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GEOLOGY AND MINERAL RESOURCES OF THE BETHESDA CHURCH AREA, GREENE COUNTY, GEORGIA

by

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ATLANTA

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INTRODUCTION

Purpose of the Investigation

The Bethesda Church area in Greene County, Georgia, is on the eastern flank of the northeast-southwest trending metamorphic belt, where the metamorphic grade declines.

This area was chosen for investigation because (1) its relict textures, lithologies and structural relations can shed light on the geologic history of a little-known part of the state and (2) in the area are hydrothermal alteration zones of the type often associated with ore deposits.

By detailed geologic mapping the distribution of the different rock types has been traced out. By the outcrop patterns, the observed field relations, and petrographic study an attempt has been made to deduce the origin of the rocks and to unravel at least the outlines of the geologic history of this part of the state.

Location and Size of Area

The Bethesda Church area (Fig. 1) is 55 miles southeast of Athens, 75 miles east of Atlanta, in Greene County, Georgia, and comprises about 40 square miles. It is mostly northeast of Union Point, Georgia, but includes a part of the city. It lies east of Georgia Highway 77 which connects Union Point and Lexington, north of Georgia Highway 44 which connects Union Point and Washington, and west of Georgia Highway 22.

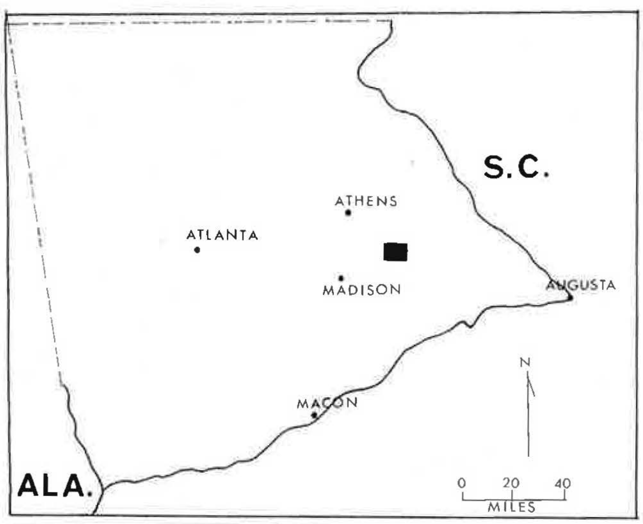

Figure 1. Location of the area.

Topography

The area is within the physiographic area called the Washington Plateau (Fig. 2) by LaForge (LaForge, Cooke, Keith, and Campbell, 1925). The plateau comprises the eastern and southeastern portion of Midland Georgia, bordered on the west and northwest by the Midland Slope and southwest by the Coastal Plain. Generally the plateau is a smooth upland whose surface descends gently to the southeast from 800 feet above sea level at its northwestern margin to about 500 feet at its southeastern margin.

The plateau is trenched by numerous streams which flow generally southeast to the Coastal Plain. Dendritic drainage usually prevails with streams commonly entrenched 50-75 feet below the surrounding area.

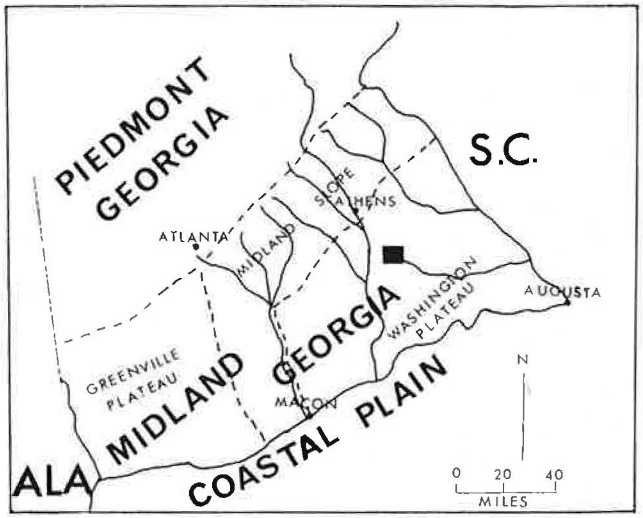

Figure 2. Physiographic divisions of Midland Georgia.

Drainage

South Fork crosses the area in an east-west direction. Its principal tributary is Mitchell Hill Creek which drains the southeastern part of the area. The northeastern part is drained principally by the southeast-flowing North Fork and its main tributary, White Creek. The North Fork and South Fork join to the southeast to form the Little River which in turn flows eastward into the Savannah River.

Previous Work

Watson (1902, p. 182) reported the occurrence of porphyritic granites in Greene County. Hopkins (1914, p. 293) briefly mentioned that the Union Point area is composed of hornblende gneiss, and gabbro-diorite. The state geologic map published in 1939 shows the rocks underlying the Bethesda Church area as hornblende gneiss, dioritic gneiss, gabbro and injection gneiss of probable Pre-cambrian age. Crickmay (1952) included these rocks in the Wacoochee belt.

Procedure

Field. Field data were plotted on aerial photographs at a scale of 1:7,920. Foot traverses were first done along the roads and streams which provided most of the outcrops. Contacts were walked out.

Field work was done during 10 weeks of the summer 1963 and 2 weeks during December 1963.

Laboratory. Laboratory work was done during 1963-64 at the University of Georgia.

The petrographic study involved 105 thin sections. Minerals were identified by their optical properties, measured partly with a U-stage. Fifteen sections were stained (Baily and Stevens, 1960) to facilitate identification of K-feldspar. A Norelco X-ray diffractometer was used to identify the micas, garnets, and clay minerals.

PETROLOGY

General Statement

Schists, quartzite, biotite gneisses, hornblende gneisses, amphibolites and granites constitute the older rocks found in the area. Quartz veins, muscovite pegmatites, quartz feldspar rocks, diabase dikes and rhyolite dikes are younger and less extensive rock types. The older rocks, with the exception of the amphibolites, have a distinct foliation and trend to the northeast with predominantly vertical dips. The amphibolites, while not having a distinct foliation, do conform to the general trend of the surrounding rocks. These older rocks, especially the basic types, are probably derived from the metamorphism of mafic intrusive or extrusive rocks. The biotite gneisses probably resulted from the metamorphism of sediments or intermediate intrusive igneous rocks. The schist conceivably resulted from the metamorphism of sediments or possibly extrusive igneous rocks.

The younger muscovite pegmatites and quartz veins are generally parallel or perpendicular to the foliation of the surrounding rocks and commonly show evidence of baking the surrounding rocks.

Diabase dikes everywhere transect the regional trend of older rocks. Trends range from N20°W to N40°W with 10-15° variation along the strike of any one dike.

The rhyolite dikes trend from N55°W to N70°W across the regional trend. They exhibit apparent bleaching effects on the surrounding rocks and are slightly metamorphosed.

The rocks are described below on the basis of lithology and in a chronological sequence, the oldest rocks being those which exhibit a distinct foliation, the younger being those which exhibit no foliation (amphibolites), and the youngest being the muscovite pegmatites, quartz veins, rhyolite dikes and diabase dikes.

Under the terminology of this report an amphibolite and hornblende gneiss are metamorphic rocks which contain hornblende and plagioclase as major constituents with varying amounts of quartz. The distinction between the two is made on the basis of the presence or absence of foliation. A hornblende gneiss possesses a distinct foliation; whereas, an amphibolite does not.

PETROGRAPHY

Schist

Three schist bands are present in the area. These include quartz-mica schist, mica-quartz schist and mica schist.

Quartz-mica Schist. In the southwestern part of the area (Plate 1) the quartz-mica schist crops out as saprolite and as weathered protuberences in road cuts near the Greene-Taliaferro County line. The rock extends northeast into Taliaferro County, but its extent to the southwest is unknown. Hornblende gneiss borders it on the northwest; the contact is apparently conformable.

Cropping out within the quartz-mica schist are small bodies of chloritized talcose amphibolite whose relationship to the schist is unclear because of poor exposure. Found also within the schist is a ferruginous-manganiferous zone that is four feet wide. The zone trends N70°E and dips 65° northwest parallel to the schistosity of the enclosing rock.

Megascopically the schist is composed of coarse white mica and quartz. In most specimens pyrite and grayish-black splotches of iron oxide and visible. The latter are especially prevalent in weathered specimens. X-ray diffraction patterns show the schist to be composed essentially of paragonite, muscovite and quartz.

Mica-quartz Schist. On the northwest side of hornblende gneiss 1 (Plate 1) is a fine- to medium-grained mica-quartz schist. This rock type occurs intermittently along strike. However, conspicuous outcrops are 400 yards east of the Mitchell Hill Gold Mine where attitude measurements give a N65°E trend with vertical dips. Where present, the schist is bordered on the southeast by hornblende gneiss I and on the northwest by biotite gneiss I. The apparent thickness of the unit is 75-100 feet.

East of the Mitchell Hill Gold Mine the rock is a grayish orange-pink (5YR7/2), fine- to medium-grained mica-quartz schist which has crinkled foliation. This rock contains abundant magnetite which is unevenly distributed. The largest grains are found in veinlets of quartz, 1 mm. wide, which are bent and contorted.

Flakes of mica, 1 mm. in length, and aligned parallel to the foliation are strikingly visible as well as the quartz, which constitutes the remainder of the rock.

Along strike to the northeast the rock becomes coarser grained and pyritic. The pyrite occurs as splotches 1 mm. or less across, and as distinct 0.5 mm. octahedra which exhibit striations. Some of the pyrite has been oxidized and occurs as splotches throughout the rock. The pyrite splotches are mainly along schistosity planes. The cubes are randomly distributed.

Microscopically the rock is composed of 60-65 percent quartz, 10-12 percent coarse muscovite and 20-25 percent very fine mica.

The quartz is present as fractured, granulated and strained grains, a fraction of a millimeter across, which contain inclusions of mica.

Muscovite is in colorless flakes 1 mm. or less across, which are somewhat bent in places. The muscovite commonly has splotches and minute granular grains of opaque material around or dusted within them, or reddish-brown irregular-shaped masses of iron oxide. Commonly the muscovite is cross-cutting and surrounded by sworls of fine mica.

Sheafs of very fine mica, irregular in shape and ranging from 2 mm. to a fraction of a millimeter in size, are conspicuously present. These sworls are commonly wrapped around grains of quartz or are along grain boundaries. Commonly, irregular grains of black opaque magnetite are scattered around and within the very fine aggregates of mica.

Mica Schist. In the road cuts 800 yards west of the Anderson residence, are spotted outcrops of a silvery-gray, very fine-grained, mica schist. This schist is also found 2000 feet east of the Anderson residence along a sawmill road.

The rock trends N 72°-80° E and dips 60-65° northwest. In a road cut 1000 yards west of Anderson's residence is a saprolite contact between the schist and a dark red, clayey saprolite which contains only a very small amount of very fine quartz. Relict hornblende boxworks were observed in the saprolite. Rough trend of the contact between the two rocks is N70-80°E.

The origin of the quartz-mica schist and mica schist are not considered in detail; however, the origin of the mica-quartz schist is discussed below.

The field data suggest that the mica-quartz schist occurs intermittently, and that it is related to biotite gneiss I which borders the schist on the northwest or to the quartzite which underlies the Mitchell Hill Gold Mine along strike to the southwest. Two things suggest the former: first, although outcropping in a top soil pit as a 75+ foot band, the schist is not present 700 feet east of the soil pit. Instead, contorted biotite gneiss I is present. Secondly, near the irregular contact between the gneiss and schist there is an increase in the contortion of the biotite gneiss. The schist displays the same type of contortion along with abundant quartz veinlets. Away from the contact the biotite gneiss shows no contortion.

Microscopically biotite gneiss I shows evidence of granulation of quartz, oligoclase and micas (see microscopic description of biotite gneiss I). The schist displays the same cataclastic effects on the quartz and micas suggesting that both rocks were affected by the same movement.

Mineralogically the two rocks are different. This implies that these differences were original or that there has been removal or addition of material, possibly concurrent with the deformational episode. If the two rocks were originally the same, then the movement causing the cataclastic effects could have been accompanied by silicification, forming the schist. Alternately, if the mineralogical differences were original, then the quartzitic schist could be related mineralogically to the quartzite which underlies Mitchell Hill Gold Mine. The latter explanation seems more plausible since their mineralogy is very similar.

The presence of the rock as an intermittent band suggests that the schist was probably a sediment or a felsic volcanic rock. Three assay samples from the schist were collected (see Economic Geology section).

Quartzite

Mitchell Hill Gold Mine is underlain by a quartzite. It composes a hill which rises 100 feet, rather steeply, above the creek at its base. This quartzite could be related to the mica-quartz schist and biotite gneiss I, since the quartzite lies west along the strike of the biotite gneiss and mica-quartz schist.

According to Jones (1909) a shaft passes several hundred feet through the quartzite and for a few feet beyond into a gneiss or mica schist. This could be the gneiss or schist found east of the gold mine. The shaft is now partially filled and the quartzite cannot be traced due to scarcity of exposures. However, the quartzite at the gold mine and the schist east of the ridge are probably related.

Megascopically the rock is a white, fine-grained quartzite which contains numerous veins of quartz and minute octahedra of pyrite abundantly scattered throughout.

Microscopically the rock is composed predominantly of irregularly shaped, slightly sutured, undulose grains of quartz, 0.5 mm. or less in diameter. Lesser amounts of microcline and plagioclase are present, and minor amounts of clinozoisite and epidote pseudomorph the plagioclase. Shreds of white mica, magnetite/ilmenite, and sphene are scattered through the rock.

Within the rock there is a fluctuation in grain size from coarse to fine and back to coarse, resembling graded bedding. No secondary overgrowths were observed. Also present are roughly spherical aggregates, 3-4 mm. in diameter, of quartz and feldspar which appear to have once formed larger grains.

Jones (1909) suggested that the rock might be either a light-colored igneous rock of granitic composition which had been sheared, silicified and impregnated with pyrite; or that it might represent a clastic rock that had been silicified and sheared. The latter is the more plausible because there is a vague banding which might be bedding, the grains are more or less rounded, and there are spherical aggregates of quartz and feldspar which might represent clastic particles.

Biotite Gneiss

The area is underlain by three biotite gneisses. Specifically these are biotite gneiss I, biotite-quartz-oligoclase gneiss and biotite gneiss II. The first two could be synonymous since they have essentially the same mineralogy, with few exceptions, and lie along strike of each other.

Biotite Gneiss I. Biotite gneiss I crops out immediately south of Mitchell Hill Creek. Exposures are in the small streams which traverse it and eventually join Mitchell Hill Creek. The best outcrops are 400 yards east of Mitchell Hill Gold Mine in a topsoil pit. The biotite gneiss is 150 feet thick at this outcrop. Another outcrop is five hundred feet east of the pit in a small stream. This outcrop is characterized by contorted bands.

Trend of the foliation of the biotite gneiss ranges from N60°E to N70°E; the dips are vertical. Pods of mica pegmatite traverse it in places, with 2 to 3 inch pieces of muscovite found as float.

Megascopically the biotite gneiss is light gray, coarse- to fine-grained, well foliated and crinkled in places. Mineral constituents are biotite, muscovite, quartz, and feldspar. Bands of biotite alternate with quartz-feldspathic layers. These bands of biotite range from 1/8 mm. to 1/4 mm. in width and are crinkled. Muscovite in the biotite bands is sometimes parallel with the biotite, sometimes crosscutting. The quartz-feldspathic bands range from 1/8 mm. to 1 cm. in width depending upon the grain size of the rock. In the crinkled biotite gneiss the biotitic bands may be broken or stretched apart and V-shaped. This crinkling occurs predominantly in the region 500 yards east of Mitchell Hill Gold Mine.

Microscopic data and a modal analysis are given in Tables 1 and 4 respectively.

Biotite-Quartz-Oligoclase Gneiss. Cropping out 1800 yards northeast of Mitchell Hill Gold Mine, along Mitchell Hill Creek, is a band 100 feet wide of fine- to medium-grained, biotite-quartz-oligoclase gneiss. It crops out as car-size boulders and crumbly saprolite in Mitchell Hill Creek, 400 yards east of its confluence with the South Fork. The gneiss is bordered on each side by coarse-grained amphibolite in Mitchell Hill Creek. Because of the rapidity of weathering of the gneiss, its contact relations with the amphibolite are obscure.

Megascopically the gneiss is grayish-white, fine- to medium-grained, granoblastic and composed predominantly of biotite, quartz, and feldspar (Fig. 3). Conspicuous in some specimens are megacrysts of feldspar, 3-4 mm. in diameter, in a matrix of biotite, quartz, and feldspar. The rock is faintly foliated. Samples found 400 yards east of the Mitchell Hill Creek and South Fork confluence have a coarser matrix and larger feldspar megacrysts, 5-10 mm. in diameter.

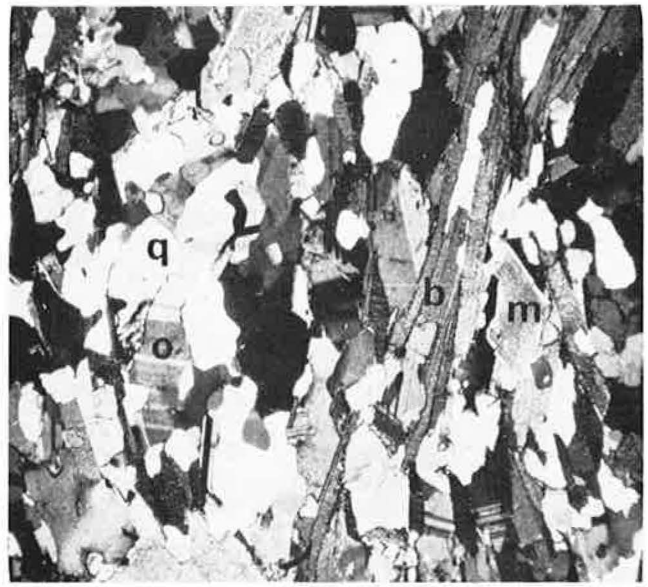

Figure 3. Characteristic texture of biotite gneiss I. Quartz (q), oligoclase (o), muscovite (m), and biotite (b). Crossed nicols, X 20.

Optical data and mineral descriptions are given in Table 2 and a point count analysis in Table 4.

The relation between this rock type and biotite gneiss I east of Mitchell Hill Gold Mine is un-

TABLE 1
BIOTITE GNEISS I

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Oligoclase	anhedral equant	3/4-1 mm.	biax. (—)	albite pericline	9-11° ⊥ X	
Biotite	books	3-4 mm. in length	biax. (—)	none	parallel	X=mod. yellow (5Y7/6)
Quartz	irregular, somewhat rounded	3/4 mm.	uni.(+)			

Approximately 95% of the oligoclase is fresh and the remainder is slightly saussuritized (Fig. 3). Products are epidote and sericite. Oligoclase displays fracturing and straining effects near zone of shearing. Numerous minute prismatic inclusions of apatite are present.

Interleaving of biotite with muscovite and biotite with apatite is very common. Muscovite also cross-cuts some biotite flakes. Where biotite and muscovite are interleaved, fine streaks of granular magnetite are present along cleavages and edges of muscovite. Minute grains of rutile are scattered around the edges of biotite and parallel with cleavages. Biotite flakes are bent in rocks collected from the zone of shearing. Biotite commonly has inclusions of quartz and a minute mineral enclosed by a pleochroic halo.

Quartz is found as inclusions in biotite, muscovite and as irregularly distributed grains in oligoclase; commonly displays cataclastic effects in specimens near zone of shearing.

certain. The two differ in several ways. First, biotite gneiss I east of Mitchell Hill has a distinct foliation due to parallel alignment of the biotite flakes, whereas, the biotite-quartz-oligoclase gneiss has only a sub-parallel alignment of biotite and no visible foliation. Secondly, biotite gneiss I contains no allanite, whereas, the biotite-quartz-oligoclase gneiss does. Thirdly, they differ in amount of modal biotite. The two rock types are similar in that they are along strike, that neither shows any K-feldspar when stained with sodium cobaltinitrite, and both contain approximately the same amounts of oligoclase and quartz. Probably the two rocks are the same. They both are shown as biotite gneiss on Plate 1.

Biotite Gneiss II. One mile east of the Union Point city limits, along Georgia Highway 44, biotite gneiss II crops out as a 6 X 8 foot weathered protuberance in a cut on the south side of the road. From this point to the southeast and northwest the outcrops are few. The gneiss trends N50°E and dips vertically.

The best outcrops of biotite gneiss II are along the stream between the William Poss residence and the Bethesda Church. This unnamed stream will hereafter be referred to as Poss's Creek. Good outcrops also occur in South Fork to the northwest and southeast of the South Fork and Poss's Creek junction. Other outcrops are present in streams west of Bethesda Church.

Conspicuous outcrops of an interlayered hornblende gneiss which contains epidote boudins are found 300 feet west of the South Fork and Poss's

TABLE 2

BIOTITE-QUARTZ-OLIGOCLASE GNEISS

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Oligoclase	equant to elongate; boundaries irregular, slightly sutured	3/4-1 1/4 mm.	biax.(—)	albite, pericline	9-11° ⊥ X	
Quartz	equant; irregular boundaries	3/4-1 mm.	uni.(+)			
Biotite	ragged flakes	1/2-3/4 mm. across	biax.(—)		parallel	X=grayish yellow (5Y8/4) to mod. yellow (5Y7/6) Z=light olive brown (5Y5/6)
Epidote	majority skeletal, some euhedral	1 mm.	biax.(—) 2V=75°	polysynthetic 30-40% grains	slightly inclined	

Accessory: Rutile, magnetite and/or ilmenite, muscovite.

Slight saussuritization of the oligoclase has produced sericite and epidote mainly along cleavage and twin planes. Sericite ranges in grain size from very fine aggregates to individual flakes 1/16 to 1/8 mm. across, which are ragged, sieved and surrounded by finer flakes. Epidote is generally present as ragged patches in the oligoclase which seems to alter more in the center of the grains than randomly.

Quartz grains exhibit undulose extinction and are fractured. Fine quartz inclusions are in the epidote and oligoclase.

The biotite occurs as sub-parallel ragged flakes which are abundantly dusted with magnetite around the edges of books and along cleavages. Where biotite is altering to epidote and is within a fraction of a millimeter of altering oligoclase, in a majority of cases, no epidote is in the oligoclase; if biotite is not near, the epidote is frequently in the oligoclase.

The epidote grains are spottily distributed. Zoned and twinned euhedral grains of moderate yellow (5Y7/6) allanite surrounded by epidote grains are frequent. A prevalent relationship is subhedral epidote surrounded by grains of magnetite with the magnetite surrounded by biotite. The epidote with fair crystal shapes tend to cross-cut the biotite or to surround it. The first stage of alteration of the biotite to epidote is marked by the appearance of minute grains of epidote along the biotite cleavages. Commonly associated with this reaction are rounded minute grains of rutile. Both epidote and rutile surround each other. The epidote grains contain inclusions of quartz and oligoclase.

Creek junction along the Poss's Creek steam bed, and in the small stream flowing into Poss's Creek, 1500 yards west of where the South Fork and Poss's Creek join. The contacts are conformable.

Saprolite of the gneiss can be observed in road cuts. The biotite gneiss II saprolite is a light yellowish-red clay containing fine-grained grayish-white flakes of mica and angular quartz grains. In road cuts, where the gneiss protrudes 6 to 8 inches above the saprolite, it exhibits a blocky spheroidal type weathering pattern.

The character of the biotite gneiss is varied. Grain size ranges from very fine- to coarse-grained and even megacrystic types. These grain size variations are along and across strike. Pronounced changes in grain size occur near the junction of South Fork and Poss's Creek. Here the gneiss takes on a foliated megacrystic texture with plagioclase being the megacryst. The rock is almost a fine-grained quartzite 800 feet east of the contact with the coarse-grained amphibolite along Georgia Highway 44. In the streams west of Bethesda Church the gneiss is extremely coarse-grained and well foliated.

The biotite gneiss has quartz veins, muscovite-bearing pegmatites, diabase dikes and rhyolite dikes within it. The diabase dikes and rhyolite dikes always transect the foliation, whereas, the quartz veins and muscovite pegmatites, and sometimes aplites are roughly parallel and perpendicular to the foliation.

Diabase dikes ranging in width from 2 feet to 30 feet cut the biotite gneiss (Plate 1). No visible evidence of alteration is observed in the field, however, microscopically one section of the biotite gneiss in contact with the diabase shows alteration (see microscopic description).

Three rhyolite dikes are present in the biotite gneiss, but no field evidence of alteration was observed due to poorness of outcrops.

The contact between the biotite gneiss and the amphibolite containing quartz megacrysts, lying on the northwest side of the gneiss, is present in two localities. One of the contacts is in a stream, 1200 yards south of the Old Copper Mine, on the south side of South Fork. This contact displays an intrusive relationship of amphibolite within the biotite gneiss. A similar relation is also present in another stream outcrop 1300 yards to the west. Contact relations between the gneiss and the coarse-grained amphibolite on the southeast side are seemingly regular, but uncertain in many places.

Megascopically the biotite gneiss is a grayish-white, fine- to coarse-grained, muscovite-biotite-quartz-feldspar, crystalloblastic gneiss. Locally the rock is an augen gneiss, and along Highway 44 it is noticeably quartzitic.

The silvery muscovite occurs as flecks 1/2 mm. in length to flakes 5 mm. in length. It is present within biotite flakes parallel to the biotite bands and as randomly oriented flakes. In the augen gneiss the muscovite and biotite seemingly wrap around the augens.

Black biotite is present as flecks a fraction of a millimeter in length and as books, 1 to 1/2 mm. in length, aligned to give the rock its gneissic texture. These folia or bands of biotite and muscovite are 1/8 mm. wide.

Quartz grains, 1 to 3 mm. in diameter, occur along with feldspar in the lighter part of the gneiss. The light-colored bands are 4-5 mm. in width. Commonly, grains of quartz, 1 cm. in diameter, are evenly distributed through the rock.

Feldspar is present as grains, 1 to 4 mm. in diameter, and as augen 2 mm. wide and up to 1 cm. in length. Together with quartz, the feldspar constitutes greater than 80 percent of the gneiss. The feldspar and quartz grains are vaguely elongated parallel to the foliation.

Partly weathered pyrite is sparingly present in some specimens.

Tables 3 and 4 give the optical properties and microscopic description, and modal analyses of the biotite gneiss, respectively.

Shape, contact relations and overall mineral composition should be considered in suggesting an origin for the biotite gneisses. The shape of each rock body is generally tabular and conforms to the surrounding rocks. Contacts between the

TABLE 3
BIOTITE GNEISS (II)

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Oligoclase	anhedral	2X1 mm. augen & 1 mm.	biax.(—) 2V=78-86°	albite & pericline	13-16° ⊥ X	
Quartz	irregular sutured	2-3 mm. & 1/2-3/4 mm.	uni.(+)			
Biotite	slender flakes	4/5X1/2 mm. & one 3/4 mm.	biax.(—)		parallel	X=pale yellowish orange (10YR8/6) to grayish yellow (5Y8/4) Z=grayish brown (5YR3/2) to grayish olive (10YR4/2)

(Table 3 continued on next page.)

TABLE 3—(Continued)

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Microcline	anhedral	3 mm. & one 1 mm.	biax.(−)	gridiron		
Muscovite	slender flakes & books	1-6 mm.	biax.(−)		parallel	colorless
Epidote	skeletal euhedral	1 mm.	biax.(−)	polysyn-thetic rarely	parallel	
Clinozoisite	skeletal euhedral	1 mm.	biax.(+)	polysyn-thetic rarely	slightly inclined	

Accessory: zircon, sphene, red iron oxide, rutile, apatite, pyrite, magnetite/ilmenite.

Oligoclase shows evidence of cataclastic deformation. Commonly, formerly equant oligoclase grains, 3 mm. X 2 mm., are fractured and granulated into smaller grains. The majority of the grains show marked undulose extinction. Twinning lamellae are parallel to the gneissic texture in 90 percent of the cases.

Saussuritization of oligoclase is not as extensive in some sections as in others. The alteration occurs preferentially in small grains, and they are almost completely covered with very fine, white mica and fine-grained epidote-clinozoisite. Alteration also occurs along the edges in some of the larger grains. Saussuritization is along cleavages and twin planes and around the borders in other specimens.

Inclusions of oligoclase dusted with minute black opaque materials commonly occur in microcline.

The biotite gneiss altered by the diabase dike shows that 95 percent of the oligoclase grains are covered by a low birefringent, medium relief, turbid material. In places this material is fluffy and cotton textured and radiates from the center of the oligoclase grains. Within this fluffy material are small, high relief, high birefringent, reddish grains which resemble rutile. Surrounding most of the oligoclase grains, and closely associated with the turbid material, are flakes of a light green, moderate relief, low birefringent, slightly pleochroic mineral which resembles chlorite.

Most of the quartz grains are elongated parallel to the gneissic banding. A mortar texture is prevalent. The quartz grains with abundant undulose extinction are fractured and granulated into smaller grains. Inclusions in the quartz are cut by fractures. Vermicular or myrmekitic quartz is common near the contact between oligoclase and microcline.

Epidote and clinozoisite are commonly associated with biotite and muscovite and less commonly with plagioclase. Zoning between epidote and clinozoisite is common. Occasionally zoning between a pleochroic yellow epidote (piedmontite?) and common epidote is present.

Euhedral epidote both cross-cuts and parallels the biotite cleavage traces. Epidote and clinozoisite are commonly found along twinning and cleavage planes in oligoclase. Clinozoisite is predominant in this respect. Commonly where epidote replaces biotite, rutile and sphene are found between epidote and biotite grains.

Biotite is scattered through the gneiss in bands, giving a distinct foliation, or wrapped around oligoclase augen. In all sections biotite is dusted with grains of black opaque material or has opaque matter closely associated with it, especially when muscovite and epidote are present. A common textural relationship is epidote either cross-cutting or parallel to the cleavage of biotite, surrounded by magnetite, biotite and muscovite.

Rounded grains of rutile are found around the edges and along cleavage traces of the biotite. In the biotite are occasional minute, highly berefringent inclusions surrounded by halos. Euhedral sphene, transects a biotite flake occasionally.

Muscovite is present in varying amounts in all sections. It is colorless and highly birefringent. It may be interleaved with the biotite or cross-cut it. Where muscovite surrounds biotite, the borders of the biotite are lighter in color and small splotches and grains of opaque material are scattered around the muscovite.

Twinned microcline is present in varying amounts. Its boundaries with quartz may be sutured and may show undulose extinction and fracturing. Large grains of microcline are surrounded by grains of oligoclase. The microcline is unaltered in all sections and contains minute reddish needle inclusions. When microcline and oligoclase are in contact a myrmekitic texture is present 50 percent of the time.

TABLE 4. POINT-COUNT ANALYSES OF BIOTITE GNEISS I, BIOTITE-QUARTZ-OLIGOCLASE GNEISS AND BIOTITE GNEISS II IN VOLUMETRIC PERCENT

	Biotite Gneiss I 91-70	Biotite-Quartz Oligoclase Gneiss 91-35	Biotite Gneiss II 91-56	Biotite Gneiss II 109-70	Biotite Gneiss II 207-11	Biotite Gneiss II 89-26	Biotite Gneiss II 109-79
Oligoclase	46.99	55.48	58.61	57.59	65.44	47.59	57.32
Quartz	19.70	22.57	24.73	27.31	20.21	24.86	25.59
K-feldspar			6.31	4.72	1.84	21.93	4.32
Biotite	26.84	14.93	3.36	3.03	9.61	2.54	5.08
Muscovite	6.08	.44	3.02	4.38		1.47	2.71
Epidote-clinozoisite		4.20	2.02	2.26	2.30	1.14	2.90
Sauss. Mica		1.56	.67	.21	.46		1.35
Rutile, Sphene & Apatite	present	.38	.87	.21	.14	.34	.53
Red Iron Oxide & Opaque	.39	.44	.41	.29	.00	.13	.20
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

91-70 Collected 500 yards east of Mitchell Hill Gold Mine.

91-35 Collected 1800 yards northeast of Mitchell Hill Gold Mine.

91-56 Collected 1500 yards northeast of Proctor residence, near biotite gneiss-coarse-grained amphibolite contact.

109-70 Collected in Poss's Creek, 300 feet west of South Fork.

207-11 Collected 1 mile northeast of the Bethesda Community Center.

89-26 Collected in stream bed of White Creek.

109-79 Collected along South Fork, 1500 yards northeast of the Bethesda Church.

biotite gneiss I and the mica-quartz schist are somewhat irregular due to movement that has deformed each and at times appear to be gradational. The contact between biotite gneiss I and the coarse-grained amphibolite on the northwest is irregular and unpredictable with the amphibolite probably intruding the gneiss. Contact relations between biotite gneiss II and hornblende gneiss II are conformable. However, an intrusive relation between the gneiss and the coarse-grained amphibolite on the southeast and the amphibolite with quartz megacrysts on the northwest is evident from the irregular nature of the contacts and occurrence of inclusions within the amphibolites.

Compositionally the gneisses differ (Table 4), but their occurrence as narrow bands suggest they could have all formed from sediments which were subsequently metamorphosed.

Hornblende Gneiss

Four hornblende gneiss bands underlie parts of the area. For the sake of simplicity and lack of sufficient evidence to correlate these bands with each other, they are discussed individually below. Each has been assigned a number, thus giving hornblende gneiss I, hornblende gneiss II, hornblende gneiss III and hornblende gneiss IV. All have been studied in some detail.

Hornblende Gneiss I. Hornblende gneiss I crops out south of the Mitchell Hill Gold Mine as a band at least 600 feet wide. Fresh outcrops are in a small stream which joins Mitchell Hill Creek 600 feet west of its intersection with South Fork, and in a road cut approximately two miles southeast of the Harris residence. The remaining outcrops are saprolite. The hornblende gneiss trends N70°E-N60°E and dips vertically. The gneiss is bordered on the southeast by a light-colored quartz-mica schist. The contact is not exposed, but appears to be regular and conformable. Contacts between purplish mica-quartz schist and biotite gneiss on the northwest appear to be conformable also, but the actual contact, again, is not observed.

The hornblende gneiss contains abundant coarse quartz-feldspar bands, 1-2 inches wide, which are parallel to the gneissic banding. Alteration along the margins of the bands has changed hornblende to biotite and chlorite for a distance of 1/4-1/2 inch from the band margins. Within the quartz-feldspar bands are scattered coarser prismatic hornblende grains.

Fresh exposures display epidote boudins within the hornblende gneiss. The boudins range from 1/2 inch to 2 feet in width and 2 inches to 3 feet in length, and their long dimensions parallel the foliation. They contain veins of white quartz, 1/4 to 1/2 inch wide, generally parallel to the long dimension, but some quartz veins randomly traverse the boudins. In one outcrop a vein, ptygmatically folded and offset, continues completely through a boudin. Some of the boudins have been bent into "U" shapes. The hornblende gneiss thickens and thins around the boudins. Contacts between gneiss and boudins are gradational.

Megascopically the rock is a light to dark green, fine- to medium-grained, crystalloblastic, hornblende-plagioclase gneiss. Its variable appearance is caused by the light green, fine-grained, dense zones (boudins) of epidote, which are irregularly distributed through the rock type. Microscopic data for the gneiss are given in Table 5.

Hornblende Gneiss II. Hornblende gneiss II enters the area 800 feet west of the contact between biotite gneiss II and the coarse-grained amphibolite along Georgia highway 44. The gneiss has a N53°E trend and continues through the area in this direction, outcropping in road cuts as a dark-red-brown clay containing a small percentage of quartz and in streams which traverse or parallel it.

It occurs as a four foot wide band surrounded by biotite gneiss in the road cut of Georgia highway 44. Further to the northeast, especially 300 feet west of the South Fork and Poss's Creek junction along Poss's Creek stream bed, and in the small stream flowing into Poss's Creek 1500 yards west of the South Fork and Poss's Creek join, the gneiss is present in at least four bands. These bands range in thickness from five feet to over 100 feet and are separated by 20 to 50 foot bands of biotite

TABLE 5

HORNBLENDE GNEISS I

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism	Approx. %
Hornblende	subhedral to anhedral	1/2 mm. in length	(—) 2V=82°	occasionally	Z ∧ C=20°	X=light greenish gray (5GY8/1) Y=light olive gray (5Y5/2) Z=grayish yellow green (5GY5/2) X < Z < Y	45-50
Andesine	anhedral	1/2 mm. in diam.	(+)	rarely albitic	16-18° ⊥ X		45 - 50
Epidote in Hbn. gneiss	patchy skeletal anhedral	1 mm.	(—) 2V=75—80°	none	parallel	slightly	5-8
Epidote in boudins	mosaics of subhedral to euhedral	3/4 mm. to 4 mm. across	(—) 2V=75—80°	none	parallel	slightly	95% of boudin
Quartz	irregular	1 mm.	uni.(+)				

Accessory: rutile, apatite, zircon, pyrite, magnetite and/or ilmenite.

Microscopically hornblende occurs in both the gneiss and boudins. Within the gneiss epidotization of hornblende is rare and only minute granular grains of epidote locally occur within and around hornblende. Minute rounded grains of rutile are commonly found along hornblende cleavages and partially surrounding hornblende. This phenomena is generally associated with the epidotization of hornblende. Very few hornblende grains are in the epidote boudins; those present are found either as inclusions in epidote or around the edges of epidote grains. The intermediate zone between the hornblende gneiss and the epidote zone contains prismatic grains of hornblende, but with epidote predominating over hornblende. Inclusions of quartz, plagioclase, apatite and a black opaque mineral frequently occur in the hornblende.

(Table 5 continued on next page.)

TABLE 5—(Continued)

Andesine is slightly saussuritized along the edges and along twinning planes in the hornblende gneiss. In the epidotic zones saussuritization is strong. Small inclusions of quartz are in the andesine. They are most noticeable in the lath-shaped plagioclase grains which are 2 to 4 mm. in length, but they also occur in grains less than 1 mm. Other inclusions are hornblende, rutile and minute prismatic grains of apatite.

The epidote is derived from alteration of hornblende and andesine. The majority is skeletal and patchy in appearance and contains sinuous inclusions of quartz. Epidote comprises 95 percent of the boudins and the remainder is quartz (Fig. 4 illustrates the texture of the boudins.), saussuritized andesine and epidotized hornblende.

Rutile is a secondary alteration product of hornblende. Within the centers of the rutile grains as well as along the partings, there is commonly a black opaque material, which is probably magnetite and/or ilmenite. Less commonly the rutile is partially surrounded by the opaque material.

All other accessories occur as inclusions in the major minerals.

The rocks exhibit a micro-banding or layering in some sections, the layering due to differences in grain size. In the coarser "layers" the andesine occurs as twinned laths 4 to 5 mm. across.

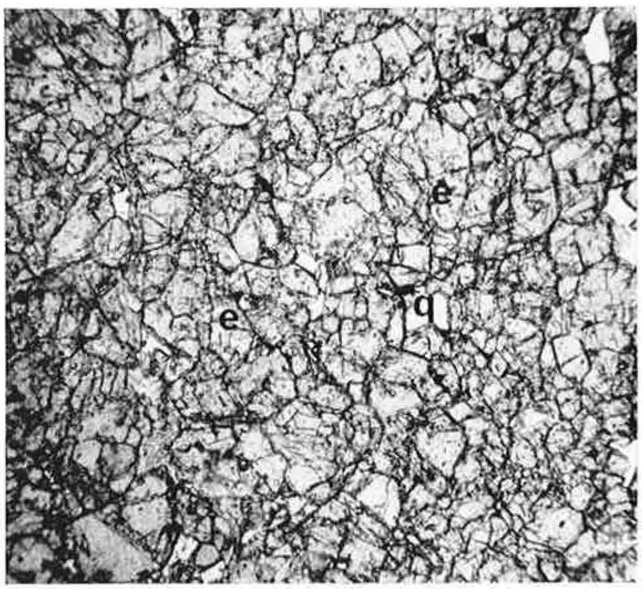

Figure 4. Photomicrograph of epidote boudin. Epidote (e) and quartz (q). 0.5 mile east of Mitchell Hill Gold Mine. Uncrossed nicols, X 20.

gneiss. Observations at three localities in partially weathered rock indicate that the inter-layering of the gneisses is conformable with the surrounding biotite gneiss.

Conspicuously present in these bands are epidote boudins. Northeast of South Fork, boudins of epidote from 1 inch to 6 inches in width and 2 inches to 1 foot in length are within the hornblende gneiss. Some of the boudins are not separated, but thicken and thin. The boudins of epidote are continuous along and across strike and increase to the northeast.

The bands of hornblende gneiss are indistinguishable megascopically and microscopically.

Present within hornblende gneiss II are quartz veins, muscovite-bearing pegmatites, diabase dikes and rhyolite dikes. The diabase dikes and rhyolite dikes always transect foliation, whereas, the quartz veins and muscovite pegmatites, and sometimes aplites are roughly parallel and perpendicular to the foliation.

The diabase dikes range in width from 2 feet to 30 feet, cut the hornblende gneiss with no visible evidence of alteration observed due to poorness of exposure.

Three rhyolite dikes are present in the gneiss but again field evidence is insufficient to ascertain any alteration effects.

Megascopically the hornblende gneiss is a grayish-black, fine- to medium-grained, crystalloblastic rock. The visible hornblende is fine prismatic grains aligned parallel, giving the rock its distinct foliation. Grayish plagioclase is the only other major constituent. It occurs as fine equant grains distributed in bands between paper-thin prismatic grains of hornblende.

Veinlets of epidote 1/16 mm. to 1/2 mm. wide traverse the rock in some specimens, not necessarily parallel to the foliation. Some transect earlier veinlets of epidote. Occasional fine quartz grains are present. Minute (less than 1 mm.) veinlets of quartz are found parallel to gneissic banding in some specimens.

Tables 6 and 7 give microscopic data and a point count analysis of hornblende gneiss II, respectively.

Hornblende Gneiss III. Exposed in the road cut west of Flint Lake and along a drainage ditch on the west side of the lake are hornblende gneiss III and a megacrystic amphibolite. The best outcrops of the two rocks are in the South Fork, both northeast and southwest of the road. The hornblende gneiss extends in a northeasterly direction in the area to at least the Old Copper Mine, where inadequate exposure prevents further delineation. The foliation strikes N53°E and dips vertically.

The hornblende gneiss contains epidote-quartz veins, 2 inches or less in width, and epidote boudins, 1 1/2 to 3 inches thick and 6 to 9 inches long. The latter are aligned parallel to the foliation.

The porphyritic amphibolite intrudes the hornblende gneiss. Intrusive relations include irregular contacts, inclusions of the gneiss in the amphibolite, and amphibolite truncating the epidote-quartz veins in the gneiss.

In the road cut west of Flint Lake are two sets of fractures: N40°E and N50°W. Both sets are

TABLE 6
HORNBLENDE GNEISS II

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Hornblende	prismatic	1 mm. or less	(−) 2V=78°		Z ∧ C = 17 - 19°	X=moderate greenish yellow (10Y7/4) Y=mod. olive brown (5Y4/4) Z=dusty yellow green (5GY5/2) Absorption X < Z < Y
Andesine	elongate anhedral	1/2 mm. diam.	(+) 2V=78°	albite pericline	16-18° ⊥ X	
Chlorite	feathery rosettes	1 mm.	(−)		parallel	α=grayish yellow (5Y8/4) γ=grayish yellow green (5GY7/2)
Epidote	anhedral; patchy	1/2 mm. in diam.	(−) 2V=78°		parallel	α= very pale orange (10YR8/2) β=pale greenish yellow (10Y8/2)

Accessory: Rutile, quartz, apatite and magnetite and/or ilmenite.

The prismatic grains of hornblende are aligned in planer units giving gneissic foliation. Most of the hornblende is unaltered, but parts of it have altered to epidote or to chlorite along the edges.

The majority of the andesine grains are unaltered, but a few have been saussuritized, yielding small grains of epidote. Inclusions of euhedral apatite and irregularly shaped quartz grains are present.

Most of the epidote forms from the alteration of hornblende to epidote and chlorite; this alteration is spotted throughout the sections. In places epidote and low birefringent rosettes of chlorite are associated.

Rutile, quartz, apatite and magnetite and/or ilmenite are scattered accessory minerals. Opaque minerals are associated with the alteration of hornblende to chlorite, epidote and rutile. Apatite commonly occurs as prismatic inclusions in andesine.

Table 7. Point-Count Analysis of Hornblende Gneisses in Volumetric Percent.

	Hornblende Gneiss I 109-74	Hornblende Gneiss III 225-1
Andesine	53.59	42.46
Hornblende	29.60	50.29
Epidote	6.91	1.97
Quartz	4.54	1.71
Sauss. Mica	.50	.32
Rutile & Apatite		3.15
Chlorite	1.57	
Red Iron Oxide	.07	
Opaque (magnetite, ilmenite & pyrite)	3.22	.10
	100.00	100.00

109-74 Fine-grained hornblende gneiss collected in Poss's Creek, 300 feet west of South Fork.

225-1 Fine-grained hornblende gneiss collected in road cut west of Flint Lake.

offset 2 to 3 inches. A quartz vein 1/2 inch wide is offset 4 inches in the N50°W direction.

Also present in the road cut is a mica pegmatite 2 to 4 inches wide trending N30°W, which intersects a dark-green, fine-grained, amphibolitic dike, 4 inches wide, which has a general trend of N45°E. The two dikes are in both gneiss and amphibolite. The mica pegmatite behaves in a regular manner, whereas, the amphibolite dike is sinuous in character. North of the intersection of the two, the amphibolite dike is offset in a N50-60°W direction for 4 feet in several places. The mica pegmatite cuts the amphibolite dike. Near the contact the amphibolitic dike is offset 1 to 2 inches in at least seven places by the N50°W fracture system. The mica pegmatite is not offset by this set. Nearby, the N40°E set offsets the N50°W set 2 inches in a northeast direction. The mica pegmatite is not offset by this fracture set.

The following sequence of events is based on the preceding observations:

1) Formation of the hornblende gneiss with

development of foliation, followed by probable intrusions of porphyritic amphibolite.

2) Emplacement of amphibolitic dikes.
3) Development of northwest fracture set, offsetting amphibolite dike in northwest direction.
4) Formation of northeast fracture set and offset of the northwest set.
5) Emplacement of the pegmatitic dike.

Megascopically the hornblende gneiss is a dark-gray to black, hard, heavy, fine- to medium-grained, foliated rock which commonly has minute epidote veinlets traversing it. Linear rows of pyrite are parallel to the foliation.

The epidote boudins are light green, hard and very fine-grained. They frequently have veins of clear quartz, 1/4 inch wide, parallel to the long direction of the boudin.

Optical and mineral descriptions of hornblende gneiss III are given in Table 8 and a model analysis in Table 7.

Hornblende Gneiss IV. Hornblende gneiss IV enters the area 600 feet southeast of the Anderson residence. The gneiss continues to the northeast, cropping out conspicuously in road cuts near the Battle residence and Randolph Church. It trends northeasterly with foliation dipping steeply to the southeast.

Conspicuously present are epidote-quartz veins and boudins of epidote, which contain numerous veins of quartz, within the hornblende gneiss. These boudins vary from 1/4 inch to 4 inches in width and 6 to 9 inches long. The boudins are from 2 inches to 2 feet apart and decrease in amount to the northeast. Some of the epidote zones are not boudinaged.

Near the Battle residence pink zeolite veins occur frequently in the epidotic zones.

The contacts between the gneiss and the amphibolite are irregular but regionally conformable. Contacts between the mica schist to the northwest and the gneiss appear conformable.

Megascopically the rock is a light-gray-green, fine-grained, crystalloblastic hornblende gneiss.

The microscopic description of the gneiss is given in Table 9.

The distribution, relation to surrounding rock, mineralogy and texture of the hornblende gneisses aid in deciphering their origin. All the gneisses occur as distinct bands which are conformable in trend to all the other foliated rocks in the area. None show any intrusive relationships. All have epidote boudins within them. Mineralogically all the gneisses are fine- to medium-grained and composed predominantly of basic minerals. Microscopically there is no evidence of large metasomatic changes, thus the assumption that very little chemical change has occurred during metamorphism seems valid. If this is the case, then the hornblende gneisses probably represent metamorphosed basaltic flows. The epidote boudins within the gneisses could represent the segregation of epidote into bands during metamorphism or could be original chemical differences within the basaltic rock.

Amphibolite

Coarse-Grained Amphibolite. The coarse-grained amphibolite, gabbro according to Hopkins (1914), first appears in the area along Georgia Highway

TABLE 8
HORNBLENDE GNEISS III

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Hornblende	subhedral; anhedral	1/2 mm.	(—) 2V = 82°		Z ∧ C = 20°	X=light greenish gray (5GY8/1) Y=light olive gray (5Y5/2) Z=grayish yellow green (5GY7/2) X < Z < Y
Andesine An 38-42*	anhedral	1/8-1/4 mm. laths	(+)	albite	18-22° ⊥ X	

Accessory: Quartz, rutile, apatite

Epidote from hornblende and andesine, saussuritized mica, magnetite/ilmenite, and pyrite are present in all sections.

The hornblende is altered very little. Occasional minute grains of epidote are found around the edges of the hornblende. Commonly granular masses of rutile are present around prismatic hornblende grains.

Saussuritization of andesine is slight. Minute prismatic grains of apatite are included in the andesine. Highly birefringent epidote grains less than 1/16 mm. in diameter are scattered sparsely through the gneiss.

Rounded granular grains and masses of rutile, 1/2 mm. in diameter, are mainly around the hornblende. The rutile frequently has a black opaque mass of magnetite and/or ilmenite in the center and around the edges of the granular masses.

Quartz is present as irregularly shaped grains, a fraction of a millimeter across, scattered throughout the rock.

TABLE 9

HORNBLENDE GNEISS IV

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism	Approx. %
Hornblende	splintery	3 mm. to 1 mm.	(−)	occasional	Z ∧ C = 15-19°	very light green	50-60
Andesine	irregular equant	1 mm. 1-2 mm.	(+)	rarely albitic	15-17° ⊥ X		40-50
Quartz	irregular	1/2 mm.	uni.(+)				5-10
Epidote	patchy; anhedral	1/2 mm.	(−)	occasional polysyn-thetic	parallel	none	frac. to 5

The pleochroism, though not measured, of hornblende in this rock is a lighter green than in the other hornblende bearing rocks. Epidotization along the cleavages and edges of the hornblende grains accompanied by rutile is common. This reaction is more prevalent in finer-grained specimens. Sieved inclusions of quartz are in the hornblende grains.

The equant grains of andesine have poikiloblastic inclusions of irregularly shaped quartz which composes 30 percent of the andesine grains. Prismatic hornblende and apatite are the remaining inclusions. The larger andesine grains have prismatic grains of hornblende forming a circular pattern around them. Bluish granular and needle-shaped clinozoisite occurs sparingly in the andesine grains.

Quartz commonly occurs as poikiloblastic inclusions, as minute veinlets traversing randomly through the gneiss and as scattered grains throughout the rock.

Epidote-clinozoisite are strewn throughout the rock. Commonly hornblende is surrounded by epidote and epidote is in turn surrounded by reddish-brown, opaque splotches of iron oxide. The boudins are predominantly epidote.

44, approximately 0.8 mile east of Bethesda Community Center. It continues through the area in a northeasterly direction and leaves the area at the Taliaferro-Greene County line, along Georgia Highway 44.

The best road outcrops are along Georgia Highway 44, 500 yards east of Bethesda Community Center. Here, and for 0.3 mile east, the rock is talcose and chloritic and contains scattered pyrite cubes, 2 to 3 mm. across. At outcrops east of Bethesda Community Center pod-shaped mica zones are scattered within the rock. They are aligned northeast-southwest. In places, notably on the old Asbury property and 300 feet east of Poss' dairy barn, the rock is extremely coarse grained and very talcose and chloritic (see Talc, Economic Geology section).

The outcrop 500 yards east of South Fork on Georgia Highway 44 displays chloritization and vermiculization of the amphibolite, which is crumbly, hummocky and riblike in this cut. Within the cut are numerous quartz-feldspar dikes, muscovite pegmatites, a rhyolite dike and a dike marked by graphic intergrowths of quartz and feldspar. The width of the dikes varies from less than one inch to 15 feet. The muscovite pegmatites have small "offshoots" into the amphibolite. The quartz-feldspar dikes alter the amphibolite marginally to brown, crenulated, vermiculitic schist 1 to 4 inches wide, depending upon the size of the dike. Not all the dikes are bounded by crenulated schist. Near the east end of the cut there are 1/2 inch veinlets of epidote-quartz. The white, very fine-grained, rhyolite dike is 12 feet wide and trends N55°W. Along its margins the amphibolite appears bleached.

The amphibolite contains two retrograde zones to the northeast. The first is 700 yards east of the Greene-Taliaferro County line along Georgia Highway 44. It is 100 feet wide, composed of a dark-gray, extremely coarse-grained, talcose-chloritic rock which has conspicuous 2 mm. cubes of pyrite. This zone is bounded on each side by coarse-grained amphibolite. Both rocks contain veins of quartz and muscovite pegmatites.

The second zone is 1200 yards due north of the Proctor residence. Boulders of a light gray-green, medium-grained, chloritic rock, 2 feet square or less, are found as float and protuberances on a hillside on the west side of a small stream. This rock has cubes of pyrite, 2 to 3 mm. in diameter, throughout. The float zone is approximately 300 feet wide and 400 feet long. Poor exposures elsewhere prevent tracing of the zone.

Fresh outcrops of the amphibolite are in the stream bed of Mitchell Hill Creek and north of Highway 44 along South Fork. Exposed in stream beds are randomly oriented veinlets of epidote, 1/8 mm. to 1 cm. wide, which are abundantly present and stand out in relief from the amphibolite. The epidote veinlets increase to the northeast. Veinlets two inches wide with clusters of euhedral epidote crystals are near North Fork. Veins of white quartz traverse through the epidote clusters.

Contact of the amphibolite with the biotite gneiss, on the northwest side, is generally parallel to the foliation of the biotite gneiss. The contacts in South Fork show an increase in grain size within the biotite gneiss, and a trace of foliation in the amphibolite, which is finer grained here than elsewhere. Contacts with the biotite gneiss to the southeast are irregular and not parallel to the regional trend.

Megascopically the fresh rock is a dark-green, heavy, crystalloblastic, medium- to coarse-grained amphibolite. The principal minerals are hornblende and plagioclase. The hornblende occurs as equidimensional to slightly elongate interlocking grains exceeding 6 mm. in length in the coarser rocks. In finer grained rocks the hornblende (1 to 2 mm. across) is more equidimensional and is the main constituent. The plagioclase is irregular in shape to slightly elongated, being 4 to 5 mm. across in the coarser rocks and 3/4 to 1 mm. across in the finer grained rocks; it is more lath-shaped in the finer grained rocks.

Pyrite and magnetite are the only other visible constituents in the rock and they occur as irregularly shaped splotches and minute octahedra which have reddish iron-oxide rims.

In the retrograded rocks, chlorite, hornblende and light-greenish epidotic minerals are the only visible constituents.

In weathered crumbly rocks, which are lighter in color, several constituents are visible. The light color is caused by the weathering of plagioclase which takes on a "waxy" appearance. Hornblende alteration to chlorite in fresh rock becomes clearly visible in slightly weathered rock. Greenish casts of epidote also become more visible, occurring within plagioclase and around the hornblende.

Microscopic and optical data are given in Table 10; modal analyses in Table 11.

In considering the origin of the amphibolite, its overall bulk chemical composition, relation to the surrounding rocks, and the shape and texture of the rock should be considered.

Modal analyses of four representative amphibolites show that hornblende and andesine are approximately equal in the rock (Table 11). Though the rock type varies in grain size throughout the area, this mineralogic relationship is fairly constant.

The contact relations were not observed with the surrounding rock types. The amphibolite does conform to the regional trend, but its irregular shape and size suggest that it originated as an intrusive. The overall coarse-grained nature of the rock, the absence of distinct foliation, the mineral assemblage and the predominance of lath-shaped plagioclase grains all suggest that the rock could have originally been a basic intrusive, probably a gabbro, that has been slightly metamorphosed. The presence of abundant epidote veins, the prev-

TABLE 10
COARSE-GRAINED AMPHIBOLITE

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Hornblende	irregular prismatic grains	1/8 to 6 mm.	(—) 2V= 78-84°	occasional	Z ∧ C = 17-25°	X=light greenish gray (5GY8/1) Y=light olive gray (5Y5/2) Z=grayish yellow green (5GY5/2) X<Z<Y
Andesine An 37-42*	equant to lath-shaped irregular grains	5 mm. 1 mm.	(+) 2V= 81-85°	albite pericline	22-27° ⊥ X	
Epidote	rarely euhedral; mostly skeletals & spindles	1 mm. or less	(—) 2V= 70-83°	polysynthetic	parallel	none
Clinozoisite	Euhedral rhombs; rarely skeletals & spindles	1 mm. or less	(+)	polysynthetic	slightly inclined	none
Chlorite	feathery rosettes	2 mm. or less	(—) low 2V		parallel	yellowish gray (5Y8/1) to light green (5G8/1)

Accessory: Saussurite mica, apatite, rutile, sphene, pyrite and other opaques.

(Table 10 continued on next page.)

Hornblende is evenly distributed throughout the rock. Epidotization of the hornblende is common with the products being epidote, biotite, chlorite, rutile and sphene. This alteration is along cleavages, fractures, grain boundaries and patches within the hornblende.

Commonly where hornblende has altered to chlorite, and epidote is not associated with the change, there is an increase in the amount of black opaque magnetite around the hornblende grains. The hornblende in some sections has numerous rodlike inclusions, with high relief, parallel to cleavage directions. In hornblende grains which have altered almost completely, these inclusions increase in size and begin to cluster into larger grains which can be identified as epidote and rutile. The biotite flakes are sparingly found along hornblende cleavages, and within the biotite flakes are flakes of feathery chlorite which parallel the biotite cleavage traces.

Euhedral apatite grains, 1 mm. in length, with opaque needlelike inclusions cross-cut the hornblende grains locally. Poikiloblastic inclusions of quartz, apatite, andesine, and sphene are commonly in the hornblende. Often there are inclusions of a fine-grained mineral with a halo.

Andesine is evenly distributed through the rock. Saussuritization of the andesine ranges up to 75 percent in some sections. Alteration is along cleavages, twin planes, edges, fractures and patches within the mineral, and is most readily visible in grains cut at oblique angles to cleavage and twinning planes. The products are fine-grained sericite and clinozoisite. In places the clinozoisite and epidote are zoned, whereas in other sections the bluish birefringent clinozoisite is confined to andesine and the highly birefringent epidote to hornblende. The sericite is in 1/16 mm. flakes surrounded by very fine sericite aggregates, Extensive saussuritization causes the andesine grains to assume a grayish-black cloudy appearance with marked undulose extinction.

The andesine laths commonly have minute needlelike inclusions which are both reddish to black and light green in polarized light. They are randomly distributed in andesine grains. Minute, rounded, liquid inclusions are also common, as are apatite and quartz inclusions. The larger apatite grains, 1 mm. in length, are commonly euhedral and parallel to andesine with lamellae. Quartz occurs as minute, irreguarly shaped inclusions and rarely as veinlets along albite twin planes, crossing from one lamellae to another.

Two epidote minerals, epidote and clinozoisite, are dispersed through the rock. They are commonly zoned. Epidote has formed from the epidotization of hornblende and saussuritization of andesine. It replaces hornblende along cleavage edges and also occurs as patches within hornblende. Commonly, epidote occurs around the edges, cleavages and twinning lamellae, and as patches within andesine grains. The majority of epidote is from andesine.

Euhedral rhombic-shaped epidote and spindle-shaped epidote are commonly surrounded by chlorite, with the spindles parallel to cleavage traces in the chlorite. In rare cases the euhedral epidote cuts the chlorite flakes in half. Commonly epidote is present within chlorite, which is in turn partly surrounded by hornblende grains. Associated grains of rutile are scattered around and within the epidote.

Veinlets of epidote, 1/8 mm. to 3/4 mm. in width, show differences depending upon the size of the veinlet. Where the smaller veinlets of epidote cross hornblende, the hornblende is readily altered to epidote. However, where the veinlets cross andesine, only small scattered grains of epidote are present. This suggests that plagioclase is not as susceptible to alteration along the epidote veinlets as is hornblende. Epidote reaction rims surrounded by chlorite and small rounded grains of rutile, are common. Secondary iron-oxide spots are present in epidote. Larger veinlets, 3/4 mm. or greater in width, have a thicker selvage of epidote and chlorite bordering the veinlet. Andesine laths, next to the veinlets, have embayments of epidote. The andesine twinning becomes patchy and absent near veinlets, and the twinning lamellae are slightly bent. Near the vein there is an increase in colorless mica. Most of the epidote grains have euhedral to subhedral shapes near the veinlets and also increase in grain size.

Chlorite commonly replaces hornblende and epidote with very little opaque matter associated with either transformation. The chlorite is typically found as feathery rosettes and as slender flakes either surrounding hornblende or occurring as patches in hornblende and as flakes parallel to hornblende cleavages. Epidote and rutile are found either as spindle-shaped inclusions parallel to the chlorite cleavage traces and edges or as epidote surrounding chlorite with rutile partially surrounding epidote.

Accessory apatite and zircon are scattered rarely throughout the section as inclusions in the major minerals. Opaque magnetite and/or ilmenite and pyrite are present in small amounts.

TABLE 11. POINT-COUNT ANALYSES OF COARSE-GRAINED AMPHIBOLITE EXPRESSED IN VOLUME PERCENT

	109-12	109-89	91-54	91-45
Andesine	42.98	32.58	40.49	32.08
Hornblende	42.64	47.43	40.68	38.58
Epidote and Clinozoisite	4.92	7.32	4.46	10.00
Sauss. Mica	.67	5.21	9.60	5.83
Chlorite	.20	6.21	2.79	10.56
Apatite	.87	.54	.74	.77
Rutile and Sphene	.73	.25	.56	
Quartz	1.60	.46	.68	2.12
Opaque	5.39			.06
	100.00	100.00	100.00	100.00

109-12 400 yards east of Bethesda Community Center along Georgia Highway 44.
109-89 3/4 mile northeast of Mitchell Hill Mine, along Mitchell Hill Creek.
91-54 3/4 mile northwest of where South Fork crosses Georgia Highway 44, along South Fork.
91-45 200 yards east of South Fork Bridge in stream 100 feet south of Georgia Highway 44.

alence of retrograde effects on the major minerals, along with the same retrograde effects on all surrounding rocks, the presence of the slightly metamorphosed rhyolite dikes and the alteration of the rock by the quartz-feldspar dikes all suggest that the rock has been slightly metamorphosed.

Amphibolite with Quartz Megacrysts. Actual outcrops of the amphibolite with quartz megacrysts are found 500 feet northeast of Durham's Lake and 2500 feet northwest of the Durham residence. Both outcrops are in former soil pits. A prominent north-northeast trending ridge, locally called "Rattlesnake Ridge", 1 mile east of the C. Durham residence, is underlain by this amphibolite.

Saprolite with abundant rounded megacrysts of quartz is present in most of the road cuts that pass over the amphibolite. Sawmill roads and many of the fields underlain by the rock are completely covered with 4 mm. to 1 cm. in diameter quartz megacrysts. The quartz megacrysts in the saprolite increase to the northeast. Nevertheless, certain problems cause difficulty in mapping this rock type.

The lack of adequate exposure of this rock type, along with the presence of bands of biotite gneiss whose extent was not decipherable within the amphibolite, and the irregular distribution of quartz megacrysts in the saprolite suggest that either more than one rock type underlies this portion of the area or that the rock has a variable mineral assemblage (probably a combination of both). Further division could be made on the basis that the amphibolite in places does not contain visible but microscopic quartz. The presence of characteristic euhedral hornblende, microcline, and the yellow pleochroic epidote are useful microscopic indicators.

Biotite mica occurs in the saprolite in varying amounts. This further complicates mapping of the saprolite. Typically mica is not found in amphibolites. Some saprolite outcrops contain an abundance of mica, whereas, at other places the saprolite contains only small amounts. The amount of biotite may vary in one saprolite outcrop.

Quartz is absent from the saprolite in road cuts along the dirt road that passes on the western side of the Bethesda Church. Outcrops of the amphibolite, 300 feet southeast of South Fork, are notably void of any visible quartz. Quartz is generally absent in the road cut 300 feet northwest of South Fork; however, there the saprolite has zones that contain quartz megacrysts.

Found cropping out in three places within the amphibolite is a grayish-white, coarse-grained, biotite-quartz-feldspar gneiss. Crumbly and weathered outcrops are found 1200 yards northwest of the M. Durham residence along the fork of a stream. Another outcrop is found 1 1/2 miles due east of the C. Durham residence along a sawmill road on C. Durham's property. The gneiss at this locality is composed of fine-grained quartz and white chalky feldspar separated by bands of biotite. The latter two localities are areas in which the saprolite contains abundant megacrysts of quartz.

Amphibolite in the road cuts between the Bethesda Church and the South Fork is altered. Here dark-green, coarse-grained crumbly rock is composed of biotite, vermiculite, hornblende and "waxy" plagioclase. The outcrops have abundant swarms of muscovite pegmatites throughout. The pegmatites range in size from less than 1 inch to 3 feet in width. Some are offshoots from larger pegmatites; others are pod-shaped and seemingly not connected. There is an increase in brown mica in small lenses and in parallel folia which trend N45°E. The outcrops contain greenish veins of quartz and epidote, 1/4 to 1 inch wide, which trend N75°W. There is no visible alteration around these veins.

Near the northern end of the road cut, 300 feet southeast of South Fork, a quartz-feldspar rock with euhedral hornblende grains, 4 to 6 mm. in diameter, is present. It contains rounded grains of quartz, 2 to 3 mm. in diameter and is relatively unaltered compared to the brownish micaceous rock type found elsewhere in the road cut.

The relation of the amphibolite to the biotite gneiss II to the southeast is uncertain, however, intrusions of amphibolite in the biotite gneiss are present 1200 yards south of the Old Copper Mine in small streams that run into South Fork. This suggests that the contact is somewhat irregular and possibly intrusive in nature. Inadequate exposures prevent the exact contact being located. To the northwest the contact between the hornblende gneiss and the amphibolite is somewhat irregular and not continuous. The contacts are based on the quartz content of the saprolite.

Megascopically the amphibolite is a light to dark green and is extremely variable in grain size and in mineral constituents. The amphibolite grain size ranges from fine to coarse grained.

Equant, euhedral grains of hornblende, less than 1 mm. to 8 mm. in diameter, are scattered through the rock in such a manner that they sometimes overlap. The large euhedral grains of hornblende are in a fine to medium-grained matrix of epidote, plagioclase and finer grained hornblende. In all specimens studied the hornblende occurs as euhedral grains as well as finer anhedral grains in the groundmass. In some outcrops the groundmass of the rock has been weathered and leached leaving the large equant hornblende grains etched in relief. This gives the rock a rough surface texture.

In some samples hornblende displays a type of "graded bedding". In these samples the euhedral hornblende grains are 1 to 2 mm. in size and increase in size up to 6 to 8 mm. toward a single row of grains, 1 cm. in diameter, followed by a gradual decrease in grain size.

Megacrysts of quartz (Fig. 5), 4 mm. to 1 cm. in diameter, glass clear, oblate, spherical and elongate in any one specimen, occur in the amphibolite. Euhedral equant hornblende is present in specimens with quartz megacrysts, but it is seemingly finer grained than where quartz is absent. Three prominent features can be observed about the megacrysts: in somewhat weathered specimens, 5 to 10 percent of the megacrysts turn to a "waxy" white clayey material; in weathered and fresh specimens, a brownish-green reaction rim

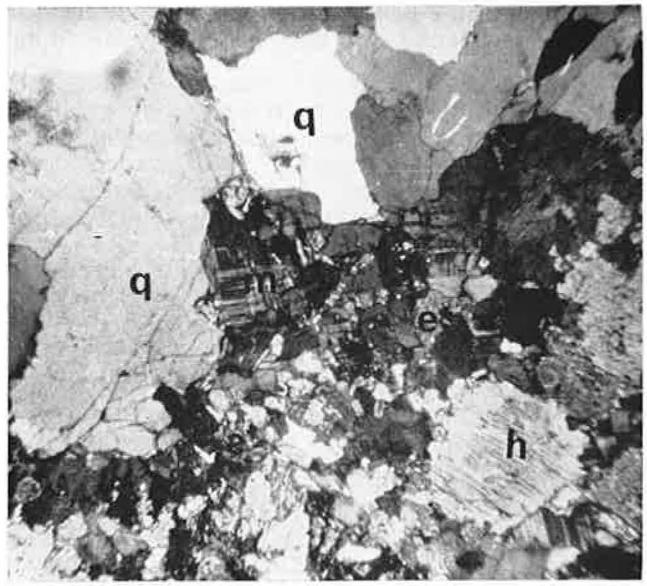

Figure 5. Microcline (m), hornblende (h), epidote (e), around periphery of quartz (q) megacryst. Crossed nicols, X 20.

TABLE 12

AMPHIBOLITE WITH QUARTZ MEGACRYSTS

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Hornblende	equant, euhedral & anhedral prismatic	6 to 8 mm. & 1 mm. or less	(—) 2V= 82-84°	commonly twinned	Z ∧ C = 17-19°	X=light greenish gray (5GY8/1) Y=light olive gray (5Y5/2) Z=grayish yellow green (5GY5/2) X<Z<Y
Andesine An 40-46*	prismatic, lath-shaped	1 mm. or less	(+) 2V=85°	albite & pericline	20-22° ⊥ X	
Epidote-clinozoisite	euhedral, subhedral, also patchy, skeletal	2 mm. or less	(—) (+)	polysynthetic commonly	parallel	none
Quartz	rounded to subrounded	4 mm.-1 cm. in diam.	uni. (+)			
Microcline	anhedral, equant to subequant	3/4 mm. to 1 mm.	biax. (—)	gridiron		

Accessories: sphene, rutile and apatite

(Table 12 continued on next page)

TABLE 12—(Continued)

Hornblende is present as large equant grains and as small splintery grains. The alteration of hornblende to epidote along cleavages, edges and fractures is prevalent. The small splintery grains of hornblende are preferentially altered more than are the larger more equant grains. Numerous rodlike epidote inclusions, 1/2 mm. in length, are found along the cleavages of the hornblende.

Andesine is generally almost completely saussuritized to clinozoisite and a very fine flaky sericite. This alteration is best developed along grain edges, cleavages and twin planes, and as patches within the andesine. Andesine is almost completely obliterated, assumes a dark cloudy appearance and shows marked undulose extinction. It is abundantly dusted with a very fine-grained opaque matter. A few andesine grains found near euhedral hornblende are little altered. This is also true of andesine around megacrysts of quartz. Colorless inclusions of various shapes are abundant within the andesine.

Both epidote and clinozoisite are abundant. Zoning prevails, but anomalous clinozoisite commonly is associated with andesine; whereas, epidote occurs with hornblende. A third variety of epidote (?) is present, always as an inclusion in hornblende. This epidote is pleochroic in shades of yellow and is surrounded by yellowish-green (5Y8/1) common epidote.

Quartz occurs as large megacrysts which are fractured into 12 to 18 irregular shaped, somewhat sutured grains that exhibit undulose extinction (Fig. 5). The boundaries of the quartz megacrysts are irregular and in contact with andesine, hornblende, microcline, and epidote. Microcline composes 10 to 15 percent of some megacrysts and is found either within or rimming the quartz megacrysts. Hornblende and andesine are rarely present as inclusions.

Fresh grains of microcline are present in all sections (Fig. 5). It comprises less than 10 percent of the rock by volume. It occurs predominantly around or within quartz megacrysts and rarely as inclusions in hornblende.

(epidote) is present around the megacrysts; the megacrysts are abundantly fractured. In some speciments the quartz megacrysts compose 25 to 30 percent of the rock and in others not more than one percent.

The finer grained groundmass contains visible saussuritized lath-shaped plagioclase. Epidote is a most conspicuous component.

Quartz-feldspar veinlets, 1/4 to 2 inches wide, randomly traverse the rock. Near the margins of these veinlets, hornblende has been incorporated into the veinlets with a notable increase in its grain size.

In some float specimens zoning is common. This is an alteration of euhedral hornblende zones with little quartz surrounded by zones of the same material with abundant quartz. Milky quartz veins, 1/4 to 1/2 inch wide, are found in both masses. The quartz veins cut the quartz megacrysts and distort them.

Microscopically the amphibolite is composed predominantly of quartz megacrysts, euhedral hornblende, fine-grained plagioclase, epidote and hornblende. An ill-defined relict diabase texture is present. Table 12 gives optical data and microscopic descriptions of the rock components.

Relict diabase texture, spotty non-pleochroic relicts in hornblende (possibly pyroxene) and the general overall chemical composition all indicate that this was a basic igneous rock. The field distribution though not well defined, and the presence of quartz megacrysts in a rock, which usually contains only accessory quartz, suggest that a basaltic rock with silica-filled vesicles could have been metamorphosed to produce the amphibolite. Alternately, the absence of foliation, presence of a relict diabase texture, coarse grain size, spotty non-pleochroic relicts in hornblende (possibly pyroxene) the presence of quartz and overall mineral composition, the "graded bedding" and zoning of the quartz (any large metamorphic effects would wipe these out), all could indicate that the rock was once a quartz gabbro which has undergone a slight metamorphism, producing an amphibolite. The latter seems more plausible.

Porphyritic Amphibolite. Exposed in the road cuts west of Flint Lake is a porphyritic amphibolite. Outcrops are also present in South Fork, both northeast and southwest of the road for a distance of 1/2 mile in each direction.

The amphibolite crops out in 10 to 15 foot wide irregular patches and as 1 to 2 foot wide stringers in contact with hornblende gneiss III. The contact between the two rocks is irregular and unpredictable. There are no clear-cut baking relations, but there is an apparent decrease in grain size of the megacrystic amphibolite near the contact of the two rocks. Inclusions of gneiss in the amphibolite and amphibolite truncating the epidote-quartz veins in the gneiss are further evidence of an intrusive relation. The amphibolite possesses no foliation.

Structural data concerning fracture sets, muscovite pegmatites and amphibolite dikes were previously discussed with hornblende gneiss III.

Contacts between the metapyroxenite and the porphyritic amphibolite are seemingly irregular though exposed only in the saprolite.

Megascopically the porphyritic amphibolite is a gray-black rock composed predominantly of hornblende and plagioclase in varying grain size. The plagioclase occurs as white laths 1 to 5 mm. in length, as well as euhedral grains, 3 to 4 mm. in diameter, in a hornblende-plagioclase-epidote matrix. Hornblende is present primarily as prismatic grains, 1 to 2 mm. in length, without parallel alignment. In some specimens are conspicuous biotite flakes, 5 mm. in diameter.

Veinlets of quartz, epidote and calcite (0.5 mm. or less in width) randomly traverse some specimens. Microscopic descriptions and modal analyses of the porphyritic amphibolite are given in Tables 13 and 14 respectively.

An igneous origin for the amphibolite is indicated by its intrusive relations. The rock could be derived from a basic intrusive.

Metapyroxenite

This rock crops out extensively in the spillway of Flint Lake and 500 feet east of the spillway. Outcrops are good along the road on the west side of the lake and south along the road to Georgia Highway 44. Prominent outcrops are found 500 feet north of the intersection toward Flint Lake.

TABLE 14. POINT-COUNT ANALYSES OF PORPHYRITIC AMPHIBOLITE EXPRESSED IN VOLUME PERCENT

	225-33	225-35
Hornblende	32.88	39.88
Andesine An 44-46*	41.01	36.49
Epidote-Clinozoisite	21.42	14.23
Sauss. Mica	1.76	.13
Quartz	.81	.13
Rutile, Apatite & Sphene	.34	1.23
Chlorite	1.62	7.78
Opaque (includes magnetite/ilmenite and pyrite)	.16	.13
	100.00	100.00

225-33 Collected 400 yards northeast of Flint Lake.
225-35 Collected 600 yards northeast of Flint Lake, in South Fork stream.

TABLE 13

PORPHYRITIC AMPHIBOLITE

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Hornblende	subhedral anhedral prismatic	2 mm.	(—) 2V= 80-82°	occasionally	Z ∧ C = 20-22°	X=light greenish gray (5GY8/1) Y=light olive gray (5Y5/2) Z=grayish yellow-green (5GY7/2) X < Z < Y
Andesine An 44-46*	euhedral megacrysts & anhedral grains	5 mm. in diam. 1 mm.	(—) 2V= 82-84°	albite & pericline	21-23° ⊥ X	
Epidote-Clinozoisite	elongate euhedral grains	1 mm.	(—) (+)		parallel slightly inclined	non-pleochoric
Chlorite	feathery	1 mm.	(—)		parallel	light green

Accessory: apatite, rutile, magnetite and/or ilmenite and pyrite.

Hornblende occurs as grains, irregular in shape, with ragged edges and as prismatic grains. Both are sieved. Chloritization and epidotization is evident along the edges of hornblende. Opaque grains of magnetite are closely associated with these reactions. Prismatic grains of hornblende thicken and thin around the megacrysts of andesine, suggesting that the prismatic grains may have been pushed apart by growing megacrysts.

All of the andesine is saussuritized along cleavages, twinning planes and around margins, and completely altered in places. In specimens containing megacrysts of andesine and finer grains of andesine in the matrix, the larger megacrysts are preferentially saussuritized. The products of saussuritization are euhedral elongate epidote and clinozoisite and very fine-grained sericite. Numerous minute needle inclusions are in the andesine.

Epidote and clinozoisite are associated 90 percent of the time with plagioclase and about 10 percent with hornblende.

The chlorite is associated with hornblende.

TABLE 15

METAPYROXENITE

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism	Approx %
Augite	euhedral to anhedral patchy grains	1 mm.	(+) 2V=55°	commonly	Z ∧ C = 43-45°	non-pleochroic	10-15
Hornblende	subhedral to anhedral,	1 1/2 cm. or less	(−)		Z ∧ C = 17-25°	light bluish green to olive green	60-65
Epidote-Clinozoisite	anhedral, patchy, skeletal	2 mm. or less	(−) (+)				20-25

Accessories: apatite, rutile and opaques.

Augite is commonly surrounded by fibrous hornblende or occurs as felted non-pleochroic patches within hornblende.

Hornblende occurs as feathery and fibrous grains, but mostly as patchy anhedral grains with ragged edges. Commonly it contains irregular shaped, high birefringent, deep-yellow pleochroic grains, 1 mm. or less in diameter, of epidote (piedmontite). There are also deep-yellow pleochroic patches scattered through some hornblende grains. The epidote grains commonly have black opaque patches within them. All are then surrounded by hornblende. Rodlike inclusions of a high birefringent mineral are common in hornblende. Commonly rounded "knobby" grains of rutile, 1/8 mm. across, occur within and around hornblende crystals.

Both epidote and clinozoisite occur within the metapyroxenite, but epidote predominates. The epidote rarely replaces hornblende, although it does occur along the cleavages and edges of hornblende.

In the outcrops around Flint Lake, the metapyroxenite contains abundant, randomly oriented, veinlets of quartz and feldspar, 1/2 inch or less in width. In the Flint Lake spillway the rock is intensely sheared and faulted, but possesses no distinct foliation. The lack of adequate exposures prevented an accurate delineation of the rock's extent.

The irregular contacts between the metapyroxenite and the hornblende gneiss and porphyritic amphibolite, which are northwest of the metapyroxenite, can be traced west of Flint Lake to the road. In the road cut at the intersection of Georgia Highway 44 and the road west of Flint Lake, a 2 X 3 foot outcrop of amphibolite is present. This rock is medium in grain size and does not show any visible retrograde effects as does the extremely coarse-grained metapyroxenite. Outcrops of this amphibolite can be found 1200 yards to the northeast. Whether this amphibolite is the same as the Flint Lake metapyroxenite is unknown.

Megascopically the metapyroxenite is a dark-green, heavy, extremely coarse-grained rock. It contains grains of hornblende, 1 cm. or less in diameter, separated by light-greenish medium-grained epidote.

Table 15 gives optical properties and mineral descriptions of this rock.

The presence of relict pyroxene, coarse-grained nature of the rock and the overall mineral assemblage indicate that this rock was an ultrabasic, intrusive, igneous rock. The absence of foliation indicates a younger age than the foliated rocks.

Granite

Granite saprolite exposures are present within the Woodville city limits and extending 3000 feet east of the city limits along the bituminous-surfaced road. No actual outcrops were observed, but a light-yellowish-red, medium- to coarse-grained, clayey saprolite containing fairly abundant amounts of quartz, gray-to-black fine mica and relict feldspar grains is present.

The saprolite changes in texture 3000 feet east of Woodville to a dark-red, fine-grained saprolite which is composed predominantly of clay with very small amounts of quartz and mica. The clayey saprolite exhibits relict boxwork or "honeycomb" structures along with a faint foliation which could be hornblende gneiss. Contact relations between the two rocks are obscure. The granite saprolite is continuous along the dirt road which trends north after it forks off from the bituminous road 3000 feet east of Woodville.

Granite is also found 300 feet west of Union Point city limits on Georgia Highway 44, along the north-flowing tributary of the South Fork. Outcrops in this stream are of a white-gray, medium- to coarse-grained, biotite-quartz-feldspar granite. The biotite is randomly scattered 1 to 2 mm. flakes in medium- to coarse-grained interlocking quartz and feldspar. Possible saprolite of the rock is found 600 yards east of Union Point city limits, 150 feet north of Georgia Highway 44 intersection with the bituminous-surfaced road. The saprolite is in contact with metapyroxenite saprolite.

Quartz Veins and Pegmatites

Quartz veins and muscovite pegmaties are abundant. The quartz veins are 1/2 foot wide to a fraction of an inch in width. The majority are either parallel or perpendicular to the foliation of the rocks. Some pinch out within 18 inches, others can be traced 25 to 30 feet. Commonly they are along fracture sets when they are parallel or perpendicular to the foliation of the rocks. The quartz veins commonly are offset along a northwest-southeast set of fractures from 1 inch to 1.5 feet.

Locally, where quartz veins traverse epidote boudins, there is a noticeable increase in the grain size of the epidote. In some boudins there are very coarse-grained clusters of epidote within the quartz veins.

Muscovite pegmatites, like the quartz veins, are abundant. Like the veins, they are, in the majority of cases, roughly parallel or perpendicular to the foliation of the surrounding rocks if the rocks have a foliation. The pegmatitic rocks vary in grain size from fine grained to extremely coarse grained, containing in addition to quartz, feldspar and muscovite, biotite, magnetite and epidote in varying amounts. One pegmatite, to be discussed in another section, is being mined. Some of the larger ones are found east of the Poss residence along Georgia Highway 44 in road cuts.

In the country rocks the medium- to coarse-grained muscovite pegmatites and aplites range in size from 6 inches to 2 feet in width. They are continuous in all outcrops observed. A slight thickening and thinning is commonly present. In dirt road cuts, 200 feet to the north of North Fork, there are numerous pegmatites. At this locality hornblende gneiss is the country rock and locally it has been biotitized and chloritized by the pegmatites. There are numerous grains of hornblende within the pegmatitic material. The pegmatitic bands are 1/4 to 3 inches wide and are parallel to the gneiss foliation. These pegmatitic bands alternate with brownish biotitized and chloritized hornblende bands which range from 1/2 to 6 inches wide. Parallel hornblende laths within the quartz-feldspar groundmass increase in grain size. The biotitized and chloritized bands of hornblende gneiss are around the margins of the muscovite bearing pegmatitic material and grade laterally into less altered hornblende gneiss.

The alteration of the surrounding rocks by the quartz veins and especially the pegmatites, indicates that they are younger than the enclosing rocks.

Rhyolite Dikes

Rhyolite dikes are found in four places. The most accessible one is in a road cut west of South Fork of the Little River along Georgia Highway 44. In this road cut the dike is 12 feet wide and trends N55°W in coarse-grained amphibolite. A second dike is 900 yards northeast of the Poss residence along Poss's Creek. It is 15-18 feet wide and trends N78°W.

Cropping out 1000 yards west of M. Durham's residence is a third rhyolite dike. It is 15+ feet wide and trends N70°W. It can be traced for 500 feet in a northwest direction to the stream crossing. Because of poor exposure the only relationships between the rhyolite and surrounding rock types that can be obtained are in the Georgia Highway 44 road cut west of South Fork of the Little River. Here, apparent bleaching (?) of the surrounding crumbly chlorite-vermiculite amphibolite is apparent for 1 1/2 feet from the contact. At the contact there is a change in color, grain size, and mineral type. Near the contact the crumbly saprolite is brownish, fine-grained and clayey, with abundant mica. Six to eight inches away from the contact there is a gradual change in color toward a greenish black and an increase in grain size. One and one-half feet away from the contact a greenish-black clayey saprolite with mica still exists, but relict hornblende grains can be seen as well as "waxy" feldspar grains.

Megascopically the rhyolite is whitish gray and porphyritic. It contains colorless, 1 to 3 mm., euhedral quartz grains with the characteristic beta-quartz shapes, and 1 to 3 mm., pinkish, euhedral microcline grains. Both are found in a fine groundmass composed of quartz, feldspar, biotite and muscovite. In places, notably west of M. Durham's residence, pyrite cubes, 1 mm. or less in diameter, are sparingly scattered through the rock.

The microscopic description and optical data of the rock is given in Table 16.

The presence of these slightly metamorphosed rhyolite dikes in rocks that have been metamorphosed as high as the amphibolite facies shows that they are younger than the surrounding rocks. The fine grain size and the presence of morphological beta quartz indicates that the dikes were formed near the surface and cooled rapidly. Possibly the dikes were "feeder" dikes to surface flows near the end of the metamorphism. Possibly they are even younger and are concurrent with evidence of vulcanism on the Coastal Plain.

Diabase Dikes

Eight previously unreported diabase dikes are in the area (see Plate 1). They cut all the other rocks. They range in width from 2 feet up to 50 feet. Some can be traced for 3 miles. Their trend ranges from N20°W to N40°W with variations in any one dike; the dip is mostly vertical. The width of the dikes varies by 2 to 5 feet from one outcrop to another. Best exposures are in road cuts that cross the dikes. The largest dike in the area is in front of the Proctor residence along Georgia Highway 44. The dike here has split into two parts. The larger dike 40 feet wide, the smaller apophysis is 2 feet wide and 10 to 15 feet west of the larger dike.

In the same outcrop the dike cuts a white, extremely coarse-grained pegmatite. The pegmatite is bent and contorted on both sides of the diabase. The majority of the dikes are partially weathered,

TABLE 16
RHYOLITE DIKES

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Comments
Microline	euhedral phenocryst	1 mm. to 3 mm.	(—) 2V = 78°	gridiron		N $_\beta$ = 1.5240
Quartz	bipyramidal(?) & anhedral	3 mm. in diam. to 1 mm.	uni. (+)			Characteristic beta-quartz morphology
Oligoclase An 29-33*	equant laths	2 mm. or less	(+) 2V = 82°	albite	10-13° ⊥ X	
Muscovite Biotite	shreds	1/2 mm. or less				

Part of the microcline occurs as euhedral aggregates 1 to 2mm. across which are abundantly fractured. The edges of the larger grains of microcline commonly have irregular embayments filled by the finer matrix minerals and in places there are apparent inclusions of the matrix minerals. The gridiron twinning of the microcline is very close, giving a felted or quilted appearance (Fig. 6). Some microcline grains display a vague zoning optically. Irregular, minute fractures filled by quartz are in a few microcline grains.

Quartz occurs as phenocrysts (Fig. 7), and a fine-grained matrix constituent. The phenocrysts of quartz, like the microcline, have embayments around the grain margins and the finer grained matrix minerals fill the embayments. This gives the quartz a resorbed appearance.

Oligoclase has abundant fine-grained inclusions of mica and is commonly dusted with irregular brown to black opaque masses.

Muscovite and biotite occur as shreds, 1/2 mm. across or less, and commonly interleaved. Black opaque material parallel to cleavage traces are common, as well as around the shreds of mica.

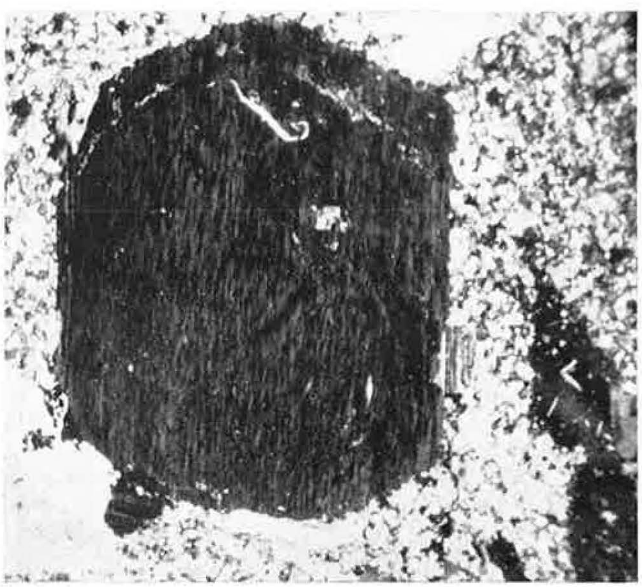

Figure 6. Euhedral microcline in rhyolite dike. Crossed nicols, X 20.

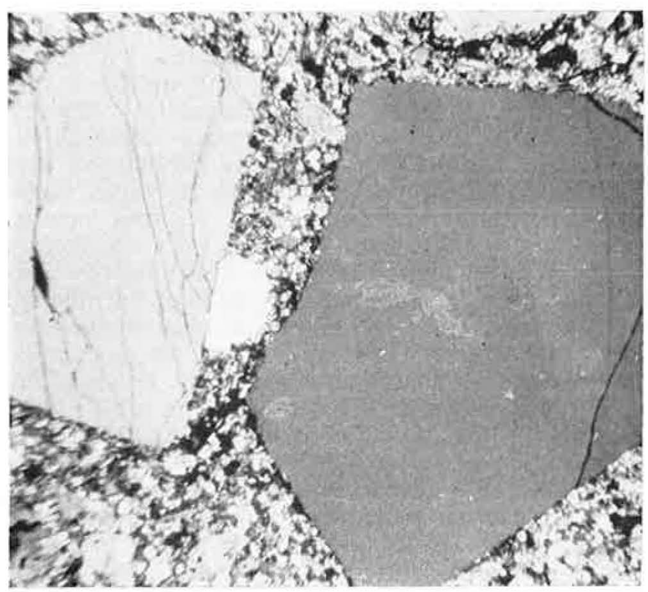

Figure 7. Euhedral quartz grain with characteristic beta-quartz shape. Crossed nicols, X 20.

forming spheroidal boulders in streams and road cuts and a dark red-brown clay with relict diabase fragments. Float of the diabase can be traced readily by its resistance to weathering and the spheroidal shape of the residual boulders.

Megascopically the diabase is a dark greenish-black, hard, heavy fine- to medium-grained rock with diabasic texture. Dark-gray microlites of plagioclase can be seen randomly oriented with the spaces between microlites filled by light-green grains of pyroxene.

Optical data and the microscopic description of the diabase is given in Table 17.

The origin and age of the diabase dikes of Georgia have been considered by Lester and Allen (1950). They related the origin to post-Paleozoic

TABLE 17
DIABASE DIKES

Mineral	Shape	Size	Optic Sign 2V	Twinning	Extinction	Pleochroism
Augite	anhedral	1 mm.	(+)		Z∧C= 48°	non-pleochroic pale green-brown
Labradorite An 62-69*	subhedral microlites	1 mm. length	(+) 2V = 84-86°	occasional	36-40° ⊥ X	
Olivine	anhedral	1 mm.				

Accessories: magnetite and pyrite.

Augite is unaltered.

Labradorite is relatively unaltered, but some grains are cloudy. The microlites are separated from each other by anhedral augite.

Colorless olivine grains are scattered through the rock. Some grains are half olivine and half augite, suggesting an augite replacement of olivine. Very fine, transparent, acicular grains with parallel extinction and index of refraction greater than balsam radiate from some olivine grains.

Minute scattered, subhedral to anhedral grains of magnetite and pyrite are disseminated sparingly. The magnetite is commonly found along the edges of the augite.

downwarps which opened fissures in the crystalline rocks. They suggested that the source was a relatively deep magmatic basin and that all the dikes in the Georgia Piedmont came from the same magma source.

Darton (1880), Roberts (1923) and others dated the dikes that occur from Virginia to Connecticut as Triassic in age on the basis of stratigraphic position. Lester and Allen concluded also that the unmetamorphosed character of the dikes indicate a post-Paleozoic age. Their wide distribution in rocks older than Cretaceous and absence from Cretaceous and younger rocks implies either a Triassic or Jurassic age.

STRUCTURE

A strong regional schistosity and foliation is impressed on most of the rocks. The trend is northeast-southwest with mostly vertical dips.

Fracture sets in the rocks are predominantly parallel and perpendicular to the foliation. They become more conspicuous to the northeast. Sets range from N28°E to N50°E and from N40°W to N62°W. The quartz veins, quartz-feldspar dikes and muscovite pegmatites are commonly parallel to one of these directions. Quartz-feldspar "dikes", muscovite pegmatites, and quartz veins which trend parallel to the gneissic banding are locally offset by the N50 to 62°W trending set of fractures. This offset is for 1 to 2.5 feet in the northwest-southeast direction. They are fractured along the N38 to 40° E direction but not offset. In places, notably in the road cut west of Flint Lake, the northeast fracture set offsets the northwest set 1 to 2 inches in the northeast direction.

Possible shear zones are at Flint Lake within the metapyroxenite and near the Mitchell Hill Gold Mine. The extent of these zones is not known.

Epidote boudins are abundant in all the hornblende gneisses in the area, whereas, the amphibolites do not exhibit any boudinaging, which would indicate that their history began after the most intense folding and deformation had subsided.

A glance at the attitude measurements plotted on Plate 1 reveals that there are two distinct trends present. One is N60 to 70°E and the other is N40 to 45°E, both with predominantly vertical dips. By projecting these two distinct attitude trends to the southwest, it becomes obvious that they would intersect at some point outside the area to the southwest.

Two obvious explanations are present. Either a regional reorientation of the stress fields has occurred or a deflection of the foliated rocks occurred when the emplacement of the gabbro took place. This gabbro is now the coarse-grained amphibolite described previously. The latter explanation seems more plausible. If this explanation is true, then this is further evidence that the amphibolite was originally an intrusive rock and post dates the metamorphism which impressed a foliation on the surrounding rocks.

GEOLOGIC HISTORY

Metamorphic History

The earliest decipherable episodes are the deposition of sedimentary and pyroclastic (?) rocks, intercalated with basaltic flows, followed by the intrusion of gabbro, granite and pyroxenite. The rocks were then metamorphosed to the amphibolite facies. Synchronous with the metamorphism was the development of the foliation, folding, boudinaging, and emplacement of quartz veins and pegmatites. The amphibolites, granite and metapyroxenite do not exhibit foliation and therefore, are probably subsequent to this first metamorphism.

A second period of less intense metamorphism caused cataclastic and retrograde effects on the hornblende, biotite and plagioclase. This retrograding effect increases to the northeast within the hornblende-bearing rocks. The biotite gneiss near Mitchell Hill Gold Mine and the hornblende gneiss west of Flint Lake show very little retrograde effects. Fracturing parallel and perpendicular to foliation, followed by offsetting of the quartz veins and pegmatites in a northwest-southeast direction also occurred during this period.

The zones of shearing between the biotite gneiss and mica-quartz schist east of Mitchell Hill Gold Mine and within the metapyroxenite took place during this period. The crinkling of primary foliation and the cataclastic textures present in both the gneiss and schist attest to this fact. Since the metapyroxenite exhibits no foliation and if it was emplaced subsequent to the first metamorphism, then the shearing occurred either concurrent with or in waning stages of the second metamorphism.

Postdating the pegmatites are the rhyolite dikes which alter and transect the regional trend of the surrounding rocks. The dikes display slight metamorphic effects, implying either their emplacement during the waning stages of the second metamorphism or later intrusion and subjection to a possible third metamorphism.

The diabase dikes are subsequent to the rhyolite dikes and pegmatites. Evidence for this includes the cutting of the pegmatites by the diabase dikes, chilling effects on country rock and no evidence of metamorphic effects. They cut across the regional trend.

Post-Crystallization Alteration

Epidotization. Epidotization affects hornblende along cleavages and grain edges. This process seems to increase to the northeast within the hornblende-bearing rocks. The epidotization is closely associated with veinlets of epidote and is commonly accompanied by flakes and rosettes of chlorite, grains of rutile and rarely biotite. Within the biotite-bearing rocks epidote commonly replaces biotite. Accompanying this change is muscovite.

Saussuritization. The plagioclase feldspars are commonly saussuritized along cleavages and margins. The principal products are epidote and clinozoisite and saussurite mica. The epidote minerals predominate. Common epidote is confined to hornblende and clinozoisite prevails within and around plagioclase. In some rocks the two epidotes are zoned. Epidote predominates in the zoning cases. This occurrence is notable to the northeast.

Significance of Post-Crystallization Alteration

The reactions and the products of the above cannot be listed as balanced chemical equations. Instead they were all occurring synchronously. Whether interaction and exchange of the chemical components between the different minerals occur depends upon the minerals involved and pressure, temperature and the availability of a transporting agent. An example in which little exchange occurred is the presence of epidote and clinozoisite in the same rock. These minerals represent a possible disequilibrium within the rock, since clinozoisite and epidote could easily combine and form an epidote intermediate in composition if certain physical and chemical conditions are met. In places, the conditions were met and exchange of chemical constituents did occur, and common epidote is the predominate epidotic mineral.

The formation of epidote, biotite, chlorite and talc from hornblende and the saussuritization of plagioclase represent volume changes. The changes could have been accomplished by the introduction of water.

Summary

The mineral assemblage of the hornblende and biotite gneisses and their distribution as continuous conformable bands suggest that they were originally interlayered sediments and basaltic flows. The irregular shape, basic mineral assemblages, and grain size of the amphibolites and metapyroxenite indicate they originated as intrusive rocks. The ubiquity of hornblende and its subhederal shape in the layered mafic rocks indicate that the rocks were metamorphosed to the amphibolite facies.

Cataclastic textures, crinkled foliation, offset of quartz veins and pegmatites, baking by pegmatites, and hydrothermal alteration suggest a second, less intense, metamorphism. The hydrothermal alteration is evidenced by breakdown of hornblende to epidote, chlorite and rutile. These products are found predominantly as patchy, irregular-shaped grains along cleavages and grain boundaries.

The slight metamorphic effects, present in an area metamorphosed to the amphibolite facies, and the cross-cutting relations connote the emplacement of the rhyolite dikes in waning stages of the second metamorphism or possibly during a third metamorphism.

The unmetamorphosed nature, cross-cutting relations, and chilling effects on bordering rocks indicate that the diabase dikes are subsequent to the rhyolite dikes and are post-metamorphic.

It is not certain whether the two periods of metamorphism can be separated by a long time interval or whether they are successive stages in one main event.

SAPROLITE MINERALOGY

Saprolite samples of the biotite gneisses, hornblende gneisses and amphibolites were collected to determine the mineral constitutents in weathered residuum of these rocks. Care was taken not to collect soil samples. The samples were analyzed for bulk mineral constituents and then for clay size fraction of the saprolite.

The biotite gneiss saprolite is a light-red, clayey, powdery type which contains very fine quartz and silvery-gray mica. X-ray diffraction patterns from 5 different localities showed that kaolinite, 10A° mica and an abundant amount of quartz are present. This substantiates the petrographic study in that abundant quartz and feldspar and mica are present in the thin sections. In the weathering processes the quartz and mica remain essentially the same, although the mica is slightly hydrated and decomposed. The feldspar decomposes to kaolinite.

The hornblende gneiss saprolite is generally a dark-red to brown, clayey type which contains minute grains of quartz. X-ray patterns show that the saprolite is mostly kaolinite with low intensity peaks of 10A° mica in some samples. A little quartz is in all samples.

The occurrence of kaolinite only and little or no montmorillonite suggests that both the plagioclase and hornblende decompose to kaolinite. The appearance of 10A° mica can be related to saussuritization which is observed in the petrographic work.

Typical saprolite of the amphibolites is a dark brown-red clay with a minor amount of quartz. A few samples contain grayish-white flakes of mica. X-ray diffraction patterns of bulk saprolite without mica show the clay to be kaolinite and minor quartz. Patterns of samples with mica show chlorite, vermiculite, kaolinite and quartz. This agrees with the petrographic study with one exception; vermiculite was not recognized in the thin sections.

ECONOMIC GEOLOGY

This section is a brief description of minerals and rocks which have been mined or prospected in the area.

Copper

Reynolds Prospect—This prospect is located on the Malcolm Durham property. The workings include an old shaft 100+ feet deep and four newly excavated trenches around the shaft. These trenches resulted from a drilling program carried out by the Tennessee Copper Company in 1960. According to Mr. Owen Kingman and Mr. Otis Gibson, geologists for the Tennessee Copper Company (personal communication), the methods used and the results obtained from the prospecting program are as follows:

1) A total of 2000 feet of superdip magnetic traverse was run over the prospect without locating an anomaly.
2) A sum of 4,650 feet of self-potential traverses was run over the prospect area without finding an anomaly.
3) Three holes were drilled on the property to a depth of 280 feet below the surface and 400 feet along strike. No mineralization of value was found.
4) The rock intersected by the drill holes consisted of amphibolite or hornblende gneiss with occasional alternate bands of granite gneiss. The general strike of the rock is N20°E with an approximate dip of 75°NW. A few grains of pyrite are observed in the core; calcite is common as a fracture filling.
5) Each hole intersected a fault which is estimated to strike N12°E.

Surficially the country rock is a dark green, extremely chloritized amphibolite or hornblende gneiss, abundantly peppered with pyrite cubes, and with abundant blue and green stains of the secondary copper minerals, malachite and azurite.

Gold

Mitchell Hill Gold Mine—Jones (1909) reported that gold had been mined in commercial quantities from here. It was exploited as early as 1852 and in 1875 by Mr. William Smith. Mr. Smith reportedly obtained nine to fifteen dollars worth of gold per week. Subsequent to Mr. Smith's operation, a mining company drove a tunnel several hundred feet into a ridge and ran several cross-drifts. There is no record of gold removed by this operation.

The auriferous rock is the quartzite described in a previous section. Jones reported an assay value of $1.24 per ton. Three assay samples collected by the writers yielded values of $1.75, $0.87 and $0.70 per ton. Although these values are below ore grade, the prospect warrants further investigation, especially east along the schist band which lies along strike of this auriferous locality.

Iron and Manganese

Deposits of iron and manganese are found in the southeastern part of the area (see Plate 1). The deposit is in a 3.5 to 4 foot zone of quartz, garnet and magnetite, striking N70°E and dipping 65° northwest, parallel to the schistosity of the mica-schist which encloses it.

A vertical shaft was sunk in 1916 or 1917 to a depth of 80 feet and drifts 30 and 28 feet were extended to the northeast and southwest respectively. Hard and soft ore 23 inches between a hanging wall of micaceous schist and a footwall of quartz, kaolin and a little mica, was present in the northeast drift (Hull, LaForge and Crane 1919).

Float of the zone can be traced 1/2 mile.

Kaolin

On the Hester property 0.3 mile east of the Poss residence a weathered pegmatite has been mined for kaolin. According to Veatch (1908), the kaolin formed from the weathering of a 15 to 20 foot wide northwest-southeast trending pegmatite. A shaft 40 feet deep was dug and two drifts run longitudinally for 50 feet. Part of the open pit workings of the pegmatite are now covered by road fill. No exposures of the weathered pegmatite were observed by the writers.

Pegmatite

Old Sunshine Mine—This property is presently owned by Mr. William Poss. The mine workings are in a cut about 150 feet long by 75 feet wide and 20 feet deep. The mine was originally opened about 1944 for scrap mica. Subsequent to 1944, the mining of feldspar was begun by B. P. Tuggle. The operation stopped about 1954, but Mr. W. F. Stuckey reopened the mine in 1963 to produce quartz.

The pegmatite has a 6 to 8 foot wide clear quartz core surrounded by feldspar with silvery-gray herringbone mica within fractures in the feldspar and in pockets scattered randomly through the rock. Clusters of spessartite garnet 4 to 8 inches wide are found randomly in the feldspathic portion of the pegmatite. Some of the garnets are golf-ball size. Also within the feldspar are brownish-black splotches of radioactive minerals. Furcron (1955), described these as occurring in veinlets and aggregations in the feldspar. A spectrographic analysis reported by Furcron shows niobium to be the major element with U, T, Y, Ca, Si, Fe and Ta as minor elements. An X-ray analysis by Vernon J. Hurst showed the radioactive mineral to be metamict.

Minable amounts of scrap mica and feldspar and quartz remain.

Talc

Talc is found in at least three places. The first locality is 0.5 mile west of Bethesda Community Center on the old Asbury property. Hopkins (1914) briefly described this occurrence. According to Mr. Hackney, a local resident in the area, this locality is called the "old lead prospect". The actual outcrop is on a small knoll 500 feet south of Georgia Highway 44, now completely covered by vegetation; however, numerous prospecting pits are visible. The country rock was an amphibolite or gabbro, which is now extremely talcose and chloritic in places. Two-inch veins of bladed talc are in some float boulders. To the southwest scattered float contains pyrite cubes 4 mm. in diameter.

Talcose amphibolite is also 0.5 mile east of the Poss residence in a pasture. This outcrop is on the south side of Georgia Highway 44. The outcrops are in a drainage ditch within the pasture, 500 yards east of the dairy barn. No vein talc was found.

Talcose outcrops of a basic rock are found 1200 yards southeast of Mitchell Hill Gold Mine in the southeast portion of Plate 1. These outcrops are 2 X 4 foot protuberances in a road cut. The rock is a chloritized-talcose basic rock similiar to the two noted above. No vein talc was found.

SUMMARY AND CONCLUSIONS

This investigation was undertaken to determine the geologic history of the Bethesda Church area. The study began by detailed field work and subsequently followed by a petrographic study. The nature of the various lithologies was first delineated and their distribution plotted to produce a geologic map. The rocks were then studied petrographically for mineralogy, texture, and alteration effects. Both the petrographic study and the distribution of the rocks were used in an attempt to outline the metamorphic history and origin of the rocks.

The saprolite mineralogy of the prevalent rock types was investigated, as was the economic mineral potential of the area.

The following conclusions result from this study:

1. The principal rock types in the Bethesda Church area are amphibolite and hornblende gneiss, with lesser amounts of biotite gneiss, schist, metapyroxenite, quartzite and granite. Three different types of amphibolite are present. One contains megacryst of quartz, possibly a metamorphosed vesicular basalt or quartz gabbro. Another is a coarse-grained variety, likely a metamorphosed gabbro. The third is a porphyritic variety. The hornblende and biotite gneisses likely represent originally intercalated basalt flows and graywacke sediments.

2. Two periods of metamorphism, separated by intrusive activity, are present. During the first period the rocks were metamorphosed to the amphibolite facies. The development of foliation and folding were concurrent with this period. This was followed by intrusions of gabbro and pyroxenite. Cataclastic effects accompanied by shearing and subsequent hydrothermal alteration occurred during the second period of metamorphism.

3. Slightly metamorphosed rhyolite dikes crosscut the regional trend and indicate a period of vulcanism subsequent to or during the waning stages of the latter metamorphism.

4. Late cross-cutting diabase dikes are unmetamorphosed and their chilled contact suggests that they are post-rhyolite.

5. The saprolite mineralogy varies distinctly and predictably for each rock type.

6. Possible economic deposits of feldspar, iron ore, mica, quartz and gold are present.

*Plagioclase compositions determined with the Fedorow-Nikitin type stereogram plot. See Emmons, R.C., 1943, The Universal Stage, Geological Society of America, Memoir 8. 205 pp.

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Plate 1

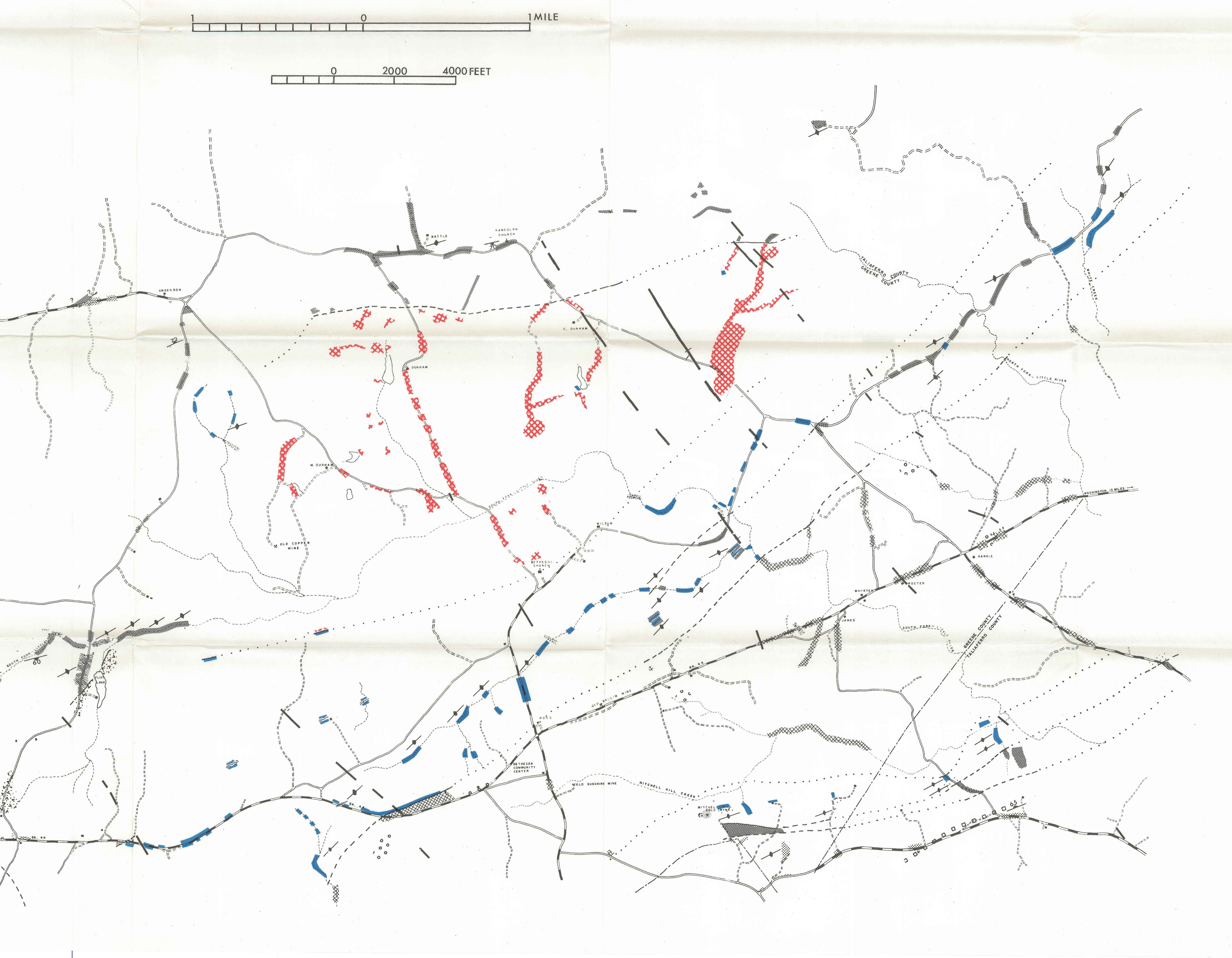
Information Circular 35
Georgia Department of
Mines, Mining, and Geology
A. S. Furcron, Director

GEOLOGIC MAP of the

BETHESDA CHURCH AREA GREENE COUNTY, GEORGIA

by

Jack H. Medlin
1967



EXPLANATION

- Quartz muscovite paragonite schist
- Mica quartz schist
- Quartzite
- Biotite gneiss
- Hornblende gneiss I, II, III, IV
- Coarse grained amphibolite
- Amphibolite with quartz megacrysts
- Porphyritic amphibolite
- Metapyroxenite
- Granite
- Ferruginous manganiferous zone
- Rhyolite dikes
- Zones of hydrothermal alteration
- Diabase dikes

SYMBOLS

- Inferred contacts
- Probable contacts
- Contacts
- Strike and dip of foliation
- Foliation vertical
- Old mines and prospects
- Sample for gold assay