STRATIGRAPHY OF PLEISTOCENE TERRACE DEPOSITS IN VIRGINIA[1,2]

By
Wayne E. Moore
Virginia Polytechnic Institute
Blacksburg, Virginia

ABSTRACT

Three new post-Yorktown formations underlying Pleistocene terraces are recognized on the Coastal Plain of Virginia south of the James River. Two of these new formations underlie both the Sunderland and the Wicomico terraces. The other new formation underlies the Dismal Swamp terrace and the Princess Anne terrace. A Sangamon age is reasonable for the Wicomico terrace. The Sunderland terrace is interpreted as the subaerial equivalent of the Wicomico terrace and thus of Sangamon age. Terrace deposits cannot universally be given the formation name of the terrace surface they underlie because in Virginia the same formation underlies two different terraces. The Dismal Swamp terrace is interpreted as forming in a tidal lagoon, separated from the open ocean by a chain of barrier islands. The Princess Anne terrace is the open ocean equivalent of the Dismal Swamp terrace and thus of the same age.

---

1. Published with the permission of the State Geologist of Virginia.

2. Presented before the Southeastern Section, Geological Society of America in Tallahassee, Florida, March 22, 1956.

Introduction.-This study of the Pleistocene deposits of the Virginia Coastal Plain was made as a part of the Summer Seasonal Field Investigations sponsored by the Virginia Division of Geology to evaluate the prospects for increased mineral production on the Virginia Coastal Plain. The field work was done during the summer of 1955, and the study was limited to the Virginia Coastal Plain south of the James River. Mr. John Kent Kane II assisted the writer in the field. Dr. Edwin O. Gooch spent three days with the author in the field and made a number of magnetometer measurements. Mr. William McGill, Director, Division of Geology, encouraged the writer throughout this study. The writer is indebted to the following men for their review of the field relationships and their helpful criticism of the writer's interpretation of the data during a field trip in December, 1955: Dr. J. T. Hack, Mr. Allen Sinnott, Mr. G. C. Tibbitts, Jr., Dr. B. W. Nelson, Dr. S. S. Obenshain, Dr. C. I. Rich, and Dr. R. D. Krebs. The writer was aided by the discussions stimulated by those who attended the Virginia Academy of Science Geology Field Trip to review the field relationships.

General.-Figure 1 diagrammatically shows the stratigraphic relationships that exist between the Sunderland, Wicomico, and Dismal Swamp terraces and the underlying sediments. The geomorphic terms "terrace" and "scarp", as used here, refer to land forms only and do not refer to nor imply the existence of any deposits genetically related to them. The distinction is necessary because, as shown in Figure 1, the Sunderland and Wicomico terraces are underlain by the same formation. This clearly indicates that although two distinct geomorphic units exist, the underlying sediments are not so obviously related to one or the other of these land forms. A stratigraphic nomenclature, independent of topographic form, is necessary to describe these formations and to interpret the geologic history of the terraces.

Three formations are necessary to interpret the Pleistocene geologic history of the Virginia Coastal Plain south of the James River. These formations are herein named the Sedley formation, the Kilby formation, and the Nansemond formation. The Sedley formation is younger than the Miocene Yorktown formation, but it is older than either the Sunderland terrace of the Wicomico terrace. The Kilby formation overlies the Sedley formation and directly underlies both the Sunderland and the Wicomico terrace surfaces. The Nansemond formation is younger than the Wicomico terrace, the Sedley formation, and the Kilby formation, and it underlies the Dismal Swamp terrace and the Princess Anne terrace.

Sedley Formation.-The Sedley formation is made up of sands, sandy clays, and clays. It overlies older Tertiary formations, usually Miocene formations. The Sedley formation is typically exposed in roadcuts near creeks and swamps north and east of Sedley, Southampton County, Virginia. The formation is especially well exposed where highway 631 crosses Black Creek. The Sedley formation is also well exposed at the following localities, as is the overlying Kilby formation: Roanoke-Webster brick pit west of Suffolk; on highway 10 east of Hopewell where it crosses Walls Run, a tributary of Powell Creek; on highway 626 where it crosses Gray's Creek northwest of Surry; and on highway 618 where it crosses Seacock Swamp northwest of Ivor.

The exact age of the Sedley formation is unknown except that it is older than the Wisconsin glacial stage and younger than the Miocene Yorktown formation as it is exposed at Suffolk, Virginia. No fossils have been found, as yet, in the Sedley formation. When the work of Stephenson and MacNeil (1954) and Hack (1955) is considered, there exists the possibility that the

Sedley formation is of late Miocene age. In many respects the Sedley formation is much like Hack's North Keys sand (1955) in that it overlies the fossiliferous Tertiary formations and is in turn overlain by a gravel bed. Stephenson and MacNeil found fossils in similar beds in northern Virginia which led them to feel that the beds there were of Yorktown age.

The Sedley formation is thin bedded to massive and of shallow water origin. Within the Sedley formation are bluish-gray clay beds quite similar to younger clays known to be of estuarine and lagoonal origin. At some localities the Sedley formation appears to be conformable with the Yorktown formation, but other localities indicate that it unconformably overlies the Yorktown or older formations. The clays of the Sedley formation have been and are being used as brick clays in the Suffolk area.

The Sedley formation is sandy or silty at most localities. Clay beds become more common to the east beneath the Wicomico terrace. These clay beds are best developed around Suffolk and northeast of Burrowsville. The Sedley formation has a maximum thickness of 40 feet south of Zuni, Virginia along the Blackwater River, but it is normally 20 to 30 feet thick.

The top of the Sedley formation is marked by an iron rich zone consisting of either limonite platelets or alternating thin beds of red clay and white clay. This iron rich zone is an excellent marker for the top of the Sedley formation when the basal cobble zone of the overlying Kilby formation is absent. S. S. Obenshain, C. I. Rich, and R. D. Krebs, soil scientists at Virginia Polytechnic Institute, expressed the opinion in the field that the iron rich zone at the top of the Sedley formation might be caused by ground water concentrations of iron in the upper part of the Sedley formation after the

Kilby formation had been deposited over the Sedley formation. The top of the Sedley formation occurs at an elevation of approximately 50 feet except for a local area around Dendron, Virginia, where the top of the formation rises to an elevation of about 65 feet.

Figure 2 shows the contact of the Sedley formation and the overlying Kilby formation. The following section, which includes the Sedley formation and the Kilby formation, was measured along highway 618 where it crosses the Seacock Swamp south of Crumpler's School in Southampton County:

Sedley-Kilby formations. Section measured April 15, 1956.

Bed	Thickness in feet
Kilby formation	
3. Sand and gravel, clayey, with scattered clay lenses Mottled red and buff colors. To top of hill on road.	16.5
2. Cobble zone at culvert to field road going east.	0.3
Sedley formation	
1. Clay, gray with limonite mottling. Upper five feet becomes more iron stained toward top. Locally there are limonite ledges near top of formation.	11.0

Covered to foot of hill and swamp.

Kilby Formation.-The Kilby formation is named for the town of Kilby in Nansemond County, Virginia west of Suffolk. The formation is well exposed at elevations above 50 feet throughout the area of the Wicomico terrace and along the larger streams which empty into the James River in the Sunderland terrace area. Roadcuts near tributaries to the Nansemond River and to the Blackwater River show excellent exposures of the formation. An especially good exposure of the Kilby formation is located on highway 631 where it crosses Black Creek in Southampton County.

The Kilby formation overlies the Sedley formation (Figures 1 and 2). The base of the Kilby formation is marked by a thin cobble zone along the James River and east of the Blackwater River. The distribution of the Cobble zone is shown in Figure 5. Frequently this zone consists of a single layer of cobbles and boulders ranging from 2 to more than 12 inches in diameter. Most localities show at least some evidence of these large cobbles, and they constitute the best evidence for the base of the Kilby formation. These large cobbles and boulders appear to be confined to this zone, which normally occurs at an elevation of 50 feet. The cobble zone is thickest in the area just west of the Blackwater River. The cobbles are less common and tend to be smaller in the eastern part of the Wicomico terrace, and they are absent, except along the James River, west of a line drawn 2 or 3 miles west of Sedley and Dendron, Virginia. The Kilby formation becomes finer toward the top, where it is a sandy loam, but thin gravel lenses, usually of fine pea-sized gravel, may be found in the upper part of the formation.

The cobble zone at the base of the Kilby formation continues west along the James River to the vicinity of Hopewell; it remains at an elevation of 50 feet. The constant elevation of the base of the Kilby formation is remarkable.

The basal member of the Kilby formation along the Assamposick Swamp and its tributaries consists of medium to coarse sands instead of the cobble zone. Sands or fine gravel, instead of the cobble zone, also mark the base of the Kilby formation south of Holland and Suffolk.

The origin of the Kilby cobble zone is difficult to explain for three reasons: 1) the zone is thin, seldom being as much as one foot thick, 2) boulders 6 to 12 inches in diameter can be found throughout the area covered by the cobble zone, and 3) the cobble zone occurs at a constant elevation of 50 feet except for one local area around Dendron, Virginia. Wentworth (1930) advanced an explanation for these exceptional boulders that seems to explain best their known distribution. Wentworth advanced the theory that these boulders were rafted into the sea by river ice. Wentworth's rafting theory accounts for these facts: 1) some of the boulders are striated by abrasion while the cobbles were held firmly in the ice, 2) the distribution of boulders to the east can be limited by melting the ice floes in the ocean and dropping the rafted boulders, 3) the absence of boulders north of the James River and their wide distribution to the south is explained by a longshore current flowing south, 4) the western limit of the cobble zone resulted from the presence of a shoreline there, and, 5) rafting the boulders into position permits a widespread, thin, horizontal plane of deposition. The most serious objection to Wentworth's ice-rafting theory is its inability to explain without question why this ice-rafting was confined to this one brief period of time.

Rafting the boulders with icebergs will not explain their distribution, as pointed out by Wentworth (1930), because these exceptional boulders are not generally distributed on the Virginia Coastal Plain. These boulders,

in Virginia, are confined to the area shown in Figure 5 south of the James River and to a similar area south of the Potomac River.

The writer considers it unlikely that these cobbles and boulders were transported and deposited by river currents, because of the widespread, random distribution on a horizontal plane of these exceptionally large boulders. There are no features in the sediments to suggest current velocities great enough to transport such large boulders.

Cross-bedding is common in the Kilby formation, and the currents producing the cross-bedding came from the west-northwest. The Kilby formation appears to contain more heavy minerals than the Sedley formation.

Nansemond Formation.-The Nansemond formation is named for the excellent exposures that can be seen in bluffs along the Nansemond River in Nansemond County, Virginia. The type locality is at Newmans Point on the Nansemond River (Figure 3).

The following section was measured at Newmans Point:

Section measured April 15, 1956

Bed	Thickness in feet
Nansemond formation (Pleistocene)	
7. Oyster shells in black loam, to top of bluff	1.0
6. Sand, fine to medium grained, buff colored.	5.2
5. Clay, grey colored with limonite streaks.	6.3
4. Cobbles in sand.	0.3-0.5
3. Soil?, residual. red sandy, with limonite ledges.	2.5
2. Clay, silty and limonitic.	
Unconformity	
Yorktown formation (Miocene)	
1. Yorktown shell marl with abundant mollusks.	1.0-2.0
Total exposed to base of bluff.	16.8-18.0

The Nansemond formation is composed of fine sands, clays, and peat. Locally the beds contain marine fossils, mostly shallow water Mollusca. The Nansemond formation underlies the Dismal Swamp terrace and the Princess Anne terrace. The Nansemond formation is younger than the Sedley or Kilby formation. Near the westernmost margins of the Dismal Swamp terrace, between Reid's Ferry and the Nansemond River, the Nansemond formation laps onto remnants of the Kilby and Sedley formations not eroded away prior to deposition of the Nansemond formation.

The Nansemond formation has been studied most along the Nansemond River and in the western part of the Dismal Swamp terrace because the low relief of the Dismal Swamp terrace does not afford numerous natural exposures. The character of the Nansemond formation in the area where it is best known, and to the east, where it has been seen in excavations, indicates that the formation is a tidal flats deposit that accumulated behind a barrier island chain, now known as Pongo Ridge, which extended in a north-south direction through Oceana, Virginia. Similar deposits are accumulating today between the barrier island offshore and the eastern peninsula of Virginia. The thick peat zones in the Dismal Swamp probably represent peat accumulation in tidal channels and sounds that became cut off from the sea when the barrier islands became continuous.

Conspicuous accumulations of oyster shells occur at the surface on prominent points along the Nansemond River at elevations ranging from 15 to 20 feet. These oyster beds are believed to be fossil accumulations along the Nansemond River, but their occurrence at the surface makes it possible for them to be artificial and the result of human activities. These oyster beds are believed to be fossil because they are confined to those points whose surface elevations lie below 20 feet and to those points that extend to within

a given distance from the axis of the Nansemond estuary.

Stratigraphic Implications.-The new formation names proposed here are necessary because the names "Sunderland formation" and "Wicomico formation" are meaningless. Both of these terraces are underlain by the same formation, not two different formations as was previously believed. Similarly, one formation underlies both the Dismal Swamp and Princess Anne terraces.

These new stratigraphic names, however, do not in themselves solve the problem. The previous conception of the relationships between Atlantic Coastal Plain Pleistocene terraces and their associated sediments is shown in Figure 4. This concept necessitates a depositional origin for the terraces and requires that each terrace represent a different age. Early in this study it became obvious that the stratigraphy of the terrace sediments was not in harmony with the terrace relationships as they are shown in figure 4.

How can the fact that one formation underlies two terraces be incorporated into the generally held concept that these terraces constitute two different surfaces formed at two different times of Pleistocene sea level maxima? These sea level maxima are believed to coincide with interglacial stages when the earth was ice free. The writer has not been able to incorporate this stratigraphic fact into this older idea.

Sunderland-Wicomico Relationships.-Wentworth (1930) made a number of observations and conclusions in connection with his excellent study of the sand and gravel resources of the Coastal Plain of Virginia which the writer's own observations confirm. There are three of these that are fundamental to the problem posed above:

1. The Sunderland terrace is underlain by sediments which appear to be primarily fluvial in origin.

2. The Wicomico terrace is underlain by sediments which are primarily marine in origin.

3. South of the James River and along the Potomac River there are areas underlain by cobbles and boulders of exceptional size. South of the James River this cobble zone is the basal member of the Kilby formation (Figures 1 and 5).

The distribution of the cobble zone, shown in Figure 5, is not controlled by the Surry scarp which separates the Sunderland terrace from the Wicomico terrace. This cobble zone is horizontal. The sediments underlying the cobble zone, the Sedley formation, have a finer texture than the overlying Kilby formation. The sedley formation also underlies both the Sunderland terrace and the Wicomico terrace. The writer can interpret these facts concerning the sediments underlying the Sunderland and Wicomico terraces in only one way—the Sunderland and Wicomico terraces are of the same age and are simply the subaerial and submarine equivalents of each other; they do not constitute two different sea level stands nor two different interglacial stages.

Let us summarize the evidence for this interpretation:

1. The Sunderland and Wicomico terraces are underlain by the same formation, coarser grained and more poorly sorted to the west beneath the Sunderland terrace but finer grained and better sorted to the east beneath the Wicomico terrace. This is the Kilby formation.

2. The base of the Kilby formation consists of a cobble zone made up of cobbles and boulders of exceptional size. This cobble zone underlies both the Sunderland terrace and the Wicomico terrace. Wentworth believed that these exceptional boulders constituted stones carried downstream and into the sea by river ice. The pattern of their distribution is best explained by this theory.

3. A profile from the Sunderland terrace across the Surry scarp onto the Wicomico terrace is almost identical with a profile across the barrier islands on the Eastern Shore of Virginia into the Atlantic Ocean (Figure 6). The upper profile of the Sunderland terrace, the Surry scarp, and the Wicomico terrace was made from topographic maps along a line perpendicular to the Surry scarp about two and one-half miles south of Surry, Virginia. The lower profile was made from navigation charts and is across Cobb Island and perpendicular to the shore.

4. Although the Sunderland terrace is more dissected and the underlying sediments more oxidized than is the case for the Wicomico terrace, this does not in itself mean that the surface is older than the Wicomico surface. If the Sunderland and Wicomico terraces are subaerial and submarine equivalents, the Sunderland terrace would have been subjected to weathering during the entire time that it was forming. The Wicomico terrace would have been subjected to subaerial weathering and erosion only since the time that sea level fell and exposed it.

You may ask why there are not two formations instead of just one if the Sunderland terrace is underlain by fluvial sediments and the Wicomico terrace is underlain by marine sediments. Only one formation can be mapped for two reasons:

1. The transition between the fluvial sediments beneath the Sunderland terrace and the marine sediments beneath the Wicomico terrace is gradual. The principal differences between the two areas is one of particle size and degree of sorting. The continuity of the basal cobble member of this formation also indicates the physical unity of the Kilby formation.

2. The Kilby and Sedley formations can be separated readily, but it has not been possible to substantiate any formations lying solely beneath the Sunderland terrace or the Wicomico terrace.

The sequence of events which led to the development of these formations and terraces is relatively simple. The Sedley formation accumulated under estuarine conditions while sea level was rising as the ice from the preceeding glacial stage melted. The pre-Sedley estuary of the James River became filled with sediment at the end of Sedley time. This ended the deposition of the Sedley formation.

Deposition of the Kilby formation commenced when river ice began to raft cobbles and boulders down the James River. At this time the shoreline was essentially north-south and limited the distribution of cobbles to the west. As the river ice melted in the sea, the distribution of cobbles was limited to the east and to the south. Longshore currents prevented ice drift, and thus cobble deposition, north of the James River. After the James River became graded, all additional sediment carried to the sea was deposited on the growing delta of the James River. As the delta was extended seaward, the shoreline along the southern part of the delta assumed a more northeast trend until sea level fell as the next glacial stage began. This sea level drop exposed the Surry scarp and the Wicomico surface. The Sunderland terrace surface represents the subaerial portion of this delta. The Sunderland-Wicomico surface is a depositional profile.

If the Wicomico and Sunderland terraces are not submarine and subaerial equivalents, then the only alternate explanation is that the Wicomico terrace is a terrace of marine erosion. The width and the low gradient of the Wicomico surface makes an erosional origin difficult to conceive, although it must be considered as a possibility.

Age of Sunderland-Wicomico Terraces.-No new factual information concerning the age of these terraces is available, but certain age interpretations seem more reasonable than others. A Sangamon age seems likely for the Wicomico terrace from two sources:

1. Leverett (1934) has traced Illinoian gravels into the Wicomico terraces in Pennsylvania. This is the only positive correlation between glacial and marine events in this general area. This suggests that the Wicomico terrace can be no older than the Sangamon. If the Wicomico terrace of Leverett is the equivalent of the Wicomico terrace in Virginia, the surface can hardly be younger than Sangamon unless it is a terrace of erosion. This is considered unlikely.

2. Estimates for the amount of sea level rises yet to occur when all glacial ice has melted range from about 60 feet to 160 feet (Flint, 1947; Trowbridge, 1954). The latest estimates place the figure at about 125 feet. A sea level rise of 110 feet would just flood the Wicomico terrance, but would not cover the Sunderland terrace in Virginia. This would indicate that barring substantial and fortuitous crustal movements in the area or sea level changes independent of glaciation, only one glacial stage has occurred since the Wicomico terrace was formed.

Because the Sunderland and the Wicomico terraces are underlain by the same formation, it would seem that the Sunderland terrace is also of Sangamon age. If the evidence for a Sangamon age for the Wicomico terrace is correct, then the Sunderland terrace can be older than Sangamon only if the Wicomico terrace is a terrace of erosion. These two terraces are believed to be the same age. A Sangamon age seems most likely.

The Dismal Swamp and Princess Anne terraces are also subaerial and submarine equivalents. These two terraces are separated by a sand ridge known as Pungo Ridge which is interpreted as a barrier island chain comparable to the barrier islands off the present Atlantic coast. The Nansemond formation, which underlies the Dismal Swamp-Princess Anne terrace, consists mostly of sediments that accumulated in the lagoon between the Pungo Ridge and the mainland. Similar sediments are accumulating today between barrier islands off the Eastern Shore of Virginia and the peninsula. The formation of the Dismal Swamp-Princess Anne terrace probably occurred during a warm stage in the Wisconsin. The radiocarbon age of the past in the Dismal Swamp is over 20,000 years. The Princess Anne terrace, which lay seaward from the Pungo Ridge, was formed as a submarine surface.

Bibliography

Clark, W. B., and Miller, B. L., 1912, Physiography and geology of the Coastal Plain province of Virginia: Va. Geol. Survey, Bull. IV.

Flint, R. F., 1947, Glacial geology and the Pleistocene epoch: New York, John Wiley and Sons, pp. 1-589.

Hack, J. T., 1955, Geology of the Brandywine Area and origin of the upland of southern Maryland: U. S. Geol. Survey Prof. Paper 267-A, pp. 1-41.

Leverett, F., 1934, Glacial deposits outside the Wisconsin terminal moraine in Pennsylvania: Pa. Geol. Survey, 4th Ser. Bull. G-7, pp. 1-123.

Stephenson, L. W., and MacNeil, F. S., 1954, Extension of Yorktown formation (Miocene) of Virginia into Maryland: Geol. Soc. America Bull., Vol. 65, No. 8, pp. 733-738.

Spangler, W. B., and Peterson, J. J., 1950, Geology of Atlantic Coastal Plain in New Jersey, Delaware, Maryland, and Virginia: Am. Assoc. Petrol. Geol. Bull., Vol. 34, No. 1, pp. 1-99.

Trowbridge, A. C., 1954, Mississippi River and Gulf Coast terraces and sediments as related to Pleistocene history: Geol. Soc. America Bull. 65, No. 8, pp. 793-812.

Wentworth, C. K., 1930, Sand and gravel resources of the Coastal Plain of Virginia: Va. Geol. Survey Bull. 32, pp. 1-146.