VIRGINIA DIVISION OF MINERAL RESOURCES PUBLICATION 5

GEOLOGY OF THE OMEGA, SOUTH BOSTON, CLUSTER SPRINGS, AND VIRGILINA QUADRANGLES

RONALD D. KREISA

COMMONWEALTH OF VIRGINIA

DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES

Robert C. Milici, Commissioner of Mineral Resources and State Geologist

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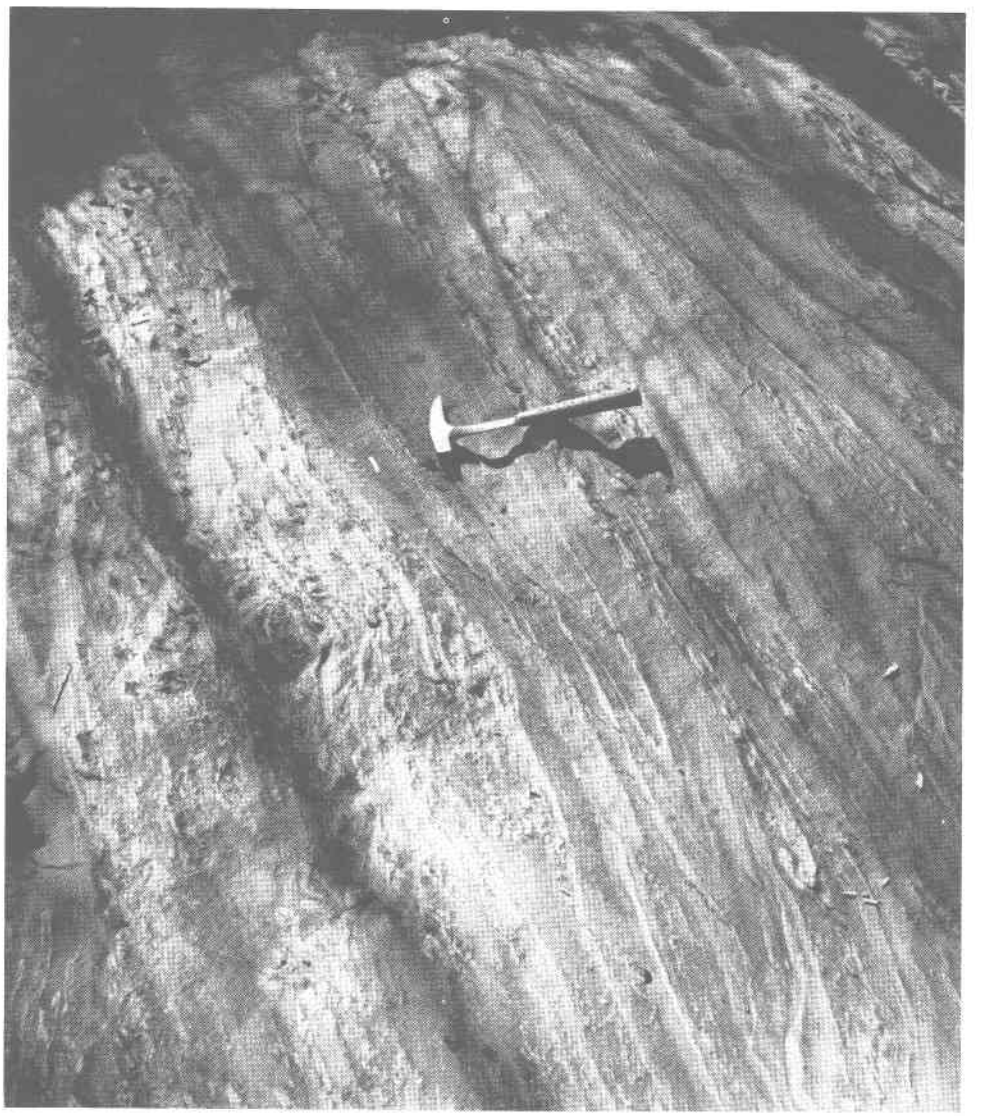

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FRONT COVER: Isoclinal folds in the gneiss unit along Halfway Creek approximately 2.0 miles (3.2 km) southeast of Cluster Springs, Cluster Springs quadrangle (Plate 2).

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DEPARTMENT OF PURCHASES AND SUPPLY
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GEOLOGY OF OMEGA, SOUTH BOSTON, CLUSTER SPRINGS AND VIRGILINA QUADRANGLES, VIRGINIA

By

Ronald D. Kreisa[1]

ABSTRACT

The Omega, South Boston, and the Virginia portions of the Cluster Springs and Virgilina 7.5-minute quadrangles are in Halifax County and within the Piedmont physiographic province. The bedrocks are composed of mostly metamorphic rocks of Precambrian age; unmetamorphosed sedimentary rocks of Triassic age occupy a small basin in the Omega quadrangle area. Late Triassic igneous dikes cut both the strata of the basin and surrounding crystalline rocks. Quaternary alluvium is common along major streams.

The metamorphic rocks in the western approximately two-thirds of the area consist of two mappable units: biotite gneiss and gneiss. These units have been metamorphosed at the almandine-amphibolite grade and deformed into isoclinal folds, which are in places steeply overturned. Later these rocks were refolded into a broad north-northeastward plunging anticline. The less intensely deformed and metamorphosed rocks in the eastern third of the mapped area, the Hyco and Aaron formations, lie mainly within the western limb of a major synclinorium.

Copper has been mined from quartz veins in the middle member of the Aaron Formation. Crushed stone is being produced from the gneiss unit and just north of the study area the biotite gneiss unit has been quarried for roadstone.

INTRODUCTION

The Omega, South Boston, and the Virginia portions of the Cluster Springs and Virgilina 7.5-minute quadrangles (shown on Plates 1, 2) are in the Piedmont physiographic province near the Virginia-North Carolina boundry (Figure 1). The mapped area, comprising 202 square miles (523 sq km) in south-central Halifax County within the Southside Planning District, is bounded by 78°45′ and 79°00′ west longitudes, 36°45′ north latitude, and the Virginia-North Carolina boundry.

Previously published geologic data on the area include a map of the rocks and results of investigations on copper deposits of the Virgilina district (Laney, 1917) and also the results of reconnaissance mapping and ground-water studies (LeGrand, 1960) and of reconnaissance mapping (Tobisch and Glover 1969). Mapping for this report was completed between June, 1972 and June, 1974.

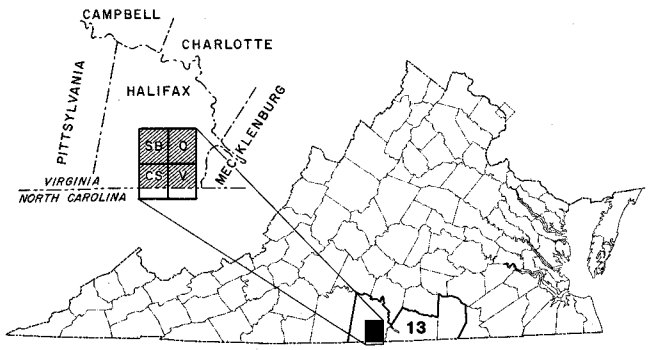

Figure 1. Index map showing location of the Omega (O), South Boston (SB), Cluster Springs (CS), and Virgilina (V) quadrangles in Planning District 13, Virginia.

James F. Conley aroused the interest of the author in this study and made available rock samples, a fossil collection from Triassic rocks, field notes, and field maps compiled during Conley's preliminary mapping of the area in 1965 and 1967. William S. Henika contributed valuable suggestions and David L. Wooley of the Virginia Department of Highways, Lynchburg District Office, made several drill cores available for study. Richard K. Bambach assisted the author in the identification of Triassic fossils.

Numbers preceded by "R" or by "F" in parentheses (for example, R-5657) correspond to sample localities shown on Plates 1 and 2. The samples and thin sections are on file in the Virginia Division of Mineral Resources repository where they are available for examination.

STRATIGRAPHY AND PETROGRAPHY
(Technical Discussion)

PRECAMBRIAN ROCKS

Biotite Gneiss

The biotite gneiss unit is composed of biotite gneiss with some interlayered mica schist, and one amphibolite layer (Table 1). The unit is in the western and northern parts of the South Boston quadrangle, in the western part of the Cluster Springs quadrangle and in the northern corner of the Omega quadrangle (Plates 1, 2). In upland areas the biotite gneiss has generally weathered to light-colored sandy loams; fresh exposures generally occur only in stream valleys such as along Myers Creek (Plates 1, 2) and in the headwaters of Mikes Creek (Plate 2) and Coleman Creek (Plate 2).

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Table 1. — Geologic formations in the Omega, South Boston, Cluster Springs and Virgilina quadrangles.

Age	Name	Character
Quaternary	Alluvium	Clay, silty clay, sand, pebbles, cobbles, and angular rock fragments.
	Terrace deposits	Layered clay-rich sand with well-rounded quartz cobbles and pebbles.
Triassic	Diabase dikes	Fine-grained diabase.
	Sedimenary rocks (Plate 1 only)	Grayish-red and yellowish-gray feldspathic sandstone, siltstone, and shale and rare conglomerate.
Paleozoic(?)	Quartz veins	Quartz veins mineralized with bornite, chalcocite, and chalcopyrite; accessory epidote, chlorite, carbonate, and feldspar.
Precambrian(?)	Aaron Formation (Plate 1 only)	*Upper member:* light-gray to purple phyllite, metavolcanic sandstone, and slate; small amount of green slate and metasandstone, very fine-grained metasandstone and metamudstone, and greenstone. *Middle member:* metabasalt composed largely of light-green, schistose, mafic volcanic rocks; minor amount of metavolcanic sandstone and schistose and phyllitic, felsic metavolcanic rocks. *Lower member:* mainly green slate interbedded with light-gray to green metasandstone; small amount of greenstone and gray to purple slate, phyllite, and metavolcanic sandstone; prominent zone of interbedded sandy metaconglomerate, conglomeratic metasandstone, metasandstone, and slate.
Precambrian	Quartz diorite	Fine- to medium-grained quartz diorite; locally, small areas of diorite.
	Hyco Formation	Light-gray sericite schist containing augen-shaped quartz and feldspar phenocrysts; south of the Dan River uppermost part consists largely of interlayered metamorphosed felsic volcanic breccia and tuffaceous greenstone.
	Metagabbro (Plate 2 only)	Metagabbro and hornblende metadiorite composed of hornblende and plagioclase with accessory sphene, ilmenite, and biotite.
	Ultramafic rocks (Plate 2 only)	Ultramafic rocks composed of actinolite, chlorite, epidote, and pyroxene.
	Granite dikes and sills	Medium-grained granite to quartz monzonite, some fine-grained and pegmatoidal.
	Gneiss	Mainly medium-grained hornblende-biotite gneiss; lesser amounts of fine- to medium-grained biotite gneiss, hornblende gneiss and hornblende amphibolite, and mica schist.
	Biotite gneiss	Fine- to medium-grained biotite gneiss interlayered with minor amounts of mica schist.

Biotite gneiss, which makes up from 90 to 95 percent of the unit, shows considerable textural variation. Well-foliated, porphyroblastic biotite gneiss with migmatitic layering (Figure 2; Plate 1, R-5657) and weakly foliated,

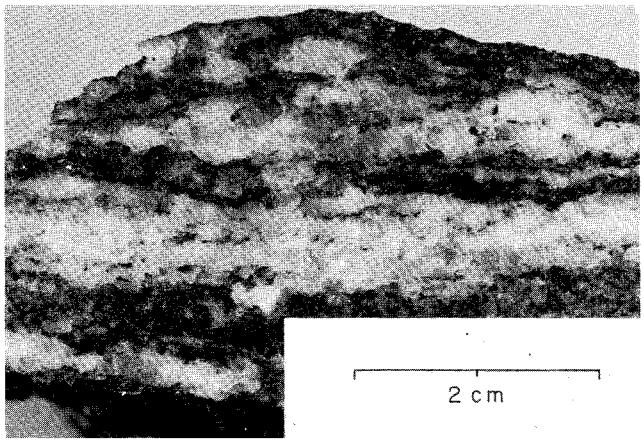

Figure 2. Migmatitic layering in biotite gneiss (Plate 1, R-5657) from the biotite gneiss unit, about 0.25 mile (0.40 km) north of State Highway 304, along Woods Creek, Omega quadrangle. (Sawn slab.)

commonly lineated, unlayered, porphyroblastic gneiss (Figure 3; Plate 2, R-5658) are the most common rock types. The gneiss is fine (<1 mm) to medium (1 to 5 mm) grained and contains plagioclase porphyroblasts generally ranging from 2 to 10 mm, but with some as large as 11 cm. Porphyroblasts may be absent, especially where the rock is fine grained. In a few places the gneiss contains compositional banding which may represent original layering. In thin section, quartz and

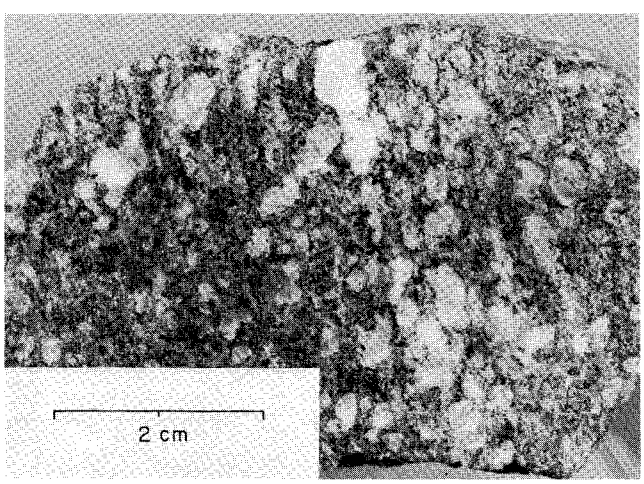

Figure 3. Unlayered, porphyroblastic biotite gneiss (Plate 2, R-5658) from the biotite gneiss unit, at Hupp's Mill Plaza, City of South Boston. (Sawn slab.)

feldspar compose the matrix and are granoblastic; in some samples quartz crystals show an elongate texture (Figure 4; Plate 2 R-5659). Parallel flakes of biotite define the foliation. The mineral and chemical compositions of typical biotite gneiss are listed in Tables 2 and 3.

Interlayered mica schist and mica-rich gneiss compose between 5 and 10 percent of the biotite gneiss unit. One amphibole gneiss layer several feet thick was noted along the headwaters of Mikes Creek in the northwestern corner of the South Boston quadrangle (see Plate 2). The interlayered mica schist and mica-rich

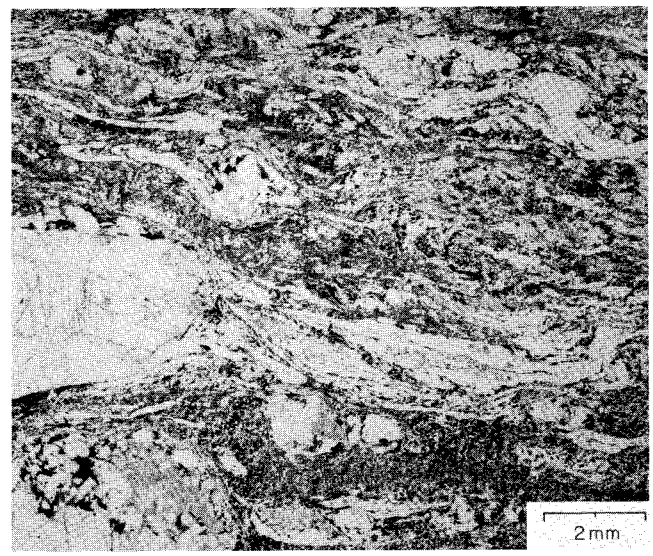

Figure 4. Elongate texture in biotite gneiss (Plate 2, R-5659) from the biotite gneiss unit, about 400 feet (122 m) southeast of State Road 802, along Myers Creek, northeastern corner of South Boston quadrangle. (Photomicrograph, plane-polarized light.)

gneiss generally occur as discontinuous lenses, but some layers may be traced for more than a mile. Rock types include silvery muscovite schist and range to dark-gray, porphyroblastic biotite-muscovite-garnet schist. West of the sillimanite isograd (Figure 5), sillimanite occurs in the schist as idioblastic rods. In thin section, the schistosity is produced by parallel micas, sillimanite rods and layers, and strongly elongated quartz lenses and crystals. Except for higher Na_2O and K_2O abundances, the chemical composition of the biotite gneiss unit (Table 3) is generally compatible with the average chemical composition of graywacke as used by Pettijohn (1957, p. 307). The high alumina content of the interlayered mica schist and several occurrences of what seem to be relict sedimentary clasts in the biotite gneiss suggest a sedimentary origin for the unit. The high alkali content of the biotite gneiss suggests that it may have been either a volcanic sandstone or, in part, a felsic pyroclastic rock. A discordant Pb/Pb age of 740 m.y. was obtained from zircons collected from this unit (Glover and others, 1971).

Gneiss

The gneiss unit includes three major rock types: hornblende-biotite gneiss; biotite gneiss; and hornblende gneiss and hornblende amphibolite. Some mica schist is interlayered in the gneiss unit. The gneiss unit is generally mantled by red and yellow clay loam and

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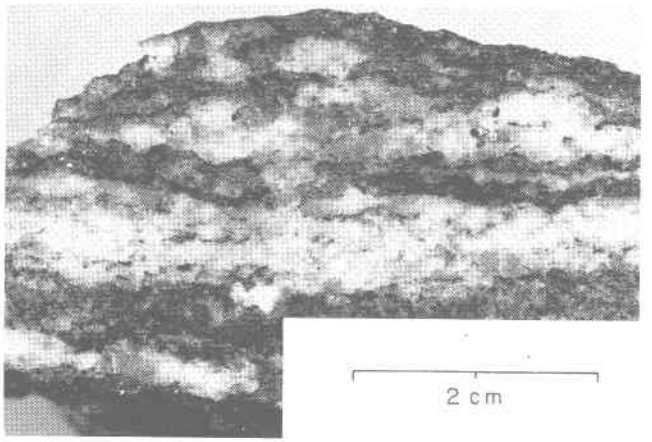

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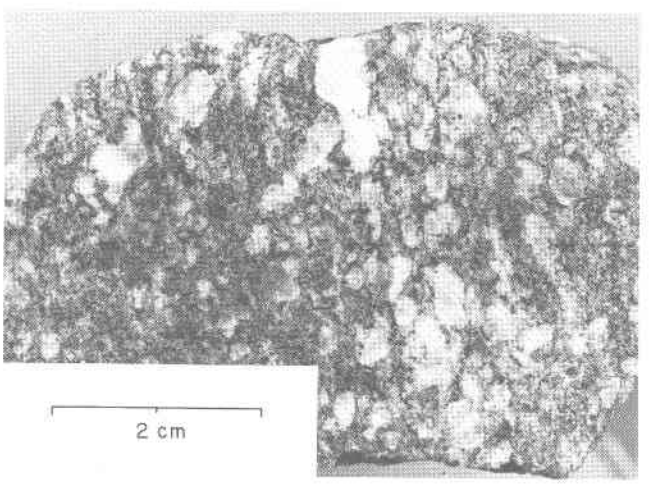

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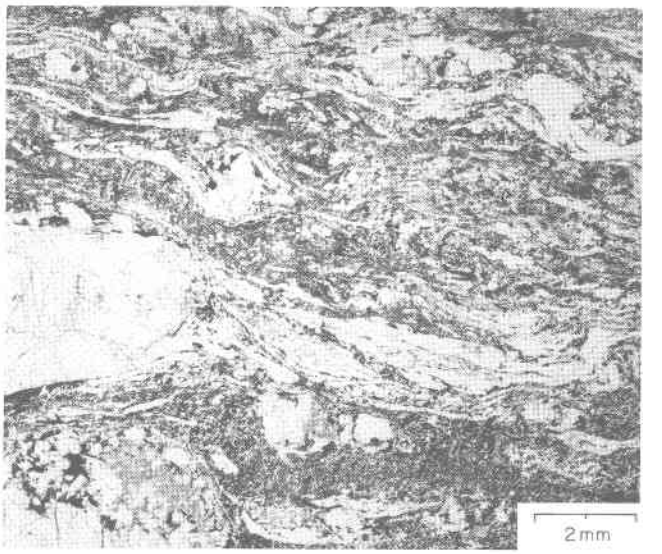

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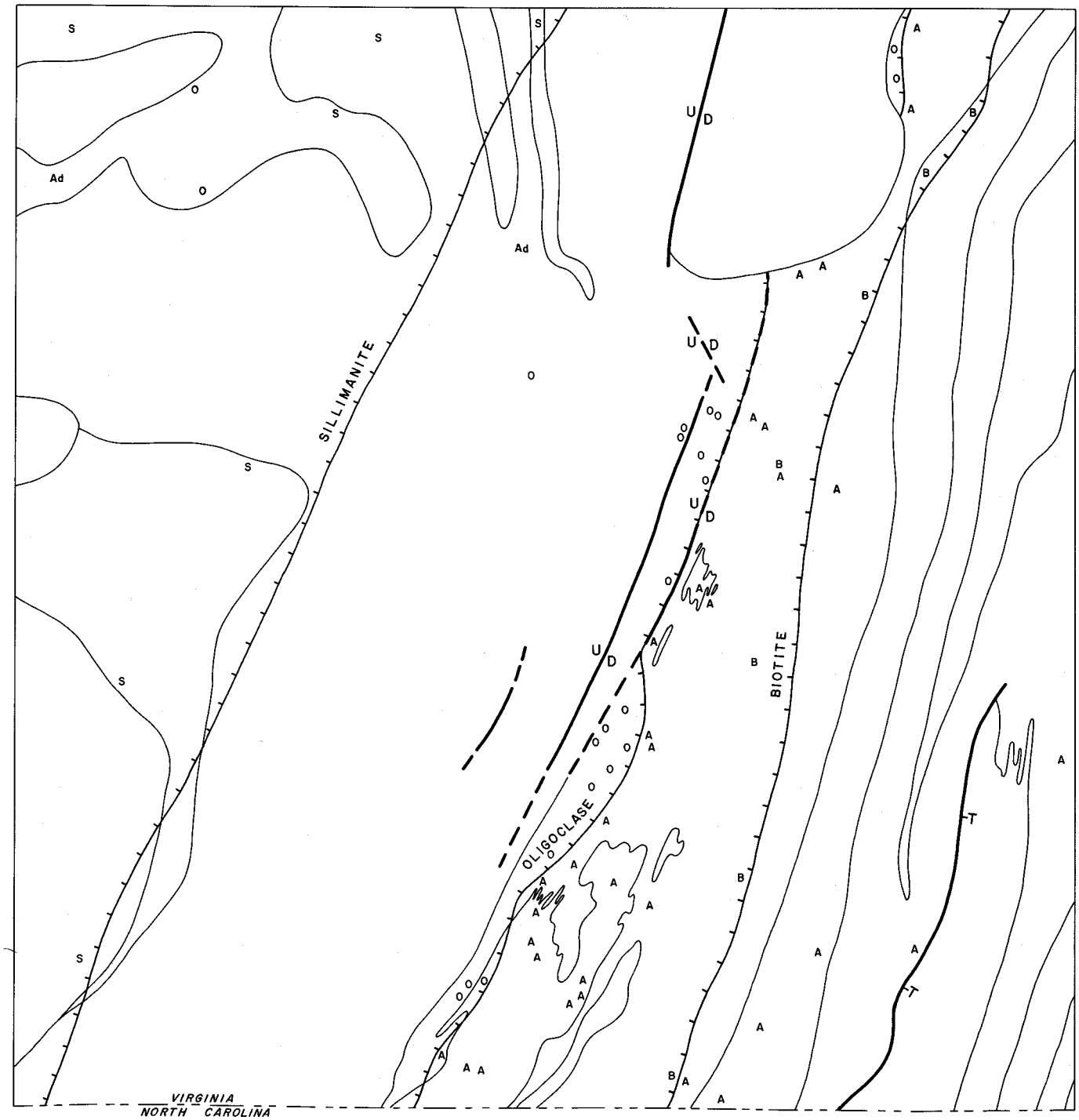

EXPLANATION

CONTACT BETWEEN STRATIGRAPHIC UNITS AS SHOWN ON PLATES 1 AND 2

U D FAULT; DASHED WHERE INFERRED; U, UPTHROWN SIDE; D, DOWNTHROWN SIDE; T, OVERTHRUST SIDE

ISOGRAD

S SILLIMANITE

O OLIGOCLASE

A ALBITE

B BIOTITE

Ad ANDESINE

0 1 2 MILES

0 1 2 3 KILOMETERS

N

Figure 5. Map of the Omega, South Boston, Cluster Springs, and Virgilina quadrangles showing biotite, oligoclase, and sillimanite isograds.

yellowish sandy loam soils and a thick, brown saprolite. Extensive areas of weathered rock and saprolite occur in Virginia Department of Highways and Transportation "borrow pits" along U. S. Highway 58 east of Riverdale (Plate 2) and in deep roadcuts along U. S. Highway 501 from Riverdale south to the Hyco River. Fresher rock occurs in many streams such as along Halfway Creek east of Cluster Springs (Plate 2).

The gneiss unit overlies the biotite gneiss unit and is overlain by the Hyco Formation. Where observed, the contact of the gneiss unit with the underlying biotite gneiss unit is gradational over approximately 100 feet (30 m). Across the Omega and Virgilina quadrangles the gneiss unit and the Hyco Formation are in fault contact (Plate 1), but in the Cluster Springs quadrangle the gneiss unit is apparently conformably overlain by the Hyco.

Although it does not occur at every outcrop, foliated, almost fissile, hornblende-biotite gneiss (Plate 2; R-5666, R-5667) is the characteristic rock type in the gneiss unit. It may be interlayered with biotite gneiss or hornblende gneiss (or both). It is generally medium grained, rarely porphyroblastic and contains quartz-feldspar segregation layers. Layering in the hornblende-biotite gneiss is sharp and distinct in the eastern half of its outcrop area. In thin section the unit shows strongly aligned biotite and amphibole and granoblastic quartz and feldspar. The mineral and chemical compositions of the hornblende-biotite gneiss are listed in Tables 2 and 3.

Greenish-black, fine- to medium-grained hornblende gneiss and hornblende amphibolite (Plate 1, R-5678; Plate 2, R-5679) occur in most parts of the gneiss unit. Hornblende-rich rocks are especially abundant in the eastern part of its area of exposure, which is stratigraphically near its top. The Vulcan Materials Company "active" quarry (number 1, Plate 1) in the northwestern part of the Omega quadrangle is within the amphibole-rich upper part of the gneiss unit; the quarry is now inactive. The hornblende gneiss generally shows compositional layering, which probably mimics original layering. The amphibole gneiss layers are commonly sheared into boudins (Figure 6) because they are structurally more competent than interlayers of biotite gneiss and hornblende-biotite gneiss. The mineral and chemical compositions of the hornblende-rich rocks are listed in Tables 2 and 3. Euhedral prehnite and laumontite-leonhardite were collected as vein fillings and probably represent late hydrothermal activity associated with emplacement of Mesozoic diabase dikes.

Fine- to medium-grained, well foliated biotite gneiss is the third common rock type in the gneiss unit (Plate 1, R-5671, R-5672). It is generally similar in appearance to the hornblende-biotite gneiss, except for a higher percentage of plagioclase porphyroblasts and more quartz-feldspar segregation layers. Thin sections show strongly aligned biotite and granoblastic quartz and plagioclase.

Figure 6. Boudins of amphibole gneiss from the gneiss unit along U.S. Highway 501, about a mile north of the Hyco River, Cluster Springs quadrangle (Plate 2).

Minor amounts of mica schist occur at several outcrops in the gneiss unit near the contact with the biotite gneiss (Plate 2, R-5680, R-5681). These schists are texturally and mineralogically similar to those in the biotite gneiss unit.

Two areas within the gneiss unit are distinctive. One of these areas consists of layered gneiss and lies between the two parallel normal faults shown on Plate 1. It terminates at the western fault, but in the Cluster Springs quadrangle the western boundary of the layered gneiss is gradational into more typical rocks of the gneiss unit. The layered unit is significantly finer grained than the gneiss unit and lacks both porphyroblasts and quartz-feldspar migmatite layers (Plate 1, R-5676, R-5677) common to the typical gneiss. This zone, approximately a mile (1.6 km) wide, is apparently the result of slightly less intense, metamorphism than in rocks to the west. The second atypical area within the gneiss unit is shown as "gn" on Plate 2. It consists of interlayered biotite gneiss and hornblende gneiss that either lack or have very minor amounts of hornblende-biotite gneiss; several thin beds of pelitic schist also occur within these rocks.

The chemical compositions, small-scale interlayering, and variability of the three major rock types suggest that they were originally a sequence of volcanic rocks. The hornblende-biotite gneisses are andesitic and the hornblende gneisses are basaltic to andesitic in composition. The interlayered biotite gneisses probably represent felsic volcanic rocks and volcanic sandstones. The high alumina schists, which are rare, indicate that minor amounts of pelitic sedimentary rocks were also present. Relict igneous textures in mafic layers in the gneiss unit suggest that metagabbros and metadiorites were intrusions.

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The gneiss unit overlies the biotite gneiss unit and is overlain by the Hyco Formation. Where observed, the contact of the gneiss unit with the underlying biotite gneiss unit is gradational over approximately 100 feet (30 m). Across the Omega and Virgilina quadrangles the gneiss unit and the Hyco Formation are in fault contact (Plate 1), but in the Cluster Springs quadrangle the gneiss unit is apparently conformably overlain by the Hyco.

Although it does not occur at every outcrop, foliated, almost fissile, hornblende-biotite gneiss (Plate 2; R-5666, R-5667) is the characteristic rock type in the gneiss unit. It may be interlayered with biotite gneiss or hornblende gneiss (or both). It is generally medium grained, rarely porphyroblastic and contains quartz-feldspar segregation layers. Layering in the hornblende-biotite gneiss is sharp and distinct in the eastern half of its outcrop area. In thin section the unit shows strongly aligned biotite and amphibole and granoblastic quartz and feldspar. The mineral and chemical compositions of the hornblende-biotite gneiss are listed in Tables 2 and 3.

Greenish-black, fine- to medium-grained hornblende gneiss and hornblende amphibolite (Plate 1, R-5678; Plate 2, R-5679) occur in most parts of the gneiss unit. Hornblende-rich rocks are especially abundant in the eastern part of its area of exposure, which is stratigraphically near its top. The Vulcan Materials Company "active" quarry (number 1, Plate 1) in the northwestern part of the Omega quadrangle is within the amphibole-rich upper part of the gneiss unit; the quarry is now inactive. The hornblende gneiss generally shows compositional layering, which probably mimics original layering. The amphibole gneiss layers are commonly sheared into boudins (Figure 6) because they are structurally more competent than interlayers of biotite gneiss and hornblende-biotite gneiss. The mineral and chemical compositions of the hornblende-rich rocks are listed in Tables 2 and 3. Euhedral prehnite and laumontite-leonhardite were collected as vein fillings and probably represent late hydrothermal activity associated with emplacement of Mesozoic diabase dikes.

Fine- to medium-grained, well foliated biotite gneiss is the third common rock type in the gneiss unit (Plate 1, R-5671, R-5672). It is generally similar in appearance to the hornblende-biotite gneiss, except for a higher percentage of plagioclase porphyroblasts and more quartz-feldspar segregation layers. Thin sections show strongly aligned biotite and granoblastic quartz and plagioclase.

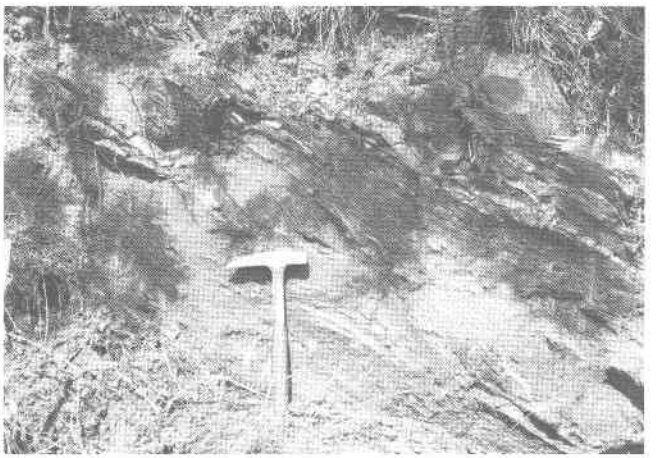

Figure 6. Boudins of amphibole gneiss from the gneiss unit along U.S. Highway 501, about a mile north of the Hyco River, Cluster Springs quadrangle (Plate 2).

Minor amounts of mica schist occur at several outcrops in the gneiss unit near the contact with the biotite gneiss (Plate 2, R-5680, R-5681). These schists are texturally and mineralogically similar to those in the biotite gneiss unit.

Two areas within the gneiss unit are distinctive. One of these areas consists of layered gneiss and lies between the two parallel normal faults shown on Plate 1. It terminates at the western fault, but in the Cluster Springs quadrangle the western boundary of the layered gneiss is gradational into more typical rocks of the gneiss unit. The layered unit is significantly finer grained than the gneiss unit and lacks both porphyroblasts and quartz-feldspar migmatite layers (Plate 1, R-5676, R-5677) common to the typical gneiss. This zone, approximately a mile (1.6 km) wide, is apparently the result of slightly less intense, metamorphism than in rocks to the west. The second atypical area within the gneiss unit is shown as "gn" on Plate 2. It consists of interlayered biotite gneiss and hornblende gneiss that either lack or have very minor amounts of hornblende-biotite gneiss; several thin beds of pelitic schist also occur within these rocks.

The chemical compositions, small-scale interlayering, and variability of the three major rock types suggest that they were originally a sequence of volcanic rocks. The hornblende-biotite gneisses are andesitic and the hornblende gneisses are basaltic to andesitic in composition. The interlayered biotite gneisses probably represent felsic volcanic rocks and volcanic sandstones. The high alumina schists, which are rare, indicate that minor amounts of pelitic sedimentary rocks were also present. Relict igneous textures in mafic layers in the gneiss unit suggest that metagabbros and metadiorites were intrusions.

Granite Dikes and Sills

There are granite dikes and sills in the high-rank parts of both the biotite gneiss and the gneiss units (Plate 1, R-5691). The geometry of the bodies is generally difficult to determine because of limited exposure, but the dikes seem to be more common than the sills. None of these are large enough to be shown on the geologic maps (Plates 1, 2) because they range only from 3 to 17 feet (1 to 5 m) in thickness. Although the bodies vary in abundance from place to place, only the area between the two parallel normal faults (Plate 1), an area of oligoclase grade metamorphism (Fig. 5), seems to be devoid of them. Good exposures of several dikes occur in the Virginia Department of Highways and Transportation "borrow pit" at the intersection of U. S. Highways 304 and 58 (Plate 2). The dikes and sills are more resistant to erosion than any rocks west of the major synclinorium shown on Plate 1, and are thus exposed where other rock types may not be. This feature makes them appear to be the dominant rock type in some areas. However, in streams, where outcrops are more continuous, they make up less than 1 percent of the rocks exposed.

The mineral and chemical compositions of the dikes and sills, shown in Tables 2 and 3, range from those of granite to quartz monzonite. They are granitic in texture, commonly with a poorly developed foliation produced by alignment of some of the muscovite. The dikes and sills range from fine-grained to pegmatoidal, but medium-grained varieties predominate.

Ultramafic Rocks

There are several small areas of poorly exposed and extremely weathered ultramafic rocks in the northwestern and north-central parts of the South Boston quadrangle (Plate 2). Weathered ultramafic rocks are in the cut of the Norfolk and Western Railway beneath State Road 654 about 2 miles (3 km) northwest of South Boston. They seem to be concordant with the enclosing gneiss unit. One sample (R-5726) analyzed by X-ray diffraction was composed entirely of actinolite. Epidote, chlorite, and euhedral pyroxene were also observed in these rocks.

Metagabbro

The metagabbro unit occurs at several locations in the South Boston and Cluster Springs quadrangles (Plate 2). Excellent exposures can be seen in the small stream about 0.8 mile north of State Road 678 in the northwestern corner of the South Boston quadrangle. The unit is apparently concordant with enclosing rocks of the gneiss unit. The rock unit is generally gabbroic in composition with a color index greater than 40, but there are also minor amounts of diorite. The unit is coarse grained (>5.0 mm) and has a relict subophitic texture. It is composed of hornblende (altered from pyroxene) and plagioclase with accessory sphene, ilmenite, and biotite. Hornblende crystals as large as 15 mm were observed; the cores of several hornblende crystals have relict pyroxene cleavage.

Hyco Formation

The Hyco Formation was originally named the Hyco quartz porphyry by Laney (1917, p. 20-23) for the excellent exposures at its type section along the Hyco River between State Roads 738 and 744 and for about 0.7 mile (1.1 km) west of Hyco (Plate 1). There are somewhat more accessible exposures of rocks with typical Hyco lithologies along the Norfolk, Franklin, and Danville Railway at Christie (Plate 1) almost 4 miles (6 km) west of Virgilina. The name is here changed to the Hyco Formation, as it is composed of different lithologies. The dimensions of the unit within this mapped area are essentially as described by Laney (1917). Its thickness is at least 15,000 feet (4,572 m). Conley (1978, p. 137) concluded that Laney's (1917) Goshen schist represents at least a portion of the Hyco Formation and that it is an unneeded name.

The predominant lithologic unit of the formation is a light-gray sericite schist, generally with augen-shaped relict quartz and feldspar phenocrysts (Plate 1, R-5696). There is a marker zone, consisting largely of interlayered, metamorphosed, felsic volcanic breccia and tuffaceous greenstone at the top of the formation south of the Dan River (shown as "vb" on Plate 1). Soil developed on the formation is characteristically light-colored silt loam generally containing abundant angular quartz fragments.

The texture of the Hyco Formation is dominated by a regional metamorphic foliation, but much primary texture has been preserved. Strong alignment of sericite

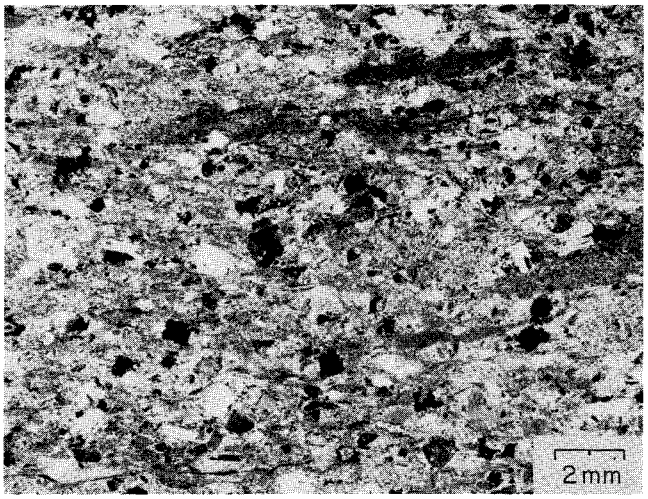

Figure 7. Metamorphosed crystal-lithic tuff (Plate 1, R-5695) from the Hyco Formation along the Norfolk, Franklin, and Danville Railway at Christie, Virgilina quadrangle. (Photomicrograph, cross-polarized light.)

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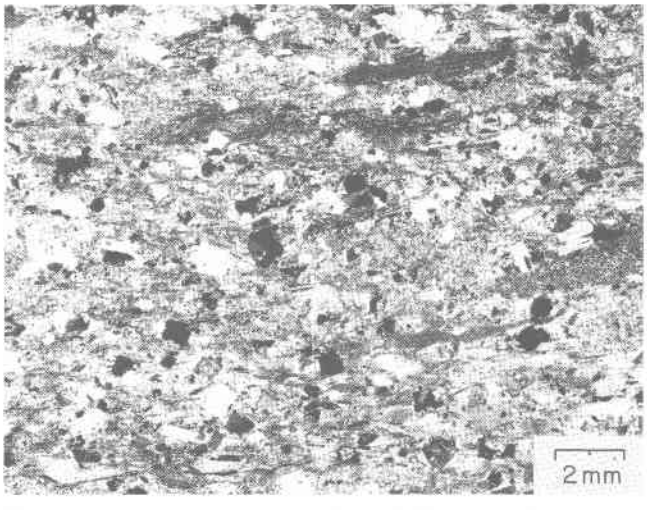

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and other micas, and to a lesser extent elongation of relict phenocrysts of quartz and plagioclase, define the schistosity. This schistosity becomes increasingly more pronounced to the west across the outcrop belt of the formation. Relict textures clearly show that the Hyco Formation is largely volcanic in origin. The majority of the unit is metamorphosed crystal tuff and crystal-lithic tuff (Figure 7; Plate 1, R-5695). Rotated, rounded, and broken crystals of quartz and euhedral plagioclase from 0.5 to 2 mm in diameter can be seen in most thin sections. Metamorphosed, fine-grained igneous rock fragments are abundant in many samples. Some extremely elongate siliceous rock fragments probably represent collapsed pumice. Much of the matrix is composed of fine-grained quartz and sericite that may have originally been glass. Diagnostic relict volcanic textures are harder to recognize along the western boundary of the formation because of increase in metamorphic grade and development of schistosity. Recrystallization has obliterated relict volcanic textures (Plate 1, R-5697) west of the oligoclase isograd (Figure 5). Rocks in this area are fine-grained mica gneiss and sericite schist.

Several other rock types are found within the Hyco Formation. A few beds of light-gray metavolcanic sandstone near the top of the unit north of the Dan River are texturally and mineralogically similar to metavolcanic sandstone in the lower parts of the overlying Aaron Formation. At the top of the formation south of the Dan River, significant amounts of greenstone (Plate 1, R-5701) are interbedded with a distinctive, light-gray felsic metavolcanic breccia and finer-grained, felsic pyroclastic rocks (Plate 1, R-5700). The metavolcanic breccia (Figure 8; Plate 1, R-5698) commonly contains

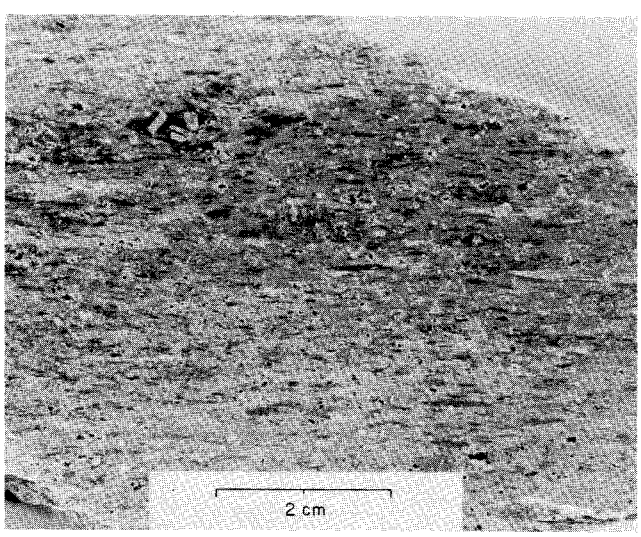

Figure 8. Metamorphosed felsic volcanic breccia (Plate 1, R-5698) from the Hyco Formation, U.S. Highway 58 near Omega, central part, Omega quadrangle. (Sawn slab.)

flattened rock fragments up to 50 mm in length. Where the formation is present west of the oligoclase isograd (Figure 5), the greenstone has recrystallized to fine-grained amphibole gneiss.

The mineral and chemical compositions of samples from the Hyco Formation are listed in Tables 2 and 3. Except for slightly lower values of K_2O, the two felsic samples analyzed are comparable to the average composition of rhyolite given by Nockolds (1954). A Pb/Pb age of 620 m.y. was determined from zircons obtained from near the top of the Hyco Formation (Glover and others, 1971).

Quartz Diorite

Quartz diorite intrudes the basal part of the Hyco Formation from the Virginia-North Carolina boundary (Plates 1, 2) north-northeastward to Shady Grove (Plate 1). It also occurs discontinuously as sill-like bodies in the Hyco Formation from the Hyco River north-northeastward for 2.7 miles (4.3 km) (Plate 1). The unit includes several textural and compositional varieties. Interior parts of the intrusions are essentially undeformed. These rocks are fine- to medium-grained and have igneous textures that are subdiabasic (Figure 9; Plate 1,

Figure 9. Quartz diorite (Plate 1, R-5685) with subdiabasic texture, 1.75 miles (2.82 km) west of Christie along Norfolk, Franklin, and Danville Railway, Virgilina quadrangle. (Photomicrograph, cross-polarized light.)

R-5685), pilotaxitic and hypidiomorphic (Figure 10; Plate 1, R-5686). The last is characterized by abundant myrmekitic intergrowths of quartz and plagioclase. Near contacts, the quartz diorite is deformed into a micaceous augen gneiss. Plagioclase crystals have been rotated, broken, and rounded, and they commonly penetrate one another. Aggregates of biotite and muscovite have been strung out in the plane of foliation and much of the quartz has recrystallized into augen-shaped masses.

The rock has been classified as quartz diorite on the basis of a quartz content of less than 20 percent and a predominance of plagioclase, and on the assumption

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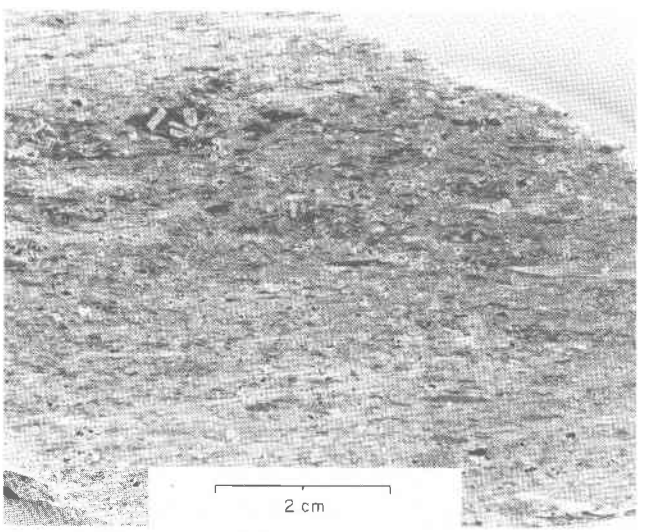

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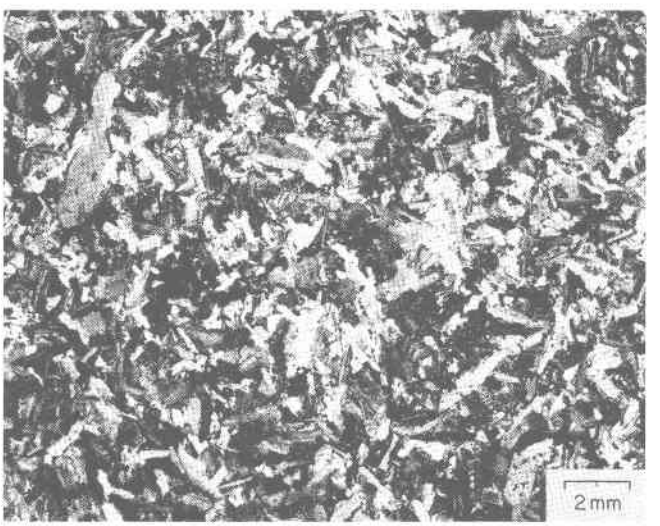

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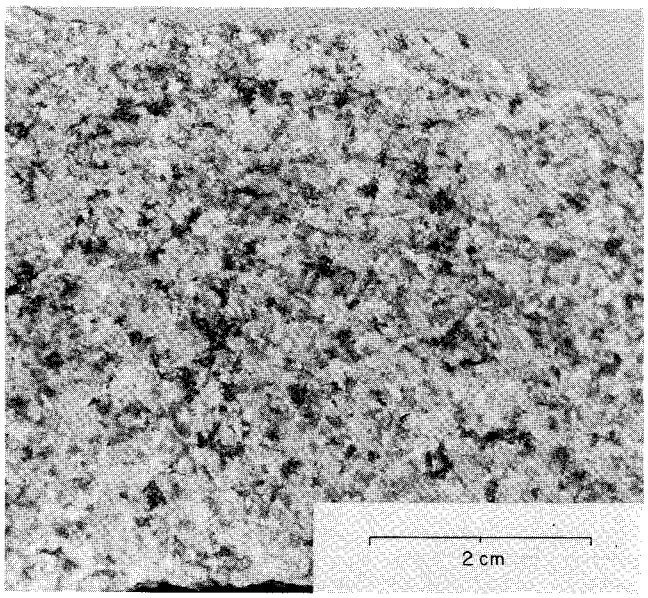

Figure 10. Quartz diorite (Plate 1, R-5686) with granular texture, along small stream approximately 0.3 mile (0.5 km) south of State Highway 96 approximately 1.6 miles (2.6 km) northwest of Christie.

that the present albitic composition of the plagioclase is the alteration product of more calcic plagioclase, with alteration at the greenschist metamorphic grade. The high silica and low potassium feldspar contents (Tables 2, 3) place the composition near trondhjemite (IUGS Subcommission on the Systematics of Igneous Rocks, 1973).

There are several small areas of dioritic and gabbroic rocks within the quartz diorite; dioritic ones are shown as "d" on Plates 1, 2. Their genetic relationships to the quartz diorite is unknown. Several mafic xenoliths in the quartz diorite are evidence that the diorite and gabbro may predate slightly the quartz diorite.

The quartz diorite does not cut units younger than the lower Hyco (present study and Conley, 1978), and it seems to be contemporaneous with the upper part of the Hyco Formation. Similar and probably closely related plutons concordantly intrude the lower part of the Virgilina synclinorium (Conley, 1978). A discordant radiometric U-Pb date of 650 ± 30 m.y. was obtained from zircons taken from these plutons (McConnell, 1974). This date and that of 620 m.y. obtained from a sample near the top of the Hyco (Glover and others, 1971) indicate that emplacement of the quartz diorite preceded the end of Hyco time.

PRECAMBRIAN(?) ROCKS

Aaron Formation

Watson (1911) used the term "Virgilina Group" for a wide belt of rocks in the area of Virgilina. Laney (1917) called a portion of the "series" the Virgilina greenstone and named the Aaron slate for rocks both above and below the greenstone. The name of the slate and greenstone sequence is here changed to the Aaron Formation. It includes a lower slate member, a middle mafic metavolcanic member (formerly the Virgilina greenstone) and an upper slate member (Plate 1). The sequence appears to be conformable and the Aaron appears to conformably overlie the Hyco Formation.

Lower member: The lower member of the Aaron Formation is approximately 3,000 feet (914 m) thick and crops out in two north-northeastward trending strike belts, one on the western limb of the major synclinorium shown on Plate 1 and the other in a medial anticlinal structure near the center of the synclinorium. It is largely a sequence of metamorphosed clastic rocks that overlies the Hyco Formation and includes slate, phyllite, metasandstone, metaconglomerate, and minor greenstone. Most of these rock types are characterized by a well-developed slaty cleavage, generally parallel to bedding. The member may be recognized in saprolite by its characteristic slaty chips. It is exposed as fresh rock in streams.

The majority of the lower member consists of green slate (R-5704; this designation was incorrectly located with the conglomerate on Plate 1) interbedded with slaty-cleaving, light-gray to green metasandstone (Plate 1, R-5706, R-5707). Bedding is generally conspicuous and graded-bedding is common in both rock types. Grain size is variable in the metasandstone but fine- and very-fine-grain sizes predominate. Irregularities on bedding surfaces that may represent cross-bedding or scour (or both) were observed at several locations.

The metasandstone of the lower member is rich in quartz and contains a micaceous matrix (Table 2). Lithic fragments are common in the coarser beds. In the lower part of the member the metasandstone is white and contains little or no chlorite. Metasandstone higher in the section tends to have progressively increasing amounts of chlorite. Chert fragments (devitrified glass?) in all parts of the member suggest a significant contribution of sediment from a volcanic terrain. A relatively high percentage of magnetite is concentrated along bedding planes. The mineral composition of the slate is similar to the metasandstone, except for an expected higher proportion of mica.

In thin section the foliation of the rock is displayed by parallelism of mica and to a much lesser extent by slightly elongated quartz and plagioclase grains. Excluding the micaceous matrix, the metasandstone is poorly to moderately sorted. Chemical analyses of two samples of the member (Table 3), one a metasandstone, the other a slate, revealed abnormally high Na_2O for both samples with respect to sandstones and abnormally low K_2O for the slate with respect to shales (shale and sandstone data from Pettijohn, 1957, p. 106). These data are indicative of a volcanic source for the metasandstone and slate.

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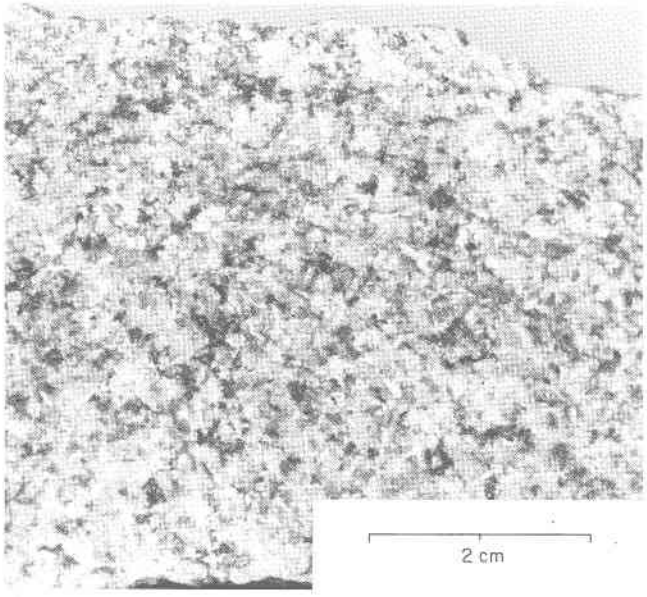

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Aaron Formation

Watson (1911) used the term "Virgilina Group" for a wide belt of rocks in the area of Virgilina. Laney (1917) called a portion of the "series" the Virgilina greenstone and named the Aaron slate for rocks both above and below the greenstone. The name of the slate and greenstone sequence is here changed to the Aaron Formation. It includes a lower slate member, a middle mafic metavolcanic member (formerly the Virgilina greenstone) and an upper slate member (Plate 1). The sequence appears to be conformable and the Aaron appears to conformably overlie the Hyco Formation.

Lower member: The lower member of the Aaron Formation is approximately 3,000 feet (914 m) thick and crops out in two north-northeastward trending strike belts, one on the western limb of the major synclinorium shown on Plate 1 and the other in a medial anticlinal structure near the center of the synclinorium. It is largely a sequence of metamorphosed clastic rocks that overlies the Hyco Formation and includes slate, phyllite, metasandstone, metaconglomerate, and minor greenstone. Most of these rock types are characterized by a well-developed slaty cleavage, generally parallel to bedding. The member may be recognized in saprolite by its characteristic slaty chips. It is exposed as fresh rock in streams.

The majority of the lower member consists of green slate (R-5704; this designation was incorrectly located with the conglomerate on Plate 1) interbedded with slaty-cleaving, light-gray to green metasandstone (Plate 1, R-5706, R-5707). Bedding is generally conspicuous and graded-bedding is common in both rock types. Grain size is variable in the metasandstone but fine- and very-fine-grain sizes predominate. Irregularities on bedding surfaces that may represent cross-bedding or scour (or both) were observed at several locations.

The metasandstone of the lower member is rich in quartz and contains a micaceous matrix (Table 2). Lithic fragments are common in the coarser beds. In the lower part of the member the metasandstone is white and contains little or no chlorite. Metasandstone higher in the section tends to have progressively increasing amounts of chlorite. Chert fragments (devitrified glass?) in all parts of the member suggest a significant contribution of sediment from a volcanic terrain. A relatively high percentage of magnetite is concentrated along bedding planes. The mineral composition of the slate is similar to the metasandstone, except for an expected higher proportion of mica.

In thin section the foliation of the rock is displayed by parallelism of mica and to a much lesser extent by slightly elongated quartz and plagioclase grains. Excluding the micaceous matrix, the metasandstone is poorly to moderately sorted. Chemical analyses of two samples of the member (Table 3), one a metasandstone, the other a slate, revealed abnormally high Na_2O for both samples with respect to sandstones and abnormally low K_2O for the slate with respect to shales (shale and sandstone data from Pettijohn, 1957, p. 106). These data are indicative of a volcanic source for the metasandstone and slate.

There is a separately mappable unit of metacon-

glomerate-bearing beds (Figure 11) approximately 1,000 feet (305 m) above the base of the lower member ("cg" on Plate 1). The unit is within a sequence of interbedded

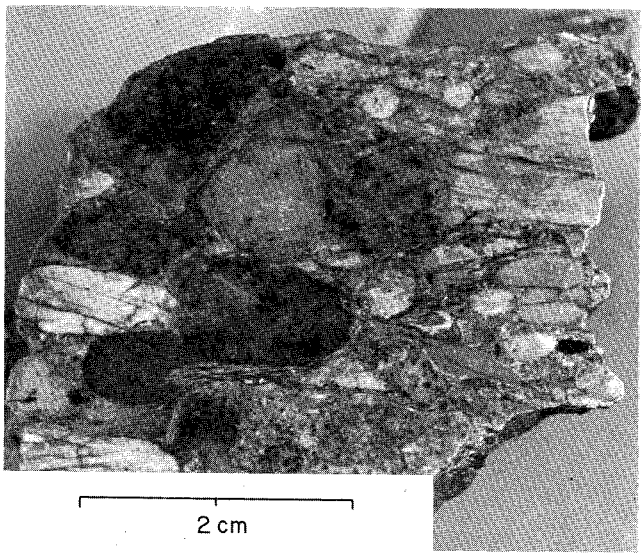

Figure 11. Metaconglomerate from the lower member of the Aaron Formation, approximately a mile north of State Highway 96, along Bluewing Creek, Virgilina quadrangle (Plate 1). (Sawn slab.)

slate and metasandstone and consists of one or more thin (1.0- to 20.0- foot, 0.3- to 6.1-m, thick) beds of metamorphosed, sandy conglomerate, conglomeratic sandstone, and granule conglomerate. It is a reliable marker zone along virtually the entire western limb of the synclinorium. The pebbles and cobbles are generally less than an inch in diameter but range to as much as 10 inches (25 cm). Most pebbles and cobbles are composed of polycrystalline quartz; other types include diorite, diabase, rhyolite porphyry, chert (divitrified glass?), felsic plutonic rock, schist, and quartz arenite and other sandstone types.

Interbedded with the light-gray and green metasandstone and slate of the lower member are lesser amounts of gray to purple slate, metavolcanic sandstone, and phyllite. These rocks owe their color to high percentages of white mica and abundant hematite. The hematite is an alteration product of magnetite and may show cores of magnetite in thin section. The mineral composition of the lower member is comparable to that of purple rock types in the upper member of the Aaron Formation (Table 2). Relict euhedral crystals and lithic fragments seen in thin section suggest that these rock types are largely metamorphosed tuffs.

Interbedded greenstone composes a relatively minor portion of the lower member. Mineral composition and texture of the greenstone are similar to those of the overlying middle member of the Aaron Formation. Most of the rocks are metatuffs, but some amygdaloidal flows are also present.

Middle member: The middle member of the Aaron Formation is approximately 2,500 feet (762 m) thick, and is composed largely of light-green, schistose, mafic metavolcanic rocks (Plate 1, R-5717, R-5718). It contains minor amounts of metavolcanic sandstone and schistose and phyllitic felsic metavolcanic rocks. The member crops out on the limbs of several smaller structural features near the axis of the synclinorium (Plate 1). It is composed of rock types more resistant to weathering than others within the synclinorium and generally underlies ridges of 100 feet (30 m) or more in relief. The member is covered by a thin clay-rich soil and is well exposed along most roads and streams. Especially good exposures occur along the Norfolk, Franklin, and Danville Railway in the town of Virgilina and along State Highway 96, a mile (1.6 km) west of Virgilina.

Although the middle member shows a moderately strong metamorphic overprint, many primary volcanic textures have been preserved. Alignment of platy and acicular metamorphic minerals (for example, chlorite, actinolite) and the elongation of quartz and feldspar crystals, rock fragments, and other primary features such as amygdules produce a strong schistosity. However, the rock generally lacks the cleavage of the underlying lower member of the Aaron. The mafic and felsic metavolcanic rocks are dominantly composed of pyroclastic material (Figure 12; Plate 1, R-5721). The

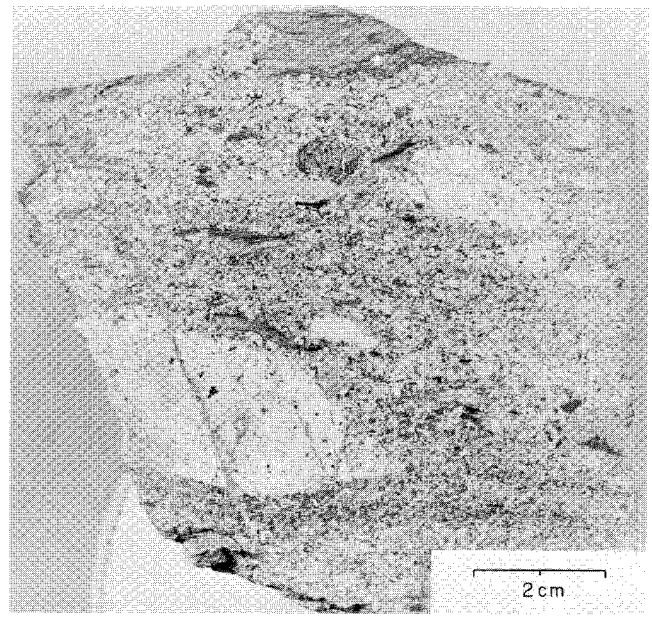

Figure 12. Metamorphosed lithic-tuff (Plate 1, R-5721, see Figure 14) from the middle member of the Aaron Formation, State Road 738 approximately 1.25 miles (2.01 km) north of State Highway 96, Virgilina quadrangle. (Sawn slab.)

size ranges from fine ash to volcanic breccia, but ash- and fine-lapilli-size fragments are most common. Many of the rocks show relict vesicles and amygdules (Figure 13; Plate 1, R-5719), and probably represent lava flows. In thin section the pyroclastic rocks have volcanic rock fragments, crystals, epidotized and chloritized blebs that may have been amygdules, and highly elongated

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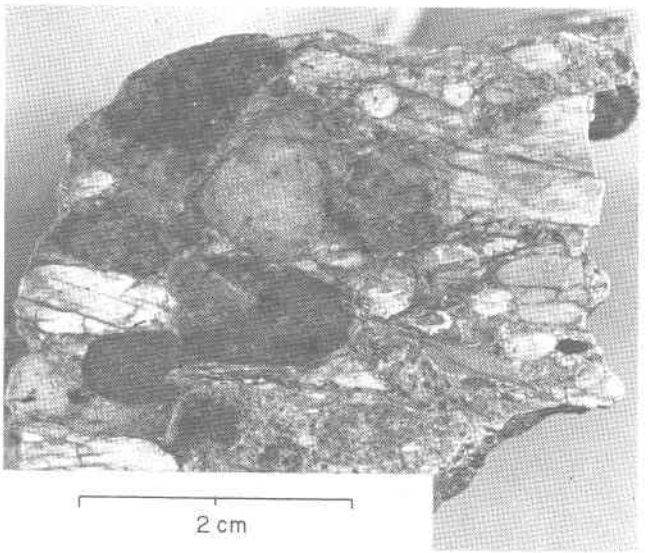

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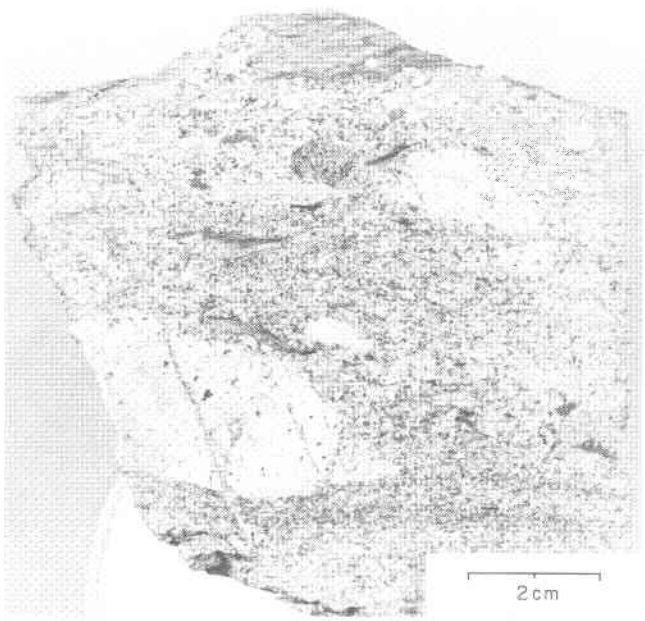


Figure 12. Metamorphosed lithic-tuff (Plate 1, R-5721, see Figure 14) from the middle member of the Aaron Formation, State Road 738 approximately 1.25 miles (2.01 km) north of State Highway 96, Virgilina quadrangle. (Sawn slab.)

size ranges from fine ash to volcanic breccia, but ash- and fine-lapilli-size fragments are most common. Many of the rocks show relict vesicles and amygdules (Figure 13; Plate 1, R-5719), and probably represent lava flows. In thin section the pyroclastic rocks have volcanic rock fragments, crystals, epidotized and chloritized blebs that may have been amygdules, and highly elongated

Table 2. — Mineral compositions of rocks of the Omega, South Boston, Cluster Springs and Virgilina quadrangles.

Lithology and Stratigraphic Unit	Essential Minerals	Accessory Minerals (<5 percent)
Biotite gneiss (biotite gneiss unit)	plagioclase, quartz, biotite[1]	microcline[2], muscovite, epidote, magnetite, zircon, garnet, sphene, apatite, allanite, sillimanite
Mica schist (biotite gneiss and gneiss units)	quartz, biotite, plagioclase, muscovite[3]	microcline[2], sillimanite[2], garnet[2], epidote, orthoclase, pyrite, magnetite, zircon
Hornblende-biotite gneiss (gneiss unit)	plagioclase, hornblende, biotite, quartz, epidote[3]	microcline, magnetite, hematite, pyrite, chlorite, sphene, apatite
Hornblende gneiss (gneiss unit)	plagioclase, hornblende, quartz, epidote[3]	biotite, chlorite, microcline, magnetite, pyrite, hematite, pyroxene, garnet (prehnite, laumontite-leonhardite in veins)
Biotite gneiss (gneiss unit)	plagioclase, quartz, biotite[1]	muscovite, microcline, epidote, garnet, pyrite, magnetite, hematite, zircon, apatite, sphene, chlorite
Sericite schist (Hyco Formation)	quartz, plagioclase, white mica	epidote, chlorite, biotite, ilmenite, magnetite, carbonate, microcline, sphene, paragonite, hematite, zircon, tourmaline, actinolite
Felsic metavolcanic breccia (Hyco Formation)	quartz, white mica, plagioclase	magnetite, hematite, epidote, chlorite, ilmenite, piemontite
Quartz diorite (quartz diorite unit)	plagioclase, quartz	biotite[2], muscovite[2], microcline[2], epidote, chlorite, magnetite, zircon, sphene, carbonate
Metasandstone (lower member of Aaron Formation)	quartz, white mica, plagioclase	chlorite, epidote, magnetite, ilmenite, tourmaline, biotite, hematite
Slate (lower member of Aaron Formation)	quartz, chlorite, white mica, plagiclase	epidote, magnetite, hematite, ilmenite, biotite
Greenstone (middle member of Aaron Formation)	tremolite-actinolite[1] chlorite[1], epidote	plagioclase[2], white mica, magnetite, ilmenite, talc, quartz
Purple phyllite (upper member of Aaron Formation)	white mica, quartz	magnetite, hematite[2], chlorite, plagioclase, ilmenite
Granite dikes and sills (granite dikes and sills unit)	microcline, quartz, plagioclase	muscovite, biotite, epidote

[1]accessory in some samples
[2]essential in some samples
[3]absent or accessory at higher metamorphic grade

fragments that may represent collapsed pumice fragments. Relict subophitic texture suggests that some of the greenstone may have been sills or dikes.

The mineral and chemical compositions of the middle member are listed in Tables 2 and 3. Chemical analyses were made of four greenstone samples, all of which are of basaltic composition with very low alkali content. The felsic metavolcanic rocks which occur in the member are restricted largely to the southeastern part of the Virgilina quadrangle (Plate 1).

Upper member: The upper member occurs in two synclines in the eastern part of the Omega and Virgilina quadrangles (Plate 1). Good exposures of this member occur along State Road 601 southeast of the Hyco River and along State Road 730 north of the river. The unit is composed of bedded, light-gray to purple phyllite, metavolcanic sandstone, and slate. Some rocks in the eastern syncline are medium grained but in the western one the rocks are largely fine grained. They are characterized by a flaggy to slaty cleavage similar to that

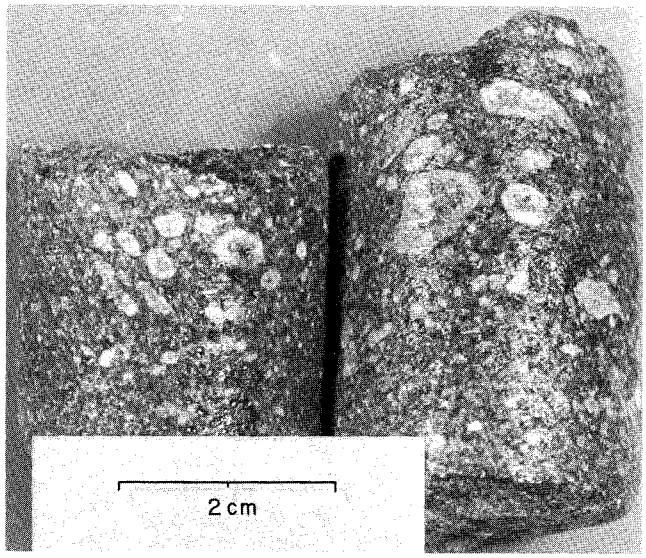


Figure 13. Amygdules in the metavolcanic rock (Plate 1, R-5719) from the middle member of the Aaron Formation, State Road 601, bridge over Hyco River, Omega quadrangle.

which occurs in the lower member of the Aaron. Lithic fragments, chert (divitrified glass?), and relict euhedral crystals seen in thin section suggest that much of the gray and purple rock was originally volcanic ash.

Several other rock types occur in lesser amounts within the upper member. They include green slate and metasandstone similar to those of the lower member, minor amounts of greenstone, and thinly laminated, very fine metasandstone and metamudstone (Figure 14; R-5712, incorrectly shown as the more northerly one of the two "R-5121's" on Plate 1). The laminations of the latter rock type range from 1 to 10 millimeters in thickness.

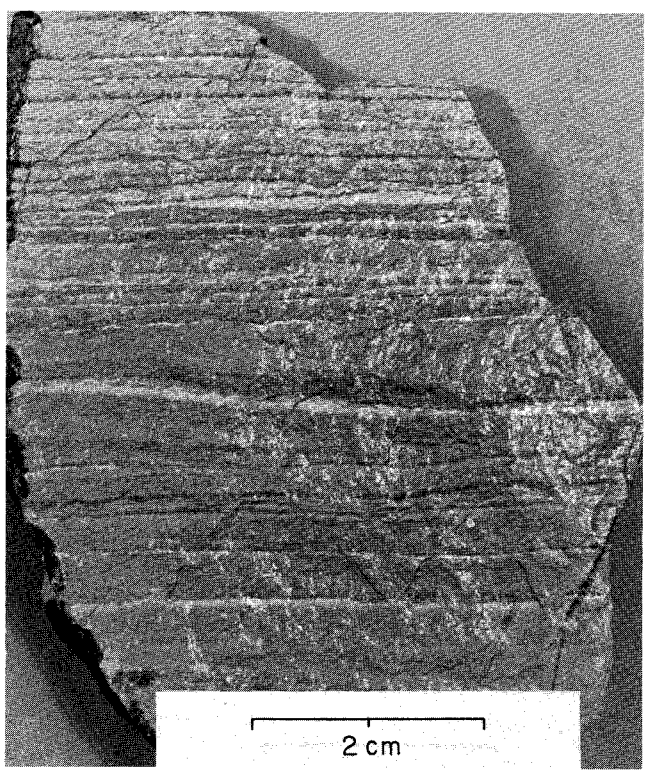


Figure 14. Thinly laminated mudstone (R-5712, incorrectly designated as the more northerly R-5721, Plate 1) from the upper member of the Aaron Formation, approximately 0.7 mile (1.13 km) north-northwest of the intersection of State Road 730 and U.S. Highway 58, Omega quadrangle.

PRECAMBRIAN OR PALEOZOIC ROCKS

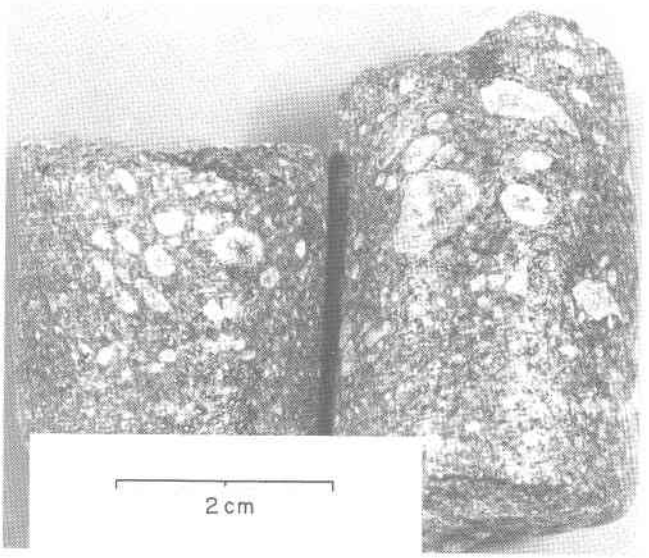
Quartz Veins

Quartz veins of Precambrian or Paleozoic age occur in abundance in the rocks of the major synclinorium shown on Plate 1, and to a much lesser extent in the rocks to the west of it. None of these quartz veins are shown on the geologic maps (Plates 1, 2) because of limited exposures. Most of the veins have a strike roughly parallel to the foliation of the units they intrude, but seem to have been emplaced after the foliation had formed. They are generally from a few inches to 3.0 feet (0.9 m) thick and rarely exceed 10 feet (3 m). Veins occurring within the middle member of the Aaron Formation are mineralized with bornite, chalcocite, chalcopyrite and accessory epidote, chlorite, carbonate, and feldspars.

TRIASSIC SYSTEM

Sedimentary Rocks

There is a portion of a small basin with Triassic rocks in the northern part of the Omega quadrangle (Plate 1). It contains red and yellowish-gray feldspathic sandstone, siltstone, shale and rarely conglomerate. These rocks are largely covered by Quaternary alluvium and terrace deposits of the Dan and Banister rivers, or by waters of the John H. Kerr Reservoir. Weathered rock is exposed along State Road 613 east of State Highway 304 and along State Road 716 about 1.0 mile (1.6 km) east of Wolf Trap (Plate 1). The rocks have a strike parallel to the eastern and southeastern edges of the basin and a dip from 24 to 42 degrees to the west and the northwest. The most common rock in the basin is grayish-red feldspathic sandstone (R-5727, Plate 1) composed of quartz, plagioclase, microcline, biotite, muscovite, schistose rock fragments, magnetite, and a large percentage (as great as 40 percent) of hematite cement. Much of the feldspar is weathered to clay. The sandstone is largely medium- to coarse-grained, but fine- (2 to 3 mm) to very coarse-grained sandstone is common. Sorting and rounding are generally poor. Grayish-red shale and gray claystone is interbedded with the sandstone in several places. There are abundant fossils in one outcrop of shale approximately a mile east of Wolf Trap on State Road 716 (F-900). The following fossils were collected from this locality: a species of bivalve (superfamily Unionacea) which is common; three species of crustacea, *Cyzicus* sp. (a branchiopod),



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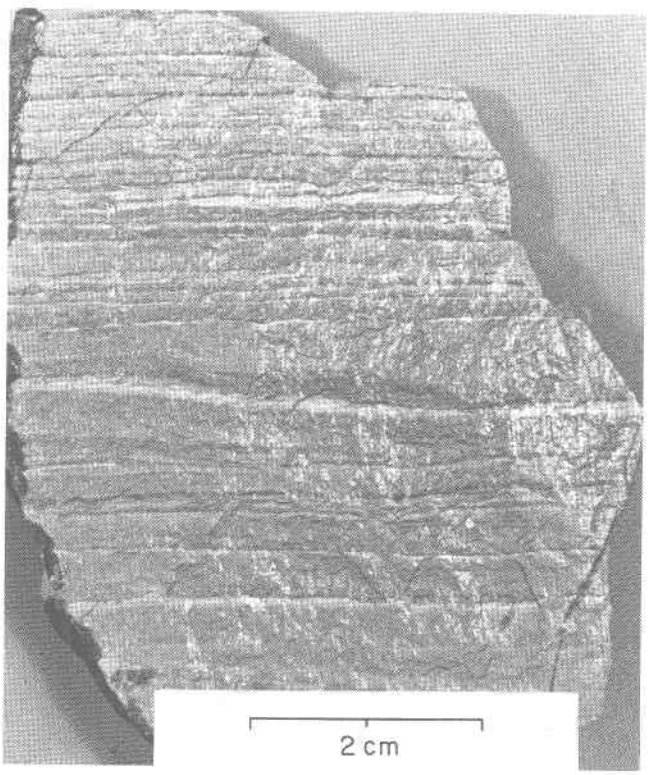

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Table 3. — Chemical compositions of Precambrian and Precambrian(?) rocks from the Omega, South Boston, Cluster Springs and Virgilina quadrangles (X-ray fluorescence analyses by O. M. Fordham, Jr.)

LITHOLOGY and STRATIGRAPHIC UNIT	COMPONENT (Weight Percent)									
	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	LOF[2]
Biotite gneiss (biotite gneiss unit) R-5660	66.26	13.80	6.99	2.39	1.62	2.82	3.96	0.94	0.11	1.11
Biotite gneiss (biotite gneiss unit) R-5656	73.05	14.46	1.59	0.37	1.48	3.16	4.59	0.24	0.03	1.04
Biotite gneiss[3] (biotite gneiss unit) R-5655	71.61	13.39	4.14	1.47	1.90	2.97	2.08	0.63	0.04	1.78
Biotite gneiss (biotite gneiss unit) R-5654	66.96	16.02	3.91	1.54	3.67	4.20	2.23	0.52	0.06	0.89
Hornblende-biotite gneiss[3] (gneiss unit) R-5665	59.23	17.03	6.71	2.59	6.23	3.82	1.61	0.75	0.12	1.20
Hornblende-biotite gneiss[3] (gneiss unit) R-5664	53.10	17.77	9.07	4.03	7.85	3.47	1.82	1.00	0.14	1.74
Hornblende gneiss (gneiss unit) R-5675	54.35	16.62	8.83	3.97	7.19	3.09	1.27	0.77	0.17	3.73
Hornblende gneiss (gneiss unit) R-5673	56.41	16.56	7.36	4.11	7.38	3.70	1.13	0.77	0.14	2.44
Hornblende gneiss (gneiss unit) R-5674	47.45	15.81	15.68	4.95	9.77	2.58	0.87	1.33	0.26	1.29
Biotite gneiss (gneiss unit) R-5670	66.52	17.39	2.75	1.33	3.72	4.77	1.73	0.47	0.02	1.29
Felsic pyroclastic rock (Hyco Formation) R-5694	73.16	13.42	2.19	0.53	1.67	2.40	3.06	0.40	0.06	3.11
Felsic pyroclastic rock[3] (Hyco Formation) R-5692	73.42	13.97	2.06	0.51	0.64	3.10	3.53	0.27	0.06	2.46
Greenstone (Hyco Formation) R-5693	56.20	16.12	8.55	2.57	5.84	3.40	1.89	1.11	0.22	4.10
Quartz diorite (quartz diorite unit) R-5684	71.55	14.22	2.38	0.72	2.47	3.86	2.12	0.37	0.11	2.20
Quartz diorite (quartz diorite unit) R-5683	68.22	15.10	3.45	0.78	1.73	4.77	3.58	0.46	0.14	1.77
Quartz diorite (quartz diorite unit) R-5682	71.98	14.28	2.46	0.61	0.38	4.97	3.09	0.38	0.10	1.76
Metasandstone (lower member of Aaron Formation) R-5703	73.37	11.19	2.57	0.61	2.74	3.57	1.51	0.44	0.10	3.89
Slate (lower member of Aaron Formation) R-5702	67.80	13.76	6.17	1.91	1.66	2.45	2.39	0.78	0.10	2.98
Greenstone (middle member of Aaron Formation) R-5718	48.45	14.68	10.66	9.04	8.22	2.84	0.41	0.70	0.17	4.72

Table 3. (Continued)

LITHOLOGY and STRATIGRAPHIC UNIT	COMPONENT (Weight Percent)									
	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	LOF[2]
Greenstone[3] (middle member of Aaron Formation) R-5717	49.78	13.49	10.15	8.52	9.28	2.58	0.38	0.64	0.17	4.99
Greenstone (middle member of Aaron Formation) R-5719	47.69	14.83	9.16	3.82	15.02	1.20	0.46	0.72	0.15	6.95
Greenstone[3] (middle member of Aaron Formation) R-5716	51.78	13.78	9.81	8.56	7.80	2.62	0.29	0.79	0.15	4.40
Slate[3] (upper member of Aaron Formation) R-5713	61.50	16.41	10.46	2.29	1.01	2.51	0.72	0.83	0.16	4.10
Granite dike (granite dikes and sills unit) R-5690	72.33	14.42	1.21	0.27	1.14	4.32	4.81	0.15	0.02	1.31

[1]Adjusted so that sum of components is 100 percent
[2]Loss on fusion at 1100°C
[3]Sample may be slightly weathered

Darwinula sp. (an ostracode), and several pieces of malacostracan carapaces; and fish scales (Osteichthyes).

Conglomerate was noted at two locations. At one crop, in a stream bed 2,000 feet (610 m) northeast of Ebenezer Church, the rock consists of subrounded cobbles in a grayish-red, medium-grained sandstone matrix. The cobbles are composed largely of oxidized granitic mica gneiss. The exposure is within 100 feet (30 m) of the fault that bounds the western edge of the Triassic basin. At the other, near the eastern edge of the basin, an 8-inch- (20-cm-) thick bed of conglomerate (R-5728, Plate 1) consists of metamorphic rock fragments and pebbles of quartz. The pebbles are angular to subrounded and poorly sorted suggesting short transportation and deposition in fluvial and alluvial environments. The immature nature of most the sediments deposited in this Triassic basin is strongly suggestive of fluvial environments. The relatively thin-bedded fossiliferous shale and clay beds may represent a local lacustrine environment.

Diabase Dikes

Diabase dikes of Late Triassic age have intruded pre-Triassic rocks in several places. They are vertical and generally trend from due north to N60°W. Most are fine-grained diabase that in thin section has a typical subdiabasic texture with elongate laths of plagioclase and anhedral pyroxene and olivine. Accessory minerals include biotite, magnetite, and chlorite.

One diabase dike in the central part of the South Boston and Cluster Springs quadrangles (Plate 2), corresponds to a north-south-trending magnetic high as seen on U. S. Geological Survey Map GP-747 (1971). This magnetic anomaly shows that there is diabase at depth along this zone, although it was not seen in the field in all places along its trend.

QUATERNARY SYSTEM

Terrace Deposits

Alluvial terrace deposits occur primarily along the Dan and Banister rivers and represent flood-plain deposits laid down at times when these streams flowed at higher elevations. These deposits are generally composed of layered, clay-rich sand, commonly with abundant well-rounded quartz cobbles and pebbles. There are extensive cobble deposits south of Wolf Trap (Plate 1) and in the area between U. S. Highway 58 and the Dan River (Plate 2). The cobbles and high-angle cross-bedding (Figure 15) attest to the high-energy environment under which these deposits were formed. Data on the thickness of the deposits is generally lacking, but deposits from 2.0 to 10.0 feet (0.6 to 3.0 m) thick have been observed in road and railroad cuts. Older terraces are seen as small, thin patches of sand and gravel on tops and upper slopes of some hills; the deposits have been mostly removed by erosion. Terraces are otherwise indicated in this area by extremely sandy A-soil

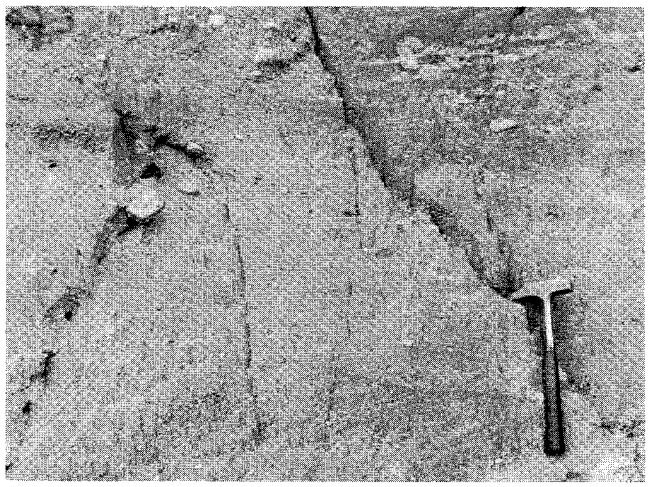


Figure 15. Cross-bedded alluvial terrace deposit, north end of U.S. Highway 304 bridge over the Dan River, South Boston quadrangle (Plate 2).

horizons, scattered rounded pebbles on the surface, and flat-topped profiles of interfluves.

Alluvium

The valley floors of major streams are generally covered with alluvium (Plates 1, 2). In the smaller streams these deposits are strongly influenced by the local source of material. Those which drain areas covered by extensive terrace deposits are rich in sand and rounded cobbles and pebbles derived from erosion of these deposits. Other small streams have alluvial deposits composed of bedded clay, silty clay, sand, and angular to subrounded rock fragments which have been derived from the physical and chemical weathering of rocks in local drainage basins. Larger rivers generally have extensive alluvial deposits that reflect a more diverse provenance. These deposits have abundant bedded sand with some gravel and cobble layers.

STRUCTURE

The major geologic structures in the area of this report are the west limb of the north-northeastward-trending Virgilina synclinorium; an unnamed, open, north-northeastward-plunging anticline, which contains refolded previously existing, nearly recumbent isoclinal folds; a normal fault with steep dip which bounds the western edge of a basin with Triassic rocks; and two normal faults containing silicified mylonite that extend southwestward across the report area. Folds were interpreted from geometric configurations of stratigraphic units; strike and dip of rocks; and foliations that include schistosity, slaty cleavage, slip cleavage, and compositional layering. The position of some faults was inferred from occurrences of breccias, fracture zones, and mylonites.

VIRGILINA SYNCLINORIUM

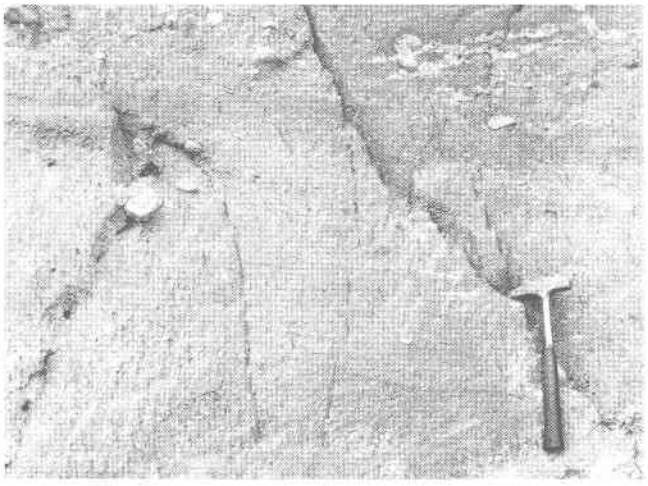
The Virgilina synclinorium, originally described by Laney (1917, p. 42-46) and named by Brown (1953) consists of several anticlines and synclines within a larger north-northeastward-trending synclinal structure (Plate 1). The axis of the synclinorium is here interpreted to pass about 0.8 mile (1.3 km) east of Virgilina (Plate 1). Three major secondary folds, an anticline and two synclines, plunge north-northeastward across the quadrangle. A relatively minor reverse fault separates the anticline from the western syncline of the synclinorium. The anticline has been thrust to the west over a part of the eastern limb of this syncline. The northern terminus of the anticline is marked by several minor folds. There are additional minor structures in all parts of the synclinorium, but these are unmappable due to lack of marker beds and poor rock exposures. Local reversals and divergence of bedding attitudes are evidence of the presence of minor structures (Plate 1). Most of the axial planes of folds in the synclinorium have very steep dips (60° to 90°) to the southeast. Slaty cleavage is generally parallel to the axial planes of folds and is also parallel to bedding, except along fold hinges, indicating a system of isoclinal folds. The dip of cleavage and bedding becomes generally less steep along the western edge of the synclinorium as does foliation in the gneiss unit to the west; the change in the orientation of foliation was also noted by Tobisch and Glover (1969, Figure 2).

FOLDS TO THE WEST OF THE VIRGILINA SYNCLINORIUM

The gneissic rocks west of the Virgilina synclinorium were warped into a set of greatly attenuated, overturned isoclinal folds and deformed later during broad, open folding (front cover of Publication 5). The axial planes of the earlier set of folds generally have a dip of about 45°E in the eastern part of the area and become progressively more flat-lying to the west. This is in part observable in schistosity which is generally parallel to the limbs of the isoclinal folds. Elongate, north-trending folds northeast of South Boston are representative of this early deformation (Plates 1, 2). Later these isoclines were folded into a major northeastward-plunging anticline as can be seen from the northeastward-plunging lineation and wraparound pattern of the foliations south of the Dan River (Plate 2). These second-generation folds are also easily recognizable in the outcrop pattern of the rocks in the north-central and northeastern part of the South Boston quadrangle (Plate 2).

FAULTS TO THE WEST OF THE VIRGILINA SYNCLINORIUM

A normal fault with steep dip bounds the western edge of a basin containing Triassic sediments at Wolf Trap (Plate 1), and two parallel faults, marked by zones of mylonite and silicified mylonite, have been traced



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southward from the Dan River just south of this basin. Other, shorter, and in part different trending, faults occur southeast of Riverdale and east of Cluster Springs (Plate 2). Most faults contain a fractured rock zone 100 feet (30 m) or more in width; fractures increase in number toward the central part of the zone. Breccia (Figure 16; Plate 2, R-5722) and siliceous mylonite are

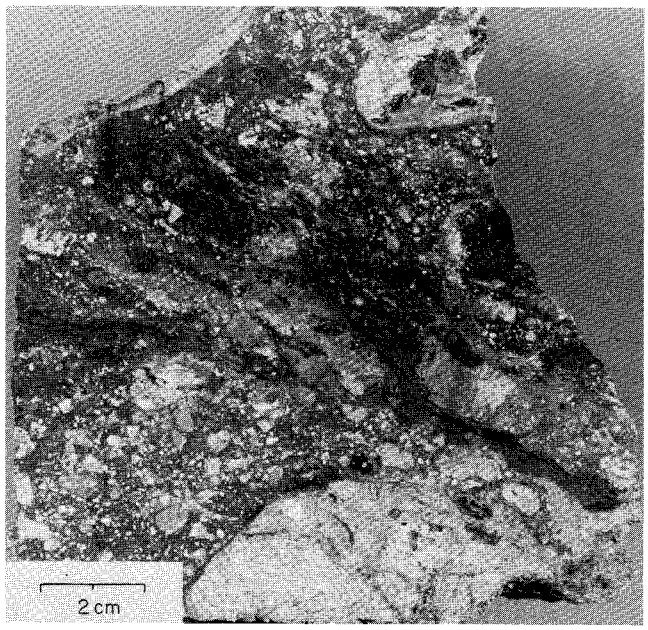


Figure 16. Fault breccia (Plate 2, R-5722) from fault that extends across State Road 744 approximately 2.0 miles (3.2 km) southeast of Riverdale, South Boston quadrangle. (Sawn slab.)

in the central part of some of these faults; microbreccia and protomylonite occur within the fracture zones as noted in thin section (Figure 17; Plate 1, R-5723). The

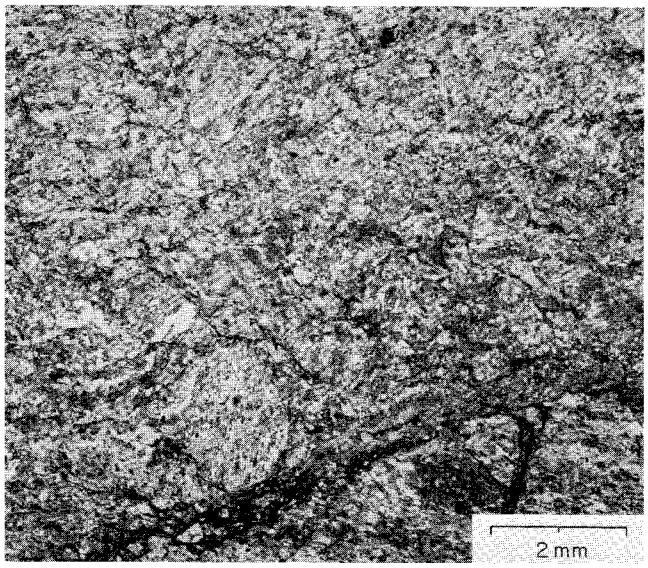


Figure 17. Protomylonite (Plate 1, R-5723) associated with a normal fault approximately 0.8 mile (1.3 km) west of State Road 744 along Hyco River, Virgilina quadrangle. (Photomicrograph, cross-polarized light.)

fault zones are generally replete with minor faults of small displacement. At least two faults have major displacement: the fault that borders the western side of the basin containing Triassic rocks; and the more easterly of the two parallel normal faults farther south. At this latter fault an abrupt change in metamorphic grade was effected by the movement (Figure 5).

AEROMAGNETIC SURVEY

Aeromagnetic contours on "Aeromagnetic Map of The South Boston Quadrangle, Halifax County, Virginia, and Person and Granville Counties, North Carolina" (U. S. Geological Survey Map GP-747, 1971) show that rocks of the Virgilina synclinorium have magnetic patterns of high relief and that contours parallel major structural trends. The lower metasedimentary unit of the Aaron Formation has the highest magnetic susceptibility of any of the rocks within the Virgilina synclinorium. This apparently is related to magnetite in the metasandstones. The magnetic pattern over the unit shows strong contrast with contiguous metavolcanic rocks of the Aaron and Hyco formations. Local closed highs over parts of the basal Hyco Formation are apparently related to the quartz diorite body which intrudes it. The rocks in the western two-thirds of the mapped area have less magnetic relief, and the linear highs are related to diabase dikes.

ECONOMIC GEOLOGY

Stone

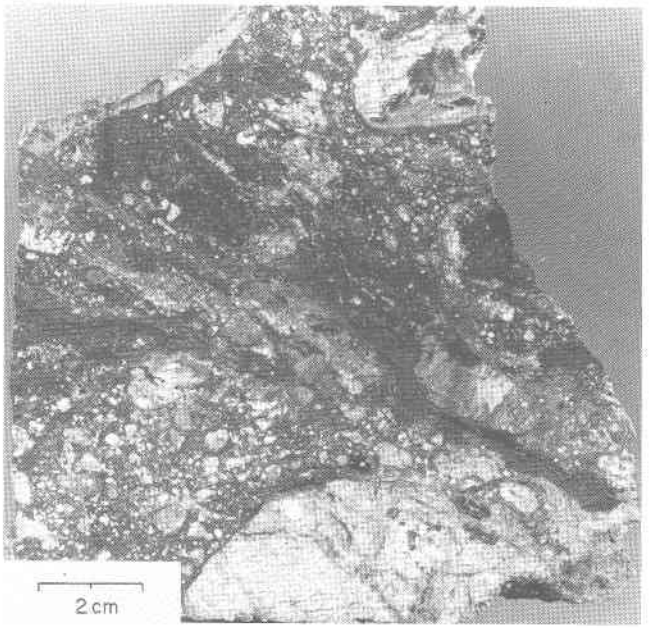
Amphibole gneiss, biotite gneiss, and quartz diorite are potential sources of crushed stone. Amphibole gneiss in the gneiss unit is quarried just south of Wolf Trap Creek about 0.3 mile (0.5 km) east of State Road 304 by the Vulcan Materials Company (Plate 1). The gneiss unit contains similar amphibole-rich zones in its upper part south and southwest of this quarry (Plates 1, 2). Rocks of the biotite gneiss unit have been quarried by the Virginia Department of Highways. An inactive quarry in this unit is located in the Halifax quadrangle near Toots Creek about 1,700 feet (518 m) north of the South Boston quadrangle and about 1,700 feet (518 m) west of U. S. Highway 501. The quartz diorite that intrudes the basal part of the Hyco Formation has not been quarried, but may be a source of crushed stone as the central parts of the larger bodies are weakly foliated and might yield favorable test results for abrasion and adhesion.

Parrott (1954, p. 50) reports the following results from physical tests on a sample of gneissic rock from the South Boston quadrangle: specific gravity, 2.67; absorption, 0.79; soundness, 0.57; and Los Angeles loss at grading A, 49.2 percent.

Sand

Sand for highway use has been obtained along the

southward from the Dan River just south of this basin. Other, shorter, and in part different trending, faults occur southeast of Riverdale and east of Cluster Springs (Plate 2). Most faults contain a fractured rock zone 100 feet (30 m) or more in width; fractures increase in number toward the central part of the zone. Breccia (Figure 16; Plate 2, R-5722) and siliceous mylonite are



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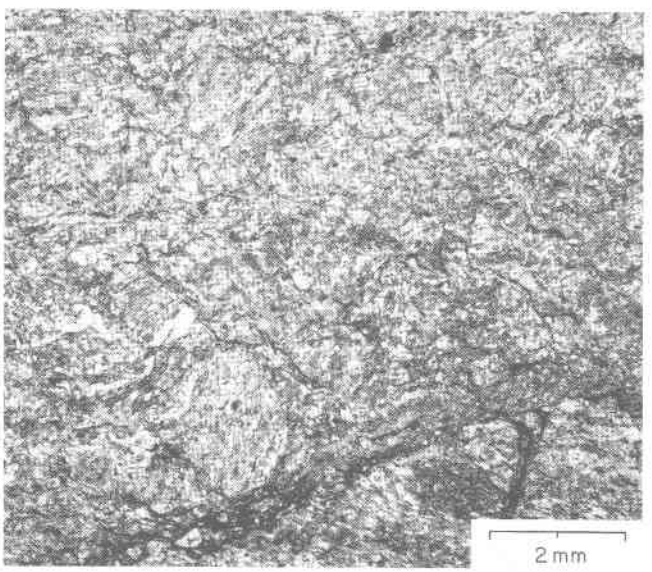

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Sand

Sand for highway use has been obtained along the

Banister River near U. S. Highway 304 northeast of South Boston.

Copper

Copper ore was produced from the Aaron Formation from the mid-1800's until about World War I. Numerous small mines and prospect pits were opened during that time, especially during the early 1900's; about 750,000 pounds of copper was produced from the Virgilina District (Sweet, 1976b, p. 25). The abandoned mines and larger prospect pits are shown on Plate 1 (locations plotted by Sweet). Twenty of these are in the middle member and one in the lower member of the formation. Copper occurs in quartz veins as bornite, chalcocite, and chalcopyrite. Minor amounts of native copper have been noted in the country rock (Laney, 1917, p. 155). The veins also contain minor amounts of pyrite, silver, and gold. The U. S. Bureau of Mines investigated the High Hill and Seaboard mines during World War II. This study included digging several trenches and drilling 11 test boreholes (Newberry and others, 1948). For a further discussion of ores and a historical review of mining see Laney (1917), Poole (1974) and Sweet (1976b).

Clay Materials

Recent analyses of clay weathered from the Hyco

Table 4. — Potential uses of clay, shale, and slate from the Omega and Virgilina quadrangles.

Location	Formation	Sampled interval	Potential Use
Roadcut, 2.8 miles (4.5 km) west of Virgilina on south side of State Highway 96, approximately 0.5 mile (0.8 km) southeast of its intersection with State Road 862 (Plate 1, R-3688)[1]	Lower member of Aaron Formation	Composite of grab samples believed to be representative of light-olive-gray to grayish-orange and yellowish-gray to grayish-purple, tuffaceous, partly weathered, schistose slate	Face brick, sewer pipe, and most structural clay products
Approximate 2-acre site near the intersection of the Norfolk, Franklin and Danville Railway and State Road 740 in Christie, approximately 3.8 miles (6.1 km) west of Virgilina (Plate 1, R-5338)[2]	Residuum from Hyco Formation	Auger sample of very pale-orange clay	Face brick, sewer pipe
Approximate 2-acre site near the intersection of the Norfolk, Franklin and Danville Railway and State Road 740 in Christie, approximately 3.8 miles (6.1 km) west of Virgilina (Plate 1, R-5339)[2]	Residuum from Hyco Formation	Four feet (1.2 m) of auger sample of dark-yellowish-orange to grayish-yellow clay	Face brick, sewer pipe, and quarry tile
Approximately 0.9 mile (1.4 km) northeast of Wolf Trap (Plate 1) about 4 miles east of South Boston[3]	Triassic	brownish-red shale	Common brick and drain tile
Riverbank, 1.4 miles (2.3 km) east of Wolf Trap, on the east-northeast bank of and under the bridge over the Banister River on State Road 716 approximately 0.85 mile (1.37 km) by road east-northeast of its intersection with State Road 727 (R-6812, not shown on Plate 1)[4]	Residuum from Triassic shale	Composite of two representative channel samples of clay, taken about 25 feet (8 m) apart (horizontally) in the thickest part of the exposure	Structural clay products (e.g., building brick at 1100°-1250°C)
Roadcut, 2.2 miles (3.5 km) north of Wolf Trap, on the north side of State Road 613 approximately 0.85 mile (1.37 km) by road east of its intersection with Virginia Highway 304 (R-6813, not shown on Plate 1)[4]	Residuum from Triassic shale	Composite of two representative channel samples of clay, taken about 25 feet (8 m) apart (horizontally) in the thickest part of the exposure.	Structural clay products (e.g., building brick at 1150°-1250°C)

[1]Modified after Sweet (1973); sample on file in the Virginia Division of Mineral Resources repository, where it is available for examination.
[2]Modified after Sweet (1976a); sample on file in the Virginia Division of Mineral Resources, where it is available for examination.
[3]Modified after Ries and Somers (1917).
[4]Unpublished data; available from the Virginia Division of Mineral Resources.

Formation and slate from the lower member of the Aaron Formation show that these units are potential sources of raw material for face brick, tile, or sewer pipe (Table 4; Sweet, 1973, p. 121 and Sweet, 1976a, p. 42-43). Shale from the Triassic rocks at Wolf Trap (Plate 1) has been used in the manufacture of brick (Ries and Somers, 1917, p. 23-24). They report this material to be suitable for making brick and tile. Residuum from Triassic shales has been sampled and evaluated at two additional locations north and east of Wolf Trap. These materials are reportedly suitable for structural clay products (Table 4).

Graphite

Graphite occurs north of State Road 678 about 0.25 mile (0.40 km) west of Mikes Creek approximately 4 miles (6 km) west-northwest of South Boston (Plate 2). It is found in a partially overgrown pit and its mode of occurrence is uncertain. Several samples (R-5729) collected are composed almost entirely of graphite. Deposits at this locality were mined some time prior to the Civil War, according to local residents. A similar occurrence of graphite was reported roughly on strike with this deposit along Drake's Branch in Charlotte County adjacent to Halifax County (Watson, 1907, p. 189).

REFERENCES

Brown, W. R., 1953, Structural framework and mineral resources of the Virginia Piedmont, *in* McGrain, Preston, Proceedings of the Southeastern Mineral Symposium, 1950: Kentucky Geol. Survey Reprint ser. 9, Spec. Pub. 1, p. 88-111.

Conley, J. F., 1978, Geology of the Piedmont of Virginia — interpretations and problems, *in* Contributions to Virginia Geology III: Virginia Division of Mineral Resources Pub. 7, p. 115-149.

Conley, J. F., and Bain, G. L., 1965, Geology of the Carolina slate belt west of the Deep River-Wadesboro Triassic basin, North Carolina: Southeastern Geology, vol. 6, no. 3, p. 117-138.

Glover, Lynn, III and others, 1971, U-Pb dating of Carolina slate belt and Charlotte belt rocks, Virgilina district, Virginia and North Carolina (abs.): Geol. Soc. America Abs., vol. 3, no. 5, p. 313.

Glover, Lynn, III, and Sinha, A. K., 1973, The Virgilina Formation, a late Precambrian to Early Cambrian(?) orogenic event in the central Piedmont of Virginia and North Carolina: *in* the Byron N. Cooper Volume, Am. Jour. Sci., vol. 273-A, p. 234-251.

IUGS Subcommission on the Systematics of Igneous Rocks, 1973, Plutonic rocks — classification and nomenclature: Geotimes, vol. 18, no. 10, p. 26-30.

Laney, F. B., 1917, The geology and ore deposits of the Virgilina district of Virginia and North Carolina: Virginia Geol. Survey Bull. 14, 176 p.

LeGrand, H. E., 1960, Geology and ground-water resources of Pittsylvania and Halifax counties: Virginia Division of Mineral Resources Bull. 75, 86 p.

McConnell, K. I., 1974, Geology of the late Precambrian Flat River complex and associated volcanic rocks near Durham, North Carolina: Unpublished M. S. thesis, Virginia Polytech. Inst. and State Univ., 64 p.

Newberry, A. W. and others, 1948, Investigation of the Virgilina copper district, Virginia and North Carolina: U. S. Bureau Mines Rpt. Inv. 4384, 12 p.

Nockolds, S. R., 1954, Average chemical compositions of some igneous rocks: Geol. Soc. America Bull., vol. 65, p. 1007-1032.

Parrott, W. T., 1954, Physical test results of the Virginia Highway statewide aggregate study: Virginia Department of Highways, 68 p.

Pettijohn, F. J., 1957, Sedimentary rocks (2nd ed.): New York, Harper and Brothers, 718 p.

Poole, J. L., 1974, Notes on some abandoned copper, lead, and zinc mines in the Piedmont of Virginia: Virginia Minerals, vol. 20, no. 2, p. 10-14.

Ries, Heinrich, and Somers, R. E., 1917, The clays of the Piedmont province, Virginia: Virginia Geol. Survey Bull. 13, 86 p.

Sweet, P. C., 1973, Analysis of clay, shale and related materials — southern counties: Virginia Division of Mineral Resources, Mineral Resources Report 12, 183 p.

_____ 1976a, Clay-material resources in Virginia: Virginia Division of Mineral Resources, Mineral Resources Report 13, 56 p.

_____ 1976b, Abandoned copper mines and prospects in the Virgilina District, Virginia: Virginia Minerals, vol. 22, no. 3, p. 25-34.

Tobisch, O. T., and Glover Lynn, III, 1969, Metamorphic changes across part of the Carolina slate belt-Charlotte belt boundary, North Carolina and Virginia: U. S. Geol. Survey Prof. Paper 650-C, p. C1-C7.

U. S. Geological Survey, 1971, Aeromagnetic map of the South Boston quadrangle, Halifax County, Virginia, and Person and Granville counties, North Caolina: U. S. Geol. Survey, Geophys. Inv. Map GP-747, scale 1:62,500.

Watson, T. L., 1907, Mineral resources of Virginia: Lynchburg, Va., J. P. Bell Co., 618 p.

_____, 1911, Geological Map of Virginia: Virginia Geological Survey.

Williams, Howel, Turner, F. J., and Gilbert, C. M., 1954, Petrography — an introduction to the study of rocks in thin sections: San Francisco, W. H. Freeman and Co., 406 p.

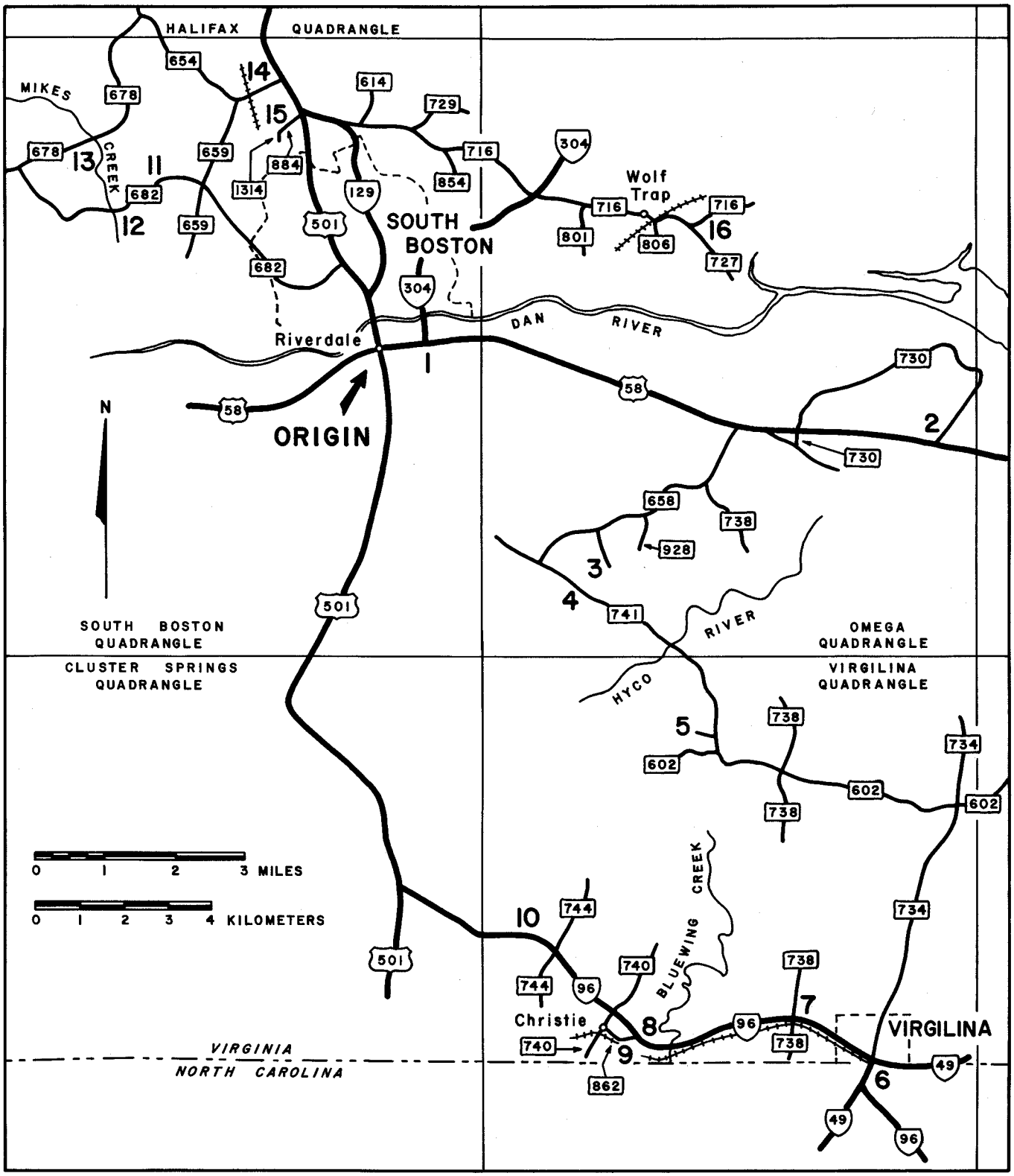

Figure 18. Road log map.

APPENDIX
ROAD LOG

The following road log is a guide to important geologic features visible along or near highways in or adjacent to the Omega, Cluster Springs, South Boston, and Virgilina, 7.5-minute quadrangles (Figure 18). Distances between points of interest, as well as cumulative mileage, are shown. *Permission should be obtained from the owner before entering and collecting any samples from private property; failure to obtain such permission violates trespass laws and is punishable under law.*

Cumulative miles (km)	*Distance miles (km)*	*Explanation*
0.0 (0.0)	0.0 (0.0)	Begin road log at intersection of U. S. Highways 58 and 501 in Riverdale across the Dan River from South Boston (Plate 2); go east on U. S. Highway 58.
0.7 (1.1)	0.7 (1.1)	*STOP 1.* Precambrian gneiss unit consisting of hornblende-biotite gneiss, biotite gneiss, and hornblende gneiss. Borrow pit behind Ward Mobile Homes sales lot. Hornblende gneiss occurs as boudins in several places.
		Note also several nearly vertical, weakly foliated, granite dikes. Continue eastward on U. S. Highway 58.
1.4 (2.2)	0.7 (1.1)	Leave South Boston quadrangle (Plate 2), enter Omega quadrangle (Plate 1). Continue east on U. S. Highway 58.
6.3 (10.1)	3.9 (7.9)	Intersection with State Road 730. Continue east on U. S. Highway 58.
8.4 (13.5)	2.1 (3.4)	Turn left onto State Road 730.
8.7 (14.0)	0.3 (0.5)	*STOP 2.* Upper member of the Aaron Formation; thinly laminated rocks from here back to U. S. Highway 58 in roadcuts. Return to U. S. Highway 58.
9.0 (14.5)	0.3 (0.5)	Turn right onto U. S. Highway 58.
11.8 (19.0)	2.8 (4.5)	Turn left onto State Road 658.
14.6 (23.5)	2.8 (4.5)	*STOP 3.* Turn on unimproved road to left; park vehicles and walk approximately 0.6 mile (1.0 km) south along unimproved road to unnamed stream. Good exposure in stream bed of fault breccia and fine-grained gneiss. The gneiss is typical of the gneiss unit generally found between the two parallel normal faults. Continue southwestward on State Road 658.
15.6 (25.1)	1.0 (1.6)	Turn left onto State Road 741.
16.1 (25.9)	0.5 (0.8)	*STOP 4.* Mylonite associated with the westernmost normal fault in roadcut. Continue southeastward on State Road 741.
17.9 (28.8)	1.8 (2.9)	Hyco River.
18.2 (29.3)	0.3 (0.5)	Leave Omega quadrangle, enter Virgilina quadrangle. Continue southeastward on State Road 741.
19.7 (31.7)	1.8 (2.9)	*STOP 5.* Interlayered greenstone and felsic metavolcanic breccia, typical of top of Hyco Formation, found along unimproved road to right and in surrounding fields and roadcuts. Continue on State Road 741.
19.8 (31.9)	0.1 (0.2)	Turn left onto State Road 602.
23.3 (37.5)	3.5 (5.6)	Turn right onto State Road 734 at Red Bank.
26.2 (42.2)	2.9 (4.7)	Intersection of State Highways 96 and 49 with State Road 734 in the town of Virgilina. Drive south on State Highway 96 (and 49).
26.3 (42.3)	0.1 (0.2)	*STOP 6.* Metabasalt of middle member of Aaron Formation, exposed in railroad cut of Norfolk, Franklin, and Danville Railway. Drive north on State Highway 96 (and 49).
26.4 (42.5)	0.1 (0.2)	Intersection with State Road 734 in Virgilina. Turn left and continue on State Highway 96.
27.6 (44.4)	1.2 (1.9)	*STOP 7.* Middle member of Aaron Formation, which contains many volcanic lithic fragments. Intersection of State Highway 96, and State Road 738. Continue westward on State Highway 96.

Cumulative miles (km)	*Distance miles (km)*	*Explanation*
29.5 (47.5)	1.9 (3.1)	*STOP 8.* Lower member of Aaron Formation: includes slate, metasandstone, and conglomerate outcrop in roadcut west of Bluewing Creek. Good exposures of slate and conglomerate also occur 0.2 mile (0.3 km) south along Norfolk, Franklin, and Danville Railway. Continue westward on State Highway 96.
30.0 (48.3)	0.5 (0.8)	Turn left onto State Road 862.
30.4 (48.9)	0.4 (0.6)	*STOP 9.* Hyco Formation at the village of Christie. Excellent exposure along Norfolk, Franklin, and Danville Railway. Continue northwestward on State Road 862.
30.5 (49.1)	0.1 (0.2)	Turn right onto State Road 740.
30.8 (49.6)	0.3 (0.5)	Turn left onto State Highway 96.
32.6 (52.5)	1.8 (2.9)	*STOP 10.* Quartz diorite unit exposed in highway roadcut. Continue westward on State Highway 96.
33.1 (53.3)	0.5 (0.8)	Leave Virgilina quadrangle (Plate 1), enter Cluster Springs quadrangle (Plate 2). Continue on State Highway 96.
34.4 (55.4)	1.3 (2.1)	Turn right onto U. S. Highway 501. Exposures of gneiss unit of Precambrian age from here north to Riverdale, along U. S. Highway 501.
38.5 (62.0)	4.1 (6.6)	Leave Cluster Springs quadrangle, enter South Boston quadrangle and continue on U. S. Highway 501.
43.0 (69.2)	4.5 (7.2)	Cross U. S. Highway 58 at Riverdale and continue northward on U. S. Highway 501.
44.4 (71.5)	1.4 (2.3)	In South Boston, turn left onto Edmunds Street (State Road 682) at traffic light.
47.4 (76.3)	3.0 (4.8)	Bear to the left at stop sign and stay on State Road 682.
48.2 (77.6)	0.8 (1.3)	*STOP 11.* Biotite gneiss is well exposed along streams on both sides of road. Continue westward on State Road 682.
48.9 (78.7)	0.7 (1.1)	*STOP 12.* Mica gneiss crops out in weathered exposures in roadcuts on both sides of Mikes Creek. Continue westward on State Road 682.
50.7 (81.6)	1.8 (2.9)	Turn right onto State Road 678.
52.0 (83.7)	1.3 (2.1)	*STOP 13.* Tightly folded isoclines which have been gently refolded are exposed 300 feet (91 m) south of road along small stream. Continue on State Road 678.
53.6 (86.3)	1.6 (2.6)	Leave South Boston quadrangle, enter Halifax quadrangle to the north. Continue on State Road 678.
54.1 (84.1)	0.5 (0.8)	Turn right onto State Road 654.
54.6 (87.9)	0.5 (0.8)	Leave Halifax quadrangle, enter South Boston quadrangle (Plate 1). Continue on State Road 654.
55.9 (90.0)	1.3 (2.1)	Bear left at stop sign and continue on State Road 654.
56.1 (90.3)	0.2 (0.3)	*STOP 14.* Ultramafic rocks occurring in weathered exposures along railroad cut north of bridge over Norfolk and Western Railway. Continue on State Road 654.
56.6 (91.1)	0.5 (0.8)	Turn right onto U. S. Highway 501.
57.1 (91.1)	0.5 (0.8)	Turn right onto State Road 884 approximately 200 feet beyond light at intersection of U. S. Highway 501 and State Highway 129.
57.6 (92.7)	0.5 (0.8)	Turn left onto State Road 1314.
57.8 (93.0)	0.2 (0.3)	*STOP 15.* Biotite gneiss with garnetiferous mica-sillimanite schist in weathered exposure. Return to traffic light at intersection of U. S. Highway 501 and State Highway 129.
58.5 (94.1)	0.7 (1.1)	Cross U. S. Highway 501 onto State Highway 129.

Cumulative miles (km)	*Distance miles (km)*	*Explanation*
59.2 (95.3)	0.7 (1.1)	Turn left onto State Road 716.
60.9 (98.0)	1.7 (2.7)	Leave South Boston quadrangle (Plate 2), enter Omega quadrangle (Plate 1). Continue on State Road 716.
62.2 (100.1)	1.3 (2.1)	Cross State Highway 304 and continue to the east on State Road 716.
64.1 (103.2)	1.9 (3.1)	Cross Southern Railway at Wolf Trap.
64.8 (104.3)	0.7 (1.1)	*STOP 16.* Quaternary terrace gravel deposits at intersection of State Roads 716 and 727 and to the right along State Road 727. Continue on State Road 716.
65.2 (104.9)	0.4 (0.6)	Triassic sandstone and shale containing abundant fossils.
		END OF LOG

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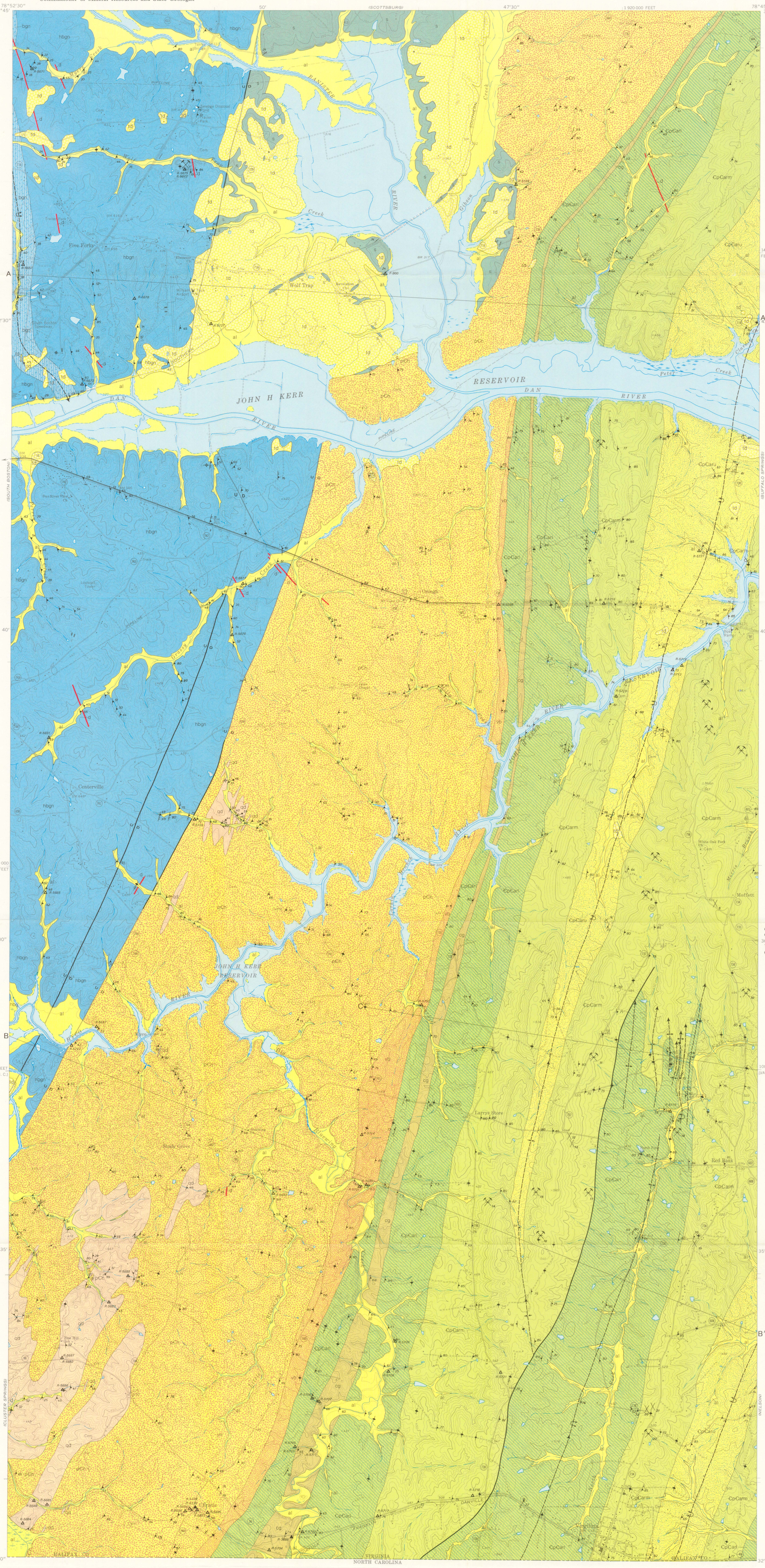
COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
DIVISION OF MINERAL RESOURCES
James L. Calver
Commissioner of Mineral Resources and State Geologist



Base map from U. S. Geological Survey, 1968 (74 PR) Omega, and 1968 Virgilina Quadrangles, 7½-minute series

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Commonwealth of Virginia

EXPLANATION

CENOZOIC — QUATERNARY

al — Alluvium
Clay, silty clay, sand, pebbles, cobbles, and angular rock fragments.

td — Terrace deposits
Sand, pebbles, and cobbles.

MESOZOIC — TRIASSIC

d — Diabase dikes
Fine-grained diabase.

s — Sedimentary rocks
Shale, siltstone, feldspathic sandstone, and rarely conglomerate.

PRECAMBRIAN

€p€aru, €p€arm, €p€arl, cg — Aaron Formation
€p€aru, upper member: light-gray to purple phyllite, metavolcanic sandstone, and slate; small amount of green slate and metasandstone, very fine grained metasandstone and mudstone, and greenstone. €p€arm, middle member: metabasalt composed largely of light-green, schistose, mafic volcanic rocks; minor amount of metavolcanic sandstone and schistose and phyllitic, felsic metavolcanic rocks. €p€arl, lower member: mainly green slate interbedded with light-gray to green metasandstone; small amount of greenstone and gray to purple slate, phyllite, and metavolcanic sandstone; cg, interbedded sandy metaconglomerate, conglomeratic sandstone, metasandstone, and slate.

qd, d — Quartz diorite
Fine- to medium-grained quartz diorite. d, diorite.

p€h, vb — Hyco Formation
Light-gray sericite schist containing augen-shaped quartz and feldspar phenocrysts. vb, interlayered metamorphosed felsic volcanic breccia and tuffaceous greenstone.

hbgn — Gneiss
Mainly medium-grained hornblende-biotite gneiss; small amount of fine- to medium-grained biotite gneiss, hornblende gneiss and hornblende amphibolite, and mica schist.

bgn — Biotite gneiss
Fine- to medium-grained biotite gneiss interlayered with minor amount of mica schist.

CONTACTS

Exposed or approximate

FOLDS

Anticline—trace; direction of plunge
Syncline—trace; direction of plunge
Overturned anticline—trace
Overturned syncline—trace

FAULTS

Black line where exposed or approximate; gray line where covered or inferred; U, upthrown side; D, downthrown side; T, overthrust side

ATTITUDE OF ROCKS

56 — Strike and dip of beds
76 — Strike and dip of overturned beds
Horizontal beds

FOLIATION

74 — Strike and dip of schistosity
Strike of vertical schistosity
80 — Strike and dip of cleavage
Strike of vertical cleavage
73 — Strike and dip of compositional layering
Strike of vertical compositional layering

LINEATION

44 — Direction and angle of plunge of inclined rodding or intersection of two foliations

MINES, QUARRY, AND PROSPECTS

Active quarry
1. Vulcan Materials Company (gneiss)

Abandoned copper mine
2. Kay
3. High Hill
4. High Hill
5. High Hill
6. Baynham
7. Pontiac
8. Pontiac
10. Pandora
11. Wall
14. Dorothy
15. Littlejohn
16. Littlejohn
17. Seaboard
18. Morong
22. Anaconda

Copper prospect
9. Unnamed
12. Ester May
13. Abbot
19. Unnamed
20. Unnamed
21. Unnamed

SAMPLE LOCATIONS

R-5600 — R, repository number of sample
R-3688 — Sample of raw material having potential commercial use; R, repository number of sample
F-900 — F, repository number of fossil sample

GEOLOGIC MAP OF THE OMEGA AND VIRGILINA QUADRANGLES, VIRGINIA

Geology by Ronald D. Kreisa

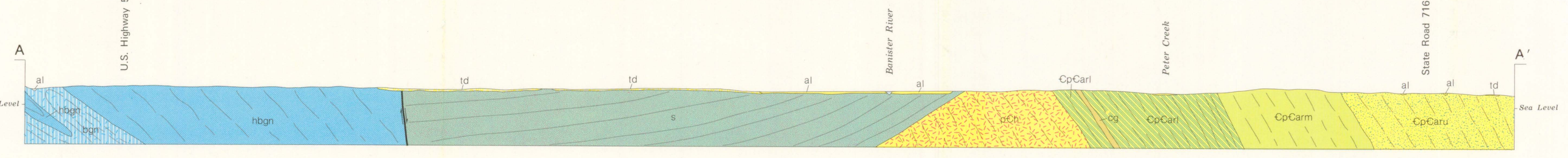
SCALE 1:24 000

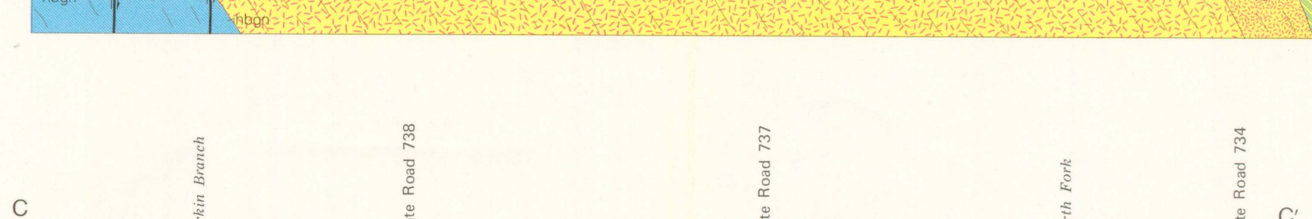
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

1977

UTM GRID AND 1968 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION





CROSS SECTION DESIGN:

1. No vertical exaggeration.
2. Subsurface structure interpreted from surface measurements.
3. Thickness of alluvium diagrammatic.

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF CONSERVATION AND ECONOMIC DEVELOPMENT
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James L. Calver
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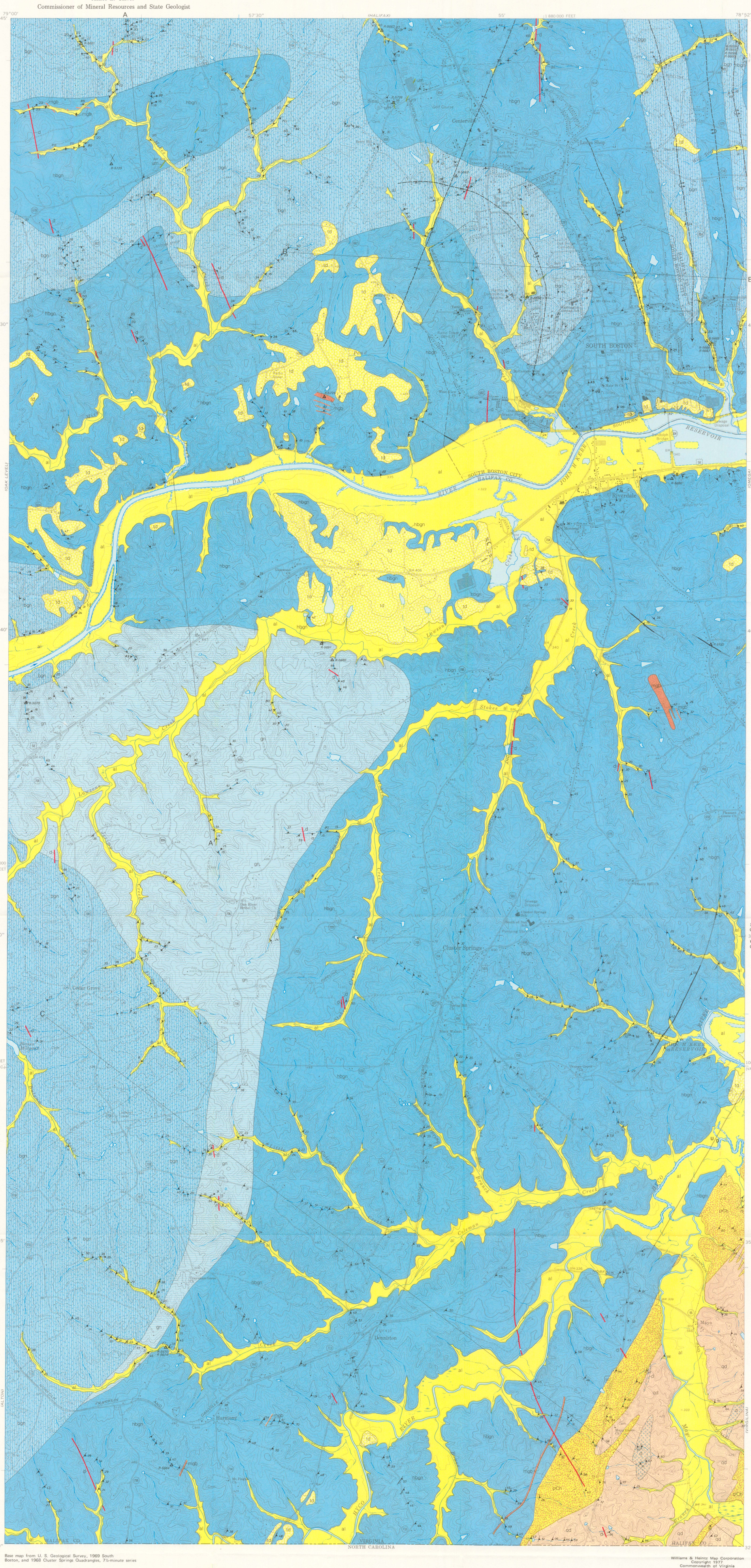

Base map from U. S. Geological Survey, 1969 South Boston, and 1968 Cluster Springs Quadrangles, 7½-minute series

Williams & Heinz Map Corporation
Cartography by Ronald D. Kreisa
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Fine- to medium-grained quartz diorite. d, diorite.

pCh — Hyco Formation
Light-gray sericite schist containing augen-shaped quartz and feldspar phenocrysts.

mgb — Metagabbro
Metagabbro and hornblende metadiorite.

um — Ultramafic rocks
Ultramafic rocks composed of actinolite, chlorite, epidote, and pyroxene.

hbgn, gn — Gneiss
Mainly medium-grained hornblende-biotite gneiss; small amount of fine- to medium-grained biotite gneiss, hornblende gneiss and granodiorite gneiss. hbgn, hornblende gneiss. gn, fine- to medium-grained biotite gneiss, hornblende gneiss and hornblende amphibolite, and mica schist.

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Fine- to medium-grained biotite gneiss interlayered with minor amount of mica schist.

CONTACTS

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Overturned syncline—trace

Direction and angle of plunge of hinge line of minor anticlinal isocline showing strike and dip of axial plane

Direction and angle of plunge of hinge line of minor synclinal isocline showing strike and dip of axial plane

FAULTS

Black line where exposed or approximate; gray line where covered or inferred; U, upthrown side; D, downthrown side

FOLIATION

Strike and dip of schistosity

Strike of vertical schistosity

Horizontal schistosity

Strike and dip of cleavage

Strike and dip of compositional layering

LINEATION

Direction and angle of plunge of mineral lineation

Direction and angle of plunge of inclined rodding or intersection of two foliations

Direction of horizontal rodding or intersection of two foliations

PROSPECT

graphite

SAMPLE LOCATIONS

R, repository number of sample

GEOLOGIC MAP OF THE SOUTH BOSTON AND CLUSTER SPRINGS QUADRANGLES, VIRGINIA

Geology by Ronald D. Kreisa

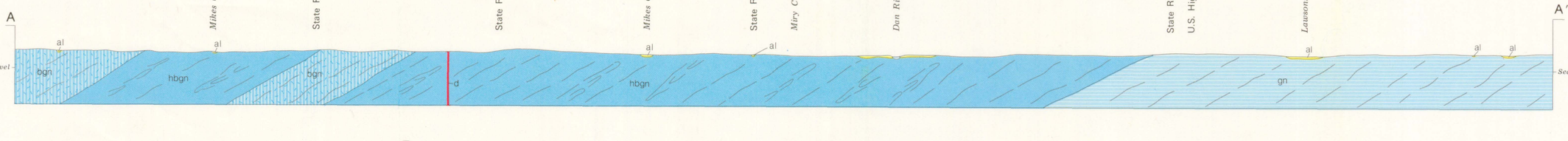
SCALE 1:24 000

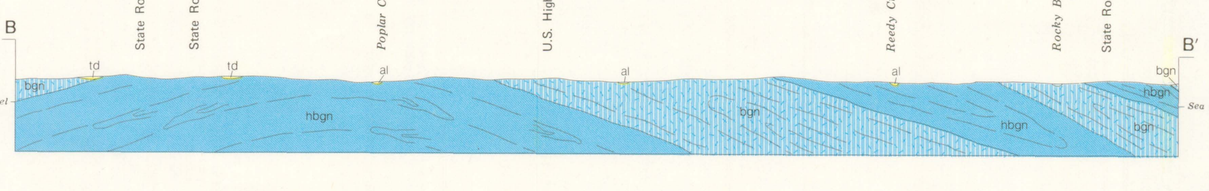
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

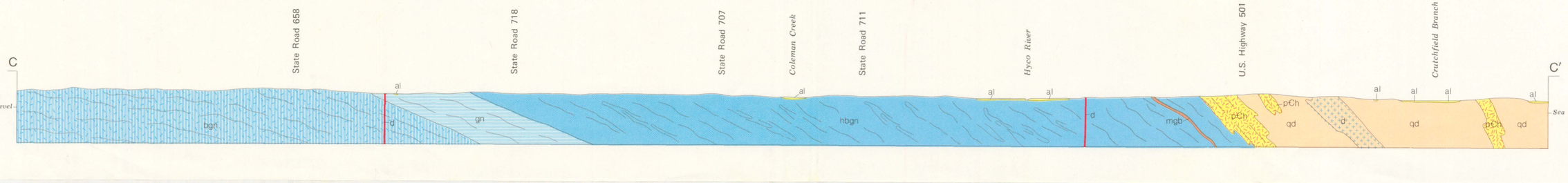
1977

UTM GRID AND 1968 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

QUADRANGLE LOCATION







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