GEOLOGY OF SELECTED MAFIC AND ULTRAMAFIC ROCKS OF GEORGIA: A REVIEW

Compiled by
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GEORGIA GEOLOGIC SURVEY

INFORMATION CIRCULAR 82

Cover photo: Typical outcrop of metagabbroic rocks of the Brasstown complex, exposed along the shore of Lake Chatuge, near the old Lower Bell Creek corundum mine, approximately 1-3/4 miles north of Hiawassee, Towns County, Georgia.

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GEOLOGY OF SELECTED MAFIC AND ULTRAMAFIC ROCKS OF GEORGIA: A REVIEW

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INTRODUCTION

Mafic and ultramafic rocks which have been metamorphosed to various degrees, are relatively common throughout the Appalachian Blue Ridge and Piedmont provinces (Figure 1). In many parts of the world these rock types serve as important sources of economic minerals including platinum, chromite, serpentine, talc, asbestos, and corundum. With the exception of the northernmost Piedmont geologic province, there is a notable lack of detailed information on these bodies in Georgia. Previous geological investigations tended to illustrate mafic and ultramafic bodies on relatively small-scale maps and treat them as accessory units within a larger geologic framework. Such small scale mapping tended to substantially limit information on these bodies. Consequently, an investigation that summarizes the petrography, geochemistry, and structure of mafic and ultramafic rocks in Georgia would fill a significant void in information by providing a data base for delineating areas of possible economic mineral potential associated with such rocks. This publication is intended to provide a point of reference for exploratory investigations and to serve as an aid in assessing the feasibility of exploiting areas of mafic and ultramafic rock.

Bodies described in this report are grouped into three geologic provinces as defined by McConnell and Abrams (1984). Each province—Blue Ridge, northern Piedmont, and southern Piedmont—is treated as a separate chapter. The Blue Ridge province, as defined, is bordered on the north and west by the Cartersville fault and on the south and east by the Allatoona fault. The northern Piedmont province lies between the Allatoona fault and the Brevard fault zone. The southern Piedmont includes those rocks lying south and east of the Brevard fault zone and north and west of the fall line.

Within this report, a number of rock bodies have been described as "metagabbro." This designation includes all gabbros that have been subjected to regional metamorphism. In some cases, large gabbros appear to have undergone little or no metasomatism, whereas in other cases the gabbros appear to have transformed completely to amphibolite. Intermediate gradations — amphibolite rock with relict igneous textures and minerals — also occur.

METHODS OF INVESTIGATION

Mafic and ultramafic bodies, exclusive of those thought to be extrusive in origin, were located by reviewing existing publications, theses, dissertations, and unpublished material in the technical files of the Georgia Geologic Survey. Relevant information from these sources was plotted on U.S. Geological Survey 7.5 minute topographic quadrangles and then modified during reconnaissance field mapping carried out from October 1983 to September 1984. A total of 51 samples were collected for additional thin-section analysis. The anorthite content of plagioclase feldspar was estimated by the Michel-Levy method (Kerr, 1977). Geochemical analyses by atomic absorption spectrometry were performed on 24 samples from 13 of the 25 rock bodies examined. Sampling for geochemistry was restricted to the least altered lithologies, thereby excluding serpentines and talc-anthophyllite schists.

AN OVERVIEW OF PREVIOUS INVESTIGATIONS

Statewide investigations of mafic and ultramafic bodies and their associated minerals are scarce. An early investigation of the occurrence and mining methods for corundum associated with ultramafic rocks in Georgia was performed by King (1894). Hopkins (1914) presented a descriptive listing of asbestos, talc, and soapstone occurrences in Georgia and commented on the methods of mining and production. Hunter (1941) described the geometries of forsterite-bearing ultramafites in North Carolina and northernmost Georgia.

BLUE RIDGE

Although other smaller occurrences are known to exist, mafic and ultramafic rocks in the Blue Ridge can be largely assigned to three major occurrences (the Newtown Sill in Fannin and Gilmer Counties, the Chatsworth talc district in Murray County, and the Marble Hill Hornblende Schist in Pickens County).

In Fannin County, LaForge and Phalen (1913) first described concordantly bedded "pseudodiorite" within the

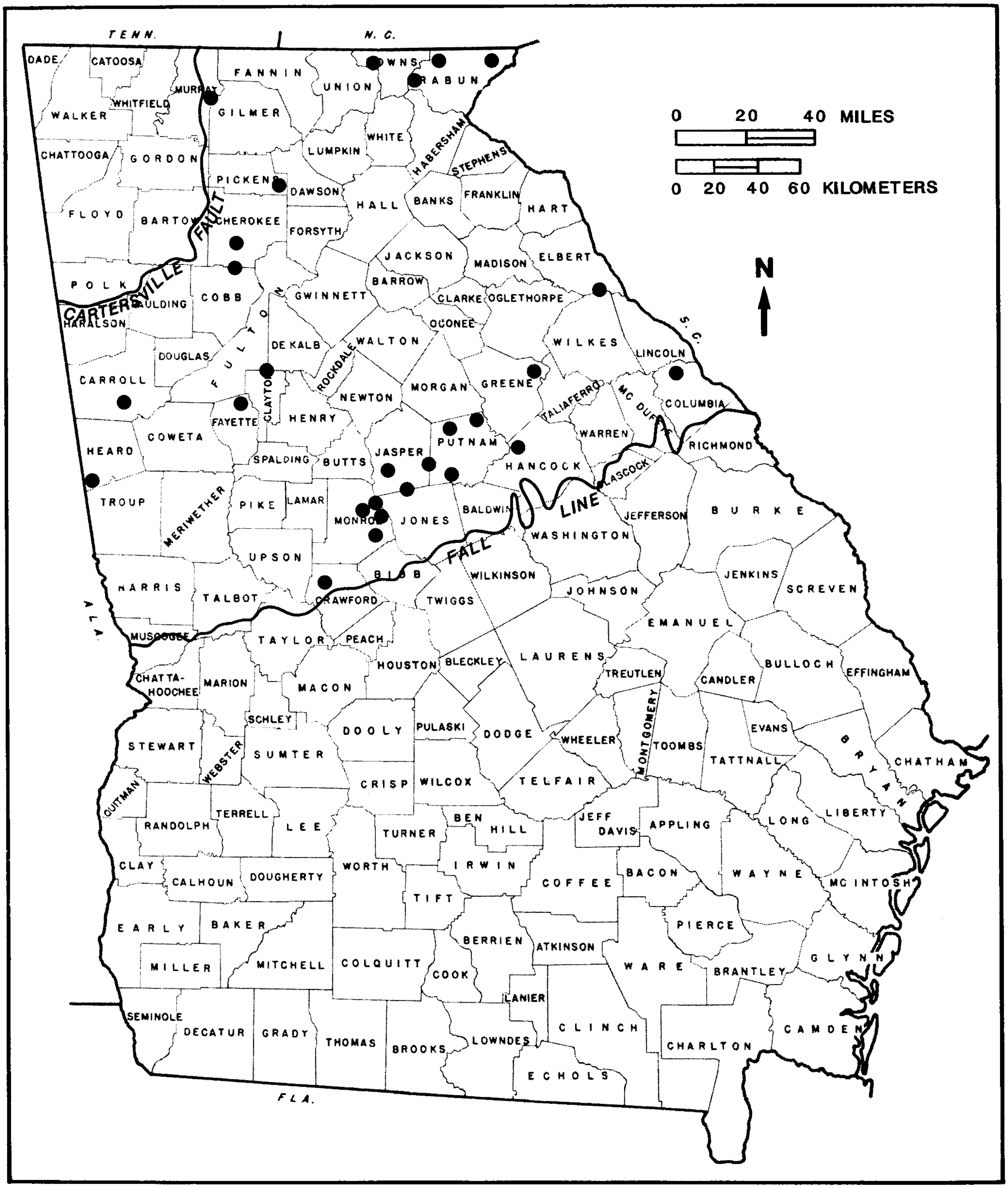


Figure 1. Generalized location map of mafic and ultramafic rock bodies described in this report.

Great Smoky formation. Hurst (1955) remapped and named these gabbro-like rocks the Newtown Sill. He suggested two possible origins: 1) "a diabasic or gabbroic sill" or 2) "the subaqueous extrusion of thin basalt flows" (Hurst, 1955, pgs. 62-63). Abrams (1985) noted the spatial association of the sill to sulfide mines and prospects in Fannin County and suggested a genetic relationship between the sill and the sulfide mineralization.

Several previous investigations give detailed maps of the Marble Hill Hornblende Schist. The earliest of these investigations was Bayley's (1928) report on the "Geology of the Tate Quadrangle, Georgia." A subsequent report on the Tate Quadrangle was published by Fairley (1965). A more specific report dealing primarily with the Murphy Marble, but also including hornblende schists and metagabbro rock associated with the Murphy Marble, was prepared by Power (1978). Bayley's (1928) report on the Tate Quadrangle assigned all mafic rocks near Marble Hill to the Roan gneiss, which according to Bayley (1928) was an all-encompassing unit introduced by Keith (1907) to include all of the hornblende schists, hornblende gneisses, and schistose diorites that occur as lenticular bodies within the Carolina gneiss. Bayley (1928) interpreted some of the hornblendic rocks to have a sedimentary protolith and others, particularly those associated with Great Smoky Group rocks, to have an igneous protolith. He grouped all hornblendic rocks, however, into the Roan gneiss. Fairley (1965), in his revision of the geology of the Tate quadrangle, separated hornblendic rocks in the Marble Hill area into two groups. He called the hornblende schists associated with the Murphy Marble the Marble Hill Hornblende Schist, and he described two elliptical bodies east of Marble Hill as metagabbro. Fairley, (1965) interpreted the Marble Hill Hornblende Schist as metasedimentary and the metagabbro as igneous in origin. He also suggested that the protolith of the metagabbro was intruded after the main episode of metamorphism.

In a report on the regional stratigraphy and paleogeography of the Murphy belt group, Power and Forrest (1973) equated the Marble Hill Hornblende Schist with the Andrews Schist of Keith (1907). They interpreted schist units above the Marble Hill Hornblende Schist, which Fairley (1965) indicated were equivalent to the Andrews Schist, as the Mineral Bluff Formation (Hurst, 1955). However, due to its distinctiveness, subsequent reports (Costello and others, 1982; McConnell and Abrams, 1984) have retained Fairley's usage of the Marble Hill Hornblende Schist in the Marble Hill area.

Talc deposits in Murray County, known as the Chatsworth talc district, are associated with the Ocoee Supergroup and Fort Mountain gneiss. Various origins for the talc have been suggested. Hopkins (1914) interpreted the talc deposits as altered basic intrusions present in Ocoee Supergroup rocks while Furcron and others (1947) suggested a sedimentary origin. Needham and Hurst (1970) agreed with Furcron and others (1947) interpretations but also suggested interaction with the parent magma of the Fort Mountain gneiss. Needham (1972) interpreted the talc deposits to be an altered body which intruded the Fort Mountain gneiss.

NORTHERN PIEDMONT/BLUE RIDGE?

The northern Piedmont contains some of the largest and historically most economically productive mafic and ultramafic rock units in Georgia. The largest and most intensively studied of these bodies in the northern Piedmont are: the Laura Lake Mafic Complex in Cobb and Cherokee counties; the Kellogg Creek Mafic Complex in Bartow, Cherokee, Cobb, and Paulding Counties; and the Lake Chatuge complex in Towns and Union Counties, Georgia and Clay County, North Carolina.

The Laura Lake Mafic Complex is the largest mafic and ultramafic rock complex in Georgia. Hurst (1952) first mapped portions of the Laura Lake Mafic Complex in his report on the geology of the Kennesaw-Sweat Mountain area. Later, McConnell and Costello (1980) presented the results of mapping in the northern Piedmont and outlined the mass of a large composite mafic body that they informally designated the "Laura Lake mafic complex." Higgins and Zeitz (1975) characterized the aeromagnetic signature of the complex as a series of elongate highs and lows. McConnell and Abrams (1984) formally named this group of mafic rocks in western Cobb County the Laura Lake Mafic Complex. They recognized the presence of banded iron formation associated with some phases of the Laura Lake Mafic Complex, suggesting that the complex contained an extrusive phase.

The Kellogg Creek Mafic Complex (McConnell and Abrams, 1984) is located in southeastern Bartow and northwestern Cobb Counties. The rock was originally interpreted as a metagabbro with talc and serpentine occupying shear zones along its margins (Crawford and Medlin, 1970, p. 8). Part of the Kellogg Creek Mafic Complex, southwest of the area mapped by Crawford and Medlin (1970), was delineated on the geologic map of Paulding and Haralson Counties by Hurst and Crawford (1970). Crawford (1976) remapped the Kellogg Creek Mafic Complex in northeastern Paulding County (Burnt Hickory Ridge 7.5 minute quadrangle). In 1978, Wallace studied the chemistry and petrography of a portion of the Kellogg Creek Complex. Her investigation recognized the chemical complexity of the Kellogg Creek Complex. McConnell and Costello (1980) outlined the outcrop area of the complex and informally termed it the Kellogg Creek gabbro. McConnell and Abrams (1984) renamed this body the Kellogg Creek Mafic Complex for exposures along Kellogg Creek in southern Cherokee County. The term "mafic complex" was used to denote the variety of lithologies observed in this rock assemblage.

The first detailed study of mafic and ultramafic rocks within the vicinity of Lake Chatuge were those of Hartley (1971, 1973) who proposed that the rocks represent a folded, differentiated, intrusive sill. Hartley and Penley (1974) first illustrated the regional occurrences of these rocks, which they called the Lake Chatuge Sill, as distinct ring-like bodies. Recent studies involving regional syntheses include the works of Shellebarger (1981), Long (1983), Nelson (1983, 1985), and Nelson and Zeitz (1983). Nelson (1983, 1985) and Nelson and Zeitz (1983) proposed that the mafic and ultramafic rocks of the Lake Chatuge area represent part of a dismembered section of oceanic crust exposed in two erosional windows.

SOUTHERN PIEDMONT

In the southern Piedmont, major occurrences of mafic and ultramafic rock are limited to the Charlotte belt and Carolina slate belt of east-central Georgia, the Soapstone Ridge complex near Atlanta, and unnamed rocks in western Troup County near LaGrange.

Hopkins (1914) was the first to describe mafic rocks in east-central Georgia as a "belt" of hornblende gneiss and "gabbro-diorite" which extends from Monroe County northeastward to Elbert County. Medlin and Hurst (1967) examined the Greene County area and mapped "amphibolite with quartz megacrysts" (metagabbro). Reconnaissance mapping in Greene County, illustrated on the Geologic Map of Georgia (Georgia Geologic Survey, 1976) depicts these rocks as "gabbro." According to Medlin and Hurst (1967), a chlorite schist exposure south of Georgia Highway 44 was once quarried for local use. A long-abandoned copper prospect, which was never commercially developed, also occurs on the Durham family property. Medlin and Hurst (1967) reported the occurrence of malachite and azurite staining on chloritized amphibolite surface rocks around this prospect.

The first descriptive investigation of mafic rocks in Columbia County was by Hopkins (1914). Hopkins designated the mafic lithologies of Columbia County as the easternmost occurrence in Georgia of a belt of mafic rocks extending from Hancock County. His megascopic description of the mafic rocks in Columbia County is quite accurate and includes observations of several textural and mineralogical variations. Worthington (1964) described "dunite" and "serpentine," exposed north of Augusta (Pollards Corner area), in his regional investigation of nickel concentrations in mafic and ultramafic rocks throughout the southeastern United States. McLemore (1965) mapped the Pollards Corner area of Columbia County and noted a regional trend of mafic and ultramafic bodies that are parallel to the foliation of enclosing felsic gneisses. Hurst and others (1966) performed a geochemical survey on the largest of these bodies, noting the occurrence of anomalous nickel concentrations.

Austin (1965) classified mafic rocks in Elbert County as "metadolerite dikes" and "hornblende metagabbro." He interpreted them as intruding into older metavolcanic lithologies. More recent investigations include reconnaissance mapping of the area as illustrated on the Geologic Map of Georgia (Georgia Geologic Survey, 1976) and Thurmond and Whitney's (1979) investigation of Carolina slate belt metavolcanic rocks, south of the present study area.

Hopkins (1914) first described the asbestos, talc and soapstone deposits in western Georgia. Ballard (1948) published a report on the Louise chromite deposits in central Troup County. The chromite deposits were explored during his investigations with the construction of 81 test pits and one 55′ shaft (Ballard, 1948). The deposits at Louise were determined to be low-grade and to have a high iron to chromium ratio. Grant (1949) reported on the petrography of core samples from the Louise deposits. Bentley and Neathery (1970) placed rocks in Troup County into two complexes: the Dadeville and Opelika complexes, which are separated from each other by the Stonewall line, a feature they considered to be either a fault or an unconformity. The Dadeville complex, comprising the northwestern part of Troup County, contains six major rock groups including mafic and ultramafic rocks of the Ropes Creek Amphibolite, Smith Mountain and Boyds Creek mafic complexes (Bentley and Neathery, 1970). Sears and others (1981) redefined the Dadeville complex into three units: Zebulon Formation, Ropes Creek Amphibolite, and Argicola Schist. They also reported on the mafic and ultramafic rocks in the Boyds Creek Mafic Complex in eastern Alabama. Stow and others (1984) published chemical analyses on most of the major mafic and ultramafic rock units in the Alabama Piedmont, including those that trend into Troup County. Amphibolites from the Ropes Creek Amphibolite were interpreted by Stow and others (1984) to represent the same episode of volcanism and to have formed in an oceanic rift environment.

Localized ultramafic occurrences in DeKalb, Fulton, Heard, and Jackson Counties were described by Prowell (1972). These bodies were not studied in this report.

BLUE RIDGE MAFIC AND ULTRAMAFIC ROCKS

INTRODUCTION

In this report the Blue Ridge province of Georgia is considered as the area bounded to the west and north by the Cartersville thrust fault and to the south and east by the Allatoona thrust fault (McConnell and Costello, 1980; McConnell and Abrams, 1984). This area is equivalent to the western Blue Ridge belt of Hatcher (1978). The Blue Ridge province consists predominantly of an assemblage of metasedimentary rocks and widely scattered occurrences of Grenville-age basement. The major post-Grenville metamorphic event of the Blue Ridge occurred during the Taconic orogeny (Hatcher, 1978) and attained at least upper amphibolite facies over a large area;

metamorphic grade increases to the south and east. One significant feature of the Blue Ridge is the notable absence of large quantities of mafic and ultramafic rocks. Three rock bodies of mafic to ultramafic composition are recognized in the Blue Ridge. One of these, the Newton Sill in Fannin and Gilmer Counties, is suggested to be a subaqueous basaltic flow (Abrams, 1985). A second occurrence includes numerous talc bodies in the Chatsworth talc district that are associated with the Fort Mountain gneiss in Murphy County, and the third occurrence is the Marble Hill metagabbro. Two of these bodies, the Chatsworth talc district and the Marble Hill metagabbro, are discussed below.

MARBLE HILL METAGABBRO

Metagabbro and hornblende schist occur within the Georgia Marble District near Marble Hill, Pickens County (Figure 2). These lithologies occur within the Murphy belt group, a sequence of lower Paleozoic metasedimentary rocks extending from Bryson City, North Carolina to Canton, Georgia. Keith (1907) first described the Murphy belt sequence at Murphy, North Carolina. Fairley (1965) described the metagabbroic rocks exposed in Pickens County; while smaller occurrences of ultramafic and mafic rocks were described by Bayley (1928). Van Horn (1948) described talc deposits of the Murphy belt group in western North Carolina. Power (1978) summarized the lithologies in the vicinity of Marble Hill as (from oldest to youngest): thinly bedded mica schist (Brasstown Formation), marble (Murphy Marble), calc-silicate rock (Marble Hill Hornblende Schist), and garnet-mica schist (Mineral Bluff Formation).

The Marble Hill area is structurally complex and several studies have arrived at distinctly different interpretations. Bayley (1928) outlined the synclinal nature of rocks in and near Marble Hill and indicated that rocks of the Murphy belt group were bounded on the east by the southward extension of Laforge and Phalen's (1913) Whitestone fault. In this interpretation, the Murphy Marble, as it crops out in the Marble Hill area, was interpreted to be exposed in a half window through the Whitestone thrust sheet. Fairley (1965) discounted the presence of the Whitestone fault in the Tate Quadrangle and interpreted the outcrop pattern of the Murphy Marble to be the result of interference between two major fold generations; an early northeast-southwest trending fold generation (i.e., the Murphy syncline) cross folded by later northwest-southwest trending folds. McConnell and Costello (1984) agreed in part with both Bayley (1928) and Fairley (1965), but suggested that the outcrop pattern of the Murphy Marble was the result of interference between three fold generations instead of two. The first two fold generations were northeast-southwest trending and resulted in the initial formation of the Murphy syncline and then the subsequent development of the syncline's arcuate outcrop pattern. Later southeast trending folds, first recognized by Fairley (1965), were interpreted by McConnell and Costello (1984) to be third generation folds. Because of the intermittent presence of the Nantahala Formation along the eastern limb of the Murphy syncline, McConnell and Costello (1984) agreed with Bayley's (1928) interpretation of the Whitestone fault.

Metamorphic grade in the Marble Hill area is middle to upper amphibolite facies as indicated by the presence of kyanite throughout the area (Furcron and Teague, 1945). Metamorphic mineral assemblages found in the Marble Hill area are outlined by McConnell and Abrams (1984, page 55).

Mafic rocks of the Marble Hill Hornblende Schist are composed of well foliated, fine-grained, "salt and pepper" amphibolites consisting of well-oriented grains of plagioclase and hornblende with accessory biotite (Fairley, 1965). These schists surround the metagabbroic rocks and are best exposed structurally above the Murphy Marble at the New York and Kennesaw Mines near Marble Hill. Their association with, and local gradation into, the Murphy Marble strongly suggests a sedimentary protolith for schists of the Marble Hill Hornblende Schist.

Metagabbroic rocks within the Marble Hill Hornblende Schist occur in two elliptical shaped outcrop areas east of Marble Hill (Figure 2). These mafic rocks are medium to coarse grained and are composed of amphibole, pyroxene and plagioclase. Fairley (1965) described the metagabbros as occurring in "small patches" within fine-grained amphibolites. Minor ultramafic rock is also associated with the small pods of mafic rock. In the smaller of the two elliptical bodies of metagabbro as mapped by Fairley (1965), a fine-grained rock of apparent ultramafic composition is present. This ultramafic rock is non-foliated, fine-grained, and is composed of chlorite and fibrous amphibole, probably anthophyllite. The association of mafic and ultramafic rocks and the texture of the metagabbros suggest an igneous protolith. Other mafic and ultramafic rocks present outside the Marble Hill area occur as small pods or sills within the surrounding schists and gneisses. No thin-section studies or geochemical analyses were conducted on the gabbroic rocks.

CHATSWORTH TALC DISTRICT

Talc has been produced from numerous talc deposits in Murray County (Figure 3) since 1872. Hopkins (1914) was the first to describe the mining activities in the area. Furcron and others (1947) described the geology of the district and mapped in detail a number of the mines. Needham and Hurst (1970) provided additional geologic data for both the mines and the district, including a 1:27,500-scale map of the area. Needham (1972) provided additional information on the general geology and geochemistry of the area.

The Cohutta schist — which is predominately a chlorite, talc, serpentine, dolomite and actinolite rock—is the host material for the talc bodies of the Chatsworth district (Furcon and others 1947). The Cohutta schist

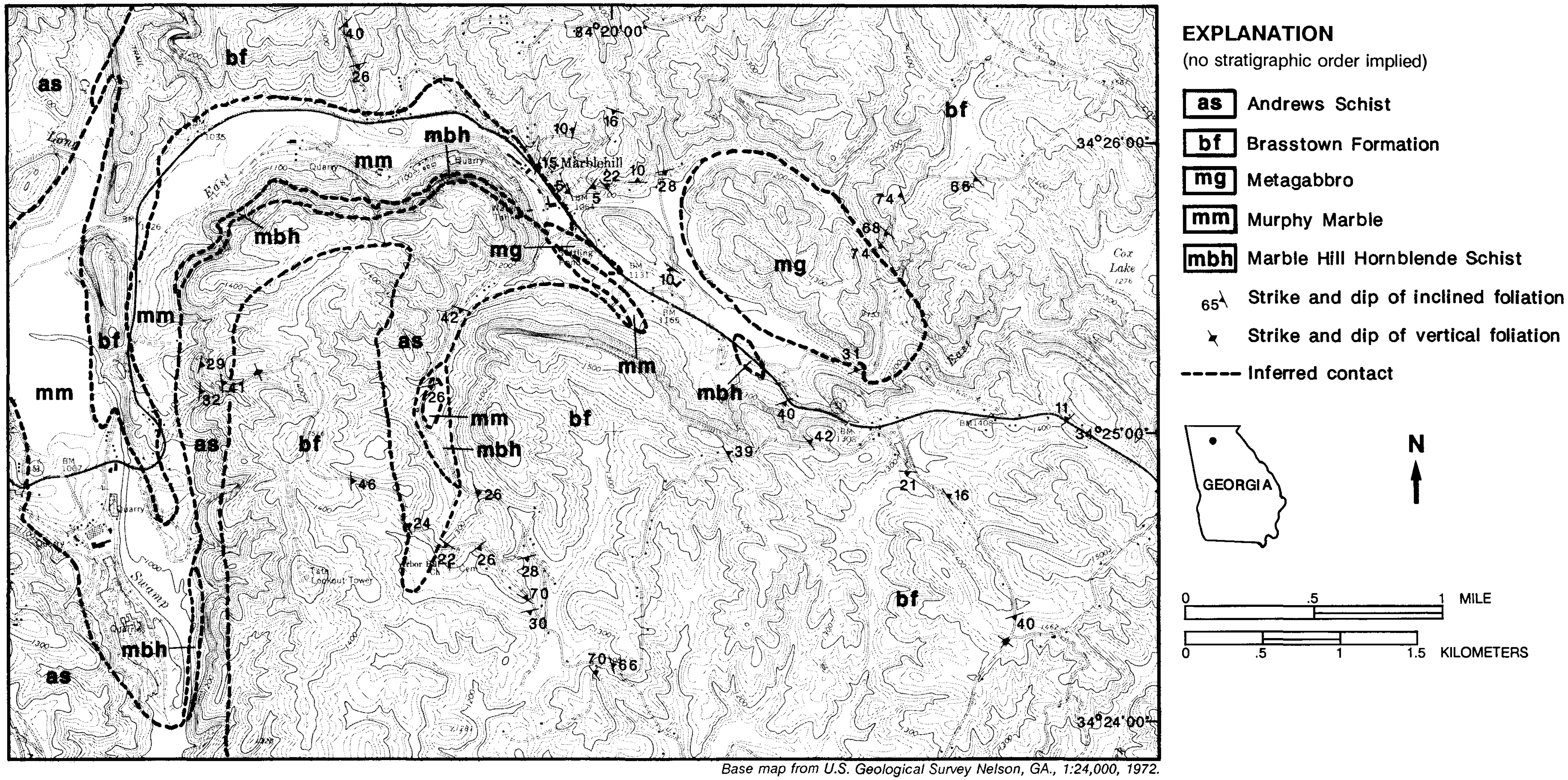


Figure 2. Location map of the Marble Hill metagabbro, Pickens County.

occurs as discontinuous lens-shaped bodies within the Fort Mountain gneiss (Figure 3). Needham and Hurst (1970) and Needham (1972) consider the Fort Mountain gneiss to be an orthogneiss that exhibits a cataclastic texture in thin-section. The gneiss is otherwise chemically unaltered except in areas adjacent to the Cohutta schist. In these areas, carbonate alteration may be pervasive.

Needham (1972) divided the Cohutta schist into seven lithologic types: massive talc, talc carbonate, massive serpentine, massive chlorite, talc-chlorite, serpentine-chlorite, and a tremolite rock termed nephrite. The talcose and chloritic rocks are gneissic to schistose in hand specimen and display a cataclastic texture. The serpentine and nephrite rocks, apparently more resistant to deformation, are homogenous with no preferred mineral alignment.

Furcron and others (1947) interpreted the schist to be a metamorphosed impure dolomitic rock which was partially assimilated by the surrounding Fort Mountain gneiss; dolomitic portions of the dolomitic rock were altered to talc and serpentine. Needham and Hurst (1970) agreed with this interpretation of a sedimentary origin for the Cohutta schist; however, they redefined the Cohutta schist to include all talc deposits in Murray County regardless of their origin. The protolith to the Fort Mountain gneiss has been interpreted by Furcron and others (1947) and by Needham (1972) to be a metamorphosed granitic rock.

The geologic map of the area (Figure 3) by Needham (1972) does not indicate the presence of the Cartersville-Great Smoky thrust fault and minor splays east of the fault within the talc district. However, Needham (1972) did discuss in detail the presence of these faults within the text of his report. Many of the thrust splays appear to control the outcrop pattern of the Fort Mountain gneiss and possibly the Cohutta schist. The possibility of folding superimposed over the thrust faults cannot be discounted. Needham (1972) presents petrographic and geochemical data which supports an igneous origin for Cohutta schist. Data supporting an ultramafic origin of the talc include: 1) the presence of trace amounts of chromite and concentrations of cobalt and nickel greater than what is normally found in marls or dolomite; 2) the presence of relict olivine grains; and 3) the general stratigraphic and structural controls of the Cohutta schist. Furthermore, Needham (1972) believes that the schist was tectonically emplaced into its present position.

Talc was first mined in the Murray County area in about 1872, was initially mined from outcrop, and was of poor grade. Around 1910, some of these mines were enlarged and underground workings were developed. By the 1940's, talc was utilized as a filler in tires; consequently both crayon-grade and filler-grade talc were being exploited. Since 1960, there has been a general decline in the production of talc from the district and in the early 1970's only three mines — the Georgia, Earnest and Rock Cliff Mines — were in production. United Catalysts, Inc. recently (1987) reopened the Earnest Mine and at the same time closed the Rock Cliff Mine.

NORTHERN PIEDMONT MAFIC AND ULTRAMAFIC ROCKS

INTRODUCTION

The northern Piedmont province is bounded on the northwest by the Allatoona fault and on the southeast by the Brevard fault zone (Figure 1). This area is equivalent to the eastern Blue Ridge belt of Hatcher (1978). Lithologies in the northern Piedmont consist predominately of metasedimentary and metavolcanic rocks of various compositions with widely scattered occurrences of metamorphosed felsic plutons. In contrast to the Blue Ridge province, mafic and ultramafic bodies of widely varying sizes are abundant in the northern Piedmont. Generally, lithologies of the northern Piedmont can be assigned either one of two stratigraphic units: the New Georgia Group or the Sandy Springs Group (McConnell and Abrams, 1984). Metamorphic grade varies from upper green schist facies to upper amphibolite facies with metamorphic grade increasing to the east and south.

Many of the mafic and ultramafic rock bodies appear to have been thrust into their current structural position. These bodies are generally lensoid in shape and may be dismembered ophiolite sequences. Hatcher and others (1984) proposed the Laurel Creek complex is such a rock body. The Lake Chatuge complex, Dicks Creek suite, Lake Burton dunite and Beavert Mountain suite may also be dismembered ophiolities.

LAKE CHATUGE COMPLEX

Two distinct masses of mafic and ultramafic rocks, having a ring-shaped outcrop pattern, occur within Union and Towns Counties, Georgia, and Clay County, North Carolina (Figure 4). These rocks, termed the Lake Chatuge Sill by Hartley and Penley (1974), "are believed to form a separate thrust slice of oceanic crust between the Hayesville and Great Smoky thrust sheets" (Nelson, 1985). Nelson (1985) interprets this complex as a window of ultramafic and mafic rock representing diapirs or small intrusions, not sills as inferred by Hartley and Penley (1974). Because of the uncertain emplacement history of the ultramafic and mafic rocks in this area, all such rocks are referred to as the Lake Chatuge complex.

The Lake Chatuge complex crops out in ring-like patterns along the flanks of two southwesterly elongate domal features: Brasstown Bald, Georgia, and Garland Mountain, North Carolina. This mafic and ultramafic complex separates two distinct lithologic terranes (Figure 4). Rocks "outside" and structurally above the complex (pbg; Richard Russell Formation, Hayesville thrust sheet) consist predominately of fine to medium grained, locally garnetiferous, biotite-plagioclase-quartz gneiss with local thin layers of fine grained mica schist and biotite quartzite. Rocks "within" and structurally below the ring complex (gms; Ocoee Supergroup, Great Smoky thrust sheet) consist predominately of medium- to coarse-grained garnet-mica

EXPLANATION

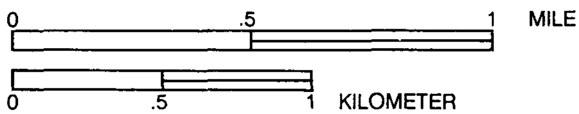
(for Figure 3 - map on facing fold-out page)

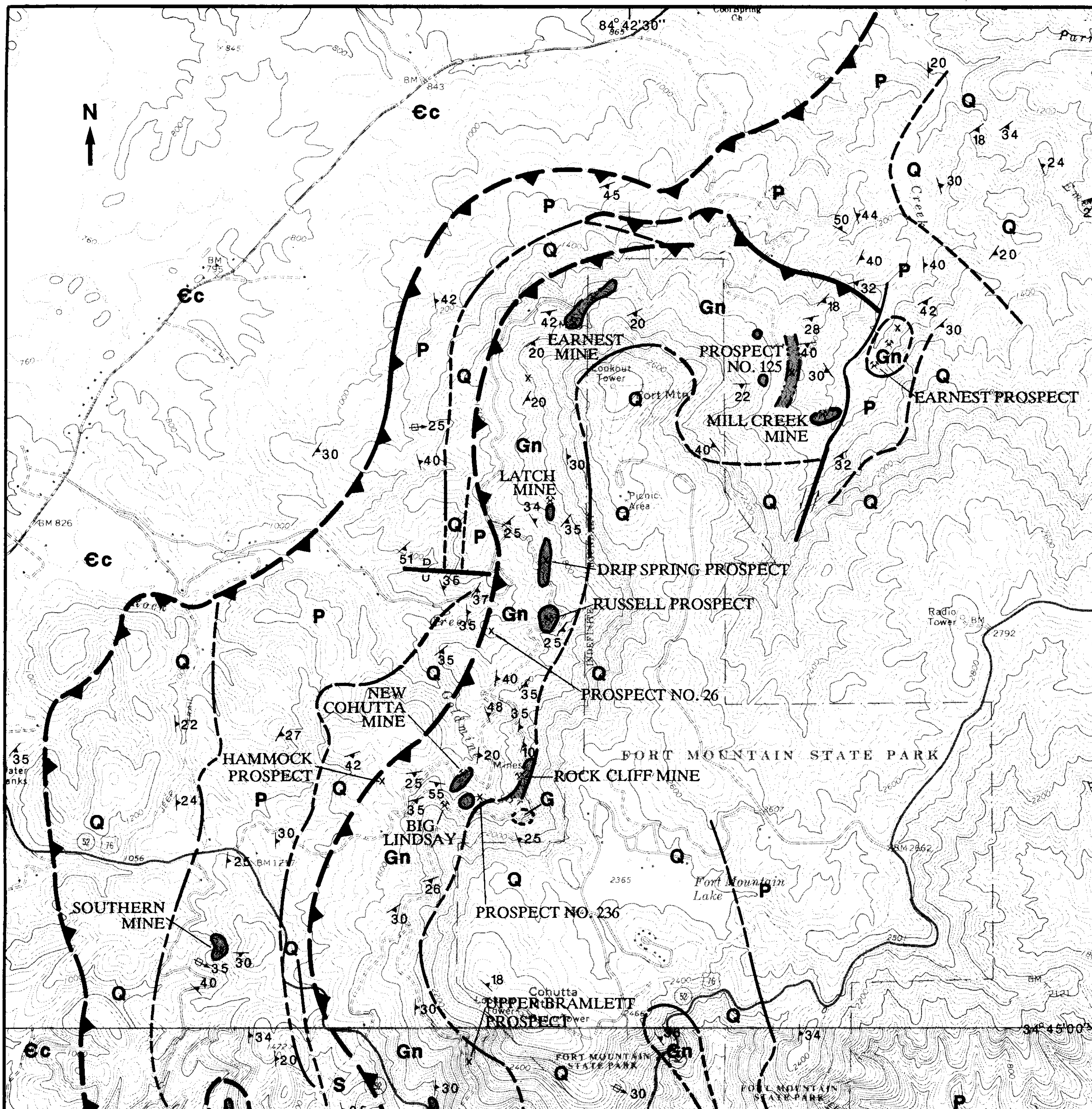
- **G** Granite
- (shaded box) Cohutta schist
- **A** Altered diabase
- **€c** Conasauga formation

GREAT SMOKY GROUP

- **Q** Coarse clastics
- **Gn** Fort Mountain gneiss
- **P** Phyllite and slate
- **S** Schist

- Strike and dip of foliation
- Trend and plunge of lineation
- Active mine
- Abandoned mine
- x Prospect
- Thrust fault, dashed where inferred
- Wrench fault
- High angle fault (U / D)
- Contact, dashed where inferred





Base map from U.S. Geological Survey 1:24,000 maps: Crandall, GA., 1971 and Ramhurst, GA., 1985.

Figure 3. Location map of the Chatsworth talc district (modified from Needham, 1972).

schist with local thin layers of fine-grained biotite-plagioclase-garnet gneiss (Nelson 1985; Nelson and Zeitz, 1983). Ocoee Supergroup rocks are considered part of Hatcher's (1978) western Blue Ridge belt which crop out approximately 3 km (2mi) northwest of the study area and northwest of the Hayesville thrust fault. Consequently the Ocoee Supergroup is exposed in two erosional windows through the Hayesville thrust sheet. The existence of a Hayesville thrust sheet, as originally defined by Hatcher (1978), was based largely on the virtual absence of volcanic, mafic and ultramafic rocks within the western Blue Ridge and a scarcity of Grenville basement rocks in the northern Piedmont belt.

Nelson (1985) proposed thrust contacts for both the internal and external margins of the Lake Chatuge complex, thereby suggesting that the entire body is a tectonic slice outlining a window through the Hayesville sheet. Cross-sections through the Lake Chatuge complex (Nelson, 1985, Figure 18) imply that the complex is in the shape of a doughnut. If this interpretation is correct, the presence of additional concealed mafic and ultramafic rock of significant areal extent is unlikely. Mafic rocks comprising the Lake Chatuge complex are reported to have mantle affinities on the basis of geochemistry (Hartley, 1973), suggesting that the complex may be a fault emplaced slab of oceanic crust (ophiolite). Considering that no prominent metamorphic grade discontinuity exists between rocks of the Hayesville thrust sheet and those within the ring complexes, the Hayesville fault, if it exists, is most likely a pre-metamorphic thrust as proposed by Hatcher (1978). The geologic map report of the Lake Chatuge complex (Figure 4) does not indicate the upper thrust plate defined by Nelson (1985).

In the Lake Chatuge complex, amphibolite and associated metagabbroic rocks predominate. The dominant mafic lithology is a dark-green to black, fine-grained, well-foliated amphibolite. Hornblende-plagioclase gneiss, grading into a locally garnetiferous hornblende gneiss with a well-defined foliation, also is present within the complex.

Metagabbroic lithologies generally occur as green to greenish-black, weakly-foliated to non-foliated rocks with well-preserved intrusive igneous textures (i.e., compositional layering, interlocking crystal mosaics), consisting of a plagioclase-hornblende assemblage. Hopkins (1914) described an olivine gabbro host rock for the Hog Creek Corundum Mine, located 4 km (2.5 mi) west of Hiawassee.

Metagabbroic rocks have been grouped with amphibolite where the two lithologies are closely associated. Although the amount of exposure is limited, amphibolite and metagabbroic rocks are commonly observed to be interlayered. In such instances, individual lithologies range in thickness from approximately 0.5 meter to several meters; however, the metagabbroic rocks are generally exposed as float and colluvium. Additional field studies may determine whether the metagabbroic rocks can be consistently mapped as distinct lithologic units.

Isolated outcrops of chlorite-talc schist are closely associated with the more altered portions of the metagabbroic rocks and generally occur either at the edge of the complex or where the complex is thinnest. The chlorite-talc schist may represent retrogressively metamorphosed mafic and ultramafic rock.

Hartley (1971, 1973) reported that dunite occurs as scattered outcrops near the shoreline of Lake Chatuge. He states that the dunite consists of forsterite olivine partially altered to antigorite serpentine. He also noted an occurrence of disseminated chromite grains (up to 2mm in diameter) in the dunite. Dunite was not observed by the authors.

Thin-section data suggest that the Lake Chatuge complex is a highly differentiated body of intrusive origin. Lithologies within the complex range from olivine pyroxenite (sample JG-1, Table I) to an anorthositic gabbro (sample HW-4, Table I). Most of the gabbroic rocks of the complex have hornblende as the major mafic component. Hartley (1973) suggested that the hornblende is a metamorphic alteration of the original igneous pyroxene. In many instances the hornblende has retained the parting and schiller luster characteristic of diallage. With the exception of the olivine pyroxenite (sample JG-1, Table I), subhedral to euhedral clinozoisite is ubiquitous in samples taken from the complex and was most likely formed during metamorphism at the expense of plagioclase. Strained plagioclase twins in samples from the Lake Chatuge complex are common, suggesting that the body experienced deformation subsequent to, or synchronous with, metamorphic recrystallization. Mineralogy of an amphibolite (sample JG-2, Table I) is similar to the metagabbroic phase of the Lake Chatuge complex. Amphibiolites throughout the complex may therefore be recrystallized equivalents of metagabbroic rock.

In the late 1800's and early 1900's, a number of corundum and asbestos mines and prospects were developed in the Lake Chatuge complex. Most of these mines and prospects have been covered by Lake Chatuge or filled in by land owners (Hartley, 1973). The Hog Creek Corundum Mine (Ballard, 1946), located northeast of Hiawassee (Figure 4), consisted of a vertical shaft approximately 15 m (45 ft.) deep and a trench 60 m (190 ft.) long. The Bell Creek Corundum Mine (Ballard, 1943), located north of Hiawassee (Figure 4), consisted of a shaft, several pits and a trench. The host rock at both mines is a chlorite schist; the corundum at Hog Creek occurs within veins and within the host rock. Occurrences of the corundum at Bell Creek are unknown (Ballard, 1943). There are no production records for any of these mines, nor can it be ascertained when the mines were abandoned. They were probably abandoned in the early 1900's.

DICKS CREEK SUITE

This suite is informally named for two exposures of mafic and ultramafic rock on both sides of Dicks Creek in the

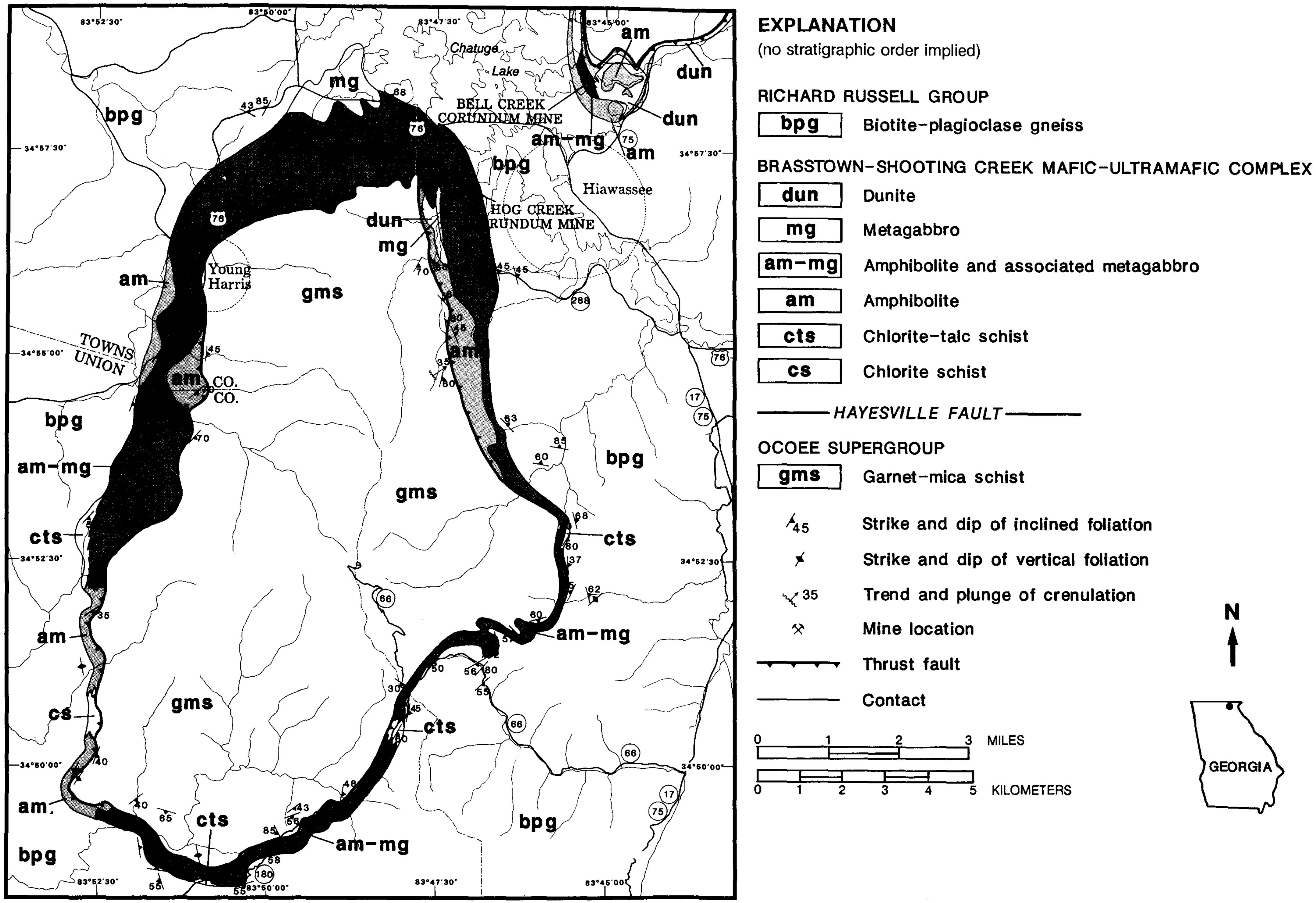


Figure 4. Generalized geologic map of the Lake Chatuge complex, Towns and Union Counties.

TABLE I

ESTIMATED MODAL PERCENTAGES OF SAMPLES FROM THE LAKE CHATUGE COMPLEX

	HW-1	HW-2	HW-3	HW-4	JG-1	JG-2
Antigorite					25	
Chlorite						tr.
Clinozoisite	35	5	9	5		2
Diallage					10	
Epidote						tr.
Hornblende	64	59	71	35		85
Olivine					20	
Opaques		tr.	tr.	tr.	4	1
Plagioclase		35	20	60		11
Sphene	1					
Uralite		tr.			41	

southwestern corner of the Hightower Bald 7.5 minute quadrangle, Rabun Co. (western portion of Figure 5). The suite consists of two, near-parallel, ellipsoidal bodies that trend northwesterly and are concordant to the foliation of enclosing gneisses and schists. The two bodies are surrounded by interlayered biotite gneisses and schists of the Hayesville thrust sheet. The larger, eastern body crops out approximately 2 km (1.25 mi) northwest of the Lake Burton dunite and approximately 0.25 km (0.15 mi) northwest of the Shope Fork thrust fault (Hatcher, 1979). The smaller body crops out 0.8 km (0.5 mi) west of the larger body. Nelson (1983) mapped the two bodies as being emplaced along steeply dipping splays off of the Shope Fork fault.

The two bodies underlie a parallel, northwest-trending ridge system. Exposures consist predominantly of boulder float along the crests and slopes of the ridges. The larger, eastern body is a small intrusive complex and consists of mappable areas of amphibolite, siliceous serpentinite and olivine pyroxenite. The siliceous serpentine rock tends to be a ridge former. The smaller, western body appears to consist entirely of serpentinite without silica.

Thin-section analysis of the olivine pyroxenite in the eastern body (sample HTB- 1, Table II) reveals that the pyroxenite is medium-grained and near-equigranular, consisting predominately of augite, olivine, and amphibole. This unit exhibits a crude banding defined by a planar arrangement of fine-grained magnetite and spinel. Although olivine and augite are relatively unaltered, amphibole appears to be a metamorphic alteration product of an original pyroxene and occurs either in a fibrous form (actinolite?) or as aggregates of fine grains. A few of the fibrous amphiboles exhibit crude banding. A chemical analysis of sample HTB-1 is given in Appendix A.

LAKE BURTON DUNITE

The Lake Burton dunite is exposed in the north-central section of the Lake Burton 7.5 minute quadrangle on U.S. Highway 76 approximately 20 km (12 mi) west of Clayton, Rabun County, Georgia (eastern portion, Figure 5). The dunite lies within a northeast trending assemblage of metasedimentary schists, graphite schist, amphibolite, and hornblende gneiss bounded on the northwest by the Shope Fork fault (Hatcher, 1979) and on the southeast by the Chattahoochee fault (Hurst, 1973; McConnell and Abrams, 1984). In the area of Lake Burton, width of the assemblage is approximately 5.6 km (3.5 mi). This assemblage has been referred to as undifferentiated Tallulah Falls Formation (Hatcher, 1971, 1974; German, 1985) and as Great Smoky Group (Hatcher, 1976). Nelson (1985) designated these rocks as part of the Helen-Coweeta Terrane. Rocks in the immediate vicinity of the dunite are an interlayered sequence of fine- to medium-grained, feldspar-muscovite-biotite-quartz gneiss, amphibolite, and medium- to coarse-grained mica schist. Nelson (1983) mapped the dunite as a klippe and suggested that it has a genetic relationship to the Dicks Creek suite (2 km northwest) which occurs within the Hayesville thrust sheet (Figure 5). Nelson's map (1983) indicated a continuous exposure of ultramafic rock between the two Lake Burton ultramafic units displayed in Figure 5, however German (personal communication) did not observe continuous exposures of ultramafic rock in this area.

The Lake Burton dunite occupies a southwest-trending ridge and is best exposed in two abandonded borrow pits on U.S. Highway 76 and as boulder float on the ridge slopes and crest just south of the highway. The ridge drops away steeply to the north and only scattered boulder float occurs on the northern slope.

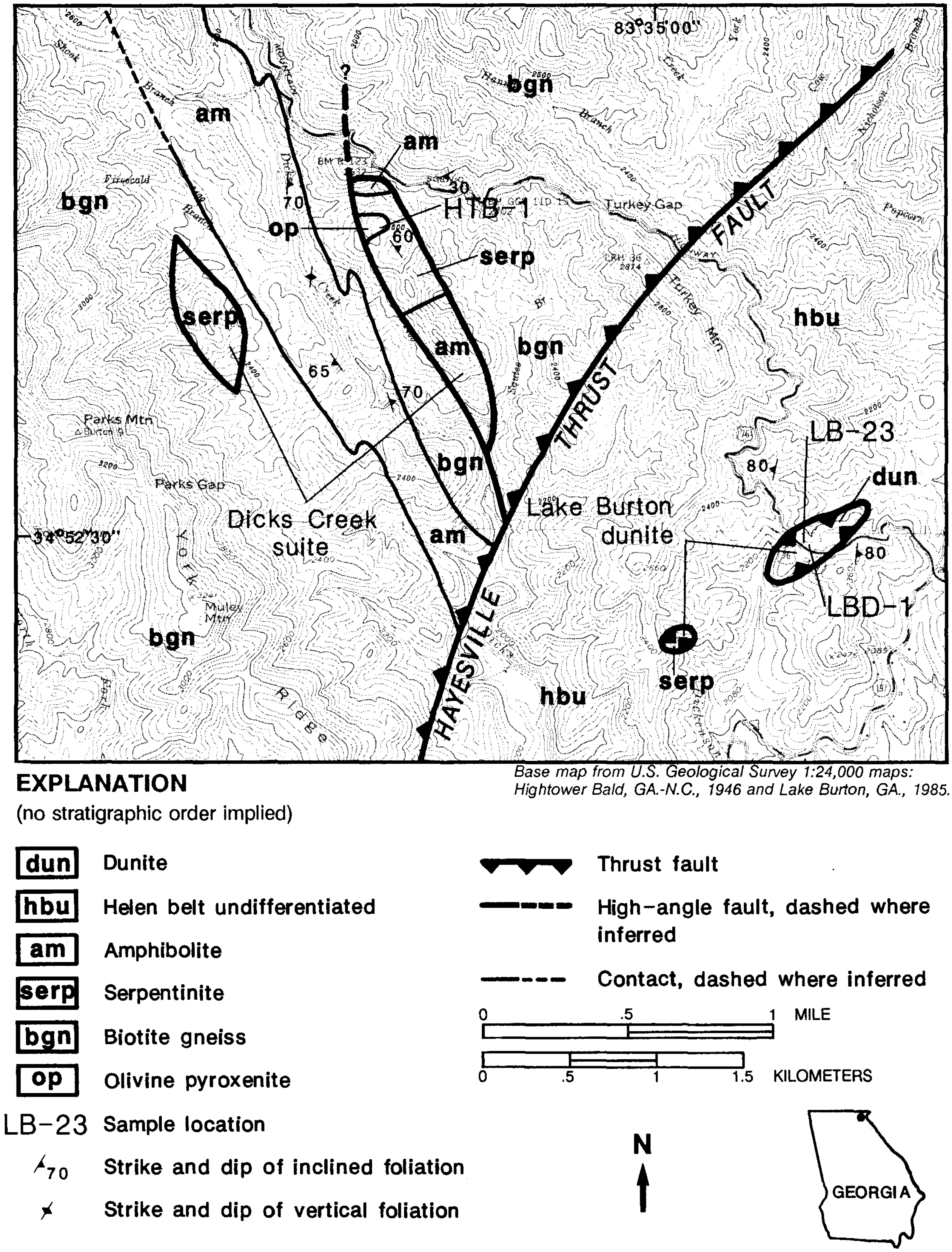


Figure 5. Location map of Dicks Creek suite and Lake Burton dunite, Rabun County.

TABLE II

ESTIMATED MODAL PERCENTAGES OF SAMPLES FROM THE DICKS CREEK SUITE, LAKE BURTON DUNITE, BEAVERT MOUNTAIN SUITE AND HOLLY SPRINGS ULTRAMAFITE

	HTB-1 Dicks Creek	LB-23 Lake Burton	D-23 Beavert Mountain	SC-1 Holly Springs	SC-1a Holly Springs
Amphibole/Hornblende	27				
Anthophyllite			20		
Augite	37				
Chlorite				32	
Chrysotile		3	1		
Carbonate				22	38
Enstatite		10			
Magnetite	4	3	2	10	10
Olivine	28	84	71		
Plagioclase	1				
Quartz	1				
Spinel	2				
Talc			5	36	52

In the outcrop, the body is a light green, fine-grained, subequigranular dunite with a saccharoidal texture and ubiquitous serpentinization. Local fractures have an abestiform mineral (antigorite?). At the northwestern margin of the body on U.S. Highway 76, shearing is suggested by the presence of strongly foliated talcose schist.

German (personal communication) reported the presence of a number of prospect pits and adits south and west of the larger of the two rock bodies, downhill of Highway 76. The Lake Burton area was at one time drilled; however, no data are available regarding such drilling.

A thin-section analysis of one sample (LB-23, Table II) from the body contains fine-grained xenomorphic olivine and a minor amount of subhedral orthopyroxene(?). Serpentine (chrysotile?) occupies areas between the grains and also occurs as small veinlets within olivine and pyroxene grains. Magnetitie grains are evenly distributed, ovoid, and exhibit a crude alignment of their long axes. This alignment may reflect shearing related to emplacement of the bodies into their present structural positions. A chemical analysis of the dunite (LDB-1) is included in Appendix A.

BEAVERT MOUNTAIN SUITE

The Beavert Mountain suite is informally named for exposures of three altered ultramafic rock bodies on the southern and western slopes of Beavert Mountain in the northeastern section of the Dillard 7.5 minute topographic quadrangle, Rabun County (Figure 6). Exposures occur mostly in cuts and adits from abandoned asbestos prospects in the ultramafic bodies. The prospects have been described by King (1894), Hopkins (1914), and Cook (1978). No geologic maps were included in any of these older reports. It is not known when these prospects were abandoned.

The easternmost body is a dark, talc-serpentinite containing up to 30 percent magnetite based on a hand specimen from the prospect tailings. A few boulder exposures, composed almost entirely of serpentine (chrysotile?), occur near the apparent southern margin of the body. The northern contact of the body is exposed in an adit upslope from the prospect tailings. In this adit, the ultramafic body is predominately a strongly foliated, sheared, talc schist in sharp, concordant contact with metagreywacke of undifferentiated Tallulah Falls Formation described by Hatcher (1971, 1974) and German (1985).

The two western bodies (Figure 6) are exposed immediately west of and near the head of Beavert Branch of Betty Creek. The southernmost of the western bodies is a fine-grained, partially altered dunite (Sample D-23) containing a fine-grained talc scattered throughout an olivine matrix. As with the easternmost body (described above), the northern portion of the body is a sheared talc schist in concordant contact with a metagreywacke of the Tallulah Falls Formation. Elsewhere, the contact between the ultramafic body and

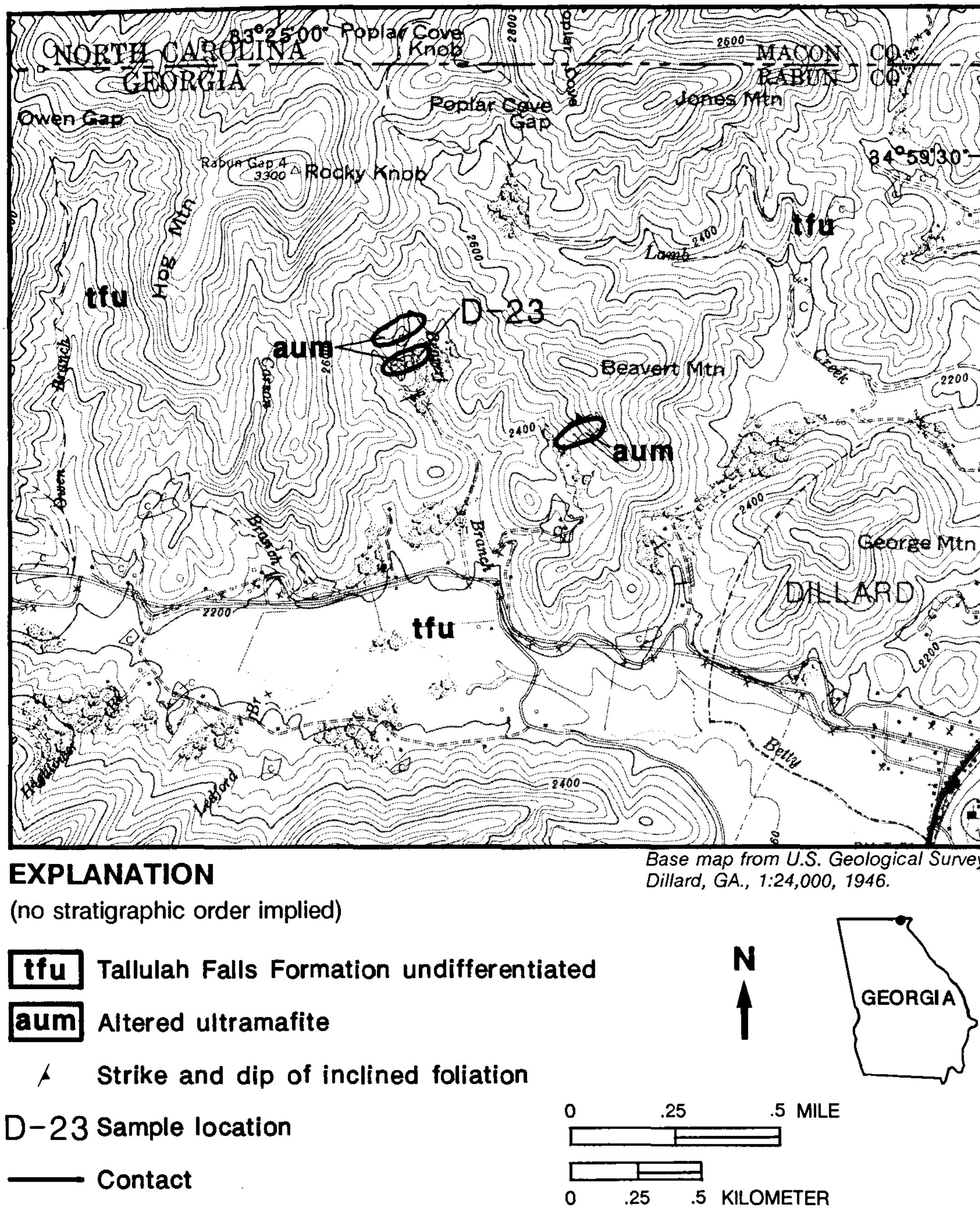


Figure 6. Location map of the Beavert Mountain suite, Rabun County (modified after German, 1985).

undifferentiated Tallulah Falls Formation is not observed, but is believed to be faulted. Immediately upslope from the talc schist is a weathered exposure of mica schist which areally separates the two western bodies. At its inferred southern margin, the northern body consists mostly of serpentinite which grades upslope into altered dunite similar to that in the southern body. As with the two other bodies in the suite, the northern margin of the northern-most body is a foliated talc schist. The contact between the ultramafic body and the undifferentiated Tallulah Falls Formation is not observed.

A thin-section from the southern body on Beavert Branch (sample D-23, Table II) indicates that the rock is composed predominately of a fine-grained xenomorphic mosaic of olivine. Anthophyllite is abundant (approximately 20 modal percent, Table II) and occurs as nonoriented, elongate, columnar fibers. Talc occurs as a distinct vein and in isolated clusters. Chrysotile is sparse and occurs as a few isolated veinlets.

LAUREL CREEK MAFIC-ULTRAMAFIC COMPLEX

The Laurel Creek mafic-ultramafic complex crops out along Laurel Creek in the Satolah 7.5 minute quadrangle, extreme northeastern Rabun County (Figure 7). This area was first described by King (1894), followed by Hopkins (1914), and Hatcher (1971). Petty (1982) mapped the area in detail.

The complex consists of distinct pods of mafic and ultramafic rocks within or adjacent to a garnet amphibolite of variable width (Figure 7). The largest pod (Figure 8) referred to as the Laurel Creek Mine (King, 1894) and the Laurel Creek olivine deposit (Hunter, 1941), consists of a dunite core surrounded by a hydration halo of serpentinized dunite, talc schist, soapstone and chlorite schist (Petty, 1982). In smaller bodies along strike (Figure 7) soapstone and serpentine predominate (Hatcher, et al, 1984; Petty, 1982).

The entire complex is emplaced within metagreywacke and amphibolite of the Tallulah Falls Formation (Hatcher, 1971), along what Petty (1982) proposed to be a premetamorphic thrust. Petty (1982) further suggests that the mafic rocks within the complex are compositionally similar to gabbro and may be mafic cumulates associated with ophiolite assemblages.

Corundum was first discovered in the Laurel Creek area in the early 1870's. In 1880, the largest ultramafic pod (Laurel Creek Mine) was mined for asbestos. Waste material from this mine consisted of "hard and heavy rock" which later that year was identified as corundum. From 1880 to 1892, the mine was one of the primary sources of corundum for the United States. In 1893, the mine was closed due to economic and mining conditions (King, 1894).

Approximately 2 km (1.25 m) northeast of the Laurel Creek Mine was the Hicks Asbestus [sic] Mine which reportably produced "considerable asbestos." Corundum was reported to occur at this locale; however, the area was believed to be "salted" (King, 1894). This mine may be the Reed Branch Mine (War Minerals Memorandum 1, 1942) which produced a limited amount of asbestos in 1941.

LAURA LAKE MAFIC COMPLEX

The Laura Lake Mafic Complex described in McConnell and Abrams (1984) and McConnell and Costello (1980) crops out in western Cobb and southern Cherokee Counties. The complex is the largest mafic complex in the northern Piedmont of Georgia (Figure 9); outcrop area is approximately 210 square km (80 square mi), extending from southeast of Canton, Cherokee County, to southwest of Marietta, Cobb County.

The Complex is composed predominantly of a variably migmatitic fine- to medium-grained garnet amphibolite with lesser amounts of pyroxene (relict?)-bearing metagabbro, quartz dioritic gneiss, mafic pegmatite(?), ultramafic rock, and banded iron formation (exhalative facies). Ultramafic rocks are a very minor phase of the Complex and are composed of chlorite and anthophyllite with little to no relict textures or mineralogy. Mafic pegmatite(?) is composed of coarse hornblende crystals in a quartz and feldspar matrix which may represent the anatectic partial melt fraction of the Complex and, therefore, the neosome in a migmatitic complex. Amphiboles in the neosome were observed up to 5 cm in diameter. Magnetite occurs as medium to coarse grains in the more felsic members, and grains as large as 0.5 cm across are common porphyroblasts in amphibolite. Along the western margin of the Laura Lake Mafic Complex, a distinct and mappable unit of intermediate gneiss is present. This gneiss is locally quarried for aggregate near Kennesaw and is quartz dioritic in composition. Hurst (1952) informally named this rock the Kennesaw gneiss, and McConnell and Abrams (1984) formalized its name as the Kennesaw Gneiss Member for exposures east of the town of Kennesaw. Mappable units of the Complex (figure 9) are: the Kennesaw Gneiss Member metaquartz diorite (11d), Laura Lake undifferentiated (11u) and ultramafic rock (um).

The Complex is exposed in Sandy Springs Group rocks within the Chattahoochee thrust sheet (McConnell and Abrams, 1984). Banded iron formation rocks (McConnell and Abrams, 1984) within the Complex appear to be chemically similar to New Georgia Group amhibolites. This similarity and their proximity (the Complex is immediately east of the New Georgia Group) has led to speculation by McConnell and Abrams (1984) that the two rock sequences may be related, and suggest the following hypotheses. The Complex may be: 1) a portion of the New Georgia Group exposed in a window through the Chattahoochee thrust sheet; 2) an intrusion of New Georgia Group rocks into the Sandy Springs Group; or 3) a slice of New Georgia Group rocks that, with the Sandy Springs Group, were thrust over rocks of the New Georgia Group along the Chattahoochee fault. Exposures are not

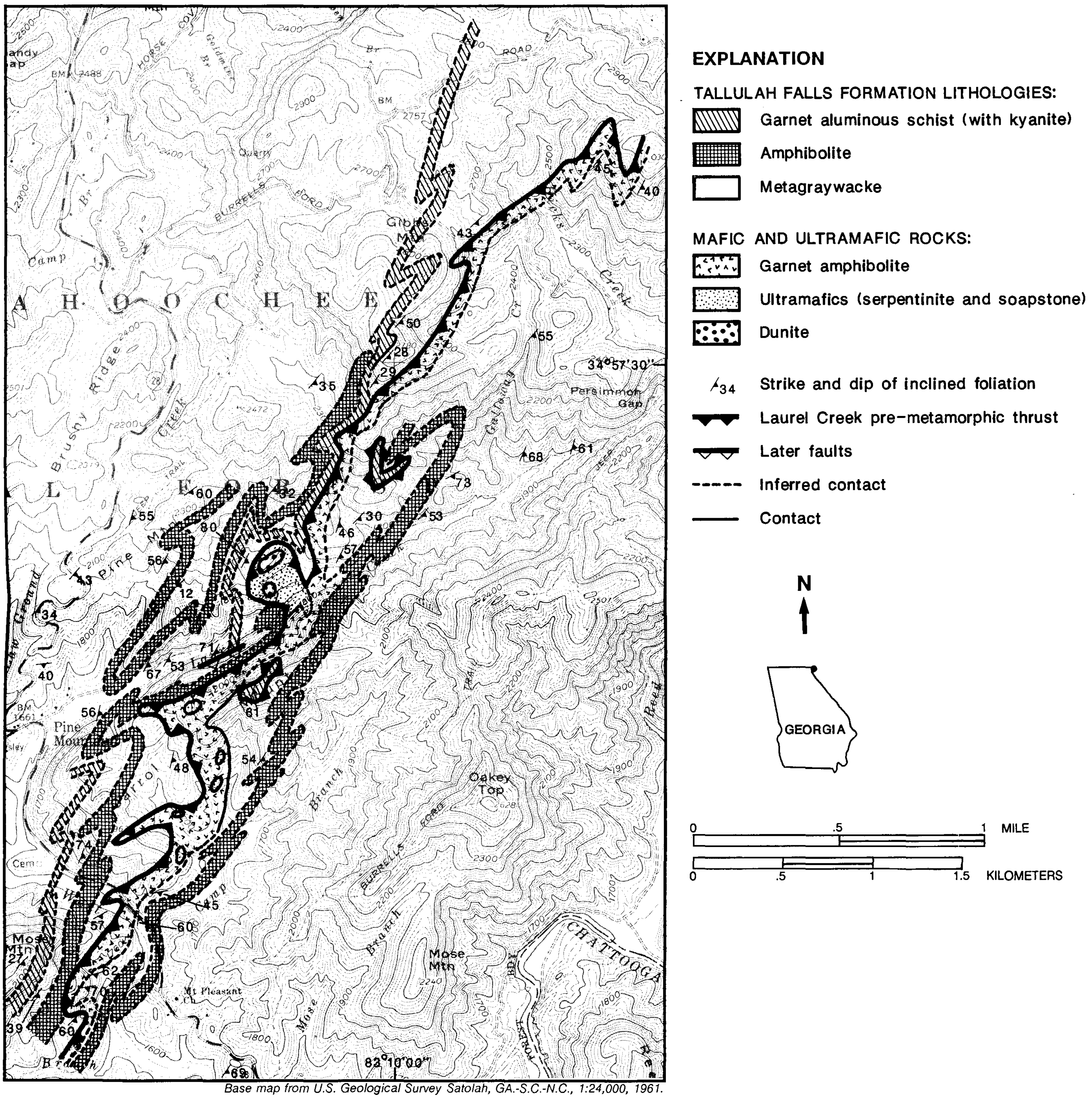


Figure 7. Location map of the Laurel Creek mafic–ultramafic complex (modified after Petty, 1982).

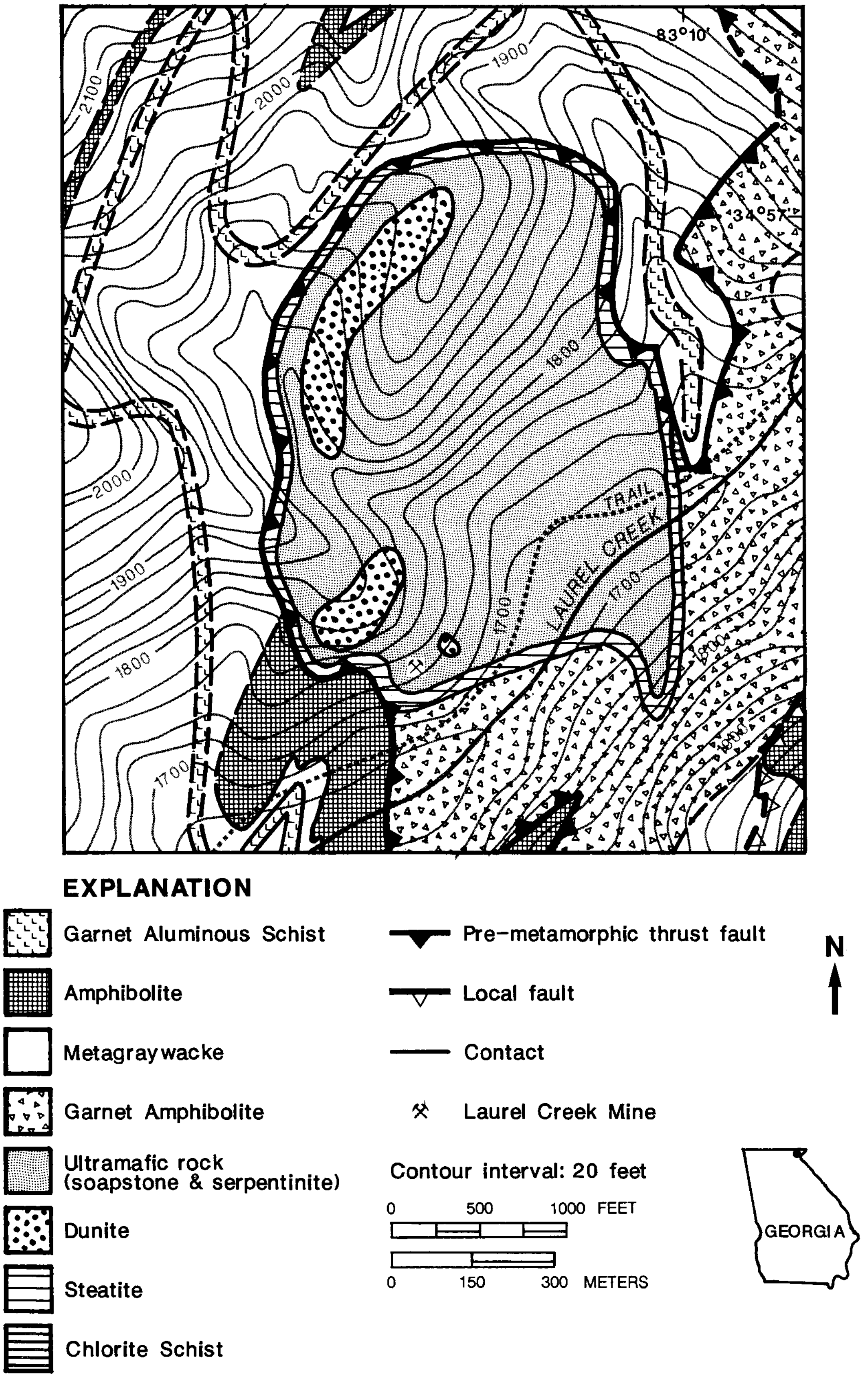


Figure 8. Generalized geologic map of the Laurel Creek Mine area (from Petty, 1982).

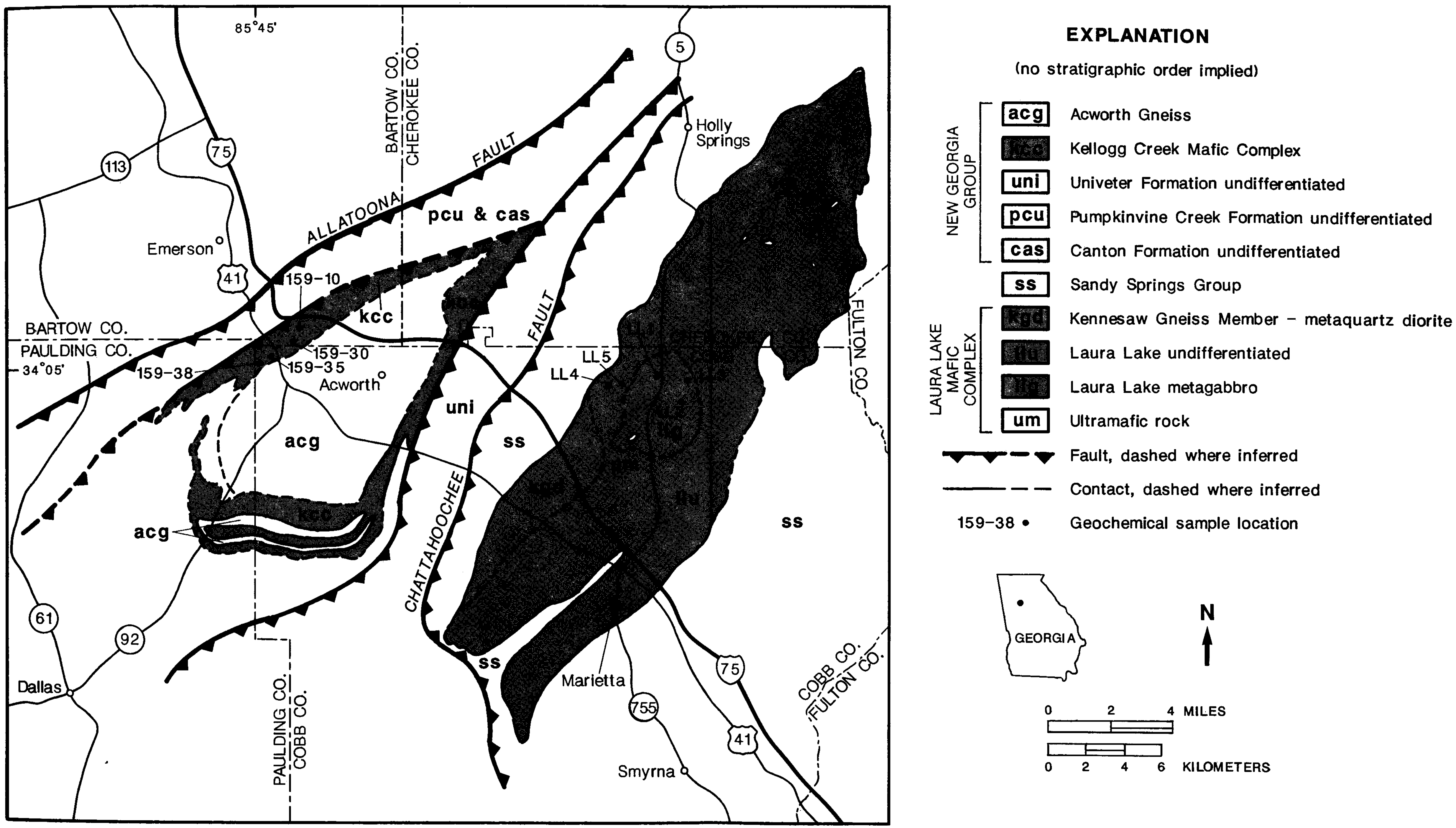


Figure 9. Location map of the Laura Lake Mafic Complex, Cobb and Cherokee Counties; and the Kellogg Creek Mafic Complex, Bartow, Cherokee, Cobb and Paulding Counties (modified from McConnell and Abrams, 1984).

sufficient to prove one interpretation over another, although McConnell and Abrams (1984) favor thrusting of the two groups along the Chattahoochee fault (Alternative 3).

Rocks of the Laura Lake Mafic Complex have been metamorphosed to the middle to upper amphibolite facies. While the specific metamorphic grade of Laura Lake rocks is not known, kyanite-bearing mica schists are exposed to the east of the outcrop area of the Complex. Migmatization and apparent partial melting within the Complex and the country rock, suggest a metamorphic grade of at least upper amphibolite facies.

Metagabbro, which retains a relict gabbroic texture, occurs near the center of the Complex in a roughly circular area. The metagabbro is neither uniform or continuous and locally grades into amphibolite which may reflect local variation of fluid pressure during metamorphism.

The metagabbro is weakly foliated to nonfoliated and contains interlocking amphibole grains with interstitial plagioclase. Amphibole also occurs as smaller inclusions within the plagioclase. The plagioclase is andesine in composition and is relatively unaltered. Amphibole generally makes up approximately 60 percent of the rock and plagioclase approximately 30 percent. Quartz, epidote, garnet and opaques are common accessory minerals. In one of the five samples from the metagabbroic facies, garnets occur as thin coronas on plagioclase grains.

Ultramafic rocks, cropping out as boulders of chlorite-actinolite schist, occur as thin lenses scattered sporadically throughout the outcrop area of the Laura Lake Mafic Complex. These rocks are dominantly composed of amphibole, relict(?) pyroxene, chlorite and opaques. Bladed grains of anthophyllite and tremolite are present in this facies. Pyroxene commonly comprises as much as 20 percent of the rock and is partially altered to hornblende. Chlorite occurs as both clinochlore and penninite and comprises approximately 15 percent of the rock.

Whole-rock and partial trace element chemical analyses of five samples from the metagabbroic facies of the Complex are listed in the appendix. Samples LL1, LL2, and LL3 (Figure 9) were obtained from within the metagabbro. As indicated in Appendix B, there is no apparent significant enrichment of chrome, nickel, cobalt and vanadium within the Complex. Additional whole-rock chemical analyses of the Complex are included in McConnell and Abrams (1984). Rogers and Lester (1953) reported the presence of titanite within and along the borders of pegmatite dikes north and west of Kennesaw Mountain.

KELLOGG CREEK MAFIC COMPLEX

Mafic and ultramafic rocks of the Kellogg Creek Mafic Complex (McConnell and Abrams, 1984) crop out in portions of Bartow, Cherokee, Cobb and Paulding Counties (Figure 9). The outcrop pattern of the Complex forms the limbs of a "tear-drop" shaped antiformal feature that is approximately centered on the town of Acworth. The Acworth Gneiss, a leucocratic, medium-grained biotite-quartz-plagioclase rock (McConnell and Abrams, 1984), occurs in the central part of this antiform.

The Kellogg Creek Mafic Complex and the Acworth Gneiss are both members of the New Georgia Group which is present in the northern Piedmont of Georgia, north and northwest of Atlanta (McConnell and Abrams, 1984). The New Georgia Group is a sequence of predominantly metavolcanic and metaplutonic rocks with lesser amounts of interlayered flysch-facies metagreywacke and schist. The vast majority of all massive sulfide and gold occurrences in the northern Piedmont of Georgia are hosted by rocks of the New Georgia Group; however, none are known to be associated with the Kellogg Creek Mafic Complex.

The Kellogg Creek Complex is composed of a complexly deformed assemblage of hornblende gneiss, amphibolite, medium-grained pyroxene(?)-amphibole-plagioclase gneiss (metadiorite-metagabbro), coarse-grained pyroxene(?)-amphibole-plagioclase rock (mafic pegmatite?) and ultramafic rock. Locally occurring ultramafic rocks vary in mineralogy from chlorite-anthophyllite bearing lithologies to serpentine talc and chlorite-bearing varieties.

The garnet-bearing mica schists of the Kellogg Creek Mafic Complex have attained a minimum of garnet grade metamorphism. Subsequent to this progressive metamorphic event, parts of the Kellogg Creek Mafic Complex were retrogressively metamorphosed along imbricate fault slices from the Allatoona thrust (McConnell, 1980). Retrogressive metamorphism locally altered the mineral assemblages within the complex to greenschist facies as indicated by the presence of chlorite and clinozoisite.

The outcrop pattern of the Complex outlines a bulbous antiformal structure that broadens to the southwest and tapers to the northeast. This northeastward tapering is characteristic of the entire New Georgia Group outcrop area. Internally, rocks of the Complex have textures that vary from largely undeformed metagabbroic and metapegmatitic(?) to well-foliated amphibolites. The availability of fluids during metamorphism and the location of the body relative to a major shear zone seem to have played the dominant role in the development of deformational fabrics in the Complex. In general, areas away from the margins of the Complex contain a greater proportion of rocks with relict igneous textures.

Intense shearing, suggested by textures in rocks along the margin of the Kellogg Creek Mafic Complex, and the presence of several different rock units along strike on the northern and southern outer margins of the Complex, suggest that the Kellogg Creek Mafic Complex is bordered by faults. Internal contacts, those within the bulbous antiformal structure, are characterized by complex interlayering and the presence of xenoliths of amphibolite within the Acworth Gneiss. These contacts are interpreted to indicate that the Kellogg Creek Mafic Complex is, at least in part, intrusive. Along the southwestern margin of the Kellogg Creek Mafic Complex, mafic rocks are in contact with garnet-mica schist and metagreywacke. These metasediments locally are similar to lithologies in the Sandy Springs Group (Higgins and McConnell, 1978) and were interpreted as klippe of the Chattahoochee thrust sheet exposed to the west of the main trace of the fault (McConnell and Abrams, 1984).

On the northwestern border of the Complex, metagabbroic rocks are in contact with felsic gneisses of the Pumpkinvine Creek Formation (McConnell, 1980; McConnell and Abrams, 1984). Textures indicative of intense shearing are common along this contact and the felsic gneisses of the Pumpkinvine Creek Formation are absent towards the north of Acworth. For these reasons, the northwestern contact of the Kellogg Creek Complex is interpreted as a fault (Crawford, 1976; McConnell and Abrams, 1984). However, the exact location of the northeastern portion of the fault is uncertain due to the similarity of amphibolites in the Pumpkinvine Creek Formation and amphibolitized portions of the Kellogg Creek Mafic Complex. Detailed chemistry and petrology may help to differentiate between the amphibolites in the two units and more accurately determine the contact.

On the southeastern margin of the Kellogg Creek Mafic Complex are rocks of the Univeter Formation (McConnell and Abrams, 1984), which are traceable from near Dallas, Georgia, northeastward to Helen. Along this regional trend, the Univeter Formation is successively in contact on the northwest with undifferentiated New Georgia Group rocks, the Kellogg Creek Complex, Pumpkinvine Creek and Canton Formations. The absence of these units along the regional trend of the northern contact of the Univeter Formation, and local evidence for shearing has led to a fault interpretation for this contact.

In hand specimen and thin section, rocks of the Kellogg Creek Mafic Complex display a wide range of textures and compositions. Generally, these textures include: salt and pepper amphibolite; fine- to medium-grained metadiorite and metagabbro; and medium- to coarse grained rocks composed of large grains of amphibole and relict pyroxene in a quartz and feldspar matrix. Few "true" ultramafic rocks occur within the Kellogg Creek Mafic Complex, and only medium-grained talc-chlorite rocks are associated with shear zones. Amphibolites of the Kellogg Creek Complex are poorly foliated and are composed of hornblende, zoisite, clinozoisite, plagioclase, pyroxene (relict?), and chlorite. Hornblende occurs as bladed or equant grains and as alteration rims around pyroxene. Larger hornblende grains commonly are poikiloblastic, with quartz inclusions. Plagioclase is generally altered to epidote and zoisite but locally occurs as unaltered grains that probably are of metamorphic origin.

Metagabbroic rocks are composed of large (up to 0.5 cm) hornblende grains in a groundmass of altered plagioclase, hornblende, zoisite, clinozoisite and chlorite (Figure 18). Opaques are rare. Hornblende grains are xenoblastic with serrated edges. Relict pyroxene occurs locally and is partially altered to hornblende. Saussuritization of plagioclase is quite extensive; local accumulations of epidote group minerals completely replace plagioclase. Chlorite occurs as a common alteration product of hornblende. Quartz occurs as secondary fracture fillings.

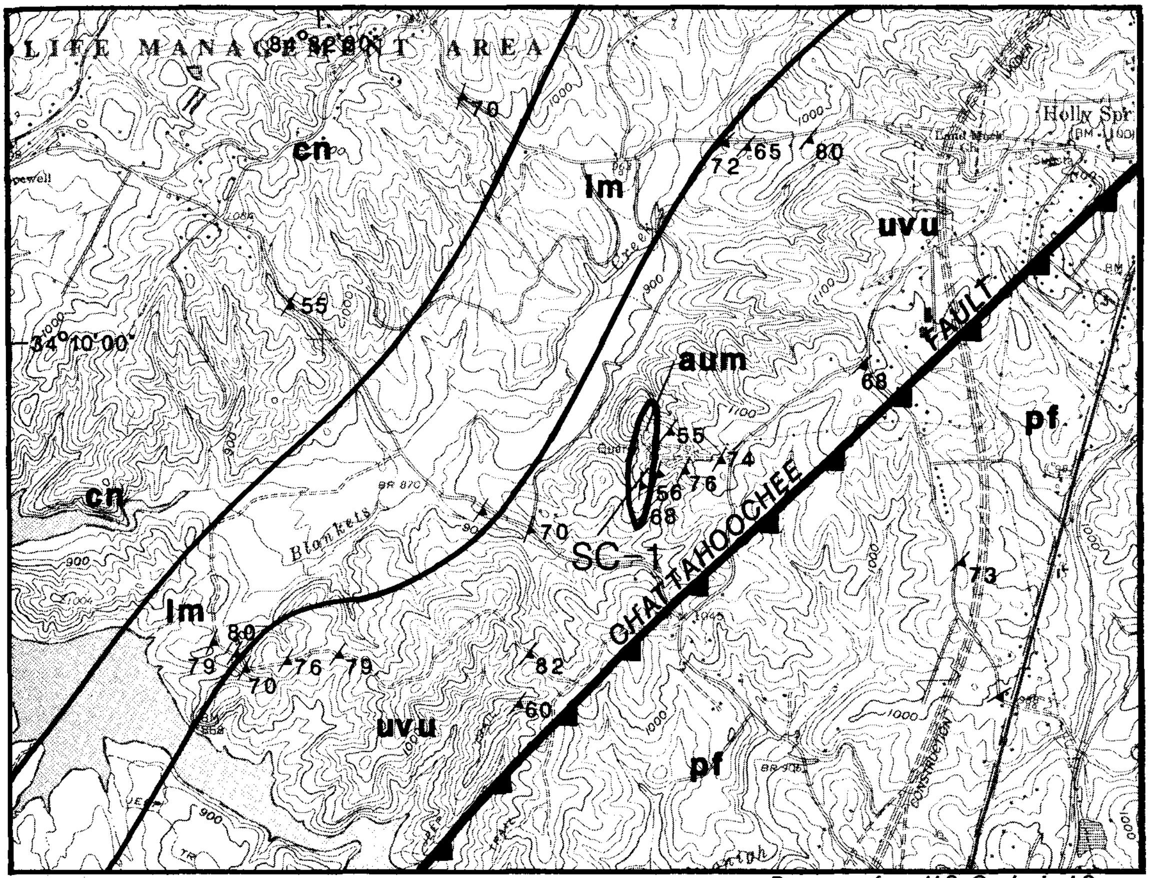
The metasomatic facies of the Complex is composed of large grains (up to 2 cm) of amphibole in a light colored, coarsely crystalline groundmass of epidote-group minerals and other tentatively identified minerals including akermanite, idocrase(?) and wollastonite(?). Minor chlorite and quartz are also present. Opaque minerals are rare. Four chemical analyses of samples from the Complex are listed in Appendix C. The mineralogy of this facies suggests either the presence of an intense alteration zone or the presence of primary, calcareous rock within the Complex. In hand-specimens, the texture of the metasomatic facies gives the appearance of a mafic hornblende-plagioclase pegmatite, however, the mineralogy suggests that the composition and texture may be the result of intense alteration prior to or during metamorphism.

HOLLY SPRINGS ULTRAMAFITE

The Holly Springs ultramafite is informally named for exposures approximately 2 kilometers (1.24 mi) southwest of the town of Holly Springs, Cherokee County, within the South Canton 7.5 minute quadrangle (Figures 9 and 10). The body is exposed in two adjacent, abandoned quarries (Hopkins, 1914) and was once used as a source of "verde antique," an ornamental building stone. The ultramafite is inferred to be ellipsoidal in shape and has an exposed width of less than 100 meters and length of less than 600 meters. Lithologies observed in the quarries are massive, altered ultramafic rock and talc-chlorite schist with veins of coarse dolomite and chlorite. The massive material is a dark-green, aphanitic rock criss-crossed by veinlets of serpentine. Fine- to medium-grained magnetite is abundant in the rock and locally occurs in dense concentrations.

The ultramafite is emplaced within the Univeter Formation (McConnell and Abrams, 1984). Within the immediate vicinity of the Holly Springs ultramafite, the Univeter Formation consists of an interlayered sequence of garnet-mica schist, biotite-quartz schist, amphibolite. Foliation of enclosing lithologies, trends nearly north-south and dips approximately 70 degrees to the south. Several meters away from the exposed body, the average foliation of enclosing schists is approximately N35°E near the ultramafite's margins.

A thin section of massive ultramafite (sample SC-1, Table II) reveals a fibrous, nonfoliated texture comprised predominantly of fine-grained, subhedral grains of carbonate in a matrix of fine-grained chlorite and talc. Although there is no overall foliation, talc and chlorite exhibit local alignment. Coarse-grained carbonate is also present. Magnetite is evenly distributed throughout and occurs as subrounded grains with dimensions very similar to the



Base map from U.S. Geological Survey South Canton, GA., 1:24,000, 1985.

EXPLANATION

(no stratigraphic order implied)

cn	Canton Formation
aum	Altered ultramafite
lm	Lost Mountain Amphibolite
pf	Powers Ferry Formation
uvu	Univeter Formation undifferentiated
70	Strike and dip of inclined foliation
SC-1	Sample location
——	Contact
▼	Thrust fault

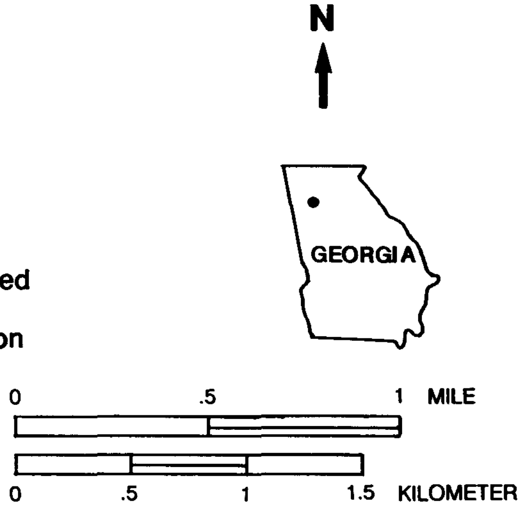


Figure 10. Location map of the Holly Springs ultramafite, Cherokee County.

carbonate. Magnetite grains have uneven boundaries, which most likely are a result of non-penetrative fracturing.

A thin-section of a schistose ultramafic rock (sample SC-1a, Table II) obtained from the margin of the body, reveals a pronounced foliation defined by aligned veins of fibrous talc and the long axes of lenticular carbonate augen. Magnetite grains offset the foliation to a slight degree and occur in the same form as in sample SC-1 but exhibit fracturing to a greater extent along their margins.

CARROLLTON SUITE

This suite is informally named for five ultramafic bodies that crop out within the Carrollton 7.5 minute quadrangle east of Carrollton, Carroll County (Figure 11). Rocks of this suite consist of talcose serpentinite with local occurrences of chloritic schist. The ultramafites are lenticular in map view and have an average strike of N30°E, which is generally parallel to the strike of the foliation enclosing lithologies. The largest body in the suite was identified and mapped by Crawford (1970). Lithologies surrounding the suite are locally schistose granitic gneiss with hornblende-rich interlayers. McConnell and Abrams (1984) included these ultramafic as part of their Dog River Formation and interpreted them as a chlorite alteration assemblage. The suite was once prospected as a source for talc and asbestos (Hopkins, 1914) although economic potential is limited by the small size of the bodies and proximity to the Carrollton city limits.

SOUTHERN PIEDMONT MAFIC AND ULTRAMAFIC ROCKS

INTRODUCTION

The southern Piedmont province of Georgia, as referred to in this report, is the area of exposed crystalline rock south of the Brevard fault zone and north of the Fall Line (Figure 1). Rocks of the southern Piedmont consist predominately of low- to high-grade metasediments and felsic to mafic metavolcanic gneisses, schists and migmatites, and pre- to post-kinematic granitic plutons. South of the Towaliga fault, King (1955) and Overstreet and Bell (1965) subdivided the southern Piedmont into the medium- to high-grade Kings Mountain, Charlotte, and Kiokee belts and low-grade Carolina slate belt. However, reconnaissance mapping by the authors [present study and Vincent (1984)] suggests that the Charlotte belt and at least part of the Carolina slate belt in Georgia represent a single, continuous, volcano-sedimentary depositional event. This relationship was proposed for the Charlotte and Carolina slate belts along the North Carolina-Virginia border by Tobisch and Glover (1969).

Numerous mafic and ultramafic rock bodies occur within Monroe, Jasper and Putnam Counties. Those bodies found in Monroe County were initially interpreted as cupolas on a post-metamorphic batholith (Mathews, 1967; Prather, 1971; and Carpenter and Prather, 1971). These workers identified mafic hornfelsic rock bordering the intrusions; the hornfels were considered to be the result of thermal contact metamorphism of the country rock. Hatcher and others (1984) recognized poly-deformational effects within these "aureoles" and suggested that the hornfels represented hydrated reaction zones along the margins of the mafic intrusions.

Higgins and others (1984) proposed that all mafic and ultramafic rocks found south of the Towaliga fault are part of a melange assemblage termed the Macon melange. They proposed that portions of the Charlotte, Kiokee, Kings Mountain, Pine Mountain, and Inner Piedmont belts are part of this melange. According to this model, the Juliette slice of the Macon melange, which is characterized by an abundance of mafic and ultramafic "clasts" (up to 16 km long and 3 km wide), consists of dismembered portions of an ophiolite sequence.

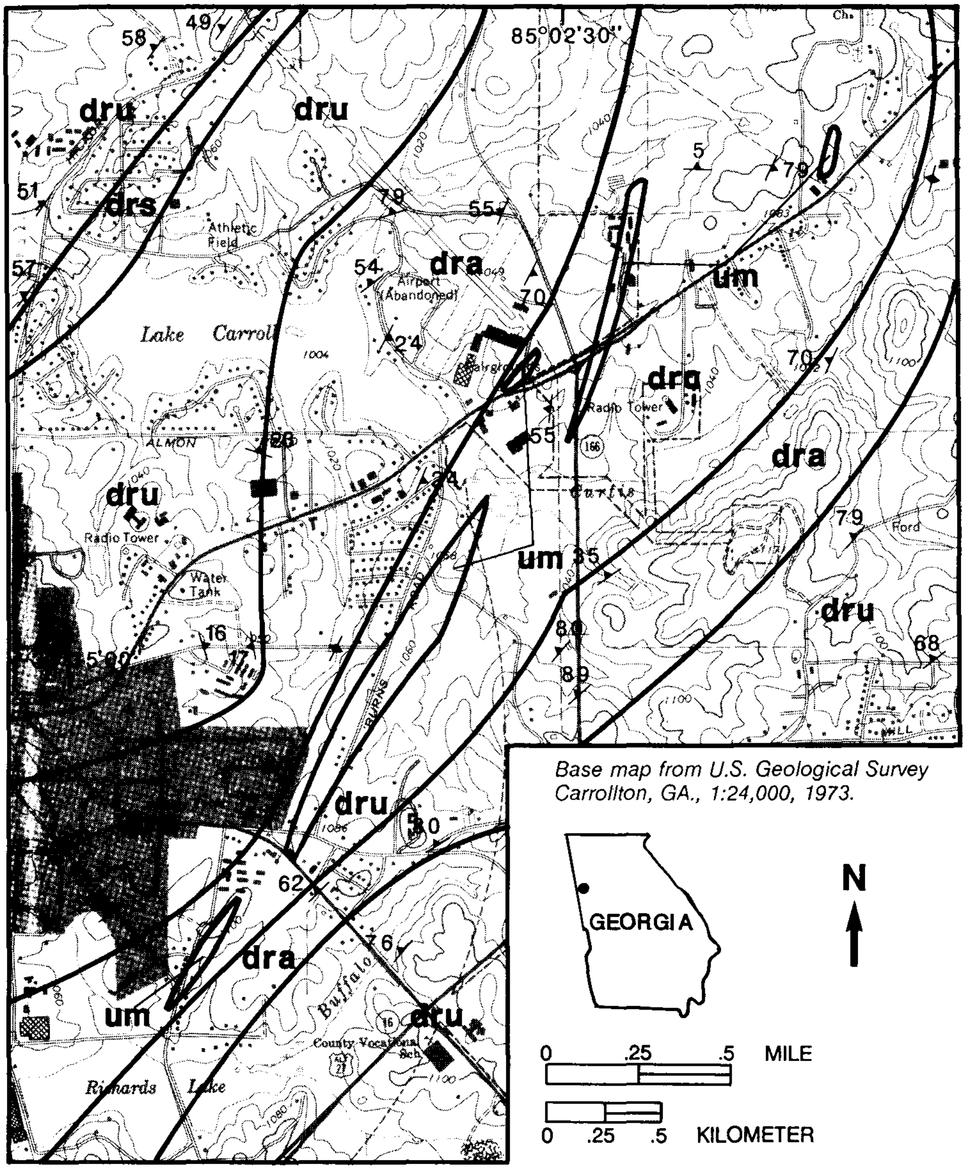
Mapping and geochemical studies within the Monroe, Jasper and Putnam Counties area by Hatcher and others (1984) and Hooper (1986) indicate that the mafic and ultramafic rocks are all related and part of an island arc mafic complex rather than melange. Hooper (1986) called this the Berner mafic complex and suggests that the Berner complex is the spatial equivalent to Avalon terrane rocks of the Charlotte belt and Carolina slate belt defined by Williams and Hatcher (1983). Hooper (personal communication) has not determined the northeast boundary of the Berner complex, but suggests that it extends to at least the Siloam Granite in east Putnam County and Greene County.

The Soapstone Ridge Complex (Higgins and others, 1984; Higgins and Atkins, 1981) is a disrupted ophiolite complex located within the Atlanta metropolitan area. This body was first described by King (1957).

Numerous ultramafic rocks are confined within an east trending zone at Pollard's Corner, Columbia County (Hopkins, 1914; McLemore, 1965). These ultramafic rocks were previously mined for epsom salts.

SOAPSTONE RIDGE COMPLEX

The Soapstone Ridge Complex (Higgins and others, 1980; Higgins and Atkins, 1981) is an areally extensive (greater than 4 km, 2.5 mi) and disrupted ophiolite complex, consisting of mafic and associated ultramafic rock occupying Soapstone Ridge and vicinity within the Southeast Atlanta 7.5 minute quadrangle, Clayton, DeKalb and Fulton Counties (Figure 12). Hopkins (1914) first described the ultramafic rocks of Soapstone Ridge as altered pyroxenite in his bulletin on talc and soapstone deposits in Georgia. King (1957) described the following lithologies at Soapstone Ridge: hornblendite, actinolite-chlorite schist, anthophyllite schist, chlorite-magnetite schist, diopside gabbro, feldspathic amphibolite, metagran-



EXPLANATION

(no stratigraphic order implied)

um Ultramafic

dru Dog River Formation undifferentiated

dra Dog River amphibolite

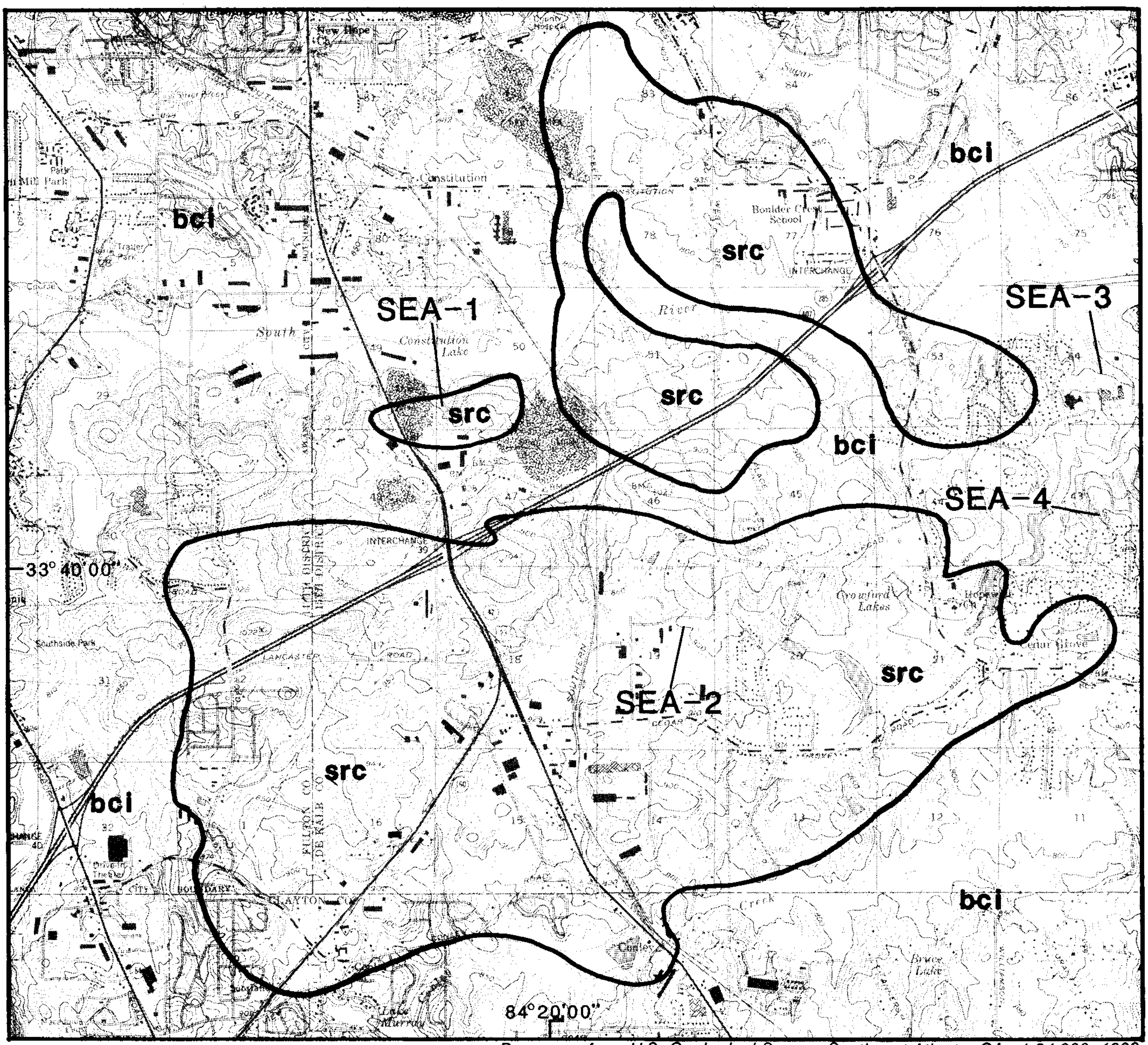
drs Dog River schist

70 Strike and dip of inclined foliation

Strike and dip of vertical foliation

Contact

Figure 11. Location map of ultramafic rock near Carrollton, Carroll County (from German, 1988).



Base map from U.S. Geological Survey, Southeast Atlanta, GA., 1:24,000, 1983.

EXPLANATION

(no stratigraphic order implied)

src Soapstone Ridge Complex

bci Big Cotton Indian Formation: biotite gneisses, amphibolites and minor schist

SEA-1 Sample location

—— Contact

0 .5 1 MILE

0 .5 1 1.5 KILOMETERS

N

Figure 12. Location map of the Soapstone Ridge Complex, Clayton, DeKalb and Fulton Counties (from McConnell and Abrams, 1984).

ite and mylonitic, quartz-sillimanite schist. He suggested that the mylonitic sillimanite schist, being structurally beneath the Soapstone Ridge ultramafic rock, represented a thrust fault upon which ultramafic rock body was emplaced. This interpretation was supported by Higgins and Atkins (1981) who formally named the ultramafic rocks in this area as the Soapstone Ridge Complex. They believe that the Complex was thrust into its current structural position in early Middle Ordovician time, and that it was folded during and after its emplacement. The Complex is now less than 200 meters (656 ft) thick.

Numerous erosional windows are observed within the Complex; however, the location map of the Complex (Figure 12) indicates only the largest of these windows. Granites and granite gneisses are present throughout the Complex. Some of these granites and granite gneisses are thought to be pre-thrust and therefore transported into place, whereas most are thought to be post-thrust intrusions with an approximate age of 325 m.y. (Higgins and Atkins, 1981).

Chemical analyses of three samples taken from the Soapstone Ridge Complex (SEA-1, SEA-2, SEA-3) are included in Appendix D. Blake (1982) described the mineralogical characteristics of some of the amphiboles in the Complex; few of which occur in an asbestiform habit.

WHITEWATER CREEK METAGABBRO

A small (650 m by 625 m; 2000 ft by 1900 ft) metagabbro informally named the Whitewater Creek metagabbro is exposed as boulder outcrop immediately west of Whitewater Creek in the Glenn 7.5 minute quadrangle, Heard County (Figure 13). The metagabbro is medium-grained with rare occurrences of pyroxene porphyry. Exposures are most obvious along a secondary road intersecting the metagabbro (Figure 13). The surrounding country rock is a coarse-grained biotite granite gneiss; however, intense weathering has concealed the gabbro-granite gneiss contact.

Thin-sections (samples of GL-1 and GL-2, Table III) indicate that hornblende and augite are the dominant mafic minerals. Augite is relatively unaltered. Hornblende occurs as an alteration of an original clino-pyroxene and has retained the cleavage and schiller luster characterisitic of diallage. Sample GL-1 (Table III) is extensively altered and contains minor amounts of secondary quartz and feldspar, both of which occur as small, widely scattered aggregates. Replacement of plagioclase by clinozoisite is pervasive throughout sample GL-1; whereas, the plagioclase in GL-2 is unaltered. A chemical analysis of a sample from the rock body (sample GL-2) is listed in Appendix D.

MORNING CREEK METAPYROXENITE

This body is informally named for exposures of metapyroxenite occupying a small knoll immediately west of Morning Creek in the southernmost part of the Riverdale 7.5 minute quadrangle, Fayette County (Figure 14). The body is a dark- green, medium-grained, nearly equigranular metapyroxenite. The metapyroxenite is foliated near the margins of the unit; however, the contact with the country rock is not exposed. An area of outcrop and boulder float east of Morning Creek is gabbroic in composition, and may be a dike associated with the intrusive body.

TABLE III

ESTIMATED MODAL PERCENTAGES OF SAMPLES FROM THE WHITEWATER CREEK METAGABBRO AND MORNING CREEK METAPYROXENITE

	Whitewater Creek		Morning Creek Metapyrozenite		
	GL-1	GL-2	RIV-1	RIV-2	RIV-2a
Carbonate	tr.				
Chromite(?)	tr.			tr	tr.
Clinozoisite	3	tr.		3	5
Epidote	tr.			4	
Hornblende	62	75	55	84	93
Magnetite	tr.	tr.		tr.	tr.
Microcline	tr.				
Plagioclase	tr.	3	25	7	1
Pyroxene	33	21	20	1	
Quartz	1				
Sericite	tr.				

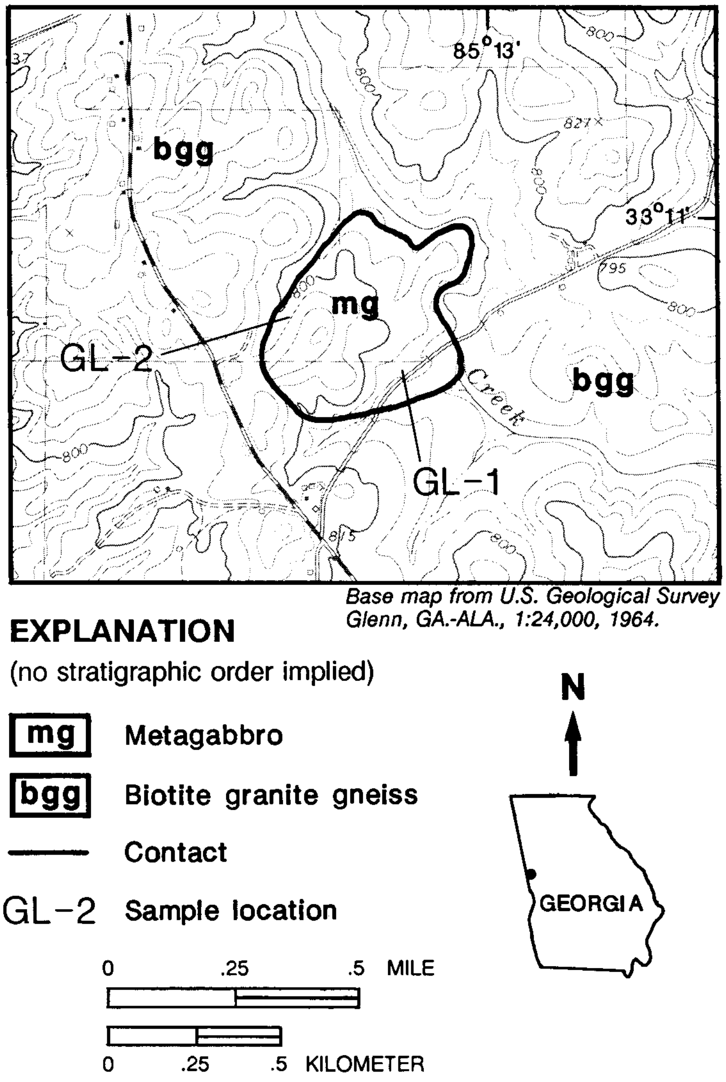
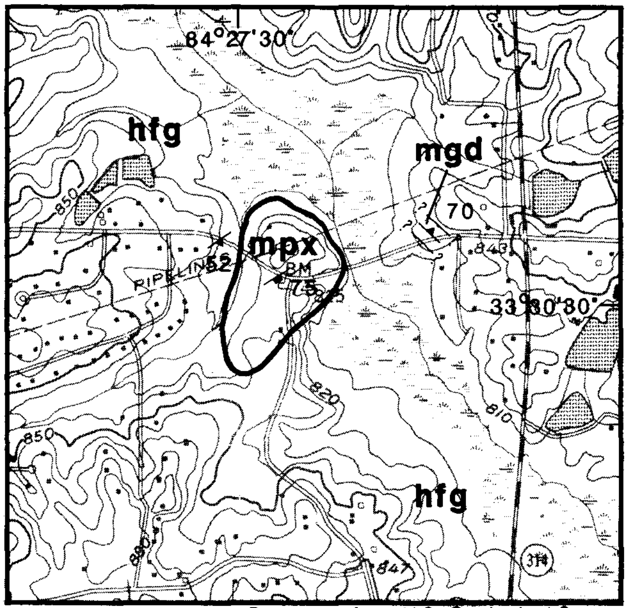


Figure 13. Location map of the Whitewater Creek metagabbro, Heard County.



Base map from U.S. Geological Survey Riverdale, GA., 1:24,000, 1982.

EXPLANATION

(no stratigraphic order implied)

N

mpx Metapyroxenite

hfg Hornblende felsic gneiss

mgd Metagabbroic dike

52 Strike and dip of inclined foliation

75 Strike and dip of inclined jointing

Contact

0 .25 .5 MILE

0 .25 .5 KILOMETER

Figure 14. Location map of the Morning Creek metapyroxenite, Fayette County.

Samples taken from the metapyroxenite (RIV-2 and RIV2a, Table III) are composed almost entirely of interlocking, equant, non-aligned hornblende. Plagioclase (An_{60}) occurs either as a few fine-grained, isolated aggregates rimmed by clinozoisite or as relict grains almost totally clouded by clinozoisite. The hornblende is a replacement of pyroxene. Augite is rare.

A single thin section sample from the intrusive dike (RIV-1, Table III) reveals a pronounced foliation defined by alignment of subhedral hornblende and augite. Plagioclase occurs in an intergranular form and is concentrated in aggregates parallel to the foliation. The presence of augite and plagioclase suggests that this dike may represent a differentiated phase of a pyroxenite magma.

DURHAM TOWN METAGABBRO

The Durham Town metagabbro is informally named for exposures near the community of Durham Town, in the extreme northeastern corner of Greene County, Georgia (Figure 15). The mafic body consists of metagabbro surrounded by interlayered micaceous quartzo-feldspathic gneiss, biotite schist, and amphibole-biotite schist. These surrounding lithologies are interpreted as metasedimentary and metavolcanic rocks. The presence of hornblende gneiss and gabbro was first noted by Hopkins (1914). Medlin (1964) and Medlin and Hurst (1967) summarized the geology of the area and noted the presence of copper and gold mineralization.

The rocks in the area surrounding the metagabbro are lithologically similar to metavolcanic and metasedimentary units mapped to the south by Vincent, (1984). Country rocks near the metagabbro have been metamorphosed at lower to middle amphibolite facies and consist of micaceous quartzo-feldspathic gneiss interlayered with amphibole-biotite schist and biotite-muscovite schist. However, on the northern side of the metagabbro, the country rocks exhibit pronounced cataclastic textures and appear to be at a lower grade of metamorphism (upper greenschist to lower amphibolite facies). This may be due to their proximity to the northeast-trending Middleton-Lowndesville fault zone, which lies approximately one to two km (0.6 to 1.2 mi) north of the study area.

The Durham Town metagabbro is a relatively homogeneous, porphyritic metagabbro composed of relict phenocrysts of hornblende, variably altered to actinolite in a groundmass of plagioclase laths altered to fine- to medium-grained, subhedral to euhedral clinozoisite and epidote. The only notable variation in mineral content between samples from the gabbro is the proportion of clinozoisite to epidote (Samples PH-5 and W-1, Table IV). A chemical analysis of W-1 is included in Appendix D.

Except for two exposures of equigranular metagabbroic rock near the inferred southern contact of the body, the porphyritic texture is consistent throughout. Exposures of the metagabbro are poor, consisting predominately of isolated boulders of float and dark reddish-brown saprolite. Consequently, contact relations with surrounding schists and gneisses are uncertain and emplacement history of the metagabbro is not known.

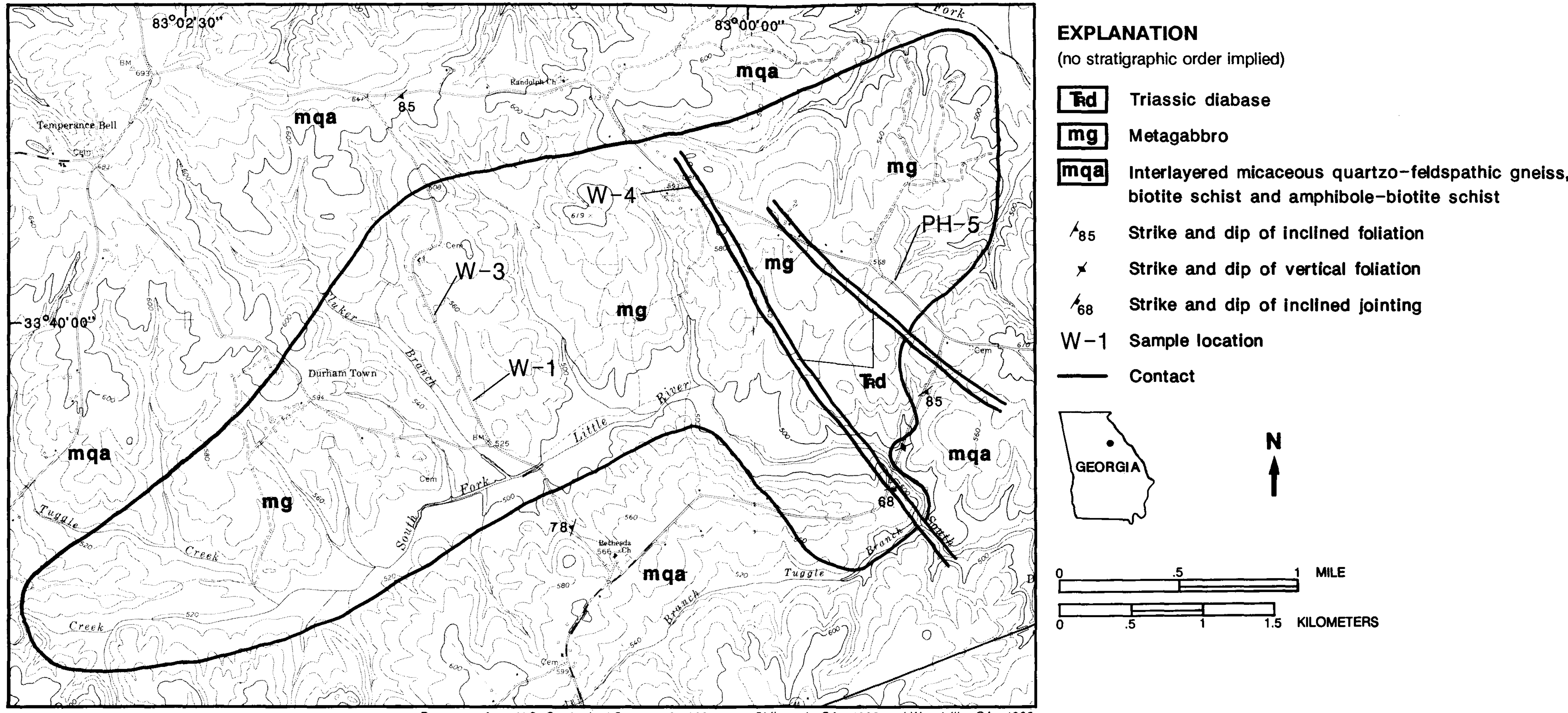
At least two unmetamorphosed (Mesozoic?) diabase dikes have intruded the gabbro. The diabase occurs as float throughout the area and is noticeably concentrated in the eastern section of the gabbro.

Isolated outcrops of mafic rock (not shown on Figure 15) occur to the south and northwest of the metagabbro

TABLE IV

ESTIMATED MODAL PERCENTAGES OF SAMPLES FROM THE DURHAM TOWN METAGABBRO

	PH-5	W-1	W-3
Antigorite			
Augite			
Clinozoisite	35	1	5
Epidote	1	25	25
Hornblende	63	68	68
Magnetite	tr.	tr.	tr.
Olivine			
Plagioclase	tr.	5	1
Quartz			tr.
Sphene			tr.
Uralite		tr.	tr.



Base map from U.S. Geological Survey 1:24,000 maps: Philomath, GA., 1966 and Woodville, GA., 1965.

Figure 15. Location map of the Durham Town metagabbro, Greene County.

(Medlin, 1964, Medlin and Hurst, 1967). Approximately 1 km (0.5 mi) west of the crossroads community of Bethesda, in the extreme southeast corner of the Woodville 7.5 minute quadrangle, a few float boulders of chlorite schist occur in the north side of Georgia Highway 44. According to Medlin and Hurst (1967), the "main" chlorite schist outcrop is located approximately 500 feet south of the highway. This outcrop was not located by the authors of this report. In the south-central part of the Woodville 7.5 minute quadrangle at Flint Lake and along a secondary road north of Georgia Highway 44, Medlin and Hurst (1967) mapped exposures of metapyroxenite. The present writers observed several float cobbles of weathered chlorite-actinolite schist along Highway 44 and along the secondary road approximately 0.76 kilometers south of Thornton Creek. It is uncertain whether these small outcrops are related to the Durham Town metagabbro.

Medlin (1964) and Medlin and Hurst (1967) noted the presence of copper and gold mineralization in the area. Gold was extracted in commercial quantities from 1852 to 1875 (Jones, 1909). It is not known when the gold mining activity was abandoned. In 1960, a copper prospect was drilled by the Tennessee Copper Company; no significant mineralization was intersected (Otis Gibson, personal communication, cited in Medlin and Hurst 1967). The presence of iron, manganese and pegmatite dike were also noted in the area of the gabbro by Medlin and Hurst (1967).

BURKS MOUNTAIN SUITE

The Burks Mountain suite is informally named after Burks Mountain, a distinct topographic feature in the Evans 7.5 minute quadrangle in northern Columbia County (Figure 16). Topographic relief in this area is greater than in any other part of the southern Piedmont in eastern Georgia. The Burks Mountain suite lies approximately 14 km (9 mi) north of the Coastal Plain onlap, approximately 9.5 km (6 mi) south of the Modoc zone of cataclastic rocks and occupies part of the northwestern flank of the Kiokee belt. Kiokee rocks are typically an interlayered sequence of micaceous quartzo-feldspathic gneiss, amphibole-biotite schist, and biotite-muscovite schist. They are similar in appearance to metasedimentary and metavolcanic lithologies of the Carolina slate belt and Charlotte belt north of the Modoc fault zone, but are of higher metamorphic grade (staurolite subfacies, almandine-amphilolite facies) than Carolina slate belt rocks and have undergone a more intense deformation. Kiokee belt rocks within the study area have a preponderance of micaceous quartzo-feldspathic gneisses compared to the mafic schists. These mafic schists apparently exist as discontinuous lenses and layers and crop out only locally.

Mafic and ultramafic bodies in this area exist as discontinuous pods of varying sizes and are confined to an east-west trending zone 12.5 km (8 mi) long and 1.5 km (1 mi) wide. The bodies are concordant to the surrounding regional foliation.

Hopkins (1914) and LeGrand and Furcron (1956) briefly described the ultramafic rocks of this area. Worthington (1964) reported nickel concentration in the saprolite ranging from 0.083% to 0.462%. McLemore (1965) mapped the area in detail and identified a zone of relatively pure talc. McLemore's geologic map has been modified for this report.

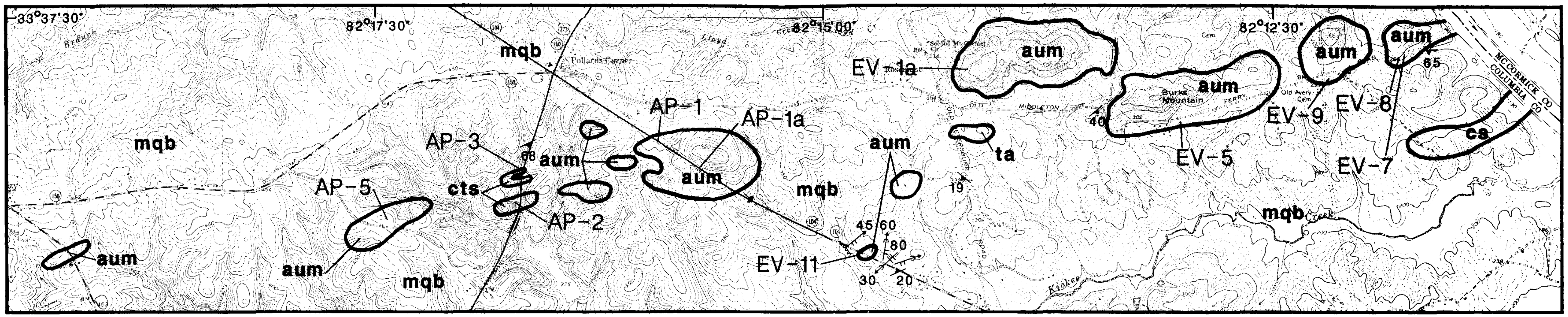
Mafic bodies of the Burks Mountain suite consist predominately of serpentine ± talc ± silica rock. Chlorite ± talc schist locally occurs either within the smaller bodies or near the inferred contacts of bodies exposed on Burks and Dixie Mountains. Mafic rocks occupy prominent topographic highs at Burks and Dixie Mountains due to the presence of silica (drusy quartz) as an alteration of serpentine. In outcrop, the altered (siliceous) mafic rocks have a distinctive, fine grained, flinty appearance and commonly contain visible grains of magnetite ranging from 0.25 to 0.50 centimeters in diameter. Although exposures of the smaller rock bodies are common, rocks underlying Burks and Dixie Mountains only occur as boulder float along the slopes and at the bases of the two mountains. Anthophyllite ± talc rock with siliceous material occurs in lesser abundance. A weathered, serpentinized dunite(?), which retains its original texture, occurs as a fine grained rock with megascopic magnetite on the south side of Burks Mountain and within a small rock body approximately 3.1 km (2 mi) south of Pollards Corner.

Material that can be classified as pure or near-pure talc occurs within the study area. The largest exposure, which is podiform in shape, was observed in a roadcut approximately 1.6 km (1 mi) north of Georgia Highway 104 on the Old Petersburg Road. This talc pod crops out within micaceous quartzo-feldspathic gneisses and biotite-muscovite schists of the Kiokee belt.

Thin sections of samples from the Burks Mountain suite (Table V) reveal at least three distinct lithofacies, based on differences in texture and mineral content. These appear due to varying alteration conditions and intensities. One lithofacies consists of serpentinite formed from dunites. These usually have their original intrusive textures preserved. Sample EV-5 reveals a mosaic of highly altered olivine exhibiting a fine-grained, equigranular, and saccharoidal texture typical of a dunite. Little original olivine remains however, and rocks are dominated by serpentine and iddingsite pseudomorphs. Sample EV-8 consists predominately of cross fiber chrysotile and anthophyllite. This rock contains remnant olivine which exhibits a cumulate texture with minor amounts of scapolite(?) and intercumulate plagioclase.

Rocks of the second lithofacies are mafic schists with schistosity defined by alignment of chlorite, anthophyllite, or talc (samples EV-la, EV-7, EV-9, and AP-3) grains. A cross-fiber texture is commonly present and is best shown by chlorite occurring in isolated clusters. Talc generally has a platy form, and is found in all three lithofacies.

Third facies rocks are a dense, siliceous talc-chlorite rock. Weathered samples commonly have pitted surfaces



Base map from U.S. Geological Survey 1:24,000 maps: Appling, GA., 1981; Clarks Hill, GA.-S.C., 1964; Evans, GA.-S.C., 1980 and Leah, GA., 1971.

EXPLANATION

(no stratigraphic order implied)

ta	Talc
mqb	Muscovite quartz
cts	Chlorite-talc schist
cs	Chlorite schist
aum	Altered ultramafite

AP-1	Sample location
68	Strike and dip of inclined foliation
	Strike and dip of vertical foliation
45 50	Bearing and plunge of crenulation cleavage

Bearing and plunge of minor fold axis:

60 80	antiform
30	synform
	Contact

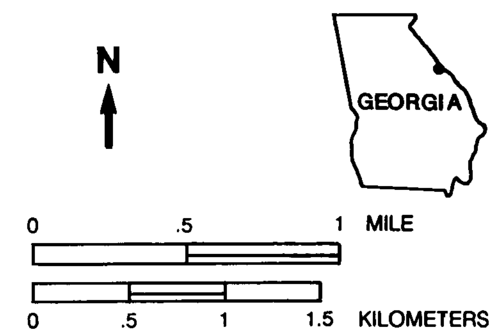


Figure 16. Location map of the Burks Mountain suite, Columbia County.

TABLE V

ESTIMATED MODAL PERCENTAGES OF SAMPLES FROM THE BURKS MOUNTAIN SUITE

	EV-5	EV-8	EV-11	EV-1a	EV-7	EV-9	AP-3	AP-1	AP-1a	AP-2	AP-5
Anthophyllite		51			5	25					
Antigorite?/Serpentine	90	tr.	90								
Apatite							tr.				
Chlorite	tr.		tr.	90	3	74	81			5	
Chromite(?)								25	15	tr.	
Chrysotile		35									
Magnetite	4	3	4	10	1	tr.	15	1	6	1	5
Olivine		10									
Periclase(?)	tr.		tr.								
Perovskite					tr.						
Quartz				tr.				72	20	68	60
Scapolite		1			1						
Talc	5		5		90	tr.	4	1	59	tr.	15
Uralite								tr.		25	20

that are filled with drusy quartz. The presence of quartz (ranging from 20 to 75 modal percent) reflects a supergene enrichment due to the inherent instability of ultramafic rock that has been exposed at the surface (samples AP-1, AP-1a, AP-2, and AP-5). The presence of excess silica is commonly interpreted as a product of hydration reactions such as the following (unbalanced equation):

$$MgSi0_2 + H_20 = H_2Mg_3Si_20_9 + Mg0 + Si0_2$$

enstatite + water introduced = serpentine + manganese oxide + silica (quartz)

Replacement quartz, after olivine, exhibits pronounced undulatory extinction and commonly contain fine inclusions of opaque minerals (chromite (?) and magnetite). Both talc and chlorite tend to occur in isolated clusters, a feature more common in other facies.

Opaque minerals occur in all samples analyzed from the suite. Magnetite is by far the most abundant opaque mineral and exhibits a wide variation in abundance. It occurs either as fine, widely scattered grains; as discreet aggregates; or as broken, relict grains. In some samples (EV-7, and AP-2) magnetite tends to be concentrated in aggregates with chlorite and talc. Chromite(?) appears to be restricted to rocks of the third facies and, like magnetite, varies widely in modal percent. The highest modal percent chromite (?) was observed in sample AP-1 (25 percent visual estimate, Table V).

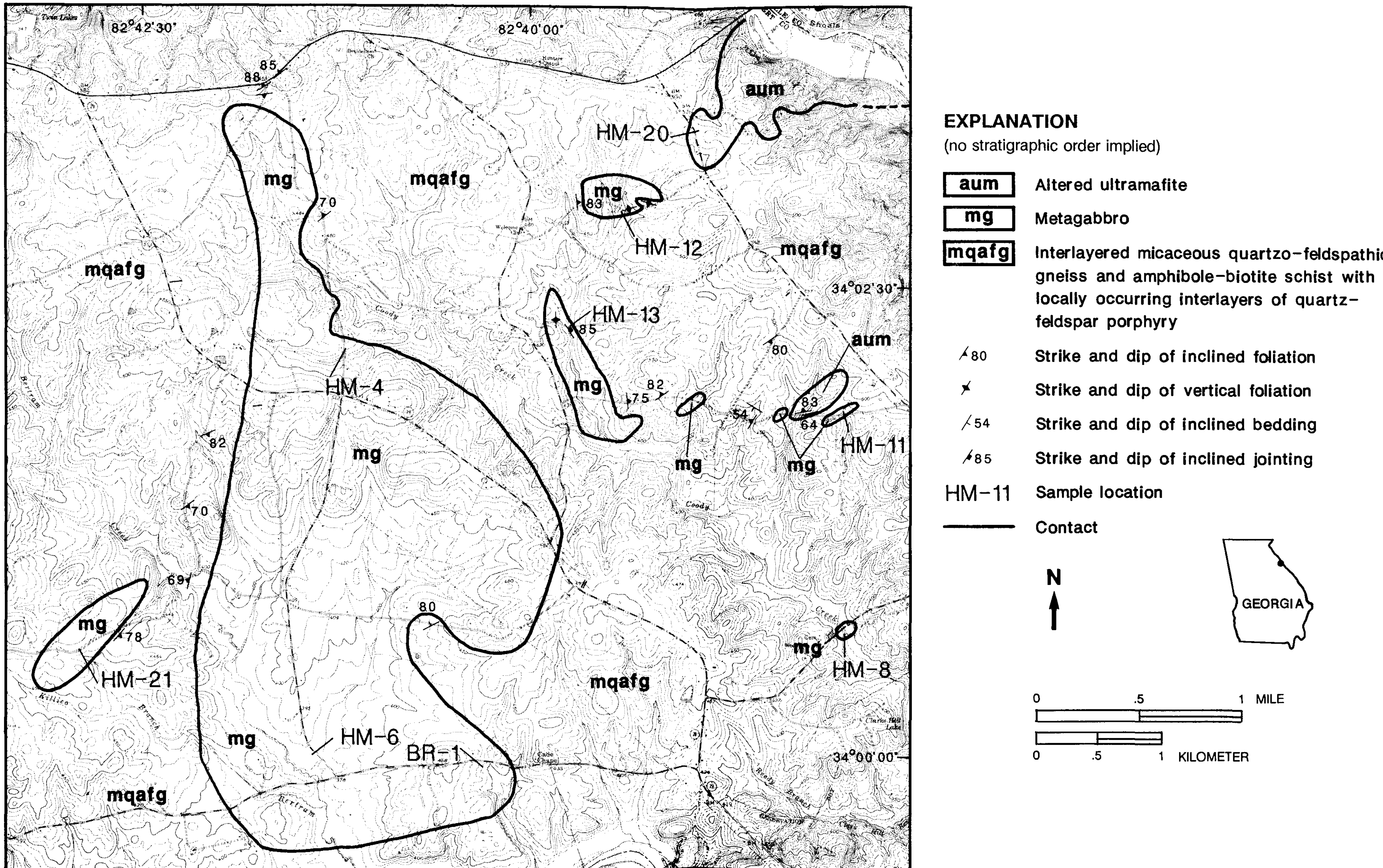
In the 1960's, the J.M. Huber Corporation conducted an exploration drilling program on Burks Mountain. Data obtained from the drilling did not indicate the presence of significant economic mineralization. A small serpentine pit, located on Burks Mountain, was mined as a source for epsom salt. Total product is unknown.

COODY CREEK SUITE

The Coody Creek suite is informally named for extensive exposures of metamorphosed mafic and ultramafic rocks near Coody Creek in the Heardmont 7.5 minute quadrangle in southeastern Elbert County (Figure 17).

Austin (1965) interpreted the mafic lithologies as intrusive sills and dikes within the metavolcanic country rock. Although the metagabbroic rocks probably were of intrusive origin, a large percentage are small bodies which are concordant with, and gradational into, surrounding mafic to intermediate metavolcanic rocks. However, in some instances, the metagabbroic rocks exist as angular, rotated blocks which appear to be dismembered fragments from a larger body. Most of the mafic bodies in the area, therefore, probably do not represent individual intrusions. Instead, they exist predominantly as dismembered portions of a larger body scattered over a large area within the Carolina slate belt. This report describes areas where the largest and most homogeneous of the bodies occur. Other mafic and ultramafic rock bodies occur within the area and are not mapped separately. In Figure 17, areas designated as either "mg" or "aum" are relatively homogeneous masses.

The Coody Creek area lies within the northwestern flank of the Carolina slate belt in eastern Georgia. Rocks consist predominantly of metagabbroic material and low-grade



Base map from U.S. Geological Survey 1:24,000 maps: Broad, GA., 1955 and Heardmont, GA.-S.C., 1985.

Figure 17. Location map of the Coody Creek suite, Elbert County.

(upper greenschist facies), interlayered, felsic and mafic metavolcanic rocks consisting of amphibole-biotite schists and micaceous quartz-feldspar schists. The metavolcanic rocks are similar to the Little River Series described by Crickmay (1952) in Lincoln, Wilkes, and McDuffie Counties.

The Coody Creek suite occupies an area of strong magnetic anomalies (Zeitz and others, 1980) that is bounded immediately to the north by the Middleton-Lowndesville fault zone. The strong magnetic signature of mafic rocks creates a steep magnetic gradient across the Middleton-Lowndesville fault to the northwest. This gradient can be traced southwestward, into the south-central Piedmont, as a linear magnetic feature parallel to the Middleton-Lowndesville fault.

The largest body, designated as "mg" on Figure 17, is a medium- to coarse-grained, dark-green to black, metagabbro with zones of chlorite schist (location BR-1) and amphibolite (location HM-4). Intrusive textures are apparent in the metagabbro and relict amygdules are observed within the amphibolite. The chlorite schists contain aggregates of non-foliated, randomly orientated chlorite and actinolite porphyroblasts. Due to limited exposure, amphibolities and chlorite schists were not mapped separately.

Smaller areas designated on Figure 17 as "mg" consist of homogeneous bodies of metagabbroic material surrounded by the metavolcanic (mqafg) lithologies. A concordant gradational contact into mafic metavolcanics is observed at some outcrops. The presence of these gradational contacts may reflect intrusive and extrusive magmatic phases; however, detailed geologic mapping would be necessary to substantiate such a relationship. Megascopically, these smaller metagabbroic bodies appear to be slightly finer-grained (e.g. HM-11) and more recrystallized (e.g. HM-8) than the larger mass.

Two distinct bodies of ultramafic rock ("aum," Figure 17) were observed in the area. These are homogeneous masses of dark-green, medium-grained, rocks with a poorly defined schistosity composed predominantly of chlorite and talc. Exposures of the larger ultramafic body immediately west of the Savannah River (Figure 17) consist of abundant boulder float concentrated most notably along ridge crests. Exposures of the smaller ultramafic body are restricted to a single road cut and sparse boulder float along the east edge of Figure 17.

Thin-sections show that the mafic bodies are metagabbroic in composition. Regardless of the degree of alteration of the metagabbros, no discernable foliation was observed in petrographic analysis.

The metagabbros vary mainly in their degree of recrystallization (Table VI). Hornblende is the dominant mafic mineral. Schiller luster inherited from the original pyroxene is discernable in less altered grains. With increasing alteration, actinolite exists as pseduomorphs after hornblende. Epidote and clinozoisite, formed at the expense of plagioclase, occur in one or two of the following forms within a single sample: cloud inclusions in plagioclase; widely scattered grains; or aggregate pseudomorphs after coarse-grained plagioclase. Plagioclase (An 41-57) exhibits considerable variation in the amount of alteration to epidote and clinozoisite from one sample to another and within a single thin-section. Plagioclase in sample HM-6 is the least altered, existing as coarse-grained laths with strained and offset twins.

The most altered sample (BR-1) was taken near the southern extremity of the largest metagabbroic body. This sample contains very little unaltered pyroxene and is classified as actinolite-chlorite schist with a randomly orientated porphyroblastic texture. Actinolite and chlorite form pseudomorphs after either pyroxene or hornblende.

Chlorite and talc dominate a thin-section taken from the larger ultramafic body. These minerals occur in discreet, separate masses (sample HM-20). Some of the chlorite masses exhibit a crude foliation whereas others do not. The talc flakes are slightly coarser than chlorite and show no preferred orien-

TABLE VI
ESTIMATED MODAL PERCENTAGES OF SAMPLES FROM THE COODY CREEK MAFIC-ULTRAMAFIC SUITE

	HM-4	HM-6	HM-8	HM-11	HM-12	HM-20	BR-1
Actinolite		tr.	tr.		67		30
Chlorite					20	54	69
Clinozoisite	4	tr.		tr.			
Epidote	1	tr.	10	20	2		tr.
Hornblende	64	54	86	44	10		
Opaques	10	5	tr.	tr.	tr.	1	
Plagioclase	21	30	3	35	tr.		
Pyroxene						tr.	1
Quartz				tr.			
Serpophite		10					
Talc						45	

tation. A very few grains of remnant pyroxene are observed in the thin section. Three chemical analyses from the suite (Appendix D) reveal that samples HM-6, HM-8, and HM-21 are dissimilar, indicating a lack of chemical homogeneity throughout the Coody Creek suite.

BERNER MAFIC COMPLEX

Mafic and ultramafic rocks that crop out throughout Jasper County, eastern Monroe County, and Putnam County have been interpreted to represent a mafic island arc system (Hooper, 1986). Alternatively, Higgins, et al. (1984) suggest that these rocks may be part of an assemblage, termed the Juliette slice of the Macon melange.

Gladesville Gabbro

The most areally extensive mafic and ultramafic rock body within the Berner complex/Juliette slice (Hooper, 1986; Higgins, et al. 1984) is the Gladesville gabbro (Figure 18) with a maximum length of 12 km (7.5 mi) and average width of 1.5 km (1 mi). Although Hopkins (1914) described a cataclastic hornblende gabbro in the vincinity of the Gladesville gabbro, Matthews (1967) was the first to describe this body in detail. Matthews concluded that the Gladesville gabbro was a 7 km (23,000 ft.) thick, post-metamorphic, rhythmically-layered, mafic intrusion—similar to the Bushveld complex of South Africa and the Stillwater complex of Montana. Describing the body as occurring within a distinct topographic despression, Matthews interpreted the contact between the Gladesville and the country rock as occurring at the base of the break in slope. There are few outcrops of the body (other than saprolite), although there are numerous occurrences of boulder outcrop and float.

A geophysical and geochemical survey in the vicinity of the body (Carpenter and Hughes, 1970) indicates that there is no pronounced gravity high associated with the intrusion and that a localized copper anomaly was present in the northern portion of the body. The copper anomaly was later drilled to a depth of 325m (1000ft) with no anomalous concentrations of sulfides noted.

Hooper (1986) re-examined the body as part of his studies of the Berner mafic complex and recognized four rock types. They are: 1) a medium-grained olivine bearing, two pyroxene gabbro; 2) a coarse-grained olivine-free, two pyroxene gabbro; 3) a coarse-grained amphibole gabbro; and 4) a fine-grained granular gabbro. Volumetrically, Types 1 and 2 predominate. Using the gravity data of Carpenter and Hughes (1970), Hooper calculated the depth to the center of the body to be approximately 500m (1500 ft); the shape of residual profiles are symmetrical to assymetrical, indicating a simple vertical or inclined body. Hooper (1986) was unable to produce a solution logical and compatible with the geologic information available. Unlike Matthews (1967), Hooper placed the contact between the Gladesville gabbro and the surrounding rock within the topographic low; thus, reducing the size of the rock body.

The major constituent of the olivine bearing two pyroxene gabbro, (Type 1) is euhedral to subhedral plagioclase of variable size. The plagioclase displays undulose extinction and may show deformation twins of bent lamellae. These are characteristics common to all four types of gabbro. Ophitic to subophitic intergrowths with orthopyroxene are common. Clinopyroxene and orthopyroxene occur as subhedral and fractured phenocrysts. Poikilitic orthopyroxene enclosed plagioclase and olivine, clinopyroxene, and opaques. Within the clinopyroxene, elongate bleb-shaped exsolution lamellae of orthopyroxene and amphibole occur locally. Olivine is generally anhedral and inclusion free, although locally it is embayed and shows partial to total replacement by orthopyroxene-magnetite (spinel) symplectites. Complex coronas, containing two to three shells or zones, are ubiquitously developed between the olivine and plagioclase. The shell sequence from olivine to plagioclase is 1) orthopyroxene, 2) amphibole or amphibole-spinel symplectite, and 3) clinopyroxene-spinel symplectite.

Type 2, two pyroxene gabbro is predominately composed of plagioclase that is subhedral and inequigranualar. Clinopyroxene and orthopyroxene phenocrysts are also subhedral and inequigranular. Subophitic to ophitic intergrowths of orthopyroxene with plagioclase occur locally. Single shell coronas of amphibole around opaques is ubiquitously developed in this phase lithology.

Amphibole, occurring as elongate grains, as equigranular to granular crystals, or as oikocrysts enclosing plagioclase dominates the Type 3, coarse grained amphibole gabbro. Plagioclase is subhedral and inequigranular. In Type 4, fine grained, granular, two pyroxene gabbro, plagioclase is the dominant mineral followed in abundance by orthopyroxene and clinopyroxene. Single shell coronas of amphibole are ubiquitously developed around opaque minerals.

Hooper (1986) did not note the presence of rhythmic layering in any of the four gabbros or within the 325m (1000ft) drill core that penetrated lithologic Types 2, 3, and 4 gabbros. This contradicts Matthews (1967) observations of saprolitic exposures of rhythmetic layered olivine and anorthosite. Hooper (1986) states that the outcrops containing olivine layering described by Matthews (1967) are unavailable; however, he does report the presence of anorthosite rhythmic layering within amphibole gneisses outside of the Gladesville gabbro.

The presence of oikocrysts and symplectic intergrowths in the Gladesville gabbro has been interpreted to reflect solid-state metamorphism in a relatively, dry environment (Hooper, 1986). Although the igneous mineralogy of the Gladesville is relatively unchanged, Hooper (1986) also believes that the presence of deformed

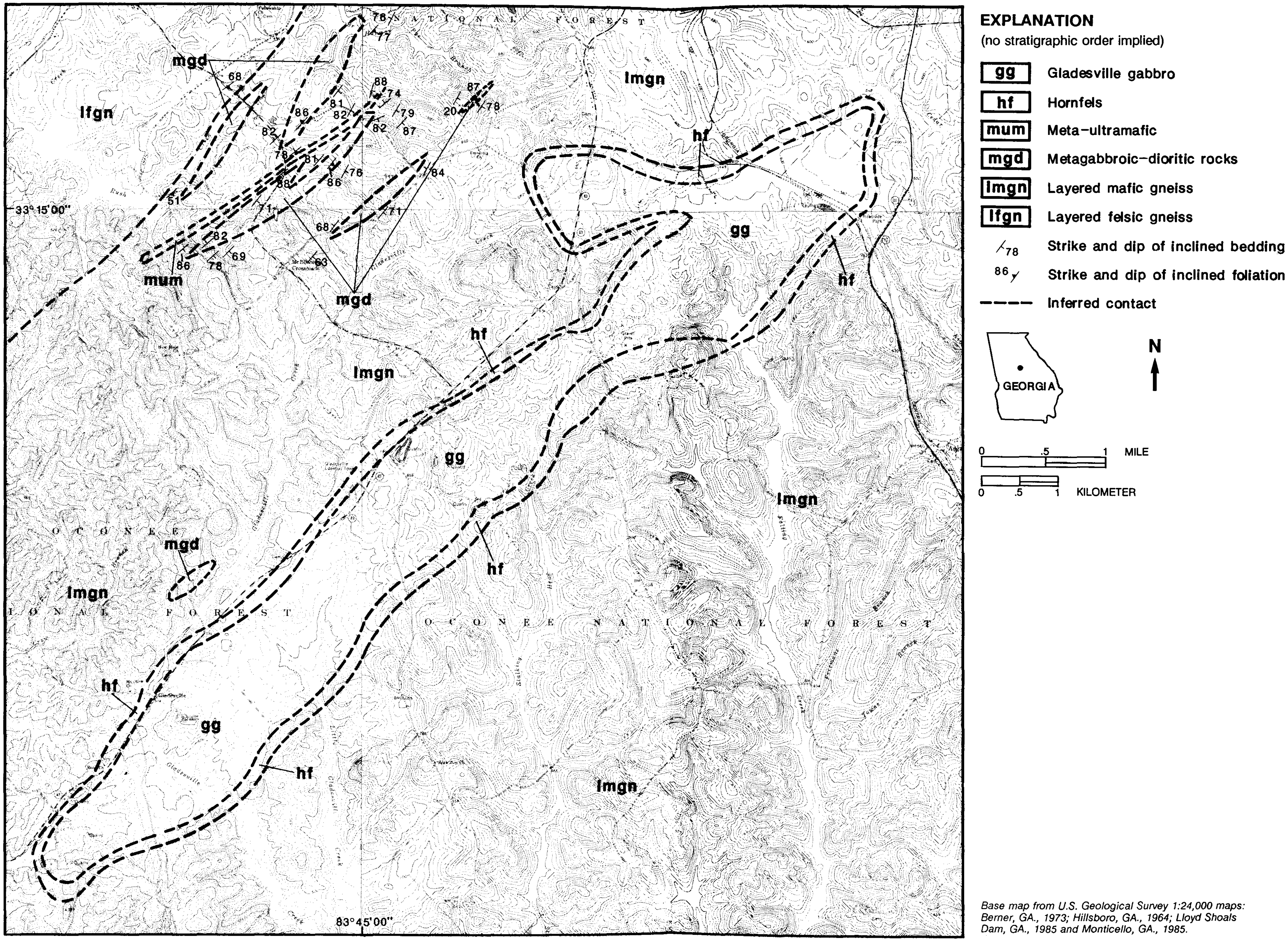


Figure 18. Location map of the Gladesville gabbro and metagabbro exposed north of McElheney's Crossroads, Jasper County (modified after Hooper, 1986 and Matthews, 1967).

plagioclase twins, kinked pyroxenes, and an undulatory extinction of some plagioclase and pyroxene phenocrysts indicates pervasive dynamic metamorphism.

Trace element variations within the Gladesville suggest that the four rock types present are not the result of crustal fractionation. Hooper believes that the Gladesville gabbro is not a simple stratiform pluton; rather, it is two distinct gabbro bodies, each with its own magma sources and each with their own distinct crystallization histories.

Juliette Mafic Suite

Three prominent gabbroic bodies, informally named the Juliette mafic suite, occur in easternmost Monroe County (Figure 19) 5 km (3 mi), south of the Gladesville gabbro. These ellipsoidal bodies are nearly parallel and are concordant with the foliation of enclosing gneisses and schists. Of all gabbroic bodies examined in the southern Piedmont for the present investigation, the Juliette suite is the least altered and was most likely emplaced during the waning stages of regional dynamic metamorphism. Carpenter and Prather (1971) informally named individual rocks bodies within this suite, from north to south, as the Juliette, Berry Creek and Holly Grove norites. These bodies are considered to be part of Hooper's (1986) Berner mafic complex.

Excluding the gabbroic bodies themselves, country rocks within this suite consist of at least three mappable units: amphibolite (am); an interlayered sequence of medium-grained micaceous quartzo-feldspathic gneiss, amphibolite, and amphibole-biotite-plagioclase gneiss with local interlayers of fine-grained biotite-plagioclase gneiss (mga); and porphyroblastic biotite-plagioclase gneiss (pbp).

Exposures of Juliette suite rocks occur in cuts along the main highways and as float along secondary roads; however, no streams were checked for outcrop during this investigation. Very little textural or mineralogical variation is observable between these three bodies; each body consists of dark-gray to black, medium- to coarse-grained, equigranular gabbro. One outcrop of chlorite schist was exposed near the center of the northernmost body. Only a fraction of the Berry Creek norite, mapped by Prather (1971) along Berry Creek south of the City of East Juliette, was observed by the present investigators. The impounding of Lake Juliette and construction of a coal gasification facility has obliterated exposures of the body except for limited outcrops along U.S. Highway 23.

Contact aureoles, mapped by Prather (1971) and outlining the three gabbroic bodies, were not observed during the present investigation. Amphibolite within the immediate vicinity of the two northern bodies has a spotty appearance and exhibits a faint igneous texture. This lithology was interpreted by Prather (1971) to reflect contact metamorphism of mafic country rock by the gabbro.

The Juliette norite exhibits well developed coronite textures near the body's margin. The coronas consist of a core of irregularly embayed olivine enclosed by augite, hornblende, and intergrowths of pale green spinel. Most likely these coronite textures are of metamorphic origin and developed where olivine and plagioclase phenocrysts were in contact with one another and reacted with the available water. Similar textures are described by Hooper (1986) in the Gladesville gabbro.

Monticello Metagabbro

In the southwesternmost corner of the Monticello 7.5 minute quadrangle, Hooper (1986) noted the presence of metagabbroic rock within layered amphibolitic gneisses (Figure 18). These metagabbros are part of Hooper's (1986) Berner mafic complex. The metagabbro crops out as scattered boulders occupying a low area between two topographic highs. These boulders are predominantly medium to coarse-grained equigranular rocks containing approximately fifty percent plagioclase. The metagabbro occurs within a regionally extensive amphibolite unit.

A thin section from the body (sample MO-1, Table VII) reveals that the primary pyroxene has altered to large segregated aggregates of fine-grained hornblende. Plagioclase grains are approximately the same size as the hornblende aggregates and exhibit strained albite and pericline twins. Clinozoisite exists as fine subhedral grains that occur most notably along the plagioclase-hornblende grain boundaries. A chemical analysis (sample MO-1) is included in Appendix D.

GRIGGS CHAPEL METAGABBRO

An exposure of coarse-grained metagabbro occurs on Georgia Highway 212, approximately 17 km (10 mi) south of Monticello in the northeastern corner of the Stanfordville 7.5 minute quadrangle, Jasper County. The size of the body (850 m x 650 m), as illustrated on Figure 20, is approximate; its surface outcrop can be estimated from the local topography and the darker reddish-brown nature of soils derived from gabbroic rocks. The body is surrounded by highly weathered amphibolite, resulting in inferred contacts. A geochemical analysis is included in Appendix D; minerals observed in thin section are listed in Table VII.

METAGABBRO EXPOSED NEAR CEDAR CREEK

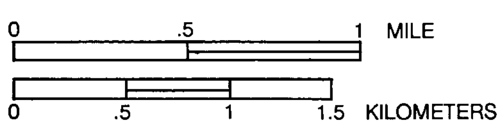
Scattered boulder outcrops of metagabbro occur near the base of a moderate slope at the headwaters of a tributary of Cedar Creek, in the southern portion of the Stanfordville 7.5 minute quadrangle, Jasper County (Figure 21). This area is approximately 7.2 km (2.5 mi) south of the Griggs Chapel metagabbro described above. The metagabbro is coarse-grained, equigranular, and contains scattered megascopic flakes of biotite.

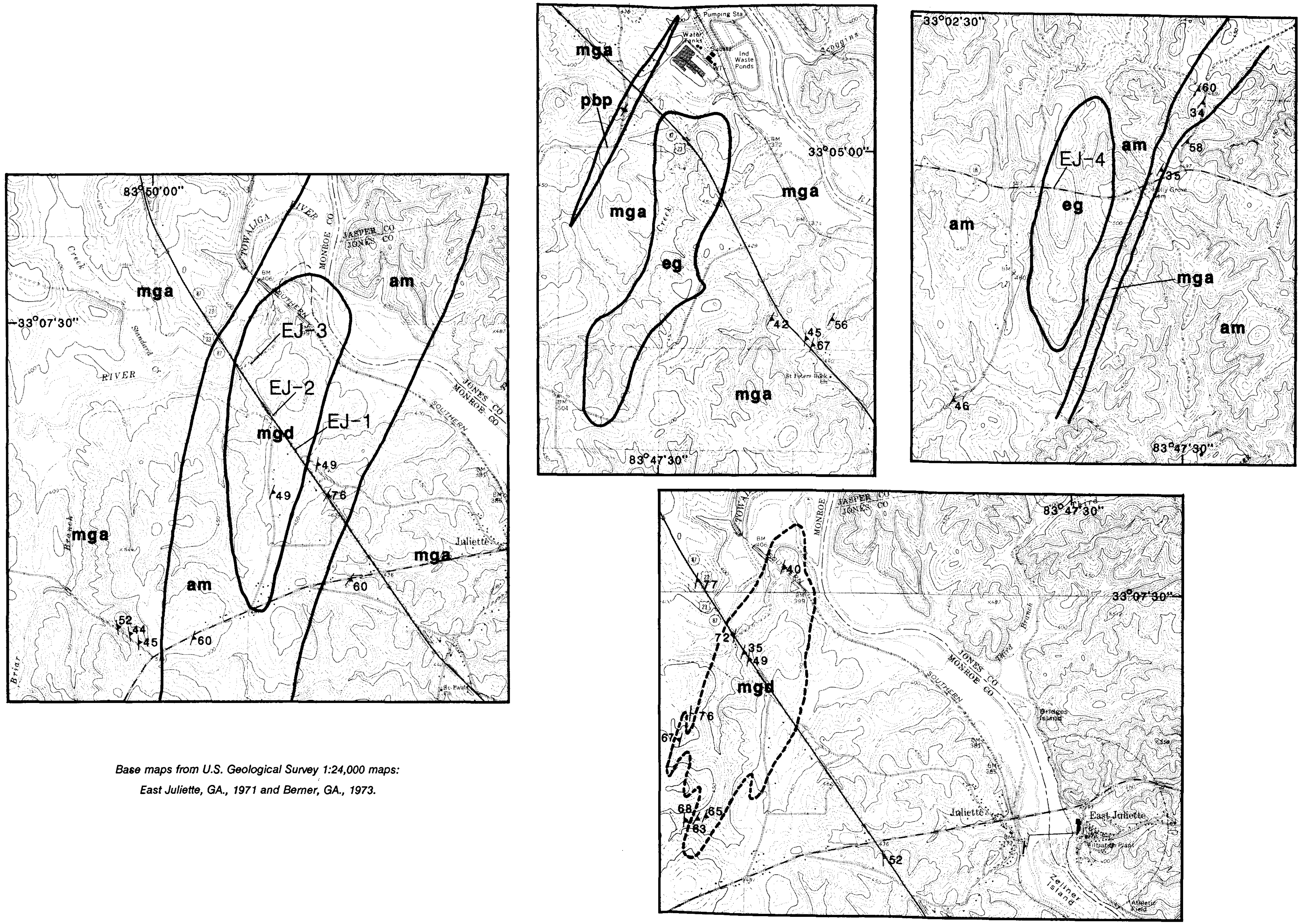
A road cut immediately west of the mapped area shows that the surrounding lithologies are a sequence of interlayered hornblende-biotite schist, felsic biotite gneiss, and biotite schist. Within this sequence are small blocks and

EXPLANATION
(no stratigraphic order implied)

am	Amphibolite
eg	Equigranular gabbro
mgd	Metagabbroic-dioritic rock
mga	Micaceous quartzo-feldspathic gneiss, amphibolite and amphibole-biotite-plagioclase gneiss with local interlayers of fine grained biotite-plagioclase gneiss
pbp	Porphyroblastic biotite-plagioclase gneiss
56	Strike and dip of inclined foliation
	Strike and dip of vertical foliation
52	Strike and dip of inclined bedding
EJ-1	Sample location
———	Contact
-------	Inferred contact

N





Base maps from U.S. Geological Survey 1:24,000 maps: East Juliette, GA., 1971 and Berner, GA., 1973.

Figure 19. Location map of the Juliette mafic suite, Monroe County.

TABLE VII

ESTIMATED MODAL PERCENTAGES OF SAMPLES FROM SMALL MAFIC BODIES IN JASPER, PUTNAM, AND HANCOCK COUNTIES

	Monticello MO-1	Griggs Chapel ST-1	Cedar Creek ST-2	Little River EAT-1	Shoulderbone Creek SHB-1	Flatrock LSW-1	Lake Sinclair LSW-2
Actinolite					30		
Anthophyllite					tr.		
Apatite		tr.	tr.				
Augite						40	34
Biotite		3	4			3	tr.
Chlorite					45		
Chromite(?)	tr.	tr.					
Clinozoisite	12			tr.			
Diallage					25		
Epidote				3			
Hornblende	42	25	34	72			
Magnetite	tr.	12	3	5	tr.	5	2
Olivine	tr.					1	7
Orthopyroxene		20	23				
Plagioclase	45	39	36	20		50	47
Talc		tr.					
Uralite		tr.				tr.	tr.

pods of gabbroic rock similar to the boulder material described above. At one location, the biotite schist is folded around a gabbroic block. The gabbroic block is truncated by a zone of siliceous breccia (flinty crush rock). These field relationships suggest that this particular block is a fragment of a larger dismembered "parent" body.

A thin-section from this rock body (ST-2, Table VII), contains plagioclase with strained albite twin lamellae, clouded by traces of ultrafine, dark inclusions. Pyroxene appears to be partially altered to hornblende. A chemical analysis from the body (sample ST-2gc,) is included in Appendix D.

METAGABBRO EXPOSED AT THE LITTLE RIVER, PUTNAM COUNTY

Black, dense, massive, coarse-grained metagabbro (Figure 22) is exposed 7 km (4.5 mi) southwest of Eatonton at the Little River, along a secondary road north of U.S. Highway 129 in the Eatonton 7.5 minute quadrangle. The metagabbro, first described by Libby (1971), consists predominantly of hornblende with microscopic magnetite and fine, disseminated plagioclase (EAT-1, Table VII). Fine, disseminated grains of pyrite occur in parts of the exposure. The metagabbro is inferred to be ellipsoidal in shape and is best exposed in a deep road cut through a knoll beside the Little River. The body appears to be homogeneous; however, an indistinct foliation is visible near the inferred contact to the southwest. The metagabbro may be substantially larger than illustrated in Figure 22 because an amphibolite, which has similar weathering characteristics, surrounds it. A chemical analysis of the body (Sample EAT-1) is included in Appendix D.

ULTRAMAFIC ROCK EXPOSED SOUTHWEST OF MUSELLA COMMUNITY

Of the two ultramafic bodies illustrated on the State Geologic Map of Georgia in Crawford County, only one could be located by the present investigators (Figure 23). The body is located in the Culloden 7.5 minute quadrangle southwest of Musella on a secondary road approximately 2.6 km (1.5 mi) west of its intersection with U.S. Highway 341. The body consists predominantly of weathered, dark-green, medium-

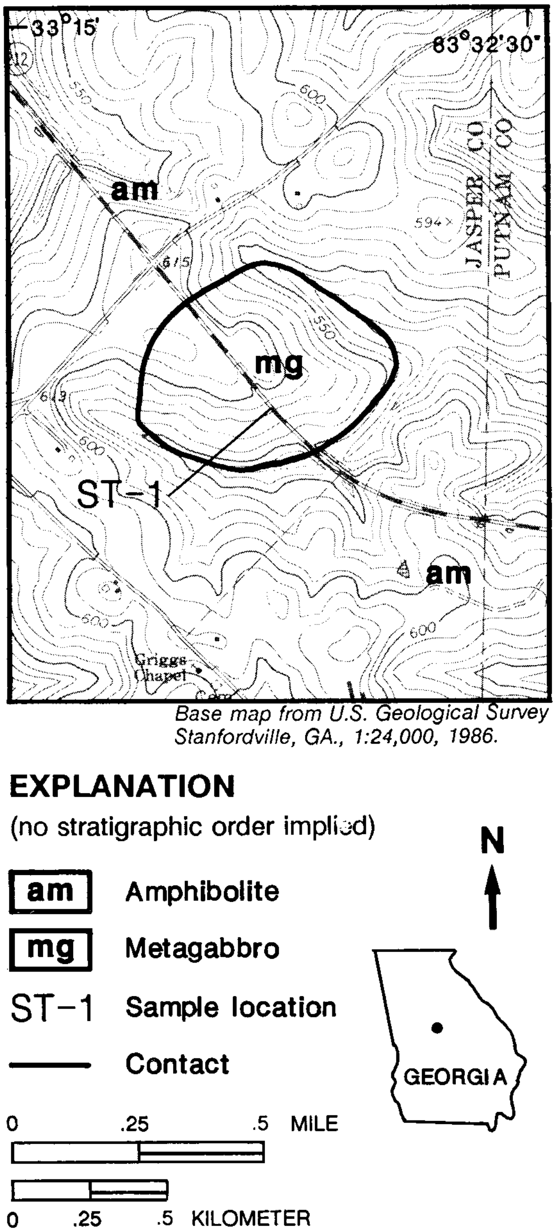
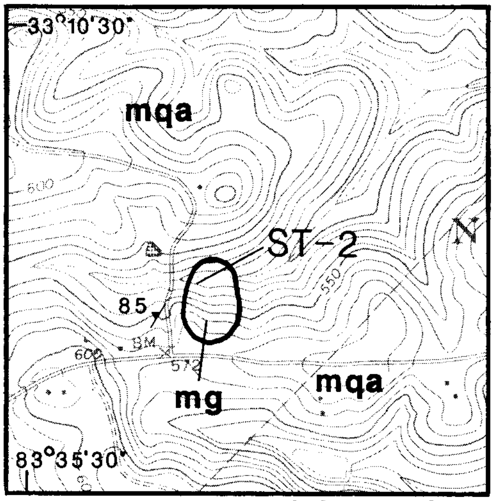


Figure 20. Location map of metagabbro near Griggs Chapel, Jasper County.



Base map from U.S. Geological Survey Stanfordville, GA., 1:24,000, 1986.

EXPLANATION

(no stratigraphic order implied)

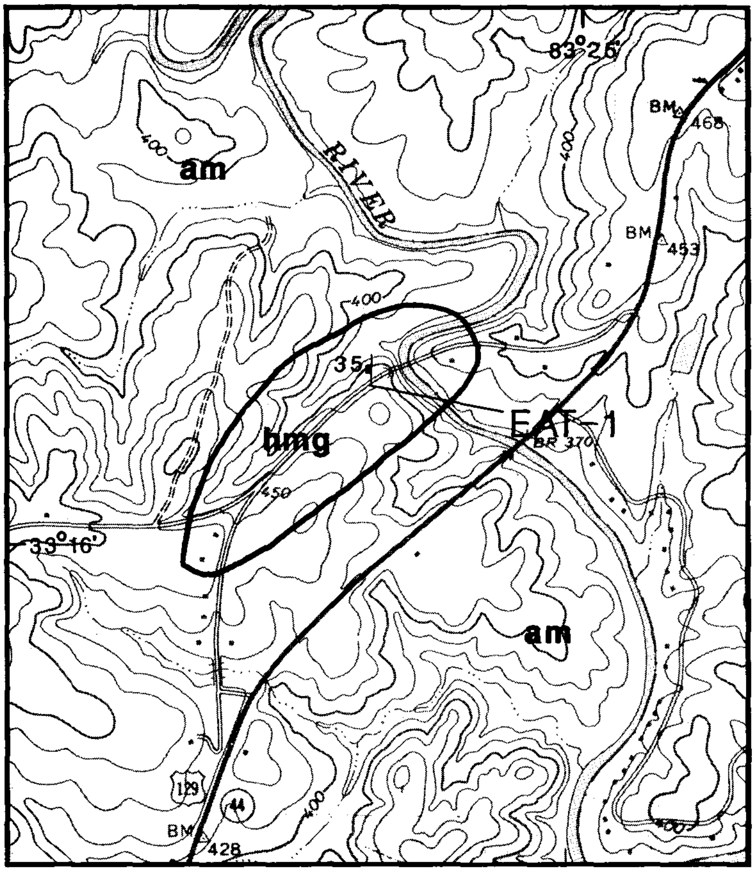
N ↑

mg	Metagabbro
mqa	Interlayered micaceous quartzo-feldspathic gneiss, biotite schist, and amphibole-biotite schist
85	Strike and dip of inclined foliation
ST-2	Sample location
——	Contact

0 .25 .5 MILE

0 .25 .5 KILOMETER

Figure 21. Location map of the metagabbro near Cedar Creek, Jasper County.



Base map from U.S. Geological Survey Eatonton, GA., 1:24,000, 1985.

EXPLANATION

(no stratigraphic order implied)

am Amphibolite

hmg Hornblende metagabbro

35 Strike and dip of inclined jointing

EAT-1 Sample location

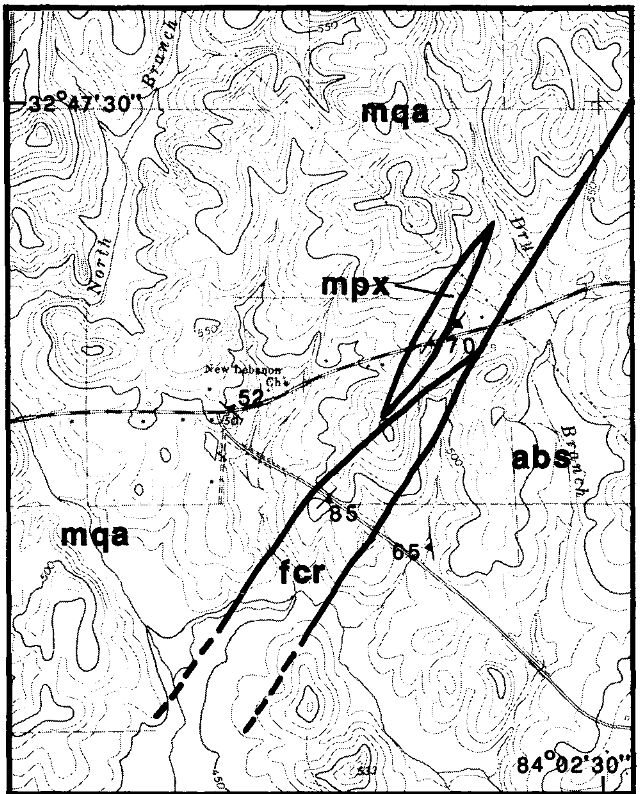
—— Contact

N ↑

0 .25 .5 MILE

0 .25 .5 KILOMETER

Figure 22. Location map of metagabbro exposed near Little River, Putnam County.



Base map from U.S. Geological Survey Culloden, GA., 1:24,000, 1974.

EXPLANATION
(no stratigraphic order implied)

N

abs	Interlayered amphibolite and biotite schist
mpx	Hornblende–actinolite schist
mqa	Interlayered micaceous quartzo–feldspathic gneiss, biotite schist and amphibole–biotite schist
fcr	Ultramylonite – "flinty crush rock"
65	Strike and dip of inclined foliation
	Strike and dip of vertical foliation
	Contact
	Inferred contact

0 .5 1 MILE

0 .5 1 1.5 KILOMETERS

Figure 23. Location map of ultramafic rock near Musella, Crawford County.

grained hornblende-actinolite schist. A very small pod of weathered, steatized ultramafic rock is enclosed within the schist and exhibits sharp contacts.

CHLORITE-ACTINIOLITE SCHIST NEAR SHOULDERBONE CREEK

In northwestern Hancock County, within the Shoulderbone 7.5 minute quadrangle, an ellipsoidal ultramafic body crops out in a cut along Georgia Highway 16 northwest of Shoulderbone Creek (Figure 24). Extensive boulder float consisting of chlorite-actinolite schist is exposed in pastures along a secondary road intersecting the highway. Immediately to the northeast of the body, small pods of equigranular, coarse-grained metagabbro and chlorite-actinolite schist occur within the interlayered biotite-muscovite schist and amphibolite.

A thin-section of sample SHB-1 (Table VII) reveals a foliation defined by crude alignment of chlorite grains. The rock is composed predominantly of medium-grained chlorite, actinolite, and pyroxene. Pyroxene grains are either partially or entirely altered to actinolite with the coarser grains exhibiting the greatest alteration. A very few grains of anthophyllite are oriented on parallel to the chlorite flakes.

DIABASE

Isolated boulders of medium-grained, equigranular gabbroic material are exposed at the Putnam County community of Flatrock in an old road bed immediately west of U.S. Highway 441 (Lake Sinclair West 7.5 minute quadrangle). The rock has a diabasic appearance and a few of the smaller boulders exhibit spheroidal weathering. Boulders of medium-grained, equigranular gabbroic rock also occur along a private gravel road beside an inlet of Lake Sinclair in the central area of the Lake Sinclair West 7.5 minute quadrangle, Putnam County. Surrounding these two bodies are micaceous quartzo-feldspathic gneiss, coarse-grained biotite-plagioclase gneiss, and amphibolite.

A thin-section (sample LSW-1, Table VII) from the Flatrock gabbroic body shows that the rock has a diabasic texture and consists predominantly of augite and plagioclase. Augite occurs as elongate to stubby grains that exhibit only slight uralitization. Plagioclase occurs as elongate laths with strained twin lamellae and moderate to heavy sericitization. A few widely scattered grains of olivine occur showing slight alteration to chrysotile. Biotite (primary?) occurs as fine, widely scattered flakes. A sample taken from the Lake Sinclair body (LSW-2) is similar to sample LSW-1 (Table VII) obtained at the community of Flatrock. LSW-2 has somewhat more olivine approximately 7 modal percent) and only a trace of biotite. A few plagioclase grains in sample LSW-2 exhibit extensive myrmekitic intergrowths that are heavily sausseritized.

Data listed in Appendix D indicate that samples LSW-1 (Flatrock) and LSW-2 (Lake Sinclair) are from very similar rock-types. These chemical similarities and the slight degree of alteration observed in samples LSW-1 and LSW-2 suggest both bodies may be parts of a single connected mass, most-likely a diabasic dike.

ADDITIONAL OCCURRENCES

A number of small mafic bodies are shown on the Geologic Map of Georgia (Georgia Geologic Survey, 1976) which are briefly described below. Descriptions of these bodies are based on limited field mapping and to a lesser extent, by thin-section study. Some of the bodies were described in a number of research theses.

LINCOLN COUNTY

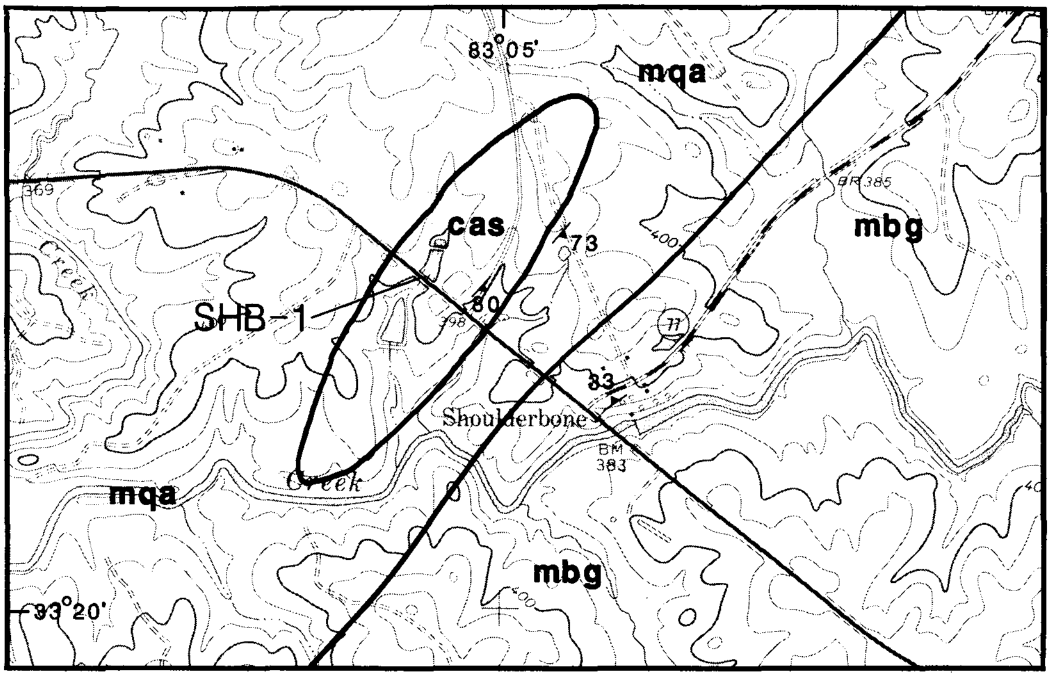
A gabbro body crops out in easternmost Lincoln County, in the northernmost part of the Lincolnton 7.5 minute quadrangle adjacent to Clark Hill Reservoir. Within the area mapped as "gabbro," the present investigators observed a single float cobble of metagabbroic material along with relatively thin (less than 0.5 meter), dark, aphanitic, mafic material interlayered with felsic gneiss and pelitic schist.

OGLETHORPE COUNTY

A northwest-southeast trending elongate body of "gabbro" is in the southeastern part of the county. Exposures of this rock body are especially poor, consisting of mafic float cobbles in areas of cultivation. The cobbles are dark-green to black, dense, and aphanitic with no plutonic igneous textures observed by the present investigators. Features that may be relict amygdules are present in aphanitic mafic material within the Lexington 7.5 minute quadrangle immediately west of the "gabbro." A thin-section analysis of this material reveals the "amygdules" to be discreet aggregates of medium-grained clinozoisite in a fine-grained matrix of actinolite, plagioclase, and magnetite. Consequently, the protolith of this material may well have been a porphyritic-aphanitic rock composed of plagioclase phenocrysts in a basaltic groundmass. Considering the above observations, the area in question is most likely underlain by metamorphosed, extrusive, mafic rocks of slightly varying composition.

HARALSON COUNTY

In eastern Haralson County, within the Draketown 7.5 minute quadrangle, Crawford (1969) mapped a body of gabbro in an area underlain by granitic gneiss. Reconnaissance mapping during the present investigation reveals that the area in question is part of an extensive southwest-northeast trending belt of medium-grained amphibolite, approximately 1.3 km wide, bordered on either side by fine-



Base map from U.S. Geological Survey Shoulderbone, GA., 1:24,000, 1972.

EXPLANATION
(no stratigraphic order implied)

mqa	**Interlayered micaceous quartzo-feldspathic gneiss, biotite schist, and amphibole-biotite schist**
mbg	**Migmatitic biotite gneiss**
cas	**Chlorite-actinolite schist**
33	**Strike and dip of inclined foliation**
——	**Contact**
SHB-1	**Sample location**

N

0 .5 1 MILE

0 .5 1 KILOMETER

Figure 24. Chlorite-actinolite schist near Shoulderbone Creek, Hancock County.

grained quartz-mica schist. Interlayered with the medium-grained amphibolite are two, small, nearly linear areas of coarse-grained amphibolite. Megascopically, hornblende and plagioclase in the coarse-grained amphibolite occurs as discontinuous aggregate blebs that are apparently a result of deformation. This amphibolite is not believed to be intrusive in nature because of the lack of relict igneous textures.

JASPER COUNTY

Four small gabbro bodies occur in Jasper County to the west-northwest of the large Gladesville gabbro; the two northern bodies are in the Lloyd Shoals Dam 7.5 minute quadrangle. Within the area of the northernmost gabbro, the present investigators observed a saprolite exposure of coarse-grained, garnet-mica schist and a thin, cross-cutting, dike-like amphibolite. Within the area of the second northern gabbro, an interlayered sequence of biotite-muscovite schist and amphibolite is observed. The two southern gabbros were mapped within the Berner 7.5 minute quadrangle. Outcrops within the areas of these mapped bodies consist of micaceous felsic gneiss and/or an interlayered sequence of micaceous felsic gneiss, biotite-muscovite schist, amphibolite, and quartz-feldspar porphyry. In short, none of the small areas previously mapped as gabbro around the Gladesville gabbro were observed in the present investigation.

In exteme southeastern Jasper County, the Geologic Map of Georgia (1976) illustrates an ultramafic rock cropping out at the intersection of a secondary road and Cedar Creek in the central area of the Stanfordville 7.5 minute quadrangle. At this locale, the present investigators observed good exposures of approximately east-west trending amphibolite cropping out on both sides of the Cedar Creek floodplain.

LUMPKIN COUNTY

LaForge and Phalen (1913) mapped two elongate bodies of ultramafic rock in an area occupying part of the southernmost Suches 7.5 minute quadrangle. Reconnaissance mapping during this investigation reveals that amphibolite underlies these locations. Ultramafic lithologies are sparse in the area and exist as small, widely scattered pods of chlorite-anthophyllite schist.

TROUP COUNTY

Occurrences of high-iron chromite in west-central Troup County were investigated by the Georgia Geologic Survey and the Work Projects Administration (WPA) during the early 1940's. Additional work was conducted by the U.S. Bureau of Mines in the mid-1940's. Additional work was conducted by the U.S. Bureau of Mines in the mid-1940's. General locations of the prospected areas were in Land Lots 32, 239, 240 and 242, District 7 (Beasly and Turner properties), approximately 2 to 3 km (1 to 2 mi) southeast of the community of Louise, Troup County. During the WPA study, seven core holes were drilled, 18 trenches, 231 pits and 12 shafts were dug. One of these shafts, 15 m (45 feet) in depth was sunk on a magnetic anomaly. No significant mineralization was noted within this shaft. The U.S. Bureau of Mines continued investigating the area through the mid-1940's with no significant results. WPA records at the Georgia Geologic Survey indicate that the chromite occurs as disseminated grains and lenses within altered perioditite and dunite. There have been no known recorded investigations of this area since the 1940's.

PUTNAM COUNTY

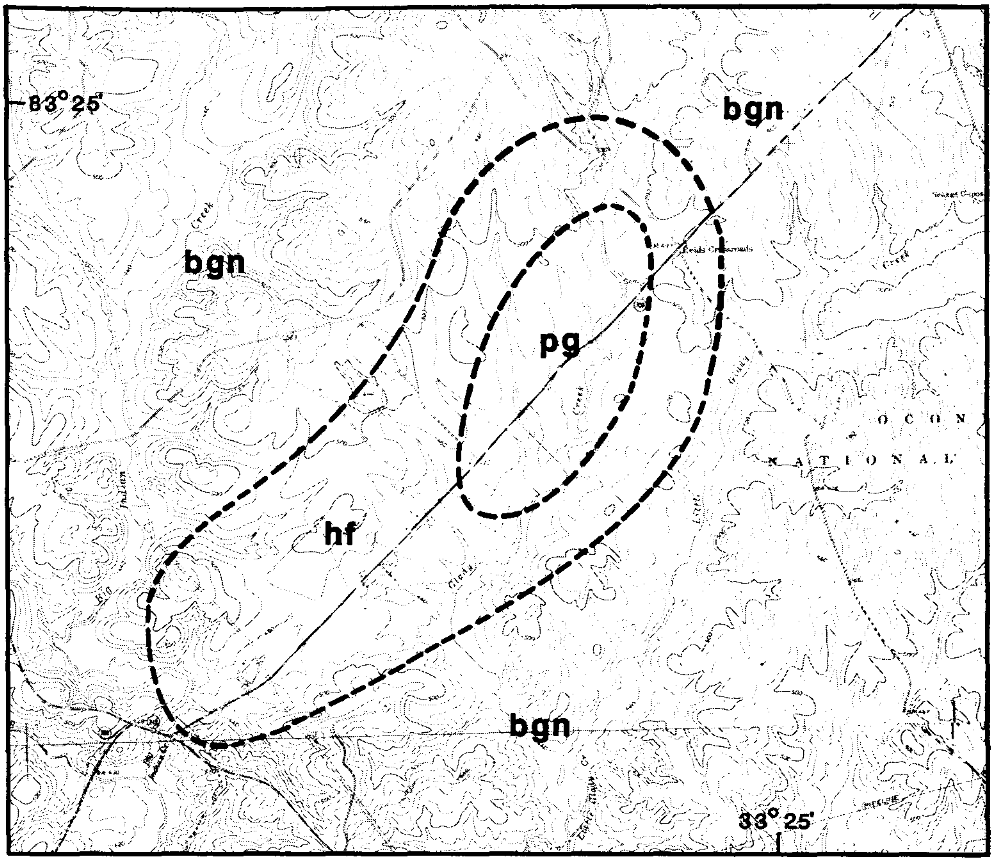
Numerous mafic to ultramafic bodies have been reported to occur throughout Putnam County. None of these bodies were located by the current investigators. This may be because of recent human activities in the general area or because of the reconnaissance nature of the present project.

Presley's Mill Gabbro

An extensive area of mafic rock was mapped by Meyers (1968) and Libby (1971) within the Rock Eagle 7.5 minute quadrangle in northwestern Putnam County. Meyers (1968) informally named this mafic rock body the Presley's Mill gabbro (Figure 25). According to Meyers (1968), the complex consists of diorite-gabbro, hornblende-hypersthene gabbro, olivine gabbro, and pyroxenite. Occurring within and around the gabbro, Meyers (1968) noted the presence of pyroxene-hornfels facies rocks, although no zone of contact metamorphism was mapped. Libby (1971) mapped a zone of hornfelsic rocks surrounding the gabbro and extended the zone southwest of the gabbro for a distance of approximately 1.3 km (0.8 mi.)

Exposures of mafic lithologies in the area are especially poor, consisting almost exclusively of sparse, widely scattered boulder and cobble float in a thickly-vegetated, low-lying area. According to Libby's (1971) map, exposures of hornfels facies rocks are much more abundant than those of hornblende-hypersthene gabbro and diorite-gabbro. The material that Meyers (1968) and Libby (1971) refer to as pyroxene-hornfels is a dark, nearly aphanitic rock with no megascopically discernable foliation. A thin-section of this material shows a very fine-grained, nearly granoblastic rock composed of 47% augite, 42% plagioclase, and 10% magnetite. Augite and magnetite grains exhibit a very crude alignment. Locally, fine to medium-grained hornblende (<1%) appear to be secondary after augite. In such instances, hornblende has inherited the cleavage form and direction of original augite.

No structural relations could be deduced between lithologies that Meyers (1968) and Libby (1971) mapped as gabbro and hornfels due to extreme lack of undisturbed outcrop. Meyers (1968) and Libby (1971) interpreted that



Base map from U.S. Geological Survey 1:24,000 maps: Eatonton, GA., 1972 and Rock Eagle Lake, GA., 1972.

EXPLANATION

(no stratigraphic order implied)

pg Presley's Mill gabbro

hf Pyroxene hornfels

bgn Interbanded biotite/hornblende gneisses

----- Inferred contact

N

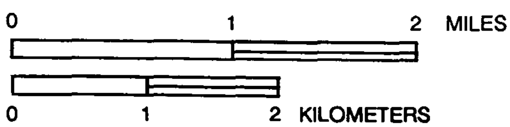
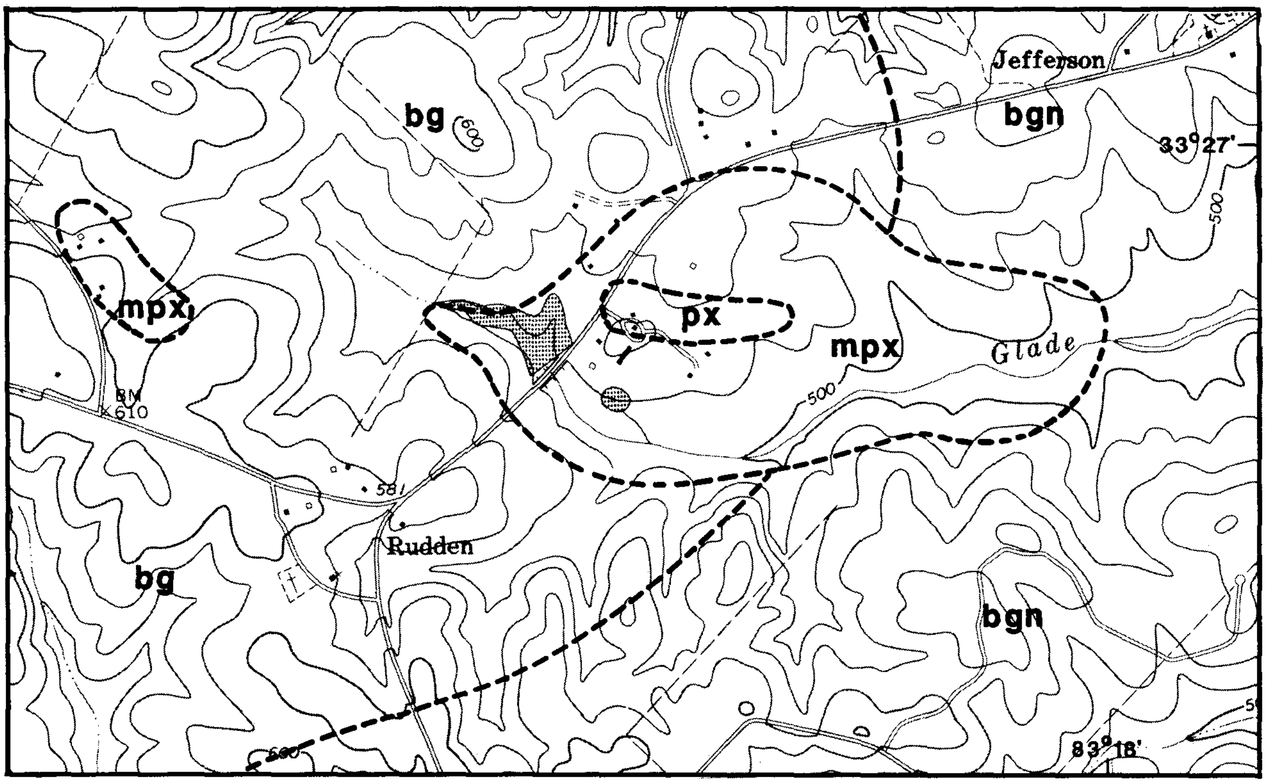


Figure 25. Location map of the Presley's Mill gabbro, Putnam County (from Libby, 1971).



Base map from U.S. Geological Survey Harmony, GA., 1:24,000, 1972.

EXPLANATION
(no stratigraphic order implied)

px	**Pyroxenite**
mpx	**Metapyroxenite**
bgn	**Interbanded biotite gneiss and hornblende gneiss**
bg	**Biotite gneiss**
-------	**Inferred contact**

0 .5 1 MILE

0 .5 1 KILOMETER

Figure 26. Location map of the Rudden metapyroxenite, Putnam County (from Libby, 1971).

the fine-grained, aphanitic mafic rocks were hornfels formed by contact metamorphism as a result of intrusion of gabbroic magma. Alternatively, the fine-grained mafic "hornfels" material could represent a chilled intrusive margin with a partially developed flow foliation. Considering that no pattern could be discerned from surface exposures of mafic rock in the area, the gabbro may have been extensively dismembered or deformed subsequent to its initial crystallization and emplacement.

Rudden Metapyroxenite

In northwestern Putnam County, within the Harmony 7.5 minute quadrangle, Libby (1971) mapped two small bodies of mafic rock which he informally named the Rudden pyroxenite and Rudden metapyroxenite (Figure 26). Exposures are especially poor in the area and are almost exclusively restricted to a very few scattered cobbles of metapyroxenite float occurring in a field on the south side of a secondary road. Near the southwestern margin of the mapped body is a small, weathered exposure of hornblende-bearing diorite material. Within the area Libby (1971) mapped as metapyroxenite, exposures of hornblende-bearing dioritic material, micaceous quartzo-feldspathic gneiss, amphibolite, and metagabbroic pods were observed along with float cobbles of metagabbro. Considering that these pods are the only exposures of mafic lithologies observed for either "body," any mafic or ultramafic rocks in the area probably exist as small, isolated blocks and pods and not as extensive, homogeneous units of mappable areal extent.

Other Bodies

Libby (1971) mapped two other ultramafic bodies in Putnam County north and south of a hornblende metagabbro exposed at the Little River (Libby, 1971, p. 78) (Figure 22). The southernmost body was mapped along U.S. Highway 129 approximately 1.2 km (0.75 mi) south of the hornblende metagabbro. The area encompassing the mapped "body" was observed by the present investigators to consist of red-brown soils and weathered amphibolite. No intrusive rocks were observed here. The second body mapped by Libby (1971) is exposed near the intersection of a secondary road and the Little River approximately 2.9 km (1.8 mi) upstream from the hornblende metagabbro (page 78). At this locale, the present investigators observed red-brown amphibolitic soils and a breached, abandoned, stone dam constructed of metagabbroic boulders. The boulders are widely scattered around the dam and are in the stream bed. Although some of the metagabbro boulders are probably close to being in place, human activity at the site makes any analyses suspect.

SUMMARY

Major occurrences of ultramafic rock in Georgia are largely limited to the Piedmont geologic province. The northern Piedmont (i.e., north and west of the Brevard fault zone) contains the most areally extensive mafic rock bodies including the Laura Lake and Kellogg Creek Mafic Complexes. Relatively large ultramafic bodies in the northern Piedmont include those in the Lake Chatuge complex.

South and east of the Brevard zone, most of the mafic and ultramafic bodies occur as geographically-adjacent and dismembered pods and lenses. This dismembered pattern probably reflects a combination of lack of exposure in the southern Piedmont and primary igneous and sedimentary features. Major mafic to ultramafic rock bodies south of the Brevard include the Soapstone Ridge Complex, the Gladesville gabbro, the Coody Creek zone suite and the Burks Mountain suite. The area in the vicinity of the Gladesville gabbro has recently been considered part of the Berner mafic arc complex. Alternatively, this area around the Gladesville, as well as a possibly large part of the Georgia Piedmont, may be a part of a regional melange sequence.

One talc body, in the Pollards Corner area of the Burke Mountain suite, Columbia County, requires additional subsurface investigations to determine the extent and quality of the talc.

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APPENDICES

APPENDIX A

CHEMICAL ANALYSES OF THE DICKS CREEK SUITE AND THE LAKE BURTON DUNITE

	HTB-1 Dicks Creek	LDB-1 Lake Burton
SiO_2	43.90	39.90
Al_2O_3	5.53	0.38
Fe_2O_3	5.99	3.83
FeO	8.74	7.89
CaO	3.46	0.12
MgO	27.80	39.80
MnO	0.20	0.18
K_2O	0.14	0.01
Na_2O	0.50	0.05
P_2O_5	0.07	0.02
TiO_2	0.42	0.01
LOI	0.78	2.53
Total	97.53	94.72

Trace Elements (ppm)

	HTB-1 Dicks Creek	LDB-1 Lake Burton
Cr	1500	1600
Ni	1000	1300
Co	115	135
V	145	30

APPENDIX B

CHEMICAL ANALYSES OF FIVE SAMPLES FROM THE LAURA LAKE MAFIC COMPLEX

	LL-1	LL-2	LL-3	LL-4	LL-5
SiO_2	44.0	43.80	47.60	46.20	44.60
Al_2O_2	14.70	19.0	18.70	14.0	19.30
Fe_2O_2	6.10	5.40	3.73	3.82	3.97
FeO	9.72	8.19	6.45	6.73	7.50
CaO	11.70	11.60	10.80	16.20	12.60
MgO	7.98	6.95	6.15	9.45	7.01
MnO	0.26	0.21	0.21	0.33	0.17
K_2O	0.52	0.40	0.77	0.82	0.47
Na_2O	1.59	1.78	2.25	1.81	1.40
P_2O_5	0.03	0.04	0.06	0.06	0.03
TiO_2	0.82	0.48	0.41	0.41	0.62
LOI	0.88	0.72	1.12	0.51	1.50
Total	98.30	98.67	98.24	100.34	99.17
	Trace elements (ppm)				
Cr	110	85	185	660	55
Ni	45	35	55	195	45
Co	50	40	30	55	45
V	515	435	295	270	540

APPENDIX C

CHEMICAL ANALYSES OF SAMPLES FROM THE KELLOGG CREEK MAFIC COMPLEX

	159-10	159-30	159-38	159-35
SiO_2	47.0	45.80	55.20	43.90
Al_2O_3	12.30	9.92	4.98	24.0
Fe_2O_2	2.01	2.24	3.90	1.89
FeO	3.80	4.39	7.20	1.17
CaO	15.40	12.40	11.0	16.40
MgO	14.60	18.20	12.30	4.86
MnO	0.14	0.12	0.23	0.06
K_2O	0.25	0.08	0.23	0.44
Na_2O	0.71	0.48	0.61	2.01
P_2O_5	0.01	0.02	0.46	0.09
LOI	2.43	3.82	1.52	2.14
Total	98.65	97.47	97.63	96.96
	Trace Elements (ppm)			
Cr	320	1200	240	780
Ni	85	270	110	95
Co	45	65	60	10
V	195	175	285	80

APPENDIX D
CHEMICAL ANALYSES OF MAFIC-ULTRAMAFIC ROCK UNITS IN THE SOUTHERN PIEDMONT

	Soapstone Ridge Complex			Durham Town Metagabbro	Coody Creek Mafic/Ultramafic Complex		
	SEA-1	**SEA-2**	**SEA-3**	**W-1gc**	**HM-6gc**	**HM-8gc**	**HM-21**
$Si0_2$	51.30	51.30	51.10	47.70	43.50	51.60	46.10
Al_20_3	18.40	16.50	20.20	18.10	18.20	10.10	18.80
Fe_20_2	1.89	1.96	2.05	4.06	5.53	3.44	3.09
Fe0	3.02	3.10	2.74	2.84	7.53	5.40	3.15
Ca0	12.70	12.40	12.70	15.10	10.70	12.30	15.80
Mg0	9.28	11.10	8.54	7.91	5.24	13.70	9.12
Mn0	0.10	0.10	0.10	0.11	0.14	0.22	0.11
K_20	0.24	0.22	0.21	0.64	0.49	0.85	0.23
Na_20	1.59	1.48	1.52	0.89	2.63	1.06	0.98
P_20_5	0.04	0.04	0.01	0.06	0.03	0.05	0.02
$Ti0_2$	0.23	0.21	0.10	0.29	3.12	0.32	0.08
L0I	1.40	1.49	1.27	1.86	2.16	2.04	2.29
Total	100.19	99.90	100.54	99.56	99.27	101.08	99.77
			Trace Elements (ppm)				
Cr	305	440	90	120	40	735	320
Ni	210	245	170	90	100	115	60
Co	30	35	35	35	50	40	45
V	125	110	75	215	475	240	120

APPENDIX D (continued)

	Gladesville Complex EJ-4gc	Whitewater Creek GL-2	Gladesville Monticello M0-1	Griggs Chapel ST-1gc	Cedar Creek ST-2gc	Little River EAT-1gc	Flatrock LSW-1gc	Lake Sinclair LSW-2gc
SiO_2	45.20	53.0	46.0	44.40	47.10	45.80	52.60	52.90
Al_2O_3	24.90	9.41	23.80	16.20	13.70	14.80	14.80	14.60
Fe_2O_2	2.35	1.95	2.57	8.93	2.73	6.90	3.69	3.25
FeO	2.76	4.35	1.46	6.0	7.08	9.30	5.49	6.02
CaO	14.0	16.0	15.80	9.72	10.40	10.10	10.40	9.51
MgO	6.91	13.80	5.70	6.30	10.70	6.10	7.74	6.85
MnO	0.08	0.16	0.08	0.16	0.16	0.23	0.16	0.16
K_2O	0.16	0.80	0.26	1.24	2.06	0.45	1.91	1.98
Na_2O	1.46	0.65	1.05	2.84	2.44	1.83	2.16	2.22
P_2O_5	0.02	0.09	0.02	0.11	0.26	0.11	0.07	0.08
TiO_2	0.10	0.26	0.13	1.45	1.62	1.58	0.54	0.54
LOI	0.63	1.29	1.08	0.48	1.09	0.96	0.94	1.15
Total	98.57	101.76	97.95	97.83	99.34	98.16	100.50	99.26
Trace Elements (ppm)								
Cr	180	1200	135	85	470	55	250	240
Ni	135	220	55	65	245	35	135	125
Co	35	40	20	40	50	45	40	40
V	50	195	110	460	240	540	235	235

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