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DIVISION OF MINERAL RESOURCES

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BON AIR QUADRANGLE

GEOLOGY OF THE BON AIR QUADRANGLE, VIRGINIA

By Bruce K. Goodwin[1]

1980

EXPLANATION

UNIT CHARACTERISTICS / GEOLOGIC AND ECONOMIC FACTORS AFFECTING LAND MODIFICATION

	Symbol	Unit characteristics	Geologic and economic factors affecting land modification
CENOZOIC	al	Alluvium: *floodplain deposits of gray, stratified sand, silt, gravel and clay.*	Subject to periodic flooding: seasonal perched water table; unstable in deep cuts or excavations; severe limitations for construction due to flooding; good potential for farming and as a source of topsoil.
	sg	Sand and gravel: *yellowish-gray to moderate-reddish-brown silty sand with minor amounts of gravel mottled with iron-oxide; particle sizes range from clay to cobbles with fine sand dominant; locally finely laminated, or cross-bedded; includes sediments deposited in fluvial, nearshore, and strandline environments.*	Deep to very deep, well-drained sandy soil; high to moderate permeability; depth to granite saprolite ranges from a few inches to 10 feet (3.0 m); slight limitations for construction; moderate limitations for drain fields, ponds, and landfills.
	g_2	Gravel: *rounded quartz pebbles with sandy to clayey-sand matrix, commonly stained with iron oxide; pebbles, up to 25 percent of the unit, average size 2 inches (5 cm); locally bedded.*	Well-drained, moderately permeable, gravelly, sandy soil; relatively stable in deep cuts; moderate to slight limitations for construction; severe limitations for drain fields, ponds, and landfills.
	g_1, c	Gravel: *g_1, abundant, well-rounded pebbles and cobbles in a sandy to clayey-sand matrix; gravel dominantly of vein quartz and quartzite with minor amounts of gravel composed of metamorphic and igneous rocks; quartzite clasts commonly deeply weathered in a partially cemented matrix on flat uplands south of the James River; locally 5 to 10 feet (1.5-3.0 m) thick, laminated, yellowish-gray, silty fine sand at base; basal contact sharp south of river, commonly gradational north of river. c, nine elliptical-shaped depressed areas filled with clay and silty clay with a sand rim; minor amounts of scattered quartz gravels.*	North of James River: has discontinuous distribution, caps hills; deposits thinner than those south of river; gravels uncemented; well drained; gradational contact with underlying granite saprolite; relatively stable in deep cuts; slight limitations for construction; severe limitations for drain fields, ponds, and landfills. Material has been used for fill. South of James River: occupies broad flat surface and isolated remnants; vertical sequence is: soil; sandy loam 8 to 18 inches (20-46 cm); loamy clay 2 to 10 feet (0.6-3.0 m); and weakly cemented gravels 3 to 15 feet (0.9-4.6 m). Well-drained; good surface permeability, decreasing with depth; relatively stable in deep cuts; slight limitations for construction; moderate to severe limitations for drain fields, ponds, and landfills. Material has been used for fill. *c:* shallow, elliptical depressions with a narrow sand rim; clayey soil; poorly drained; impermeable; interior drainage; severe limitations for any type of construction.
TRIASSIC	d	Diabase dike: *dark-greenish-black to black diabase.*	Weathers to large, crusty-surfaced boulders; soil bright red with impermeable clay; difficult to excavate; limited distribution; severe limitations for foundations and drain fields.
	cm	Newark Group: *cm, coal measures, micaceous, medium- to coarse-grained sandstone, arkosic sandstone, carbonaceous sandstone, black shale, red shale, and thin coal seams; sandstone weathers orange-brown, may contain a few rounded quartz pebbles; shale weathers brownish-red.*	Shale: thick clayey impermeable soil and saprolite; poorly drained, seasonally high water table; severe limitations for foundations, excavations, and drain fields. Sandstone: soil and saprolite thin on slopes; maximum depth to bedrock 10 feet (3.0 m); moderate permeability; locally poorly drained; easily excavated to about 10 feet (3.0 m); moderate to severe limitations for foundations, excavations, and drain fields. Resources limited to thin coal beds.
PALEOZOIC	Pzpb, Pzpbm, pq	Petersburg granite: *Pzpb, fine- to coarse-grained, uniform to porphyritic, foliated to nonfoliated granite, granodiorite, and minor quartz monzonite. Pzpbm, porphyritic granodiorite to quartz monzonite; moderate-orange-pink potassium feldspar phenocrysts over 1 inch (2.5 cm) in length commonly oriented parallel or subparallel to a faint to strong foliation; groundmass dominated by quartz and plagioclase. pq, closely jointed, highly fractured granite with quartz filling the fractures and joints.*	Deep to very deep, well-drained soil; clay seams in saprolite; soil and saprolite permeability moderate to high; impermeable bedrock; subsoil slightly sticky and plastic when wet; excavation requires power equipment, blasting required for bedrock; depth to bedrock variable, 6 to 50 feet (1.8-15.2 m); frequency of joints highly variable; relatively stable in excavations; slight limitations for construction; moderate limitations for drain fields and ponds. Potential source of topsoil, except in quartz-rich zones *(pq)*; crushed stone; fine-grained phase has been used as a dimension stone.
PRECAMBRIAN(?)	gn	Gneiss: *granite gneiss and biotite-rich gneiss; well-foliated; locally cut by pegmatites, quartz veins, and small granite dikes.*	Granite gneiss: deep to very deep, well-drained soil; clay seams in saprolite; soil and saprolite permeability moderate to high; impermeable bedrock; subsoil slightly sticky and plastic when wet; excavation requires power equipment; difficult to compact; relatively stable in excavations; slight limitations for construction; moderate limitations for drain fields and ponds; source of topsoil. Biotite-rich gneiss: deep to very deep, dark-red, clayey soil; soil and saprolite permeability low; impermeable bedrock; subsoil sticky and plastic when wet; yields under moderate loads; slopes and cuts unstable; severe limitations for drain fields; moderate to severe limitations for foundations. Very low economic potential as a source of crushed stone due to limited distribution.

KEY

CONTACTS
Exposed or approximate
Covered or inferred

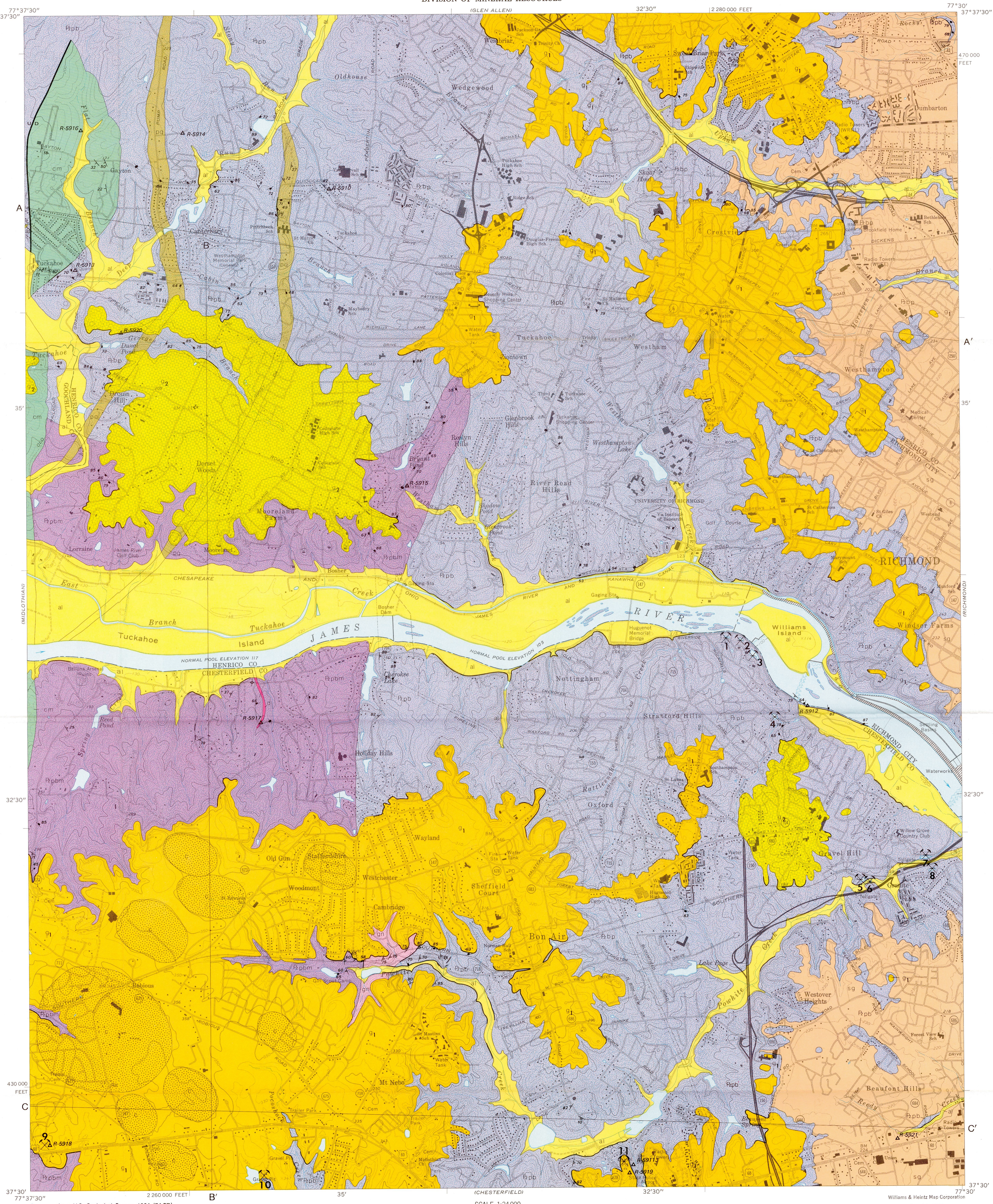
FAULT
Approximate (black line); covered (gray line); U, upthrown side; D, downthrown side

ATTITUDE OF ROCKS
Strike and dip of beds
Strike and dip of joints
Strike of vertical joints

FOLIATION
Strike and dip of foliation
Strike of vertical foliation
Direction and angle of plunge of lineation

QUARRIES
Active (intermittent) 9-10. Sand and gravel
Abandoned 1-8. Granite 11. Sand and gravel

SAMPLE LOCATIONS
R-5911 R, repository number of sample on file at Virginia Division of Mineral Resources
Modified land: Extensive cut or fill due to grading



Base map from U.S. Geological Survey, 1964 (74-PR)
Bon Air Quadrangle, 7½ Minute Series

Williams & Heintz Map Corporation

SCALE 1:24 000

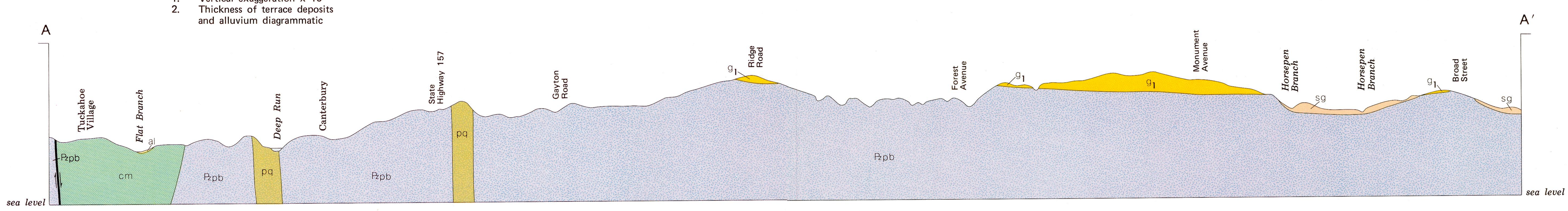
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

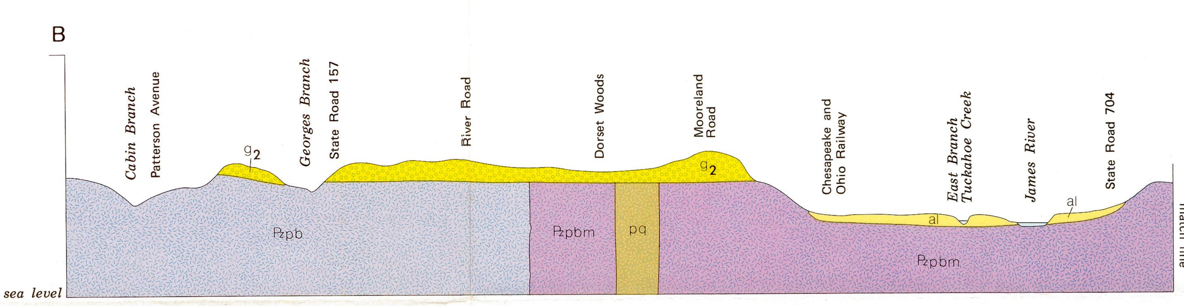
1980

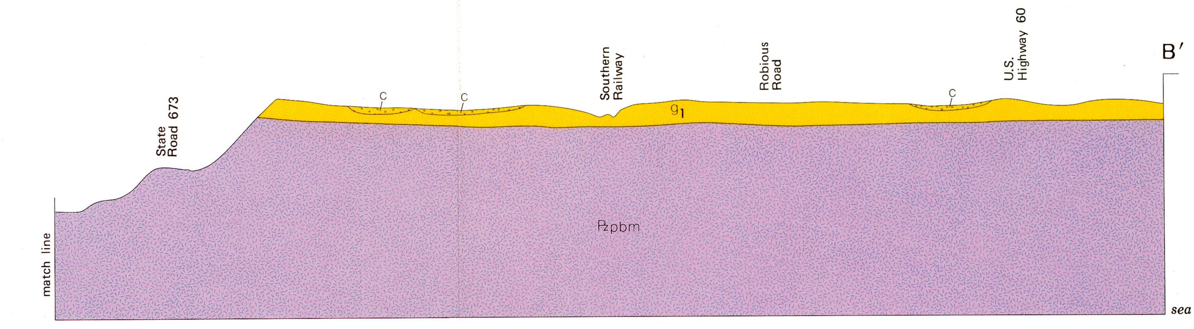
UTM GRID AND 1974 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

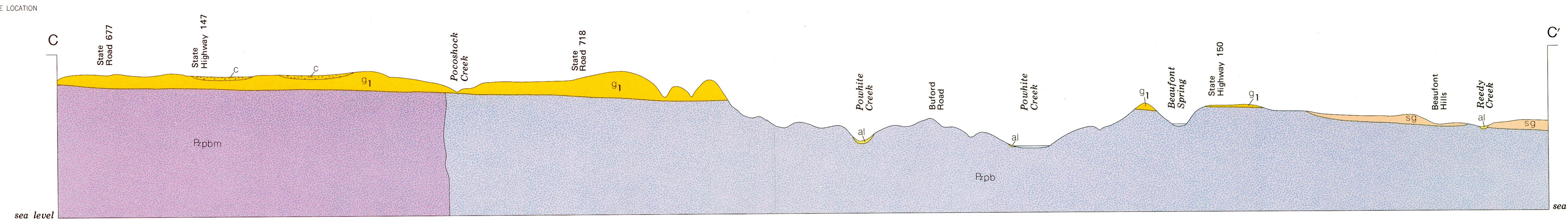
QUADRANGLE LOCATION

CROSS SECTION DESIGN
1. Vertical exaggeration x 10
2. Thickness of terrace deposits and alluvium diagrammatic









The Bon Air 7.5 minute quadrangle area lies astride the Fall Zone, which separates igneous and metamorphic rocks of the Piedmont province from sediments of the Coastal Plain province. Nonmarine sand, clay, and gravel overlie eroded igneous and metamorphic rocks in the eastern third of the area along the edge of the Coastal Plain. Coarse gravels extend westward over the Piedmont surface as caps on many of the higher hills. A small portion of the Triassic lowland subprovince is represented near the western border of the quadrangle. Low, gently rolling terrain generally characterizes the area. In some places, such as adjacent to the floodplain of the James River and some of the larger streams, slopes are steep. In other places, such as in the southwestern portion of the quadrangle, the surface is conspicuously flat, relatively undissected, and underlain by a thick accumulation of gravels. In addition, in the eastern third and especially in the extreme southeastern corner of the area, slopes are gentle and veneered by Coastal Plain sediments.

Deep weathering of the crystalline rocks has produced a thick residual soil and bedrock outcrops are rare. Saprolite is exposed over most of the area that is without gravels. Total relief south of the James River is 280+ feet (85+ m); north of the James River total relief is 250+ feet (76+ m).

STRATIGRAPHY

PRECAMBRIAN OR LOWER PALEOZOIC ROCKS

Gneiss

Along a short stretch of Powhite Creek granite gneiss, biotite gneiss, and some augen gneiss are exposed, mostly as saprolite. Due to the paucity of exposures and limited aerial extent, these rocks are included in a single mapping unit. The gneisses are strongly foliated, well jointed, and have pegmatites (in most places less than a foot thick), thin quartz veins and granitic sills and dikes. Biotite-rich phases of the gneisses weather to a deep dark-reddish-brown, highly clayey saprolite.

Similar gneisses underlie most extensive areas to the west in the Midlothian and Hylas quadrangles (Goodwin, 1970). The gneiss in the Bon Air quadrangle is interpreted as a roof pendant of host rock which is preserved within the intrusive Petersburg granite.

UPPER PALEOZOIC ROCKS

Petersburg Granite

Petersburg granite is the basement rock in most of the area (R-5910, R-5911, R-5912, R-5913, R-5914). The Petersburg granite consists of three phases. One phase is light-gray to moderate-orange-pink and medium grained; another is very light gray and relatively fine grained; and the third is porphyritic. The last phase occurs adjacent to the Richmond basin (Bloomer, 1939, p. 142-143). Composition ranges from granite to quartz monzonite to granodiorite and the textures range from nonfoliated to well-foliated, fine- to coarse-grained, and equigranular to porphyritic. In some exposures the rock has numerous joints and thin quartz, aplite, and pegmatite dikes. In other exposures it is massive. Because the rocks are poorly exposed and deeply weathered and because the phases are in close association, separate entities of the granite were not mapped. One exception is the coarse granite porphyry that is in the western part of the area, but even the boundary for this unit is poorly defined. Some granite with equigranular texture occurs within the area shown as granite porphyry on the map and, conversely, some porphyritic granite occurs within the main mass of the Petersburg granite.

In the granite porphyry, potassium feldspar phenocrysts more than 1 inch (2.5 cm) in length are set in a matrix of medium-grained, anhedral quartz and plagioclase (R-5915). Much of the rock is foliated and where foliation is well developed it is enhanced by a parallel or subparallel arrangement of the phenocrysts.

Two narrow, north trending zones of jointed rock within the Petersburg are characterized by numerous quartz veins and thin pegmatite dikes. Most of these dikes are only a few inches thick but some are one to two feet (0.3–0.6 m) thick. These zones contain many unusual occurrences of quartz including botryoidal masses of elongate crystals, concentric growths of crystals, and drusy, vuggy masses of crystals. Slickensides are common on joint surfaces and quartz veins are offset slightly along some of the joints. In some places there are brecciated shear zones that were permeated by silica-rich fluids.

Zircons from a medium-grained, massive quartz monzonite in the Petersburg granite were determined to be 330± 8 million years of age (Wright, Sinha, and Glover, 1975).

TRIASSIC SYSTEM

Newark Group

Sedimentary rocks of the Newark Group occur in the western portion of the quadrangle. The narrow belt of Newark sediments marks the eastern edge of the Richmond basin and Newark sediments also occupy a small basin along Flat Branch. The two basins may be connected, but evidence is lacking because alluvial deposits along Tuckahoe Creek cover the area of possible junction.

Arkosic sandstone (R-5916), micaceous sandstone, carbonaceous sandstone, shale, and coal constitute the coal measures of the Newark Group (Goodwin, 1970). A portion of the eastern margin of the basin is exposed at the Tuckahoe Village Shopping Center where conglomeratic arkosic sandstone overlies porphyritic Petersburg granite nonconformably. There is no evidence of faulting. At the western margin of the basin, however, along Flat Branch, the granite adjacent to the margin may be formed by a normal fault with a steep easterly dip. Direct evidence for faulting is lacking.

Large boulders composed of relatively unweathered Petersburg granite occur a short distance from the Triassic sediments along Flat Branch (Shaler and Woodworth, 1899, p. 507, pl. XLIX). These are conspicuous along Gayton Road. A likely history of the boulders is that they were produced by partial weathering of granite prior to deposition of Triassic sediments, covered and protected by Triassic sediments, and then exhumed by weathering and erosion (Shaler and Woodworth, 1899). Rounded masses of spheriodally weathered granite measuring more than ten feet (3 m) in diameter are well displayed in the eastern end of the Tuckahoe Village Shopping Center.

Palynological data are indicative of a Late Triassic age for the sediments of the Richmond basin (Cornet and others, 1973).

Diabase Dikes

One of the two greenish-black to black diabase dikes observed was too small to map. It is in the granite along State Route 718 near the gravel-granite contact. The larger dike (R-5917) is in the quartz monzonite porphyry phase of the Petersburg granite approximately 0.7 mile (1.1 km) northwest of Holiday Hills.

[1]Department of Geology, College of William and Mary, Williamsburg, Virginia 23185

TERTIARY SYSTEM

Gravels

There are two units dominated by coarse gravels. They differ in clast composition, degree of weathering and cementation, elevation, and direction of inclination of their basal contacts. The higher, apparently older gravel unit occurs on upland surfaces south and north of the James River. These deposits are up to forty feet (12 m) thick. The size of the average clast is 2 to 3 inches (5-8 cm), but cobbles with a maximum dimension of more than 9 inches (23 cm) occur. Well-rounded pebbles and cobbles are abundant and the matrix is sand with a variable amount of clay (R-5918). Clast sphericity ranges from low to high and roundness ranges from angular to fairly well rounded. Discoidal pebbles and cobbles tend to be oriented parallel to bedding. Most of the clasts are primarily vein quartz, quartzite, and quartz sandstone. Some of the quartzite clasts include Skolithos. A few clasts are composed of metamorphic rocks, igneous rocks, or chert. Typically, all these rock particles are stained reddish-brown on the surface but are unstained on freshly broken surfaces; the particles also commonly weather yellowish-brown to reddish-brown and some are partly decomposed. Many of the quartzite and sandstone clasts are so deeply weathered that they may be reduced to a sandy powder by pressure of the fingers. Locally the matrix contains much clay, probably derived in large part from the decomposition of feldspar and diluted from overlying beds. Some of the clay may be primary. Incipient cementation is by iron oxide, silica, and clays. Locally a finely laminated yellowish-gray silt (R-5919) underlies the gravels.

An upper loam member overlies the gravel with a conformable and gradational contact. The loam is reddish-brown, contains a few scattered siliceous pebbles, and ranges from a featheredge to more than 10 feet (3 m) thick. It was not mapped separately.

The high level gravels south of the James River contain more clasts with regard to matrix than do those to the north, especially when compared to those at higher elevations. Gravels to the south are also more highly cemented and more highly decomposed. The larger quantity of clasts is indicative of a higher energy fluvial environment of deposition for the deposits south of the river.

Because the lower contacts of the gravels are at similar elevations south and north, the deposits are considered to be time equivalents. South of the James River the high level gravels occupy a broad, flat, relatively undissected upland surface. Remnants of gravel occur on hills just east of the intersection of U.S. Highway 60 and Chippenham Parkway and westward across and beyond the quadrangle. Similar gravels are in the Midlothian area (Shaler and Woodworth, 1899; Mathews and others, 1965; Goodwin, 1970; and Goodwin and Johnson, 1970). The gravels were deposited on a nearly planar surface, with some channels, which today has a gentle eastward inclination of about nine feet per mile (1.6 m per km). The basal contact of the gravel deposits is at an elevation of 250 feet (76 m) in the southeastern quadrant of the quadrangle, 330 feet (101 m) in the southwestern corner, and 390 feet (119 m) at the western edge of the Midlothian quadrangle. The maximum observed elevation, above 450 feet (137 m), occurs in the Fine Creek Mills quadrangle, which is the next quadrangle west of the Midlothian quadrangle. North of the James River, high level gravels are a thin cover on the upper hills and extend from a minimum elevation of 250 feet (76 m) at the intersection of Broad Street and Bremo Avenue to a maximum elevation of 310 feet (94 m) at the intersection of Parham Road and Quioccasin Road.

Although the elevation of the basal contact is in accord north and south of the James River, the nature of the contact is commonly different on the two sides of the river. On the south side the contact with the underlying saprolite is invariably sharp and is commonly marked by a thin basal conglomerate. Many gravel contacts exposed on hillsides are marked by a sharp break in slope. In places gravel has acted as a resistant cap-rock. To the north contacts range from somewhat sharp in eastern exposures, where channeling in the underlying saprolite is more extensive, to gradational in western exposures. The gradational sequence is from granite to reworked saprolite to gravel. A gradational contact between saprolite and gravel is exposed in the parking area of Regency Square Mall.

The age of the high level gravels is uncertain. This unit is higher and more weathered than Quaternary alluvium and is assigned to the Tertiary. The underlying Petersburg granite appears to have been weathered to saprolite before the gravel was deposited.

The lower, younger Tertiary gravels (R-5920) are terrace remnants adjacent to the James River; only one large patch north of the James River and one small area south of the James remain. The unit is more than 40 feet (12 m) thick in places.

Coarse gravels are dominant and whereas cobbles up to 7 inches (18 cm) in diameter occur, the average clast diameter is approximately 2 inches (5 cm). Massive gravel beds up to 8 feet (2.4 m) thick are locally interlayered with clayey sand beds, although most gravel beds are less than five feet thick. There are a few scattered round quartz pebbles within the sandy beds. The matrix is sand with varying amounts of clay. Discoidal pebbles and cobbles have their long axes oriented parallel to bedding. Quartz clasts dominate. The clasts are less weathered than those of the high level gravel unit. At most exposures the gravels are highly oxidized and iron stained and the matrix has been stained dark reddish brown. The gravels generally are not cemented.

The base of this lower gravel unit slopes toward the James River from the north and the south; elevation decreases from about 250 feet (76 m) to less than 180 feet (55 m) on the north side and from 240+ feet (73 m) to less than 180 feet (55 m) on the south side of the river. The slope of the contact may be as much as 50 feet per mile (9.4 m per km).

These lower level Tertiary gravels are considered to have been deposited by the James River when it was above its present elevation; the unit may be time equivalent with the sand and gravel unit.

Sand and Gravel

A thin veneer of sand and gravel (R-5921) overlies an eroded, gently sloping surface of Petersburg granite in the eastern part of the quadrangle. The unit is a featheredge at an elevation of 240 feet (73 m) in the Bon Air quadrangle and thickens to more than 80 feet (24 m) in the Yellow Tavern quadrangle to the east (Daniels and Onuschak, 1974). In the Bon Air quadrangle it is commonly less than 10 feet (3 m) thick.

The sand and gravel unit is composed of yellowish-gray to reddish-brown sediments that range in size from clay to cobbles. In places the fine sands are laminated and they may be mottled with iron oxide. Commonly there are a few scattered, rounded quartz granules and pebbles within a silty sand or fine sand matrix. Locally there are gravel beds several feet thick within the silty sand which also commonly contains gravel stringers.

The relationship between the high level gravels and sand and gravel unit can be seen in the eastern one-third of the quadrangle and on the eastern end of cross sections A-A' and C-C'. The high level gravel unit has a minimum elevation of 250 feet (76 m) and the sand and gravel attains a maximum elevation of 240 feet (73 m).

Granite saprolite is commonly exposed in the intervening 10 feet (3 m). On the basis of these and other observations, the following geologic history is inferred. The high level Tertiary gravels were deposited on a broad, weathered, gently inclined and channeled surface of Petersburg granite. Following a rise in sea level to a height about 240 feet (73 m) above its present stand, the seaward edge of the Petersburg granite was eroded to form a slight scarp which is just east of the intersection of U.S. Highway 60 and Chippenham Parkway and in several areas north of the James River. The scarp and the fine, well-sorted sediments to the east of it are suggestive of a marine origin. Several small hills of Petersburg granite, some capped by Tertiary gravels, became islands in this sea as they were eroded and isolated.

Around these islands were strandline and nearshore deposits. As sea level lowered, regressive and fluvial sand and gravel was deposited on the eroded granite surface. Small-to-medium-sized deltas probably formed seaward of the mouths of streams which emptied into this receding sea (Daniels and Onuschak, 1974).

QUATERNARY SYSTEM

Alluvium

The floodplains of the James River and the valley floors of several smaller streams are mantled by deposits of gray, poorly sorted, stratified sand, gravel, silt, and clay. These commonly contain organic material, are moist, and are subject to periodic flooding.

Depressions on the Upland Surface

At least nine elliptical, shallow depressions occur on the flat, undissected upland surface of the highest Tertiary gravels in the southwestern quarter of the quadrangle. There are an additional dozen similar depressions on the same surface in the adjacent Midlothian quadrangle (Johnson and Goodwin, 1967; Goodwin and Johnson, 1970). These depressions or basins are commonly at elevations of 340 to 350 feet (104-107 m), and are filled by 5 to 10 feet (1.5-3 m) of massive, brownish-gray silty clay with a few scattered, rounded quartz pebbles. A low ridge or rim of fine sand surrounds the depressions. The sandy sediments of the rim grade laterally into the brownish-gray silty clay of basin interiors. In one basin this gradation occurs over a horizontal distance of 125 feet (38 m). In general, the width of the gradational zone varies directly with the "diameter" of the basin. Commonly the rim, if undissected by erosion, is from 5 to 10 feet (1.5-3 m) high and, although this relief is often too low to be seen on the topographic map, it can usually be detected on aerial photographs. In the quadrangle, the maximum dimensions of the basins range from 0.25 miles to 1.05 miles (0.4-1.7 km). The long axes of the basins trend N80°W.

In the quadrangle, the basins appear to be restricted to the highest upland surface south of the James River. Reconnaissance studies of surrounding areas do not reveal any similar basins on Piedmont rocks which lack a gravel veneer. They are also absent in areas dissected by erosion. The development of the depressions does not appear to be related to the type of bedrock which underlies the upland gravels. For example, in the Bon Air quadrangle all of the depressions have developed on gravels overlying the Petersburg granite, whereas in the Midlothian quadrangle some depressions have formed on gravels overlying coal measures, sandstones, and shales of Triassic age. The elliptical depressions in the Bon Air and Midlothian quadrangles are very similar to the well-studied Carolina Bays of the central and southern Atlantic Coastal Plain. Therefore, they are considered to be Carolina Bays which have developed on gravel west of the Fall Line.

Basins whose rims are undissected by streams have interior drainage. Consequently, the clayey sediments are usually moist and support water-loving plants and some basin interiors contain swamps.

ECONOMIC GEOLOGY

Stone

The Petersburg granite is a potential source of crushed stone and dimension stone. Two kinds of granite have been quarried: a "coarser-textured" light-gray granite suited for general building purposes and a "finer-textured," dark-blue-gray granite extensively used for monument stones (Watson, 1910, p. 93). Both are homogeneous, equigranular granite possessing good working qualities (Watson, 1910).

Large quantities of granite suitable for dimension stone occur within the area. However, the best quality stone with the least amount of overburden lies adjacent to the floodplain of the James River where the James, its tributaries and slope wash have reduced the overburden to a thin mantle.

The Petersburg granite is variable in composition, texture and joint development. Although this variability is not desirable in dimension stone, the rock may be used for crushed stone. From the Petersburg granite a sufficient amount of crushed stone could be supplied to meet future needs of this region. In areas where the granite is covered by a thick residue of saprolite, production cost may be relatively great.

As Richmond and its suburbs continue to expand, the demand for crushed stone will continue to increase. The major problems in developing the crushed stone resources will probably result from the increased urbanization and public reluctance to have crushed stone operations in close proximity to residential communities.

Coal

Thin beds of coal occur in the Triassic sediments near Gayton. The thicker Triassic coal beds occur outside the quadrangle to the west in the main Richmond basin (Goodwin, 1970). Coal potential in the Bon Air quadrangle is limited because the beds are thin and irregular. Urbanization will also restrict their availability. Methane, which may be associated with the coal, might provide a source of energy if sufficient quantities of the gas exist.

Clay Materials

Although clay has not been worked in this area, several units exposed here have been exploited commercially in adjacent areas. The major limiting factor is the high degree of urbanization.

Tests on a sample of saprolite of the Petersburg granite from the base of a construction trench at the intersection of Interstate Highway 95 and Broad Street in the Richmond quadrangle indicate that the saprolite is suitable for face brick (Daniels and Onuschak, 1974, p. 38). Raw properties and slow firing data have been recorded (Sweet, 1976, p. 43). Large quantities of similar, deeply weathered granite saprolite within the Bon Air quadrangle commonly are covered with gravel.

Clay obtained from shales in the coal measures of Triassic age along Gayton Road in the Midlothian quadrangle was tested (Johnson and Tyrrell, 1967, p. 87). The clay has potential use in the manufacture of face brick and structural tile. Other clay-materials derived from the weathering of Triassic shales within the present area may be suitable for similar purposes.

In the Bon Air quadrangle Tertiary clay is usually thin where it overlies the Petersburg granite. The clay is thicker in the Richmond area and has been used for brick-making (Darton, 1911).

Sand and Gravel

Gravel has been produced from the older, high level Tertiary gravels at several places. Only a few of these pits are in operation and activity is intermittent. In general, this unit contains deeply weathered clasts, is partially cemented and oxidized, and is a poor source of high quality sand and gravel. The primary use is as fill.

The younger, lower level Tertiary gravels have also been worked at several places. The presence of clayey matrix and excessive amount of ferruginous material in the deposits limits their use as aggregate.

Six miles east of the Bon Air quadrangle, several large sand and gravel deposits of Tertiary age have been worked.

ENVIRONMENTAL GEOLOGY

Environmental geology of the area is related to the rock units shown on the geologic map. Field observations on the lithology, rock fractures, slope stability, and erodibility, in conjunction with soil surveys of Chesterfield County (Mathews, 1970) and Henrico County (Clay, 1975), were used in writing the environmental geology summary. In this summary, printed adjacent to the stratigraphic columns, the terms slight, moderate, and severe indicate the degree to which the surficial and near surface material is suitable for the designated land use. The term "slight" means that generally soils will be satisfactory for the designated use. "Moderate limitations" implies that the soil may or may not be satisfactory for the designated use. In such cases on-site investigations may be necessary to determine suitability. "Severe limitations" means that in most cases the unit will not be satisfactory for the designated use, although on-site investigation may show that limited sites within it may be used. Any particular site development or proposed land modification should be preceded by a detailed on-site investigation by a professional geologist or engineer.

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Portions of the publication may be quoted if credit is given to the Virginia Division of Mineral Resources. It is recommended that reference to this report be made in the following form:
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