LATEST THINKING ON THE STRATIGRAPHY OF SELECTED AREAS IN GEORGIA

Edited by

Perry B. Wigley

Department of Natural Resources
Environmental Protection Division
Georgia Geologic Survey

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Cover photo: Gouge zone related to faulting along the Great Smoky fault at Carters Dam, Georgia. At this location, Ocoee Supergroup rocks are thrust over shales of the Conasauga Formation. (Photo courtesy of Keith I. McConnell.)

LATEST THINKING ON THE STRATIGRAPHY OF SELECTED AREAS IN GEORGIA

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Atlanta
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INTRODUCTION

by

Perry B. Wigley

The three papers presented in part A of this volume mark the beginning of revisions to and systemization of the stratigraphy of the Georgia Piedmont, Blue Ridge and Coastal Plain. This volume also is published as part of the Committee on Stratigraphic Units of North America (COSUNA) revision of the stratigraphic nomenclature of North America.

Part A consists of three papers which provide interpretations regarding the stratigraphy of selected areas in the Blue Ridge and Piedmont of Georgia and adjacent parts of Alabama. Two features which are especially significant about all three of these reports are: (1) they present stratigraphic interpretations in structually complex areas where multiple deformation plays an important role in the orientation of stratigraphic sequences; and (2) there is movement away from the old "belt" concept first introduced in Georgia by G.W. Crickmay in 1952. In other words, some of the authors in this edition propose that prior stratigraphic interpretations were based on the assumption that only a single major folding event had affected the rocks. If the rocks were multiply deformed in these areas, then the previously proposed stratigraphic sequences could be easily inverted. Also, other authors have presented new stratigraphic interpretations regarding the old "belt" terminology by suggesting that lithologic units are traceable across "belt" boundaries, thereby implying that the "belt" concept is essentially unworkable.

The paper by Sears, Cook, Gilbert, Carrington and Schamel deals with the stratigraphy and structure of the Pine Mountain window in Georgia and Alabama. This is a structurally complex area where interpretations of stratigraphy are complicated by the presence of two vertically stacked nappes. Their interpretation differs from earlier works in that they have recognized that there are inverted sections on the lower limbs of the nappes and that there has been considerable confusion differentiating between the Grenville "basement" and the Pine Mountain Group. Further complications include facies variations and other structural complications.

Higgins and Atkins have contributed significantly to Piedmont geology by the recognition of a mappable stratigraphy southeast of the Brevard Zone. Within eugeosynclinal flysch-like rocks which range in thickness from 6,000 m (20,000 ft) to possibly as much as 18,000 m (60,000 ft.), they have named and mapped the Atlanta Group which they subdivided into 12 formations and 3 members. This stratigraphy was developed in terrane where 5 fold generations and a high grade of regional metamorphism occur. Further complications include deep weathering of the rocks , which requires that the interpretations be made chiefly on poor outcrops and saprolite.

Abrams and McConnell have revised the stratigraphy of the area around the Austell-Frolona antiform in west-central Georgia. Earlier interpretations were based on the premise that there had been only one major folding event in the area, but detailed field mapping has shown that at least four major folding events have affected the rocks and that present outcrop patterns were caused by second generation folds. Thus the Austell-Frolona area represents an antiformal syncline. Earlier workers had interpreted the area as an anticline, thus Abrams' and McConnell's interpretations of stratigraphic relationships are quite different from the previous concepts.

Part B will be published later and will include papers on other physiographic provinces including the Coastal Plain.

THE STRATIGRAPHY OF THE PIEDMONT SOUTHEAST OF THE BREVARD ZONE IN THE ATLANTA, GEORGIA AREA

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INTRODUCTION

The Appalachian Piedmont of the southeastern United States is a vast terrane of multiply metamorphosed, multiply folded, deeply weathered igneous, metaigneous, and metasedimentary rocks. Lack of recognizable stratigraphy that can be mapped for any distance has generally been considered characteristic of the Piedmont southeast of the Brevard Zone (the so-called "Inner Piedmont"), and most workers have simply divided the area into "belts."

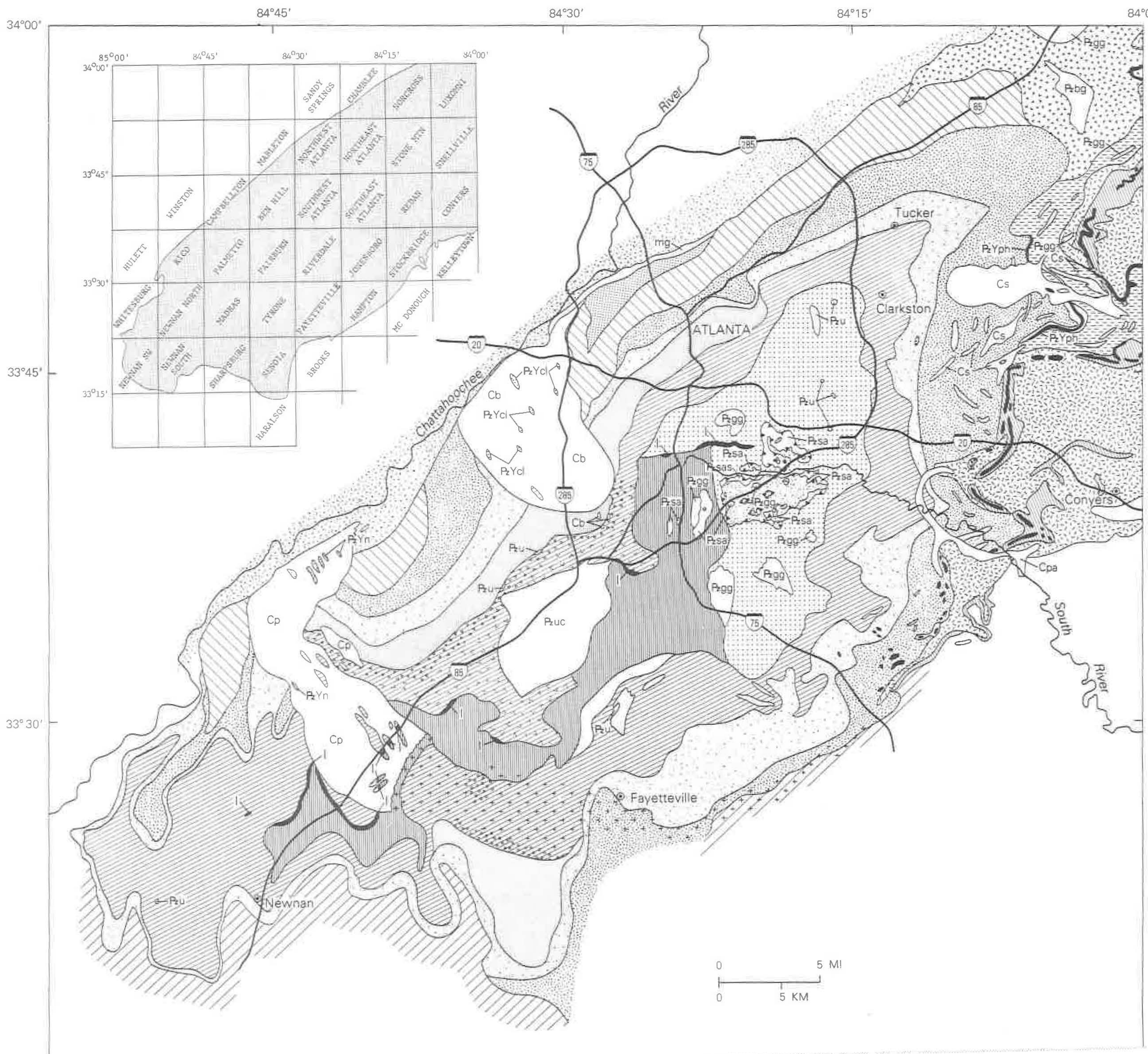
The purpose of this paper is to describe a mappable stratigraphy in the area around Atlanta, Ga. (fig. 1), to establish formal names for the units, and to briefly summarize the geology of the Atlanta area.

THE ATLANTA GROUP

The Atlanta Group is here named from the area around Atlanta, Ga. (fig. 1), southeast of the Brevard Zone. The group consists of 12 formations (see fig. 1 for stratigraphic relations): the Inman Yard Formation, the Wolf Creek Formation, the Promised Land Formation with its Hannah Member, the Norcross Gneiss, the Clairmont Formation, the Senoia Formation, the Wahoo Creek Formation, the Stonewall Formation, the Clarkston Formation with its Fairburn and Tar Creek Members, the Big Cotton Indian Formation, the Intrenchment Creek Quartzite, and the Camp Creek Formation. These units crop out in a major regional synform (fig. 1), the Newnan-Tucker synform (Higgins and others, 1980; Atkins and Higgins, 1980), that is probably a synformal syncline. From closure to closure, the synform is more than 90 km (56 mi) long, and more than 40 km (25 mi) wide at its widest point. The synform is modified locally by several generations of later folds (Atkins and Higgins, 1978, 1980).

The age of the Atlanta Group is not precisely known. However, the Clairmont, Promised Land, Wahoo Creek, and Clarkston Formations are intruded by the Panola and (or) Stone Mountain granites (fig. 1). Both granites have yielded concordant zircon ages of about 325 m.y. (Higgins and others, unpub. data), thus defining the minimum age of much of the Atlanta Group as pre-Late Mississippian (Harland and others, 1964). On the basis of regional relations and a 1,100 m.y. or older radiometric age of zircon from the Lanier Mountain Quartzite Member of the Snellville Formation (discussed later), the Atlanta Group is estimated to be younger than about 1,100 m.y. [late Precambrian; late Proterozoic (y or z)]. The group is tentatively assigned an age of late Proterozoic (z; latest Precambrian) and (or) early Paleozoic. The reasoning for this assignment is discussed in a later section.

The stratigraphic order given in this paper (fig. 1) depends upon the Newnan-Tucker synform being a syncline. So far, we have not found any top and bottom criteria to substantiate the synclinal interpretation. If future work shows that this structure is really a synformal anticline, our stratigraphic sequence would be reversed.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MABLETON
NORTHWEST ATLANTA
NORTHEAST ATLANTA
STONE MTN
SNELLVILLE
WINSTON
CAMPBELLTON
BEN HILL
SOUTHWEST ATLANTA
SOUTHEAST ATLANTA
REDAN
CONYERS
HULETT
RICO
PALMETTO
FAIRBURN
RIVERDALE
JONESBORO
STOCKBRIDGE
KELLEYTOWN
WHITESBURG
NEWNAN NORTH
MADRAS
TYRONE
FAYETTEVILLE
HAMPTON
MC DONOUGH
NEWNAN SW
NEWNAN SOUTH
SHARPSBURG
SENOIA
BROOKS
HARALSON
River
Chattahoochee
Tucker
Clarkston
ATLANTA
Conyers
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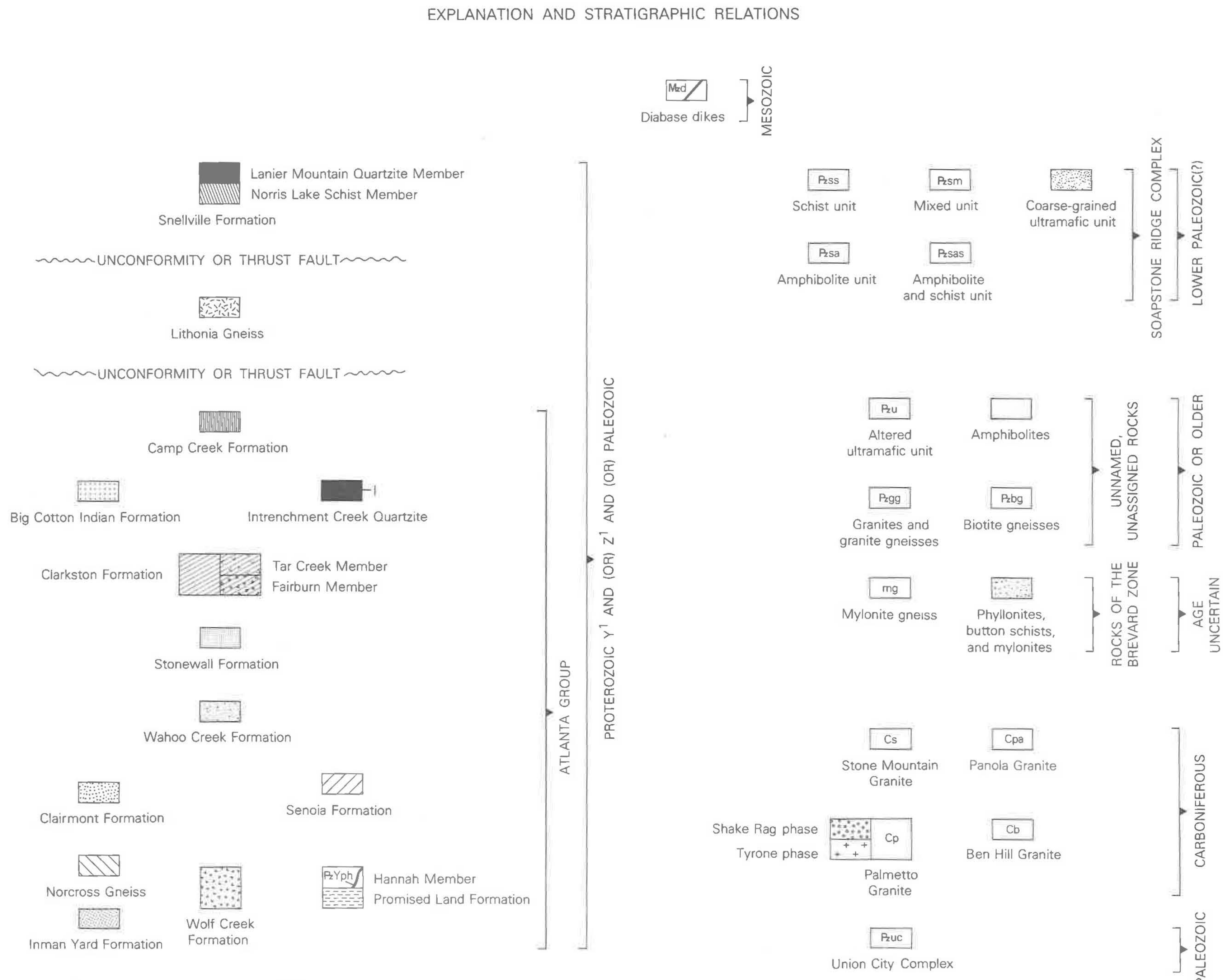

[1]PROTEROZOIC Y—800 m.y. to 1600 m.y.; PROTEROZOIC Z—base of Cambrian to 800 m.y.

Figure 1. Geologic map of the Atlanta area southeast of the Brevard Zone.

Inman Yard Formation

The Inman Yard Formation is here named for, and its type section given as, Inman Yard in the Northwest Atlanta, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973), where typical exposures are found in deep cuts on the northern side of the railroad yard west of Marietta Road (fig. 2). The Inman Yard consists of porphyroblastic biotite-plagioclase gneiss, porphyroblastic granite gneiss, and sillimanite-muscovite schist. The biotite-plagioclase gneiss is typically well-foliated, locally banded, and contains large porphyroblasts of K-feldspar scattered through the matrix. It weathers to a dark-red soil containing large blebs of kaolinite derived from the porphyroblasts. The granite gneiss is typically a medium-grained, light-gray, poorly foliated biotite-muscovite-bearing rock containing large porphyroblasts of K-feldspar. It weathers to a grayish-tan soil. The schist is lustrous silver-gray and generally crinkled. It weathers to a light-grayish micaceous soil. The biotite-plagioclase gneiss and the schist are generally interlayered on a scale of less than 1 m (3 ft), whereas the granite gneiss forms large outcrop areas without the other rock types.

The Inman Yard Formation is apparently the oldest unit in the Atlanta Group, and its base is not exposed. Its contact with the overlying Norcross Gneiss is relatively sharp and apparently conformable. Solely on the basis of map distribution, the Inman Yard is estimated to be about 700 m (2,300 ft) thick; this is probably greater than its true thickness because of isoclinal folding. The Inman Yard has only been found on the northwest flank of the Newnan-Tucker synform in northwest Atlanta. It is probably partly correlative with the Wolf Creek Formation (fig. 1). To the northwest, the Inman Yard is in sharp contact with button schist and phyllonite of the Brevard Zone. Before metamorphism, the rocks of the Inman Yard Formation were probably a flysch sequence of graywackes and shales intruded by porphyritic granites.

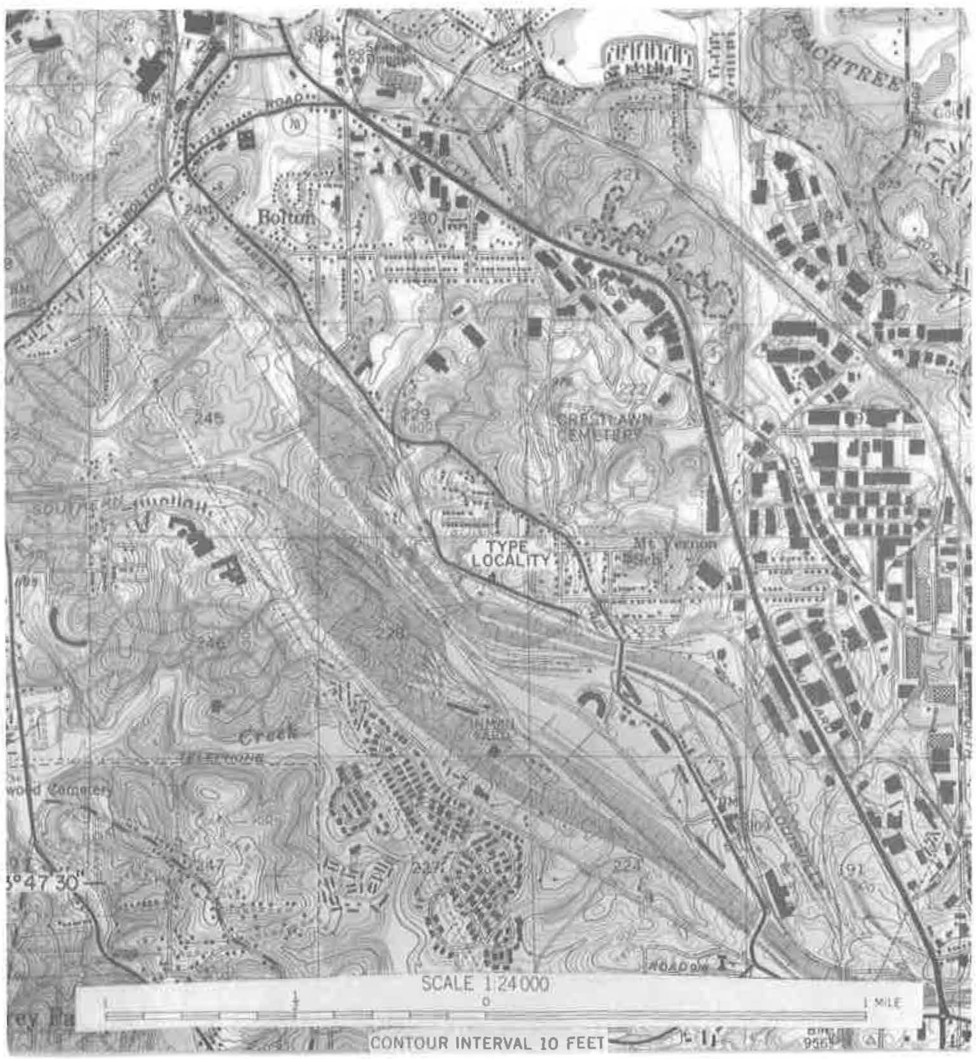

Figure 2. Part of the Northwest Atlanta quadrangle, showing type section of the Inman Yard Formation.

Wolf Creek Formation

The Wolf Creek Formation is here named for exposures along and near Wolf Creek in the Luxomni, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; fig. 3). It consists of thinly laminated, commonly sheared, fine-grained amphibolite interlayered on a scale of a centimeter to a few meters with lustrous silvery-gray biotite-muscovite button schists. Locally, thin layers of felsite are present. The amphibolite weathers to thin chips of ocherous saprolite and ultimately to orange-red to ocher-colored soil. The schist weathers to micaceous "buttons" (Higgins, 1971, p. 72) that cover the ground. Similar rocks elsewhere have been mapped as part of the Brevard Zone.

To the northwest, the Wolf Creek grades into button schists and phyllonites of the Brevard Zone; the contact is gradational and has been placed at the last amphibolite. To the southeast, the Wolf Creek is in gradational contact with rocks of the Promised Land Formation; the contact has been placed at the last appearance of button schist or mica schist. To the southwest, the Wolf Creek is in relatively sharp contact with the Clairmont Formation and Norcross Gneiss (fig. 1). The Wolf Creek is probably correlative with parts of the Norcross Gneiss and the Inman Yard and Promised Land Formations. On the basis of map distribution, the Wolf Creek is determined to be approximately 1,200 m (3,940 ft) thick.

Before metamorphism, the Wolf Creek Formation was probably a sequence of interbedded shales and basaltic tuffs.

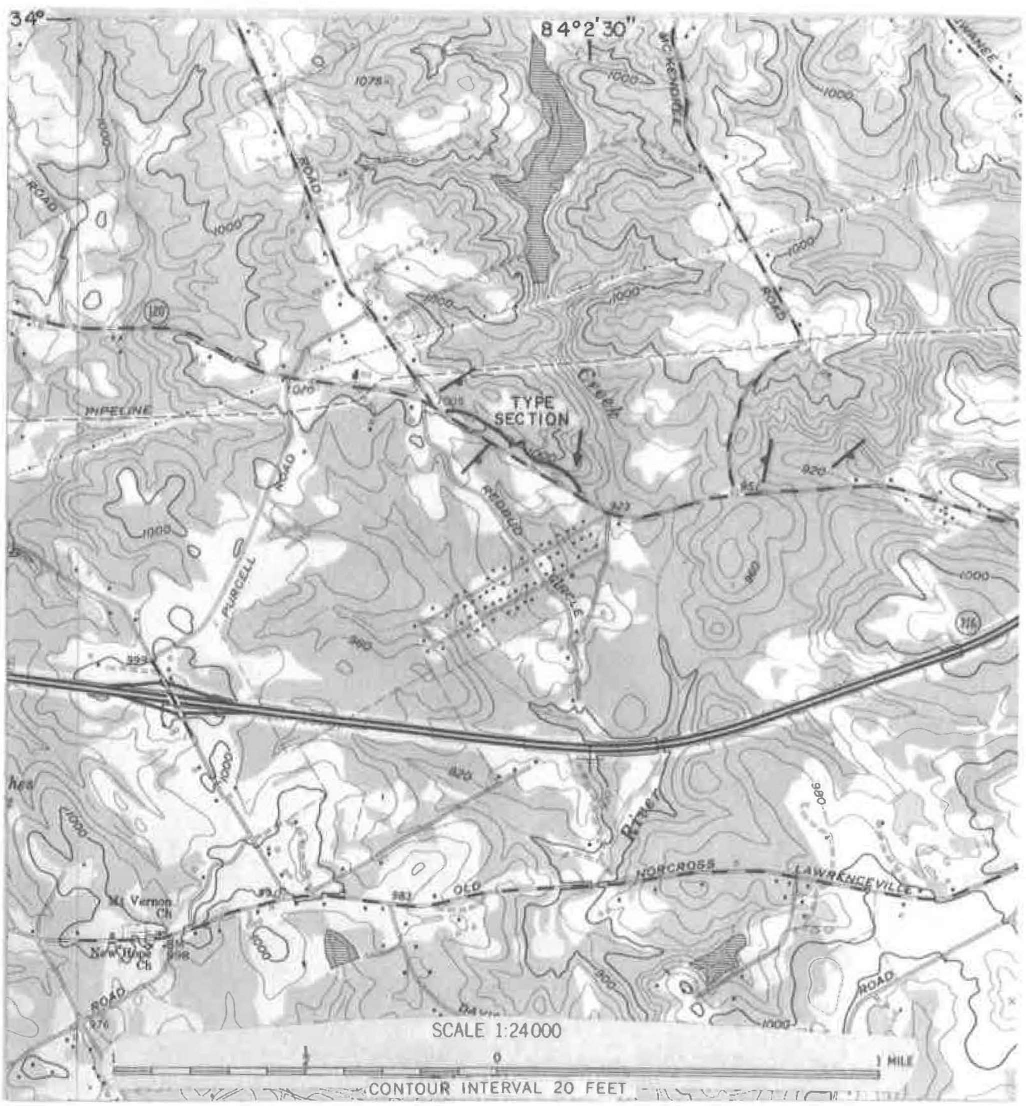

Figure 3. Part of the Luxomni quadrangle, showing type section and other typical outcrops (marked by foliation symbols) of the Wolf Creek Formation.

Promised Land Formation

The Promised Land Formation is here named for exposures around the small community of Promised Land (name not shown on quadrangle map) at the intersection of Rock Bridge Road and Georgia Highway 124, approximately 1 km (0.6 mi) east of the Yellow River in the Snellville, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1972; fig. 4). Typical exposures are found in roadcuts on both sides of Highway 124 where it crosses the Yellow River. The Promised Land consists of massive to thinly layered, medium-grained, gray, banded biotite-granite gneiss interlayered on a centimeter-to-meter scale with fine-grained, dark-green to greenish-black, blocky hornblende-plagioclase amphibolite. The granite gneiss weathers to a pink clayey saprolite, and the amphibolite, to a blocky ocherous saprolite.

A thin unit of quartzite and muscovite-quartz schist at the top of the Promised Land Formation is here named the Hannah Member for good exposures where the powerline crosses the first road running southwest from just northwest of Hannah Cemetery (Snellville, Ga., U.S. Geol. Survey 7½-min. topographic quadrangle; fig 5). Good outcrops of the Hannah are found along the powerline for several hundred meters on each side of the road. The Hannah is composed almost entirely of muscovite and quartz in varying proportions along strike. Fresh outcrops are nearly white. It weathers to a sandy micaceous soil. The Hannah is never more than 3 m (9.8 ft) thick.

The contact of the Promised Land Formation with the Wolf Creek Formation appears gradational. The contact of the Promised Land with the Clairmont Formation is sharp, especially where the Hannah

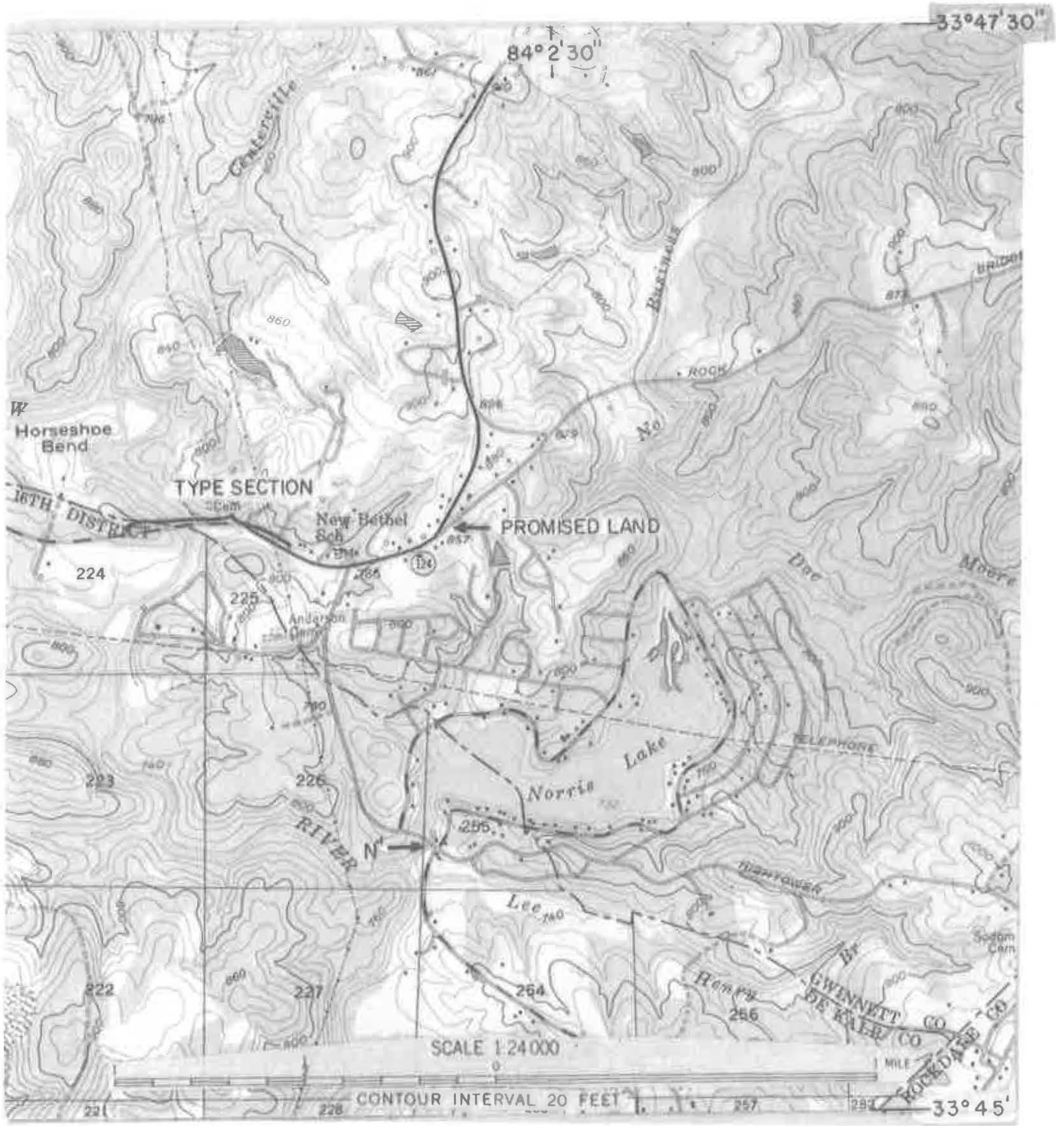

Figure 4. Part of the Snellville quadrangle, showing type locality of the Promised Land Formation and type section. The arrow marked **N** points to type locality of the Norris Lake Schist Member of the Snellville Formation.

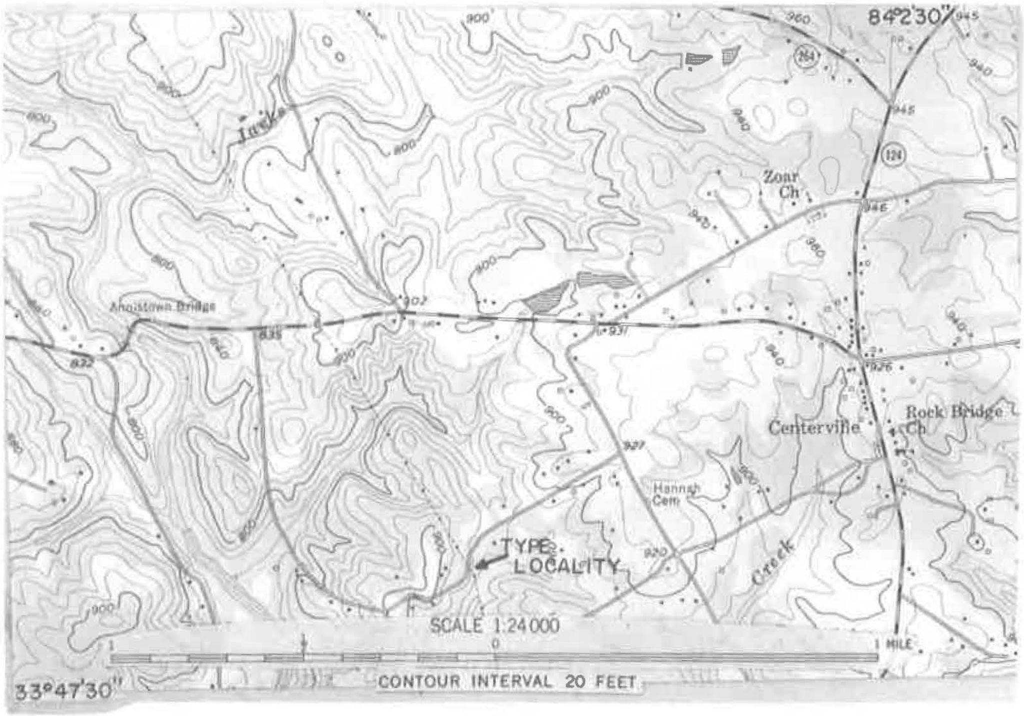

Figure 5. Part of the Snellville quadrangle, showing type locality of the Hannah Member of the Promised Land Formation.

Member is present (fig. 1), and is probably conformable. The contact of the Promised Land with the Lithonia Gneiss is sharp, but is probably a tectonic contact. On the basis of map distribution, the Promised Land Formation is determined to be 400-1,500 m (1,312-4,921 ft) thick.

The Promised Land originally may have been a sequence of interbedded mafic and felsic volcanic and (or) volcaniclastic rocks. Alternatively, it may have been mafic volcanic and (or) volcaniclastic rocks that were intruded by felsic rocks. Because of the fine scale of the interlayering, the first alternative seems more likely.

Norcross Gneiss

The Norcross Gneiss is here named for exposures in and around the city of Norcross, in the Norcross, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973). Typical exposures are found in the industrial parks on both sides of Jimmy Carter Boulevard just southeast of Interstate 85 (fig. 6). The Norcross is a light-gray epidote-biotite-muscovite-plagioclase gneiss that is fairly well foliated. Locally, the gneiss contains amphibolite, but invariably in distinct pods and (or) lenses in contrast to the beds of amphibolites in the Clairmont Formation. The Norcross Gneiss weathers to grayish-white rounded boulders and finally to an orangish-pink clayey saprolite and soil. The contact between the Norcross and the overlying Clairmont Formation is gradational over a few tens of meters and is apparently conformable. The Norcross is probably correlative with parts of the Wolf Creek and Promised Land Formations (fig. 1). On the basis of map distribution, the Norcross appears to be about 2,000 m (6,560 ft) thick, but the fact that it is everywhere nearly flat lying suggests that this apparent thickness is far greater than the real thickness.

No solid evidence has been found to indicate whether the Norcross is an ortho- or paragneiss. Its homogeneity would suggest an igneous parentage and its long linear outcrop belt would suggest a sedimentary parentage. It may have been a volcaniclastic rock.

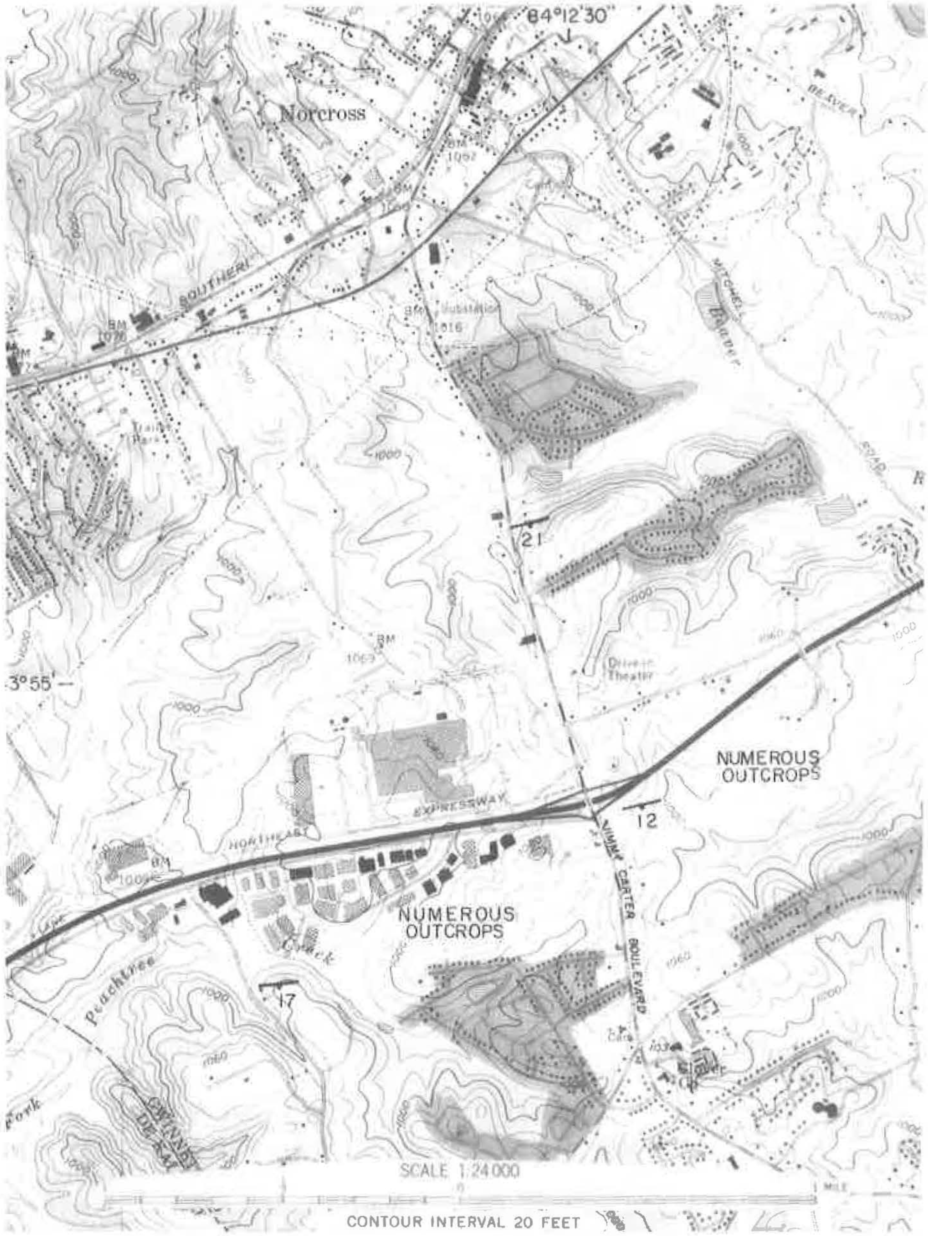

Figure 6. Part of the Norcross quadrangle, showing the town of Norcross (type locality) and other typical outcrops marked by foliation symbols or simply labeled "numerous outcrops."

Clairmont Formation

The Clairmont Formation is here named for fresh exposures around the intersection of Clairmont Road and Interstate 85 in the Northeast Atlanta, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle; fig. 7). Typically, the Clairmont is a well-foliated, medium-grained biotite-plagioclase gneiss intimately interlayered with fine- to medium-grained hornblende-plagioclase amphibolite (fig. 8). Locally, the gneiss is porphyroblastic. The gneiss generally has thin bluish-gray bands alternating with whitish-gray bands and with amphibolite. The layering is on the order of a few centimeters and is commonly very contorted. Epidote and garnet are locally present as accessory minerals in the gneiss. Locally, amphibolite makes up entire outcrop areas with little or no biotite gneiss present. Some areas have only sparse amphibolite and consist of thinly banded gneiss. The intimate interlayering of

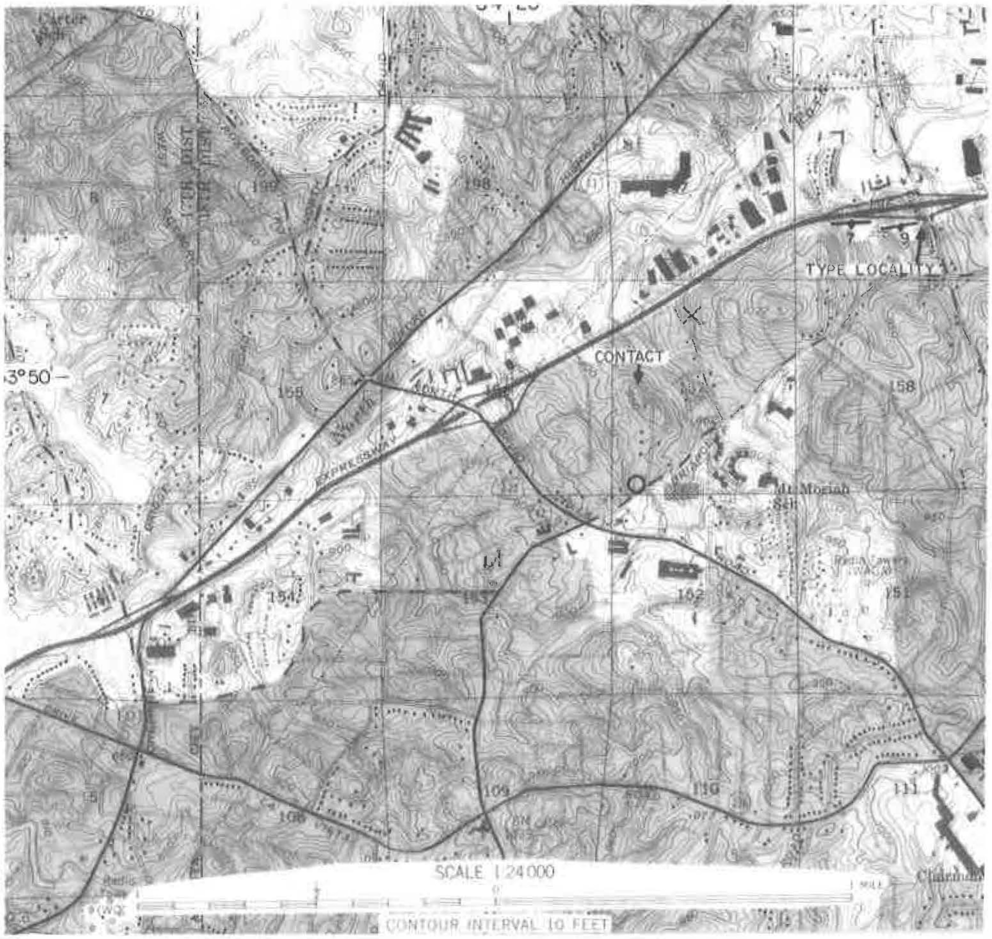

Figure 7. Part of the Northeast Atlanta quadrangle, showing type locality of the Clairmont Formation. Arrow points to the exposed contact between the Clairmont and Wahoo Creek Formations behind Parkwood Hospital. Structure symbols and X's mark good Clairmont exposures. ○ marks a good exposure of the Wahoo Creek.

Figure 8. Typical contorted gneiss and amphibolite of the Clairmont Formation in a roadcut beside the northeast-bound lanes of Interstate 85, about 0.3 km (0.25 mi) southeast of Clairmont Road.

amphibolite with gneiss is in contrast with the Norcross Gneiss in which the amphibolite forms discrete pods and lenses.

Even in saprolite outcrops, the distinctive finely banded character of the Clairmont is preserved. On further weathering, the Clairmont forms a dark-red soil containing ocherous bands derived from amphibolite.

The contact between the Clairmont and the underlying Norcross appears to be conformable and gradational over a few tens of meters (about 100 ft). The contacts between the Clairmont and the Wolf Creek, Promised Land, and Senoia Formations are relatively sharp and probably conformable. The contact between the Clairmont and the overlying Wahoo Creek Formation is gradational over less than a meter (3 ft) and can be seen in an outcrop behind Parkwood Hospital in the Northeast Atlanta, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; figs. 7 and 9). The Clairmont Formation appears to be correlative with part of the Senoia Formation (fig.1).

On the basis of map distribution, the Clairmont appears to be 500-1,500 m (1,640-4,920 ft) thick. Its original thickness is probably less.

Before metamorphism, the Clairmont was probably a sequence of graywacke and pelitic graywacke intimately interbedded with mafic volcaniclastic rocks.

Figure 9.

The contact between the Clairmont and Wahoo Creek Formations exposed behind Parkwood Hospital (see fig. 7). The contact appears gradational over about 1 m (3 ft). Arrow **W** points to typical light-colored slabby gneiss of the Wahoo Creek Formation; arrow **C** points to typical gneiss of the Clairmont Formation. Largely hidden by weeds in this photograph, the contact interval consists of an interlayering of the two rock types.

Senoia Formation

The Senoia Formation is here named for outcrops in and around the city of Senoia, in the Senoia, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1965). The type section is designated as the exposures along the first road running west from Georgia Highway 85 southwest of Keg Creek (fig. 10). Other good exposures are found along the road between Gary Summers Road and McIntosh Trail northwest of Senoia (fig. 10). The Senoia consists of garnet-biotite-muscovite schist intimately interlayered with fine-grained hornblende-plagioclase amphibolite on a scale of 1-3 m (3-10 ft). Thin layers of spessartine quartzite are locally present near the contact with the overlying Wahoo Creek Formation.

Biotite gneiss is also present in the upper part of the Senoia, especially east of the city of Senoia, and sillimanite is more common in the upper part of the formation than toward the base. The schist weathers to a purple-pink micaceous saprolite, the amphibolite to a blocky ocherous saprolite, and the spessartine quartzite to a hard, black blocky saprolite.

Figure 10. Part of the Senoia quadrangle, showing type section of the Senoia Formation and location of other good exposures.

The Senoia is probably correlatve with most of the Clairmont Formation (fig. 1). Its lower contact has not yet been mapped. Its upper contact with the Wahoo Creek Formation is relatively sharp and probably conformable. It could represent simply a thickening of the purple-pink weathering schist and amphibolite in the lower part of the Wahoo Creek Formation. Because the lower contact has not yet been mapped, the thickness is unknown. Before metamorphism, the Senoia was probably a sequence of interbedded shales, marine mafic volcaniclastic rocks, and local thin beds of manganiferous sandstones.

Wahoo Creek Formation

The Wahoo Creek Formation is here named for good exposures along Wahoo Creek in Newnan North, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; figs. 11 and 1). The Wahoo Creek is one of the most distinctive units of the Atlanta Group and has been mapped completely around the Newnan-Tucker synform (fig.1). It is generally a nearly white, fine- to medium-grained muscovite-plagioclase-quartz gneiss that is distinctively slabby (fig. 12). Locally, the gneiss has porphyroblasts of K-feldspar and has pitted weathering surfaces. In addition to the light-colored gneiss, the Wahoo Creek has minor amounts of amphibolite and two other distinctive rock types. Approximately the lower 15-30 m (50-100 ft) of the Wahoo Creek is purple-pink weathering schist and amphibolite. This lithology is not present everywhere, but where present, it is a good contact marker. Perhaps the most spectacular lithology in the Wahoo Creek is thinly layered epidote, calcite, and diopside-bearing gneiss commonly called calc-silicate. The layering of this gneiss is remarkably thin (a few centimeters to tens of centimeters) and straight. The calc-silicates are characteristically slabby like the light-colored gneiss. These rocks appear to be lenses within the

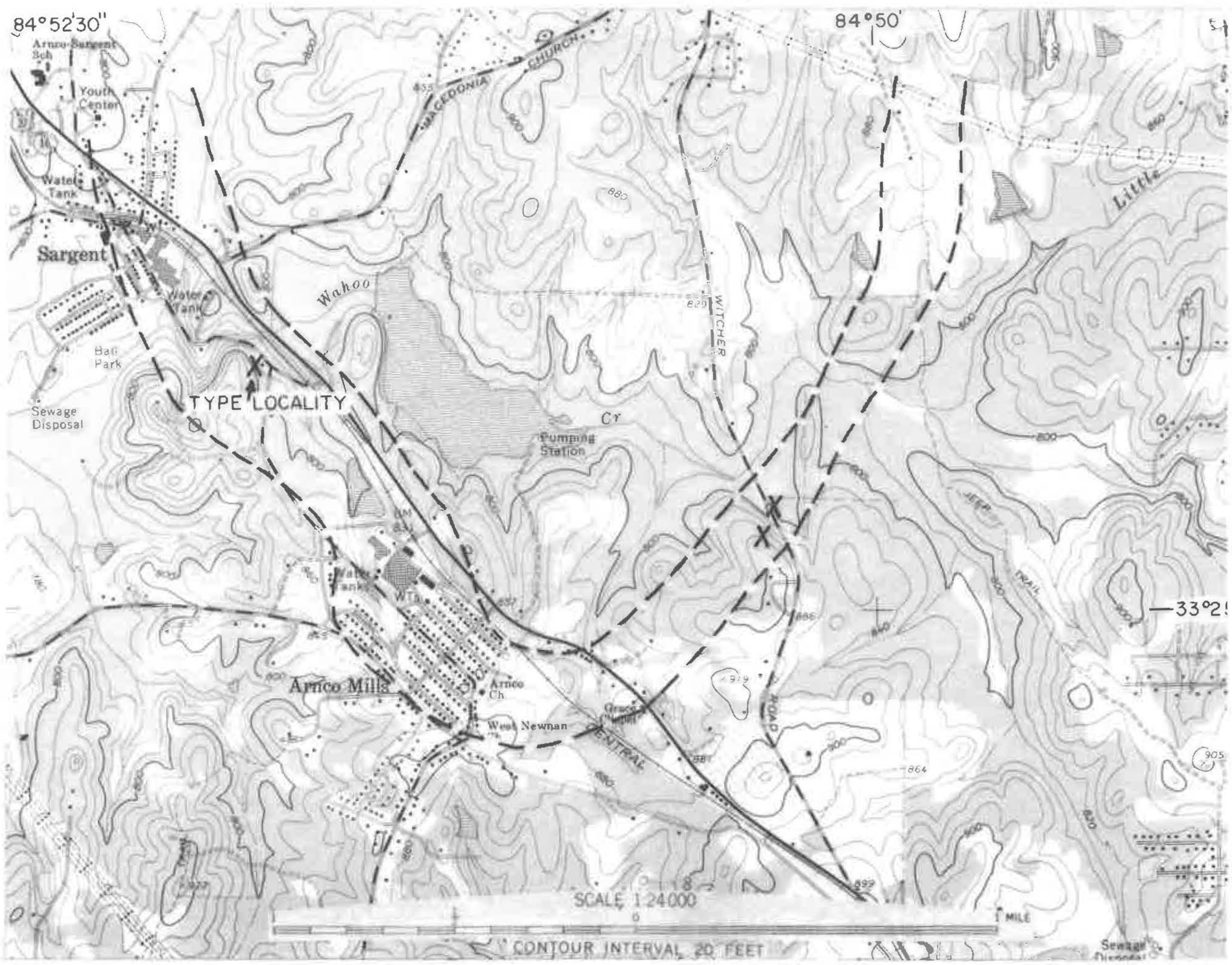

Figure 11. Part of the Newnan North quadrangle, showing type locality and other good outcrops (marked by **X**'s) of the Wahoo Creek Formation.

A

B

Figure 12. (a) Typical evenly layered, slabby gneiss of the Wahoo Creek Formation along Briarcliff Road, about 0.3 km (0.25 mi) north of North Druid Hills Road in the Northeast Atlanta quadrangle.

(b) Close-up of part of the same outcrop to show the fine layering. Knife is 8 cm long.

light-colored gneiss and probably account for only about 5 percent of the formation. Where deeply weathered, the Wahoo Creek forms a dark-pink soil. Along most of the Wahoo Creek outcrop belt (fig. 1) the topography is knobby, and both the relief and elevation are greater than in the areas on either side.

The lower contact of the Wahoo Creek is gradational over about 1 m (3 ft; see fig. 9) as described earlier. The upper contacts with the Stonewall Formation and the Clarkston Formation (fig. 1) are generally sharp and probably conformable.

The Wahoo Creek Formation is nearly flat lying through most of its outcrop belt and thus locally attains an outcrop width of more than 6 km (3.7 mi). Where it is steeply dipping, however, it is only about 300 m (1,000 ft) thick. We estimate that the real thickness is 300-800 m (1,000-2,600 ft).

The Wahoo Creek was probably originally a felsic volcaniclastic rock. The "calc-silicate" lenses could represent premetamorphic altered zones, or they could have been calciferous sediments deposited as lenses in a subaqueous volcaniclastic rock.

Stonewall Formation

The Stonewall Formation is here named for exposures in and around the community of Stonewall, in the Fairburn, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; fig. 13). The Stonewall consists of medium-grained biotite gneisses and fine-grained hornblende-plagioclase amphibolites, interlayered in various proportions and lesser amounts of sillimanite-biotite schists. Many of the amphibolites have small amounts of biotite, and epidote is fairly common in the gneisses. Some bodies of amphibolite are large enough to be mapped separately. The gneisses in the Stonewall generally weather to a dark-red clayey soil, the amphibolites to blocky ocherous saprolite, and the schists to pink micaceous soils.

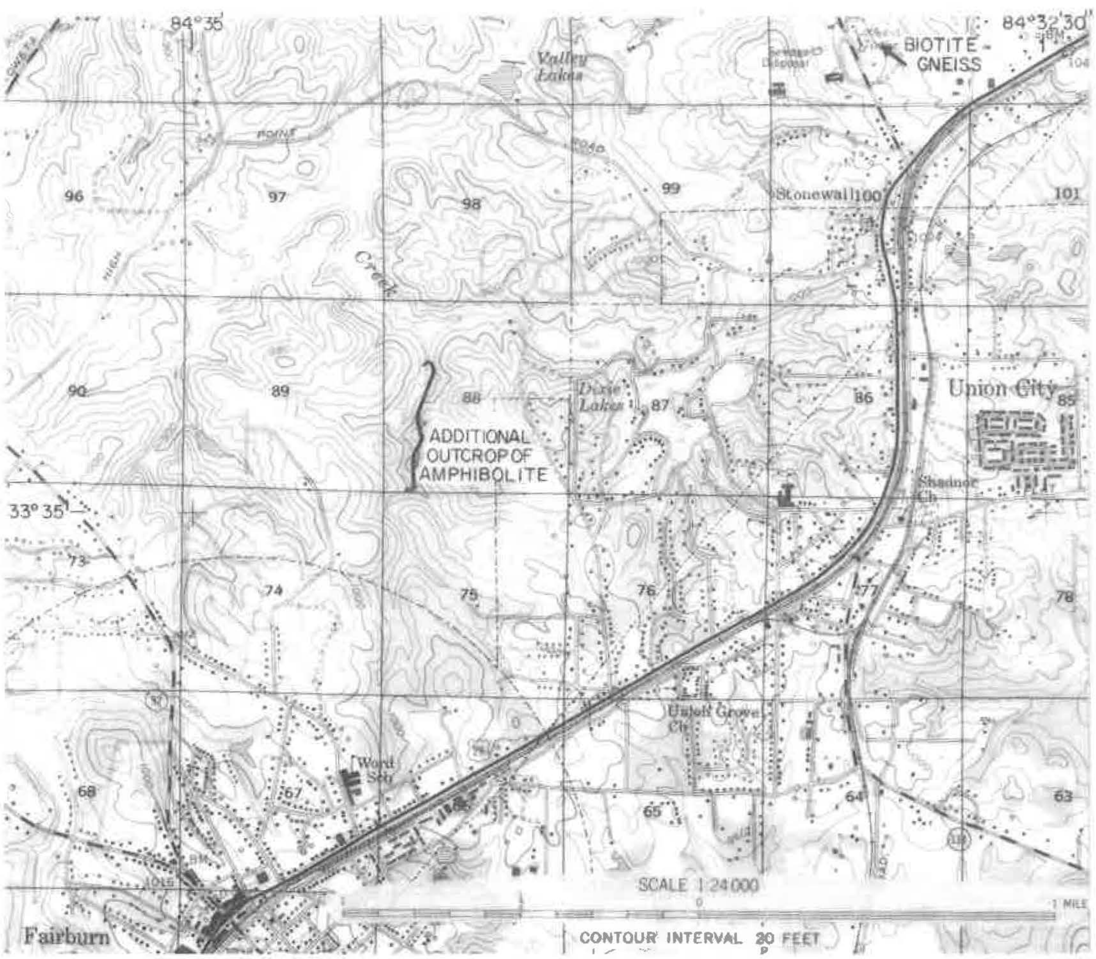

Figure 13. Part of the Fairburn quadrangle, showing Stonewall, Ga., type area of the Stonewall Formation, and Fairburn, Ga., type area of the Fairburn Member of the Clarkston Formation.

The contact between the Stonewall and the underlying Wahoo Creek Formation is sharp and probably conformable, as is the contact with the overlying Clarkston Formation. On the basis of map distribution, the Stonewall is probably 1,000-1,500 m (3,281-4,921 ft) thick. The Stonewall Formation was probably originally a sequence of interbedded graywackes, shales, and mafic volcanic rocks.

Clarkston Formation

The Clarkston Formation is here named for the city of Clarkston, in the Stone Mountain, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973). Nearly continuous outcrops along the Georgia Railroad and East Ponce de Leon Avenue (Stone Mountain Highway) from Clarkston to Mountain Industrial Boulevard (fig. 14) are designated the type section. Typical outcrops of the Clarkston are also found along Mountain Industrial Boulevard north of East Ponce de Leon Avenue (fig. 15).

The Clarkston Formation is composed of purple-pink weathering sillimanite-garnet-quartz-plagioclase-biotite-muscovite schist and ocher-weathering, fine-grained hornblende-plagioclase amphibolite. The schist and amphibolite are interlayered on a scale of 1-20 m (3-66 ft). Biotite-plagioclase gneiss is a minor constituent of the Clarskton. Locally, the schists of the Clarkston are slightly graphitic.

On the northwestern limb of the Newnan-Tucker synform, from East Point, Ga. to near Palmetto, Ga. (fig. 1), the Clarkston Formation is divisible into two members. The Fairburn Member (lower) is here named for outcrops in and around the city of Fairburn, in the Fairburn, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; fig. 13). It consists almost entirely of schist that is generally crinkled and locally contains small red garnets. Where the garnets are present, the schist weathers to a purple-pink saprolite; where they are

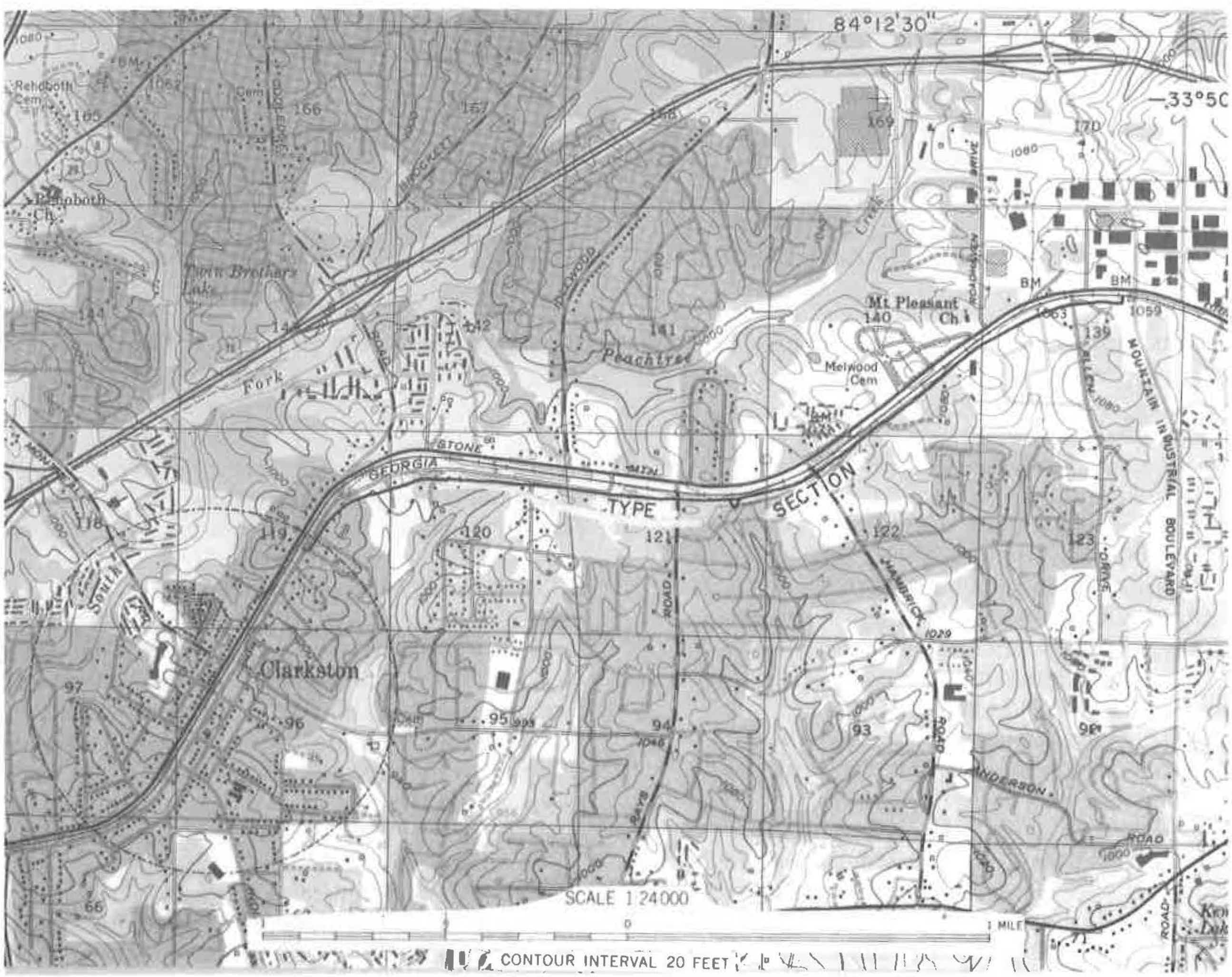

Figure 14. Part of the Stone Mountain quadrangle, showing type section of the Clarkston Formation.

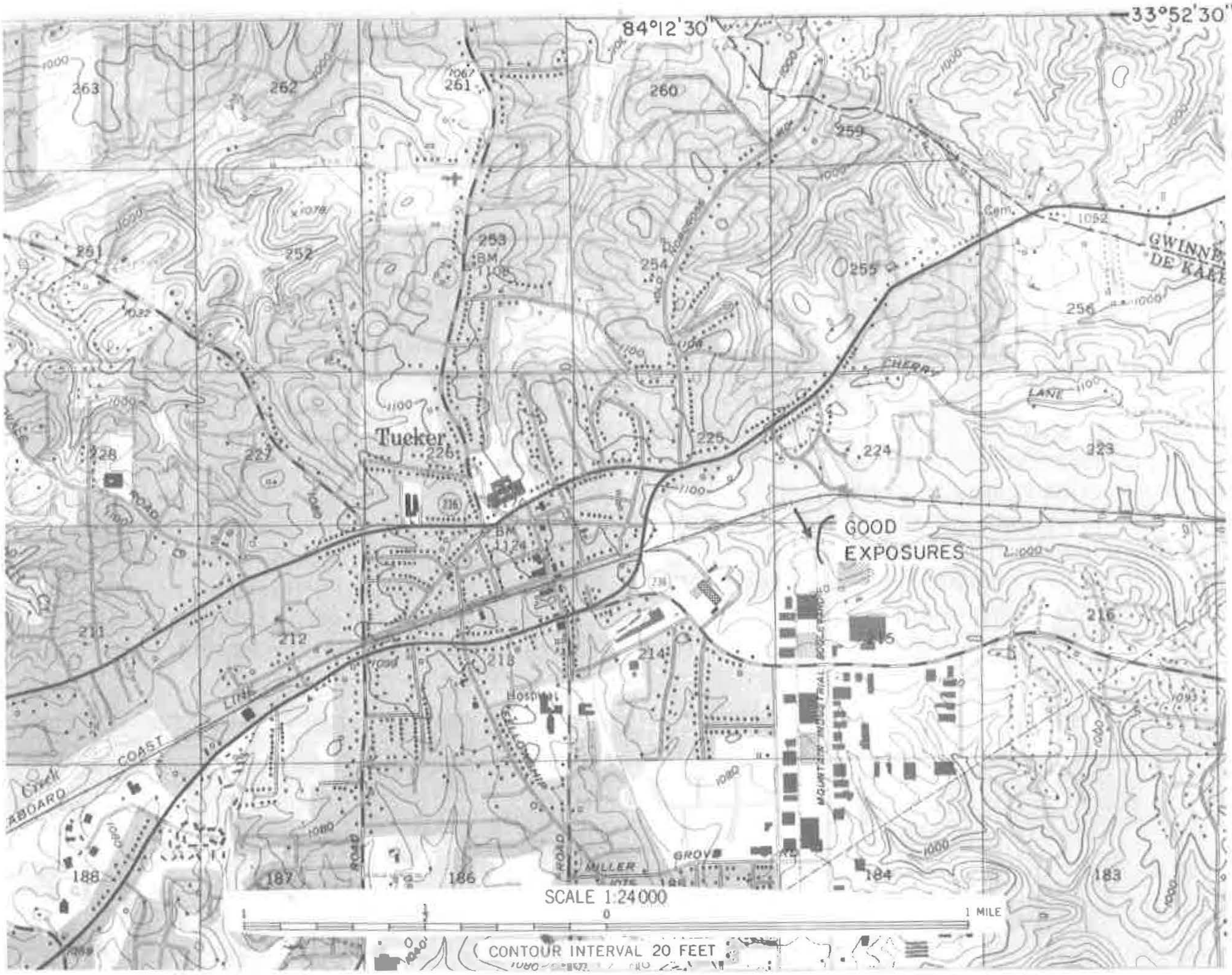

Figure 15. Part of the Stone Mountain quadrangle, showing other good exposures (arrow) of the Clarkston Formation mentioned in the text.

absent, it weathers to a gray saprolite. The Tar Creek Member (upper) of the Clarkston is here named for outcrops along roads around Tar Creek in the Fairburn, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; fig. 16). It consists of purple-pink-weathering sillimanite-garnet-quartz-plagioclase-biotite-muscovite schist and ocher-weathering, fine-grained hornblende-plagioclase amphibolite like the Clarkston undivided. In the Fairburn quadrangle, the Tar Creek Member has been intruded by both the Union City Complex and Palmetto Granite.

The contact of the Clarkston with the underlying Wahoo Creek Formation is generally sharp and probably conformable. The contact of the Clarkston with the overlying Big Cotton Indian Formation is gradational over about 100 m (328 ft). The contact between the Clarkston and the Intrenchment Creek Quartzite is sharp and conformable, as is the contact between the Clarkston and the Camp Creek Formation where the Intrenchment Creek is absent.

On the basis of map distribution, the Clarkston is estimated to be about 800-2,500 m (2,625-8,200 ft) thick. The Fairburn Member is probably 400-1,000 m (1,312-3,280 ft) thick, and the Tar Creek Member is probably 400-1,500 m (1,312-4,920 ft) thick. Like the Wahoo Creek Formation, the Clarkston has been mapped completely around the Newnan-Tucker synform (fig. 1).

The intimately interlayered schists and amphibolites that constitute the bulk of the Clarkston Formation were probably originally shales and mafic volcaniclastic rocks. The biotite gneisses in the formation were probably graywackes.

Figure 16. Part of the Fairburn quadrangle, showing type area (arrows) of the Tar Creek Member of the Clarkston Formation.

Big Cotton Indian Formation

The Big Cotton Indian Formation is here named for exposures near Big Cotton Indian Creek and its tributaries in the Jonesboro, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; fig. 17). The Big Cotton Indian underlies a large part of the trough area of the Newnan-Tucker synform (fig. 1). It is composed of biotite-plagioclase gneisses (locally porphyritic), hornblende-plagioclase amphibolites, and smaller amounts of biotite-muscovite schist. The gneisses weather to a dark-red saprolite and soil, the amphibolites to blocky ocherous saprolite and ocherous soil, and the schist to a dark-pink micaceous soil. North of about the area of Soapstone Ridge, biotite gneiss is more abundant in the formation, whereas to the south, granite gneisses make up increasingly more of the formation.

The contact of the Big Cotton Indian with the underlying Clarkston Formation is gradational over about 100 m (328 ft) and is locally difficult to map. Its contact with the Camp Creek Formation is also gradational over about the same interval.

The Big Cotton Indian Formation is estimated to be as much as 4,000 m (13,125 ft) thick, on the basis of map distribution. However, its true thickness is probably much less.

Most of the biotite gneisses in the Big Cotton Indian Formation were probably originally graywackes, but some of the more massive bodies may be metaplutonic rocks. The amphibolites were probably mafic volcanic rocks, and the schists, aluminous shales. Most of the granite gneisses in the formation are probably metaplutonic rocks.

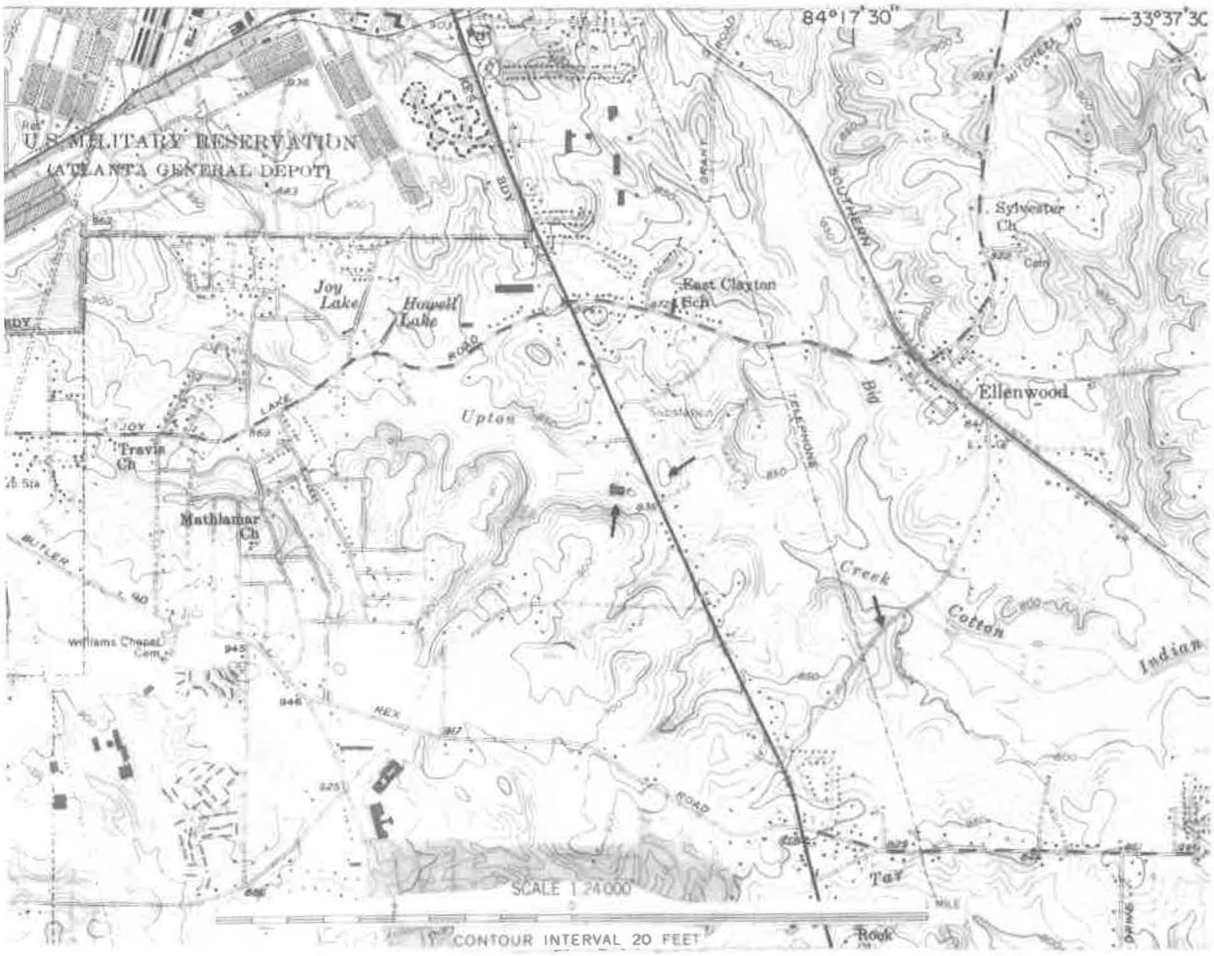

Figure 17. Part of the Jonesboro quadrangle, showing type area of the Big Cotton Indian Formation. Good typical exposures are indicated by arrows.

Intrenchment Creek Quartzite

A thin unit of spessartine quartzite and spessartine mica schist is here named the Intrenchment Creek Quartzite for outcrops in excavations for the landfill beneath the powerline just west of Intrenchment Creek in the Southeast Atlanta, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; fig. 18). The Intrenchment Creek is composed of about 15-30 percent spessartine garnet and 70-85 percent quartz. Because of the manganiferous garnets, it weathers to blocky, hard black quartzite and finally to black sandy soil. Similar rocks elsewhere have been called coticule rocks (Clifford, 1960; Schiller and Taylor, 1965; Kramm, 1976; Grapes, 1978) and gondite (Fermor, 1909). The Intrenchment Creek is never more than about 3 m (10 ft) thick. It is discontinuous, but where present, it is between the Clarkston and Camp Creek Formations. An exception to this is the thin layer of Intrenchment Creek Quartzite east of Lakewood Heights (fig. 1).

The origin of manganiferous quartzites and associated manganiferous schists has been the subject of many studies during the past 15 years (see Grapes, 1978). Following Grapes (1978, p. 31-33), we suggest that the spessartine quartzite and schist of the Intrenchment Creek represent oceanic sediments of an oxidized zone. The iron and manganese in these rocks may have been introduced by halmyrolytic alteration from associated mafic volcanic rocks.

Camp Creek Formation

The Camp Creek Formation is here named for roadcut outcrops along Fairburn-Jonesboro Road (Georgia Highway 138) on both sides of Camp Creek in the Riverdale, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1954; fig. 19). The Camp Creek consists of massive granite gneisses interlayered with thin [less than 1 m (3 ft)], fine-grained, dark-green hornblende-plagioclase amphibolites. The granite gneisses weather to sandy

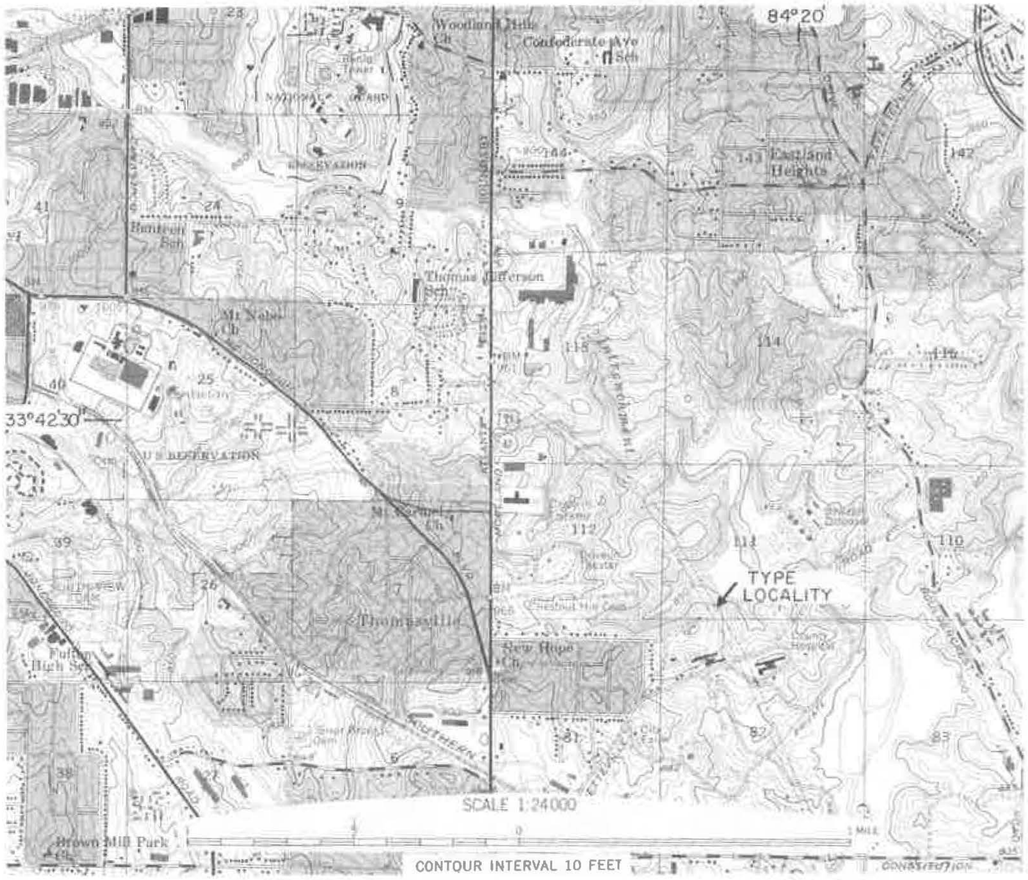

Figure 18. Part of the Southeast Atlanta quadrangle, showing type locality of the Intrenchment Creek Quartzite.

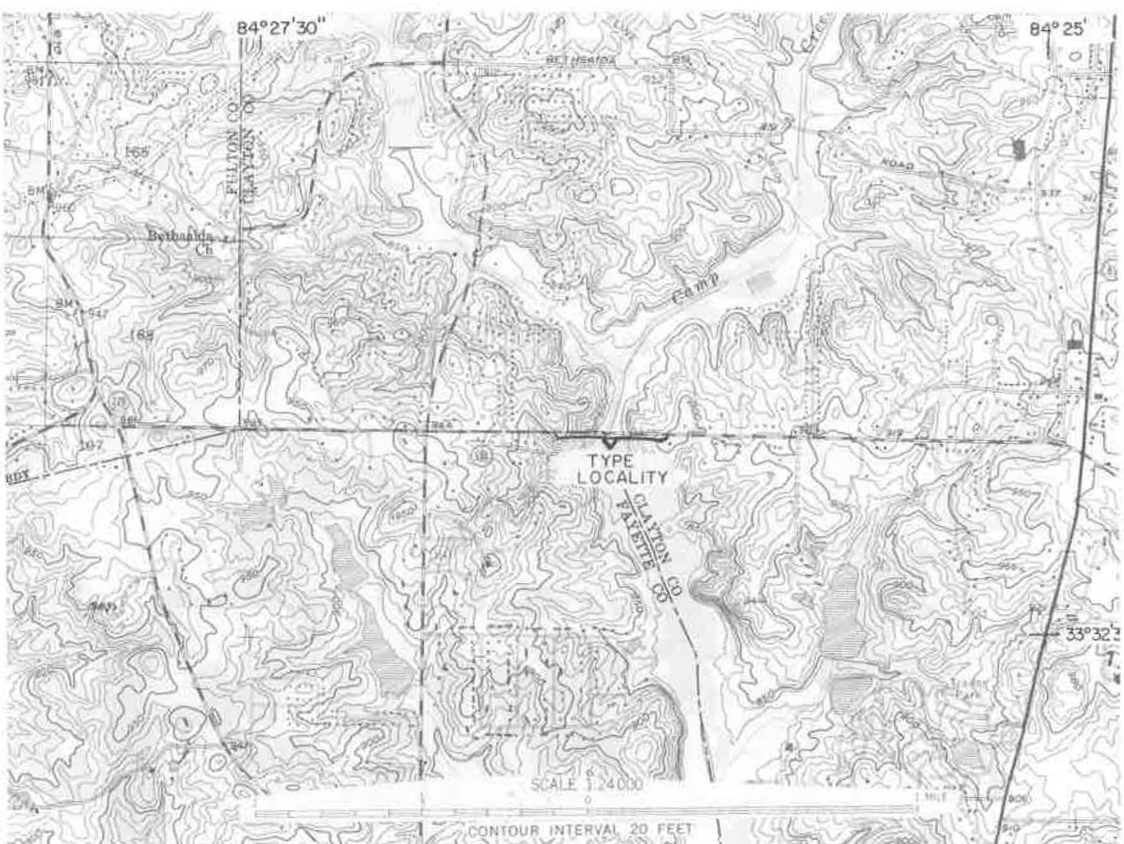

Figure 19. Part of the Riverdale quadrangle, showing type area of the Camp Creek Formation.

light-colored soils, and the amphibolites to blocky ocherous saprolite and finally to ocherous soils.

The Camp Creek Formation is the youngest unit of the Atlanta Group. Its contacts with all other units except the Big Cotton Indian Formation are relatively sharp and probably conformable. On the basis of map distribution, the Camp Creek is estimated to be 600-3,000 m (1,969-9,843 ft) thick.

ROCKS OUTSIDE THE ATLANTA GROUP

Lithonia Gneiss

The Lithonia Gneiss crops out over a large area east of Atlanta, Ga. (fig. 1). The name Lithonia has long been used for this major rock unit of the Georgia Piedmont. Watson (1902) called it the "Lithonia area of contorted granite gneiss." Crickmay (1952; Georgia Geol. Survey, 1939) referred to it as "Granite gneiss, Lithonia type," believing it to be a metamorphosed granite. Herrmann (1954) considered it a migmatite, and called it Lithonia Gneiss. This name was formally adopted by Higgins and Zietz (1975).

The Lithonia Gneiss is a hard, fine-to medium-grained, light-gray to whitish-gray muscovite-biotite-microcline-oligoclase-quartz gneiss that has a well-defined and commonly contorted gneissic banding. Garnetiferous layers are locally present in the gneiss, which has a variety of accessory minerals (Herrmann, 1954, p. 13). The large pavement outcrops at Arabia Mountain (fig. 20) in the Conyers, Ga. quadrangle (U.S. Geol. Survey 7½-min.

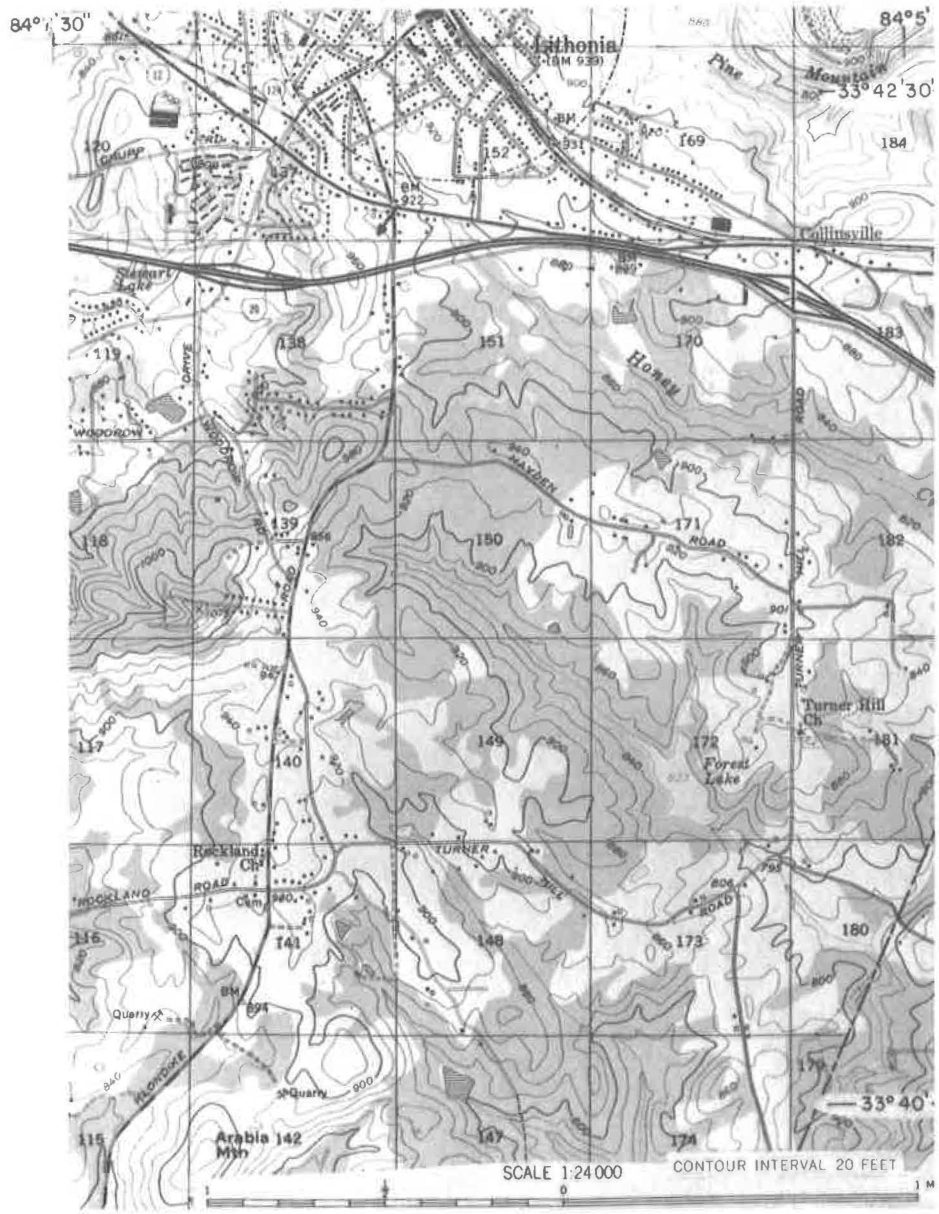

Figure 20. Part of the Conyers quadrangle, showing Arabia Mountain, type locality of the Lithonia Gneiss. Arrow points to borrow-pit outcrop of the Snellville Formation with its Lanier Mountain Quartzite and Norris Lake Schist Members.

topographic quadrangle, 1972; fig. 20) are here designated the type locality. Pavement outcrops are characteristic of the Lithonia Gneiss, but where the unit is deeply weathered it forms light, whitish-yellow sandy soils, that are reliable criteria for geologic mapping.

The map pattern of the Lithonia (fig. 1) does not conform with the structural patterns of the Atlanta Group rocks in the Newnan-Tucker synform, and the gneiss is not found west of the Wahoo Creek Formation outcrop belt on the eastern limb of the synform. Strikes of layering in the Lithonia are at various angles to strikes of compositional layering and foliation in rocks of the Atlanta Group at their contact with the gneiss (Atkins, unpub. data). Although we have not seen the contact of the Lithonia with rocks of the Atlanta Group in outcrop, we have seen no evidence of gradational relations. The contact, therefore, appears to be relatively sharp. We tentatively interpret the contact of the Lithonia with the Atlanta Group rocks as a thrust fault, the Lithonia being thrust over the Atlanta Group rocks. If this interpretation is correct, the thrust fault may mark the sole of a large nappe. Alternative interpretations would be (1) that the contact of the Lithonia with the Atlanta Group rocks is an unconformity; or (2) that the Lithonia is a metaplutonic rock that intruded the Atlanta Group rocks. The contact between the Lithonia and the Snellville Formation is either an unconformity or a thrust fault (see next section).

The age of the Lithonia is uncertain at present. Preliminary radiometric ages of zircons from the gneiss (Higgins and others, unpub. data) suggest an age of about 375 m.y. for part of the gneiss, but this age is still open to interpretation.

Interpretation of the origin of the Lithonia Gneiss must await detailed geochemical and geochronological studies now in progress.

Snellville Formation

The Snellville Formation is here named for exposures within the city limits of Snellville, in the Snellville, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadgrangle, 1973). The type locality is designated as the large roadcut outcrops on Lanier Mountain (fig. 21). The Snellville consists of two members, both present on Lanier Mountain.

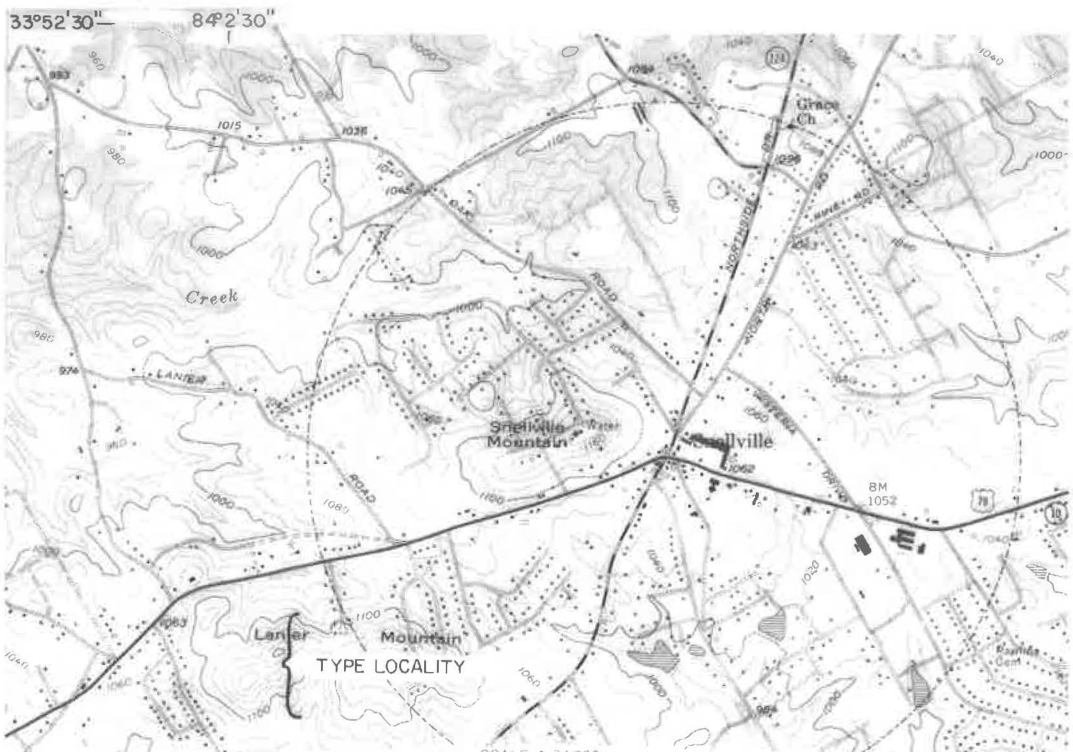

Figure 21. Part of the Snellville quadrangle, showing type locality of the Snellville Formation and its Lanier Mountain Quartzite Member.

The lower member is here named the Norris Lake Schist Member (see Herrman, 1954) for outcrops in No Business Creek, just below the dam at Norris Lake, in the Snellville quadrangle (fig. 4). The Norris Lake consists of interlayered garnet-biotite-muscovite schist, biotite-muscovite schist, thin hornblende-plagioclase amphibolites, and minor amounts of biotite gneiss and quartzite. Biotite gneiss is only found near the base of the member, where it is interlayered with amphibolite and schists. Schist is by far the most abundant rock in the Norris Lake. Near its upper contact with the Lanier Mountain Quartzite Member, the Norris Lake contains thin layers of micaceous quartzite. The schists in the member weather to a red micaceous saprolite, and the amphibolites to blocky ocherous saprolite.

The upper member of the Snellville Formation is here named the Lanier Mountain Quartzite Member for outcrops at the formational type locality (fig. 21) and natural outcrops along the top of Lanier Mountain (see fig. 21 and location description above). The Lanier Mountain ranges from "clean" quartzite composed almost entirely of quartz, through muscovitic quartzite, to garnetiferous, sillimanitic, muscovitic quartzite. It generally holds up low ridges. Where garnets are present, as at the type locality, they are generally flattened and smeared. Sillimanite is locally abundant on parting planes.

Other good outcrops of the Snellville Formation (both members) are found on Elijah Mountain, near Klondike, in the Conyers, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1972), and in a large borrow pit on the west side of Klondike Road just noth of Interstate 20 in the Conyers quadrangle (figs. 20 and 22).

The Norris Lake Schist Member is approximately 30 m (98 ft) thick, and the Lanier Mountain Quartzite Member is 1-3 m (3-10 ft) thick. Locally, the two members occur separately.

The Snellville Formation overlies the Lithonia Gneiss and the Wolf Creek, Clairmont, and Wahoo Creek Formations (fig. 1). It is probably younger than all units of the Atlanta Group. The lower contact of the Snellville is locally discordant with the underlying rocks (figs. 23 and 24), and, as stated above, the Snellville overlies different units in different places. Moreover, the map pattern shows that the Snellville does not conform with the Newnan-Tucker synform; locally, the Snellville lies athwart the contact between the Lithonia Gneiss and rocks of the Atlanta Group. The lower contact of the Snellville is either a folded thrust contact, or

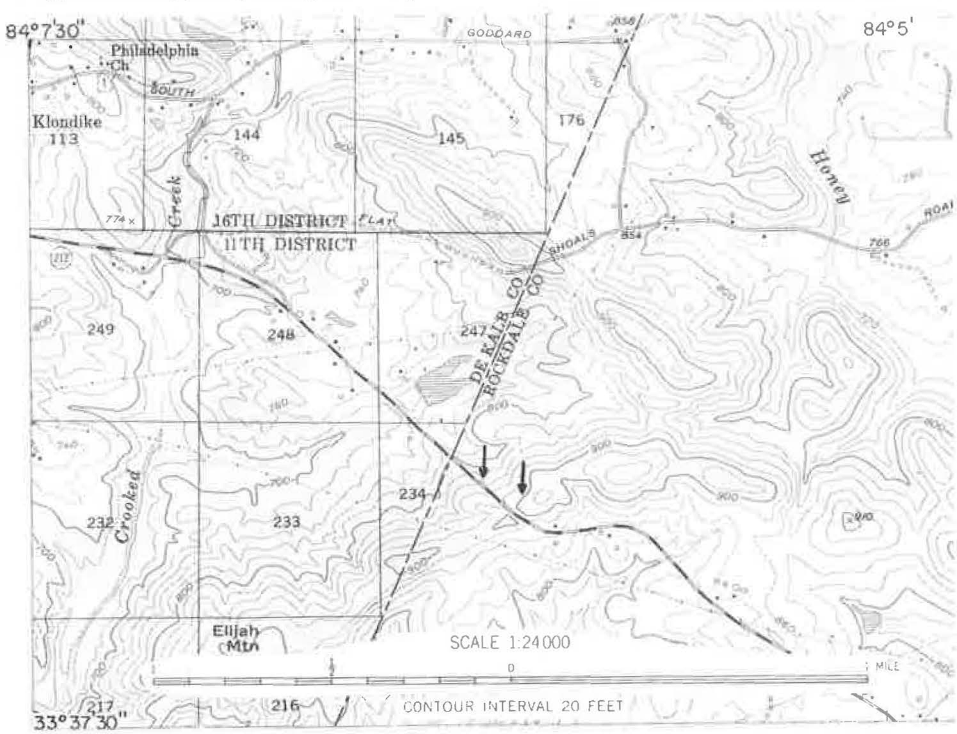

Figure 22. Part of the Conyers quadrangle, showing location (arrows) of good exposures of the Snellville Formation on Elijah Mountain.

Figure 23. Photograph of the unconformity or thrust contact beneath the Lanier Mountain Quartzite Member of the Snellville Formation near Stockbridge, Ga. (see fig. 25).

Figure 24. Part of the Stockbridge quadrangle, showing location (arrow) of the unconformity or thrust contact shown in figure 23.

a folded angular unconformity (Atkins, 1978; Atkins and Higgins, 1980). The contact relations are still under investigation.

Because the Snellville is intruded by the Stone Mountain and Panola Granites (fig. 1), it must be older than about 325 m.y. Detrital zircons from the Lanier Mountain Quartzite Member have yielded an age of about 1,100 m.y. (or possibly slightly older), defining a maximum age for the unit.

The Norris Lake Schist Member of the Snellville probably originally consisted of aluminous shale and smaller amounts of mafic volcaniclastic rock. The Lanier Mountain Quartzite Member was sandstone and slightly pelitic sandstone.

MAFIC AND ULTRAMAFIC IGNEOUS ROCKS

Soapstone Ridge Complex

The Soapstone Ridge Complex of mafic and ultramafic igneous rocks is here named for Soapstone Ridge, within the city limits of Atlanta, in the Southeast Atlanta, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; fig. 25). The complex underlies more than 40 km^2 (15.4 mi^2), making it the largest mafic-ultramafic complex in the Appalachians south of Maryland.

The Soapstone Ridge Complex is a multiply folded thrust sheet, probably nowhere more than about 200 m (656 ft) thick. This sheet has been dissected into four main parts (fig. 1) by the South River and its tributaries. In addition, there are many erosional windows through the thrust sheet; only the largest of these are shown on the geologic map. Some of the areas of granite or granite gneiss shown on the map may be plutons that intruded the complex after it was thrust into place; others may be plutonic rocks that intruded the complex before thrusting and were transported with the sheet. Most, however, are probably rocks of the Big Cotton Indian Formation exposed in windows. One important window in the northernmost segment of the complex exposes Intrenchment Creek Quartzite. The basal thrust fault is exposed at several places but is best seen in steep cuts at the truck depot on the east side of Moreland Avenue

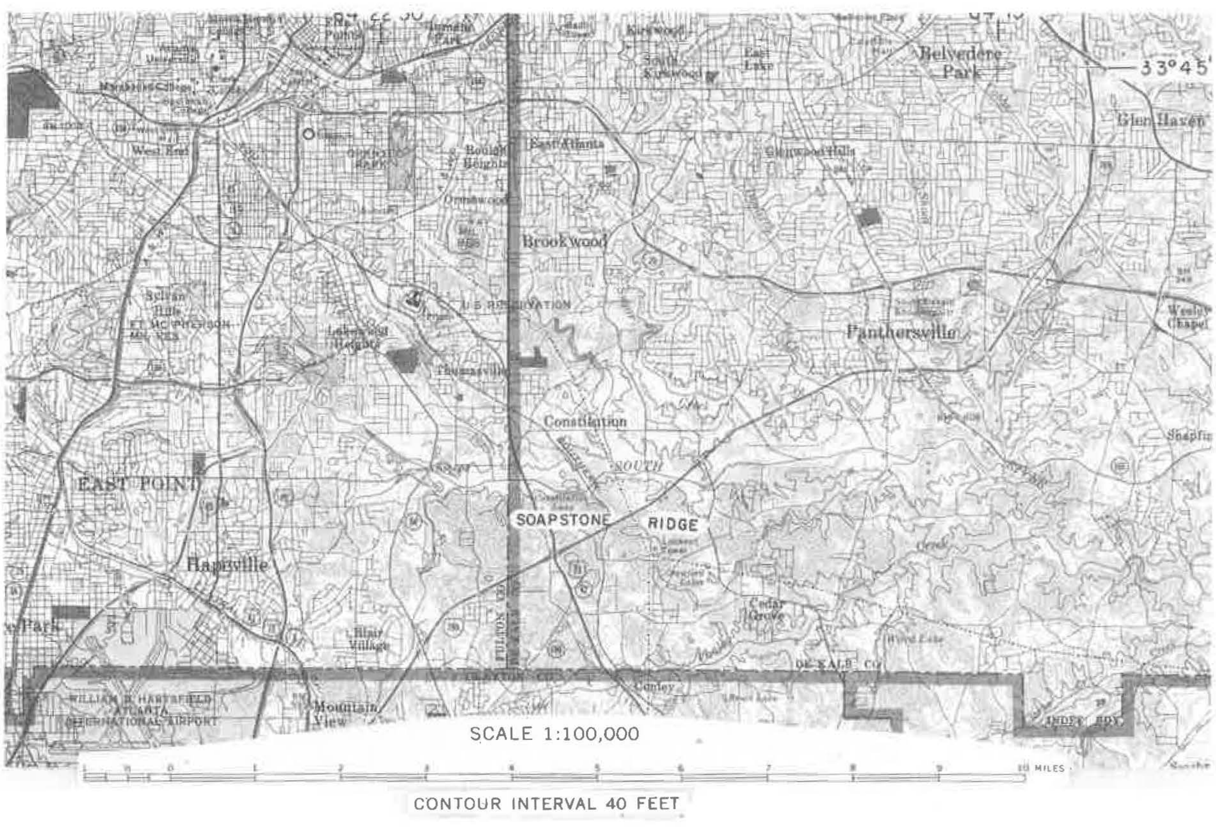

Figure 25. The Southeast Atlanta quadrangle, taken from the 1:100,000-scale Greater Atlanta region map (U.S. Geol. Survey, 1974), showing type area of the Soapstone Ridge Complex.

(U.S. Highway 23) just south of the South River in the Southeast Atlanta quadrangle (fig. 26). In these cuts, actinolite-chlorite-talc schist of the Soapstone Ridge Complex rests in sharp contact upon gneiss of the Big Cotton Indian Formation. Complex folds in the gneiss are cut off by the fault, and in the eastern end of the outcrop, a 1 m (3 ft) thick pegmatite dike and several 30 cm (1 ft) thick quartz veins end at the thrust contact. Extensive excavations on the ridge immediately south of the truck depot show several linear repetitions of the basal units of the complex and of Atlanta Group rocks. Some of these features are due to antiforms being cut by the excavation surface; others are due to imbricate thrusts (Higgins and others, 1980).

The Soapstone Ridge Complex is composed chiefly of metamorphosed mafic and ultramafic rocks. Almost all of these rocks have been extensively altered, so that relict minerals such as pyroxene and olivene are extremely rare. Nevertheless, the complex can be roughly divided into six major lithologic units:

(1) a thin unit (~ 6 m; ~ 20 ft) of sillimanite-quartz blastomylonite and epidosite, that crops out discontinuously at the base of the complex;

(2) actinolite-chlorite-talc schist, near the base of the complex, that is probably the result of shearing of more massive rocks during emplacement of the complex;

(3) a mixed unit composed of about equal amounts of metamorphosed mafic rocks (mostly amphibolites and metagabbros) interlayered with fine- to medium-grained metamorphosed ultramafic rocks (probably mostly metadunites and metaperidotites);

(4) a mixed unit composed of fine-grained amphibolite and actinolite-chlorite-talc schist;

(5) a unit composed entirely of fine-grained amphibolite; and

(6) a unit of massive, medium- to very coarse-grained metamorphosed mafic rock (probably mostly metatroctalite; see fig. 27), the most common rock type of the main part of the complex on Soapstone Ridge (fig. 1).

The time of emplacement of the Soapstone Ridge Complex is important to interpretations of the tectonic history of the Atlanta area and to determination of the age of the Atlanta Group. Some of the small granitic bodies that appear to have intruded the complex after it was emplaced

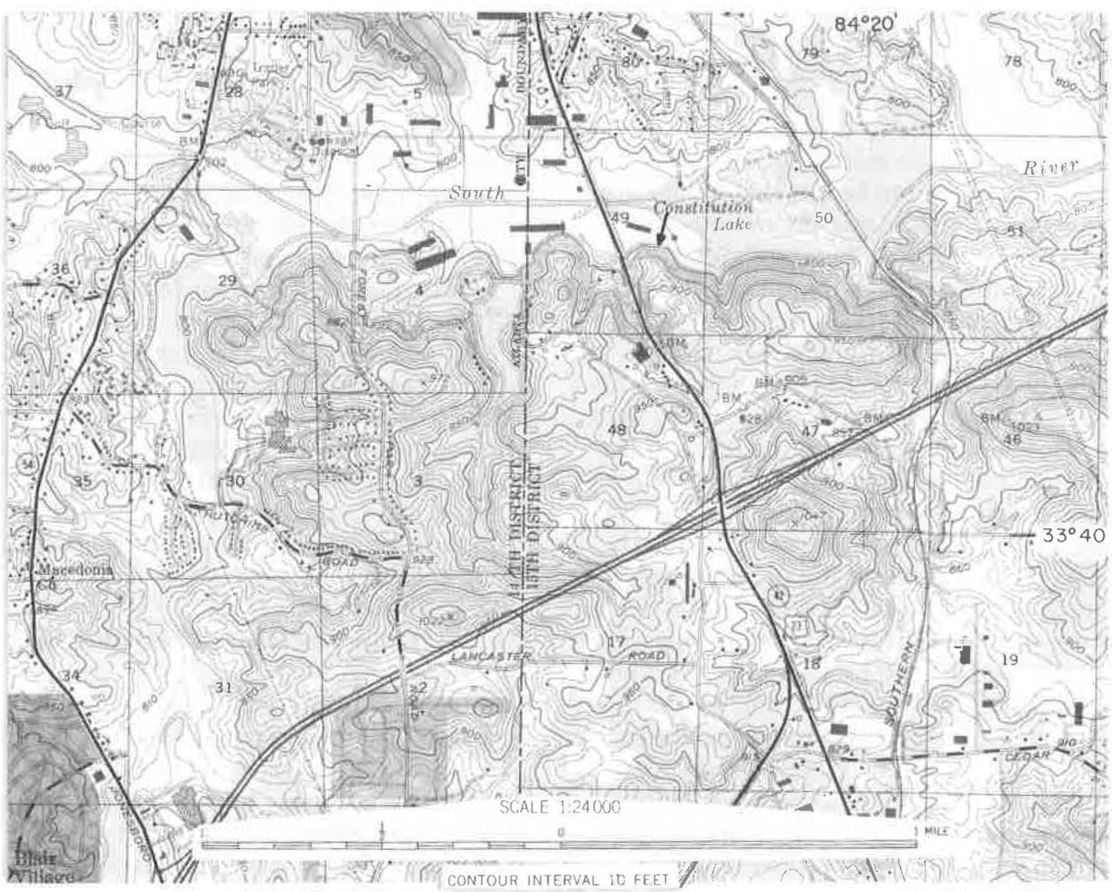

Figure 26. Part of the Southeast Atlanta quadrangle, showing location (arrow) of the large cuts in the truck depot where the thrust fault at the base of the Soapstone Ridge Complex is exposed.

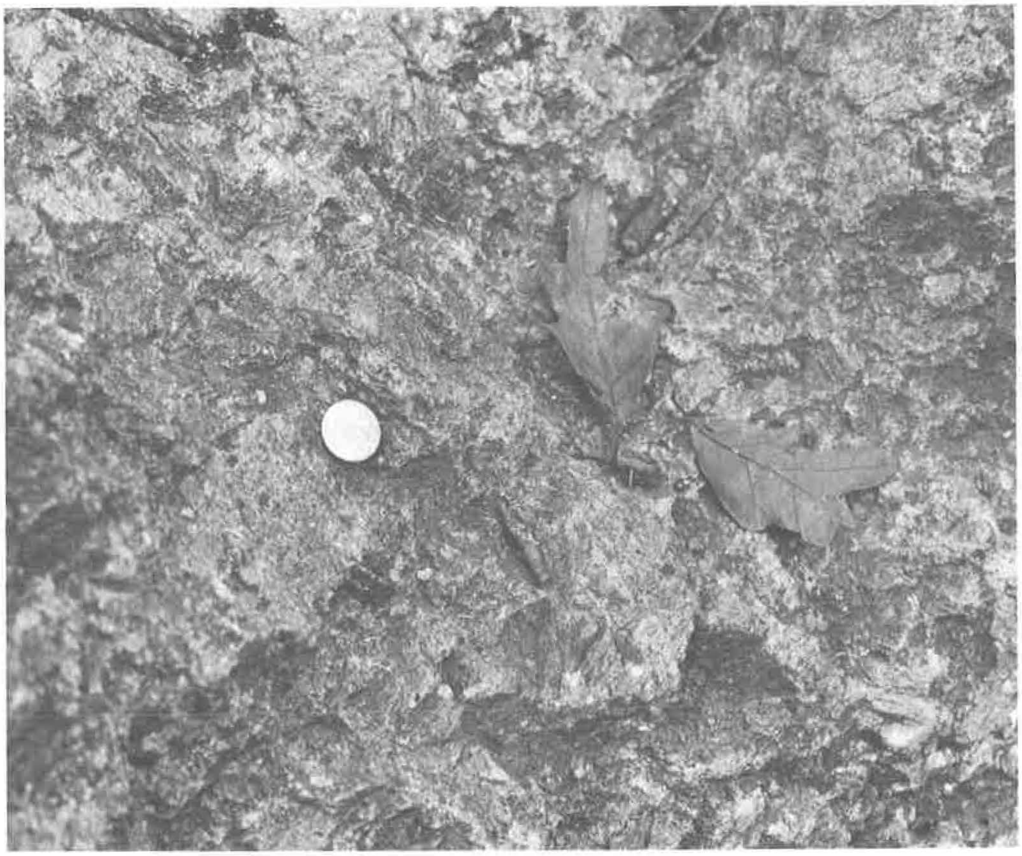

Figure 27. Typical coarse-grained metatroctolite of the Soapstone Ridge Complex. Diameter of coin is 1.8 cm.

bear a strong resemblance texturally and mineralogically to the Stone Mountain Granite. If such a lithologic correlation is valid, then the complex had to be emplaced before about 325 m.y. ago. The fact that the complex is multiply folded and strongly metamorphosed also constitutes evidence that it was emplaced before about 325 m.y. ago. The first generation of folds in the Atlanta area (Buck Branch folds of Atkins and Higgins, 1978, 1980) have not been recognized in the rocks of the complex, and, in fact, the thrust fault at the base of the complex cuts these folds in the country rocks. The rocks of the complex are, however, folded by all later generations of folds. If the unconformity beneath the Snellville Formation is really an unconformity and not a thrust fault, and if it is roughly correlative with the Taconic unconformity, as we have suggested (Atkins, 1978; Atkins and Higgins, 1978), then the complex must have been emplaced after the early Early Ordovician (Knox time). On the basis of these data and speculations, we suggest that the Soapstone Ridge Complex was emplaced by low-angle (nearly flat) thrusting in the early Middle Ordovician, the time of slope reversal in the Valley and Ridge province, and also the approximate time of emplacement of similar complexes elsewhere in the Appalachians (Williams, 1971; Kennedy and Phillips, 1971; Upadhyay and others, 1971; Williams and Smyth, 1973; Crowley, 1976; Morgan, 1977; Fisher and others, in press). We further suggest that the Soapstone Ridge Complex is the remnant of a disrupted ophiolite complex, obducted onto the North American Continent (Higgins and others, 1980). Whatever the origin of the complex, if it was thrust onto the Atlanta Group in Middle Ordovician time, it would restrict the age of most of the Atlanta Group to pre-Middle Ordovician.

Other metamorphosed ultramafic rocks

In addition to the large Soapstone Ridge Complex, numerous small bodies of highly altered ultramatic rocks are scattered throughout the Atlanta area. These bodies may be related to the Soapstone Ridge Complex, but are found within different stratigraphic units and are too small and discontinuous to warrant formal stratigraphic names.

Other metamorphosed mafic rocks

Outcrop areas within many of the formations of the Atlanta Group are made up almost entirely of amphibolite. The largest of these amphibolite areas have been shown separately on the geologic map (fig. 1). Most of the amphibolites are hornblende - plagioclase amphibolites, and most were probably mafic tuffs before metamorphism. These units are also found within different stratigraphic units and are too small and discontinuous to warrant formal stratigraphic names.

GRANITIC PLUTONIC ROCKS

Five major bodies of granitic rock have intruded the rocks of the Atlanta Group, and two of these, the Stone Mountain and Panola Granites, have also intruded the Lithonia Gneiss and the Snellville Formation (fig. 1). In addition, there are numerous smaller unnamed bodies of granite and granite gneiss. Four of the major granite bodies have already been named, but will be described here for completeness. The fifth is named in this paper.

Union City Complex

Granite and granite gneisses of the Union City Complex are here named for exposures around Union City, in the Fairburn, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973). Some of the best exposures are around Shannon Shopping Mall at the intersection of Georgia Highway 138 and Interstate 85 (fig. 28). The

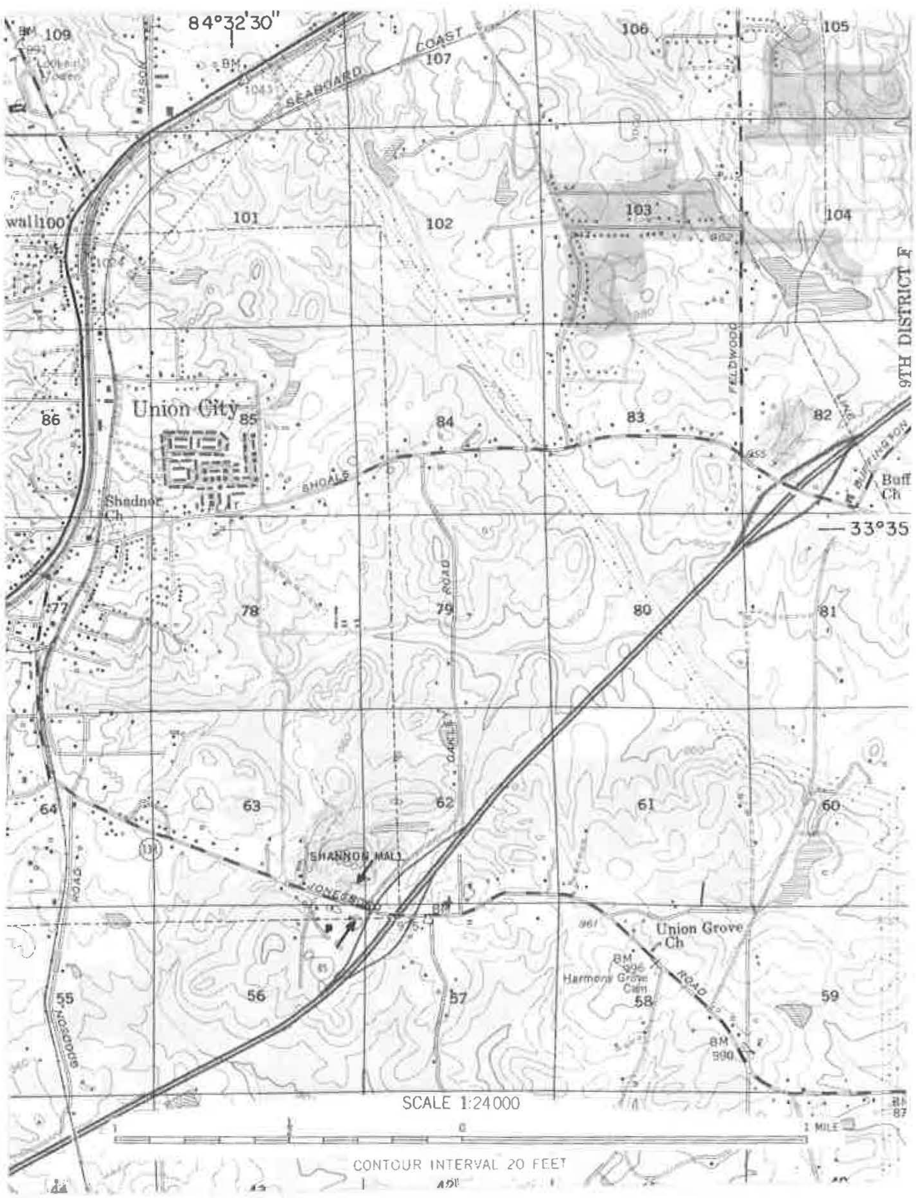

Figure 28. Part of the Fairburn quadrangle, showing type area (Union City) of the Union City Complex. Arrows point to some of the best exposures, now within Union City limits.

Union City is a complex of granites and granite gneisses that are not separable in the field, even at 1:24,000-scale mapping. The granites range from unfoliated to slightly foliated; most are porphyritic muscovite-biotite granites. The granite gneisses are mostly foliated and are generally richer in biotite than the granites. The Union City Complex underlies more than 63.7 km^2 (24.6 mi^2) in Fulton and Fayette Counties (fig. 1).

The Union City rocks intrude the Clarkston and Camp Creek Formations and Intrenchment Creek Quartzite of the Atlanta Group. The age of the Union City is unknown, but is probably Paleozoic.

Ben Hill Granite

The name Ben Hill Granite has been in use for many years. The type locality is the community of Ben Hill, in the Ben Hill, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973; fig. 29). The Ben Hill underlies more than 109.3 km^2 (42.2 mi^2) in Fulton County (fig. 1) and is thus of batholithic size. It is a coarse-grained, porphyritic, muscovite-biotite-quartz-plagioclase-microcline rock (Cofer, 1958). Blocky, commonly zoned, microcline phenocrysts, locally as much as 5 cm (2 in) long, make up 20-70 percent of the rock. Large pedestal-boulder outcrops are characteristic of the Ben Hill. Where deeply weathered, the Ben Hill forms a light-colored, tan-yellow soil that contains abundant weathered microcline phenocrysts.

The Ben Hill Granite has intruded the Clarkston, Stonewall, Wahoo Creek, and Clairmont Formations and the Norcross Gneiss (fig. 1). Its contact with these units is generally sharp and markedly discordant. However, the contact zone is locally marked by many dikes and sill-like layers of Ben Hill Granite alternating with the altered country rocks over about a 30 m (100 ft) interval. Numerous xenoliths of country rock are found in the Ben Hill, and eight large xenoliths, or more likely roof pendants, have been mapped (fig. 1). Some of the small xenoliths and the large roof pendants can be identified as belonging to units of the Atlanta Group.

Figure 29. Part of the Ben Hill quadrangle, showing the community of Ben Hill, type locality (or area) of the Ben Hill Granite.

The age of the Ben Hill Granite is at present unknown, but radiometric dating is in progress by the U.S. Geological Survey. On the basis of preliminary zircon ages, the Ben Hill is tentatively assigned an age of about 325 m.y.

Palmetto Granite

The name Palmetto Granite has been used for many years. The type locality is the small town of Palmetto, in the Palmetto, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1968; fig. 30). The Palmetto is the largest granitic batholith in the Atlanta area, underlying more than 242.4 km^2 (93.6 mi^2) in Fayette, Coweta, Henry, and Fulton Counties (fig. 1). In outcrop, the Palmetto is almost identical with the Ben Hill Granite. It is a coarse-grained porphyritic rock (fig. 31a) that has virtually the same mineralogy, outcrop characteristics, and weathering characteristics as the Ben Hill. Both granites are easily mappable even where outcrop is absent, because they leave a distinctive soil littered with pieces of feldspar phenocrysts (fig. 31b). Possibly, the Ben Hill and Palmetto Granites are cupolas of the same batholith.

The Palmetto Granite has intruded the Norcross Gneiss, the Senoia, Clairmont, Wahoo Creek, Stonewall, and Clarkston Formations, the Intrenchment Creek Quartzite, and the Camp Creek Formation (fig. 1). The contact relations of the northwesternmost part of the batholith, northwest of about the Fayette-Coweta County line, are similar to those of the Ben Hill Granite (see above). To the east and southeast, however, the Palmetto becomes increasingly rich in xenoliths and

Figure 30. Part of the Palmetto quadrangle, showing the town of Palmetto, type locality of the Palmetto Granite.

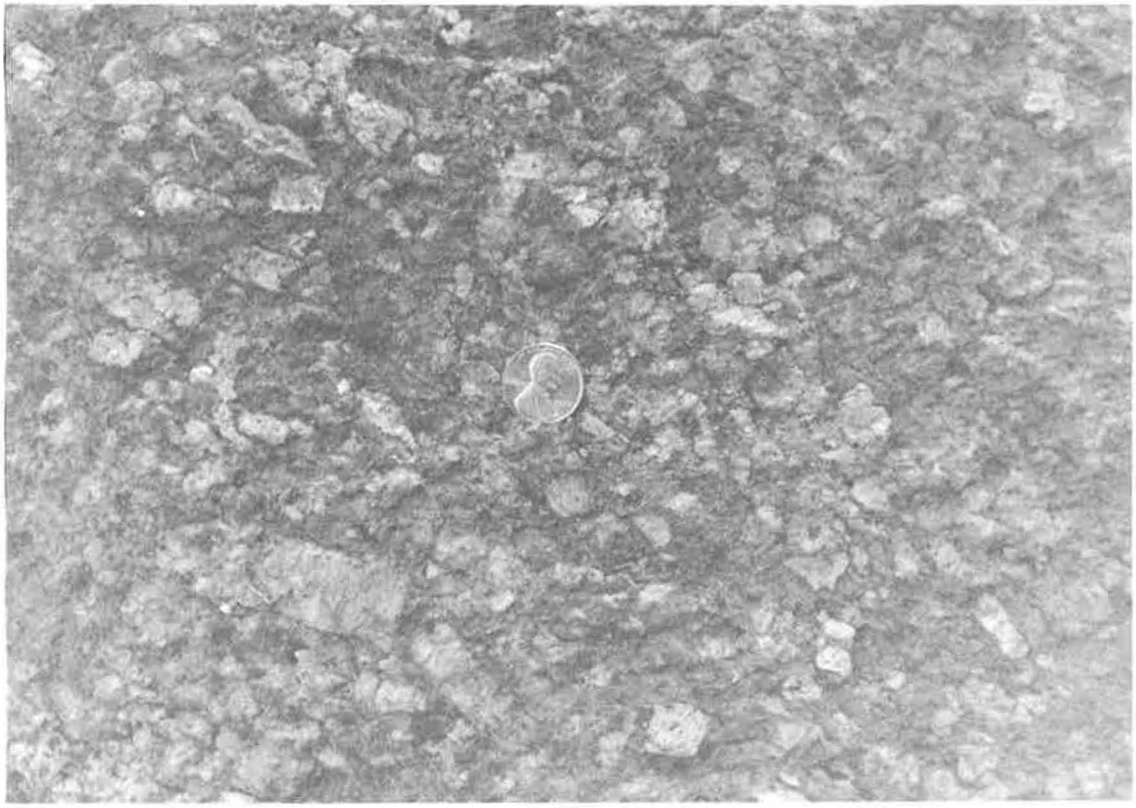

Figure 31a. Typical Palmetto Granite, showing large euhedral feldspars. This is identical in outcrop to Ben Hill Granite. Diameter of coin is 1.8 cm.

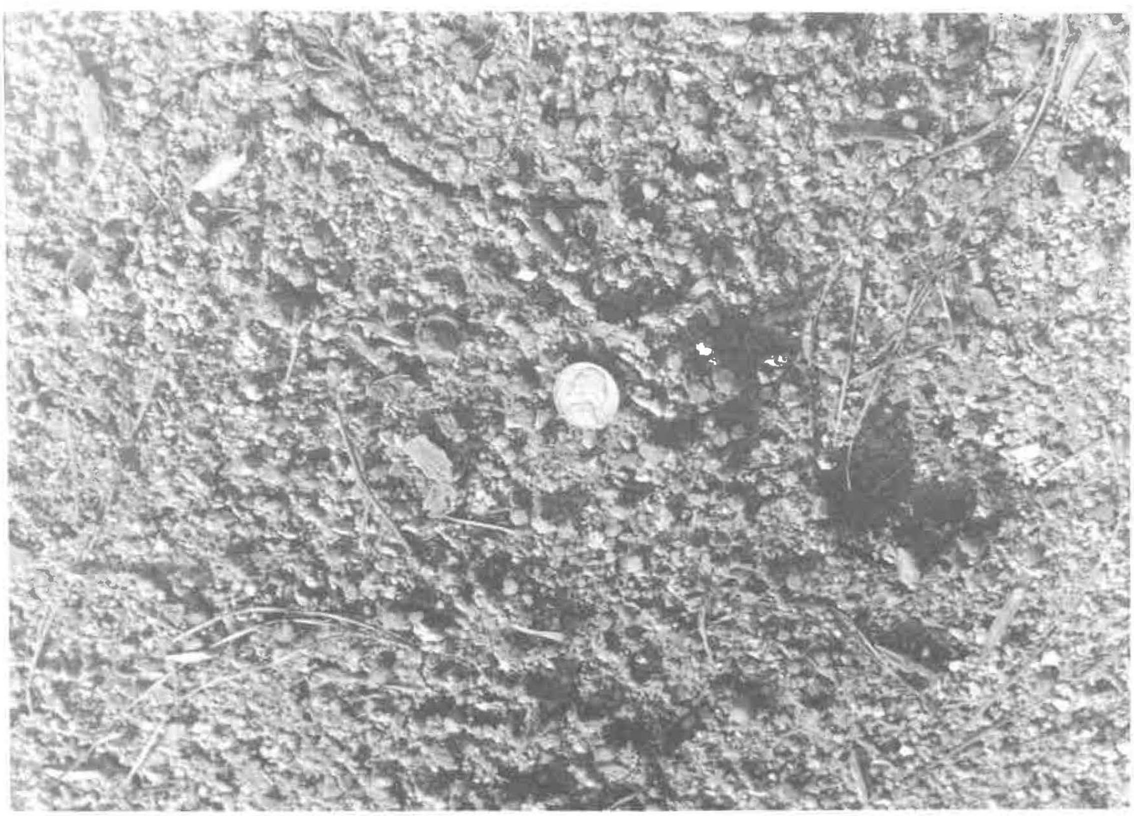

Figure 31b. Distinctive soil derived from weathering of the Palmetto Granite. The numerous blocky grains are pieces of feldspar phenocrysts. Diameter of coin is 2.1 cm.

large areas of altered country rocks; in fact, in this area as much as 50 percent of the exposure is of country rocks. This has allowed us to map the country-rock units of the Atlanta Group through the granite with remarkable contact control (fig. 1); we have shown the granite outcrop area with patterns over the county-rock units. Within the granite, schists are exceptionally rich in quartz and sillimanite, and locally have euhedral and subhedral feldspar porphyroblasts as much as 3 cm long (fig. 32a). This area of country rock and granite is referred to as the Tyrone phase for the small community of Tyrone, in the Tyrone, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1965; fig. 32b). Earlier workers mapped this phase as a separate granite, the "Tyrone Granite," but our mapping shows that it is simply a phase of the Palmetto. We have also separated another phase of the Palmetto, which we call the Shake Rag phase for the small community of Shake Rag (Tyrone quadrangle; fig. 33.) This phase consists of granite and country rocks that have been so highly altered that they have as much as 60 percent sillimanite and quartz and can be mapped as a separate unit (fig. 1). The nearly layer-by-layer intrusion of the Palmetto Granite into the country rocks suggests slow, "permissive intrusion," as do the aureole effects.

Like the Ben Hill Granite, the age of the Palmetto is unknown; radiometric age dating is in progress by the U.S. Geological Survey. On the basis of preliminary zircon ages, the Palmetto is tentatively assigned an age of about 325 m.y.

Relationship of the Ben Hill and Palmetto Granites to structure and to the Brevard Zone

Both the Ben Hill and the Palmetto Granites appear to have been emplaced along axial traces of north-to northwest-trending cross folds that fold the Newnan-Tucker synform (fig. 1). These folds are probably the Elijah Mountain generation (third generation) folds of Atkins and Higgins (1978, 1980). In addition, however, the long east-and southeast-trending "tail" of the Palmetto curves across the Newnan-Tucker synform.

The northwestern contacts of both granites are with cataclastic phyllonites, mylonites, and button schists of the Brevard Zone. Near these contacts, the granites are sheared and foliated, and their microcline phenocrysts are commonly augen-shaped. Both granites have "tails" that extend northeast along the Brevard Zone (fig. 1). These relations could be interpreted as indicating that the granites were emplaced during right-lateral movement on the Brevard, the bends and "tails" of the granites being due to a drag effect during emplacement.

Figure 32a. Distinctive feldspar porphyroblasts in mica schist. Diameter of coin is 2.1 cm.

Figure 32b. Part of the Tyrone quadrangle, showing type locality (community of Tyrone) of the Tyrone phase of the Palmetto Granite.

Stone Mountain Granite

The Stone Mountain Granite is best known for its type locality, Stone Mountain, a prominent monadnock of nearly bare granite that stands approximately 250 m (820 ft) above the surrounding terrain (Atkins and Joyce, 1980; fig. 34). The main body of the granite underlies more than 27.4 km^2 (10.6 mi^2) in Dekalb County, east of Atlanta (fig. 1). In addition, six satellitic plutons of Stone Mountain Granite are large enough to map, and many bodies (including dikes and sills) are too small to map separately.

Many petrographic and petrologic studies of the Stone Mountain Granite have been published (Herrmann, 1954; Grant, 1962, 1969; Wright, 1966; Whitney and others, 1976; Whitney and Stormer, 1977; Atkins and others, 1980). The Stone Mountain is a whitish-gray, unfoliated, fine- to medium-grained, homogeneous biotite-muscovite-microcline-oligoclase-quartz rock, that has a hypidiomorphic-granular texture (Herrmann, 1954; Wright, 1966; Whitney and others, 1976). The rock is actually a quartz monzonite or adamellite, but the name "granite" is retained because of long usage. The Stone Mountain becomes slightly less leucocratic (more biotitic) away from the type locality. The granite characteristically forms pavement outcrops; where deeply weathered, it forms a light-tan-yellow sandy soil.

The Stone Mountain Granite has intruded the Promised Land, Clairmont, and Snellville Formations and the Lithonia Gneiss. Its contacts are sharp and markedly discordant. It was probably emplaced

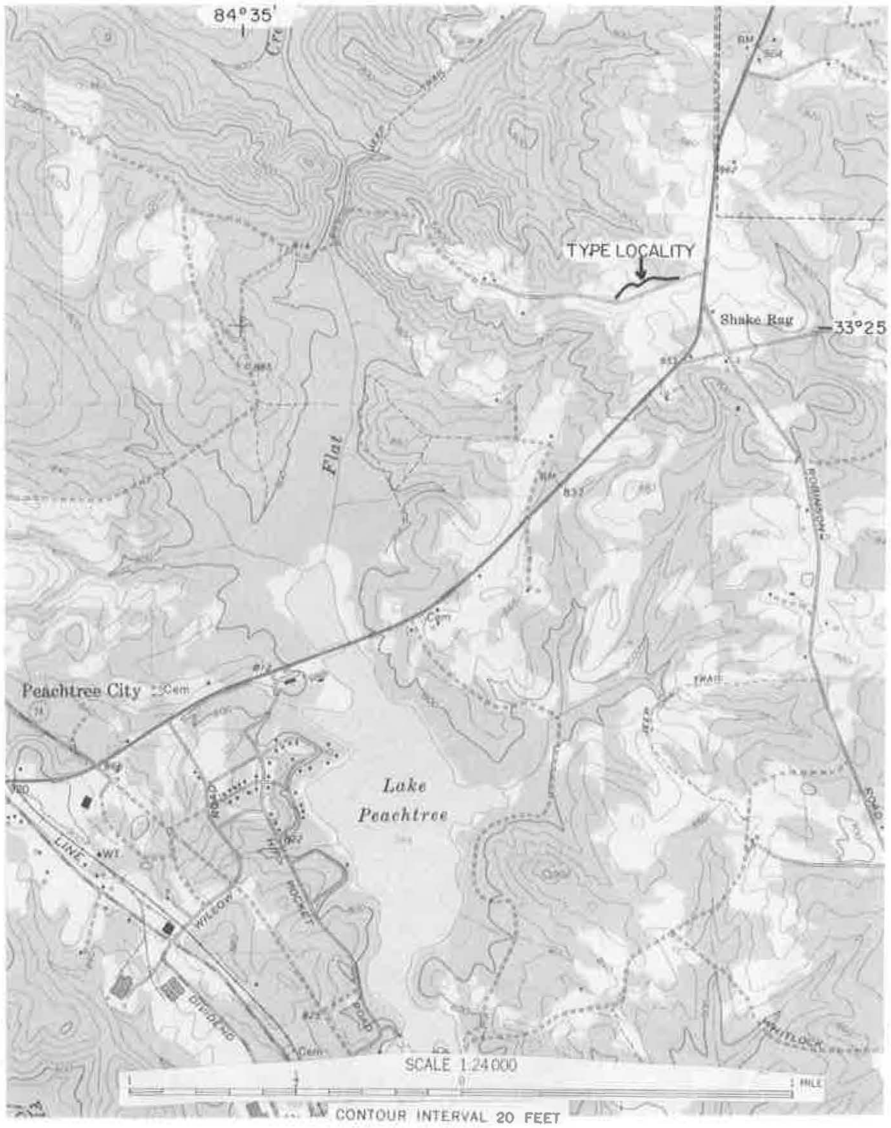

Figure 33. Part of the Tyrone quadrangle, showing location of type locality of the Shake Rag phase of the Palmetto Granite.

during the very latest phase of metamorphism and locally has had an aureole effect on the high-grade country rocks within a few meters (tens of feet) of the contact (Grant, 1962; Atkins, unpub. data). The Stone Mountain contains xenoliths that can generally be identified with the country-rock units, but they are mostly smaller and far less abundant than xenoliths in the Ben Hill and Palmetto Granites.

Whitney and others (1976) published Rb-Sr isochrons for Stone Mountain Granite, and stated that the age is 291 ± 7 m.y. However, their data show considerable scatter. Reanalysis of their data by J.G. Arth (U.S. Geol. Survey) shows that regression of the whole rock data (using a decay constant of 1.42 x $10^{-11}y^{-1}$) gives 280 ± 34 m.y. Two concordant zircon ages from the Stone Mountain (Higgins and others, unpub. data) indicate that it is about 325 m.y. old. The reinterpreted Rb-Sr data agree with this age within analytical uncertainty. We accept the 325 m.y. date as the age of the pluton.

Whitney and others (1976) proposed that the Stone Mountain Granite originated by partial melting of Lithonia Gneiss. New geochemical data (Atkins and others, 1979) suggest that the Stone Mountain is anatectic, but that it was not derived from Lithonia Gneiss.

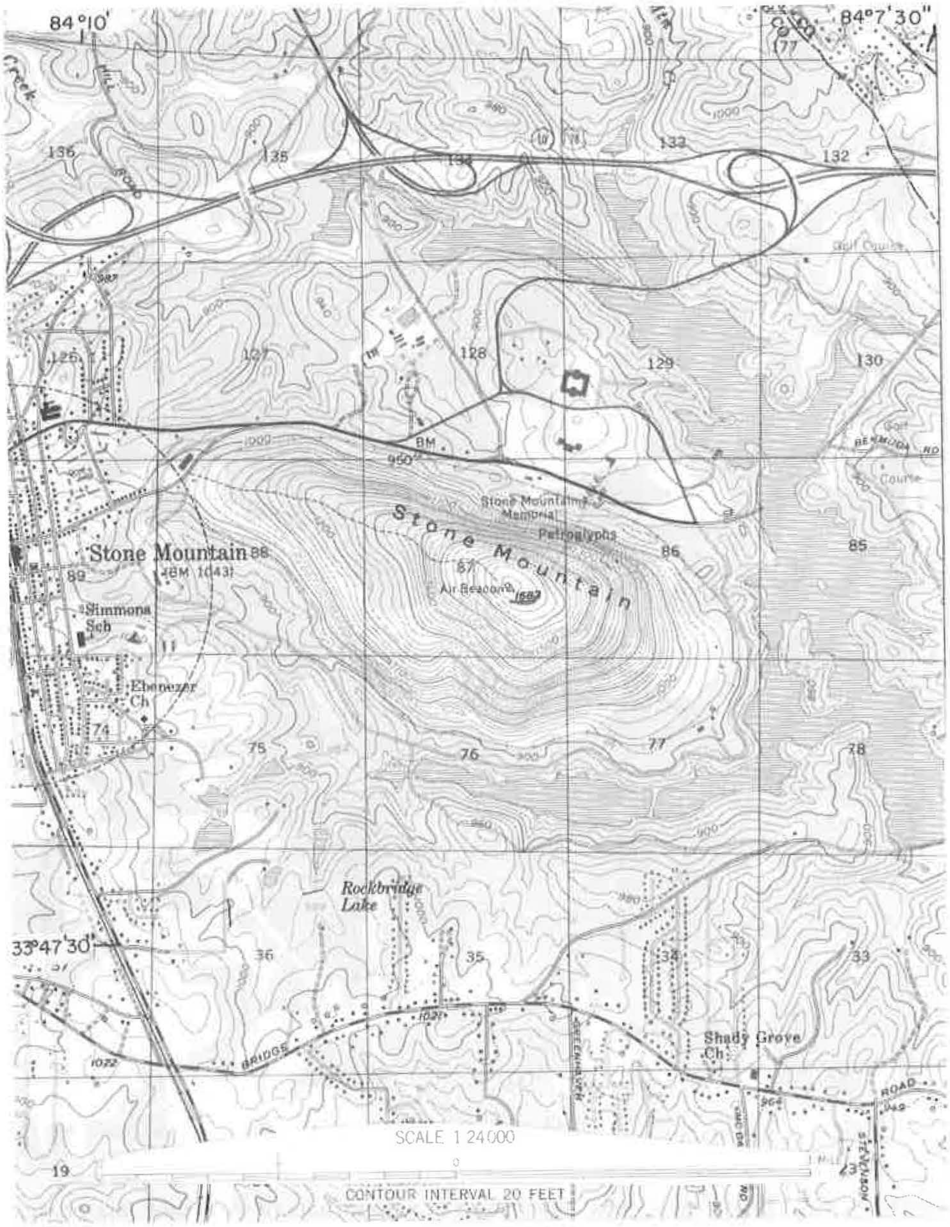

Figure 34. Part of the Stone Mountain quadrangle, showing Stone Mountain, type locality of Stone Mountain Granite.

Panola Granite

The name Panola Granite has long been in use in Georgia and was formalized by Higgins and Zietz (1975). The type locality is Panola Shoals of the South River in the Redan, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1956; fig. 35). The Panola has a three-pronged map pattern (fig. 1) and underlies about 10.6 km^2 (4.0 mi^2) in Dekalb, Henry, and Rockdale Counties. In contrast to the Stone Mountain Granite, it has no mappable satellite bodies.

The Panola Granite is a very homogenous, medium-grained, dark-gray, biotite-oligoclase-quartz-microcline rock that lacks a discernible foliation. It forms pavement outcrops, the largest of which is a monadnock known as Pig Mountain in Panola Mountain State Park (Redan, Ga., U.S. Geol. Survey 7½-min. topographic quadrangle, 1956; Atkins, 1977; fig. 35). The Panola weathers to a dark-red clayey soil.

The Panola Granite has intruded the Lithonia Gneiss and the Clairmont, Wahoo Creek, Clarkston,

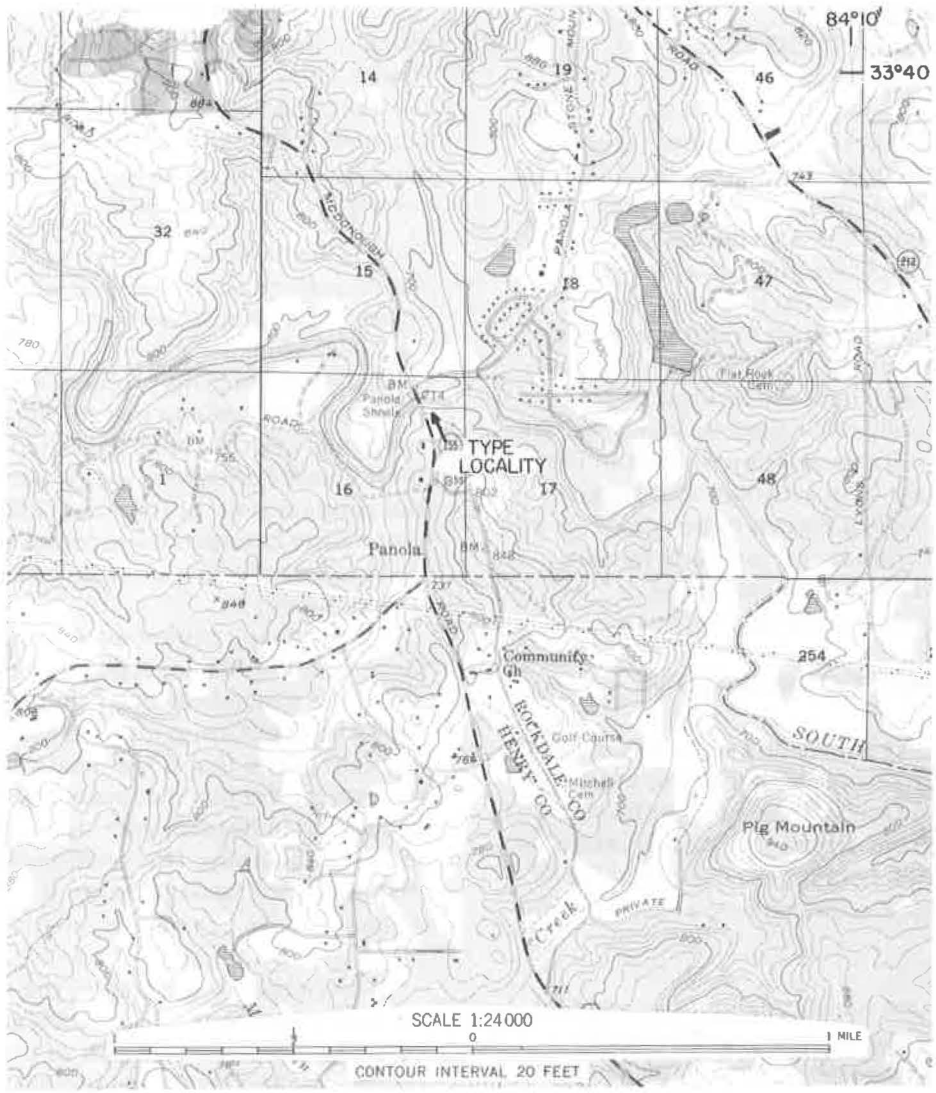

Figure 35. Part of the Redan quadrangle, showing type locality (Panola Shoals) of the Panola Granite and Pig Mountain where the rock is well exposed.

and Snellville Formations. Like the Stone Moutain Granite, its contacts are generally sharp and markedly discordant (fig. 1), although locally its contact is a diffuse zone where the granite is intimately interleaved with granitized country rock. Small xenoliths are locally abundant in the Panola. Concordant radiometric age dates on zircons from the Panola Granite (Higgins and others, unpub. data) indicate that it is about 325 m.y. old, approximately the same age as the Stone Mountain Granite. Geochemical data suggest that the Panola is of crustal derivation and from a very different magma than the Stone Mountain Granite (Atkins and others, 1979).

Pegmatite and aplite dikes

At least three generations of pegmatite and aplite dikes have intruded the rocks of the Atlanta area. The oldest dikes cut the earliest generation of folds (Buck Branch folds of Atkins and Higgins, 1978, 1980), but are folded by the second generation folds (Klondike folds of Atkins and Higgins, 1978, 1980). The two younger sets of dikes cut all fold generations, but one set cuts the other. The dikes are too small and discontinuous to show on the geologic map, and their ages are unknown.

DIABASE DIKES

The rocks of the Atlanta area are cut by northwest-trending dikes of fine-grained, greenish-black to black augite diabase (not shown on fig. 1), part of a swarm of dikes in eastern North America (King, 1971) and around the Atlantic Ocean (May, 1971). The dikes range in width from a few centimeters to about 30 m (100 ft) and in length from a few meters (tens of feet) to more than 5 km (3 mi) in the Atlanta area. They have intruded every rock unit in the area (except for surficial deposits) and may be structurally controlled by joints that are axial planar to the third generation of folds in the area (Elijah Mountain folds of Atkins and Higgins, 1978, 1980). The dikes are known to be Mesozoic in age, probably Late Triassic and (or) Early Jurassic. They set a definitive minimum age to the deformation and metamorphism.

REGIONAL CORRELATIONS

Our reconnaissance shows that some of the units of the Atlanta Group crop out east of the outcrop area of the Lithonia Gneiss, in what is probably another major synform. Rocks that closely resemble those of the Snellville Formation crop out as far southeast as Newton County (Georgia Geol. Survey, 1976).

The most important question about the regional correlations of the Atlanta Group and Snellville Formation is how these units relate to the Sandy Springs Group (Higgins and McConnell, 1978a, 1978b) northwest of the Brevard Zone. Kline (1979) has now mapped unquestionable Sandy Springs units southeast of the Brevard Zone in Gwinnett County, just northeast of the nose of the Newnan-Tucker synform. Kline's work suggests that the Wolf Creek Formation is at least partly correlative with the Powers Ferry Formation of the Sandy Springs Group. If this interpretation is correct, some of the phyllonites in the Wolf Creek probably represent phyllonitized (cataclastic) gneisses. This interpretation would also make the Inman Yard Formation correlative or partly correlative with the Powers Ferry Formation; the lithologies are similar. Most of the Atlanta Group would then be older than most of the Sandy Springs Group (older than the Chattahoochee Palisades Quartzite); the possible unconformity between the Powers Ferry Formation and the rest of the Sandy Springs Group (Higgins, 1966, 1968; Higgins and McConnell, 1978a, 1978b) would be correlative with the possible unconformity beneath the Snellville Formation; and much of the Sandy Springs Group (above the Powers Ferry Formation) would be correlative with the Snellville Formation. Lithologic resemblance between the Snellville and most of the Sandy Springs is strong. Major problems with these correlations, however, are:

(1) If the Snellville and the upper part of the Sandy Springs are correlative, and younger than the Atlanta Group, why are they absent from the major part (including the trough area) of the Newnan-Tucker synform? This problem would seem to be resolved if we assume that the synform is a synformal anticline, but then the Inman Yard and Wolf Creek Formations would have to be some of the younger units of the Atlanta Group, and the correlation between these formations and the Powers Ferry Formation would become highly questionable;

(2) In the Hog Mountain, Ga. quadrangle (U.S. Geol. Survey 7½-min. topographic quadrangle, 1973), the Chattahoochee Palisades Quartzite of the Sandy Springs Group dips southeastward about 45° beneath gneiss that is identical in all respects (except for the fact that both units are more sheared than normal) with the Norcross Gneiss of the Atlanta Group. This relationship indicates either that the Sandy Springs Group is older than the Atlanta Group, or that the Atlanta has been thrust upon the Sandy Springs; and

(3) The absence of some of the more distinctive units of the Atlanta Group, such as the Wahoo Creek Formation, northwest of the Brevard Zone, despite the fact that considerable outcrop areas exist there (Higgins, 1968; Crawford and Medlin, 1974), argues against the proposed correlation.

We tentatively accept the hypothesis that the rocks of the Atlanta Group in the Newnan-Tucker synform are thrust upon the rocks of the Sandy Springs Group along the Brevard Zone and upon imbricate thrusts associated with the zone, and that the synform is probably a large refolded nappe. Further work may show that the Newnan-Tucker synform is really a synformal anticline, rather than a synformal syncline. If this is true, then our stratigraphy would be exactly reversed.

SUMMARY

Regardless of their age and relationships to other rocks of the area, the rocks of the Atlanta Group represent a eugeosynclinal flysh-like sequence at least 6,000 m (20,000 ft) thick, and possibly as much as 18,000 m (60,000 ft) thick. These rocks probably accumulated in a short period of time in a deep-water environment in a rapidly subsiding basin. We suggest that they were then folded and metamorphosed during Taconic orogeny, then uplifted and eroded. As the rocks were being uplifted and thrust continentward, the Soapstone Ridge Complex was thrust into place. Sometime after the Early Ordovician, the Snellville Formation was deposited unconformably upon the Atlanta Group rocks and the Lithonia Gneiss. Subsequently, all of these rocks were deeply buried, remetamorphosed, folded at least four times (Atkins and Higgins, 1978), and intruded by at least two generations of granitic plutons.

Despite this complex geologic history, a recognizable stratigraphy that can be mapped over a large area has been determined in the Piedmont of the Atlanta area.

ACKNOWLEDGEMENTS

Sam M. Pickering, Jr., former State Geologist of Georgia, initiated this project and was a constant inspiration during much of the early phases. We have been helped in the field in different areas by the mapping of J.O. Costello, Stephen Kline, and especially R.E. Dooley. Atkins was assisted in the field by Lisa Joyce. We are grateful for photographic assistance by S.M. Pickering, Jr., and for constructive reviews by S.M. Pickering, Jr., C.W. Cressler, D.J. Milton, J.W. Clarke, G.S. Gohn, and W.H. McLemore. Discussions with colleagues, too numerous to name individually, on informal field trips in the area have greatly helped our interpretations.

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STRATIGRAPHY AND STRUCTURE OF THE PINE MOUNTAIN WINDOW IN GEORGIA AND ALABAMA

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ABSTRACT

Rocks within the Pine Mountain window of the western Georgia and eastern Alabama Piedmont consist of two district groups, a highly variable Grenville basement complex, and an infolded, younger, metasedimentary cover sequence, the Pine Mountain Group. Included within the basement complex are the Jeff Davis "Granite", Woodland Gneiss, Cunningham "Granite", Whatley Mill Gneiss, Wacoochee Gneiss, and unnamed charnockitic units. The Pine Mountain Group is composed of a lithostratigraphically simple sequence consisting of the Sparks Schist, Hollis Quartzite, and Manchester Formation.

The dominant structural features within the Pine Mountain window are two vertically stacked nappes. The structurally higher Thomaston nappe occupies the Thomaston area of Georgia while the second, named herein the Auburn nappe, is dominant within Lee County, Alabama. Both nappes plunge gently to the northeast. The Auburn nappe plunges beneath the Thomaston nappe in eastern Lee County, Alabama, and does not reappear to the northeast. This interpretation suggests that the Pine Mountain window is **not** bounded on the northwest by cataclastically deformed rocks classically assigned to the Towaliga fault, but is bounded further to the northwest by what is currently considered to be a normal fault.

Prior confusion with respect to the stratigraphy of the Pine Mountain Group has resulted from (1) the presence of previously unrecognized inverted sections within the lower limbs of nappes, (2) improper distinction between units comprising the Grenville basement sequence and the Pine Mountain Group proper, (3) previously unrecognized facies variations transverse to the orogenic belt, and (4) the tectonic juxtaposition of dissimilar facies of the Manchester Formation. Available evidence indicates that (1) the Quartzite Member of the Manchester Formation is equivalent to the Hollis Quartzite, (2) the Upper Schist Member of the Manchester Formation is equivalent to the Sparks Schist, (3) only the Lower Schist Member of the Manchester Formation should be considered as Manchester Formation, (4) the Chewacla Marble and Chewacla Schist are facies within the Manchester Formation, and (5) the Sparks Schist and Halawaka Schist are correlative. On the basis of lithologic sequence and cover-basement relationships, rocks of the Pine Mountain Group are tentatively correlated with the Lower to Middle Cambrian cratonic cover of the Valley and Ridge province.

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The Pine Mountain window[1], extending from the Coastal Plain cover in southern Lee County, Alabama, northeastward for about 165 kilometers (km) to central Lamar County, Georgia, exposes parautochthonous rocks of cratonic affinity that underlie allochthonous eugeoclinal rocks of the Inner Piedmont and Uchee belts (figs. 1 and 2). Because of structural complexity, the rocks within the window are inadequately and inconsistently described.

Rocks within the window consist of two distinct groups, a highly variable Grenvillian basement complex (>1 b.y. old), (Odom and others, 1973), which has been given various names, and an infolded, younger metasedimentary cover sequence, the Pine Mountain Group. The Pine Mountain Group contains associated ortho-quartzite, calcareous and aluminous schist, and dolomitic marble, which contrast dramatically with the amphibolites, gneisses, granites, schists and migmatites of the Piedmont allochthon.

It is our purpose to present a coherent stratigraphic section for formations comprising the Pine Mountain Group and to show their continuity and correlative nature as modified by variations in depositional environment, degree of metamorphism, and structural complexity. Furthermore, probable lithostratigraphic correlations will be made with rocks of the Blue Ridge and Valley and Ridge provinces.

The data on which this discussion is based are derived from a review of works referenced herein and our accumulated field notes representing both detailed and reconnaissance mapping within the Pine Mountain window and Valley and Ridge province over the last several years.

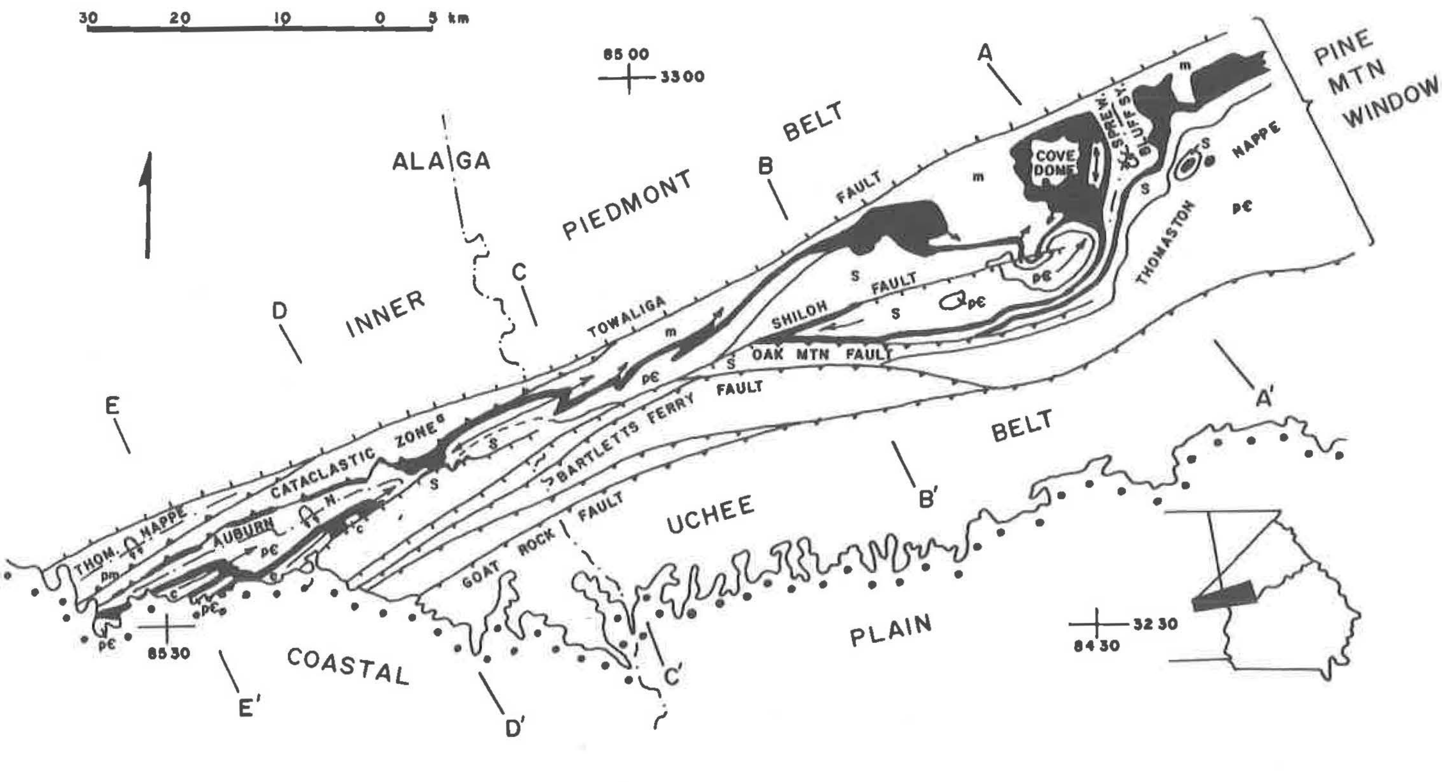

Figure 1. Generalized geologic map of Pine Mountain window. Black - Hollis Quartzite; dots - Cretaceous and younger rocks; pm - Pine Mountain Group undivided; m - Manchester Schist; c - Chewacla schist and marble; s - Sparks Schist; pc - basement rocks undivided; unpatterned - Piedmont allochthon. Faults: sawteeth-thrust faults, teeth on upper plate; bars - normal faults, bars on downthrown block. Sources: Bentley, Neathery and Scott (in press), Schamel and Bauer (1980), Cook (1979), Carrington (unpublished).

[1]Also referred to variously in the literature as the Pine Mountain belt and Pine Mountain block.

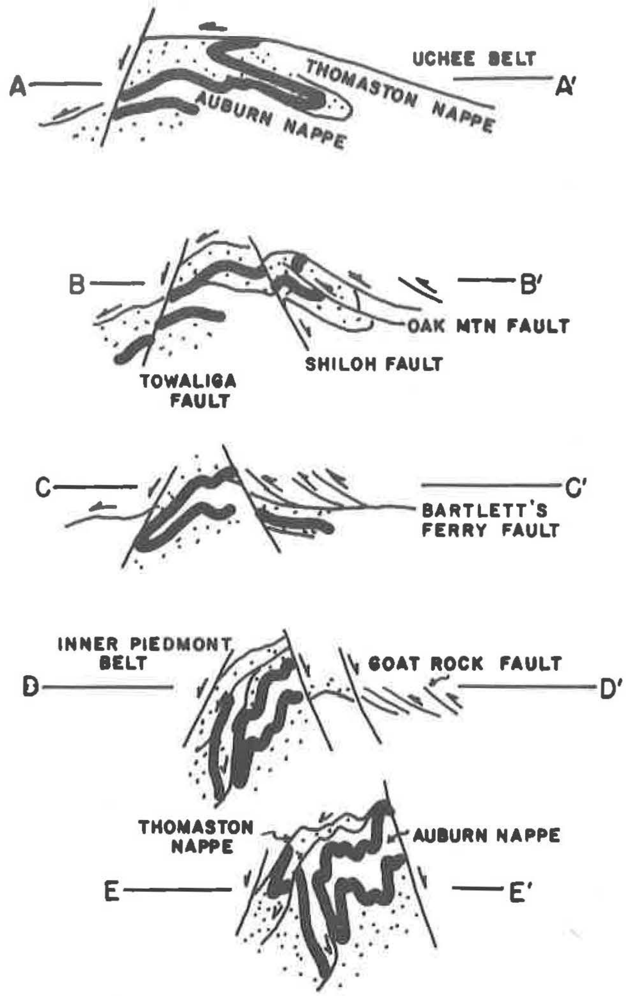

Figure 2. Schematic cross sections through Pine Mountain window. Black- Hollis Quartzite; stippled- Pine Mountain Group. Same scale as figure 1.

INTRODUCTION

Rocks within the Pine Mountain window, including cataclastic rocks, were grouped into the Wacoochee belt by Adams (1933). Later, Crickmay (1952) redefined the Wacoochee belt as bounded by mylonites of the Towaliga and Goat Rock faults. Bentley and Neathery (1970) described the Alabama portion of the Pine Mountain "structural block" as the sequence of rocks that lie between the northwest edge of the Towaliga fault zone and the northwest edge of the Goat Rock fault zone.

Bentley, Neathery, and Scott (in press) provide the most concise description of major lithologic units of the Pine Mountain Group in Alabama. Their interpretation is based on reconnaissance field mapping and tracing of marker units into the section described in Georgia by Crickmay (1935), Hewett and Crickmay (1937) and Clarke (1952). In Alabama the Pine Mountain Group includes the Hollis Quartzite, Chewacla Marble and schist, Manchester Formation and, in our interpretation, the Halawaka Schist. In Georgia the group includes the Sparks Schist, Hollis Quartzite and Manchester Formation.

The Hollis Quartzite was initially described in Alabama by Adams (1926), and is predominantly a metaorthoquartzite that locally contains narrow, discontinuous arkosic zones. Because the Hollis Quartzite has undergone pervasive recrystallization, the resulting fabrics are locally subtle where viewed in outcrop and have been mistakenly identified as primary sedimentary features such as bedding and crossbedding.

The Chewacla Marble (Prouty, 1916) is a poorly exposed dolomite marble, closely associated with the Hollis Quartzite in Lee County, Alabama. The unit does not occur in Georgia and is unknown northeast of the Spring Villa antiform (fig. 3). Associated aluminous, locally graphitic schists generally have been ascribed to the Manchester Formation as originally defined in Georgia by Crickmay (1935).

Pine Mountain Group rocks were first noted in Georgia in the vicinity of Pine Mountain by Galpin (1915). The presence and significance of the Hollis Quartzite in west-central Georgia were described in moderate detail by Adams (1930). Crickmay (1935) defined the Pine Mountain series as consisting of the Hollis Quartzite and the Manchester Formation, an ill-defined sequence of aluminous, locally graphitic muscovite schist and quartzite. An additional aluminous metasedimentary unit, the Sparks Schist, and various granitic units including the Woodland Gneiss and Cunningham Granite, now grouped in the basement complex, were shown to be present in the Warm Springs vicinity by Hewett and Crickmay (1937). Crickmay (1952) included the Sparks Schist and Chewacla Marble (of Alabama) in the Pine Mountain series. Clarke (1952) removed the time significance by applying the name Pine Mountain Group and subdivided the Manchester Formation into three lithostratigraphic units.

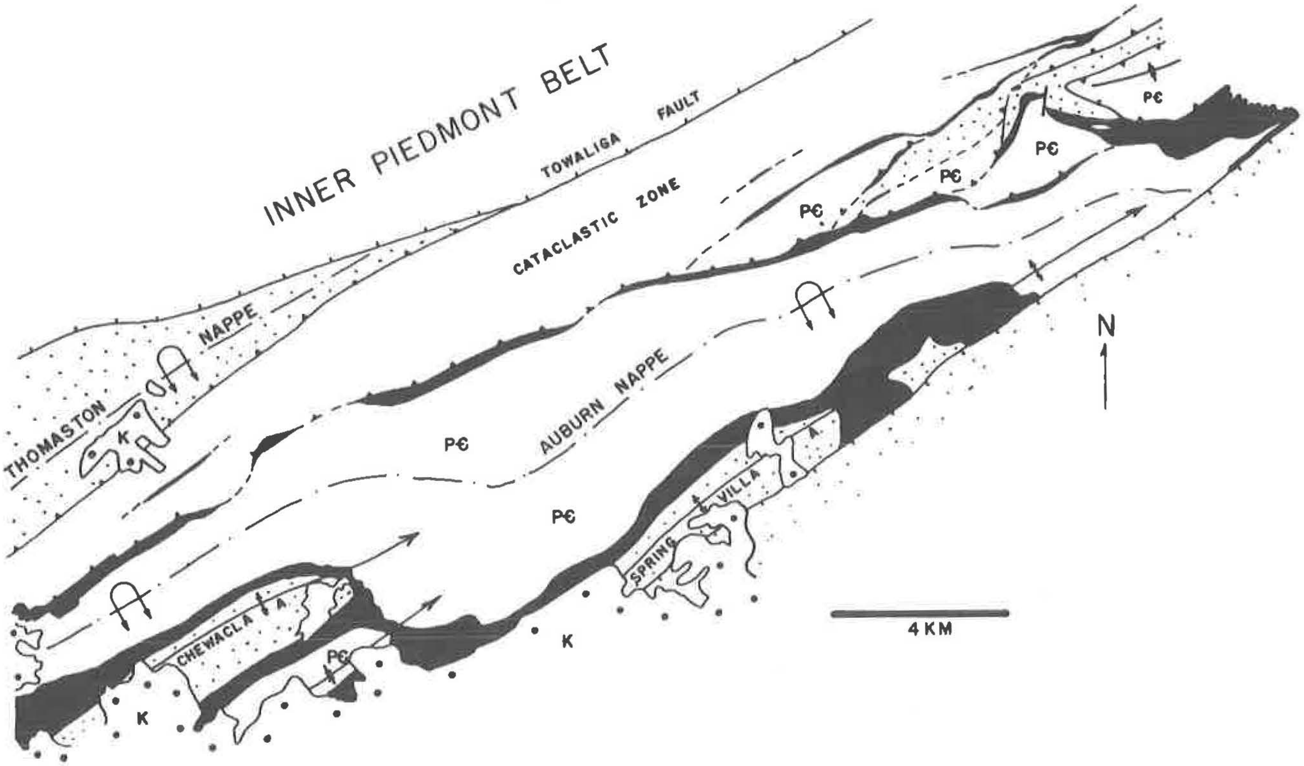

Figure 3. Detailed map of Auburn, Ala. area. Black- Hollis Quartzite; light stipple- Pine Mountain Group; PC- Precambrian rocks undivided; K- Cretaceous rocks. See figure 1 for location.

In Alabama, the Grenvillian basement complex includes a distinctive augen gneiss, the Whatley Mill Gneiss, and a variable schist-gneiss complex, the Wacoochee Gneiss (Bentley, Neathery and Scott, in press). In Georgia, basement rocks include the Woodland Gneiss, Cunningham Granite, and Jeff Davis Granite (Hewett and Crickmay, 1937; Clarke, 1953).

Cataclastic rocks consisting predominantly of prophyroclastic blastomylonite, blastomylonite, mylonite, and siliceous microbreccia have been described within the Pine Mountain structural block by Crickmay (1933), Grant (1967) and Higgins (1971). Recent mapping by Schamel and Bauer (1980), Sears (1980), Bentley and Neathery (1970) and Grant (1967) has somewhat revised knowledge of the general lithostratigraphic distribution and extent of major units, and suggested new relationships within the Pine Mountain window proper as well as with the Inner Piedmont allochthon.

STRATIGRAPHY

A proper understanding of stratigraphy within the Pine Mountain window depends on the (1) interpretation of the structural relationship between rocks ascribed to the basement complex and Pine Mountain Group; (2) evidence that, in many instances, units of the Pine Mountain Group are exposed in the lower limbs of nappes and hence are overturned; and (3) recognition of increased structural complexity and progressive lithologic variation to the southwest as a result of depositional facies changes, increased metamorphic grade, and structural juxtaposition of different sedimentological facies of equivalent rocks. When these factors are considered, the stratigraphy of the belt is resolved into a simpler, more regular sequence than has been interpreted previously.

It now appears certain, based on detailed mapping (Schamel and Bauer, 1980; Sears, 1980) and geochronological investigation (Odom and others, 1973), that felsic gneisses, "granites", augen gneisses and charnockites generally ascribed to the Wacoochee Group throughout the extent of the window represent a variably retrograded and deformed, granulite facies basement complex of Grenville age ($>$1 b.y.). This interpretation has been delayed until now, due to the mineralogical and textural diversity of rock types and widely variable degrees of cataclasis and recrystallization. Specifically, it is now appropriate to collectively group the Jeff Davis "Granite", charnockite series rocks, Woodland Gneiss, Cunningham "Granite", Wacoochee Gneiss, and Whatley Mill Gneiss as Grenvillian basement. This diverse basement complex is unconformably (Clarke, 1952, p. 9) overlain by the younger, stratigraphically coherent metasedimentary sequence of the Pine Mountain Group. This interpretation requires that the aluminous Halawaka Schist, included with Wacoochee belt units in Alabama (Bentley, Neathery and Scott, in press), be ascribed to the Pine Mountain Group.

Within the Lee County, Alabama, portion of the Pine Mountain block, detailed mapping in Chewacla State Park northeastward to the Lake Ogletree area (Cook, 1979), along what is interpreted to be the lower limb of a nappe, clearly demonstrates that an almost complete section of the Pine Mountain Group is preserved in what is herein named the Chewacla antiform (fig. 3). An equivalent section is exposed further to the northeast in a similar *en echelon* structure herein named the Spring Villa antiform (fig. 3). These folds are subsidiary components of the Pine Mountain antiform. The stratigraphic succession found in these areas consists of 150 to 250 meters (m) of thick- to thin-"bedded" Hollis Quartzite in fault contact with and structurally underlying (stratigraphically overlying) the Whatley Mill Gneiss of the Grenville basement. Structurally below (stratigraphically above) the Hollis Quartzite and in gradational contact with it is a locally calcareous chloritic schist here informally termed the Chewacla schist. This unit is absent intermittently along strike due to tectonic attenuation and/or facies changes. Its apparent thickness ranges up to approximately 300 m. It is characterized by local dolomitic horizons and grades structurally downward (stratigraphically upward) into the Chewacla Marble. Maximum apparent thickness of the Chewacla Marble is in the core of the Chewacla antiform in Lee County, Alabama, and is approximately 300 m. Extreme variability in thickness is the apparent result of mobility of the ductile marble during the tectonic development of the block.

By adhering to this stratigraphic sequence, and recognizing facies changes within the Chewacla marble-schist series, satisfactory lithostratigraphic correlation can be made with rocks to the northeast along the extent of the Pine Mountain block, and a proper explanation of the complex structural framework may be derived as shown in the section on structural geology.

The detailed relationship between lithostratigraphic units and the dated Grenville basement implies that part of the Manchester Formation as defined by Clarke (1952) in the Thomaston area is overturned and correlative with units observed in the Warm Springs, Ga. area and in Alabama (Schamel and Bauer, 1980). The "Upper Schist Member" as originally described is in fault contact with various units of the structurally overlying Grenville basement. The "Upper Schist Member" is stratigraphically overlain by the "Quartzite Member of the Manchester Formation" and ultimately by the "Lower Schist Member" (Clarke, 1952). Inherent in this interpretation is the correlation of the "Upper Schist Member" of the Manchester Formation of Clarke (1952) with the Sparks Schist of Hewett and Crickmay (1937). This makes the "Quartzite Member of the Manchester Formation" (Clarke, 1952) equivalent to the Hollis Quartzite. The "Lower Schist Member" of Clarke then becomes the stratigraphic equivalent of the Chewacla marble-schist sequence of Lee County, Alabama, (fig. 4). Ambiguities between the geologic map of the Warm Springs Quadrangle (Hewett and Crickmay, 1937) and the Thomaston Quadrangle (Clarke, 1952) are thus resolved with the Manchester Formation of Hewett and Crickmay (1937) being equivalent to the "Lower Schist Member" of Clarke (1952).

This stratigraphic interpretation results in the inescapable conclusion that the lithologically equivalent Sparks Schist of Georgia and the Halawaka Schist of Alabama are, in fact, the same formation. The absence of this formation within the Chewacla and Spring Villa antiforms and its occurrence to the northwest of what formerly has been thought to be the leading edge of the Towaliga fault are due to structural transposition of facies as illustrated in figures 2 and 5.

Based on the preceding stratigraphic interpretation, formational thickness between the Georgia

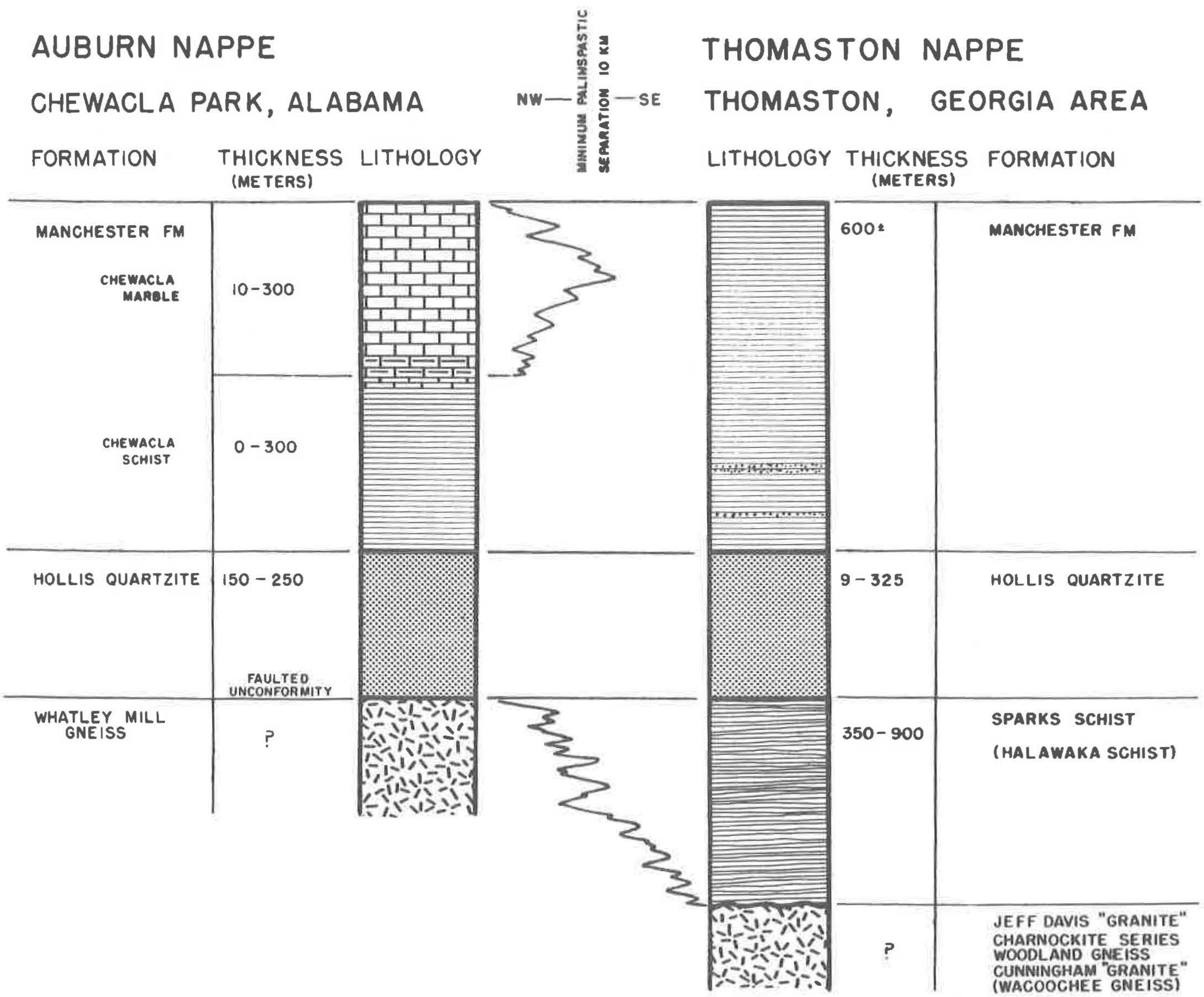

Figure 4. Lithostratigraphic correlation between the lower limbs of the Auburn and Thomaston nappes.

and Alabama segments of the Pine Mountain window are consistent (fig. 3). The Hollis Quartzite generally ranges between 100 and 250 m in thickness within Lee County, Alabama. Hollis Quartzite in the Thomaston-Warm Springs, Ga., vicinities has been shown by Clarke (1952), Hewett and Crickmay (1937), and Schamel and Bauer (1980) to range from approximately 9 to 335 m in thickness, the most frequently given figures being between 90 and 250 m. In consideration of the fact that only the "Lower Schist Member" of Clarke (1952) may now be considered the Manchester Formation, the apparent average thickness of approximately 600 m is consistent with the measured apparent thickness of the equivalent Chewacla marble-schist sequence of 630 m.

STRUCTURAL GEOLOGY

The rocks within the Pine Mountain window are deformed into two major northwest-vergent, isoclinal, recumbent nappes, cored by Grenville basement gneisses and outlined by the supracrustal metasediments of the Pine Mountain Group (figs. 1 and 2). The nappes are segmented and truncated by ductile shear zones related to emplacement of the Piedmont allochthon.

The Thomaston nappe (Schamel and Bauer, 1980) is the structurally higher nappe. Its axial surface occupies the region around Thomaston, Ga., and its hinge underlies Indian Cave and Bull Trail Mountains. The upper limb is cut out by the Bartlett's Ferry and

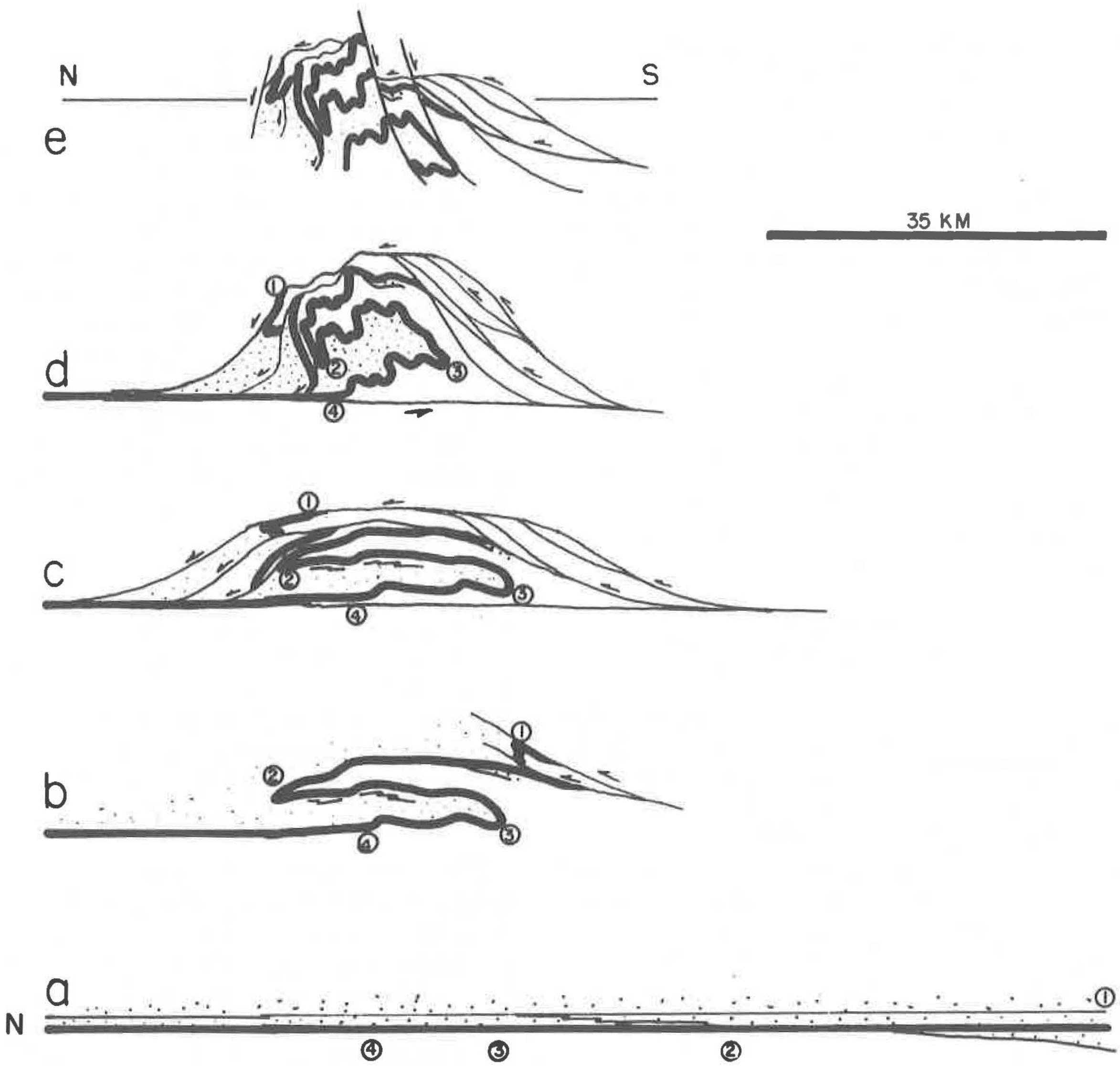

Figure 5. Palinspastic restoration of rocks exposed in Pine Mountain window.

associated faults. The axial surface of the nappe is broadly folded around the Pine Mountain antiform, which is the principal megascopic structure of the Pine Mountain window.

The Thomaston nappe is underlain by the highly attenuated, isoclinal Sprewell Bluff syncline (fig. 1), which is cored by schist of the Manchester Formation. The axial surface of the Sprewell Bluff syncline occupies the valley between Bull Trail and Pine Mountains, but is faulted out farther west by the Oak Mountain fault, which is a possible splay of the Bartlett's Ferry fault.

The lower limb of the Sprewell Bluff syncline is broadly warped into a series of domes and antiforms with curvilinear axial traces. The most conspicuous dome forms "The Cove", a topographic basin drained by the Flint River. The Hollis Quartzite of the lower limb of the syncline supports the impressive ridges of Pine and Oak Mountains, whereas less resistant rocks of the underlying Sparks Schist and basement complex occupy topographically low areas in the cores of the upwarps.

The Hollis Quartzite is the key to the structural geometry of the Pine Mountain window. It can be traced nearly continuously in the lower limb of the Sprewell Bluff syncline for 110 km, from the vicinity of Woodbury, Ga., to the Coastal Plain overlap in Alabama. In Alabama the quartzite is generally more steeply dipping than in Georgia, and hence supports less imposing ridges.

Southeast of Auburn, Ala., the Hollis Quartzite outlines the Auburn nappe, which plunges gently to the east-northeast beneath the Thomaston nappe. The axial surface of the Auburn nappe has been tightly refolded into the northwest-vergent Chewacla and Spring Villa antiforms (figs. 1 and 3). In the hinge area of the nappe the axial surface is vertical or dips steeply to the southeast. The hinge itself either underlies Cretaceous rocks of the Coastal Plain or has been faulted out by thrust faults in the axial surface.

To the north, the Auburn nappe contacts a thick belt of steeply dipping cataclastic rocks classically assigned to the Towaliga fault zone. Preliminary mapping in this belt has outlined several repetitions of the north-facing sequence of gneiss-quartzite-schist, in a pattern interpreted as a complex of imbricated fault slices.

North of the cataclastic belt is a large synform containing schists and thin quartzites assigned by Bentley, Neathery, and Scott (in press) to the Pine Mountain Group. This synform is herein interpreted to be the refolded hinge of the Thomaston nappe (fig. 3) or a related parasitic fold. It is proposed that the axial surface of the Sprewell Bluff syncline is faulted out by the Oak Mountain fault (fig. 2), and that the Thomaston nappe has been thrust northwestward over the Auburn nappe, together with imbricated slices of the upright limb of the Auburn nappe (fig. 5). Therefore, the cataclastic zone north of the Auburn nappe is herein considered to be the Oak Mountain fault zone rather than the Towaliga fault zone.

Significant differences in the degree of tectonism occur along the strike of the Pine Mountain window. These differences cannot be attributed to variations in material behavior with tectonic level, although deeper levels are exposed in the Auburn area than in the Thomaston area. The fundamental differences are in the degree of cataclasis and the tightness of the later phase of folding.

In the Thomaston area, the Pine Mountain Group has a penetrative, layer-parallel schistosity that is parallel to the axial surfaces of the isoclinal folds. Basement rocks range from unfoliated charnockitic granite to well-foliated gneisses in the core of the Thomaston nappe (Schamel and Bauer, 1980). Although broadly warped, the schistosity is not generally disrupted by cataclasis in much of the Georgia segment of the window. Lithostratigraphic units are coherent and continuous and lack abrupt thickness variations attributable to tectonic attenuation. About 10-15 km east of the Chattahoochee River, the schistosity is tightly folded in about the same region in which the well-known blastomylonite zones of the Goat Rock, Barlett's Ferry and "Towaliga" (Oak Mountain) faults become prominent. West of this area, virtually all rocks of the Pine Mountain window between the Halawaka-Wacoochee belt and the Thomaston nappe at Auburn are cataclastically deformed to some degree. The cataclastic schistosity parallels compositional layering and major lithostratigraphic boundaries, and is itself deformed into tight to isoclinal, northwest-vergent folds. Lithostratigraphic units range markedly in thickness and continuity, and, particularly north of the Auburn nappe, are lenticular in map pattern and deformed by an anastomosing system of through-going shear surfaces.

In Alabama, virtually no pristine textures are preserved in the basement rocks, which range from augen gneisses to blastomylonites. The Hollis Quartzite is nearly everywhere a quartz-mylonite, and schists are generally disrupted. Extremely attenuated, rootless, isoclinal folds of quartz stringers and compositional bands are present in the Chewacla Marble.

These deformational features are interpreted to have resulted from the splaying-off of a major shear zone from the base of the Piedmont allochthon into the underlying rocks of the Pine Mountain window. Such a subthrust imbricate fault is compatible with current interpretations of the origin of the Brevard Zone as a thrust fault which ruptures the Piedmont allochthon (Cook and others, 1979; Hatcher, 1971).

Schamel and Bauer (1980) recognized the significance of post-metamorphic, high-angle normal faults in the Warm Springs area. The Bartlett's Ferry cataclastic zone is down-dropped along the Shiloh Fault against rocks of the Pine Mountain window. A normal fault is herein inferred to cut off the axial surface of the Auburn nappe and juxtapose rocks of the upright limb of the Thomaston nappe (Wacoochee-Halawaka = Woodland-Sparks) against Hollis of the inverted limb of the Auburn nappe.

The Towaliga fault at Towaliga Creek has been shown by Schamel and Bauer (1980) to be a post-metamorphic normal fault along which rocks of the Inner Piedmont are dropped against the Pine Mountain block. Following Schamel and Bauer (1980) we favor restricting the name "Towaliga Fault" to that late normal fault, and favor the designation "Bartlett's

Ferry Fault" for the decollement underlying the Piedmont allochthon. Further mapping is needed to determine whether the northern boundary of the Pine Mountain window in Alabama is a late normal fault or a thrust fault lying in the schistosity, but preliminary observations suggest that it is a normal fault.

The Pine Mountain antiform may have formed as a manifestation of thickening of the parautochthon by the stacking of nappes and imbricate thrust sheets (fig. 5). Consequently, the exposed culmination of the antiform in Alabama may correspond to the greatest tectonic overlap.

REGIONAL STRATIGRAPHIC RELATIONSHIPS

The earliest attempt to place the Pine Mountain Group into a regional stratigraphic framework was that of Clarke (1952),who proposed that the cover rocks of the Pine Mountain "belt" might be correlative with the lower Paleozoic sequence of the Valley and Ridge province to the northwest. Clarke based his assumption on the association of the Hollis Quartzite with the Chewacla Marble, which he believed to be lithologically similar to lower Paleozoic dolomites — we presume the Shady Dolomite or some member of the Knox Group. [It is interesting to note that implicit in Clarke's proposal is the concept of the Blue Ridge and Inner Peidmont as a major crystalline overthrust, a conclusion apparently justified by recent geophysical data (for example, Cook and others, 1979)].

We would like to emphasize that, in the absence of fossils or other unequivocal evidence which could establish the age and stratigraphic affinities of the Pine Mountain Group, any regional correlations are speculative. However, correlations can be proposed based on lithologic type and sequence, inferred protolith, known age relationships, and geometric consistency with possible models of southern Appalachian orogenesis.

Provided that the Pine Mountain Group is indeed directly correlative with some other sequence within the southeastern United States, several alternatives are possible. These include correlation with one or more of the following:

(1) some part of the Paleozoic sequence of the Valley and Ridge;
(2) the immediate cover sequence over the Corbin Gneiss of northwest Georgia;
(3) the rocks of the Jackson's Gap Group in the Brevard Zone;
(4) the Murphy Marble belt; or
(5) the middle- to upper-Paleozoic rocks of the Suwanee Basin.

Although superficial similarities exist, direct correlation with the latter two are improbable because of major differences in lithologic associations. The carbonates of the Murphy belt stratigraphically overlie an extremely thick Precambrian clastic sequence lithologically dissimilar to the much thinner Sparks-Hollis sequence. Correlation with the Suwanee Basin sequence is contraindicated by absence of carbonates in the Suwanee Basin, absence of rhyolitic volcanics in the Pine Mountain belt, and cover-basement relationships — the Pine Mountain Group unconformably overlies billion-year old Grenville basement (Odom and others, 1973), whereas the Suwanee clastics overlie much younger (527-634 m.y.) basement (Bass, 1969) in either conformable (Barnett, 1975) or thrust fault (Arden, 1974) contact.

In their interpretation of the Inner Piedmont as a nappe, Bentley and Neathery (1970) suggested that the Jackson's Gap and Pine Mountain groups were correlative, based both on lithologic similarity and a map pattern which indicates that the Jackson's Gap lithologies may curve around the southwestern terminus of a synformal Inner Piedmont and pass into the Pine Mountain Group outcrop belt. More recent mapping within the Alabama Piedmont (Charles C. Wielchowsky, personal commun.) indicates that individual units within the Jackson's Gap Group are oriented obliquely to the strike of the Brevard, traversing the Brevard from east to west, and truncated by faults at each boundary of the Brevard zone. The Brevard zone is used in the sense of a transport zone, which includes cataclastic rocks and associated stratigraphic units. Graded bedding indicates that stratigraphic "up" is to the south, and that the boundary faults of the Brevard cut up-section to the southwest. Stratigraphically, the Jackson's Gap consists of locally graphitic sericite-quartz phyllites grading upward into metaorthoquartzites and metaconglomerates. Weilchowsky has noted (personal commun.) that the lithologies and succession are similar to the Sparks-Hollis sequence, and speculates that the Jackson's Gap lithologies might represent a detached nappe of Pine Mountain Group rocks. This concept is geometrically compatible with interpretation of the Inner Piedmont as a major overthrust, with the Jackson's Gap sequence representing a nappe structurally below the Inner Piedmont and structurally above or equivalent to the Thomaston nappe (fig. 6).

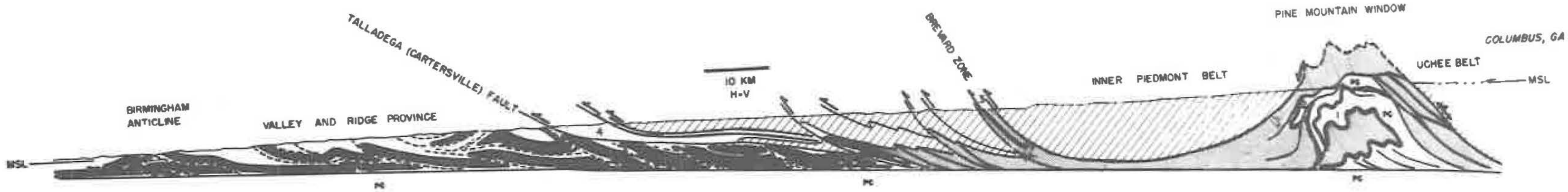

Figure 6. Balanced cross section of the Appalachian orogen, Birmingham, Ala. to Columbus, Ga. Normal displacement on the Towaliga or Shiloh faults restored to illustrate original thrust relationships. Explanation of symbols: 1 - Auburn nappe; 2 -Thomaston nappe; 3 - Jackson Gap nappe; 4 - structural position of Corbin - Pine Log in northwest Georgia; pє- Grenville basement; stipple- transport zone involving sheared and isoclinally folded Upper Proterozoic and Lower Paleozoic rocks; broad black band-Knox Group in Valley and Ridge and subcropping thrust belt; narrow black band- Weisner Formation, Jackson Gap quartzites, and Hollis Quartzite; diagonal rule- Piedmont allochthon. Modified from Roeder and Gilbert (unpublished) and Roeder and others. (1978) by addition of Pine Mountain belt details (Sears, this report).

On the basis of the criteria described, correlation of the Pine Mountain Group with lowermost Paleozoic sediments of the Valley and Ridge seems viable. The gross lithologic sequence in the easternmost Valley and Ridge thrust sheets of Georgia and Alabama includes an Eocambrian (?) slate and quartzite sequence, the Weisner Formation, succeeded by the Lower Cambrian Shady Dolomite, and originally resting unconformably upon Grenville basement. The Pinelog Formation[1] metaclastics unconformably overlying the billion-year-old Corbin Gneiss[1] (Odom and others, 1973) may also represent a part of the same sequence as earlier proposed by Kesler (1950). Our interpretation differs from Kesler's in that we consider metasedimentary remnants as infolded Lower Paleozoic lithologies (Weisner-Chilhouse-Rome) and their cataclastic equivalents. Lithologies within the Weisner Formation are areally diverse, being dominated in some areas by locally feldspathic conglomeratic orthoquartzites, and in other areas by interbedded quartzites, slates, and arenaceous slates. In areas where the Hollis Quartzite is relatively less tectonized, it consists of locally conglomerate orthoquartzites, with greater or lesser amounts of nondescript quartz-muscovite schists which exhibit compositional banding that may reflect bedding of the protolith. Thus, regional stratigraphic relationships and lithologies within the Hollis permit (but do not prove) correlation with the similar Weisner. This correlation is consistent with interpretation of the Inner Piedmont and Blue Ridge as a major overthrust (Cook and others, 1979).

In view of the above criteria, we propose that the Pine Mountain Group, a part of the Pinelog Formation, Jackson's Gap Group, and the Weisner-Shady sequence of the Valley and Ridge province all represent parts of an Eocambrian to Lower Cambrian shelf sequence, dissected by Late Paleozoic thrusting. Figure 6 is a schematic representation of an unpublished cross section of the southernmost Appalachians (Georgia-Alabama) described by Dietrich Roeder and O.E. Gilbert, Jr. (oral presentation at a Penrose Conference on "Chronology of thrusting in orogenic terranes", May 1978) and by Roeder and others (1978).

CONCLUSIONS AND RECOMMENDATIONS

The following section summarizes conclusions based on the interpretations presented herein, and strongly urges that they be considered in the formulation of future working hypotheses for continued research within the Pine Mountain window. Furthermore, these conclusions necessarily emphasize gaps and weaknesses in our geologic knowledge and consequently result in the accompanying recommendations.

All major quartzites within the Pine Mountain block are, in all probability, the Hollis Quartzite. This conclusion and the relationship of Pine Mountain Group rocks with the Grenville basement require that the lithostratigraphy be resolved into a simple section consisting of the Sparks Schist, typically in contact with Grenville basement and correlative with the Halawaka Schist (the name Halawaka should be dropped in favor of the earlier-described Sparks Schist). The Sparks is overlain by the Hollis Quartzite, which is in turn overlain by the Manchester Formation. The Manchester Formation is now defined as equivalent to only the "Lower Schist Member" of Clarke (1952) and is correlative with the Chewacla marble-schist sequence of Lee County, Alabama. The Chewacla Marble and Chewacla schist should be given member status within the Manchester Formation.

Lithologic changes within the Manchester Formation are due to facies variations transverse to the orogenic belt. Proximity of abrupt contacts between carbonate (Chewacla Marble member) and aluminous pelite facies (Manchester Schist) of the Manchester Formation is simply the result of the tectonic juxtaposition of the exposed lower limb of the Thomaston nappe or upper limb of the Auburn nappe with the partially eroded lower limb of the Auburn nappe. Care must be taken in the interpretation of stratigraphic thickness and positions due to the local dominance of overturned sections, the involvement of all rocks within the window in several episodes of folding and faulting, and thickening and attenuation of units within the noses and limbs of major structures.

An erosional surface was developed upon granitic rocks comprising the Grenville basement over which the now metasedimentary Pine Mountain Group was deposited. Both the Pine Mountain Group and the Grenville basement sequence have been tectonically deformed into the present nappe-dominated framework. It is highly probable that basement units within the Pine Mountain block were at one time uniformly metamorphosed to granulite facies, but that these units have been subsequently retrograded during prograde

[1]The terms Pinelog Formation and Corbin Gneiss Complex are defined by Costello and McConnell (1981), part B of this volume.

metamorphism of the rocks of the window along the general southwest trend so that true granulites are currently known only in the Thomaston and Warm Springs area, whereas once similar units in the Alabama portion of the block now reflect extensive recrystallization of sillimanite grade. In addition, the basement complex has been further modified during a related major episode of cataclastic deformation and recrystallization.

The dominant structural features within the Pine Mountain window are two vertically stacked recumbent nappes. The upper one occupies the Thomaston area of Georgia and is called the Thomaston nappe (Schamel and Bauer, 1980) while the second, named herein the Auburn nappe, is dominant within Lee County, Alabama. Both nappes plunge gently to the northeast. The Auburn nappe plunges beneath the Thomaston nappe in eastern Lee County and does not reappear to the northeast. Axial surfaces are sheared and refolded in a progressively less complex manner to the northeast.

The Pine Mountain window is bounded by cataclastic rocks of the Barlett's Ferry and Goat Rock faults on the southwest, but is **not** bounded on the northwest by the cataclastic zones that are classically considered to be the Towaliga fault. Instead, rocks of the Pine Mountain Group are bounded on the northwest by what is interpreted to be a normal fault that parallels the northermost zone of blastomylonites generally attributed to the Towaliga fault. Thus, the true Towaliga fault lies up to 2 km to the northwest of the northernmost blastomylonites. This normal fault (Towaliga) in Lee County, Alabama, appears to truncate the upright limb of a remnant of the Thomaston nappe.

Cataclastic zones, dominated by blastomylonites and porphyroclastic blastomylonites, are extensively developed along the northwestern portion of the block, but in Lee County, Alabama, they are confined only to rocks of the Auburn nappe. This cataclasis is wholly penetrative and appears to be subsequent to or late in the development of the nappe-dominated tectonic framework. The true Towaliga fault is herein considered to be the dominant normal fault bounding the Pine Mountain block on the northwest rather than the northernmost conspicuous zone of cataclasis.

The preceding conclusions make it wholly appropriate to formally consider the Pine Mountain structural block as a window that has been further complicated by subsequent normal faulting. It is therefore recommended that future work refer to only the Pine Mountain window and that the descriptive terms "block" and "belt" be discarded.

Tentative correlation with lithostratigraphically similar sequences suggests that the Pine Mountain Group, Pinelog Formation, Jackson's Gap Group (Brevard Zone) and the Weisner-Shady sequence may all represent parts of an Eocambrian to lower Cambrian shelf sequence that has been dissected by late Paleozoic thrusting.

A number of questions remain unresolved. Detailed petrography is almost entirely lacking for rocks constituting the Pine Mountain Group. Petrographic analysis would greatly contribute toward the complete understanding of the provenance of the Hollis Quartzite and associated Manchester Formation. Furthermore, the determination of bulk chemistry within the Manchester Formation coupled with palinspastic modeling of the Pine Mountain Group could define the true extent of facies changes within the Chewacla marble-schist and pelite sequence. A detailed investigation of the metamorphic history of both the Pine Mountain Group and underlying basement rocks is desirable. It is conceivable that remnants of pristine basement may be preserved within the southwestern portion of the window and it may be possible to determine pre-Caledonian features of the Grenville complex.

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STRATIGRAPHY OF THE AREA AROUND THE AUSTELL-FROLONA ANTIFORM; WEST-CENTRAL GEORGIA

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ABSTRACT

The structural and lithologic complexity of rocks in northwestern Georgia between the Brevard fault zone and the Allatoona-Hayesville fault has hindered development or detailed stratigraphic sequences. Only within the last twelve (12) years have detailed stratigraphic sequences been proposed in this area; however,these sequences were based on the premise that only one major folding event has deformed the rocks in western Georgia. Detailed investigations now show that at least four major folding events have affected the rocks in this area and that second generation folds are responsible, to a large extent, for the present outcrop patterns.

We present a detailed stratigraphy for a small part of the northern Piedmont west of Atlanta using multiple deformation as the basis for our interpretation. This area includes the northeastern terminus of the Austell-Frolona antiform and the Villa Rica antiform. We believe that the Austell-Frolona represents an antiformal syncline with the oldest rocks in this area exposed along its northwestern limb, in the Villa Rica antiform. Rocks in the Villa Rica antiform are primarily metavolcanic in origin and are herein termed the Mud Creek Formation. Stratigraphically overlying these metavolcanic rocks, in the Austell-Frolona antiform, are the predominantly metasedimentary rocks of the Andy Mountain Formation and the Bill Arp Formation. These formations have been intruded by a large mass of quartz monzonite termed the Austell Gneiss.

All of the above formations lie on the overturned limb of a refolded first generation (F_1) fold. Therefore, rocks that lie in the core of the Austell-Frolona antiform in this area and appear to be the oldest rocks present are actually the youngest units of our stratigraphic sequence.

INTRODUCTION

The structural and lithologic complexity of rocks between the Brevard fault zone and the Allatoona-Hayesville fault in northwestern Georgia has hindered stratigraphic interpretation and, until recently, rocks have been placed in large, broad-based groups (i.e., Ashland and Wedowee). Crawford and Medlin (1970) showed that these large rock groupings were not valid in the Piedmont north of the Brevard zone, but it was only in the last 12 years that they and other authors (Higgins, 1966, 1968; Crawford and Medlin, 1970, 1973, 1974; and Medlin and Crawford, 1973) began to develop detailed stratigraphic sequences in this area. These first detailed stratigraphic sequences appear to be, in general, based on the assumption of only one major folding event. Recent workers have shown that at least four (McConnell and Costello, 1980), and in some places six, folding events (Hatcher, 1977) have affected the rocks of the northern Piedmont. It has also been shown that second-generation folds are largely responsible for the outcrop patterns present in this same area (McConnell and Abrams, 1978; R.D. Hatcher, written commun., 1978). The best example of this is the refolded Austell Gneiss in the nose of the Austell-Frolona antiform. There, S_1 foliation in the Austell-Gneiss as defined by the alignment of minerals (i.e., biotite and microcline) bends around the nose of the second generation fold. With these factors in mind, it is possible that stratigraphic sequences based on the assumption of only one major folding event could be inverted.

This report presents a stratigraphic sequence for a small part of the northern Piedmont in and around the Austell-Frolona antiform (Austell-Frolona anticlinorium of Crawford and Medlin, 1973) (fig. 1).

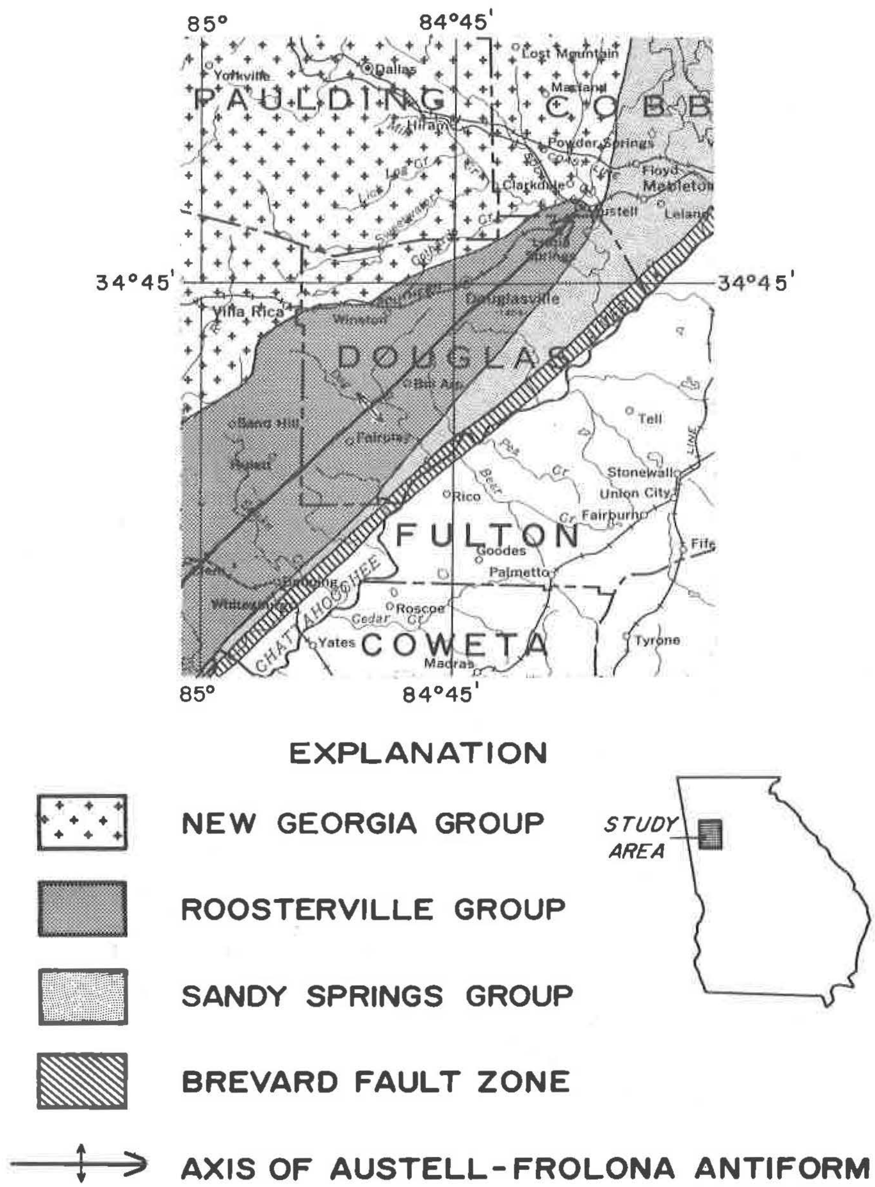


Figure 1. Boundaries of the New Georgia and Roosterville groups.

Initial work on the stratigraphy of this area was begun by Crawford and Medlin (1970, 1971, 1973 and 1974). We intend to revise and expand on their stratigraphy with multiple deformation as a major consideration in our interpretation. Although this report deals mainly with the rocks in and northwest of the Austell-Frolona antiform, a summary report on the stratigraphy and structure of the entire northern Piedmont is in progress.

GENERAL STRATIGRAPHY

Rocks between the Brevard fault zone and the Allatoona-Hayesville fault in western Georgia have been grouped into three major rock groups (McConnell and Costello, 1980); the Sandy Springs Group (Higgins and McConnell, 1978), the Dallas group, and the Roosterville group. McConnell and Costello (1980) informally introduced the term Roosterville group and suggested probable equivalence with portions of the Sandy Springs Group. While our work supports this interpretation, further work is necessary to confirm it. The informal term Roosterville group is therefore retained in this paper. (fig. 1). We are herein formally substituting the term New Georgia Group for the informal Dallas group of McConnell and Costello (1980) to prevent possible confusion with the better known geographic locality of Dallas, Tex. The Roosterville group and the New Georgia Group represent redefinitions of rocks formerly included in the variously defined Ashland and Wedowee and also in the numerical classifications of Crawford and Medlin (1973). Rocks of the New Georgia Group represent an interlayered sequence of metamorphosed mafic and felsic volcanic and plutonic rocks with a small component of metasedimentary rocks. In contrast, the Roosterville group is composed primarily of metasedimentary rocks that appear to resemble rocks of the Sandy Springs Group.

In this report, we define those rocks near the boundary between the New Georgia and Roosterville groups. Specifically, the rocks included are those in and northwest of the Austell-Frolona antiform, near the antiform's northeastern terminus (fig. 2). McConnell and Costello (1980) placed the boundary between the Roosterville and New Georgia groups parallel to the northwestern limb of the Austell-Frolona antiform, but placed rocks of dacitic (i.e., the Villa Rica Gneiss) composition within the Roosterville group. We interpret these dacitic rocks as felsic volcanics or possibly hypabyssal intrusives and, therefore, place them in the New Georgia Group. The boundary between the New Georgia and Roosterville groups is still parallel to the northwestern limb of the Austell-Frolona antiform, but now rock sequences of predominantly sedimentary origin (Roosterville group) on the southeast are separated from rocks of predominantly volcanic and plutonic origin (New Georgia Group) on the northwest (fig. 1). This boundary is somewhat arbitrary as a gradational relationship exists between the metavolcanics of the New Georgia Group and the metasediments of the Roosterville group.

STRUCTURE

Rocks between the Brevard fault zone and the Allatoona-Hayesville fault have been affected by at least four folding events. First generation (F_1) folding is characterized by northeast trending, isoclinal folds that are overturned to the northwest. These folds occurred coincidentally with amphibolite facies metamorphism and developed an axial planar schistosity (S_1), now expressed as the regional foliation. F_2 folds fold the S_1 schistosity and are largely responsible for outcrop patterns. This is particularly evident at the northeastern terminus of the Austell-Frolona antiform (F_2) where S_1 foliations in the Austell Gneiss and Bill Arp Formation (The Union Grove Church schist of Crawford and Medlin, 1974) bend around the nose of the fold (fig. 3). F_2 folds are upright to slightly overturned to the northwest and are generally coaxial, but not coplaner, with F_1 folds. Axial planar schistosity is only developed in the hinges of F_2 folds.

Post F_2 folding events do not maintain a consistent orientation and style throughout the entire northern Piedmont. In general, the orientation and intensity of the later fold events depend on the location. In the area of this report, F_3 folds trend north-northeast and are upright to slightly overturned to the northwest. F_4 folds are generally broad, open warps that trend to the northwest and plunge moderately. Where these later folds are well-developed, particularly on the northwestern flank of the Austell-Frolona antiform, their superposition on earlier structures produces conspicuous interference patterns (fig. 2).

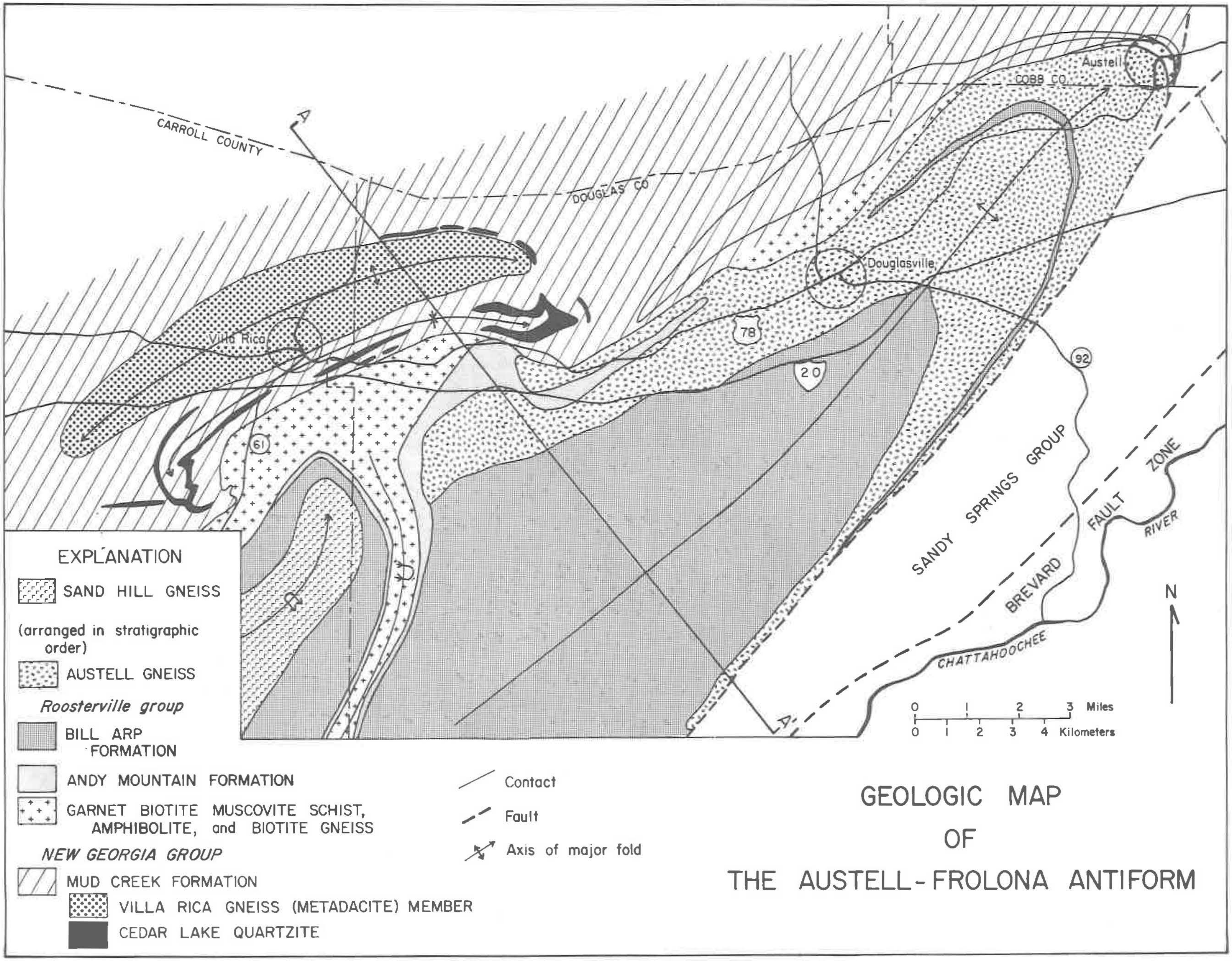
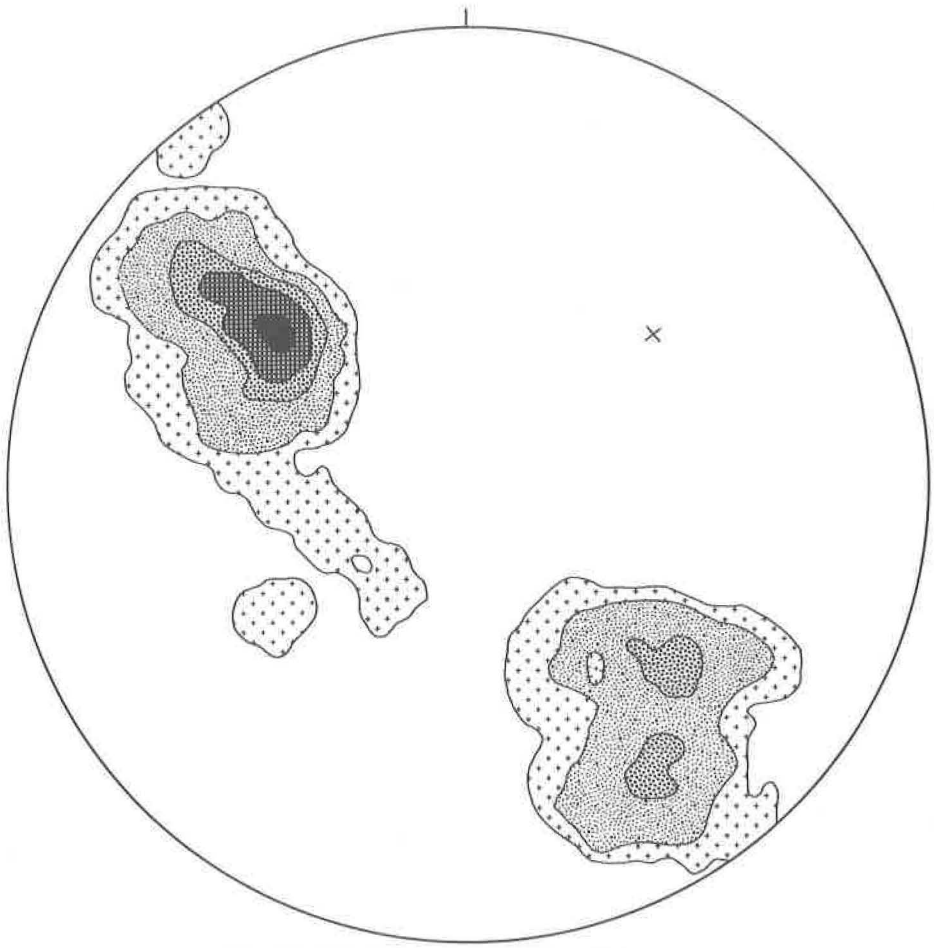


Figure 2. Geologic map of the Austell-Frolona and Villa Rica antiforms.



STEREO PLOT OF POLES TO S_1 FOLIATIONS
AUSTELL GNEISS AT THE NOSE OF THE AUSTELL-FROLONA ANTIFORM
SHOWING DEFORMATION BY F_2 FOLDS

Figure 3. Poles to foliation in the Austell Gneiss. *= pole to the plane of the poles or axis of F_2 fold.

Within the area of this report, structure is dominated by the Austell-Frolona antiform, a regional structure which extends from Austell, Ga. to Roanoke, Ala. (Medlin and Crawford, 1973). Throughout most of its length, the Austell-Frolona antiform is overturned to the northwest, but near its northeastern terminus, the structure becomes upright and plunges to the northeast (Medlin and Crawford, 1973; Crawford and Medlin, 1973, 1974). The Austell Gneiss lies in the nose of the antiform at its northeastern terminus. We interpret the Austell-Frolona to be an antiformal syncline (fig. 4), based on evidence of multiple deformation of the area and the gradational relationship of rocks of the New Georgia Group into rocks of the Roosterville group. This gradational zone is characterized by a general decrease upward of metavolcanic lithologies and a corresponding thickening of the metasedimentary sequence. This is best illustrated in exposures on the northwestern side of the Austell-Frolona antiform.

The Villa Rica antiform, a parasitic upwarp on the northwestern limb of the Austell-Frolona antiform, is coaxial and nearly coplanar with the Austell-Frolona. It formed contemporaneously with the larger scale Austell-Frolona and is cored by a thin lens of felsic gneiss termed the Villa Rica Gneiss, a body of dacitic composition. Rocks in and adjacent to the Villa Rica antiform are included in the New Georgia Group. These units structurally overlie and stratigraphically underlie the rocks which core the Austell-Frolona antiform (Roosterville group).

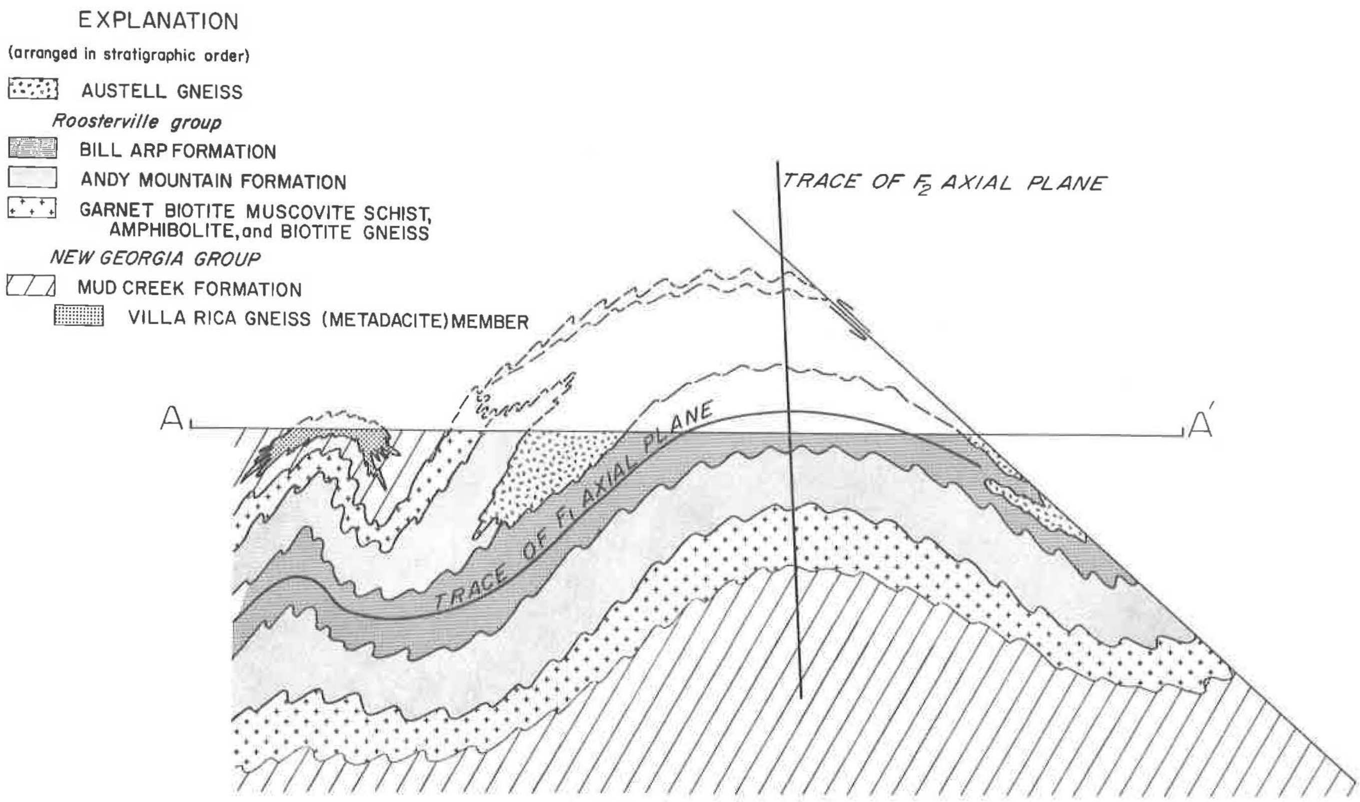


Figure 4. Cross section through the Austell-Frolona and Villa Rica antiforms.

Southeast of the Austell-Frolona antiform, the Sandy Springs Group lies in fault contact with rocks of the Roosterville group (fig. 2). Two reverse faults, the Chattahoochee fault (Hurst, 1973; Medlin and Crawford, 1973; Crawford and Medlin, 1973) and the Blairs Bridge fault (McConnell and Abrams, 1978), have juxtaposed rocks of the Sandy Springs Group with rocks in the Austell-Frolona antiform. Where the massive Austell Gneiss is present, northwestward movement was impeded, and the Blairs Bridge fault block overrode the Chattahoochee fault block (McConnell and Abrams, 1978). Northeast of Austell, where the Austell Gneiss is absent, lithologic units are not cut out by the Blairs Bridge fault, which dies out to the northeast.

DETAILED STRATIGRAPHY

NEW GEORGIA GROUP

New Georgia Group rocks in this area are exposed on the northwestern flank of the Austell-Frolona antiform in the Villa Rica antiform (McConnell, unpublished map; and Pate, 1980). New Georgia Group rocks are dominantly metavolcanic and metaplutonic rocks which grade upward (through decreasing abundance of metavolcanic rocks) into rocks of the Roosterville group. Rock types include amphibolite, granitic gneiss, and metadacite, with minor biotite gneiss, mica schist, and quartzite. Extensive linear zones of sulfide and gold mineralization are characteristic of the New Georgia Group rocks. In the area of this report, we designate the upper portion of the New Georgia Group rocks the Mud Creek Formation (table 1).

Table 1

(arranged in stratigraphic order)

Austell Gneiss

Roosterville group
- Bill Arp Formation
- Andy Mountain Formation

New Georgia Group
- Mud Creek Formation
  - Villa Rica Gneiss Member
  - Cedar Lake Quartzite Member

Mud Creek Formation

The type location of the Mud Creek Formation is here named for exposures near and along Mud Creek (fig. 5). In general, the Mud Creek Formation is composed of amphibolite, hornblende gneiss, biotite gneiss, mica schist, and quartzite in decreasing order of abundance. This formation stratigraphically underlies and grades upward into rocks of the Roosterville group.

Locally garnetiferous, equigranular hornblende plagioclase amphibolite and hornblende gneiss make up the bulk of the Mud Creek Formation. Garnet-biotite-quartz-plagioclase gneiss within the amphibolite is discontinuous and grades along strike into a garnet-biotite schist. The amphibolite is interlayered with biotite gneiss, schist, and quartzite within a metavolcanic sequence. Because of their distinct characteristics, the Villa Rica Gneiss and the Cedar Lake Quartzite have been designated as members of the Mud Creek Formation.

The Villa Rica Gneiss is a biotite-quartz plagioclase (An27) gneiss with accessory amounts of muscovite and epidote. The Villa Rica Gneiss (fig. 6) was originally introduced as the Villa Rica granite by Hayes (unpublished map). Hayes named the Villa Rica granite for type exposures around the town of Villa Rica, but he also included all uniform textured felsic gneisses of the northwestern Georgia Piedmont in his definition of the Villa Rica granite. McCallie (*in* Yeates and others, 1896) also called exposures of the leucocratic gneiss in and around Villa Rica a granite. More recently Crawford (1970) (1970) referred to the body as a granite gneiss. Sanders (in press) has determined that the Villa Rica Gneiss is low in potassium and has suggested that it is chemically similar to a trondhjemite (fig. 7). We interpret the Villa Rica Gneiss (justification presented below) to be a felsic metavolcanic and therefore classify it as a metadacite.

The origin of the Villa Rica Gneiss is uncertain; however, recent field mapping and examination of core (courtesy of Cities Service Corp., Ducktown, Tenn.) from holes drilled near several abandoned mines and prospects within and at the boundaries of the Villa Rica Gneiss suggest that the Villa Rica Gneiss is not a large independent body of leucocratic gneiss. Although not completely conclusive, interfingering with the surrounding

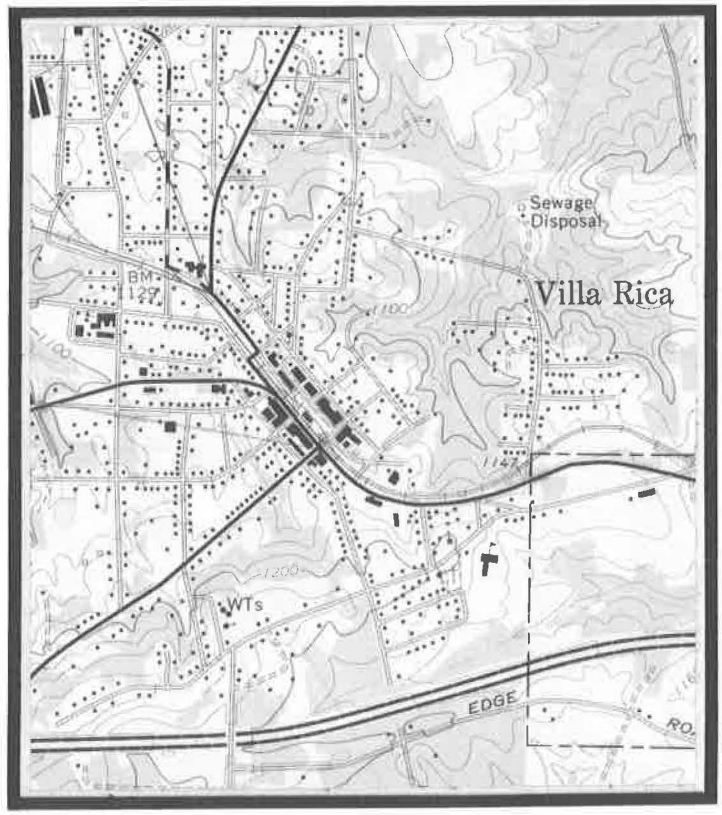


Figure 6. The type locality of the Villa Rica Gneiss Member of the Mud Creek Formation (U.S. Geological Survey, Villa Rica, Georgia, 7.5 min. topographic quadrangle).

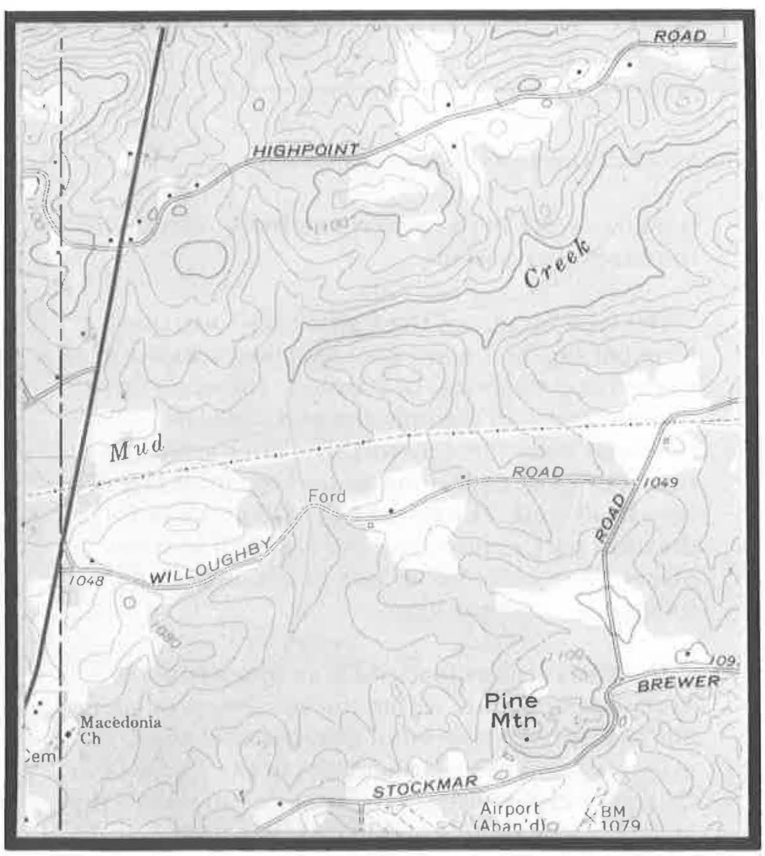


Figure 5. The type locality of the Mud Creek Formation (U.S. Geological Survey, New Georgia, Georgia, 7.5 min. topographic quadrangle).

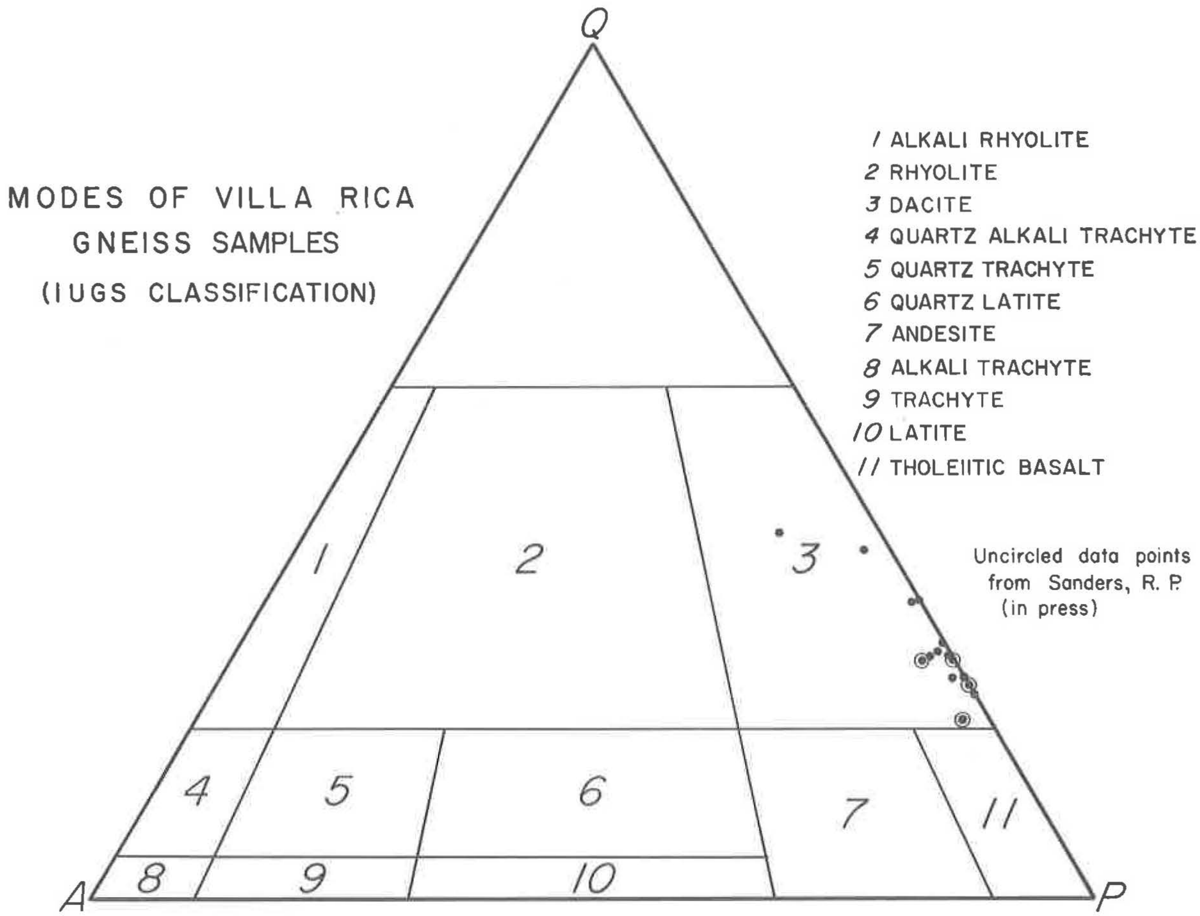


Figure 7. Qz-Ab-Or diagram of modes from the Villa Rica Gneiss (I.U.G.S. Classification).

lithologies, the general concordancy of the contacts, and the association with other volcanogenic lithologies and ore deposits (Abrams and others, 1981) strongly support a volcanic origin. An alternate and closely related hypothesis which would reflect similar contact relationships is that the Villa Rica Gneiss represents a hypabyssal intrusive.

A gneiss similar in texture and mineralogy to the Villa Rica Gneiss is located to the northeast along the northwestern flank of the Austell-Frolona antiform. This body appears to occupy the same structural and stratigraphic position as the Villa Rica Gneiss and may represent a northeastern extension of the Villa Rica. Cross folding by F_3 folds is an explanation for the separation in map view. Sanders (personal commun. 1981) has found this gneiss to be chemically dissimilar to the Villa Rica Gneiss. His work has revealed higher K_2O, MgO, Fe_2O_3 and CaO values and lower SiO_2 and Na_2O values than those in the Villa Rica Gneiss. Although the structural and stratigraphic evidence for both gneisses is similar, work in the area is needed to determine the exact relationships.

The type locality of the Cedar Lake Quartzite Member (fig. 8) is named for excellent exposures at Cedar Lake northwest of Winston. The quartzite is interlayered with amphibolite and varies in thickness from 1 to 4 meters. The interlayering may reflect original deposition or perhaps infolding on a very small scale. The Cedar Lake Quartzite is, for the most part, continuous, but is absent in some places along strike either due to attenuation during folding or nondeposition.

The Cedar Lake Quartzite is an important stratigraphic marker within the volcanic sequence. The presence of layers and disseminated grains of magnetite and specular hematite in the Cedar Lake Quartzite distinguish it from other quartzites in the area. In some areas, iron oxides constitute up to 70 percent of the coarse to microcrystalline banded quartzite. This oxide phase grades locally into a

Figure 8. The type locality of the Cedar Lake Quartzite Member of the Mud Creek Formation (U.S. Geological Survey, Winston, Georgia, 7.5 min. topographic quadrangle).

manganiferous or garnetiferous quartzite with garnet constituting up to 25% of the rock. The Cedar Lake Quartzite probably represents a metamorphosed banded iron formation, similar to those commonly associated with volcanogenic ore deposits (i.e., Bathhurst, Broken Hill). It formed as a part of the volcanic cycle which produced the mafic and felsic volcanics that now occur as amphibolites, hornblende gneisses, and low potassium felsic gneisses of the Mud Creek Formation.

ROOSTERVILLE GROUP

As previously defined, rocks of the Roosterville group are dominantly metasedimentary with associated felsic intrusives and minor interlayered amphibolite. Rock types include:quartzite, mica and graphitic schists, and metagraywacke. In the area of this report, rocks of the Roosterville group have been divided into two formations: the Andy Mountain Formation and the Bill Arp Formation. (table 1).

Andy Mountain Formation

The oldest unit of the Roosterville group in this area is the Andy Mountain Formation which is herein named for Andy Mountain, 1.5 mi. west of Winston, where there are excellent exposures of quartzite and schist within the type locality (fig. 9). The rocks of this formation are interpreted to stratigraphically underlie rocks of the Bill Arp Formation. Due to refolding, they now structurally overlie the Bill Arp and the intrusive Austell Gneiss in this area. Rocks to the southwest in the core of the Austell-Frolona antiform have been termed the Frolona formation by Crawford and Medlin (1974). Based on their description, the Frolona formation appears to be equivalent to the Andy Mountain Formation. Crawford and Medlin interpreted the Austell-Frolona as an antiform which was affected by a single fold event and placed their Frolona formation in the core of the fold as the oldest unit, stratigraphically underlying the Bill Arp Formation. Based on our interpretation of stratigraphic relationships and multiple folding within the Austell-Frolona,we believe it represents a second generation, overturned syncline. The Andy Mountain Formation (our Frolona formation equivalent) is still interpreted to be older than the Bill Arp Formation. While all original facing criteria have been destroyed by metamorphism and multiple deformation, the gradational transition from a predominantly metavolcanic sequence (New Georgia Group) upward into a predominantly metasedimentary sequence (Roosterville group) supports this structural interpretation.

Rocks of the Andy Mountain Formation are dominantly siliceous schists and quartzite with local horizons of gneiss. The quartzite is best exposed at Andy Mountain where the unit occurs as a clean, sugary quartzite. Locally, along strike garnetiferous zones are present. The unit as a whole is discontinuous, probably due to nondeposition or attenuation during folding.

Schist units are gradational into quartzite. They vary from medium-grained garnet-muscovite-quartz schist to graphitic garnet-muscovite-quartz schist. Other accessory minerals in the schists include chlorite, biotite, staurolite, and tourmaline. Chlorite results from the alteration of garnet. Garnets are poikiloblastic and commonly show evidence of rotation. In areas where garnets are most abundant, they stand out on the weathered surface to give the rock a spotted appearance.

A relatively small part of the Andy Mountain Formation is composed of an equigranular garnet-biotite-plagioclase-quartz gneiss. The gneiss is characterized by lenses of ptygmatically folded quartz. Accessory minerals in the gneiss are: hornblende, chlorite, muscovite, and calcite.

Bill Arp Formation

The Bill Arp Formation (fig. 10) was introduced informally in 1974 by Crawford and Medlin to apply to those rocks that structurally underlie the Austell Gneiss and structurally overlie their Frolona formation. The type locality of the Bill Arp Formation is located at the community of Bill Arp, Ga. In this report, we are formalizing the rocks described by Crawford and Medlin (1974) as the Bill Arp Formation, but are also expanding the unit to include Crawford and Medlin's Union Grove Church schist. The Union Grove Church schist is petrographically indistinct from the Bill Arp and we believe that it represents an infolded slice or possibly a roof pendant of the Bill Arp Formation within the metaigneous Austell Gneiss.

The Bill Arp Formation consists dominantly of interlayered mica schists and metagraywacke. Rock types include garnet-biotite-muscovite-plagioclase-quartz schist, muscovite schist, quartz-muscovite-biotite schist, muscovite-biotite-quartz-plagioclase schist and metagraywacke. The uniform, medium- to fine-grained metagraywacke is composed of muscovite, biotite, plagioclase, and up to 65% quartz with minor amounts of epidote, chlorite, hornblende and garnet. Calcareous concretions, possible original limey lenses, occur as elongate features parallel to the plane of foliation in the metagraywacke. These concretions have a concentrically zoned mineralogy with calcite and quartz as the dominant minerals (Sanders and others, 1979). The concretions are best observed in exposures on Interstate 20 at Georgia Highway 5.

The Bill Arp Formation stratigraphically overlies the rocks of the Andy Mountain Formation and was intruded semi-concordantly by the Austell Gneiss. Xenoliths of the Bill Arp Formation within the Austell Gneiss are common. These are best

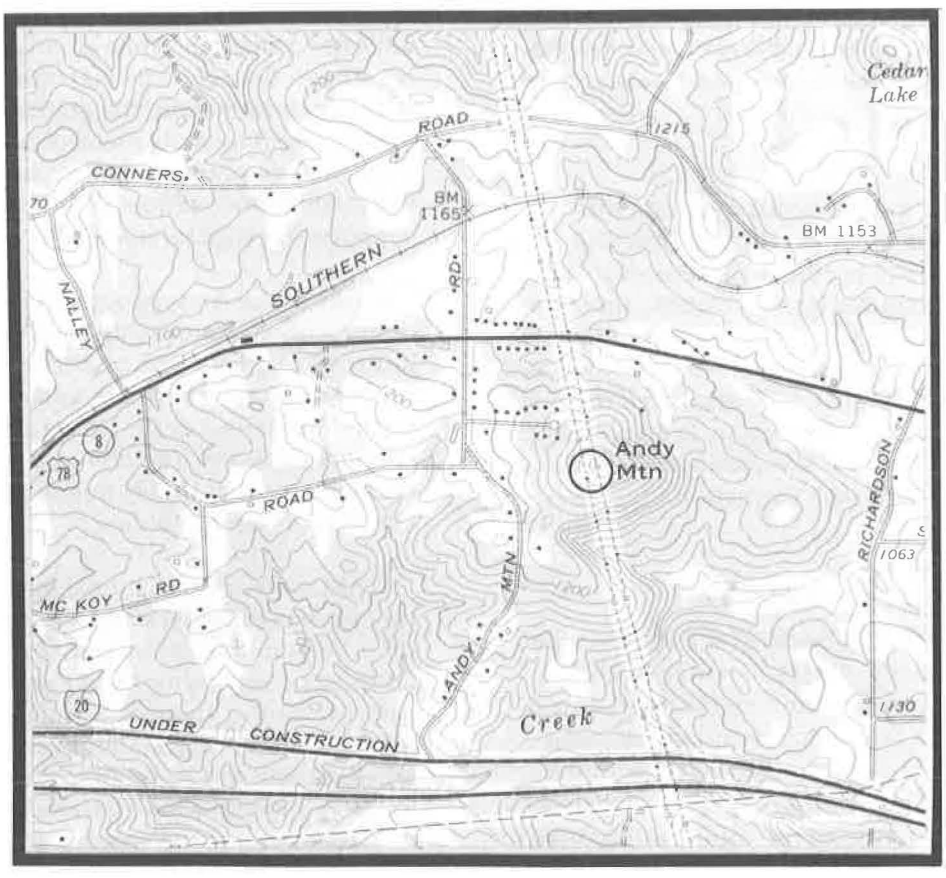


Figure 9. The type locality of the Andy Mountain Formation (U.S. Geological Survey, Winston, Georgia, 7.5 min. topographic quadrangle).

observed in a roadcut located on Interstate 20, 1¼ miles west of its junction with Georgia Highway 5. Many of the xenoliths have a hornfels texture that overprints the regional metamorphic fabric.

Austell Gneiss

Medlin and Crawford (1973) introduced the term Austell Gneiss for exposures of felsic gneiss at the type locality in and around the town of Austell (fig. 11). Their terminology revises an earlier description

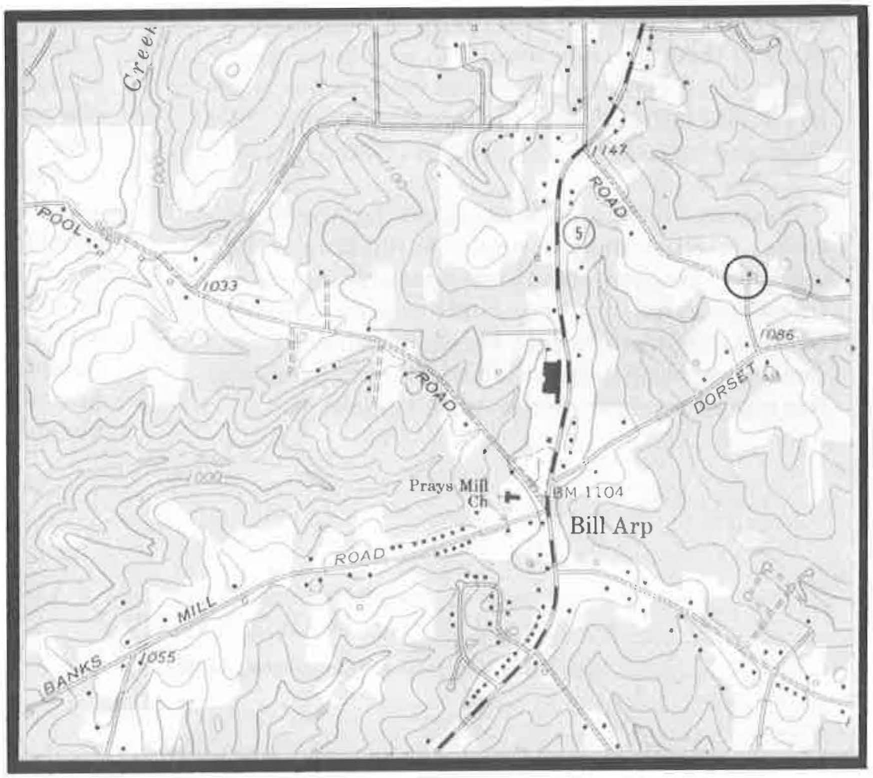


Figure 10.

The type locality of the Bill Arp Formation (U.S. Geological Survey, Winston, Georgia, 7.5 min. topographic quadrangle).

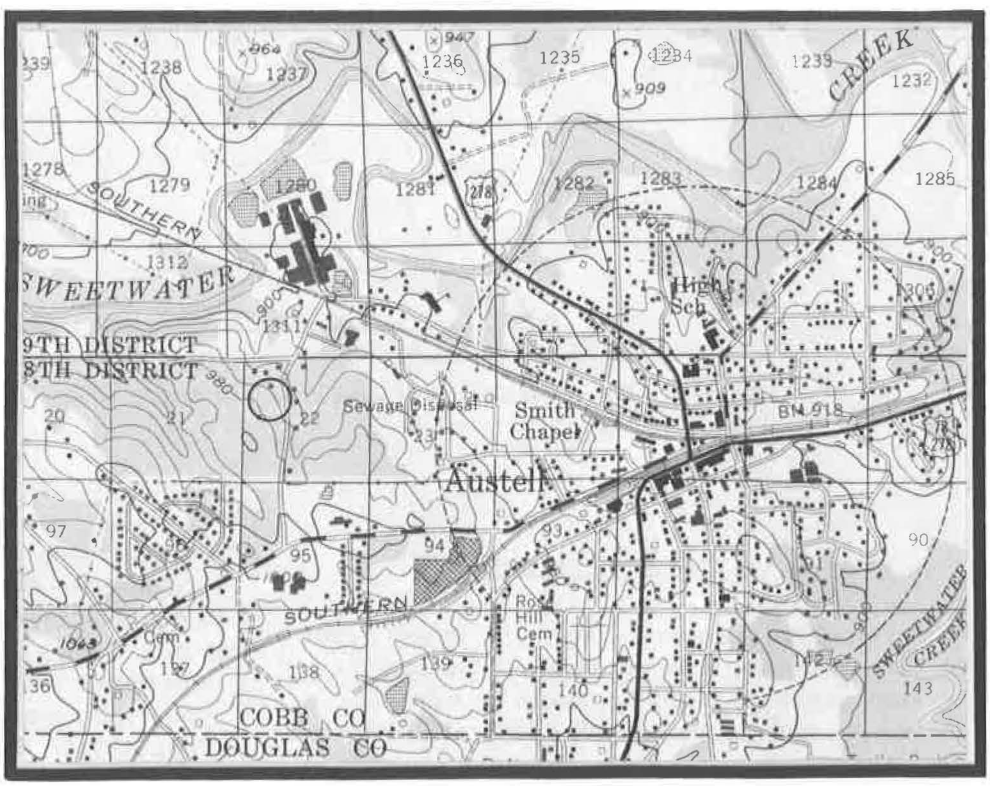


Figure 11.

The type locality of the Austell Gneiss (U.S. Geological Survey, Austell, Georgia, 7.5 min. topographic quadrangle).

of the Austell as the Austell granite by Hayes (unpublished map). Hayes also included all augen gneisses of the northwestern Georgia Piedmont in the definition of the Austell granite. Crickmay (1952) described the Austell as a granite and used Hayes' terminology. Shepis (1952), in a detailed study of the body, described it as a "granite augen gneiss." Less extensive work was done in the area by Higgins (1966, 1968), Crawford and Medlin (1973, 1974) and McConnell and Abrams (1978).

Previous workers have suggested that the Austell Gneiss is sedimentary in origin. At the time of their work, the excellent exposures now present on Interstate 20 had not been cut to expose xenoliths of Bill Arp Formation with excellent contact metamorphic textures within the Austell Gneiss. In this report we redefine the Austell Gneiss as a metaigneous body that is intrusive into the rocks of the Roosterville group.

The Austell Gneiss varies from a medium- to coarse-grained blastoporphyritic gneiss to an equigranular, fine- to coarse-grained, nonporphyritic rock (Crawford and Medlin, 1974). Equigranular textures are more prevalent near the margins and along the limbs of the folded gneiss where the body has been stretched or sheared. The Austell crops out as large pavement type outcrops and has an outcrop area of 35 sq. mi. (Coleman and others, 1973). It is dominantly a biotite-oligoclase-(An 17)-quartz-microcline gneiss of quartz monzonitic composition (fig. 12 and Crawford and Medlin, 1974). Accessory minerals include large euhedral to subhedral grains of allanite and sphene as well as minor amounts of muscovite, garnet, hornblende, calcite, epidote, chlorite, and apatite.

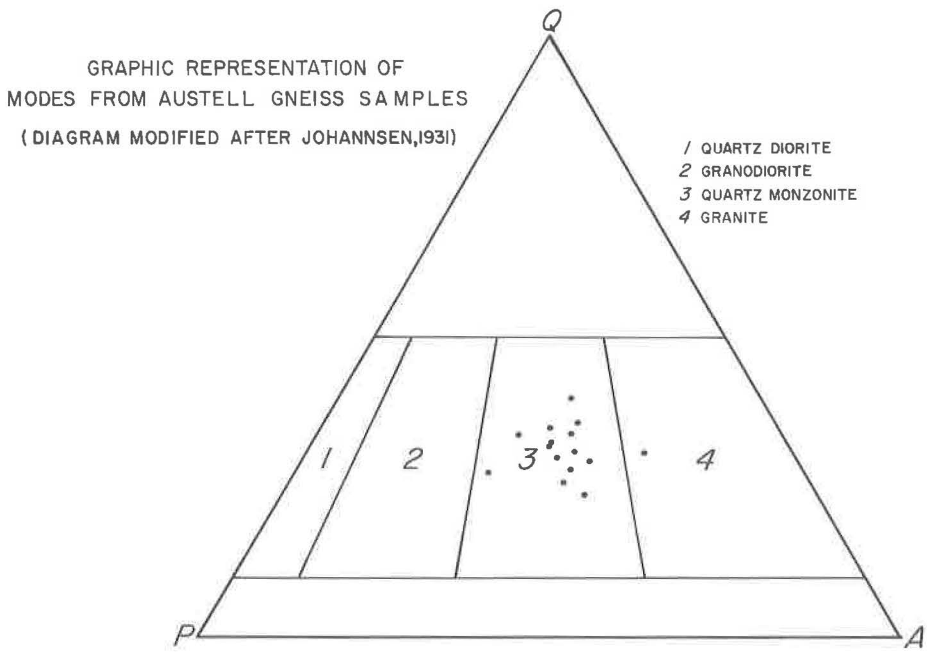


Figure 12. Qz-Ab-Or diagram of modes from the Austell Gneiss (after Johannsen, 1931).

CONCLUSIONS

This report presents a stratigraphic interpretation for a small area of the northwestern Georgia Piedmont. Multiple fold episodes have greatly complicated the stratigraphic relationships within the report area. New Georgia Group rocks are recognized to structurally overlie, but stratigraphically underlie, rocks of the Roosterville group. Although relative age relationships between units remain the same, previously determined stratigraphic sequences within the Roosterville group (Crawford and Medlin, 1974) based on a less complex structural interpretation (i.e., one fold event) were fortuitous. Based on multiple folding and stratigraphic relationships between the New Georgia and Roosterville groups, the Austell - Frolona antiform (Roosterville group) is now interpreted to be a refolded, recumbent syncline; therefore, units which now core the antiform, previously determined by Crawford and Medlin (1974) as the oldest units of the stratigraphic sequence, are still interpreted as the oldest rocks of the Roosterville group. Only with an understanding of the structural complexities of the northern Piedmont can detailed stratigraphies be developed; therefore, previously determined stratigraphic sequences based on only one major folding event must now be re-evaluated.

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