80, fig. 22.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 42.

Occurrence.—The outcrops at Aquia Creek, Virginia, and Friendly, Maryland, contain this species but not in abundance. It is not present in any of the subsurface material examined.

Remarks.—The specimens seem to be identical with those described by Schwager from the Middle Eocene of northern Africa. The inaequilateral oblique chambers of the adult specimens are characteristic.

Recorded from the Paleocene and Eocene, the species occurs in the Wilcox formation near Ozark, Alabama, and in the Tuscahoma sand, Hatchetigbee marl and Salt Mountain limestone of Alabama, all of Wilcox age.

Family HETEROHELICIDAE

Genus BOLIVINOPSIS Yakovlev, 1891

BOLIVINOPSIS sp.

Small specimens of this genus occur in the Gardner and Southern Maryland Cleaners wells in the Piscataway portion of the Aquia. The test is short with the sides parallel and the early portion clearly planispiral becoming biserial in the later portion.

Genus GÜMBELINA Egger, 1899

GÜMBELINA WILCOXENSIS Cushman and Ponton

(Pl. 3, fig. 8)

Gümbelina wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 66, pl. 8, figs. 16, 17.—Toulmin, Journ. Pal., vol. 15, 1941, p. 597, pl. 80, fig. 24.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 10, pl. 1, figs. 13, 14.

Description.—"Test biserial, periphery broadly rounded; chambers distinct, much inflated, increasing very rapidly in the adult so that the last four chambers make up a very considerable amount of the entire test; sutures distinct, depressed; wall distinctly papillate throughout; aperture a low opening at the base of the last-formed chamber in the median line. Length 0.45 mm.; breadth 0.35 mm.; thickness 0.25 mm." (Cushman and Ponton, 1932)

Occurrence.—The Friendly, Maryland, locality is the only outcrop locality containing this species. In the subsurface it was found in the Buchheister and Southern Maryland Electric Cooperative wells.

Remarks.—This is an extremely small species, but it is easily recognized by the rapid increase in the size of the chambers and the papillate surface.

It has been recorded only from beds of Wilcox age. It occurs in the Wilcox formation near Ozark, Alabama, and in the Salt Mountain limestone, Tuscahoma sand and Bashi formation of that state.

Genus EOUVIGERINA Cushman, 1926

EOUVIGERINA EXCAVATA Cushman

(Pl. 3, fig. 9)

Eouvigerina excavata Cushman, Contr. Cushman Lab. Foram. Res., vol. 16, 1940, p. 66, pl. 11, fig. 18.—Cushman and Todd, l. c., vol. 18, 1942, p. 35, pl. 6, figs. 20, 21.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 10, pl. I, fig. 18; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 42, pl. 7, fig. 7.—Cushman and Todd, l. c., vol. 22, 1946, p. 58, pl. 10, fig. 16.

Description.—"Test small, mostly biserial, in the adult quadrangular in end view, tapering, greatest breadth formed by the last two chambers, initial end rounded; chambers very distinct, the broader faces deeply excavated, the angles of the chamber raised into narrow plate-like projections; sutures distinct, strongly raised; wall smooth, finely perforate; aperture terminal, rounded, with a distinct neck and lip. Length 0.18–0.25 mm.; diameter 0.08–0.10 mm." (Cushman, 1940)

Occurrence.—In outcrop this species is present only at Friendly, Maryland, but it occurs in all the well material from the Western Shore of Maryland.

Remarks.—Described from the Paleocene, Naheola formation, of Alabama, this species is also recorded from the Wilcox, Bashi formation, of Alabama.

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA cf. CACUMENATA Cushman and Parker

Quite a number of specimens which compare very closely with this species occur in the Nanjemoy and Aquia formations in the Southern Maryland Cleaners well in Charles County, Maryland. The test is small, tapers to a subacute initial end and is ornamented with longitudinal costae. The sutures on the Aquia specimens are usually not visible or are very indistinct.

This species was described from the Midway of Texas (Contr. Cushman Lab. Foram. Res., vol. 12, 1936, p. 40).

BULIMINA OVATA d'Orbigny

(Pl. 3, figs. 10, 11)

Bulimina ovata d'Orbigny, Foram. Foss. Bass. Tert. Vienne, 1846, p. 185, pl. 11, figs. 13, 14.—Cushman and Parker, U. S. Geol. Survey, Prof. Paper 210-D, 1947, p. 106, pl. 25, figs. 8, 9 (See this reference for further synonymy).

Description.—"Test of medium size, not more than twice as long as broad, oval in shape, the broadest portion about one-third of the way down from the apertural end, consisting of 2 or 3 whorls, the last-formed whorl forming one-half or more of the test; chambers somewhat inflated; sutures distinct, depressed; wall smooth, somewhat translucent, perforate, the perforations sometimes arranged in regular lines to give a faintly striate appearance; aperture loop-shaped, with a well defined lip and tooth." (Cushman and Parker, 1947)

Occurrence.—At Aquia Creek, Virginia, this species occurs in abundance in a zone 9 feet thick. Rare specimens are present in the Potomac Creek, Virginia, and Friendly, Maryland, material. It is not present in the subsurface material from the Western Shore of Maryland.

Remarks.—This species ranges from Eocene to Recent. In the Wilcox Eocene it has been recorded from near Ozark, Alabama, and from the Salt Mountain limestone of Alabama.

Genus ENTOSOLENIA Ehrenberg, 1848

ENTOSOLENIA cf. LAEVIGATA (Reuss)

(Pl. 3, figs. 12a, b)

A few specimens which resemble this species were found at Aquia Creek, Virginia, and in the Southern Maryland Electric Cooperative well, Charles County, Maryland. The specimens are practically identical with the form figured from the Paleocene, Coal Bluff Marl member of the Naheola formation, of Alabama (Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 43, pl. 7, fig. 11). The thick peripheral keel extends out as a broad compressed neck at the end of which is the aperture.

ENTOSOLENIA cf. MARGINATA (Walker and Jacob)

(Pl. 3, fig. 13)

A number of specimens from the outcrop at Aquia Creek, Virginia, and Friendly, Maryland, and from the subsurface in the Buchheister and Southern Maryland Electric Cooperative wells may be referred to this species. The translucent test is very small, much compressed and oval in outline. The periphery is slightly keeled. The entosolenian tube can be observed in some of the specimens.

ENTOSOLENIA OSLATUS Shifflett, n. sp.

(Pl. 3, figs. 14a–c)

Description.—Test single chambered, subcircular in outline, not much compressed, with two peripheral keels which join to form a constriction at either side of the aperture and then form the lip-like margin of the aperture; wall clear with the entosolenian tube showing distinctly; aperture terminal, unusually broad, narrowly elliptical. Length 0.23 mm.; breadth 0.18 mm.; thickness 0.1 mm.

Holotype (Cushman Coll. No. 57602) from the Wilcox Eocene, Aquia formation, 4½ feet above the indurated ledge known as zone 3 of Clark at Aquia Creek, Stafford County, Virginia.

Entosolenia oslatus, new species, does not resemble any previously described form.

Occurrence.—*Entosolenia oslatus* occurs in the Piscataway substage of the Aquia formation at Aquia Creek, Virginia, and at Friendly, Maryland. It is also present in the Kierstead and Buchheister water wells, Prince George's County, Maryland, and in the Southern Maryland Electric Cooperative well in Charles County.

Remarks.—Distinguished by very definite and constant characters this form is easily recognized. Its occurrence in the Paleocene portion of the Buchheister well indicates that its range is at least Paleocene and lower Eocene.

Genus VIRGULINA d'Orbigny, 1826

VIRGULINA WILCOXENSIS Cushman and Ponton

(Pl. 3, fig. 15)

Virgulina wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 67, pl. 8, fig. 22.—Cushman, Spec. Publ. No. 9, Cushman Lab. Foram. Res., 1937, p. 6, pl. 1, fig. 17.—Cushman and Garrett, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 82, pl. 14, figs. 19–21.—Cushman, l. c., vol. 16, 1940, p. 67, pl. 11, fig. 19.—Kline, Miss. State Geol. Survey, Bull. 53, 1943, p. 49, pl. 6, fig. 24.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 11, pl. 1, figs. 19, 20; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 24, pl. 4, fig. 24.

Description.—"Test elongate, fusiform, somewhat compressed, about 2½ times as long as broad, early portion irregularly spiral, adult irregularly biserial, periphery rounded; chambers distinct, very slightly inflated; sutures distinct, very slightly depressed; wall smooth, distinctly perforate; aperture a broad, comma-shaped opening at the base of the apertural face in the median line. Length 0.50 mm.; breadth 0.15 mm.; thickness 0.10 mm." (Cushman and Ponton, 1932)

Occurrence.—A number of specimens of this species were found in outcrop at Aquia Creek, Virginia, and Friendly, Maryland. Rare specimens were found in the Kierstead well in Prince George's County, Maryland.

Remarks.—This species is recorded from the Paleocene and Wilcox Eocene. The types are from the Wilcox, Tuscahoma sand, north of Ozark, Alabama, and it has been reported from the Wilcox Bashi formation of Alabama.

Genus LOXOSTOMA Ehrenberg, 1854

LOXOSTOMUM cf. WILCOXENSIS Cushman and Ponton

No specimens referable to this species occur in the outcrop, but in the subsurface samples are a number of specimens which may belong to this form. It is present in the Charles County wells and in the Buchheister well in Prince George's County, Maryland. The backward-sloping sutures are characteristic of the slender test which has nearly parallel sides.

This species was described from the Wilcox Eocene near Ozark, Alabama.

Genus ANGULOGERINA Cushman, 1927

ANGULOGERINA PARVULA (Cushman and Thomas)

(Pl. 3, fig. 16)

Uvigerina parvula Cushman and Thomas, Journ. Pal., vol. 3, 1929, p. 178, pl. 23, figs. 3, 4.
Angulogerina parvula Cushman and Edwards, Contr. Cushman Lab. Foram. Res., vol. 13, 1937, p. 86, pl. 12, fig. 19.—Howe, La. Dept. Conserv., Geol. Bull. No. 14, 1939, p. 72, pl. 8, fig. 15.

Description.—"Test minute, elongate, 1½–2½ times as long as broad, fusiform, in the later portion triangular in cross-section, periphery lobulate; chambers numerous, distinct, somewhat inflated; sutures distinct, depressed; wall in the early portion ornamented with numerous, longitudinal costae, 20–25 in the complete circumference, in the adult becoming entirely smooth; aperture with a short, somewhat tapering neck, and a slight lip. Length 0.22–0.27 mm.; breadth 0.11–0.19 mm." (Cushman and Edwards, 1937)

Occurrence.—This species occurs in outcrop at Aquia Creek, Virginia, and at Friendly, Maryland. It is present in all the wells examined from Charles and Prince George's counties except the Southern Maryland Cleaners well.

Remarks.—The lobulate periphery and inflated chambers make this species easily distinguishable from the other two species of this genus found in the Aquia material.

A. parvula has been recorded only from the Eocene.

ANGULOGERINA VIRGINIANA Cushman

(Pl. 3, fig. 17)

Angulogerina virginiana Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 25, pl. 4, fig. 23; l. c., p. 44, pl. 7, fig. 19.

Description.—"Test minute, elongate, tapering, triangular in section, the sides concave and the angles slightly rounded, triserial except for the last 2 or 3 chambers in the adult which are irregularly uniserial; chambers of the early portion indistinct, in the adult somewhat separated and more inflated; sutures indistinct except in the very last portion in the adult where they are somewhat depressed; wall ornamented with fine longitudinal costae continuous over most of the test; aperture in the adult terminal, with a short neck and slight lip. Length 0.30–0.40 mm.; diameter 0.10–0.12 mm." (Cushman, 1944)

Occurrence.—Present in the Piscataway substage of the Aquia formation at Aquia Creek, Virginia, and Friendly, Maryland, this species also occurs in all the Charles County and Prince George's County wells except the Maryland State Police well.

Remarks.—The small tapering test ornamented with longitudinal costae is distinctive.

The only record for this species besides the Aquia formation is from the Naheola formation of Alabama.

ANGULOGERINA WILCOXENSIS (Cushman and Ponton)

(Pl. 3, fig. 18)

Pseudouvigerina wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 66, pl. 8, fig. 18.

Angulogerina wilcoxensis Cushman and Garrett, l. c., vol. 15, 1939, p. 84, pl. 14, figs. 24, 25.—Toulmin, Journ. Pal., vol. 15, 1941, p. 599, pl. 80, fig. 30.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 44, pl. 7, fig. 18.

Description.—"Test small, elongate, about twice as long as broad, sides in the adult nearly parallel, triangular in transverse section, the angles with two distinct ribs, and a deep channel between; chambers fairly distinct, not inflated, in the adult triserial; sutures fairly distinct, strongly curved, not depressed; wall coarsely perforate; aperture in the adult terminal with a short neck and slight lip. Length 0.30 mm.; diameter 0.15 mm." (Cushman and Ponton, 1932)

Occurrence.—In the Virginia outcrop material this species occurs predominantly at Potomac Creek, although a few specimens were found at Aquia Creek. It is rare in the Friendly, Maryland, material. In the subsurface in Maryland it occurs in all the wells except the Gardner and Maryland State Police wells.

Remarks.—The triangular test with distinct ribs at the angles makes *A. wilcoxensis* easy to distinguish from the other species of this genus in the Aquia formation.

This species is recorded from the Tuscahoma sand, Bashi formation, Hatchetigbee marl and Salt Mountain limestone of Alabama, all of Wilcox age. It is recorded also from the Paleocene, Naheola formation, of Alabama.

Family ELLIPSOIDINIDAE

Genus ELLIPSONODOSARIA A. Silvestri, 1900

ELLIPSONODOSARIA (?) sp.

Several incomplete specimens which probably belong to this genus occur in the Friendly, Maryland, outcrop. The rounded inflated chambers in a rectilinear series are separated by limbate sutures.

Family ROTALIIDAE

Genus DISCORBIS Lamarck, 1804

DISCORBIS AMICUS Shifflett, n. sp.

(Pl. 3, figs. 19a, b)

Description.—Test small, trochoid, circular in outline, dorsal side convex, ventral side concave, periphery sub-acute, slightly lobulate; chambers distinct, not inflated, 8–10 slender chambers arranged in a spiral visible dorsally, usually six chambers visible ventrally, the last chamber composing about $\frac{1}{3}$ of the ventral side of the test; sutures distinct, curved, dorsally limbate, composed of clear shell material and flush with the surface, ventrally depressed; wall calcareous, perforate; aperture a small arched slit at the base of the last-formed chamber between the periphery and the umbilical region. Diameter up to 0.2 mm.; thickness up to 0.06 mm.

Holotype (Cushman Coll. No. 57603) from the Aquia formation at Friendly, Prince George's County, Maryland.

Discorbis amicus, new species, resembles *D. huneri* Howe, but the periphery is not so acute and the ventral side does not show irregular inner ends to the chambers.

Occurrence.—This species occurs in outcrop in the Aquia formation at Friendly, Maryland. In the subsurface it is present in all the water wells from the Western Shore of Maryland except the Kierstead well.

DISCORBIS CALYPTRA Shifflett, n. sp.

(Pl. 3, figs. 20a, b)

Description.—Test sub-rounded in outline, with the ventral side slightly concave, strongly umbilicate, dorsal side strongly convex, periphery sub-acute; chambers distinct, 10 to 12 visible on the dorsal side, 7 in the last-formed whorl, increasing uniformly in size as added; sutures curved, slightly limbate in the earliest part, depressed in the later part both dorsally and ventrally; wall coarsely perforate with clear shell material visible dorsally over the central part; aperture an elongated opening extending from the periphery to the umbilical region on the ventral side beneath a projecting lip. Length 0.40 mm.; breadth 0.33 mm.; thickness 0.13 mm.

Holotype (Cushman Coll. No. 57604) from the Wilcox Eocene, Aquia formation ,zone 6 of Clark, from Aquia Creek, Stafford County, Virginia.

Discorbis calyptra, new species, resembles the figures of *D. oligospiratus* Galloway and Heminway (New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Islands, 1941, vol. 3, pt. 4, p. 384) but differs from it in the slightly concave ventral side and the periphery which is sub-acute throughout the test, whereas the ventral side of *D. oligospiratus* is flat, and the periphery is subangular in the early part of the test but becomes "broadly rounded and shouldered on the dorsal side in most of the last whorl".

Occurrence.—This new species is present at Potomac Creek and Aquia Creek in Virginia and at Friendly, Maryland. It occurs in all the subsurface material examined.

Genus LAMARCKINA Berthelin, 1881

LAMARCKINA WILCOXENSIS Cushman

(Pl. 3, figs. 21a, b)

Lamarckina wilcoxensis Cushman, Contr. Cushman Lab. Foram. Res., vol. 2, 1926, p. 9, pl. 1, fig. 3.—Cushman and Ponton, l. c., vol. 8, 1932, p. 70, pl. 9, fig. 4.—Cushman, Spec. Publ. No. 5, Cushman Lab. Foram. Res., 1933, pl. 29, figs. 19a–c.—Glaessner, Problems of Paleontology, Moscow Univ., vols. 2–3, 1937, p. 381, pl. 2, figs. 29a–c.—Cushman and Garrett, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 84, pl. 14, figs. 30, 31.—

Brotzen, Sver. Geol. Under., Ser. C, no. 451, 1942, pp. 36–37, fig. 12; 12, 13.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 12, pl. 1, figs. 32–35; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 26, pl. 4, fig. 25.

Description.—"Test small, thick, slightly longer than broad, periphery sharply angled, slightly lobulate, last-formed coil consisting of about 7 chambers inflated, but the central early chambers forming a distinct umbo; sutures depressed or occasionally limbate; ventral side somewhat convex, strongly umbilicate, smooth and highly polished; aperture with an elongate projecting area from the last-formed chamber. Length 0.35–0.40 mm.; thickness 0.25 mm." (Cushman, 1926)

Occurrence.—This species is rare at Potomac Creek but occurs in abundance at Aquia Creek, Virginia. It is present at Friendly, Maryland, in the outcrop and in all the subsurface material from Charles County and Prince George's County, Maryland.

Remarks.—This species has been recorded from the Wilcox of Alabama in the Tuscahoma sand and the Bashi formation.

Genus VALVULINERIA Cushman, 1928

VALVULINERIA SCROBICULATA (Schwager)

(Pl. 3, figs. 22, 23)

Anomalina scrobiculata Schwager, Palaeontographica, vol. 30, 1883, Pal. Theil, p. 129, pl. 29 (6), fig. 18.

Valvulineria scrobiculata Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 70, pl. 9, fig. 5.—Cushman and Garrett, l. c., vol. 15, 1939, p. 85, pl. 14, figs. 32, 33.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 13, pl. 2, figs. 1, 2; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 26, pl. 4, fig. 27.

Occurrence.—Restricted to the Piscataway substage in the outcrop, this species is found abundantly at Aquia Creek, Virginia, and at Friendly, Maryland. It occurs in all the Charles County and Prince George's County wells; and, although it is not completely restricted to the Piscataway substage in the subsurface, it is rare above this substage and occurs abundantly in it.

Remarks.—Schwager originally described this species from the middle Eocene of northern Africa. "The test is smooth with 8–10 chambers in the adult whorl, ventral side umbilicate, and the chambers with a distinct lip-like projection over the umbilical area." (Cushman and Ponton, 1932)

This species is recorded in America only from the Wilcox Eocene, Tuscahoma sand and Bashi formation, of Alabama.

VALVULINERIA WILCOXENSIS Cushman and Ponton

(Pl. 4, figs. 1a, b)

Valvulineria wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 70, pl. 9, fig. 6.—Cushman and Garrett, l. c., vol. 15, 1939, p. 85, pl. 15, figs. 1, 2.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 13, pl. 1, figs. 36, 37; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 26, pl. 4, fig. 26.

Description.—"Test nearly circular in side view, periphery slightly lobulate, nearly bilaterally symmetrical, umbilical region slightly depressed on the ventral side; chambers very distinct, 6 or 7 in the last-formed whorl, inflated; sutures distinct, slightly curved; strongly limbate on the ventral side, less so on the dorsal side in the early stages, sutures of the later portion depressed, not limbate; wall smooth, distinctly perforate; aperture a low opening, running from the median line onto the ventral side beneath the somewhat flattened lip of the ventral margin of the chamber. Diameter 0.75 mm.; thickness 0.30 mm." (Cushman and Ponton, 1932)

Occurrence.—In outcrop this species, like the preceding, is restricted to the Piscataway substage of the Aquia formation and is found at Aquia Creek, Virginia, and Friendly, Maryland. It is not abundant in the subsurface and occurs only in the Buchheister and the Maryland State Police wells.

Remarks.—This species is not always easily distinguishable from *V. scrobiculata*; however, it has inflated chambers which are fewer in number than in *V. scrobiculata* and do not possess a lip-like projection over the umbilical area. Typical specimens of *V. wilcoxensis* are much less abundant than *V. scrobiculata*, both in outcrop and subsurface material.

This species is characteristic of the Wilcox Eocene, although rare specimens were found in the Buchheister well in the Nanjemoy portion of the section. The types are from the Tuscahoma sand of Alabama, and it is recorded from the Bashi formation of that state.

VALVULINERIA sp.

Closely coiled specimens of this genus with numerous chambers and limbate sutures occur in a few samples from the outcrop at Friendly, Maryland. On the ventral side the chambers have small projections over the umbilical area. These specimens are probably merely a variety of *V. scrobiculata*, differing from the species in being more closely coiled and full-bodied.

Genus GYROIDINA d'Orbigny, 1826

GYROIDINA SOLDANII d'Orbigny,

var. OCTOCAMERATA Cushman and G D. Hanna

(Pl. 4, figs. 2a–c)

Gyroidina soldanii d'Orbigny, var. *octocamerata* Cushman and G D. Hanna, Proc. Calif. Acad. Sci., ser. 4, vol. 16, 1927, p. 223, pl. 14, figs. 16–18.—Cushman, Spec. Publ. No. 16, Cushman Lab. Foram. Res., 1946, p. 31, pl. 6, fig. 15 (See this reference for further synonymy).

Description.—"Test small, dorsal side flattened, ventral side very convex, composed of about three coils, the last formed one consisting of eight chambers, periphery broadly rounded, ventral side with the umbilical region strongly depressed; chambers distinct, sutures distinct, slightly depressed, on the dorsal side somewhat oblique, on the ventral side radial; wall finely perforate, smooth and polished; aperture elongate, arched, from the periphery at least half way to the umbilicus along the ventral border of the last formed chamber, with a very slightly developed lip. Length 0.50 mm., breadth 0.45 mm., thickness 0.35 mm." (Cushman and Hanna, 1927)

Occurrence.—In outcrop this species is rare in the Piscataway substage of the Aquia formation at Friendly, Maryland, and is entirely absent at Aquia Creek, Virginia. It occurs in some abundance at Potomac Creek, Virginia. In the subsurface material it ranges from the Paleocene into the Nanjemoy. It was found in all the wells studied from the Western Shore of Maryland, except the Kierstead well.

Remarks.—The number of chambers in the last-formed whorl ranges from seven to nine, but most specimens show eight.

This widely distributed species occurs throughout the Eocene.

Genus EPONIDES Montfort, 1808

EPONIDES LABIOMARGUS Shifflett, n. sp.

(Pl. 4, figs. 3, 4)

Description.—Test trochoid, biconvex, ventral side more strongly convex, periphery rounded, slightly lobulate; chambers distinct, increasing gradually in size as added, eight to

ten chambers visible dorsally, five or six chambers visible ventrally; sutures distinct, limbate, dorsally oblique, nearly straight, ventrally radial, straight to slightly curved; wall calcareous, perforate; aperture ventral, extending from the umbilicus almost to the periphery, a long slit at the base of the last chamber which has a distinctive rolled margin. Length 0.25 mm.; breadth 0.20 mm.; thickness 0.16 mm.

Holotype (Cushman Coll. No. 57605) from the Eocene, Aquia formation, at the type locality on Aquia Creek, Stafford County, Virginia from zone 6 of Clark.

Eponides labiomargus bears a marked resemblance to *Pulvinulinella obtusa* (Burrows and Holland) but differs in the apertural characteristics. The aperture of *P. obtusa* is somewhat loop-shaped and lies almost in the plane of coiling while the aperture of this species is a slit-like opening at an angle to the plane of coiling.

Occurrence.—In outcrop this species is restricted to the Piscataway substage of the Aquia formation and is found abundantly at Aquia Creek, Virginia, and Friendly, Maryland. It is present in all the subsurface material examined from the Western Shore of Maryland and is very useful in distinguishing the two substages of the Aquia formation.

EPONIDES LOTUS (Schwager)

(Pl. 4, figs. 5, 6)

Pulvinulina lota Schwager, Palaeontographica, vol. 30, 1883, Pal. Theil, p. 132, pl. 28 (5), fig. 9.

Eponides lotus Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 71, pl. 9, fig. 8.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 13, pl. 2, figs. 5, 6 (See this reference for further synonymy); Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 26; l. c., p. 46, pl. 7, fig. 26.

Occurrence.—This species is common but not abundant in all the Aquia material examined, both outcrop and subsurface.

Remarks.—In the subsurface this rather large and distinctive form, which was described originally from the middle Eocene of northern Africa, is very useful in recognizing the first appearance of the Eocene. The very convex dorsal side with clear shell material over the central area is characteristic.

Pulvinulina schreibersii d'Orbigny recorded by Bagg (Bull. Amer. Pal.; No. 10, 1898, p. 331, pl. 3, fig. 2) probably represents this characteristic form.

This species is recorded from the Eocene of several geographical localities. In the Atlantic Coast states, it is recorded from the Tuscahoma sand and the Bashi formation, Wilcox age, of Alabama and from the Paleocene, Naheola formation, of Alabama.

EPONIDES sp.

(Pl. 4, figs. 7a, b)

A few specimens of this genus occur at Potomac Creek, Virginia. They cannot be specifically identified. The tests are biconvex and consist of two or three whorls with numerous small non-inflated chambers. The very slightly depressed dorsal sutures are not oblique but lie almost at a 90° angle with the spiral suture.

Genus SIPHONINA Reuss, 1850

SIPHONINA WILCOXENSIS Cushman

(Pl. 4, fig. 8)

Siphonina wilcoxensis Cushman, Proc. U. S. Nat. Mus., vol. 72, Art. 20, 1927, p. 3, pl. 2, figs. 1–3.—Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 70, pl. 9, fig. 7.—Cushman and Garrett, l. c., vol. 15, 1939, p. 86, pl. 15, figs. 7–9.—Israelsky, Proc.

6th Pac. Sci. Congress, 1939, p. 578, pl. 7, fig. 3.—Toulmin, Journ. Pal., vol. 15, 1941, p. 605, pl. 81, figs. 15, 16.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 14, pl. 2, figs. 3, 4; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 27; p. 46, pl. 7, fig. 27.

Description.—"Test subcircular in outline, slightly more convex ventrally, periphery sharply acute and delicately serrate, slightly lobate; chambers five in number in the last whorl, slightly inflated on the ventral side; dorsal sutures flush with the surface, oblique, marked by the serrate edges of the chambers, ventral sutures slightly depressed, nearly radial; surface distinctly punctate; aperture an elongate opening parallel to the periphery on the ventral side, outlined by a narrow lip but without a neck. Diameter up to 0.3 mm." (Toulmin, 1941)

Occurrence.—This species was not found in the outcrop material of the Aquia formation. It occurs in the Buchheister, Southern Maryland Cleaners and Maryland State Police wells in the Aquia and ranges up into the Nanjemoy.

Remarks.—The records for this species include Wilcox Eocene occurrences in the Tuscahoma sand, Bashi formation and Salt Mountain limestone of Alabama and the Paleocene occurrence in the Coal Bluff marl member of the Naheola formation of Alahama.

Family CASSIDULINIDAE

Genus CERATOBULIMINA Toula, 1915

CERATOBULIMINA sp.

A few specimens referable to this genus occur in the Aquia portion of the Buchheister water well in Prince George's County, Maryland. The specimens have opaque, highly polished walls and are larger than the very similar *Lamarckina wilcoxensis* Cushman.

Genus PULVINULINELLA Cushman, 1926

PULVINULINELLA DANVILLENSIS Howe and Wallace

(Pl. 4, figs. 9a, b)

Pulvinulinella danvillensis Howe and Wallace, La. Dept. Conserv., Geol. Bull. No. 2, 1932, p. 71, p. 13, fig. 7.—Bergquist, Mississippi State Geol. Survey, Bull. 49, 1942, p. 91, pl. 9, fig. 4.—Cushman and Herrick, Contr. Cushman Lab. Foram. Res., vol. 21, 1945, p. 70, pl. 11, fig. 9.

Description.—"Test small, almost equally biconvex, almost circular in outline; periphery acute; chambers numerous, about nine in the last-formed coil; sutures distinct, on the ventral side straight, radial, on the dorsal side straight, but intersecting acutely with the previous coil; central area on the ventral side filled with clear calcareous material; wall calcareous, very finely perforate; aperture an elongate slit parallel to the periphery, located in a depressed notch in the apertural face on the ventral side midway between the periphery and the umbilicus. Diameter 0.15 mm.; thickness 0.07 mm." (Howe and Wallace, 1932)

Occurrence.—This species is very rare at Aquia Creek, Virginia, but a number of specimens were found at Friendly, Maryland. It is not abundant in the subsurface of the Western Shore of Maryland but occurs in all the material examined.

Remarks.—This extremely small but distinctive species was described from the Jackson Eocene of Louisiana. This is the first report of its presence in beds of Wilcox Eocene age.

Genus ALABAMINA Toulmin, 1941

ALABAMINA WILCOXENSIS Toulmin

(Pl. 4, figs. 10a, b)

Pulvinulinella exigua var. *obtusa* Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 71, pl. 9, figs. 9a–c.—Jennings, Bull Amer. Pal., vol. 23, 1936, p. 192, pl.

31, figs. 4a, b.—Howe, La. Dept. Conserv., Geol. Bull. No. 14, 1939, p. 81, pl. 11, figs. 4–6.

Pulvinulinella obtusa Cushman and Garrett, Contr. Cushman Lab. Foram. Res., vol. 15, 1939, p. 87, pl. 15, figs. 12, 13.

Alabamina wilcoxensis Toulmin, Journ. Pal., vol. 15, 1941, p. 603, pl. 81, figs. 10–14, text fig. 4A-C.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 24, 1948, p. 10, pl. 2, figs. 18–20.

Description.—"Test trochiform, close coiled, sub-circular in outline, unequally biconvex or plano-convex, ventral side strongly convex, periphery bluntly acute; five or six chambers in the final whorl; wall smooth, finely perforate; sutures flush with the surface, on the dorsal side almost straight, oblique to the periphery, on the ventral side radial; aperture a long narrow opening on the ventral side at the base of the septal face, with a supplementary indentation extending peripherally from the true aperture, formed by a fold in the wall of the test and not opening into the interior of the chamber. Diameter up to 0.42 mm.; height up to 0.21 mm." (Toulmin, 1941)

Occurrence.—*Alabamina wilcoxensis* is rare at Potomac Creek, Virginia, but is abundant at Aquia Creek, Virginia, and Friendly, Maryland. Present in all the wells from the Western Shore of Maryland, it is very useful in differentiating the Piscataway and Paspotansa substages of the Aquia formation.

Remarks.—This species has approximately the same range in the Aquia material as *Eponides labiomargus* which it somewhat resembles on the dorsal side. It is much larger than the latter species, however, and the apertural characters are different. The periphery of *A. wilcoxensis* is rather acute while that of *E. labiomargus* is rounded.

This species is recorded from both the Wilcox and Claiborne Eocene. It is present in the Wilcox near Ozark and Woods Bluff, Alabama, and in the Salt Mountain limestone of Alabama, and also occurs in the Hornerstown formation, Wilcox age, in New Jersey.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA COMPRESSA Plummer

Globigerina compressa Plummer, Univ. Texas, Bull. 2644, 1927, p. 135, pl. 8, fig. 11.—Jennings, Bull. Amer. Pal., vol. 23, no. 78, 1936, p. 193, pl. 31, fig. 8.—Glaessner, Problems of Paleontology, Moscow Univ., vols. 2–3, 1937, p. 382, pl. 4, fig. 32.—Toulmin, Journ. Pal., vol. 15, 1941, p. 607, pl. 82, figs. 1, 2.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 44, pl. 8, figs. 5, 6.

Description.—"Test small, rotaliform, closely coiled, somewhat compressed, equally biconvex; peripheral margin bluntly angular, lobate; chambers increasing gradually, 5 in last-formed whorl, moderately inflated, overlapping on dorsal face; sutures distinctly depressed and strongly curved on the dorsal side; shell wall thin, smooth, finely punctate; aperture a single moderately arched slit protected by a definite flaring flap at base of septal face and extending into the small but distinct umbilical depression. Diameter up to 0.4 mm.; average 0.3 mm." (Plummer, 1927)

Occurrence.—A few specimens of this species were found at Friendly, Maryland, but it is not present in the Virginia outcrop material. Rare specimens occur in the Southern Maryland Electric Cooperative and Buchheister wells, but in the latter it is in the Paleocene portion of the section.

Remarks.—Described from the Midway of Texas and present in the Naheola formation of Paleocene age in Alabama, this form also occurs in the Wilcox Eocene, being found in the Salt Mountain limestone of Alabama and the Hornerstown formation of New Jersey.

GLOBIGERINA cf. OUACHITAENSIS Howe and Wallace

(Pl. 4, figs. 11–13)

Specimens occurring fairly commonly in the Piscataway substage of the Aquia at Aquia Creek and at Friendly, Maryland, seem identical with the figures and description of *Globigerina ouachitaensis*, first published in the Louisiana Geological Bulletin No. 2, 1932, p. 74. Rare specimens were also found in the wells in Charles County, Maryland, and in the Buchheister well, Prince George's County. The high spire on the dorsal side and the four chambers of the last whorl visible on the ventral side are distinctive characteristics. The species has been recorded from the Claiborne Eocene, Cook Mountain formation, and from the Jackson Eocene of Louisiana.

GLOBIGERINA cf. PSEUDO-BULLOIDES Plummer

(Pl. 4, figs. 14, 15)

A small *Globigerina* closely resembling this species described in University of Texas Bulletin 2644, 1927, p. 133, occurs in marked abundance in the Piscataway substage at Aquia Creek, Virginia, and Friendly, Maryland. It was found rarely in the Paspotansa substage from Potomac Creek, Virginia. The species is abundant in all the subsurface material from the Western Shore of Maryland.

Most of the Aquia specimens have the typical punctate wall, but some have a smooth wall. The chambers are more inflated ventrally than dorsally, and the specimens appear almost plane dorsally. However, most of them possess a slightly elevated spire of small chambers dorsally. The five-chambered last coil is typical although occasionally six chambers are present.

This species has been recorded from the Midway of Texas, Alabama, Mississippi, Florida and Arkansas. It has been reported also from the Upper Eocene of Ecuador.

GLOBIGERINA TRILOCULINOIDES Plummer

(Pl. 4, figs. 16, 17)

Globigerina triloculinoides Plummer, Univ. Texas, Bull. 2644, 1927, p. 134, pl. 8, figs. 10a–c.—Jennings, Bull. Am. Pal., vol. 23, 1936, p. 193, pl. 31, fig. 10.—Glaessner, Moscow Univ., Publ. Lab. Paleontology, vols. II–III, 1937, p. 382, pl. 4, figs, 33a, b.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 16, 1940, p. 72, pl. 12, fig. 15.—Toulmin, Journ. Pal., vol. 15, 1941, p. 607, pl. 82, fig. 3.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 43, pl. 8, figs. 1, 2.—Thalmann, Stanford Univ. Publ., Univ. Ser., Geol. Sci., vol. 3, no. 1, 1942, p. 13.—Beck, Journ. Pal., vol. 17, 1943, p. 609, pl. 108, figs. 2, 3.—Kline, Miss. State Geol. Survey, Bull. 53, 1943, p. 59, pl. 6, figs. 12, 13.—Cooper, Journ. Pal., vol. 18, 1944, p. 353, pl. 54, figs. 12, 13.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 15, pl. 2, figs. 11, 12.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 48, pl. 8, fig. 4.—Cushman and Todd, l. c., vol. 22, 1946, p. 64.—Detling, Journ. Pal., vol. 20, 1946, p. 359, pl. 51, fig. 2.

Description.—"Test spiral, trochoid, composed of about 2 convolutions, the last of which is composed of 3½ very rapidly increasing and highly globose chambers; periphery very broadly rounded and distinctly lobate; shell surface strongly reticulate; superior face rounded with a very low spire of neatly coiled tiny chambers of the preceding whorl; inferior face rounded with a very shallow umbilical depression; aperture a small arched slit on the last chamber and edged with a more or less prominent, delicately notched flap that extends from a point near the periphery to the umbilical depression. Greatest diameter up to .35 mm.; usually less." (Plummer, 1927)

Occurrence.—This species is fairly common in all the material, both outcrop and subsurface.

Remarks.—*Globigerina triloculinoides* is easily recognized by the reticulate surface and the three, or three and a half, globose chambers visible on the ventral side, the last-formed being larger and separated from the preceding ones by a distinct transverse suture.

This species is recorded frequently from the Midway (Paleocene) of the Gulf Coastal Plain. In the Wilcox Eocene of Alabama it is reported from the Salt Mountain limestone and from the Bashi formation. It is also found in the Hornerstown formation of New Jersey.

Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman, 1927

GLOBOROTALIA cf. ANGULATA (White)

(Pl. 4, figs. 18a–c)

A few specimens with definite characters which probably belong to this species were found in the Piscataway substage of the Aquia formation from Aquia Creek, Virginia, and Friendly, Maryland. It occurs also in all the wells from the Western Shore of Maryland except the Maryland State Police well.

There are four or five chambers in the last whorl in a rosette-like arrangement on the flattened dorsal side. The convex ventral side, angled periphery and spinose wall are other constant characters.

This species was described from the Upper Cretaceous, Velasco formation, of the Tampico embayment area of Mexico (Journ. Pal., vol. 2, 1928). It has subsequently been recorded from the Tertiary of the Caucasus and from the Eocene of East Borneo.

GLOBOROTALIA MEMBRANACEA (Ehrenberg)

(Pl. 4, figs. 19a, b)

Planulina membranacea Ehrenberg, Mikrogeologie, 1854, pl. 25, 1A, (not fig. 41); pl. 26, fig. 43.
Pulvinulina membranacea Cushman, Bull. Amer. Assoc. Petr. Geol., vol. 10, no. 6, 1926, p. 608, pl. 21, figs. 10a, b.
Globorotalia membranacea M. P. White, Journ. Pal., vol. 2, 1928, p. 280, pl. 38, figs. 1a–c.—Glaessner, Problems of Paleontology, Moscow Univ., vols. 2–3, 1937, p. 385, pl. 4, figs. 38a–c.—Toulmin, Journ. Pal., vol. 15, 1941, p. 608, pl. 82, figs. 4, 5.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 45, pl. 8, fig. 10.—Applin and Applin, Bull. Amer. Assoc. Petr. Geol., vol. 28, no. 12, 1944, pl. 5, fig. 2.

Description.—"Test trochiform, moderately compressed, biconvex, longer than broad, periphery lobate, acute, carinate; chambers distinct, inflated on the ventral side only, five or six in number in the last whorl, increasing regularly in size as added, small chambers of preceding whorl forming a very low spire on the dorsal side of the test, ventral side with small, umbilical depression; sutures on the dorsal side curved, limbate and flush with the surface, joining with the peripheral carina, ventral sutures depressed, nearly radiate; wall smooth, polished; aperture an arched opening at the base of the septal face, extending from the periphery to the umbilicus. Length up to 0.44 mm.; width up to 0.35 mm.; thickness up to 0.19 mm." (Toulmin, 1941)

Occurrence.—This species is rare in the Virginia and Maryland outcrop material and in the Buchheister, Gardner and Southern Maryland Electric Cooperative wells.

Remarks.—Recorded from the Upper Cretaceous and Paleocene, this species also occurs in the Wilcox Eocene, Salt Mountain limestone, of Alabama.

GLOBOROTALIA WILCOXENSIS Cushman and Ponton

(Pl. 4, figs. 20-22)

Globorotalia wilcoxensis Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 71, pl. 9, fig. 10.—Cushman and Garrett, l. c., vol. 15, 1939, p. 88, pl. 15, figs. 21, 22.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 15, pl. 2, figs. 14, 15.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 27.

Description.—"Test plano-convex, dorsal side flat, ventral side strongly convex, slightly umbilicate, periphery subacute in the later portion, rounded in the earlier stages; chambers distinct, four making up the last-formed whorl in the adult, of uniform shape, increasing regularly in size as added; sutures distinct, very slightly curved; nearly radial, slightly depressed; wall distinctly perforate with the early portion strongly papillate or with short spines, in the later chambers largely confined to the peripheral angle; aperture a semicircular opening toward the umbilical end of the ventral side of the last-formed chamber. Length 0.50 mm.; breadth 0.40 mm.; thickness 0.25 mm." (Cushman and Ponton, 1932)

Occurrence.—*Globorotalia wilcoxensis* is present in the Virginia and Maryland outcrop material and in the water wells on the Western Shore of Maryland except the Maryland State Police and Gardner wells.

Remarks.—This species has been found only in the Wilcox Eocene and may be characteristic of this horizon. It has been recorded from the Tuscahoma sand and Bashi formation of Alabama.

GLOBOROTALIA WILCOXENSIS Cushman and Ponton,

var. ACUTA Toulmin

(Pl. 4, figs. 23a-c)

Globorotalia wilcoxensis Cushman and Ponton, var. *acuta* Toulmin, Journ. Pal., vol. 15, 1941, p. 608, pl. 82, figs. 6-8.—Cushman and Renz, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 12, pl. 3, fig. 2.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 15, pl. 2, figs. 16, 17.—Cushman, Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 48, pl. 8, fig. 5.

Description.—"Test trochiform, plano-convex, dorsal side flat, ventral side strongly convex, deeply umbilicate, periphery strongly lobate, acute, and bounded by a thick flange; chambers distinct, about 4½ in the last whorl, increasing regularly in size as added; sutures distinct, on the dorsal side slightly curved, limbate, slightly if at all depressed, on the ventral side radiate, depressed; wall roughened with minute, low spinose processes, especially along the peripheral border, aperture an arched opening on the ventral side of the final chamber extending from the peripheral flange to the umbilicus. Length 0.46 mm.; width 0.37 mm.; thickness 0.24 mm." (Toulmin, 1941)

Occurrence.—The variety is more abundant in the Aquia formation than the species and occurs in all the outcrop and subsurface material examined.

Remarks.—The variety is typically much larger than the species and is easily distinguished from it by the acute periphery and the chambers on the ventral side which are angular rather than rounded.

It occurs in the Wilcox Eocene of Alabama in the Salt Mountain limestone and the Bashi formation and it has also been recorded from the Paleocene of Alabama and Trinidad.

Family ANOMALINIDAE

Genus ANOMALINA d'Orbigny, 1826

ANOMALINA UMBONIFERA (Schwager)

(Pl. 5, figs. 1, 2)

Discorbina umbonifera Schwager, Palaeontographica, vol. 30, 1883, Pal. Theil, p. 126, pl. 27 (4), fig. 14.

Anomolino umbonifero Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 72, pl. 9, fig. 11.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 15, pl. 2, figs. 18, 19; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 28, pl. 4, fig. 30; p. 49, pl. 8 fig. 6.

Description.—"The test is nearly bilateral, and the aperture is in the median line; 7 or 8 chambers make up the last-formed whorl, the sutures slightly curved and somewhat limbate but not raised, wall finely but distinctly perforate. Diameter 0.40 mm.; thickness 0.15 mm." (Cushman and Ponton, 1932)

Occurrence.—This species is abundant in the Aquia formation in both substages, and occurs in all the outcrop and subsurface material.

Remarks.—Originally described from the middle Eocene of northern Africa, *Anomolina umbonifera* is recorded from the Tuscahoma sand and from the Bashi formation, both of Wilcox Eocene age, from Alabama.

Genus CIBICIDES Montfort, 1808

CIBICIDES HOWELLI Toulmin

(Pl. 5, figs. 3a, b)

Cibicides cf. *pseudoungerianus* Cushman and Garrett, Contr. Cushman Lab. Foram. Res.' vol. 15, 1939, p. 88, pl. 15, figs. 25, 26.

Cibicides howelli Toulmin, Journ. Pal., vol. 15, 1941, p. 609, pl. 82, figs. 16–18.—Cushman and Renz, Contr. Cushman Lab. Foram. Res., vol. 18, 1942, p. 13, pl. 3, fig. 10.—Cushman, Amer. Journ. Sci., vol. 242, 1944, p. 18, pl. 2, figs. 21, 22; Contr. Cushman Lab. Foram. Res., vol. 20, 1944, p. 28, pl. 4, fig. 29; p. 50, pl. 8, fig. 9.

Description.—"Test plano-convex, subcircular in outline, earlier whorls on dorsal surface obscured by growth of shell material, ventral surface very convex, almost conical, capped by an elevated, low, rounded, smooth umbonal boss of clear to translucent shell material, periphery narrowly angled in the early portion of the last whorl, becoming bluntly angled or rounded in the later portion; chambers 9 or 10 in number in the final whorl, increasing gradually in size as added; dorsal sutures moderately curved, ventral sutures more gently curved than the dorsal, early sutures on dorsal and ventral sides flush with the surface, later sutures slightly depressed; wall coarsely perforate; aperture a slit-like opening at the base of the final chamber, arching across the periphery and extending onto the dorsal side. Length up to 0.55 mm.; width up to 0.42 mm.; thickness up to 0.24 mm." (Toulmin, 1941)

Occurrence.—This is a common species in the outcrop of the Aquia formation and is much more abundant in the Piscataway substage than in the Paspotansa substage. It is common in the subsurface material from the Western Shore of Maryland.

Remarks.—The Aquia specimens vary considerably in the amount of shell material over the early whorls on the dorsal side. Many specimens are entirely plane dorsally while the growth of shell material on others makes the dorsal side convex. The conical umbonal boss of clear shell material on the ventral side is a constant and distinguishing characteristic.

This species was described from the Wilcox Eocene, Salt Mountain limestone, of Alabama, but also occurs in the Paleocene in the Coal Bluff marl member of the Naheola formation of Alabama.

CIBICIDES MARYLANDICUS Shifflett, n. sp.

(Pl. 5, figs. 4–6)

Description.—Test plano-convex, sub-circular in outline, dorsal side flat, ventral side convex, periphery acute, non-lobate, sometimes outlined with a rim of clear shell material; chambers distinct, increasing gradually in size as added, last chamber somewhat inflated

ventrally, usually twelve chambers visible dorsally in the adult, six to seven chambers visible ventrally; sutures usually distinct, curved, dorsally limbate and flush with the surface except the last suture which may be depressed, ventrally slightly depressed; wall calcareous, rather coarsely perforate; aperture variable, usually a small rounded opening with a slight lip near the base of the last-formed chamber on the ventral side immediately at the periphery but sometimes extending as a short narrow slit on the dorsal side. Length 0.33 mm.; width 0.25 mm.; thickness 0.13 mm.

Holotype (Cushman Coll. No. 57606) from the Eocene, Aquia formation, at Friendly, Prince George's County, Maryland.

Cibicides marylandicus resembles *C. westi* Howe but does not possess the sigmoid ventral sutures of that form, and the aperture is a rounded opening rather than a small arched slit.

Occurrence.—This species does not occur in the Virginia outcrop material, but numerous specimens were found in the Friendly, Maryland, material. It is a fairly common species in the subsurface material from the Western Shore of Maryland.

CIBICIDES NEELYI Jennings

(Pl. 5, figs. 7, 8)

Cibicides neelyi Jennings, Bull. Am. Pal., vol. 23, no. 78, 1936, p. 197 (39), pl. 5, figs. 4a–c.

Description.—"Test plano-convex, dorsal side flat to slightly depressed, ventral side convex with an umbo of clear shell material; periphery narrowly rounded; 8 to 9 chambers in the final whorl which is strongly embracing; sutures on the dorsal side curved, limbate and raised in the earlier part of the whorl, becoming simple and depressed in the later part as do the dorsal sutures; the earlier sutures are often masked by growth of secondary tissue; surface of the test strongly punctate; aperture an arched opening embracing the periphery and extending dorsally beneath the final chamber. Diameter, up to 0.65 mm.; thickness, up to 0.25 mm." (Jennings)

Occurrence.—A few specimens occur in outcrop at Friendly, Maryland. It is rather common in the subsurface material from Charles and Prince George's counties, Maryland.

Remarks.—The coarse punctation of the wall is the distinctive characteristic of this species which was described from the Hornerstown formation of New Jersey.

CIBICIDES PRAECURSORIUS (Schwager)

(Pl. 5, figs. 9a, b)

Discorbina praecursoria Schwager, Palaeontographica, vol. 30, 1883, Pal. Theil, p. 125, pl. 27 (4), fig. 12, pl. 29 (6), fig. 16.

Cibicides praecursorius Cushman and Ponton, Contr. Cushman Lab. Foram. Res., vol. 8, 1932, p. 72, pl. 9, fig. 14.—Cushman, l. c., vol. 20, 1944, p. 49, pl. 8, figs. 7, 8 (See this reference for further synonymy).—ten Dam, Med. Geol. Stichting, ser. C-V, no. 3, 1944, p. 134, pl. 5, fig. 11.—Cushman and Todd, Contr. Cushman Lab. Foram. Res., vol. 22, 1946, p. 65, pl. 11, figs. 20, 21.

Description.—"Test trochiform, plano-convex, dorsal side flat or nearly flat, ventral side moderately convex; periphery acute, slightly lobate; chambers distinct, seven to nine in the final whorl, slightly inflated on both sides in the later part of the whorl, increasing regularly in size as added, of uniform moderately curved shape; sutures distinct, slightly depressed on the dorsal side, more deeply depressed on the ventral side and radiating from a low small umbo, rather strongly curved on dorsal side, slightly curved on ventral side; wall smooth, rather finely perforate, polished; aperture a low slit at base of final chamber on the ventral side, arching across the periphery onto the dorsal side where it extends along the base of the

last two chambers. Length 0.37 mm.; width 0.33 mm.; thickness 0.16 mm." (Toulmin, 1941)

Occurrence.—This is a fairly abundant species in the Virginia and Maryland outcrop material and it occurs in the subsurface material of the Western Shore of Maryland except in the Gardner and Southern Maryland Cleaners wells.

Remarks.—This species is easily recognized by the perforate wall and the deformed appearance of the test which looks as if it had been subjected to a lateral pressure which creased or wrinkled the test.

Originally described from the middle Eocene of northern Africa, this species has been recorded in this country from the Wilcox, Tuscahoma sand, Bashi formation and Salt Mountain limestone, of Alabama. In the Paleocene it is present in the Netherlands, Trinidad, Alabama and Arkansas.

Genus STICHOCIBICIDES Cushman and Bermudez, 1936

STICHOCIBICIDES CERVICULUS Shifflett, n. sp.

(Pl. 5, figs. 10a–c)

Description.—Test trochoid, attached by the flattened dorsal side, ventral side convex, periphery acute, lobulate, outlined with a rim of clear shell material; chambers distinct, increasing regularly in size as added, last chamber somewhat inflated ventrally; sutures distinct, dorsally slightly limbate, flush with the surface, ventrally depressed; wall calcareous, coarsely perforate; aperture round, with a short neck and distinct lip, at the peripheral margin of the last chamber on the ventral side. Length 0.34 mm.; breadth 0.30 mm.; thickness 0.06 mm.

Holotype (Cushman Coll. No. 57607) from the Aquia formation, Paspotansa substage, at Potomac Creek, King George County, Virginia.

Stichocibicides cerviculus does not resemble any previously described species.

Occurrence.—A few specimens were found in the uppermost part of zone 9 of Clark at Potomac Creek, and one specimen was found in zone 8 at Aquia Creek. The species was not found in the subsurface material examined.

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EXPLANATION OF PLATE 1

(All figures × 58)

1. Proteonina difflugiformis H. B. Brady.
2. Reophax curtus Cushman.
3. Reophax sp.
4. Ammodiscus incertus d'Orbigny.
5. Haplophragmoides sphaeriloculum Cushman. a, dorsal; b, ventral.
6. Ammobaculites sp.
7. Cyclammina sp. a, dorsal; b, ventral.
8, 9. Spiroplectammina wilcoxensis Cushman and Ponton. 8, microspheric; 9, megalospheric.
10. Quinqueloculina cf. harrisi Howe and Roberts. a, dorsal; b, ventral.
11. Trochammina exigua Cushman and Applin. a, dorsal; b, ventral.
12. Trochammina howei Cushman. a, dorsal; b, ventral.
13. Trochammina sp. a, dorsal; b, ventral.
14. Robulus knighti Toulmin.
15, 16. Robulus midwayensis (Plummer), var. virginianus Shifflett, n. var.
17, 18. Robulus wilcoxensis Cushman and Ponton.

EXPLANATION OF PLATE 2

(All figures × 58)

1. Marginulina toulmini Cushman.
2. Dentalina communis d'Orbigny.
3. Dentalina cf. hexacostata Howe.
4. Dentalina virginiana Cushman.
5. Dentalina wilcoxensis Cushman.
6. Nodosaria sp.
7. Vaginulina plumoides Plummer.
8. Lagena clavata (d'Orbigny).
9. Lagena costata (Williamson).
10. Lagena laevis (Montagu).
11. Lagena hexagona (Williamson).
12, 13. Guttulina irregularis (d'Orbigny).
14, 15. Guttulina problema d'Orbigny. 14 a, b, opposite sides.
16. Guttulina wilcoxensis Cushman and Ponton. a, b, opposite sides.
17. Globulina cf. gibba d'Orbigny.
18. Globulina inaequalis Reuss.
19. Globulina minuta (Roemer).
20. Glandulina abbreviata Neugeboren.
21. Glandulina laevigata d'Orbigny.
22. Globulina munsteri (Reuss).
23. Pyrulina sp.
24. Pseudopolymorphina decora (Reuss). a, b, opposite sides.

EXPLANATION OF PLATE 3

(All figures × 58)

1. Pseudopolymorphina wilcoxensis Cushman and Ponton. a, b, opposite sides.
2. Sigmomorphina semitecta (Reuss).

3. S. semitecta (Reuss), var. terquemiana (Fornasini). a, b, opposite sides.
4. Polymorphina advena Cushman, var. nuda Howe and Roberts.
5. Polymorphina sp. a, b, opposite sides.
6. Nonion planatum Cushman and Thomas.
7. Nonionella insecta (Schwager).
8. Gümbelina wilcoxensis Cushman and Ponton.
9. Eouvigerina excavata Cushman.
10, 11. Bulimina ovata d'Orbigny.
12. Entosolenia cf. laevigata (Reuss). a, side view; b, peripheral view.
13. Entosolenia cf. marginata (Walker and Jacob).
14. Entosolenia oslatus Shifflett, n. sp. a, side view; b, peripheral view; c, apertural view.
15. Virgulina wilcoxensis Cushman and Ponton.
16. Angulogerina parvula (Cushman and Thomas).
17. Angulogerina virginiana Cushman.
18. Angulogerina wilcoxensis (Cushman and Ponton).
19. Discorbis amicus Shifflett, n. sp. a, dorsal; b, ventral.
20. Discorbis calyptra Shifflett, n. sp. a, dorsal; b, ventral.
21. Lamarckina wilcoxensis Cushman. a, dorsal; b, ventral.
22, 23. Valvulineria scrobiculata (Schwager). 22, dorsal; 23, ventral.

EXPLANATION OF PLATE 4

(All figures × 58)

1. Valvulineria wilcoxensis Cushman and Ponton. a, dorsal; b, ventral.
2. Gyroidina soldanii d'Orbigny, var. octocamerata Cushman and G D. Hanna. a, dorsal; b, apertural; c, ventral.
3, 4. Eponides labiomargus Shifflett, n. sp. 3, dorsal; 4, ventral.
5, 6. Eponides lotus (Schwager). 5, dorsal; 6, ventral.
7. Eponides sp. a, dorsal; b, ventral.
8. Siphonina wilcoxensis Cushman.
9. Pulvinulinella danvillensis Howe and Wallace. a, dorsal; b, ventral.
10. Alabamina wilcoxensis Toulmin. a, ventral; b, dorsal.
11–13. Globigerina cf. ouachitaensis Howe and Wallace. 11, dorsal; 12, apertural; 13, ventral.
14, 15. Globigerina cf. pseudo-bulloides. 14, dorsal; 15, ventral.
16, 17. Globigerina triloculinoides Plummer. 16, dorsal; 17, ventral.
18. Globorotalia cf. angulata (White). a, dorsal; b, peripheral; c, ventral.
19. Globorotalia membranacea (Ehrenberg). a, dorsal; b, ventral.
20–22. Globorotalia wilcoxensis Cushman and Ponton. 20, dorsal; 21, peripheral; 22, ventral.
23. Globorotalia wilcoxensis Cushman and Ponton, var. acuta Toulmin. a, dorsal; b, peripheral; c, ventral.

EXPLANATION OF PLATE 5

(All figures × 58)

1, 2. Anomalina umbonifera (Schwager). 1, dorsal; 2, ventral.
3. Cibicides howelli Toulmin. a, dorsal; b, ventral.
4–6. Cibicides marylandicus Shifflett, n. sp. 4, dorsal; 5, apertural; 6, ventral.
7, 8. Cibicides neelyi Jennings. 7, dorsal; 8, ventral.
9. Cibicides praecursorius (Schwager). a, dorsal; b, ventral.
10. Stichocibicides cerviculus Shifflett, n. sp. a, dorsal; b, apertural; c, ventral.

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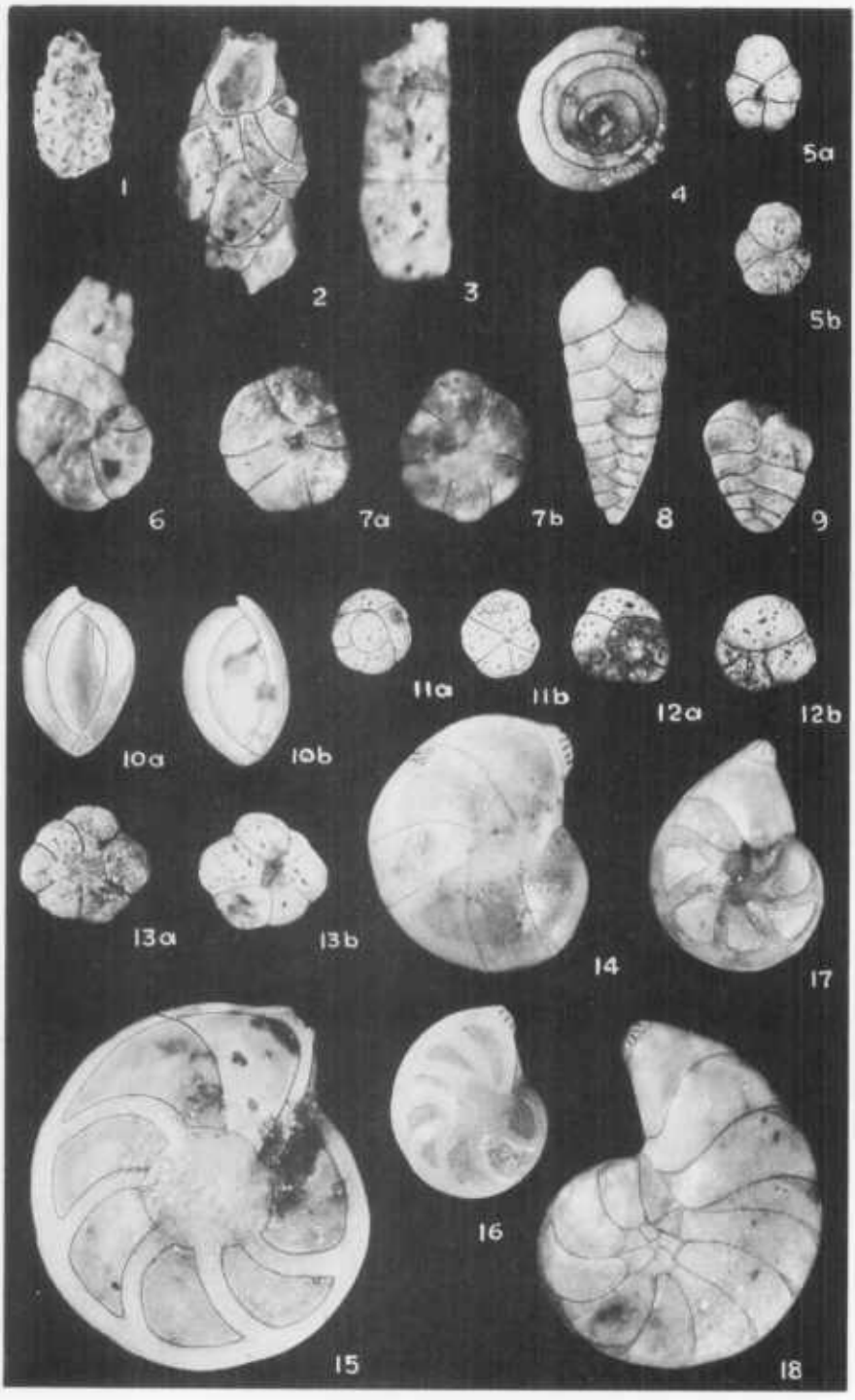
11. Robulus cf. piluliferus Cushman. Paleocene.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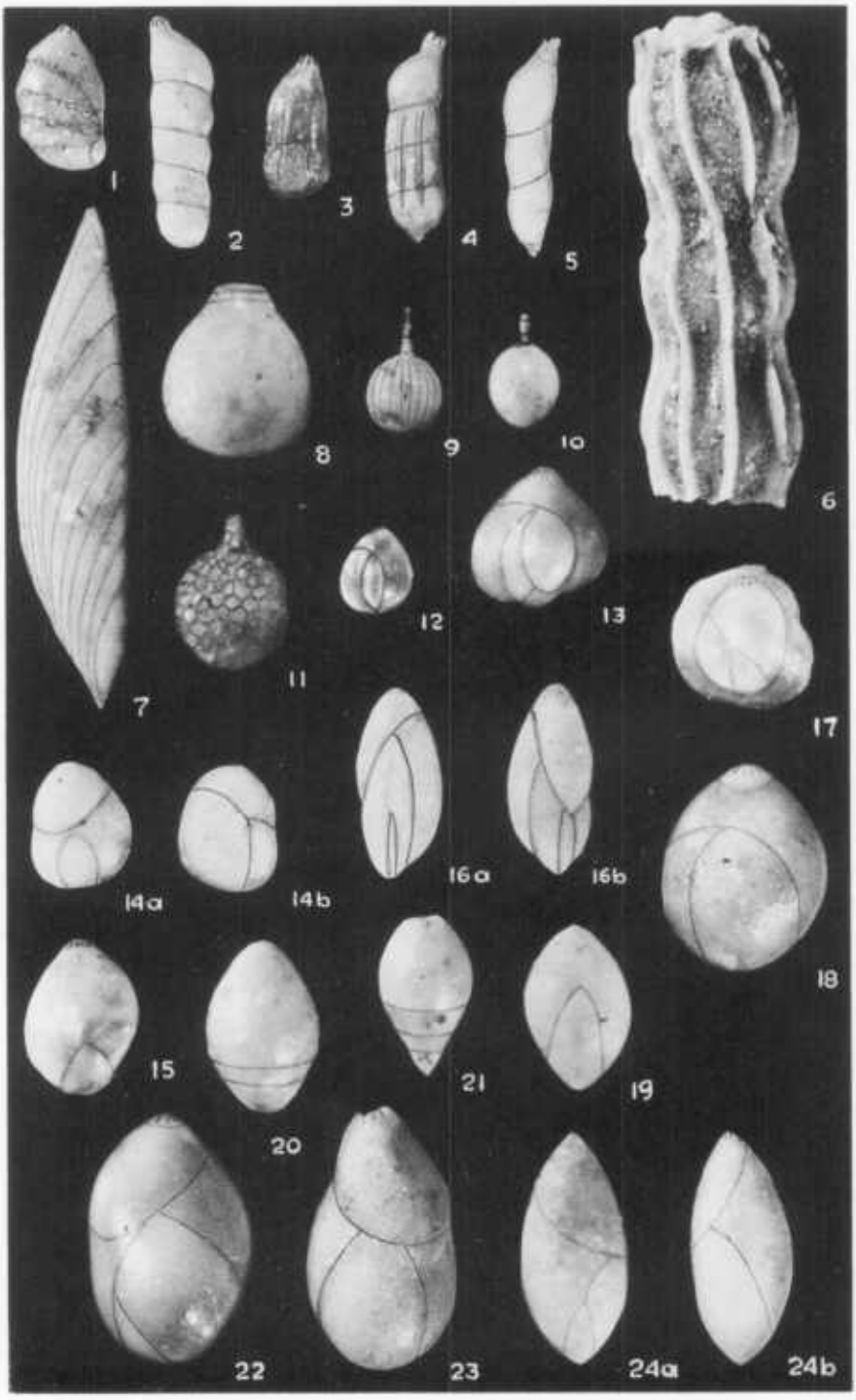
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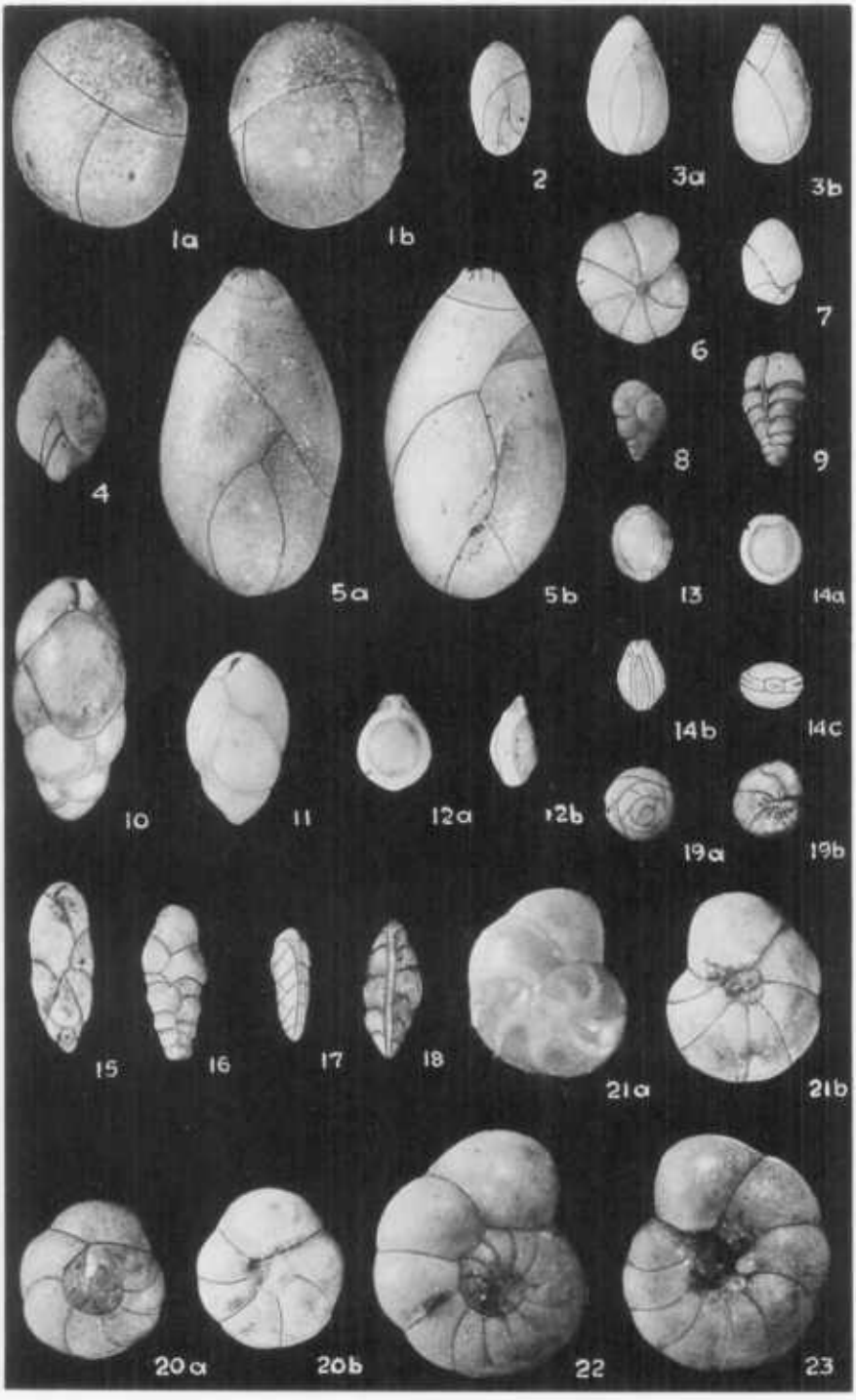
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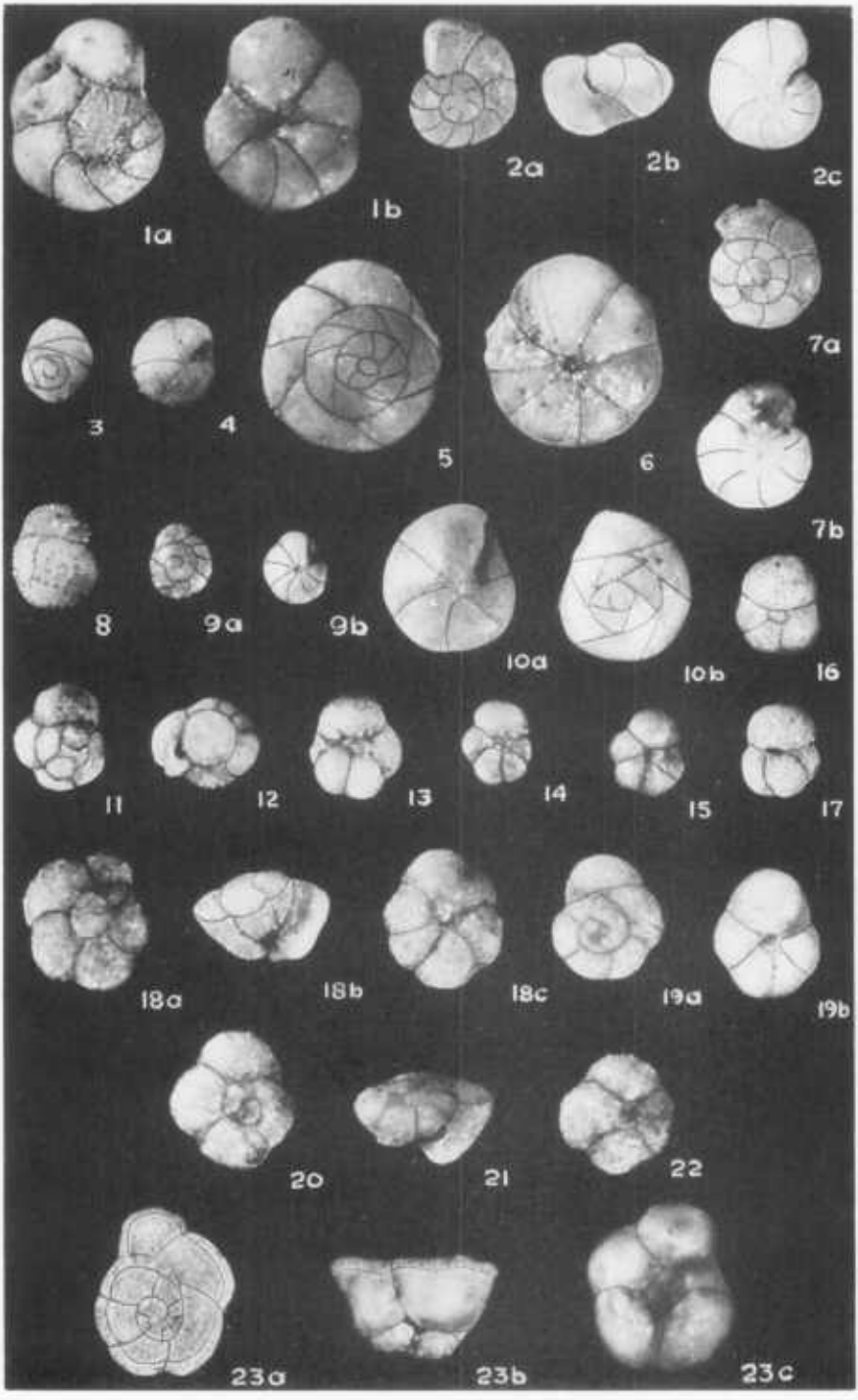
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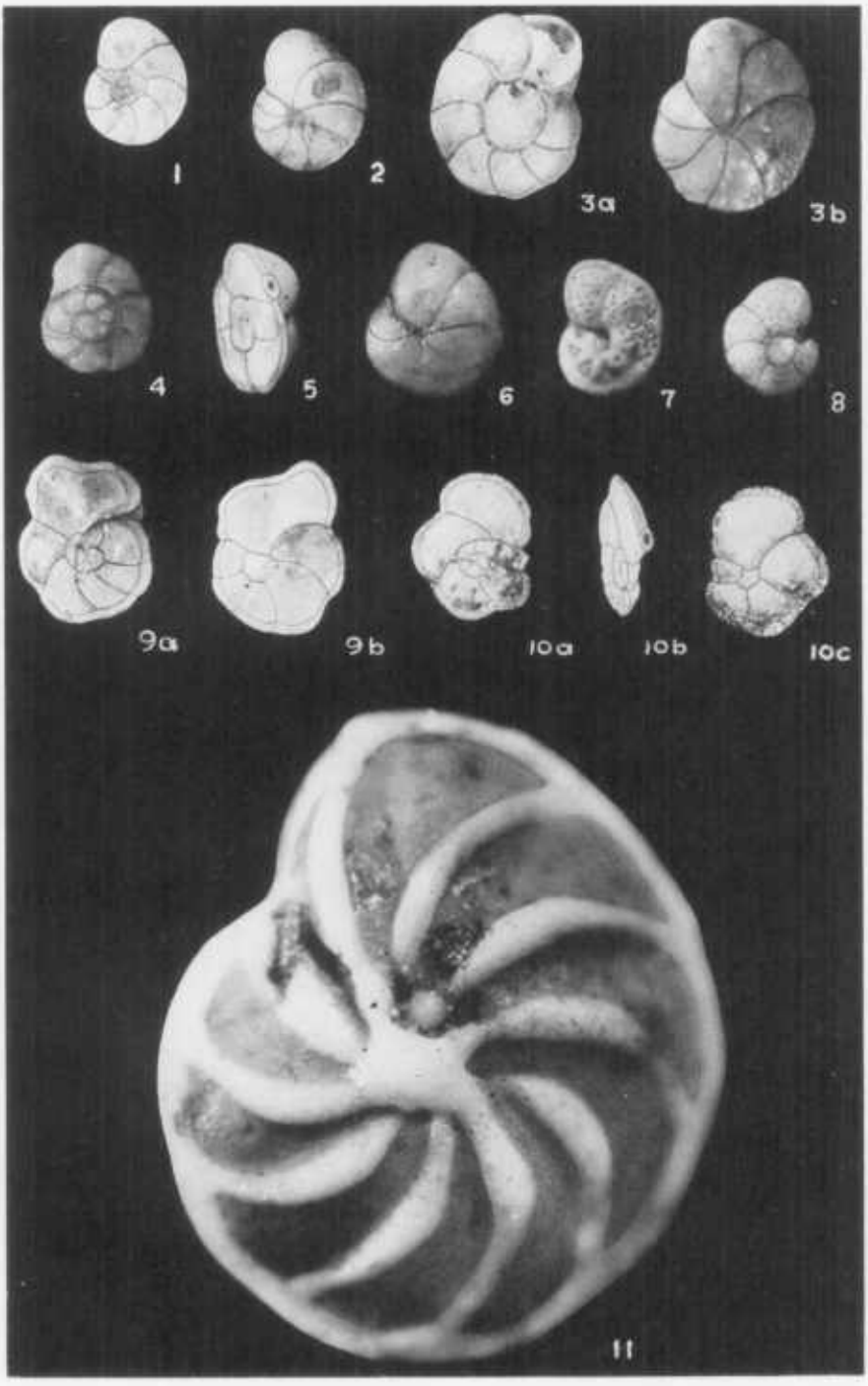
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9a
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10b
10c
11

INDEX

FIGURE 4—*Vertical Distribution Chart of Foraminifera, from the Outcrop of the Aquia Formation at Aquia and Potomac Creeks, Stafford and King George Counties, Virginia*

PISCATAWAY

Zone 2: 0–6″; 1–1½′; 2–2½′; 3–3½′; 4–4½′; 5–5½′; 6–6½′; 7–7½′; 8–8½′; 9–9½′; 10–10½′; 11–11½′; 12–12½′; 13–13½′; 14–14½′; 15–15½′; 16–16½′

Zone 3: 16½–17′

Zone 4: 18½–19′; 19½–20′; 20½–21′; 21½–22′; 22½–23′; 23½–24′

Zone 5: 26–26½′

Zone 6: 27–27½′

Zone 7: 28–28½′; 29–29½′; 30–30½′; 31–31½′; 32–32½′; 33–33½′

PASPOTANSA

Zone 8: 34–34½′; 35–35½′; 36–36½′; 37–37½′; 38–38½′; 39–39½′; 40–40½′; 41–41½′; 42–42½′; 43–43½′; 44–44½′; 45–45½′; 46–46½′; 47–47½′; 48–48½′; 49–49½′; 50–50½′; 51–51½′; 52–52½′; 53–53½′; 54–54½′; 55–55½′; 56–56½′; 57–57½′; 58–58½′; 59–59½′; 60–60½′; 61–61½′; 62–62½′; 63–63½′; 64–64½′

Proteonina difflugiformis H. B. Brady
Reophax curtus Cushman
Reophax sp.
Ammodiscus incertus d'Orbigny
Haplophragmoides sphaeriloculum Cushman
Ammobaculites sp.
Cyclammina sp.
Spiroplectammina wilcoxensis Cushman & Ponton
Quinqueloculina harrisi Howe & Roberts
Trochammina exigua Cushman & Applin
Trochammina howei Cushman
Trochammina sp.
Robulus knighti Toulmin
Robulus midwayensis (Plummer), var. *virginianus* Shifflett, n. var.
Robulus wilcoxensis Cushman & Ponton
Darbyella sp.
Marginulina toulmini Cushman
Dentalina communis d'Orbigny
Dentalina hexacostata Howe
Dentalina virginiana Cushman
Dentalina wilcoxensis Cushman
Nodosaria sp.
Lagena clavata d'Orbigny
Lagena costata (Williamson)
Lagena laevis (Montagu)
Guttulina irregularis d'Orbigny
Guttulina problema d'Orbigny
Guttulina wilcoxensis Cushman & Ponton
Globulina cf. *gibba* d'Orbigny
Globulina inaequalis Reuss
Globulina minuta (Roemer)
Globulina münsteri (Reuss)
Pyrulina sp.
Glandulina abbreviata (Neugeboren)
Glandulina laevigata d'Orbigny
Pseudopolymorphina decora (Reuss)
Pseudopolymorphina wilcoxensis Cushman & Ponton
Sigmomorphina semitecta (Reuss)
Sigmomorphina semitecta (Reuss), var. *terquemiana* (Fornasini)
Polymorphina advena Cushman, var. *nuda* Howe & Wallace
Polymorphina sp.
Nonion planatum Cushman & Thomas
Nonionella insecta (Schwager)
Bulimina ovata d'Orbigny
Entosolenia cf. *laevigata* (Reuss)
Entosolenia cf. *marginata* (Walker & Jacob)
Entosolenia oslatus Shifflett, n. sp.
Virgulina wilcoxensis Cushman & Ponton
Angulogerina parvula (Cushman & Thomas)
Angulogerina virginiana Cushman
Angulogerina wilcoxensis Cushman & Ponton
Discorbis calyptra Sbifflett, n. sp.
Lamarckina wilcoxensis Cushman
Valvulineria scrobiculata (Schwager)
Valvulineria wilcoxensis Cusbman & Ponton
Gyroidina soldanii d'Orbigny, var. *octocamerata* Cushman & G D. Hanna
Eponides labiomargus Sbifflett, n. sp.
Eponides lotus (Schwager)
Eponides sp.
Pulvinulinella danvillensis Howe & Wallace
Alabamina wilcoxensis Toulmin
Globigerina cf. *ouachitaensis* Howe & Wallace
Globigerina cf. *pseudo-bulloides* Plummer
Globigerina triloculinoides Plummer
Globorotalia cf. *angulata* (White)
Globorotalia membranacea (Ehrenberg)
Globorotalia wilcoxensis Cushman & Ponton
Globorotalia wilcoxensis Cushman & Ponton, var. *acuta* Toulmin
Anomalina umbonifera (Schwager)
Cibicides howelli Toulmin
Cibicides praecursorius (Schwager)
Stichocibicides cerviculus Shifflett, n. sp.

FIGURE 8—*Distribution Chart of the Foraminifera, Southern Maryland Electric Cooperative Well, Charles County, Maryland. Elevation 179'*

Spiroplectammina wilcoxensis Cushman & Ponton	
Quinqueloculina harrisi Howe & Roberts	
Robulus midwayensis (Plummer), var. *virginianus* Shifflett, n. var.	
Marginulina toulmini Cushman	
Dentalina communis d'Orbigny	
Dentalina virginiana Cushman	
Nodosaria affinis Reuss	
Lagena clavata d'Orbigny	
Lagena costata (Williamson)	
Lagena laevis (Montagu)	
Guttulina irregularis d'Orbigny	
Guttulina problema d'Orbigny	
Guttulina wilcoxensis Cushman & Ponton	
Globulina inaequalis Reuss	
Sigmomorphina semitecta (Reuss), var. *terquemiana* (Fornasini)	
Polymorphina advena Cushman, var. *nuda* Howe & Wallace	
Nonion planatum Cushman & Thomas	
Bolivinopsis sp.	
Gümbelina wilcoxensis Cushman & Ponton	
Eouvigerina excavata Cushman	
Entosolenia cf. *laevigata* (Reuss)	
Entosolenia cf. *marginata* (Walker & Jacob)	
Entosolenia oslatus Shifflett, n. sp.	
Loxostoma cf. *wilcoxensis* Cushman & Ponton	
Angulogerina parvula (Cushman & Thomas)	
Angulogerina virginiana Cushman	
Angulogerina wilcoxensis Cushman & Ponton	
Angulogerina sp.	
Discorbis amicus Shifflett, n. sp.	
Discorbis calyptra Shifflett, n. sp.	
Lamarckina wilcoxensis Cushman	
Valvulineria scrobiculata (Schwager)	
Gyroidina soldanii d'Orbigny, var. *octocamerata* Cushman & G D. Hanna	
Eponides labiomargus Shifflett, n. sp.	
Eponides lotus (Schwager)	
Pulvinulinella danvillensis Howe & Wallace	
Alabamina wilcoxensis Toulmin	
Globigerina compressa Plummer	
Globigerina cf. *ouachitaensis* Howe & Wallace	
Globigerina cf. *pseudo-bulloides* Plummer	
Globigerina triloculinoides Plummer	
Globorotalia cf. *angulata* (White)	
Globorotalia membranacea (Ehrenberg)	
Globorotalia wilcoxensis Cushman & Ponton	
Globorotalia wilcoxensis Cushman & Ponton, var. *acula* Toulmin	
Anomalina umbonifera (Schwager)	
Cibicides howelli Toulmin	
Cibicides marylandicus Shifflett, n. sp.	
Cibicides neelyi Jennings	
Cibicides praecursorius (Schwager)	

231–234′
234–240′
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245–246′
246–253′
253–260′
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540–545′

			Piscataway
		Paspotansa	
	AQUIA	NANJEMOY	
PAL-EOCENE	EOCENE		

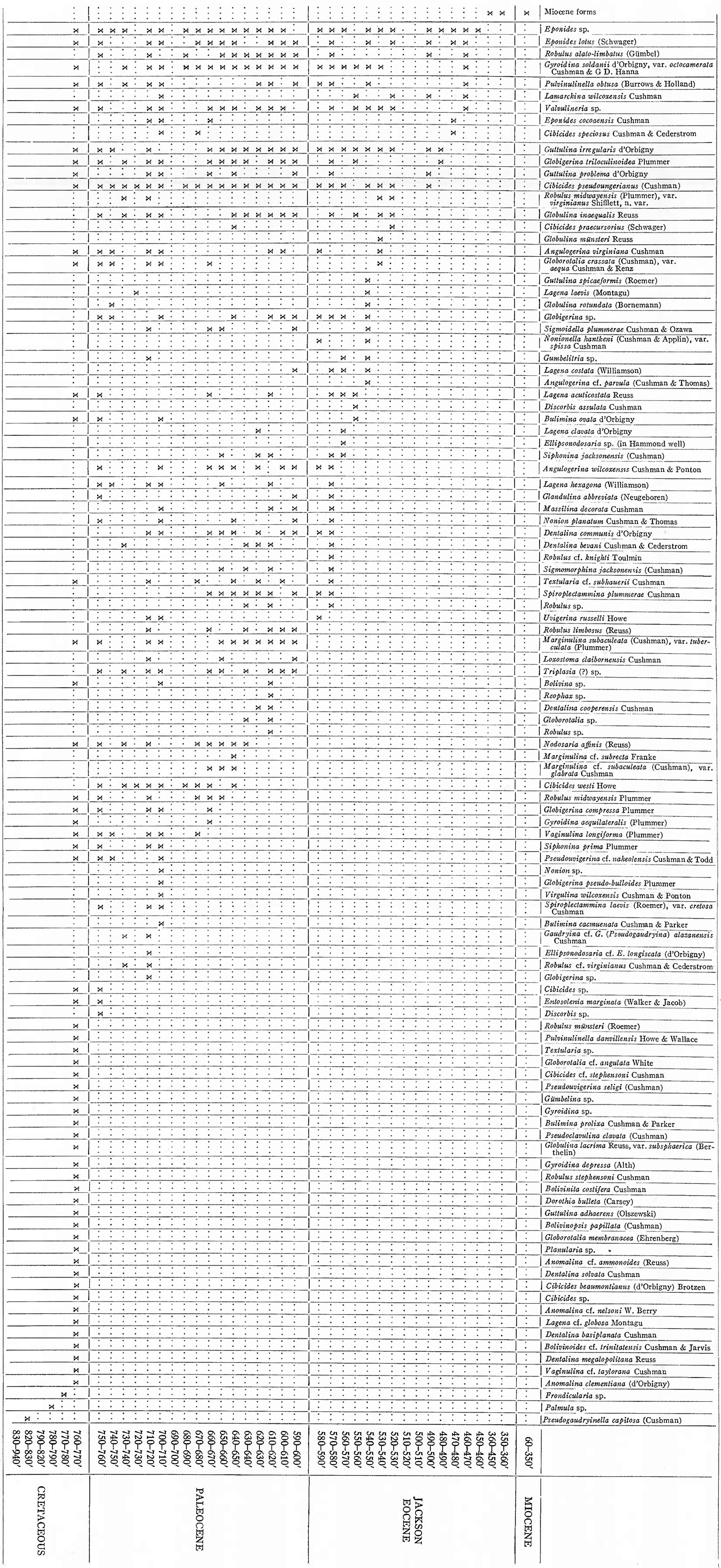

FIGURE 13—*Distribution Chart of the Foraminifera, Dorchester Water Company Well, Dorchester County, Maryland. Elevation 16'*

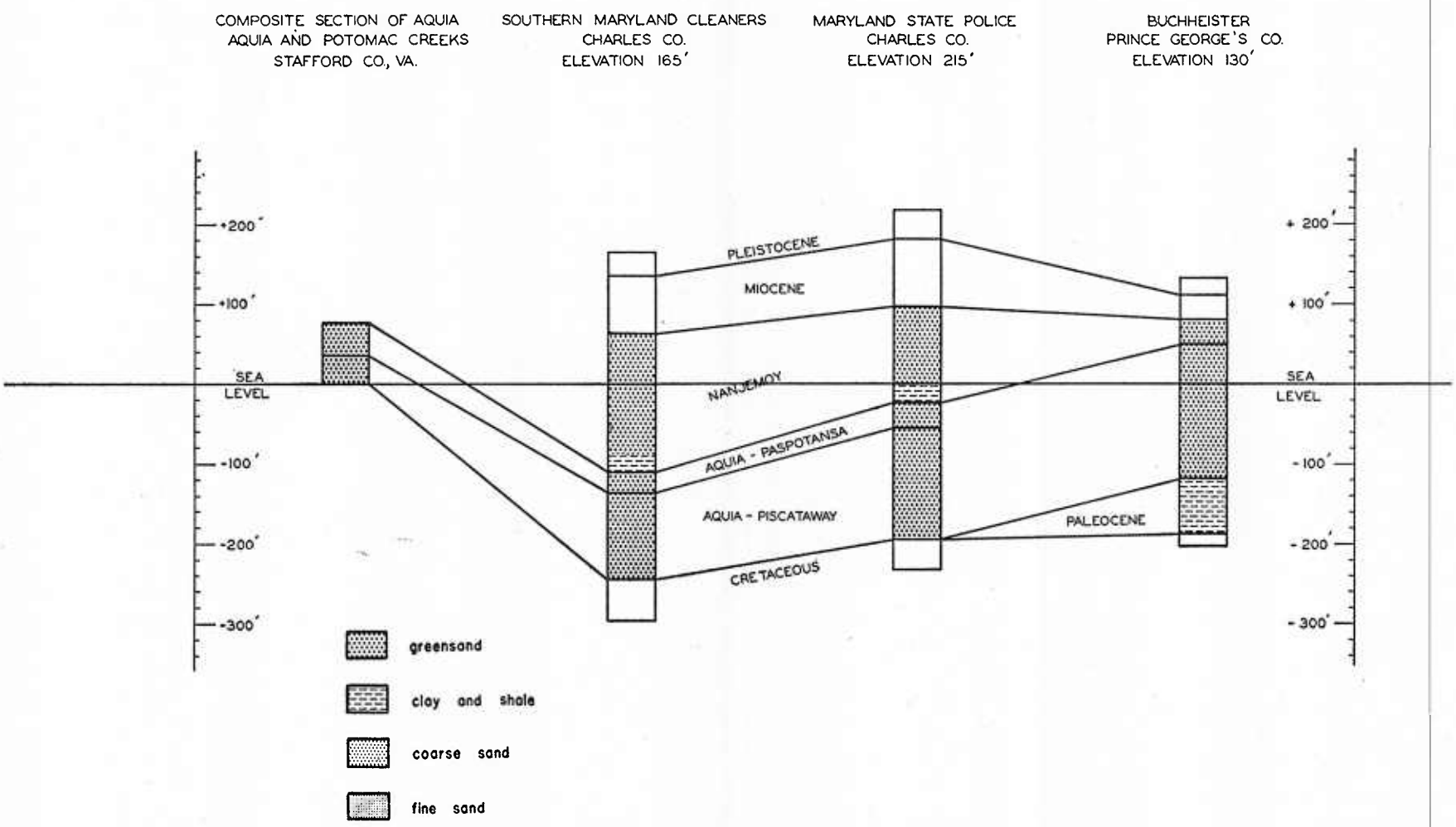

FIGURE 19—*Correlation of Tertiary sections from Stafford County, Virginia to Prince George's County, Maryland.*

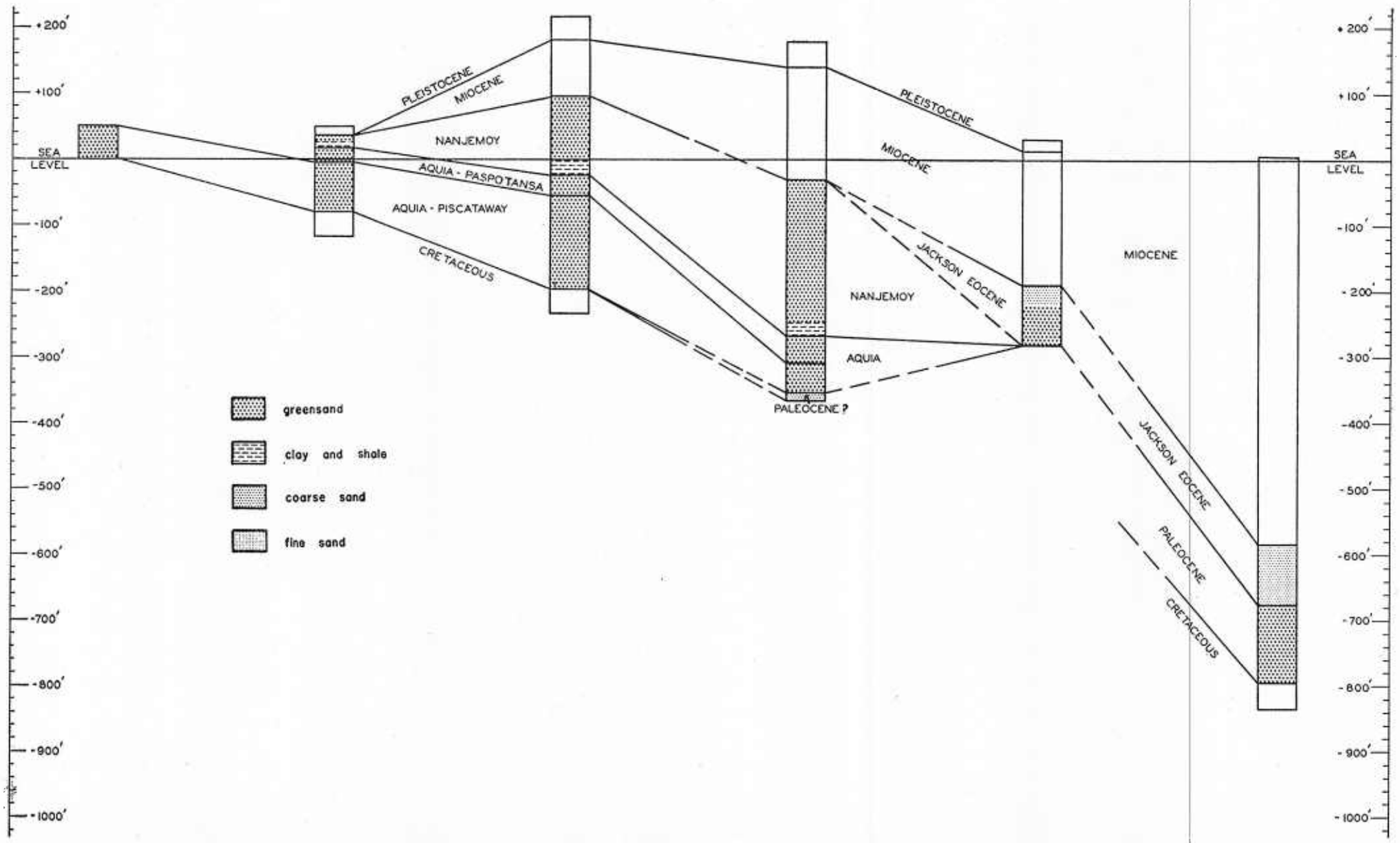

FIGURE 20—*Correlation of Tertiary sections from Prince George's County to Somerset County, Maryland.*

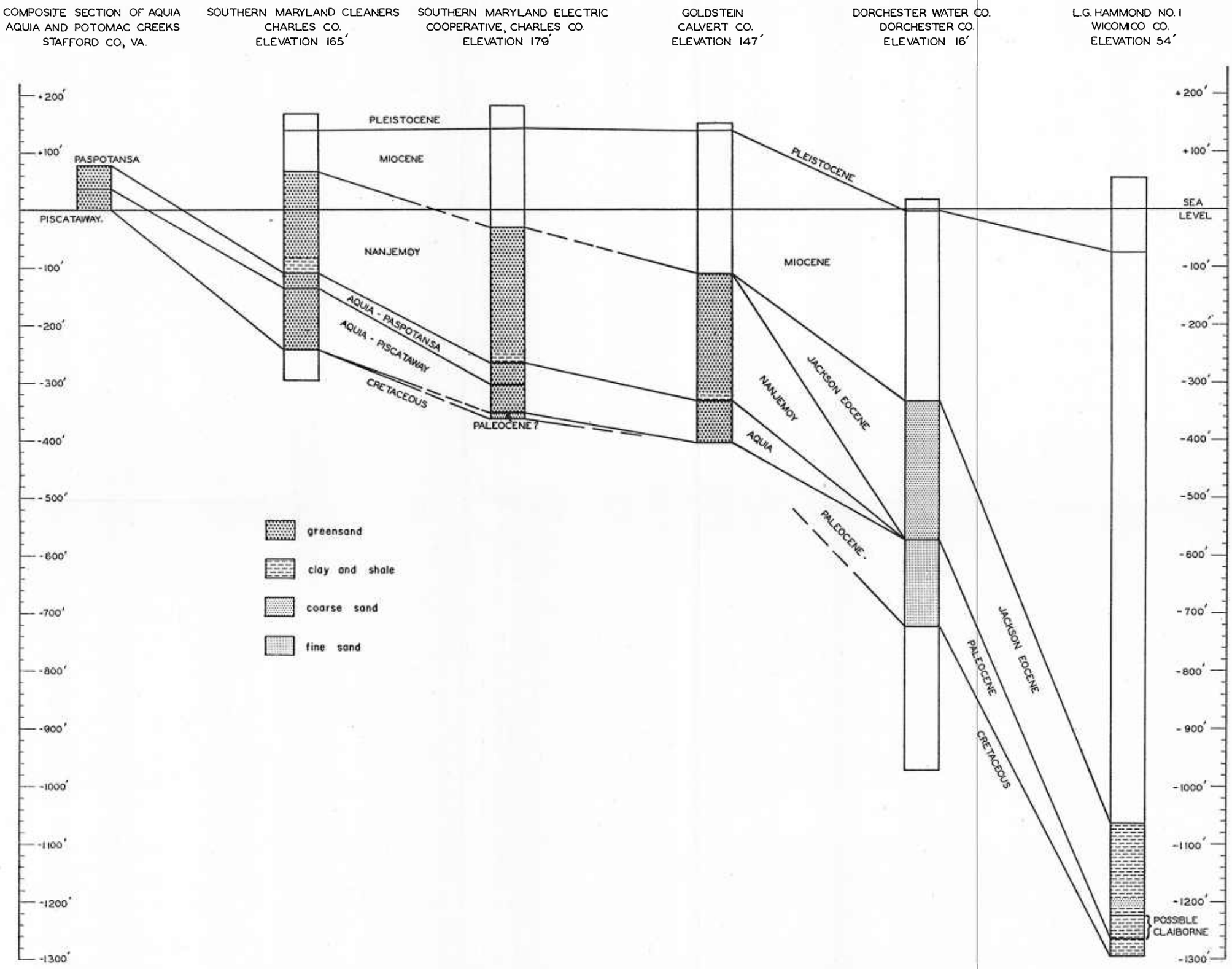

FIGURE 21—*Correlation of Tertiary sections of the Western and Eastern shores of Maryland.*