COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
Box 3667, University Station
Charlottesville, Virginia
James L. Calver, Commissioner of
Mineral Resources and State Geologist

Information Circular 6

GUIDEBOOK
to
THE COASTAL PLAIN OF VIRGINIA
NORTH OF THE JAMES RIVER

Charlottesville, Virginia
1962

Page vi, 2: ... Fredricksburg... should read... Fredericksburg... and... Potomic ... should read... Potomac...

Page 4, in caption: ... Formation... should read... formations...

Page 15, Clark and Miller (1912): ... Turitella... should read... Turritella...

Page 18: ... Turn left on U. S. Highway 360 at Warsaw... should read... Turn right on U. S. Highway 360 at Warsaw...

Page 19: ... Turn right on "one way" dirt road... should read... Turn right on "one way" park road to battlefield...

Page 21: ... Proceed on "one way" dirt road and turn right on State Highway 238... should read... Proceed on "one way" park road and turn right on State Highway 238...

Page 22: ... Straight ahead on State Road 1001 at intersection of State Highway 238 and State Road 1001 (about one block) ... should read... Stay on State Highway 238 past the entrance of Visitor Center of Yorktown Battlefield to the intersection with State Road 1001...

... Turn right on U. S. Highway 17 and cross George P. Coleman Memorial Bridge... should read... Straight ahead on State Road 1001 for approximately 2 blocks and turn right on U. S. Highway 17 to cross George P. Coleman Memorial Bridge...

Page 23: ...7.7 (mileage) 71.6 (accumulative mileage)... should read
...9.4 73.3... and succeeding accumulative mileages

...73.2...	should read	...74.9...
...73.8...	"	...75.5...
...74.7...	"	...76.4...
...75.1...	"	...76.8...
...75.4...	"	...77.1...

Page 25: ...77.6 (accumulative mileage) ... should read ...79.3...
...79.0... " ...80.7
...187... " ...189...

Page 26, line 14: ... laterally in layers... should read... laterally into layers...

Page 44, Clark, W. B., 1910: ... American... should read... America...

Virginia Division of Mineral Resources
Charlottesville, Virginia

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NORTH OF THE JAMES RIVER

This guidebook was prepared under the general direction of James L. Calver, State Geologist of Virginia. The following staff members of the Virginia Division of Mineral Resources who helped in preparation of the guidebook are James L. Ruhle, compilation of text; Robert C. Milici and Bruce Hobbs, editing and field check; Richard H. DeKay, field check; and John Wilson, map illustrations. Horace G. Richards, Associate Curator, Academy of Natural Sciences of Philadelphia, assisted in the preliminary planning and in the checking of fossil lists.

Charlottesville, Virginia
1962

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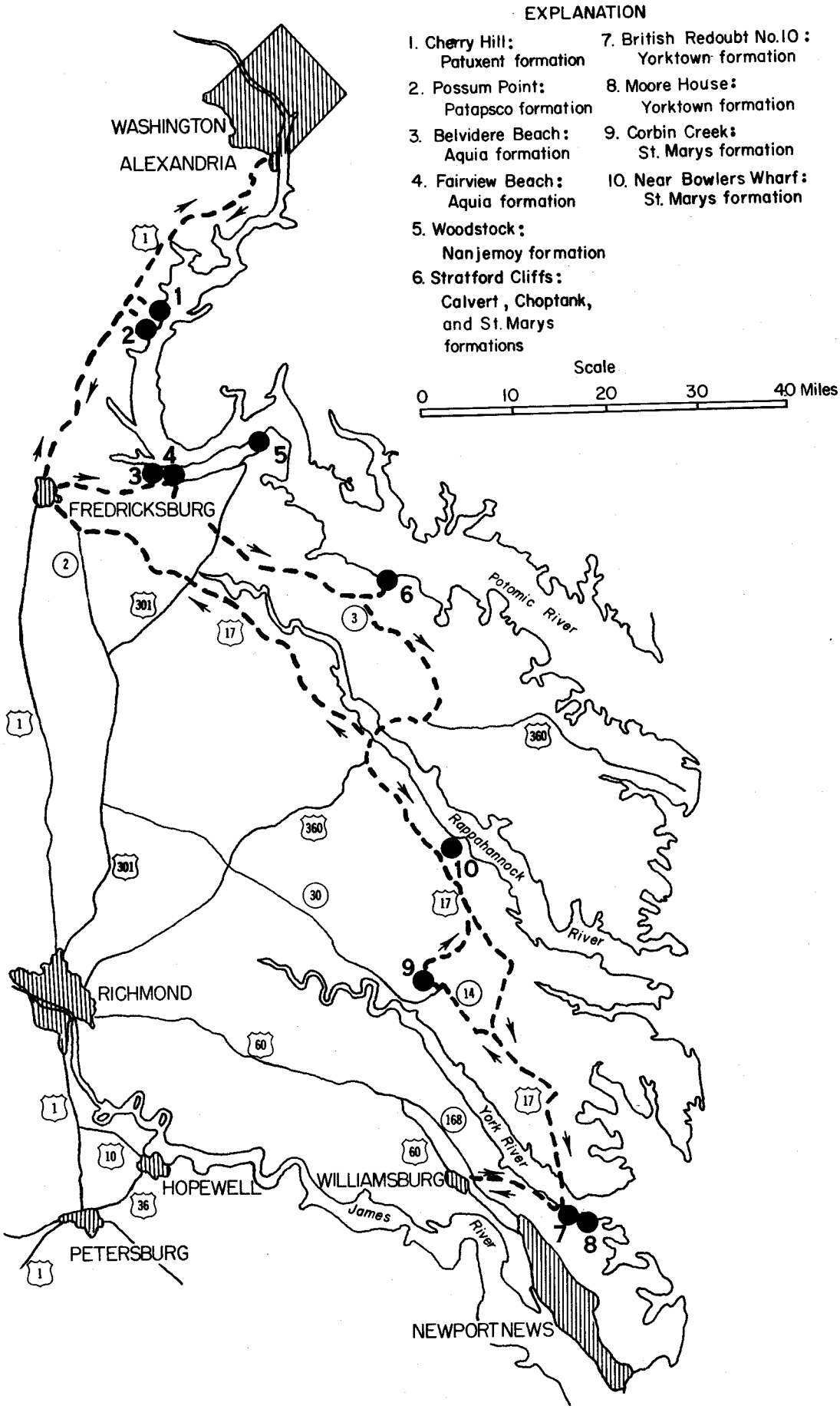

Figure I. Map of localities and route

GUIDEBOOK TO THE COASTAL PLAIN OF VIRGINIA NORTH OF THE JAMES RIVER

by
James L. Ruhle

INTRODUCTION

Geologic formations of the Coastal Plain have been described in the literature for approximately 150 years. In order to meet the demand for a guide to the famous localities at which these formations may be seen and studied, this publication was prepared. The first use of this information as a guidebook was made in October 1962 during the Third Annual Field Conference of the Atlantic Coastal Plain Geological Association. Localities include Lower Cretaceous, Eocene, and Miocene strata and were selected because either they are "type localities" or they contain material which is representative of the formations in the Coastal Plain (Figure 1).

GEOGRAPHICAL SETTING

The Coastal Plain province of Virginia consists of a gently sloping lowland that has a maximum elevation of slightly over 400 feet in rolling hills along the Fall Zone. The Fall Zone extends southwestward from Washington along a line through Fredericksburg and thence southward through Richmond, Petersburg, and Emporia. The Virginia portion of the Coastal Plain province has an area of approximately 10,000 square miles, which constitutes about 25 percent of the area of the Commonwealth, and has an average east-west width of about 100 miles. Between the Fall Zone and the Chesapeake Bay, the area is bounded on the north by the Potomac River and is divided southward by the Rappahannock, York, and James rivers. The Potomac and James rivers (Trans-Blue Ridge types) have their headwaters in the Appalachian Plateau and the Ridge and Valley provinces. The Rappahannock and York rivers, (Piedmont types), have their headwaters mainly in the Piedmont province. Smaller rivers, such as the Piankatank and Great Wicomico (Coastal Plain types), have their headwaters originating in the Coastal Plain province.

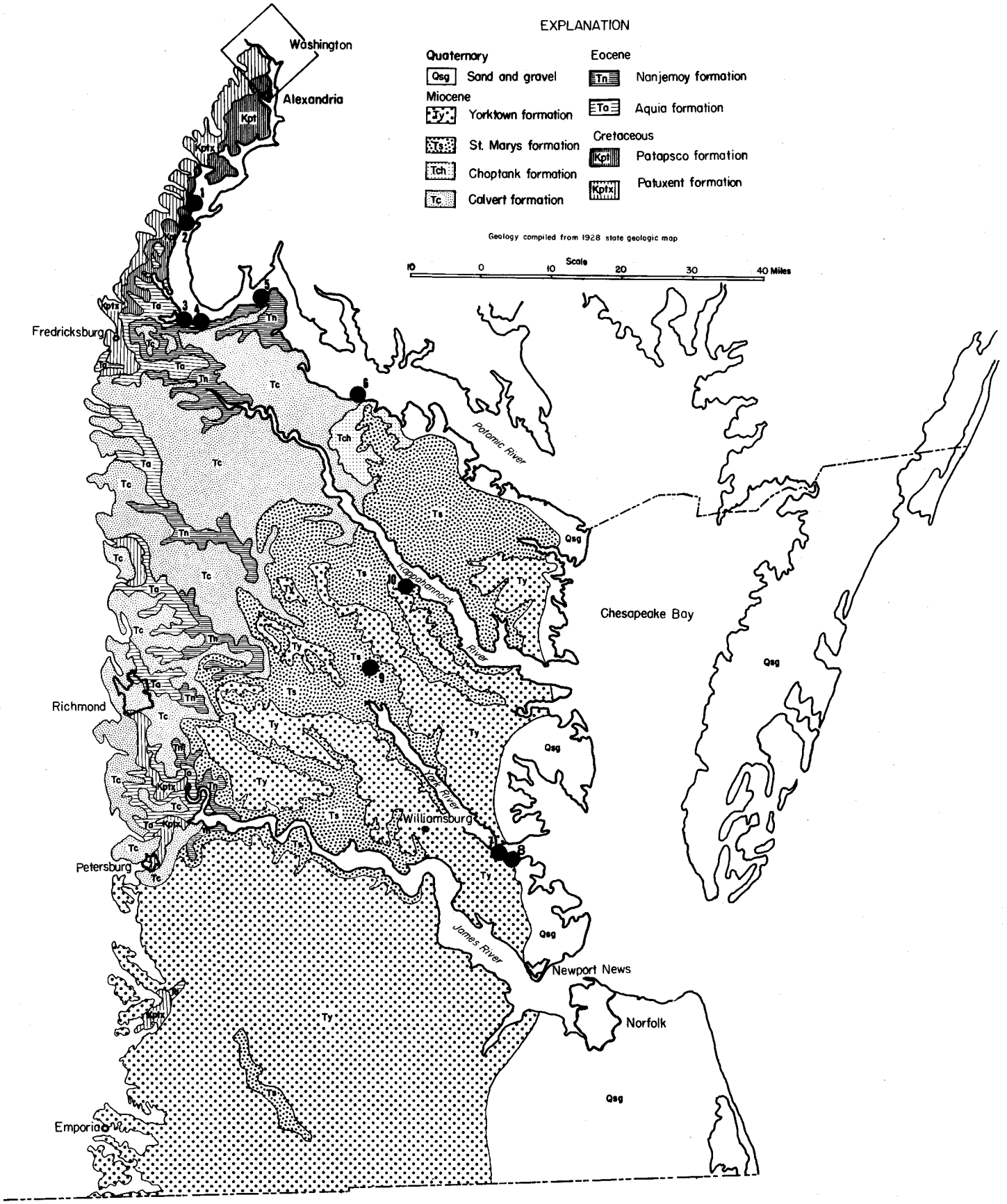

Figure 2. Generalized geologic map of the Coastal Plain of Virginia

The submerged portion of the Coastal Plain, the Continental Shelf, continues from the Virginia shoreline for approximately 65 miles, and has an area of approximately 5000 square miles. The surface generally is a broad plain sloping gently seaward, although it is decidedly undulatory near shore. These undulations form elliptical shoals with their long diameters parallel to the shoreline. Two submarine canyons, the Washington and the Norfolk, occur as notches in the shelf.

GEOLOGICAL SETTING

Formations exposed in the Coastal Plain of Virginia are of Lower Cretaceous, Eocene, Miocene, Pliocene, and Pleistocene ages (Figure 2). They strike approximately parallel to the Fall Zone, and have a monoclinal easterly dip which changes from 50 feet a mile in the older deposits to less than 5 feet a mile in the younger deposits.

The Coastal Plain sediments have been deposited on igneous and metamorphic rocks (crystalline rocks) and Triassic (?) sediments. Along the Fall Zone the deposits are relatively thin; erosional outliers of Lower Cretaceous and Tertiary formations occur west of the main outcrop. The thickness of the sediments progressively increases eastward. At Mathews, Mathews County, a well encountered crystalline rocks at a depth of 2320 feet; a well at Fort Monroe, 25 miles south of Mathews, reached these rocks at 2246 feet. Other wells have penetrated Upper Cretaceous, Paleocene, and Upper Eocene (Jackson age) units that are overlapped by younger sediments and are not exposed at the surface. The succession of formations of the Coastal Plain of Virginia, and a tentative correlation with New Jersey and Gulf Coast equivalents, is given in Table 1.

Geophysical investigations (Ewing, Crary, and Rutherford, 1937) carried out across the Continental Shelf indicate that the depth to crystalline rocks is over 12,000 feet just off Cape Henry. A seismic discontinuity between supposedly consolidated Triassic-Jurassic sediments and semi-consolidated Cretaceous and younger sediments shows a reversal in dip between 10 and 60 miles off Cape Henry.

HISTORICAL SUMMARY

The geological literature of the Coastal Plain of Virginia, which spans a period of nearly two centuries, includes about a thousand references. The earliest reference contains a

Table 1. Correlation chart of Cretaceous and Tertiary Formation in Virginia with those of the Northern Atlantic and Gulf coasts

AGE	NEW JERSEY	DELAWARE	MARYLAND	VIRGINIA	GULF
Pliocene	Beacon Hill	Bryn Mawr (?)	Brandywine Bryn Mawr	Upland gravels and sands (in part)	Goliad
Miocene	Cohansey Kirkwood	Chesapeake group (undifferentiated)	Chesapeake gr.: St. Marys, Choptank, Calvert	Chesapeake gr.: Yorktown, St. Marys, Choptank, Calvert	Pascagoula Hattiesburg Catahoula
Eocene	"Jackson" (subsurface)	Piney Point (?) (subsurface)	Piney Point	Chickahominy (subsurface)	Jackson
	Shark River Manasquan	unnamed sediments	Pamunkey gr.: Nanjemoy	Pamunkey gr.: Nanjemoy	Claiborne
	Vincentown		Aquia	Aquia	Wilcox
Paleocene	Hornerstown	mainly subsurface	Brightseat	Mattaponi subsurface	Midway
Upper Cretaceous	Monmouth group: Tinton, Red Bank, Navesink, Mount Laurel	Red Bank Navesink-Mt. Laurel	Monmouth	not recognized in outcrop	Navarro
	Matawan group: Wenonah, Marshalltown, Englishtown, Woodbury, Merchantville	Wenonah Merchantville	Matawan		Taylor
	Magothy	Magothy	Magothy		Austin
	Raritan	Raritan	Raritan		Woodbine
Lower Cretaceous	Absent in outcrop	Undifferentiated: Patapsco, Patuxent	Potomac group: Patapsco, Arundel, Patuxent	Potomac group: Patapsco, Patuxent	Comanche

geological description of the shell marl (Yorktown formation) of the York River area (Lincoln, 1783). Stratigraphic studies, which were made at the start of the 1800's, contain descriptions of the lithologies of the Coastal Plain formations and were still Wernerian in nature. The works of Timothy A. Conrad and William B. Rogers marked the first departure from this concept. Rogers, the first "State Geologist" of Virginia (1835-41), and Conrad were among the first to lay the foundation for faunal studies of Tertiary formations of the Virginia portion of the Coastal Plain using systematic and stratigraphic paleontology. Invertebrate fossils, and later, megascopic plant fossils, were used to identify formational units, particularly those of the Lower Cretaceous formations. The principal workers in the field of paleobotany include William M. Fontaine, E. Wilber Berry, Lester F. Ward, and Frank H. Knowlton. About this time, geologic mapping was in progress in the Coastal Plain of Virginia by Nelson H. Darton and W J McGee. Darton wrote several geological folios, and McGee described the distribution of the terrace gravels and the Lower Cretaceous sediments. In the early 1900's, William B. Clark and Benjamin L. Miller studied the geology of the Coastal Plain. Their "Physiography and geology in the Coastal Plain province of Virginia," which appeared in 1912, is much in use today. In the present century refined methods, such as micropaleontology, palynology, sedimentary petrology, geophysics, geochemistry, and aerophotography have been used to decifer the geology of the Coastal Plain of Virginia.

Table 2 contains the stratigraphic terminology that has evolved through the years from the time Maclure grouped all rock units under "Alluvial formation" to the present time.

MIOCENE

Maclure 1809	Finch 1824	Conrad 1835	Rogers 1836	Conrad 1838	Rogers 1840	Tuomey 1843	Dana 1863	Sullivant 1875	Heilprin 1882	Meyer 1888	Darton 1891	Dall & Harris 1892	Clark 1897	Clark et al 1904	Clark & Miller 1906,1912
Alluvial fm. (in part)	Tertiary (in part)	Medial Pliocene	Miocene	Medial Tertiary (Miocene)	Yellow marl		Yorktown epoch		Virginian (Middle Atlantic Miocene)	Atlantic group (in part)	Chesa-peake fm.	Chesa-peake gr.			Yorktown fm
					Blue marl									St. Marys fm.	St. Marys fm.
		Older Pliocene												Choptank fm.	Choptank fm.
						Infu-sorial stratum		Bermuda tripoli	Marylandian (Lower Atlantic Miocene)				Richmond earth	Calvert fm.	Calvert fm.

EOCENE

Maclure 1809	Finch 1824	Conrad 1832	Rogers 1835	Meyer 1888	Darton 1891	Clark 1895	Clark, et al 1901			Cushman & Cederstrom, 1945
Alluvial fm. (in part)	Tertiary (in part)	Middle Tertiary	Eocene	Atlantic group (in part)	Pamunkey fm.	Woodstock stage	Pamunkey group	Nanjemoy fm.	Woodstock mem.	Same as Clark, et al 1901
									Potapaco mem.	
								Aquia fm.	Marlboro clay	
						Aquia Creek stage			Paspotansa mem.	
									Piscataway mem.	

UPPER CRETACEOUS THROUGH EOCENE

Cushman & Cederstrom, 1945	Cederstrom 1957	Loeblich & Tappan 1957	
Chickahominy fm. (subsurface)	Chickahominy fm. (subsurface)		
Same as Clark, et al 1901	Same as Clark, et al 1901	Eocene	Nanjemoy fm.
		Paleo-cene	Aquia fm.
	U.Cret.-Paleocene	Mattaponi fm. (subsurface)	

LOWER CRETACEOUS

Maclure 1809	Finch 1824	Rogers 1840		Fontaine 1879		McGee 1886		McGee 1888		Fontaine 1889		Ward 1895	Marsh 1896		Ward, et al 1905		Clark&Miller 1906			Clark 1910		Spangler &Peterson 1950		Dorf 1952	
Alluvial fm. (in part)	Newer Secon-dary	Jurassic	Sand-stone fm.			Jurassic-Cretaceous	Potomac fm.	Potomac formation	Upper or clay mem.	Lower Cretaceous	Upper or clay mem.	Aquia Creek & Mount Vernon series	Jurassic	Potomac or Jurassic fm.	Lower Cretaceous	Brooke beds	L. Cret.	Patapsco fm.		Lower Cretaceous	Patapsco fm.	U. Cret.	Patapsco fm.	Lower Cretaceous	Patapsco fm.
				Jur.-Cret.	Fredericks-burg beds					Potomac or Younger Mesozoic						Mount Vernon beds	Jurassic Potomac group	Arundel fm.							
					James River beds				Lower or sand-stone mem.		Lower or sand-stone mem.	Rappahan-nock & James River series				Rappahan-nock & James River beds		Patuxent fm.			Patuxent fm.	L. Cret.	Patuxent fm.		Patuxent fm.

Table 2. Chronological development of names applied to geologic units in the Coastal Plain of Virginia

ROAD LOG AND LOCALITY DESCRIPTIONS

FIRST DAY OF FIELD CONFERENCE
Friday, October 12, 1962

Departure time, 8:00 a.m. E. D. T. (7:00 a.m. E. S. T.)
Greyhound Bus Terminal, Alexandria, Virginia

Mileage	Accumulative Mileage	Itinerary
0.0	0.0	Leave bus terminal and proceed south from North Washington Street to South Washington Street.
0.4	0.4	Turn right on Gibbon Street.
0.2	0.6	Turn left on St. Patrick Street, and proceed south on U. S. Highway 1.
16.4	17.0	On right: Clay pit of the Woodbridge Clay Products Company. Quantico slate (Ordovician?) and clay are obtained from this pit for the manufacture of brick and tile.
4.0	21.0	On left: Outcrop of cross-bedded sands of the Patuxent formation.
3.2	24.2	Turn left on State Road 635 at Texaco Station.
3.6	27.8	Turn left on dirt road just before railroad crossing.
0.3	28.1	STOP 1: PATUXENT FORMATION - RAILROAD CUT NEAR CHERRY HILL (1 hour and 15 minutes)

Walk north along the railroad tracks. The Patuxent formation crops out for nearly half a mile along the railroad. The lithology is varied in both horizontal and vertical directions.

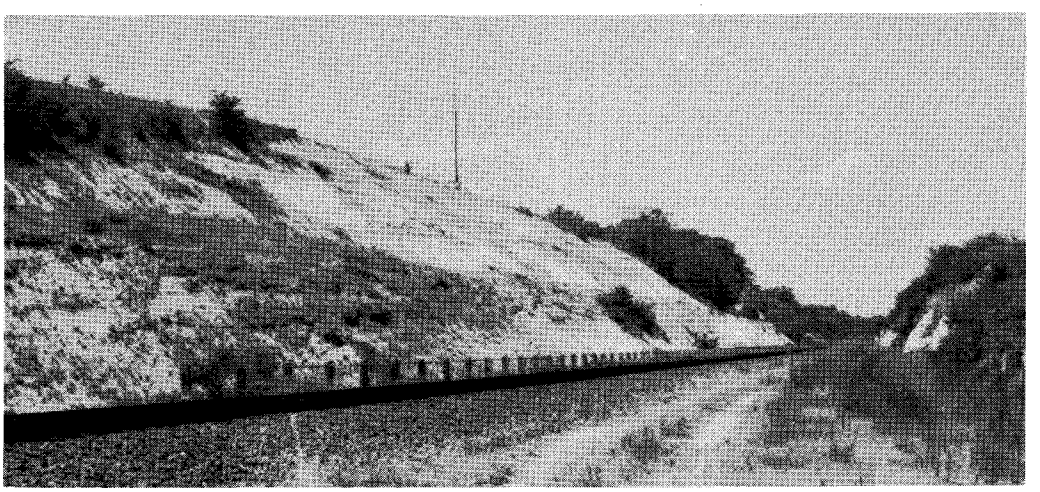

Figure 3. Arkosic sands of the Patuxent formation

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4.0	21.0	On left: Outcrop of cross-bedded sands of the Patuxent formation.
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3.6	27.8	Turn left on dirt road just before railroad crossing.
0.3	28.1	STOP 1: PATUXENT FORMATION - RAILROAD CUT NEAR CHERRY HILL (1 hour and 15 minutes)

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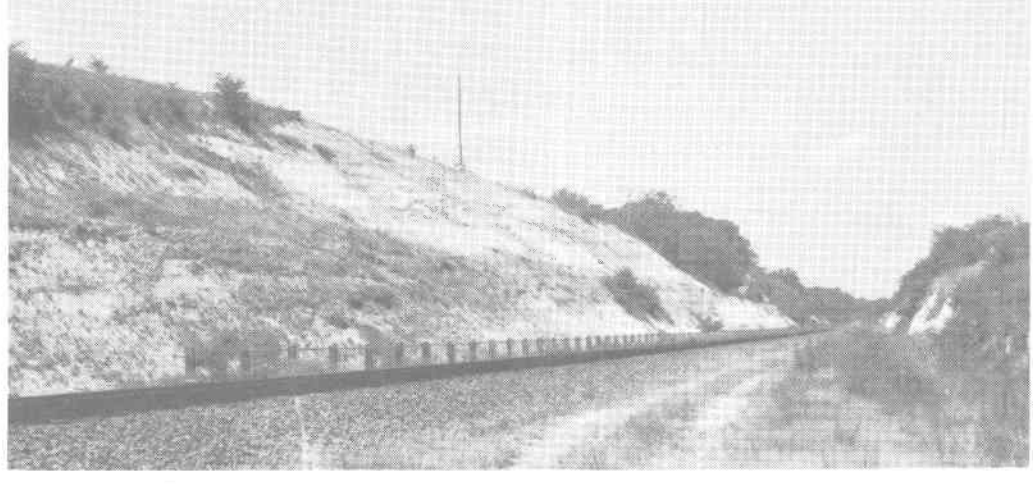


Figure 3. Arkosic sands of the Patuxent formation

The following section was measured at the southern end of the outcrop, on the west face of the cut.

	Thickness	Description
PLEISTOCENE	15'	Gravel and loam, gray-brown, sandy
	0.5'	Sandstone, red-brown, limonitic
PATUXENT FORMATION	15'	Sand, gray, medium-grained, arkosic, cross-bedded, containing pebbles, and thin clay laminae
	0.5'	Sandstone, red-brown, limonitic
	2'	Clay, gray, very plastic
	12'	Sand, gray to white, medium- to coarse-grained, arkosic, cross-bedded
	1'	Sandstone, red-brown, limonitic
	10'	Clay, gray-green, compact, silty, micaceous
	4.5'	Sand, red-brown, medium to fine-grained, silty
	4'	Clay, gray-green, compact, laminated, silty, micaceous
	2.5'	Sand, red-brown, fine-grained, micaceous
	3'	Silt, olive-gray, compact, laminated
	3'	Sand, gray to yellow, medium-grained, micaceous, with silt laminae, containing pebbles
	8'	Sand, gray to buff, medium- to coarse-grained, cross-bedded, arkosic, micaceous, containing pebbles, and clay balls

Berry (1912) recorded the following plant species from this area:

Arthrophyta
- Equisetum burchardti (Dunker) Brongniart

Pteridophyta
- Scleropteris elliptica Fontaine
- Onychiopsis goepperti (Schenk) Berry
- Cladophlebis parva Fontaine

Cycadophyta
- Podozamites sp.
- Dioonites buchianus (Ettingshausen) Bornemann

Coniferophyta
Feistmantelia oblonga Ward
Nageiopsis zamoides Fontaine
Nageiopsis longifolia Fontaine
Sequoia ambiqua Heer
Sphenolepis kurrianum (Dunker) Schenk
Sphenolepis sternbergiana (Dunker)

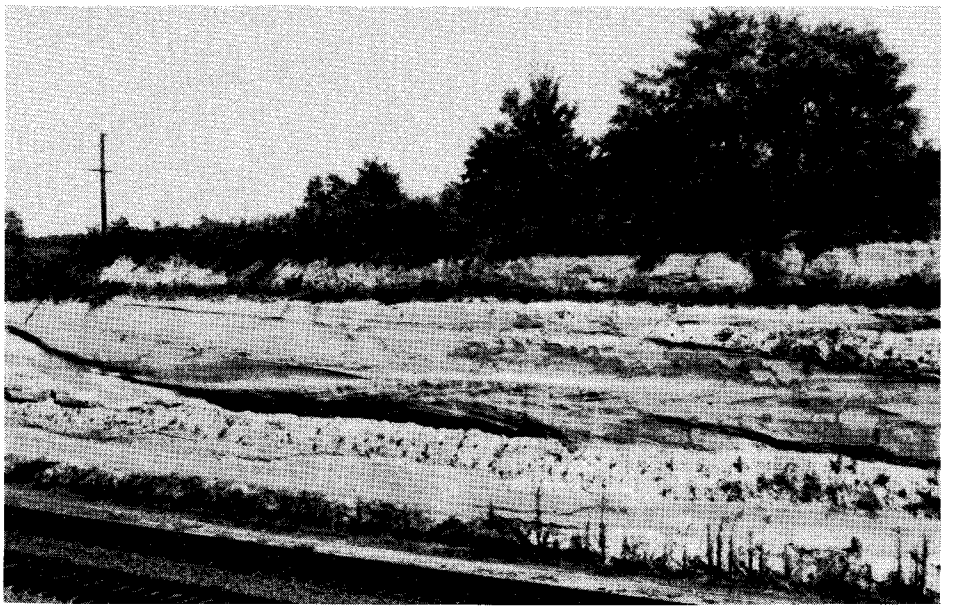


Figure 4. Cross-bedded sands with clay balls and lenses which occur in the Patuxent formation – note iron oxide stains

3.9	32.0	Return to and turn left on U. S. Highway 1.
1.2	33.2	Turn left on State Road 633.
1.3	34.5	On left: Outcrop of cross-bedded sands of the Patuxent formation.
2.6	37.1	STOP 2: PATAPSCO FORMATION - RAILROAD CUT NEAR POSSUM POINT (45 minutes)

Walk about 300 yards north along the railroad tracks. The Patapsco formation crops out for a short distance along the railroad.

	Thickness	Description
PLEISTOCENE	4'	Gravel and loam, brown, sandy
PATAPSCO FORMATION	4'	Clay, buff, very plastic
	20'	Clay, red-brown to pink with gray mottling, silty, few pebbles
	6'	Clay, gray to buff, very plastic

Coniferophyta
Feistmantelia oblonga Ward
Nageiopsis zamoides Fontaine
Nageiopsis longifolia Fontaine
Sequoia ambiqua Heer
Sphenolepis kurrianum (Dunker) Schenk
Sphenolepis sternbergiana (Dunker)

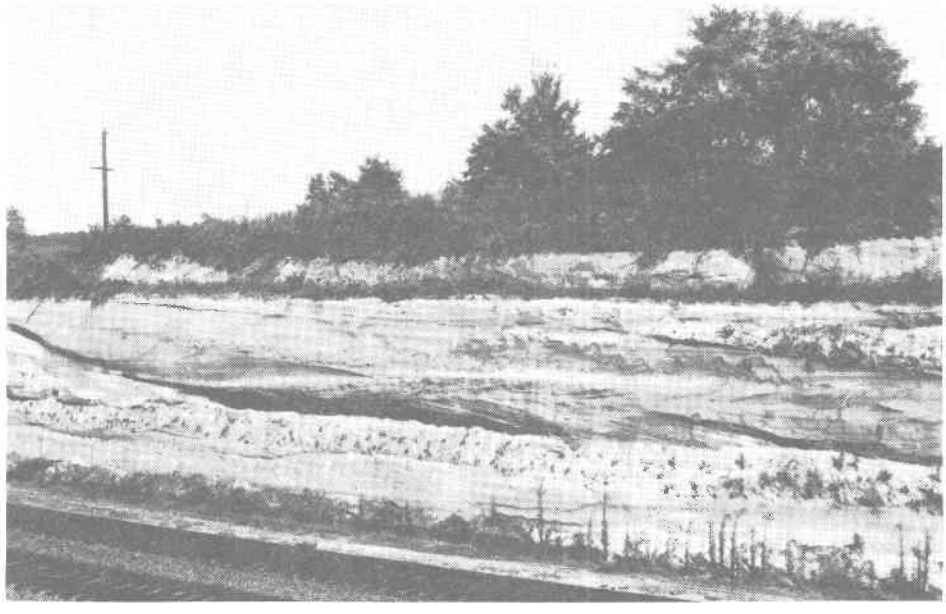


Figure 4. Cross-bedded sands with clay balls and lenses which occur in the Patuxent formation – note iron oxide stains

3.9	32.0	Return to and turn left on U. S. Highway 1.
1.2	33.2	Turn left on State Road 633.
1.3	34.5	On left: Outcrop of cross-bedded sands of the Patuxent formation.
2.6	37.1	STOP 2: PATAPSCO FORMATION - RAILROAD CUT NEAR POSSUM POINT (45 minutes)

Walk about 300 yards north along the railroad tracks. The Patapsco formation crops out for a short distance along the railroad.

	Thickness	Description
PLEISTOCENE	4'	Gravel and loam, brown, sandy
PATAPSCO FORMATION	4'	Clay, buff, very plastic
	20'	Clay, red-brown to pink with gray mottling, silty, few pebbles
	6'	Clay, gray to buff, very plastic

0.3'	Sandstone, red-brown, limonitic
3'	Sand, gray-brown, medium-grained

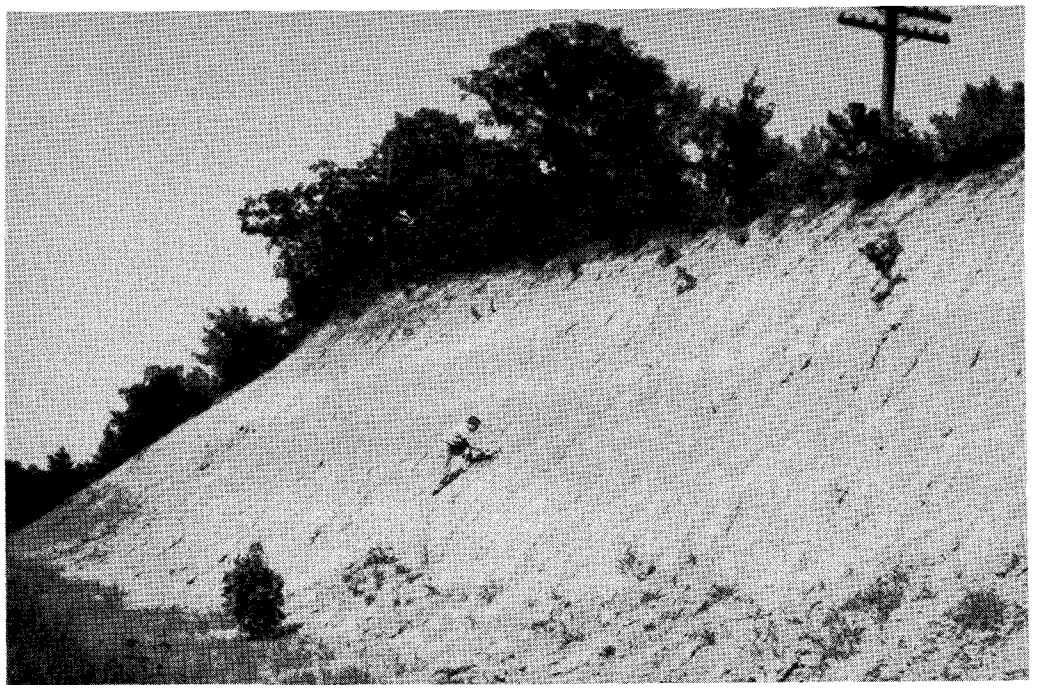


Figure 5. Variegated clay strata of the Patapsco formation

Berry (1912) recorded the following plant fossils from this area:

Pteridophyta
Acrostichopteris longipennis Fontaine

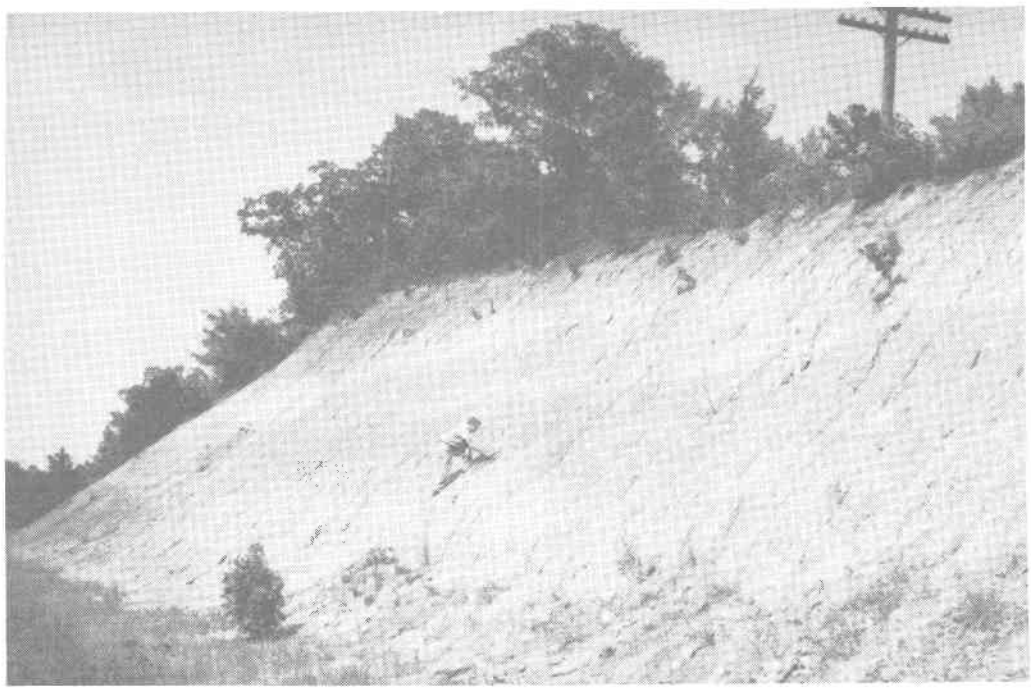
Coniferophyta
Brachyphyllum crassicaule Fontaine
Sphenolepis sternbergiana (Dunker) Schenk

Cycadophyta
Zamites tenuinervis Fontaine

Angiospermophyta
Sassafras sp.

4.0	41.1	Return to and turn left on U. S. Highway 1.
1.0	42.1	On right: Outcrop of Quantico slate at base of hill.
		Numerous outcrops of the Potomac group occur between Dumfries and Fredericksburg.
20.4	62.5	Turn left after crossing the Rappahannock River, and proceed on Princess Anne Street into Fredericksburg.

0.3'	Sandstone, red-brown, limonitic
3'	Sand, gray-brown, medium-grained



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Angiospermophyta
Sassafras sp.

4.0	41.1	Return to and turn left on U. S. Highway 1.
1.0	42.1	On right: Outcrop of Quantico slate at base of hill.
		Numerous outcrops of the Potomac group occur between Dumfries and Fredericksburg.
20.4	62.5	Turn left after crossing the Rappahannock River, and proceed on Princess Anne Street into Fredericksburg.

1.3	63.8	Turn left on State Highway 3.
0.4	64.2	Cross the Rappahannock River and turn left on State Highway 218.
8.4	72.6	Turn left on State Road 600 at Cities Service gas station.
2.3	74.9	Turn right on State Road 654.
3.2	78.1	STOP 3: AQUIA FORMATION - BELVIDERE BEACH (45 minutes). See "Virginia Minerals," vol. 8, no. 3, fig. 3, 1962.

Walk about 100 yards upstream. The Aquia formation crops out along the river bluff.

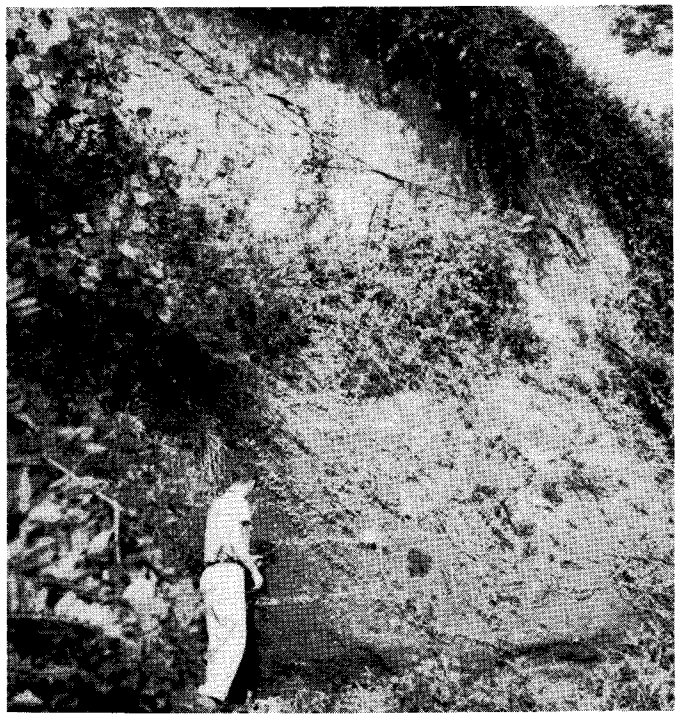


Figure 6. Fossiliferous layers in the Aquia formation

	Thickness	Description
PLEISTOCENE	3'	Sand, brown, coarse-grained
AQUIA FORMATION	10'	Sand, buff, fine-grained, unfossiliferous
	2'	Sand, brown, fine-grained, glauconitic, argillaceous, fossiliferous
	5'	Sand, gray-green, fine-grained, glauconitic, argillaceous, fossiliferous

1.3	63.8	Turn left on State Highway 3.
0.4	64.2	Cross the Rappahannock River and turn left on State Highway 218.
8.4	72.6	Turn left on State Road 600 at Cities Service gas station.
2.3	74.9	Turn right on State Road 654.
3.2	78.1	STOP 3: AQUIA FORMATION - BELVIDERE BEACH (45 minutes). See "Virginia Minerals," vol. 8, no. 3, fig. 3, 1962.

Walk about 100 yards upstream. The Aquia formation crops out along the river bluff.

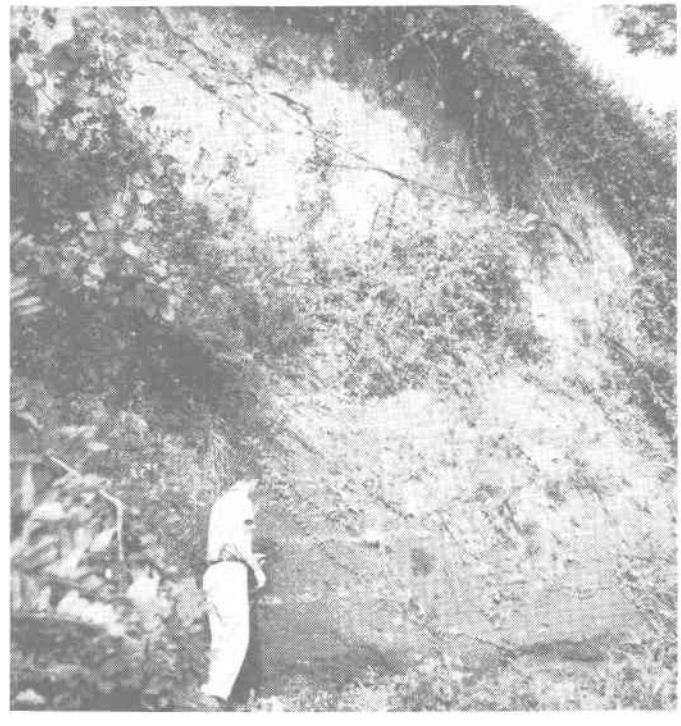


Figure 6. Fossiliferous layers in the Aquia formation

	Thickness	Description
PLEISTOCENE	3'	Sand, brown, coarse-grained
AQUIA FORMATION	10'	Sand, buff, fine-grained, unfossiliferous
	2'	Sand, brown, fine-grained, glauconitic, argillaceous, fossiliferous
	5'	Sand, gray-green, fine-grained, glauconitic, argillaceous, fossiliferous

Berry (1934, 1936) recorded the following plant species from this locality:

Pinus lynni
Ficus aquiana

Gildersleeve (1942) recorded the following fauna from this locality:

Pelecypoda
- Cucullaea gigantea
- Venericardia planicosta
- Pecten johnsoni
- Ostrea compressirostra
- Meretrix ovata
- Crassatellites alaeformis
- Protocardia lenis

Gastropoda
- Fulguroficus argutus
- Tudicla marylandica
- Turritella mortoni var. post-mortoni
- Turritella mortoni
- Turritella humerosa

Vertebrata
- Myliobatus magister
- Myliobatus copeanus
- Thecachampsa sericodon
- Odontaspis elegans
- Otodus obliquus
- Phyllodus medius
- Phyllodus toliapicus
- Phyllodus marginalis
- Phyllodus speciosus
- Trionyx virginiana

5.5	83.6	Return to and turn left on State Highway 218.
5.2	88.8	Turn left on State Road 609.
1.0	89.8	STOP 4: AQUIA FORMATION - FAIRVIEW BEACH (1 hour and 15 minutes)

OBTAIN PERMISSION to gain access to beach properties. Residents have asked that SAMPLES NOT BE TAKEN from the boulders that are present on the beach. Walk about 25 yards upstream. Indurated boulders of the Aquia formation crop out at the base of the river bluff.

	Thickness	Description
PLEISTOCENE	3'	Gravel and loam, buff, sandy
AQUIA FORMATION ?	12'	Sand, brown to buff, fine-grained, micaceous

AQUIA FORMATION	5'	Sandstone, gray-brown, fine-grained, glauconitic, calcareous, with numerous fossil molds and casts, particularly of Turritella mortoni.

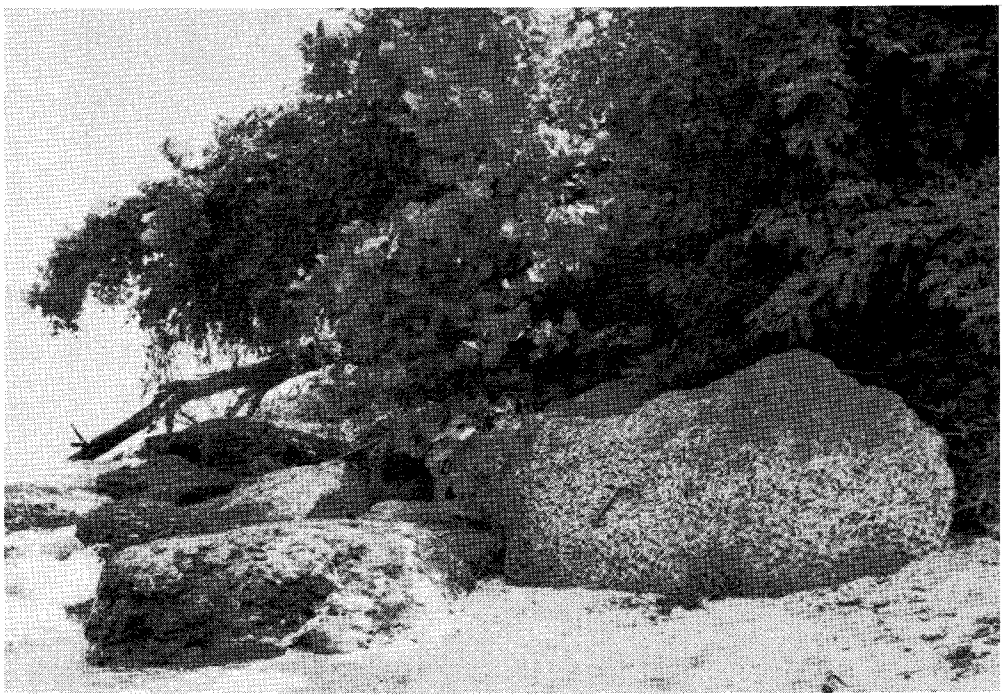


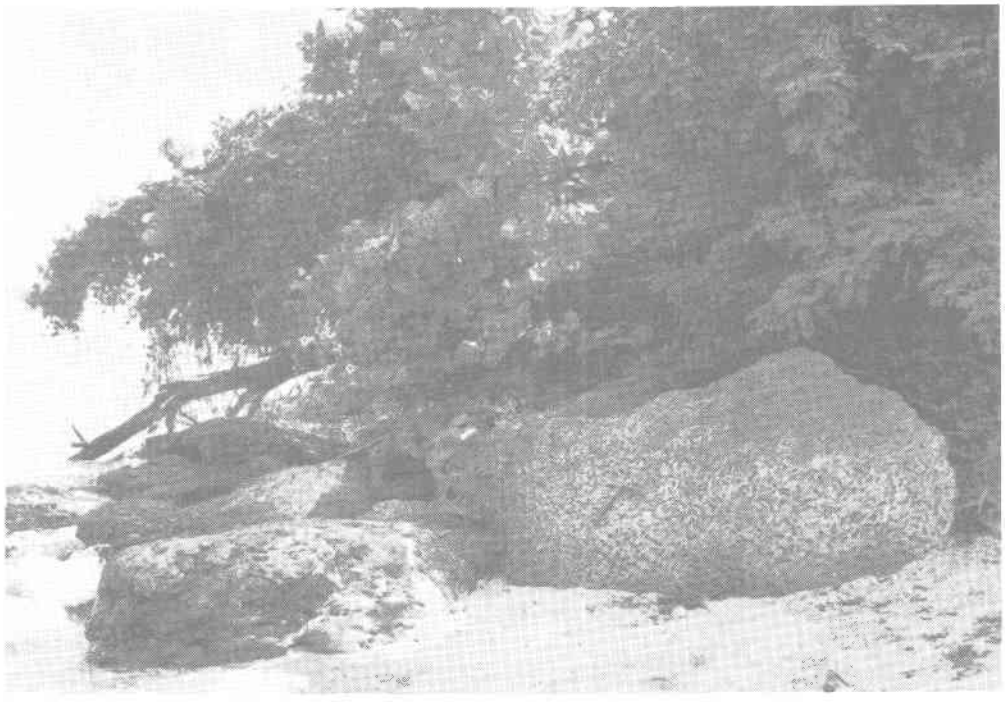
Figure 7. Blocks of calcareous sandstone from the Aquia formation containing casts and molds of Turritella mortoni

Cushman (1944) recorded the following Foraminifera from this locality:

Reophax curtus Cushman
Haplophragmoides cf. sphaeriloculum Cushman
Spiroplectammina wilcoxensis Cushman and Ponton
Gaudryina sp.
Trochammina howei Cushman
Robulus wilcoxensis Cushman and Ponton
Darbyella wilcoxensis Cushman and Garrett
Globulina gibba d'Orbigny
Pseudopolymorphina wilcoxensis Cushman and Ponton
Sigmomorphina semitecta (Reuss) var. terquemiana (Fornasini)
Bulimina ovata d'Orbigny
Angulogerina virginiana Cushman
Valvulineria wilcoxensis Cushman and Ponton
Eponides lotus (Schwager)
Siphonina wilcoxensis Cushman
Pulvinulinella obtusa (Burrows and Holland)
Anomalina umbonifera (Schwager)

1.0	90.8	Return to and turn left on State Highway 218 and proceed one mile to junction of State Highway 218 and State Road 609.

AQUIA FORMATION	5'	Sandstone, gray-brown, fine-grained, glauconitic, calcareous, with numerous fossil molds and casts, particularly of Turritella mortoni.



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Pseudopolymorphina wilcoxensis Cushman and Ponton
Sigmomorphina semitecta (Reuss) var. terquemiana (Fornasini)
Bulimina ovata d'Orbigny
Angulogerina virginiana Cushman
Valvulineria wilcoxensis Cushman and Ponton
Eponides lotus (Schwager)
Siphonina wilcoxensis Cushman
Pulvinulinella obtusa (Burrows and Holland)
Anomalina umbonifera (Schwager)

1.0	90.8	Return to and turn left on State Highway 218 and proceed one mile to junction of State Highway 218 and State Road 609.

0.0	0.0	To alternate stop, STOP 5, bear left on State Highway 218.
7.2	7.2	Turn left on State Highway 206.
2.3	9.5	Turn left on State Highway 624.
1.7	11.2	Bear left on State Road 624.
0.4	11.6	Turn left on gravel road (marker sign, "Scoggin").
1.2	12.8	ALTERNATE STOP – STOP 5: NANJEMOY FORMATION – WOODSTOCK Walk about 20 yards to the right of the house and follow path down to the River. The Nanjemoy formation crops out about 20 yards downstream from the path at the base of the bluff.

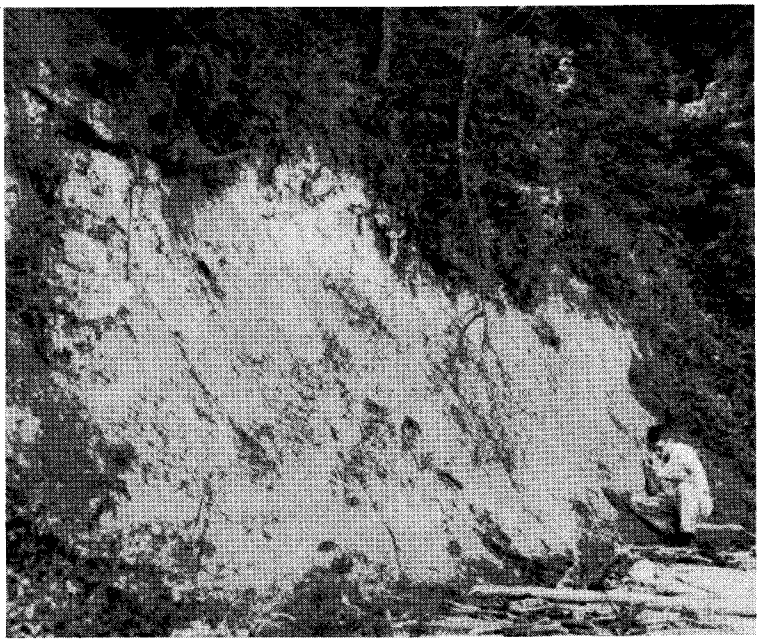


Figure 8. Argillaceous greensand of the Nanjemoy formation

	Thickness	Description
NANJEMOY FORMATION	16'	Sand, red-brown, fine-grained, clay content increases toward the upper part; material is mottled red and buff.
	10'	Sand, olive to brown, fine-grained, glauconitic, silty, locally argillaceous, and containing thin laminae of medium-grained sand.

Clark and Miller (1912) recorded the following invertebrate species from the lowest six feet of this section, which they called the Potapaco member:

Pelecypoda
Venericardia potapacoensis

0.0	0.0	To alternate stop, STOP 5, bear left on State Highway 218.
7.2	7.2	Turn left on State Highway 206.
2.3	9.5	Turn left on State Highway 624.
1.7	11.2	Bear left on State Road 624.
0.4	11.6	Turn left on gravel road (marker sign, "Scoggin").
1.2	12.8	ALTERNATE STOP — STOP 5: NANJEMOY FORMATION — WOODSTOCK Walk about 20 yards to the right of the house and follow path down to the River. The Nanjemoy formation crops out about 20 yards downstream from the path at the base of the bluff.

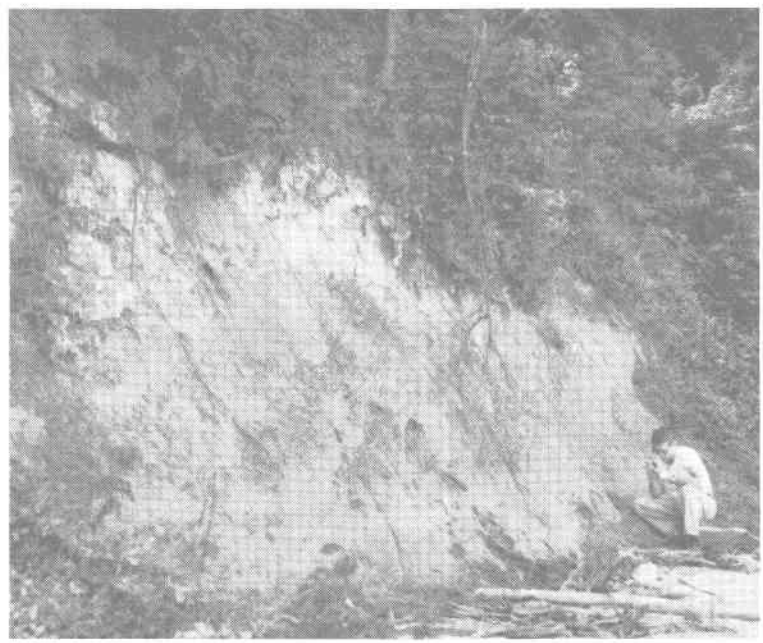


Figure 8. Argillaceous greensand of the Nanjemoy formation

	Thickness	Description
NANJEMOY FORMATION	16'	Sand, red-brown, fine-grained, clay content increases toward the upper part; material is mottled red and buff.
	10'	Sand, olive to brown, fine-grained, glauconitic, silty, locally argillaceous, and containing thin laminae of medium-grained sand.

Clark and Miller (1912) recorded the following invertebrate species from the lowest six feet of this section, which they called the Potapaco member:

Pelecypoda
Venericardia potapacoensis

Gastropoda
- Tornatellaea bella Conrad
- Cylichna venusta Clark
- Ringicula dalli Clark

The following invertebrate species were recorded by Clark and Miller (1912) from the next 20 feet of the section, which they called the Woodstock member:

Pelecypoda
- Corbula oniscus Conrad
- Meretrix subimpressa Conrad
- Pecten dalli Clark
- Ostrea sellaeformis Conrad
- Glycymeris idoneus (Conrad)
- Leda cultelliformis (Rogers)
- Protocardia lenis Conrad

Gastropoda
- Mitra potomacensis Clark and Miller
- Mesalia obruta (Conrad)
- Strepsidura subscalarina Heilprin
- Turitella potomacensis Clark and Miller

Gildersleeve (1942) recorded the following species from this locality:

Pelecypoda
- Ostrea sellaeformis
- Meretrix ovata
- Corbula sp.
- Corbula aldrichi
- Venericardia potapacoensis
- Nucula ovula
- Leda cultelliformis
- Leda parva
- Leda sp.

Gastropoda
- Turritella potomacensis
- Litiopa marylandica

Foraminifera
- Cibicides fletcheri
- Cibicides conoides
- Cibicides lobatulus
- Cibicides sp.
- Planularia sp.
- Bulimina gracilis
- Globigerinia bulloides
- Globigerinia sp.
- Lagena sulcata
- Nonion pizarrensis
- Polymorphina austriaca
- Globulina gibba
- Pyrulina albatrossi
- Rotalia beccarii
- Valvulineria floridans
- Discorbis sp.

Ostracoda
Cytheridea perarcuata
Cytheridea mulleri
Cythere marylandica
Cythere oliveri
Cythere sp.
Bairdiidae subdeltoidea

1.1	13.9	Return to and turn right on State Road 624.
2.1	16.0	Turn left on State Highway 206.
0.7	16.7	Turn right on U. S. Highway 301.
8.8	25.5	Turn left on State Highway 3 at intersection of U. S. Highway 301 and State Highway 3. At this intersection, return to route between Stops 4 and 6.

1.0	91.8	Turn right on State Road 609.
2.4	94.2	Turn left on State Road 677.
0.2	94.4	Turn left on State Highway 3.
5.2	99.6	Cross intersection of State Highway 3 and U. S. Highway 301; stay on State Highway 3.
19.4	119.0	Turn left on State Highway 214 at Atlantic service station.
1.2	120.2	Turn left at Stratford Hall and Plantation.
2.1	122.3	STOP 6: CALVERT, CHOPTANK, AND ST. MARYS FORMATIONS — STRATFORD CLIFFS (1 hour and 15 minutes) Walk upstream from the Old Mill for about 25 yards. The Calvert, Choptank, and St. Marys formations crop out along the river in the Stratford Cliffs.

	Thickness	Description
PLEISTOCENE	40'	Sand, red-brown to buff, coarse-grained, containing some gravel
ST. MARYS FORMATION	3'	Clay, red-brown, very plastic, laminated, contains nodules and laminae of iron oxide.
	5'	Clay, dark gray, very plastic
CHOPTANK FORMATION	35'	Sand, olive, fine-grained, becomes argillaceous upward

	0.5'	Sandstone, red-brown, limonitic
	6'	Sand, brown, fine-grained, argillaceous
CALVERT FORMATION	35'	Clay, olive to brown, compact, sandy, well jointed and stained with iron oxide, contains diatoms, becomes more sandy upward

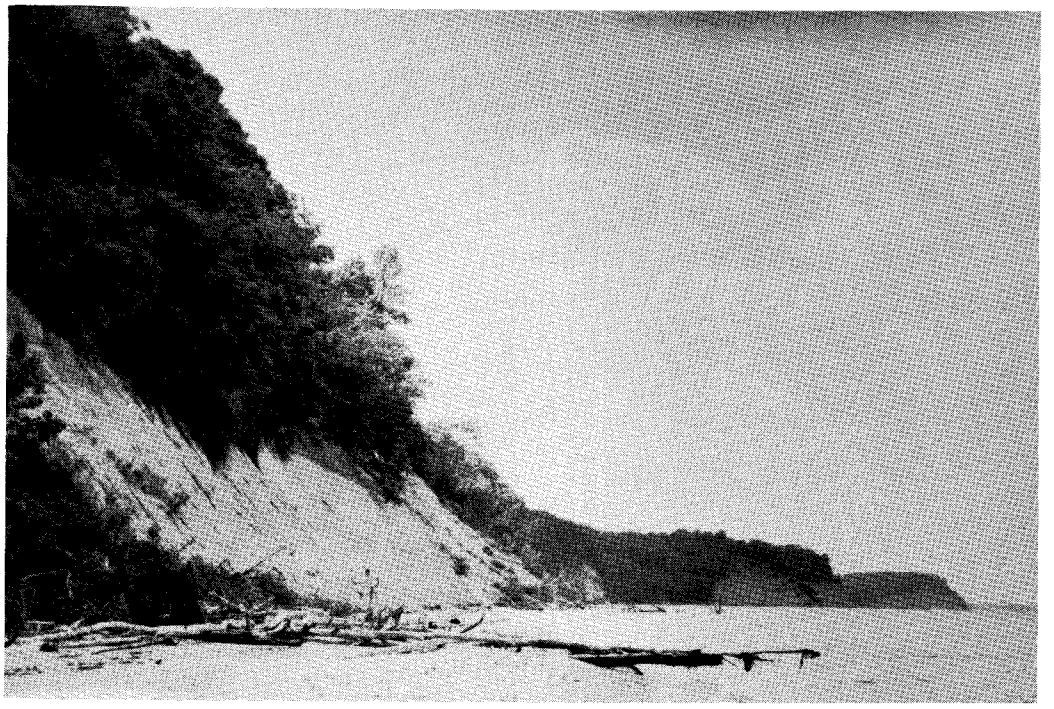
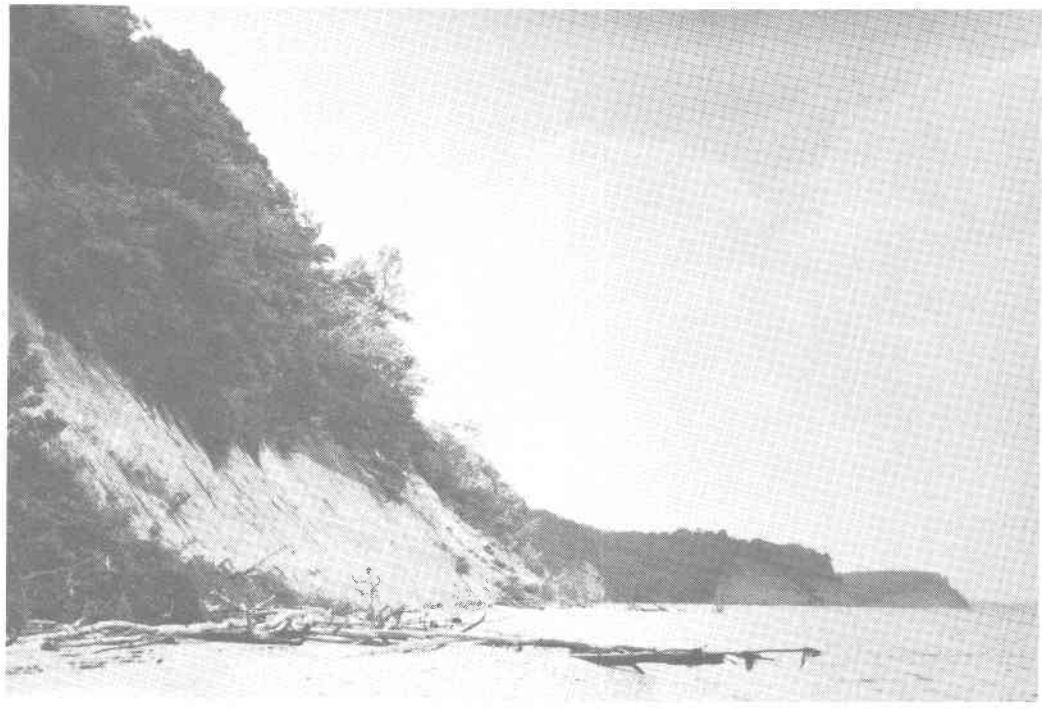


Figure 9. Diatomaceous clays of the Calvert formation

Mansfield (1943) placed the upper limit of the Calvert formation at this locality about 5 feet above a thin bed containing Isocardia. Mansfield recorded the following invertebrate species from the Choptank formation at this locality:

Pelecypoda
- Crassatellites marylandicus (Conrad)
- Crassatellites turgidulus (Conrad)
- Phacoides crenulatus (Conrad)
- Diplodonta subvexa (Conrad)
- Isocardia fraterna (Say) var.
- Cardium sp.
- Venus plena (Conrad)?
- Pecten madisonius Say
- Arca staminea Say
- Pecten marylandicus Wagner
- Astarte obruta Conrad
- Thracia sp.
- Dosinia sp.
- Corbula idonea Conrad

	0.5'	Sandstone, red-brown, limonitic
	6'	Sand, brown, fine-grained, argillaceous
CALVERT FORMATION	35'	Clay, olive to brown, compact, sandy, well jointed and stained with iron oxide, contains diatoms, becomes more sandy upward



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Pelecypoda
- Crassatellites marylandicus (Conrad)
- Crassatellites turgidulus (Conrad)
- Phacoides crenulatus (Conrad)
- Diplodonta subvexa (Conrad)
- Isocardia fraterna (Say) var.
- Cardium sp.
- Venus plena (Conrad)?
- Pecten madisonius Say
- Arca staminea Say
- Pecten marylandicus Wagner
- Astarte obruta Conrad
- Thracia sp.
- Dosinia sp.
- Corbula idonea Conrad

Mansfield (1943) recorded the following invertebrate species from the St. Marys formation from this locality:

Pelecypoda
- Glycymeris subovata (Say) var.
- Arca sp.
- Ostrea disparilis Conrad
- Astarte aff. obruta Conrad
- Euloxa latisulcata (Conrad)
- Chione cf. athleta Conrad
- Spisula confraga (Conrad)
- Corbula sp.

Gastropoda
- Turritella plebeia Say
- Turritella variabilis Conrad

2.1	124.4	Return to and turn right on State Highway 214.
1.3	125.7	Turn left on State Highway 3.
18.2	143.9	Turn left on U. S. Highway 360 at Warsaw.
5.7	149.6	Cross Rappahannock River.
1.3	150.9	Turn left on U. S. Highway 17 - 360 at Tappahannock.
2.5	153.4	Turn left on U. S. Highway 17.
59.7	213.1	Cross York River via George P. Coleman Memorial Bridge.
0.3	213.4	Turn right on Colonial Parkway at Yorktown.
11.4	224.8	Turn right on State Highway 132 Y at Information Center.
0.4	225.2	Turn left on State Highway 132.
0.8	226.0	Turn right on Duke of Gloucester Street.
0.1	226.1	Turn right at William and Mary College and proceed west on U. S. Highway 60 Z or Richmond Road.
0.8	226.9	END OF FIRST DAY'S TRIP

SECOND DAY OF FIELD CONFERENCE
Saturday, October 13, 1962

Departure time, 8:15 a.m. E.S.T. (9:15 a.m. E.D.T.)
Williamsburg, Virginia

Mileage	Accumulative Mileage	Itinerary
0.0	0.0	Proceed to Colonial Parkway.
1.7	1.7	Bear right on State Highway 132 Y.
0.4	2.1	Turn left on Colonial Parkway.
13.3	15.4	Cross State Highway 238 and proceed to Visitor Center of Yorktown Battlefield. Stop and OBTAIN PERMISSION from the Superintendent of Colonial National Historical Park to gain access to the beach area.
0.4	15.8	Turn right on "one way" dirt road.
0.3	16.1	STOP 7: YORKTOWN FORMATION — COLONIAL NATIONAL HISTORICAL PARK, YORKTOWN BATTLEFIELD, NEAR BRITISH REDOUBT #10 (1 hour and 15 minutes). See "Virginia Minerals," vol. 8, no. 3, p. 7 #6 (figures 4 and 5), 1962

Follow path down to the river and walk upstream a short distance. The Yorktown formation crops out at several locations along the right bank of the York River.

	Thickness	Description
YORKTOWN FORMATION	6'	Shell layer, brown, indurated
	12'	Coquina, tan, soft, cross-bedded, slightly sandy, with thin limonitic lenses, and a few large shells
	6'	Coquina, red-brown, slightly indurated, with thin limonitic lenses and a few large shells

Extensive collections of both macro and micro-fossils have been made from the bluffs extending along the York River in this area. Thirty significant fossils from the Yorktown formation at Yorktown are listed (Roberts, 1932):

Coelenterata
Astrangia lineata Conrad
Septastrea marylandica Conrad

Pelecypoda
- Arca centenaria Say
- Arca incile Say
- Asaphis centenaria Conrad
- Astarte undulata Say
- Carditamera arata Conrad
- Crassatellites undulatus Say
- Dosinia acetabulum Conrad
- Glycymeris americana De France
- Glycymeris subovata Say
- Ostrea disparilis Conrad
- Pecten jeffersonius var. edgecombensis Conrad
- Pecten madisonius Say
- Plicatula marginata Say
- Teredo calamus Lea
- Venericardia granulata Say
- Venus tridacnoides Lamark

Gastropoda
- Calliostoma philanthropus Conrad
- Crepidula aculeata var. costata Conrad
- Crepidula plana Say
- Crucibulum constrictum Conrad
- Ecphora quadricostata Say
- Fissuridea redimicula Say
- Oliva litterata Lamark
- Polynices heros Say
- Turritella alticostata Conrad
- Vermetus virginica Conrad

Scaphopoda
- Dentalium attenuatum Say

Arthropoda
- Balanus convavus Brown

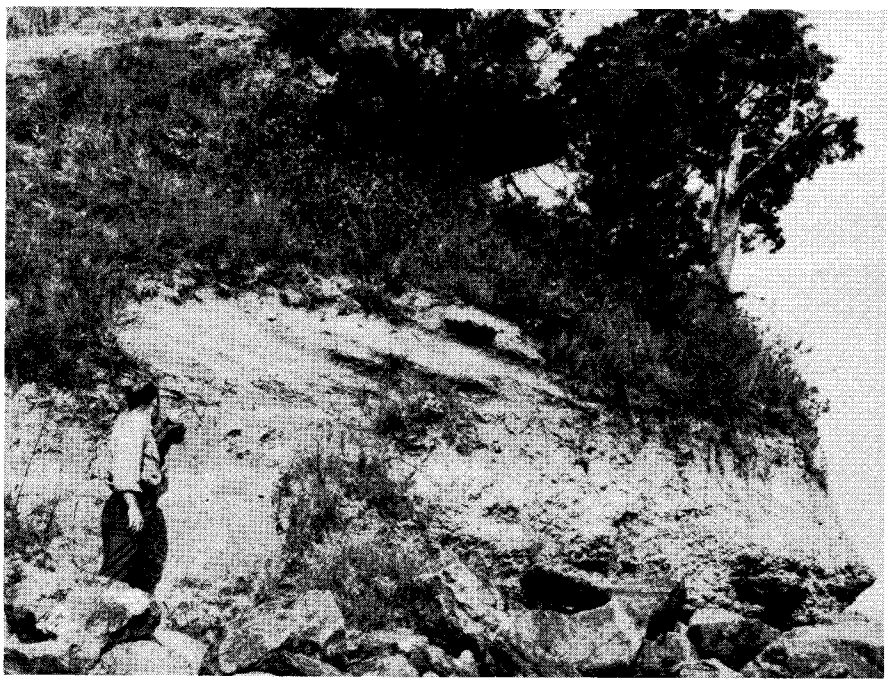


Figure 10. Fossiliferous beds and cross-bedded strata of the Yorktown formation

Pelecypoda
- Arca centenaria Say
- Arca incile Say
- Asaphis centenaria Conrad
- Astarte undulata Say
- Carditamera arata Conrad
- Crassatellites undulatus Say
- Dosinia acetabulum Conrad
- Glycymeris americana De France
- Glycymeris subovata Say
- Ostrea disparilis Conrad
- Pecten jeffersonius var. edgecombensis Conrad
- Pecten madisonius Say
- Plicatula marginata Say
- Teredo calamus Lea
- Venericardia granulata Say
- Venus tridacnoides Lamark

Gastropoda
- Calliostoma philanthropus Conrad
- Crepidula aculeata var. costata Conrad
- Crepidula plana Say
- Crucibulum constrictum Conrad
- Ecphora quadricostata Say
- Fissuridea redimicula Say
- Oliva litterata Lamark
- Polynices heros Say
- Turritella alticostata Conrad
- Vermetus virginica Conrad

Scaphopoda
- Dentalium attenuatum Say

Arthropoda
- Balanus convavus Brown

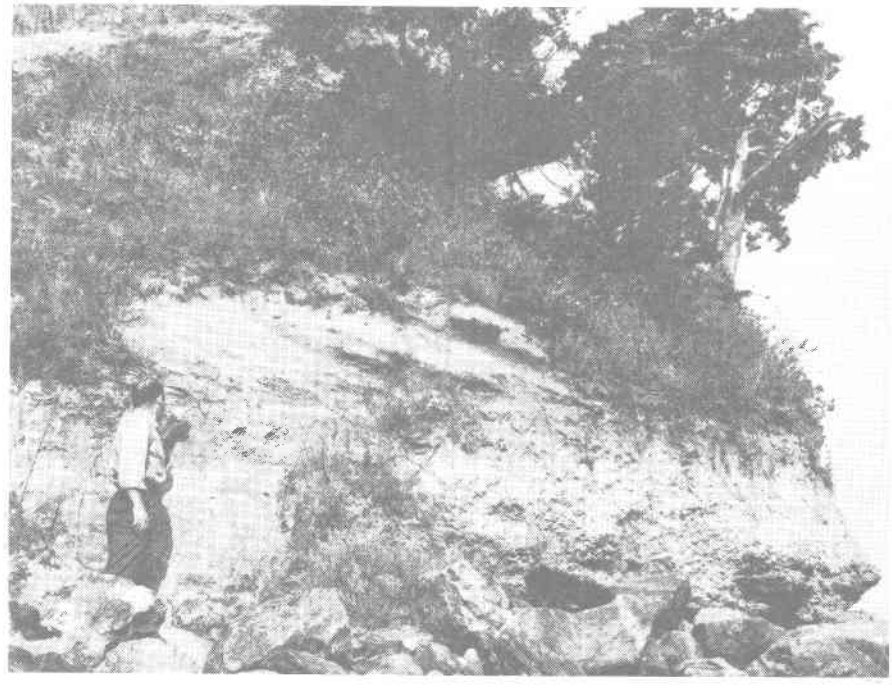


Figure 10. Fossiliferous beds and cross-bedded strata of the Yorktown formation

0.3	16.4	Proceed on "one way" dirt road and turn right on State Highway 238.
0.0	0.0	To alternate stop - STOP 8, turn left on State Highway 238.
0.7	0.7	Turn left on State Road 676.
0.1	0.8	Turn right on first dirt road into parking lot.
0.1	0.9	ALTERNATE STOP — STOP 8: YORKTOWN FORMATION — MOORE HOUSE Follow path down to river and walk upstream about 50 yards. The Yorktown formation crops out for several miles from this point westward along the York River.

Figure 11. Shell marl of the Yorktown formation

	Thickness	Description
YORKTOWN FORMATION	15'	Sand, brown to gray-brown, medium- to fine-grained, slightly fossiliferous
	15'	Shell marl, gray, sandy, slightly argillaceous
	5'	Sand, brown, medium-grained, very argillaceous, fossiliferous

See fossil list of STOP 7

0.3	16.4	Proceed on "one way" dirt road and turn right on State Highway 238.

0.0	0.0	To alternate stop - STOP 8, turn left on State Highway 238.
0.7	0.7	Turn left on State Road 676.
0.1	0.8	Turn right on first dirt road into parking lot.
0.1	0.9	ALTERNATE STOP — STOP 8: YORKTOWN FORMATION — MOORE HOUSE Follow path down to river and walk upstream about 50 yards. The Yorktown formation crops out for several miles from this point westward along the York River.

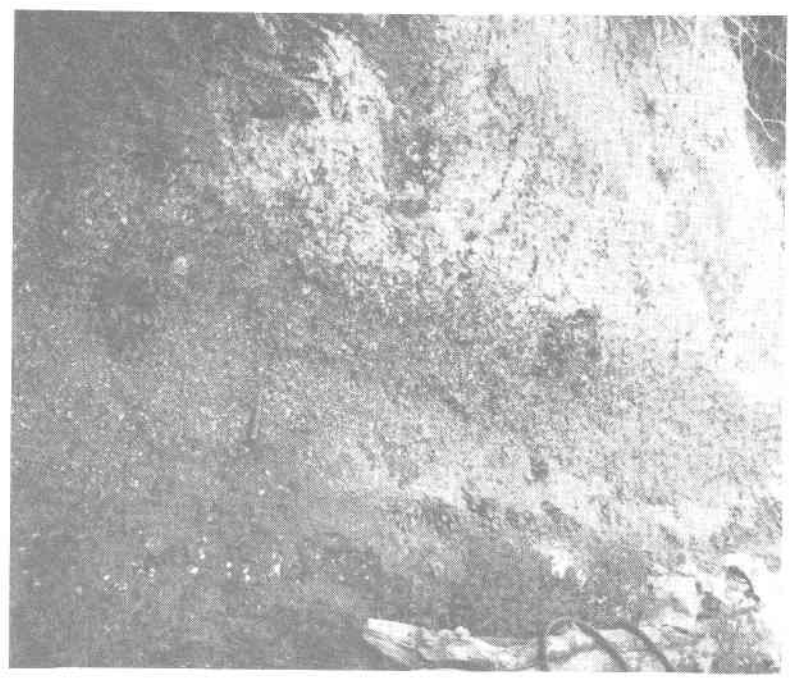


Figure 11. Shell marl of the Yorktown formation

	Thickness	Description
YORKTOWN FORMATION	15'	Sand, brown to gray-brown, medium- to fine-grained, slightly fossiliferous
	15'	Shell marl, gray, sandy, slightly argillaceous
	5'	Sand, brown, medium-grained, very argillaceous, fossiliferous

See fossil list of STOP 7

0.2	1.1	Return to and turn right on State Highway 238.
0.7	1.8	Proceed on State Highway 238 to intersection of State Highway and "one way" dirt road of Yorktown Battlefield.
1.4	17.8	Straight ahead on State Road 1001 at intersection of State Highway 238 and State Road 1001 (about one block).
0.1	17.9	Turn right on U. S. Highway 17 and cross George P. Coleman Memorial Bridge.
24.1	42.0	Turn left on State Highway 14 at Adner.
6.4	48.4	Turn left and stay on (nearest two-lane highway) State Highway 14.
1.8	50.2	Turn right and stay on State Highway 14.
2.6	52.8	STOP 9: ST. MARYS FORMATION — CORBIN CREEK (30 minutes). See "Virginia Minerals," vol. 8, no. 3, p. 7 #5 (figures 4 and 5), 1962

The St. Marys formation crops out along Corbin Creek, on the left immediately below the bridge. Access to the formation may be gained by crossing bridge and walking along path through woods.

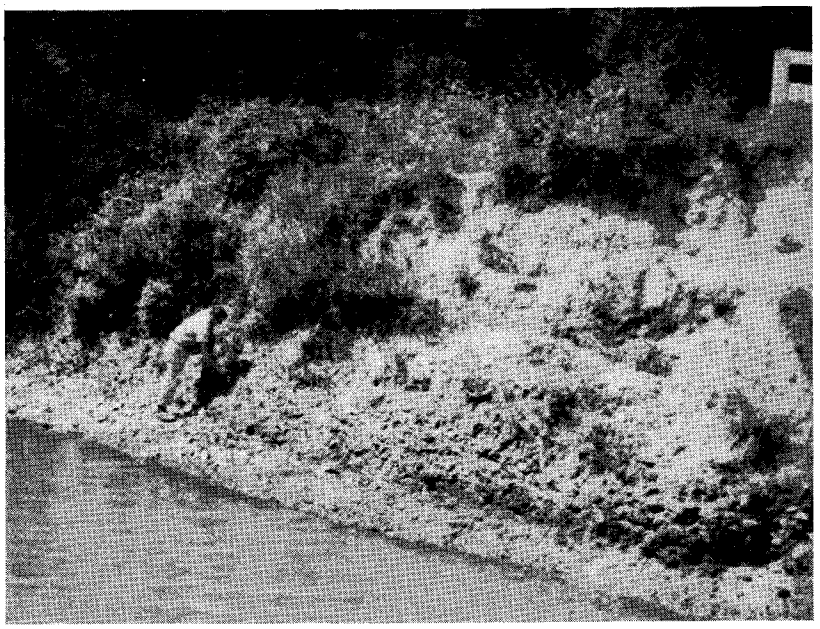


Figure 12. Isognomon maxillatum zone in the St. Marys formation

	Thickness	Description
PLEISTOCENE	5'	Sand, buff, to brown, fine-grained, argillaceous, containing gravel in some places

0.2	1.1	Return to and turn right on State Highway 238.
0.7	1.8	Proceed on State Highway 238 to intersection of State Highway and "one way" dirt road of Yorktown Battlefield.

1.4	17.8	Straight ahead on State Road 1001 at intersection of State Highway 238 and State Road 1001 (about one block).
0.1	17.9	Turn right on U. S. Highway 17 and cross George P. Coleman Memorial Bridge.
24.1	42.0	Turn left on State Highway 14 at Adner.
6.4	48.4	Turn left and stay on (nearest two-lane highway) State Highway 14.
1.8	50.2	Turn right and stay on State Highway 14.
2.6	52.8	STOP 9: ST. MARYS FORMATION — CORBIN CREEK (30 minutes). See "Virginia Minerals," vol. 8, no. 3, p. 7 #5 (figures 4 and 5), 1962

The St. Marys formation crops out along Corbin Creek, on the left immediately below the bridge. Access to the formation may be gained by crossing bridge and walking along path through woods.

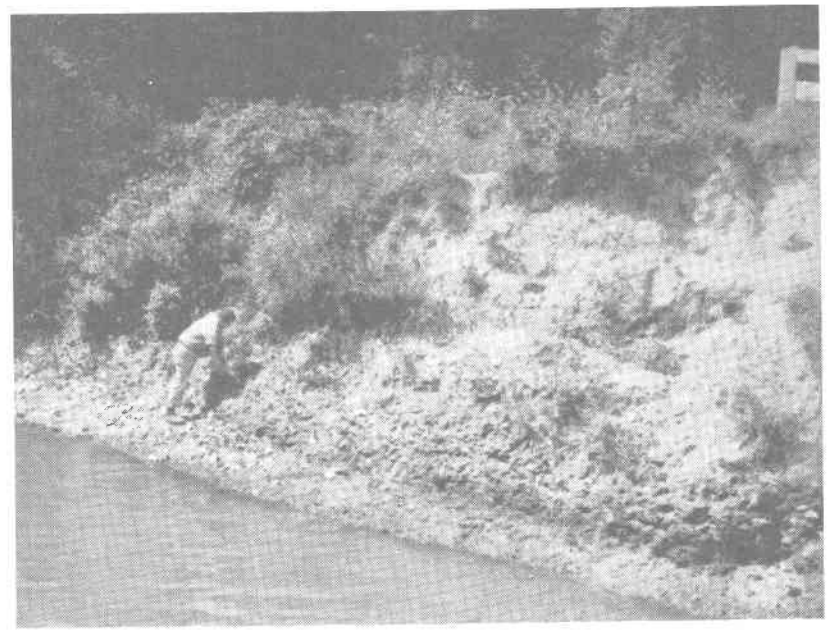


Figure 12. Isognomon maxillatum zone in the St. Marys formation

	Thickness	Description
PLEISTOCENE	5'	Sand, buff, to brown, fine-grained, argillaceous, containing gravel in some places

ST. MARYS FORMATION	5'	Sand, blue-gray, fine-grained, very fossiliferous, argillaceous.

The following invertebrate species from this locality are listed (Ruhle, 1962):

Brachiopoda
- Discinisca lugubris

Pelecypoda
- Isognomon maxillatum
- Chlamys jeffersonia
- Anomia aculeata

Gastropoda
- Calliostoma philanthropum
- Turritella alticostata
- Ecphora quadricostata

Scaphopoda
- Dentalium attenuatum

Arthropoda
- Balanus concavus

1.8	54.6	Proceed to and turn right on State Road 603.
6.6	61.2	Turn left on State Road 612.
2.7	63.9	Turn left on U. S. Highway 17.
7.7	71.6	Turn right on State Road 602 at Oakley.
1.6	73.2	Turn right on State Road 644.
0.6	73.8	Straight ahead on State Road 656, proceed to South Hill Bank.
0.9	74.7	Turn left on Pine Tree Road.
0.4	75.1	Turn right on River Side Drive.
0.3	75.4	STOP 10: ST. MARYS FORMATION – NEAR BOWLER'S WHARF (1 hour) Walk about 100 yards upstream. The St. Marys formation crops out for nearly a mile along the right bank of the Rappahannock River.

	Thickness	Description
PLEISTOCENE	15'	Sand, gray to red-brown, medium-grained, silty, minor amounts of gravel

ST. MARYS FORMATION	12'	Sand, green-gray, very fine-grained, argillaceous, slightly glauconitic, fossiliferous, particularly Spisula (Hemimactra) rappahannockensis Gardner

Figure 13. Fossiliferous argillaceous sand and silt strata of the St. Marys formation

The following fossils were recorded from this area (Clark and Miller, 1912)

Pelecypoda
- Arca staminea Say
- Venus
- Ostrea

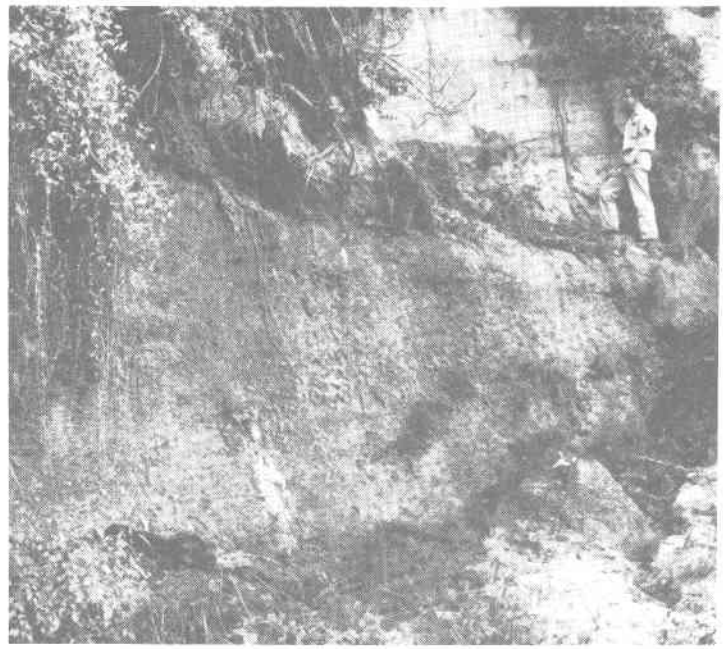
Gastropoda
- Fulgur coronatum Conrad
- Turritella plebeia Say

Scaphopoda
- Dentalium attenuatum Say

Gardner (1943, 1948) recorded the following fossils from this area:

Pelecypoda
- Nucula proxima Say
- Pododesmus (Monia?) philippi Gardner
- Dosinia (Dosinidia) acetabulum Conrad
- Venus (Mercenaria) berryi Gardner
- Macoma virginiana Conrad
- Spisula (Mactromeris) bowlerensis Gardner
- Spisula (Hemimactra) rappahannockensis Gardner
- Kuphus calamus Lea

ST. MARYS FORMATION	12'	Sand, green-gray, very fine-grained, argillaceous, slightly glauconitic, fossiliferous, particularly Spisula (Hemimactra) rappahannockensis Gardner



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- Spisula (Hemimactra) rappahannockensis Gardner
- Kuphus calamus Lea

Gastropoda
Turritella plebeia carinata Gardner

2.2	77.6	Return to and turn right on State Road 602.
1.4	79.0	Turn right on U. S. Highway 17 at Center Cross.
108	187	Return to Fredericksburg via U. S. Highway 17 and Alexandria via U. S. Highway 1.

STRATIGRAPHY

LOWER CRETACEOUS

Potomac Group

Patuxent formation - The formation, named from the Patuxent River, Maryland, (Clark, 1897), constitutes the basal portion of the Potomac group. The Patuxent generally overlies with marked unconformity the crystalline rocks beneath the Coastal Plain sediments. In a limited area around Doswell, about 20 miles north of Richmond, the Patuxent overlies Triassic sediments.

The lithologic character of the Patuxent formation is varied in vertical and in horizontal directions. The deposits consist chiefly of gray to buff arkosic sands and sandstones most of which are cross-bedded. Chloritic clays are locally abundant. Gravels are common in the Patuxent deposits. They occur in distinct beds or are irregularly distributed throughout strata of fine materials. Indurated arkosic conglomerate is present in several areas along the Appomattox and James rivers. The sands of this formation locally are indurated, and over a hundred years ago were used as a building stone. At Aquia Creek a sandstone from this formation was quarried for the construction of the White House, the old portion of the Capitol, and other public buildings in Washington. The old lighthouse at Cape Henry is also built of this Aquia "freestone." Beds of sand grade laterally in layers of clay or the sand and clay beds are interstratified. The Patuxent clays are generally uniform gray to buff in color and therefore can be readily distinguished from the variegated clays of the Patapsco formation.

The general strike of the Patuxent formation throughout Virginia is approximately north. The dip is east at a rate of about 50 feet a mile. The surface of crystalline rocks upon which the formation rests is irregular so that the thickness of the overlying deposits is not uniform. Where exposed, the Patuxent beds are from 250 to 300 feet thick. The Patuxent sands and conglomerates are in general unfossiliferous, but many species of flora have been collected from clay balls, and lenses, and the more argillaceous sands.

The Patuxent waters may have been shallow and estuarine in character. The position of laminations in cross-bedded sands and gravels is evidence that the directions of the currents were diverse. The presence of numerous land plants in the clays shows the proximity to the land (Clark and Miller, 1912).

Patapsco formation - The formation received its name from the Patapsco River, Maryland, (Clark, 1897). The formation overlies unconformably the Patuxent formation in Virginia. The upper surface of the Patapsco is irregular and apparently was eroded in pre-Eocene time. The contact between variegated clays of the Patapsco formation with overlying greensands of the Aquia formation is easily recognized.

The lithology of the Patapsco, like that of the Patuxent formation, is different from place to place. Patapsco sediments are more uniform and finer-grained than those of the Patuxent and consist chiefly of variegated clays that grade into lighter colored sandy clays. In Virginia the sediments are generally lighter in color than those of Maryland and contain smaller amounts of iron oxides. The strike of the Patapsco beds in Virginia is approximately north and the dip is east at a rate of about 30 feet a mile. The thickness of the formation where it is exposed is about 150 feet. The Patapsco deposits contain a few molluscan fossils that lived in a brackish habitat; these fossils are indicative of local estuarine conditions (Clark and Miller, 1912).

UPPER CRETACEOUS - PALEOCENE

Mattaponi formation - Upper Cretaceous - Paleocene sediments are distinguished primarily by the contained Foraminifera and have been named the Mattaponi formation (Cederstrom, 1957). These sediments are recorded from many wells north of the James River. The type section occurs in wells that are in Westmoreland County at Washingtons Birthplace and Colonial Beach. The abundance of fossils in the Mattaponi formation is varied. Lithologically, the unit ranges from variegated clays, commonly mottled, to dark clays and glauconitic sands.

PALEOCENE AND EOCENE

Pamunkey group

Aquia formation - The Aquia formation received its name from Aquia Creek, Stafford County, Virginia (Clark and others, 1901). It overlies unconformably the irregularly eroded surface of the formations of the Potomac group. The formation consists primarily of medium- to fine-grained glauconitic sands, or greensands, that are locally cemented with silica. Some greensands are interbedded with shell layers; commonly these occur in outcrops as ledges and nodules that range up to 4 feet thick. The greensands have minor amounts of muscovite and may weather

to a reddish brown or yellow color because of the iron oxide content. Argillaceous beds are present; there is less clay in the Aquia than in the overlying Nanjemoy formation. Coarse sands and gravels occur near the base of the formation.

The strike of the Aquia formation is approximately north and the dip is east at the rate of 12 to 15 feet a mile. The thickness of the Aquia formation is about 100 feet where it is exposed.

The Aquia formation is divided into two units: the lower, or Piscataway member, and the upper, or Paspotansa member. The Piscataway member received its name from Piscataway Creek, Prince Georges County, Maryland. The Paspotansa member received its name from Paspotansa Creek, King George County, Virginia. During the time the sediments of the Aquia formation were deposited, the climate was slightly warmer than at present and rather uniform and equitable, more like that of eastern South Carolina and Florida (Gildersleeve, 1942); in contrast, however, the Foraminifera present are indicative of cool water (Shifflett, 1948). On the basis of the foraminiferal content, the water is believed to have been deep (Cushman, 1944). Another writer made the notation that the water was at least 50 fathoms deep (Shifflett, 1948). The Aquia formation, according to Shifflett, was deposited in a narrow elongated basin of local extent in eastern Virginia and Prince Georges and Charles counties, Maryland.

Nanjemoy formation - This formation received its name from Nanjemoy Creek, Charles County, Maryland (Clark and others, 1901). It is composed chiefly of fine-grained glauconitic sands or greensands, is less glauconitic and less calcareous than the underlying Aquia formation, and is devoid of indurated beds. Gypsum (selenite) crystals, or rosettes, commonly occur in cavities that have developed at the intersection of joint planes throughout the Nanjemoy formation, particularly in the argillaceous portions. The base of the Nanjemoy is generally marked by a 20-foot thick bed of compact white and pink clay called the Marlboro clay (from Marlboro, Maryland).

The formation has been divided into two members: the lower, Potapaco member, and the upper, Woodstock member; each has a thickness of approximately 60 feet. The Potapaco member was named from Potapaco Creek that is now listed as Port Tobacco Creek, Charles County, Maryland on more recent maps. It is composed chiefly of greensand, which in some places is argillaceous and in others, gypseous. This member, especially in its lower portion (Marlboro

clay), is more argillaceous than the underlying Aquia formation. The Woodstock member was named from the old homestead, Woodstock, that was west of Mathias Point, King George County, Virginia. This member is characterized by fine homogeneous greensands that are less argillaceous than the underlying Potapaco beds.

The strike of the Nanjemoy is approximately north and the dip is east at the rate of 12 to 15 feet a mile. The thickness in outcrop is about 125 feet. The climate, as indicated by the characteristics of fauna in the Nanjemoy formation, was slightly warmer than at present and rather uniform and equitable, more like that of eastern South Carolina and Florida (Gildersleeve, 1942).

UPPER EOCENE
(subsurface)

Chickahominy formation - The Chickahominy formation has been designated as Upper Eocene in age (Cushman and Cederstrom, 1945). These sediments are recorded from wells in the eastern part of the York-James peninsula and the type section is described from wells at the Navy Mine Depot, Yorktown, York County. Lithologically, the unit consists of glauconitic and pyritic blue-gray and dull brown clays.

MIOCENE

Chesapeake group

Calvert formation - This formation received its name from Calvert Cliffs, Calvert County, Maryland (Shattuck, 1902). It overlies unconformably the Nanjemoy and older sedimentary formations and in some places it overlaps the igneous and metamorphic rocks that underlie these formations.

The Calvert formation consists primarily of compact sandy, diatomaceous clay that is dark-gray or olive and buff, where weathered. The clays locally grade into fine-grained, buff sands, or into diatomaceous earth. Diatomaceous earth is the most distinguishing constituent of the formation. This material commonly occurs in bold, almost vertical cliffs that are about 100 feet high in some places. Joints occur in the Calvert formation and are stained with iron oxide.

The strike of the Calvert formation is north and the dip is east at the rate of about 10 feet a mile. The thickness of the beds is approximately 200 feet.

Plants that occur in the Calvert formation are representative of a coastal flora that had an affinity for warm-temperate waters and an environment similar to that existing today in South Carolina, Georgia, and the Gulf Coast region (Berry, 1917). Mann (in Berry, 1917) noted that the diatoms indicate a comparatively shallow, strictly marine habitat with relatively warm or subtropical temperature. The habitat of the Calvert pelecypods, which was in close proximity to an estuary, probably was one of calm, slightly saline waters and muddy bottoms at depths ranging from 20 to 25 fathoms (Mongin, 1959).

Choptank formation - The Choptank formation was named from the Choptank River, Talbot County, Maryland (Shattuck, 1902). It is exposed in a small area of Richmond and Westmoreland counties, Virginia.

The formation consists of dark-brown, unconsolidated, fossiliferous sand interbedded with indurated sand layers. Its attitude has not been definitely determined in Virginia; its thickness is approximately 50 feet. Because of the limited extent and poorly preserved molluscan fauna, very little is known about the Choptank formation in Virginia. Pelecypod fossils in the Choptank formation are believed to have accumulated when they were transported from great depths by strong currents of a transgressive sea (Mongin, 1959).

St. Marys formation - This formation was named from exposures in St. Marys County, Maryland (Shattuck, 1902).

The formation is composed chiefly of sand and clay, with beds that contain greensand. The sand is commonly gray and is yellow to brown where it is stained with iron oxides. Some beds of sand have been consolidated into sandstone layers. Isolated pebbles occur within the formation. The clay of the St. Marys formation is blue to gray and is chiefly unconsolidated. Locally the sands and clays are very fossiliferous.

The strike of the formation is northeast-southwest and the dip is east at the rate of about 10 feet a mile. The maximum thickness of the formation is about 180 feet.

Mansfield (1943) divided the St. Marys formation in Virginia into a lower, nearly unfossiliferous unit that consists of dark-gray sandy clay, and an overlying fossiliferous unit that

contains two faunal zones: the lower or zone 1, the Bulliopsis quadrata zone, and the upper or zone 2, the Crassatellites meridionalis zone. Zone 1 has predominantly blue to greenish sandy clay. Zone 2 consists of bluish sandy clay overlain by loose light-colored sands. The St. Marys formation, in many places, was deposited in a transgressive sea and contains a genera typical of tropical or temperate water (Mongin, 1959).

Yorktown formation - The Yorktown formation was named from exposures near Yorktown, Virginia (Clark and Miller, 1906).

The lithology of the formation consists of coquina, sand, clay, sandy clay, and shell marl. Coquina beds range up to 50 feet thick and cross-bedded structure is well developed in some places. They are composed of pulverized marine molluscan shells, cemented by calcium carbonate and are tan to reddish-brown depending upon the iron oxide content. Locally, the coquina is a soft material, but in places is a consolidated resistant rock that has been used as a building stone. The sands are buff colored, unconsolidated, and commonly fossiliferous. A few grains of glauconite are distributed through the beds of sand. The clays grade into sandy clays. Most of the clay is dark-blue to gray and is very fossiliferous.

The Yorktown formation is one of the most fossiliferous formations represented in Atlantic Coastal Plain sediments. The fauna is mainly molluscan, but other invertebrates and some vertebrates are present.

Mansfield (1943) divided the Yorktown formation in Virginia and North Carolina into two faunal zones: the lower or zone 1, Pecten clintonius zone, and the upper or zone 2, Turritella alticostata zone. Zone 1 consists largely of medium-grained gray to buff sands. Zone 2 has three parts. The lowest part contains coarse sand with many specimens of Chama, gray to buff sands, and laminated clay. The middle part has sands and cross-bedded clays with broken shells. The upper part consists largely of gray to blue sands that weather to buff.

The strike of the formation is northeast-southwest and the dip is toward the southeast at the rate of a few feet a mile. Locally, the beds are horizontal or have a slight dip to the west. The thickness of the formation is approximately 125 feet. Remnants of the dissected Yorktown overlie the crystalline rocks in the area south of Petersburg. North of Virginia the formation is not present and has no exposed equivalent.

At the end of the Miocene (Yorktown) a multitude of species of all sizes and families abounded as in the present-day tropical seas; forms like the Chamas and Crepidulas flourished for a time and then slowly diminished in number (Mongin, 1959). The Yorktown seas were open as indicated by the Ostracoda (Malkin, 1953) and Foraminifera (McLean, 1956) assemblages. The saline seas ranged in depth from 25 to 100 meters. Fossil assemblages of the Yorktown formation more probably represent contemporaneous ecological habitats rather than biostratigraphic zones (McLean, 1956; 1957).

PLIO-PLEISTOCENE

Pleistocene and probable Pliocene sediments consist of a complex series of largely unconsolidated gravels, sands, and loams, partly of fluvial and partly of marine origin. These sediments, which range up to about 50 feet in thickness, overlie the older strata as terrace deposits. They are intimately related to the present surface and cover the entire area, except for steep bluffs where active erosion has exposed the underlying formations. Numerous publications have appeared concerning these deposits, namely those of McGee, Darton, Wentworth, Cooke, and others.

LIST OF FOSSILS

PATUXENT FORMATION

Over 50 plant species are recorded which are diagnostic of the Patuxent formation. Below are listed the more common species which are restricted to this formation (Berry, 1912; Dorf, 1952):

Arthrophyta
- Equisetum lyelli Mantell

Pteridophyta
- Schizaeopsis americana Berry
- Ruffordia goepperti (Dunker) Seward
- Acrostichopteris parvifolia Fontaine
- Dryopteris dentata (Fontaine) Berry
- Onycheopsis brevifolia (Fontaine) Berry
- Taeniopteris nervosa Berry
- Scleropteris elliptica Fontaine

Cycadophyta
- Dioonites buchianus (Ettingshausen) Bornemann
- Zamites crassivervis Fontaine
- Cycadeospermum spatulatum Fontaine
- Podozamites inaequilateralis (Fontaine) Berry

Coniferophyta
- Cephalotaxopsis magnifolia Fontaine
- Cephalotaxopsis brevifolia Fontaine

Angiospermophyta
- Ficophyllum oblongifolium (Fontaine) Berry
- Proteaephyllum ovatum Fontaine
- Rogersia longifolia Fontaine

PATAPSCO FORMATION

About 50 plant species are recorded which are diagnostic of the Patapsco formation. Below are listed the more common species which are restricted to this formation (Berry, 1912; Dorf, 1952):

Pteridophyta
- Acrostichopteris longipennis Fontaine

Cycadophyta
- Dichotozamites cycadopsis

Coniferophyta
- Araucarites aquiensis Fontaine
- Pinus vernonensis Ward
- Widdringtonites ramosus (Fontaine) Berry

Angiospermophyta
- Populus potomacensis Ward
- Populophyllum reniforme Fontaine

Angiospermophyta (continued)
Nelumbites virginiensis (Fontaine) Berry
Nelumbites tenuinervis (Fontaine) Berry
Sapindopsis magnifolia Fontaine
Sapindopsis brevifolia Fontaine
Celastrophyllum parvifolium (Fontaine) Berry
Celastrophyllum acutidens Fontaine
Sassafras potomacensis Berry
Araliaephyllum crassinerve (Fontaine) Berry
Araliaephyllum magnifolium Fontaine
Aristolochiaephyllum crassinerve Fontaine
Sterculia elegans Fontaine
Ulmophyllum brookense (Fontaine) Knowlton

AQUIA FORMATION

The following species are found only in the Piscataway member of the Aquia formation (Clark and Miller, 1912):

Pelecypoda
Phenacomya petrosa (Conrad)
Pholadomya marylandica Conrad
Lithophaga marylandica Clark and Martin
Ostrea compressirostra var. elepidota Dall

Vertebrata
Trionyx virgiana Clark
Synechodus clarkii Eastman
Odontaspis elegans (Agassiz)

The following species of invertebrates are found only in the Paspotansa member of the Aquia formation (Clark and Miller, 1912):

Coelenterata
Paracyathus marylandicus Vaughan
Balanophyllia desmophyllum Milne Edwards and Haime

Brachiopoda
Platidia marylandica Clark and Martin

Pelecypoda
Diplodonta marlboroensis Clark and Martin
Crassatellites alta (Conrad)

Gastropoda
Pleurotoma harrisi Clark
Pleurotoma potomacensis Clark and Martin
Cancellaria potomacensis Clark and Martin
Mitra pomonkeyensis Clark and Martin
Tudicla marylandica Clark and Martin
Calyptraphorus jacksoni Clark
Aporrhais potomacensis Clark and Martin

Among the species of invertebrates which are restricted to the Aquia formation but found in both its members are (Clark and Miller, 1912):

Coelenterata
- Trochocyathus clarkeanus Vaughan
- Eupsammia elaborata (Conrad)

Pelecypoda
- Panopea elongata Conrad
- Meretrix ovata var. pyga (Conrad)
- Dosinopsis lenticularis (Rogers)
- Lucina aquiana Clark
- Venericardia planicosta var. regia Conrad
- Crassatellites alaeformis Conrad
- Crassatellites aquiana Clark
- Ostrea compressirostra Say
- Leda cliftonensis Clark and Martin

Gastropoda
- Turritella mortoni Conrad
- Turritella humerosa Conrad
- Scala virginiana Clark
- Gibbula glandula (Conrad)

The following species of Foraminifera are recorded by Gildersleeve (1942) from the Aquia formation:

- Anomalina bilateralis
- Dentalina baggi
- Nodosaria consorbrina
- Polymorphina gibba
- Robulus americanus
- Nonion pizarrensis
- Rotalia advena
- Discorbis isabelleana
- Epistomina elegans

Gildersleeve (1942) recorded the following Ostracoda from the Aquia formation:

- Cytherella submarginata
- Cytheridea mulleri
- Cythere plebeia
- Bairdia subdeltoidea

Listed below are the more common species of Foraminifera which are recorded from the Aquia formation of Virginia (Cushman, 1944):

- Reophax curtus Cushman
- Spiroplectammina wilcoxensis Cushman and Ponton
- Robulus wilcoxensis Cushman and Ponton
- Darbyella wilcoxensis Cushman and Garrett
- Dentalina cf. communis d'Orbigny
- Dentalina virginiana Cushman
- Guttulina cf. problema d'Orbigny
- Globulina gibba d'Orbigny
- Pseudopolymorphina wilcoxensis Cushman and Ponton
- Sigmomorphina semitecta (Reuss) var. terquemiana (Fornasini)
- Bulimina ovata
- Angulogerina virginiana Cushman
- Lamarckina wilcoxensis Cushman

Foraminifera (continued)
Valvulineria wilcoxensis Cushman and Ponton
Valvulineria scrobiculata (Schwager)
Pulvinulinella obtusa (Burrows and Holland)
Anomalina umbonifera (Schwager)
Cibicides praecursorius (Schwager)
Cibicides howelli Toulmin

The following species of Foraminifera are restricted to the Piscataway member at several outcrops (Shifflett, 1948):

Quinqueloculina cf. harrisi Howe and Roberts
Marginulina toulmini Cushman
Dentalina cf. hexacostata Howe
Dentalina virginiana Cushman
Dentalina wilcoxensis Cushman
Vaginulina plumoides Plummer
Lagena hexagona (Williamson)
Lagena laevis (Montague)
Glandulina abbreviata (Neugeboren)
Glandulina laevigata d'Orbigny
Pseudopolymorphina wilcoxensis Cushman and Ponton
Sigmomorphina semitecta (Reuss)
Polymorphina advena Cushman, var. nuda Howe and Wallace
Nonionella insecta (Schwager)
Gumbelina wilcoxensis Cushman and Ponton
Eouvigerina excavata Cushman
Entosolenia cf. laevigata (Reuss)
Entosolenia cf. marginata (Walker and Jacob)
Entosolenia oslatus Shifflett
Virgulina wilcoxensis Cushman and Ponton
Angulogerina parvula (Cushman and Thomas)
Angulogerina virginiana Cushman
Discorbis amicus Shifflett
Valvulineria wilcoxensis Cushman and Ponton
Valvulineria scrobiculata (Schwager)
Eponides labiomargus Shifflett
Pulvinulinella danvillensis Howe and Wallace
Globigerina compressa Plummer
Globorotalia cf. angulata (White)
Cibicides marylandicus Shifflett
Cibicides neelyi

The following species of Foraminifera are restricted in the outcrop material to the Paspotansa member (Shifflett, 1948):

Ammodiscus incertus d'Orbigny
Trochammina exigua Cushman and Applin
Trochammina howei Cushman
Robulus knighti Toulmin
Stichocibicides cerviculus Shifflett

Below are listed the more common species of Ostracoda which are recorded from the Aquia formation (Schmidt, 1948):

Cytheropteron cf. midwayensis Alexander
Haplocytheridea veatchi aquia Schmidt
Haplocytheridea leei (Howe and Garrett)
Brachycythere marylandica (Ulrich)
Bythocypris parilis Ulrich

Ostracoda (continued)
Paracythereis potomaca Schmidt
Clithrocytheridea virginica Schmidt
Clithrocytheridea malkinae Schmidt
Cythereis bassleri reticulolira Schmidt
Cythereis plusculmenis Schmidt
Cythereis siegristae Schmidt
Xestoleberis longissima Schmidt

The following species of planktonic Foraminifera are recorded from the Aquia formation, and are considered to be diagnostic upper Paleocene species (Loeblich and Tappan, 1957):

Globoratalia pseudoscitula Glaessner
Globoratalia angulata (White)
Globoratalia acuta Toulmin
Globigerina spiralis Bolli
Globigerina triloculinoides Plummer
Globigerina mckannai White

NANJEMOY FORMATION

The following species of invertebrates are found only in the Potapaco member of the Nanjemoy formation (Clark and Miller, 1912):

Bryozoa
Ceriopora micropora Goldfuss

Pelecypoda
Solen lisbonensis Aldrich
Lucina astartiformis Aldrich

Gastropoda
Cypraea smithi Aldrich

The following species of invertebrates are found only in the Woodstock member of the Nanjemoy formation (Clark and Miller, 1912):

Pelecypoda
Meretrix lenis (Conrad)
Venericardia marylandica Clark and Martin
Modiolus marylandicus Clark and Martin
Leda parva (Rogers)

Gastropoda
Levifusus trabeatus Conrad
Pyrula penita Conrad
Turritella potomacensis Clark and Martin

Scaphopoda
Dentalium minutistriatum Gabb

Vertebrata
Galeocerdo latidens Agassiz

Among the forms which are limited to the Nanjemoy formation, but found in each of the members are (Clark and Miller, 1912):

Pelecypoda
Meretrix ovata var. ovata (Rogers)

Pelecypoda (continued)
- Lucina dartoni Clark
- Lucina whitei Clark
- Venericardia potapacoensis Clark and Martin
- Ostrea sellaeformis Conrad
- Leda improcera (Conrad)
- Leda potomacensis Clark and Martin
- Leda tysoni Clark and Martin
- Nucula potomacensis Clark and Martin

The following species of Foraminifera are recorded by Gildersleeve (1942) from the Nanjemoy formation:

- Cibicides fletcheri
- Cibicides conoides
- Cibicides lobatulus
- Bulimina gracilis
- Globigerina bulloides
- Lagena sulcata
- Nonion pizarrensis
- Polymorphina austriaca
- Globulina gibba
- Pyrulina albatrossi
- Rotalia beccarii
- Valvulineria floridans

Gildersleeve (1942) recorded the following Ostracoda from the Nanjemoy formation:

- Cytheridea perarcuata
- Cytheridea mulleri
- Cythere marylandica
- Cythere oliveri
- Bairdiidae subdeltoidea

CALVERT FORMATION

Below are listed the species of invertebrates which are limited to the Calvert formation (Clark and Miller, 1912):

Pelecypoda
- Arca scalaris Conrad
- Arca clisea Dall
- Pecten virgianus Conrad
- Pecten marylandicus Wagner
- Anomia suffini Conrad
- Macoma virginiana Conrad
- Cooperella carpenteri Dall
- Solecardia cossmani Dall
- Sportella constricta Conrad
- Sportella protexta Conrad
- Sportella petropolitana Dall
- Sportella pelex Dall
- Montacuta petropolitana Dall
- Diplodonta leana Dall
- Diplodonta punctulata Lea

Gastropoda
- Drillia lunatia Lea
- Adeorbis obliquistriabus Lea
- Adeorbis concavus Lea

Gastropoda (continued)
Calyptraea centralia Conrad
Calliostoma humilis Conrad
Teinostoma nana Lea
Fissuridea catelliformis Rogers

The following plant species are recorded from the Calvert formation (Berry, 1917):

Pteridophyta
Salvinia formosa Heer

Coniferophyta
Taxodium dubium (Sternberg) Heer

Angiospermophyta
Salix raeana Heer
Quercus calvertensis Berry
Carpinus grandis Unger
Ulmus basicordata Hollick
Planera ungeri Ettingshausen
Ficus richmondensis Berry
Platanus aceroides Goeppert
Podogonium verginianum Berry
Dalbergia calvertensis Berry
Leguminosites calvertensis Berry
Rhus milleri Hollick
Celastrus bruckmanni Alex. Braun
Nyssa gracilis Berry
Fraxinus richmondensis Berry

Listed below are the more common species of diatoms which are recorded from the Calvert formation (Darton, 1911):

Coscinodiscus punctatus
Coscinodiscus gigas
Coscinodiscus oculis-iridis
Systephania corona
Graspedodiscus coscinodiscus
Rhizosolenia americana
Goniothecum odontidum
Goniothecum rogersii
Biddulphia toumeyii
Triceratium obtusum
Triceratium marylandicum
Pleurosigma cf. angulatum
Spongolithus accicularis
Spongolithus caputserpentis

CHOPTANK FORMATION

Mansfield (1943) recorded the following characteristic Choptank invertebrate species, in addition to others of longer range:

Pelecypoda
Isocardia fraterna glenni Gardner
Arca staminea Say
Pecten marylandicus Wagner
Astarte obrupta Conrad

ST. MARYS FORMATION

The following species of invertebrates were found by Clark and Miller (1912) to be restricted to the St. Marys formation:

Pelecypoda
- Corbula cuneata Say
- Venus mercenaria Linne

Gastropoda
- Fasciolaria rhomboidea Rogers

Cushman and Cahill (1933) recorded the following species of Foraminifera that are restricted to the St. Marys formation:

Massilina marylandica Cushman and Cahill
Dentalina consorbrina d'Orbigny var. emaciata Reuss

Below are listed the invertebrate fossils which were found by Mansfield (1943) to be restricted to the St. Marys formation:

Pelecypoda
- Arca idonea Conrad
- Glycymeris tumulus (Conrad)
- Pododesmus (Monia?) philippi Gardner
- Pandora (Kennerlia) dalli Gardner
- Astarte (Ashtarotha) rappahannockensis Gardner
- Chione (Chamelea) dalli Olsson
- Astarte perplana Olsson
- Venus (Mercenaria) berryi Gardner
- Spisula (Mactromeris) bowlerensis Gardner
- Spisula (Hemimactra) rappahannockensis Gardner

Gastropoda
- Terebra (Hastula) simplex Conrad
- Oliva eboreus Conrad
- Fusinus parilis Conrad
- Alectrion peralta Conrad
- Turritella plebeia carinata Gardner
- Calliostoma humile Conrad

YORKTOWN FORMATION

Listed below are the more common species of invertebrates which were found by Clark and Miller (1912) to be restricted to the Yorktown formation:

Pelecypoda
- Nucula taphria Dall
- Arca limula Conrad
- Spisula delumbis Conrad
- Cardium virginianum Conrad
- Gafrarium metastriatum Conrad
- Pandora crassidens Conrad
- Anomia simplex d'Orbigny

Gastropoda
- Scaphella obtusa Emmons
- Seila adamsi Lea
- Drillia limatula Conrad

Gastropoda (continued)
Marginella limatula Conrad
Fulgur pyrum var. incile Conrad
Fulgur maximum Conrad
Urosalpinx trossulus Conrad
Crucibulum auricula var. imbricatum Sorwerby
Crepidula fornicata Say
Fissuridea redimicula Say

Cushman and Cahill (1933) recorded the following species of Foraminifera that are restricted to the Yorktown formation:

Quinqueloculina lamarckiana d'Orbigny
Dentalina communis d'Orbigny
Lagena cf. marginato-perforata (Seguenza)
Virgulina punctata d'Orbigny
Valvulineria floridana Cushman
Amphistegina lessoni d'Orbigny

Below are listed some of the more common species which were found by Mansfield (1943) to be restricted to the Yorktown formation:

Pelecypoda
Pecten (Lyropecten) jeffersonius septenarius Say
Pecten (Placopecten) clintonius Say
Pecten (Placopecten) virginianus Conrad
Pecten (Chalmys) decemnarius Conrad
Astarte symmetrica Conrad
Astarte exaltata Conrad
Astarte roanokensis Gardner
Astarte stephensoni Gardner
Astarte arata Conrad
Astarte hertfordensis meherrinensis Gardner
Astarte berryi Gardner
Astarte (Ashtarotha) undulata deltoidea Gardner
Astarte (Ashtarotha) undulata vaginulata Dall
Astarte (Ashtarotha) concentrica bella Conrad
Erycinella ovalis Conrad
Cardium (Cerastroderma) virginianum Conrad
Cardium taeniopleura Dall
Isocardia fraterna carolina Dall
Cooperella carpenteri Dall
Venus (Mercenaria) campechiensis tridacnoides (Larmarck)
Gemma magna majorina Gardner
Gemma magna virginiana Dall
Macoma virginiana conradi Dall
Abra subreflexa Say

Gastropoda
Fusinus propeparilis Mansfield
Turritella pilsbryi Gardner

The following species of Ostracoda were found by Malkin (1953) not to extend below the Yorktown formation:

Anomocytheridea floridana (Howe and Hough)
Campylocythere laeva Edwards
Clithrocytheridea virginiensis Malkin
Cytherideis agricola Howe and Hadley
Cytherideis rugipustulosa Edwards

Ostracoda (continued)
Cytherideis subaequalis ulrichi Howe and Johnson
Cytherideis echolsae Malkin
Cytherura elongata Edwards
Cytherura forulata Edwards
Cytherura wardensis Edwards
Eocytheropteron yorktownensis Malkin
Hemicythere conradi Howe and McGuirt
Hemicythere schmidtae Malkin
Loxoconcha subrhomboidea Edwards
Favella rugipunctata (Ulrich and Bassler)
Paracytheridea mucra
Paracytheridea vandenboldi Puri
Paracytheridea shattucki curta Malkin
Paracytheridea similis Malkin
Trachyleberis exanthemata gomillionensis (Howe and Ellis)
Trachyleberis vaughani (Ulrich and Bassler)

Malkin (1953) found that the following species of Foraminifera do not occur below the Yorktown formation:

Discorbis consobrina
Discorbis cf. assulata
Eponides aff. mansfieldi
Nonion granosum
Nonion aff. pizzarense
Planulina depressa
Textularia articulata
Textularia mayori

McLean (1956) listed the following species of Foraminifera the range of which is apparently restricted to the Yorktown formation:

Textularoides carteri McLean
Quinqueloculina triloculiniforma McLean
Massilina quadrans carteri McLean
Lagena palmerae McLean
Lagena pseudosulcata McLean
Guttulina pseudocostatula McLean
Bulimina preacanthia McLean
Bolivina lafayettei McLean
Discorbis turrita Cushman
Rotalia limbatobeccarii McLean
Cibicides subloba (Cushman)
Rectocibicidella robertsi McLean
Buccella parkerae Anderson

McLean (1957) listed the following species of Ostracoda which are restricted to the Yorktown formation:

Paracypris choctawhatcheensis Puri
Cytheromorpha cf. warneri Howe and Spurgeon
Loxoconcha purisubrhomboidea Edwards
Cytheropteron talquinensis Puri
Cytherura reticulata Edwards
Clithrocytheridea virginiensis Malkin
Paracytheridea vandenboldi Puri
Cushmanidea echolsae (Malkin)
Pterygocythereis americana (Ulrich and Bassler)
Actinocythereis exanthemata (Ulrich and Bassler)

Ostracoda (continued)
Actinocythereis exanthemata gomillionensis (Howe and Ellis)
Murrayina barclayi McLean
Acuticythereis laevissima Edwards
Cytheretta burnsi (Ulrich and Bassler)
Aurilia conradi (Howe and McGuirt)

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