The Geology of the Celeste 7 1/2' Quadrangle, Georgia

by

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Department of Natural Resources
Environmental Protection Division
Georgia Geologic Survey

Information Circular 94

Cover photo: The Country Store was built in the early 1900's. It originally stood in Jackson Crossroads, Georgia. The store is now a part of the Callaway Plantation Historic Site located in the southern central part of the study area.

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ABSTRACT

The lithologies of the Celeste 7 1/2 minute quadrangle are a part of the Carolina tectono-stratigraphic terrane. They may be divided into two groups, the metavolcanic units and the intrusive units.

Evidence indicates that the metavolcanics were deposited in a primitive oceanic island-arc setting, remote from Laurentia. These rocks underwent three periods of deformation during the Appalachian orogeny. The first was a period of recumbent folding that may be related to the accretion of the Carolina terrane to Laurentia. This was followed by a period of northeast trending, upright, isoclinal folding. The third event was a gentle, northwest trending regional folding. The rocks were metamorphosed to amphibolite grade. Peak metamorphism is thought to have occurred between the first and second deformational events.

The intrusive units show greenschist facies metamorphism and little sign of deformation; However, narrow northeast trending shear zones are common. Evidence suggests that these late kinematic intrusions occurred during the waning stages of metamorphism.

Numerous northwest trending faults and diabase dikes are interpreted to be the result of the rifting of the North American and African continents. The area was subsequently uplifted and eroded to its present surface.

INTRODUCTION

The purpose of this study is to evaluate the geology of the Celeste 7 1/2 minute quadrangle area, Wilkes County, Georgia at a scale of 1 : 24,000. The study was part of a Master's Thesis for the University of Georgia (Hall, 1991). Petrographic, geochemical, and structural data were collected to discern the deformational events and degree of regional metamorphism in the area. The petrography of the lithologies within the study area is provided. The geologic history of the Celeste quadrangle is discussed in order to relate the lithologies to the tectonic framework of the Southern Appalachians.

The Celeste 7 1/2 minute quadrangle is located in western Wilkes County, Georgia (figure 1). The northwestern city limits of Washington, Georgia is located in the southeastern corner of the quadrangle.

The quadrangle lies in the Washington Plateau district of the Eastern Piedmont Physiographic Province (Clark and Zisa, 1976). Topographically the area consists of a gently rolling terrain with a maximum elevation of 680 feet and a minimum elevation of approximately 420 feet. The streams in the study area form a complex drainage pattern.

The area is subject to intense chemical weathering due to the humid, subtropical climate of Georgia. As a result, hard rock outcrops are scarce.

Field data were collected by traversing primary and secondary roads, logging roads, streams, powerlines, and topographic anomalies in the study area. The freshest outcrops were usually found in and around streams. These data were then plotted on a 1 : 24,000 scale base map.

Petrographic analyses of 51 thin sections were conducted with the use of a petrographic microscope. An electron microprobe was also used to distinguish actinolite from hornblende in two samples. Major element analysis was done for seven whole rock samples from the study area.

The earliest published works of the geology of the study area were concerned with specific mineral occurrences. Watson (1902) described the granites and gneisses of Georgia and commented that few outcrops of granite were known in Wilkes County despite the fact that at the time it was bordered to the north and west by the two largest granite producing counties in the state; namely Elbert and Lincoln. In a report on the gold deposits in Georgia, Jones (1909) described occurrences of gold near the study area, such as the Latimer mine to the east and the Stoney Ridge mine to the south. In a report on the feldspar and mica deposits in Georgia, Galphin (1915) mentioned the occurrence of numerous, yet small pegmatite dikes in Wilkes County.

Crickmay (1952) divided the crystalline rocks in the region into metamorphic belts. He showed the study area to be underlain by the slates, phyllites, schists, and volcanics of the Little River belt and the Uchee belt. He did not provide a description of the Uchee belt, commenting that no detailed mapping had been done there at the time.

A general geologic map of Wilkes county was published by Crawford (1968). This map shows the study area to be underlain by granite gneiss and biotite muscovite granite to the northwest and hornblende gneiss, biotite gneiss, and amphibolites to the southeast. The map also shows a small band of quartz muscovite sericite schist in the southwestern corner of the study area.

An early geologic map of Georgia compiled by Cooke and others (1939) indicated that the area is underlain by biotite gneisses and schists, and biotite muscovite granite. The most recent geologic map of Georgia (Georgia Geologic Survey, 1976) shows the study area underlain by (from north to south): granite; undifferentiated metavolcanics, sericite phyllites, meta-argillites, and quartz mica schists; metadacite; granitic gneiss; undifferentiated granite gneiss and amphibolites.

The geology of nearly all the 7 1/2' quadrangles surrounding the study area is described in several theses completed by University of Georgia students (Young, 1985; Conway, 1986; Dunnagan, 1986; Hutto, 1986; Rogero, 1986;

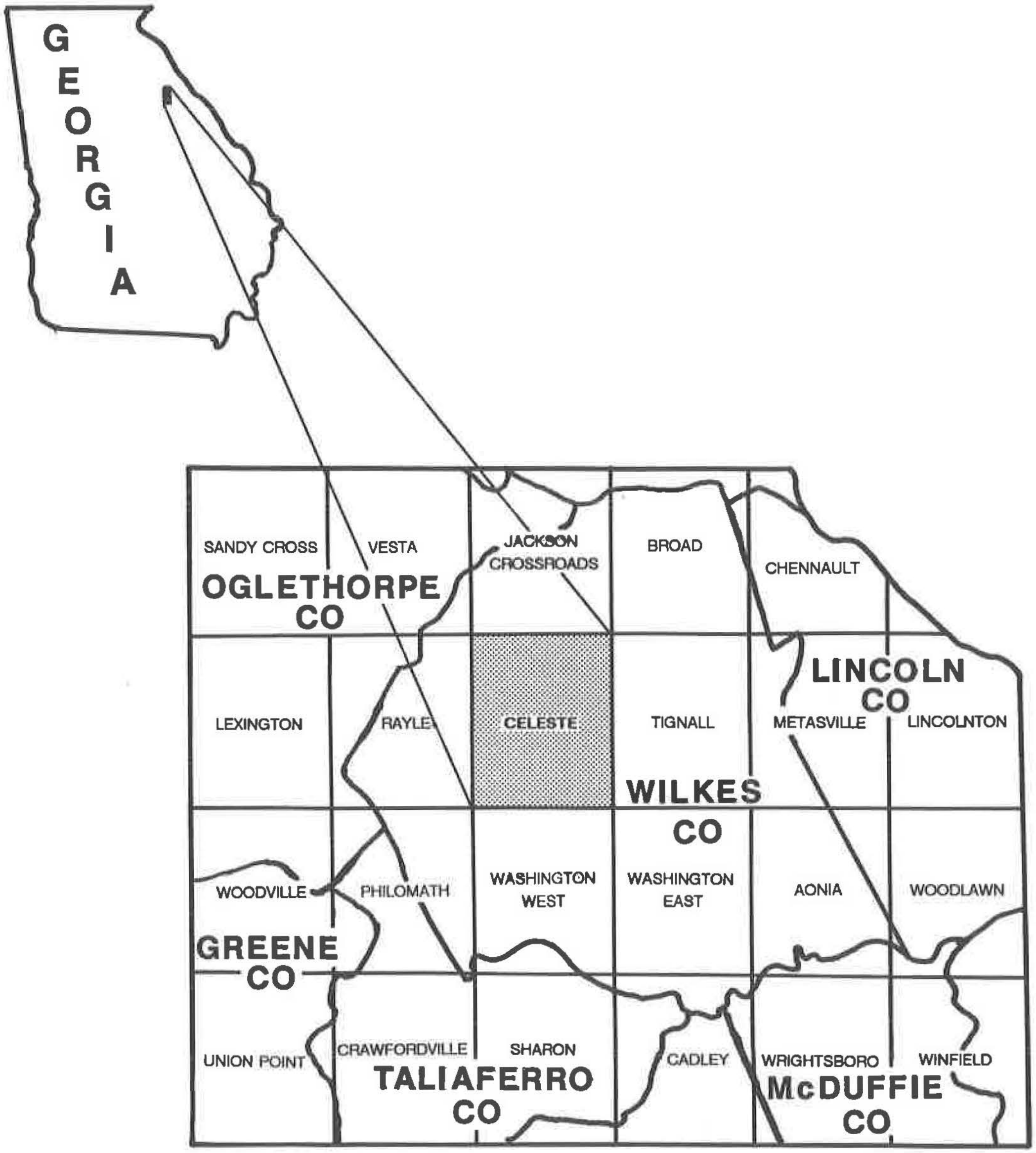


Figure 1. Location map of the study area.

Turner, 1987; Von Der Heyde, 1990).

REGIONAL GEOLOGY

The Piedmont of Georgia has been divided into northeast trending geologic belts based on lithology, structure, and metamorphic grade (Crickmay, 1952; Hatcher, 1972; Whitney, 1980) (figure 2). Previous workers indicate that the Charlotte belt - Slate belt boundary passes through the Celeste quadrangle (Dunnagan, 1986; Rogero, 1986). There has been controversy concerning the nature of this boundary. Some geologists have suggested that the contact between these belts is an unconformity (Hatcher, 1972; Glover, 1974; Delia, 1982), however the lack of a basal conglomerate disputes this theory. Best and others (1973), Conway (1986) and Dunnagan (1986) have suggested that the belts are separated by a thrust fault, while Griffin (1978), Halik (1983), and Kirk (1985) suggest an infrastructure/suprastructure relationship in which the Charlotte belt evolved beneath the Slate belt. An excellent overview of the Charlotte belt - Slate belt controversy is found in Von Der Heyde (1990).

Several workers theorize the development of the southern Appalachian orogen through a series of accretionary events that correlate with the Paleozoic orogenies (the Taconic, Acadian, and Alleghanian) that collectively formed the orogen (Williams and Hatcher, 1982, 1983; Secor and others, 1983; Horton and others, 1989). The region is therefore divided into a number of tectonostrat-igraphic terranes (Hatcher, 1987).

The study area lies within the Carolina terrane. The term, Carolina terrane is used by Secor and others (1983) to include rocks previously assigned to the Slate and Charlotte belts. Horton and others (1989) also include much of the Kiokee belt, the Belair belt, and the Battleground Formation of the Kings Mountain belt. The Carolina terrane is interpreted to have originated in a volcanic arc setting and may represent a composite terrane (Whitney and others, 1978; Horton and others, 1989).

Dunnagan (1986) and Rogero (1986) assign lithologies striking into the Celeste quadrangle to the Charlotte belt and Slate belt. The lithologies of the study area are not assigned to belts, rather referred to collectively as part of the Carolina terrane. Since the terms "Carolina slate belt" and "Charlotte belt" are used in many of the references cited, a brief description of each is provided.

The Carolina slate belt (or Slate belt) consists of an assemblage of Late Precambrian to Middle Cambrian metavolcanic and metasedimentary rocks, which extend southwest from near Petersburg, Virginia for over 400 miles to central Georgia (Sundelius, 1970). In Georgia these rocks are called the Little River series (Crickmay, 1952). The Northern Little River series (NLRS) and the Southern Little River series are separated by the higher grade rocks of the Charlotte belt. A portion of the study area is underlain by the NLRS.

The lithologies of the Slate belt include mafic and felsic metavolcanics, metavolcanoclastics, and metasedimentary rocks such as siltstones, claystones and wackes (Sudelius, 1970). Geochemical evidence indicates that these lithologies originated in a volcanic island arc setting where oceanic crust is being subducted beneath oceanic crust (Whitney and others, 1978). Sundelius (1970) reports that the Slate belt rocks of South Carolina do not exceed greenschist grade metamorphism. However, workers in Georgia report amphibolite grade conditions in the Little River Series (Whitney and others, 1978; Young, 1985; Hutto, 1986).

The structure of the Slate belt is characterized by vertical to steeply dipping, northeast trending, isoclinal folds (Sundelius, 1970; Whitney and others, 1978).

The Charlotte belt, which is named for its type locality in Charlotte, North Carolina, extends from Virginia to Alabama (King, 1955; Hatcher, 1972). Lithologies that are common to the Charlotte belt are biotite gneiss, amphibole gneiss, migmatite, amphibolite, mica schist, and a variety of pre- to post-metamorphic intrusives (Tobisch and Glover, 1969; Griffin, 1978; Whitney and others, 1980). This geologic belt underlies the southeastern portion of the study area.

Low to upper amphibolite grade metamorphism is reported throughout the Charlotte belt (Butler and Ragland, 1969; Tobisch and Glover, 1969; Thurmond, 1980; Delia, 1982).

Like the Slate belt, deformation of the Charlotte belt is characterized by a steeply dipping, tight, isoclinal fold pattern (Tobisch and Glover, 1971; Griffin, 1978).

PETROLOGY OF THE ROCKS OF THE CELESTE 7 1/2' QUADRANGLE

The rocks of the Celeste quadrangle are assigned to three groups: (1) the northern metavolcanic assemblage; (2) the southern metavolcanic assemblage; (3) intrusive units. The lithologies are not assigned to geologic belts. In addition, the biotite gneiss unit is presented as a higher grade stratigraphic equivalent of the southern volcanic unit.

Powell's (1979) morphological classification scheme for rock cleavage is used in this report. All igneous intrusions in the study area are named in accordance with the I.U.G.S. classification scheme (Strekeisen, 1976) unless otherwise noted. Modal analyses are based on visual estimates from thin sections. Major element analyses of seven whole rock samples are shown in table 1.

All lithologic names not beginning with the prefix "meta-" should be assumed metamorphosed unless otherwise

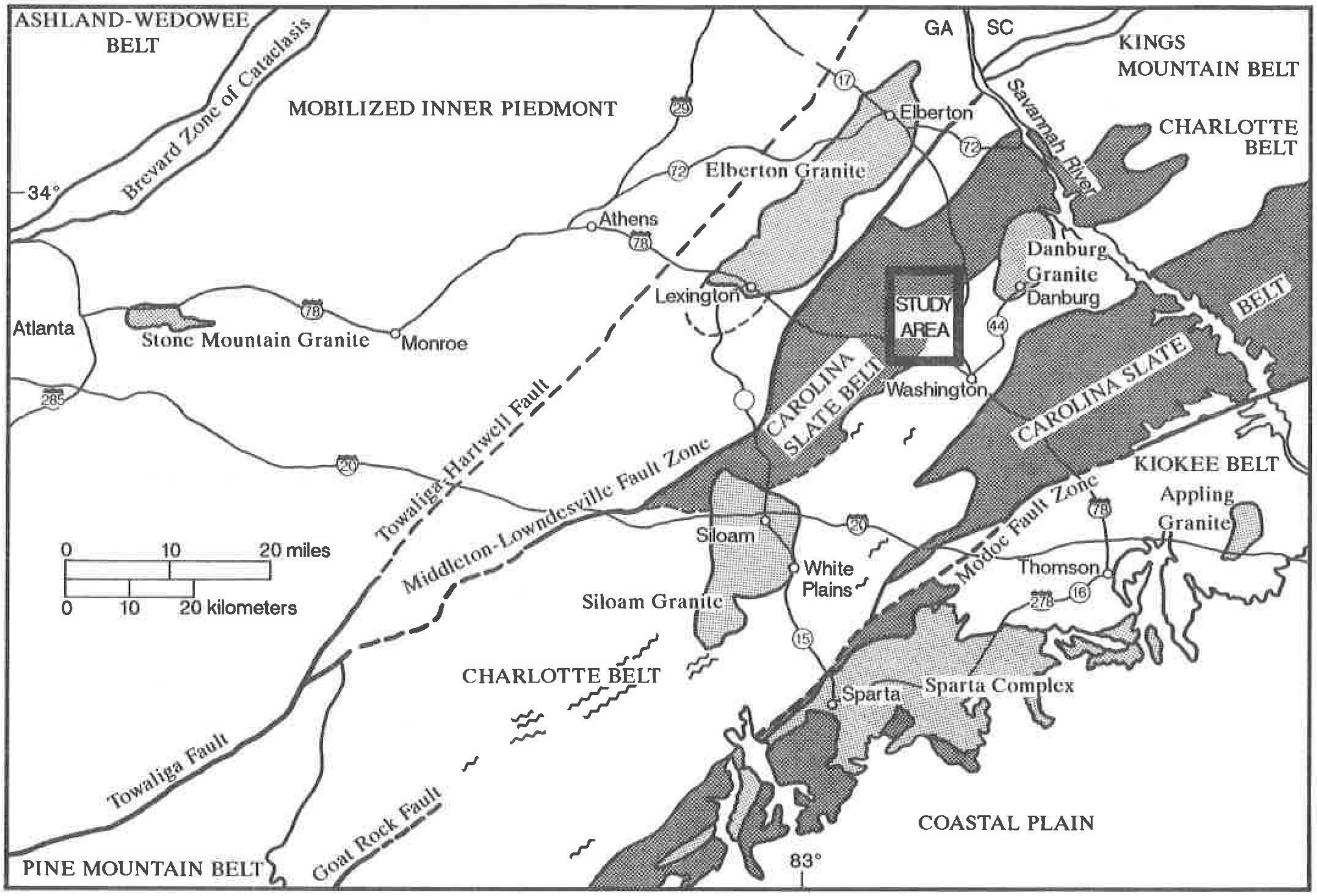


Figure 2. Major geologic belts of the southern Appalachians. The study area is outlined. (Modified from Whitney and others, 1980.)

Table 1. Major element analyses of 7 whole rock samples from the Celeste 7 1/2' quadrangle.

	1	2	3	4	5	6	7
SiO_2	74.50	69.50	46.80	70.70	64.60	76.20	76.70
TiO_2	0.38	0.39	1.30	0.65	0.93	0.08	0.07
Al_2O_3	13.60	14.80	17.11	14.50	14.80	12.10	12.00
Fe_2O_3	2.74	3.57	3.02	1.33	4.35	0.80	0.97
FeO	0.48	0.58	9.73	2.60	4.55	0.36	0.44
MnO	0.01	0.09	0.19	0.10	0.19	0.01	0.07
MgO	0.57	0.93	6.21	0.53	1.31	0.08	0.15
CaO	0.15	3.22	11.29	2.44	3.56	0.57	0.94
Na_2O	0.34	3.61	2.29	4.66	3.00	3.25	3.63
K_2O	4.16	1.74	0.24	1.87	1.47	5.27	3.85
P_2O_5	0.15	0.09	0.27	0.16	0.10	0.02	0.05
S	0.02	0.02	0.03	0.08	0.01	0.02	0.02
L.O.I.	2.40	1.08	0.69	0.39	0.40	0.34	0.29
Total	99.50	99.62	99.17	100.01	99.27	99.10	99.18

Sample: 1 - crystal tuff; 2 - dacitic crystal tuff; 3 - amphibolite (biotite gneiss unit); 4 - biotite gneiss; 5 - biotite gneiss; 6 - Jackson Crossroads granite; 7 - Middle Creek granite.

stated.

Northern Metavolcanic Assemblage

Northern Volcanic Unit

The northern volcanic unit lies in the center of the northern portion of the study area. Crystal tuffs and dacite crystal tuffs make up the bulk of this unit, along with minor mafic metavolcanics, and phyllites. Soils overlying the unit are orange to tan in color and quartz rich. Saprolite and hardrock outcrops are very rare; however, float is abundant.

The crystal tuff is a quartz sericite schist. Hand samples are silvery grey and variably stained with iron oxides. A well developed foliation is formed by the alignment of phyllosilicates. Relic phenocrysts of quartz are usually visible.

Petrographic analyses reveal sericite, quartz and sometimes altered plagioclase as the primary minerals. Modal analyses of metavolcanic unit lithologies are shown in table 2. A well developed disjunctive anastomosing cleavage is defined by sericite. Quartz is found in the matrix and as relic phenocrysts. In the matrix the quartz is very fine grained and has a granoblastic texture. The quartz phenocrysts are sometimes elongated and medium to fine grained. They are commonly recrystallized to varying degrees. Plagioclase phenocrysts are altered to epidote and sericite. Euhedral crystals of this mineral (figure 3) lend support to the conclusion that this rock is volcanic in origin. Matrix plagioclase is fine grained, granoblastic, and seldom exhibits albite twinning.

The alteration and commonly complete absence of plagioclase in this lithology indicates that it has undergone hydrothermal alteration. A geochemical analysis of the crystal tuff (table 1) supports this conclusion by showing a high potassium and low calcium and sodium content. The presence of a small zone of quartz and pyrite mineralization provides further support.

In hand sample the dacite crystal tuff is dull grey with medium grained phenocrysts of quartz and plagioclase. In thin section the rock exhibits a well developed, closely spaced, disjunctive, smooth foliation defined by fine grained biotite and sericite. Medium grained biotite forms a spaced, discrete, crenulation cleavage. The phenocrysts are primarily plagioclase (oligoclase), which is variably altered to epidote and sericite.

Occasional float of a mafic metavolcanic rock is found in the metavolcanic unit. In hand sample the rock is light green, very fine grained and displays small white streaks of fine grained quartz.

In thin section, amphibole and epidote are the main mineral constituents along with minor sericite. A well developed, moderately spaced, disjunctive, smooth foliation is defined by the preferred orientation of sericite. A lineation is defined by the preferred alignment of amphibole in the direction of the foliation. Microprobe analysis of the amphibole reveals hornblende rimmed with actinolite, indicating retrograde metamorphism of this amphibolite grade lithology. The protolith of this rock is believed to be a basalt. The streaks of recrystallized quartz grains are interpreted as flattened amygdules.

Northern Sedimentary Unit

The northern sedimentary unit can be traced from the Jackson Crossroads quadrangle (Young, 1985), southward into the study area where it intercepts the wide Clark Creek floodplain. Within the floodplain, all evidence of the underlying geology is covered by quaternary alluvium. Rare, very weathered float of a well laminated meta-argillite provides the only evidence of this unit in the study area. Hand samples are silver-grey in color with laminae measuring 2mm to 4mm thick. The laminae appear to be alternating micaceous and quartz bearing micaceous layers. Due to the poor condition of the samples, no thin sections were made of this lithology. Young (1985) reports that this lithology is interlayered with metavolcanics.

Southern Metavolcanic Assemblage

The southern metavolcanic assemblage lies in the southwestern corner of the Celeste quadrangle and consist of three interlayered lithologies. One of these is a quartz sericite schist which dominates the southeastern portion of the assemblage. This unit can be traced along strike to the southwest to the Washington West quadrangle where it was mapped by Dunnagan (1986). The lithology continues southwestward into the Philomath quadrangle and is described by Conway (1986) as a part of his lower volcanic unit. The other two lithologies, seen primarily as saprolite, may be interpreted as intermediate and mafic volcanics. The occurrence of these two lithologies appears to increase across the assemblage to the northwest forming the southern volcanic unit.

Quartz Sericite Schist

The quartz sericite schist occurs as the dominant lithology in the southeastern portion of the southern volcanic assemblage. Overlying soils are quartz rich and tan in color. The rock forms a silvery pink to maroon saprolite containing abundant muscovite, sericite and quartz. Outcrops of this schist are poor, however small chips of float can be found in the areas that overlie this lithology. Only one foliation formed by the alignment of muscovite and sericite is seen in outcrop. This foliation is parallel to regional strike.

Table 2. Modal analyses of northern volcanic unit lithologies.

	A	B	C	D
plagioclase (phenocrysts)	-	3	-	10
quartz (phenocrysts)	-	7	-	3
plagioclase (matrix)	-	5	-	34
quartz (matrix)	8	20	10	25
actinolite	-	-	50	-
biotite	-	-	-	8
muscovite	22	-	-	-
epidote	-	8	40	10
sericite	67	55	tr	10
sphene	-	-	-	tr
Opaques	3	2	tr	tr

A and B: crystal tuff.
C: mafic volcanic.
D: dacite crystal tuff.

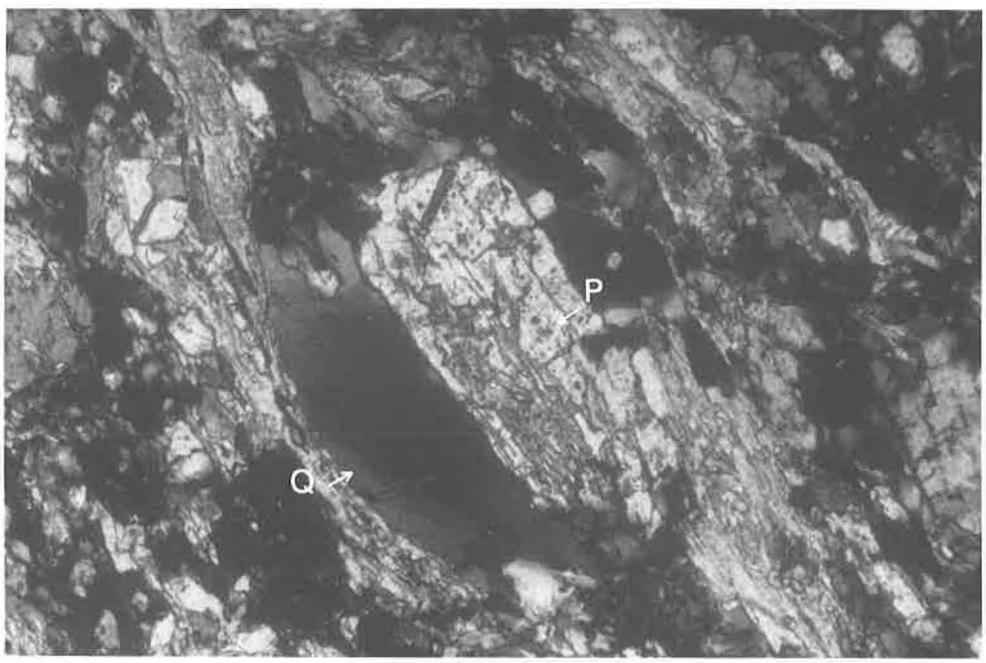


Figure 3. Photomicrograph of a crystal tuff from the northern metavolcanic assemblage. A euhedral plagioclase phenocryst (P) is shown included in quartz (Q). Field of view 1.3mm.

Hand samples show a silver colored, well foliated, fine grained rock. Variable amounts of quartz, sericite and muscovite are present as primary minerals. Occasionally cubes of limonite formed by the alteration of pyrite are present in trace quantities. Because this unit is highly weathered, samples suitable for petrographic analyses are more quartz rich than the lithology as a whole.

In thin section the rock exhibits a well developed, anastomosing to smooth, closely spaced, disjunctive cleavage formed by the alignment of phyllosilicates. Quartz and muscovite are the primary minerals. The quartz grains exhibit a strong undulatory extinction. One sample contains approximately 3 percent biotite aligned parallel to the foliation. Modal analyses are given in table 3.

Although pre-existing textures have been obliterated by deformation, evidence for the volcanic origin of this unit has been well documented by Dunnagan (1986). The lack of calcium minerals suggests that these rocks were hydrothermally altered prior to deformation.

Southern Volcanic Unit

As previously mentioned, two lithologies primarily seen as saprolite comprise the southern volcanic unit. A few hard rock outcrops can be found where the unit crosses Beaverdam Creek. These lithologies are found interlayered with the quartz sericite schist and occur with increasing frequency to the northwest to form the southern volcanic unit. Layers vary in thickness from <1 ft. to as much as 50 ft. One lithology forms a red and orange mottled, clay rich saprolite containing approximately 5 to 10 percent quartz and abundant flakes of hydrated biotite. This lithology is interpreted to be a biotite gneiss probably of volcanic origin. The other lithology is an amphibolite and forms a brick red, very cohesive saprolite. Hornblende and oligoclase are the primary minerals and minor amounts of biotite are also present. One small ditch outcrop of this lithology does display amygdules. A basalt is the indicated protolith for this lithology. A modal analysis is given in table 3.

Biotite Gneiss Unit

The biotite gneiss unit underlies a small area along the southern border of the Celeste quadrangle. It is also found as a roof pendant between the Jackson Crossroads and biotite granites. This unit consists of a biotite gneiss with interlayered amphibolites. Quartz epidote granofels occurs as float.

The biotite gneiss unit is dominantly a medium grained biotite gneiss consisting of finely interlayered, 1-4 cm thick quartzo-feldspathic and mafic horizons. Migmatitic textures indicative of the onset of anatexis are rarely observed. The overlying soil is deep red-brown and contains abundant flakes of hydrated biotite. While hard rock outcrops of this lithology are extremely rare, saprolite outcrops are distinctive and common. Both soil and saprolite proved to be very useful for mapping this assemblage.

In thin section the rock is chiefly comprised of granoblastic plagioclase and quartz with lesser amounts of biotite and several accessory minerals. The plagioclase (oligoclase) rarely exhibits albite twinning, but can be distinguished from quartz which exhibits an undulose extinction under crossed polars. Furthermore the plagioclase shows a faint "cloudiness" under uncrossed polars, while the quartz appears very clear. Brown biotite forms a rough, moderately spaced, disjunctive cleavage parallel to compositional layering. Both this mineral and garnet (tr) show minor alteration to chlorite. Other minerals, occurring in trace amounts, are shown in table 4.

Previous work has generated two interpretations for the protolith of the biotite gneiss. The first interpretation is that the rocks are metamorphosed greywackes of volcanic origin (Dunnagan, 1986; Conway, 1986; Lovingood, 1983). Von Der Hyde (1990), in contrast, suggests that they are pyroclastic rocks which have been metamorphosed to amphibolite grade. The author prefers a metavolcanic as the protolith for the rocks making up the biotite gneiss within the Celeste quadrangle. Although any contact between the two units has been destroyed by the intrusion of the Jackson Crossroads Granite and the biotite granite, the southern volcanic unit and the biotite gneiss unit seem to differ only in metamorphic grade. Furthermore, one outcrop within the biotite gneiss unit displays a well preserved volcaniclastic texture. Chemical analyses from the biotite gneiss compare favorably with those of pyroclastics analyzed by Whitney and others, (1978).

The amphibolite is a black, fine to medium grained rock displaying a well developed lineation formed by the preferred alignment of hornblende. This rock occurs sporadically as float and fresh rock outcrops in the biotite gneiss assemblage. Traces of pyrite are visible in hand sample and a slight magnetism indicates the presence of magnetite.

Petrographic analysis of the fine grained amphibolite reveals an equigranular, granoblastic texture formed by plagioclase (oligoclase) and green, pleochroic, prismatic hornblende. Retrogression of hornblende to chlorite is observed in some samples. Minerals occurring in minor amounts include epidote, sphene, and opaques.

The mineralogy of the medium grained amphibolite is similar to that of the fine grained rock. The most significant difference is that the hornblende occurs as larger poikiloblastic grains. The amphibolites are interpreted as metabasalts. Model analyses are given in table 4.

Abundant float of quartz epidote granofels is ubiquitous in the biotite gneiss unit. Equigranular, fine grained quartz

Table 3. Modal analyses of southern volcanic assemblage lithologies.

	A	B	C	D
sericite	37	7	62	-
quartz	60	75	23	-
amphibole	-	-	-	55
plagioclase	-	-	-	43
muscovite	-	15	-	-
biotite	3	-	-	2
epidote	tr	-	5	-
chlorite	tr	-	-	-
sphene	-	-	-	tr
opaques	tr	3	tr	tr

A, B, and C: quartz sericite schist
D: amphibolite

Table 4. Modal analyses of rocks from the biotite gneiss unit.

	A	B	C	D
amphibole	45	62	-	-
plagioclase	46	36	43	48
quartz	2	-	42	38
biotite	tr	-	15	10
muscovite	-	-	-	2
epidote	2	-	-	2
sphene	-	1	-	tr
chlorite	tr	tr	tr	tr
garnet	-	-	tr	-
Opaques	5	1	tr	tr

A: medium grained amphibolite
B: fine grained amphibolite
C: biotite gneiss
D: biotite gneiss

and epidote are the major mineralogic components of this rock. Hornblende, biotite, and pyrite are seen in trace amounts. Since the granofels are found in all lithologies and commonly occur as crosscutting lenses, the protolith could be an alteration of the original rocks along fractures.

Intrusive Lithologies

Biotite Granite

The biotite granite underlies most of the southeastern corner of the study area. Soils over this unit are orange and have a characteristic "scattering" of quartz sand on the surface and abundant cobble size quartz float. Deep, steep sided ravines are very common and provide excellent saprolite exposures. Hard rock outcrops, however, are extremely rare.

Four distinct intrusive phases are found in the study area. They are a biotite granite, a biotite bearing granite, a leucocratic granite, and a hornblende biotite granodiorite. The unit has a very complex intrusive history that is beyond the scope of this study. Dikes of each of these phases can be seen crossing the others even in very small exposures. As many as seven phases have been reported in one exposure outside the study area (Gilles Allard, pers. comm.). Exposures of the unit within the Celeste quadrangle show the biotite granite as the dominant phase. Many of the leucocratic dikes may be attributed to the nearby Jackson Crossroads and Middle Creek granites. Pegmatites are common in this unit.

The biotite granite phase forms a red orange, biotite rich saprolite, containing very fine grained quartz. The tan to cream colored saprolite of the biotite bearing granite shows a medium grained rock composed of quartz, feldspar, and minor biotite. The leucocratic phase is seen as a medium grained, white rock commonly containing traces of muscovite or biotite. Due to the lack of fresh samples, a precise I.U.G.S. classification of these lithologies is not possible.

A hard rock exposure of the hornblende, biotite granodiorite is found approximately 1000 ft. south of the Beaverdam Creek ford. The outcrop is very small and may represent either a small intrusive plug, or a large xenolith. The rock is variably foliated due to ductile deformation. This lithology forms a dark grey, quartz and biotite rich saprolite. In hand sample the rock is medium grained and composed of hornblende, biotite, quartz and feldspar. Petrographic analysis reveals andesine. Euhedral plagioclase grains display albite twins and show only a slight alteration to sericite and epidote. Zoning of this mineral is faintly detected under crossed polars. The quartz is slightly recrystallized, elongated in the direction of the foliation, and displays an undulose extinction. Biotite, which defines the foliation, displays a brown pleochroism. Green, pleochroic hornblende is seen as subhedral prisms. Trace amounts of epidote are seen as euhedral crystals, indicating that this is a primary phase. A modal analysis is provided in table 5.

Xenoliths of amphibolite and biotite gneiss are common in the biotite granite unit. They may represent portions of the biotite gneiss unit, and, as expected, become more common near the contact with that unit.

Jackson Crossroads Granite

The Jackson Crossroads Granite (Young, 1985) underlies approximately two-thirds of the study area. Soils that form over the unit are yellow to pale orange and contain abundant quartz grains. The rock forms a white saprolite, variably stained by iron oxides according to its location in the soil profile, with a well preserved granitic texture. Light gray, hard rock outcrops and boulders are common in streams, on hillsides, and occasionally on hill tops. Pavement outcrops are small and rare. Fresh surfaces are creamy white.

In hand sample one notes a leucocratic, fine to medium grained, hypidiomorphic granular granite consisting of subhedral feldspar, interstitial quartz, and variable amounts of biotite not exceeding 3 percent. Grain size averages between 3 - 5mm.

In thin section the major rock forming minerals are plagioclase (albite and oligoclase), quartz, and K-feldspar (table 6). Minor amounts of biotite are omnipresent. The subhedral, medium grained plagioclase commonly exhibits albite twinning lamellae, which are sometimes bent. Very few zoned plagioclase crystals are observed. Sericite and epidote are the major alteration products of this mineral. The variation in plagioclase composition may indicate that albitization only occurred when enough fluids were available to facilitate the reaction, as suggested by Hutto (1986). Fine to medium, anhedral quartz grains show a pronounced undulatory extinction. Crystals of K-feldspar are fine to medium grained and anhedral. The characteristic cross-hatch pattern that is seen in this mineral under crossed polars is usually visible, though variably distorted. Biotite occurs as disseminated, green, pleochroic flakes. Only in the vicinity of a shear zone does biotite show a preferred orientation. This phase is occasionally seen retrograding to chlorite.

Evidence shows that the Jackson Crossroads granite is a late kinematic intrusive that was emplaced after peak metamorphism. Other than narrow, northeast striking, ductile shear zones, the body shows little sign of deformation. Greenschist metamorphism is indicated by the presence of chlorite, sericite, and epidote as alteration products.

Zones of ductile deformation are clearly seen in this intrusive. These shear zones strike to the northeast and can be found across the study area in that direction. The degree of ductile deformation is variable. Some outcrops show an alignment of biotite and elongated or "ribboned" quartz.

Roadside outcrops southeast of Flint Hill Church (Field Stop 6) show quartz recrystallized to an aphanitic groundmass surrounding ellipsoidal crystals of feldspar (figure 4).

The Jackson Crossroads granite intrudes all of the other lithologies in the map area except the Middle Creek granite (Rogero, 1985). Xenoliths of an older granitic intrusion are seen in the saprolite walls of an inactive borrow pit located just north of the Wilkes County Airport (figure 5). These xenoliths are similar in appearance to the biotite rich phase of the biotite granite. At Field Stop 7, near the contact between these two units, fine grained leucocratic injections into the coarser grained biotite granite provides evidence that the Jackson Crossroads granite is the later intrusive.

The Jackson Crossroads granite can be traced to the northwestern portion of the Tignall 7.5' quadrangle, where it has been mapped as the Tignall granite by Rogero (1985). Recent work by Gilles Allard, (pers. comm.) verifies this conclusion.

Jackson Crossroads Granite (Mafic Phase)

Two areas within the Jackson Crossroads granite are highlighted as a mafic phase of the pluton. These areas are characterized by a lack of hard rock outcrops, deep ravines with vertical walls, and an increase in biotite (apx. 5%). The ravines, which provide abundant saprolite exposures, are a geomorphic feature not found in the main granite body. The deep weathering profile and increased biotite content indicate a more mafic lithology. The quartz content is similar to that of the typical Jackson Crossroads granite. Because the change between this lithology and the granite appears gradual, it is interpreted by the author as a phase of the Jackson Crossroads granite, rather than a separate intrusive.

Middle Creek Granite

The Middle Creek granite, first described by Rogero (1986), intrudes the biotite granite unit in the southeastern portion of the study area. This unit is very similar to the Jackson Crossroads granite in appearance and composition. Light gray, hard rock outcrops and boulders occur in and along streams. Weathering produces an orange saprolite and light orange, quartz rich soils. Hand samples reveal a fine to medium grained, equigranular, leucocratic, muscovite granite.

From petrographic analysis, the primary minerals are quartz, potassium feldspar and albite. Muscovite is present in quantities from 1 to 3 percent. A modal analysis is shown in table 6. Epidote and sericite are present as alteration products of plagioclase. The albitization of plagioclase indicates metamorphism under greenschist conditions. Bent and broken plagioclase grains and a strong undulose extinction exhibited in quartz grains attest to the deformation of this lithology.

The metamorphic grade and chemical composition of this rock indicate an intrusive of similar age and composition to the Jackson Crossroads Granite (table 6.)

Pegmatite Dikes

Pegmatites are common in the study area. They are composed of quartz, feldspar, and sometimes muscovite, and display a graphic texture in places. No thin sections were made of these rocks.

Diabase Dikes

Diabase dikes were observed in places in the study area. Outcrops of this rock are dark grey and very fresh, but sometimes display a red-orange surficial weathering. Samples are black on the fresh surface and composed of fine grained laths of plagioclase (labradorite) and augite.

STRUCTURE

The structural geology of the Celeste quadrangle is very difficult to resolve. The rocks in this area have experienced polyphase deformation. In addition, due to the intense chemical weathering in the area, exposures are few and poor. Other complicating factors are the disruption of structural patterns by syn to post-kinematic intrusions and faulting.

Because the limited amount of data that are found in one quadrangle is not enough to provide a complete structural interpretation, previous work in the region surrounding the study area is also used to formulate a structural model. Three deformational events have been proposed for the rocks within the study area. At least one period of ductile deformation affected the rocks in the area. Several northwest trending brittle faults were also noted.

An early deformational event (D_1) has been noted by previous workers. This event is marked by a period of recumbent folding (F_1) of the Carolina terrane rocks (Conway, 1986; Dunnagan, 1986; Turner, 1987). The resulting S_1 fabric is only seen in the noses of F_2 folds, which do not outcrop in the study area.

The second deformational event formed the dominant regional foliation (S_2). The average orientation of this foliation is N67E dipping steeply to both north and south. Contoured stereographic projection of poles to S_2 indicates northeast trending, upright, isoclinal folding (F_2). Contacts between the interlayered lithologies of the southern volcanic assemblage are parallel to S_2.

A third deformational event is seen on a regional scale as broad, northwest trending folds. The F_3 folds have been reported by several workers in the region surrounding the study area (Thurmond, 1980; Delia, 1982; Murphy, 1984; Dunnagan, 1986; Rogero, 1986).

Table 5. Modal analyses of the biotite, hornblende granodiorite.

quartz	20
plagioclase	58
K-feldspar	10
hornblende	5
biotite	5
muscovite	-
epidote	1
sphene	1
zircon	tr
sericite	-
opaques	tr

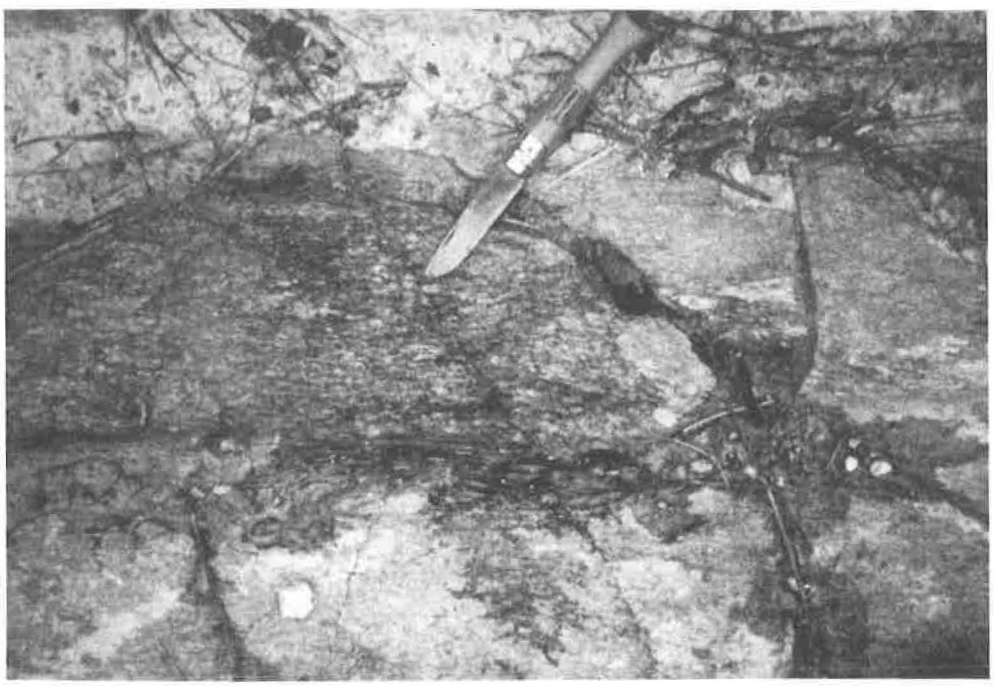


Figure 4. Outcrop of sheared Jackson Crossroads granite.

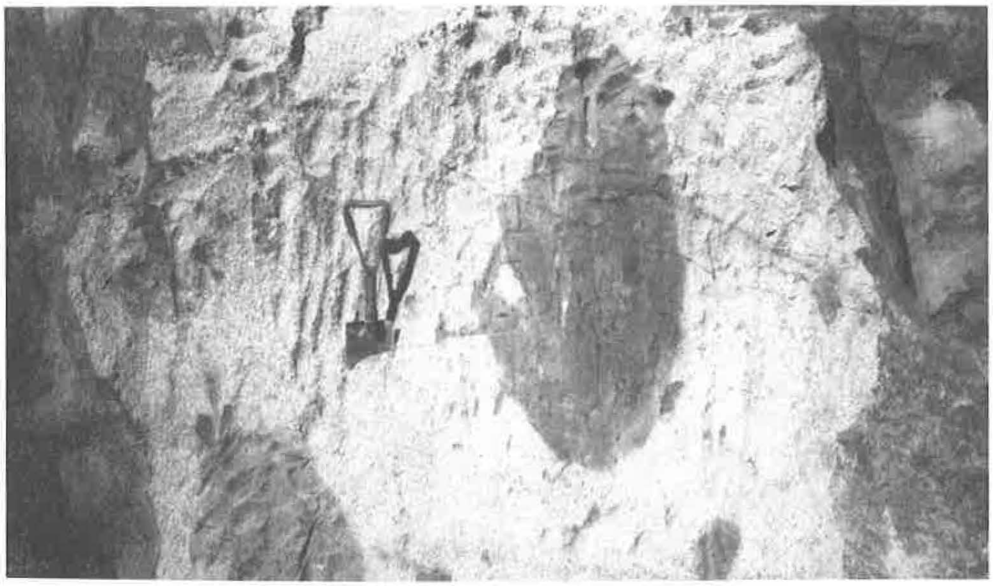


Figure 5. Saprolite outcrop of the Jackson Crossroads granite with a xenolith of a previous granitic intrusion.

Table 6. A) Modal analyses of the Jackson Crossroads granite (JC) and the Middle Creek granite (MC).
B) Chemical analyses of the Jackson Crossroads granite (JC) and the Middle Creek granite (MC).

A)	JC	JC	JC	MC
quartz	35	37	28	30
plagioclase	34	25	36	33
K-feldspar	31	33	36	36
biotite	tr	3	3	-
muscovite	-	tr	tr	tr
epidote	tr	1	tr	tr
sericite	tr	1	tr	tr
sphene	-	tr	-	-
zircon	tr	-	-	tr
opaques	-	tr	-	tr

B)	JC	MC
SiO_2	76.70	76.20
TiO_2	.07	.08
Al_2O_3	12.00	12.10
Fe_2O_3	.97	.80
MnO	.07	.01
MgO	.15	.08
CaO	.94	.57
Na_2O	3.63	3.25
K_2O	3.85	5.27
P_2O_5	.05	.02
SO_3	.02	.02
L.O.I.	.29	.34
Totals	98.98	98.94

Several narrow zones of ductile deformation are found in various outcrops of the Jackson Crossroads granite and three in the biotite granite unit. The mylonitic texture usually observed consist of "ribboned" quartz and the alignment of phyllosilicates. A greater degree of deformation is observed in the ditch outcrops along the road to the southwest of Flint Hill Church. Here the quartz is recrystallized to an aphanitic groundmass which is surrounding ellipsoidal grains of feldspar, giving the rock an augen texture.

The locations of these shear zones on the geologic map of the Celeste quadrangle (plate I) suggest a wide zone of heterogeneous shearing striking from the southwestern to northeastern corners of the area. Inadequate exposure prevents a precise definition of this structure in the study area; however, it has been well documented to the southeast of the Celeste quadrangle by previous workers (Conway, 1986; Dunnagan, 1986; Hutto, 1986). The average strike of the ductile fabrics in the study area is N51E. However, individual measurements range from N27E to N75E. Davis (1980) and Conway (1986) suggest that this deformation represents a splay off the Middleton-Lowndesville cataclastic zone. Secor and others (1988) describe a later ductile deformational event, which affected portions of the Kiokee belt, Modoc zone, and Slate belt. Either or both deformational events may be responsible for the ductile deformation in the Celeste quadrangle.

Several faults were discovered in the study area. These northwest trending structures are quite common in the Carolina terrane and have been noted by previous workers in the area surrounding the Celeste quadrangle (Young, 1985; Conway, 1986; Dunnagan, 1986; Hutto, 1986; Rogero, 1986; Turner, 1987; Von Der Heyde, 1990). The truncation or displacement of lithologies, presence of silicified zones, and topography helped to define the faults.

Joints in the study area are usually near vertical and striking to the northwest. Well developed jointing is found in the Jackson Crossroads and Middle Creek granites.

METAMORPHISM

All of the rocks in the Celeste 7 1/2' quadrangle have undergone regional metamorphism with the exception of a few diabase and quartz dikes. Metamorphism is interpreted to be isochemical. This interpretation is supported by geochemical analyses of rocks from the study area. These analyses show chemical compositions that reflect those of the igneous protoliths.

Barrovian or Buchan type metamorphism is suggested by the mineral assemblages present in the study area. Because a precise geothermal gradient is not known, a range of 25°C/km to 40°C/km is assumed.

The possible pressure and temperature conditions for metamorphism in the study area are shown in figure 6. The rocks of the Celeste quadrangle range from greenschist to amphibolite facies. No sillimanite was observed in the outcrops, hand samples, or thin sections. Conditions approaching anatexis are indicated by the localized migmatization of the biotite gneiss unit. Therefore, the upper limit of metamorphism is interpreted to fall to the left of the reaction Muscovite + Albite + Kspar + Quartz + H_2O -> Liquid (Thompson and Tracy, 1979).

The lower limit of metamorphism is marked by the reaction Stilpnomelane + Muscovite -> Biotite + Muscovite (Winkler, 1976), due to the absence of stilpnomelane and the common occurrence of muscovite and biotite in the lithologies.

Chlorite replaces and\or rims biotite in all of the biotite bearing samples collected throughout the study area. Chlorite is seen replacing hornblende in the biotite gneiss unit.

Hornfels found near the contact between the Jackson Crossroads granite and the southern volcanic unit are the result of contact metamorphism. No other evidence of contact metamorphism is seen in the study area.

GEOLOGIC HISTORY

The geologic history of the Celeste quadrangle can be divided into four stages, as follows:

Stage 1. The deposition of the Carolina terrane lithologies.

Stage 2. The accretion, deformation, and metamorphism of the Carolina terrane and subsequent late-kinematic intrusives.

Stage 3. The formation of the ductile deformation and later gentle, northwest trending, regional folds.

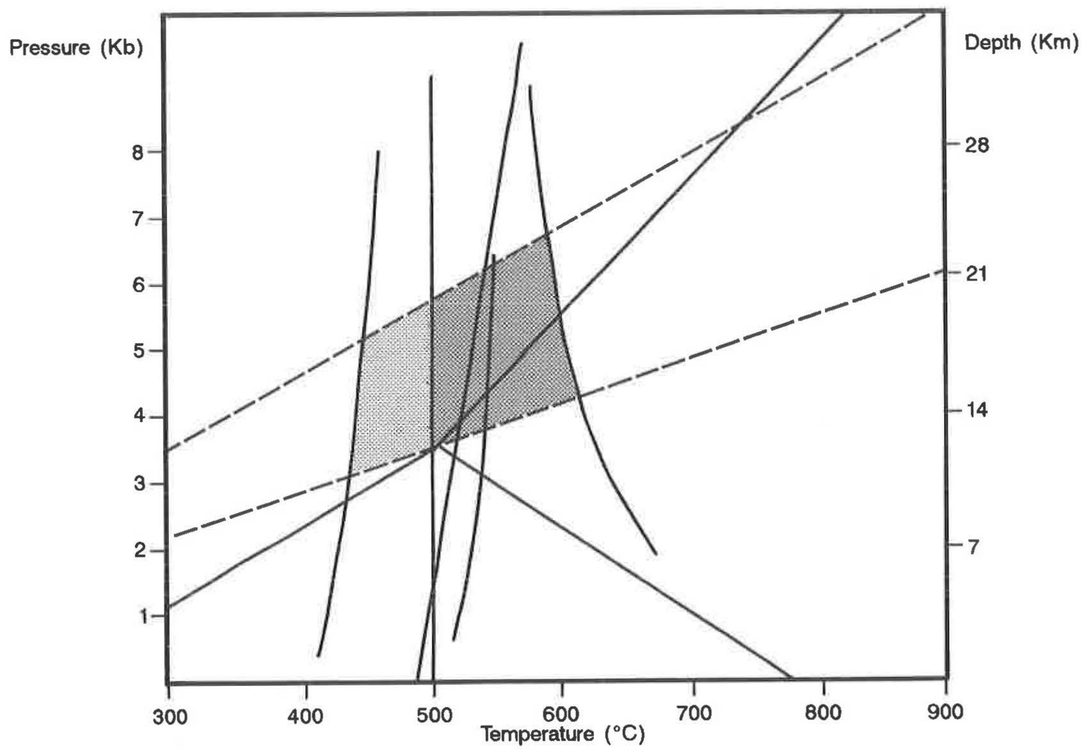
Stage 4. The formation of brittle fault zones and diabase dikes and subsequent regional uplift and erosion.

A discussion of each of these stages and the timing of events follows.

Stage 1

The Carolina Terrane was deposited at this stage. This includes southern and northern volcanic assemblages and the biotite gneiss unit in the study area. The author feels that the mafic rocks were deposited first and that the metasedimentary unit is the youngest non-intrusive lithology in the study area.

The period of alteration that produced the quartz sericite schists may be synvolcanic. Sulfide mineralization is associated with the small alteration zones in the northern volcanic assemblage.



a. Light stipple - intrusive lithologies
b. Heavy stipple - non-intrusive lithologies

1. Andalusite - Kyanite - Sillimanite triple point (Holdaway, 1971)
2. Stilpnomelane + Muscovite -> Biotite + Muscovite (Winkler, 1976)
3. Actinolite -> Hornblende (Hyndman, 1972)
4. Albite +/- Plagioclase -> Plagioclase (Hyndman, 1972)
5. Fe-Chlorite + Quartz -> Almandine (Hsu, 1968)
6. Muscovite + Albite + Kspar + Quartz + H_2O -> Liquid (Thompson and Tracy, 1979)

Figure 6. Possible metamorphic conditions for lithologies in the Celeste quadrangle.

Previous work has uncovered clues and provided valuable information about the geologic and geographic origin as well as the age of the Carolina terrane. Geochemical investigations of Slate belt rocks indicate that they were deposited during the evolution of a primitive oceanic island arc which was formed by the subduction of oceanic crust beneath oceanic crust (Whitney and others, 1978). The presence of middle Cambrian, Atlantic province trilobites, specifically *Paradoxides, Peronopsis, Tomagnostus,* and two species of Agraulidae, indicates a remote geographic origin with respect to Laurentia (Secor and others, 1983). The presence of the Ediacarian fossil, *Pteridium*, (Gibson and others, 1984) suggests deposition near Gondwana.

The lithologies of the Slate belt are considered to be early to mid-Cambrian in age. Dallmeyer and others (1986) concludes that the rocks of the Georgia and South Carolina Slate belt are younger than those of North Carolina. The Lincolnton Metadacite has been dated at 562 +/-20 Ma (Rb/Sr) and 568 +/-8 Ma (U/Pb) (Carpenter and others, 1978). This is the oldest known Slate Belt rock exposed in Georgia.

Stage 2

After deposition the Carolina terrane rocks suffered two deformational events and regional metamorphism. The lithologies were intruded by the biotite granite, the Jackson Crossroads granite, and the Middle Creek granite sometime after the second deformational event, during the waning stages of metamorphism.

The first deformational event formed the F_1 recumbent folds and the resulting S_1 foliation reported by previous workers (Conway, 1986; Dunnagan, 1986; Turner, 1987). It is possible that this event is related to the accretion of the Carolina terrane to the North American continent with the closing of the Iapetus Ocean. Cook and others (1979) and Williams and Hatcher (1982, 1983) feel that accretion was contemporaneous with the Acadian orogeny. Secor and others (1983) theorize that evidence of Ordovician metamorphism is indicative of a Taconic accretion. Paleomagnetic studies in the Albermarle Group of North Carolina indicate that the Carolina terrane was at or near the Iapetus coast of Laurentia by the late Ordovician (Vick and others, 1987; Noel and others, 1988). Horton and others (1989) also prefer an accretion during the Taconic orogeny.

During the second deformational event the northeast trending, tight, isoclinal folds were formed. This F_2 folding event transposed the pre-existing S_1 foliation parallel to S_2 along the limbs of the F_2 folds.

Metamorphic grade in the study area ranges from greenschist to amphibolite. Conway (1986) reports that fibrolite is bent and broken by the S_2 fabric. This indicates that the peak of regional metamorphism had been reached prior to the D_2 event. Dallmeyer and others (1986) suggests that a major thermal event affected the rocks of the Carolina terrane in Georgia and South Carolina between 340 and 360 Ma (Acadian), based on $^{40}Ar/^{39}Ar$ data. Glover et al. (1983) suggest that only localized greenschist metamorphism occurred in this area, during the Acadian orogeny. Whole-rock K-Ar ages averaging 483 +/-15 Ma from Carolina terrane rocks of North Carolina indicate a Taconic metamorphic event (Kish et al., 1979). At this time, the question of whether peak metamorphism in the study area was achieved in the Taconic or Acadian orogeny can not be answered. Further geochronological investigations must be conducted to provide a more precise time frame.

The lack of an S_2 fabric in the biotite granite, Jackson Crossroads granite, and Middle Creek granite indicate intrusion after the D_2 event. As previously mentioned, the D_2 event is believed to have occurred after peak metamorphism (Conway, 1986). This and the presence of greenschist facies mineral assemblages in the Jackson Crossroads and Middle Creek granites indicate that the intrusions either occurred late in the metamorphic event, or as post metamorphic intrusions which were later metamorphosed to greenschist grade during the Alleghanian orogeny.

Stage 3

The Alleghanian orogeny is interpreted to be the result of the convergence and collision of Laurentia and Gondwana (Cook and others, 1979; Secor and others, 1986b). This event may be responsible for the gentle, northwest trending, regional folds (F_3). Dallmeyer and others (1986) date the Alleghanian orogeny between 267 and 315 Ma.

As previously mentioned, past workers suggest that the ductile deformation zone in the Jackson Crossroads granite is a splay off the Middleton-Lowndesville cataclastic zone (Davis, 1980; Conway, 1986). The absence of ductile fabric in the Elberton granite indicates that ductile deformation occurred between 350 and 400 Ma (Whitney and others, 1980). A later (Alleganian) ductile deformation occurred between 267 and 290 million years ago, which affected portions of the Kiokee belt, Modoc zone, and Slate belt (Secor and others, 1986a). Not enough information is known to determine whether one or both of these deformational events formed the ductile foliations in the Celeste quadrangle.

Stage 4

The decoupling of North America and Africa occurred during the Triassic to Jurassic periods (Hatcher, 1972). The extentional forces of this event are probably responsible for the northwest trending brittle faults and diabase dikes (Secor and others, 1986). Following this event, the area was uplifted and eroded to its present surface.

ECONOMIC GEOLOGY

Gold

There are no previously recorded gold prospects within the boundaries of the Celeste quadrangle. Since most of

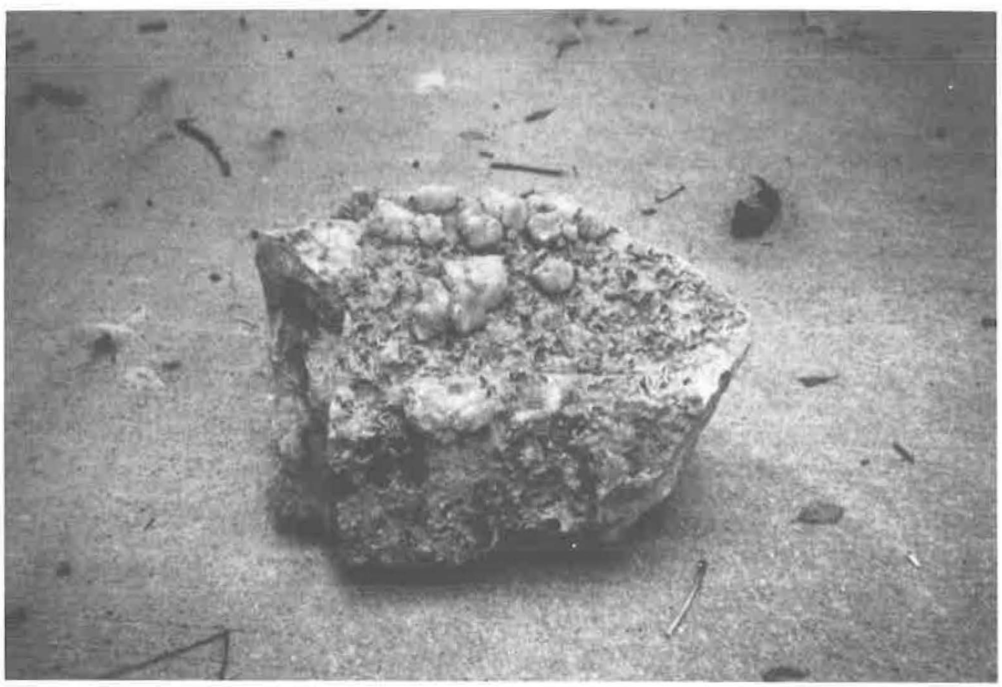


Figure 7. Pale amethyst clusters on a silicified boulder from the Jackson Crossroads granite. The boulder is approximately 1 foot in diameter.

the study area is occupied by two large intrusive bodies, the chances of a finding deposit of significant size is greatly reduced. A small alteration zone is present in the northern volcanic assemblage (plate I). This very small area shows evidence of silicification, epidotization, and very local pyrite mineralization. Unfortunately, a sample from this locality was found to contain less than the detectable limit of gold when subjected to fire assay.

Previous work indicates that the quartz sericite schist in the southeastern corner of the Celeste quadrangle is a hydrothermally altered metavolcanic (Dunnagan, 1986). Gold and sulfide mineralization could have occurred during the alteration process; however, no sulfide mineralization was observed while mapping.

Amethyst

Amethyst was observed in the northeastern quadrant of the study area. The mineral is found along the brittle fault zones within the Jackson Crossroads granite. Samples collected are pale and translucent (figure 7).

Industrial/Dimension Stone

A small borrow pit is present in the study area, just north of the Wilkes County Airport, where the Jackson Crossroads granite has been mined for road metal. There are exposures of this granite scattered across the area which may indicate the presence of fresh rock near the surface locally. Although the rock is mineralogically homogeneous, its very pale color and varying degrees of ductile deformation may discourage its use as a dimension stone. However, the Jackson Crossroads granite may provide an excellent source of crushed rock. The very deep weathering profile and heterogeneity of the biotite granite make it an unlikely candidate for either industrial or ornamental uses.

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THE GEOLOGY OF THE CELESTE 7 1/2' QUADRANGLE, GEORGIA

by

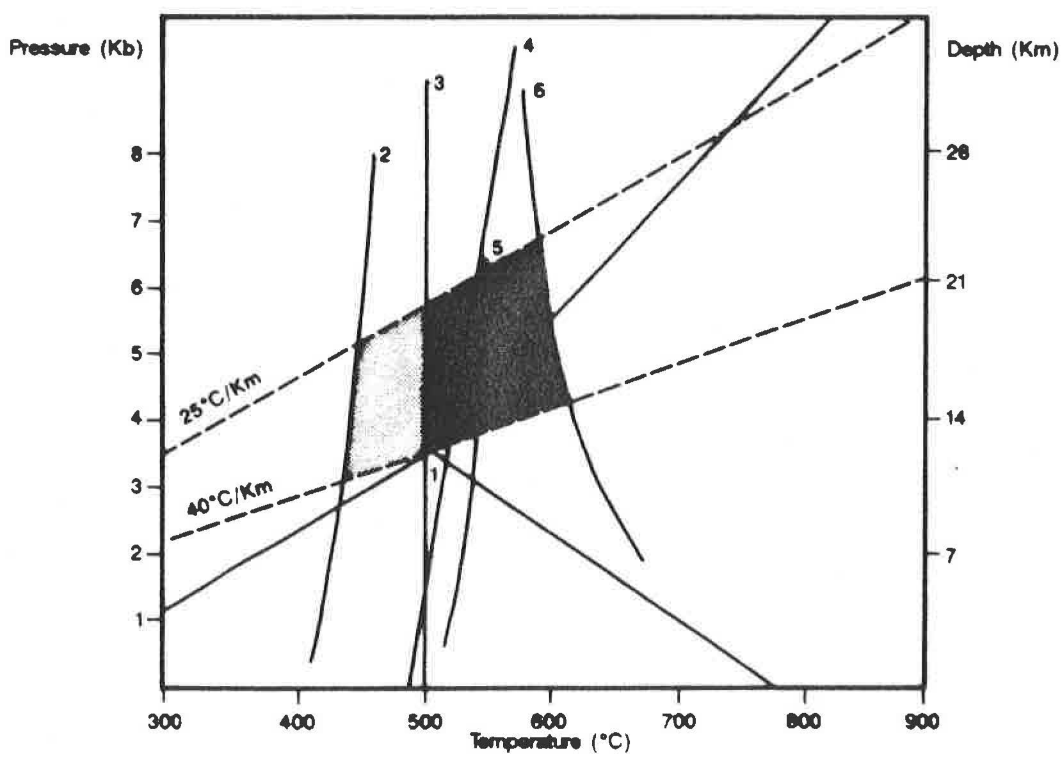
Mark E. Hall

GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

INFORMATION CIRCULAR 94

ERRATA SHEET

<u>Page 16, figure 6--</u>
Graph should be labeled as follows:



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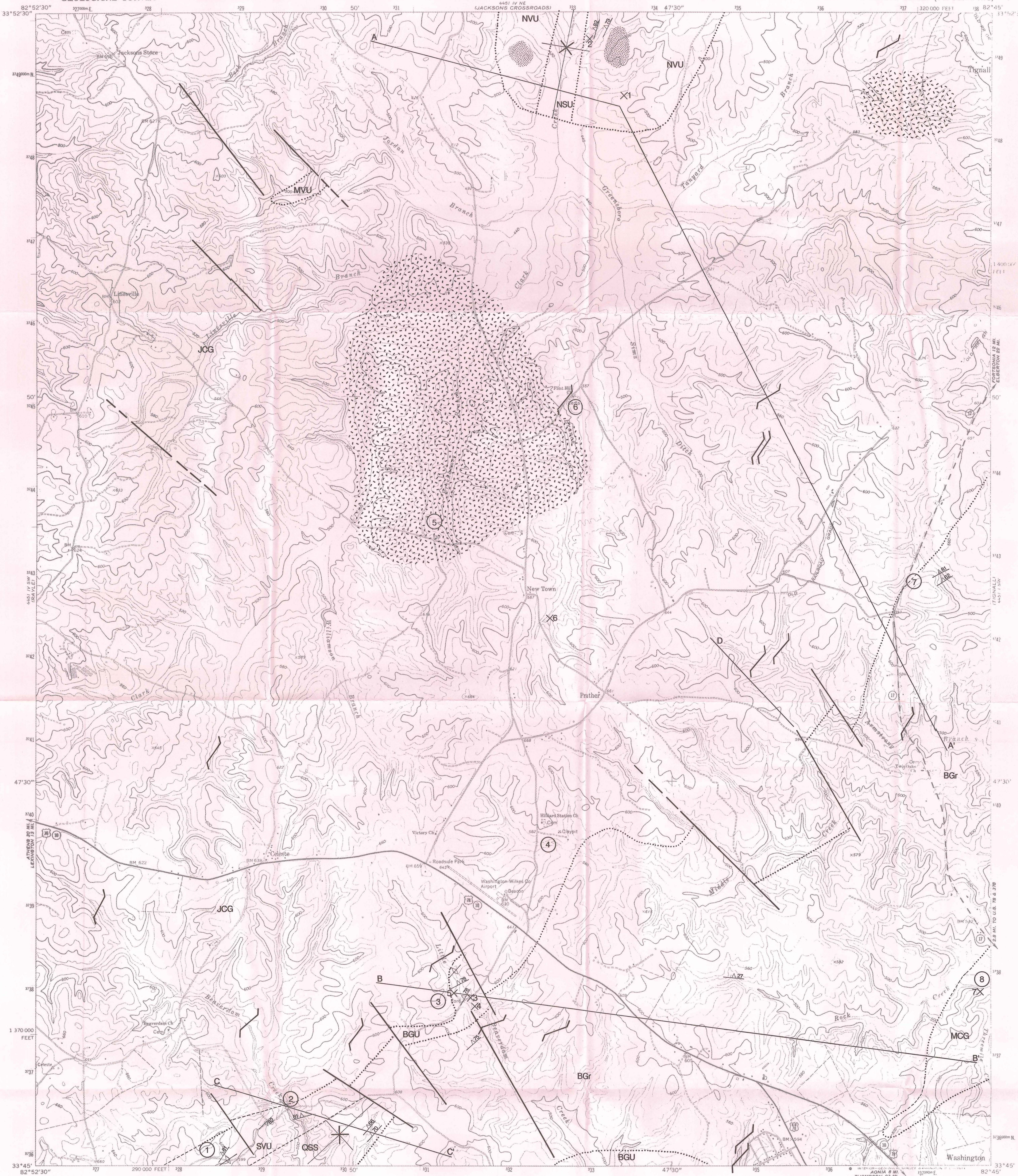

Northern Metavolcanic Assemblage

- NSU — Northern Sedimentary Unit
- NVU — Northern Volcanic Unit
- Silicified Zones

Southern Metavolcanic Assemblage

- QSS — Quartz Sericite Schist
- SVU — Southern Volcanic Unit
- BGU — Biotite Gneiss Unit

Intrusives

- JCG — Jackson Crossroads Granite
- Jackson Crossroads Granite (Mafic phase)
- MCG — Middle Creek Granite
- BGr — Biotite Granite
- D — Diabase Dike

- Approximate Contact
- Hypothetical Contact
- Strike and Dip of Foliation
- Brittle Fault
- Ductile Fault
- Inferred Synform
- Field Stop
- Cross Section
- Geochemical Sample Site

Geology and Compilation
by
Mark E. Hall
1993

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1970. Field checked 1971

Polyconic projection. 1927 North American datum
10,000-foot grid based on Georgia coordinate system, east zone
1000-meter Universal Transverse Mercator grid ticks, zone 17, shown in blue

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
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A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ROAD CLASSIFICATION

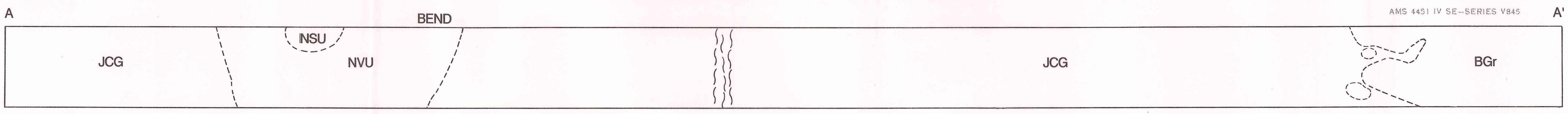
Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U. S. Route — State Route

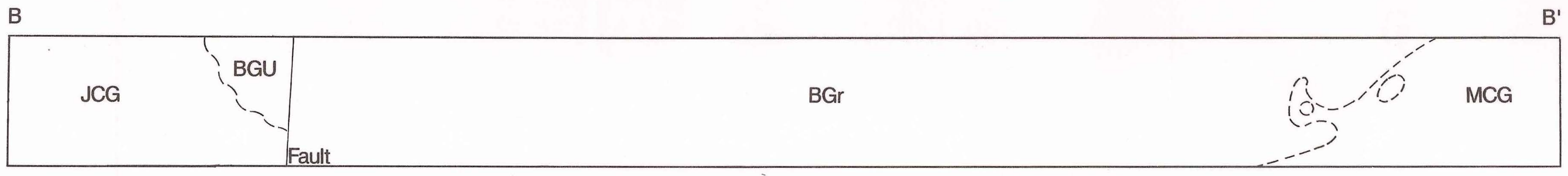
QUADRANGLE LOCATION

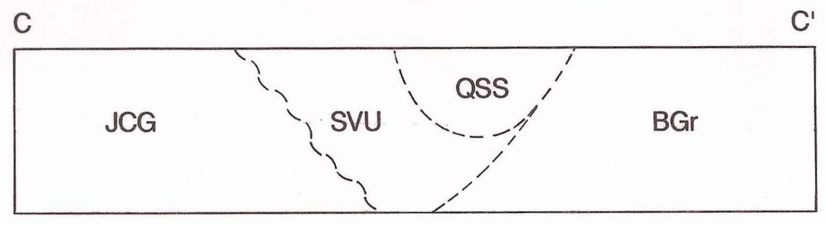
CELESTE, GA.
N3345—W8245/7.5

1971

AMS 4451 IV SE—SERIES V845







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Dk. Green	Geochemical and geophysical studies
Dk. Blue	Hydrology
Olive	Economic geology
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