GEOLOGY AND MINERAL RESOURCES OF THE ASHLAND QUADRANGLE, VIRGINIA

by

Robert E. Weems

1982

OPEN FILE REPORT 82-2

VIRGINIA DIVISION OF MINERAL RESOURCES

CONTENTS

	Page
Abstract	1
Introduction	3
Stratigraphy	3
Upper Paleozoic Rocks	3
Petersburg Granite	5
Triassic System	5
Doswell Formation	5
Stagg Creek Member	6
Falling Creek Member	8
Newfound Member	9
Jurassic System	12
Diabase dikes	12
Cretaceous System	12
Patuxent Formation	12
Tertiary System	13
Aquia Formation	13
Marlboro Clay	15
Chesapeake Group	15
Lower cycle	15
Upper cycle	17
Sands and gravels	18
Quaternary and Tertiary(?) System	19
Gravel and sand	19
Colluvium	21
Alluvium	21

Economic Geology 22

Coal 22

Shell and glauconitic marls 22

Gravel 23

Clay materials 24

Diatomaceous sediments 24

Geologic Factors Affecting Land Modification 24

References 30

Index .....

ILLUSTRATIONS

Plate | Page

1. Geologic map of the Ashland quadrangle, Virginia .....

Figure | Page

1. Index map 4
2. Circular diagrams 7
3. Boulder bed 14

TABLES

1. Summary of rock characteristics and geologic and economic factors affecting land modification in the Ashland quadrangle 26

ABSTRACT

The Ashland quadrangle is underlain by rocks and sediments ranging in age from upper Paleozoic (about 323 million years) to Recent in age. The oldest rock unit is the Upper Devonian or Lower Mississippian Petersburg Granite. Rocks and sediments of Triassic (Doswell Formation), Jurassic (diabase dikes), Cretaceous (Patuxent Formation), Paleocene (Aquia Formation, Marlboro Clay), Miocene (Chesapeake Group in part), Pliocene and Pleistocene (Chesapeake Group in part, terrace gravels) ages are represented. The major structural feature in the area is the Taylorsville basin. It is the fault bounded to the northwest and southeast. Three small faults were observed along the southeast margin of the basin in this quadrangle. The basin sediments and surrounding bedrock are largely covered in this quadrangle by sediments of the Coastal Plain (Cretaceous to Recent in age), which dip eastward at an angle of less than one degree and also thicken in an easterly direction. The most prominent units geomorphically are the Pliocene/Pleistocene terrace gravels, which form a series of nearly flat terrace surfaces bounded by relatively steep slopes which descend in stairstep fashion from the uplands toward the major streams.

Coal, shell marl, glauconitic shell marl, and gravel have all been exploited in this quadrangle. The first three resources were extracted only in the 19th century, but gravel is presently being excavated.

Because most of the area is covered by thin terrace sands, clays, and gravels, the natural soil fertility is low but the soil textures are frequently good for farming and with fertilizers produce good crops. These terrace deposits are easily excavated and shallow excavations

should encounter no hard bedrock that may require blasting or drilling. The two highest terrace gravels and the Cretaceous Patuxent Formation are excellent aquifers giving the area good to excellent ground water potential.

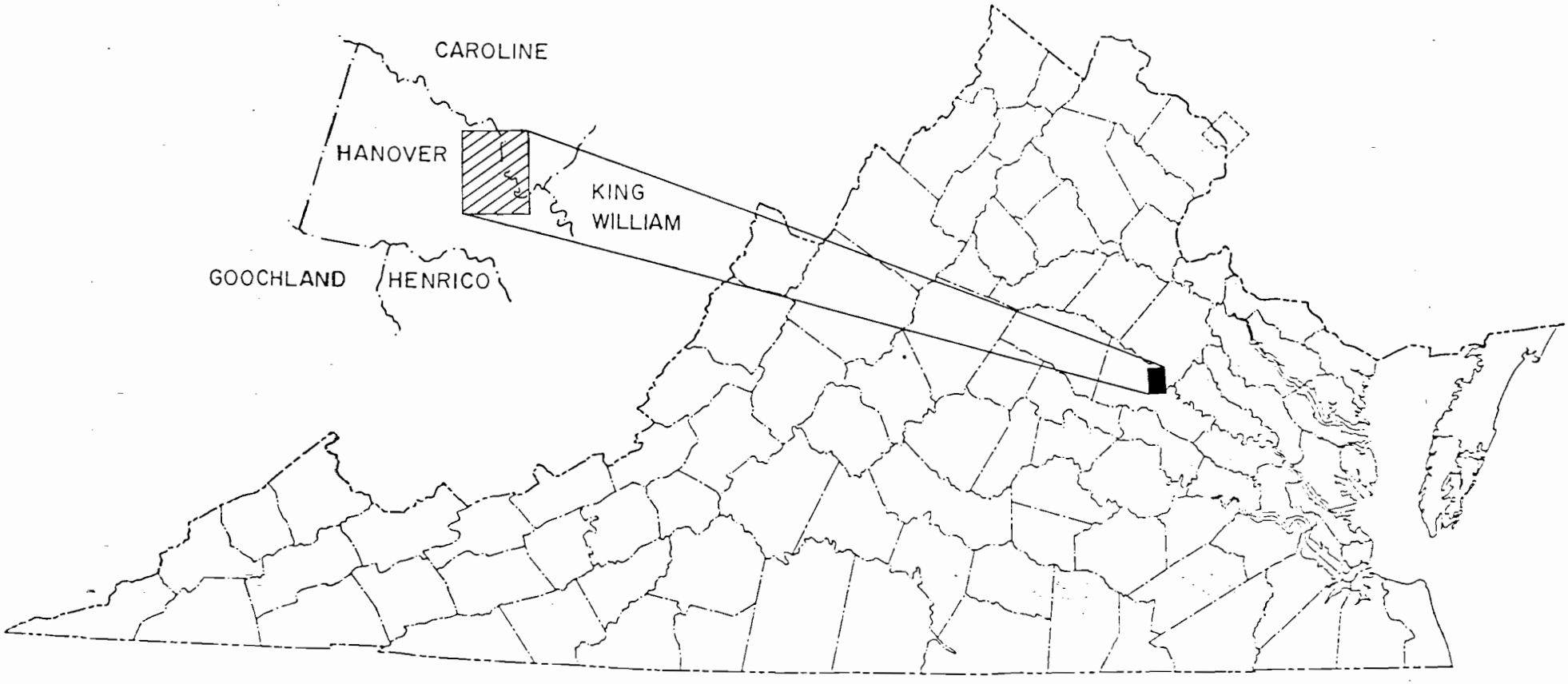
INTRODUCTION

The Ashland 7.5-minute quadrangle, located 15 miles (24 km) north of Richmond, Virginia, in Hanover County, includes an area of 59 square miles (154 sq. km, Figure 1). All streams in the quadrangle are part of the Pamunkey River drainage system, except for Stony Run in the far southwest corner which is part of the James River drainage system. The quadrangle lies along the western border of the Coastal Plain Stream-flow patterns were originally developed on low, flat terrace surfaces which are now deeply dissected. The larger streams, which have cut down to consolidated rock (Triassic or older), are partially adjusted to the grain of the basement lithologies. The terrain ranges from 30 to 260 feet (9-79 m) above sea level, with steep bluffs occurring only locally where river meanders are cutting deeply into their banks. Formerly the area was largely agricultural but suburban growth adjacent to Interstate Highway 95 is rapidly altering the character of the area.

Early geologic reconnaissence of this region was conducted by Rogers (1884). Knowlton (1889, Watson (1913), Sanford (1913), Clark and Miller (1912) and Roberts (1928) have briefly commented on the geology of this quadrangle.

STRATIGRAPHY

UPPER PALEOZOIC ROCKS


CAROLINE
HANOVER
KING
WILLIAM
GOOCHLAND
HENRICO

Petersburg Granite

The oldest rock unit which crops out in this quadrangle is the Petersburg Granite of Stose. This unit has been dated at 323± 10 million years in age (Wright and others, 1975) which indicates it is latest Devonian or earliest Mississippian in age. The granite crops out only in a small area near the confluence of the North Anna and South Anna rivers (Locality 1) and along a small tributary stream south of the South Anna in the eastern half of the quadrangle. Several wells dug during the course of field work south and southeast of Ashland were observed to have bottomed in granite, indicating that it also occurs beneath the younger coastal plain sediments south and east of the outcrop area. One fresh, typical sample (R-5284) has the following mineralogical composition: quartz 32%, potassium feldspar 43%, plagioclase feldspar 21% and muscovite 4%. Near faults the granite has a mylonitic texture and locally in the fault zones has undergone extensive chloritization.

TRIASSIC SYSTEM

Doswell Formation

Rocks of Triassic age occur in the Taylorsville basin, a fault-bounded graben with a pronounced northwest tilt. The major bounding fault is the Fork Church fault along the northwest side of the basin in the Hanover Academy quadrangle (Weems, 1980a, 1981). Along the southeast side of the basin several small faults have been recognized which suggest an en echelon down drop of beds along that margin of the basin (Section B-B'). Palynomorphs extracted from the sediments of the

basin indicate that deposition occurred during late Middle Carnian and probably early Late Carnian (early Late Triassic) time (Cornet, 1977). The Triassic rocks in the Taylorsville basin are defined as the Doswell Formation with three conformable members (Weems, 1980a).

Stagg Creek Member

The Stagg Creek, the oldest member of the Doswell Formation, is named for the section exposed along Stagg Creek south of State Route 54, Hanover Academy quadrangle (Weems, 1980a). The member consists mostly of sandstone and conglomerate containing clasts of the Petersburg granite (Figure 2) and is about 800 feet (244 m) thick. The best exposure in the Ashland quadrangle is in bluffs along the south bank of the South Anna River 1 km west of where the Chesapeake and Ohio Railroad crosses that river (Locality 2). East of the Chesapeake and Ohio Railway trestle over the South Anna River a poor exposure of the Triassic-granite contact, in which the granite is heavily saprolitized, suggests a nonconformable contact with the granite may define the base of this member. Elsewhere in the quadrangle exposures of the Triassic-granite contact clearly are mylonitic fault zones. The top of the Stagg Creek Member is defined to be at the base of the first occurrence in the section of a black shale or flaggy, laminated sandstone of the overlying Falling Creek Member.

To supply large quantities of sand and clasts in Triassic time, surrounding lands must have eroded steadily and had well established drainage channels. The lack of extremely angular cobbles, however, suggests that no prominent fault scarps existed at this early stage

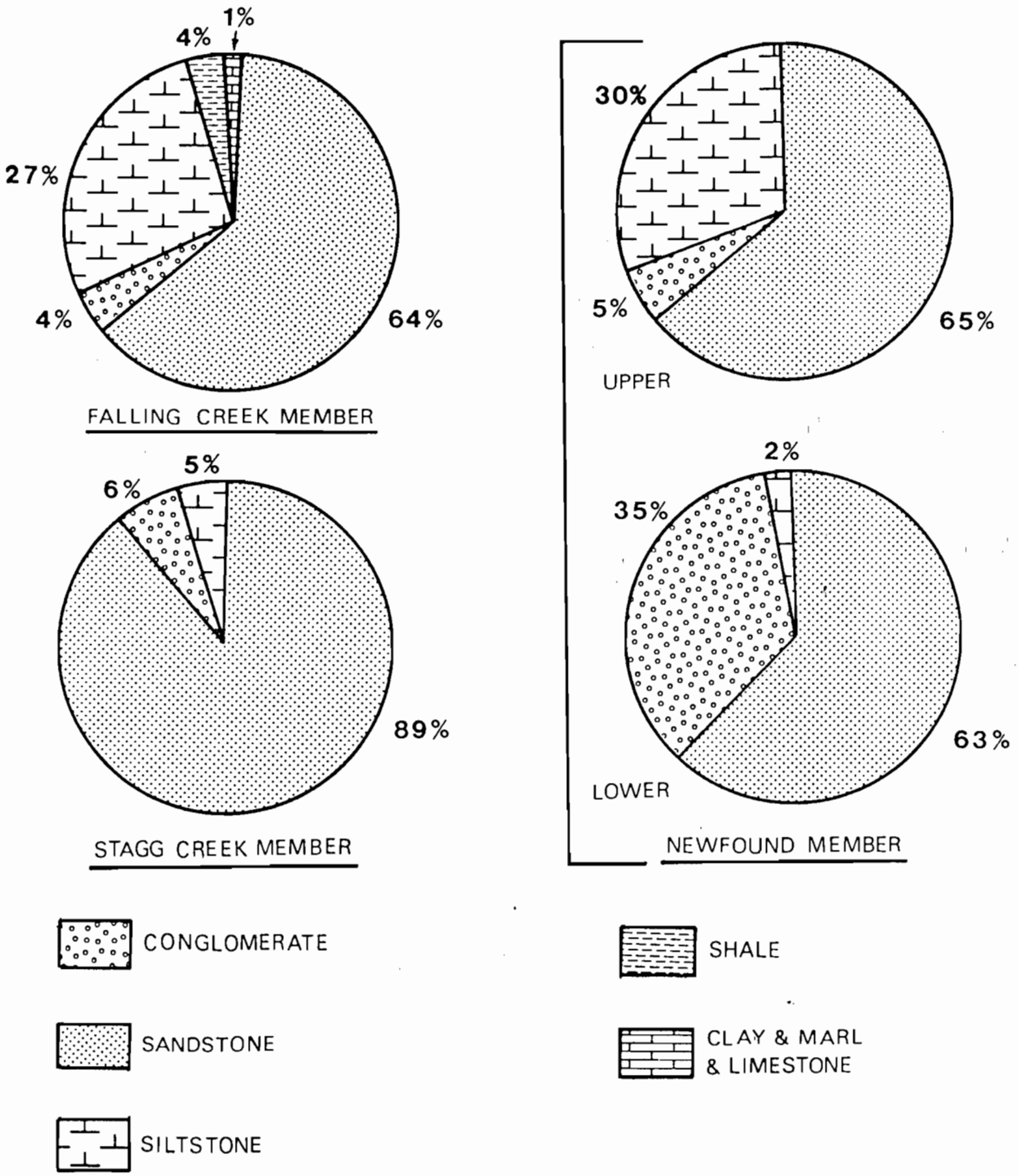


Figure 2. Circular diagrams showing relative proportions of different lithologies in the members and facies within the Doswell Formation.

along the basin margins. The lack of shales or well-laminated sandstones in the basin suggests that the basin floor, while lower than the surrounding terrain, was generally well above the water table. No fossils except palynomorphs have been recovered from this member (Cornet, 1977).

Falling Creek Member

The middle member of the Doswell Formation is the Falling Creek Member. Vertebrate remains of two fish, Dictyopyge macrurus and D. meekeri (Schaeffer and McDonald, 1978) and three archosaurs (Rutiodon cf. R. carolinensis, Doswellia kaltenbachi and an unidentified rauisuchid (Weems, 1980b)) have been recovered by the author. Palynomorphs from this member indicate it is entirely of Late Middle Carnian age Cornet, 1977). The average composition of this 1200 foot (366 m) thick member is shown in figure 2. Siltstones, shales and flaggy fine- to medium-grained sandstones predominate. The less resistant siltstones and shales are not well exposed in most places, but the small creeks leading into Falling Creek contain numerous small outcrops of the shales and siltstones. It is from such exposures along and near Falling Creek that this member is named (Weems, 1980a). Although a few quartz-rich conglomerates occur in this horizon along Falling Creek and along the South Anna River, there is no compelling evidence to suggest that there was a significant change of relief at the edge of the basin during deposition of the Falling Creek Member. The shales, siltstones, fine-grained sandstones and occasional coals indicate low relief and high water table in the basin.

Most siltstones are gray to black. The prominent bedding in many of the shales and the occurrence of presumably fresh-water fossil fish indicates that most of these siltstones and shales represent lacustrine environments of deposition. The mottled appearance of some of the siltstones and the lack of stratification in others is interpreted to indicate that they have been bioturbated. Since no marine fossils have been found in the Taylorsville basin, these siltstones are assumed to represent paludal environments or possibly well aerated lake bottoms. The most complete exposed section of this member is along the south bank of the South Anna River east of Interstate 95 (Locality 3).

Newfound Member

The Newfound is named for exposures along small tributaries of the Newfound River in the Hanover Academy quadrangle (Weems, 1980a). The base of this member is marked by the last occurrence of black shale, gray micaceous laminated siltstone, or flaggy sandstone in the underlying Falling Creek member. The Newfound Member is about 3000 feet (914 m) thick and can be divided into two broadly intertonguing facies, distinguished by the abundance or scarcity of siltstones and conglomerates.

Conglomerate/sandstone facies: This facies is best exposed along the Richmond, Fredericksburg and Potomac Railway between the South Anna and Little Rivers (Locality 4). Other excellent exposures occur in the bluffs along the South Anna River just east of U. S. Highway 1 (Locality 5) and in the bluffs along Little River just west of U. S. Highway (Locality 6). The conglomerate/sandstone facies consists predominantly

of massive sandstones and conglomerates, with siltstones rare to absent (Figure 2). Occassional trunk casts of Araucarioxylon are found, but otherwise megafossils appear to be absent. Clasts in the conglomerates are generally subrounded to rounded, and consist of vein quartz, biotite gneiss, and mylonite. This suggests transport from the northwest as does the tendency of this facies to thicken in that direction. At its thickest, the conglomerate/sandstone facies probably does not exceed 1000 feet (305 m). Palynomorphs from a lense stratigraphically low in this member indicates it is at least partly of latest Middle Carnian age (Cornet, 1977).

Siltstone/sandstone facies: This facies generally contains much more siltstone than the conglomerate/sandstone facies (Figure 2). Where fresh, the siltstones are gray, but generally the siltstones have been weathered to a maroon red color. In its highest stratigraphic levels the siltstone/sandstone facies sands and conglomerates are poorly consolidated and cemented. In the western portion of the basin the siltstone/sandstone facies is younger than the conglomerate/sandstone facies, but in the Ashland quadrangle, especially along the Little and North Anna Rivers, it broadly intertongues with the conglomerate/sandstone facies and is there both younger and in part equivalent in age to the conglomerate/sandstone facies. At its thickest, near the center of the basin, the siltstone/sandstone facies is probably 2000 feet (610 m) thick. The age of the siltstone/sandstone facies is not yet clearly established, but the fact that palynomorphs from the basal conglomerate/sandstone facies are of latest Middle Carnian age suggests that this facies is probably of early Late Carnian age. This unit is soft and not well exposed, but a small outcrop can be

seen north of Morris Bridge on the east bank of the North Anna River (Locality 7).

Newfound deposition seems to have commenced with a major influx of sediment from the northwest and only minor influx from the southeast, presumably resulting from motion largely concentrated along the northwest border fault. Coarse-grained sandstones and conglomerates spread eastward from the western edge of the basin in a series of coalescing deltas which produced the conglomerate/sandstone facies. To the east many siltstones and fine-grained sandstones were deposited during the waning phase of this depositional pulse (but no shales), indicating deposition under less energetic conditions than to the west. No evidence of tectonic activity along the eastern margin of the basin is known above the basal 300 feet (97 m) of this member. Instead transport only from the northwest is suggested. During late Newfound deposition, tectonic activity waned and siltstones and fine-grained sandstones were deposited across the entire basin. Very late during Newfound deposition, however, a second pulse of activity along the northwestern border fault seems to have occurred. Extremely angular clasts were shed into the basin along its western margin in the Hanover Academy quadrangle. Many of these clasts are so angular that they suggest, unlike in earlier times, that a true fault scarp was developed along the west margin of the basin. Rock tumbled off of this scarp and was transported only a short distance before coming to rest with little or no rounding. The degree of rounding increases rapidly southeast of the border fault. No evidence of activity along the east margin of the basin at this late stage of development is known.

JURASSIC SYSTEM

Diabase Dikes

Four fine- to coarse-grained, massive and extremely hard diabase dikes cut across Triassic and older rocks at a nearly vertical angle, striking N 10° W to N 30° W. Dikes were not observed cutting across Cretaceous or younger rocks and no such relationships have been reported elsewhere (King, 1961). Therefore these dikes must be of latest Triassic or Jurassic age. Recent palynomorph studies in New Jersey and Connecticut (Cornet, Traverse and McDonald, 1973; Cornet, 1977) suggest that in those basins extrusive volcanism did not begin until, and continued into, Jurassic time. Thus by analogy a Jurassic age for the diabase dikes in the Taylorsville basin seems most likely. One of these dikes is well exposed just north of Taylorsville (Locality 8).

CRETACEOUS SYSTEM

Patuxent Formation

The oldest unit exposed in the Coastal Plain of Virginia is the Patuxent Formation which is of Early Cretaceous (Aptian-Barremian) age (Reinhardt and others, 1980). This is a predominantly sandy unit with occasional lenses of clay, gravel, and even boulders. Only fine- to medium-grained white to yellowish orange sand was observed in outcrop in the Ashland quadrangle, but a prominent boulder bed developed at the base of the overlying Aquia Formation is probably derived from a lag concentrate of Patuxent clasts. This suggests that much coarser phases of the Patuxent are present even though they are not now exposed.

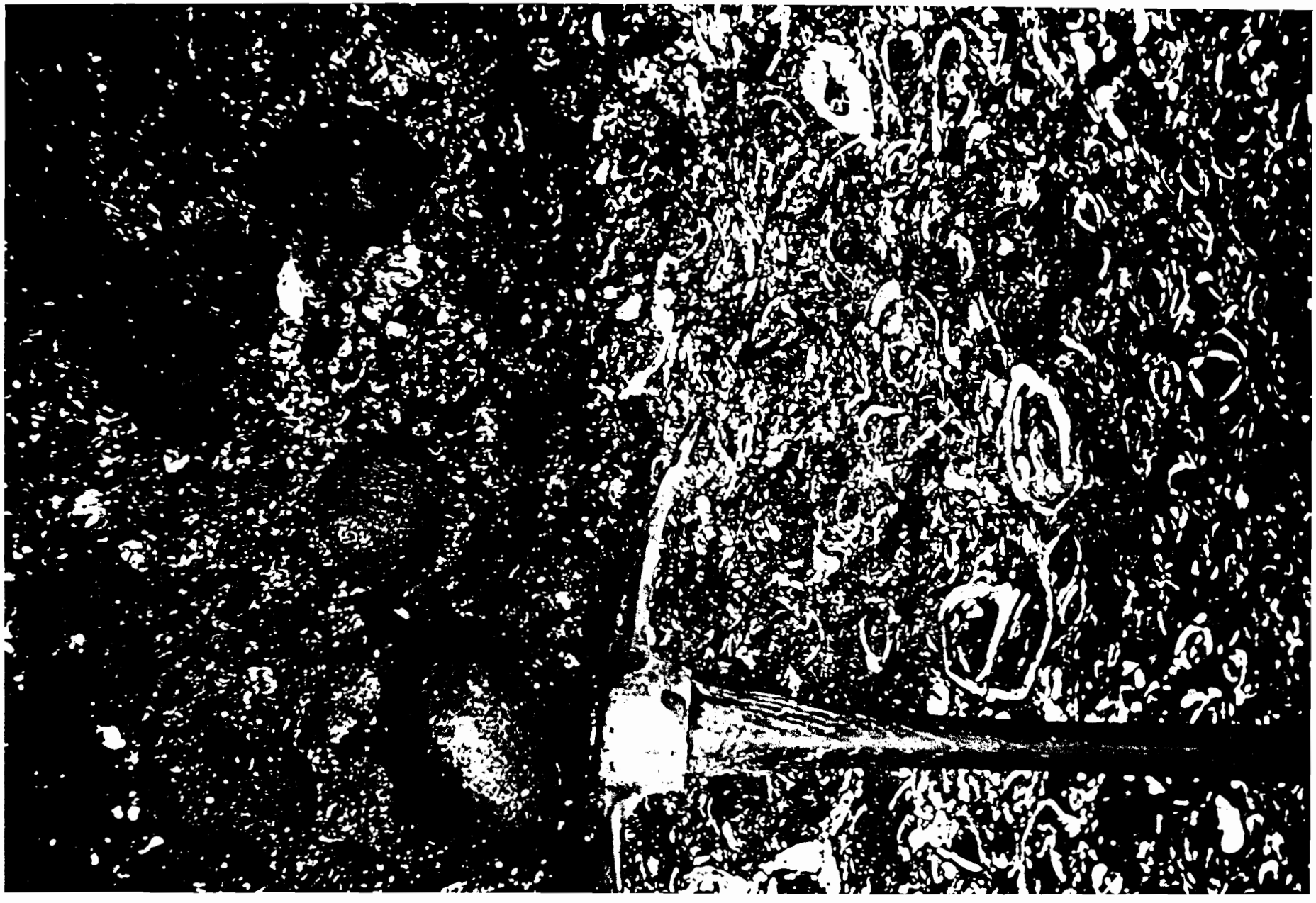
Although similar boulder beds occur in the Patuxent to the south, no evidence of them has been found north of this quadrangle. No fossils were observed in this unit, but its lithology, lack of obvious dip and position at the base of the Coastal Plain sequence clearly indicates it is the Patuxent. So far as could be determined, the Patuxent rests on the Petersburg granite in the outcrop region, which is only around the confluence of the North Anna and South Anna rivers where they form the Pamunkey River, for example Locality 9.

TERTIARY SYSTEM

Aquia Formation

The Aquia Formation is a dark green, clayey, glauconitic sand containing numerous shells or, where weathered, casts of shells (Clark and Martin, 1901). It is exposed along the North Anna River only across the river from Bear Island and along the bluffs of the Pamunkey River in the eastern part of the Ashland quadrangle (for example, Locality 10). At its base in the Ashland quadrangle is a lag deposit of pebbles, cobbles and boulders up to 3 feet in maximum diameter (Figure 3). These are all quartz, quartzite, and chert and apparently were derived from the underlying Patuxent Formation. The top of this formation is either the conformably overlying Marlboro Clay or a thin layer of quartz pebbles and sharks' teeth marking the base of the unconformably overlying lower cycle of the Chesapeake Group (time equivalent to the Choptank Formation of Maryland). The age of the Aquia has been established to be late Paleocene (Thanetian) (Loeblich and Tappan, 1957)

Figure 3.—Boulder bed at the base of the Aquia Formation northeast of Wickham Crossing along south bank of Pamunkey River.



on the basis of planktonic foraminifera. The contained fossils indicate it was deposited in a shallow marine environment.

Marlboro Clay

This unit was once mapped as a member of the Nanjemoy Formation (Clark and Miller, 1912), but more recently has been accorded formational status (Glaser, 1971; Teifke, 1973). Outcrops just east of the Ashland quadrangle show clearly that the clay lies conformably upon the Aquia and is unconformably overlain by the Nanjemoy Formation. In the Ashland quadrangle area this unit is a tough, plastic gray to pink clay containing rare casts of pelecypod shells. Although not observed in the Ashland quadrangle, this unit was seen several hundred feet east of the eastern quadrangle boundary on the south bank of the Pamunkey River. Therefore it is presumed to barely extend into the Ashland quadrangle along the south bank of the Pamunkey River. Probably it is no more than a foot thick in this region.

Chesapeake Group

Lower Cycle

Beds of Miocene age cropping out in the Ashland quadrangle have been assigned in the past to the Lower to Middle Miocene Calvert Formation (Clark and Miller, 1912) because their gray, clayey, diatomaceous and non-glauconitic lithologies are very similar to those of the Plum Point Member of the Calvert in Maryland. Abbott (1978) has shown that the "Calvert" diatomites in Richmond are actually time equivalent the Middle Miocene (Serravallian) Choptank Formation of

Maryland, and samples sent by the author to Abbott (written communication, 1981) from the Ashland quadrangle also yielded diatoms of Choptank age. No clear unconformity can be demonstrated between the Calvert and Choptank and the two units are probably conformable. Thus, the proper name to be applied to the Middle Miocene beds in the Ashland quadrangle is presently uncertain, and the term "lower cycle" therefore is used to designate these beds in this report. This serves to contrast these beds with a later sandier "upper cycle" sequence of Upper Miocene to Lower Pliocene age beds representing a separate transgressive-regressive cycle unconformably overlying the lower cycle (Newell and Rader, 1982). The lower cycle thus encompasses beds partly or wholly time-equivalent with the Calvert, Choptank, and St. Marys formations of Maryland (Shattuck, 1904), and the upper cycle encompasses beds partly or wholly equivalent to the Claremont Manor and Cobham Bay members of the Eastover Formation (Ward and Blackwelder, 1980) and the Yorktown Formation. In this quadrangle, the lower cycle appears to include only beds time-equivalent to the Choptank as defined in the Calvert Cliffs of Maryland.

The lower cycle is represented by medium-gray, sparsely diatamaceous clay that weathers to pale-gray blocky chips which often are notably sulferous. The base of this unit is marked by a sandy layer, often less than a foot thick, that may contain sparse quartz pebbles, phosphate sand and pebbles, and worn and rolled bones of fish and cetaceans. In the Hanover quadrangle to the east the contact of the lower and upper cycle is exposed at Gravetts Mill Pond. There the contact is prominently burrowed, pebbly, and scattered bones, teeth, and quartz cobbles lie upon the eroded lower cycle surface. Only one

weathered exposure of this contact was observed in the Ashland quadrangle along the Richmond, Fredericksburg and Potomac Railroad north of Ashland (Locality 11). Good exposures of this unit can be seen in the gulleys south of Wickam Crossing (Locality 12) and in a road cut along State Road 646 two kilometers east of those gulleys where that road descends from the surface of g5 to the surface of g7 (Locality 13). The sediments of the lower cycle appear everywhere to be leached of calcareous material, though molds and casts of shells attest to the former presence of calcareous material.

Upper Cycle

The upper cycle of the Chesapeake Group is represented in the Ashland quadrangle by a lower dark-gray, micaceous clayey sand horizon of estuarine to lagoonal origin grading up to a bluish-gray (where fresh) or pale-yellowish-brown, fine-grained sand that represents deposits formed in a shallow shelf environment. The contact between these two phases appears to be gradational and conformable, and probably represents a prolonged transgression during which marginal marine environments were progressively overridden by westwardly migrating shelf environments. Grains of heavy minerals are obvious where the higher, more sandy beds are fresh, and bivalve shells may be sparsely to abundantly present. As these beds become leached the clam shells dissolve, sometimes leaving molds and casts. These frequently collapse, however, and leave no obvious trace of their former existence. Under extreme leaching, the heavy minerals are destroyed and the constituent heavy metals become incorporated to form hydroxides and oxides that may locally cement the sands into lenses of sandstone. This unit may be

seen overlying the lower Chesapeake cycle at Locality 11, along the Richmond, Fredericsburg and Potomac Railroad north of Ashland. The upper boundary is placed at the base of a prominent bed of cobbles that marks the base of the overlying terrrace gravel, g2.

Sands and Gravels

Two units of sand and gravel, g1 and g2, are here considered to be clearly of Tertiary age. These gravels also have been mapped to the west and south (Goodwin, 1970, 1981; Weems, 1981), and may possibly be equivalent to the Bryn Mawr (Bascom, 1924) and Brandywine (Clark, 1915) gravels respectively. Sand and gravel unit g1 is heavily leached, so that quartz grains are pitted and zircon crystals are the sole remaining heavy detrital mineral. Metamorphic cobbles are thoroughly saprolitized, and many of the sandstone clasts can be crushed by hand due to the leaching of the original cementing material. Reddish hues are often predominant in exposed sections. This unit only barely extends into the southwestern corner of the Ashland quadrangle, where it occurs at elevations above 240 feet.

Sands and gravels referred to g2 are widespread in the Ashland quadrangle, and underlie the terrace surface that lies at about 210 feet elevation along the eastern border of the quadrangle and slopes upward gently to 240 feet elevation at the western margin of the quadrangle. The base of this unit is marked by a prominent line of well-rounded, often discoidal pebbles and cobbles, usually about 1 foot thick. Clasts of metamorphic or igneous origin are extremely rare, but when encountered are thoroughly saprolitized. Most clasts are composed of quartzite or vein quartz, and are of a size and mineralogy that suggest

that they may have accumulated as the stable residue from reworking of the g1 gravels. Above the cobble bed, this unit grades upward into clayey sands which are subangular. Hues on the g2 outcrops tend more to oranges than is the case of exposures of the reddish g1 lithologies. The poorly sorted, clayey, and subangular character of the sands suggests that they accumulated in a fluviodeltaic environment. No fossils are known to have been directly derived from this unit, but quartzite clasts bearing Scolithus tubes and chert clasts bearing fossil corals, brachiopods and bryozoans from the Lower Devonian Helderberg Group attest to the influx of sediment into this area from beyond the Blue Ridge Mountains. g2 is well exposed in the Richmond, Fredericksburg, and Potomac Railroad cuts north of Ashland (Locality 14).

The exact age of these two Tertiary gravels is uncertain. At present correlation of the older g1 gravel with the lower Chesapeake cycle seems most likely, but correlation with the upper cycle as yet cannot be precluded. Regional relationships suggest a correlation of g2 with the upper Chesapeake cycle (Newell and Rader, 1982).

QUATERNARY AND TERTIARY(?) SYSTEMS

Gravel and Sand

Five younger terrace gravel units occur at lower elevations than g2. There is no fossil evidence for the age of any of them, so they are presumed to be of Pliocene and Pleistocene age. All of these gravels contain fresh clasts of metamorphic rocks. This contrasts them sharply with the older, saprolitized Tertiary gravels. The oldest of these

gravels (g3) underlies a terrace at about 180 feet (55 m) elevation, while the remainder underlie terraces at about 150 feet (45 m) elevation (g4), 120 feet (35 m) elevation (g5), 100 feet (30 m) elevation (g6), and 75 feet (22 m) elevation (g7). All of these terraces become more widespread and better developed to the east of this quadrangle. Their relationship with the units described by Oaks and Coch (1973) along the York-James peninsula are presently indeterminate. g3 and g6 are not well exposed, but g4 can be seen in the Richmond, Fredericksburg and Potomac Railroad cut between the South Anna and Little Rivers (Locality 4), g5 in a road cut along State Road 646 in the southeast quadrant of the quadrangle (Locality 13), and g7 can be seen in the bluff on the west bank of the North Anna River between Little River Crossing and South Anna (Locality 15).

These gravel deposits probably formed during warm interglacial intervals, when sea level was relatively high and the gradients of these streams were consequently low and the streams sluggish. Since sea level has oscillated up and down in repetitive cycles, the occurrence of these gravel beds at successively lower levels attests to a long term rise in the land level in this region. If g2 is actually equivalent to the Yorktown Formation, which is about 3.5 million years old, a net uplift since that time of 1.5cm/1000 years is indicated to bring the stream base level down to its present point (40 feet above sea level). This would imply that g3 is 2.7 million years old, g4 is 2.1 million years old, g5 is 1.5 million years old, g6 is 1.1 million years old, and g7 is 0.6 million years old. Since there is no way presently to check if the uplift rate was indeed uniform, these age assignments are only tentative until they can be independently checked.

The prominent north-south trend along the North Anna River in this quadrangle apparently has been produced by the migration of the North Anna eastward, as evidenced by the wider outcrop belts of the gravel beds on the west side of that river as compared to its east side. A comparison of section C-C' with section A-A' shows that this has occurred along the base of the Coastal Plain section. Thus the North Anna has been able to downcut most easily obliquely, remaining in the unconsolidated Coastal Plain sediments and avoiding cutting into the consolidated Triassic strata. Since the regional dip of the Coastal Plain beds is east, the North Anna has tended to align along the regional strike of these beds, which is north-south.

Colluvium

In two areas, one east of the North Anna River and one south of the Pamunkey River, the meandering rivers seem to have cut deeply into the side of their respective valley walls and then abandoned the channels. The oversteepened banks then collapsed, leaving large debris slopes that are geomorphically distinct from the terrace deposits. These jumbled deposits have been mapped according to their probable mode of origin; probably the more southerly deposit is considerably older than the one farther north.

Alluvium

Thin alluvial deposits are present in the flood plains of most streams and rivers. Along major stream courses, generally rounded pebbles, cobbles and boulders occur at the base of the alluvium which are derived from the metamorphic terrane located west of this

quadrangle. These deposits grade upward to loose sands. In smaller, local drainages pebbles and cobbles from the terrace deposits (g1 to g7) may be present or deposits may be largely sandy. These deposits are presumed to be of Holocene age (less than 10,000 years old).

ECONOMIC GEOLOGY

A number of economic enterprises have been attempted in the past in the Ashland quadrangle. Most were started for purely local markets and were soon displaced by other, more competitive enterprises elsewhere. Coal, shell marl, glauconitic shell marl, and gravel have all been exploited.

COAL

Coal was mined at least as early as the 1830's in the neighboring Hanover Academy quadrangle (Rogers, 1884) but no record of any mines in the Ashland quadrangle is known. Nevertheless, an old coal mine developed in the Falling Creek Member of the Doswell Formation was located south of the South Anna River in the western part of the Ashland quadrangle (see map). This operation was abandoned before anyone's memory and no stories about its operation persist (Fairfax Davis, oral communication, 1973). Presumably it was mined for local consumption.

SHELL AND GLAUCONITIC MARLS

Marls were mined in the 19th century and spread on fields to increase soil fertility and even today fragments of shark's teeth in the fields of the Ashland quadrangle attest to their former use. The

glauconitic Aquia was the best source of these marls. Glauconitic shell marl pits were once operated just northeast of the present Chesapeake and Ohio tracks between Wickam Crossing and Blanton Crossing in the Ashland quadrangle (R. R. Taylor, personal communication, 1973) but have since been all but obliterated by filling and slumping. Their approximate location is shown on the map. Other old pits existed on the property of Marl Ridge. They were developed in Miocene shell beds immediately south of State Highway 54 halfway between Ashland and Hanover Courthouse, along the bluffs of Mechumps Creek (prospects S1 to S3).

GRAVEL

The Tertiary gravel (g2) and the Quaternary terrace gravel g5 have been the chief sources of gravel up to the present time. Extensive gravel mining has occurred along Slayden Creek in beds of g2 age, and much potential still exists in this quadrangle. Terraces g4 and g7 have been occasionally locally exploited, but these generally have a relatively large clay and silt content which renders then much less useful. Because it is easy to quarry and is close at hand, local gravel is a prime source of fill for road construction in the area. Three fine aggregate samples from the Caroline County portion of this quadrangle have been analysed by the Virginia Department of Highway: (1954) (Samples C-2444, C-2445, and C-4323). The basal Aquia gravel was apparently exploited for tools by the Indians, for numerous chips and flakes from these fine-grained quartzites and nearly grainless cherts were seen in the fields above the outcrops of this gravel. While of no

current economic importance, this constitutes the earliest known exploitation of mineral resources in this quadrangle.

CLAY MATERIALS

The Marlboro Clay is extremely thin (about 1 foot) in this region and is only locally present along the eastern border of the quadrangle. The Middle Miocene clays are extensive in the central and eastern part of the quadrangle, and occur between elevations of 40 to 170 feet. These have never been exploited, and generally are avoided because they are sticky and have poor fertility.

DIATOMACEOUS SEDIMENTS

Some of the Middle Miocene clay horizons contain diatoms, but these are a very subordinate component of this material, probably nowhere constituting as much as 10 percent of the bulk matrix. Nothing that could be regarded as a diatomite was observed in this quadrangle.

GEOLOGIC FACTORS AFFECTING LAND MODIFICATION

Most units in this quadrangle are soft and can be readily excavated. The Petersburg Granite, Doswell Formation (except the siltstone/sandstone facies of the Newfound Member) and the Jurassic dikes are exceptions. Normally these are only found in low areas along the major creeks and rivers from the North Anna River westward. The clay facies of the lower cycle of the Chesapeake Group and the Marlboro Clay are quite sticky, but in contrast the Patuxent Formation and the terrace gravels (g1-g7) are easily excavated and are useful as fill.

Since most of the area is overlain by 10 feet or more of terrace gravel, only deeper excavations will normally have to contend with hard or sticky substrates. Table 1 summarizes the rock characteristics as related to land modification.

The terrace gravels (especially g2) offer excellent shallow water supplies. They are highly susceptible to industrial or septic contamination, however, so care must be excercised to preserve the quality of this abundant and cheaply reached resource. The Patuxent Formation east of the North Anna River is the major deep aquifer; water is abundant but "hard". West of the North Anna deep wells are generally good producers only where local fault or joint patterns permit rapid groundwater flow.

Soil characteristics in the quadrangles are summarized in Hodges and others (1980) and in Draft Environmental Impact Statement Phase II Facilities Plan, Hanover County, Va.: U.S. Environmental Protection Agency Region III (Philadelphia). In general, areas underlain by Petersburg granite have Vance-Chesterfield-Pouncey soil associations, regions underlain by Triassic rocks have (Pinkston-Mayodan-Creedmoor)-Bourne-Marlboro soil associations, regions underlain by g1 to g4 deposits have Marlboro-Coxville-Faceville, Coxville-Duplin-Marlboro, (Gravelly and Clayey soils)-Vaucluse-Kempsville or Faceville-Kempsville-Sassafrass soil associations, and regions underlain by g5-g7, and alluvial deposits have Marlboro-Bourne-Faceville, Coxville-Duplin-Marlboro, Pamunkey-Altavista-Molena, or Chewacla-Wehadkee-Fresh water swamp soil associations.

Table 1.--Summary of rock characteristics and geologic and economic factors affecting land modifications in the Ashland quadrangle.

	Summary of Rock Characteristics	Geologic and Economic Factors Affecting Land Modification
al	Alluvium: Flood plain deposits of sand, silt, clay and gravel.	Periodically flooded; cuts and excavations subject to sliding and sloughing; flooding severely limits non-farm use.
col	Colluvium: Deposits formed by mass slump or landsliding along steep banks formerly undercut by North Anna River and Pamunkey River.	Loose, unconsolidated material, likely to slide or slump further if undercut.
g7	Terrace deposit: Developed beneath terrace at 75 feet elevation; sands, pebbles and cobbles, occasional lignitic clays; gravel clasts of igneous, metamorphic and sedimentary origin.	Sand and gravel highly permeable, good shallow aquifer but readily contaminated by surface water and affected by moderate drought.
g6	Terrace deposit: Developed beneath terrace surface at 100 feet; sand, pebbles, and cobbles, gravel clasts of igneous, metamorphic and sedimentary origin.	Sand and gravel highly permeable, good shallow aquifer but readily contaminated by surface water and affected by moderate drought. Commonly an excellent fill.
g5	Terrace deposit: Developed beneath terrace surface at 120 feet; sand, pebbles, cobbles and boulders; gravel clasts of igneous, metamorphic and sedimentary origin.	Sand and gravel highly permeable, good shallow aquifer but readily contaminated by surface water and affected by moderate drought. Commonly an excellent fill.
g4	Terrace deposit: Developed beneath terrace surface at 150 feet; sand, clay, pebbles, cobbles and erratic boulders; gravel clasts of igneous, metamorphic and sedimentary origin.	Sand and gravel clayey, moderately permeable, good shallow aquifer but affected by moderate drought. Sporadic boulder erratics may produce minor difficulties in excavation.
g3	Terrace deposit: Developed beneath terrace surface at 180 feet; sand, pebbles, and cobbles; gravel clasts of igneous, metamorphic and sedimentary origin.	Sand and gravel clayey, moderately permeable, good shallow aquifer but affected by moderate drought.

g2	Terrace deposit: Developed beneath terrace surface at 210-240 foot elevation; sand, clay, pebbles and cobbles; gravel clasts composed almost entirely of vein quartz, quartzite, sandstone and chert, rarely saprolitized clasts of other types.	Sand and gravel grading upward into clayey sand and sporadic clay lenses. Moderately to poorly permeable near surface, highly permeable at base. Excellent shallow aquifer affected only by prolonged drought. Basal sands and gravels commonly an excellent fill.
g1	Terrace deposit: Developed beneath terrace surface above 240 feet elevation; sand, clay, pebbles and cobbles; gravel clasts highly weathered and saprolitized except for quartz.	Sand and gravel grading upward into clayey sand and sporadic clay lenses. Moderately to poorly permeable near surface, highly permeable near base. Excellent shallow aquifer affected only be prolonged drought. Basal sands and gravels commonly an excellent fill.
Tcu	Chesapeake Group: Upper Cycle fine to medium-grained sand and clayey sand with abundant heavy minerals and/or iron-cemented sandstones; generally yellow but rarely blue or gray where extremely fresh; between 120 and 180 feet elevation.	Except for sandstone lenses, unconsolidated, poorly packed and extremely permeable; excellent aquifer wherever clay content is low, affected only by extreme drought. Commonly unstable as a foundation support.
Tcl	Chesapeake Group: Lower Cycle: Clay to sandy clays, numerous lenses of snail shell impressions, sparsely diatomaceous; medium-gray weathering to pale-gray; breaks into blocky lumps; between 40 and 175 feet elevation.	Unconsolidated but extremely sticky and gummy material. Firmly packed but difficult to dig or drain. Permeability poor.
Tm	Marlboro Clay: Gray to pink clay, probably found only along extreme southeastern border of quadrangle; at 40 feet elevation, 1 foot thick at most.	Unconsolidated but extremely sticky and gummy material. Permeability poor.
Ta	Aquia Formation: Sand, glauconitic, dark green, where fresh containing numerous shells; prominent bed of boulders developed at base of formation.	Unconsolidated but firmly packed. Glauconite and shells impart considerable fertility to this unit. Permeability moderate to poor, depending on clay content.

Kptx	Patuxent Formation: Fine- to medium-grained sands, white to yellowish orange; exposed only near confluence of North and South Anna rivers and along Pamunkey River. Gravel beds suspected to be present but unconfirmed.	Unconsolidated but firmly packed sand. Very permeable and an excellent aquifer (for hard water). Unaffected by drought.
Jd	Diabase dikes: Dark greenish-gray to black diabase; broken line where buried but presence confirmed by proton magnetometer.	Weathers into hard, large, rough surfaced, rounded to subrounded boulders and bright red clay. Difficult to excavate and where unweathered may require blasting.
TRns	Doswell Formation, Newfound Member, siltstone/sandstone facies: interbedded soft siltstones and sandstones; sandstones massive and light brown to orange-brown, siltstones gray when fresh but weather to maroon red.	Moderately consolidated to unconsolidated, easily excavated. Moderately permeable.
TRnc	Doswell Formation, Newfound Member, conglomerate/sandstone facies: Massive, cross-bedded light brown to orange-brown sandstones and conglomerates, well consolidated except where severely weathered; forms prominent cliffs on steep slopes.	Well consolidated, difficult to excavate. Permeability poor, water flows only along joint sets.
TRf	Doswell Formation, Falling Creek Member: Flaggy sandstones, siltstones and shales; minor coals and conglomerates. Sandstones light brown to orange-brown, siltstones and shales green, gray or black. Some sandstones and shales calcareous.	Sandstones well consolidated, siltstones and shales soft. Calcareous sandstones may require blasting to excavate. Permeability poor, water flows only along joint sets.
TRs	Doswell Formation, Stagg Creek Member: Massive, light brown to orange-brown conglomerates and sandstones, minor blue to gray siltstones.	Sandstones and conglomerates well consolidated, difficult to excavate. Permeability poor, water flows only along joint sets.

PCpb Petersburg Granite: Light gray, faintly foliated, moderately jointed granite containing occasional biotite-rich xenoliths; highly fractured near faults and commonly chloritized.

Rock quite hard, massive and not easily broken up except where faulted. Permeability poor, water flows only along faults and joints sets. Often weathers to poorly permeable sandy clay near faults and joints.

REFERENCES

Abbott, W. H., 1978, Correlation and zonation of Miocene strata along the Atlantic margin of North America using diatoms and silicoflagellates: Marine Micropaleontology, vol. 3, p. 15-34.

Bascom, Florence, 1924, The resuscitation of the term Bryn Mawr gravel, U. S. Geological Survey Professional Paper 132-H, p. 117-119.

Clark, W. B., 1915, The Brandywine Formation of the Middle Atlantic Coastal Plain: American Jour. Sci., vol. 40, ser. 4, p. 499-506.

Clark, W. B., and Martin, G. C., 1901, The Eocene deposits of Maryland in Eocene: Maryland Geol. Survey, p. 19-92.

Clark, W. B., and Miller, B. L., 1912, The physiography and geology of the Coastal Plain province of Virginia: Virginia Geol. Survey Bull. 4, 174 p.

Cornet, Bruce, 1977, The palynostratigraphy and age of the Newark Supergroup: Unpublished Ph.D. thesis, Pennsylvania State Univ., University Park, Penn., 505 p.

Cornet, B., Traverse, A., and McDonald, N. G., 1973, Fossil spores, pollen, and fishes from Connecticut Indicate Early Jurassic Age for part of the Newark Group: Science, vol. 182, (no. 411), p. 1243-1247.

Glaser, J. D., 1971, Geology and mineral resources of southern Maryland: Maryland Geol. Survey Rept. Inv. 15, 84 p.

Goodwin, B. K., 1970, Geology of the Hylas and Midlothian quadrangles, Virginia: Virginia Division of Mineral Resources Rept. Inv. 23, 51 p.

_____, 1981, Geology of the Glen Allen quadrangle, Virginia: Virginia Division of Mineral Resources Publication 31, text and 1:24,000 scale map.

Hodges, R. L. and others, 1971, Soil survey of Hanover County, Virginia: U. S. Dept. Agriculture Soil Conservation Service, 218 p.

King, P. B., 1961, Systematic pattern of Triassic dikes in the Appalachian region: U. S. Geol. Survey Prof. Paper 424-B, p. B93-B95.

Knowlton, F. H., 1889, The fossil wood and lignite of the Potomac Formation: U. S. Geol. Survey Bull. 56, 72 p.

Loeblich, A. R., Jr., and Tappan, H. N., 1957, Correlation of the Gulf and Atlantic Coastal Plain Paleocene and lower Eocene formations by means of planktonic Foraminifera: Jour. Paleontology, vol. 31, no. 6, p. 1109-1137.

Newell, W. L. and Rader,E. K., 1982, Tectonic control of cyclic

sedimentation in the Chesapeake Group of Virginia and Maryland in Lyttle, P. T., Central Appalachian Geology, NE-SE Geological Society of America Field Trip Guidebooks: American Geological Institute, Falls Church, Virginia p. 1-27.

Oaks, R. Q., Jr., and Coch, N. K., 1973, Post-Miocene stratigraphy and morphology, southeastern Virginia: Virginia Division of Mineral Resources Bull. 82, 135 p.

Reinhardt, Juergen, Christopher, R. A., and Owens, J. P., 1980, Lower Cretaceous stratigraphy of the core, in Geology of the Oak Grove Core: Virginia Division of Mineral Resources Publication 20, part 3, p. 31-52.

Roberts, J. K., 1928, The Geology of the Virginia Triassic: Virginia Geol. Survey Bull. 29, 205 p.

Rogers, W. B., 1884, A reprint of annual reports and other papers on the geology of the Virginias: New York, D. Appleton and Co., 832 p.

Sanford, Samuel, 1913, The underground water resources of the Coastal Plain province of Virginia: Virginia Geol. Survey Bull. 5, 361 p.

Schaeffer, Bobb, and McDonald, N. G., 1978, Redfieldiid fishes from the Triassic-Liassic Newark Supergroup of Eastern North America: Bulletin American Museum of Natural History, vol. 159, art. 4, p. 131-173.

Shattuck, G. B., 1904, Geological and paleontological relations, with a review of earlier investigations in Miocene: Maryland Geological Survey, p. 33-137.

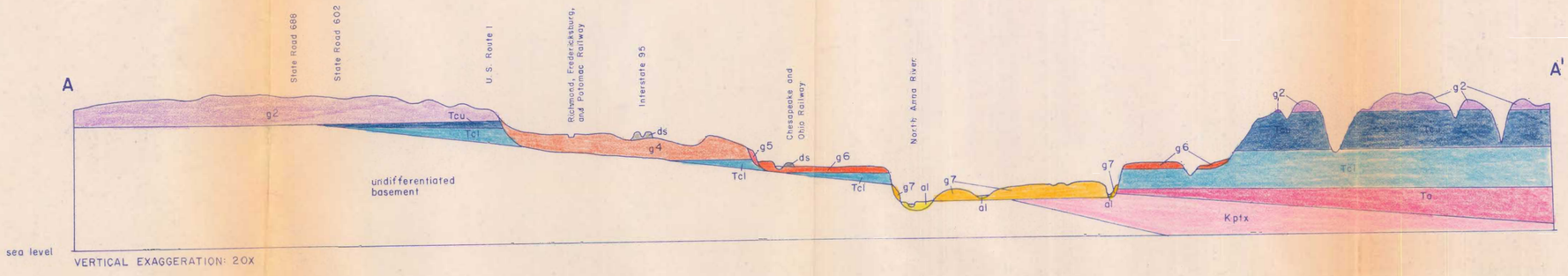
Teifke, R. H., 1973, Stratigraphic units of the Lower Cretaceous through Miocene series in Geologic Studies, Coastal Plain of Virginia: Virginia Division of Mineral Resources Bulletin 83, part 1, p. 1-78.

U.S. Environmental Protection Agency, 1978, Draft of environmental impact statement, phase II facility plan, Hanover County, Virginia: Engineering Science Company report to Region III office of EPA, Philadelphia.

Virginia Department of Highways, 1954, Physical test results of the Virginia highway state aggregate survey: Division of Purchase and Printing, Richmond, 68 p.

Ward, L. W., and Blackwelder, B. W., 1980, Stratigraphic revision of Upper Miocene and Lower Pliocene beds of the Chesapeake Group, Middle Atlantic Coastal Plain in Contributions to Stratigraphy: U.S. Geological Survey Bulletin 1482-D, p. D1-D61.

Weem, R. E., 1980a, Geology of the Taylorsville Basin, Hanover County, Virginia, in contributions to Virginia Geology-IV: Virginia Division of Mineral Resources Publication 27, p. 23-38.


A
A'
State Road 688
State Road 602
U. S. Route 1
Richmond, Fredericksburg, and Potomac Railway
Interstate 95
Chesapeake and Ohio Railway
North Anna River
g2
Tcu
Tcl
ds
g4
g5
g6
g7
al
Kptx
Ta
undifferentiated basement
sea level
VERTICAL EXAGGERATION: 20X
B
B'
State Road 694
U. S. Route 1
State Road 738
Richmond, Fredericksburg, and Potomac Railway
Interstate 95
Power Line
South Anna River
State Road 738
Chesapeake and Ohio Railway
Pamunkey River
Ꞧns
Ꞧnc
Jd
Ꞧf
Ꞧs
Pzpb
Kptx
Ta
sea level
C
C'
State Highway 54
Richmond, Fredericksburg, and Potomac Railway
U. S. Route 1
Interstate 95
Slayden Creek
Chesapeake and Ohio Railway
State Road 646
Tcu
Tcl
Tm
Kptx
undifferentiated basement
sea level
VERTICAL EXAGGERATION: 20X