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Reconnaissance geologic map of the Halifax, Scottsburg, Nathalie, and Conner Lake 7.5-minute quadrangles, Halifax and Charlotte Counties, Virginia

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INTRODUCTION

A 1:48,000-scale geologic map was made of the Halifax, Scottsburg, Nathalie, and Conner Lake 7.5-minute quadrangles, which are located in the Piedmont physiographic province, south-central Virginia. The map area lies mainly in Halifax County, and it includes a small area of Charlotte County on the north side of the Roanoke River. Topographic relief ranges from about 315 feet above sea level in the Roanoke River valley to 657 feet near Acorn, which is about 3 miles northwest of Nathalie. Principal drainages are the easterly flowing Roanoke River, the southeasterly flowing Banister River, and their tributaries.

The geologic mapping was a part of a larger project to map the geology of the South Boston 30 X 60-minute quadrangle at 1:100,000 scale. Generally the report area is underlain by highly weathered rocks with deep weathering profiles and sparse fresh rock exposure. Previously workers have reported on various aspects of the geology within and near the study area (Laney, 1917; King, 1955; Espenshade and Potter, 1960; Tobisch and Glover, 1969, 1971; Glover and Sinha, 1973; Butler, 1980; Henika, 1977, 1980; Marr, 1980; Kreisa, 1980; Gates and others, 1986; Baird, 1991; Horton and Zullo, 1991; Horton and others, 1993; Virginia Division of Mineral Resources, 1993; Hibbard, 1993; Nelson, 1993; Wortman and others, 1995; Peper and others, 1996; Bradley, 1996; Ozdogan and others, 1997; Baird and Glover, 1997).

Appreciation is expressed to the land owners for giving access to their properties within the report area. They were most helpful in many other ways as well. I want to thank William Henika of the Virginia Division of Mineral Resources and James Hibbard and Philip Bradley of North Carolina State University for a helpful field conference. I also wish to acknowledge the other geologists of the U.S. Geological Survey working in nearby areas, for their helpful discussions and field conferences.

GENERAL GEOLOGY

The crystalline rocks underlying the Nathalie area form parts of two regional belts. A small part of the map area (about five percent) in the southeast corner is underlain by mostly greenschist-facies metamorphosed volcanic and sedimentary rocks that are shown as part of the Carolina slate belt on the Geologic Map of Virginia (Virginia Division of Mineral Resources, 1993). Most of the rocks, however, are amphibolite-facies metamorphic rocks that form part of the Central Virginia Volcanic-Plutonic Belt as shown on the Geologic Map of Virginia. Different names have been used for this volcanic-plutonic rock belt, or for parts of it. King (1955) considered these rocks to be the northeast extension of a lithologic zone exposed in the Charlotte area, North Carolina, a rock belt that he named the Charlotte belt. Tobisch and Glover (1969, 1971) included rocks south of the study area as a part of the same belt. Butler (1980) named the northeast extension of the host gneisses of the Charlotte belt the Milton belt, which Horton and others (1989) renamed the Milton terrane. Later Horton and Zullo (1991) used the term Charlotte metamorphic belt to include mostly amphibolite-facies metamorphic rocks west of the Carolina slate belt in North Carolina and farther north in the Milton terrane. Baird (1991) endorsed the term Charlotte metamorphic belt as introduced by Horton and Zullo (1991) but not the concept of a distinct Milton terrane, interpreting these rocks and lower-grade rocks of the Carolina slate belt as parts of the same terrane, the Carolina terrane (Secor and others, 1983). The present geologic map of the Halifax, Scottsburg, Nathalie, and Conner Lake quadrangles uses the terms Charlotte metamorphic belt and Carolina slate belt for regional zones distinguished on the basis of metamorphism independent of stratigraphy.

Except for the sedimentary rocks forming the Triassic Scottsburg and Randolph basins and some Jurassic diabase dikes, metamorphic rocks underlie the map area. The protoliths for the rocks underlying the report area are primarily volcanic and volcaniclastic with lesser amounts of sedimentary and intrusive rocks. Earlier workers in nearby areas have assigned the mapped rock units of the Charlotte metamorphic belt to either a Precambrian (Henika, 1977; Kreisa, 1980; Baird, 1991) or a Precambrian-Cambrian age (Tobisch and Glover, 1971). Glover and others (1971) reported a 740 Ma age for biotite gneiss just west of South Boston. However, Wortman and others (1995) analyzed a biotite gneiss collected from the same general area that contained a variety of zircon populations with wide ranging ages. They suggested that the gneiss is either a migmatitic orthogneiss with an Alleghanian component or is a paragneiss containing zircons of different ages. Wortman and others (1995) reported that a hornblende-biotite gneiss of the Milton terrane in the Charlotte metamorphic belt has an upper intercept zircon age of 618 Ma and a lower intercept age of 323 Ma. Bradley (1996) suggested that the 618 Ma date represents the original crystallization of the zircon in the gneiss and that the 323 Ma age date reflects a crystallization age of granitic interlayers.

Within the map area, radiometric dates for the rocks exposed in the Charlotte metamorphic belt have not been made. Some of the mapped units have been interpreted to correlate with rock units of probable Precambrian age by Baird (1991), Henika (1977), Kriesa (1980), and Tobisch and Glover (1969). Bradley (1996) indicated that biotite gneiss of the Milton terrane (Charlotte metamorphic belt) is no younger than 323 Ma.

The Chopawamsic Formation (felsic, intermediate and mafic meavolcanic and metasedimentary rocks) of Early Cambrian (?) age (Southwick and others, 1971; Conley 1978; Marr 1980; Higgins and others 1971; Pavlides, 1981), underlies parts of north-central Virginia, and may correlate with mapped units (ugx, hbf, and bmgr) underlying the study area. However this correlation is tenuous due to unmapped intervening areas.

Farther to the southwest in the Charlotte metamorphic belt, Henika (1977) mapped the geology of four 7.5-minute quadrangles near Danville, Va., which are underlain by metamorphosed sedimentary and volcanic rocks that he interpreted to be of Precambrian age. These rocks, which range from lower greenschist to upper amphibolite facies (Henika, 1977) probably correlate with similar upper amphibolite-facies rocks underlying this area. Kreisa (1980) mapped gneisses and schists that he considered to be Precambrian in age in the adjoining Omega 7.5-minute quadrangle south of the report area.

ROCKS UNDERLYING REPORT AREA

Much of the crystalline rock throughout the area has been chemically weathered to a deep saprolite. Where the saprolitization has been intense and the weathering profile is deep, it is difficult to distinguish some rock types. A variety of metamorphosed felsic to mafic volcanic and volcaniclastic rocks, and sedimentary and intrusive rocks, comprise the protoliths of the crystalline rocks underlying the study area. Rocks of the Charlotte metamorphic belt have been polydeformed and mostly are metamorphosed to amphibolite facies gneisses and schists. They include variably layered, medium-grained, quartzofeldspathic biotite gneiss; locally porphyroblastic, fine-grained biotite quartz feldspar gneiss that is locally a well-layered metagraywacke; hornblende and hornblende-biotite gneiss; amphibolite; mica gneiss; mica schist; biotite schist; quartz-muscovite schist; and granite to granodiorite gneiss. Small unmapped pegmatites and quartz veins intrude the mapped units, and variably sized quartzofeldspathic segregations are widespread.

Rocks from the Carolina slate belt appear to be less intensely deformed and have been metamorphosed to greenschist facies. They include highly weathered light-gray, fine-grained sericite schist locally containing rounded feldspar and (or) quartz grains, and a pinkish gray, fine-grained rhyolitic crystal-lithic metatuff. These metavolcanic rock units comprise the Hyco Formation of Late Proterozoic age (Laney, 1917; Glover and others, 1971; Kreisa, 1980; and Peper and others, 1996), which is flanked in the southeast corner of the map by metasedimentary rocks of the Aaron Formation.

Stratigraphy of rocks in the Charlotte metamorphic belt

The stratigraphic relationships among rock units are uncertain. The crystalline rocks have been polydeformed and regionally metamorphosed. The combination of deformation and recrystallization associated with metamorphism has destroyed or obscured primary features such as graded and cross bedding. The rocks have also been isoclinally folded. Locally, folds are recumbent and layering has been transposed by intense deformation. Therefore, the relative ages of the layered units is unknown.

Interfingering of the different metamorphic units is common at scales that could not be resolved in reconnaissance mapping. Consequently, each mapped unit is actually a distinct rock assemblage that is characterized by one dominant rock type but which also includes varying proportions of other rocks. Almost all mapped units contain layers of biotite-quartz-feldspar gneiss along with small unmapped pegmatites, quartz veins, and variably sized quartzofeldspathic segregations.

Three mapped units, those labeled bmgr, ugx, and hbf (see map and accompanying rock descriptions), form the dominant rock assemblages underlying the study area. The rock assemblage bmgr is more widespread than are other map units in the southern part of the map area, and is characterized by biotite gneiss, mica gneiss, and mica schist. These rocks are commonly interlayered with each other and with the other assemblages in the map unit. The mica gneisses and schists have a higher alumina content than the other assemblages and may represent original pelitic layers in a sedimentary sequence. Some of these mica gneisses and schists correlate with rocks that Baird (1991) mapped as pelitic schists. These rocks also correlate with a biotite gneiss of Precambrian age mapped by Kreisa (1980) near South Boston. Kreisa considered that part of the biotite gneiss had a sedimentary origin.

The rock assemblage ugx underlies most of the central and northwestern parts of the study area. The most abundant rock type in this unit is very fine-grained, light gray, biotite-feldspar-quartz gneiss that ultimately weathers to a white to cream colored friable sandy soil. Commonly this gneiss is mixed with an undivided fine-to medium-grained granite gneiss. The protolith for the biotite-feldspar-quartz gneiss is believed to be a felsic volcanic tuff or flow.

Hornblende-biotite gneiss (hbf) is a prominent rock type in the rock assemblage underlying a large part of the Conner Lake quadrangle in the northeastern quadrant of the report area; a smaller area of lithologically similar rocks is also present along the central part of the southern map boundary. These rocks are probably Precambrian in age. Bradley (1996) cited preliminary zircon age data on a similar hornblende-biotite gneiss sampled by Wortman and others (1996) where zircons have an upper intercept age of 618 Ma which is interpreted to represent the crystallization age of the mafic gneiss.

Problematic assignment of Charlotte metamorphic belt and Carolina slate belt rocks

The southernmost hornblende-biotite gneiss unit (hbf) continues along strike to the south in the adjoining Omega quadrangle where Kreisa (1980) mapped it as gneiss (hbgn). He considered these rocks to be of Precambrian age. Kreisa also included amphibolite, layered biotite gneiss, and some mica gneisses in his hgbn unit. Kreisa showed the gneiss to be in fault contact to the southeast with the Hyco Formation of the Carolina slate belt.

Bradley (1996), who recently mapped the same hornblende-biotite gneiss as his Zgn unit, had a different interpretation and considered it to be a higher grade equivalent of rocks in the Carolina slate belt. He cited Wortman and others (1996), who indicated that Nd isotopic content from a sample of high grade hbf collected in the Carolina metamorphic belt near South Boston, is more like that of the rocks of the Carolina slate belt, and probably has a similar crustal history. Bradley (1996) interpreted the hbf to be thrust over the bmgr map unit of this report, which is in the Charlotte metamorphic belt. However, Bradley's map also shows several areas where the bmgr of the lower plate appears to have interfingering stratigraphic contacts with the hbf of the upper plate, suggesting that bmgr and hbf are not tectonically juxtaposed.

Although the two mapped hbf units are separated, they are lithologically similar, and both are in the amphibolite facies of regional metamorphism. Except for locally in exposures near the fault between the Charlotte metamorphic belt and the Carolina slate belt, they are at greenschist facies. Both hbf units have similar rock assemblages, including biotite schist, biotite gneiss, felsic gneiss, amphibolite, granitic pods and lenses, and quartzofeldspathic segregations. Isolated lenses of hbf also are present in the bmgr map unit. In similar fashion, isolated lenses and layers of the bmgr map unit are also present within the hbf map unit. Those relationships are interpreted here as evidence that the units hbf and bmgr form part of a stratigraphic assemblage within the Charlotte metamorphic belt.

As shown on the map, the hbf unit is in fault contact with the Hyco Formation of the Carolina slate belt. Rocks on both sides of this fault, the Hyco shear zone, are locally sheared and possibly tectonically mixed, a factor that should be considered in sampling this zone for additional Nd isotopic studies. Further structural, isotopic, and geochemical studies are needed to fully understand the geologic relationships in this area.

Rocks of the Carolina slate belt

The Hyco Formation in the southeastern part of the map was originally named by Laney (1917) for exposures along the Hyco River south of this area. It was later mapped adjacent to this study area on the south by Kreisa (1980) in the Omega quadrangle. Kreisa indicated that the Hyco is largely made up of metamorphosed crystal tuffs and crystal-lithic tuffs. A light-gray sericitic schist, with small feldspar and quartz augen, and a light-pinkish-gray, fine-grained felsic gneiss comprise the Hyco in the study area. Zircons collected near the top of the formation have a Pb/Pb age of 620 my (Glover and others, 1971).

Slate and interbedded conglomerate of the lower member of the Aaron Formation are inferred to underlie the southeast corner of map based on projections from exposures outsided the map area (Kreisa, 1980, and J. D. Peper, written commun. and unpublished mapping, 1997). However, exposures of these rocks have not been observed within the map area, and their contacts are shown by short dashed lines on the map.

MESOZOIC ROCKS

Parts of two small Triassic basins, the Randolph and Scottsburg basins, are present in the southeastern part of the map. These basins are underlain by poorly exposed, highly weathered shale, siltstone, sandstone, arkose, and conglomerate that is undivided on the map. Some relatively thin Jurassic diabase dikes intrude the older crystalline rocks of the Charlotte metamorphic belt.

QUARTERNARY SURFICIAL DEPOSITS

The Quarternary surficial deposits consist of a thin veneer of unconsolidated coarse to fine-textured bouldery and cobbly gravel, sand, and clay that form alluvial deposits (Qal) that occupy valleys and streams. These deposits are present in all stream valleys, but only those occupying the larger valleys are shown on the map. The remnants of some terraces of coarse sand and gravel and conglomerates irregularly blanket the crystalline rocks on the north side of the Roanoke River. Colluvium, which is not mapped separately, is commonly mixed with alluvium along steep valleys and is widespread along steep hillsides.

DEFORMATION

Faults

An early Mesozoic fault separates the Triassic rocks of the Scottsburg basin and the Hyco Formation from amphibolite-facies metamorphic rocks of the Charlotte metamorphic belt. This Mesozoic fault lies along the northern extension of the late Paleozoic Hyco shear zone as defined by Hibbard (1993). This fault, which has not been directly observed within the report area, has been extended into the study area from the adjoining Omega quadrangle where it was mapped by Kreisa (1980). Some parts of the Hyco Formation near the fault have been deformed to mylonite and locally have faint shear bands. Similar ductile fabrics are more sparsely distributed over wide areas of the Charlotte metamorphic belt. Where shear fabrics are observed, the movement sense is east over west.

Elsewhere in the pre-Triassic rocks, some exposures show small faults with displacements measured in centimeters. These faults, however, do not appear to be related to any major structure, and other major faults have not been observed.

Planar structures

Foliation is well developed in the pre-Triassic crystalline rocks. Where layering and foliation are both present, they appear to be parallel.

The foliation is somewhat wavy and is defined by thin, alternating, discontinuous felsic aggregates and biotite and chlorite streaks. Felsic folia bands, streaks, layers, and (or) lenses are variable, ranging from several mm to as much as 2 cm or more in thickness. The biotite-chlorite zones or streaks are more discontinuous, in places wisp-like, much thinner, and commonly range from 1-2 mm in thickness. The felsic layers consist principally of bluish-gray quartz and feldspar, which is mostly microcline together with some plagioclase. Prominent augen of microcline and (or) quartz and feldspar aggregates are present in some gneisses. In places, a faint later cleavage displaces the schistosity in pelitic rocks.

A compositional layering is present in some garnet-bearing biotite felsic gneisses but is not easily observed elsewhere. As far as could be determined, the compositional layering in these gneisses is parallel to foliation. Except for some small folded areas in a layered biotite felsic gneiss, almost all layering strikes north to northeast and dips gently.

Some widely separated saprolite exposures along both natural and artificial cuts show that the rocks are polydeformed, recumbently folded, and the recumbent fold limbs were subsequently gently folded around east to northeasterly trending axes. In these folded exposures, the layering and foliation surfaces are parallel. The map shows that the foliation and layering in the Charlotte metamorphic belt characteristically dip gently over relatively large areas. In the northern part of the map area, the foliation attitudes and the regional distribution of map units help define a large overturned fold whose axial trace strikes east-northeast.

If the style of multiple folding of relatively small overturned folds observed in outcrop reflects the regional structure, then the fold attitudes with the relatively gentle dips probably represent second or third generation folds superposed onto the limbs of a large recumbent fold. This style of folding for this general area has been previously described (Baird, 1991; Tobisch and Glover, 1971). Tobisch and Glover (1971) reported that a large recumbent nappe forms a major structure in the Charlotte belt south of the study area.

Some of the rocks have been deformed by shearing, and they characteristically display a planar fabric (foliation/cleavage) that is locally high in chlorite and opaque minerals. Other deformed fabrics include mylonite, blastomylonite, and protomylonite. Some fractured feldspar grains are present within unfractured mylonite zones and suggest simultaneous ductile and brittle deformation of the rocks. Where porphyroclasts are common, the shear foliation anastomoses around the clasts; and locally shear bands are present.

METAMORPHISM

The crystalline rocks underlying the Charlotte metamorphic belt were mostly prograded to the sillimanite and kyanite zones of the amphibolite facies during regional metamorphism. However, sillimanite is commonly observed in rocks that also contain layers or veinlets of metamorphosed granitic rock, suggesting that some sillimanite formed as a result of the high temperatures related to emplacement of the granitic rocks.

The rocks of the Carolina slate belt have been prograded to the greenschist facies. Because of poor exposures in the border area between the Carolina slate belt and the Charlotte metamorphic belt, it is uncertain if there is a continuous metamorphic gradient or a break along the tectonic border.

Glover and others (1983) and Baird and Glover (1997) indicated that the rocks underlying the Charlotte metamorphic belt and the Carolina slate belt were regionally metamorphosed during the Taconic orogeny (450-435 Ma). Later Kunk and others (1995) reported that a 313 Ma argon-argon cooling age for hornblende near the eastern border of the Charlotte metamorphic belt and a 323 Ma cooling age for hornblende collected near the center of the belt was evidence for prograde metamorphism during the Alleghanian deformation. Ozdogan and others (1997) offered additional evidence that these rocks were deformed and metamorphosed during the Alleghanian orogeny. Biotite formed in axial-plane schistosity surfaces during a late stage of minor folding in the Charlotte metamorphic belt. This fabric is not extensively developed and is believed to have formed during the Alleghanian prograde event after the temperature peak but while the temperatures were high enough for biotite to form. Kunk and others (1995) reported that rocks of the Carolina slate belt also contain Alleghanian white mica, but that igneous hornblende from the Carolina slate belt dated at 586 Ma shows no evidence for an Acadian or Taconic event based upon argon geochronology.

ECONOMIC GEOLOGY

At the time of the field work, there were no active quarries in operation within the study area. Immediately south of the map area, however, east of South Boston, the Vulcan Materials

Company extracts crushed stone from layered hornblende-biotite gneiss. These rocks extend into the study area and could be a source of crushed stone. In addition, amphibolite gneiss, granitic gneiss, and felsic gneiss are potential sources of crushed stone.

Sand and (or) gravel for use as construction material might be obtained from wide alluvial covered areas in the Banister River and Roanoke River valleys. In addition, borrow pits could be developed in granite gneiss and felsic gneiss saprolite.

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EXPLANATION

Description of Map Units

Quaternary Deposits

Qal Unconsolidated, coarse to fine-textured, bouldery and cobbly gravel, sand, and clay; occupies valleys and streams. Only the largest and thickest deposits are shown

Qalt Coarse, cobbly and bouldery terrace gravels present at several places along north side of Roanoke River

Mesozoic Rocks

Jd, Diabase- Present as dikes that have rims with a diabasic texture and gabbroic interiors. Dikes are massive, dark gray to black, mostly fine-grained but thicker dikes are medium-grained. Principal minerals are labradorite and pigeonite with a sub-ophitic texture. Because of the paucity of exposures and the deep weathering, dike widths could not be determined and could not be satisfactorily shown at the map scale. These diabase dikes intrude the crystalline rock units

Trs Undivided clastic rocks of the Randolf and Scottsburg Triassic basins include highly weathered arkosic sandstone, siltstone, shale, and conglomerate

Metamorphosed Igneous Rocks

gr Biotite granite gneiss, fine-to medium-grained, medium gray, mostly granoblastic but is locally faintly lepidoblastic and in places sheared principally contains biotite, quartz, and feldspar, with minor chlorite, epidote, and magnetite

Lined patterns (see map symbols) may indicate the presence of different kinds of granitic bodies in the bedrock otherwise concealed by thick saprolite cover .

Metamorphosed Volcanic and Sedimentary Rocks

Aaron Formation (Late Proterozoic)

Za Light-gray to purple phyllite, slate, and fine grained metasandstone (Kreisa, 1980)

Zac Interbedded sandy metaconglomerate, metasandstone and slate (Kreisa, 1980)

Zh Hyco Formation (Late Proterozoic)-Fissile felsic metatuff, very fine grained, schistose, faintly laminated feldspar-quartz-sericite phyllitic schist. Metatuff contains some tiny magnetite grains, isolated lithic clasts, weathers to a pale tan. Very fine-grained, faintly foliated crystal felsic metatuff contains feldspar and quartz, and minor sericite and a trace of biotite; also contains some larger quartz and feldspar crystals within the finer-grained matrix. Locally contains faint bands that may represent fabrics associated with welded tuffs; weathers to a pale pink tan

Charlotte metamorphic belt

Stratigraphic order undetermined

(All rock units contain variably sized granite and pegmatite layers, pods, lenses and veinlets; quartz veins, pods and lenses are widespread. Horizontal overprint depicts a strong thorium-potassium geophysical anomaly that many represent a granitic body, a vertical overprint represents strong potassium-uranium-thorium geophysical anomaly associated with a granitic body, and a diagonal line pattern indicates areas where high percentages of granitic rocks are mixed with different map units)

Biotite gneiss

bmgr, Undivided biotite gneiss, mica gneiss, feldspathic gneiss, mica schist, biotite schist, muscovitic quartzite, granitic gneiss, thin layers of amphibolite, and minor hornblende gneiss. Biotite gneiss is granoblastic, medium to dark gray, thin to thickly layered, fine-to medium-grained, contains quartz, plagioclase An_{25-28}, biotite, locally variable amounts of hornblende, minor muscovite, epidote, and microcline. Schists include biotite schist, biotite-muscovite-quartz-plagioclase-garnet-sillimanite schist, muscovite-quartz schist, and some sericitic schists. The schists range from medium to dark gray, are strongly lepidoblastic and locally porphyroblastic. Feldspathic gneiss ranges from very fine-to medium-grained, is granoblastic and light to medium gray, and consists mostly of quartz, feldspar and biotite. Locally contains fragmental lens-like aggregates of feldspar and quartz in a very fine-grained quartz-feldspar matrix. Granitic gneiss is medium to light gray, fine-to medium-grained with some feldspar porphyroblasts locally, and contains mostly plagioclase, microcline, quartz, biotite, and muscovite; biotite varies from 1-10 percent, and in places the rock has alternating light-colored felsic-rich and darker biotite-rich bands. Some of the mica schists have two cleavages. Contains several unmapped bodies of float that is very fine-grained, faintly layered, light to medium gray, granoblastic aggregates of diopside, epidote, and plagioclase with thin tremolite porphyroblasts. A few narrow discontinuous zones of mylonite and protomylonite are present. In places the rocks the rocks are strongly lineated and sheared; some rocks are cataclastic. Contacts between other units of biotite gneiss are gradational.

bfx Consists mostly of a biotite-quartz-feldspar gneiss that is commonly associated with thin amphibolite layers; lesser amounts of other rock types, which are also common to the bmgr unit, a re also present. The unit is mostly medium-gray, thin to thickly layered, fine-grained, and is granoblastic to lepidoblastic. Composed of plagioclase (oligoclase An_{12} and andesine An_{36}), quartz, biotite, and minor garnet, epidote, muscovite, and magnetite.

grf Mostly undivided quartz-feldspar-biotite gneiss that is variably layered with biotite granite gneiss. Includes decreasing amounts of other rock types included in the bmgr map unit and some isolated pods of ultramafic rock.

ugx, Undivided felsic gneiss (light gray, fine-grained, consisting of quartz, feldspar, and some mica), mixed with granite gneiss, dioritic gneiss, and minor hornblende-granite gneiss; diagonal-line pattern indicates high percent of granitic gneisses; includes some thin interlayered biotite schist, muscovite schist, biotite gneiss, and amphibolite

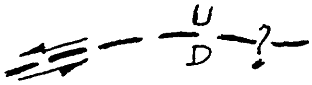
fm, Biotite felsic gneiss- mostly a variably layered, fine-grained biotite-quartz-feldspar gneiss interlayered with thin amphibolite layers, some granite gneiss, biotite schist, and thin (5-18 cm thick) muscovite-quartz schist layers that are widespread but irregularly distributed

hbf, Hornblende-biotite gneiss, medium to dark gray, mostly medium-grained, and granoblastic.

Contains highly variable amounts of hornblende (10 to 90 percent) and biotite, plagioclase ranging from oligioclase (An_{28}) to andesine (An_{43}), quartz, magnetite, and epidote. Some hornblende is chloritized. Hornblende concentrations vary widely to produce alternating hornblende-rich dark bands that are gradational into hornblende- poor felsic-rich light-gray bands. Unit includes some interlayered fine-grained biotite-quartz-plagioclase-microcline gneiss, biotite schist, discrete layers of fine-grained amphibolite, and rare muscovite schist. Also contains some undivided biotite-quartz-feldspar gneiss and granite gneiss layers and/or lenses, and rare pyroxenite-rich ultramafic pods

MAP SYMBOLS

Contact-Approximately located

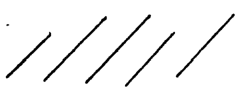


Fault-Approximately located, queried where inferred, arrows show direction of movement; U, upthrown side; D, downthrown side

Syncline, showing trace of axial plane, approximately located

Small folds showing direction of plunge
Sheared rocks, arrow shows direction of dip

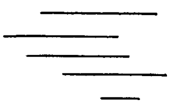
Foliation



Areas of abundant granitic gneiss within bmgr and ugx

Anomalies from airborne gamma-ray spectrometer survey (D. L. Daniels, personel commun. 1997).

Potassium, uranium, and thorium anomalies (all relatively high) associated with observed granitic body



Potassium and thorium anomalies (both relatively high) suggesting granitic body not yet observed.

CORRELATION OF MAP UNITS