COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES

GEOLOGY OF THE HANOVER ACADEMY QUADRANGLE, VIRGINIA

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1981

UNIT CHARACTERISTICS WITH GEOLOGIC AND ECONOMIC FACTORS AFFECTING LAND MODIFICATION

CENOZOIC

QUATERNARY

al — Alluvium: *Floodplain deposits of sand, silt, clay and gravel.*

Periodically flooded; cuts and excavations subject to sliding and sloughing; flooding severely limits use.

g_5 — Gravel: *Terrace base at 80 feet (24 m) elevation; sands, pebbles and cobbles, some lignitic clays; gravel clasts of igneous, metamorphic and sedimentary rocks.*

Highly permeable; good shallow aquifer but readily contaminated by surface water and affected by moderate drought.

g_4 — Gravel: *Terrace base at 100-110 feet (30-33 m); sand, pebbles, cobbles and boulders; gravel clasts of igneous, metamorphic and sedimentary rocks.*

Highly permeable; good shallow aquifer but readily contaminated by surface water and affected by moderate drought. Provides excellent fill material.

g_3 — Gravel: *Terrace base at 130-140 feet (40-43 m); sand, clay, pebbles, cobbles and local boulders; gravel clasts of igneous, metamorphic and sedimentary rocks.*

Moderately permeable; good shallow aquifer but affected by moderate drought. Boulders may produce some local difficulties in excavation.

TERTIARY

g_2 — Gravel: *Terrace base at 180-230 feet (55-70 m) elevation; dark-yellowish-orange sand, clay, pebbles and cobbles; gravel clasts composed almost entirely of vein quartz, quartzite, sandstone and chert and rarely of saprolitized clasts of other types.*

Moderately to poorly permeable near surface, highly permeable near base. Excellent shallow aquifer affected only by prolonged drought. Basal sands and gravels make an excellent fill material.

g_1 — Gravel: *Terrace base at 240-300 feet (73-91 m) elevation; red sand, clay, pebbles and cobbles; gravel clasts saprolitized except for quartz, which is etched. Gravel and sand grade upward into clayey sand.*

Moderately permeable to poorly permeable near surface, highly permeable near base. Excellent shallow aquifer in the southeast area, elsewhere too thin to be useful. Basal sands and gravels make an excellent fill material.

MESOZOIC

JURASSIC

d — Diabase dikes: *Dark-greenish-gray to black diabase.*

Weathers to rounded to subrounded boulders and bright red clay. Difficult to excavate and where fresh may require blasting.

TRIASSIC

Ŧdns, Ŧdnc, Ŧdfm, Ŧds — Doswell Formation: **Ŧdns**, Newfound Member, *(sandstone/siltstone facies). Interbedded, poorly indurated sandstones and siltstones; sandstones light-brown to reddish-brown and massive; siltstones gray where fresh, but red where weathered.*

Moderately consolidated to unconsolidated; moderately permeable; easily excavated.

Ŧdnc, Newfound Member (sandstone/conglomerate facies): *Light-brown to reddish-brown; sandstones and conglomerates with large-scale crossbeds; clasts subrounded to rounded, composed dominantly of vein quartz with lesser amounts of biotite gneiss and mylonite; well consolidated except where severely weathered; forms prominent cliffs on steep slopes.*

Generally well consolidated; permeability poor, water flows only along joint sets; difficult to excavate.

Ŧdfm, Falling Creek Member: *Light-brown to reddish-brown, fine- to medium-grained, flaggy sandstone; green, gray or black siltstone and shale; and minor amounts of coal and conglomerate. Some sandstones and shales are calcareous.*

Sandstones well consolidated, siltstones and shales easily excavated. Permeability poor, water flows only along joint sets.

Ŧds, Stagg Creek Member: *Light-brown to reddish-brown, massive conglomerates and coarse sandstones, minor amounts of blue to gray siltstones. Clasts include granite, biotite gneiss, granite gneiss, and mylonite. Cobble-sized particles are rounded, smaller ones are subrounded.*

Sandstones and conglomerates well consolidated; permeability poor, water flows only along joint sets; difficult to excavate.

PALEOZOIC

cmp, cmy, cmg — Cataclastic rocks of Hylas zone: **cmp**, *light-gray protomylonites which weather to form knobbly, rounded masses.*

Rock well-indurated and hard but usually highly fractured and easily broken up. Permeability moderate due to intense jointing. Generally weathered to poorly permeable sandy clay except in deeper stream and river valleys.

cmy, *light- to dark-gray, mylonite which weather to angular, blocky, fragments up to several centimeters in diameter. Textures of fragments range from glassy to fine-grained.*

Rock well indurated, highly fractured and easily broken up. Permeability moderate to high due to fractures. Generally weathered to poorly permeable sandy clays except in deeper stream and river valleys.

cmg, *dark- to light-gray, foliated, mylonite gneiss containing numerous augen of K-spar and hornblende; black lenses of ultramylonite commonly intercalated in the gneiss.*

Rock contains somewhat numerous fracture sets. Rock massive, not easily broken up. Permeability poor to moderate depending on abundance of fractures. Generally weathered to poorly permeable sandy clay except in deeper stream and river valleys.

Pzpb, pq — Petersburg granite: **Pzpb**, *light-gray, faintly foliated, moderately-jointed granite in places, with biotite-bearing xenoliths; highly fractured next to Hylas zone;* **pq**, *Petersburg granite with abundant, narrow quartz veins.*

Rock massive and little fractured along Falling Creek; highly fractured along Beech Creek and near Hylas zone. Where massive, permeability poor; at other places, permeability moderate. Generally weathered to form poorly permeable sandy clay except at lower elevations along Beech Creek and Falling Creek.

PRECAMBRIAN

amg — Amphibole gneiss: *Black to black-and-white speckled, moderately to well-foliated, coarse-grained, hornblende-plagioclase gneiss.*

Weathers to round to subround boulders and red clay. Poorly permeable except along joint sets, which are rare. Difficult to excavate and where unweathered may require blasting.

qg — Feldspar-quartz gneiss: *Brown to gray, white-speckled, moderately to well foliated, coarse-grained gneiss.*

Generally weathered, easy to excavate. Moderately permeable.

bgn — Biotite gneiss: *Dark- to light-gray, well-foliated, fine- to medium-grained quartz-plagioclase-biotite-K-spar gneiss.*

Where fresh, the rock is hard. Weathered to red clayey saprolites with poor permeability except along deeper stream valleys; water moves only along joint sets.

mg — Muscovite gneiss: *Silvery pale-gray to pale-blue, well-foliated, medium- to coarse-grained, quartz-muscovite-kyanite-plagioclase-biotite gneiss.*

Rock soft, weathers to poorly permeable red sandy clays; fresh rock moderately permeable.

grgn — Granite gneiss: *Light-gray, poorly foliated, fine- to medium-grained, quartz-plagioclase-K-spar-biotite gneiss.*

Generally deeply weathered to form sandy and clayey saprolites; water moves freely only along joint sets.

KEY

CONTACTS

Exposed or approximate

Covered or inferred

FOLDS

Direction and angle of plunge of minor overturned, isoclinal anticline

Direction and angle of plunge of minor overturned, isoclinal syncline

FAULTS

Exposed or approximate (black line); covered (gray line); U, upthrown side; D, downthrown side.

ATTITUDE OF ROCKS

Strike and dip of beds

FOLIATION

Strike and dip of gneiss foliation

Strike and dip of foliation in cataclastic rocks

Strike of vertical foliation in cataclastic rocks

Strike and dip of foliation in Petersburg granite

QUARRIES AND PROSPECTS

Active quarries:

1. General Crushed Stone Co.
2. Tosalma Stone Quarry, blackstone (amphibole gneiss)
3. & 4. Tosalma Stone Quarry, graystone (biotite gneiss)

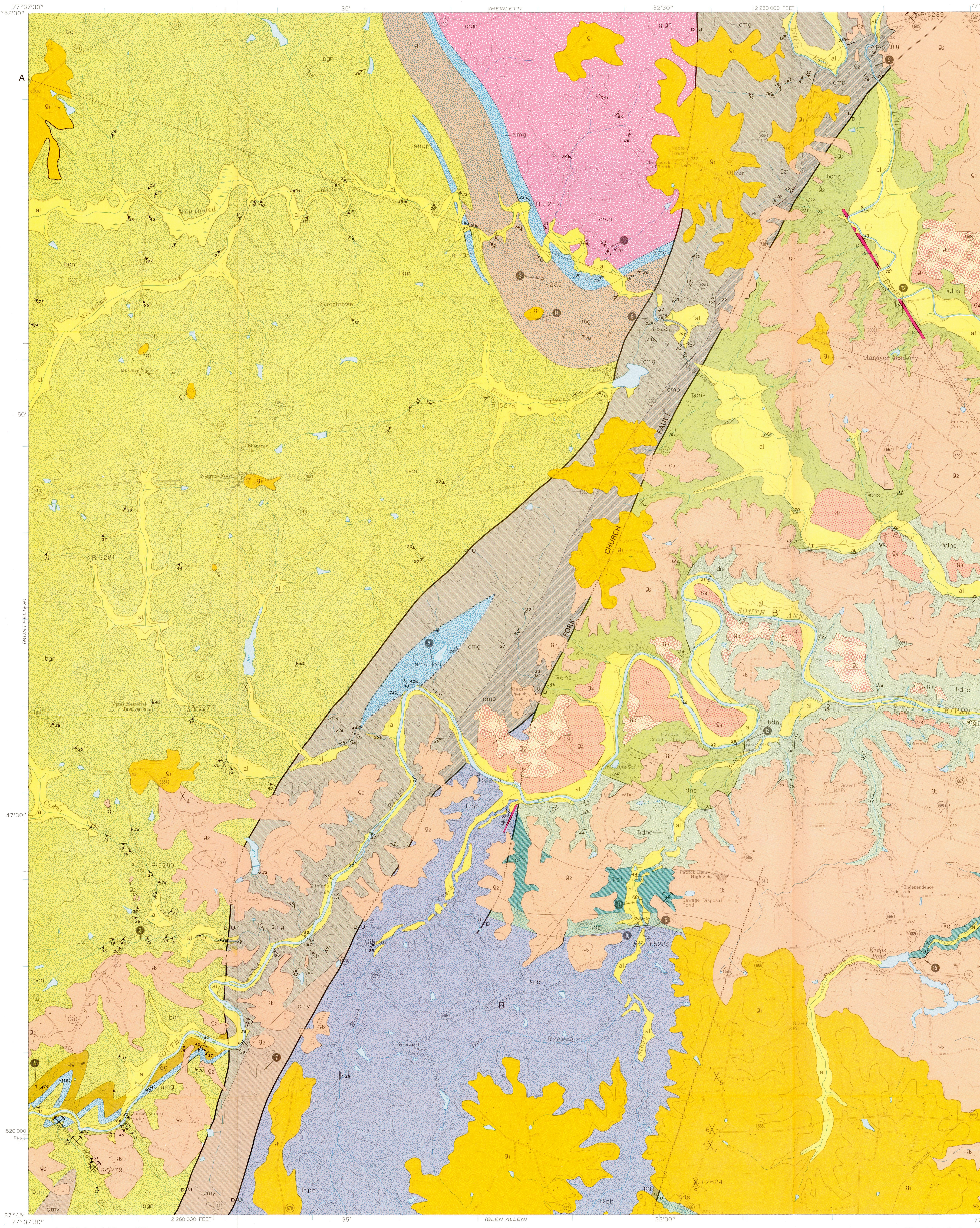
Abandoned mine: Coal mine

Prospect: 1, 2, 3, 4. muscovite
5, 6, 7, 8. zircon

SAMPLE LOCATIONS

R-5277 — R, repository number of rock sample on file at Virginia Division of Mineral Resources

Reference locality described in discussion



Base map from U.S. Geological Survey, 1969
Hanover Academy Quadrangle, 7½ Minute Series

Williams & Heintz Map Corporation
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SCALE 1:24 000
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
1981

The metamorphic rocks of the area lie northwest of a zone of fractured rocks herein named the Hylas zone. The metamorphic rock types are biotite gneiss, granite gneiss, muscovite gneiss, amphibole gneiss and feldspar-quartz gneiss, named in order of decreasing areal abundance. In the following descriptions of these units, the rocks are arranged in order of apparent decreasing age. These age relationships are based on interpretations of foliations in the rock units, which roughly delimit a large open antiformal fold. The axial trace of the fold is generally parallel to the Hylas zone and passes through the large granite gneiss body in the north-central part of the quadrangle. The structural history is undoubtedly more complex than is shown by this simple fold. Small-scale isoclinal folds, in which mineral-grain foliation parallels the fold axes, attest to a metamorphic and deformational event which occurred earlier than the event that produced the broad, open fold. In this later fold, mineral-grain foliation wraps around the fold axis. The small-scale isoclinal folds are generally well preserved in the amphibole gneiss, but in the other lithologies they are poorly preserved because these units are abundantly sheared.

The Hylas zone is an area of cataclastic rocks lying between two normal faults, the Fork Church fault and an unnamed fault northwest of it. These cataclastic rocks, which are derived from several rock types, are Upper Paleozoic to Lower Mesozoic in age.

Rocks of Triassic age are southeast of the Fork Church fault, which forms the northwest border of the Taylorsville basin (Weems, 1980a).

STRATIGRAPHY

PRECAMBRIAN OR LOWER PALEOZOIC ROCKS

Granite Gneiss

A large dome of granite gneiss, encircled by amphibole gneiss and muscovite gneiss, occupies the north-central portion of the quadrangle. The granite gneiss is light gray, poorly foliated and fine- to medium-grained. Quartz, plagioclase, potassium feldspar and biotite are the predominant minerals. A granitic pluton along strike about 20 miles (32 km) to the southwest in Goochland County intrudes a similar rock mass, the State Farm Gneiss. This pluton was dated by the whole-rock Rb-Sr method as 1 billion years (Grenville) in age (Glover and others, 1978).

The granite gneiss is intensely weathered over most of the area. Near a tributary of the Newfound River there are fresh, loose blocks of this rock (REFERENCE LOCALITY 1); elsewhere only saprolite was observed.

Muscovite Gneiss

Surrounding the granite gneiss dome in the north-central part of the Hanover Academy quadrangle is a silvery, pale-gray to pale-blue, medium- to coarse-grained gneiss that contains much muscovite and/or much kyanite. Other predominant minerals are quartz, plagioclase and biotite (Table 1). The mineral content supports the hypothesis that the rock is a metamorphosed shale, but it is possible that it represents a metamorphosed saprolite developed on the underlying granite gneiss, if it unconformably underlies the other units. Fresh exposures occur about 0.2 miles (0.3 km) south of the Newfound River (R-5283; REFERENCE LOCALITY 2).

Biotite Gneiss

This rock is generally dark gray, but locally contains light-gray interlayers. Approximate mineral compositions are given for three typical samples of this gneiss in Table 1. Quartz, plagioclase and potassium feldspar, and biotite are the predominant minerals. The K-feldspar, plagioclase and quartz are anhedral. The quartz is prominently strained. Garnets and opaque minerals are the most common accessory minerals. The garnets are anhedral, highly fractured and probably were rotated during their growth. The bulk chemistry of the biotite gneiss, the widespread occurrences of garnets and the extremely monotonous appearance of the rock is most consistent with the idea that the rock represents a metamorphosed graywacke sequence. Good exposures occur along Cedar Creek and its tributaries (REFERENCE LOCALITY 3).

Feldspar-Quartz Gneiss

This rock type crops out in places along the South Anna River in the southwestern part of the quadrangle; REFERENCE LOCALITY 4 is just north of the river. The rock is highly weathered, so the potassium feldspar/plagioclase feldspar ratio was not determined. Typically this rock is coarse grained; it contains white specks of kaolin formed from weathered feldspars. The rock may have been originally arkose or granite.

Amphibole Gneiss

This unit is a black to black-and-white speckled, foliated, coarse-grained amphibole gneiss in which hornblende and plagioclase are predominant (Table 1). It is associated with the muscovite gneiss and the feldspar-quartz gneiss or is found within the Hylas zone as lenses. The lense-like outcrop patterns, coarse-grained texture, and mineralogy all suggest that this unit originated as gabbroic to dioritic sills.

A good outcrop occurs about 3500 feet (1067 m) west-northwest of Kings Chapel (REFERENCE LOCALITY 5).

UPPER PALEOZOIC ROCKS

Petersburg Granite

The Petersburg granite is typically light gray, except near the Hylas zone, where it is highly fractured and secondarily red as a result of intense weathering along fractures. Modal analyses of two samples (R-5285, REFERENCE LOCALITY 6; and R-5286) are given in Table 1. This unit was dated at 323 ± 10 million years in age (Wright and others, 1975), a Late Devonian or Early Mississippian date.

There is a small patch of granite containing numerous quartz veins within the Petersburg granite along a small tributary to the east of the upper reaches of Stagg Creek. These rocks and similar ones occurring in linear belts to the south in the Glen Allen quadrangle are interpreted to represent fault zones, along which quartz has been precipitated extensively in fractures. Although this quartz-veined rock is exclusively developed within the Petersburg granite, its association along strike with faults affecting sediment distributions in the Triassic Taylorsville basin suggests that it was formed later than the granite.

Table 1. Modal analyses (in percent) of samples from the metamorphic and igneous terrain.

	Muscovite Gneiss	Biotite Gneiss			Amphibole Gneiss	Petersburg Granite	
	R-5283	R-5277	R-5278	R5279	R-5282	R-5285	R-5286
Quartz	37.4	36.5	26.0	37.1	3.5	26.7	29.4
Plagioclase*	13.6	42.0	17.7	14.0	20.5	35.5	38.8
Microcline	—	—	—	—	—	7.0	19.0
Potassium feldspar* (undifferentiated)	3.4	—	23.7	9.2	—	24.8	9.5
Hornblende	—	—	—	5.3	71.0	—	—
Muscovite	25.9	—	—	—	—	0.5	0.9
Biotite	19.4	19.5	27.9	12.4	—	4.6	2.4
Garnet	—	0.5	—	7.9	—	—	—
Epidote	—	—	4.7	14.1	5.0	—	—
Opaques	0.3	1.5	—	—	—	0.9	—
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

*Determinations based on results of staining of thin sections. Some potassium feldspar may be untwinned microcline.

[1] U.S. Geological Survey, Reston, Virginia

UPPER PALEOZOIC (?) TO LOWER MESOZOIC (?) ROCKS

Mylonite Gneiss, Mylonite, and Protomylonite

A group of largely cataclastic rocks that are very fine- to very coarse-grained and abundantly fractured lie within a narrow area herein named the Hylas zone. The zone is 0.5 to 2 miles (1 km to 3 km) wide in the Hanover Academy quadrangle, and separates gneisses (northwest) from Petersburg granite (southeast). The Hylas zone extends to the southwest as far as the James River in the Midlothian quadrangle (Goodwin, 1970). Possibly it continues southward of the James River under the western edge of the Triassic rocks in the Richmond basin in western Chesterfield County. The zone is covered by Coastal Plain sediments northeast of the North Anna River in the Ruther Glen quadrangle and has not been observed farther north. Rocks of the Hylas zone include the "aporhyolite" of Brown (1937) and the "metavolcanics" of Goodwin (1970). Bobyarchick and others (1976) were the first to point out the mylonitic character of these rocks.

The rocks in the Hylas zone include several lithologies. Fine-grained to glassy mylonites occur in the southwestern part of the quadrangle (REFERENCE LOCALITY 7). Augen gneiss with a fine-grained groundmass is abundant. Both the augen and the matrix were formed by cataclasis (Bobyarchick and others, 1976). In this rock, grain shape and grain size are related to each other. The larger crystals are subrounded to well rounded, and the smaller ones are more angular. The larger grains are also those with greater physical hardness. These observations support the idea of a cataclastic origin of the rock. Potassium feldspar grains are generally crushed and smeared out into crush trains, whereas garnets are commonly crushed and sheared, but are not in crush trains. Rock types in the Hylas zone include crushed rock with fine-grained textures (mylonite, "metavolcanic rocks") and crushed rock with extremely fine-grained textures (ultramylonite). There is an outcrop containing augen-bearing mylonite and ultramylonite south of the Newfound River and west of State Road 685 (REFERENCE LOCALITY 8). A rock of granitic appearance which is actually a potassium feldspar-poor protomylonite (R-5288) crops out south of the gaging station on the Little River (REFERENCE LOCALITY 9). See Table 2 for analyses.

Table 2. Modal analyses (in percent) of samples from the Hylas zone.

	R-5287[1]	R-5288[2]	R-5289[2]	R-5290[3]
Quartz	51.2	30.1	19.2	46.3
Plagioclase*	41.9	64.1	64.5	32.0
Potassium feldspar*	—	—	1.0	21.2
Biotite	4.4	4.3	11.3	—
Garnet	1.0	—	—	—
Chlorite	—	1.5	1.0	—
Laumontite	—	—	—	0.5
Opaques	1.5	—	—	—
	100.0%	100.0%	100.0%	100.0%

[1]mylonite gneiss
[2]protomylonite
[3]mylonite, Hylas quadrangle

*Determinations based on results of staining thin sections. Some potassium feldspar may be untwinned microcline.

In addition to the clearly cataclastic rocks, there are a number of rock types in the Hylas zone whose origin is obscure. Some of these rocks, which are all derived from gneisses, are similar to ones in the metamorphic terrain, except that they are more intensely strained (mylonite gneisses). Other areas contain rocks showing the effects of total and partial crushing. In the mylonite gneiss, quartz recrystallized around feldspar augen. The geometry of the large body of amphibole gneiss in the central part of the quadrangle is especially suggestive that it is a strained and only partially crushed mass within the zone.

Rocks of the Hylas zone cut the Petersburg granite (Mississippian) and rock fragments derived from the zone are in sediments of the Triassic Doswell Formation. Therefore, rock characteristics and geometry of the Hylas zone were largely established between Mississippian and Triassic time. Although Bobyarchick and others (1976) demonstrated that late stage movement along the Hylas zone was predominantly by dip slip along planes dipping 30° to 45° southeast, an early history of lateral movement cannot be precluded, especially in view of the lack of comparable lithologies anywhere on either side of the zone.

TRIASSIC SYSTEM

Rocks of Triassic age occur in the Taylorsville basin, a half graben tilted to the northwest. The Fork Church fault (Weems, 1980a), which parallels the Hylas zone and probably developed along fractures in the Hylas zone, forms the northwestern border of the basin in the Hanover Academy quadrangle. The Triassic rocks of the Taylorsville basin were named and described by Weems (1980a) from exposures in the adjoining Ashland quadrangle. A description of these rocks in the Hanover Academy quadrangle follows.

Doswell Formation

Stagg Creek Member: About 800 feet (244 m) of the Stagg Creek Member, the oldest unit of the Doswell Formation, is exposed at the type section on the west side of Stagg Creek, (REFERENCE LOCALITY 10). The lower contact of the unit, which is not exposed anywhere in the basin, is presumed to be represented by a nonconformity between the Stagg Creek Member and the Petersburg granite. The Stagg Creek Member is conformably overlain by the Falling Creek Member. The contact is defined as being at the base of the lowest flaggy sandstone or black to dark-gray shale above the base of the Stagg Creek Member. The member consists mostly of coarse sandstone (83 percent) and conglomerate (11 percent) with some siltstones (6 percent). Clasts in the coarser fractions consist of granite, biotite gneiss, granite gneiss and mylonite. Because cobbles are subrounded and rounded, it is not likely that prominent fault scarps existed along the basin margins at this stage of basin development. The basin floor was evidently generally well drained and well aerated, for most deposits are coarse and well oxidized (brownish), but there are some poorly oxided siltstones. There are fossil palynomorphs in this member.

Falling Creek Member: The middle member of the Doswell Formation, the Falling Creek Member, is 1200 feet (366 m) thick; flaggy, fine- to medium-grained sandstone (66 percent), siltstone (22 percent) and shale (10 percent) predominate. Most of the member is exposed along Stagg Creek (REFERENCE LOCALITY 11). Its contact with the overlying Newfound Member is conformable. The upper contact of the member is placed at the top of the uppermost black shale, gray, micaceous laminated siltstone, or flaggy sandstone in the unit. Most of the fine-grained units in the Falling Creek Member are covered. Siltstone and shales are exposed along small creeks leading into Falling Creek.

Conglomerates make up about 1 percent of the member, and there was probably no uplift at the basin margins in Falling Creek time. The shales, siltstones and fine-grained sandstones and the few coal lenses (totaling about 1 percent of the member) near the middle and top of this member are indicative of low relief and poorly developed drainage in the depositional basin. Most of the siltstones and shales are gray to black. The prominent bedding in many of the shales and the occurrence of apparently freshwater fossil fish are indicative 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 are likely due to bioturbation of the sediments in ancient times. No marine fossils have been found in the Taylorsville basin.

Remains of two fish, *Dictyopyge macrurus* (Redfield, 1841) and *D. meekeri* Schaeffer and McDonald, 1978, and three archosaurs—a parasuchian *cf. Rutiodon carolinensis* Emmons, 1856; *Doswellia kaltenbachi* Weems, 1980; and an unidentified saurischian dinosaur or rauisuchid—were recovered in the Ashland quadrangle (Weems, 1980b). Palynomorphs from this member indicate a late middle Carnian age (Cornet, 1977).

Newfound Member: This member is about 3000 feet (914 m) thick and is divided into two broadly intertonguing facies distinguished on relative abundance of siltstones and conglomerates. *Sandstone/Conglomerate Facies:* This facies is best exposed along the banks of Stagg Creek north and south of State Highway 54. It consists predominantly of massive sandstone (93 percent) and conglomerate (4 percent); siltstone makes up the rest of the unit. Clasts are generally subrounded to rounded and consist of vein quartz, biotite gneiss and mylonite. The composition of the clasts matches that of the older rocks to the northwest of the Taylorsville basin, and the member thickens in that direction. This facies probably does not exceed 1000 feet (305 m) in thickness. There are a few trunk casts of *Araucarioxylon sp.*, but other megafossils are absent. Palynomorphs from a lense near the base of this facies indicate it is of latest middle Carnian age (Cornet, 1977). *Sandstone/Siltstone Facies:* This facies, which consists of sandstone (75 percent), siltstone (20 percent) and conglomerate (5 percent), is exposed north and northwest of the Janeway estate (next to the Janeway Airstrip) southeast of Hanover Academy. The exposures at State Road 688 and Little River (REFERENCE LOCALITY 12) are typical; those along Stagg Creek appear less silty than most, probably because silty beds are selectively covered there. Fresh exposures of the siltstones are gray, but the rock weathers red. The highest beds in this facies contain poorly indurated sands and gravels. The contact of the sandstone/conglomerate facies and the sandstone/siltstone facies is well exposed at Horseshoe Bridge on the South Anna River (REFERENCE LOCALITY 13).

In the Ashland quadrangle, the sandstone/siltstone facies broadly intertongues with the sandstone/conglomerate facies. Farther west, the finer deposits overlie the coarser ones. Thus the sandstone/siltstone facies is in part younger than the sandstone/conglomerate facies and in part equivalent in age to it. Near the center of the basin, the sandstone/siltstone facies is probably about 2000 feet (610 m) thick. The age of the sandstone/siltstone facies may be of early late Carnian age based on its relationship to the sandstone/conglomerate facies.

Deposition of the Newfound Member seems to have commenced with a major influx of sediment from the northwest, presumably accompanying movement along the Fork Church fault. Coarse-grained sandstone and conglomerate spread eastward from the western edge of the basin in a series of coalescing deltas. To the east siltstone and fine-grained sandstone accumulated under lower energy conditions. During late Newfound time, fault activity waned and siltstones and fine-grained sandstones were deposited across the entire basin. But in latest Newfound time, a second major pulse of activity probably occurred along the fault. Angular clasts were shed into the basin at its western margin. The angularity of the clasts is evidence that there was a fault scarp along the western margin of the basin during late Newfound time. The degree of rounding of the clasts increases rapidly a short distance southwest of the border fault.

JURASSIC SYSTEM

Diabase Dikes

Two fine-grained, massive diabase dikes cut Triassic and older rocks in the quadrangle. The dikes were mapped in places when they were not exposed by surveying with a proton magnetometer. Each of the dikes is nearly vertical; the strikes are N30°W and N10°E. No similar diabase dikes cut Cretaceous or younger rocks (King, 1961) and the dikes are judged to be Jurassic in age.

TERTIARY SYSTEM

Gravel and Sand

Terrace "gravel" deposits similar to the gravels and sands mapped by Goodwin (1970) as g_1 and g_2 are in the area; the older unit, g_1, occurs at elevations above 240 feet (73 m). It is largely confined to the southeastern part of the quadrangle but occurs elsewhere in isolated patches. There is an outcrop of this poorly exposed unit along State Road 685, 1.5 miles (2.4 km) east of Scotchtown (REFERENCE LOCALITY 14). Characteristics include a red color, saprolitized cobbles, pitted quartz cobbles, and a heavy mineral fraction largely made up of zircon. These sediments have been severely weathered. A zirconiferous sandstone reported by Watson and Hess (1913), but which I did not see, may have been from lenses in the g_1 unit.

The younger unit, g_2, is at elevations between 180 to 230 feet (70 to 76 m) and is characterized by orangish hues, abundant saprolitized clasts, and unpitted quartz clasts. The heavy mineral assemblage is more diverse than that of g_1. Nearly all clasts are vein quartz, quartzite, sandstone or chert. In this unit, as in other terrace gravel units, deposits are coarsest at the base and become finer upward. A good exposure is near the intersection of State Road 669 and Falling Creek (REFERENCE LOCALITY 15).

QUATERNARY AND TERTIARY (?) SYSTEMS

Gravel and Sand

Three younger terrace gravels, presumably of Quaternary age, but possibly in part of Pliocene age, occur at lower elevations than the gravels previously described. The younger deposits all contain abundant, fresh metamorphic clasts—a characteristic distinguishing them from the older terrace gravels. The base of the highest and oldest of these younger gravels (g_3) lies at about 130-140 feet (40-43 meters) elevation, the base of the next younger (g_4) lies at 100-110 feet (30-33 meters) elevation, while the youngest (g_5) lies at 80 feet (24 meters) elevation. Each of these terraces is more widespread and better developed to the east in the Ashland quadrangle and beyond that area.

Alluvium

Thin alluvial deposits are along the floodplains of most streams and rivers. The basal parts of the deposits generally contain angular to rounded pebbles, cobbles, and boulders of varied composition. These clasts grade upward into sands and clayey sands.

ECONOMIC GEOLOGY

GRAVEL

Tertiary gravel units g_1 and g_2 and the younger terrace gravel g_4 are the chief sources of gravel. Gravels g_3 and g_5 are also locally exploited, but these deposits generally have a relatively large clay and silt content. The gravel deposits are a prime source of base material for road construction in the area.

CRUSHED STONE AND DIMENSION STONE

By far the most abundantly used mineral resources are the rocks in and near the Hylas zone (active quarry 1). These rocks are recovered for crushed stone. Near Ground Squirrel Bridge, southwestern part of area, several quarries are in amphibole gneiss (active quarry 2) and jointed biotite gneiss near the Hylas zone (active quarries 3 and 4); the product is dimension stone. The reserves appear to be extensive. Physical test data for samples of rock from six localities within this quadrangle have been reported (Parrott, 1954, p. 66).

IRON

Iron-enriched saprolites in areas of metamorphic rocks were probably a source of iron for early settlers. Scotchtown had an early foundry and the remnants of an old iron foundry probably identical with the Scotchtown enterprise were unearthed at Rocketts Mill just west of State Road 685 and the Newfound River (Mrs. I. C. Blickenstaff, personal communication, 1972). This foundry probably used local, residual iron sources only.

MICA

Mica was mined or prospected at several localities (prospects 1, 2, 3, and 4) (Brown, 1962). Production from the prospects ceased after a few months of operation when the pod-shaped lenses were mined out. The market for sheet muscovite is currently low, but the market for scrap and flake mica is increasing (Zlobic, 1980).

COAL

Coal was mined in the 1830's (Rogers, 1884). The coal came from near the middle of the Falling Creek Member of the Doswell Formation (abandoned mine 5).

ZIRCON

Watson and Hess (1913) reported prospects for zirconiferous sandstones in the southeast part of the area (prospects 5, 6, 7, 8; R-2624).

ENVIRONMENTAL GEOLOGY

Tens of feet of saprolite overlie most rock units in the area; such weathered rock is readily excavated. Fresh, hard rock is exposed in low areas along major streams and in a few places at higher elevations, principally in areas underlain by amphibole gneiss or diabase dikes.

Saprolites have low permeability and low rates of groundwater flow, whereas fractured fresh rock of the Hylas zone and various gravel deposits have high rates of groundwater flow. The gravels are a valuable water source where they are as much as 15 to 20 feet (5 to 7 m) thick, but groundwater in gravels is especially susceptible to contamination.

Soil types in the area are associated with rock types as follows. In general, areas underlain by metamorphic rocks (gneisses and Hylas zone rocks) have Wedowee-Vance-Appling, Pacolet-Cecil-Poindexter or Fluvanna-Colfax-Worsham soils; areas underlain by Petersburg granite have Vance-Chesterfield-Pouncey soils; areas underlain by Triassic rocks have Pinkston-Mayodan-Creedmoor-Bourne-Marlboro soils; areas underlain by terrace deposits have Marlboro-Bourne-Faceville, Marlboro-Coxville-Faceville or Coxville-Duplin-Marlboro soils; and alluvial deposits have Augusta-Chewacla-Altavista soils (Clay, 1975; U.S. Environmental Protection Agency, 1978).

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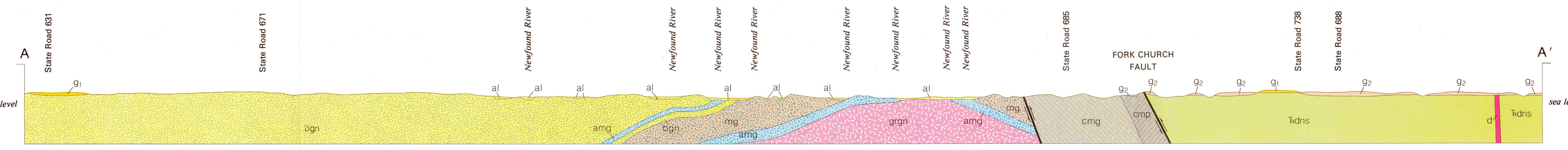
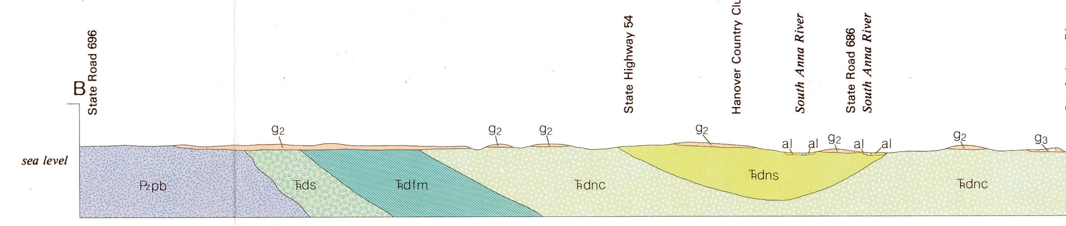
REFERENCE NOTE

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:
Weems, R. E., 1981, Geology of the Hanover Academy quadrangle, Virginia: Virginia Division of Mineral Resources Publication 30, text and 1:24,000 scale map.

CROSS SECTION DESIGN

1. No vertical exaggeration.
2. Subsurface structure interpreted from surface measurements.
3. Thickness of terrace deposits and alluvium approximate.