COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION
AND ECONOMIC DEVELOPMENT

DIVISION OF MINERAL RESOURCES

MIOCENE AND PLEISTOCENE FORAMINIFERA AND OSTRACODA OF SOUTHEASTERN VIRGINIA

JAMES D. McLEAN, JR.

REPORT OF INVESTIGATIONS 9

VIRGINIA DIVISION OF MINERAL RESOURCES

James L. Calver
Commissioner of Mineral Resources and State Geologist

CHARLOTTESVILLE, VIRGINIA
1966

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PART 1–TEXT
PART 2–TAXONOMY AND FOSSIL PLATES

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DEPARTMENT OF PURCHASES AND SUPPLY
RICHMOND
1966

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PART 1—TEXT

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MIOCENE AND PLEISTOCENE FORAMINIFERA AND OSTRACODA OF SOUTHEASTERN VIRGINIA

By

JAMES D. MCLEAN, JR.[1]

ABSTRACT

A review of the known stratigraphic ranges and ecologies of Foraminifera and Ostracoda from the Virginia-Maryland Pleistocene and Miocene sediments is incorporated into a study of well sections and outcrop samples to determine the Pleistocene-Miocene contacts in southeastern Virginia. Occurrences of microfossils are plotted for all samples studied and lithologies are given for well sections. Several species are reported from outcrops of the Yorktown Formation that have not previously been noted. In the Chesapeake Bay subsurface, the Yorktown is found to have been planed off, leaving a contact between the Pleistocene and the St. Marys (Miocene), with a remarkable uniformity of thickness for the St. Marys Formation of about 50 feet. Redeposition of Miocene forms in the Pleistocene is discussed, and the value of *Elphidium florentinae* as a local guide for the Pleistocene is indicated.

INTRODUCTION

A number of persons working in the Virginia Coastal Plain area have approached the writer at different times with the problem of differentiating Pleistocene sediments from older beds on a microfaunal basis; this report is the culmination of work done on the problem. As in any such work as this, the results must be termed preliminary.

All material derived from this study has been placed in the collections of the Paleontological Research Institution, including the types and illustrated specimens. Quite aside from its suitability as a depository in its own right, the Paleontological Research Institution was selected in this instance because the earlier collections of Miocene forms from the Yorktown Formation

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made by the author are absolutely essential to a full understanding of the material developed here; it was decided that these two sets of slides should be available together to supplement and elucidate each other.

This study was well under way when it became evident that the resulting report would be too large and would require too many illustrations to allow the McLean Laboratory to publish it. The Virginia Division of Mineral Resources kindly agreed to underwrite the costs of illustrations and manuscript preparation. It is important to note, however, that the author is responsible for whatever errors of any kind that may appear, and that the conclusions arrived at are the author's own, and should not be imputed to any other person or organization.

ACKNOWLEDGEMENTS

Dr. James L. Calver, State Geologist, kindly helped the author in this work. In addition, the author has had the usual very kind and considerable assistance of the Paleontological Research Institution and its Director, Dr. Katherine V. W. Palmer.

Samples were furnished by Mr. Nicholas K. Coch of Yale University, Dr. Kenneth Bick of the College of William and Mary, and Dr. Phillip Wyman Harrison, formerly of the Virginia Institute of Marine Science and now with the U. S. Coast and Geodetic Survey, Oceanographic Data Analysis Branch. The major part of the well samples used in this study was donated by Dr. Harrison, who has worked closely with the author on various aspects of the study of the Chesapeake Bay subsurface problem as it particularly deals with the Pleistocene-Miocene contact and the Pleistocene faunas. Dr. Horace G. Richards of the Academy of Natural Sciences of Philadelphia kindly allowed the use of his macrofossil data for the material supplied by Mr. Coch.

The drafting of the sections and maps was supervised by Mr. Floyd K. Huston, who placed the various lines of correlation and prepared the base diagrams of several of these figures. Last, but certainly not least, the author acknowledges the patient and competent work of his very efficient laboratory assistant, Mrs. Elizabeth C. Huston, who washed and picked samples, organized the slides, and labelled them for final deposition. Mrs. Huston also

participated in the research and organizational details that so heavily weigh upon successful completion of this type of research. Mrs. Elizabeth A. Aud patiently typed and revised the manuscript time after time, and she and Mrs. Huston operated the data-processing system that led to the production of the range charts and the listing of species in the well sections. To all of these kind people, the author extends his grateful appreciation for making this report a possibility, and finally, a fact.

GEOLOGIC RANGES OF FORAMINIFERA AND OSTRACODA IN VIRGINIA AND MARYLAND— MIOCENE THROUGH RECENT

In Table 1 which shows the geologic ranges of species, all range data available in the references cited have been included. A number of species are listed that are not identified as to species, but are given designations such as "sp. A," or simply "sp." These are included because some of them appear on range charts of the cited references and because they are found in the geologic units assigned; in the Virginia-Maryland area these forms seem to be restricted to certain stratal units.

There are some very definite ecological implications from the distribution of species; most of the available published record with regard to Miocene ecology is based upon the work of Harbans S. Puri, and the results of his studies and those of others indicate that many designations of stratigraphic units are, in fact, ecologic rather than stratigraphic. Correlation of stratal units must be done on the basis of discrimination between purely ecologic and purely stratigraphic differences. When the ecological factors are considered, it is found that some quite significant-looking relationships between different beds are actually of less stratigraphic importance than would otherwise be suspected. Experience in Gulf Coast subsurface work, buttressed by a large literature, shows that ecology is a much more considerable factor than earlier workers ever suspected.

The range chart (Table 1) is constructed from a data-processing system utilizing the Friden flexowriter. Each species is entered on a separate card along with the known range data. The cards are stacked to demonstrate the stepped-down distribution

Table 1.—Geologic ranges of Foraminifera and Ostracoda from Miocene and younger units, Virginia-Maryland and Florida. Virginia-Maryland units are shown in the column on the left; Florida units are on the right.

	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	Cancellaria	Ecphora	Arca	Yoldia	Shoal River	Oak Grove	Chipola
CYTHERURA BAJACALA	X														
HEMICYTHERURA CLATHRATA	X														
NONION GRATELOUPI D ORBIGNY	X	X	X	X					X	X	X				X
BOLIVINA STRIATULA	X	X		X											
VIRGULINA PUNCTATA	X		X	X					X	X					
BUCCELLA DEPRESSA	X			X											
BUCCELLA HANNAI	X			X											
CYTHERURA ELONGATA	X			X											
ELPHIDIUM ADVENA	X			X											
LAGENA MELO	X			X											
POLYMORPHINA NOVANGLIAE	X			X											
QUINQUELOCULINA WHEELDONI	X			X											
SIGMOMORPHINA CONCAVA	X			X											
SIGMOMORPHINA SEMITECTA TERQUEMIANA	X		X	X											
CYTHERURA WARDENSIS	X			X					X	X	X				
AURILA CONRADI	X			X					X	X	X				
NODOSARIA CATESBYI	X			X					X	X	X				
POROEPONIDES LATERALIS	X			X					X		X				
SIGMOMORPHINA WILLIAMSONI	X			X						X	X				
ANOMOCYTHERIDEA FLORIDANA	X			X							X				
PURIANA RUGIPUNCTATA	X			X					X	X	X	X	X		
SIGMOMORPHINA PEARCEYI	X			X										X	X
HULINGSINA ULRICHI	X			X							X	X	X	X	X
CYTHERURA FORULATA	X			X											
ORIONINA BERMUDAE	X			X					X	X	X				X
PSEUDOPOLYMORPHINA CF. NOVANGLIAE	X			X											
CASSIDULINA LAEVIGATA CARINATA	X		X		X				X	X	X				
PYRGO SUBSPHAERICA	X		X		X								X		X
ELPHIDIUM POEYANUM	X	X	X		X										
ACUTICYTHEREIS LAEVISSIMA	X			X		X									
DYOCIBICIDES BISERIALIS	X		X	X	X	X			X	X	X				X
CANCRIS SAGRA	X	X	X	X		X			X	X	X				X
TEXTULARIA MAYORI	X		X	X	X	X			X	X		X	X		
DISCORBIS CANDEIANA	X			X	X	X			X						X
SIGMOIDELLA KAGAENSIS	X		X				X								
GUTTULINA PULCHELLA	X	X					X								
ENTOSOLENIA QUADRATA	X	X	X				X								
DISCORBIS VALVULATA	X		X				X		X		X				X
NONIONELLA AURIS	X		X	X	X	X	X		X	X	X				X
BOLIVINA PLICATELLA	X		X			X	X		X	X	X		X	X	X
GLOBULINA INAEQUALIS VAR. CARIBAEA	X	X	X				X			X					X
ENTOSOLENIA LUCIDA	X	X	X			X	X								
ROTALIA BECCARII VAR. TEPIDA	X	X	X		X	X	X		X	X					
ACTINOCYTHEREIS EXANTHEMATA MARYLANDICA	X							X	X	X	X				
ROTALIA BASSLERI	X			X	X	X	X								
TEXTULARIA CF. T. FOLIACEA	X						X						X		
HANZAWAIA CONCENTRICA	X			X	X	X	X		X	X	X				X
LOXOCONCHA RETICULARIS	X			X		X	X		X	X					
HULINGSINA ASHERMANI	X			X		X	X				X	X	X	X	X
CYTHEROMORPHA CF. WARNERI	X			X		X	X		X	X					
ACTINOCYTHEREIS EXANTHEMATA	X			X		X	X			X	X	X	X	X	X
ELPHIDIUM INCERTUM	X	X	X	X	X	X	X		X						
DISCORBIS FLORIDANA	X	X	X	X		X	X		X		X				
LAGENA LAEVIS	X	X	X			X	X								
QUINQUELOCULINA SEMINULA	X	X	X	X	X	X		X	X		X				
CASSIDULINA CRASSA	X	X	X				X	X	X	X	X				
GUTTULINA AUSTRIACA	X		X	X			X	X	X	X					X
TEXTULARIA CANDEIANA	X		X	X		X	X	X	X		X				
TEXTULARIA GRAMEN	X		X	X	X	X	X	X	X		X				X
BULIMINELLA ELEGANTISSIMA	X	X	X	X	X	X	X	X	X	X	X				X

Table 1.—*Continued.*

	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	Cancellaria	Ecphora	Arca	Yoldia	Shoal River	Oak Grove	Chipola
UVIGERINA AUBERIANA	.	X	.	X	.	.	X	.	X	.	.	X	.	X	.
CIBICIDES CF. LOBATULUS	.	X	.	X	.	X	.	X	.	X	.	X	.	X	.
GUTTULINA PROBLEMA	.	X	.	X	.	.	.	X	.	X	.	.	.	.	.
CIBICIDELLA VARIABILIS	.	X	.	.	X	.	X	.	X	.	.	.	.	.	X
DENTALINA CF. PYRULA	.	X	.	.	X	.	.	X	.	X	.	X	.	.	.
LAGENA HISPIDA	.	X	.	.	.	.	X	.	X	.	.	.	.	.	.
LAGENA TENUIS	.	X	.	X	.	.	X	.	X	.	.	.	.	.	.
ENTOSOLENIA ORBIGNYANA	.	X	.	X	.	.	.	X	.	X	.	.	.	.	.
BULIMINA INFLATA	.	X	.	.	.	.	.	.	X	.	.	X	.	.	.
LAGENA ACUTICOSTA	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.
LAGENA CLAVATA	.	X	.	X	.	X	.	X	.	X	.	X	.	.	.
ELPHIDIUM CLAVATUM	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM FLORENTINAE	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
ANGULOGERINA OCCIDENTALIS	.	.	X	.	X	.	.	.	.	X	.	X	.	.	.
TRILOCULINA CF. T. TRIGONULA	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.
PSEUDOPOLYMORPHINA JONESI	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
BUCCELLA MANSFIELDI	.	.	.	X	.	X	.	X	.	.	.	X	.	.	.
ELLIPSOLAGENA BIDENS	.	.	.	X	.	.	X	.	X	.	.	.	X	.	.
NONION PIZARRENSIS	.	.	.	X	.	X	.	X	.	X	.	.	.	X	.
ORBULINA UNIVERSA	.	.	.	X	.	.	.	X	.	X	.	.	.	.	.
PSEUDOPOLYMORPHINA DECORA	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.
PSEUDOPOLYMORPHINA RUTILA	.	.	.	X	.	X	.	.	?	.	X	.	X	.	.
AMPHISTEGINA SP.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
ANGULOGERINA SP.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
ACTINOCYTHEREIS GOMILLIONENSIS	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.
BAIRDOPPILATA TRIANGULATA	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.
BOLIVINA LAFAYETTEI	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
BUCCELLA PARKERAE	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
BULIMINA PREACANTHIA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
CAMPYLOCYTHERE LAEVA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
CIBICIDES SUBLOBUS	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
CLITHROCYTHERIDEA VIRGINIENSIS	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
CUSHMANIDEA ECHOLSAE	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
CYTHERETTA ULRICHI	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
CYTHERIDEIS AGRICOLA	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.
CYTHERIDEIS RUGIPUSTULOSA	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.
CYTHEROPTERON TALQUINENSIS	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.
CYTHERURA RETICULATA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
DENTALINA CF. INTERMEDIA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
DENTALINA KAICHERAE	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
DENTALINA SP. A	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
DENTALINA SP. B	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
DENTALINA SP. C	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
DISCORBIS REHDERI	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
DISCORBIS TURRITA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
DYOCIBICIDES PERFORATUS	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM JOHNSTONAE	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM KAICHERAE	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
ENTOSOLENIA CARTERI	.	.	.	.	X	.	.	.	.	X	.	X	.	X	.
ENTOSOLENIA CARTERI ALPHA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
EOCYTHEROPTERON YORKTOWNENSIS	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. A	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. B	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. C	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. D	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. E	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GLOBIGERINOIDES SP. F	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GLOBIGERINOIDES SP. G	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GLOBOROTALIA MENARDII	.	.	.	.	X	.	.	.	.	X	.	X	.	.	.
GUTTULINA PALMERAE	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GUTTULINA PSEUDOCOSTATULA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GUTTULINA SP. A	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
GUTTULINA SP. B	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
HEMICYTHERE SCHMIDTAE	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
LAGENA GLOBULOHISPIDA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.

Table 1.—*Continued.*

	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	Cancellaria	Ecphora	Arca	Yoldia	Shoal River	Oak Grove	Chipola
LAGENA HEXAGONA SCALARIFORMIS	.	.	.	X	.	.	.	.	X	X	.	.	.	.	.
LAGENA PALMERAE	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
LAGENA PSEUDOSULCATA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
LAGENA SUBSTRIATA	.	.	.	X	.	.	.	.	X	X	X	.	.	.	.
LOXOCONCHA PURISUBRHOMBOIDEA	.	.	.	X	.	.	.	.	X	X	.	.	.	.	.
LOXOSTOMUM WILSONI	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MASSILINA MARYLANDICA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MASSILINA QUADRANS CARTERI	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MURRAYINA BARCLAYI	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MURRAYINA HOWEI	.	.	.	X	.	.	.	.	.	.	X	.	.	.	X
NODOSARIA SP.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
NONION ? SP. A	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
NONION ? SP. B	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
PARACYPRIS CHOCTAWHATCHEENSIS	.	.	.	X	.	.	.	.	X	X	.	.	.	.	.
PARACYTHERIDEA MUCRA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
PARACYTHERIDEA SHATTUCKI CURTA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
PARACYTHERIDEA SIMILIS	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
PARACYTHERIDEA VANDENBOLDI	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.
PLANISPIRILLINA ORBICULARIS	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
PLANULINA DEPRESSA	.	.	.	X	.	.	.	.	X	.	X	.	.	.	.
PSEUDOPOLYMORPHINA SP. A	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
PSEUDOPOLYMORPHINA SP. B	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA SEMINULANGULATA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA TRILOCULINIFORMA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
RECTOCIBICIDELLA ROBERTSI	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
ROBULUS PSEUDOIOTA	.	.	.	X	.	.	.	.	X	X	X	X	.	.	.
SIGMOILINA ? SP.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA CF. BOCKI	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA EUSTISENSIS	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA PSEUDOBLIQUA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA YORKTOWNENSIS	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIOIDES ? CARTERI	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
UVIGERINA CF. TENUISTRIATA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
VALVULINERIA WASHINGTONI	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
ROTALIA LIMBATOBECCARII	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
MASSILINA MANSFIELDI	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.
LEGUMINOCYTHEREIS ? WHITEI	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.
SIGMOMORPHINA NEVIFERA	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.
TEXTULARIA CF. T. BADENENSIS	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.
UVIGERINA CF. CARMELOENSIS	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.
LAGENA DORSEYAE	.	.	.	X	X	X	X	.	.	.	.	.	.	.	.
DISCORBIS CONSOBRINA	.	.	.	X	X	.	X	.	X	X	X	.	.	.	.
CYTHERETTA BURNSI	.	.	.	X	.	X	X	.	X	X	X	.	.	.	.
MURRAYINA MARTINI	.	.	.	X	.	X	X	.	X	X	X	.	.	.	.
SARACENARIA ? SP.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.
CIBICIDES AMERICANUS	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.
ECHINOCYTHEREIS CLARKANA	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.
ROBULUS VAUGHANI	.	.	.	X	.	.	X	.	X	.	X	.	.	.	X
SIPHOGENERINA LAMELLATA	.	.	.	X	.	.	X	.	.	.	X	.	.	.	.
UVIGERINA CALVERTENSIS	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.
PTERYGOCYTHEREIS AMERICANA	.	.	.	X	.	X	X	.	X	X	X	.	X	.	X
BULIMINA GRACILIS	.	.	.	X	X	X	X	.	.	.	.	.	X	.	.
TEXTULARIA ARTICULATA	.	.	.	X	.	X	X	.	.	X	X	.	.	.	X
DENTALINA BEVANI	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	X	X	X	X	X	X	X	X	.	.	.	X
TEXTULARIA OBLIQUA	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
MURRAYINA GUNTERI	.	.	.	.	X	.	.	.	X	X	X	.	.	X	.
CYTHERELLA CHIPOLENSIS	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X
DISCORBIS WARRENI	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.
NONION MARYLANDICUM	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.
SPIROPLECTAMMINA EXILIS	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.
UVIGERINA DIRECTA	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.
GLOBIGERINOIDES SP. A	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.
LAGENA SP. A	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.
LAGENA SP. C	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.
NONION MEDIOCOSTATUS	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.

Table 1.—*Continued.*

	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	Cancellaria	Ecphora	Arca	Yoldia	Shoal River	Oak Grove	Chipola
VIRGULINELLA MIOCENICA	.	.	.	.	X	X	X	.	.	X	X	.	.	.	X
VALVULINERIA FLORIDANA	.	.	.	.	X	X	X	.	X	X	X	.	X	.	X
CYTHERURA CORYELLI	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
HEMICYTHERE PUNCTISTRIATA	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MASSILINA GLUTINOSA	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
MASSILINA QUADRANS	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X
PARACYTHERIDEA SHATTUCKI	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA CONTORTA VAR. STRIATA	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
TEXTULARIA CONSECTA	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
TEXTULARIA ULTIMA-INFLATA	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
BOLIVINA OBLIQUA	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
BULIMINELLA CURTA	.	.	.	.	.	X	X	.	.	X	X	.	.	.	.
CLITHROCYTHERIDEA DIAGONALIS	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
CYTHERIDEIS SUBAEQUALIS	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
DENTALINA CF. D. COMMUNIS	.	.	.	.	.	X	X	.	X	X	X	.	.	.	.
GLOBIGERINA ALTISPIRA	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
HAPLOCYTHERIDEA SUBOVATA	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
POLYMORPHINA SCHLUMBERGERI	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
PSEUDOPOLYMORPHINA STRIATA	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
UVIGERINA SUBPEREGRINA	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.
VIRGULINA FUSIFORMIS	.	.	.	.	.	X	X	.	X	X	.	.	.	.	.
BOLIVINA FLORIDANA	.	.	.	.	.	X	.	X	.	X	X	.	.	.	.
GLOBULINA FIMBRIATA	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.
GLOBULINA MINUTA	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.
GLOBULINA INAEQUALIS	.	.	.	.	.	X	X	X	X	X	X	.	.	.	X
PSEUDOPOLYMORPHINA DUMBLEI	.	.	.	.	.	X	X	X	X	.	X	.	.	.	.
ROBULUS AMERICANUS	.	.	.	.	.	X	X	X	X	.	X	.	.	.	X
BOLIVINA CALVERTENSIS	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
BOLIVINA MARGINATA	.	.	.	.	.	.	X	.	.	.	X	.	.	.	X
CANCRIS SAGRA VAR. COMMUNIS	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
CYTHERETTA INAEQUIVALVIS	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.
CYTHERETTA PLEBIA	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
DISCORBIS CAVERNATA	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
GLOBIGERINA SP. B. CLAPP	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
GLOBIGERINOIDES SP. B.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
GUTTULINA ELEGANS	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
GUTTULINA RECTIORNATA	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
MARGINULINA SP. D CLAPP	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
MARGINULINA SP.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
NODOGENERINA ADVENA	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
NONION GRATELOUPI CLAPP	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
PLANULARIA SP.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
PSEUDOPOLYMORPHINA ADVENA VAR. NUDA	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
ROBULUS AMERICANUS VAR. SPINOSUS	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.
ROBULUS BRANNERI	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
SIGMOIDELLA SP.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
SIPHOGENERINA SPINOSA	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TEXTULARIA SPINOSA	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TRACHYLEBERIS DORSICORNIS	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
HENRYHOWELLA EVAX	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
TRACHYLEBERIS RADIATA	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
UVIGERINA KERNENSIS	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
VAGINULINA SP.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
BIGENERINA FLORIDANA	.	.	.	.	.	.	X	X	.	.	.	.	X	X	.
GLOBULINA ROTUNDATA	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X
NONION ADVENUM	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X
PYRULINA FUSIFORMIS	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.
SPIROPLECTAMMINA MISSISSIPPIENSIS	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.
POLYMORPHINA ADVENA NUDA	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.
PARAFISSURINA MARGINATA	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.
BOLIVINA MARGINATA MULTICOSTA	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.
LAGENA SULCATA	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.

of species from the most recent to the oldest occurrence of the form, and the resulting pattern shows the known present limits of each form.

Each sample is being listed by means of faunal content with these same data cards; this means that the stratigraphic implications of each sample are being plotted against the data of the master range chart. Designation of ages, wherever given, is based on this comparison. The correlations given are thus mechanically derived from the chart. If age definitions are incomplete, it is because the faunal data are not complete enough to provide correlation.

Several important comparative points can be established from mechanical comparison. Species limited to one stratal unit are, of course, interesting as potential "marker" forms. The mechanical comparison also displays overlaps of species which may limit an age. A number of samples, particularly the material supplied by Coch in 1963, may consist of mixed faunas due to redeposition. Guides from several age units thereby show a discrepancy in faunal overlaps (if two given species do not appear in the same range or age column, but do appear in a given sample, the sample may be mixed). The same principle, applied to well samples, can either indicate contamination due to drilling operations, or redepositional mixture. Either situation may be the case; however, the worn condition of certain suspect species may indicate redeposition, because drilling operations do not normally cause microfossil specimens to be damaged.

Gaps between age units (that is, a species is found in the Yorktown Formation and in Recent assemblages with no record for the Pliocene or Pleistocene) may be due to three causes: 1) the form involved did not encounter favorable ecological conditions in the missing ages, 2) the sediments involved have been eroded away prior to present times, or 3) samples from these ages have simply not been found. Samples are far from complete; the Pliocene in particular is too little studied or known to give any real demonstration of its absence or presence. Pleistocene sediments are found to have existed; part of the problem here with regard to microfossils is that many of the Pleistocene

sediments appear to have been formed under conditions inimical to the presence or preservation of Foraminifera and Ostracoda. An even more serious lack may lie in the relatively little study given these sediments in this and other areas.

With a data-processed file of range cards, it is easy to modify and reconstruct the range chart. Revision on a day-to-day basis is both desirable and practical, if these files are kept up to date. With this type of data assembly, accurate correlations can be achieved, especially if detailed ecological data are incorporated as well. At present, these data are not available.

In the tables that follow (Tables 2-4), are summaries of statistical data on the interrelationships of the various faunas. It would seem, from the mechanistic tabulation processes, that the correlations between faunas in the Virginia-Maryland Miocene and that of Florida are largely on the basis of living forms; that is, the correlation is of more ecological than stratigraphic significance.

Stratigraphic correlation must be based upon the extinction points of the faunas—microfaunas of the types being considered here have a built-in survival factor in that their widespread geographic ranges allowed them to live on whereas the forms most susceptible to ecological rigors died out. Climatic and oceanographic conditions may fluctuate widely in geologic times—but oceanic faunas can simply migrate to better climes.

Certain conclusions can be drawn from the total number of species per age group; these are both ecologic and stratigraphic. It is almost impossible to separate the two subjects, because they regulate the faunal content of a stratum concurrently. Many apparent stratigraphic breaks are now known to be ecological in nature—extreme care is necessary to determine whether the "extinction" of a form is due to ecologic shift or to evolutionary extinction. The same is true of the first appearance of a species. A glance at the range chart (Table 1) shows discontinuities that are ecological in nature—the number of species in a given age unit is due to favorable ecology even more than to extinction or creation of a number of species. As shown in Table 2, for instance, of the 68 species known to be still living, all had representatives in older sediments. Our knowledge of living Ostracoda

Table 2.—Distribution of Foraminifera and Ostracoda in the Virginia-Maryland Miocene to Recent units.

Stratal Unit	Total No. Species in Unit	No. Species at Top Occurrence in Unit	No. Species Restricted to Unit	No. Species in Beds Older Than Unit	No. Species in Beds Younger Than Unit
Recent	68	68	0	68	0
Pleistocene	22	3	2	20	19
Pliocene	41	8	0	41	33
Miocene					
Yorktown	150	100	79(?)	45	50
St. Marys	37	12	2	30	25
Choptank	70	25	8	57	45
Calvert	135	32	26(?)	26	103

Table 3.—Comparison between Florida Miocene and Virginia-Maryland Cenozoic units. Figures represent the number of species known to occur in both the Florida and the Virginia-Maryland units. Data for the Florida Miocene is from Puri (1953).

Florida Miocene Units	Virginia-Maryland Units							
	Recent	Pleistocene	Pliocene*	Yorktown	St. Marys	Choptank	Calvert	Older
Choctawhatchee								
Cancellaria facies	29	10	22	44	17	28	29	12
Ecphora facies	25	8	17	38	13	25	29	9
Arca facies	28	9	19	41	16	30	34	13
Yoldia facies	5	0	1	7	1	3	2	0
Alum Bluff								
Shoal River facies	8	0	3	9	4	7	9	1
Oak Grove facies	5	0	1	6	1	3	4	1
Chipola facies	19	6	13	23	12	21	23	11

*North Carolina, South Carolina, and elsewhere.

is especially meager, and these forms are known to have relatively long existence in geologic time.

Stratigraphic correlation must depend more on species range overlaps, and less on the few formationally limited "guides." The principle of range overlap is going to be a valuable and statistically valid method of determining the age of a formation. Range overlap and ecological similarity together will effect the correct correlation between formations. The Florida Miocene record (Puri, 1953) has been used to test the interformational relationships between the Virginia-Maryland Miocene and its closest relative equivalency (Table 3). It is to be noted that Puri's units are translated by him as ecological or "facies" units, and that the correlation thereby established is largely ecological.

Certain ecological inferences may be drawn from the microfauna of a given sample, even though the record for Ostracoda is very incomplete and that for Foraminifera leaves much to be desired. Benda and Puri (1962) give a four-part ecological separation in which a number of species are common to the Virginia-Maryland record—these species are listed in Table 4. McLean (1956, p. 305) tabulated the known ecologic ranges of Yorktown forms that are still living. There is considerable diversity of opinion as regards ecological limitations of depth, temperature, and salinity.

In the balance of this report, ecological assignments are made on the basis of data here tabulated. Where no evidence supports a given ecological assignment, no attempt is made to give one unless it can be inferred from definite mineral-sediment data, as in the case of the pyritized Calvertian fauna and the presence of wood or plant debris in a sample.

SUBSURFACE DATA

COLEMAN BRIDGE WELLS

Careful microscopic analyses of sediments from the Coleman Bridge test borings were made by the writer, along with foraminiferal and ostracodal studies. Well logs for the Coleman Bridge section are in Appendix I. A detailed discussion of these wells and their relationship to other surface and subsurface records in Virginia and Maryland has been presented by McLean (1956, p. 280-288).

Table 4.—Ecological occurrences of Miocene through Pleistocene Foraminifera and Ostracoda. Based on data of Benda and Puri (1962) for the Cape Romano, Florida area. Species listed also occur in Virginia Miocene through Pleistocene units.

Species	Marsh River Assemblage	Lagoon Assemblage	Mangrove Island Assemblage	Open Gulf Assemblage
Actinocythereis exanthemata		X	X	
Acuticythereis laevissima				X
Anomocytheridea floridana	X	X	X	
Aurila conradi			X	
Bolivina striatula		X		X
Buliminella elegantissima		X	X	X
Cibicides lobatulus			X	X
Cushmanidea ashermani				X
Cytheromorpha cf. *warneri*		X	X	X
Cytherura forulata	X	X	X	X
Cytherura wardensis			X	X
Elphidium advena				X
Lagena laevis				X
Loxoconcha reticularis				X
Nonion grateloupi D'Orbigny				X
Poroeponides lateralis				X
Puriana rugipunctata				X
Pyrgo subsphaerica				X
Quinqueloculina seminula			X	X
Rotalia beccarii tepida	X	X	X	X
Textularia candeiana				X
Textularia gramen				X
Textularia mayori				X
Virginulina punctata			X	X

WELLS NEAR NEWPORT NEWS AND LAMBERT POINT

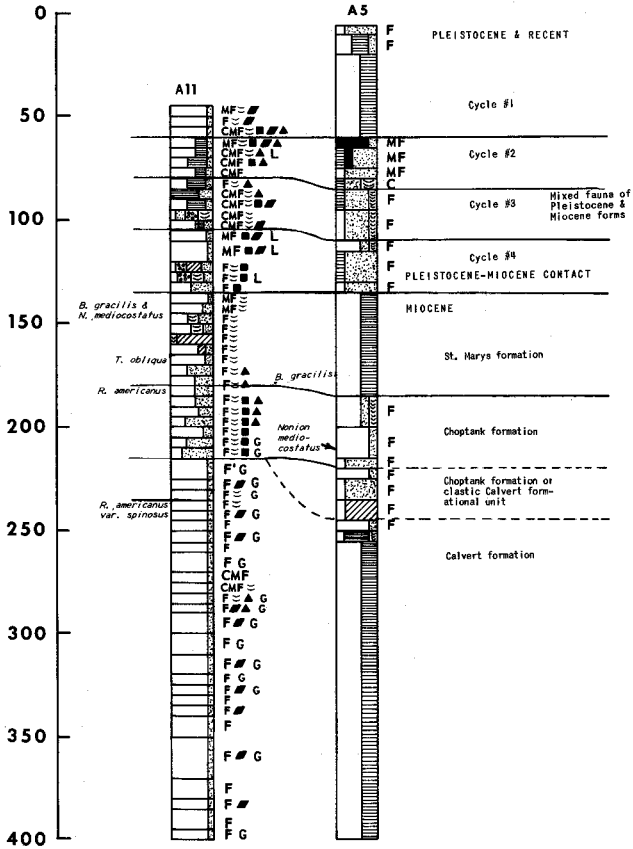
These wells have been extensively discussed by the author and by Harrison (1962). The well near Newport News is referred to as "well A-11", and the Lambert Point well is called "well A-5" (see index map of sample localities for locations). Well A-11 has been studied and described by McLean (Appendix I; Figure 6) both as to lithology and fossil content. Well A-5, on the other hand, is represented by a driller's log (Appendix I; Figure 6) and a number of floated samples that the author has picked and identified as to microfossil content. Insofar as the data from well A-5 permit, correlation between these wells is good. Figure 1 shows graphically the sediment content of wells A-11 and A-5 and the correlations. The following summary is based upon all available information, including a consideration of the work of Harrison and his colleagues.

Pleistocene Interval

Four cycles of deposition for the Pleistocene were noted for well A-11, and it was possible to determine the same cycles for well A-5. These four cycles are discussed from the tops of the wells downward. In well A-11, cycle number 1 consists of 17 feet of clay with plant debris and coarse to fine sand. The sediment is generally composed of fine material, and there are two microfossil zones that contain typical Pleistocene species. This same interval in well A-5 consists of silty clay grading upward into sand, with one microfossil interval in the center of the basal clay-silt.

Well A-11 has clay and silt with coarse to medium and fine sand containing some glauconite, limonite, plant debris, and mica in cycle number 2. This interval in well A-5 is generally silty sand that is shelly at the base and very lignitic at the top. The fauna, except for *Nonion grateloupi* Clapp, found at 65 feet in well A-11 is entirely Pleistocene in character, and *Nonion grateloupi* Clapp is by no means diagnostic.

A basal gravel and clay, ranging upward into a clay-silt with fine sand, plant debris, glauconite, and mica, characterizes the sediments of cycle number 3 in well A-11. Its equivalent, from the driller's log for well A-5, consists of shelly clayey sand which has fine sand as opposed to the coarse and medium sand for well



EXPLANATION

	GRAVEL		PLANT DEBRIS
	SAND	E	ECHINOID SPINES
	SILT	L	LIMONITE
	CLAY	G	GYPSUM
	PLANT DEBRIS		SHELLS, SHELL FRAGMENTS
	SHELL BEDS	F	FINE SAND
	SANDSTONE	M	MEDIUM SAND
▲	MICA	C	COARSE SAND
■	GLAUCONITE		

NOTE: SAND SIZES ARE ACCORDING TO THE WENTWORTH SCALE. THE RELATIVE PERCENTAGES OF MAJOR SEDIMENT ELEMENTS ARE INDICATED BY SYMBOLS IN THE COLUMN FOR EACH BORING.

Figure 1. Correlation between well A-11 and well A-5.

A-11. In both wells, this interval is marked by a fauna that contains numerous Miocene species of Ostracoda and Foraminifera. A mechanical correlation of this fauna favors a Yorktown age for it, but the Miocene forms, although there are a large number of species, are completely overshadowed by a flooding of *Elphidium florentinae* and of forms known to have lived in the Pleistocene. Moreover, the Miocene species are generally eroded or broken forms as opposed to the freshness of the Pleistocene elements. The occurrence of these Miocene elements in well A-5 caused the author to assign the interval originally to the Miocene (Harrison, 1962), but closer study resulted in its being placed in the Pleistocene.

Not only is this fauna highly suggestive of a redepositional phase from the physical and statistical evidence of the microfossils themselves, but there are also a number of additional facts to consider. First, although the range data of the fauna suggest a Yorktown age if mechanically correlated, the aspect of the fauna itself does not resemble a typical Yorktown sample as collected from the York-James Peninsula. Furthermore, the basal Yorktown as depicted by early authors (such as Mansfield) is exposed along the James River upstream from well A-11 and well A-5. Neither well contains either a basal or upper Yorktown fauna in the entire section; nor is this present in a well at Fort Eustis which is roughly between the Carters Grove basal outcrop of the Yorktown and well A-11.

Structurally, this absence of the Yorktown strata can be ascribed to post-Yorktown uplift and erosion which removed Yorktown beds in this vicinity. Such erosion also seems to have occurred in the Chesapeake Bay Bridge-Tunnel area and in the Coleman Bridge section at Yorktown.

Cycle number 4, the basal Pleistocene unit in these wells, is characterized by clays with varying amounts of gravel, sandstone, and medium to fine sand with shell beds or shell fragments. In well A-11 the unit has a uniform content of glauconite and some limonite. The limonite could be from oxidation of the samples, but a lower section containing glauconite has no oxidation to limonite; and the barren nature of the layers, plus the decayed character of the shells, strongly suggest exposure to weathering. This glauconitic type of sediment is also present in

the Pleistocene in the Coleman Bridge section at Yorktown. Glauconite is not a characteristic mineral of Yorktown Formation sediments in the York-James Peninsula. In well A-11, the Miocene contact occurs directly beneath this glauconitic interval, at 135 feet. The author correlates this barren glauconitic interval of well A-11 with a predominantly sand section in well A-5. According to Harrison (personal communication), this correlation places the base of the Pleistocene at an excessive depth for well A-5, and he would prefer the base at 110 feet, or even higher. If the contact is set at 110 feet in well A-5, the Pleistocene-Miocene mixed fauna rests directly on top of the Miocene. Such a correlation does not consider the relation of the sand section of well A-5 to the graveliferous section in well A-11; it likewise ignores the fact that a barren zone exists for both sets of beds involved, as well as the fact that these heterogeneous clastic units are immediately underlain by a clayey section which can be faunally equated with the St. Marys Formation.

Pleistocene-Miocene Contact

Bulimina gracilis and *Nonion mediocostatus* are the important guides for establishing the Miocene top in wells A-11 and A-5. The clay-silt bed of well A-5 which contains *Bulimina gracilis* is barren of fossils in most of the upper half. In well A-11, the fauna is more complete, but it is very small as to number of specimens per sample. *Elphidium florentinae* is not present in the Miocene of wells A-5 and A-11; the barren zones are between *E. florentinae* and the Miocene faunal elements in both wells.

Miocene Intervals

Faunally, there is no way to separate the Miocene units in well A-5 from each other; the separations must be made lithologically and by comparison with well A-11. However, it should be noted that none of these subsurface Miocene units has the variety or faunal distinctiveness of the Virginia-Maryland Miocene outcrops. In general, the Miocene strata of wells A-11 and A-5 seem to indicate either unfavorable nearshore environments or actual swampland conditions that did not support microfaunal life. This is in distinct contrast to the outcrop indications and should prove important paleoecologically as more evidence is ac-

cumulated. The Yorktown Formation is absent in both wells. This absence is probably due to post-Yorktown uplift and erosion.

Absence, for the most part, of Yorktown guide assemblages, plus the dominance of *Bulimina gracilis,* the occurrence of *Nonion mediocostatus,* and the nature of the sediments in well A-11, indicate the presence of the St. Marys Formation. This is also confirmed by the occurrence of *Textularia obliqua* within the interval.

In well A-11, the Choptank is transitional with the St. Marys so far as sediments are concerned. The only sedimentological criterion that shows any promise for differentiation is that the Choptank of well A-11 contains traces of glauconite. *Robulus americanus,* a Choptank guide, occurs at 180 feet in well A-11 in the middle of an otherwise non-diagnostic stratum. The upper portion of the Choptank and the base of the St. Marys contain traces of muscovite. There are no species in well A-5 that can be used to separate the St. Marys, Choptank, or Calvert; the contacts between these formations in well A-5 are arrived at on the basis of lithology and by projection from well A-11.

In well A-11 the Calvert Formation consists of a sandy clay that contains *Robulus americanus spinosus,* a guide fossil, at 245 feet. The entire interval, from 200 feet to the bottom of the well at about 400 feet, contains much plant debris and gypsum in the clay, which are suggestive of a swampy or land-locked environment of brackish or even anaerobic waters. For the most part, this clay is barren of microfossils, and many occurrences of microfossils that are listed may be from downwell drilling contamination. Nevertheless, there are a number of forms which first occur in this interval, and their poor state of preservation, in addition to pyritic inclusions in the tests, indicates that these particular forms are *in situ* in the samples. The occurrences of Calvert species suggest that they came from sporadic incursions of seawaters into a Miocene swamp, which was an environment of death for these more oceanic forms. Neither well A-5 nor well A-11 penetrates all of the Calvert Formation.

CHESAPEAKE BAY BRIDGE-TUNNEL WELLS

The author described sedimentary samples from wells A-1 and A-2 in the Chesapeake Bay Bridge-Tunnel area (Appendix

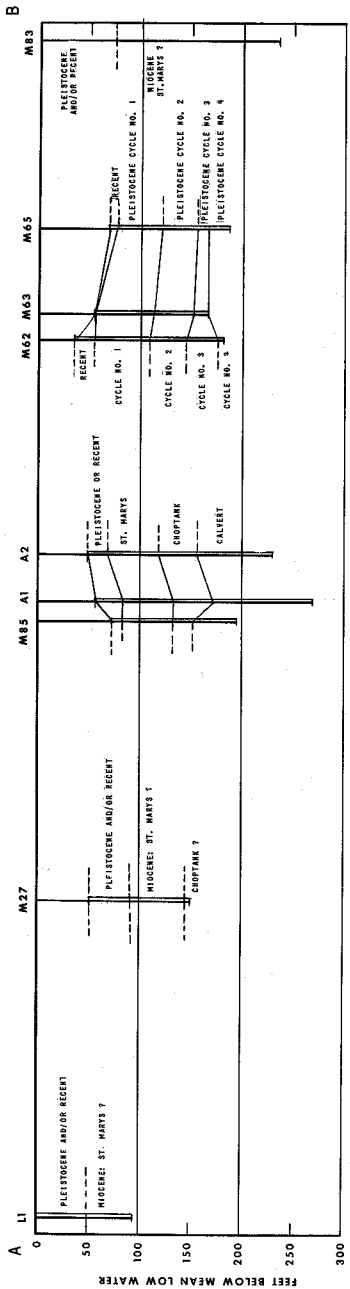


Figure 2. Spacing and correlation of Chesapeake Bay Bridge-Tunnel wells. Double lines show sample recovery for each well. Correlations in wells L-1, M-27, and M-83 are inferred from data of Harrison; all other correlations are based on paleontological and sedimentological studies.

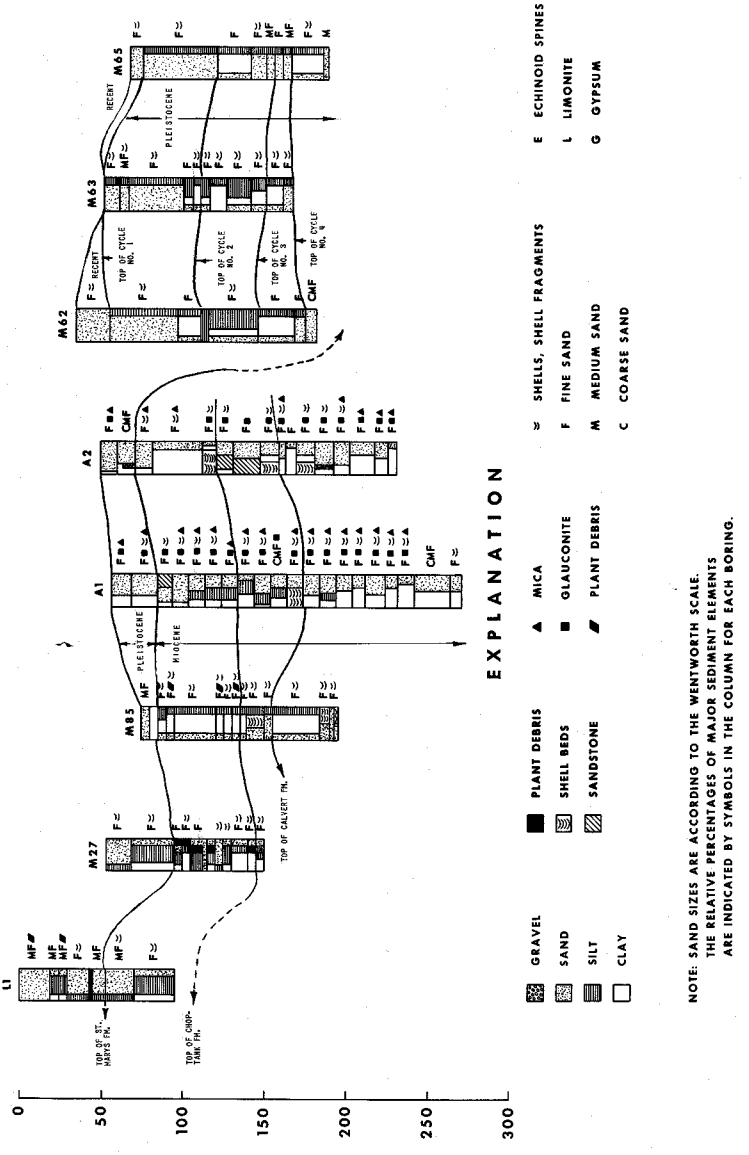


Figure 3. Detailed lithology and correlation of Chesapeake Bay Bridge-Tunnel wells (see Figure 5).

I; Figure 7) and extracted microfossils from them. Floated microfossils were provided by Wyman Harrison from wells M-85, M-62, M-63, and M-65, but the lithologic descriptions of these wells and of L-1 and M-27 are from driller's logs. A study of these materials indicates that wells M-62, M-63, and M-65 did not penetrate the Miocene; wells M-85, A-1, and A-2 did penetrate a very distinctive Miocene boundary which was rich with microfossils of pre-Yorktown age. No faunal information is available for wells L-1 and M-27, and the Miocene-Pleistocene contact line shown in these wells (Figures 2, 3) is after Harrison (1962, p. 46).

Pleistocene Interval

As in the case of wells A-11 and A-5 near Newport News and Lambert Point, the sections penetrated by wells M-62, M-63, and M-65 can be separated into four sedimentological cycles (Figure 4). It is important to note, however, that this does not imply that these cycles are either correlative with each other, or that the author conceives these cycles to be definable according to the standard terminologies of the Pleistocene glacial-interglacial periods. The brackish- and fresh-water microfaunas do not contain species that can be used for paleontological separation; indeed, these faunal assemblages cannot be correlated with each other from well to well. In this connection, it is interesting to note that the interval assigned by Harrison (1962, p. 46) to the Pleistocene in well L-1 can also be split into four such "cycles" of deposition. It must be stressed that the data available from wells M-62, M-63, and M-65 permit several alternative interpretations to the one presented here; this interpretation is simply the one that best seems to fit the observed phenomena and is a reflection of the abrupt ecological shifts in the Pleistocene intervals of the Chesapeake Bay region.

Pleistocene-Miocene Contact

Wells M-85, A-1, and A-2 have a distinctive Pleistocene-Miocene contact boundary that is characterized by the presence of *Bulimina gracilis* and other Miocene forms; in a few places, *Nonion mediocostatus* is also present. This particular section,

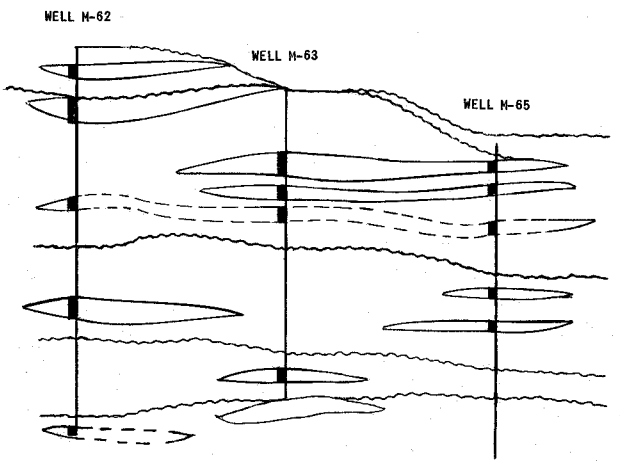


Figure 4. Occurrences of Foraminifera and Ostracoda and correlation of Pleistocene sections in Chesapeake Bay Bridge-Tunnel wells. Wavy lines represent boundaries between the four cycles of Pleistocene sediments and an overlying Recent unit. Closed lenticular symbols show an interpretation of faunal correlations based on microfossil occurrences.

however, also has an extensive admixture of *Elphidium florentinae* in the Miocene zone; this is in sharp contrast to all other records so far discussed. In the other areas, including the classic Miocene outcrops, *Elphidium florentinae* has not been reported, nor has any form equivalent to it been found. As previously mentioned, a mixture of Miocene forms occurs in the Pleistocene in the wells near Newport News and Lambert Point, and Coch considers material from Surry and Isle of Wight counties containing *Elphidium florentinae* to be of Miocene age. In both of these instances, the evidence as shown by the mixing of zonal species, the broken condition of the Miocene tests, and their small numbers points rather decisively to redeposition.

In the case of the section penetrated by wells M-85, A-1, and A-2, the faunal mixing has a different aspect. Both the Miocene forms and *Elphidium florentinae* are numerous and fresh and unbroken, and in none of these wells was *E. florentinae* found in the Pleistocene where it could have resulted in downward contamination due to drilling. It could therefore be concluded that *Elphidium florentinae* has a demonstrated Miocene occurrence, except for two important considerations. First, in other occurrences this species is found in a distinctly brackish- to fresh-water environment; whereas in wells M-85, A-1, and A-2 this form is in sediments that contain a distinctly oceanic fauna, and this is corroborated by the nature of the sediments. Second, the Miocene oceanic faunal elements contain no other species that can be called exclusively Pleistocene in age. Elsewhere, except for the Surry and Isle of Wight county area, there is no indication that *Elphidium florentinae* occurs in the Miocene—and numerous collections have been made and studied.

Downward drilling contamination in well samples is the rule rather than the exception; it is also by no means uncommon to encounter such contaminants in a well where the source bed contributing the contaminating elements is not recognizable. It is rather remarkable, nonetheless, to find three closely spaced wells that have this identical condition. That downward contamination occurred in these wells is undeniable; it is so excessive as to obscure some otherwise clear-cut unit correlations. Additionally, the occurrences of *Elphidium florentinae* in other undoubted Pleistocene units indicate that this species is almost the only form present in these small stringers—stringers that could eas-

ily be bypassed in sample recoveries. And it is possible that the Pleistocene-Miocene contact zone in these three wells consists of contiguous faunal units that were mixed in the very sample showing this contact. Thus these rather remarkable "coincidences of contamination" can be explained as the net result of several purely mechanical sampling-mixing effects.

Miocene Intervals

Because of the proximity of wells M-85, A-1, and A-2, it is possible to establish numerous lines of correlation between them (Figure 5). It should be stressed that these correlations are based on paleontological and sedimentological-structural considerations.

The age of the youngest Miocene unit in wells M-85, A-1, and A-2 has been established as St. Marys Formation; even more significant, perhaps, is the discovery that the St. Marys in the Chesapeake Bay Bridge-Tunnel area has a remarkably uniform thickness compared with the St. Marys of the Coleman Bridge section and with the section penetrated by the wells near Newport News and Lambert Point (wells A-11 and A-5). The significance of this fact can be better appreciated if one bears in mind that the Miocene units (from the Yorktown through the Calvert) are apparently conformable to each other; indeed, the separation between Calvert, Choptank, and St. Marys formations in this and other studies is based in large part on changes in faunal assemblages, not on sedimentary changes. It is true there are differences in sedimentation, but these are gradual and merge into each other so that the faunas need to be used for accurate separation of the various units. Faunal elements are indicative of succeeding sedimentary fluctuations, and often are the only criteria for determination of environmental changes which affect rates of deposition. Because, at least in the area under study, the Miocene appears to be a sequence of more or less continuous deposition, the elevation of the upper contact in wells that penetrate the St. Marys Formation is interesting. The several sections studied have a minimum of 50 feet of displacement in these beds, despite their uniform thickness. Well M-27 has a 50-foot interval containing much plant material that correlates with the St. Marys interval (also with plant material) in well M-85. The Yorktown is present in an area that is centrally located with ref-

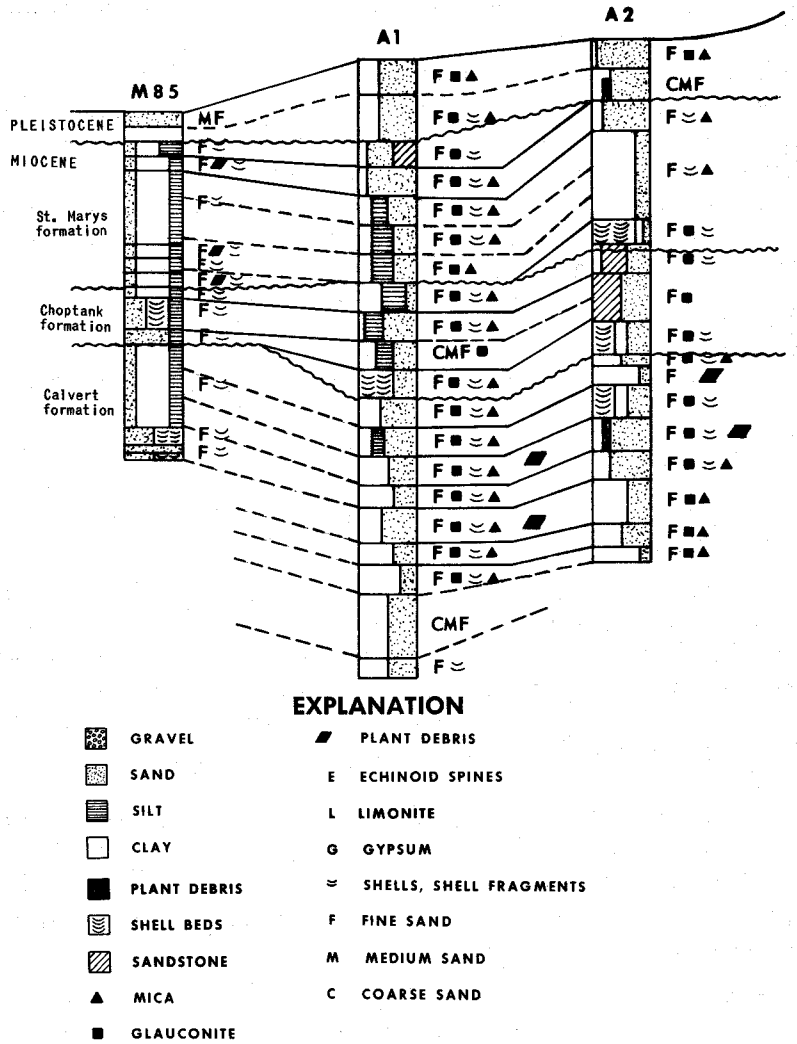


Figure 5. Correlation of Pleistocene and Miocene formations and stratal units in Chesapeake Bay Bridge-Tunnel wells (see Figure 3). Wavy lines denote formational boundaries; solid lines denote boundaries of stratal units of similar lithology. Dashed lines show inferred boundaries of units that have lateral variations in lithology.

erence to the mouth of the Chesapeake Bay, the Coleman Bridge section, and wells A-11 and A-5; it is absent from the Chesapeake Bay Bridge-Tunnel section and the well at Franklin. There is no recognition of sediments of Pliocene age in the area. The hiatus between the Pleistocene and the St. Marys in the sections discussed here is considerable and may be evidence of erosional planation on a rather large scale. If so, the Yorktown has been planed off and the erosional surface at the top of the St. Marys is the result of regional planation. This event occurred in post-Yorktown time, after which Pleistocene deposition and/or structural displacements occurred.

The Choptank Formation in the Chesapeake Bay Bridge-Tunnel wells is transitional between the Calvert and the St. Marys. In the area of study, the Choptank is coarser than either the St. Marys or the Calvert, and locally contains more macrofossils in the form of shell beds. These beds are composed mainly of fragmented shells.

Calvert Formation units in the Chesapeake Bay Bridge-Tunnel wells are similar to equivalent units in wells A-11 and A-5; the interval is largely unfossiliferous, largely composed of clay, and contains units that have plant remains or lignitic parts. The sparse microfossils appear to have been brought into the Calvert sediments as incursions from open-sea faunas by way of storm activity. The broken tests, the presence of pyrite inclusions in these tests, their scattered nature and limited numbers, and the presence of gypsum throughout the Calvert samples of well A-11 all point to an anaerobic or marine swamp condition which would be a thanatocoenosis for Foraminifera and Ostracoda brought in from open-sea waters.

Oceanic faunas are present in Calvert samples from the York-James Peninsula beneath units that are analogous to the previously described, largely unfossiliferous Calvert beds. Unfortunately, the base of the Calvert is not represented in samples received for the present study, so the thickness and base relationships of this Calvert swamp unit could not be defined. Calvert Foraminifera and Ostracoda reported from this swamp unit are typical oceanic forms and include diagnostic species for the Calvert; their presence in these beds cannot be due to drilling contamination, and there is no indication in the sediments of redepositional activity.

In the York-James Peninsula, the oceanic phase of the Calvert is characterized by the occurrence of *Siphogenerina lamellata* in large numbers, along with other beautifully preserved, large microfossils that perhaps form the most distinctive fauna in this region. This stratum occurs at 670 feet in a well at Crisfield, Maryland (McLean, 1950). In the York-James Peninsula, the *Siphogenerina lamellata* zone occurs at a minimum depth of 215 feet, but the average depth is closer to 300 feet. These depths indicate that the sections here discussed would not reach the *Siphogenerina lamellata* zone.

WELL AT FRANKLIN, VIRGINIA

Samples from the Camp Manufacturing Company well 4 at Franklin, Nansemond County, Virginia, were examined (Appendix I). The section from 0 to 70 feet is barren of microfossils and appears to be composed of typically Pleistocene-type sediments; a single fish vertebra occurs at 50 to 60 feet.

The Miocene units begin at 70 feet and end at 110 feet where the Eocene or Paleocene interval is indicated by the presence of typical glauconitic and pyritic material. At 170 feet a micaceous, apparently continental, section begins which is devoid of fossils, except for considerable plant debris. The report of a shell fragment at 240 to 250 feet is considered to be due to downwell drilling contamination. The interval from 170 feet to the bottom of the well at 770 feet is assigned to undifferentiated sediments of Cretaceous age.

A strictly mechanistic correlation indicates the following Miocene units in the well: 70-80 feet, undifferentiated Miocene; 80-90 feet, St. Marys Formation; 90-110 feet, Choptank Formation with Eocene-Paleocene faunal elements in the basal portion. From a practical point of view, the unit correlations are best considered as questionable, but the interval is of undoubted Miocene age. There is no indication of a Yorktown unit in this well; the record is distinctly pre-Yorktown in age and faunistic character. There is no indication of a Calvert interval either. Because the entire Miocene section was penetrated and samples were taken at 10-foot intervals, it is felt that one, or both, of these formations should have been found if they are present in this area. Part of the non-fossiliferous interval above the 70-foot

level may be equivalent to the Yorktown—if so, it is a continental Yorktown. Following is a list of fossils from the well at Franklin:

Depth (Feet)	Species
70-80	*Bulimina gracilis* *Nonion pizarrensis*
80-90	*Bulimina gracilis* *Nonion mediocostatus* *Nonion pizarrensis* *Nonionella auris* *Textularia pseudobliqua* *Globigerina* sp. *Robulus* sp. *Marginulina* sp.
90-100	*Globigerina* sp. E *Globorotalia menardii* *Robulus americanus* *Rotalia beccarii* var. *tepida* *Textularia eustisensis* *Cancris* sp. Hispid sigmomorphinas
100-110	*Bulimina gracilis* *Cibicides americanus* *Textularia pseudobliqua* *Nonion pizarrensis* *Globigerina* sp. *Sigmomorphina* sp. Eocene or Palocene microfauna
120-130	Eocene or Palocene microfauna

SURFACE AND NEAR-SURFACE DATA

LOCALITIES NEAR WILLIAMSBURG

Dr. Kenneth F. Bick, Geology Department, College of William and Mary, supplied a number of outcrop and near-surface samples from localities near Williamsburg for examination; the result of this examination further clarifies the general relation-

ship of the Yorktown Formation to underlying and overlying strata. In addition, several forms not previously reported from the Yorktown Formation occur in these samples. Despite a number of assertions to the contrary by other workers, the Yorktown microfauna seems to be unique to the York-James Peninsula. Typical Yorktown Formation microfaunas do not occur in the subsurface material of either the Coleman Bridge section or in many of the other subsurface samples from the Chesapeake Bay area. Neither is the Yorktown present in a well at Franklin, Virginia. The material submitted by Coch, although it contains Miocene elements mixed with Pleistocene, does not show much affinity with the typical Yorktown faunas; instead, the Miocene forms seem to be ecologically different if they are of Yorktown age.

No significant amount of glauconite has been noted in the Yorktown samples from the Williamsburg area. Also, the Yorktown samples so far observed by McLean, in this and previous work, are significantly non-micaceous, whereas mica is an important constituent of other local beds or strata. Fossil lists and other data pertaining to samples from the Williamsburg area are given in Appendix II.

ISLE OF WIGHT AND SURRY COUNTY LOCALITIES

Samples from Isle of Wight and Surry counties (see index map of sample localities) were collected by Mr. Nicholas Coch, Yale University, and made available to the author for study. Descriptions of this material are presented in Appendix II, and in Table 5 the species of microfossils which were identified are listed. Determinations made on the material from Isle of Wight and Surry counties permit the following correlations. On the basis of the Foraminifera, samples from locality 14 (Appendix II) could have been ascribed to the Yorktown alone, but Richards identified the macrofossils as Pleistocene or Miocene. All other samples from this area must be considered to be Pleistocene in age if *Elphidium florentinae* can be considered to be restricted to a post-Miocene age. It appears that most of these samples contain mixtures of Miocene and Pleistocene forms and must be considered Pleistocene in age with redepositional elements from the Miocene.

Table 5.—List of microfossil species from Isle of Wight and Surry counties.

Species	Locality													
	5	7	8	10	11	14	18	26	27	30	31	36	37	54
Hanzawaia concentrica	X	....	....	....	X	X	X	....	X	....	X	....	....	....
Bolivina cf. *lafayettei*	X	....	....	....	X	X	X	....	X	....	....	....	....	....
Elphidium florentinae	X	X	X	X	X	....	X	X	X	X	X	X	X	X
Nonion sp.	X	....	....	....	....	....	....	....	....	....	....	....	....	....
Rotalia beccarii var. *tepida*	....	X	X	X	....	....	....	....	X	....	....	....	X	....
Discorbis consobrina	....	....	X	X	....	....	....	....	....	....	....	....	....	....
Buccella depressa	....	....	....	X	X	X	X	X	X	X	....	X	X	X
Textularia gramen	....	....	....	X	X	X	X	....	X	X	X	X	....	....
Globigerina sp. E	....	....	....	X	X	X	X	....	X	....	X	....	....	....
Uvigerina auberiana	....	....	....	X	....	....	X	....	....	....	....	....	....	....
Nonionella auris	....	....	....	X	....	....	X	....	....	....	....	....	....	....
Lagena laevis	....	....	....	X	....	....	....	....	....	....	....	....	....	....
Loxostomum wilsoni	....	....	....	X	....	....	....	....	....	....	....	....	....	....
Angulogerina occidentalis	....	....	....	X	....	....	....	....	....	....	....	....	....	....
Uvigerina subperegrina	....	....	....	X	....	....	....	....	....	....	....	....	....	....
Orbulina universa	....	....	....	X	X	....	....	....	....	....	....	....	....	....
Bolivina floridana	....	....	....	X	....	....	....	....	....	....	....	....	....	....
Entosolenina sp.	....	....	....	X	X	X	....	....	....	....	....	....	....	....
Striate *Bolivina*	....	....	....	X	....	....	....	....	....	....	....	....	....	....
Bolivina paula	....	....	....	X	X	....	X	....	....	....	....	....	....	....
Cytherura wardensis	....	....	....	X	....	....	....	....	....	....	....	....	....	....
Cytherura bajacala	....	....	....	X	X	X	X	....	....	....	....	....	X	....
Discorbis floridana	....	....	....	X	X	X	X	....	X	....	....	....	....	....
Lagena pageae	....	....	....	....	X	....	X	....	....	....	....	....	....	....
Quinqueloculina seminula	....	....	....	....	X	X	X	....	....	....	....	....	....	....
Bolivina sp.	....	....	....	....	X	....	....	....	....	....	....	....	....	....

Table 5.—*Continued*

Species	Locality													
	5	7	8	10	11	14	18	26	27	30	31	36	37	54
Textularia candeiana	....	....	....	....	X	....	....	....	....	....	....	....	....	....
Buliminella elegantissima	....	....	....	....	....	X	X	X	X	X	....	X	X	X
Lagena tenuis	....	....	....	....	....	....	X	....	....	....	....	....	....	....
Sigmomorphina semitecta terquemiana	....	....	....	....	....	....	X	....	....	....	....	....	....	....
Virgulina punctata	....	....	....	....	....	....	X	....	....	....	....	....	....	....
Lagena clavata	....	....	....	....	....	....	X	....	....	....	X	....	X	....
Cytherura reticulata	....	....	....	....	....	....	X	....	....	....	....	....	....	....
Loxoconcha purisubrhomboidea	....	....	....	....	....	....	X	....	....	....	....	....	....	....
Cytheromorpha warneri	....	....	....	....	....	....	X	....	....	X	....	....	....	....
Cibicides americanus	....	....	....	....	....	....	X	X	....	....	....	....	....	....
Cibicidella variabilis	....	....	....	....	....	....	....	X	....	....	....	....	....	....
Nonion grateloupi	....	....	....	....	....	....	....	X	....	....	....	....	X	....
Lagena sulcata	....	....	....	....	....	....	....	....	X	....	....	....	....	....
Uvigerina cf. *carmeloensis*	....	....	....	....	....	....	....	....	X	....	....	....	....	....
Cibicides sublobus	....	....	....	....	....	....	....	....	X	....	....	....	....	....
Quinqueloculina sp.	....	....	....	....	....	....	....	....	X	....	....	....	X	....
Uvigerina sp.	....	....	....	....	....	....	....	....	....	....	....	....	X	....
Quinqueloculina triloculiniforma	....	....	....	....	....	....	....	....	....	....	....	....	X	....
Cytherura clathrata	....	....	....	....	....	....	....	....	....	....	....	....	X	....
Robulus pseudoiota	....	....	....	....	....	....	....	....	....	....	....	....	X	....

CORRELATIONS

The use of single species of microfossils as index forms to delineate specific geologic age units is risky unless the ranges of these species are well established. In the area of this study, a number of forms appear to be good guides. The range chart (Table 1) shows that 79 species of Foraminifera and Ostracoda are apparently restricted to the Yorktown Formation; most of these "restricted" forms are either newly described species, or they are forms that could not be definitely given specific names. Some of the species described by McLean (1956, 1957) as new are still included in the restricted column for the Yorktown Formation; these may now be looked upon with increasing favor as acceptable guides for the formation until extensions of range are found. But, it is felt that most of the 79 species currently listed in this category of restricted species will prove to be extended in range. For example, the range of *Globigerina* sp. E has been extended in this study.

There are other, more reliable indices of age and ecology. The most elusive indicator, from a standpoint of description, is the aspect of the entire fauna in a given sample, especially when the relationship to mineralogy of the sediment is included. The abundance of species, numbers of individuals per sample, general size of specimens, absence of certain forms, condition of preservation of the specimens, etc. all go into the stratigraphic and ecologic assignments. Where the term "*Nonion mediocostatus* zone" is used, it should be remembered that the name indicates a specific assemblage of faunal-sedimentological factors, and that, in some cases, *Nonion mediocostatus* itself may not be present in a given sample at all. The presence or absence of a single species such as *Nonion mediocostatus* within a given sample is governed by a number of very complex ecologic and structural considerations, to say nothing of the imperfection of sampling. The total population of an assemblage, not a single guide, denotes the zone.

PLEISTOCENE SERIES

The most marked aspects of the Pleistocene beds in the area are their heterogeneous character, often completely devoid of fossil remains, and the presence of wood or plant fragments. The beds are not continuous over great distances. Where fossils oc-

cur in the Chesapeake Bay subsurface and in the Coleman Bridge section (and other subsurface units), the macrofossil material is generally badly broken, and microfossils are sparse. Where they are at all numerous, one or two species dominate the assemblage; and they are brackish- to fresh-water forms that are associated with plant or wood fragments. Many of the shell walls are extensively damaged. Diatoms are present in many samples; in some cases it appears that Miocene elements are redeposited in the Pleistocene sediments. As might be expected, the fossiliferous units are discontinuous, not even being correlatable between wells that are closely spaced. The dominant species are *Elphidium florentinae*, nondescript Nonions, and, in some places, *Elphidium clavatum*. The contrast between Pleistocene and Miocene beds is quite marked, both lithologically and faunally.

Elphidium florentinae is totally absent from typical Yorktown (Miocene) beds that crop out in the York-James Peninsula, but its value as a Pleistocene guide is seriously in question elsewhere in the area under study. The subsurface occurrences of *Elphidium florentinae* in Miocene beds may be easily explained by downward contamination from drilling operations. The presence of this species in samples from Surry and Isle of Wight counties may be due to contamination in one form or another; the difficulty with this hypothesis is that the form is present in considerable numbers in certain well intervals with typical Miocene faunas, and, in this material the Miocene elements may be *in situ*. The possibility exists that the range of *Elphidium florentinae* could extend into the Miocene.

The absence of *Elphidium florentinae* in the Yorktown Formation outcrops is very easily explained. These Yorktown beds are uniformly saline, open-ocean beds, and *E. florentinae* is clearly not an oceanic species. The St. Marys and Choptank beds, on the other hand, are markedly different in faunal content, and they may contain brackish or nearshore units where *E. florentinae* could flourish.

Most of the samples examined from Surry and Isle of Wight counties contained no microfossils; those containing fossils were studied extensively, and the results are shown in Table 5. *Elphidium florentinae* occurred in all but one of the fossiliferous samples. Coch has expressed the opinion that the fossiliferous samples from this area are of Miocene age; if he is correct, then

Elphidium florentinae has a Miocene range. If, on the other hand, this material is of Pleistocene age, with redeposits of Miocene faunal elements, then *E. florentinae* can function as a valuable guide species for the Pleistocene.

Study of the Surry and Isle of Wight county faunas reveals that, although Miocene microfossil elements are quite extensive, they occur sporadically and are associated with species not hitherto found in Miocene beds. This material has concentrations of *Elphidium florentinae,* and in some cases concentrations of *Rotalia beccarii* var. *tepida,* a long-ranging brackish-water species which is not present in the Yorktown Formation, but does occur in the more brackish elements of the Miocene and in Pleistocene and Recent material. "Guide" species occur in the material which are limited to the Miocene; these "guides" denote a mixing of several Miocene strata in the area, because there is no clear-cut definition of strata from a faunistic point of view. The species which survived into the Pleistocene are in the ascendency. Typical Miocene forms are numerically insignificant in given samples as compared to the Pleistocene species which are small in number of species, but quite numerous as individuals. Much evidence, such as the eroded condition of microfossil forms, the spotty geographic occurrence of fossil beds, their non-relation to each other, and the variety and abundance of barren sediments in the major part of the material, seems to indicate redeposition of Miocene oceanic species in brackish or nearshore Pleistocene (?) beds. Dr. Horace G. Richards, of the Academy of Natural Sciences of Philadelphia, has confirmed this thesis on the basis of his review of macrofossil forms found in these same beds.

Because the outcrops of the four Miocene units have been systematically collected and studied in the Maryland and Virginia areas by McLean (1956, 1957), Sabol (1960), Clapp (1948), and Malkin (1953) and because *Elphidium florentinae* has not been found at any locality in these beds by any of these collectors, it would seem that the presence of this species can be taken to indicate a post-Miocene age for the containing sediment, unless the possibility of downwell contamination exists as it does in the Chesapeake Bay subsurface sections. For these reasons, the present study indicates that the majority of the Surry County and Isle of Wight County fossil material is of Pleistocene, or at least post-Miocene, age. There is no indication that Pliocene

sediments are present in any of the material examined for this study.

MIOCENE SERIES

Yorktown Formation

The character of the Yorktown Formation faunas has been well established by means of Foraminifera, Ostracoda, and Mollusca. The range chart (Table 1) depicts the uniqueness of the microfossil faunas of the Yorktown and their relation to other faunas. New material in the Williamsburg area samples furnished by Bick (Appendix II) confirms the uniqueness of the Yorktown faunas and shows the Yorktown to be easily distinguishable. Seventy-nine species are shown to be "restricted" to the Yorktown; the majority of these must be discounted because they are new species and unnamed forms, but a number of them may well be restricted to the formation.

Faunistically, the Yorktown has some surprising affinities to the Calvert Formation; this relationship is due to a close similarity in the ecologies of the two formations. The Yorktown and Calvert formations contain species which are mutually exclusive of each other, and the character of these differing faunal elements points to a stratigraphic or time separation, with the Calvert being significantly older. By judicious attention to the presence of "guides" and by consideration of the local geographic situation, the forms common to the Yorktown and Calvert can be used locally as safe guides for the Yorktown. Indeed, it is the faunal character that these forms give a sample that makes the Yorktown Formation easily recognized in a well section. The appearance of older "guides" in the section, as in the case of a drilling operation, serves to pick up the Calvert at some distance below the Yorktown, and, the intervening faunas and sedimentary units show a definite separation between the two formations.

Recognizing the top of the Yorktown poses no problem in subsurface work; generally the first "flooding" of a variegated fauna in a well sample in the Chesapeake Bay region denotes the Yorktown. The faunas are quite different from those in the Pleistocene. The base of the Yorktown is more difficult to recognize, but there are a number of criteria to apply. First, the marked micaceous character of St. Marys beds can furnish a clue; the

Yorktown sediments of the York-James Peninsula generally lack micaceous particles. Second, the appearance of St. Marys guides, *Nonion mediocostatus* and/or *Clithrocytheridea diagonalis* is of value. Third, although scattered occurrences of *Bulimina gracilis* and *Buliminella elegantissima* are found throughout the Yorktown Formation, they make up a very small part of the fauna, being represented by only one or two specimens per sample; these forms are more abundant in the St. Marys. The material from the Williamsburg area reveals several localities that are exceptions to this criterion; these beds are basal Yorktown, where such conditions may be expected.

St. Marys Formation

Sparsity of microfossils in a sample helps delineate the St. Marys from the Yorktown Formation. The micaceous character of many St. Marys beds also helps. *Nonion mediocostatus* and *Clithrocytheridea diagonalis* are guides for the St. Marys and are absent from the Yorktown; *Bulimina gracilis* and *Buliminella elegantissima* are generally present in considerable numbers. St. Marys faunas are markedly sparse in numbers of species and in numbers of individuals per sample, and they lack such species as *Nodosaria catesbyi, Sigmomorphina nevifera, Pseudopolymorphina rutilia, Guttulina palmerae, Lagenidae,* and other more oceanic forms. The St. Marys Formation in the Virginia Chesapeake Bay area appears to be transitional, indicating shallow to almost brackish waters. It may prove difficult to distinguish the base of the Yorktown from the top of the St. Marys in some places; in most cases the distinction seems to be rather clear cut, but it appears to be ecologic, rather than stratigraphic. *Textularia obliqua* and *Murrayina gunteri* seem to be restricted to the St. Marys.

Choptank Formation

In the Coleman Bridge section, the Choptank is represented by a non-fossiliferous bed that lacks mica. Shattuck (1904), and later Clapp (1948), show the Choptank to be at least partially unfossiliferous in Maryland. The fossiliferous beds in the Choptank are notably more prolific in numbers of species than the St. Marys; most of the fauna in the Choptank overlaps into younger and older beds. *Sigmomorphina nevifera* is present in Choptank beds and in the Yorktown, but not in the intervening St. Marys.

The same holds true for *Lagena dorseyae, Textularia* cf. *badenensis,* and *Uvigerina* cf. *carmeloensis.* Several shallow-water forms (of oceanic-salinity environments) are apparently restricted to the Choptank: *Cytherura coryelli, Hemicythere punctistriata, Massilina glutinosa, M. quadrans, Paracytheridea shattucki, Quinqueloculina contorta* var. *striata, Textularia consecta,* and *T. ultima-inflata. Clithrocytheridea diagonalis* was originally thought to be restricted to the Choptank and Calvert, but this study reveals its presence in the St. Marys as well. The Choptank grades into the Calvert; the principal difference appears to be that the Choptank is a shallower phase than the Calvert, but a deeper water phase than the St. Marys. *Bolivina floridana* is present in the Choptank and should be an important guide species. *Robulus americanus* is present in Choptank and older sediments.

Calvert Formation

In Maryland, the Calvert is a well-developed oceanic formation with many distinctive species of Foraminifera and Mollusca and a number of Ostracoda. Of the 26 species restricted to the formation, the more important guides are: *Robulus americanus* var. *spinosus, Siphogenerina lamellata,* and *Siphogenerina spinosa.* A single occurrence of *S. lamellata* in one Yorktown Formation sample is believed to be redepositional; the form has not otherwise been encountered in beds above the Calvert. In the Calvert, where it does occur, *S. lamellata* is numerous.

According to Clapp (1948), the top of the Calvert Formation where it crops out in Maryland is barren of microfossils. This formation has a pyritized zone in the Coleman Bridge section and is characterized by a pyritized and broken fauna in the Chesapeake Bay subsurface. In the York-James Peninsula, the Calvert shows no faunal lapse, but is immediately succeeded by the Choptank *Bolivina floridana* zone. The Calvert microfossils are large, fresh, and well developed where the pyritic or swamp environment is absent, and the fauna is varied and distinctive. It can be readily separated from the underlying Eocene unit described by Cederstrom (1945); this Eocene unit is characterized by being very glauconitic and sandy. Calvert microfauna typical of an oceanic environment were transported into barren or toxic swamp environments, as indicated by the presence of fragmented and pyritized tests.

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APPENDIX I

WELL LOGS AND FAUNAL DISTRIBUTION LISTS

The following well logs and faunal distribution lists, along with data for surface and near-surface samples shown in Appendix II, form the basis for the correlations. A number of well records are represented by driller's logs because only washed samples were available for these wells; it was not considered advisable to attempt to log these samples as to lithologic content because the clay and silt portions of the sediments were lost. Because Foraminifera and Ostracoda were recovered (as recorded in the appropriate places), these driller's logs were used in construction of the detailed cross sections; and the correlations between them were established on paleontological criteria. Locations of the wells and sample localities are shown on the index map (in pocket).

COLEMAN BRIDGE WELLS

Located on the York River between Gloucester Point and Yorktown. Samples obtained from Mr. W. T. Parrott, Virginia Department of Highways.

Well 1-SW

(Total depth: 160 feet)

Depth (Feet below mean low water)	Sample Description
101.0	Mainly coarse to medium sand with many granules and small pebbles; some violet and blue-smoky quartz grains; 15% fine sand; a little glauconite and a few fragments of fine-grained glauconite sandstone; some shell fragments.
112.4	Very fine sand and a little tan-brown clay; a little mica; some decayed shell fragments.
123.0	Similar to 112.4′ except much decayed shell material, many Ostracoda, some Foraminifera, trace of mica; *Dentalium?* fragment.
132.0	Similar to 112.4′ except much more clay, no fossil material.
141.0	Similar to 112.4′ except slightly more clay; some shell material.
151.0	Sandy, silty, flaky, micaceous gray-tan clay with a very few decayed shell fragments.
160.0	Light-brown clay and fine sand; a few medium-size grains; decayed shell fragments; much mica; many echinoid spines; a few pyrite-filled and pyritized Foraminifera, apparently redepositional (*Robulus* cf. *calcar*); some badly preserved Gastropoda.

List of species in well 1-SW, Coleman Bridge section. Fossil occurrences are indicated at appropriate depths in feet below mean low water.

	-101.0	-112.4	-123.0	-132.0	-141.0	-151.0	-160.0
ACTINOCYTHEREIS EXANTHEMATA GOMILLIONENSIS	.	.	X	.	.	.	.
ACTINOCYTHEREIS EXANTHEMATA MARYLANDICA	.	.	X	.	.	.	.
BOLIVINA PAULA	.	.	.	.	.	.	.
BOLIVINA STRIATULA	.	.	.	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	.	.	.	.
BUCCELLA DEPRESSA	.	.	X	.	.	.	.
BUCCELLA HANNAI	.	.	.	.	.	.	.
BUCCELLA PARKERAE	.	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	.	.	X	.
CASSIDULINA LAEVIGATA CARINATA	.	.	.	.	.	.	.
CIBICIDES SUBLOBUS	.	.	.	.	.	.	.
CLITHROCYTHERIDEA DIAGONALIS	.	.	X	.	.	.	.
CLITHROCYTHERIDEA VIRGINIENSIS	.	.	.	.	.	.	.
CUSHMANIDEA ULRICHI	.	.	X	.	.	.	.
CYTHERETTA ULRICHI	.	.	X	.	.	.	.
CYTHEROPTERON TALQUINENSIS	.	.	.	.	.	.	.
DISCORBIS CONSOBRINA	.	.	.	.	.	.	.
DISCORBIS FLORIDANA	.	.	.	.	.	.	.
DYOCIBICIDES PERFORATUS	.	.	.	.	.	.	.
ECHINOCYTHEREIS CLARKANA	.	.	X	.	.	.	.
ELPHIDIUM FLORENTINAE	.	.	.	.	.	.	.
ELPHIDIUM INCERTUM	.	.	.	.	.	.	.
GLOBIGERINA SP. E	.	.	.	.	.	.	.
GUTTULINA PSEUDOCOSTATULA	.	.	.	.	.	.	.
HANZAWAIA CONCENTRICA	.	.	.	.	.	.	.
LOXOCONCHA PURISUBRHOMBOIDEA	.	.	.	.	.	.	.
MURRAYINA BARCLAYI	.	.	.	.	.	.	.
MURRAYINA GUNTERI	.	.	.	.	.	.	.
MURRAYINA HOWEI	.	.	X	.	.	.	.
MURRAYINA MARTINI	.	.	X	.	.	.	.
NONION GRATELOUPI D ORBIGNY	.	.	.	.	.	.	.
NONION MEDIOCOSTATUS	.	.	X	.	.	.	X
NONION PIZARRENSIS	.	.	X	.	.	.	X
INDETERMINATE NONION	.	.	.	.	.	.	.
NONIONELLA AURIS	.	.	X	.	.	.	.
PLANULINA DEPRESSA	.	.	.	.	.	.	.
QUINQUELOCULINA SEMINULA	.	.	.	.	.	.	X
ROBULUS AMERICANUS	.	.	.	.	.	.	.
HISPID SIGMOMORPHINAS	.	.	.	.	.	.	.
TEXTULARIA ARTICULATA	.	.	.	.	.	.	.
TEXTULARIA EUSTISENSIS	.	.	.	.	.	.	X
TEXTULARIA GRAMEN	.	.	.	.	.	.	.
TEXTULARIA OBLIQUA	.	.	.	.	.	.	.
TEXTULARIA PSEUDOBLIQUA	.	.	.	.	.	.	.
TEXTULARIA YORKTOWNENSIS	.	.	X	.	.	.	.
WOOD FRAGMENTS	.	.	.	.	.	.	.
ECHINOID SPINES	.	.	.	.	.	.	.
CIBICIDELLA VARIABILIS	.	.	X	.	.	.	.
NONION SP.	.	.	X	.	.	.	.
ROBULUS CALCAR	.	.	.	.	.	.	X

Well 1-SE

(Total depth: 200 feet)

Depth (Feet below mean low water)	Sample Description
98.5	Mainly medium to fine sand with considerable coarse sand and a few granules and small pebbles; a few green and black-green glauconite nodules; a few violet quartz grains; decayed shell fragments; a little gray clay; coal (?) fragment.
118.5	Fine sand with some gray-brown clay; considerable mica; a few coarse grains; decayed shell fragments; echinoid spine fragments; four broken Foraminifera.
128.5	Similar to 118.5′ except finer and no coarse grains; more echinoid spines, more Foraminifera; many Ostracoda; a little mica.
139.5	Similar to 128.5′ except coarser texture and more clay; no Foraminifera or Ostracoda; a bit more mica.
150.0	Indurated, flaky, sandy, clayey silt; no fossils; clay-silt gray.
160.0	Mainly fine sand and tan clay with mica; pyrite masses and pyritized Foraminifera; decayed shell fragments; Ostracoda; Foraminifera.
170.0	Silty, sandy, greasy, tan clay; Foraminifera; Ostracoda.
180.0	Silty, sandy, greasy, buff clay; some pyritized material; fragment of a *Turritella* (*alticostata*?); Foraminifera; Ostracoda.
180.5	Mainly fine to medium sand and some clay; much decayed shell material; two gastropod fragments and one dubious foraminifer.
190.0	Micaceous, silty, sandy, tan clay and decayed shell fragments; no Foraminifera.
200.0	Similar to 190.0′ except less shell material.

List of species in well 1-SE, Coleman Bridge section. Fossil occurrences are indicated at appropriate depths in feet below mean low water.

	-98.5	-118.5	-128.5	-139.5	-150.0	-160.0	-170.0	-180.0	-180.5	-190.0	-200.0
ACTINOCYTHEREIS EXANTHEMATA GOMILLIONENSIS	.	.	.	.	.	.	.	X	.	.	.
ACTINOCYTHEREIS EXANTHEMATA MARYLANDICA	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA STRIATULA	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA DEPRESSA	.	.	.	.	.	.	X	.	.	.	.
BUCCELLA HANNAI	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA MANSFIELDI	.	X	.	.	.	.	.	.	.	.	.
BUCCELLA PARKERAE	.	.	.	.	.	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	.	X	X	X	.	.	.	.
CASSIDULINA LAEVIGATA CARINATA	.	.	.	.	.	.	.	.	.	.	.
CIBICIDES LOBATULUS	.	.	.	.	X	.	.	.	.	.	.
CIBICIDES SUBLOBUS	.	.	.	.	.	.	.	.	.	.	.
CLITHROCYTHERIDEA DIAGONALIS	.	.	.	.	X	.	.	.	.	.	.
CLITHROCYTHERIDEA VIRGINIENSIS	.	.	.	X	.	.	.	.	.	.	.
CUSHMANIDEA ULRICHI	.	.	.	.	.	.	.	.	.	.	.
CYTHERETTA ULRICHI	.	.	X	.	.	.	.	.	.	.	.
CYTHEROPTERON TALQUINENSIS	.	.	X	.	.	.	.	.	.	.	.
DISCORBIS CONSOBRINA	.	.	.	.	.	.	.	.	.	.	.
DISCORBIS FLORIDANA	.	.	.	.	.	.	.	.	.	.	.
DYOCIBICIDES PERFORATUS	.	.	.	.	.	.	.	.	.	.	.
ECHINOCYTHEREIS CLARKANA	.	.	X	.	.	.	.	.	.	.	.
ELPHIDIUM FLORENTINAE	.	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM INCERTUM	.	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. E	.	.	.	.	.	.	.	.	.	.	.
GUTTULINA PSEUDOCOSTATULA	.	.	.	.	.	.	.	.	.	.	.
HANZAWAIA CONCENTRICA	.	.	.	.	.	.	.	.	.	.	.
LOXOCONCHA PURISUBRHOMBOIDEA	.	.	X	.	.	.	X	.	.	.	.
MURRAYINA BARCLAYI	.	.	.	.	.	.	.	.	.	.	.
MURRAYINA GUNTERI	.	.	.	.	.	.	.	.	.	.	.
MURRAYINA HOWEI	.	.	.	.	.	.	.	.	.	.	.
MURRAYINA MARTINI	.	.	X	.	.	.	.	.	.	.	.
NONION GRATELOUPI D ORBIGNY	.	.	.	.	.	.	.	.	.	.	.
NONION MEDIOCOSTATUS	.	X	X	.	.	X	X	X	.	.	.
NONION PIZARRENSIS	.	.	X	.	.	X	X	X	.	.	.
INDETERMINATE NONION	.	.	.	.	.	.	.	.	.	.	.
NONIONELLA AURIS	.	.	.	.	.	.	.	.	.	.	.
PLANULINA DEPRESSA	.	.	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA SEMINULA	.	.	.	.	.	.	.	.	.	.	.
ROBULUS AMERICANUS	.	.	.	.	X	X	X	.	.	.	.
HISPID SIGMOMORPHINAS	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA ARTICULATA	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA EUSTISENSIS	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA GRAMEN	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA OBLIQUA	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA PSEUDOBLIQUA	.	.	X	.	.	.	.	.	.	.	.
TEXTULARIA YORKTOWNENSIS	.	.	.	.	.	.	.	.	.	.	.
WOOD FRAGMENTS	.	.	.	.	.	.	.	.	.	.	.
ECHINOID SPINES	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA SP.	.	.	X	.	.	.	.	.	.	.	.
GAUDRYINA SP.	.	.	.	.	X	X	X	.	.	.	.
OSTRACOD SP.	.	.	.	.	.	.	.	X	.	.	.

Well 3-S

(Total depth: 160 feet)

Depth (Feet below mean low water)	Sample Description
85.0	Granules and small pebbles; mainly coarse to medium sand with some fine sand; trace of glauconite; shell fragments; black coal-like grains.
95.0	Mainly fine sand with some brown-tan clay and mica; decayed shell fragments; Foraminifera; Ostracoda.
105.0	Similar to 95.0′ except much shell material; balanid fragments; echinoid spines; many Ostracoda and a few Foraminifera.
115.0	Similar to 95.0′ except more clay; little shell material; many echinoid spines; Foraminifera; Ostracoda.
125.0	Similar to 95.0′ except no Foraminifera or Ostracoda.
135.0	Similar to 125.0′ except a few Foraminifera and some coarse grains; no Ostracoda.
145.0	Flaky, silty, sandy, gray clay; sandstone fragments; a little decayed shell material; some coarse material and a little fine sand; no Foraminifera or Ostracoda.
155.0	Gray-brown clay and fine sand with some pebble-size to medium-sand-size grains; pyritic fragments; venerid shell fragments; pecten fragment; pyritic Foraminifera; no Ostracoda; some mica.
160.0	Mainly plastic brown clay with much fine sand; some pyritic fragments; mica; echinoid fragments; shell fragments; crab claw tip; Ostracoda; pyritic Foraminifera.

List of species in well 3-S, Coleman Bridge section. Fossil occurrences are indicated at appropriate depths in feet below mean low water.

	-85.0	-95.0	-105.0	-115.0	-125.0	-135.0	-145.0	-155.0	-160.0
ACTINOCYTHEREIS EXANTHEMATA GOMILLIONENSIS	.	.	X	.	.	.	.	.	.
ACTINOCYTHEREIS EXANTHEMATA MARYLANDICA	.	.	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	.	.	.	.	.	.
BOLIVINA STRIATULA	.	.	.	.	.	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	X	.	.	.	.	.
BUCCELLA DEPRESSA	.	.	.	.	.	.	.	.	.
BUCCELLA HANNAI	.	.	.	.	.	X	.	.	.
BUCCELLA PARKERAE	.	.	X	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	.	.	.	.	.	.
CASSIDULINA LAEVIGATA CARINATA	.	.	.	.	.	.	.	.	.
CIBICIDES SUBLOBUS	.	.	.	.	.	.	.	.	.
CLITHROCYTHERIDEA DIAGONALIS	.	X	X	X	.	.	.	.	.
CLITHROCYTHERIDEA VIRGINIENSIS	.	.	.	.	.	.	.	.	.
CUSHMANIDEA ULRICHI	.	.	X	.	.	.	.	.	.
CYTHERETTA ULRICHI	.	.	X	.	.	.	.	.	.
CYTHEROPTERON TALQUINENSIS	.	.	.	.	.	.	.	.	.
DISCORBIS CONSOBRINA	.	.	.	.	.	.	.	.	.
DISCORBIS FLORIDANA	.	.	.	.	.	.	.	.	.
DYOCIBICIDES PERFORATUS	.	.	.	.	.	.	.	.	.
ECHINOCYTHEREIS CLARKANA	.	.	.	X	.	.	.	.	.
ELPHIDIUM FLORENTINAE	.	.	.	.	.	.	.	.	.
ELPHIDIUM INCERTUM	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. E	.	.	.	.	.	.	.	.	.
GUTTULINA PSEUDOCOSTATULA	.	.	.	.	.	.	.	.	.
HANZAWAIA CONCENTRICA	.	.	.	.	.	.	.	.	.
LOXOCONCHA PURISUBRHOMBOIDEA	.	X	.	.	.	.	.	.	.
MURRAYINA BARCLAYI	.	.	.	.	.	.	.	.	.
MURRAYINA GUNTERI	.	.	.	.	.	.	.	.	.
MURRAYINA HOWEI	.	.	X	X	.	.	.	.	.
MURRAYINA MARTINI	.	.	X	.	.	.	.	.	.
NONION GRATELOUPI D ORBIGNY	.	.	.	.	.	.	.	.	.
NONION MEDIOCOSTATUS	.	.	X	X	.	X	.	X	X
NONION PIZARRENSIS	.	.	X	X	.	X	.	X	X
INDETERMINATE NONION	.	.	.	.	.	.	.	.	.
NONIONELLA AURIS	.	.	.	.	.	.	.	X	.
PLANULINA DEPRESSA	.	.	.	.	.	.	X	.	.
QUINQUELOCULINA SEMINULA	.	.	.	.	.	.	.	.	.
ROBULUS AMERICANUS	.	.	.	X	.	.	.	.	.
HISPID SIGMOMORPHINAS	.	.	.	.	.	.	.	.	.
TEXTULARIA ARTICULATA	.	.	.	.	.	.	.	.	.
TEXTULARIA EUSTISENSIS	.	.	.	.	.	.	.	.	.
TEXTULARIA GRAMEN	.	.	.	.	.	.	.	.	.
TEXTULARIA OBLIQUA	.	.	.	.	.	.	.	.	.
TEXTULARIA PSEUDOBLIQUA	.	.	.	.	.	X	.	.	X
TEXTULARIA YORKTOWNENSIS	.	.	.	.	.	.	.	.	.
WOOD FRAGMENTS	.	.	.	.	.	.	.	.	.
ECHINOID SPINES	.	.	X	X	X	.	.	.	.
CYTHERETTA ? SP.	.	.	X	.	.	.	.	.	.
TEXTULARIA SP.	.	X	.	.	.	.	.	.	.
OSTRACOD SP.	.	.	.	.	.	.	.	X	.
CRAB CLAW	.	.	.	.	.	.	.	X	.

Well 1-NE

(Total depth: 200 feet)

Depth (Feet below mean low water)	Sample Description
89	Much coarse, clear, violet, milky sand and also same in medium to fine sands; trace of organic (?) black grains.
99	Coarse to fine clear sand with a few pale-purple and blue grains; some brown clay.
108	Very fine sand and gray clay; Foraminifera; shell fragments.
114	Fine sand trace; a few coarse violet and blue grains; mainly gray unctuous clay; shell fragments; Ostracoda; mica.
124	Mainly fine clear sand with much gray-brown clay and many decayed shell fragments; Foraminifera.
134	Gray clay and fine clear sand with black grains (glauconite?); plant fragments.
144	Gray-brown clay with much fine clear sand; mica flakes; a few fragments of shell.
154	Gray-brown clay and very fine clear sand; shell fragments; mica flakes.
164	Fine sand and clay; Foraminifera; shell fragments; minute mica flakes.
174	Gray-brown silty clay and very fine clear sand; mica flakes; Foraminifera; shell and shell fragments.
184	Reddish-brown to gray, silty, sandy clay-shale.
194	Sandy, plastic, gray-brown clay.
200	Similar to 194′ except more shaly; shell fragments.

List of species in well 1-NE, Coleman Bridge section. Fossil occurrences are indicated at appropriate depths in feet below mean low water.

	-89	-99	-108	-114	-124	-134	-144	-154	-164	-174	-184	-194	-200
ACTINOCYTHEREIS EXANTHEMATA GOMILLIONENSIS	.	.	.	.	.	.	.	.	.	.	.	.	.
ACTINOCYTHEREIS EXANTHEMATA MARYLANDICA	.	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	.	X	.	.	.	X	X	X	.	.
BOLIVINA STRIATULA	.	.	.	.	.	.	.	.	X	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA DEPRESSA	.	.	X	.	X	.	.	.	.	X	X	.	.
BUCCELLA HANNAI	.	.	.	.	.	.	.	.	.	.	.	X	.
BUCCELLA PARKERAE	.	.	.	.	.	.	.	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	.	X	.	.	X	X	X	X	X	.
CASSIDULINA LAEVIGATA CARINATA	.	.	.	.	.	.	.	.	X	.	.	X	.
CIBICIDES SUBLOBUS	.	.	.	.	.	.	.	.	.	.	.	.	.
CLITHROCYTHERIDEA DIAGONALIS	.	.	.	.	.	.	.	.	.	.	.	X	.
CLITHROCYTHERIDEA VIRGINIENSIS	.	.	.	.	.	.	.	.	.	.	.	.	.
CUSHMANIDEA ULRICHI	.	.	.	.	.	.	.	.	.	.	.	.	.
CYTHERETTA ULRICHI	.	.	.	.	.	.	.	.	.	.	.	.	.
CYTHEROPTERON TALQUINENSIS	.	.	.	.	.	.	.	.	.	.	.	.	.
DISCORBIS CONSOBRINA	.	.	.	.	.	.	.	.	.	.	.	.	.
DISCORBIS FLORIDANA	.	.	.	.	.	.	.	.	.	.	.	.	.
DYOCIBICIDES PERFORATUS	.	.	.	.	.	.	.	.	.	.	.	.	.
ECHINOCYTHEREIS CLARKANA	.	.	.	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM FLORENTINAE	.	.	.	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM INCERTUM	.	.	.	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. E	.	.	.	.	.	.	.	.	.	.	.	X	.
GUTTULINA PSEUDOCOSTATULA	.	.	.	.	.	.	.	.	.	.	.	.	.
HANZAWAIA CONCENTRICA	.	.	.	.	.	.	.	.	.	.	.	.	.
LOXOCONCHA PURISUBRHOMBOIDEA	.	.	.	.	.	.	.	.	.	.	.	.	.
MURRAYINA BARCLAYI	.	.	.	.	.	.	.	.	.	.	.	.	.
MURRAYINA GUNTERI	.	.	.	.	.	.	.	.	.	.	.	.	.
MURRAYINA HOWEI	.	.	X	.	.	.	.	.	.	.	.	X	.
MURRAYINA MARTINI	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION GRATELOUPI D ORBIGNY	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION MEDIOCOSTATUS	.	.	X	.	.	.	.	X	X	X	X	X	.
NONION PIZARRENSIS	.	.	X	.	.	.	.	X	X	X	X	X	.
INDETERMINATE NONION	.	.	.	.	.	.	.	.	.	.	.	.	.
NONIONELLA AURIS	.	.	.	.	.	.	.	X	X	.	.	.	.
PLANULINA DEPRESSA	.	.	.	.	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA SEMINULA	.	.	.	.	.	.	.	.	.	.	.	.	.
ROBULUS AMERICANUS	.	.	.	.	.	.	.	.	.	.	.	X	.
HISPID SIGMOMORPHINAS	.	.	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA ARTICULATA	.	.	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA EUSTISENSIS	.	.	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA GRAMEN	.	.	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA OBLIQUA	.	.	.	.	.	.	.	.	.	.	X	X	.
TEXTULARIA PSEUDOBLIQUA	.	.	.	.	.	.	.	.	.	X	.	.	.
TEXTULARIA YORKTOWNENSIS	.	.	X	.	X	.	.	.	.	.	.	.	.
WOOD FRAGMENTS	.	.	.	.	.	.	.	.	.	.	.	.	.
ECHINOID SPINES	.	.	.	.	.	.	.	.	.	.	X	.	.
GASTROPOD SP.	.	.	.	.	.	.	.	X	.	.	.	.	.
ROBULUS SP.	.	.	.	.	.	.	.	.	.	.	.	X	.
PYRGO DENTICULATA	.	.	.	.	.	.	.	.	.	X	.	.	.

Well 1-NW

(Total depth: 158 feet)

Depth (Feet below mean low water)	Sample Description
88.5	Very coarse to fine sand; 10% pebble- to granule-size material; a little gray clay; glauconite nodules; violet quartz grains.
98.5	Mainly pebbles to very coarse sand; a few glauconite nodules.
118.5	Fine sand with 15% tan-gray clay, much decayed shell material; balanid fragments; echinoid spines; Foraminifera; numerous Ostracoda; mica.
128.5	Fine sand and some tan-gray clay; trace of decayed shell; echinoid spines; Foraminifera; Ostracoda; mica.
138.5	Fine sand and 15% brown-gray clay; a few medium-coarse grains; mica; no fossils.
148.5	Plastic gray-brown clay and fine sand; a few decayed shell fragments; no Foraminifera or Ostracoda.
158.5	Plastic gray-brown clay with mica and fine sand; shell fragments; pyritized Foraminifera; one ostracod; turritellid fragment.

List of species in well 1-NW, Coleman Bridge section. Fossil occurrences are indicated at appropriate depths in feet below mean low water.

	-88.5	-98.5	-118.5	-128.5	-138.5	-148.5	-158.5
ACTINOCYTHEREIS EXANTHEMATA GOMILLIONENSIS	.	.	X	.	.	.	.
ACTINOCYTHEREIS EXANTHEMATA MARYLANDICA	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	.	.	.	.
BOLIVINA STRIATULA	.	.	.	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	.	.	.	.
BUCCELLA DEPRESSA	.	.	X	X	.	.	.
BUCCELLA HANNAI	.	.	.	.	.	.	.
BUCCELLA PARKERAE	.	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	.	.	X	.
CASSIDULINA LAEVIGATA CARINATA	.	.	.	.	.	.	.
CIBICIDES SUBLOBUS	.	.	.	.	.	.	.
CLITHROCYTHERIDEA DIAGONALIS	.	.	X	X	.	.	.
CLITHROCYTHERIDEA VIRGINIENSIS	.	.	.	.	.	.	.
CUSHMANIDEA ULRICHI	.	.	.	X	.	.	.
CYTHERETTA ULRICHI	.	.	X	.	.	.	.
CYTHEROPTERON TALQUINENSIS	.	.	.	.	.	.	.
DISCORBIS CONSOBRINA	.	.	.	.	.	.	.
DISCORBIS FLORIDANA	.	.	.	.	.	.	.
DYOCIBICIDES PERFORATUS	.	.	.	.	.	.	.
ECHINOCYTHEREIS CLARKANA	.	.	X	X	.	.	.
ELPHIDIUM FLORENTINAE	.	.	.	.	.	.	.
ELPHIDIUM INCERTUM	.	.	.	.	.	.	.
GLOBIGERINA SP. E	.	.	.	.	.	.	.
GUTTULINA PSEUDOCOSTATULA	.	.	.	.	.	.	.
HANZAWAIA CONCENTRICA	.	.	.	.	.	.	.
LOXOCONCHA PURISUBRHOMBOIDEA	.	.	X	.	.	.	.
MURRAYINA BARCLAYI	.	.	.	X	.	.	.
MURRAYINA GUNTERI	.	.	X	.	.	.	.
MURRAYINA HOWEI	.	.	X	X	.	X	.
MURRAYINA MARTINI	.	.	.	X	.	.	.
NONION GRATELOUPI D ORBIGNY	.	.	.	.	.	.	.
NONION MEDIOCOSTATUS	.	.	X	X	.	X	.
NONION PIZARRENSIS	.	.	X	.	.	X	.
INDETERMINATE NONION	.	.	.	.	.	.	.
NONIONELLA AURIS	.	.	.	.	.	X	.
PLANULINA DEPRESSA	.	.	.	.	.	.	.
QUINQUELOCULINA SEMINULA	.	.	.	.	.	.	.
ROBULUS AMERICANUS	.	.	.	.	.	.	.
HISPID SIGMOMORPHINAS	.	.	.	.	.	.	.
TEXTULARIA ARTICULATA	.	.	.	.	.	.	.
TEXTULARIA EUSTISENSIS	.	.	.	.	.	.	.
TEXTULARIA GRAMEN	.	.	.	.	.	.	.
TEXTULARIA OBLIQUA	.	.	.	.	.	.	.
TEXTULARIA PSEUDOBLIQUA	.	.	.	.	.	X	.
TEXTULARIA YORKTOWNENSIS	.	.	.	.	.	.	.
WOOD FRAGMENTS	.	.	.	.	.	.	.
ECHINOID SPINES	.	.	.	.	.	.	.
GASTROPOD SP.	.	.	.	.	.	X	.
TEXTULARIA SP.	.	.	.	X	.	.	.

Well 3-N

(Total depth: 160 feet)

Depth (Feet below mean low water)	Sample Description
75	Mainly plastic gray clay and some coarse, medium, and fine clear sand; a few dark glauconite (?) grains; a few light-blue and milky quartz grains; small Foraminifera.
85	Mainly clear fine sand and some gray-brown clay; trace of carbonaceous material; trace of glauconite; Foraminifera; a few medium-coarse, purple and blue quartz grains.
95	Mainly brown silty clay with much fine clear sand; trace of green glauconite; a bit of charred wood.
105	Much very coarse clear, milky, and violet sand with some small granule-size grains; mainly medium, clear sand; a little glauconite.
115	Mainly soft brown clay with much silt and very fine sand; shell fragments and a shell; mica flake.
125	Similar to 115′ except grayer and with Miocene or younger Foraminifera and shell fragments in better preservation.
135	Mainly very fine clear sand and brown clay; mica flakes; echinoid spines; small Foraminifera.
145	Similar to 135′ except more clay; much badly decayed shell material; no echinoid spines or Foraminifera.
155	Very sandy and silty brown-gray clay with a very few shell fragments.
160	Similar to 155′ except more decayed shell fragments.

List of species in well 3-N, Coleman Bridge section. Fossil occurrences are indicated at the appropriate depths in feet below mean low water.

	-75	-85	-95	-105	-115	-125	-135	-145	-155	-160
ACTINOCYTHEREIS EXANTHEMATA GOMILLIONENSIS	.	.	.	.	.	.	.	.	.	.
ACTINOCYTHEREIS EXANTHEMATA MARYLANDICA	.	.	.	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	.	.	.	.	.	.	.
BOLIVINA STRIATULA	.	.	.	.	.	.	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	.	.	.	.	.	.	.
BUCCELLA DEPRESSA	X	.	.	.	.	X	X	X	X	X
BUCCELLA HANNAI	.	.	.	.	.	X	.	.	.	.
BUCCELLA PARKERAE	.	.	.	.	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	.	X	.	.	X	X	X
CASSIDULINA LAEVIGATA CARINATA	.	.	.	.	.	.	.	.	.	.
CIBICIDES SUBLOBUS	.	.	.	.	.	.	.	.	.	.
CLITHROCYTHERIDEA DIAGONALIS	.	.	.	.	.	.	.	.	.	.
CLITHROCYTHERIDEA VIRGINIENSIS	.	.	.	.	.	.	.	.	.	.
CUSHMANIDEA ULRICHI	.	.	.	.	.	.	.	.	.	.
CYTHERETTA ULRICHI	.	.	.	.	.	.	X	.	.	.
CYTHEROPTERON TALQUINENSIS	.	.	.	.	.	.	.	.	.	.
DISCORBIS CONSOBRINA	.	.	.	.	X	.	.	.	.	.
DISCORBIS FLORIDANA	.	.	.	.	.	.	X	.	.	.
DYOCIBICIDES PERFORATUS	.	.	.	.	.	X	.	.	.	.
ECHINOCYTHEREIS CLARKANA	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM FLORENTINAE	X	.	.	.	.	.	.	.	.	.
ELPHIDIUM INCERTUM	X	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. E	.	.	.	.	.	.	.	.	.	.
GUTTULINA PSEUDOCOSTATULA	.	.	.	.	X	.	.	.	.	.
HANZAWAIA CONCENTRICA	.	.	.	.	X	.	.	.	.	.
LOXOCONCHA PURISUBRHOMBOIDEA	.	.	.	.	.	.	.	.	.	.
MURRAYINA BARCLAYI	.	.	.	.	.	.	.	.	.	.
MURRAYINA GUNTERI	.	.	.	.	.	.	.	.	.	.
MURRAYINA HOWEI	.	.	.	.	.	.	X	.	.	.
MURRAYINA MARTINI	.	.	.	.	.	.	X	.	.	.
NONION GRATELOUPI D ORBIGNY	.	.	.	.	.	.	.	X	X	.
NONION MEDIOCOSTATUS	.	.	.	.	X	X	X	X	.	.
NONION PIZARRENSIS	.	.	.	.	X	X	X	.	X	X
INDETERMINATE NONION	X	.	X	.	.	.	.	.	.	.
NONIONELLA AURIS	.	.	.	.	.	.	.	.	.	.
PLANULINA DEPRESSA	.	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA SEMINULA	.	.	.	.	.	.	.	.	.	.
ROBULUS AMERICANUS	.	.	.	.	.	.	.	.	.	.
HISPID SIGMOMORPHINAS	.	.	.	.	.	.	.	.	X	.
TEXTULARIA ARTICULATA	.	.	X	.	.	.	.	.	.	.
TEXTULARIA EUSTISENSIS	.	.	.	.	.	.	.	.	.	.
TEXTULARIA GRAMEN	.	.	.	.	X	.	.	.	.	.
TEXTULARIA OBLIQUA	.	.	.	.	.	.	.	.	.	.
TEXTULARIA PSEUDOBLIQUA	.	.	.	.	.	.	.	.	.	.
TEXTULARIA YORKTOWNENSIS	.	.	.	.	.	X	X	.	.	.
WOOD FRAGMENTS	.	X	X	.	.	.	.	.	.	.
ECHINOID SPINES	.	.	.	.	.	.	X	.	.	.
ROBULUS ? SP.	.	.	.	.	.	X	.	.	.	.
TROCHAMMINA ? SP.	.	.	.	.	X	.	.	.	.	.
QUINQUELOCULINA SP.	.	.	.	.	.	X	.	.	.	.
BUCCELLA SP.	.	.	.	.	.	.	.	X	.	.

WELL NEAR NEWPORT NEWS (WELL A-11)

Located near Newport News, Virginia, 520 feet offshore from U. S. bulkhead line and 30 feet off Pier 3 of the Chesapeake and Ohio Railway; long 76°26′08″W. and lat 36°58′18″N. Hammer-drive test samples. Total depth: 400 feet. See Figure 6 for list of species.

Depth (Feet below mean low water)	Sample Description
45.0-46.5	85% brown plastic clay; 15% fine to medium, rounded sand; coal (?) fragments.
50.0-51.5	95% brown plastic clay; 5% rounded fine sand; barnacle fragment.
52.0-53.5	85% brown plastic clay; 15% angular to rounded, medium to fine sand; trace of glauconite; trace of coarse sand; shell fragments; mica; black grains; plant debris.
58.0-60.0	85% brown plastic clay; 5% silt; 10% mainly medium to fine sand; mica flakes; trace of shell fragments; trace of black grains; plant debris.
65.0-66.5	95% brown, plastic, silty, micaceous clay; 5% fine to medium sand; traces of rotten shell material, coarse sand, and iron grains.
70.0-71.5	90% clay as above; 10% fine sand and some black glauconite; trace of medium-coarse sand.
75.0-75.5	85% brown, plastic, slightly silty clay; 15% medium-fine sand with some chert and coarse grains.
80.0-81.5	95% gray-tan plastic, silty, sandy, micaceous clay; 5% fine sand; plant debris.
85.0-86.5	75% brown, flaky, clayey, micaceous silt; 25% medium to fine sand; trace of rotten shell; some coarse sand grains.
90.0-91.5	85% brown silty clay; 15% fine to medium-coarse sand; mica; trace of glauconite; plant debris.
95.0-96.5	Mainly small gravel and broken shell material; about 10% brown silty clay and 20% fine to coarse sand; gastropod shell.
100.0-101.5	70% brown plastic clay; 30% coarse to fine sand and small gravel; shell fragments; black grains; plant debris.
105.0-106.5	95% brown-tan plastic clay; 5% fine to medium sand with glauconite and limonite grains; plant debris.
110.0-111.5	Sandy brown-tan plastic clay with traces of glauconite and limonite; plant debris.
120.0-121.5	Mainly fine sand with lumps of fine sandstone and larger gravel (quartz); shell fragments; glauconite grains; trace of clay.
125.0	Subangular quartz gravel and shell fragments with fine sand and glauconite; 15% clay; hematite granule.
130.0-131.5	Fine sand and yellow-tan clay; glauconite grains.
135.0-136.5	90% plastic brown clay; 10% fine to medium sand; black grains; shell fragments.
140.0-141.5	80% plastic brown clay; 20% fine to medium sand.

145.0-146.5	40% brown plastic clay; 10% fine sand; 50% shell fragments.
150.0-151.5	50% brown plastic clay; 10% fine sand; 40% shell fragments.
155.0-156.5	Calcareous fine sandstone and shell fragments; black grains.
157.0-158.0	Core. Similar to 155.0-156.5′ except a little light-tan clay.
160.0-161.5	80% plastic brown clay; 20% fine sand, sandstone, and shell fragments.
165.0-166.0	90% plastic brown clay; 10% fine sand and shell fragments; Foraminifera.
170.0-171.5	40% plastic brown clay; 60% fine sand; a few shell fragments; one echinoid spine fragment and a mica flake.
175.0-176.5	60% plastic brown clay; 40% fine sand; mica flakes; very few shell fragments; Foraminifera.
180.0-181.5	Similar to 175.0-176.5′ but with a little glauconite.
185.0-186.5	50% plastic brown clay; 50% fine sand; glauconite; mica flakes; shell fragments; echinoid spine fragment.
190.0-191.5	70% plastic brown clay; 30% fine sand; little shell material, mica, or glauconite.
195.0-196.5	30% plastic brown clay; 70% fine sand; numerous echinoid spine fragments.
200.0-200.1	80% brown clay; 20% fine sand; very few fragments of shell material and glauconite.
205.0-206.5	40% brown clay; 60% fine sand; glauconite grains and a few shell fragments; gypsum.
210.0-211.5	30% brown clay; 70% fine sand; glauconite; shell fragments; an echinoid spine fragment; gypsum.
215.0-216.5	95% mottled gray and brown plastic clay; 5% very fine sand; gypsum.
220.0-221.5	Similar to 215.0-216.5′ except contains more gypsum.
225.0-226.5	90% mottled gray and brown plastic clay; 10% very fine sand; gypsum; plant debris.
230.0-231.5	Mottled tan and brown, plastic, sandy clay; gypsum.
235.0-236.5	Similar to 230.0-231.5′ except 15% sand; gypsum.
240.0-241.5	90% brown plastic clay; 10% fine sand; gypsum.
245.0-246.5, 250.0-251.5	95% brown plastic clay; 5% fine sand; some mica.
255.0-256.5	Similar to 245.0-246.5′ except clay is a darker brown.
260.0-261.5, 265.0-266.5	Similar to 245.0-246.5′ except clay is yellow to brown and mottled; gypsum crystals.
270.0-271.5	Similar to 260.0-261.5′ except a few medium-coarse grains.
275.0-276.5	Similar to 270.0-271.5′ except shell fragments and gastropods.
280.0-281.5	Slightly sandy, brown, plastic clay.
285.0-286.5, 290.0-291.5, 295.0-296.5, 300.0-301.5, 310.0-311.5, 315.0-316.5, 320.0-321.5	Slightly sandy, gray and brown, blocky, plastic clay with a little mica.

325.0-326.5	Similar to 285.0-286.5′ except clay is all gray.
330.0-331.5,	
335.0-336.5,	
340.0-341.5,	
345.0-346.5,	
350.0-351.5,	
355.0-356.5,	
360.0-361.5,	
365.0-366.5	Similar to 285.0-286.5′ except clay is brown and gray.
370.0-371.5	Similar to 330.0-331.5′ except with white flakes and shell fragment.
375.0-376.5	Similar to 370.0-371.5′ except clay is all gray.
380.0-381.5	Similar to 375.0-376.5′ except clay is brown and gray.
385.0-386.5	Similar to 380.0-381.5′ except clay is darker brown.
390.0-391.5,	
395.0-396.5,	
398.5-400.0	Similar to 385.0-386.5′ except clay is all dark brown.

WELL AT LAMBERT POINT (WELL A-5)

Located at general cargo pier at Lambert Point, near Norfolk, Virginia; long 76°18′54″W. and lat 36°51′48″N. Total depth: 400 feet. See Figure 6 for list of species.

Depth (Feet)	Sample Description
7	Dark-gray clayey fine sand.
10, 15, 18	Dark-gray silty clay; trace of fine sand.
20, 25, 30,	
35, 40, 45,	
50, 52, 55,	
59	Dark-gray silty clay.
60, 61	Black organic matter; trace of fine sand.
64	Void (natural gas reported by driller).
65, 70	Gray silty fine to medium sand; trace of organic matter.
75, 79	Gray, clayey, fine to medium sand.
80, 82	Gray coarse sand and shell; trace of silt.
85	Gray silty fine sand; trace of shell.
95	Gray clayey fine sand; trace of shell.
110	Gray fine sandy clay; trace of shell.
115	Gray silty fine sand.
130	Gray clayey fine sand.
135	Gray silty plastic clay.
185	Gray fine sandy clay; trace of shell.
200	Gray fine sandy clay; no shell.
215	Gray clayey fine sand.
220	Gray fine sandy clay.
225	Gray clayey fine sand.
245	Gray fine sandy clay.
250	Gray silty clay; trace of shell.
255-400	Gray silty plastic clay.

CHESAPEAKE BAY BRIDGE-TUNNEL WELLS

The Chesapeake Bay Bridge-Tunnel connects Wise Point on the Eastern Shore with Chesapeake Beach in the City of Virginia Beach.

Well A-1

(Total depth: 262 feet; see Figure 7 for list of species)

Depth (Feet below mean low water)	Sample Description
55	30% brown clay; 70% fine sand with mica flakes and black (glauconite?) grains.
68	Similar to 55′ with broken shell material.
84	Shelby tube: fine clayey sand and sandstone lumps with fine black grains.
93	5% greenish-brown clay-silt; rest fine sand; a little shell material; black grains; mica flakes.
103	Similar to 93′ except 45% clay-silt.
113	Similar to 93′ except 60% clay-silt.
123	Similar to 113′ except no shell fragments.
132	Similar to 93′ except 80% clay-silt.
142	Similar to 93′ except 40% clay-silt.
152	Similar to 93′ except 60% clay-silt; few very coarse grains or granules.
161	Fine sand and shell material; few calcareous sandstone lumps; black (glauconite?) grains.
171	Fine sand with 30% brown clay; shell fragments; mica; black grains.
181	Similar to 171′ except 40% clay-silt.
191	Similar to 181′ except 50% light gray-tan clay.
202	Shelby tube: similar to 191′ except 60% clay.
210	Similar to 191′ except 40% tan clay; shell fragments.
222	Similar to 210′ except 60% tan-gray clay.
230	Similar to 210′ except 70% tan clay; more black grains than above.
239	White and tan clay; fine sand; medium to coarse grains.
262	Light-gray clay and fine sand; lumps of fine calcareous sandstone and shell fragments.

Well A-2

(Total depth: 295 feet; see Figure 7 for list of species)

Depth (Feet below mean low water)	Sample Description
48	10% gray-tan clay; 90% fine sand; mica flakes; black grains.
59	30% gray and yellow-tan clay, 70% coarse to fine sand.
60	20% gray and yellow-tan clay; 80% coarse to fine sand; a few gravel/granule grains.

70	Similar to 60′ except all sand is fine; mica flakes; shell fragments.
81, 90	70% tan-brown clay; 30% very fine sand; mica flakes; shell fragments.
101	Similar to 81′ except more shell fragments.
113	Shell bed with sandy glauconitic clay.
120	First sample: fine, calcareous, shelly sandstone with black grains and some fine sand.
120	Second sample: 85% fine sand; 15% brown clay; black grains.
130	Sandstone and fine sand.
146	Fine clayey sand and rotten shell; black grains.
158	40% tan clay; 60% very fine sand; mica flakes; shell fragments.
161	Sandy, tan-gray, plastic clay.
168	Shelby tube: rotten shell material and fine clayey sand; barnacle plates.
180	Fine sand with rotten shell material and a few granule/gravel grains; black grains.
181	Similar to 180′ except 10% brown clay and numerous black glauconite grains.
192	20% brown clay; 80% fine sand; mica flakes; shell fragments; black grains.
201	60% yellow-tan clay; 40% fine sand; mica; black grains.
215.5	Shelby tube: 50% gray-tan clay; 50% fine sand; mica; black grains.
224	Gray and brown sandy clay with black grains and mica flakes.
	Note: Samples missing at 250, 258, 265, 275, 285, and 295 feet.

Well M-62

Depth (Feet below mean low water)	Sample Description
33.5-35.0	Firm grayish-brown fine sand.
39.0-40.5,	
44.0-45.5,	
49.0-50.5	Firm gray fine sand; trace of shells.
54.0-55.5,	
59.0-60.5	Firm gray fine sand with traces of silt and shells .
64.0-65.5	Loose gray fine sand; some silt; trace of shells.
69.0-70.5,	
74.0-75.5	Firm gray fine sand; traces of silt and shells.
79.0-81.5	Firm gray fine sand; trace of shells.
85.5-87.0	Gray fine sand; trace of silt.
95.0-96.5	Gray fine sand; trace of silt and shells.
103.5-105.0	Gray silty clay; trace of fine sand; foul odor.
109.0-111.0	Soft gray clayey silt.
114.0-116.0	Soft gray clayey silt; trace of sand and shells.
122.0-124.0	Soft gray clayey silt; traces of sand and shells.

129.0-130.5,	
134.0-135.5	Soft gray clayey silt; some sand; trace of shells.
139.0-140.5	Soft gray clayey silt, with traces of sand and shells.
144.0-145.5,	
149.0-150.5,	
154.0-155.5	Soft gray silty clay; trace of sand and shells.
161.0-162.5	Soft dark-gray clay; traces of silt and fine sand.
166.0-167.5	Similar to 161.0-162.5′ except bottom 3 in. is gray silty clay; some sand.
171.0-172.5	Very compact greenish-gray fine sand; trace of silt.
174.5-176.0,	
179.5-181.0	Very compact fine to medium sand; some coarse.

List of species in well M-62, Chesapeake Bay Bridge-Tunnel. Fossil occurrences are indicated at appropriate depths in feet below mean low water.

	-33	-44	-49	-54	-59	-64	-69	-95	-103	-109	-129	-134	-139	-144	-179
ELPHIDIUM FLORENTINAE	.	X	.	X	X	X	.	X	X	.	X	X	.	.	X
CYTHERETTA ULRICHI	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA SP.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
DIATOMS	.	.	.	.	.	.	.	.	X	.	X	.	X	.	X
BUCCELLA DEPRESSA	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
GLOBULINA SP. BROKEN	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
ELPHIDIUM CLAVATUM	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.

Well M-63

Depth (Feet below mean low water)	Sample Description
50.0-51.5	Loose gray fine sand; traces of shells and silt.
54.5-56.0	Compact gray fine sand; traces of shells and silt.
59.5-61.0	Similar to 54.5-56.0′ except sand is medium compact.
64.0-65.5	Failure.
65.5-67.0	Top spoon: gray silty clay; traces of fine sand. Bottom spoon: gray fine sand; traces of silt.
69.0-70.5	Gray fine sand; traces of silt and clay.
73.5-75.0	Gray fine sand; traces of clay and silt.
78.5-80.0	Gray fine sand; traces of clay, silt, and shells.
83.5-85.0	Gray fine sand; traces of clay, silt, and shells.
88.5-90.0	Greenish-gray fine sand; traces of silt, clay, and shells.
93.5-95.0	Greenish-gray fine sand; traces of silt, clay, and shells.
98.5-100.0	Greenish-gray clayey silt; some fine sand; odor.
103.5-105.0	Greenish-gray silty clay; traces of fine sand and shells; odor.
108.5-110.0	Greenish-gray clayey silt; some fine sand; traces of shells.
113.5-115.0	Greenish-gray silty fine sand; some clay; traces of shell.

118.5-120.0	No recovery.
120.0-121.5	Greenish-gray silty fine sand; some clay; trace of shells.
124.5-126.0	Greenish-gray sandy silt; some clay; traces of shells.
129.5-131.0	Greenish-gray silty sand; some clay; traces of shell.
134.5-136.0	Greenish-gray fine sandy silt; some clay; traces of shell.
139.5-141.0, 144.5-146.0	Greenish-gray clayey silt; traces of fine sand and shells.
149.5-151.0	Medium-gray silty clay; some fine sand; thin seams of fine sand.
154.5-156.0	Similar to 149.5-151.0′ except traces of shells.
159.5-161.0	Top 6″: greenish-gray fine sand; some clay; traces of shells. Bottom 12″: medium-compact, greenish-gray, fine sand; traces of silt.
164.5-166.0	Very compact green fine sand; traces of silt and shells.

List of species in well M-63, Chesapeake Bay Bridge-Tunnel. Fossil occurrences are indicated at appropriate depths in feet below mean low water.

	—50	—73	—78	—83	—88	—93	—98	—154	—159	—164
ELPHIDIUM CLAVATUM	.	X	.	.	.	.	.	X	.	.
ELPHIDIUM FLORENTINAE	.	X	.	X	.	X	.	.	.	X
DIATOMS	.	.	.	X	.	.	.	X	.	.
NONION SP.	.	.	.	.	.	X	.	.	.	.
SIGMOMORPHINA SP.	.	.	.	.	.	X	.	.	.	.
ORBULINA SP.	.	.	.	.	.	.	.	X	.	.

Well M-65

Depth (Feet below mean low water)	Sample Description
66.5-68.0	Firm gray fine sand; trace of shells.
69.5-71.0	Gray fine sand.
76.0-77.5, 79.5-81.0	Gray fine sand; trace of silt and shells.
84.5-86.0, 89.5-91.0	Greenish-gray fine sand; some silt; trace of shells and medium sand.
94.5-96.0, 100.5-102.0, 105.0-106.5	Greenish-gray fine sand; some silt; trace of shells and clay.
110.0-111.5, 114.5-116.0	Greenish-gray fine sand; trace of silt and shells.
119.5-121.0	Soft gray silty sand; trace of clay.
124.5-126.0, 126.5-128.5	Soft gray silty clay; some sand.

131.5-133.5,	
135.5-137.0	Soft gray silty clay.
140.5-142.0	Soft gray silty sand; some shells.
145.5-147.0	Compact fine sand; trace of silt and shells.
150.5-152.0	Greenish-gray fine and medium sand; trace of silt and clay.
155.5-157.0	Greenish-gray fine sand; trace of silt and clay.
160.5-162.0	Greenish-gray fine and medium sand; trace of silt and clay.
165.5-167.0,	
170.0-171.9,	
173.0-175.0,	
178.5-180.0	Greenish-gray silty clay; some fine sand; trace of shells.
183.5-185.0	Very compact green medium sand.

List of species in well M-65, Chesapeake Bay Bridge-Tunnel. Fossil occurrences are indicated at appropriate depths in feet below mean low water.

	—66	—76	—79	—84	—89	—100	—105	—110	—114	—124	—131	—135	—140
BUCCELLA DEPRESSA	.	X	.	.	.	X	.	.	.	.	.	.	.
ELEPHIDIUM FLORENTINAE	.	X	.	X	.	X	.	X	.	X	.	.	.
ANGULOGERINA SP.	.	.	.	.	.	X	.	.	.	.	.	.	.
NONION SP.	.	.	.	.	.	X	.	X	.	.	.	.	.
CIBICIDES SP.	.	.	.	.	.	.	.	.	X	.	.	.	.
DIATOMS	.	.	.	.	.	.	.	.	X	.	X	.	.
DISCORBIS SP.	.	.	.	.	.	.	.	.	X	.	.	.	.
BROKEN NONIONS	.	.	.	.	.	.	.	.	.	.	.	X	.

Well M-85

(See Figure 7 for list of species)

Depth (Feet below mean low water)	Sample Description
74.0-75.5	Loose greenish-gray fine to medium sand; traces of shells.
79.5-81.0	Soft yellow clay.
84.5-86.0	Soft greenish-gray clay and silt; traces of sand and shell.
88.5-90.0	Greenish-gray silty clay; traces of fine sand, shell, and plant fibers.
93.5-95.0,	
98.5-100.0,	
103.5-105.0,	
108.0-110.0,	
113.5-115.0,	
118.5-120.0	Greenish-gray silty clay; traces of fine sand and shells.
123.5-125.0	Greenish-gray silty clay; traces of fine sand, shells, and plant fibers.
128.5-130.0	Greenish-gray clay; some fine sand and silt; traces of shells.

133.5-135.0	Greenish-gray sandy clay; traces of silt; shells; traces of plant fibers.
138.5-140.0	Top spoon: greenish-gray, sandy clay; traces of shell. Bottom spoon: greenish-gray, sandy clay; some shells.
143.5-145.0, 148.5-150.0	Greenish-gray, fine sand; heavy layers of shells; trace of silt.
151.5-153.0	Very compact greenish-gray fine sand; some silt; trace of shells; some parts cemented.
155.5-157.0, 160.5-162.0, 164.5-166.0	Greenish-gray clay; some silt; traces of fine sand and shells.
169.5-171.0, 179.5-181.0	Clay with some sand and silt.
184.0-185.0	Greenish-gray fine sand and shells.
189.5-191.0	Greenish-gray fine sand and trace of shells.
194.0-195.0	Compact greenish-gray fine sand and shells.

WELL AT FRANKLIN, VIRGINIA

Well 4, on property of the Camp Manufacturing Company. Total depth: 770 feet.

Depth (Feet)	Sample Description
0-10	Mainly fine clear sand with some medium-size grains, subrounded to angular; some red clay.
10-20	Similar to 0-10′ but somewhat coarser and with less red clay; some brown grains; some red chert grains.
20-30	Similar to 10-20′ but with much tan-pink clay and coarse sand; some milky quartz; considerable plant debris.
30-40	Mainly clear coarse, medium, and fine sand with a trace of light-green glauconite; gray chert.
40-50	Similar to 30-40′ except fine sand.
50-60	Mainly gray plastic clay; coarse and fine to medium quartz sand, some red and varicolored; a fish vertebra.
60-70, 70-80	Gray sandy silty clay with all sand fine grained.
80-90	Eroded shell fragments; gray clay; fine to medium sand; black botryoidal grains of glauconite.
90-100	Clear, medium to fine sand and equal-sized black glauconite grains each comprise about half of sample; much tan-gray clay; some shell fragments; echinoid spines; Foraminifera.
100-110	Some green-gray pyritic clay; about 20% dull-green glauconite; about 20% black-green glauconite; much free pyrite; 45% clear, medium to fine sand; shell fragments; Foraminifera.
110-120	Some tan-gray clay; 65% black-green glauconite; 2% yellow waxy botryoidal grains; 5% light-green glauconite; remainder of sample coarse to fine clear sand with some tinted grains; a little free pyrite; shell fragments; Foraminifera.

120-130	Tan clay; 75% black glauconite; remainder of sample medium to fine clear sand; trace of light-green glauconite; shell fragments; Foraminifera.
130-140	Some tan clay; mainly coarse to medium blue and clear sand; about 40% black glauconite; trace of light-green glauconite; shell fragments; Foraminifera.
140-150	Similar to 130-140′ except much brown clay; notably finer grains; 30% black glauconite; some lime or marl; shell fragments; Ostracoda; numerous Foraminifera.
150-160	Similar to 140-150′ except considerable brown clay; 15% black glauconite; fewer fossils; shell fragments; Ostracoda; Foraminifera.
160-170	About 25% green to tan clay, silty; about 35% light- to dark-green glauconite; very coarse to medium-fine sand, clear; one pink grain; pyrite; some lime or marl; one brown waxy grain; shell fragments; Foraminifera.
170-180	Mainly light-tan, silty, plastic clay, somewhat sandy; 5% light- to dark-green glauconite; 5% coarse to fine sand, clear; muscovite flakes.
180-190, 190-200	Mainly light-tan, silty, plastic, slightly sandy clay; fine sand; trace of glauconite; muscovite.
200-210, 210-220	Mainly tan clay; accessory material same as 180-190′; one grain of red shale.
220-230	Mainly coarse to medium clear sand with some yellow, pink, and violet grains; trace of shell; some apparently chitinous material; trace of glauconite.
230-240	Mainly fine sand and tan silt with muscovite flakes; some medium grains; trace of red silt; trace of glauconite.
240-250	Similar to 230-240′ but generally coarser and with more silt; shell fragment.
250-260	Mainly coarse clear sand with large muscovite flakes; a rose quartz fragment; a red shale fragment; trace of pyrite and glauconite.
260-270	Similar to 250-260′ but finer grained; no red shale or rose quartz.
270-280	Similar to 260-270′ but has a leaf fragment.
280-290	Yellow-tan silt; fine sand; muscovite flakes; wood fragment; some coarse grains, one violet.
290-300	Coarse to medium and fine sand with violet quartz grains; much tan silt; plant debris; pink silt fragment.
300-310	Similar to 290-300′ but leaf fragment and plant debris; no silt.
310-320	Similar to 300-310′ but more plant debris and some very coarse grains.
320-330	Mainly medium to fine sand and tan silt; one large violet grain; large muscovite flakes.
330-340	Mainly medium to fine clear sand with some cream silt; large mica flakes and fragments of pyritic silt.

340-350	Similar to 330-340′ but coarser and with less cream silt; no pyritic silt.
350-360	Similar to 340-350′ but with very little cream silt.
360-370, 370-380, 380-390	Similar to 340-350′ but no silt and only a trace of mica; violet grains.
390-400	Similar to 360-370′ but a little coarser.
400-410	Mainly clear, coarse to medium to fine sand; trace of glauconite; trace of dark-brown waxy grains; fragment of white clay.
410-420	Clear, medium to fine sand; white clay patches; violet grains; leaf fragment.
420-430	Clear coarse to medium sand; white clay patches.
430-440	Clear medium to fine sand; muscovite flakes; plant fragments.
440-450	Similar to 430-440′ but a bit coarser.
450-460	Similar to 440-450′ but grains are predominantly medium size.
460-470	Similar to 450-460′ but a bit finer grained; more white clay.
470-480	Similar to 460-470′ but grains are medium to fine size.
480-490	Mainly coarse to medium clear sand; a few white clay patches.
490-500	Mainly fine to medium clear sand; considerable brown clay; green to black glauconite.
500-510	Mainly fine to medium clear sand; much brown clay; 5% light-green to dark glauconite; trace of pyrite; patches of marl; shell fragments.
510-520	Similar to 500-510′ but coarser and less uniform.
520-530	Similar to 510-520′ but fine-grained sand; 10% glauconite; one foraminifer.
530-540	20% brown clay; considerable leaf and plant fragments; clear fine-grained sand; much green, yellow, and red silt or shale; very little glauconite.
540-550	Much tan clay; plant debris; green, yellow, and red silt or shale, but shale is largely green and includes some gray fragments; traces of glauconite; small gravel; clear fine-grained sand.
550-560	15-20% brown clay; considerable plant debris, including seed pod; mainly clear, coarse to fine sand.
560-570	Much brown clay; some plant debris; mainly clear, coarse to fine sand.
570-580	Medium to fine, clear clean sand with some coarse grains.
580-590	Similar to 570-580′ but with white clay patches.
590-600	Same as 570-580′.
600-610	Mainly medium to fine sand; two garnet fragments; a few coarse grains.
610-620	Similar to 600-610′ but a bit coarser; white clay patches.
620-630, 630-640	Same as 600-610′.
640-650	Similar to 600-610′ but with considerable brown clay; trace of glauconite; shell fragments.

650-660	15% brown clay; sand similar to that at 600-610′ but much of it is coarser; varicolored silt fragments; a brown waxy grain.
660-670	Medium clear sand with patches of gray, red, and yellow shale; coarse and fine sand; much tan clay.
670-680	Similar to 660-670′ except 15% tan clay.
680-690	Similar to 670-680′ but with leaf fragments and mica flakes; 5-8% clay.
690-700	Similar to 680-690′ but with rusty grains.
700-710	Mainly coarse to medium with some fine sand and patches of white clay.
710-720, 720-730, 730-740, 740-750	Similar to 700-710′ but with a plant fragment; about 5% brown clay.
750-760	Similar to 710-720′ but with trace of glauconite.
760-770	Mainly clear and milky quartz grains of small gravel size, with coarse to fine sand, cream-tan clay and a garnet grain.

APPENDIX II

DATA FOR SURFACE AND NEAR-SURFACE SAMPLES

MATERIAL FROM WILLIAMSBURG AREA

Outcrop and near-surface samples from the Williamsburg area were supplied by Dr. Kenneth F. Bick, Geology Department, College of William and Mary.

Locality A-1: Sewage disposal plant, Eastern State Hospital (Dunbar), 2 miles west of Williamsburg. Blue silty sand.

Buccella anderseni—common
Bulimina gracilis—rare
Elphidium sp.—common
Elphidium incertum—common
Planulina depressa—rare
Hispid sigmomorphinas—rare

Specimens are poorly preserved, and there are no diagnostic forms listed. The character of the sediments and the small listing of Foraminifera indicate St. Marys age.

Locality A-2: Sewage disposal plant, Eastern State Hospital (Dunbar), 2 miles west of Williamsburg. Sand, some shell; 5 feet above A-1.

Angulogerina occidentalis—rare
Buccella depressa—rare
Bulimina gracilis—rare
Bulimina preacanthia—rare
Cancris sagra—rare
Cibicidella variabilis—common
Discorbis floridana—rare
Elphidium johnstonae—rare
Globigerina sp. A—rare
Guttulina austriaca—rare
Guttulina palmerae—rare
Hanzawaia concentrica—rare
Lagena cf. *clavata*—rare
Lagena substriata—rare
Nonion pizarrensis—common
Planulina depressa—rare
Sigmomorphina nevifera—rare
Sigmomorphina semitecta terquemiana—rare
Hispid forms of *Globulina*—rare
Textularia sp.—broken specimens

This sample is transitional between the Yorktown Formation and the St. Marys. It is closer to basal Yorktown Formation than to typical St. Marys in faunal content. The scarcity of specimens and the lack of definitive Yorktown forms indicate a rather unsuitable

environment for the Yorktown fauna, but the increasing number of oceanic forms indicates the beginning of Yorktown ecology.

Locality A-3: Sewage disposal plant, Eastern State Hospital (Dunbar), 2 miles west of Williamsburg. Shell bed, sand matrix; 5 feet above A-2.

Angulogerina occidentalis—very common
Buccella mansfieldi—common
Bulimina gracilis—very common
Cancris sagra—rare
Cibicidella variabilis—very common
Cushmanidea sp.—rare
Discorbis floridana—common
Entosolenia carteri alpha—rare
Entosolenia sp.—rare
Globigerina sp. E—rare
Guttulina palmerae—rare
Hanzawaia concentrica—common
Hulingsina ashermani—rare
Lagena clavata—rare
Lagena dorseyae—rare
Lagena globulohispida—rare
Murrayina cf. *martini*—rare
Nodosaria catesbyi—rare
Nodosaria catesbyi hustonae—rare
Nodosaria sp., broken pieces—rare
Nonion pizarrensis—very common
Orbulina universa—rare
Planulina depressa—common
Pseudopolymorphina rutila—rare
Sigmomorphina nevifera—rare
Hispid forms of *Globulina*—rare
Textularia candeiana—common
Textularia yorktownensis—rare

This fauna is definitely shallow, open ocean, basal Yorktown in age.

Locality B-1: Larry's Marina, 3 miles southwest of Williamsburg. Sand with some shell; 4 feet above sea level.

Buccella anderseni—rare
Cibicidella variabilis—common
Discorbis floridana—rare
Hanzawaia concentrica—rare
Murrayina martini—rare
Textularia candeiana—rare
Textularia yorktownensis—rare

From nature and sparsity of fauna this is probably St. Marys Formation.

Locality B-2: Larry's Marina, 3 miles southwest of Williamsburg. Sand; 1 foot above B-1.

Nonion sp.—1 broken specimen

Probably St. Marys Formation.

Locality B-3: Larry's Marina, 3 miles southwest of Williamsburg. Shell layer, sand matrix; 3 feet above B-2.

Buccella anderseni—rare
Cibicidella variabilis—rare
Discorbis floridana—rare
Elphidium johnstonae—rare
Guttulina palmerae—rare
Hanzawaia concentrica—rare
Murrayina howei—rare
Textularia candeiana—rare
Textularia gramen—rare

Probably St. Marys Formation.

Locality B-4: Larry's Marina, 3 miles southwest of Williamsburg. Sand; 5 feet above B-3.

Angulogerina occidentalis—rare
Buccella anderseni—rare
Buccella sp.—rare
Bulimina gracilis—rare
Buliminella elegantissima—rare
Cibicidella variabilis—rare
Clithrocytheridea diagonalis—rare
Discorbis floridana—rare
Hanzawaia concentrica—rare
Planulina depressa—common
Sigmomorphina concava—rare
Textularia pseudobliqua—rare

Probably St. Marys Formation from evidence of contained microfossils; *Clithrocytheridea diagonalis* has not previously been encountered in the Yorktown.

Locality C: Campus, College of William and Mary; 50 feet (approximately) above sea level.

Actinocythereis exanthemata—rare
Acuticythereis laevissima—rare
Angulogerina occidentalis—very common
Aurila conradi—very common
Bairdoppilata triangulata—rare
Bolivina lafayettei—very common
Bolivina marginata—rare
Bolivina paula—very common

Buccella depressa—very common
Bulimina gracilis—rare
Bulimina preacanthia—rare
Buliminella elegantissima—very common
Cancris sagra—very common
Cibicidella variabilis—common
Clithrocytheridea virginiensis—rare
Cushmanidea ? sp.—rare
Cytheropteron talquinensis—rare
Cytherura reticulata—rare
Entosolenia carteri—rare
Entosolenia carteri alpha—rare
Entosolenia sp.—rare
Globigerina sp. E—common
Hanzawaia concentrica—very common
Hemicythere schmidtae—rare
Lagena melo—rare
Lagena palmerae—rare
Loxoconcha purisubrhomboidea—common
Loxoconcha reticularis—rare
Murrayina martini—common
Nodosaria catesbyi—rare
Nonion pizarrensis—common
Nonion sp.—rare
Orionina bermudae—rare
Paracypris choctawhatcheensis—rare
Planulina depressa—rare
Pseudopolymorphina rutila—rare
Quinqueloculina seminula—common
Sigmomorphina concava—rare
Sigmomorphina nevifera—rare
Sigmomorphina pearceyi—rare
Sigmomorphina semitecta terquemiana—rare
Textularia articulata—rare
Textularia candeiana—common
Textularia gramen—rare
Triloculina sp.—rare
Uvigerina cf. *tenuistriata*—rare
Virgulina punctata—rare

An undoubted Yorktown Formation fauna, fully equivalent to the basal beds at Carters Grove.

Locality D: Lake Powell dam, 4 miles southwest of Williamsburg; 5 feet below top of exposure, approximately 10 feet above sea level.

Angulogerina occidentalis—rare
Aurila conradi—rare
Bolivina lafayettei—rare
Bolivina paula—rare
Buccella anderseni—rare

Buliminella elegantissima—rare
Cancris sagra—rare
Cibicidella variabilis—rare
Discorbis floridana—rare
Globigerina sp. E—rare
Guttulina palmerae—rare
Hanzawaia concentrica—common
Lagena pseudosulcata—rare
Murrayina martini—rare
Nonion cf. *grateloupi*—rare
Planulina depressa—common
Sigmomorphina nevifera—rare
Textularia gramen—rare

This sample is St. Marys Formation (see McLean, 1956).

Locality E-1: Along State Highway 132Y, 0.5 mile north of Williamsburg, 0.25 mile west of Information Center. Sandy shell layer; 45 feet above sea level approximately.

Angulogerina occidentalis—common
Aurila conradi—common
Bolivina lafayettei—rare
Bolivina paula—rare
Buccella anderseni—common
Bulimina gracilis—rare
Bulimina preacanthia—rare
Buliminella elegantissima—rare
Cibicidella variabilis—common
Clithrocytheridea virginiensis—rare
Cytherura reticulata—rare
Dentalina kaicherae—rare
Dentalina cf. *pyrula*—rare
Discorbis floridana—rare
Entosolenia carteri alpha—rare
Entosolenia sp.—rare
Globigerina sp. E—common
Guttulina austriaca—rare
Guttulina palmerae—rare
Guttulina sp. A—rare
Hanzawaia concentrica—common
Lagena dorseyae—rare
Lagena hexagona scalariformis—rare
Lagena palmerae—rare
Lagena substriata—rare
Murrayina martini—rare
Nodosaria catesbyi—common
Nodosaria sp.—rare
Nodosaria sp., fragments—rare
Nonion cf. *grateloupi*—rare

Paracytheridea vandenboldi—rare
Planulina depressa—common
Puriana rugipunctata—rare
Hispid sigmomorphinas—rare
Sigmomorphina nevifera—rare
Sigmomorphina williamsoni, juvenile—rare
Textularia spp., broken—common
Triloculina sp.—rare

This fauna is Yorktown age, probably basal Yorktown, although some distinctive forms are missing.

Locality E-2: Along State Highway 132Y, 0.5 mile north of Williamsburg, 0.25 mile west of Information Center; 65 feet above sea level approximately.

No microfossils

From a faunal viewpoint, this sample cannot be defined; it could be either highly weathered Yorktown or later age.

Locality F-1: Williamsburg Inn, maintenance area of golf course; 45-50 feet above sea level.

Actinocythereis exanthemata—rare
Acuticythereis laevissima—rare
Angulogerina occidentalis—rare
Aurila conradi—common
Bolivina lafayettei—common
Bolivina paula—rare
Buccella anderseni—common
Bulimina gracilis—rare
Buliminella elegantissima—common
Cancris sagra—common
Cibicidella variabilis—common
Clithrocytheridea virginiensis—rare
Cytheropteron talquinensis—rare
Cytherura ? sp.— rare
Discorbis floridana—rare
Discorbis rehderi—rare
Elphidium advena—rare
Entosolenia carteri—common
Entosolenia carteri alpha—rare
Entosolenia sp.—rare
Globigerina sp. E—common
Guttulina austriaca—rare
Hanzawaia concentrica—common
Hemicythere schmidtae—rare
Loxoconcha purisubrhomboidea—rare
Murrayina howei—rare
Murrayina martini—rare

Nonion pizarrensis—common
Orionina bermudae—rare
Paracytheridea vandenboldi—rare
Planulina depressa—common
Pseudopolymorphina rutila—rare
Sigmomorphina concava—rare
Sigmomorphina nevifera—common
Sigmomorphina semitecta terquemiana—rare
Textularia articulata—common
Textularia candeiana—common
Triloculina sp.—rare

This sample is undoubtedly of basal Yorktown age, equivalent to the basal beds at Carters Grove.

Locality F-2: Williamsburg Inn, maintenance area of golf course; 70 feet above sea level approximately.

No microfossils

Either weathered Yorktown or later beds; the mineral content of the several barren beds in this material might serve to separate the units.

Locality G-1: Along Quarterpath Road, eastern Williamsburg. Shell bed; 25 feet above sea level approximately.

Angulogerina occidentalis—common
Aurila conradi—common
Bolivina cf. *floridana*—rare
Buccella depressa—rare
Buccella hannai ?—rare
Bulimina gracilis—common
Cancris sagra—rare
Cibicidella variabilis—common
Cushmanidea ulrichi—rare
Dentalina kaicherae—rare
Discorbis floridana—common
Entosolenia carteri—rare
Globigerina sp. E—common
Guttulina austriaca—common
Guttulina palmerae—common
Hanzawaia concentrica—common
Hemicythere schmidtae—rare
Lagena clavata—rare
Lagena dorseyae—rare
Lagena palmerae ?—rare
Lagena sp.—rare
Lagena substriata—rare
Leguminocythereis ? *whitei*—rare
Murrayina martini—rare

Nodosaria catesbyi—common
Nodosaria sp.—rare
Nonion cf. *grateloupi*—rare
Nonion sp.—rare
Planulina depressa—common
Puriana rugipunctata—rare
Robulus pseudoiota—rare
Robulus vaughani—rare
Sigmomorphina concava—rare
Hispid sigmomorphinas—rare
Sigmomorphina semitecta terquemiana—rare
Textularia candeiana—rare
Textularia gramen—rare
Textularia mayori—rare
Textularia yorktownensis—rare
Virgulina punctata—rare

This fauna is of undoubted basal Yorktown age, equivalent to beds at Carters Grove.

Locality G-2: Along Quarterpath Road, eastern Williamsburg, 0.5 mile north of dam.

Buccella anderseni—rare
Hanzawaia concentrica—rare
Planulina depressa—rare

This sparse sample cannot be definitely assigned; all species are still living and were present in Yorktown times. They could have been redeposited or could be contaminants from other layers.

Locality G-3: Along Quarterpath Road, eastern Williamsburg, 0.1 mile south of dam.

No microfossils

Age indeterminate.

Locality H: Colonial Parkway, 0.5 mile north of Halfway Creek, 2 miles south of Williamsburg; approximately 15 feet above sea level.

Buccella anderseni—rare
Cibicidella variabilis—common
Clithrocytheridea diagonalis—rare
Discorbis floridana—rare
Elphidium johnstonae—rare
Sigmomorphina nevifera—rare
Textularia candeiana—rare

Clithrocytheridea diagonalis has not previously been reported from Yorktown material; the nature of the fauna is indicative of St. Marys age.

Locality J-1: Kings Mill Wharf, James River. Shell bed; 25 feet above sea level approximately.

Angulogerina occidentalis—common
Aurila conradi—common
Bolivina lafayettei—common
Buccella mansfieldi—common
Bulimina gracilis—common
Buliminella elegantissima—rare
Cancris sagra—rare
Cibicidella variabilis—common
Clithrocytheridea virginiensis—rare
Cushmanidea echolsae—rare
Cushmanidea ulrichi—rare
Cytheropteron talquinensis—rare
Cytherura reticulata—rare
Dentalina kaicherae—rare
Discorbis floridana—rare
Entosolenia carteri—rare
Entosolenia sp.—rare
Globigerina sp. E—common
Guttulina austriaca—rare
Guttulina palmerae—common
Guttulina pseudocostatula—rare
Hanzawaia concentrica—common
Hemicythere schmidtae—rare
Lagena clavata—rare
Lagena dorseyae—rare
Lagena palmerae—rare
Leguminocythereis sp. ?—rare
Miliammina sp.—rare
Murrayina howei—rare
Murrayina martini—rare
Nodosaria catesbyi—common
Nodosaria catesbyi subsp. *hustonae*—rare
Nodosaria sp.—rare
Nodosaria sp., fragments—rare
Nonion pizarrensis—common
Orbulina universa—rare
Orionina bermudae—rare
Planulina depressa—common
Poroeponides lateralis—rare
Pseudopolymorphina rutila—rare
Pterygocythereis americana, juvenile—rare
Puriana rugipunctata—rare
Robulus vaughani—rare
Hispid sigmomorphinas—rare
Sigmomorphina semitecta terquemiana—rare
Textularia articulata—rare

Textularia candeiana—rare
Textularia eustisensis—rare
Textularia gramen—rare
Textularia pseudobliqua—rare
Triloculina sp.—rare

This sample is of undoubted basal Yorktown age, equivalent to beds at Carters Grove.

Locality J-2: Kings Mill Wharf, James River. Sand; 5 feet above unconformity between Miocene (undoubted) and younger rocks.

No microfossils

Age indeterminate.

MATERIAL FROM ISLE OF WIGHT AND SURRY COUNTIES

Samples from Isle of Wight and Surry counties were collected and made available for study by Mr. Nicholas Coch, Yale University. See Table 5 for a list of the microfossil species found in this material.

Locality 5: Isle of Wight County, intersection of State Highway 10 and Battery Park road, northeast corner, Pagan Pines (Smithfield). Altitude, 11 feet.

70% fine sand, 25% silt and clay, 5% shell; very fine shell fragments.

Based on the microfauna, the age is as follows: mixture of Yorktown (Miocene) and Pleistocene. Age: Pleistocene.

Locality 7: Isle of Wight County, 0.63 mile north of Benns Church, 0.07 mile east on farm road. Altitude, 27 feet.

10% fine sand, 80% silt and clay, 10% shell; abundant shells and shell fragments, all small (less than 0.5 in.).

Richards identifies the following fauna from this sample and assigns it to the Pleistocene:

Nuculana acuta Conrad
Mulinia lateralis Say
Anadara sp.
Nassarius trivittatus Say
Retusa canaliculata Say

Based on the microfauna, the age is as follows: Pleistocene.

Locality 8: Isle of Wight County, 0.63 mile north of Benns Church, 0.07 mile east on farm road. Altitude, 18 feet.

30% fine sand, 60% silt and clay, 10% shell; quite shelly; decomposed shells at base of interval.

Based on the microfauna, the age is as follows: Pleistocene-Yorktown mixture.

Locality 10: Isle of Wight County, 0.63 mile north of Benns Church, 0.07 mile east on farm road. Altitude, 15 feet.

40% fine sand, 10% medium sand, 50% shell; shell fragments and whole small shells abundant; fragments of clams and oysters noted.

Richards lists the following species from this locality:

Venericardia sp.
Glycymeria sp.

Based on the microfauna, the age is as follows: Pleistocene.

Locality 11: Isle of Wight County, 0.63 mile north of Benns Church, 0.07 mile east on farm road. Altitude, 12 feet.

30% fine sand, 10% medium sand, 40% silt and clay, 20% shell; shells (small) and shell fragments (mostly clams and oysters); conspicuous large grains of either glauconite or magnetite, probably glauconite.

Based on the microfauna, the age is as follows: Yorktown.

Locality 14: Isle of Wight County, 0.63 mile north of Benns Church, 0.15 mile east on farm road. Altitude, 15 feet.

55% fine sand, 20% silt and clay, 25% shell; large shell fragments (pectens, clams), small gastropods, echinoid spines.

Richards identifies the following fauna from this sample and assigns it to the Pleistocene ?-Miocene:

Nassarius vibex Say
Crepidula aculeata Gmelin
Crucibulum striatum Say
Seila adamsii Lea

Based on the microfauna, the age is as follows: Yorktown ?

Locality 18: Isle of Wight County, intersection of State Roads 628 and 678 (northeast corner), 0.45 mile west of Lawns Creek. Altitude, 5 feet.

15% fine sand, 75% silt and clay, 10% shell; many fragments of pectens and clams.

Based on the microfauna, the age is as follows: Pleistocene-Miocene.

Locality 26: Surry County, 2.2 miles north of Beachland (intersection of State Roads 616 and 626), entrance to farm road (farm of Joe Edwards). Altitude, 56 feet.

30% fine sand, 60% silt and clay, 10% shell; shells and shell fragments, barnacles, scaphopods, small pecten, small pelecypods.

Richards identifies the following fauna from this sample and assigns it to the Pleistocene:

Mulinia lateralis Say
Phacoides crenulatus Conrad
Retusa canaliculata

Based on the microfauna, the age is as follows: Pleistocene-Yorktown (Miocene) mixture.

Locality 27: Surry County, 2.2 miles north of Beachland (intersection of State Roads 616 and 626), entrance to farm road (farm of Joe Edwards). Altitude, 54 feet.

25% fine sand, 60% silt and clay, 15% shell; high percentage of small pelecypods, scaphopods and very small ribbed pecten fragments.

Based on the microfauna, the age is as follows: Pleistocene-Miocene mixture.

Age: Pleistocene.

Locality 30: Surry County, 1.8 miles north of Beachland, on State Road 626, entrance to lumber road. Altitude, 67 feet.

20% fine sand, 30% silt and clay, 50% shell; echinoid spines; rounded pecten fragments, pieces of large clams, many small pelecypods.

Richards identifies the following fauna from this sample and assigns it to the Pleistocene:

Mulinia lateralis Say

Based on the microfauna, the age is as follows: Pleistocene.

Locality 31: Surry County, 1.8 miles north of Beachland on State Road 626, entrance to lumber road. Altitude, 68 feet.

35% fine sand, 60% silt and clay, 5% shell; high percentage of pecten fragments; small pelecypods, pieces of large clams, echinoid spines.

Richards identifies the following fauna from this sample and assigns it to Pleistocene ?-Miocene? (mixed):

Mulinia lateralis Say
Nuculana acuta Conrad
Polinices duplicatus Say ?
Pecten madisonius Say

Based on the microfauna, the age is as follows: Pleistocene-Yorktown.

Locality 36: Surry County, 1.0 mile north of Beachland on State Road 626, pasture of farm. Altitude, 70 feet.

20% fine sand, 75% silt and clay, 5% shell; fragments of pectens and possible barnacles; echinoid spines.

Based on the microfauna, the age is as follows: Pleistocene.

Locality 37: Surry County, 1.0 mile north of Beachland on State Road 626, pasture of farm. Altitude, 68 feet.

10% fine sand, 70% silt and clay, 20% shell; echinoid spines, turritella, oysters, small pelecypod, barnacles.

Richards identifies the following fauna from this sample and assigns it to the Miocene:

Ostrea sp.

Based on the microfauna, the age is as follows: Pleistocene-Miocene.

Locality 48: Isle of Wight County, 0.17 mile southeast of intersection of State Highway 10 and Battery Park road, Pagan Pines (Smithfield). Altitude, 20 feet.

10% fine sand, 90% silt and clay.

Elphidium florentinae—probably a contamination since sample was otherwise barren.

Locality 54: Surry County, 0.75 mile south of Beachland on State Road 626. Altitude, 72 feet.

20% fine sand, 70% silt and clay, 10% shell; mostly oyster shells, echinoid spines.

Richards identifies the following fauna from this sample and assigns it to the Miocene:

Ostrea sp.
Pecten madisonius Say

Based on the microfauna, the age is as follows: Pleistocene.

Locality 89: Locality unknown. Altitude, 13 feet.

20% fine sand, 80% silt and clay; abundant scaphopods and small shell fragments.

PART 2—TAXONOMY AND FOSSIL PLATES

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MIOCENE AND PLEISTOCENE FORAMINIFERA AND OSTRACODA OF SOUTHEASTERN VIRGINIA

TAXONOMY AND FOSSIL PLATES

INTRODUCTION

While this study was under way, A. R. Loeblich, Jr. and Helen Tappan Loeblich published their classification of the Sarcodina. This classification is exhaustive and is the result of much hard work by the authors; nevertheless, it has yet to attain universal acceptance. For this reason, and because the Cushman classification is still the standard reference for Foraminifera, the Cushman concept of classification has been retained in this study.

The ostracod classification used in this study is based upon the works of Howe (1962), Puri (1953, 1958), and McLean (1957). No claim is made for finality of ostracod classification; the arrangement of ostracod classification here used is for the purpose of comparison with the works listed in the references.

Those species that are especially important to the stratigraphy of the region and those forms not encountered in the author's previous studies of the Foraminifera and Ostracoda in the Yorktown Formation (McLean, 1956, 1957) are illustrated. Most species illustrated in these earlier bulletins are not reillustrated here; however, a full synonymy is included for them, and new occurrences are listed. The author wishes to acknowledge the kind assistance of Mrs. Naida Page of the Audio-Visual Aids Department, Howard University, who very skillfully executed the camera lucida drawings of the Foraminifera and Ostracoda which make up the fossil plates in this report. The following new forms are named: *Lagena pageae,* n. sp.; *Entosolenia bifida,* n. sp.; *Nodosaria catesbyi* subsp. *hustonae,* n. subsp.; and *Bulimina gracilis* subsp. *calveri,* n. subsp.

All material derived from this study has been placed in the collections of the Paleontological Research Institution, including the types and illustrated specimens. Collection numbers listed herein are Paleontological Research Institution numbers and are prefixed P.R.I. Sample localities that are listed under occurrences are shown on the accompanying index map (in pocket) and described in Table 1.

Table 1.—Sample localities.

Coleman Bridge section.

Wells 1-NE, 1-NW, 1-SE, 1-SW, 3-N, and 3-S. On the York River between Gloucester Point and Yorktown.

Chesapeake Bay Bridge-Tunnel.

Wells A-1, A-2, M-62, M-63, M-65, and M-85. Connects Wise Point on the Eastern Shore with Chesapeake Beach in the City of Virginia Beach.

Well A-5.

General cargo pier at Lambert Point, near Norfolk, Virginia; long 76°18′54″W. and lat 36°51′48″N.

Well A-11.

Near Newport News, Virginia, 520 feet offshore from U. S. bulkhead line and 30 feet off Pier 3 of the Chesapeake and Ohio Railway; long 76°26′08″W. and lat 36°58′18″N.

Well at Franklin, Virginia.

Well 4, on property of the Camp Manufacturing Company.

Localities — Samples from localities designated with letter or letter and number were collected and furnished by Kenneth F. Bick, Department of Geology, College of William and Mary, Williamsburg, Virginia. Those from localities designated with number only were collected and furnished by Nicholas K. Coch, Department of Geology, Yale University, New Haven, Connecticut.

A-1 — Sewage disposal plant, Eastern State Hospital (Dunbar), 2 miles west of Williamsburg; blue, silty sand.

A-2 — Same locality as A-1, sample taken 5 feet higher.

A-3 — Same locality as A-1, sample taken 10 feet higher.

B-1 — Larry's Marina, 3 miles southwest of Williamsburg; 4 feet above sea level.

B-3 — Same locality as B-1; 8 feet above sea level.

B-4 — Same locality as B-1; 13 feet above sea level.

C — Campus, College of William and Mary; approximately 50 feet above sea level.

D — Lake Powell dam, 4 miles southwest of Williamsburg; 5 feet below top of exposure, approximately 10 feet above sea level.

E-1 — Along State Highway 132Y, 0.5 mile north of Williamsburg, 0.25 mile west of Information Center; approximately 45 feet above sea level.

F-1 — Williamsburg Inn, maintenance area of golf course; 45-50 feet above sea level.

G-1 — Along Quarterpath Road, eastern Williamsburg; approximately 25 feet above sea level.

G-2 — Along Quarterpath Road, eastern Williamsburg, 0.5 mile north of dam.

H — Colonial Parkway, 0.5 mile north of Halfway Creek, 2 miles south of Williamsburg; approximately 15 feet above sea level.

J-1 — Kings Mill Wharf, James River; approximately 25 feet above sea level.

5 — Isle of Wight County, intersection of State Highway 10 and Battery Park road, northeast corner, Pagan Pines (Smithfield); altitude, 11 feet.

7 — Isle of Wight County, 0.63 mile north of Benns Church, 0.07 mile east on farm road; altitude, 27 feet.

8 — Same locality as 7; altitude, 18 feet.

10 — Same locality as 7; altitude, 15 feet.

11 — Same locality as 7; altitude, 12 feet.

14 — Isle of Wight County, 0.63 mile north of Benns Church, 0.15 mile east on farm road; altitude, 15 feet.

18 — Isle of Wight County, intersection of State Roads 628 and 678 (northeast corner), 0.45 mile west of Lawns Creek; altitude, 5 feet.

26 — Surry County, 2.2 miles north of Beachland (intersection of State Roads 616 and 626), entrance to farm road; altitude, 56 feet.

27 — Same locality as 26; altitude, 54 feet.

30 — Surry County, 1.8 miles north of Beachland on State Road 626, entrance to lumber road; altitude, 67 feet.

31 — Same locality as 30; altitude, 68 feet.

36 — Surry County, 1.0 mile north of Beachland, on State Road 626, pasture of farm; altitude, 70 feet.

37 — Same locality as 36; altitude, 68 feet.

54 — Surry County, 0.75 mile south of Beachland on State Road 626; altitude, 72 feet.

89 — Locality uncertain.

TAXONOMY

Order FORAMINIFERA

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance, 1824

Textularia articulata d'Orbigny

Plate 1, Figure 1

Textularia articulata d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 250, pl. 15, figs. 16-18; Bagg, 1904, Maryland Geol. Surv., Miocene, p. 471, pl. 132, figs. 6-7; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 40, pl. 1, figs. 1a-b; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 8, pl. 1, figs. 12a-b; Lalicker and McCulloch, 1940, Allan Hancock Pac. Expedition, vol. 6, no. 2, p. 118, pl. 13, figs. 3a-d; Cushman and Ellisor, 1945, Jour. Pal., vol. 19, no. 6, p. 547, pl. 71, fig. 11; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 316, pl. 35, figs. 1-2; pl. 36, figs. 4-6, 9, 11, 15-16.

Dimension of figured hypotype P.R.I. 27154: Length 0.84 mm.

Occurrences: Figured hypotype P.R.I. 27154 from Coleman Bridge section, well 3-N at 95.0 feet; also at localities C, F-1, and J-1.

Textularia candeiana d'Orbigny

Plate 1, Figures 2, 3

Textularia candeiana d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. and nat. de l'isle de Cuba, p. 143, pl. 1, figs. 25-27; Cushman, 1922,

Carnegie Inst. Washington, pub. 311, p. 23, pl. 2, fig. 2; Cushman, 1922, U. S. Nat. Mus., Bull. 104, p. 8, pl. 1, figs. 1-3; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 41, pl. 8, figs. 4a-b; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 80, pl. 30, figs. 9-10; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 317-318, pl. 35, figs. 4, 6, 7, 10, 11; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 223.

Textularia cuyleri Copeland (not others), 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 235-236, pl. 34, figs. 8a-b.

Two small and rather untypical specimens are here figured; see McLean (1956) for typical forms. Dimensions of figured hypotypes: P.R.I. 27253: 0.67 mm long; P.R.I. 27214: 0.37 mm long.

Occurrences: Hypotype P.R.I. 27253 from locality 14; P.R.I. 27214 from locality 10; also at localities 11, A-3, B-1, B-3, C, F-1, G-1, H, J-1.

Textularia eustisensis McLean

Textularia eustisensis McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 318-319, pl. 35, figs. 5a-b.

For figures of this form, see McLean (1956).

Occurrences: Additional records for this form are: locality J-1; also Coleman Bridge section, well 1-SW at 160.0 feet; in well A-11 near Newport News at 135.0 to 140 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 142 feet; and in a well at Franklin, Virginia at 90 to 100 feet.

Textularia gramen d'Orbigny

Textularia gramen d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 248, pl. 15, figs. 4-6; Cushman, 1918, U. S. Geol. Survey, Bull. 676, p. 8, pl. 9, figs. 4-5 (not figs. 2, 3, 6); Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 17, pl. 1, figs. 5a-b; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 81, pl. 30, figs. 7-8; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 319, pl. 36, figs. 7, 12-13; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 223.

Textularia cf. *dollfussi* Copeland (not others), 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 236, pl. 34, figs. 9a-b.

Textularia megaloculata Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 237, pl. 35, figs. 1a-b.

As restricted and figured by McLean (1956) this form has the additional records listed below. Copeland's forms listed above in synonymy also seem to be this species; careful discrimination is necessary, as the name has been given to a widely diverse group of textularids.

Occurrences: Localities B-3, C, D, G-1, J-1, 10, 11, 14, 18, 27, 30, 31, 36; Coleman Bridge section, well 3-N at 115 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 to 161 feet, well A-2 at 70 to 120 feet, well M-85 at 84 to 93 feet; well A-11 near Newport News at 58 to 65 feet.

Textularia mayori Cushman

Textularia mayori Cushman, 1922, Carnegie Inst. Washington, pub. 311, p. 23, pl. 2, fig. 3; Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 7; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 17, pl. 1, figs. 6-8; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 40, pl. 1, figs. 2-3; Phleger and Parker, 1948, Geol. Soc. Amer., Mem. 46, pt. 2, p. 5, pl. 2, figs. 1-5; Puri, 1953, Florida Geol. Surv., Bull. 36, p.82, pl. 20, figs. 7-8; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 320, pl. 36, figs. 1-3.

Occurrence: A single new record for this species is locality G-1; see McLean (1956) for figures and description of this form.

Textularia obliqua Clapp

Plate 1, Figure 6

Textularia obliqua Clapp, 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 279, pl. 28, figs. 6a-c, 7a-c.

This species may be an important St. Marys Formation guide; for this reason, care should be exercised to separate it from the very similar *T. pseudobliqua* McLean. *T. obliqua* is distinctly more oblique in the slant of its sutures and is generally stubbier and more roughly arenaceous than *T. pseudobliqua*. *Textularia eustisensis* McLean is more elongate and generally much more finely arenaceous, but may easily be confused with Clapp's species. Dimension of figured hypotype P.R.I. 27316: 1.35 mm long.

Occurrences: New records for this form are: P.R.I. 27316 from well A-11 near Newport News at 165.0 feet; other speci-

mens to 185 feet in same well. Also, from Coleman Bridge section, well 1-NE at 194 to 200 feet.

Textularia pseudobliqua McLean

Plate 1, Figures 4, 5

Textularia pseudobliqua McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 320, pl. 35, figs. 8-9, pl. 36, figs. 17a-b; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 224.

This form seems to be restricted to the basal Yorktown Formation and the St. Marys Formation; it may be related to, and evolved from, *T. obliqua*. Dimensions of figured forms: P.R.I. 27192 1.47 mm long; P.R.I. 27178 1.03 mm long.

Occurrences: P.R.I. 27192 at 185-186.6 feet in well A-11 near Newport News; P.R.I. 27178 in Coleman Bridge section well 3-S at 135.0 feet; other occurrences: localities B-4 and J-1; Coleman Bridge section, well 1-SE at 128 feet, well 1-NE at 184 feet, well 1-NW at 158 feet; also from well A-5 near Lambert Point at 220 to 225 feet and well A-11 near Newoprt News at 160 feet; well at Franklin, Virginia from 80 to 110 feet.

Textularia yorktownensis McLean

Textularia pseudobliqua aspera (McLean), 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 320, pl. 36, figs. 8, 14.

Textularia yorktownensis McLean, 1959, Jour. Pal., vol. 33, no. 5, p. 969, not *T. aspera* Ehrenberg, 1838, Terquem, 1882, Brady, 1882; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 224, pl. 27, figs. 1a-b.

Further records for this species are listed below; for descriptions and figures, see McLean (1956).

Occurrences: Localities A-3, B-1, G-1; Coleman Bridge section, well 1-SW at 123 feet, well 1-NE at 108 feet, well 3-N at 125 feet; well A-11 near Newport News at 165 to 190 feet.

Textularia sp. A

Plate 1, Figures 7, 8

Occurrences: These forms, from well 3-S in the Coleman Bridge section at 95 to 105 feet, may be juvenile individuals of

T. obliqua; they are figured for further reference. Dimensions: P.R.I. 27172 0.33 mm long; P.R.I. 27181 0.42 mm long.

Textularia sp. B

Plate 2, Figure 1

Occurrence: This broken form from locality 10 is figured for further reference; it does not resemble any form found so far. Dimension of P.R.I. 27255 0.41 mm long.

Textularia sp. C

Plate 2, Figure 2

Occurrence: This unusual form, the only one found, is from locality 11 and is figured for future reference. Dimension of figured specimen, P.R.I. 27210, is 0.32 mm long.

Family MILIOLIDAE

Genus QUINQUELOCULINA d'Orbigny, 1826

Quinqueloculina lamarckiana d'Orbigny

Plate 2, Figures 3-5

Quinqueloculina lamarckiana d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. and nat. de l'isle de Cuba, p. 189, pl. 11, figs. 14, 15; Cushman, 1921, U. S. Nat. Mus. Proc., vol. 59, p. 65, pl. 15, figs. 13, 14; Cushman, 1922, Carnegie Inst. Washington, Pub. 311, p. 64; Cushman, 1924, Carnegie Inst. Washington, Pub. 342, p. 63; Cushman, 1926, Carnegie Inst. Washington, Pub. 344, p. 81; Cushman, 1929, U. S. Nat. Mus. Bull. 104, pt. 6, p. 26, pl. 2, figs. 6a-c; Cushman, 1930, Florida Geol. Survey Bull. 4, p. 20, pl. 2, figs. 3-5; Cushman and Ponton, 1932, Florida Geol. Survey Bull. 9, p. 44; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 9, pl. 2, figs. 4a-c.

Quinqueloculina auberiana d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. and nat. de l'isle de Cuba, p. 193, pl. 12, figs. 1-3; Cushman, 1918, U. S. Nat. Mus. Bull. 103, p. 79, pl. 29, figs. 3a-c; Cushman, 1918, U. S. Geol. Surv. Bull. 676, p. 23, 71, pl. 5, fig. 3; pl. 30, fig. 1.

Quinqueloculina cuvieriana H. B. Brady (not D'Orbigny), 1884, Challenger Rept., Zoology, vol. 9, p. 162, pl. 5, figs. 12a-c.

Angulate forms, as here figured, are somewhat questionably assigned to d'Orbigny's species; the specimen in Figures 5a, b (P.R.I. 27216) has a rather striate test, which may be an individual peculiarity, but which may place it in another species. Dimensions of figured specimens: P.R.I. 27208 0.31 mm long; P.R.I. 27243 0.43 mm long; P.R.I. 27216 0.80 mm long.

Occurrences: P.R.I. 27243 and P.R.I. 27216 from locality 14; P.R.I. 27208 is from locality 37.

Quinqueloculina seminula (Linnaeus)

Plate 2, Figures 6, 7

Plate 3, Figure 1

Serpula seminulum Linnaeus, 1767, Syst. Nat. ed. 12, p. 1264.

Miliolina seminulum Williamson, 1858, Rec. Forams. Great Britian, p. 85, pl. 7, figs. 183-185; Heron-Allen and Earland, 1932, Discovery Reports, vol. 4, p. 313-314, pl. 6, figs. 25-40.

Quinqueloculina seminulum Cushman, 1929, U. S. Nat. Museum, Bull. 104, p. 24, pl. 2, figs. 1-2; Boltovskoy, 1954, Revista Inst. Nacional Invest. Ciencias y Mus. Argentino Ciencias Nat. "Bernadino Rivadavia," tomo 3, no. 4, p. 258, pl. 20, figs. 1a-c.

Quinqueloculina seminula Cushman and Cole, 1930, Contrib. Cushman Lab. Foram. Res., vol. 6, pt. 4, p. 95, pl. 13, figs. 1a-c; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 19, pl. 2, figs. 1a-c (not 2); McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 321-322, pl. 37, figs. 12, 14; Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 232, pl. 34, figs. 7a-c.

This is a species whose identity has largely been lost by indiscriminate dumping of forms into it; the forms figured seem to coincide with the synonyms listed above. Dimensions: P.R.I. 27205 is 0.45 mm long; P.R.I. 27240 is 0.45 mm long; P.R.I. 27227 is 0.53 mm long.

Occurrences: P.R.I. 27205 is from locality 37; P.R.I. 27240 is from locality 11; P.R.I. 27227 is from locality 14; other occurrences are: localities 18 and C; Coleman Bridge section,

well 1-SW at 160 feet; well A-5 near Lambert Point at 100 to 105 feet; well A-11 near Newport News at 245 feet.

Quinqueloculina triloculiniforma McLean

Quinqueloculina triloculiniforma McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 322-323, pl. 37, figs. 9-11.

Occurrence: One specimen of this form occurs at locality 37. See McLean (1956) for description and figures.

Genus PYRGO Defrance, 1824

Pyrgo denticulata (H. B. Brady)

Plate 3, Figure 2

Biloculina ringens Lamarck, var. *denticulata* H. B. Brady, 1884, Challenger Rept., vol. 9, p. 143, pl. 3, figs. 4, 5; Heron-Allen and Earland, 1915, Trans. Zool. Soc. London, vol. 20, p. 551, pl. 40, figs. 11-13.

Biloculina denticulata Cushman, 1917, U. S. Nat. Mus. Bull. 71, pt. 6, p. 80, pl. 33, fig. 1; Cushman, 1921, U. S. Nat. Mus., Bull. 100, pt. 4, p. 476, pl. 98, figs. 3a, b.

Pyrgo denticulata Cushman, 1929, U. S. Nat. Mus., Bull. 104, pt. 6, p. 69, pl. 18, figs. 3, 4; Cushman and Ponton, 1932, Florida Geol. Surv. Bull. 9, p. 56, pl. 7, figs. 7, 8; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 94, pl. 5, figs. 13, 14, 15.

Occurrence: One specimen from Coleman Bridge section, well 1-NE (P.R.I. 27307) is from a depth of 184 feet; the form is 0.70 mm long.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker & Jones, 1859

Trochammina sp.

Plate 3, Figure 3

Occurrence: In the Coleman Bridge section, this form appears in well 3-N at a depth of 115 feet. Dimension of P.R.I. 27304 is 0.53 mm long.

Family LAGENIDAE

Genus ROBULUS Montfort, 1808

Robulus americanus (Cushman)

Plate 3, Figure 4

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

Robulus americanus Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 24, pl. 3, fig. 7; Cushman, 1932, Florida Geol. Surv., Bull. 9, p. 58; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 12, pl. 3, fig. 6; Renz, 1948, Geol. Soc. America Mem. 32, p. 157, pl. 12, fig. 3; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 96-97; Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 248, pl. 35, figs. 3a-b.

This important guide form occurs in several new places; dimension of the figured specimen (P.R.I. 27169) is 0.81 mm in largest diameter.

Occurrences: P.R.I. 27169 occurs in well A-11 near Newport News at a depth of 195-196.6 feet; the form extends from 180 to 380 feet in this same well. Other occurrences: Coleman Bridge section, well 1-SE at 160 feet, well 3-S at 115 feet, well 1-NE at 200 feet; well at Franklin, Virginia, at 90 feet.

Robulus americanus subsp. *spinosus* Cushman

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

Robulus americanus (Cushman) var. *spinosus* Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 24, pl. 3, figs. 7a, b; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 12, pl. 3, fig. 7; Renz, 1948, Geol. Soc. America Mem. 32, p. 157, pl. 12, fig. 4; Bermudez, 1949, Cushman Lab. Foram. Res., Special Publ. 25, p. 120-121, pl. 6, figs. 55, 56; Puri, 1953, Florida Geol. Surv. Bull. 36, p. 97, pl. 29, figs. 3, 4.

Occurrence: One new record for this guide species is in well A-11 near Newport News at 245 to 325 feet in the Calvert Formation.

Robulus calcar (Linnaeus)

Plate 3, Figure 5

"Nautilus minimus non umbilicatus", Gualtieri, 1742, Index. Test. Conch., pl. 19, fig. c.

Nautilus calcar Linnaeus, 1767, Syst. Nat., ed. 12, p. 1162, no. 272.

Lenticulina calcar (Linnaeus), Barker, 1960, Soc. Econ. and Mineral., Spec. Pub. 9, p. 146, pl. 70, figs. 9-12.

Robulus calcar Andersen, 1961, Louisiana Geol. Surv., Bull. No. 35, Part 2, p. 48-49, pl. 11, figs. 1a, b, 2a, b.

"Figure 2 in this report [Andersen, 1961] approaches the spineless form of *R. calcar* (Linnaeus), figured by Brady as *Cristellaria articulata* Reuss ("Challenger" Rept., pl. 69, figs. 10-12) which Cushman placed in synonymy with *Cristellaria lucida* Cushman (Bull. 104, U. S. Nat. Mus., pt. 4, p. 111) and which Barker (1960, p. 144, pl. 69, figs. 10-12) has given the new name *Robulus atlanticus*. Only the architecture of the aperture shows the absolute relationship between *R. calcar* (Linnaeus) and *R. atlanticus* Barker which, collectively, should be regarded as the biological range of the species *R. calcar* (Linnaeus)." (Andersen, 1961, p. 49)

Spines and other surface features in Foraminifera appear to have ecological significance, and the significance seems to be that increased ornamentation is a result of an open-sea ecology. Under this type of differentation of test configuration, we may include *Robulus americanus* and its subspecies *spinosus*. *Robulus calcar* differs from these two forms in that it possesses fewer chambers and lacks the distinctive raised sutures of *R. americanus* and *R. spinosus*. Typical examples of *R. americanus* and *R. americanus spinosus* occur in the Virginia-Maryland Miocene, and *R. calcar* (as considered here) is not a part of the *R. americanus* lineage.

Dimension of figured form (P.R.I. 27166) is 1.28 mm in largest diameter.

Occurrence: A single record exists for this species at 160 feet in well 1-SW from the Coleman Bridge section. This was erroneously referred to *R. americanus spinosus* in McLean (1956, p. 284).

Robulus pseudoiota McLean

Plate 3, Figure 6

Robulus iotus Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 25, pl. 4, figs. 1a-b; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 58; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 12, pl. 4, figs. 1a-b.

Robulus iota Puri, 1953, Florida Geol. Surv., Bull. 36, p. 97, pl. 29, figs. 1-2.

Robulus pseudoiota McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 325-326, pl. 38, figs. 2, 4.

The figured form, P.R.I. 27315, is not entirely typical for this species. Diameter of the specimen is 0.28 mm.

Occurrences: P.R.I. 27315 is from well A-11 near Newport News at 165 to 166 feet; other new localities are G-1 and 37.

Robulus sp.

Plate 3, Figure 7

Occurrences: This very minute specimen (P.R.I. 27277) was found in the Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet; a second specimen was found in the well at Franklin, Virginia at 80 to 90 feet. Largest diameter of the figured specimen is 0.24 mm.

Robulus vaughani (Cushman)

Cristellaria vaughani Cushman, 1918, U. S. Nat. Mus., Bull. 103, p. 61, pl. 22, fig. 3.

Robulus vaughani Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 59, pl. 8, figs. 5-10; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 98; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 326-327, pl. 38, figs. 3, 5, 7-9.

Lenticulina vaughani Bermudez, 1949, Spec. Pub. No. 25, Cushman Lab. Foram. Res., p. 135, pl. 8, figs. 17-20.

Occurrences: Additional occurrences of this Yorktown form are: localities G-1 and J-1. See McLean (1956) for description and figures.

Genus MARGINULINA d'Orbigny, 1826

Marginulina sp. D Clapp

Plate 4, Figure 3

Marginulina sp. D Clapp, 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 285, pl. 30, figs. 12a-b, 13a-b.

Occurrence: A single specimen, attributable to Clapp's form, came from well A-11 near Newport News, at a depth of 170 feet. Dimension of figured form, P.R.I. 27303, 1.90 mm long.

Marginulina sp. A

Plate 3, Figure 8

Occurrence: This form is from the Chesapeake Bay Bridge-Tunnel at 84 feet in well A-1. Dimension of figured form P.R.I. 27281 is 0.50 mm long.

Marginulina sp. B

Plate 4, Figure 1

Occurrence: Well A-1, Chesapeake Bay Bridge-Tunnel, had this specimen at 84 feet. Dimension of figured form, P.R.I. 27286, is 0.38 mm long.

Marginulina sp. C

Plate 4, Figure 2

Occurrence: This specimen (P.R.I. 27275) is from well A-2 from Chesapeake Bay Bridge-Tunnel at 70 feet; it measures 0.22 mm in length.

Genus DENTALINA d'Orbigny, 1826

Dentalina kaicherae McLean

Dentalina kaicherae McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 328, pl. 38, figs. 14-15, 18-19.

Occurrences: Additional records for this species, as described in McLean (1956), include localities E-1, G-1, J-1.

Dentalina cf. *pyrula* (d'Orbigny)

Dentalina cf. *pyrula* McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 328, pl. 38, fig. 11.

Occurrence: Fragments similar to those figured by McLean (1956) are found at locality E-1.

Genus NODOSARIA Lamarck, 1812

Nodosaria catesbyi d'Orbigny

Nodosaria catesbyi d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. and nat. de l'isle de Cuba, p. 16, pl. 11, figs. 8-10; Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 28, 29, pl. 5, fig. 4; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 61; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 101, pl. 26, fig. 6; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 329, pl. 39, figs. 1-4.

Nodosaria sp. ? Cushman, 1922, Carnegie Inst. Washington, vol. 17, no. 311, p. 32, pl. 4, fig. 2.

Occurrences: Typical specimens occur at localities A-3, C, E-1, G-1, J-1.

Nodosaria catesbyi subsp. *hustonae* McLean, n. subsp.

Plate 4, Figure 4

Description: Test consisting of three chambers; sutures slightly limbate and incised; initial chamber larger in diameter than others and ornamented with a short stubby spine; middle chamber shorter and smaller in diameter than others; final chamber elongate and pyriform, surmounted by a short fluted neck. Test ornamented with very indistinct costae which often disappear into smooth areas. Length of holotype P.R.I. 27321 0.65 mm.

Remarks: This is a typical *Nodosaria catesbyi* in most features except for the very smooth appearance of the test, which may be a result of ecological controls. However, the form suffi-

ciently differs from typical *Nodosaria catesbyi* to enable it to be formally described as a subspecies.

Named in honor of Mrs. Elizabeth C. Huston, Research Assistant.

Occurrences: P.R.I. 27321, locality J-1, approximately 25 feet above sea level, basal Yorktown Formation; also at locality A-3.

Nodosaria sp.

Nodosaria sp. McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 329, pl. 38, fig. 12.

Occurrences: Additional records for this species are: localities A-3, E-1, G-1, J-1; descriptions and figures are in McLean (1956).

Genus LAGENA Walker & Jacob, 1798

Lagena clavata (d'Orbigny)

Oolina clavata d'Orbigny, 1846, Foram. Foss. Bassin Tertiaire, Vienne, p. 24, pl. 1, fig. 2.

Lagena clavata Reuss, 1862, Akad. Wiss. Wien. Math. Naturwiss Kl., Sitzungsber., vol. 46, pt. 1, p. 320, pl. 1, figs. 13, 14; Terquem, 1882, Mem. Soc. Geol. France, ser. 3, vol. 2, Mem. 3, p. 25, pl. 1, fig. 2; Egger, 1893, Abhandl. kon. bay. Akad. Wiss., Munchen. Cl. 2, vol. 18, p. 324, pl. 10, fig. 68; Goes, 1894, Kongl. Svensk. Vet. Akad. Handl., vol. 25, no. 9, p. 75, pl. 13, figs. 725-727; Jones, 1895, Pal. Soc. Mon., pt. 2, p. 182, pl. 7, fig. 5; Morton, 1897, Portland Soc. Nat. Hist. Proc., vol. 2, p. 116, pl. 1, fig. 2; Reade, 1900, Geol. Mag., vol. 7, pl. 5, fig. 13; Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 10, pl. 1, fig. 15; Franke, 1925, Abhandl. Ber. Mus. Natur. und Heimatkunde und Nat. Ver., vol. 4, p. 164, pl. 5, fig. 19; Cushman, 1929, Cushman Lab. Foram. Res. Contr., vol. 5, p. 68, pl. 11, fig. 3; Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 29, pl. 5, figs. 6a-b; Hada, 1931, Tohoku Imp. Univ. Sci. Rept., ser. 4, vol. 6, p. 103, fig. 57 (in text); Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 62; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 15, pl. 5, figs. 7a-b; Asano, 1938, Tohoku Imp. Univ. Sci. Rept., ser. 2, vol. 19, no. 2, p. 216(38), pl. 37(4), figs. 57, 61; pl. 30(7), fig. 26; Cushman and LeRoy, 1938, Jour. Pal., vol. 12, no. 2, p. 125, pl. 22, fig. 14; Cushman, 1944, Contr. Cushman Lab. Foram. Res., vol. 20, pt. 1, p. 23, pl. 4, fig. 12; Cushman, 1944, Spec. Publ. No. 12, Cushman Lab.

Foram. Res., p. 21, pl. 3, fig. 6; Clapp, 1948, Maryland Dept. Geol., Mines and Water Res. Bull. 2, p. 287-288, pl. 31, fig. 4.

Lagena vulgaris Williamson var. *clavata* Williamson (not d'Orbigny), 1858, Recent British Foram., p. 5, pl. 1, fig. 6.

Lagena gracillima Mills (not Seguenza), 1900, Hull Sci. and Field Nat. Club, vol. 1, p. 147, pl. 10, fig. 19.

Amphorina elongata Costa (not Seguenza), 1864, Atti. Accad. Pont., vol. 8, pt. 2, p. 122, pl. 11, fig. 12.

Occurrences: This form, as figured by Clapp, occurs in the following additional records: localities, A-2, A-3, G-1, J-1, 18, 31, 37; well A-11 near Newport News at 165 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet, and well M-85 at 84 feet.

Lagena dorseyae McLean

Lagena sp. D Clapp, 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 291, pl. 30, figs. 19-21 (not 22 and 23).

Lagena dorseyae McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 330-331, pl. 39, figs. 8a-b.

Occurrences: See McLean (1956) for description and figures; added records are: localities A-3, E-1, G-1, J-1; well A-11 near Newport News at 135 to 170 feet; Chesapeake Bay Bridge-Tunnel, well M-85 at 84 feet.

Lagena globulohispida McLean

Lagena sp. E Clapp, 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 291, pl. 31, fig. 24.

Lagena globulohispida McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 331, pl. 39, figs. 7a-b.

Occurrences: Described by McLean (1956), this form has been found in the following new sites: locality A-3; Chesapeake Bay Bridge-Tunnel in well M-85 at 84 to 133 feet.

Lagena hexagona subsp. *scalariformis* (Williamson)

Plate 4, Figure 5

Entosolenia squamosa subsp. *scalariformis* Williamson, 1858, Recent Foraminifera of Great Britain, p. 13, pl. 1, fig. 30.

Lagena scalariformis Reuss, 1862 (1863), Akad. Wiss. Wien Sitzungsber., vol. 46, pt. 1, p. 333, pl. 5, figs. 69-71.

Lagena hexagona subsp. *scalariformis* Cushman, 1913, U. S. Nat. Mus. Bull. 71, pt. 3, p. 17, pl. 6, fig. 4; Cushman, 1927, Scripps Inst. Oceanography Bull., Tech. ser., vol. 1, p. 145; Cushman, 1929, Contr. Cushman Lab. Foram. Research, vol. 5, pt. 3, p. 72, pl. 11, fig. 17; Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 30, pl. 5, figs. 7a, b; Cushman and Parker, 1931, Contr. Cushman Lab. Foram. Res., vol. 7, p. 7, pl. 1, fig. 24; Cushman and Ponton, 1932, Florida Geol. Surv. Bull. 9, p. 62; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 15, pl. 5, figs. 9a, b.

Occurrences: This figured form, P.R.I. 27322, is from locality E-1, and measures 0.21 mm in length; another specimen was found in well M-85, Chesapeake Bay Bridge-Tunnel, at a depth of 93 feet.

Lagena laevis (Montagu)

Plate 4, Figure 6

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

Vermiculum laeve Montagu, 1803, Test. Britain, p. 524.

Lagena laevis Williamson, 1848, Annal. Mag. Nat. Hist., ser. 3, vol. 1, p. 12, pl. 1, figs. 1, 2; H. B. Brady, 1884, Challenger Rept. Zool., vol. 9, p. 455, pl. 56, figs. 7-14, ? 30; Fornasini, 1890, Accad. Sci. Istit. Bologna Mem., ser. 4, vol. 10, p. 6, pl. ?, fig. 1; Terrigi, 1893, Atti R. Accad. Lincei, ser. 4, Mem. vol. 6, p. 112, pl. 5, fig. 12; Goes, 1894, Kongl. Svensk. Vet.-Akad. Handl., vol. 25, no. 9, p. 74, pl. 13, figs. 719-722; Jones, 1895, Foram. Crag, pt. 2, p. 181, pl. 1, fig. 28; Flint, 1897, U. S. Nat. Mus. Rept., p. 306, pl. 53, fig. 6; Mills, 1900, Trans. Hull Sci. and Field Nat. Club, vol. 1, p. 147, pl. 11, fig. 28; Reade, 1900, Geol. Mag., vol. 7, pl. 5, fig. 12; Bagg, 1912, U. S. Geol. Surv., Bull. 513, p. 48, pl. 13, figs. 5-8, 10, 11; pl. 14, figs. 23, 24; Cushman, 1913, U. S. Nat. Mus., Bull. 71, pt. 3, p. 5, pl. 1, fig. 3; pl. 38, fig. 5; Chapman and Parr, 1926, Jour. Linn. Soc. Zool., vol. 36, p. 373, pl. 17, fig. 1; Hada, 1931, Tohoku Imp. Univ. Sci. Rept., ser. 4, vol. 6, p. 102, fig. 56 (in text); Cushman, 1933, U. S. Nat. Mus., Bull. 161, pt. 2, p. 19, pl. 4, fig. 5; Cushman, 1935, U. S. Geol. Surv., Prof. Paper 181, p. 22, pl. 9, figs. 3, 4; Howe, 1939, Louisiana Geol. Surv., Bull. no. 14, p. 50, pl. 6, fig. 12; Toulmin, 1941, Jour. Pal., vol. 15, no. 6, p. 593, pl. 80, fig. 7; Cooper, 1944, Jour. Pal., vol. 18, no. 4, p. 348, pl. 54, figs. 6, 7; Clapp, 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 289, pl. 31, figs. 9, 10.

Lagena clavata Cole (not d'Orbigny), 1931, Florida Geol. Surv., Bull. 6, p. 28, pl. 6, fig. 6.

Lagena perlucida Cushman and McGlamery (not Montagu), 1938, U. S. Geol. Surv., Prof. Paper 189-D, p. 105, pl. 24, fig. 11.

Occurrences: The illustrated specimen (P.R.I. 27213) is from locality 18, and it is 0.32 mm long; other specimens are from locality 10; and Chesapeake Bay Bridge-Tunnel, well A-1 at 113 feet.

Lagena melo (d'Orbigny)

Oolina melo d'Orbigny, 1839, Voy. Amer. Meridionale; Foraminiferes, tome 5, pt. 5, p. 20, pl. 5, fig. 9; Boltovskoy, 1954, Revista Inst. Nacional Invest. Ciencias Nat. y Mus. Argentino Ciencias Nat. "Bernadino Revadavia," tomo 3, no. 4, p. 268-269, pl. 23, fig. 3.

Lagena melo McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 331-332, pl. 39, figs. 12a-b.

Occurrence: This species is found at locality C, which is the only additional record for the form so far found.

Lagena pageae McLean, n. sp.

Plate 4, Figures 7-9

Description: Test about normal size for the genus; in outline rather uniformly rounded from base towards aperture, but apertural face is definitely rather broad and truncate; entire test, except for area close to aperture, is ornamented with pronounced ribs, from 6 to 8 of them visible to a side; the area between these prominent costae show very faint cross-ridges which in certain angles of light give the effect exemplified by *Lagena hexagona scalariformis* test ornamentation; in normal lighting these cross-ridges are very faintly or not at all visible; test wall calcareous, translucent, and glassy, giving a slightly cloudy effect.

Holotype—0.30 mm long, 0.19 mm wide, P.R.I. 27249

Paratype—0.25 mm long, P.R.I. 27260

Paratype—0.22 mm long, P.R.I. 27294

Remarks: Named in honor of Mrs. Naida W. Page, who illustrated the microfossils for this publication.

Occurrences: Holotype P.R.I. 27249 from locality 14; Paratype P.R.I. 27260 from locality 10; Paratype P.R.I. 27294 from Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet; additional records: locality 18 and Chesapeake Bay Bridge-Tunnel, well A-2 at 70 feet and well M-85 at 93 feet.

Lagena palmerae McLean

Lagena palmerae McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 332, pl. 39, figs. 5-6; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 226.

Occurrences: As figured and described by McLean (1956), this form occurs in localities C, E-1, G-1, J-1, and in the Chesapeake Bay Bridge-Tunnel, well M-85 at 93 feet.

Lagena pseudosulcata McLean

Plate 5, Figures 1, 2

Lagena pseudosulcata McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 332-333, pl. 39, figs. 11a-b; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 226.

This form is easily confused with *Lagena sulcata,* but it differs from that species in the short, generally lipped neck which always shows a dark area near the lip as if the interior canal widens at that point. Typical *L. sulcata* as figured herein has a produced neck which shows a continuation of the costae of the body, whereas *L. pseudosulcata* always shows a non-costate neck region. Dimensions of figured hypotypes: P.R.I. 27237 is 0.32 mm long, P.R.I. 27209 is 0.34 mm long.

Occurrences: P.R.I. 27237 is from locality 11; P.R.I. 27209 is from locality 14; also at locality D, and Chesapeake Bay Bridge-Tunnel, well A-1 at 93 feet.

Lagena substriata (Williamson)

Plate 5, Figure 3

Lagena substriata Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 31, pl. 5, fig. 14; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 333,

pl. 39, figs. 10a-b; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 226.

Occurrences: The figured specimen is from well A-1 in the Chesapeake Bay Bridge-Tunnel at a depth of 113 feet; dimension of P.R.I. 27274 is 0.25 mm long. Other records include localities A-2, E-1, G-1.

Lagena sulcata (Walker and Jacob)

Plate 5, Figures 4, 5

Serpula (*Lagena*) *sulcata* Walker and Jacob, 1798, Adam's Essays, p. 634, pl. 14, fig. 5.

Lagena sulcata H. B. Brady, 1884, Challenger Rept., vol. 9, p. 462, pl. 57, figs. 23, 26, 33, 34; Cushman, 1923, U. S. Nat. Mus. Bull. 104, pt. 4, p. 57, pl. 11, fig. 1; Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 31, pl. 5, fig. 10; Cushman and Ponton, 1932, Florida Geol. Surv. Bull. 9, p. 63; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 16, pl. 5, fig. 10; Cushman and Ellisor, 1945, Jour. Pal., vol. 19, p. 558; Bermudez, 1949, Cushman Lab. Foram. Res., Special Publ. 25, p. 118, pl. 10, fig. 48; Puri, 1953, Florida Geol. Surv. Bull. 36, p. 103-104, pl. 26, fig. 8.

Occurrences: The usefulness of this species is marred by inclusion of many diverse forms. The synonymy above specifically limits the form to those records that conform with the author's delineation of the species. The Chesapeake region forms that are equivalents are as follows: P.R.I. 27246 from locality 18 (0.29 mm in length) and P.R.I. 27163 from well A-11 near Newport News at a depth of 65 feet (0.42 mm long). Other occurrences are locality 27, and well A-11 from 52 to 85 feet.

Lagena sp.

Plate 5, Figure 8

Occurrence: The figured form is the only specimen found in our collections and is figured for further reference. P.R.I. 27288, length 0.41 mm, from the Chesapeake Bay Bridge-Tunnel, well A-1 at 93 feet.

Lagena tenuis (Bornemann)

Plate 5, Figures 6, 7

Ovulina tenuis Bornemann, 1855, Deutsch. Geol. Ges., Leitschr., Berlin, Deutschland, Bd. 7, Heft. 2, p. 317, pl. 12, fig. 3A-B (not *Lagena ampulla* Galloway and Heminway).

Galloway and Heminway (1941, p. 317) confused Bornemann's *Ovulina tenuis* with a variety which cannot be found in the literature with any certainty. They designated the variety as the type species for *Lagena ampulla*. *Ovulina tenuis* as figured by Bornemann is quite clearly not the same as *Lagena ampulla*, which has costae extending the length of the test, whereas Bornemann's figures show only a basal costation.

Occurrences: Chesapeake Bay Bridge-Tunnel, well A-2 at 101 feet and from locality 18.

Age: Oligocene to Pleistocene.

Hypotype: P.R.I. 27289, length 0.25 mm and P.R.I. 27320, length 0.38 mm.

Family POLYMORPHINIDAE

Genus GUTTULINA d'Orbigny, 1839

Guttulina austriaca d'Orbigny

Guttulina austriaca d'Orbigny, 1846, Foram. Foss. Bass. Tert. Vienne, p. 223, pl. 12, figs. 23-25; Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 29-30, pl. 4, figs. 3-5; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 333, pl. 40, figs. 1-3; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 227.

Occurrences: This common species (see McLean, 1956) occurs at the following additional localities: A-2, E-1, G-1, J-1; well A-11 near Newport News at 170 feet.

Guttulina palmerae McLean

Guttulina palmerae McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 333-334, pl. 40, figs. 4-7, 13.

Occurrences: Originally described from the Yorktown Formation in 1956, this form occurs at these additional Yorktownian localities: A-2, A-3, B-3, D, E-1, G-1, J-1.

Guttulina pseudocostatula McLean

Plate 5, Figure 9

Guttulina pseudocostatula McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 334, pl. 40, figs. 8, 10-11.

Occurrences: P.R.I. 27194 (0.85 mm long) is figured from the Coleman Bridge section, well 3-N at a depth of 115 feet; other occurrences are localities F-1 and J-1.

Guttulina sp. A

Guttulina sp. A McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 334-335, pl. 40, fig. 9.

Occurrence: A single occurrence of this form, originally recorded by McLean (1956) for the Yorktown Formation, was found at locality E-1.

Genus PSEUDOPOLYMORPHINA Cushman & Ozawa, 1928

Pseudopolymorphina rutila (Cushman)

Polymorphina regina subsp. *rutila* Cushman, 1923, U. S. Geol. Surv., Prof. Paper 133, p. 34, pl. 5, figs. 7-8.

Pseudopolymorphina rutila Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc. vol. 77, art. 6, p. 100, pl. 26, figs. 3a-b; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 36, pl. 5, fig. 20; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 67; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 19, pl. 6, fig. 11; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 105-106, pl. 21, fig. 18; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 335, pl. 41, figs. 6-9, 16-17; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 227.

Occurrences: Well documented as to typical forms and variations in McLean (1956), this species occurs in these additional Yorktown Formation localities: A-3, C, F-1, J-1.

Genus SIGMOMORPHINA Cushman & Ozawa, 1928

Sigmomorphina concava (Williamson)

Polymorphina lactea var. *concava* Williamson, 1858, Recent Foram. Great Britian, p. 72, pl. 6, figs. 151-152.

Sigmomorphina concava Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc., vol. 77, art. 6, p. 139, pl. 38, figs. 5-7; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 336, pl. 41, figs. 14, 18; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 228.

Occurrences: Typical individuals, as shown in McLean (1956) occur in the following additional localities: B-4, C, F-1, G-1; well A-5 near Lambert Point at 85 feet; Chesapeake Bay Bridge-Tunnel, well M-85 at 84 feet.

Sigmomorphina nevifera Clapp

Pyrulina albatrossi Cushman and Cahill, 1933, (not Cushman and Ozawa), U. S. Geol. Surv., Prof. Paper 175-A, p. 18, pl. 6, figs. 5a-b.

Sigmomorphina nevifera Clapp, 1948, Maryland Dept. Geol., Mines and Water Resources, Bull. 2, p. 298, pl. 34, figs. 6, 7a-b; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 336-337, pl. 41, figs. 3-5, 11.

Occurrences: Clapp's form is found in the following new localities: A-2, A-3, C, D, E-1, F-1, H.

Sigmomorphina pearceyi Cushman and Ozawa

Sigmomorphina pearceyi Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc. vol. 77, art. 6, p. 132, pl. 35, figs. 2-3; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 337, pl. 41, figs. 13, 15.

Occurrence: Locality C is the only new record for this form.

Sigmomorphina semitecta subsp. *terquemiana* (Fornasini)

Plate 6, Figures 1, 2

Sigmomorphina semitecta subsp. *terquemiana* Cushman and Ozawa, 1930, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 129-130, pl. 33, figs. 4-5, pl. 34, figs. 2-3, pl. 35, fig. 1; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 337-338, pl. 41, figs. 12, 19-24; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 228.

Occurrences: P.R.I. 27247 (length 0.35 mm) is an untypical specimen that is tentatively included in the species; P.R.I. 27287 is the more typical form and measures 0.42 mm long. Occurrences are: P.R.I. 27247 from locality 10; P.R.I. 27287 from Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet; other localities are: A-2, C, F-1, G-1, J-1, 18; well A-5 near Lambert Point at 65 feet; well A-11 near Newport News at 70 feet; Chesapeake Bay Bridge-Tunnel, well M-85 at 84 feet.

Sigmomorphina sp.

Plate 6, Figure 3

Occurrences: This form, P.R.I. 27273 (0.34 mm long), is from well A-2 in the Chesapeake Bay Bridge-Tunnel at 81 feet. It cannot be assigned to any presently known form, and there are not enough specimens available upon which to base a description of it.

Sigmomorphina williamsoni (Terquem)

Polymorphina lactea var. *oblonga* Williamson, 1858, Recent Foram. Great Britian, Ray Soc. London, p. 71, pl. 6, figs. 149-149a; Millett, 1903, Jour. Roy. Micr. Soc., p. 262, pl. 5, fig. 5; Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 147, pl. 40, figs. 7 (?), 8a-b.

Polymorphina williamsoni Terquem, 1878, Mem. Soc. Geol. France, ser. 3, vol. 1, p. 37; Heron-Allen and Earland, 1932, Discovery Reports, vol. 4, p. 393-394, pl. 12, figs. 26-28.

Sigmomorphina williamsoni Cushman and Ozawa, 1930, U. S. Nat. Mus., Proc. vol. 77, art. 6, p. 139, pl. 38, figs. 3a-b, 4a-b; Boltovskoy, 1954, Revista Inst. Nacional Invest. Ciencias Nat. y Mus. Argentino Ciencias Nat. "Bernadino Revadavia," tomo 3, no. 4, p. 272, pl. 24, figs. 2a-b; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 338, pl. 42, figs. 1-4.

Laryngosigma williamsoni Copeland (not others), 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 253, pl. 35, fig. 6.

Occurrence: A single specimen from locality E-1 may be the juvenile form of this species.

Family NONIONIDAE

Genus NONION Montfort, 1808

Nonion grateloupi (d'Orbigny)

Plate 6, Figures 5, 6

Nonionina grateloupi d'Orbigny, 1826, Annales Sci. Nat. Paris, Vol. 7, p. 294, no. 19; d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. and nat. de l'isle de Cuba, p. 46, pl. 6. figs. 6, 7; Fornasini, 1904, Accad. sci. Ist. Bologna Mem., ser. 6, vol. 1, p. 12, pl. 3, fig. 5; Cushman, 1921, U. S. Nat. Mus. Proc., vol. 59, p. 61, pl. 14, figs. 9-11; Cushman, 1922, Carnegie Inst., Washington, Pub. 311, p. 55, pl. 9, figs. 7, 8.

Nonion grateloupi Cushman, 1930, U. S. Nat. Mus., Bull. 104, pt. 7, p. 10, pl. 3, figs. 9-11; pl. 4, figs. 1-4; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 36, pl. 6, figs. 1-3; Cushman and Valentine, 1930, Stanford Univ., Dept. Geol. Contr., vol. 1, no. 1, p. 20, pl. 5, figs. 9a-b; Cushman and Parker, 1931, U. S. Nat. Mus. Proc., vol. 80, art. 3, p. 10, pl. 2, figs. 6a-b; Cole, 1931, Florida Geol. Surv., Bull. 6, p. 32, pl. 7, figs. 7, 8; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 68; Heron-Allen and Earland, 1932, Discovery Repts., vol. 4, p. 437, pl. 16, figs. 9, 10; Cushman, 1933, U. S. Nat. Mus., Bull. 161, pt. 2, p. 43, pl. 10, figs. 8a-c; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 20, pl. 7, figs. 1a-b; Cushman, 1939, U. S. Geol. Surv., Prof. Paper 191, p. 21, pl. 6, figs. 1-7; Cushman and McCulloch, 1940, Allan Hancock Pacific Exped., vol. 6, no. 3, p. 153, pl. 17, fig. 2.

Nonionina punctulata d'Orbigny, 1839, Voyage Am. Merid., vol. 5, p. 28, pl. 5, figs. 21, 22.

Nonion cf. *grateloupi* McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 340, pl. 43, figs. 7a-b.

Occurrences: Specimens that appear to be typical examples of d'Orbigny's species occur in the following localities: P.R.I. 27152 (length 0.52 mm) from Coleman Bridge section, well 3-S at 95 feet; P.R.I. 27271 (length 0.42 mm) and P.R.I. 27267 (length 0.44 mm) are both from Chesapeake Bay Bridge-Tunnel, well A-2 at 81 feet; others from Coleman Bridge section, well 3-N at 155 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet, and well A-2 at 70 feet.

Nonion grateloupi Clapp

Plate 6, Figure 4

Nonion grateloupi Clapp (not others), 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 300, pl. 35, figs. 5a-c.

Clapp's *N. grateloupi* definitely is not the same as the original species; it is a larger, more robust form with a distinctive umbilical button on one side, and pustules on the umbilicus of the opposite side. P.R.I. 27190 is a typical specimen, and is 0.79 mm long.

Occurrences: P.R.I. 27190 from Coleman Bridge section, well 1-NE at 200 feet; also from well A-11 near Newport News at 65 to 180 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet and well A-2 at 70 feet.

Nonion mediocostatus (Cushman)

Plate 6, Figures 7, 8

Nonionina medio-costata Cushman, 1926, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 4, p. 89-90, pl. 13, figs. 1a-c.

Nonion medio-costatum Cushman, 1939, U. S. Geol. Surv., Prof. Paper 191, p. 15, pl. 4, figs. 7-8; Clapp, 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 300, pl. 35, figs. 4a-c.

Nonion mediocostatus McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 339-340, pl. 42, figs. 5a-c, 7.

This is an important and distinctive guide species for the pre-Yorktown beds in the Chesapeake region. McLean (1956) discusses the form at length, and these additional records are based upon his description as limited in that discussion. Cushman enlarged the species concept of this form to include individuals that are not equivalent to our forms. Dimensions: P.R.I. 27182 is 0.57 mm at largest diameter; P.R.I. 27168 is 0.61 mm in maximum diameter.

Occurrences: P.R.I. 27182 is from Coleman Bridge section, well 3-S at 105 feet and P.R.I. 27168 is from 115 feet in same well; other occurrences are: Coleman Bridge section, well 1-SE at 118 feet, well 1-NE at 108 feet, well 1-NW at 118 feet, well 3-N at 115 feet; well A-5 near Lambert Point at 205 feet; well

A-11 near Newport News at 135 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 123 feet; well at Franklin, Virginia, at 80 feet.

Nonion pizarrensis (W. Berry)

Plate 7, Figures 1, 2

Nonionina boueana Cushman, 1918, (not d'Orbigny), U. S. Geol. Surv., Bull. 676, p. 68, pl. 25, fig. 3.

Nonion pizarrensis W. Berry, 1928, Jour. Pal., vol. 1, p. 269, text fig. 1, figs. 1-3; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 37, pl. 6, figs. 7-8; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 69; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 20, pl. 7, figs. 2a-b; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 340, pl. 42, figs. 6, 8, 10, 12; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 228.

Nonion pizarrense Cushman, 1939, U. S. Geol. Surv., Prof. Paper 191, p. 24, pl. 6, fig. 27; Clapp, 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 300, pl. 35, figs. 6a-c; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 145.

P.R.I. 27191 (0.77 mm at largest diameter) is not an entirely typical specimen; typical ones are figured by McLean (1956). This form may be confused with Clapp's *N. grateloupi*, but it lacks the umbilical button of Clapp's form. P.R.I. 27189 (diameter 0.72 mm) is a typical specimen.

Occurrences: P.R.I. 27189 is from well 1-SW, and P.R.I. 27191 is from well 3-S in the Coleman Bridge section at 105 feet; others from the same section are: well 1-SW at 123 feet, 1-SE at 128 feet, 1-NE at 108 feet, 1-NW at 118 feet, 3-N at 115 feet; also in well A-5 near Lambert Point at 85 feet; well A-11 near Newport News at 135 feet; Chesapeake Bay Bridge-Tunnel, wells A-1 at 84 feet, A-2 at 70 feet, well M-85 at 84 feet; localities A-2, A-3, C, F-1, J-1; well at Franklin, Virginia, at 70 feet.

Nonion sp.

Small, nondescript, and badly damaged specimens of *Nonion* occur throughout the record, but are mainly confined to the Pleistocene beds in the Chesapeake Bay region.

Genus NONIONELLA Cushman, 1926

Nonionella auris (d'Orbigny)

Plate 7, Figures 3, 4

Valvulina auris d'Orbigny, 1839, Voyage dans l'Amerique meridionale, vol. 5, pt. 5, Foraminiferes, p. 47, pl. 2, figs. 15-17.

Nonionina auris Cushman, 1925, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, p. 44, pl. 7, figs. 3a-c.

Nonionella auris Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 38, pl. 7, figs. 1a-c; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 21, pl. 7, figs. 6a-b; Cushman, 1939, U. S. Geol. Surv., Prof. Paper 191, p. 33, pl. 9, fig. 4; Clapp, 1948, Maryland Dept. Geol., Mines and Water Res., Bull. 2, p. 301, pl. 35, figs. 3a-c; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 341, pl. 43, figs. 1, 4; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 229.

Nonionella pseudo-auris Cole, 1931, Florida Geological Surv., Bull. 6, p. 32-33, pl. 5, figs. 4, 5.

Occurrences: Typical specimens of this form are here figured; P.R.I. 27160 (0.47 mm at largest diameter) is from well A-11 near Newport News, at 80 to 81.6 feet, and P.R.I. 27203 (0.40 mm at largest diameter) is from locality 89. Other localities include: Coleman Bridge section, well 1-SW at 123 feet, well 3-S at 160 feet, well 1-NE at 154 feet, well 1-NW at 158 feet; well A-5 near Lambert Point at 40 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet, well A-2 at 81 feet, well M-85 at 88 feet; well at Franklin, Virginia, at 80 feet.

Genus ELPHIDIUM Montfort, 1808

Elphidium advena (Cushman)

Plate 7, Figure 5

Polystomella crispa Cushman, 1918, U. S. Geol. Surv., Bull. 676, p. 69-70, pl. 27, figs. 5a-b.

Polystomella advena Cushman, 1922, Carnegie Inst. Washington, Pub. No. 311, p. 56, pl. 9, figs. 11-12.

Elphidium advenum Cushman, 1930, U. S. Nat. Mus., Bull. 104, pt. 7, p. 25, pl. 10, figs. 1-2; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 40, pl. 7, figs. 7a-b; Cushman and Ponton, 1932, Florida Geol. Surv.,

Bull. 9, p. 70, pl. 11, figs. 1a-b; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 22, pl. 7, figs. 10a-b; Cushman, 1939, U. S. Geol. Surv., Prof. Paper 191, p. 60-61, pl. 16, figs. 31-35; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 146-147.

Elphidium advena McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 341-342, pl. 43, figs. 5a-b.

Occurrences: This very rare species is represented by two specimens: P.R.I. 27159 (0.41 mm diameter) is from well A-11 near Newport News at a depth of 80 to 81.6 feet; the other specimen comes from locality F-1.

Elphidium clavatum Cushman

Plate 7, Figures 6-8

Elphidium incertum (Williamson) var. *clavatum* Cushman, 1930, U. S. Natl. Mus. Bull. 104, pt. 7, p. 20, pl. 7, figs. 10a, b; Cushman, 1939, U. S. Geol. Surv., Prof. Paper 191, p. 57, pl. 16, figs. 1, 2; Cushman, 1944, Special Pub. 12, Cushman Lab. Foram. Research, p. 25, pl. 3, figs. 32, 33; Cushman, 1948, Special Pub. 23, Cushman Lab. Foram. Research, p. 57, pl. 6, fig. 8.

Elphidium clavatum Weiss, 1954, U. S. Geol. Surv., Prof. Paper 254-G, p. 160, pl. 32, figs. 12-14.

P.R.I. 27162 is a specimen at one end of a series which grades into forms typically developed in specimens P.R.I. 27156 with marked retral processes. Weiss notes the relationship of this form to *E. florentinae,* but retains the species-separation of the two forms. P.R.I. 27162 is 0.40 mm in diameter, and the largest specimen in slide P.R.I. 27156 is 0.41 mm in diameter.

Occurrences: P.R.I. 27162 from well A-11 near Newport News at 100 to 101.6 feet; P.R.I. 27156 from same well at 80 to 81.6 feet; others from Chesapeake Bay Bridge-Tunnel, well A-2 at 161 feet and well M-63 at 73 to 154 feet.

Elphidium incertum (Williamson)

Polystomella umbilicatula var. *incerta* Williamson, 1858, Recent Foram. Great Britain, p. 44, pl. 3, figs. 82, 82a.

Elphidium incertum Cushman, 1930, U. S. Nat. Mus., Bull. 104, pt. 7, p. 18, pl. 7, figs. 4-9; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 39, pl. 7, figs. 2a-b; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 21, pl. 7, fig. 8; Cushman, 1939, U. S. Geol. Surv.,

Prof. Paper 191, p. 57, pl. 15, figs. 21-24; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 342, pl. 43, figs. 2-3.

Elphidium limatulum Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 263-264, pl. 37, figs. 5a-b.

Occurrences: Typical specimens of this form occur in well 3-N at 75 feet in the Coleman Bridge section, and in well A-11 near Newport News at 70 feet.

Elphidium florentinae Shupack

Plate 8, Figures 1-7

Elphidium florentinae Shupack, 1934, Am. Mus. Novitates 737, p. 9, pl., figs. 5a, b; Weiss, 1954, U. S. Geol. Surv., Prof. Paper 254-G, p. 159-160, pl. 32, figs. 8-11.

Elphidium brooklynense Shupack, 1934, Am. Mus. Novitates 737, p. 10, pl. figs. 7a, b.

Elphidium incertum (Williamson) var. *clavatum* Cushman, Voorthuysen, 1949, Nederlandsch Geol.-Mijnb. Genoot. Verh. Geol. ser., Deel 15, stuk 1, p. 65, pl., figs. 4b, c.

Shupack's species is potentially the single most important Pleistocene guide marker for the Chesapeake region; for this reason, we have illustrated a complete series of variants of the form as it appears in our collections. The dimensions, occurrences, and type numbers are tabulated below, followed by a listing of all known occurrences of the form in the region:

P.R.I. No.	Dimension	Locality
27170	0.35 mm	54
27241	0.36 mm	8
27234	0.38 mm	30
27215	0.38 mm	7
27219	0.41 mm	37
27158	0.51 mm	Well A-11 81′-81.6′
27217	0.38 mm	11

Occurrences: Other localities are as follows: localities 5, 10, 18, 26, 27, 31, 36, 89; Coleman Bridge section, well 3-N at 75 feet; well A-5, near Lambert Point, 35 to 200 feet; well A-11,

near Newport News, 45 to 100 feet; Chesapeake Bay Bridge-Tunnel, well A-1, 84 feet, well A-2, 70 feet, well M-85, 84 feet, well M-62, 45 to 179 feet, well M-63, 73 to 164 feet, and well M-65, 70 to 124 feet.

Elphidium johnstonae McLean

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

Nonion decoratus Copeland (not others), 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 259, pl. 37, figs. 1a-b.

Occurrences: Copeland's form, listed in synonymy above, seems to be this form; additional records are: localities A-2, B-3, H. See McLean (1956) for descriptions and figures of the species.

Family BULIMINIDAE

Genus BULIMINELLA Cushman, 1911

Buliminella elegantissima (d'Orbigny)

Plate 9, Figures 1-3

Bulimina elegantissima d'Orbigny, 1839 (1843), Voyage Am. Merid., vol. 5, pt. 5, p. 51, pl. 7, figs. 13, 14; Williamson, 1858, Recent British Foram., p. 64, pl. 5, figs. 134, 135; H. B. Brady, 1884, Challenger Rept., Zool., vol. 9, p. 402, pl. 50, figs. 20-22; Sidebottom, 1905, Manchester Lit. Philos. Soc. Mem. and Proc., vol. 49, no. 5, p. 11, pl. 2, fig. 6.

Buliminella elegantissima Cushman, 1911, U. S. Nat. Mus., Bull. 71, pt. 2, p. 89; Cushman, 1925, Cushman Lab. Foram. Res. Contr., vol. 1, pt. 2, p. 40, pl. 6, figs. 5a-b; Cushman and Kellett, 1929, U. S. Nat. Mus. Proc., vol. 75, art. 25, p. 6, pl. 3, figs. 1-3; Cushman and Wickenden, 1929, U. S. Nat. Mus. Proc., vol. 75, art. 9, p. 8, pl. 3, figs. 12a-b; Wiesner, 1929, Deutsche Sud-Polar Exped., vol. 20, Zool., p. 124, pl. 19, figs. 235, 236; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 42, pl. 8, figs. 2, 3; Cushman, Stewart and Stewart, 1930, San Diego Soc. Nat. History Trans., vol. 6, no. 2, p. 64, pl. 4, figs. 7a-b; Cushman and Parker, 1931, U. S. Nat. Mus. Proc., vol. 80, art. 3, p. 13, pl. 3, figs. 12, 13; Cole, 1931, Florida Geol. Surv., Bull. 6, p. 39, pl. 2, fig. 8; Cushman and Ponton, 1932, Cushman Lab. Foram. Res. Contr., vol. 8, pt. 3, p. 67, pl. 8, figs. 20, 21; Howe and Wallace, 1932, Louisiana

Geol. Surv. Bull. 2, p. 61, pl. 11, fig. 3; Cushman, 1933, Cushman Lab. Foram. Res., Spec. Pub. no. 4, pl. 22, fig. 3; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 23, pl. 7, figs. 13, 14; Barbat and Johnson, 1934, Jour. Pal., vol. 8, p. 12, pl. 1, figs. 12, 13; Kleinpell, 1938, Bull. Amer. Assoc. Petrol. Geol., p. 249, pl. 16, fig. 10; Cushman and Henbest, 1940, U. S. Geol. Surv., Prof. Paper 196-A, pl. 9, fig. 20; Hanna and Hertlein, 1941, State of Calif. Div. Mines, Bull. 118, pt. 2, p. 178, fig. 67 (plate), figs. 5-7; Cushman, 1944, Special Publ. No. 12, Cushman Lab. Foram. Res., p. 27, pl. 3, figs. 43, 44; Cushman, 1945, Contr. Cushman Lab. Foram. Res., vol. 21, pt. 1, p. 7, pl. 2, fig. 6; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 302-303, pl. 36, fig. 2.

Buliminella cf. *elegantissima* (d'Orbigny), McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 344, pl. 44, figs. 11a-b.

Occurrences: As we have this species, it varies somewhat in outline; the figures here included show the variations. P.R.I. 27232 (0.37 mm long) is from locality 11; P.R.I. 27223 (0.33 mm long) is from locality 37; P.R.I. 27236 (0.36 mm long) is from locality 30; other localities are: B-4, C, D, E-1, F-1, J-1, 18, 26, 27, 31, 36, 54; well A-11 near Newport News at 135 feet; Chesapeake Bay Bridge-Tunnel, well A-1, at 84 feet, well A-2 at 70 feet, well M-85 at 93 feet.

Genus BULIMINA d'Orbigny, 1826

Bulimina gracilis Cushman

Plate 9, Figures 4, 5

Bulimina gracilis Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 43, pl. 8, figs. 5a-b; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 76; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 24, pl. 7, figs. 16a-b; Cushman, 1936, Geol. Soc. Amer., Bull. 47, p. 431, pl. 5, figs. 8a-b; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 344-345, pl. 44, figs. 6, 8-10; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 229.

Bulimina elongata, Cushman and Parker, 1937, (not d'Orbigny), Contr. Cushman Lab. Foram. Res., vol. 13, pt. 2, p. 49, pl. 7, figs. 1a-b, 3a-b, (not 2a-b); Cushman, 1946, (not d'Orbigny), U. S. Geol. Surv., Prof. Paper 210-D, pl. 25, figs. 16a-c (not others); Clapp, 1948, (not d'Orbigny), Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 303, pl. 36, figs. 5-6.

Occurrences: This is an important marker form for separation of Pleistocene and Miocene beds locally, as it seems not to

occur in the Pleistocene in this region. Both figured forms are from slide P.R.I. 27167, and the largest specimen is 0.71 mm long. The figured forms are from the Coleman Bridge section, well 1-SE at 180 feet; other new occurrences are: localities A-1, A-2, B-4, C, E-1, F-1, G-1, J-1; Coleman Bridge section, well 1-SW at 160 feet, well 1-NE at 124 feet, well 1-NW at 158 feet, well 3-N at 115 feet; well A-5 near Lambert Point at 175 feet; well A-11 near Newport News at 135 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet, well A-2 at 70 feet, well M-85 at 84 feet; well at Franklin, Virginia, at 70 to 110 feet.

Bulimina gracilis subsp. *calveri* McLean, n. subsp.

Plate 9, Figure 6

Description: This subspecies differs from *Bulimina gracilis* in having a stubby but definite basal spine. Otherwise, it is entirely similar to the species. The spine may be an ecological or environmental variation of this species, as Foraminifera seem to have the capacity to acquire specialized ornamentation due to favorable environments, but this change in ornamentation due to such controls is a valid biological criterion for establishing a subspecies.

Dimension of Holotype P.R.I. 27298 is 0.72 mm long.

Remarks: Named in honor of Dr. James L. Calver, State Geologist of Virginia.

Occurrence: Chesapeake Bay Bridge-Tunnel, well A-2 at a depth of 81 feet.

Age: St. Marys (Miocene).

Bulimina inflata Seguenza

Plate 12, Figure 7

Bulimina inflata Seguenza, 1862, Accad. gioenia sci. nat. Atti, 2d ser., vol. 18, p. 109, pl. 1, fig. 10; H. B. Brady, 1884, Rept. Challenger, Zool., vol. 9, p. 406, pl. 51, figs. 10-13; Cushman, 1921, Bull. U. S. Nat. Mus., no. 100, vol. 4, p. 160, pl. 31, fig. 6; Cushman, 1922, Bull. U. S. Nat. Mus., no. 104, pt. 3, p. 93, pl. 21, fig. 1; Cole, 1927, Bull. Amer. Pal., vol. 14, no. 51, p. 25, pl. 3, fig. 12; Cushman, 1929, Contr. Cushman Lab. Foram. Res., vol. 5, pt. 4, p. 94, pl. 13, fig. 31; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 43, pl. 8, figs. 6a, b; Cushman and

Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 77; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 24, pl. 8, figs. 1a, b.

Occurrence: P.R.I. 27201 is 0.47 mm long and comes from locality 89; deterioration of the test made accurate rendition of the form impossible, but there is no doubt as to the identity of the species. The sample labeled "89" is not identifiable as to locality or age, partly because of a mixup in numbering by the collector.

Bulimina cf. *preacanthia* McLean

Plate 12, Figure 8

Bulimina preacanthia McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 345-346, pl. 45, figs. 2-3, 7.

Occurrences: The figured specimen (P.R.I. 27161) measures 0.29 mm long and is from well A-11 near Newport News at a depth of 65 feet. The figured form is somewhat damaged and is somewhat untypical for the species which is described and illustrated in McLean (1956). Typical specimens of the form occur at: localities A-2, C, E-1; well A-5 near Lambert Point at 185 feet; and at 385 feet in well A-11 near Newport News.

Genus ENTOSOLENIA Ehrenberg, 1848

Entosolenia bifida McLean, n. sp.

Plate 9, Figure 9

Description: Test small, smoothly oval in outline, compressed in cross section; outer periphery ornamented with a thickened process or low keel; a part of the test is slightly channeled at the apertural portion both along the keel and at either face of the test towards the aperture; aperture a simple round opening with an entosolenian tube that is bifid at the basal portion and shows an apparent channel along the length of the tube; wall very thin, calcereous, glassy; this form is extremely fragile.

Holotype: P.R.I. 27292, length 0.28 mm, width 0.14 mm, thickness about 0.07 mm.

Remarks: This form does not resemble any species listed in the Ellis and Messina Catalogue of Foraminifera and is presum-

ed to be entirely new; it is exceptionally fragile and very rare, and questionably is of either Pleistocene or Miocene derivation, as the holotype is from well A-1 at the Pleistocene-Miocene contact.

Occurrence: Well A-1 at 84 feet, Chesapeake Bay Bridge-Tunnel.

Age: Pleistocene (?), Miocene (?).

Entosolenia carteri McLean

Plate 9, Figure 7

Lagena cf. *marginato-perforata* Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 32, pl. 5, fig. 5; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 17, pl. 5, figs. 15a-b.

Lagena (Entosolenia?) carteri McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 330, pl. 39, figs. 13a-b.

Occurrences: In addition to P.R.I. 27276 (which is 0.22 mm long) and comes from well A-2 from the Chesapeake Bay Bridge-Tunnel at a depth of 70 feet, the following new records are recorded: localities C, F-1, J-1; Chesapeake Bay Bridge-Tunnel, well A-1 at 93 feet and well M-85 at 93 feet.

Entosolenia carteri form *alpha* McLean

Lagena (Entosolenia?) carteri form *alpha* McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 330, pl. 39, fig. 9.

Occurrences: This species, as described by McLean (1956), occurs in the following localities: A-3, C, E-1, F-1.

Entosolenia nodosa Wiesner

Plate 9, Figures 8a, b

Lagena (*Entosolenia*) *nodosa* Wiesner, 1931, *in* von Drygalski, Deutsche Sudpolar - Expedition, 1901-1903, Berlin U. Leipzig, Deutschland; de Gruyter, 1931, Bd. 20 (Zool. Bd. 12), p. 122.

A specimen which appears to be similar to Wiesner's species was found at locality 10. The specimen found measures 0.32 mm. According to Wiesner this species comes from the South Polar region at a depth of 385 meters.

Occurrence: Locality 10.

Age: Pleistocene—Recent.

Hypotype: P.R.I. 27251.

Entosolenia spp.

Plate 9, Figure 10

Occurrences: Small, fragile, nondescript entosolenids occur at the following places: localities A-3, E-1, F-1, J-1, 10, 14; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 to 103 feet and well M-85 at 84 to 184 feet. P.R.I. 27222 is 0.32 mm long and is from locality 14. Only one form is figured.

Genus VIRGULINA d'Orbigny, 1826

Virgulina punctata d'Orbigny

Virgulina punctata d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. & nat. de l'isle de Cuba, p. 139, pl. 1, figs. 35-36; Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 31, pl. 3, fig. 9; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 44, pl. 8, figs. 7a-b; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 25, pl. 8, figs. 8a-b; Cushman, 1937, Spec. Publ. No. 9, Cushman Lab. Foram. Res., p. 23-24, pl. 3, figs. 25-27; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 118-119, pl. 29, figs. 6-7; Parker, 1954, Bull. Mus. Comp. Zool., Harvard Univ., vol. 3, no. 10, p. 513, pl. 7, fig. 11; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 346, pl. 44, figs. 12a-b, pl. 45, figs. 1a-c.

Occurrences: This form, as described and figured by McLean (1956), also is recorded for localities C and 18.

Genus BOLIVINA d'Orbigny, 1839

Bolivina floridana Cushman

Bolivina floridana Cushman, 1918, U. S. Geol. Surv. Bull. 676, p. 47, pl. 10, fig. 4; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 46, pl. 8, figs. 15a-b; Cushman and Parker, 1931, Contr. Cushman Lab. Foram. Res., vol. 7, p. 9, pl. 2, fig. 2; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 82; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 26, pl. 11, figs. 11a-b; Barbat and von Estorff, 1933, Jour. Pal. vol. 7, p. 165; Cushman, 1937, Cushman Lab. Foram. Res. Special Publ. 9, p. 85, pl. 10, figs. 2, 3; Kleinpell, 1938, Bull.

Amer. Assoc. Petrol. Geol., vol 22, p. 271, pl. 12, fig. 1; Ellisor, 1940, Bull. Amer. Assoc. Petrol. Geol., vol. 24, no. 3, pl. 5, fig. 20; Palmer, 1940, Mem. Soc. Cubana Hist. Nat., vol. 14, no. 4, p. 299, pl. 51, figs. 1, 2; Palmer, 1941, Mem. Soc. Cubana Hist. Nat., vol. 15, no. 3, p. 303, pl. 31, fig. 4; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 306-307, pl. 36, figs. 15a-b; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 120, pl. 22, figs. 9, 10.

Bolivina decussata Cushman, 1925 (not Brady), Contr. Cushman Lab. Foram. Res., vol. 1, pt. 2, p. 31, pl. 5, figs. 6a, b.

Occurrences: This species is a marker locally for the Choptank Formation; some specimens of *B. lafayettei* resemble this form, but are not the same. Specimens referred to locality G-1 are probably extreme variants of *B. lafayettei*. *B. floridana* is redepositional in localities 10, 11, 14; it is present at 93 to 113 feet in well A-1 of the Chesapeake Bay Bridge-Tunnel.

Bolivina lafayettei McLean

Plate 10, Figures 1, 2

Bolivina lafayettei McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 346-347, pl. 45, figs. 6, 8.

Occurrences: P.R.I. 27278 (0.33 mm long) is from Chesapeake Bay Bridge-Tunnel, well A-2 at 70 feet; P.R.I. 27238 (0.28 mm long) is from locality 11, and is not entirely typical of the species; other occurrences are: localities C, D, E-1, F-1, J-1, 5, 14, 18, 27; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet.

Bolivina marginata Cushman

Bolivina marginata Cushman, 1918, U. S. Geol. Surv. Bull. 676, p. 48, pl. 10, fig. 1; Cushman, 1925, Contr. Cushman Lab. Foram. Res., vol. 1, Pt. 2, p. 30, pl. 5, figs. 5a-b; Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 45, pl. 8, figs. 9a-b; Cushman and Laiming, 1931, Jour. Pal., vol. 5, p. 110, pl. 12, figs. 6-8; Cushman and Parker, 1931, Contr. Cushman Lab. Foram. Res., vol. 7, pt. 1, p. 9, pl. 2, fig. 1; Cushman and Ponton, 1932, Florida Geol. Surv. Bull. 9, p. 81; Barbat and von Estorff, 1933, Jour. Pal., vol. 7, p. 171, pl. 23, figs. 14a, b; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 25, pl. 8, figs. 9a, b; Cushman, 1937, Cushman Lab. Foram. Res. Special Publ. 9, p. 86, pl. 10, figs. 4-6; Puri, 1953, Florida Geol. Surv. Bull. 36, p. 120-121.

Bolivina cf. *marginata* Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 306, pl. 36, figs. 16a-b.

Occurrences: Specimens tentatively assigned to this form are found at locality C and in well A-1 at 113 feet in the Chesapeake Bay Bridge-Tunnel.

Bolivina marginata subsp. *multicostata* Cushman

Plate 11, Figures 2, 3

Bolivina aernariensis subsp. *multicostata* Cushman, 1918, U. S. Geol. Surv. Bull. 676, p. 48, pl. 10, fig. 2.

Bolivina marginata subsp. *multicostata* Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 46, pl. 8, figs. 13, 14; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 82; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 25, pl. 8, figs, 10a, b; Cushman, 1937, Cushman Lab. Foram. Res. Special Publ. 9, p. 87, pl. 10, figs. 7-10; Puri, 1953, Florida Geol. Surv. Bull. 36, p. 121, pl. 22, figs. 3-6.

Occurrences: This form was found in well A-1 of the Chesapeake Bay Bridge-Tunnel; P.R.I. 27282 (a megalosphaeric form measuring 0.40 mm long) is from 113 feet; P.R.I. 27280 (a microsphaeric form measuring 0.50 mm long) is from 84 feet.

Bolivina paula Cushman and Cahill

Plate 10, Figures 3-7

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

P.R.I. No.	Dimensions	Locality
27295	0.33 mm	Well A-2 at 70 feet
27296	0.21 mm	Well A-2 at 70 feet
27297	0.31 mm	Well A-2 at 70 feet
27212	0.25 mm	Locality 18
27233	0.27 mm	Locality 11

Other occurrences: Localities C, D, E-1, F-1, 10; Coleman Bridge section, well 1-NE at 124 feet; well A-5 near Lambert Point at 100 feet; well A-11 near Newport News at 165 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet, well A-2 at 70 feet, well M-85 at 93 feet.

Bolivina plicatella subsp. *mera* Cushman and Ponton

Plate 10, Figure 9

Bolivina plicatella var. *mera* Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 82, pl. 12, figs. 4a, b; Cushman, 1937, Cushman Lab. Foram. Res. Special Publ. 9, p. 90, pl. 11, figs. 5-8; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 122, pl. 22, figs. 11, 12.

Occurrence: A single specimen, found in well A-1 of the Chesapeake Bay Bridge-Tunnel at a depth of 165 feet, seems to be this species, although it is longer and slenderer than the described species: P.R.I. 27317, length 0.43 mm.

Bolivina striatula Cushman

Plate 10, Figure 11

Plate 11, Figure 1

Bolivina striatula Cushman, 1922, Carnegie Inst. Washington, Pub. 311, p. 27, pl. 3, fig. 10; Cole, 1931, Florida Geol. Surv., Bull. 6, p. 41, pl. 2, fig. 9; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. 9, p. 154-155, pl. 18, figs. 30-31; Post, 1951, Publ. Inst. Marine Science, vol. 2, no. 1, p. 174, pl. 1, fig. 19; Boltovsky, 1954, Revista del Inst. Nacional Invest. Ciencias Nat. y Mus. Argentino Ciencias Nat. "Bernadino Rivadavia," tomo 3, no. 4, p. 281, pl. 26, figs. 2a-b; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 347, pl. 45, figs. 4a-b.

Occurrences: P.R.I. 27279 (0.37 mm long) is a badly eroded specimen from well A-1 at 84 feet in the Chesapeake Bay Bridge-Tunnel; P.R.I. 27290 (0.40 mm long) is an excellently preserved specimen from well A-2 at 81 feet in the same section. Other occurrences: well A-11 near Newport News at 165 feet; Coleman Bridge section, well 1-NE at 174 feet.

Bolivina sp. A

Plate 10, Figure 8

Occurrence: P.R.I. 27256 (length 0.31 mm) from locality 10 is the sole representative of this form and is figured for future reference.

Bolivina sp. B

Plate 11, Figure 4

Occurrence: Two specimens from locality 14 have heavy costae in the basal portion, much more pronounced than in any of our recorded costate bolivinids. P.R.I. 27228 (length 0.50 mm) is here figured for future reference, since not enough material exists for description of this form, which appears to be new.

Bolivina sp. C

Plate 10, Figure 10

Occurrence: A single specimen, P.R.I. 27207, reaches a length of 0.40 mm, and is here figured for future reference from locality 37.

Genus LOXOSTOMUM Ehrenberg, 1854

Loxostomum wilsoni McLean

Plate 11, Figures 5, 6

Loxostomum wilsoni McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 348, pl. 45, figs. 5a-b.

Occurrences: This form, described by McLean (1956) from the Yorktown Formation, occurs at the following localities: P.R.I. 27285 (length 0.33 mm) Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet; P.R.I. 27224 (length 0.35 mm) from locality 10.

Genus UVIGERINA d'Orbigny, 1826

Uvigerina auberiana d'Orbigny

Plate 11, Figure 7

Uvigerina auberiana d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. & nat. de l'isle de Cuba, p. 106, pl. 2, figs. 23, 24; Cushman, 1923, U. S. Nat. Mus. Bull. 104, pt. 4, p. 163, pl. 42, figs. 3, 4; Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 49, pl. 9, fig. 7; Cushman and Ponton, 1932, Florida Geol. Surv. Bull. 9, p. 86; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 27, pl. 9, fig. 3.

Occurrence: A single specimen, P.R.I. 27319, was found at locality 10 and measures 0.29 mm in length. The specimen is somewhat broken and eroded.

Uvigerina calvertensis Cushman

Plate 11, Figures 8, 9

Plate 12, Figure 1

Uvigerina calvertensis Cushman, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 22, pl. 15, figs. 9-10; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 348-349, pl. 46, figs. 2a-b.

Uvigerina kernensis Clapp, 1948 (not Barbat and Von Estorff), Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 308, pl. 36, fig. 24.

Occurrences: P.R.I. 27204 (0.55 mm long) is from locality 89; P.R.I. 27250 (largest specimen is 0.54 mm in length) is from locality 18. These specimens show erosion attributable to redeposition. Other new occurrences are: well A-5 near Lambert Point at 85 feet; and well M-85 in the Chesapeake Bay Bridge-Tunnel at 93 feet.

Uvigerina carmeloensis Cushman and Kleinpell

Plate 12, Figure 2

Uvigerina carmeloensis Cushman and Kleinpell, 1934, Cushman Lab. Foram. Res. Contr., vol. 10, p. 11, pl. 2, figs. 7a, b; Kleinpell, 1938, Bull. Amer. Assoc. Petrol. Geol., p. 294; Cushman and Todd, 1941, Cushman Lab. Foram. Res. Contr., vol. 17, p. 44, pl. 13, fig. 10; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 308, pl. 36, fig. 25.

Uvigerina cf. *carmeloensis* McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 349, pl. 46, fig. 1.

Occurrences: The figured specimen, P.R.I. 27291 attained a length of 0.37 mm and came from the Chesapeake Bay Bridge-Tunnel, well A-2 at 90 feet; there are specimens from well A-1 of the same section at 103 feet, and well A-11 near Newport News has the same species at 80 feet.

Uvigerina cf. *tenuistriata* Cushman (not Reuss)

Plate 12, Figures 3, 4

Uvigerina cf. *tenuistriata* McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 349, pl. 45, figs. 9a-b; pl. 46, figs. 3a-b; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 230.

Occurrences: Two specimens are figured; P.R.I. 27235 (0.40 mm long) is from locality 27, and P.R.I. 27261 (0.38 mm long) is from locality 11. Other specimens are recorded from locality C, and from the Chesapeake Bay Bridge-Tunnel, well M-85 at 84 to 133 feet.

Uvigerina sp. A

Plate 12, Figures 5, 6

Occurrences: P.R.I. 27239 (0.31 mm long) is from locality 18; P.R.I. 27221 (0.29 mm long) is from locality 37; both specimens are broken and appear to be new forms and are figured for future reference.

Uvigerina spp.

Occurrences: The following records exist for nondescript uvigerinids: well A-5 near Lambert Point, at 90 feet; well A-11 near Newport News, at 185 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet, and well A-2 at 70 feet.

Uvigerina cf. *subperegrina* Cushman and Kleinpell

Uvigerina subperegrina Cushman and Kleinpell, 1934, Cushman Lab. Foram. Res. Contr., vol. 10, pt. 1, p. 12, pl. 2, figs. 9-11; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 308, pl. 36, fig. 22.

Occurrence: A single specimen from locality 10 appears to be this form.

Genus ANGULOGERINA Cushman, 1927

Angulogerina occidentalis (Cushman)

Plate 12, Figure 9

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

Uvigerina occidentalis Cushman, 1923, U. S. Nat. Mus., Bull. 104, pt. 4, p. 169.

Angulogerina occidentalis Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 50, pl. 9, figs. 8-9; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 28, pl. 9, figs. 8a-b; Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. No. 25, p. 218, pl. 13, fig. 57; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 125, pl. 22, figs. 7-8; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 350, pl. 46, fig. 5; Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 291, pl. 43, figs. 7a-b.

Occurrences: P.R.I. 27283 is 0.24 mm long and comes from Chesapeake Bay Bridge-Tunnel, well A-2 at 70 feet; the form also occurs in same section, well A-1 at 84 feet. Other occurrences are: localities A-2, A-3, B-4, C, D, E-1, F-1, G-1, J-1.

Angulogerina sp.

Plate 13, Figure 1

Occurrences: As figured, P.R.I. 27157 measures 0.40 mm, and comes from well A-11 near Newport News at a depth of 70 feet. It is also in Chesapeake Bay Bridge-Tunnel, well A-2 at 70 feet and well M-65 at 100 feet.

Family ELLIPSOIDINIDAE

Genus PARAFISSURINA Parr, 1947

Parafissurina marginata (Walker and Jacob)

Plate 13, Figure 2

Serpula (Lagena) marginata Walker and Jacob, 1784, Test. Min., p. 3, pl. 1, fig. 7.

Vermiculum marginatum Montfort, 1803, Test. Brit., p. 524.

Oolina compressa d'Orbigny, 1839, Voyage Amerique Meridionale, pt. 5, p. 18, figs. 1, 2.

Lagenula marginata Thorpe, 1844, Brit. Marine Conch. p. 234.

Entosolenia marginata Williamson, 1848, Ann. and Mag. Nat. History, ser. 2, vol. 1, p. 17, figs. 15-17; Williamson, 1858, Rec. Foram. Gt. Britain, p. 9, 10, figs. 19-28.

Lagena marginata Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 63, pl. 8, fig. 13.

Parafissurina marginata Puri, 1953, Florida Geol. Surv., Bull. 36, p. 127, pl. 26, fig. 9.

Occurrence: This form, P.R.I. 27293, occurs sparingly in well A-1 of the Chesapeake Bay Bridge-Tunnel at 84 feet, and the figured specimen is 0.23 mm at largest diameter.

Family ROTALIIDAE

Genus DISCORBIS Lamarck, 1804

Discorbis candeiana (d'Orbigny)

Plate 13, Figures 3, 4

Rosalina candeiana d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. & nat. de l'isle de Cuba, p. 97, pl. 4, figs. 2-4.

Truncatulina candeiana Cushman, 1921, U. S. Nat. Mus. Proc., vol. 59, p. 57, pl. 13, figs. 4, 5; Cushman, 1922, Carnegie Inst. Washington Pub. 311, p. 47, pl. 6, figs. 7-9; Cushman, 1926, Carnegie Inst. Washington Pub. 344, p. 78.

Discorbis candeiana Cushman, 1931, U. S. Nat. Mus. Bull. 104, pt. 8, p. 19, pl. 7, figs. 4a-c; Cushman and Ponton, 1932, Florida Geol. Surv. Bull. 9, p. 88, pl. 13, figs. 4a-c; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 29-30, pl. 10, figs. 3a-c; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 310, pl. 37, figs. 4a-c.

Discorbis vilardeboana Cushman (not d'Orbigny), 1930, Florida Geol. Surv. Bull. 4, p. 52, pl. 10, figs. 3a-c.

Occurrences: P.R.I. 27242 (0.41 mm at largest diameter) is from locality 11 as is P.R.I. 27244 (largest diameter 0.38 mm). Another occurrence is Chesapeake Bay Bridge-Tunnel well A-1, at 84 feet.

Discorbis consobrina (d'Orbigny)

Plate 13, Figure 5

Rosalina consobrina d'Orbigny, 1839, Voyage Amerique Meridionale, vol. 5, pt. 5, p. 46, pl. 7, figs. 4-6.

Discorbis consobrina Cushman and Kellett, 1929, Proc. U. S. Nat. Mus., vol. 75, art. 25, p. 10, pl. 4, figs. 1, 2; Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 53, pl. 10, figs. 4a-c; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 88, pl. 13, figs. 3a-c; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 131, pl. 24, figs. 4-6.

Occurrences: A specimen from Coleman Bridge section, well 3-N at 115 feet, has a maximum diameter of 0.47 mm and is figured as P.R.I. 27196. Other occurrences: localities 8 and 10.

Discorbis floridana Cushman

Plate 13, Figures 6, 7

Plate 14, Figure 1

Discorbis rosacea Cushman, 1930, (not d'Orbigny), Florida Geol. Surv., Bull. 4, p. 51, pl. 9, figs. 13a-c.

Discorbis subaraucana Cushman, 1930, (not Cushman, 1922), Florida Geol. Surv., Bull. 4, p. 52, pl. 10, figs. 1a-c.

Rosalina floridana Parker, 1954, Bull. Mus. Comp. Zool., Harvard Univ., vol. 3, no. 10, p. 524-525, pl. 8, figs. 19-20.

Discorbis floridana Cushman, 1922, Carnegie Inst. Washington, Pub. 311, p. 39, pl. 5, figs. 11-12; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 21, pl. 4, figs. 7-8; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 88, pl. 13, figs. 2a-c; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 29, pl. 9, figs. 12-13; Parker, 1948, Bull. Mus. Comp. Zool., Harvard Univ., vol. 100, no. 2, pl. 5, figs. 23a-b; Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. 25, p. 238, pl. 15, figs. 16-18; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 131, pl. 24, figs. 7-9; Phleger and Parker, 1954, Geol. Soc. Amer., Mem. 46, pt. 2, p. 20, pl. 10, figs. 4a-b; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 351-352, pl. 46, figs. 9-12, 15.

Discorbis floridanus Bandy, 1954, U. S. Geol. Surv., Prof. Paper 254-F, p. 136, pl. 31, figs. 1a-c.

Occurrences: P.R.I. 27254 (0.43 mm at largest diameter) comes from locality 10. P.R.I. 27264, maximum diameter 0.26 mm, is found at Chesapeake Bay Bridge-Tunnel, well A-2 at 81 feet. Other occurrences are: Chesapeake Bay Bridge-Tunnel,

well A-2 at 70 feet and well M-85 at 84 feet; localities A-2, A-3, B-1, B-3, B-4, D, E-1, F-1, G-1, H, J-1, 11, 14, 18, 27; Coleman Bridge section, well 3-N at 135 feet; well A-5 near Lambert Point, at 95 feet; well A-11 near Newport News at 80 feet has a form (P.R.I. 27195, 0.45 mm in diameter) which is provisionally placed in this species.

Discorbis sp.

Plate 13, Figure 8

Occurrence: P.R.I. 27252, which is 0.31 mm at largest diameter, is found at locality 10; the form may be variant of *D. floridana,* but the chambers have a different shape on the dorsal side.

Discorbis rehderi McLean

Discorbis rosacea Cushman, 1918, (not *Rotalia rosacea* d'Orbigny), U. S. Geol. Surv., Bull. 676, p. 59, pl. 14, figs. 4a-c.

Rotorbinella ? rosacea Puri, 1953, Florida Geol. Surv., Bull. 36, p. 136, pl. 24, figs. 1-3.

Discorbis rehderi McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 353, pl. 46, figs. 13-14.

Occurrence: This species is found at locality F-1.

Genus VALVULINERIA Cushman, 1926

Valvulineria floridana Cushman

Plate 14, Figure 2

Valvulineria floridana Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 54, pl. 10, figs. 6a-c; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 91; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 133, pl. 29, figs. 8, 9, 10.

Occurrences: P.R.I. 27269 is 0.40 mm in diameter and was found in well A-1 at 84 feet from Chesapeake Bay Bridge-Tunnel; well M-85 has the form at 93 feet in the same section.

Genus BUCCELLA Andersen, 1952

Buccella anderseni McLean

Buccella anderseni McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 354-355, pl. 50, figs. 1a-c, pl. 51, figs. 1, 4.

Occurrences: This species is found at the following new occurrences: localities A-1, B-1, B-3, B-4, D, E-1, F-1, G-2, H; Coleman Bridge section, well 3-S at 115 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 142 feet, and well A-2 at 90 feet.

Buccella depressa Andersen

Plate 14, Figures 3-5

Eponides peruvianus Cushman and Parker, 1931, (not d'Orbigny), U. S. Nat. Mus., Proc., vol. 80, art. 3, p. 19 (not figured).

Buccella depressa Andersen, 1952, Washington Acad. Sci., Jour., vol. 42, no. 5, pp. 145-146, tf. 7a-c, 8; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, pp. 355-356, pl. 50, figs. 2-5; Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 269, pl. 38, figs. 3a-c, 4a-b.

Eponides peruvianus campsi Boltovskoy, 1954, Revista del Inst. Nacional Invest. Ciencias Nat. y Mus. Argentino Ciencias Nat. "Bernadino Rivadavia," tomo 3, no. 3, p. 204, pl. 17, figs. 6a-c, 7, 8; Boltovskoy, 1954, Revista del Inst. Nacional Invest. Ciencias Nat. y Mus. Argentino Ciencias Nat. "Bernadino Rivadavia," tomo 3, no. 4, p. 287, pl. 27, figs. 8a-b.

Buccella cf. *depressa* Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 230, pl. 27, figs. 4a-c.

Occurrences: P.R.I. 27155 measures 0.43 mm in diameter and comes from Coleman Bridge section, well 3-S at 135 feet. P.R.I. 27171 (0.33 mm diameter), locality 37; P.R.I. 27263 (0.31 mm diameter), locality 11; P.R.I. 27230 (0.32 mm diameter), locality 30. Additional records are: localities A-2, C, G-1, 10, 14, 18, 26, 27, 36, 54; Coleman Bridge section, well 1-SW at 123 feet, well 1-SE at 170 feet, well 1-NE at 108 feet, well 1-NW at 118 feet, well 3-N at 75 feet; well A-5 near Lambert Point, Norfolk, at 80 feet; well A-11 near Newport News at 165 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 123 feet, well M-85 at 93 feet, well M-62 at 129 feet, and well M-65 at 75 feet.

Buccella hannai (Phleger and Parker)

Eponides hannai Phleger and Parker, 1951, Geol. Soc. Amer., Mem. 46, p. 21, pl. 10, figs. 11-14.

Buccella hannai Andersen, 1952, Washington Acad. Sci., Jour., vol. 42, no. 5, p. 144, tf. 3a-c; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 356, pl. 51, figs. 3a-c.

Occurrences: Additional records for this species are: locality G-1; Coleman Bridge section, well 3-S at 153 feet, well 1-NE at 200 feet, well 3-N at 125 feet; well A-11 near Newport News at 135 feet.

Buccella mansfieldi (Cushman)

Plate 14, Figures 6, 7

Plate 15, Figure 1

Eponides mansfieldi Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 54, pl. 11, figs. 1a-c; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 92.

Buccella mansfieldi Andersen, 1952, Jour. Washington Acad. Sci., vol. 42, no. 5, p. 148, 149, figs. 12a, b; 13a-c; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 134, pl. 25, figs. 1, 2, 3.

Occurrences: P.R.I. 27306 (0.42 mm in diameter) from well A-11 near Newport News at 160 feet; P.R.I. 27323 (0.53 mm in diameter) at locality J-1; P.R.I. 27183 (0.48 mm in diameter) at Coleman Bridge section, well 3-S at 105 feet; other occurrences: locality A-3; Coleman Bridge section, well 1-SE at 118 feet; well A-5 near Lambert Point, at 215 feet; well A-11 at Newport News at 135 feet.

Buccella parkerae Andersen

Plate 15, Figures 2-4

Eponides mansfieldi Cushman and Parker, 1931, (not Cushman, 1930), Contr. Cushman Lab. Foram. Res., vol. 7, pt. 1, pl. 2, fig. 10a-c.

Buccella parkerae Andersen, 1952, Washington Acad. Sci. Jour., vol. 42, no. 5, p. 149, tf. 9a-c; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 356-357, pl. 51, figs. 2a-c; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 230-231, pl. 27, figs. 5a-c.

Occurrences: P.R.I. 27206, the larger of two specimens (0.31 mm in diameter), is from locality 36; P.R.I. 27270 (0.25 mm in diameter) is from Chesapeake Bay Bridge-Tunnel, well A-1 at 84 feet; other occurrences are: Coleman Bridge section, well 3-S at 105 feet; well A-5 near Lambert Point, at 185 feet; well A-11 near Newport News at 135 feet.

Genus ROTALIA Lamarck, 1804

Rotalia bassleri Cushman and Cahill

Plate 15, Figures 5, 6

Rotalia bassleri Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 30, pl. 10, figs. 7a-c; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 312, pl. 37, figs. 8a-c.

Occurrence: P.R.I. 27313 (0.42 mm in diameter) and P.R.I. 27310 (0.35 mm in diameter) are both found in well A-11 near Newport News at 165 feet.

Rotalia beccarii subsp. *tepida* Cushman

Plate 15, Figures 7, 8

Plate 16, Figures 1, 3

Rotalia beccarii Linnaeus var. *tepida* Cushman, 1926, Carnegie Instit., Washington, Publ. 344, p. 79; Kornfeld, 1931, Contr. Dept. Geol. Stanford Univ., vol. 1, no. 3, p. 91, pl. 13, figs. 3a-c; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 61, pl. 13, figs. 3a-c; Cole, 1931, Florida State Geol. Surv., Bull. 6, p. 50, pl. 3, figs. 3, 4; Stephenson, 1935, Dept. Conservation, Louisiana Geol. Surv., Bull. 6, p. 189, pl. 5, figs. 20-22; Hadley, 1936, Jour. Elisha Mitchell Sci. Soc., vol. 52, no. 1, p. 36; Le Roy, 1939, Nat. Tijdschr. Nederl.-Indie, vol. 99, pt. 6, p.256, pl. 2, figs. 1-3; Hanna and Hertlein, 1941, State of California, Div. of Mines, Bull. 118, pt. 2, p. 180, fig. 67 (plate) figs. 11-13; Le Roy, 1941, Colorado School of Mines Quart., vol. 36, no. 1, pt. 3, p. 117, pl. 2, figs. 25-27; Palmer, 1945, Bull. Amer. Pal., vol. 29, no. 115, p. 60; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 312, pl. 37, figs. 9a-c; Weiss, 1954, U. S. Geol. Surv. Prof. Paper 254-G, p. 160, pl. 33, fig. 1.

Occurrences: P.R.I. 27259 (0.40 mm in diameter) from locality 10; P.R.I. 27229 (0.27 mm in diameter) from locality 8; P.R.I. 27225 (0.32 mm in diameter) from locality 7; P.R.I. 27197

(0.35 mm in diameter) from locality 37. Other occurrences are: locality 27; well A-5 near Lambert Point, at 205 feet; well at Franklin, Virginia, at 90 feet.

Rotalia beccarii ? (Linnaeus)

Plate 16, Figures 2, 4

Occurrences: P.R.I. 27305 (0.31 mm in diameter) is from well A-5 near Lambert Point, at 205 feet; P.R.I. 27245 (0.35 mm in diameter) is from locality 27. These two specimens may be eroded *Rotalia beccarii* subsp. *tepida*.

Genus POROEPONIDES Cushman, 1944

Poroeponides lateralis (Terquem)

Rosalina lateralis Terquem, 1878, Soc. Geol. France, ser. 1, Mem. vol. 3, p. 25, pl. 2(7), figs. 11a-c.

Eponides lateralis Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 55, pl. 10, figs. 7a-c; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 92, pl. 13, figs. 8a-c; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 31, pl. 11, figs. 1a-c.

Eponides (?) lateralis Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 47-48, pl. 10, figs. 5a-c.

Pulvinulina repanda Brady, 1884, Rept. Challenger Expedition, Zool., vol. 9, p. 627, 684-685, pl. 104, figs. 18a-c.

Poroeponides repandus Miller, 1953, Contr. Cushman Found. Foram. Res., vol. 4, pt. 2, p. 59, pl. 10, figs. 1a-c.

Poroeponides lateralis Cushman, 1944, Cushman Lab. Foram. Res., Spec. Publ. 12, p. 34, pl. 4, fig. 23; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 134, pl. 24, figs. 10-12; Bandy, 1954, U. S. Geol. Surv., Prof. Paper 254-F, p. 137, pl. 30, figs. 1a-c, 3a-c; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 358-359, pl. 47, figs. 9-11, pl. 48, figs. 1-2.

Poroeponides cribrorepandus Asano and Uchio, 1951, *in* Stach, "Illustrated Cat. Japanese Tert. Smaller Foram," Pt. 14 Rotaliidae, p. 18, tfs. 134-135.

Occurrence: A specimen was found at locality A-1.

Genus CANCRIS Montfort, 1808

Cancris sagra (d'Orbigny)

Plate 16, Figure 5

Rotalina sagra d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. & nat. de l'isle de Cuba, p. 77, pl. 5, figs. 13-15.

Pulvinulina sagra Cushman, 1918, U. S. Geol. Surv., Bull. 676, p. 65, pl. 22, fig. 3, pl. 23, fig. 1.

Pulvinulina semipunctata Cushman, 1922, Carnegie Inst. Washington, Publ. 311, p. 51, pl. 8, figs. 5-6.

Cancris sagra Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 56, pl. 11, figs. 4a-c; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 74, pl. 15, figs. 2a-c; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 94, pl. 14, figs. 13a-c; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 32, pl. 11, figs. 4-5; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 359, pl. 48, figs. 3-5, 7.

Cancris communis Copeland (not others), 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 265-266, pl. 38, figs. 2a-c.

Occurrences: P.R.I. 27199 (0.46 mm in diameter) is from well A-5 near Lambert Point, at 165 feet; other specimens are present between 165 and 80 feet, the highest occurrence of this species in this well. Additional occurrences are: localities A-2, A-3, C, D, F-1, G-1, J-1; Chesapeake Bay Bridge-Tunnel, well A-1 at 181 feet.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

Cassidulina crassa d'Orbigny

Plate 17, Figure 1

Cassidulina crassa d'Orbigny, 1839 (1843), Voyage Am. Merid., vol. 5, pt. 5, p. 56, pl. 7, figs. 18-20; d'Orbigny, 1846, Foram. Foss. Bassin Tertiaire, Vienne, p. 213, pl. 21, figs. 42, 43; H. B. Brady, 1884, Challenger Rept., Zool., vol. 9, p. 429, pl. 54, figs. 4, 5; Egger, 1893, Abhandl. k. bay. Akad. Wiss. Munchen, Kl. II, vol. 18, p. 303, pl. 7, figs. 35, 36; Silvestri, 1896, Pont. Accad. Nuovi Lincei Mem., vol. 12, p. 104, pl. 2, figs. 11, 12; Morton, 1897, Portland Soc. Nat. Hist. Proc., vol. 2, p. 116, pl. 1, fig. 12; Flint, 1897 (1899), U. S. Nat. Mus. Rept.,

p. 292, pl. 38, fig. 3; Cushman, 1911, U. S. Nat. Mus., Bull. 71, pt. 2, p. 97, fig. 151; Bagg, 1912, U. S. Geol. Surv., Bull. 513, p. 43, pl. 12, figs. 6a-c; Cushman, 1922, U. S. Nat. Mus., Bull. 104, pt. 3, p. 124, pl. 26, fig. 7; Cushman, 1926, Cushman Lab. Foram. Res. Contr., vol. 2, pt. 3, p. 56, pl. 7, figs. 4a-b; Cushman, 1929, Cushman Lab. Foram. Res. Contr., vol. 5, pt. 4, p. 100, pl. 14, figs. 10a-b; Cushman and Wickenden, 1929, U. S. Nat. Mus. Proc., vol. 75, art. 9, p. 12, pl. 5, figs. 5a-c; Wiesner, 1929, Deutsche Sud-Polar Exped., vol. 20, Zool., p. 131, pl. 21, fig. 259; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 58, pl. 11, figs. 6a-b; Cushman and Parker, 1931, U. S. Nat. Mus. Proc., vol. 80, art. 3, p. 21, pl. 4, figs. 6a-b; Cole, 1931, Florida Geol. Surv., Bull. 6, p. 54, pl. 7, fig. 2; Macfadyen, 1932, Geol. Mag., vol. 69, pl. 34, figs. 6a-b; Heron-Allen and Earland, 1932, Discovery Repts., vol. 4, p. 357, pl. 9, figs. 26-33; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 33, pl. 12, figs. 2a-c; Cushman, 1936, Geol. Soc. Am. Bull., vol. 47, p. 434, pl. 5, figs. 12a-b; Cushman and McGlamery, 1938, U. S. Geol. Surv. Prof. Paper 189-D, p. 111, pl. 28, figs. 4a-c; Kleinpell, 1938, Miocene Stratigraphy of California, p. 331, pl. 12, figs. 8a, b; Cushman, 1941, Cushman Lab. Foram. Res. Contr., vol. 17, p. 37, pl. 9, figs. 23, 34; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 312-313, pl. 38, figs. 2a-c; Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 289-290, pl. 43, figs. 6a-c.

Occurrences: All records are from Chesapeake Bay Bridge-Tunnel. P.R.I. 27265 (0.20 mm in diameter) is from well A-2 at 101 feet; other records are: well A-1 at 84 feet, well A-2 at 90 feet, and well M-85 at 93 feet.

Cassidulina laevigata subsp. *carinata* Cushman

Plate 17, Figure 2

Cassidulina laevigata subsp. *carinata* Cushman, 1922, U. S. Nat. Mus. Bull. 104, Pt. 3, p. 124, pl. 25, figs. 6, 7; Cushman, 1925, Contr. Cushman Lab. Foram. Res., vol. 1, pt. 3, p. 52, pl. 8, figs. 11, 12; Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 58, pl. 11, fig. 7; Cole, 1931, Florida Geol. Surv., Bull. 6, p. 54, pl. 4, fig. 4; Cushman and Parker, 1931, Contr. Cushman Lab. Foram. Res., vol. 7, p. 14, pl. 2, fig. 14; Cushman and Ponton, 1932, Florida Geol. Surv. Bull. 9, p. 97; Nuttall, 1932, Jour. Pal., vol. 6, p. 27, pl. 6, fig. 8; Cushman and Cahill, 1933, U. S. Geol. Surv. Prof. Paper 175-A, p. 33, pl. 12, fig. 3; Ellisor, 1940, Bull. Am. Assoc. Petrol. Geol., vol. 24, pl. 6, fig. 4; Cushman and Todd, 1945, Cushman Lab. Foram. Res. Special Publ. 15, p. 62, pl. 10, fig. 11; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 128, pl. 23, figs. 5, 6.

Occurrences: P.R.I. 27268 has two specimens on slide; larger specimen measures 0.30 mm in diameter, and these specimens are from Chesapeake Bay Bridge-Tunnel, well A-1 at 84

feet; additional specimens are from well M-85 of same section at 93 feet. Other localities: Coleman Bridge section, well 1-NE at 174 feet; well A-5 near Lambert Point at 175 feet; well A-11 near Newport News at 165 feet.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

Globigerina sp. form A McLean

Plate 17, Figure 3

Globigerina sp. form A McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 362-363, pl. 52, figs. 1a-c.

Globigerina protoreticulata Copeland (not others), 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 282-283, pl. 42, figs. 1a-c.

Occurrences: This rare form, with a coarsely reticulate, trilobed test, occurs very sparingly in the following new records: P.R.I. 27266 (0.22 mm long) is from Chesapeake Bay Bridge-Tunnel, well A-2 at 101 feet; the form also occurs in well M-85 of the same section at 84 feet; other specimens are from locality A-2; well A-5 near Lambert Point at 105 feet; and well A-11 near Newport News at 180 feet.

Globigerina spp.

Plate 17, Figure 4

Plate 18, Figure 2

Occurrences: P.R.I. 27151 (0.26 mm long) comes from well A-11 near Newport News at a depth of 95 to 96.6 feet. Because recent work by many specialists has revealed that the morphological features of the Globigerinidae vary considerably within the individual species, it is possible that this specimen is a variant of *Globigerina* sp. form A of McLean. This intraspecific morphological variation may also place P.R.I. 27300 (0.33 mm long) as a form of *Globigerina* sp. form E of McLean; P.R.I. 27300 comes from well A-11 at a depth of 80 to 81.6 feet. Until the specific criteria emerge which will enable the Globigerinidae to be identified as to genus and species, the author cannot establish the relationships or identities of these two rare forms. There

are other rare, nondescript globigerinids scattered throughout the record in the Chesapeake Bay material; the forms illustrated are the only ones that are sufficiently distinctive to merit either discussion or illustration.

Globigerina sp. form B McLean

Globigerina sp. form B McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 363, pl. 52, figs. 2a-c.

Occurrence: A single record for this reticulate form is added: well A-5 near Lambert Point at 205 feet; see McLean (1956) for details and figures.

Globigerina sp. form E McLean

Plate 17, Figure 5

Plate 18, Figure 1

Globigerina sp. form E McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 364, pl. 53, figs. 1a-c.

Globigerina apertura Copeland (not others), 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 281, pl. 41, figs. 4a-c.

Occurrences: P.R.I. 27248 (0.28 mm in longest dimension) is from locality 18; P.R.I. 27211 (0.32 mm long) is from locality 14; other records are: localities 10, 11, 27, 31, A-3, C, D, E-1, F-1, G-1, J-1; well A-5 near Lambert Point at 85 to 110 feet; Coleman Bridge section, well 1-NE at 200 feet; Chesapeake Bay Bridge-Tunnel in well M-85 at 84 to 93 feet; well at Franklin, Virginia, at 90 feet.

Genus ORBULINA d'Orbigny, 1839

Orbulina universa d'Orbigny

Plate 18, Figure 3

Orbulina universa d'Orbigny, 1839, *in* de la Sagra, Histoire phys. pol. & nat. de l'isle de Cuba, p. 3, pl. 1; Cushman, 1924, U. S. Nat. Mus. Bull. 104, p. 28, pl. 5, figs. 2-9; Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 59; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 99; Bermudez, 1949, Cushman Lab. Foram. Res. Special Pub. 25, p. 282, pl. 22, fig. 3; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 149-150; not

Orbulina universa Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 286, pl. 34, fig. 1.

Orbulina cornwallisi McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 365, pl. 53, figs. 3a-b.

Occurrences: P.R.I. 27284 (diameter 0.12 mm) is from Chesapeake Bay Bridge-Tunnel, well A-2 at 90 feet; another specimen occurs in well A-11 near Newport News at 45 feet.

Family GLOBOROTALIIDAE

Genus GLOBOROTALIA Cushman, 1927

Globorotalia menardii (d'Orbigny)

Plate 18, Figure 4

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

Rotalia boueana d'Orbigny, 1846, Foram. foss. Vienne, p. 152, pl. 7, figs. 25-27.

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

Pulvinulina tumida H. B. Brady, 1884, Challenger Rept., vol. 9, p. 692, pl. 103, figs. 4-6; Cushman, 1915, U. S. Nat. Mus. Bull. 71, pt. 5, p. 56, pl. 22, fig. 3.

Globorotalia menardii Cushman, 1930, Florida Geol. Surv. Bull. 4, p. 60, pl. 12, figs. 1a-c; Cushman, 1931, U. S. Nat. Mus. Bull. 104, Pt. 8, p. 91-94, pl. 14, fig. 1; Cole and Ponton, 1932, Florida Geol. Surv. Bull. 5, p. 45, pl. 11, figs. 4, 5; Nuttall, 1932, Jour. Pal., vol. 6, p. 29, pl. 4, fig. 16; Schmidt, 1934, Eclogae geol. Helv., vol. 27, p. 45; Hadley, 1934, Bull. Am. Pal., vol. 20, no. 70-A, p. 25, pl. 3, figs. 12, 13; Coryell and Rivero, 1940, Jour. Pal., vol. 14, p. 336, pl. 42, figs. 34, 35; Bermudez, 1949, Cushman Lab. Foram. Res. Special Pub. 25, p. 286, pl. 22, figs. 24-26; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 150, pl. 25, figs. 4, 5, 6; Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 264-265, pl. 38, figs. 1a-c.

Globorotalia sp. McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 365, pl. 48, figs. 6a-b.

Occurrences: The figured specimen, P.R.I. 27257, measures 0.40 mm in diameter and comes from locality 18; another specimen was found in the well at Franklin, Virginia, at a depth of 90 feet.

Family ANOMALINIDAE

Genus PLANULINA d'Orbigny, 1826

Planulina depressa (d'Orbigny)

Truncatulina depressa d'Orbigny, 1839, Voyage dans l'Amerique Meridionale, vol. 5, pt. 5, Foraminiferes, p. 39, pl. 6, figs. 4-6.

Planulina depressa Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 60, pl. 12, figs. 2a-c; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 34, pl. 12, figs. 6a-c; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 141-142, pl. 27, figs. 1-3; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 366, pl. 48, figs. 8-11; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 232.

Occurrences: This form is quite plentiful in the so-called "basal Yorktown", but it is less abundant in beds between this and the underlying Calvert Formation where the form is also plentiful; it seems to indicate relatively deep waters and is found at the following new localities: Coleman Bridge section, well 3-S at 155 feet; localities A-2, A-3, B-4, C, D, E-1, F-1, G-1, G-2, J-1; well A-11 near Newport News at 260 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 181 feet and well A-2 at 215 feet. The form is adequately described and figured in McLean (1956).

Genus CIBICIDES Montfort, 1808

Cibicides americanus (Cushman)

Plate 18, Figure 5

Plate 19, Figure 1

Truncatulina americana Cushman, 1918, U. S. Geol. Surv., Bull. 676, p. 63, pl. 20, figs. 2, 3; pl. 21, fig. 1; Cushman, 1918, U. S. Nat. Mus., Bull. 103, p. 68, pl. 23, figs. 2a-c; Cushman, 1920, U. S. Geol. Surv., Prof. Paper 128-B, p. 70, pl. 11, figs. 10, 11; Cushman, 1922, U. S. Geol. Surv., Prof. Paper 129-E, p. 97, pl. 20, figs. 7, 8.

Cibicides americana Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 61, pl. 12, figs. 5a-c; Nuttall, 1932, Jour. Pal., vol. 6, p. 32, pl. 7, figs. 10, 11.

Cibicides americanus Cole and Gillespie, 1930, Bull. Am. Pal., vol. 15, no. 57b, p. 14, pl. 4, fig. 4; Cole and Ponton, 1930, Florida Geol. Surv., Bull. 5, p. 48, pl. 7, figs. 5, 6; Cushman and Laiming, 1931, Jour. Pal.,

vol. 5, p. 119, pl. 14, figs. 6a-c; Cushman and Parker, 1931, Cushman Lab. Foram. Res. Contr., vol. 7, p. 15, pl. 3, figs. 1a-c; Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 34, pl. 13, figs. 2a-c; Cushman 1935, U. S. Geol. Surv., Prof. Paper 181, p. 53, pl. 22, figs. 1, 2; Kleinpell, 1938, Bull. Amer. Assoc. Petrol. Geol., p. 352, pl. 8, fig. 13a-c; Galloway and Heminway, 1941, New York Acad. Sci., Sci. Surv. Porto Rico and Virgin Ils., vol. 3, pt. 4, p. 390, pl. 24, figs. 3a-c; Cushman and McGlamery, 1942, U. S. Geol. Surv., Prof. Paper 197-B, p. 75, pl. 7, figs. 8-10; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 314-315, pl. 39, figs. 4a-c.

Occurrences: P.R.I. 27258 (0.32 mm diameter) is from locality 18; P.R.I. 27301 (0.41 mm diameter) is from well A-5 near Lambert Point at 215 feet. Other occurrences are: locality 26; well A-11 near Newport News at 80 feet; and well at Franklin, Virginia, at 100 feet.

Cibicides cf. *lobatulus* (Cushman)

Truncatulina lobatula Cushman, 1918, U. S. Geol. Surv. Bull. 676, p. 60-61, pl. 17, figs. 1-3.

Cibicides lobatulus Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 315-316, pl. 39, figs. 5a-c.

Cibicides cf. *lobatulus* McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 366-367, pl. 48, figs. 12-13.

Occurrences: Additional specimens of this common form were encountered at the following new occurrences: Coleman Bridge section, well 1-SE at 170 feet; well A-11 near Newport News at 65 feet. This form is variable and too many diverse forms have been reported for it, but the synonymy of McLean (1956) effectively reflects our interpretation of this species.

Cibicides sp.

Plate 19, Figure 2

Occurrences: This form, exemplified by P.R.I. 27198 (0.50 mm in diameter) is from well A-11 near Newport News at 80 to 81 feet; another occurrence is from the Chesapeake Bay Bridge-Tunnel, well A-2 at 161 feet, and well M-85 at 124 feet.

Genus HANZAWAIA Asano, 1944

Hanzawaia concentrica (Cushman)

Plate 19, Figure 4

Truncatulina concentrica Cushman, 1918, U. S. Geol. Surv., Bull. 676, p. 64-65, pl. 21, figs. 3a-c.

Cibicides concentrica Cushman, 1930, Florida Geol. Surv., Bull. 4, p. 61-62, pl. 12, figs. 4a-c; Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 120-121, pl. 21, figs. 4-5, pl. 22, figs. 1-2; Parker, 1948, Bull. Mus. Comp. Zool., Harvard Univ., vol. 100, no. 2, pl. 1, figs. 16a-b.

Cibicides concentricus Cushman and Cahill, 1933, U. S. Geol. Surv., Prof. Paper 175-A, p. 35, pl. 13, figs. 3a-c; Cushman, 1944, Cushman Lab. Foram. Res., Spec. Pub. No. 12, p. 37, pl. 4, figs. 29a-b; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 315, pl. 39, figs. 1-2; Phleger and Parker, 1948, Geol. Soc. Amer., Mem. 46, pt. 2, p. 29, pl. 15, figs. 14-15; Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Pub. No. 25, p. 296, pl. 26, figs. 7 - 12.

Cibicidina concentricus Parker, 1954, Bull. Mus. Comp. Zool., Harvard Univ., vol. 3, no. 10, pl. 13, figs. 7, 10.

Hanzawaia concentrica Puri, 1953, Florida Geol. Surv., Bull. 36, p. 140, pl. 12, figs. 7-9; McLean, 1956, Bull. Amer. Pal., vol. 36, No. 160, p. 367-368, pl. 49, figs. 4-6; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 233, pl. 27, figs. 7a-b, 8a-b.

Cibicides americanus Copeland (not others), 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 275-276, pl. 40, figs. 2a-c.

Occurrences: This form is characteristic of the shallow-water environment, particularly between 0 and 100 meters, and a flooding of specimens with the often-associated *Rotalia beccarii* group generally indicates shallow marine waters between 0 and about 50 meters; it occurs at considerable depths, so its appearance with the deeper water form *Planulina depressa* is by no means unusual. Very typical examples of *H. concentrica* were noted at the following places: localities A-2, A-3, B-1, B-3, B-4, C, D, E-1, F-1, G-1, G-2, J-1, 5, 11, 14, 18, 27, 31; Coleman Bridge section, well 3-N at 115 feet; well A-5 near Lambert Point at 80 to 175 feet; well A-11 near Newport News at 65 to 310 feet; Chesapeake Bay Bridge-Tunnel, well A-1 at 84 to 191 feet, well A-2 at 59 to 120 feet, well M-85 at 84 to 93 feet. P.R.I. 27153 measures 0.57 mm at the largest diameter and comes from well A-2 at 59 feet.

Genus DYOCIBICIDES Cushman & Valentine, 1930

Dyocibicides perforatus Cushman and Valentine

Plate 19, Figure 4

Dyocibicides perforatus Cushman and Valentine, 1930, Contr. Dept. Geol. Stanford Univ., vol. 1, no. 1, p. 31-32, pl. 10, figs. 3a-c; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 368-369, pl. 49, figs. 8a-c.

Occurrence: A single specimen from the Coleman Bridge section, well 3-N at 125 feet is the only new record for this form, P.R.I. 27302 (0.75 mm in longest dimension).

Genus CIBICIDELLA Cushman, 1927

Cibicidella variabilis (d'Orbigny)

Plate 19, Figure 5

Truncatulina variabilis d'Orbigny, 1839, *in* Barker, Webb, and Berthelot, Hist. Nat. Iles Canaries, vol. 2, pt. 2, "Foraminiferes" p. 135, pl. 2, fig. 29; Bagg, 1912, U. S. Geol. Surv., Bull. 512, p. 84, pl. 24, figs. 1-4 (not pl. 25, figs. 4-5).

Cibicidella variabilis Cushman, 1931, U. S. Nat. Mus., Bull. 104, pt. 8, p. 127, pl. 24, fig. 3; Cushman and Ponton, 1932, Florida Geol. Surv., Bull. 9, p. 192, pl. 15, figs. 5-7; Cushman and Todd, 1945, Cushman Lab. Foram. Res., Spec. Pub. No. 15, p. 72, pl. 12, fig. 11; Clapp, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 316-317, pl. 39, figs. 8a-b; Puri, 1953, Florida Geol. Surv. Bull. 36, p. 140-141, pl. 8, figs. 4-6; McLean, 1956, Bull. Amer. Pal., vol. 36, no. 160, p. 369-370, pl. 49, figs. 9-11, 14; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 233-234.

Cibicides eccentricus Copeland, 1964, Bull. Amer. Pal., vol. 47, no. 215, p. 277-278, pl. 40, figs. 4a-c.

Occurrences: P.R.I. 27272 (largest dimension 0.40 mm) is figured from Chesapeake Bay Bridge-Tunnel, well A-2 at 70 feet. Other occurrences of this very common species are: localities A-2, A-3, B-1, B-3, B-4, C, D, E-1, F-1, G-1, H, J-1, 26; well A-5 near Lambert Point at 85 to 215 feet; well A-11 near Newport News at 135 to 210 feet; and Chesapeake Bay Bridge-Tunnel, well A-1 at 84 to 93 feet.

Order OSTRACODA

Family BAIRDIIDAE

Genus BAIRDOPPILATA Coryell, Sample & Jennings, 1935

Bairdoppilata triangulata Edwards

Bairdoppilata triangulata Edwards, 1944, Jour. Pal., vol. 18, p. 507, pl. 85, figs. 5-7; Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 223, 225, pl. 1, figs. 3-4, text figs. 1a-b; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 69-70, pl. 7, figs. 1a-d; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 234.

Occurrence: Locality C has rare specimens of this form in it; for description and figures, see McLean (1957).

Family CYPRIDAE

Genus PARACYPRIS Sars, 1925

Paracypris choctawhatcheensis Puri

Paracypris choctawhatcheensis Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 227-228, pl. 1, figs. 10-12, text figs. 2a, b, d; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 70, pl. 7, figs. 2a-d; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 234.

Occurrence: See McLean (1957) for figures and description of this form, which occurs in locality C.

Family CYTHERIDAE

Genus PARACYTHERIDEA G. W. Muller, 1894

Paracytheridea vandenboldi Puri

Cytheropteron nodosum Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 129-130 (vol. 1), pl. 38, figs. 37-40 (vol. 2).

Paracytheridea nodosa Howe et al., 1935, Florida Geol. Surv., Bull. 13, p. 37, pl. 3, fig. 7; Van den Bold, 1946, Contrib. Study Ostracoda, p. 86, pl. 16, fig. 7; Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 51, pl. 3, figs. 19-22.

Paracytheridea vandenboldi Puri, 1953, Jour. Pal., vol. 27, p. 751; Malkin, 1953, Jour. Pal., vol. 27, p. 780, pl. 79, fig. 5; Puri, 1954 (1953),

Florida Geol. Surv., Bull. 36, p. 238-240, pl. 3, fig. 7, text figs. 5a-b; Swain, 1955, Jour. Pal., vol. 29, p. 625, pl. 62, figs. 2a-b; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 75-76, pl. 8, figs. 4a-b.

Occurrences: Reported, described, and figured for the Yorktown Formation in McLean (1957), this form occurs in localities E-1 and F-1.

Genus CYTHERURA Sars, 1865 (1866)

Cytherura bajacala Benson

Plate 20, Figure 1

Cytherura bajacala Benson, 1959, Univ. of Kansas Paleontological Contributions, Arthropoda, art. 1, p. 52, pl. 4, figs. 7a-c, pl. 9, figs. 1, 11, 14.

Occurrences: This living form, described by Benson, is in the Pleistocene record for the Chesapeake region; it has not been encountered to date in Miocene beds. P.R.I. 27220 is 0.39 mm long and comes from locality 11; other specimens are found in localities 10, 14, 18, 37.

Cytherura reticulata Edwards

Plate 20, Figure 2

Cytherura reticulata Edwards, 1944, Jour. Pal., vol. 18, p. 526, pl. 88, figs. 13-16; Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 50-51; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 73, pl. 7, figs. 7a-b.

Cytherura forulata Malkin (not Edwards), 1953, Jour. Pal., vol. 27, pl. 80, figs. 23, 24? (not fig. 22).

Occurrences: P.R.I. 27202 measures 0.50 mm in length and is from locality 89. Other new occurrences are: localities C, E-1, J-1, 18.

Cytherura wardensis Howe and Brown

Cytherura wardensis Howe and Brown, *in* Howe et al., 1935, Florida Geol. Surv. Bull. 13, p. 36, pl. 1, figs. 23, 27, pl. 4, fig. 19; Howe, Brown, and Edwards, 1944, Jour. Pal., vol. 18, p. 525, pl. 88, figs. 11, 12; Puri, 1953, Florida Geol. Surv., Bull. 36, p. 241, pl. 4, figs. 1-4, text fig. 6f.

Occurrence: A single occurrence at locality 10 is recorded; comparison is with the species as described in the above synonymy.

Cytherura sp.

Occurrence: A single, nondescript form is from locality F-1.

Genus HEMICYTHERURA Elofsen, 1941

Hemicytherura clathrata (Sars)

Cytherura clathrata Sars, 1865, Forh. Vid.-Selsk., p. 77; Brady, 1868a, Linn. Soc. London Trans., vol. 26, p. 446, pl. 29, figs. 43-46; Sars, 1928, Bergen Mus., vol. 9, p. 215, pl. 100, fig. 5; Lucas, 1931, Contrib. Canadian Biol. & Fisheries, vol. 6, n.s., p. 11.

Hemicytherura cf. *H. clathrata* Benson, 1959, Univ. Kansas Paleontological Contrib., art. 1, p. 54, pl. 4, fig. 7d; pl. 7, fig. 2; pl. 9, fig. 3.

Occurrence: There are a number of specimens from locality 14 which seem very close to this form as it is shown in Benson (1959). There may be some difference in the surface ornamentation, but if so it is minor.

Genus CYTHEROPTERON Sars, 1865

Cytheropteron talquinensis Puri

Cytheropteron talquinensis Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 243, pl. 5, figs. 5-7; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 73-74, pl. 7, figs. 6a-c.

Occurrences: This interesting little form, as given in McLean (1957) occurs in localities C, F-1, J-1.

Genus CLITHROCYTHERIDEA Sars, 1925

Clithrocytheridea diagonalis Malkin

Plate 20, Figures 3-5

Clithrocytheridea diagonalis Malkin, 1953, Jour. Pal., vol. 27, p. 782-783, pl. 79, figs. 18-19, 21-22, 24; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 74, pl. 8, figs. 1a-b.

Since its description by Doris Malkin Curtis, this form has consistently been found in pre-Yorktown age beds in the Virginia-Maryland area; it is considered to be a good guide species for the St. Mary's Formation at its "top" occurrences. The form is somewhat difficult to separate from the very similar *C. virginiensis* of Mrs. Curtis, but can generally be determined by its coarser design of surface pitting. Identification of the species should be made by actual comparison of suspect forms with an identified specimen. Occurrences and dimensions of the three figured forms are as follows, from well 3-S in the Coleman Bridge section:

P.R.I. Number	Dimensions	Depth
27179	0.88 mm	95 feet
27164	0.82 mm	105 feet
27176	0.88 mm	115 feet

Other occurrences: Localities B-4, H; Coleman Bridge section, well 1-SW at 123 feet; well 1-SE at 160 feet; well 1-NE at 194 feet, well 1-NW at 118 to 128 feet.

Clithrocytheridea virginiensis Malkin

Plate 23, Figure 2

Haplocytheridea sp. aff. *H. israelskyi* Swain, 1953, U. S. Geol. Surv., Prof. Paper 234-A, p. 20, pl. 1, figs. 15-17.

Clithrocytheridea virginiensis Malkin, 1953, Jour. Pal., vol. 27, p. 783-784, pl. 79, figs. 23, 25-28; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, pp. 74-75, pl. 8, figs. 2a-g; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 235.

Occurrences: P.R.I. 27226, a juvenile specimen measuring 0.35 mm in length, is tentatively placed in this species because of the fine surface pitting; it may, however, prove to be a young molt of *C. diagonalis*, although this would seem unlikely, as it occurs in locality 31, of Pleistocene age. Other more mature and typical forms, as figured in McLean (1957), occur in the following places: localities C, E-1, F-1, J-1, and a record from 139 feet in well 1-SE of the Coleman Bridge section, where it may have fallen downhole.

Genus LEGUMINOCYTHEREIS Howe, 1936

Leguminocythereis? whitei Swain

Leguminocythereis whitei Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 43, pl. 3, figs. 14, 16-18, pl. 4, fig. 1; Malkin, 1953, Jour. Pal., vol. 27, p. 785-786, pl. 80, figs. 7-12.

Leguminocythereis (?) *whitei* McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 80, pl. 9, figs. 4a-b.

Occurrences: Locality G-1 has a single specimen of this form as figured in McLean (1957). A second leguminocytherid is in locality J-1.

Genus ACTINOCYTHEREIS Puri, 1953

Actinocythereis exanthemata (Ulrich and Bassler)

Cythere exanthemata Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 117, (vol. 1), pl. 36, figs. 1-5 (vol. 2).

Cythereis exanthemata Swain, 1948, Maryland Dept. Geol., Mines, and Water Res., vol. 2, p. 204, pl. 12, figs. 14-15.

Trachyleberis exanthemata Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 37, pl. 6, fig. 5; Malkin, 1953, Jour. Pal., vol. 27, p. 791, pl. 81, figs. 16, 19-20.

Actinocythereis exanthemata Puri, 1953, Amer. Midland Naturalist, vol. 49, p. 179-181, pl. 2, figs. 4-8, text fig. 3-f; Puri, 1954 (1953), Florida Geol. Surv. Bull., vol. 36, p. 252-253, pl. 13, figs. 6-13; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 82-83, pl. 10, figs. 1a-c; Puri and Hulings, 1957, Trans. Gulf Coast Assoc. Geol. Soc., vol. 7, p. 183; Puri, 1960, Trans. Gulf Coast Assoc. Geol. Soc., vol. 10, p. 123.

Actinocythereis aff. *exanthemata* Swain?, 1955, Jour. Pal., vol. 29, p. 634, pl. 63, figs. 5a-b, text figs. 37c, 38, 7a-c.

Occurrences: Careful discrimination is needed to separate this species from its subspecies; the typical species, as delineated in McLean (1957), occurs at the following additional localities: well 1-NW from the Coleman Bridge section at 118 feet; localities C and F-1.

Actinocythereis exanthemata subsp. *gomillionensis* (Howe and Ellis)

Plate 20, Figure 6

Plate 21, Figure 1

Cythereis exanthemata var. *gomillionensis* Howe and Ellis, 1935, *in* Howe et al., Florida Geol. Surv., Bull. vol. 13, p. 19, pl. 1, figs. 6-12, pl. 4, fig. 3; Edwards, 1944, Jour. Pal., vol. 18, p. 521, pl. 87, figs. 31-32.

Trachyleberis exanthemata gomillionensis Malkin, 1953, Jour. Pal., vol. 27, p. 792, pl. 81, figs. 15, 17-18.

Actinocythereis exanthemata var. *gomillionensis* Puri, 1953, Amer. Midland Naturalist, vol. 49, p. 181, pl. 2, figs. 1-2; Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 253, pl. 13, figs. 16-17; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 83-84, pl. 10, figs. 2a-d.

Occurrences: P.R.I. 27186 is 0.88 mm long and comes from Coleman Bridge section, well 3-S at 105 feet; P.R.I. 27308 is 0.90 mm in length and comes from well A-11 near Newport News at 195 feet; other specimens were found to 246 feet in well A-11, and in the Coleman Bridge section, well 1-SW at 123 feet and well 1-SE at 180 feet.

Actinocythereis exanthemata subsp. *marylandica* (Howe and Hough)

Plate 21, Figure 2

Cythereis exanthemata var. *marylandica* Howe and Hough, *in* Howe et al., 1935, Florida Geol. Surv. Bull. 13, p. 18, pl. 1, figs. 1-5; pl. 4, fig. 7.

Actinocythereis exanthemata marylandica Puri, 1953a, Am. Midland Naturalist, vol. 49, p. 181, pl. 2, fig. 3, text figs. c, d; Puri, 1953, Florida Geol. Surv. Bull. 36, p. 253, pl. 13, figs. 14, 15.

Occurrence: A single broken specimen, P.R.I. 27299, measures 0.88 mm in length (with a portion of the test missing) and appears to be this subspecies; it comes from the Coleman Bridge section, well 1-SW at a depth of 123 feet.

Genus ORIONINA Puri, 1953

Orionina bermudae (Brady)

Cythere vaughani Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 109-110 (vol. 1), pl. 38, figs. 25-27 (vol. 2).

Cythereis vaughani Howe et al., 1935, Florida Geol. Surv., Bull. 13, p. 24-25, pl. 3, figs. 24-26, pl. 4, fig. 12; Coryell and Fields, 1937, Amer. Mus. Nat. Hist. Novitates, no. 956, p. 9, fig. 10a; Edwards, 1944, Jour. Pal., vol. 18, p. 522, pl. 87, figs. 27-28; Van den Bold, 1950, Jour. Pal., vol. 25, p. 83.

Trachyleberis vaughani Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 37, pl. 6, figs. 6-7; Malkin, 1953, Jour. Pal., vol. 27, p. 794, pl. 82, fig. 14.

Orionina vaughani Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 254, pl. 12, figs. 15-16, text figs. 8a-c; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 88-89, pl. 11, figs. 6a-b.

Orionina bermudae Puri and Hulings, 1957, Trans. Gulf Coast Assoc. Geol. Soc., vol. 7, p. 187, fig. 11; Puri, 1960, Trans. Gulf Coast Assoc. Geol. Soc., vol. 10, p. 123, 126, pl. 1, figs. 15, 16.

Occurrences: Very typical specimens of this distinctive form occur in the following new places: localities A-3, C, F-1, J-1; the form is figured and the description is given in McLean (1957) as *O. vaughani.* Brady's description, as discovered by Puri, has priority over Ulrich and Bassler's original description of *C. vaughani.*

Genus MURRAYINA Puri, 1953

Murrayina barclayi McLean

Plate 21, Figure 3

Murrayina barclayi McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 87-88, pl. 11, figs. 4a-f.

Occurrences: P.R.I. 27200 measures 0.56 mm long and is a juvenile specimen from locality 89; the species occurs also in the Coleman Bridge section, well 1-NW at 128 feet. The more typical adult form was described and figured in McLean (1957).

Murrayina gunteri (Howe and Chambers)

Plate 21, Figure 4

Cythereis gunteri Howe and Chambers, *in* Howe, et al., 1935, Florida Geol. Surv. Bull. 13, p. 21, pl. 1, figs. 13-17; pl. 4, fig. 1.

Murrayina gunteri Puri, 1953, Florida Geol. Surv. Bull. 36, p. 256, pl. 12, figs. 6-8; text figs. 8i, j.

Occurrence: A specimen, P.R.I. 27309 (0.88 mm long) from Coleman Bridge section, well 1-NW at a depth of 118 feet, seems to match the description of this species.

Murrayina howei Puri

Plate 21, Figures 5, 6

Plate 22, Figure 1

Cythere producta Ulrich and Bassler (not Brady), 1904, Maryland Geol. Surv. Miocene, p. 115, (vol. 1), pl. 36, fig. 17, pl. 38, figs. 28-30 (vol. 2).

Cythereis producta Howe, 1935, *in* Howe et al., Florida Geol. Surv. Bull. 13, p. 22, pl. 1, figs. 31-32, 35, 37, pl. 4, figs. 11-12.

Trachyleberis martini Malkin, 1953, Jour. Pal., vol. 27, p. 793, pl. 82, figs. 6-9?, 11-13?.

Murrayina howei Puri, 1954 (1953), Florida Geol. Surv. Bull. 36, p. 255-256, pl. 12, figs. 9-10, text figs. 8g-h; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 85-86, pl. 10, figs. 4a-e; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 236-237.

Occurrences: P.R.I. 27184 (0.93 mm long) is from a depth of 105 feet and P.R.I. 27177 (0.92 mm long) is from a depth of 115 feet in well 3-S in the Coleman Bridge section; P.R.I. 27193 (0.68 mm long) is from well A-11 near Newport News at 185 to 186.6 feet. Other occurrences are: localities B-3, F-1, J-1; Coleman Bridge section, well 1-SW at 123 feet, well 1-NE at 108 to 200 feet, well 1-NW at 118 to 158 feet, well 3-N at 135 feet; well A-11 near Newport News at 86 feet.

Murrayina martini (Ulrich and Bassler)

Plate 22, Figure 2

Cythere martini Ulrich and Bassler, 1904, Maryland Geol. Surv. Miocene, p. 112-113 (vol. 1), pl. 36, figs. 11-15 (vol. 2).

Cythere micula Ulrich and Bassler, 1904, Maryland Geol. Surv. Miocene, p. 116 (vol. 1), pl. 36, figs. 18-20 (vol. 2).

Cythereis martini Swain, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 196, pl. 12, figs. 16-17.

Trachyleberis ? martini Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 29, pl. 3, figs. 8, 15.

Trachyleberis martini Malkin, 1953, (part), Jour. Pal., vol. 27, p. 793, pl. 82, fig. 10?, (not other figures).

Murrayina martini Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 256, pl. 12, figs. 11-13, text figures 8e-f; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 86-87, pl. 11, figs. 1a-c, 2a-b, 3a-d; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 237.

Occurrences: P.R.I. 27318 is 0.65 mm long and comes from well A-11 near Newport News at 80 feet; other specimens from same well extend to 210 feet, and the following additional records are available: localities A-3, B-1, C, D, E-1, F-1, G-1, J-1; Coleman Bridge section, well 1-SW at 125 feet, well 3-S at 105 feet, well 1-NW at 128 feet, well 3-N at 135 feet.

Murrayina sp.

Occurrence: A number of nondescript specimens of the genus were encountered in well A-11 near Newport News at 65 feet to 325 feet.

Genus PURIANA Coryell & Fields, 1953

Puriana rugipunctata (Ulrich and Bassler)

Cythere rugipunctata Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 118 (vol. 1), pl. 38, figs. 16-17, (vol. 2).

Cythereis rugipunctata Howe et al., 1935, Florida Geol. Surv., Bull. 13, p. 23, pl. 1, figs. 18, 20-22; pl. 4, figs. 22-23.

Favella rugipunctata Edwards, 1944, Jour. Pal., vol. 18, p. 524, pl. 88, figs. 5-6; Malkin, 1953, Jour. Pal., vol. 27, p. 797, pl. 82, fig. 24; Van den Bold, 1950, Jour. Pal., vol. 24, p. 86; Van den Bold, 1946, p. 100, pl. 10, fig. 3.

Trachyleberis ? rugipunctata Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 38, pl. 6, fig. 8.

Puriana rugipunctata Coryell and Fields, *in* Puri, 1953, Jour. Pal., vol. 27, p. 751; Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 257-8, pl. 12, figs. 18-19, text fig. 8k; McLean, 1957, Bull. Amer. Pal., vol.

38, no. 167, p. 89-90, pl. 11, figs. 5a-d; Puri, 1960, Trans. Gulf Coast Assoc. Geol. Soc., vol. 10, p. 126-127, pl. 6, fig. 18.

Occurrences: This distinctive form was adequately described and figured in McLean (1957) as per previous records; additional occurrences: localities E-1, G-1, J-1.

Genus ACUTICYTHEREIS Edwards, 1944

Acuticythereis laevissima Edwards

Acuticythereis laevissima Edwards, 1944, Jour. Pal., vol. 18, no. 6, p. 519-520, pl. 87, figs. 4-11; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 90, pl. 12, figs. 4a-g; Puri, 1960, Trans. Gulf Coast Assoc. Geol. Soc., vol. 10, p. 128, pl. 2, figs. 16, 17.

Camplocythere laevissima Malkin, 1953, Jour. Pal., vol. 27, no. 6, p. 785, pl. 80, figs. 4-6.

Occurrences: Additional records for this form, figured in McLean (1957) are: localities C and F-1.

Genus ECHINOCYTHEREIS Puri, 1953

Echinocythereis clarkana (Ulrich and Bassler)

Plate 22, Figures 3, 4

Cythere clarkana Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 98, (vol. 1), pl. 35, figs. 1-10 (vol. 2).

Cythere clarkana var. *miniscula* Ulrich and Bassler, 1904, Maryland Geol. Surv. Miocene, p. 99, (vol. 1), pl. 35, figs. 11-14 (vol. 2).

Leguminocythereis clarkana Swain, 1948, Maryland Dept. Geol. Mines, and Water Res., Bull. 2, p. 207, pl. 14, fig. 6; Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 43, pl. 6. fig. 18.

Trachyleberis clarkana Malkin, 1953, Jour. Pal., vol. 27, p. 792, pl. 82, figs. 1-3.

Echinocythereis clarkana McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 84-85, pl. 10, figs. 3a-c.

Occurrences: P.R.I. 27314 is a badly eroded specimen that measures 0.80 mm in length, and P.R.I. 27173 is a more typical specimen (0.55 mm long); both figured specimens are from well 3-S at 115 feet in the Coleman Bridge section; other occurrences

are limited to the same section, well 1-SW at 123 feet, well 1-SE at 128 feet, and well 1-NW at 118 to 128 feet.

Genus HEMICYTHERE Sars, 1925

Hemicythere schmidtae Malkin

Trachyleberis ? cf. *T. angulata* Swain, 1951 (not Sars) U. S. Geol. Surv., Prof. Paper 234-A, p. 29-30, pl. 3, figs. 9-12.

Trachyleberis ? reesidei Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 30, pl. 3, fig. 13.

Hemicythere schmidtae Malkin, 1953, Jour. Pal., vol. 27, p. 796-797, pl. 82, figs. 16-18; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 92-94, pl. 12, figs. 2a-d; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 238.

Occurrences: This species, described by Doris Malkin Curtis, is adequately figured and discussed in McLean (1957); added records are: localities C, F-1, G-1, J-1; well A-11 near Newport News at a depth of 80 feet. The outline of the test, particularly in the hinge area, serves to separate this form from the very common and very similar *Aurila conradi.*

Genus AURILA Pokorny, 1955

Aurila conradi (Howe and McGuirt)

Hemicythere conradi Howe and McGuirt, 1935, Florida Geol. Surv., Bull. 13, p. 27-28, pl. 3, figs. 31-34, pl. 4, fig. 17; Edwards, 1944, Jour. Pal., vol. 18, p. 518, pl. 86, figs. 17-18; Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 42, pl. 6, figs. 9-12; Puri, 1953, Washington Acad. Sci., Jour., vol. 43, p. 176, pl. 2, figs. 1-2; Malkin, 1953, Jour. Pal., vol. 27, p. 796, pl. 82, figs. 16-18; Swain, 1955, Jour. Pal., vol. 29, p. 635, pl. 62, figs. 3a-c.

Aurila conradi McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 94-5, pl. 11, figs. 7a-b; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 238, pl. 27, figs. 9a-c; Puri, 1960, Trans. Gulf Coast Assoc. Geol. Soc., vol. 10, p. 129-130, pl. 3, figs. 9, 10.

Occurrences: Additional records for this abundant form are: localities C, D, E-1, F-1, G-1, J-1; well A-11 near Newport News at 65 feet; Chesapeake Bay Bridge-Tunnel, well A-2 at 70 feet.

Genus LOXOCONCHA Sars, 1865

Loxoconcha purisubrhomboidea Edwards

Plate 22, Figures 5, 6

Loxoconcha purisubrhomboidea Edwards, *in* Puri, 1953, Jour. Pal., vol. 27, p. 750; Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 274, pl. 10, fig. 8, text fig. 10h; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 71-72, pl. 7, figs. 4a-e.

Loxoconcha subrhomboidea Edwards (not Brady, 1880), 1944, Jour. Pal., vol. 18, no. 6, p. 527, pl. 88, figs. 28-32; Swain (?), 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 25, pl. 2, figs. 18-19; Malkin, 1953, Jour. Pal., vol. 27, no. 6, p. 787, and pl. 80, figs. 13-17 (figured as *L. reticularis*).

Occurrences: P.R.I. 27218 (length 0.34 mm) is a rather smooth, untypical specimen from locality 37; P.R.I. 27180 (length 0.68 mm) is an eroded specimen from well 3-S, Coleman Bridge section, at 95 feet; other occurrences are: localities C, and F-1; Coleman Bridge secton, well 1-SE at 128 to 170 feet, well 1-NW at 118 feet.

Loxoconcha reticularis Edwards

Loxoconcha reticularis Edwards, 1944, Jour. Pal., vol. 18, no. 6, p. 527, pl. 88, figs. 26-27; Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 274, pl. 10, fig. 7, text fig. 10e; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 72-73, pl. 7, figs. 5a-b.

Occurrence: Locality C has a few specimens of this form as illustrated and discussed in McLean (1957).

Genus CYTHEROMORPHA Hirschmann, 1909

Cytheromorpha cf. *warneri* Howe and Spurgeon

Plate 22, Figures 7, 8

Cytheromorpha warneri Howe and Spurgeon, 1935, *in* Howe et al. Florida Geol. Surv., Bull. 13, p. 11-12, pl. 2, figs. 5, 8-9, pl. 4, fig. 4; Swain, 1951, (*C.* cf. *warneri*) U. S. Geol. Surv., Prof. Paper 234-A, p. 49, pl. 7, figs. 18-19; Malkin, 1953, Jour. Pal., vol. 27, p. 787, pl. 80, figs. 18-19; Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 277, pl. 6, figs. 5-7, text figs. 11f-g; Puri and Hulings, 1957, Trans. Gulf Coast Assoc.

Geol. Soc., vol. 7, p. 187, fig. 11; Puri, 1960, Trans. Gulf Coast Assoc. Geol. Soc., vol. 10, p. 114, pl. 3, figs. 11, 12, text fig. 36.

Cytheromorpha cf. *warneri* McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 70-71, pl. 7, figs. 3a-b.

Occurrences: P.R.I. 27262 is 0.53 mm long and comes from locality 11; P.R.I. 27231 (0.44 mm long) comes from locality 30; other specimens are from locality 18.

Genus CYTHERETTA G. W. Muller, 1894

Cytheretta ulrichi Puri

Plate 22, Figure 9

Plate 23, Figure 1

Cythere plebeia Ulrich and Bassler (not Reuss), 1904, Maryland Geol. Surv., Miocene, p. 102-103 (vol. 1), pl. 35, figs. 20-29 (vol. 2).

Cythere plebeia var. *capax* Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 103 (vol. 1), pl. 35, figs. 30-33 (vol. 2).

Cythere porcella Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 106-107 (vol. 1), pl. 36, figs. 26-33 (vol. 2).

Cytheretta plebeia Swain, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 212, pl. 14, figs. 3-4; Malkin, 1953, Jour. Pal., vol. 27, p. 790, pl. 81, figs. 1-6, 9.

Cytheretta ulrichi Puri, 1952, Jour. Pal., vol. 26, p. 204-205, pl. 39, fig. 3, text figs. 5-7; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 92, pl. 12, figs. 3a-d; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 238.

Cytheretta porcella Swain, 1951, U. S. Geol. Surv., Prof. Paper 234-A, p. 45, pl. 4, fig. 7.

Occurrences: P.R.I. 27185 (1.18 mm long) is from a depth of 105 feet and P.R.I. 27175 (0.83 mm long) is from 115 feet in well 3-S of the Coleman Bridge section. Other occurrences are: Coleman Bridge section, well 1-SW at 123 feet, well 1-SE at 128 feet, well 1-NW at 118 feet, well 3-N at 135 feet; well A-11 near Newport News at 160 to 195 feet; Chesapeake Bay Bridge-Tunnel, well M-62 at 44 to 54 feet.

Genus HULINGSINA Puri, 1958

Hulingsina ashermani (Ulrich and Bassler)

Plate 23, Figure 4

Cytherideis ashermani Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 126 (vol. 1), pl. 37, figs. 10-16; Howe et al., 1935, Florida Geol. Surv., Bull. 13, p. 14, pl. 3, figs. 8-10; Edwards, 1944, Jour. Pal., vol. 18, p. 514, pl. 86, figs. 1-4; Swain, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 195, pl. 13, fig. 1; Puri, 1952, Jour. Pal., vol. 26, p. 910, pl. 130, figs. 4-8, text figs. 1-2; Malkin, 1953, Jour. Pal., vol. 27, p. 778, pl. 78, figs. 1-13; Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 286-287, pl. 9, figs. 4-8.

Cytherideis longula Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 138 (vol. 1), pl. 37, figs. 21-27 (vol. 2); Swain, 1948, Maryland Dept. Geol., Mines, and Water Res., Bull. 2, p. 195, pl. 13, fig. 2.

Cytherideis semicircularis Ulrich and Bassler, 1904, Maryland Geol. Surv., Miocene, p. 127 (vol. 1), pl. 37, figs. 18-20 (vol. 2).

Cushmanidea ashermani McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 77-78, pl. 8, figs. 5a-f; Sabol, 1960, Bull. Amer. Pal., vol. 41, no. 191, p. 235.

Hulingsina ashermani Puri, 1958, Trans. Gulf Coast Assoc. Geol. Soc., vol. 8, p. 173.

Occurrences: P.R.I. 27311 (0.64 mm long) is from well A-11 near Newport News at a depth of 80 to 81.6 feet; locality A-3 is the only other new occurrence.

Hulingsina ulrichi (Howe and Johnson)

Plate 23, Figure 3

Cytherideis ulrichi Howe and Johnson, 1935, *in* Howe et al., Florida Geol. Surv., Bull. 13, p. 16, pl. 3, figs. 11-14; Puri, 1952, Jour. Pal., vol. 26, p. 911, pl. 130, figs. 11-13, text figs. 5-6; Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 287, pl. 9, figs. 11-13.

Cytherideis subaequalis ulrichi Malkin, 1953, Jour. Pal., vol. 27, p. 779, pl. 78, figs. 18, 21.

Cushmanidea ulrichi McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 79, pl. 9, figs. 3a-d.

Occurrence: A single specimen, P.R.I. 27188 which is 0.81 mm long, was recovered from the Coleman Bridge section, well 3-S at a depth of 105 feet.

Family CYTHERELLIDAE

Genus CYTHERELLA Jones, 1849

Cytherella chipolensis Puri

Plate 23, Figure 5

Cytherella chipolensis Puri, 1954 (1953), Florida Geol. Surv., Bull. 36, p. 300-301, pl. 17, figs. 5-6, text figs. 14e-g; McLean, 1957, Bull. Amer. Pal., vol. 38, no. 167, p. 95, pl. 12, figs. 5a-b.

Occurrence: A lone specimen from 165 to 166 feet in well A-11 near Newport News (P.R.I. 27312) reaches a length of 0.80 mm.

Ostracoda spp. *incertae sedis*

Plate 23, Figures 6-8

These specimens, of unknown genera and species, occur as follows:

P.R.I. Number	Dimensions	Localities
27165	0.59 mm	Well 3-S at 105 feet
27174	0.57 mm	Well 3-S at 115 feet
27187	0.67 mm	Well 3-S at 105 feet

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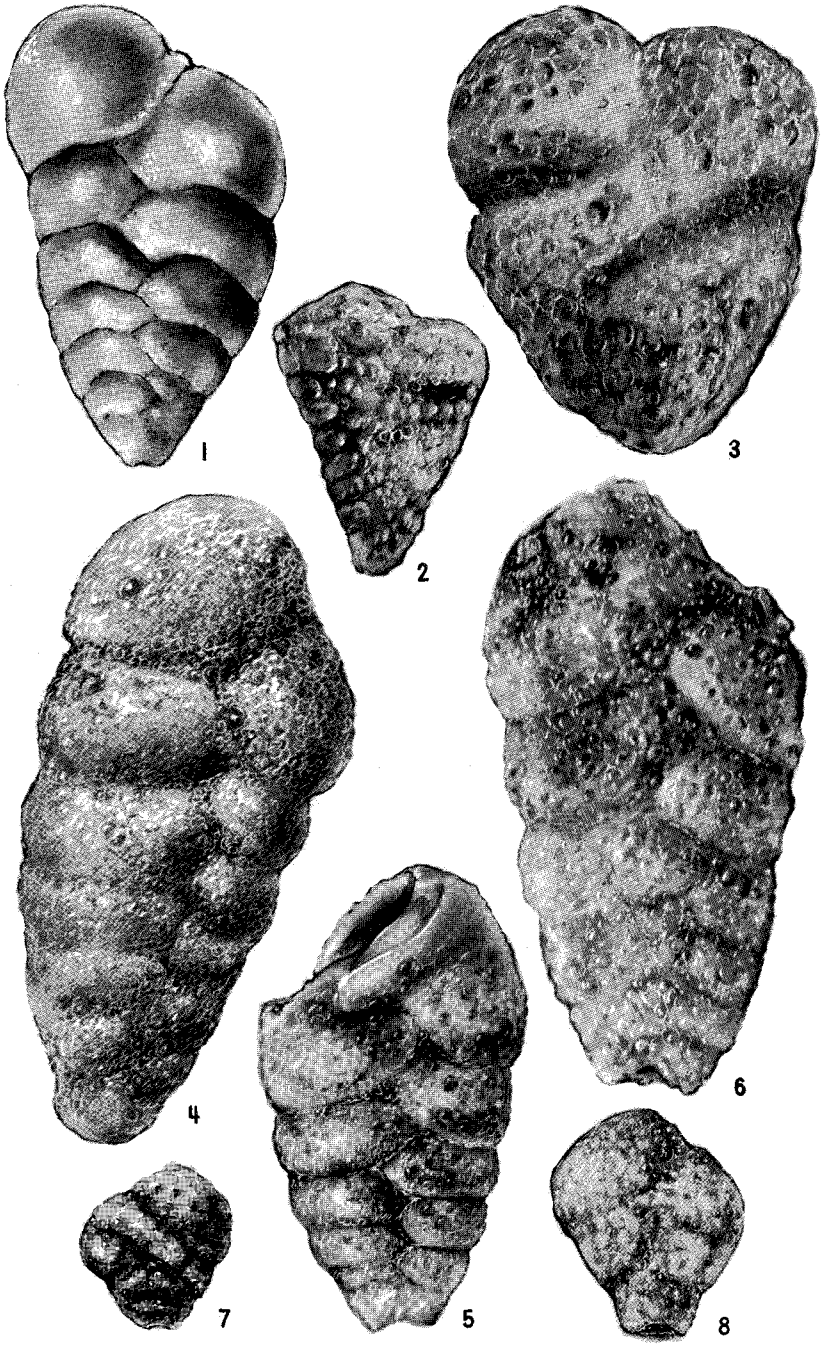
FOSSIL PLATES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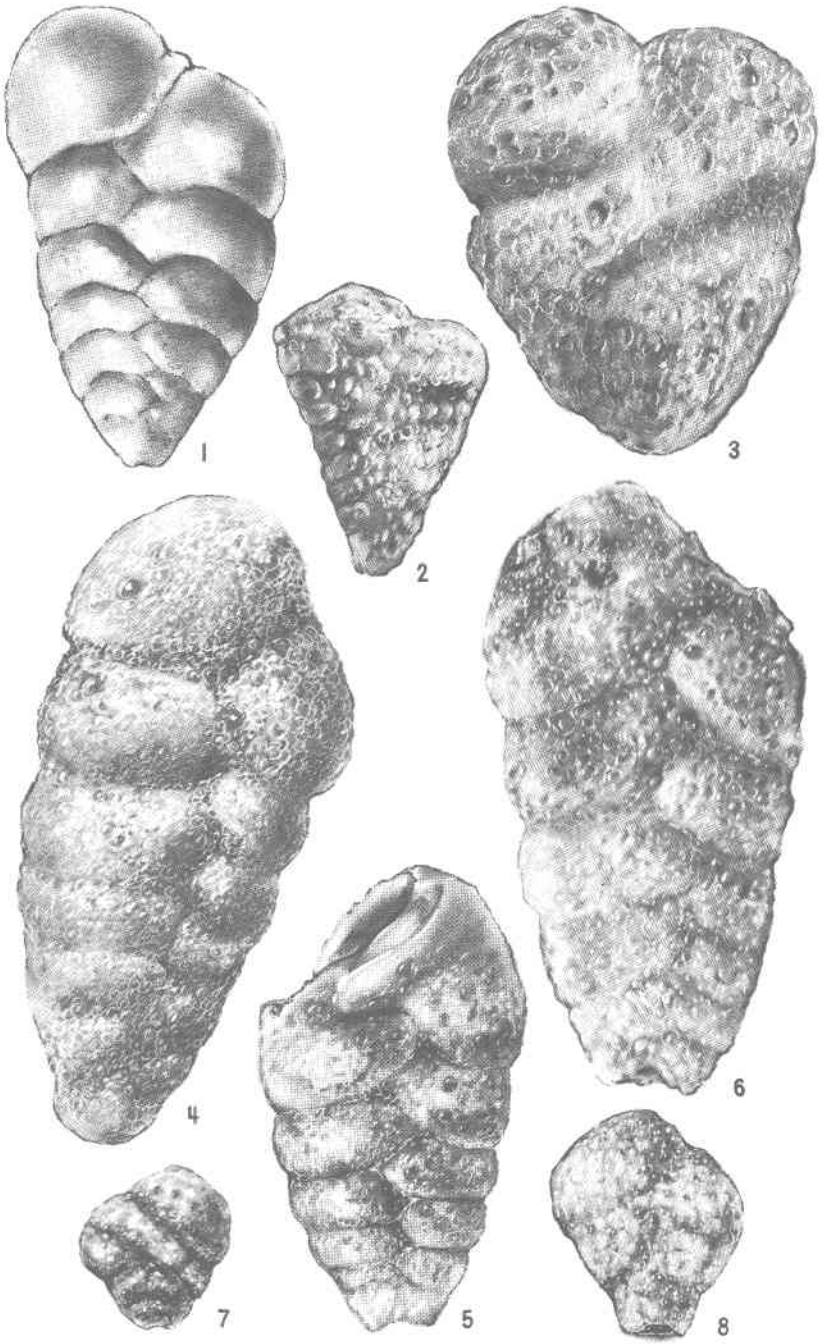
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EXPLANATION OF PLATE 1

Figure

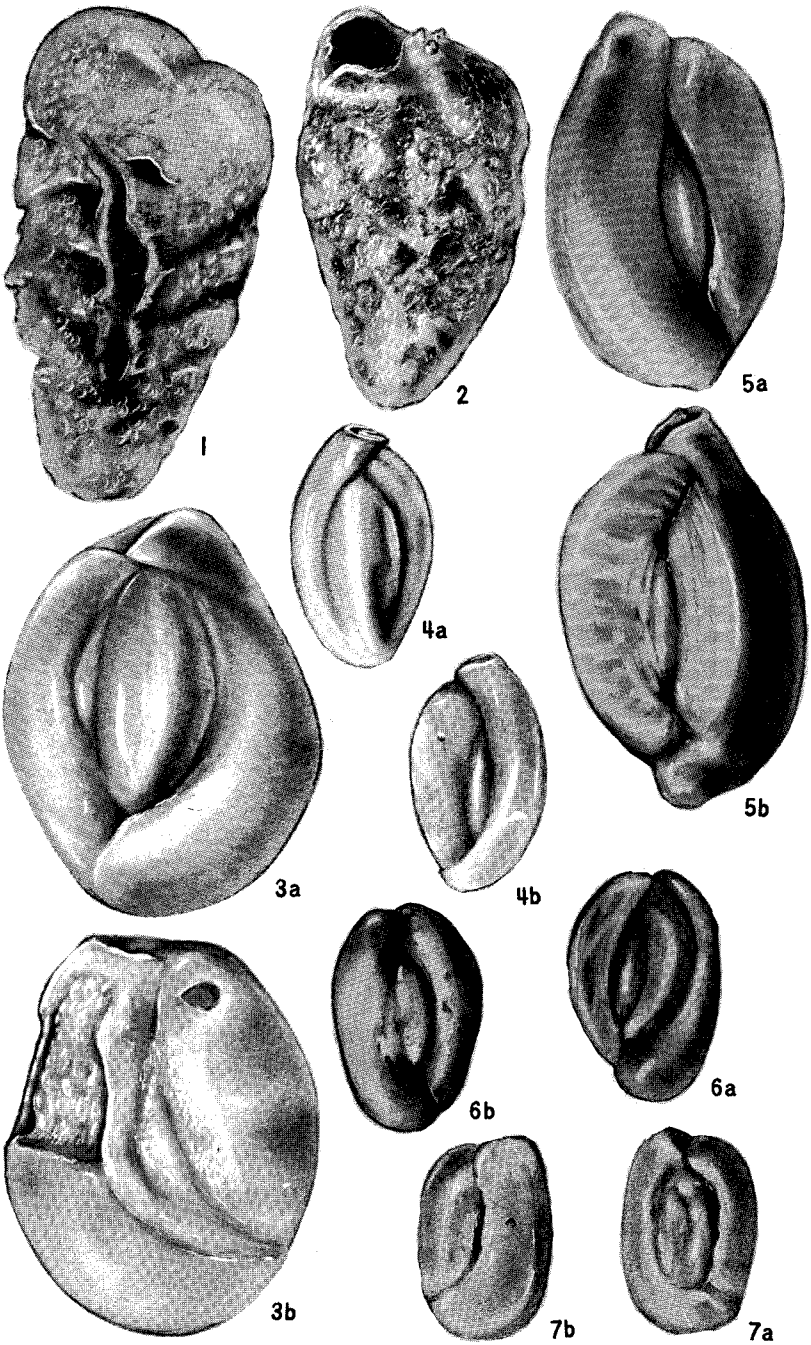
1 *Textularia articulata* d'Orbigny
Side view, P.R.I. 27154 (70X).

2, 3 *Textularia candeiana* d'Orbigny
2—Side view, P.R.I. 27253 (57X).
3—Side view, P.R.I. 27214 (162X).

4, 5 *Textularia pseudobliqua* McLean
4—Side view, P.R.I. 27192 (59X).
5—Side view, P.R.I. 27178 (58X).

6 *Textularia obliqua* Clapp
Side view, P.R.I. 27316 (59X).

7, 8 *Textularia* sp. A
7—Side view, P.R.I. 27172 (67X).
8—Side view, P.R.I. 27181 (69X).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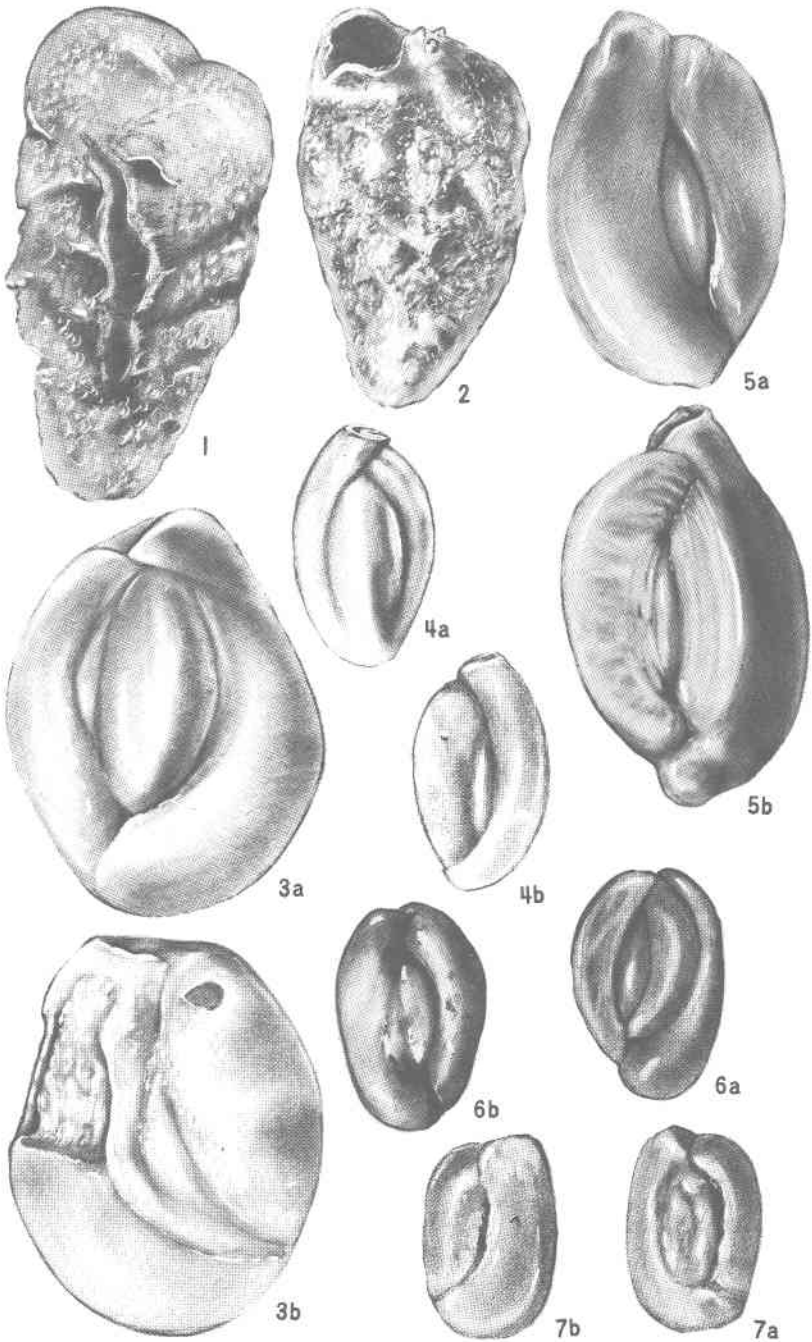
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EXPLANATION OF PLATE 2

Figure

1 *Textularia* sp. B

Side view, broken specimen, P.R.I. 27255 (156X).

2 *Textularia* sp. C

Side view, broken specimen, P.R.I. 27210 (159X).

3a, b *Quinqueloculina lamarckiana* d'Orbigny

4a, b 3a, b—Side views, P.R.I. 27208 (171X).

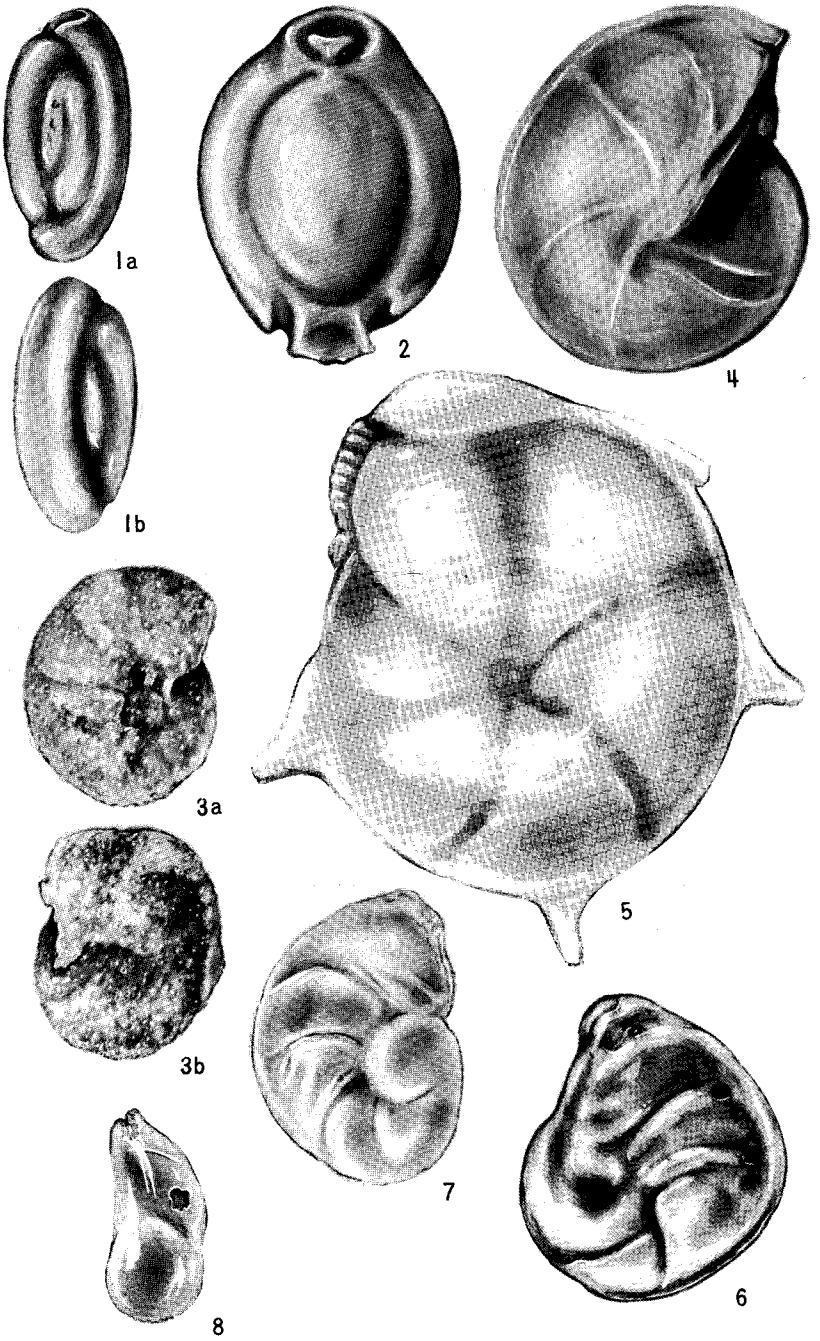
5a, b 4a, b—Side views, P.R.I. 27243 (72X).

5a, b—Side views, P.R.I. 27216 (65X).

6a, b *Quinqueloculina seminula* (Linnaeus)

7a, b 6a, b—Side views, P.R.I. 27205 (64X).

7a, b—Side views, P.R.I. 27240 (60X).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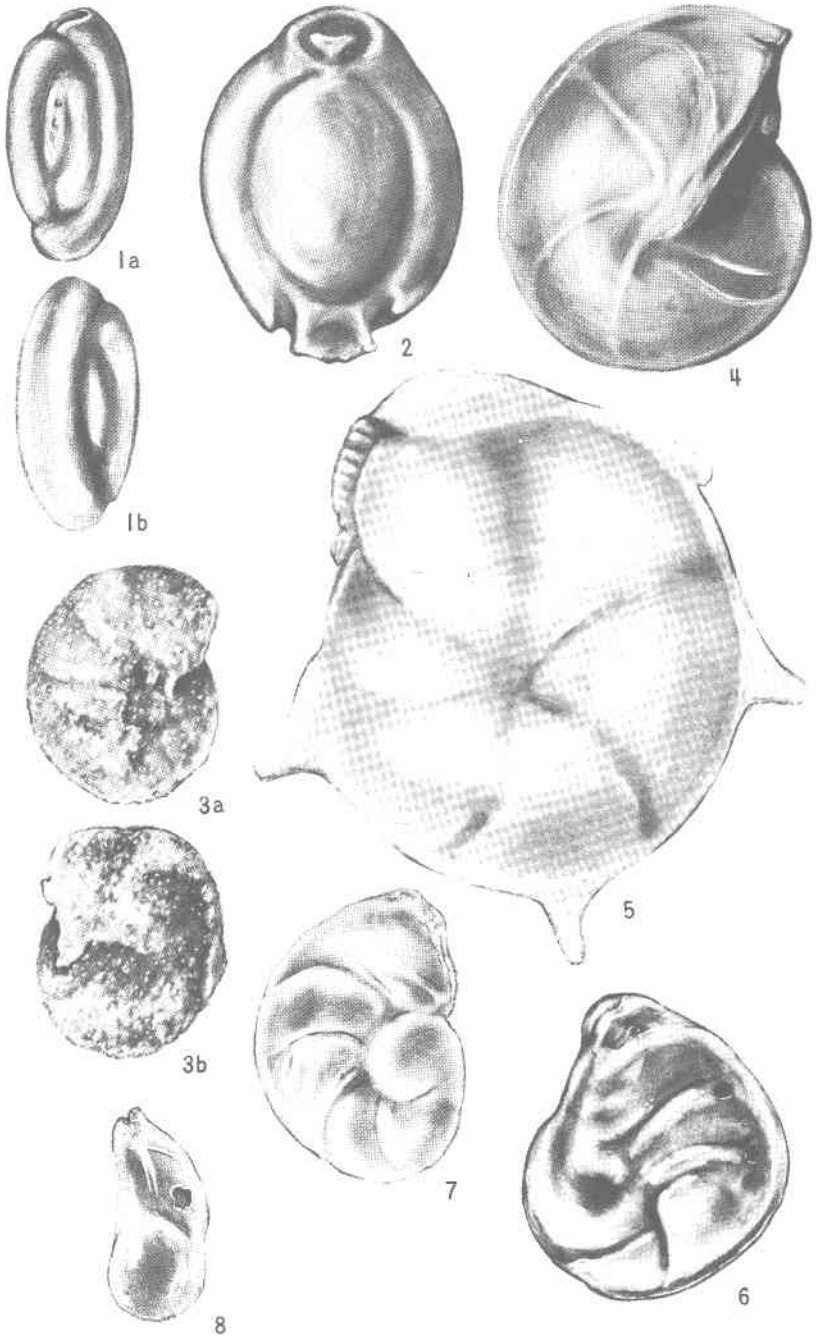
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EXPLANATION OF PLATE 3

Figure

1a, b *Quinqueloculina seminula* (Linnaeus)
Side views, P.R.I. 27227 (60X).

2 *Pyrgo denticulata* (H. B. Brady)
Side view, P.R.I. 27307 (66X).

3a, b *Trochammina* sp.
Side views, P.R.I. 27304 (58X).

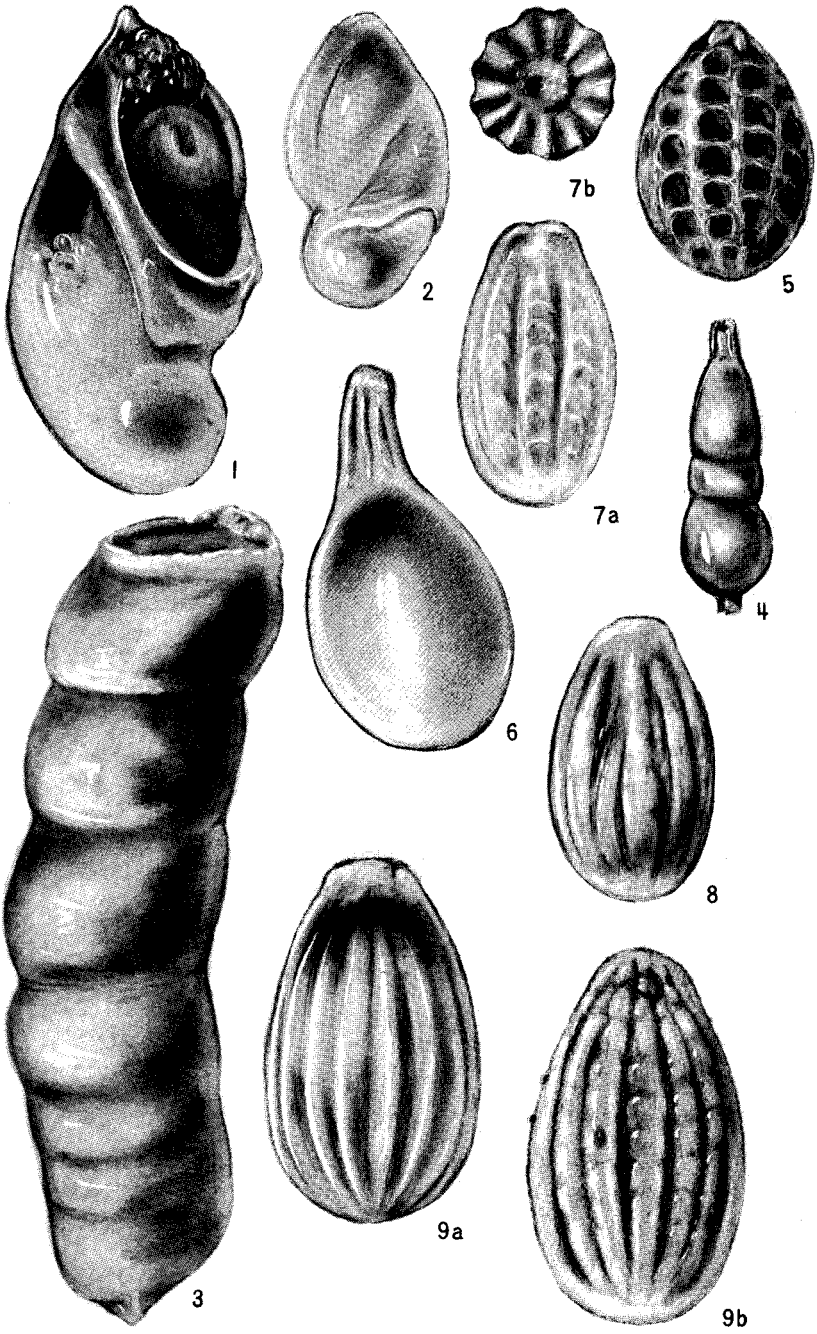
4 *Robulus americanus* (Cushman)
Side view, P.R.I. 27169 (62X).

5 *Robulus calcar* (Linnaeus)
Side view, P.R.I. 27166 (63X).

6 *Robulus pseudoiota* McLean
Side view, P.R.I. 27315 (143X).

7 *Robulus* sp.
Side view, P.R.I. 27277 (158X).

8 *Marginulina* sp. A
Side view, P.R.I. 27281 (56X).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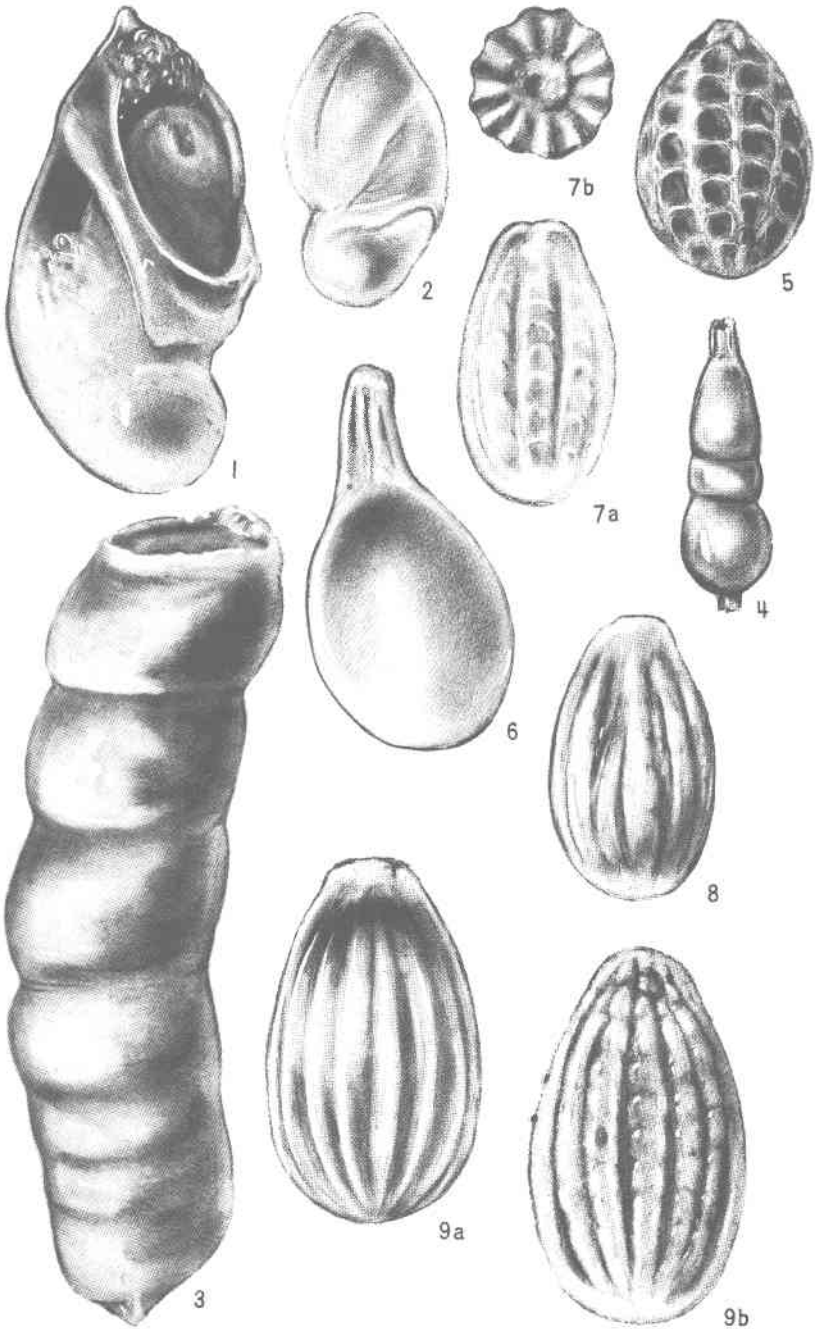
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EXPLANATION OF PLATE 4

Figure

1 *Marginulina* sp. B
Side view, P.R.I. 27286 (177X).

2 *Marginulina* sp. C
Side view, P.R.I. 27275 (173X).

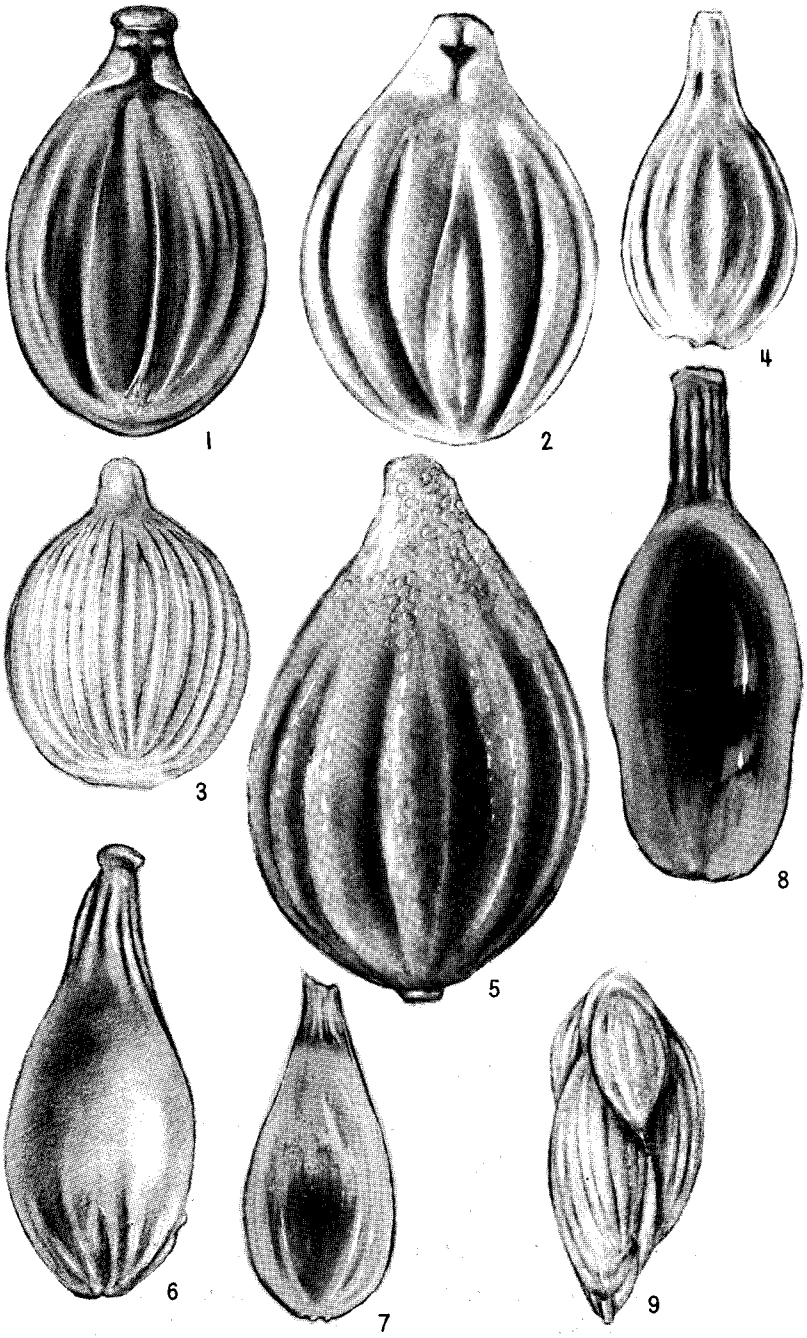
3 *Marginulina* sp. D Clapp
Side view, P.R.I. 27303 (57X).

4 *Nodosaria catesbyi* subsp. *hustonae* McLean, n. subsp.
Side view of holotype, P.R.I. 27321 (58X).

5 *Lagena hexagona* subsp. *scalariformis* (Williamson)
Side view, P.R.I. 27322 (162X).

6 *Lagena laevis* (Montagu)
Side view, P.R.I. 27213 (184X).

7a, b *Lagena pageae* McLean, n. sp.
8 7a—Side view; 7b—apertural view, paratype, P.R.I.
9a, b 27294 (144X).
8—Side view, paratype, P.R.I. 27260 (144X).
9a, b—Side views of holotype, P.R.I. 27249 (160X).
9a—Specimen lighted from normal position.
9b—Same specimen lighted from side only.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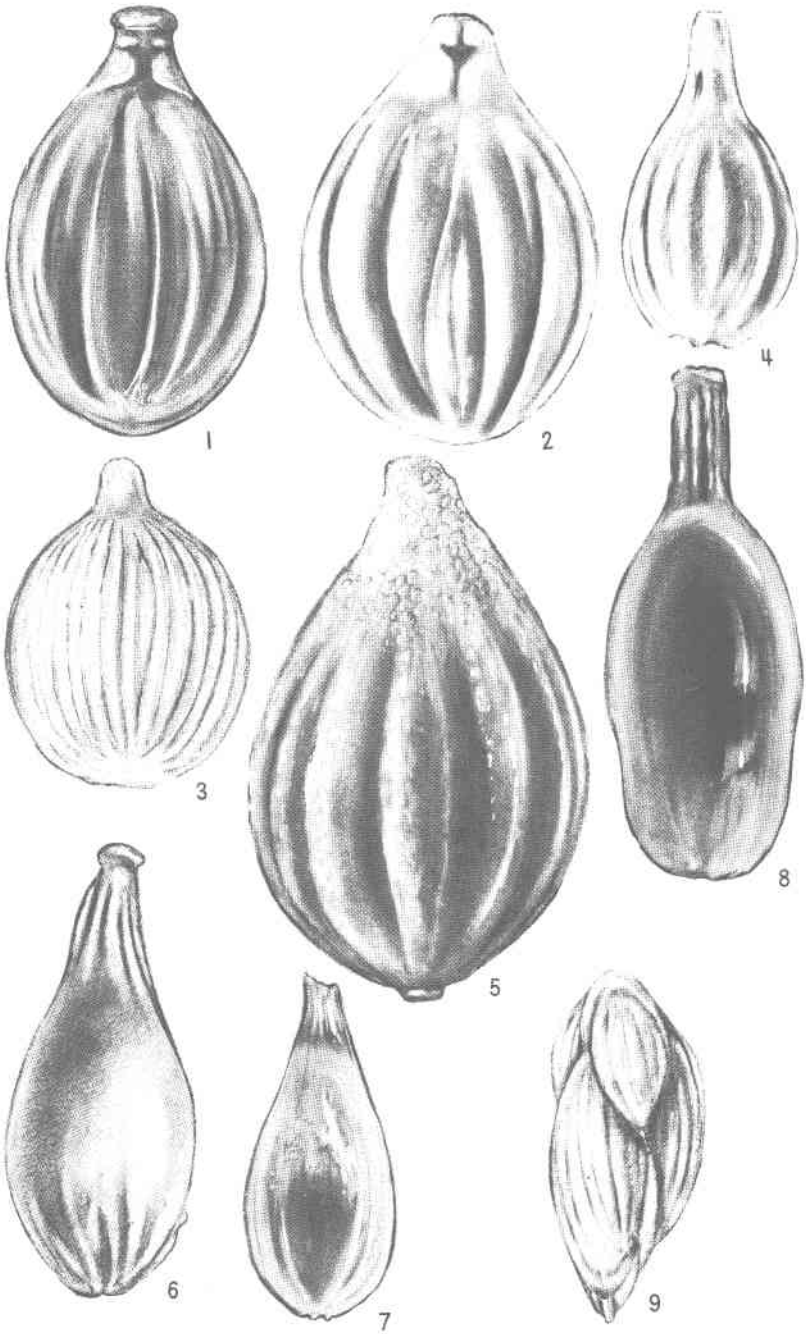
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EXPLANATION OF PLATE 5

Figure

1, 2 *Lagena pseudosulcata* McLean

1—Side view, P.R.I. 27237 (172X).

2—Side view, P.R.I. 27209 (162X).

Note difference in aperture of this specimen as compared with Figure 4 below.

3 *Lagena substriata* (Williamson)

Side view, P.R.I. 27274 (168X).

4, 5 *Lagena sulcata* (Walker and Jacob)

4—Side view, P.R.I. 27246 (148X).

5—Side view, P.R.I. 27163 (169X).

6, 7 *Lagena tenuis* (Bornemann)

6—Side view, P.R.I. 27320 (155X).

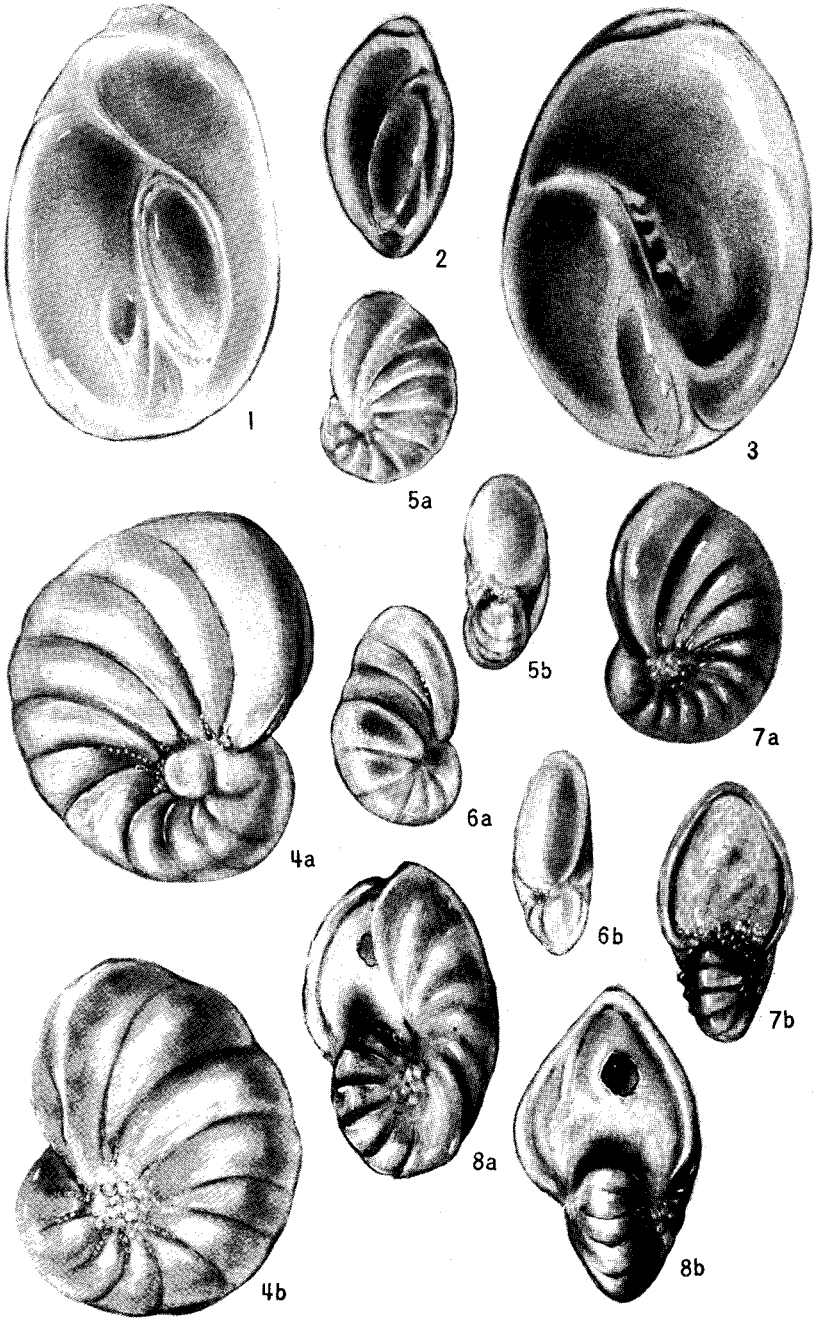
7—Side view, P.R.I. 27289 (180X).

8 *Lagena* sp.

Side view, P.R.I. 27288 (161X).

9 *Guttulina pseudocostatula* McLean

Side view, P.R.I. 27194 (55X).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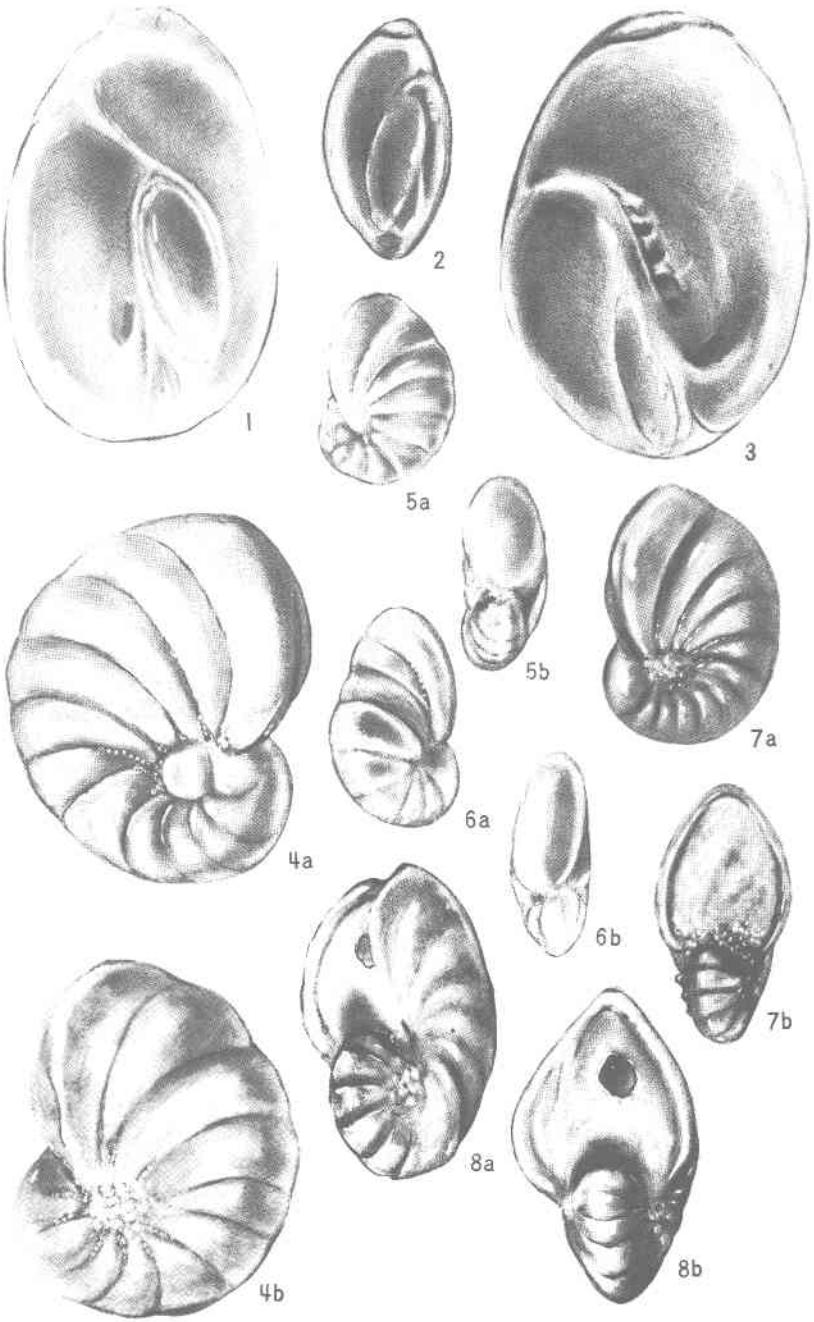
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EXPLANATION OF PLATE 6

Figure

1, 2 *Sigmomorphina semitecta* subsp. *terquemiana* (Fornasini)

1—Side view of untypical form, P.R.I. 27247 (160X).

2—Side view of typical form, P.R.I. 27287 (74X).

3 *Sigmomorphina* sp.

Side view, P.R.I. 27273 (168X).

4a, b *Nonion grateloupi* Clapp

Opposite side views of same specimen, P.R.I. 27190 (62X).

Note umbilical plug on one side and pustules on opposite side.

5a, b *Nonion grateloupi* d'Orbigny

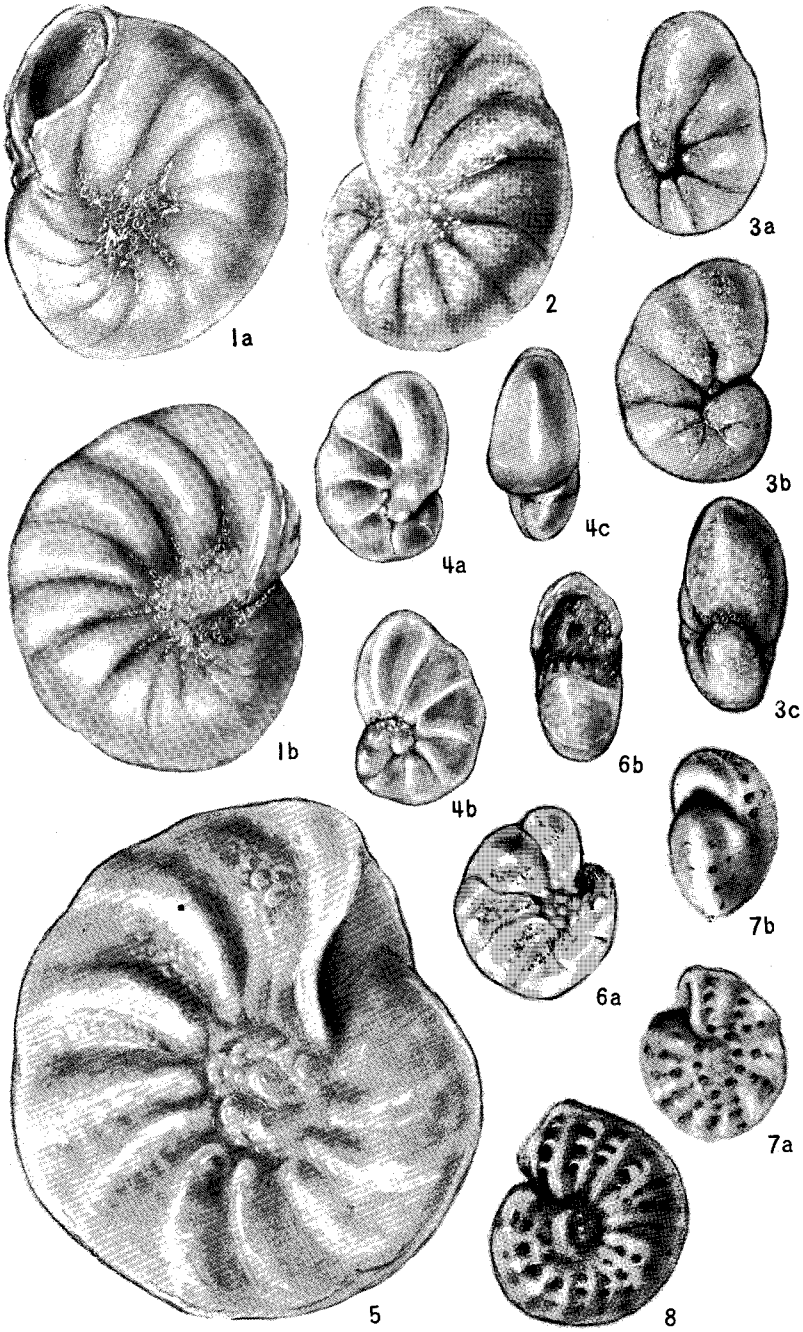
6a, b 5a—Side view; 5b—apertural view, P.R.I. 27271 (60X).

6a—Side view; 6b—apertural view, P.R.I. 27267 (64X).

7a, b *Nonion mediocostatus* (Cushman)

8a, b 7a—Side view; 7b—apertural view, P.R.I. 27182 (58X).

8a—Side view; 8b—apertural view, P.R.I. 27168 (67X).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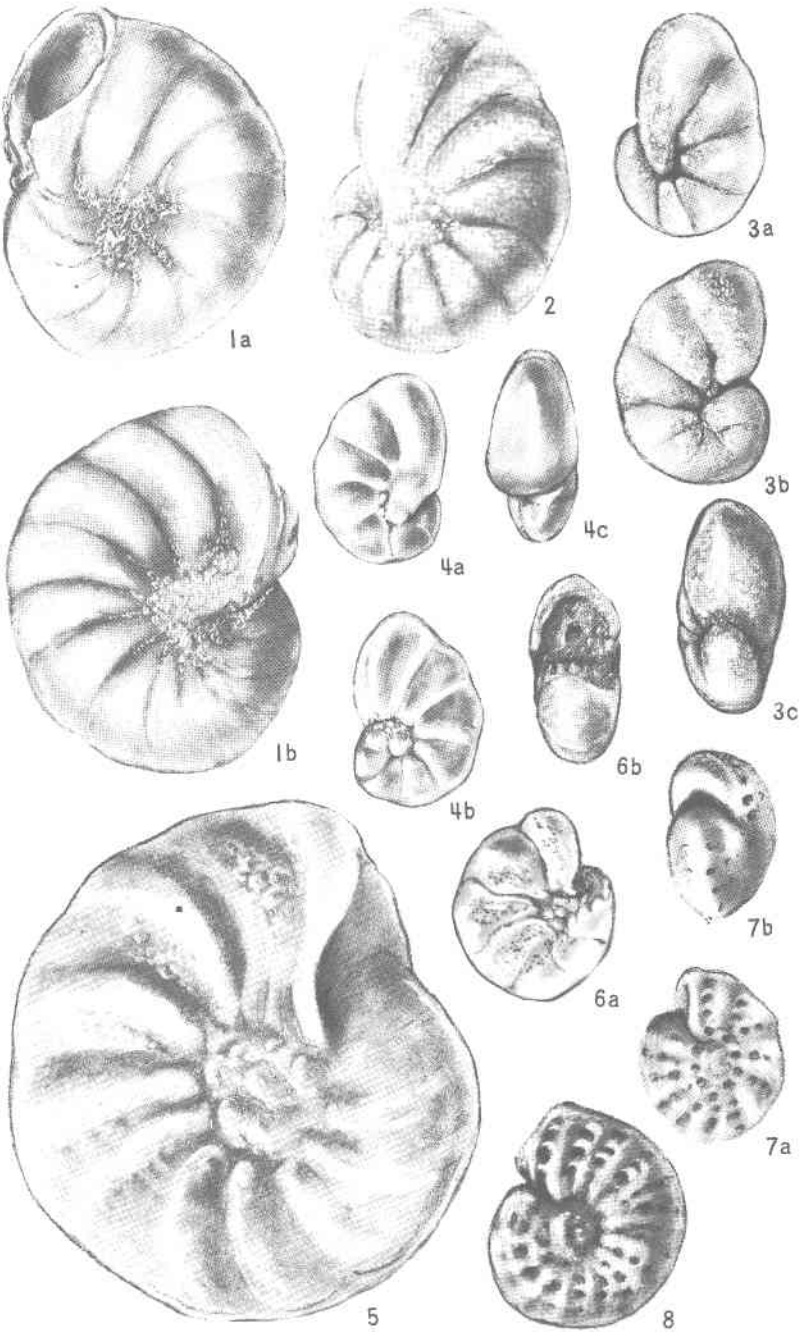
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EXPLANATION OF PLATE 7

Figure

1a, b *Nonion pizarrensis* (W. Berry)

2 1a, b—Opposite sides, P.R.I. 27191 (61X).

2—Side view, P.R.I. 27189 (63X).

3a-c *Nonionella auris* (d'Orbigny)

4a-c 3a, b—Opposite sides; 3c—apertural view, P.R.I. 27160 (60X).

4a, b—Opposite sides; 4c—apertural view, P.R.I. 27203 (63X).

5 *Elphidium advena* (Cushman)

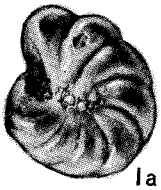
Side view, P.R.I. 27159 (163X).

6a, b *Elphidium clavatum* Cushman

7a, b 6a—Side view; 6b—apertural view, P.R.I. 27162 (62X).

8 7a—Side view; 7b—apertural view, smallest specimen on slide, P.R.I. 27156 (68X).

8—Side view, largest specimen on same slide, P.R.I. 27156 (68X).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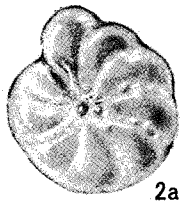
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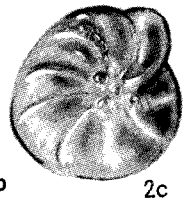
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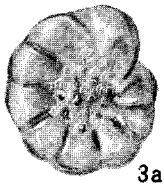
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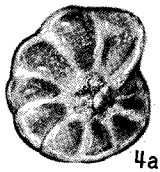
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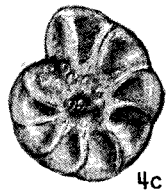
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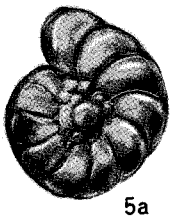
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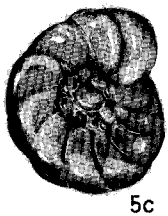
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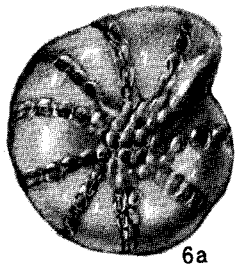
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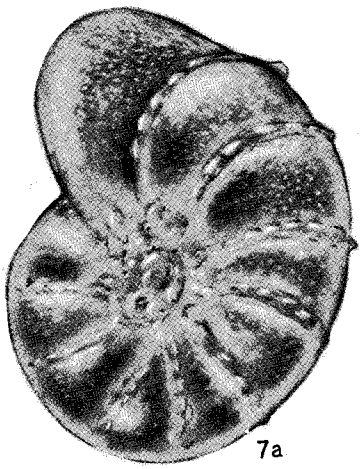
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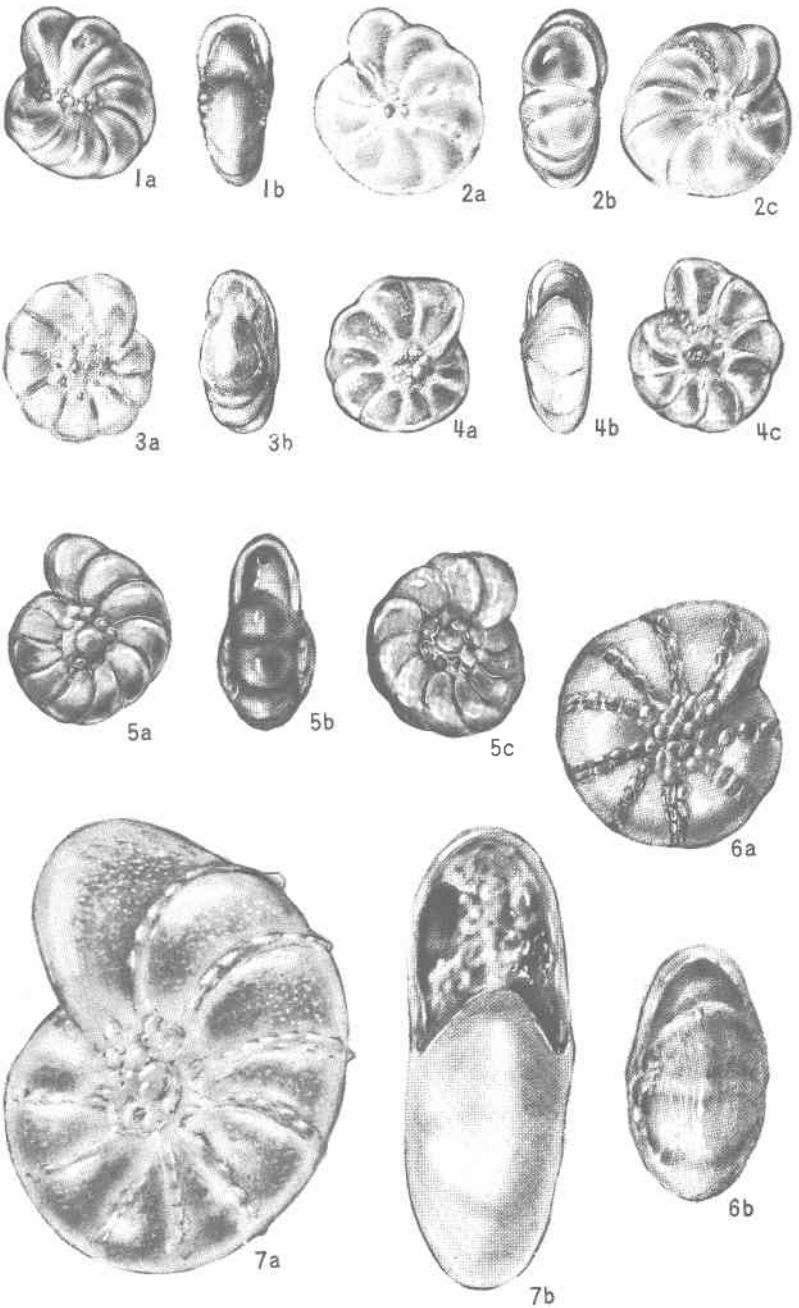
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EXPLANATION OF PLATE 8

Figure

1-7 *Elphidium florentinae* Shupack

All figures labeled b are apertural views and all figures labeled a or c are opposite sides or single sides of given specimen.

1a, b—P.R.I. 27170 (66X).

2a-c—P.R.I. 27241 (69X).

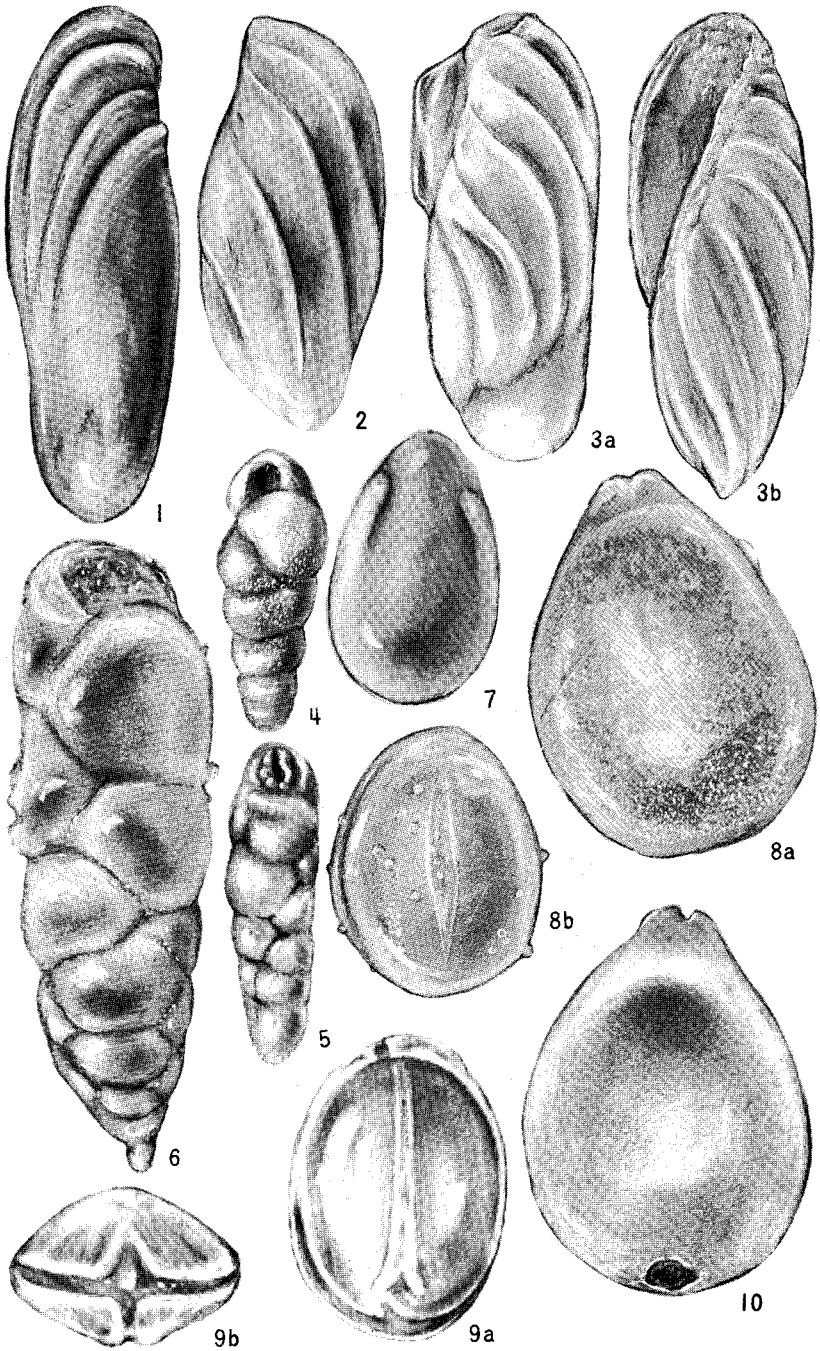
3a, b—P.R.I. 27234 (58X).

4a-c—P.R.I. 27215 (58X).

5a-c—P.R.I. 27219 (61X).

6a, b—P.R.I. 27158 (65X).

7a, b—P.R.I. 27217 (155X).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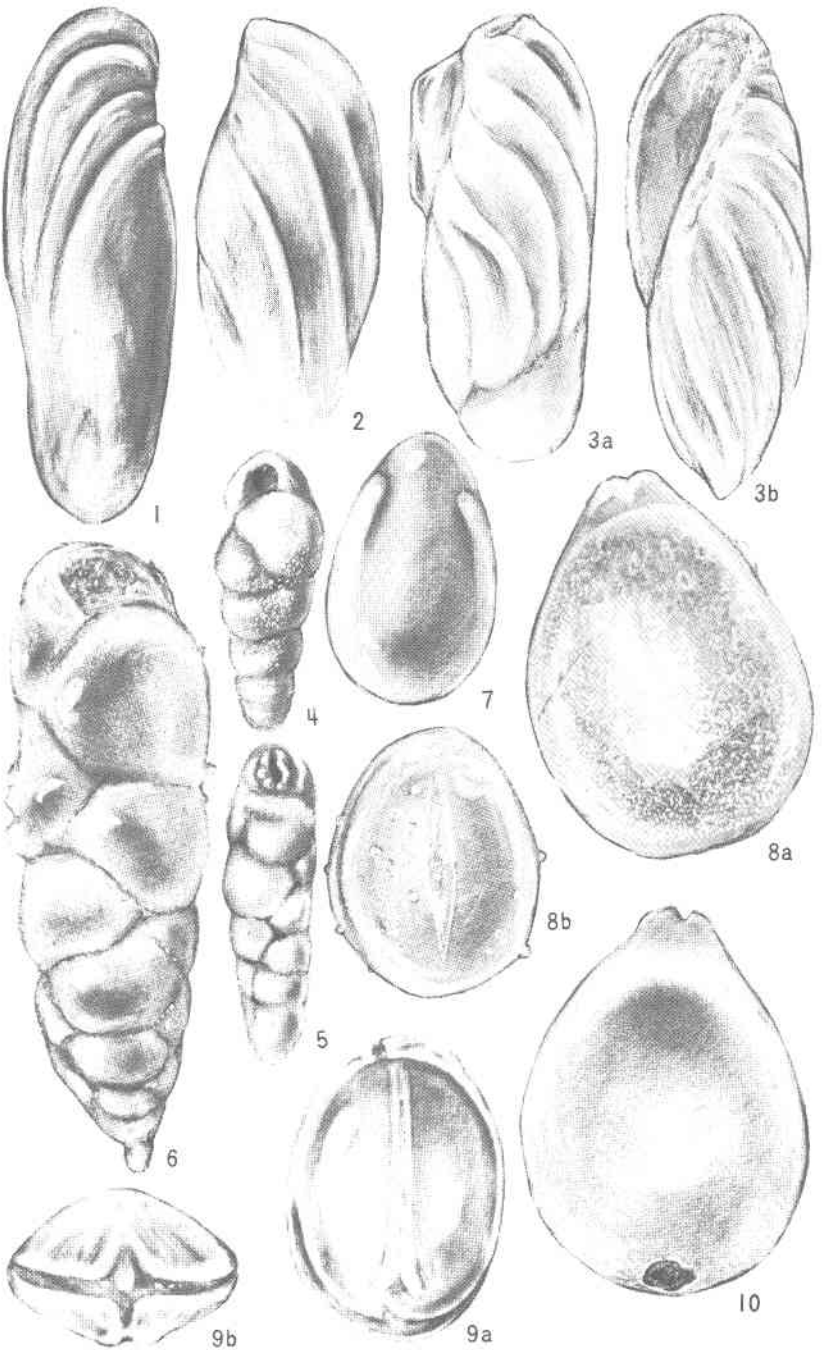
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EXPLANATION OF PLATE 9

Figure

1, 2 *Buliminella elegantissima* (d'Orbigny)

3a, b 1—Back view, P.R.I. 27232 (178X).

2—Back view, P.R.I. 27223 (164X).

3a, b—Back and apertural views, P.R.I. 27236 (180X).

4, 5 *Bulimina gracilis* Cushman

Apertural views of specimens on same slide, P.R.I. 27167 (58X).

6 *Bulimina gracilis* subsp. *calveri* McLean, n. subsp.

Apertural view of Holotype, P.R.I. 27298 (114X).

7 *Entosolenia carteri* McLean

Side view, P.R.I. 27276 (164X).

8a, b *Entosolenia nodosa* Wiesner

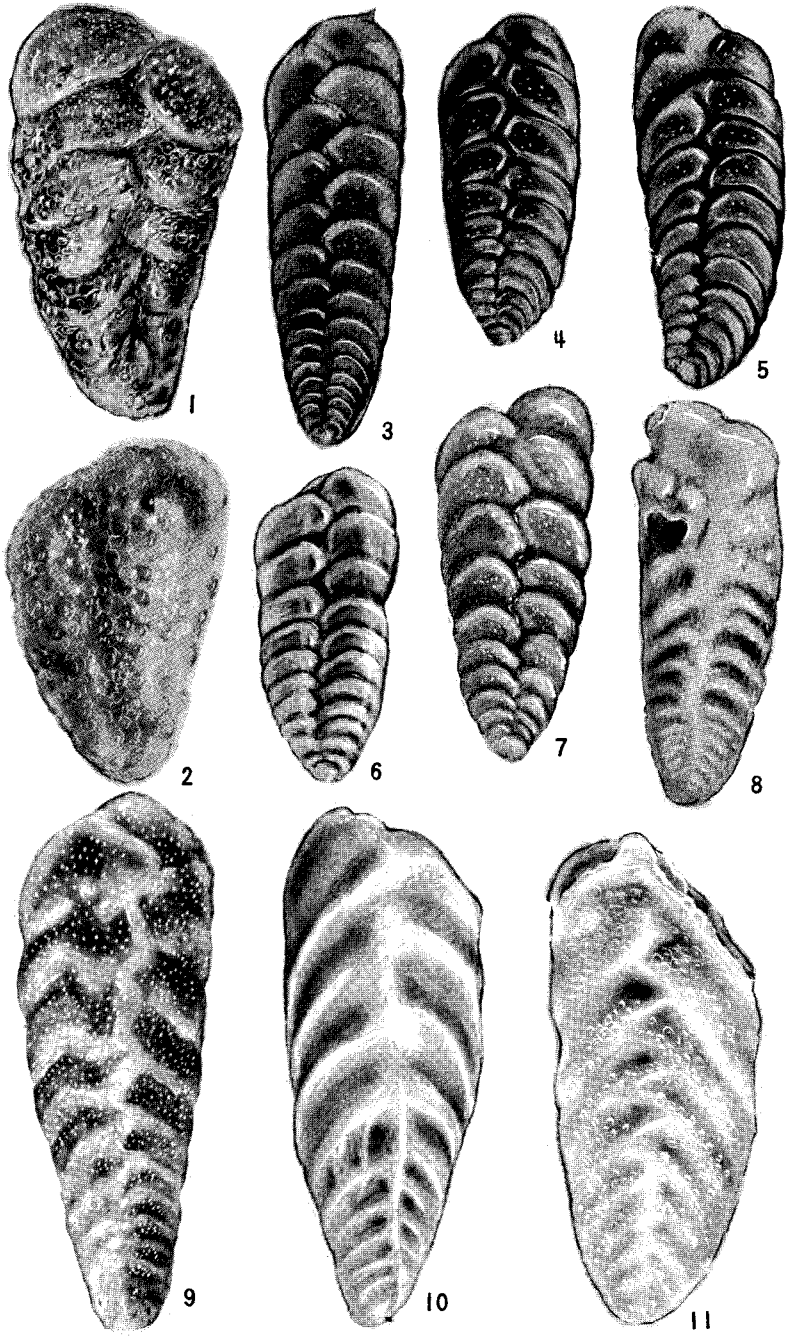
8a—Side view; 8b—apertural view, P.R.I. 27251 (156X).

9a, b *Entosolenia bifida* McLean, n. sp.

9a—Side view; 9b—apertural view of Holotype, P.R.I. 27292 (143X).

10 *Entosolenia* sp.

Side view, P.R.I. 27222 (156X).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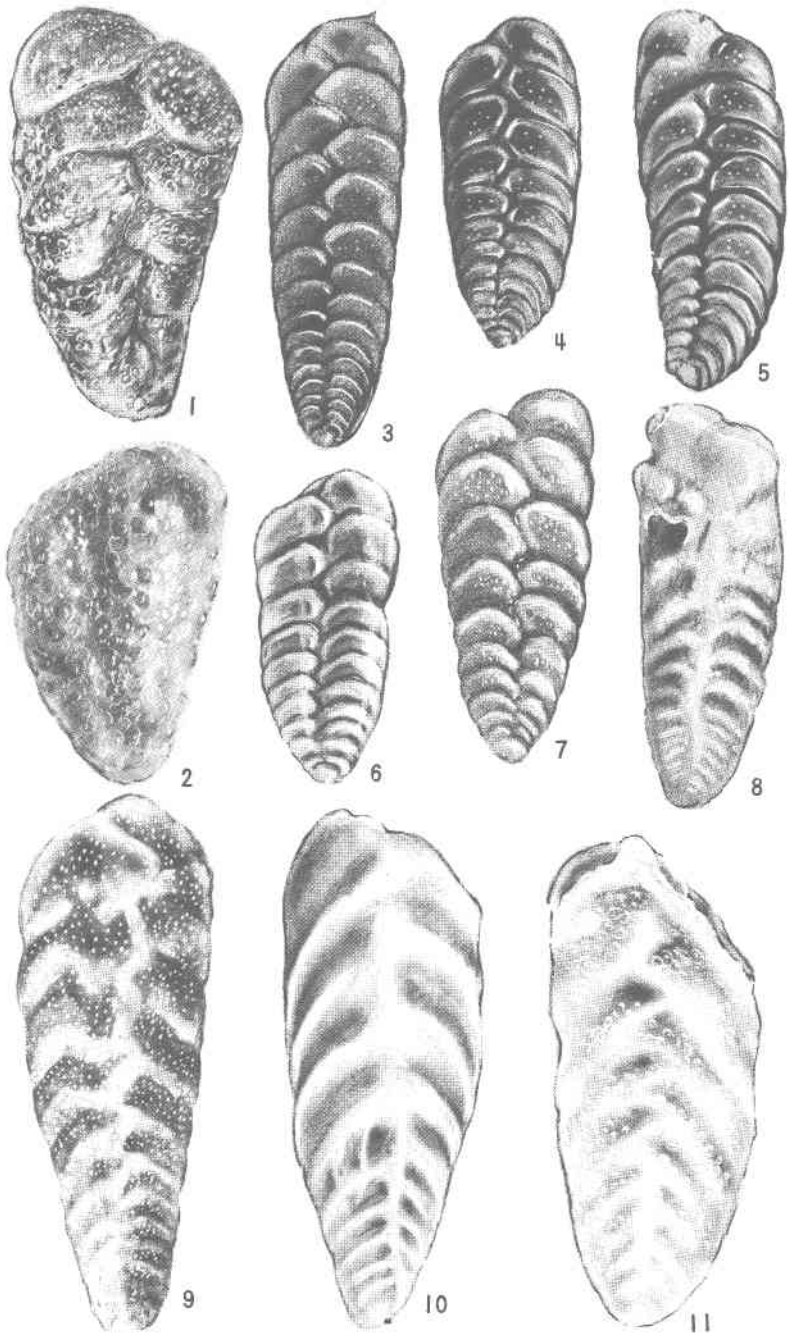
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EXPLANATION OF PLATE 10

Figure

1, 2 *Bolivina lafayettei* McLean

1—Side view, P.R.I. 27278 (164X).

2—Side view, P.R.I. 27238 (161X).

3-7 *Bolivina paula* Cushman and Cahill

3—Side view, P.R.I. 27295 (170X).

4—Side view, P.R.I. 27296 (200X).

5—Side view, P.R.I. 27297 (162X).

6—Side view, P.R.I. 27212 (160X).

7—Side view, P.R.I. 27233 (181X).

8 *Bolivina* sp. A

Side view, P.R.I. 27256 (168X).

9 *Bolivina plicatella* subsp. *mera* Cushman and Ponton

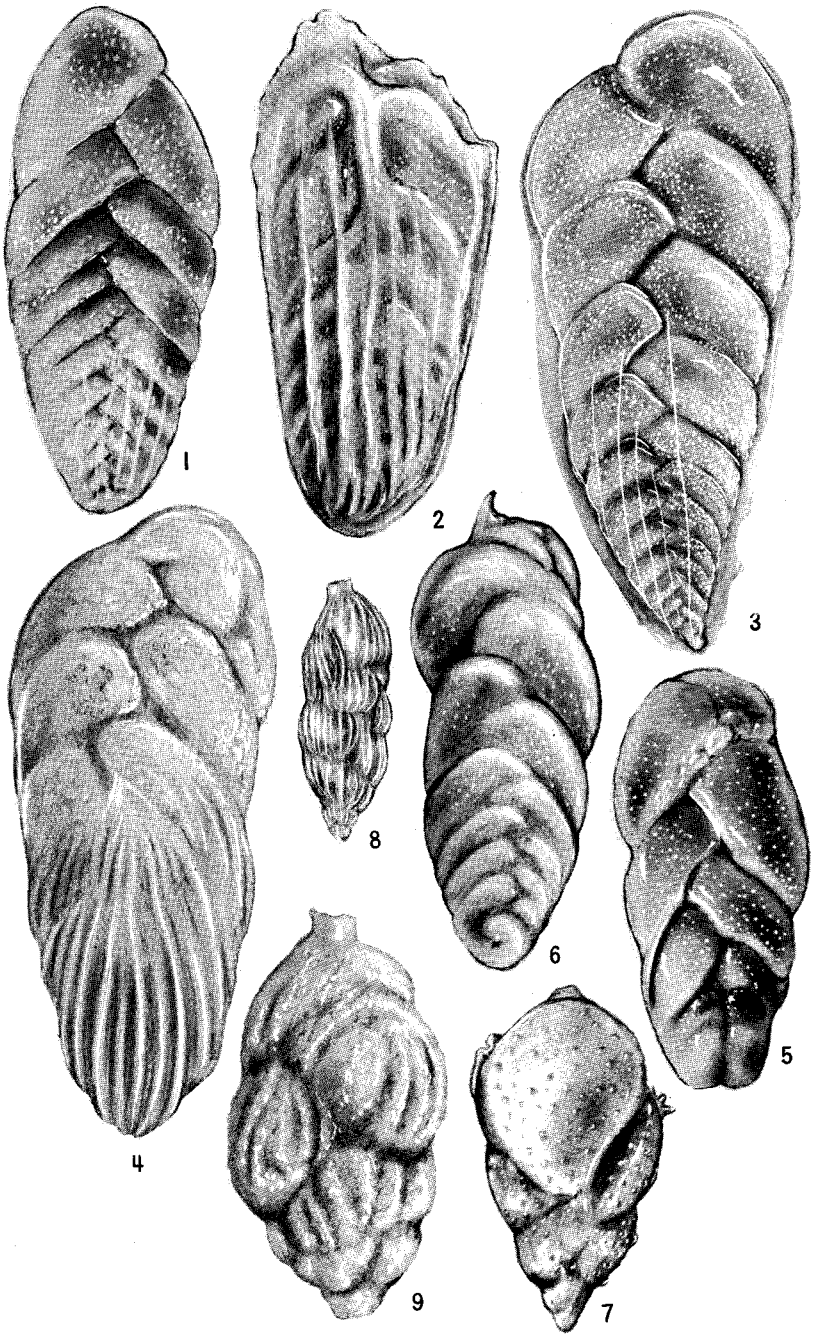
Side view, P.R.I. 27317 (165X).

10 *Bolivina* sp. C

Side view, P.R.I. 27207 (168X).

11 *Bolivina striatula* Cushman

Side view of badly damaged specimen, P.R.I. 27279 (173X).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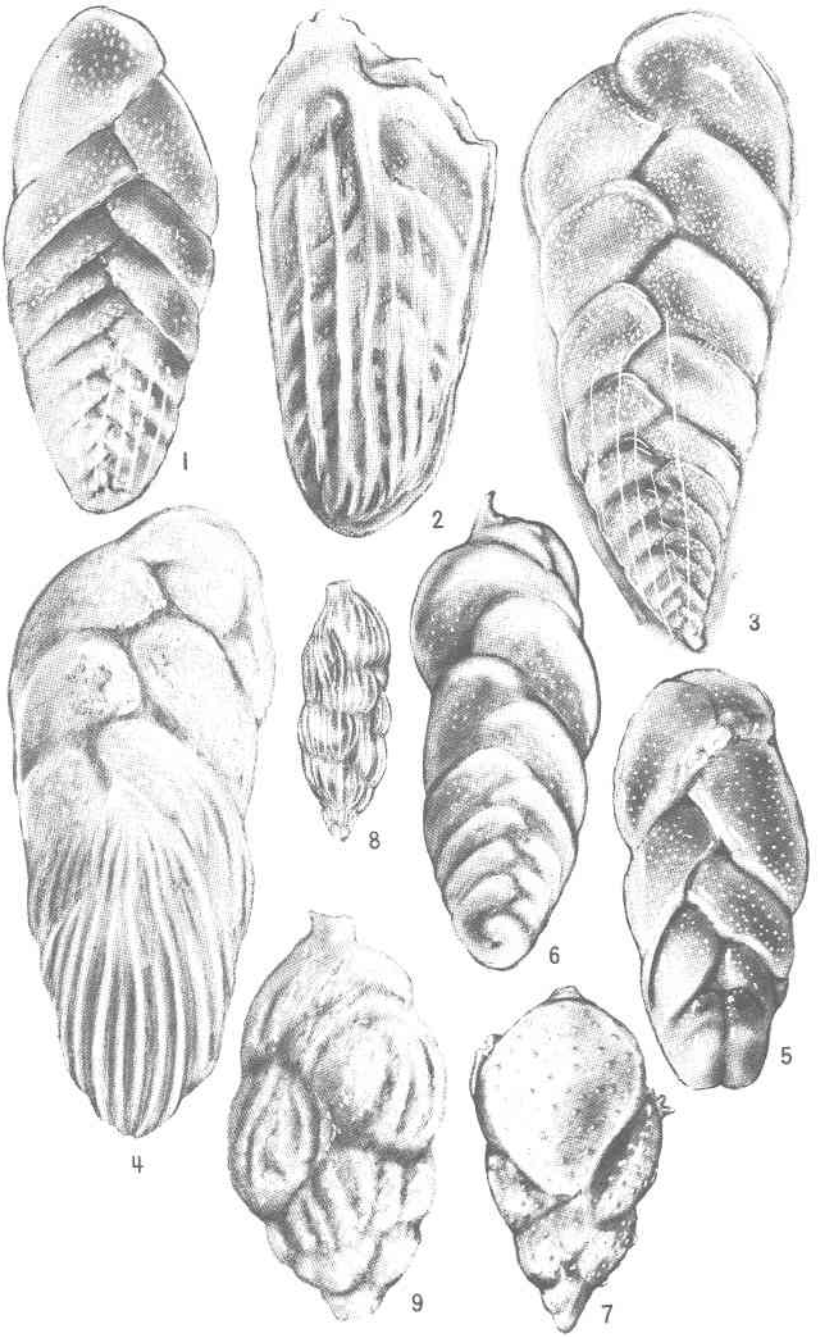
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EXPLANATION OF PLATE 11

Figure

1 *Bolivina striatula* Cushman

Side view, typical form, P.R.I. 27290 (165X).

2, 3 *Bolivina marginata* subsp. *multicostata* Cushman

2—Side view, megalosphaeric form, P.R.I. 27282 (170X).

3—Side view, microsphaeric form, P.R.I. 27280 (166X).

4 *Bolivina* sp. B

Side view, P.R.I. 27228 (164X).

5, 6 *Loxostomum wilsoni* McLean

5—Side view, P.R.I. 27285 (164X).

6—Side view, P.R.I. 27224 (177X).

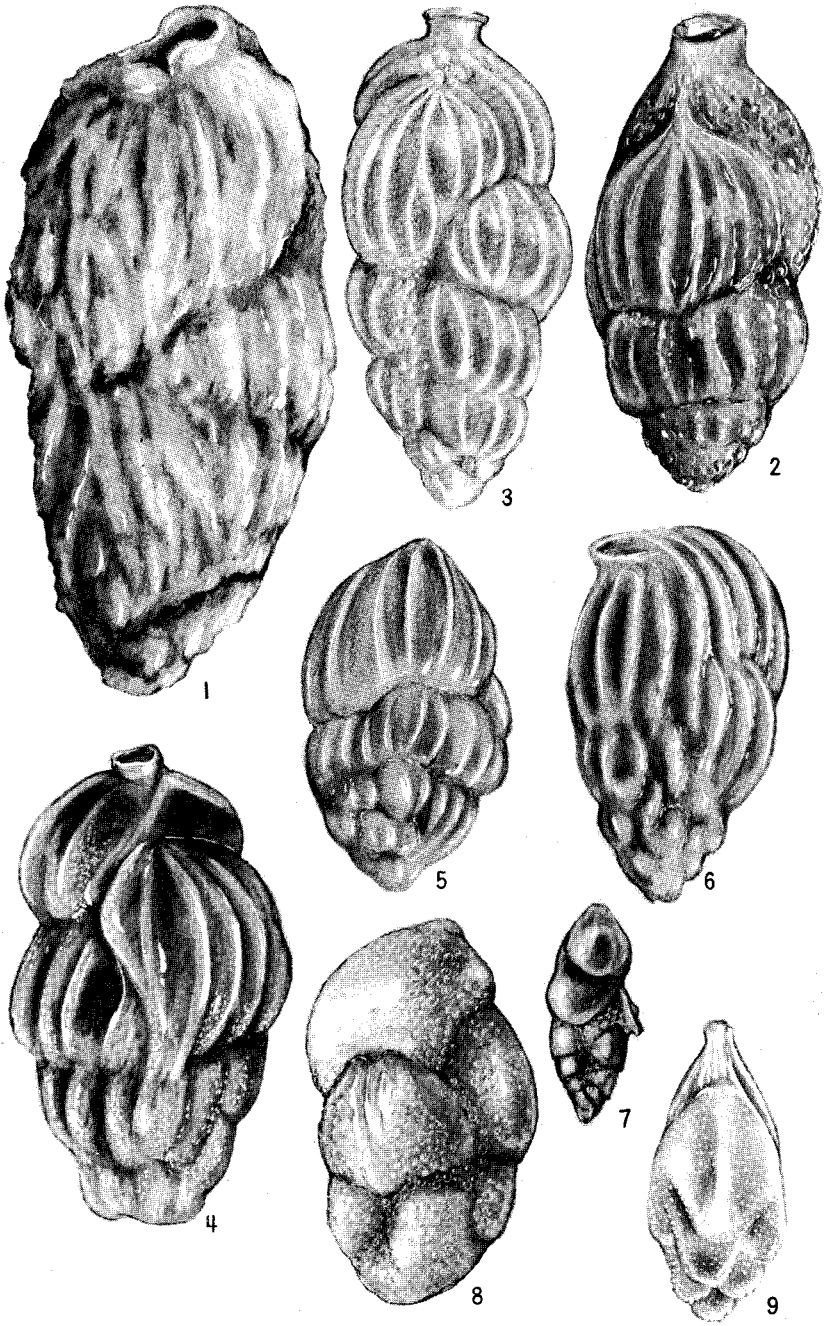
7 *Uvigerina auberiana* d'Orbigny

Side view, P.R.I. 27319 (155X).

8, 9 *Uvigerina calvertensis* Cushman

8—Side view, P.R.I. 27204 (62X).

9—Side view, juvenile form, P.R.I. 27250 (165X).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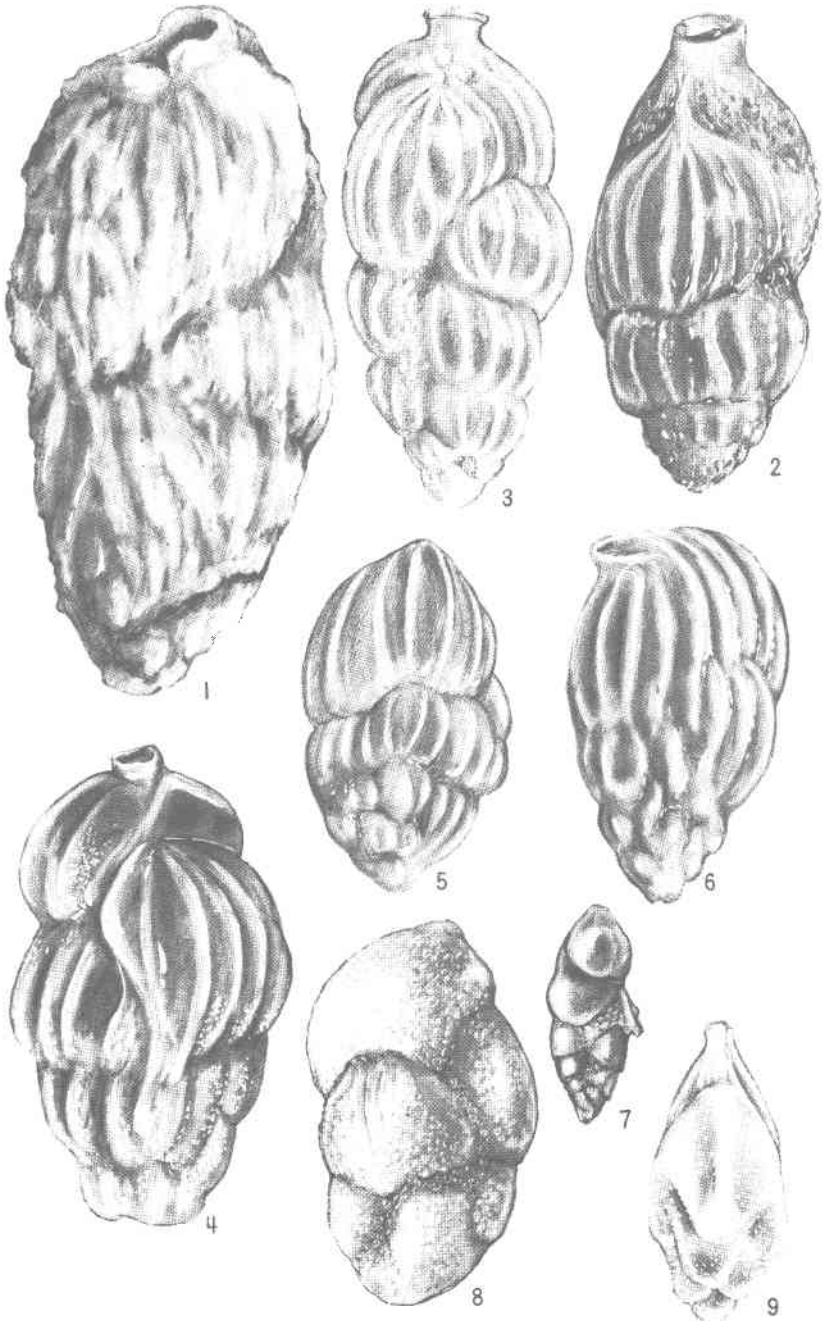
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EXPLANATION OF PLATE 12

Figure

1 *Uvigerina calvertensis* Cushman

Side view, adult form, P.R.I. 27250 (165X).

2 *Uvigerina carmeloensis* Cushman and Kleinpell

Side view, P.R.I. 27291 (168X).

3, 4 *Uvigerina* cf. *tenuistriata* Cushman (not Reuss)

3—Side view, P.R.I. 27235 (163X).

4—Side view, P.R.I. 27261 (163X).

5, 6 *Uvigerina* sp. A

5—Side view, P.R.I. 27239 (132X).

6—Side view, P.R.I. 27221 (169X).

7 *Bulimina inflata* Seguenza

Side view, P.R.I. 27201 (59X).

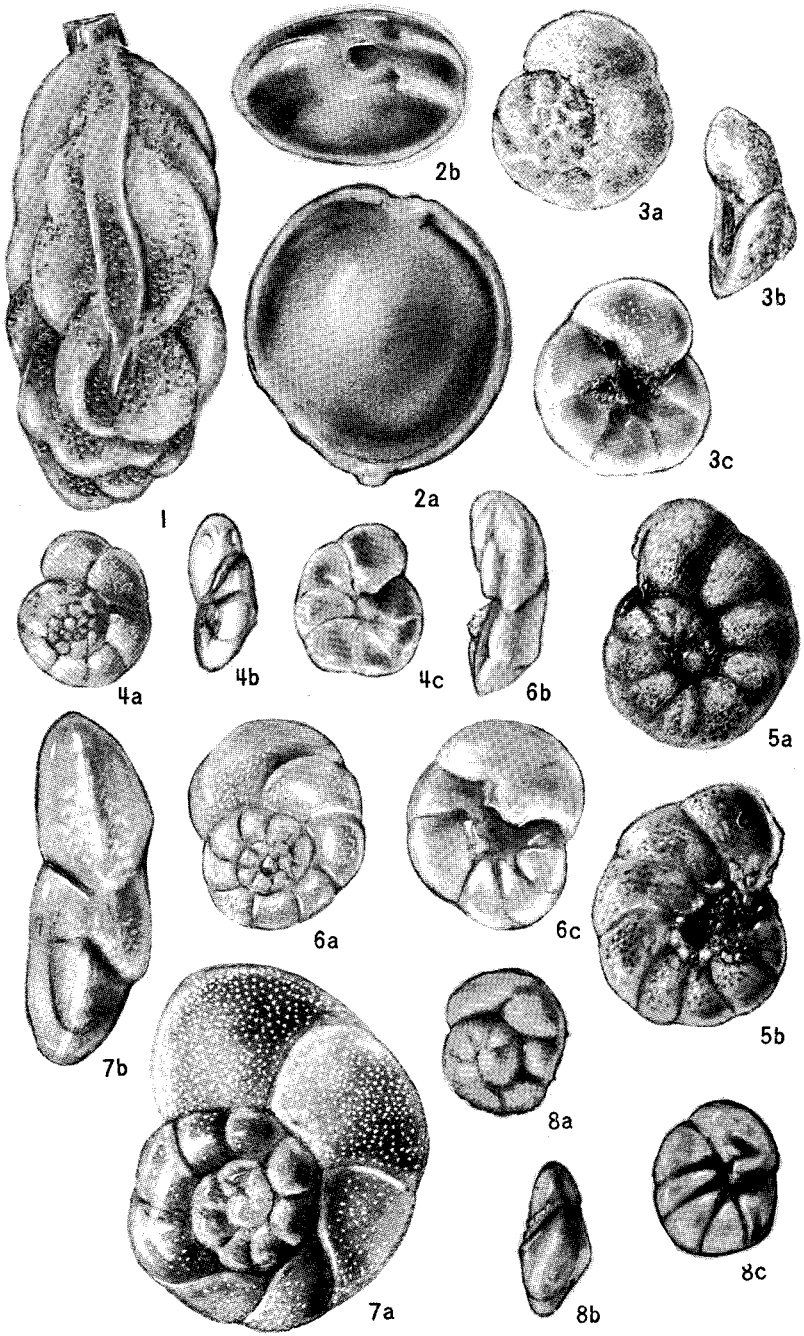
This form is not very well figured due to deterioration.

8 *Bulimina* cf. *preacanthia* McLean

Side view, P.R.I. 27161 (172X).

9 *Angulogerina occidentalis* (Cushman)

Side view, P.R.I. 27283 (163X).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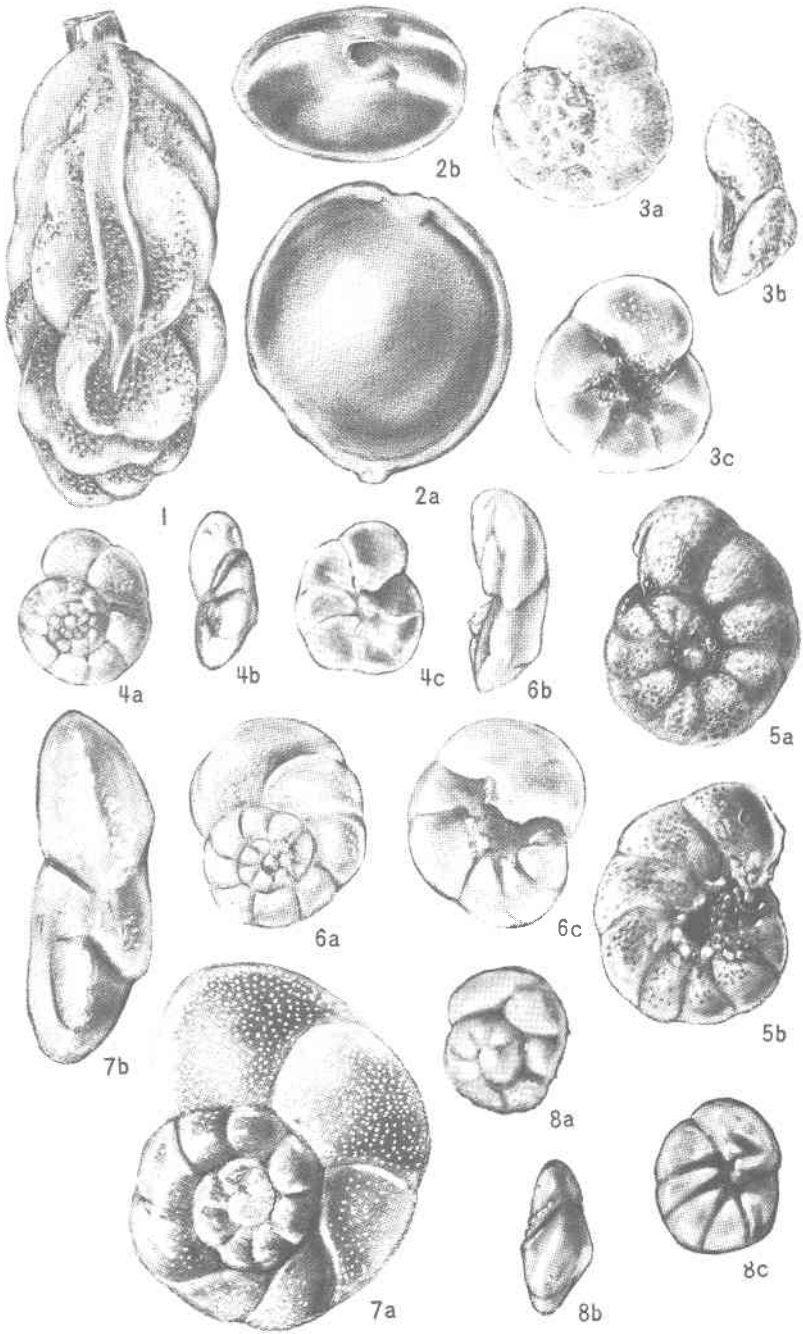
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EXPLANATION OF PLATE 13

Figure

1 *Angulogerina* sp.

Side view, P.R.I. 27157 (163X).

2a, b *Parafissurina marginata* (Walker and Jacob)

2a—Side view; 2b—apertural view, P.R.I. 27293 (161X).

3a-c *Discorbis candeiana* (d'Orbigny)

4a-c 3a—Dorsal view; 3b—apertural view; 3c—ventral view, P.R.I. 27242 (61X).

4a—Dorsal view; 4b—apertural view; 4c—ventral view, P.R.I. 27244 (52X).

5a, b *Discorbis consobrina* (d'Orbigny)

5a—Dorsal view; 5b—ventral view, P.R.I. 27196 (70X).

6a-c *Discorbis floridana* Cushman

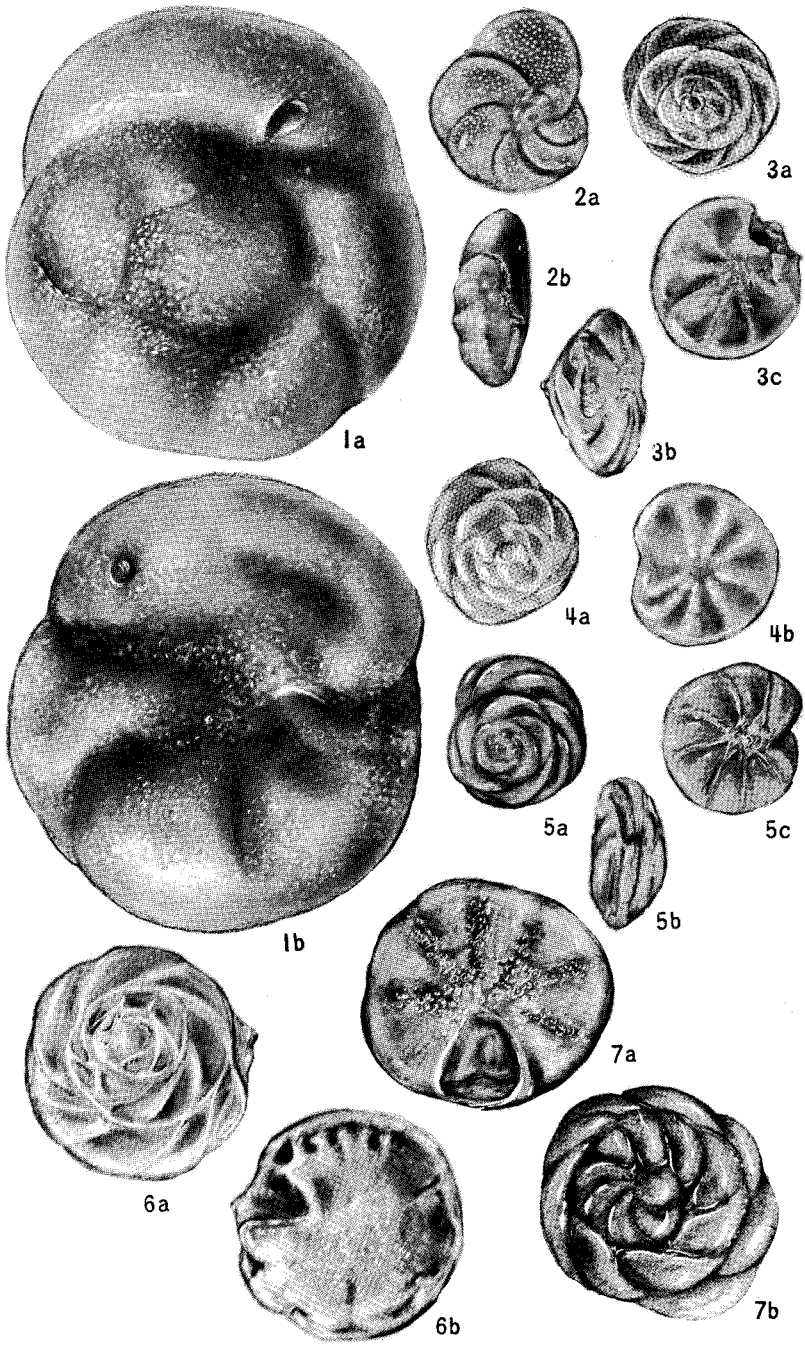
7a, b 6a—Dorsal view; 6b—apertural view; 6c—ventral view, P.R.I. 27254 (63X).

7a—Dorsal view; 7b—apertural view, P.R.I. 27264 (185X).

8a-c *Discorbis* sp.

8a—Dorsal view; 8b—apertural view; 8c—ventral view, P.R.I. 27252 (65X).

This form may be *Discorbis floridana,* but chambers of final whorl differ in shape from typical *D. floridana.*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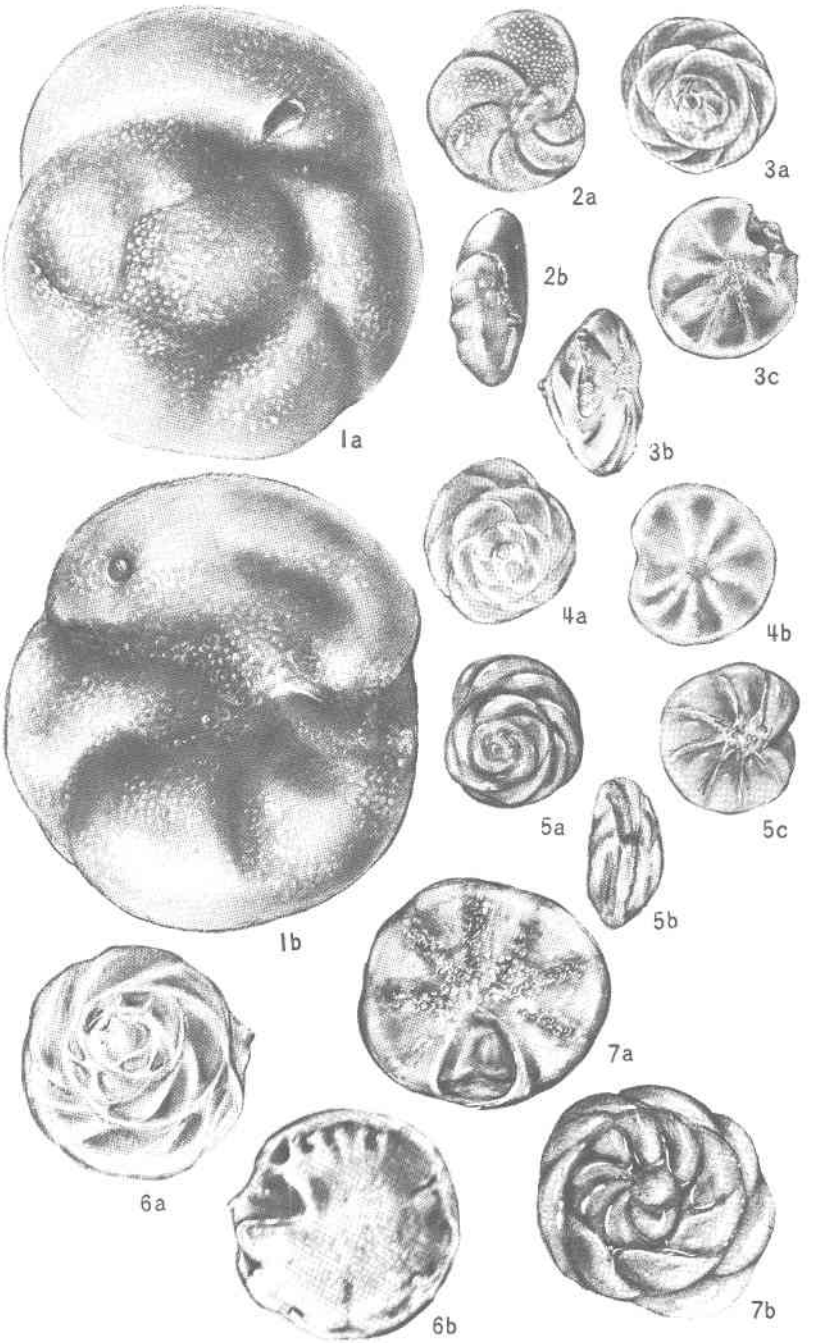
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7b

EXPLANATION OF PLATE 14

Figure

1a, b *Discorbis floridana* Cushman

1a—Dorsal view; 1b—ventral view, P.R.I. 27195 (133X).

2a, b *Valvulineria floridana* Cushman

2a—Ventral view; 2b—apertural view, P.R.I. 27269 (58X).

3a-c *Buccella depressa* Andersen

4a, b

5a-c

3a—Dorsal view; 3b—apertural view; 3c—ventral view, P.R.I. 27171 (64X).

4a—Dorsal view; 4b—ventral view, P.R.I. 27263 (71X).

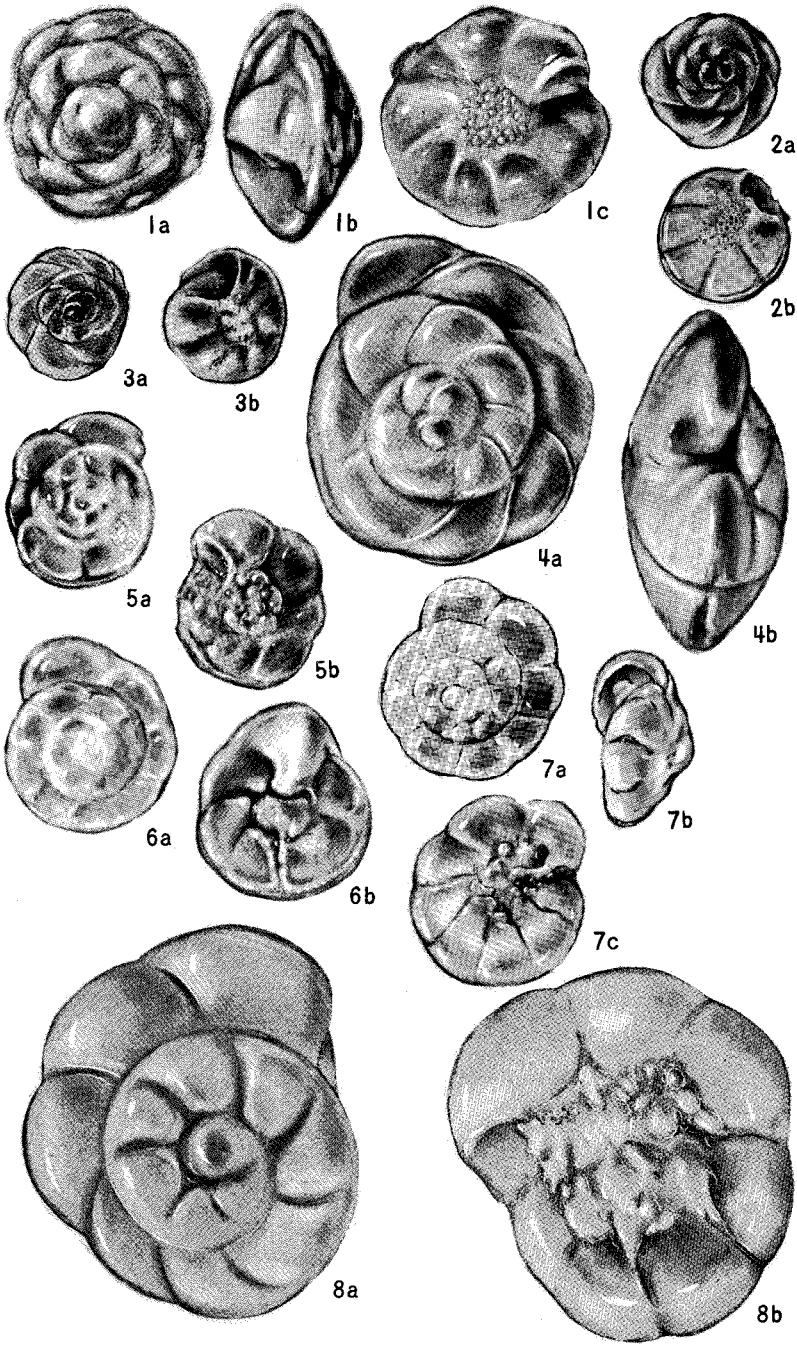
5a—Dorsal view; 5b—apertural view; 5c—ventral view, P.R.I. 27230 (59X).

6a, b *Buccella mansfieldi* (Cushman)

7a, b

6a—Dorsal view; 6b—ventral view, P.R.I. 27306 (74X).

7a—Ventral view; 7b—dorsal view, P.R.I. 27323 (60X).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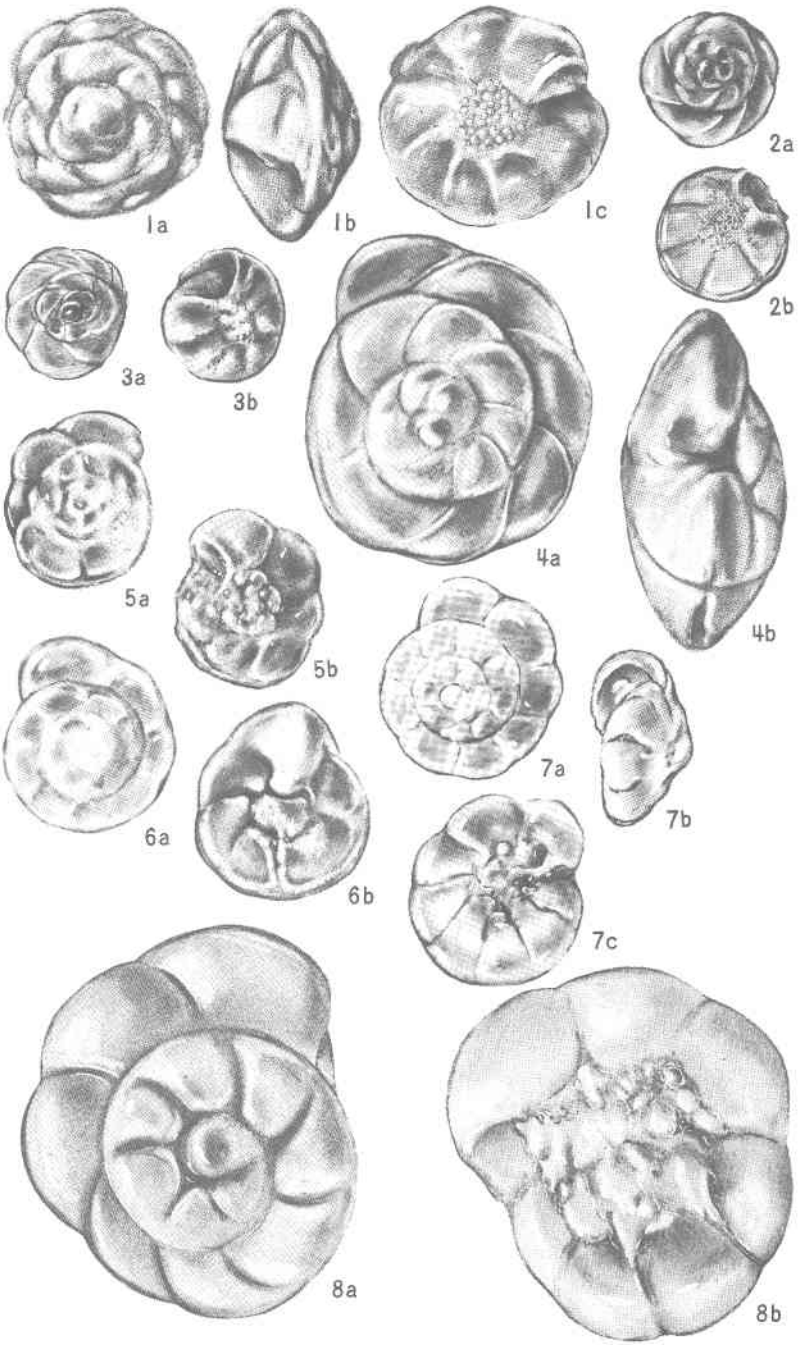
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7c
8a
8b

EXPLANATION OF PLATE 15

Figure

1a-c *Buccella mansfieldi* (Cushman)

1a—Dorsal view; 1b—apertural view; 1c—ventral view, P.R.I. 27183 (63X).

2a, b *Buccella parkerae* Andersen

3a, b 2a—Dorsal view; 2b—ventral view, P.R.I. 27206 (55X).

4a, b 3a—Dorsal view; 3b—ventral view, P.R.I. 27206 (55X).

4a—Dorsal view; 4b—apertural view, P.R.I. 27270 (176X).

5a, b *Rotalia bassleri* Cushman and Cahill

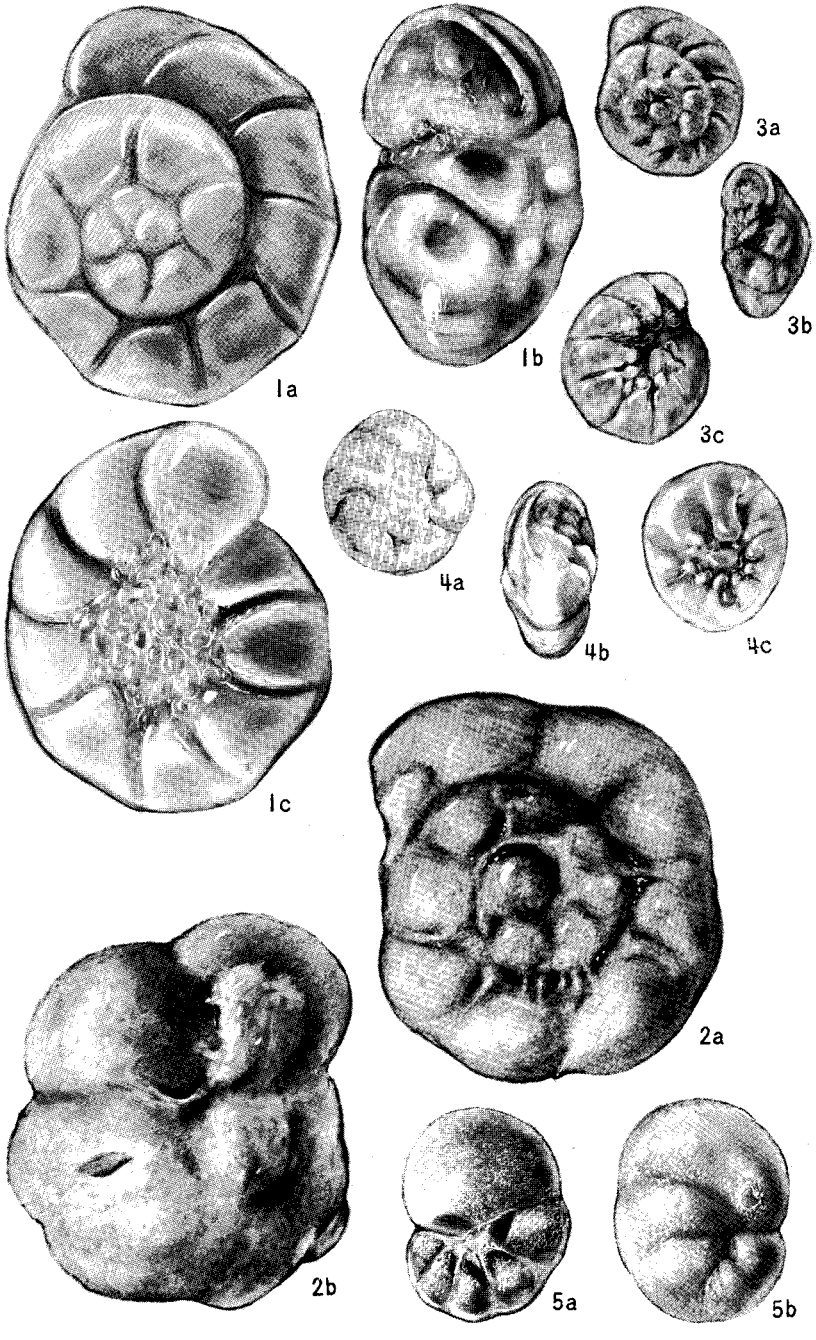
6a, b 5a—Dorsal view; 5b—ventral view, P.R.I. 27313 (57X).

6a—Dorsal view; 6b—ventral view, P.R.I. 27310 (26X).

7a-c *Rotalia beccarii* subsp. *tepida* Cushman

8a, b 7a—Dorsal view; 7b—apertural view; 7c—ventral view, P.R.I. 27259 (68X).

8a—Dorsal view; 8b—ventral view, P.R.I. 27229 (189X).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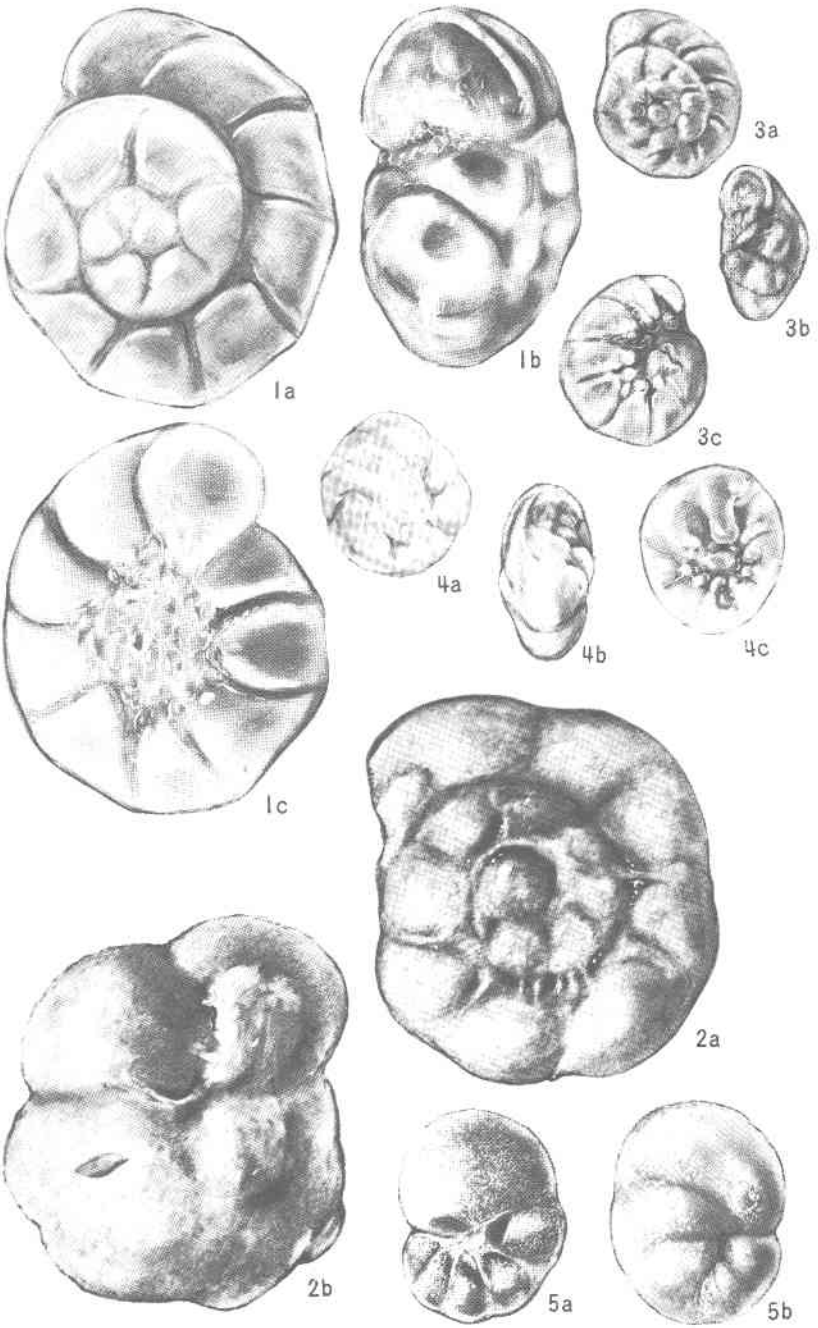
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EXPLANATION OF PLATE 16

Figure

1a-c *Rotalia beccarii* subsp. *tepida* Cushman

3a-c 1a—Dorsal view; 1b—apertural view; 1c—ventral view, P.R.I. 27225 (195X).

3a—Dorsal view; 3b—apertural view; 3c—ventral view, P.R.I. 27197 (63X).

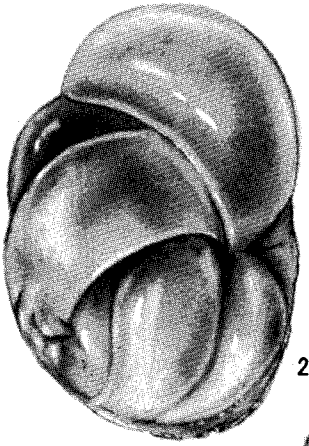
2a, b *Rotalia beccarii* ? (Linnaeus)

4a-c 2a—Dorsal view; 2b—ventral view, P.R.I. 27305 (177X).

4a—Dorsal view; 4b—apertural view; 4c—ventral view, badly eroded, P.R.I. 27245 (66X).

5a, b *Cancris sagra* (d'Orbigny)

5a—Ventral view; 5b—dorsal view, P.R.I. 27199 (63X).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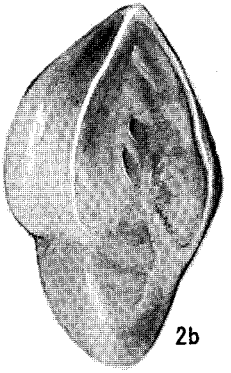
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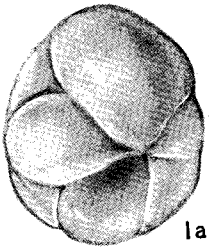
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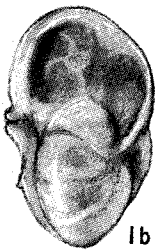
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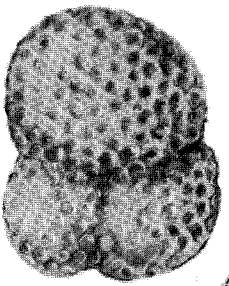
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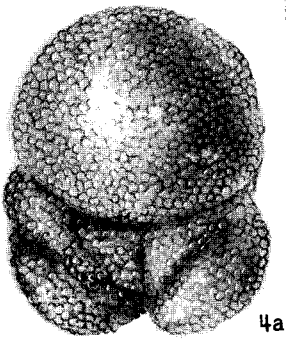
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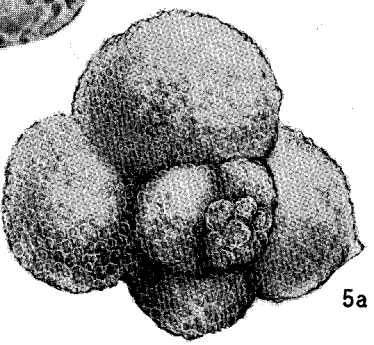
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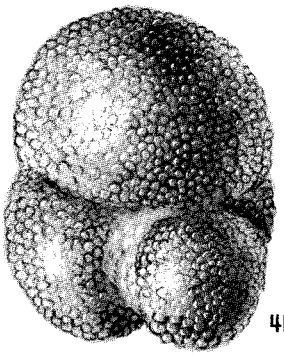
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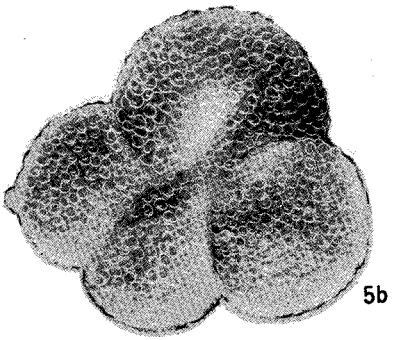
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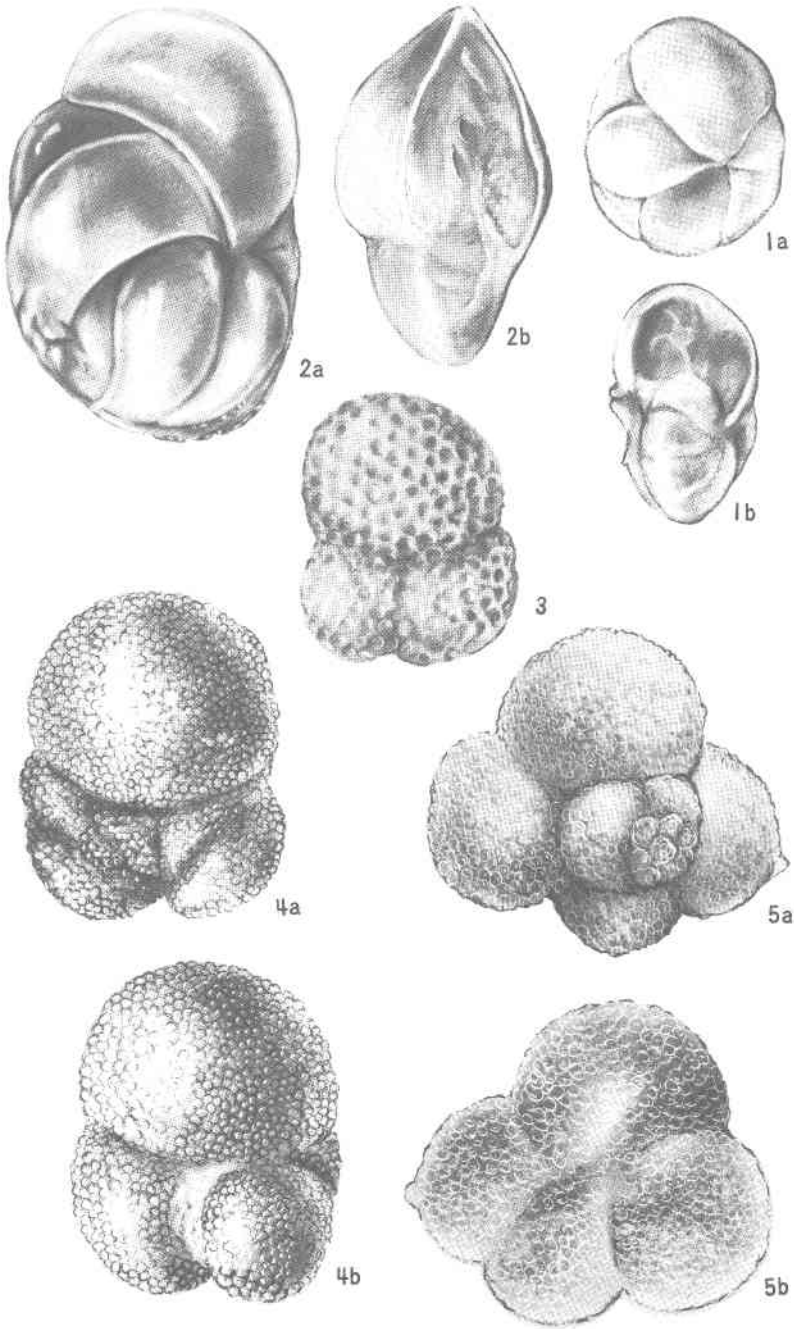
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EXPLANATION OF PLATE 17

Figure

1a, b *Cassidulina crassa* d'Orbigny

1a—Side view; 1b—apertural view, P.R.I. 27265 (155X).

2a, b *Cassidulina laevigata* subsp. *carinata* Cushman

2a—Side view; 2b—apertural view, P.R.I. 27268 (187X).

3 *Globigerina* sp. form A McLean

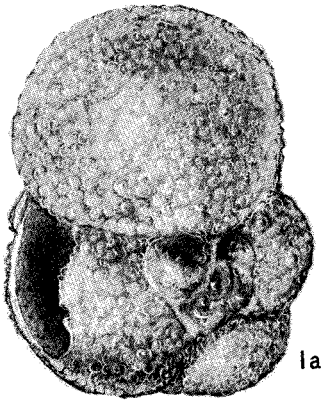
Side view, P.R.I. 27266 (180X).

4a, b *Globigerina* sp.

Opposite views, P.R.I. 27151 (165X).

5a, b *Globigerina* sp. form E McLean

Opposite views, P.R.I. 27248 (153X).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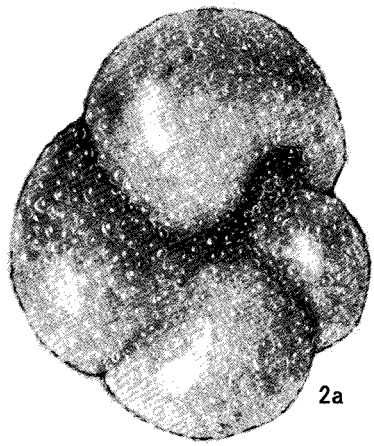
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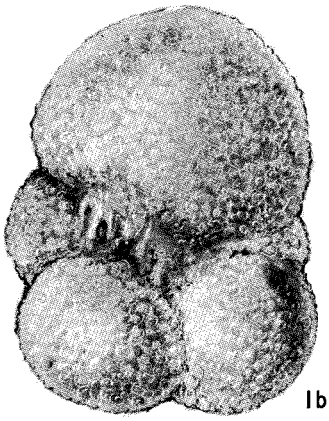
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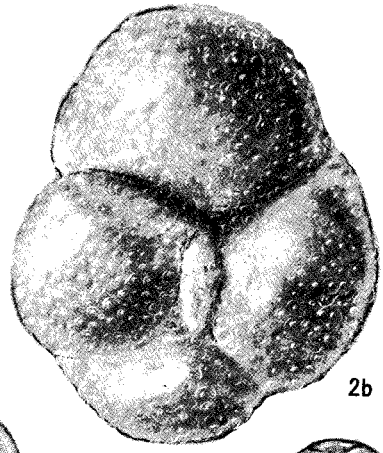
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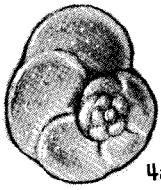
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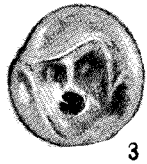
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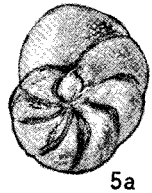
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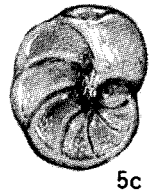
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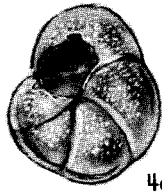
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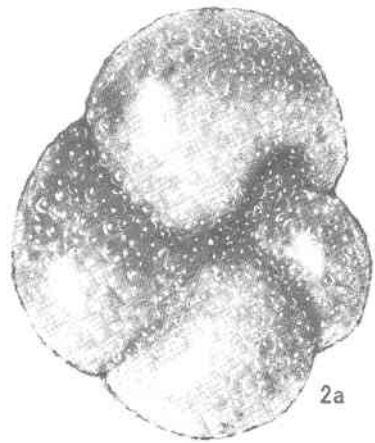
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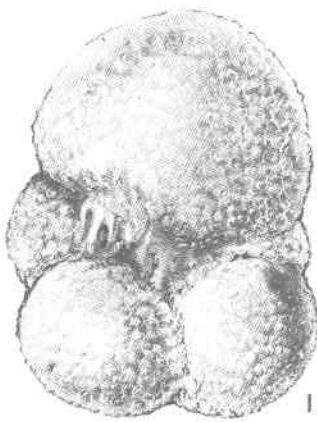
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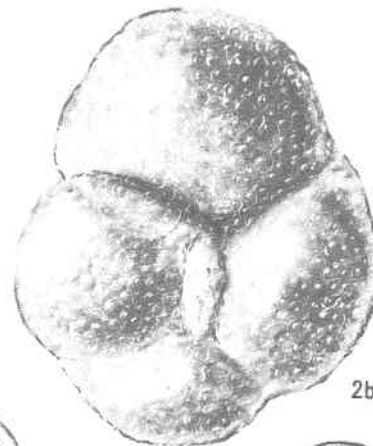
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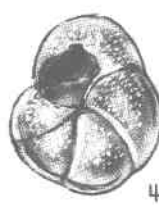
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5b

EXPLANATION OF PLATE 18

Figure

1a, b *Globigerina* sp. form E McLean

Opposite views, P.R.I. 27211 (166X).

2a, b *Globigerina* sp.

Opposite views, P.R.I. 27300 (170X).

3 *Orbulina universa* d'Orbigny

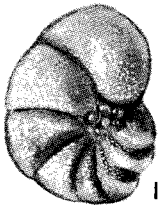
View of P.R.I. 27284 (150X).

4a-c *Globorotalia menardii* (d'Orbigny)

4a—Dorsal view; 4b—apertural view; 4c—ventral view, P.R.I. 27257 (58X).

5a-c *Cibicides americanus* (Cushman)

5a—Dorsal view; 5b—apertural view; 5c—ventral view, P.R.I. 27258 (69X).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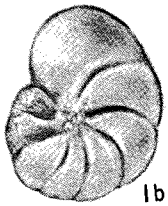
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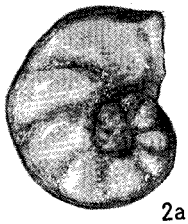
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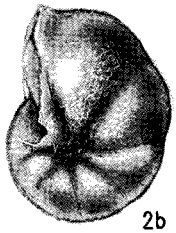
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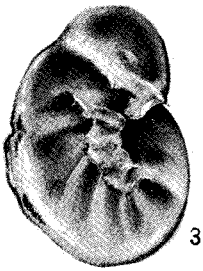
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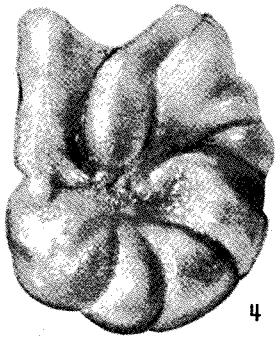
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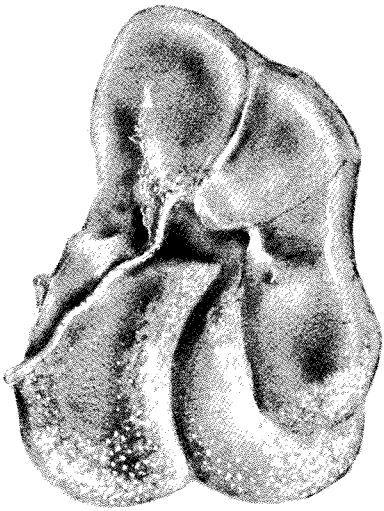
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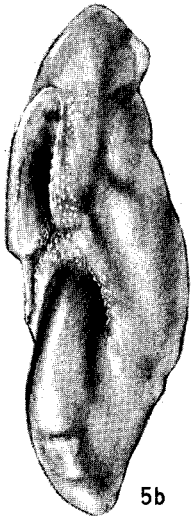
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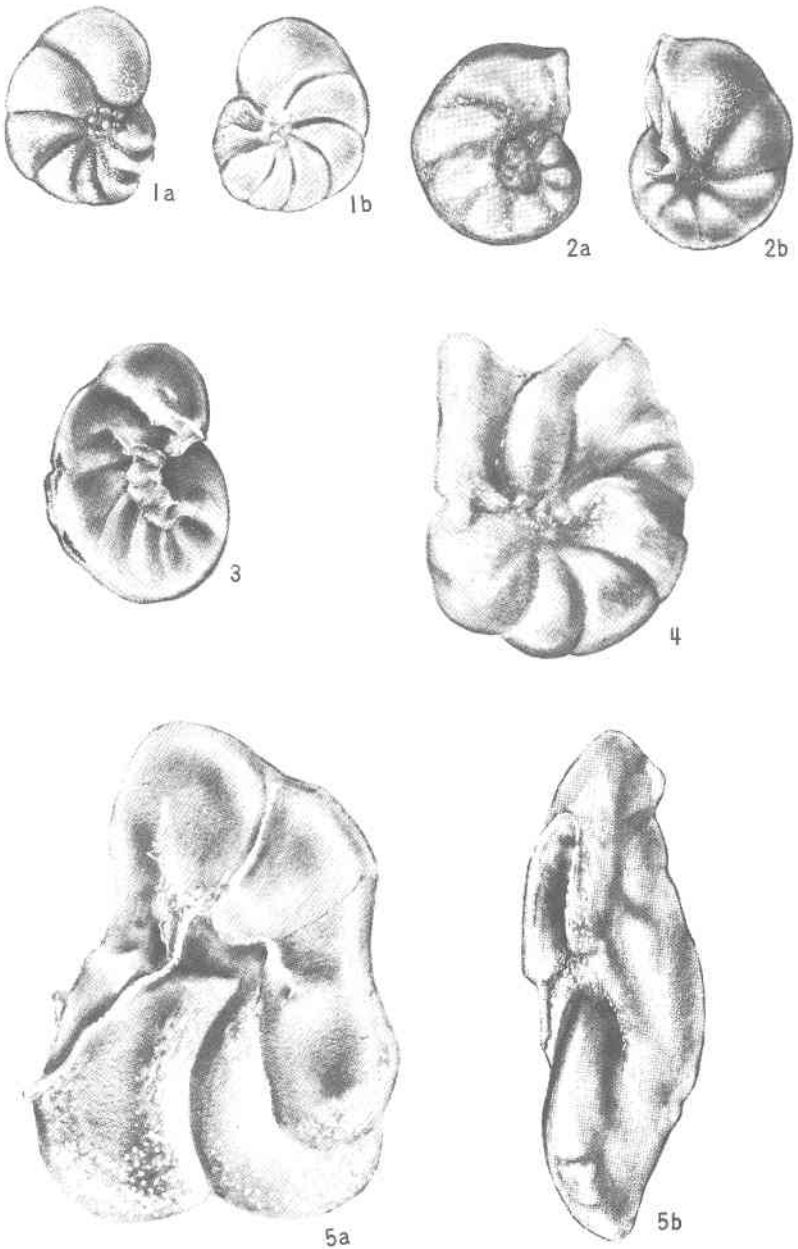
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5a
5b

EXPLANATION OF PLATE 19

Figure

1a, b *Cibicides americanus* (Cushman)

1a—Ventral view; 1b—dorsal view, P.R.I. 27301 (61X).

2a, b *Cibicides* sp.

2a—Ventral view; 2b—dorsal view, P.R.I. 27198 (56X).

3 *Hanzawaia concentrica* (Cushman)

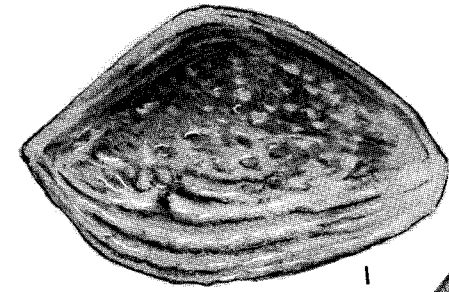
Ventral view, P.R.I. 27153 (61X).

4 *Dyocibicides perforatus* Cushman and Valentine

Dorsal view, P.R.I. 27302 (61X).

5a, b *Cibicidella variabilis* (d'Orbigny)

5a—Dorsal view; 5b—apertural view, P.R.I. 27272 (165X).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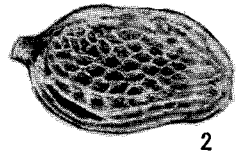
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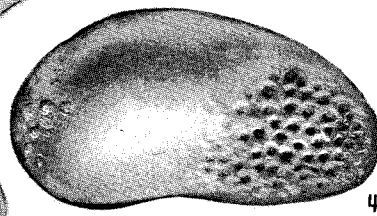
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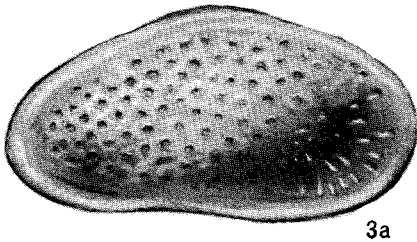
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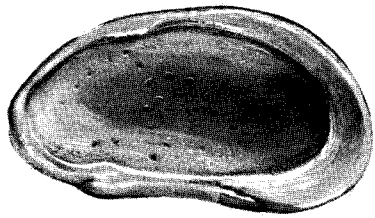
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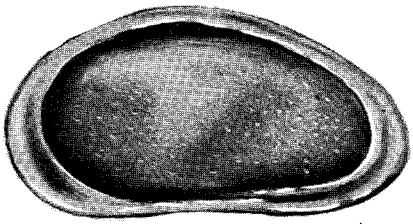
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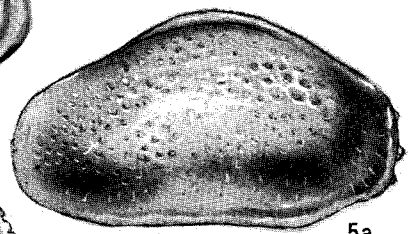
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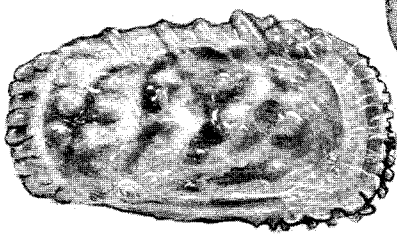
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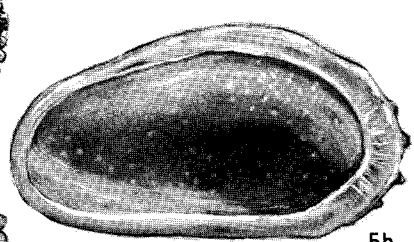
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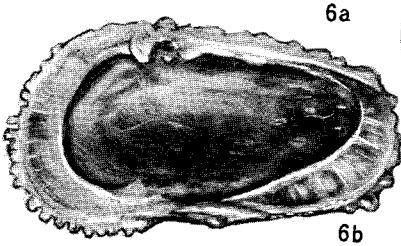
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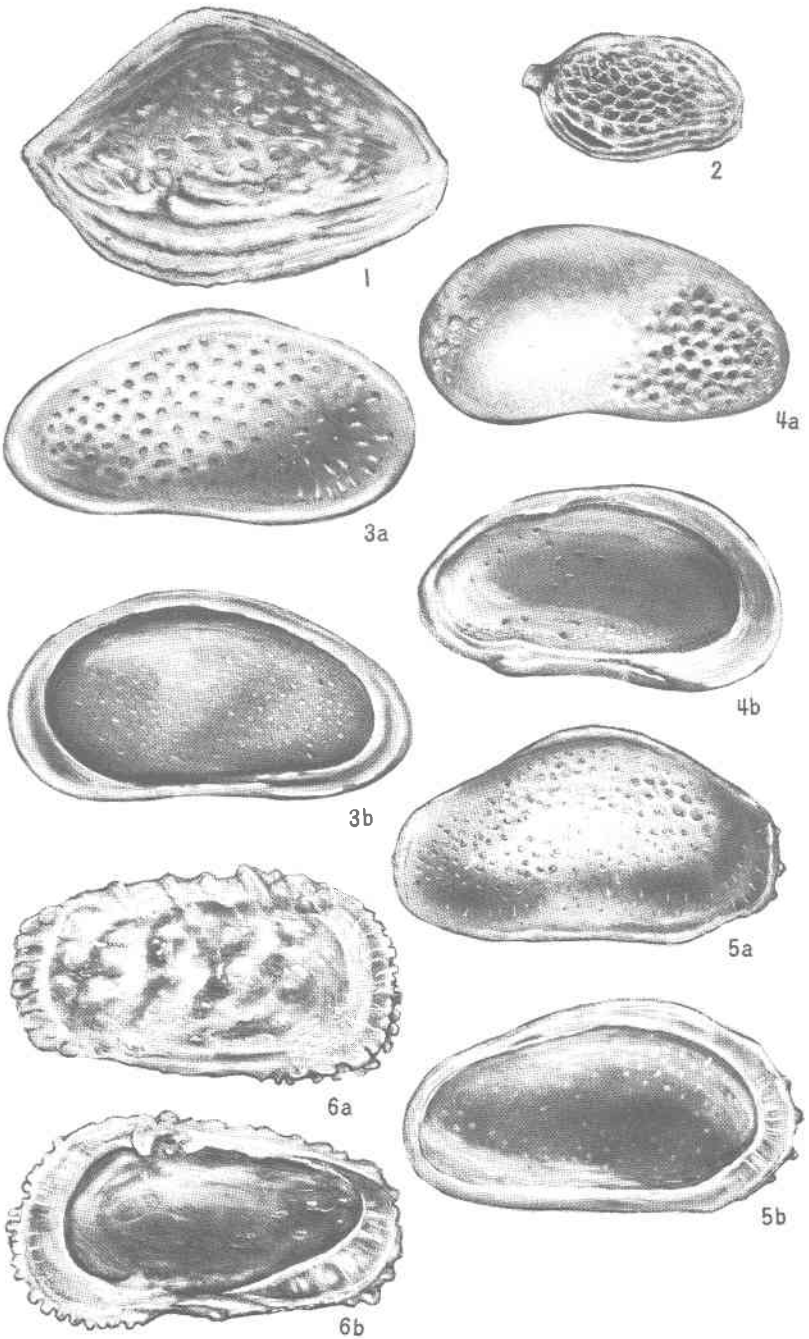
1
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6a
5b
6b

EXPLANATION OF PLATE 20

Figure

1 *Cytherura bajacala* Benson

View of P.R.I. 27220 (141X).

2 *Cytherura reticulata* Edwards

View of P.R.I. 27202 (52X).

3a, b *Clithrocytheridea diagonalis* Malkin

4a, b 3a—Exterior view; 3b—interior view of right valve, P.R.I. 27176 (60X).

5a, b

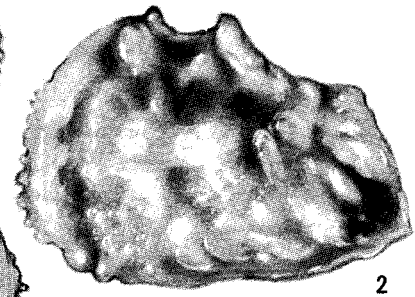
4a—Exterior view; 4b—interior view of left valve, P.R.I. 27179 (55X).

5a—Exterior view; 5b—interior view of left valve, P.R.I. 27164 (63X).

6a, b *Actinocythereis exanthemata* subsp. *gomillionensis* (Howe and Ellis)

6a—Exterior view; 6b—interior view of right valve, P.R.I. 27186 (58X).

1a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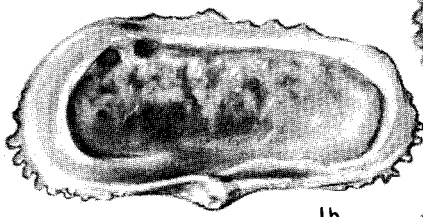
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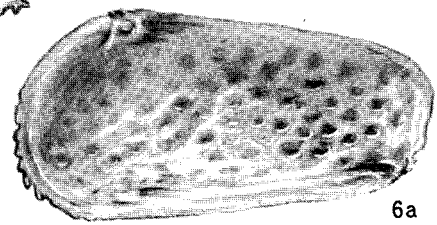
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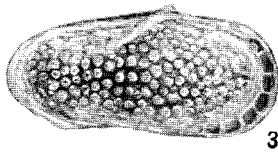
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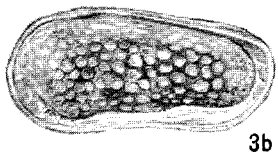
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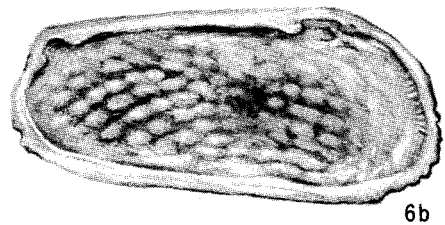
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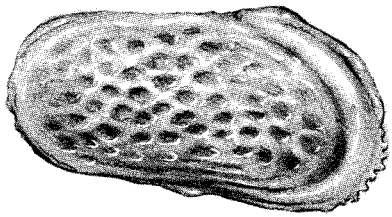
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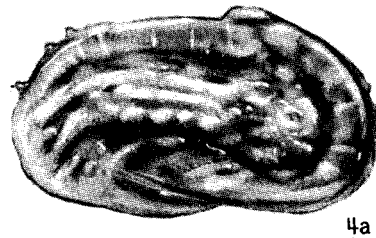
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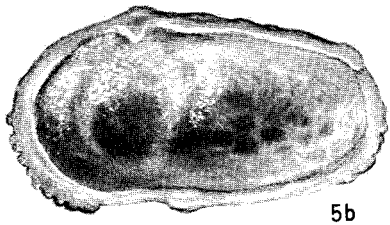
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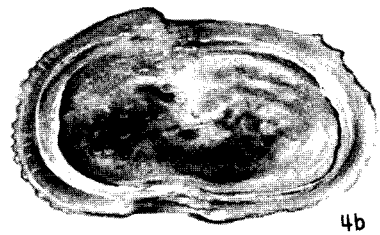
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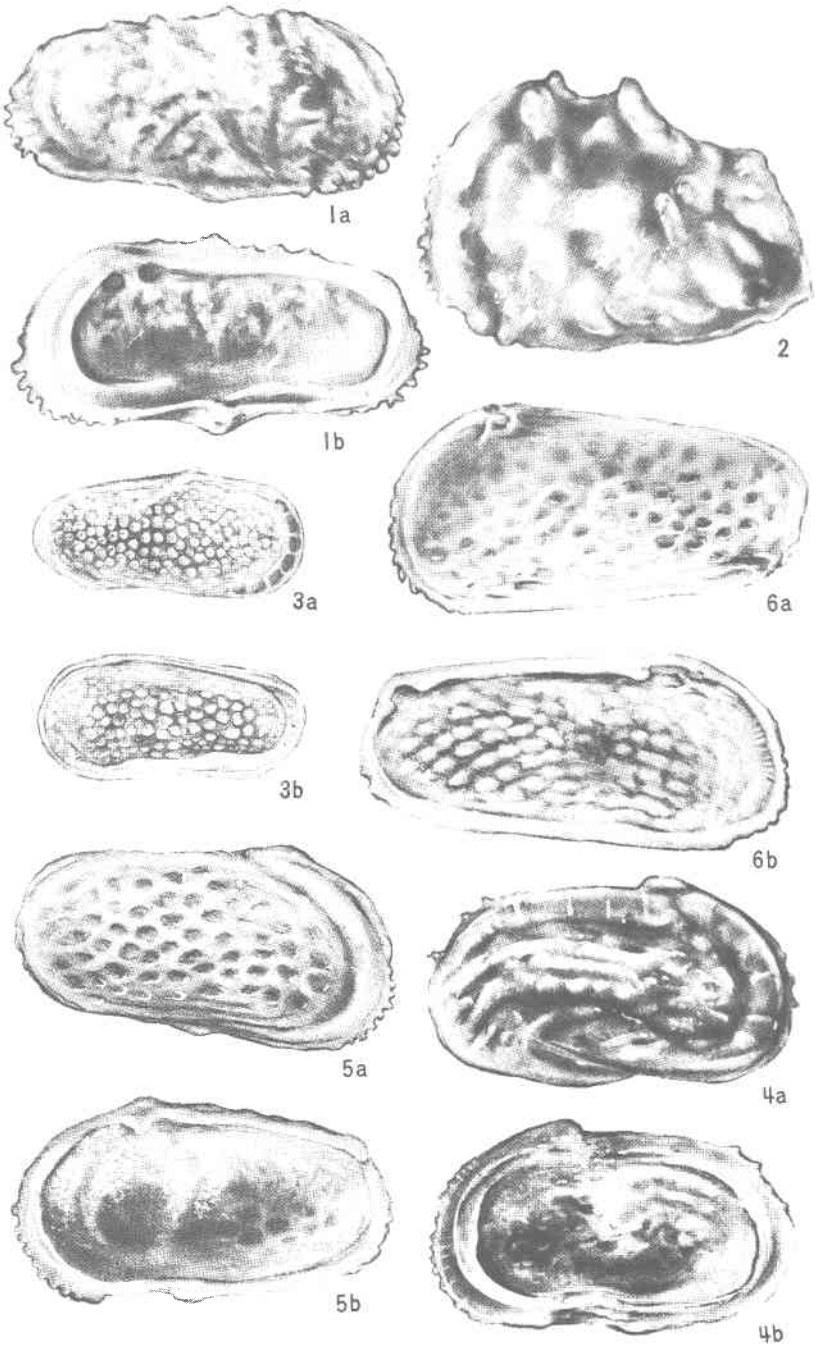
1a
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4a
5b
4b

EXPLANATION OF PLATE 21

Figure

1a, b *Actinocythereis exanthemata* subsp. *gomillionensis* (Howe and Ellis)

1a—Exterior view; 1b—interior view of right valve, P.R.I. 27308 (58X).

2 *Actinocythereis exanthemata* subsp. *marylandica* (Howe and Hough)

Exterior view of fragment, P.R.I. 27299 (59X).

3a, b *Murrayina barclayi* McLean

3a—Exterior view; 3b—interior view of right valve; juvenile form. P.R.I. 27200 (63X).

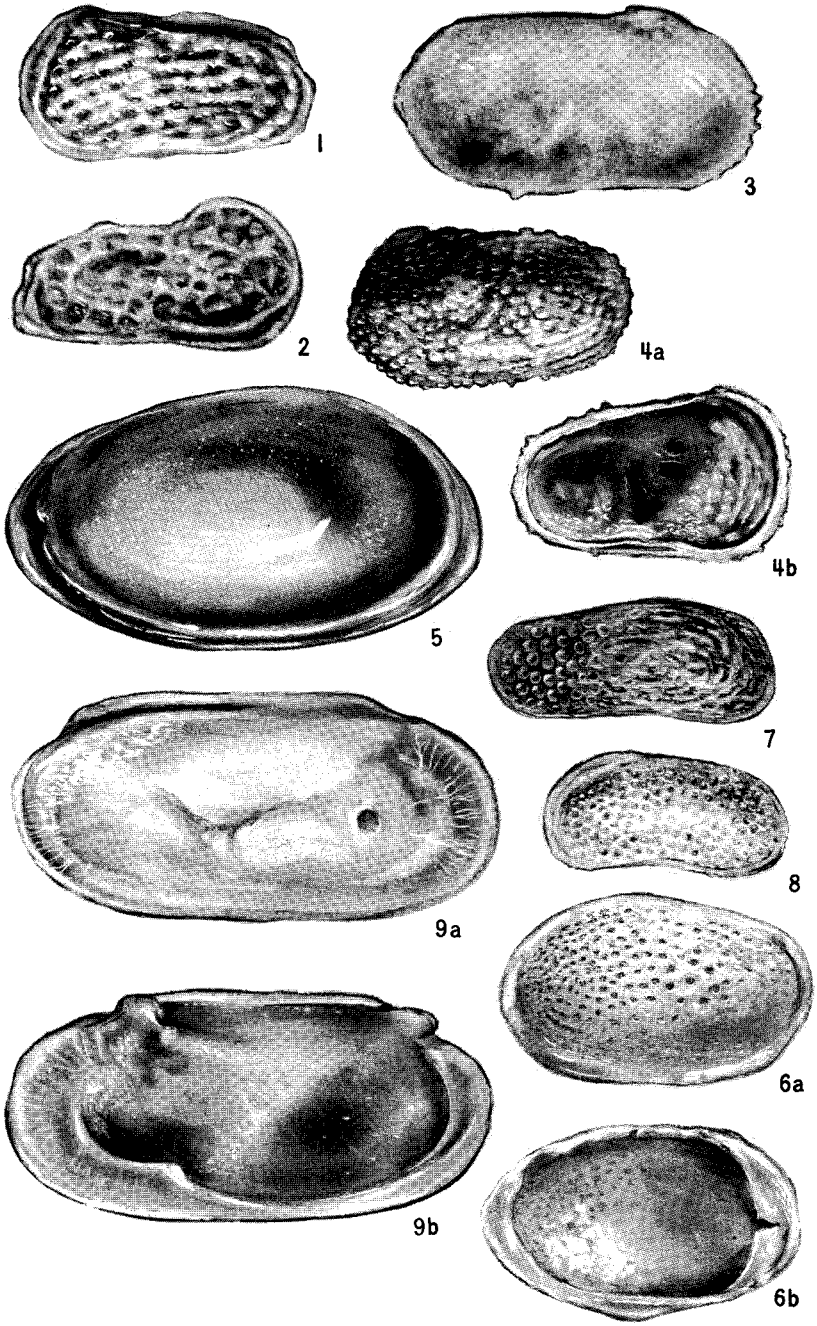
4a, b *Murrayina gunteri* (Howe and Chambers)

4a—Exterior view; 4b—interior view of right valve, P.R.I. 27309 (48X).

5a, b *Murrayina howei* Puri

6a, b 5a—Exterior view; 5b—interior view of right valve, P.R.I. 27184 (53X).

6a—Exterior view; 6b—interior view of left valve, P.R.I. 27177 (60X).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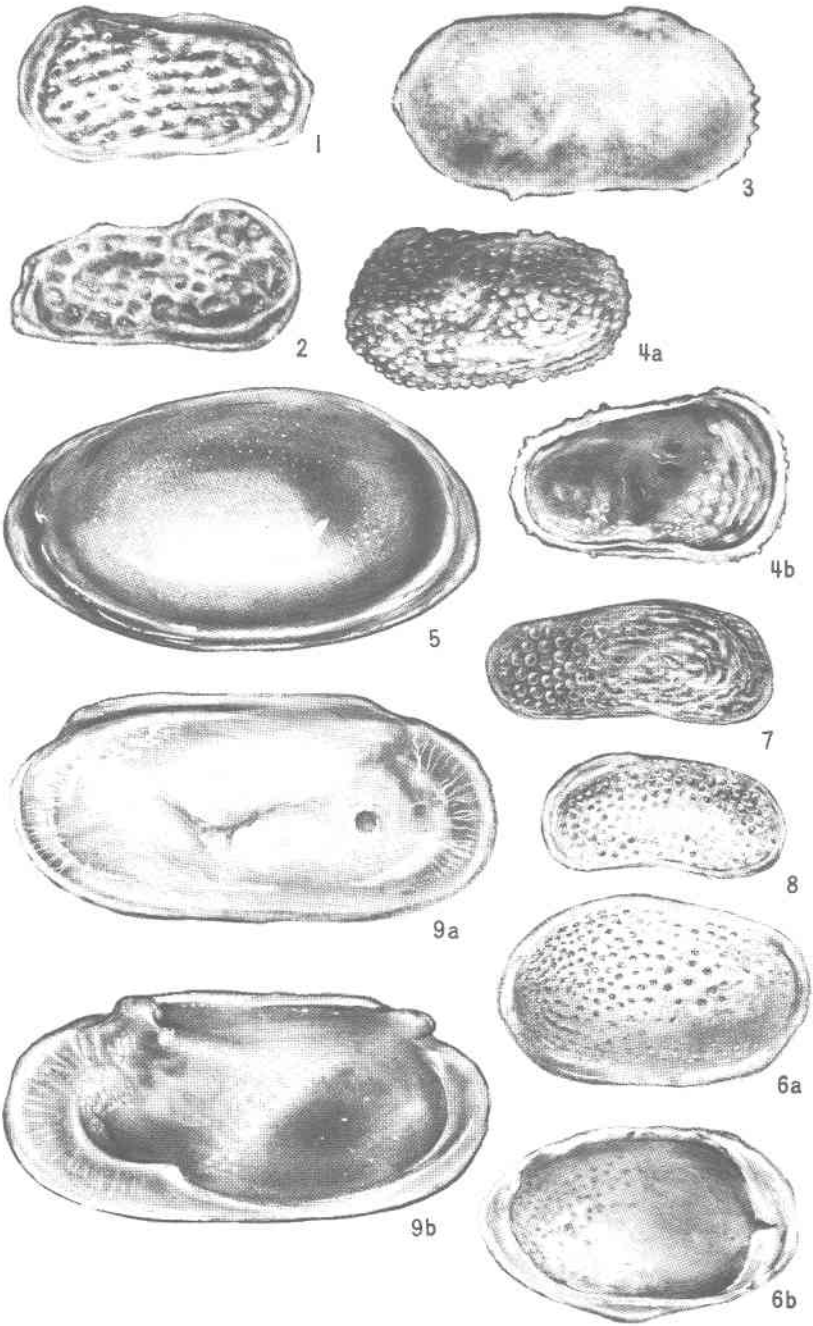
9b
6b


1
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4b
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9a
8
6a
9b
6b

EXPLANATION OF PLATE 22

Figure

1 *Murrayina howei* Puri

Exterior view of left valve, P.R.I. 27193 (57X).

2 *Murrayina martini* (Ulrich and Bassler)

Exterior view of left valve, P.R.I. 27318 (58X).

3 *Echinocythereis clarkana* (Ulrich and Bassler)

4a, b 3—Exterior view of badly eroded left valve, P.R.I. 27314 (60X).

4a—Exterior view; 4b—interior view of left valve, juvenile, P.R.I. 27173 (67X).

5 *Loxoconcha purisubrhomboidea* Edwards

6a, b 5—Exterior view of right valve, P.R.I. 27218 (182X).

6a—Exterior view; 6b—interior view of left valve, P.R.I. 27180 (60X).

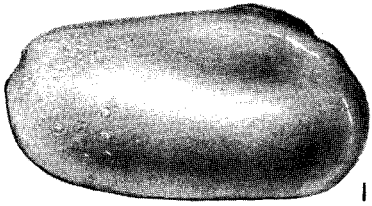
7, 8 *Cytheromorpha* cf. *warneri* Howe and Spurgeon

7—Exterior view of left valve, P.R.I. 27262 (60X).

8—Exterior view of right valve, P.R.I. 27231 (72X).

9a, b *Cytheretta ulrichi* Puri

9a—Exterior view; 9b—interior view of right valve, P.R.I. 27185 (53X).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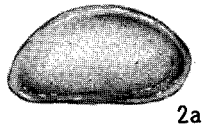
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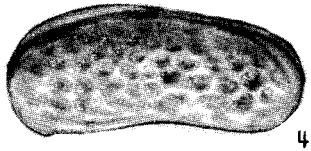
2b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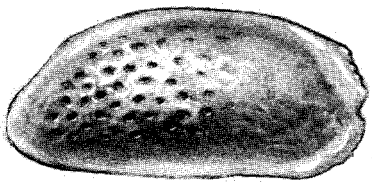
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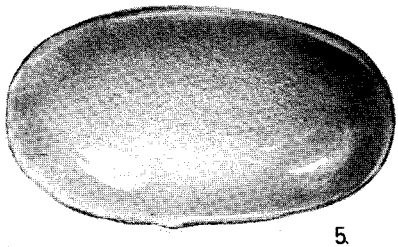
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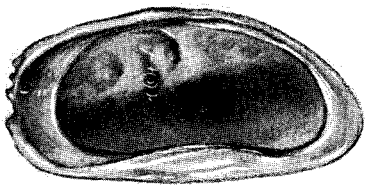
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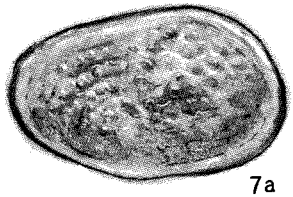
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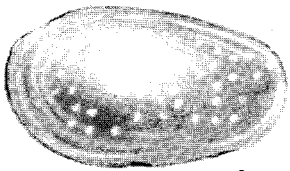
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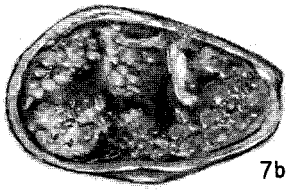
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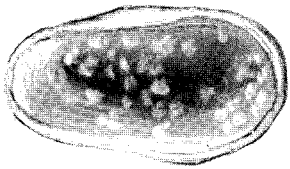
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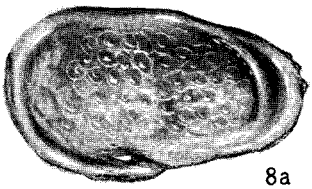
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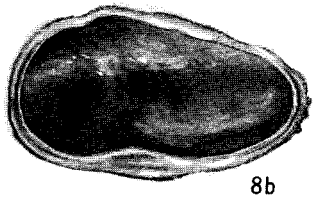
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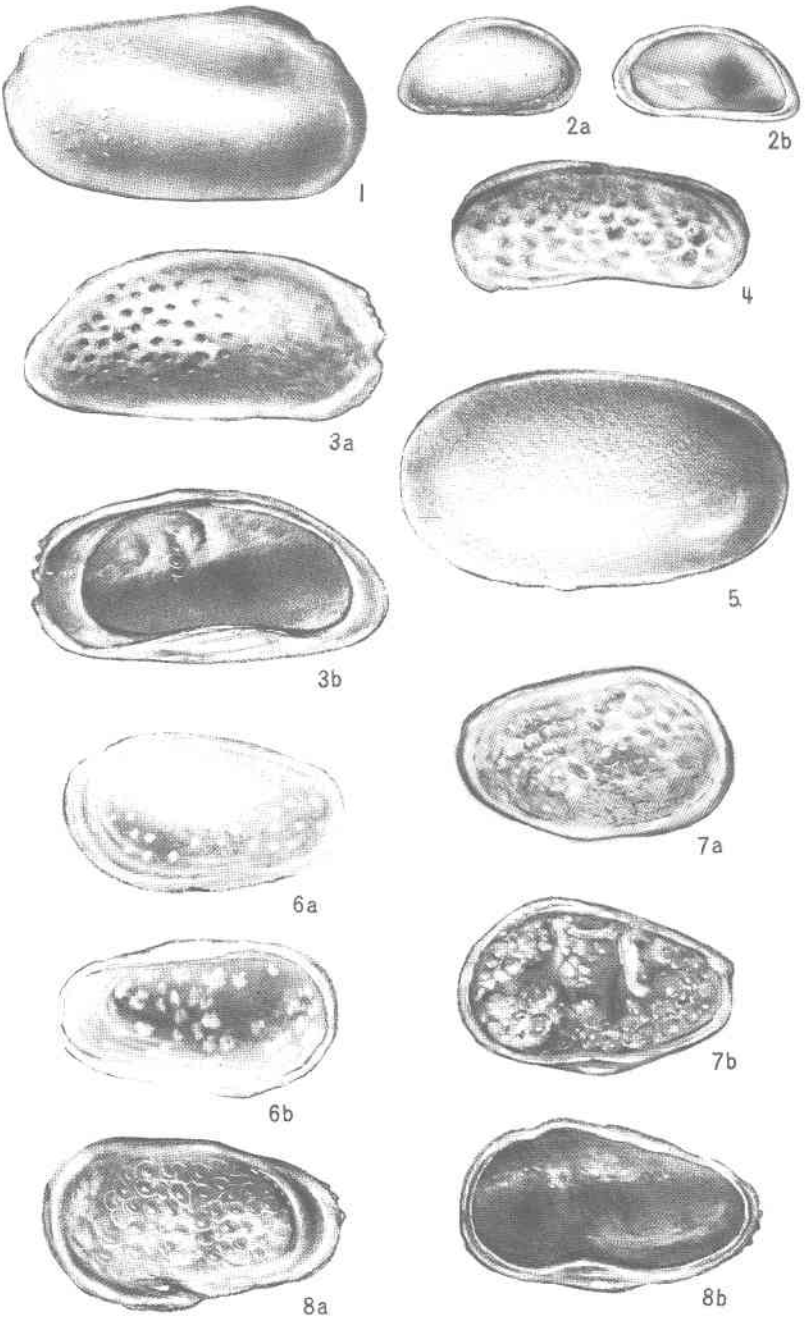
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3a
5
3b
7a
6a
7b
6b
8a
8b

EXPLANATION OF PLATE 23

Figure

1 *Cytheretta ulrichi* Puri

Exterior view of right valve, P.R.I. 27175 (57X).

2a, b *Clithrocytheridea virginiensis* Malkin

2a—Exterior view; 2b—interior view of right valve; juvenile form. P.R.I. 27226 (69X).

3a, b *Hulingsina ulrichi* (Howe and Johnson)

3a—Exterior view; 3b—interior view of right valve, P.R.I. 27188 (57X).

4 *Hulingsina ashermani* (Ulrich and Bassler)

Exterior view of left valve, P.R.I. 27311 (59X).

5 *Cytherella chipolensis* Puri

Exterior view of left valve, P.R.I. 27312 (63X).

6a, b Ostracoda *incertae sedis*

7a, b 6a—Exterior view; 6b—interior view, P.R.I. 27165 (61X).

8a, b

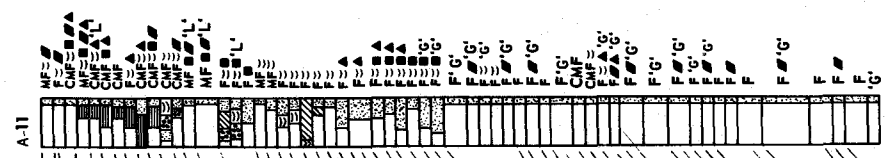
7a—Exterior view; 7b—interior view, P.R.I. 27174 (63X).

8a—Exterior view; 8b—interior view, P.R.I. 27187 (58X).

EXPLANATION

GRAVEL		PLANT DEBRIS	
SAND		E	ECHINOID SPINES
SILT		L	LIMONITE
CLAY		G	GYPSUM
PLANT DEBRIS		≈	SHELLS, SHELL FRAGMENTS
SHELL BEDS		F	FINE SAND
SANDSTONE		M	MEDIUM SAND
MICA		C	COARSE SAND
GLAUCONITE			

NOTE: SAND SIZES ARE ACCORDING TO THE WENTWORTH SCALE. THE RELATIVE PERCENTAGES OF MAJOR SEDIMENT ELEMENTS ARE INDICATED BY SYMBOLS IN THE COLUMN FOR EACH BORING.



WELL A-11 NEWPORT NEWS, VA.

	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	45	50	52	58	65	70	75	80	85	90	95	100	105	110	120	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	245	250	255	260	265	270	275	280	285	290	295	310	315	320	325	330	345	350	375	380	385
ELPHIDIUM FLORENTINAE	.	.	X	.	.	.	.	.	X	.	X	.	X	.	.	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
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ROBULUS AMERICANUS VAR. SPINOSUS	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.
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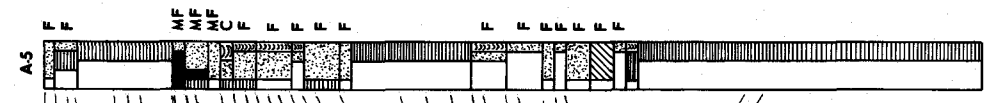
PLANULINA DEPRESSA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CUSHMANIDEA SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
FORAMS INDETERMINATE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA SEMINULA	X	X	X	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BULIMINA PREACANTHIA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.



WELL A-5 LAMBERT PT., VA.

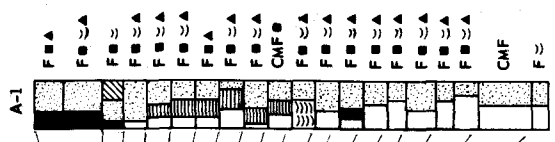
	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	7	10	15	18	35	40	45	60	61	65	70	80	85	90	95	100	105	110	115	120	130	155	165	175	185	190	200	205	215	220	225	300	305
WOOD FRAGMENTS	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM FLORENTINAE	.	.	X	.	.	.	.	.	.	.	.	.	X	X	.	.	.	X	.	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
NONIONELLA AURIS	X	.	X	X	X	X	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SIGMOMORPHINA SEMITECTA TERQUEMIANA	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	X	.	.	X	X	.	.	.	.	.	X	.
BUCCELLA DEPRESSA	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
HANZAWAIA CONCENTRICA	X	.	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	X	X	X	X	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
ECHINOID SPINES	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
OSTRA SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CANCRIS SAGRA	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
CIBICIDELLA VARIABILIS	X	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.
GLOBIGERINA SP. E	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION PIZARRENSIS	.	.	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	X	X	.	.
SIGMOMORPHINA CONCAVA	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UVIGERINA CALVERTENSIS	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.
UVIGERINA SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DISCORBIS FLORIDANA	X	X	X	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MARGINULINA SP. D CLAPP	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
QUINQUELOCULINA SEMINULA	X	X	X	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
GLOBIGERINOIDES SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP. A	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.
CASSIDULINA LAEVIGATA CARINATA	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
BUCCELLA PARKERAE	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
BULIMINA PREACANTHIA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
NONION MEDIOCOSTATUS	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.
ROTALIA BECCARII VAR. TEPIDA	X	X	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
BOLIVINA SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
GLOBIGERINA SP. B	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
BUCCELLA MANSFIELDI	.	.	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
CIBICIDES AMERICANUS	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
TEXTULARIA PSEUDOBLIQUA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.

Lists of species and graphic logs for well A-11 and well A-5.

EXPLANATION

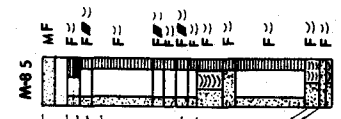
GRAVEL		PLANT DEBRIS	
SAND		E	ECHINOID SPINES
SILT		L	LIMONITE
CLAY		G	GYPSUM
PLANT DEBRIS		≈	SHELLS, SHELL FRAGMENTS
SHELL BEDS		F	FINE SAND
SANDSTONE		M	MEDIUM SAND
MICA		C	COARSE SAND
GLAUCONITE			

NOTE: SAND SIZES ARE ACCORDING TO THE WENTWORTH SCALE.
THE RELATIVE PERCENTAGES OF MAJOR SEDIMENT ELEMENTS
ARE INDICATED BY SYMBOLS IN THE COLUMN FOR EACH BORING.



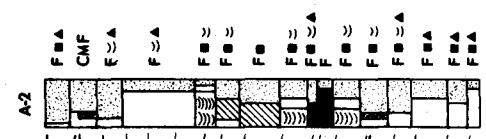
WELL A-1

	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	-55	-84	-93	-103	-113	-123	-132	-142	-152	-161	-171	-181	-191	-202	-210	-222-230	-239	-262
BROKEN NONIONS	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	X	X	X	.	.	.	.	.	X	X
ANGULOGERINA OCCIDENTALIS	.	X	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA AENIERIENSIS	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA LAFAYETTEI	.	.	.	X	.	.	.	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.
BOLIVINA MARGINATA MULTICOSTA	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	X	X	X	X	X	.	X	X	X	X	.	.	.	.	.	.	.	X	.	X	.	.	.
BOLIVINA STRIATULA	X	X	.	X	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA PARKERAE	.	.	.	X	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	X	X	X	X	X	.	X	X	X	X	.	.	.	.	X	X	X	.	.	X	.	.	.
BULIMINELLA ELEGANTISSIMA	X	X	X	X	X	X	X	X	X	X	X	X	.	.	X	.	.	X	.	.	.	.	X	.	.	.
CASSIDULINA CRASSA	X	X	X	.	.	.	X	X	.	X	X	X	X	X	.	.	.	.	.	.	.	.	X	.	.	.
CASSIDULINA LAEVIGATA CARINATA	X	.	X	.	X	.	.	.	.	X	X	X	X	.	.	.	.	.	.	.	.	.	X	.	.	.
CIBICIDELLA VARIABILIS	X	.	.	X	.	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
DISCORBIS FLORIDANA	X	X	X	X	X	.	X	X	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM FLORENTINAE	.	X	.	.	.	.	.	.	.	X	X	X	X	.	.	X	.	.	X	.	.	X	.	.	.	.
HANZAWAIA CONCENTRICA	X	.	.	X	X	X	X	X	.	X	X	.	X	.	.	.	X	.	.	.	X	.	.	.	.	.
LAGENA CLAVATA	X	X	X	.	X	X	X	X	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION GRATELOUPI CLAPP	.	.	.	.	.	X	.	.	.	X	X	X	X	.	.	.	.	.	.	X	.	.	X	.	.	.
NONION GRATELOUPI D ORBIGNY	X	X	X	X	X	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION PIZARRENSIS	.	.	X	X	X	X	X	X	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
NONIONELLA AURIS	X	.	X	X	X	X	X	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
PARAFISSURINA MARGINATA	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SIGMOMORPHINA SEMITECTA TERQUEMIANA	X	.	X	X	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA GRAMEN	X	.	X	X	X	X	X	X	.	X	.	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.
VALVULINERIA FLORIDANA	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ASTACOLUS SP.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ENTOSOLENIA SP.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SP.	.	.	.	.	.	.	.	.	.	X	X	X	X	X	.	.	.	.	X	.	.	.	.	.	.	.
MARGINULINA SP.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UVIGERINA SP.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
RIBBED LAGENA	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA FLORIDANA	.	.	.	.	X	.	X	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
ENTOSOLENIA CARTERI	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
LAGENA PSEUDOSULCATA	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA SP.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	X	X
LAGENA SP.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA MARGINATA	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UVIGERINA CF. CARMELOENSIS	.	.	.	X	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
HISPID SIGMOMORPHINAS	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
LAGENA LAEVIS	X	X	X	.	.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
LAGENA SUBSTRIATA	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION MEDIOCOSTATUS	.	.	.	.	X	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA DEPRESSA	X	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA EUSTISENSIS	.	.	.	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.
INDETERMINATE FORMS	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.
CANCRIS SAGRA	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
PLANULINA DEPRESSA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
BROKEN BOLIVINA	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
WOOD FRAGMENTS	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.



WELL M-85

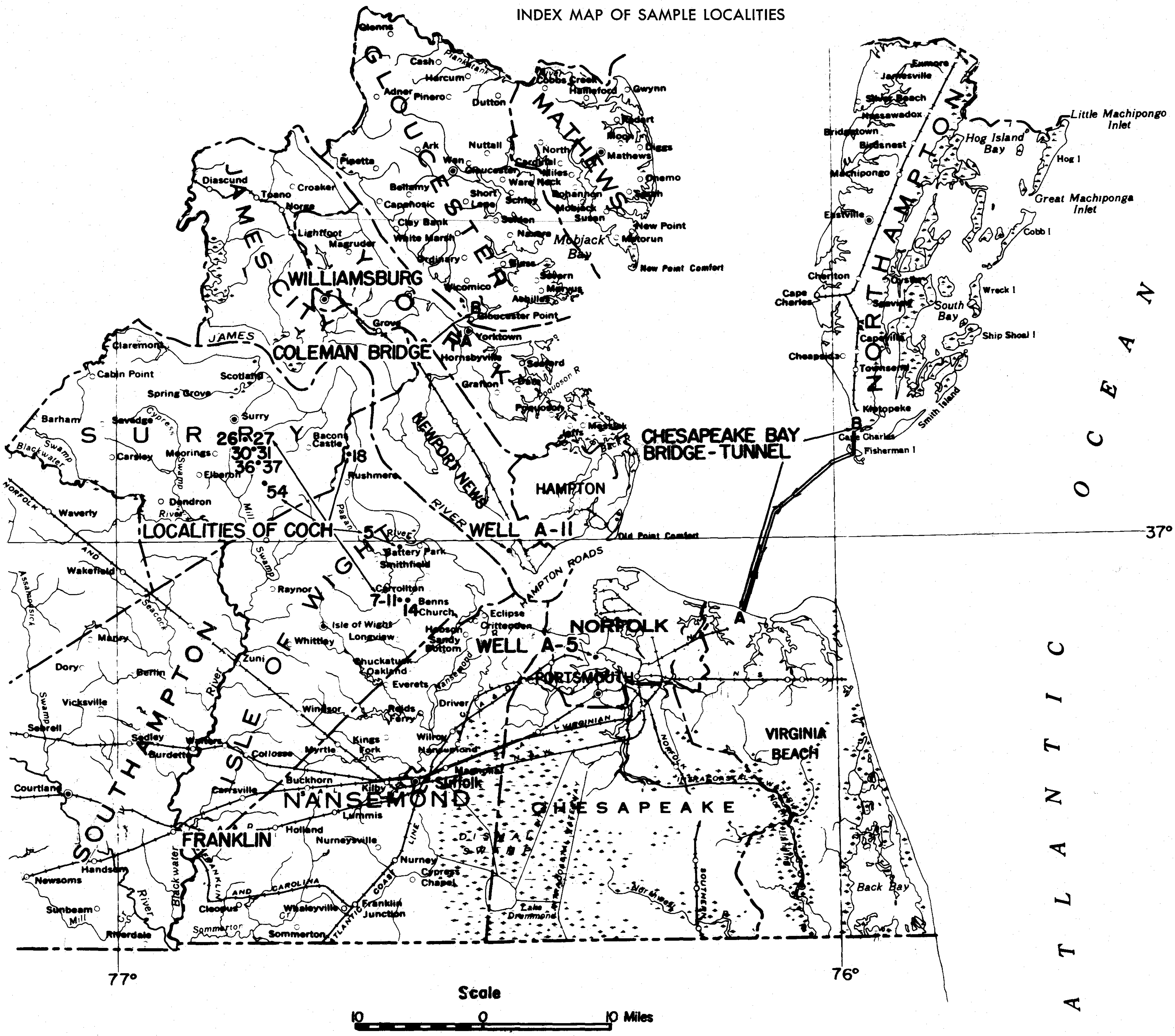
	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	74	84	88	93	98	133	138	184	189
BULIMINA GRACILIS	.	.	.	.	X	X	X	X	.	.	X	.	X	.	X	.	.
DISCORBIS FLORIDANA	.	X	X	X	X	.	X	X	.	.	X	.	X	.	.	.	.
ELPHIDIUM FLORENTINAE	.	.	X	.	.	.	.	.	.	.	X	.	X	.	X	.	.
GLOBIGERINA SP. A	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.
GLOBIGERINA SP. E	.	.	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.
HANZAWAIA CONCENTRICA	.	X	.	.	.	X	X	X	X	.	X	.	X	.	.	.	.
LAGENA CLAVATA	.	X	X	X	.	X	X	X	X	.	X	.	X	.	X	.	.
LAGENA DORSEYAE	.	.	.	.	X	X	X	X	X	.	X	.	.	.	X	.	.
LAGENA GLOBULOHISPIDA	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.
NONION PIZARRENSIS	.	.	.	X	X	X	X	X	X	.	X	.	X	.	X	.	.
SIGMOMORPHINA CONCAVA	.	X	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.
SIGMOMORPHINA SEMITECTA TERQUEMIANA	.	X	.	X	X	.	.	.	.	.	X	.	X	.	.	.	.
TEXTULARIA GRAMEN	.	X	.	X	X	X	X	X	X	.	X	.	X	.	.	.	.
UVIGERINA CF. TENUISTRIATA	.	.	.	.	X	.	.	.	.	.	X	.	.	.	X	.	.
ENTOSOLENIA SP.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.
LAGENA RIBBED	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.
BOLIVINA PAULA	.	.	.	.	X	X	X	X	X	.	.	.	X	.	.	.	.
BUCCELLA DEPRESSA	.	X	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.
BULIMINELLA ELEGANTISSIMA	.	X	X	X	X	X	X	X	X	.	.	.	X	.	.	X	.
CASSIDULINA CRASSA	.	X	X	X	.	.	.	X	X	.	.	.	X	.	.	.	.
CASSIDULINA LAEVIGATA CARINATA	.	X	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.
ENTOSOLENIA CARTERI	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.
LAGENA HEXAGONA SCALARIFORMIS	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.
LAGENA PALMERAE	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.
NONIONELLA AURIS	.	X	.	X	X	X	X	X	.	.	.	.	X	.	.	.	.
UVIGERINA CALVERTENSIS	.	.	.	.	X	.	.	X	.	.	.	.	X	.	.	.	.
VALVULINERIA FLORIDANA	.	.	.	.	.	X	X	X	.	.	.	.	X	.	.	.	.
NONION SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.



WELL A-2

	Recent	Pleistocene	Pliocene	Yorktown	St. Marys	Choptank	Calvert	Older	48	59	60	70	81	90	101	115	120	130	146	158	161	168	180	181	192	201	215	224
BROKEN NONIONS	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
HANZAWAIA CONCENTRICA	X	.	.	X	X	X	X	.	.	.	X	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.
ANGULOGERINA OCCIDENTALIS	.	X	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
ANGULOGERINA SP.	.	.	.	X	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
AURILA CONRADI	X	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA LAFAYETTEI	.	.	.	X	.	.	.	.	.	.	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA PAULA	.	.	.	X	X	X	X	X	.	.	.	X	.	X	X	X	X	X	X	.	.	X	.	.	.	.	.	.
BULIMINA GRACILIS	.	.	.	X	X	X	X	.	.	.	.	X	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.
BULIMINELLA ELEGANTISSIMA	X	X	X	X	X	X	X	X	.	.	.	X	.	X	X	X	X	.	X	.	X	.	X	.	.	.	.	.
CIBICIDELLA VARIABILIS	X	.	.	X	.	X	.	X	.	.	.	X	X	X	X	.	.	.	.	.	.	X	.	.	.	.	.	.
DISCORBIS FLORIDANA	X	X	X	X	.	X	X	.	.	.	.	X	X	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.
ELPHIDIUM FLORENTINAE	.	X	.	.	.	.	.	.	.	.	.	X	X	X	X	.	X	.	X	.	X	.	X	.	.	.	.	.
ENTOSOLENIA CARTERI	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
MARGINULINA SP.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION GRATELOUPI CLAPP	.	.	.	.	.	X	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION GRATELOUPI D ORBIGNY	X	X	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NONION PIZARRENSIS	.	.	X	X	X	X	X	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
ORBULINA UNIVERSA	.	.	X	.	.	X	X	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
TEXTULARIA GRAMEN	X	.	X	X	X	X	X	X	.	.	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA SPP.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
BOLIVINA SP.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
GLOBIGERINA SPP.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	X	.	.	X	X	.	.	.	.	.	.	.	.	.
LAGENA RIBBED	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
OSTRACODA SP.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UVIGERINA SP.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
BOLIVINA STRIATULA	X	X	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NONIONELLA AURIS	X	.	X	X	X	X	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
SIGMOROPHINA SP.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
BUCCELLA ANDERSENI	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
CASSIDULINA CRASSA	X	X	X	.	.	.	X	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
TRILOCULINA SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
UVIGERINA CF. CARMELOENSIS	.	.	.	X	.	X	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
CASSIDULINA ? SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
WOOD FRAGMENTS	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	X	.	.	.
INDETERMINATE FORAMS	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	X	.	.	X	.
DISCORBIS ? SP.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
CIBICIDES INDETERMINATE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
ELPHIDIUM CLAVATUM	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
NONIONS INDETERMINATE	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
PLANULINA DEPRESSA	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.

Lists of species and graphic logs for wells A-1, A-2, and M-85, Chesapeake Bay Bridge-Tunnel.


INDEX MAP OF SAMPLE LOCALITIES
GLOUCESTER
MATHEWS
JAMES CITY
YORK
NORTHAMPTON
SURRY
ISLE OF WIGHT
SOUTHAMPTON
NANSEMOND
CHESAPEAKE
NEWPORT NEWS
HAMPTON
NORFOLK
PORTSMOUTH
VIRGINIA BEACH
WILLIAMSBURG
FRANKLIN
COLEMAN BRIDGE
CHESAPEAKE BAY BRIDGE - TUNNEL
LOCALITIES OF COCH
WELL A-11
WELL A-5
26 27 30 31 36 37 54 18 5 7-11 14
A
B
Mobjack Bay
Hog Island Bay
Little Machipongo Inlet
Great Machipongo Inlet
South Bay
Hog I
Cobb I
Wreck I
Ship Shoal I
Smith Island
Fisherman I
Old Point Comfort
New Point Comfort
HAMPTON ROADS
JAMES RIVER
DISMAL SWAMP
Lake Drummond
Back Bay
ATLANTIC OCEAN
37°
77°
76°
Scale
10 0 10 Miles