REVISION OF STRATIGRAPHIC NOMENCLATURE IN THE ATLANTA, ATHENS, AND CARTERSVILLE 30' x 60' QUADRANGLES, GEORGIA

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GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

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ABSTRACT

This report revises the stratigraphic nomenclature and ages for some geologic units in the Atlanta, Athens, and Cartersville, Ga., 30'X60' quadrangles. The Piedmont-Blue Ridge in northern Georgia is made up of two assemblages of rocks: the parautochthonous continental margin assemblage and the allochthonous oceanic assemblage. The allochthonous assemblage was obducted onto the parautochthonous assemblage, probably in Middle Ordovician through Late Ordovician time and then was isoclinally folded. The reinterpretation of the area's stratigraphy relies on radiometrically obtained ages as well as stratigraphic placement of some key units. Detailed mapping has shown the need to either refine or consolidate the nomenclature in order to clarify the stratigraphy.

INTRODUCTION

When large areas are mapped, especially where the geology is complex, it becomes necessary to consolidate names that were based on maps of smaller areas to avoid having multiple names for the same unit. Conversely, more detailed mapping generally causes subdivision of units that were mapped in reconnaissance or in detailed reconnaissance. In the Atlanta, Athens, and Cartersville, Ga., 30'X60' quadrangles, formal stratigraphic units named over the past 50 years include many units with more than one name. The purpose of this report is to consolidate names in the Atlanta, Athens, and Cartersville quadrangles (fig. 1).

In Georgia, the Piedmont and Blue Ridge are separate physiographic provinces (Fenneman, 1938), as shown in figure 1, but are not separable as geologic provinces because the same rocks and the same stratigraphic sequences are found in both (Higgins and others, 1996). Therefore, we use the name Piedmont-Blue Ridge geologic province, as shown in figure 1

The Piedmont-Blue Ridge in northern Georgia is made up of two assemblages of rocks, here called the parautochthonous continental margin assemblage and the allochthonous oceanic assemblage. The allochthonous assemblage was obducted onto the parautochthonous assemblage, probably in Middle Ordovician through Late Ordovician time and then was isoclinally folded. The folded thrust faults were in turn displaced in a dextral wrench-fault system, similar to the San Andreas fault system in California (Crowell, 1962, 1974; Dibblee, 1977) and other wrench-fault systems (for example, Wilcox and others, 1973), probably during the Early Silurian through Jurassic or Early Cretaceous; the wrench-fault system differs from the San Andreas because it is composed of intraplate strike-slip faults (Sylvester, 1988, p. 1667, table 1), whereas the San Andreas system is an interplate system in the classification of Sylvester (1988). Folding, normal-strike-slip (oblique) faulting, and thrust/high-angle reverse faulting accompanied strike-slip/wrench faulting and all of these faults cut through the older thrust system. The strike-slip/wrench faulting spanned from high metamorphic grade, where faults are ductile shear zones containing mylonites; through low metamorphic grade, where faults are shear zones marked by retrograded mylonites; to nonmetamorphic, where the faults are marked by brittle fault breccias, microbreccias ("flinty crush-rocks"), foliated breccias, gouge, and foliated gouge (Tanaka, 1992). In its most brittle stages, the strike-slip faulting is marked by silica intrusions into extensional pull-aparts where quartz crystals have grown normal to the fracture walls and, in places, the quartz crystals have been fractured. Similar rocks have been described along late faults in the Carolinas by Garihan and others (1998, p. 284–290) who described the quartz crystals as "angle-plated quartz" and divided the cataclastic rocks into several varieties.

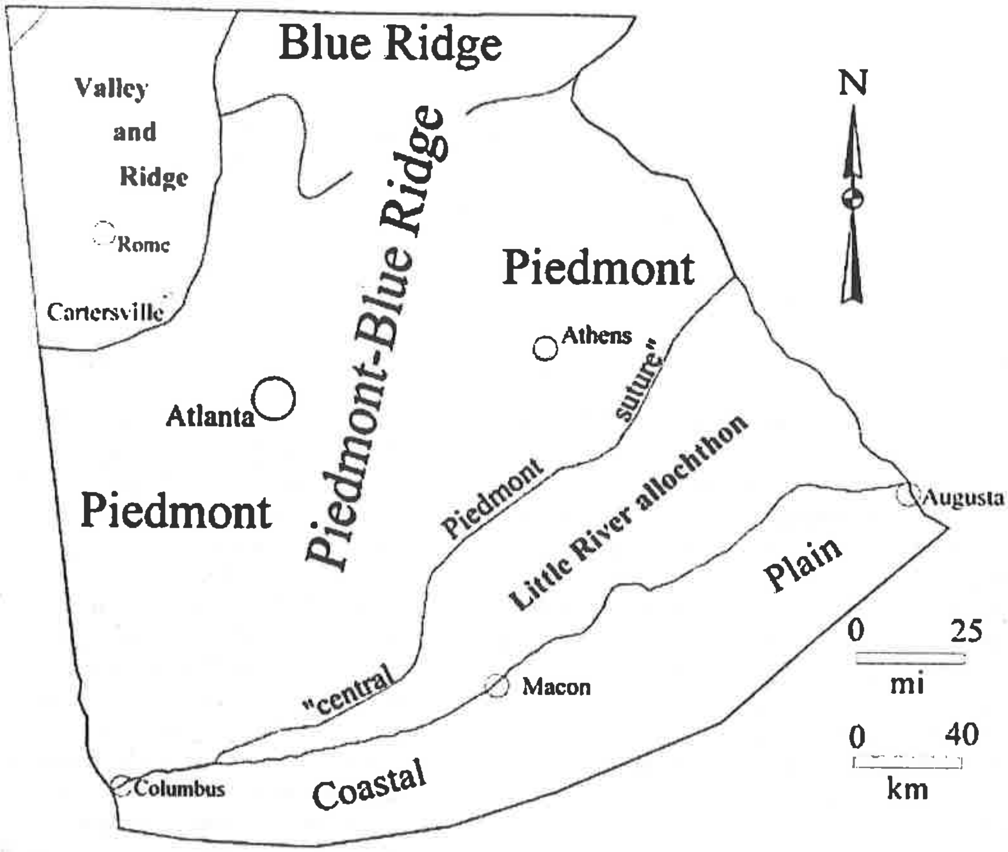

Figure 1: Geologic and physiographic provinces in northern Georgia. Geologic provinces from Higgins and others (1996); physiographic provinces from Fennerman (1938, pl. 3). Piedmont-Blue Ridge geologic province shaded.

Age Constraints

The organization of this report generally follows the rule that older units are discussed before younger units. However, because the ages are mainly inferred or represent a long range of time rather than paleontologic ages, and because the placement of some units has changed from the allochthonous to the parautochthonous assemblage and vice versa, the chronologic rule is not always followed.

Valley and Ridge Province

Middle Ordovician Rockmart Slate

Throughout the Appalachian Valley and Ridge province, Middle Ordovician dark slates are found resting in sharp contact upon Middle Ordovician continental shelf carbonate units that are the same age to within a few graptolite zones (Rodgers, 1968). In Georgia, one of the dark slates is the Rockmart Slate (Cressler, 1970), which is only known to be exposed in western Georgia, west of the recess in the Piedmont-Blue Ridge at Cartersville (figs. 1, 2). Alabama, the Middle Ordovician dark slate interval is represented by the Athens Shale (Finney and others, 1996). The age of these dark, graptolitic shales and slates is critical to establishing the time of beginning of the convergence that produced an upper Middle Ordovician to Lower Silurian clastic wedge and foreland-basin sequence and what has been called the Taconic or Taconian orogeny (as used by King, 1951; Rodgers, 1967, 1968, 1970; and Drake and others, 1989). Elsewhere in Georgia, southern Tennessee, and Alabama , the Middle Ordovician dark slate interval is represented by the Athens Shale (Finney and others, 1996). The age of these dark, graptolitic shales and slates is critical to establishing the time of beginning of the cinvergence that produced an upper Middle Ordovician to Lower Silurian clastic wedge and foreland-basin sequence and what has been called the Taconic or Taconian orogeny (as used by King, 1951; Rodgers, 1967, 1968, 1970; and Drake and others, 1989).

The Rockmart Slate is a dark-gray to nearly black, tan- to brownish-yellow-weathering, fine-grained, generally calcareous slate about 90 m thick, but without marker beds; the unit contains well-developed folds and cleavages and a Middle Ordovician graptolite fauna (Cressler, 1970; Bergström, 1973; Finney, 1980; Finney and others, 1996). The Rockmart rests in sharp contact upon the regional angular unconformity at the top of the Upper Cambrian to Early Ordovician Knox Group (Butts, 1926; Cressler, 1970; Rodgers, 1970; Mussman and Read, 1986) and upon the disconformity at the top Middle Ordovician Lenoir Limestone, which was deposited in warm, shallow water. Elsewhere in the Appalachian orogen, dark, graptolitic, Middle Ordovician pelites have been interpreted to have been deposited upon Middle Ordovician shelf carbonates when the shelf sank (Rodgers, 1968; Stanley and Ratcliffe, 1985), and Chowns and Renner (1989) have interpreted the Rockmart Slate to have been deposited in this manner. We agree with that interpretation, but we interpret the contact between the Rockmart and the underlying rocks of the carbonate-shelf sequence to be a thrust fault or detachment fault in many places, with the Rockmart having been thrust or having slid from its site of deposition farther continentward to rest again upon the Middle Ordovician unconformity upon which it was deposited. The Rockmart is confined to the western side of the bend in the orogen at Cartersville, Ga. Conodont data indicate that the base of the Rockmart is older than the base of its near counterpart, the Athens Shale of Georgia, Tennessee, and Alabama, and that it was probably deposited farther from the craton than the Athens (Bergström, 1973; Finney, 1980; Finney and others, 1996). Higgins and others (1988) suggested that the Rockmart Slate may have had a more complicated history than the Athens Shale.

Regardless of how it arrived, the position of the Rockmart Slate on top of the Lenoir Limestone indicates that slope reversal was taking place in the Georgia Appalachians during the Middle Ordovician. The Rockmart and the overlying Tellico Formation, which contains clasts of Rockmart Slate, were folded and metamorphosed under lowermost greenschist-facies conditions that produced a 2M muscovite and chlorite assemblage (Renner, 1987) before deposition of the unconformably overlying Lower and Middle Devonian Frog Mountain Sandstone (Nunan and Lipps, 1968; Cressler, 1970; Sibley, 1983; Higgins and others, 1988), which is unmetamorphosed.

Our interpretation that the Yorkville and Allatoona faults are part of the Dahlonega system of dextral strike-slip faults (Higgins and others, 1996) indicates that the Rockmart Slate may also have been transported northeastward many kilometers from its site of deposition.

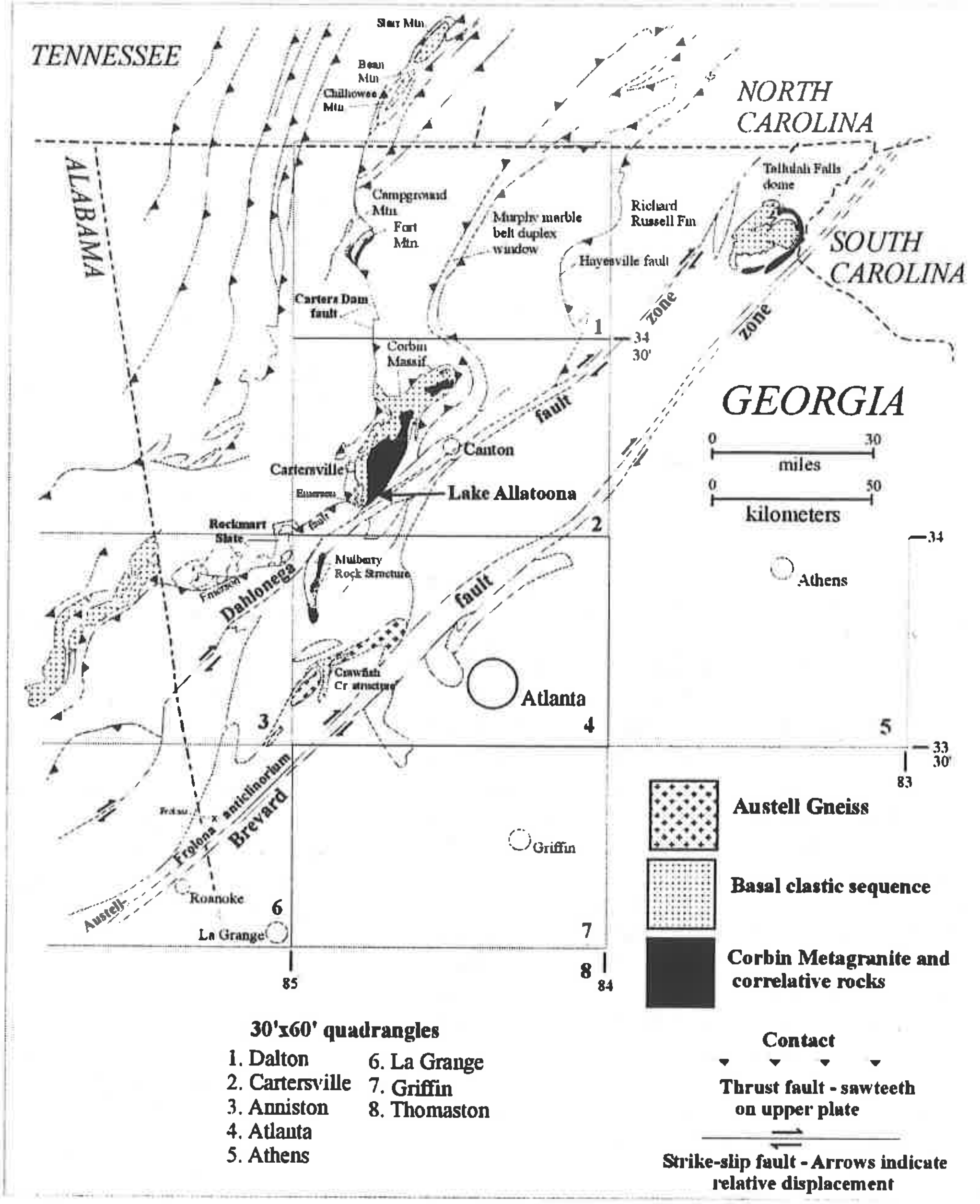

Figure 2: Generalized tectonic map of part of northern Georgia, eastern Alabama, southern Tennessee, southwestern North Carolina, and northeastern South Carolina (modified from Rankin and others, 1989) showing the location of the Atlanta, Athens, and Cartersville quadrangles and some of the geologic units and structural features discussed in the text.

Middle Ordovician Tellico Formation

In western Georgia, the Middle Ordovician Rockmart Slate is conformably or paraconformably overlain by the Middle Ordovician Tellico Formation. The Tellico is a relatively thin (~90 m thick) unit composed of low-grade metamorphosed siltstone, feldspathic sandstone, and slate with lenses of coarse, unsorted, polymictic conglomerate made up of angular to subrounded fragments, chips, pebbles, and cobbles of limestone, dolomite, slate, sandstone, chert, and quartzite in a matrix of feldspathic sandstone, sandy slate, graywacke, clay slate, or rarely dolomite or limestone. Some of the quartzite clasts in the conglomerates were metamorphosed before deposition and some of the slate clasts lithically match the underlying Rockmart Slate (Cressler, 1970; Chowns and McKinney, 1980; Sibley, 1983; Higgins and others, 1988), and Cressler (1970) and Sibley (1983), who mapped them, interpreted the slate clasts to be reworked Rockmart. Carbonate clasts lithically match rocks of the carbonate shelf sequence below the Rockmart (Cressler, 1970, p. 25). Cressler (1970, p. 30) and Higgins and others (1988, p. 81) interpreted the Tellico in western Georgia to represent depositional equivalents of the Tellico Formation and overlying Chota Formation (Neuman, 1955) in southeastern Tennessee.

Higgins and others (1988, p. 81–82) summarized evidence indicating that the Tellico Formation was derived from the east, and to a lesser extent from the southeast, rather than from the craton or the carbonate shelf. An eastern source is indicated by 1) the size and angularity of some of the noncarbonate clasts in the conglomerates, 2) the presence of clasts that were metamorphosed before sedimentation, 3) an increase in grain size in sandstone beds from west to east, 4) thickening of bedding in sandstone toward the east, and 5) the fact that the conglomerate lenses in the easternmost outcrops are thickest, have the widest lateral extent, and contain the coarsest and least rounded pebbles and cobbles. Cressler (1970, p. 30) described the Tellico as "an eastward thickening wedge of clastics."

We speculate that the Rockmart Slate and Tellico Formation exposed in western Georgia probably represent only the distal cratonward edge of a much thicker and aerially more extensive wedge of clastic sedimentary rocks overridden by the Piedmont-Blue Ridge to the east and southeast. The age and structural and (or) stratigraphic position of the Rockmart Slate and conglomerate of the Tellico indicate that orogeny was taking place oceanward (eastward-southeastward) from the Cambrian and Ordovician carbonate shelf during the Middle Ordovician.

Devonian Frog Mountain Sandstone

In western Georgia, the rocks of the carbonate shelf and the Rockmart Slate and Tellico Formation are overlain unconformably by the Devonian Frog Mountain Sandstone, a coarse-grained, proximal facies of the Armuchee Chert (Cressler, 1970). The Armuchee has a warm, shallow-water, shelly fauna that suggests deposition in quiet conditions; this was probably also the depositional environment of the Frog Mountain Sandstone, although it is less fossiliferous than the Armuchee. This quiet depositional environment suggests that the event that was responsible for placing the Rockmart Slate upon the shelf rocks had ended or changed location by the Early Devonian.

Lower Mississippian Fort Payne Chert

In the western part of the recess at Cartersville, Ga., the Middle Ordovician Rockmart Slate is unconformably overlain by the Lower Mississippian Fort Payne Chert. Near the Emerson fault, the Fort Payne consists of breccia made up of hard, angular pieces of light- to medium-gray, recrystallized chert and siltstone mixed with softer, generally smaller and more rounded, red, white, and tan pieces of similar material, all cemented into a mass by silica and iron oxide that locally forms boxwork (Cressler, 1970, p. 41–42). A warm, shallow-water fauna composed of crinoid stem plates, horn corals, brachiopods, pelecypods, and bryozoans indicate that the chert is Osagean (Cressler, 1970, p. 42–44). The age of the Fort Payne sets the time of brecciation of the chert by movement along the Emerson fault at this point as younger than Early Mississippian.

Piedmont-Blue Ridge Province

Two units in the Piedmont-Blue Ridge in northwestern Georgia, the Middle(?) to Late Proterozoic Corbin Metagranite of the Allatoona Complex and the Early Silurian Austell Gneiss, have direct bearing on age assignments. The Corbin is a metamorphosed granite that intruded older metasedimentary rocks of the Allatoona Complex.

The Austell is an orthogneiss that has intruded metasedimentary rocks of the parautochthonous continental margin assemblage. The age of the Austell (Higgins and others, 1997) can be used to infer ages of stratigraphic units, folds, foliation, and faults. In addition, four poorly foliated to nonfoliated plutons, tentatively dated as Carboniferous, can be used to infer minimum ages of stratigraphic units, folds, foliations, and faults that they intrude; these are the Stone Mountain, Palmetto, Ben Hill, and Panola plutons. However, none of the four plutons are well dated enough to set definite age limits. Detailed age dating using Pb-U, Rb-Sr and argon systems might shed light on the time of movement of some of the faults in the Brevard fault zone.

Middle(?) To Late Proterozoic Corbin Metagranite

In the western part of the Piedmont-Blue Ridge in northern Georgia, and at least as far west as the Mulberry Rock structure in the northwestern corner of the Atlanta 30'X60' quadrangle in western Georgia, basement is represented by the Allatoona Complex, which is composed of the Corbin Metagranite (name changed from Corbin Gneiss in section on Allatoona Complex), and rocks the Corbin intruded. The Corbin Metagranite has been dated by two methods. Odom and others (1973) reported Middle Proterozoic Pb-U zircon ages from the Corbin, but did not state the actual dates. Dallmeyer (1975, p. 1740–1743) reported undisturbed $^{40}Ar/^{39}Ar$ release spectra with total-gas ages of 735±15 Ma and 732±15 Ma for the Corbin and suggested (p. 1740) that "the biotite ages date the time of cooling below temperatures required for argon retention following Grenville metamorphism." A zircon sample from the Corbin exposed along the southern shore of Allatoona Lake in Red Top Mountain State Park yielded a discordant Pb-U age of a bulk sample of zircon consistent with an age for the Corbin of 1.1 to 1 Ga. However, the Corbin Metagranite is a complex rock, the dated zircons may be partly inherited detrital zircons, and previous interpretations that the Corbin has been metamorphosed to pyroxene-granulite facies are probably incorrect (see below). Nevertheless, the Corbin must be either Middle Proterozoic or Late Proterozoic and its age can therefore be used to place some limits on the age of rocks it has intruded, rocks it has supplied sediments to, and rocks it has been faulted upon or against. We have used the Middle(?) to Late Proterozoic age of the Corbin Metagranite to assign an age of Late Proterozoic as the probable older age limit for most of the nonplutonic rocks of the allochthonous assemblage in the Atlanta, Athens, and Cartersville quadrangles.

Early Silurian Austell Gneiss

Many of the chronologic assignments in the Piedmont-Blue Ridge in Georgia depend upon the age of the Austell Gneiss, which is a gray, medium- to coarse-grained, strongly foliated, biotite-oligoclase-microcline-quartz orthogneiss that crops out in the northeast end of the Austell-Frolona anticlinorium (fig. 2) on the northwestern side of the Brevard fault zone in the Atlanta 30'X60' quadrangle. In many outcrops, the Austell is a mylonite or mylonite gneiss. Where not mylonitic, the gneiss contains microcline megacrysts 5 mm to 3 cm long (Coleman and others, 1973; Crawford and Medlin, 1974; Higgins and others, 1997, in press) that make up 20 to 50 percent, but more commonly 25 to 30 percent, of the rock. Accessory minerals include euhedral to subhedral grains of sphene and allanite as well as muscovite, garnet, zircon, and opaque minerals. Minerals of probable secondary origin include epidote, chlorite, and sericite, but the age of these minerals is unknown. The chemical composition of the Austell Gneiss (Higgins and others, 1997) is close to that of a "minimum-melt" (Tuttle and Bowen, 1958) and rare-earth elements, other trace elements, and isotopic ratios indicate that the Austell Gneiss was produced by anatectic melting of older quartz-feldspar gneiss that may have been the Corbin Metagranite basement (Higgins and others, 1997).

One bulk zircon sample from the Austell Gneiss was dated by Stern (unpub. data) by the Pb-U method and yielded a datum that fits close to the concordia curve at 430 Ma. Six samples dated by J.G. Arth (U.S. Geological Survey, Menlo Park, Calif.) gave a Rb/Sr whole-rock isochron age of 432±8 Ma. Zircon from two samples of Austell Gneiss were prepared by size and magnetic properties into nine "splits" and dated by the Pb-U-Th method by J.L. Wooden (U.S. Geological Survey, Menlo Park, Calif.). We therefore interpret the age of the Austell to be about 430 Ma, which is the time of crystallization of the granitic magma (Higgins and others, 1997).

The Austell Gneiss intrudes the Bill Arp Formation and the Gothards Creek Gneiss. Austell Gneiss can be seen intruding schist and metagraywacke of the Bill Arp Formation in lit-par-lit fashion at their contact along the northern fork of

Little Bear Creek, in the Campbellton, Ga., 7.5-minute quadrangle. Xenoliths of Bill Arp Formation schist in Austell Gneiss can be seen in the roadcut along the left side of the east-bound lanes of Interstate 20, approximately 3.5 km west of the juncture of Interstate 20 with Georgia Highway 5. The contact between the Austell Gneiss and the Gothards Creek Gneiss west and northwest of Austell, Ga., is a mixed zone of strongly deformed, layered Gothards Creek Gneiss intruded in a lit-par-lit fashion by Austell Gneiss; this lit-par-lit intrusion can be seen in a pavement outcrop on the south bank of Sweetwater Creek, about 60 m west of U.S. Highway 278 (Camp Creek Parkway) in the Austell, Ga., 7.5-min quadrangle (Higgins, unpub. data). So, the Bill Arp Formation and Gothards Creek Gneiss must be older than the Austell Gneiss and, therefore, as old or older than Early Silurian. Moreover, if the Austell Gneiss intruded the fault(s) that carried the allochthonous assemblage and placed it upon the parautochthonous assemblage, as appears to be the case, then the allochthonous assemblage and the fault(s) at its base must be older than Early Silurian. Because the Gothards Creek Gneiss is completely bounded by faults, it is unknown whether it belongs to the allochthonous or parautochthonous assemblage. One interpretation permitted by the present evidence is that the Gothards Creek is sheared and recrystallized basement gneiss because it is rich in biotite and, because of its structural position above the Bill Arp Formation, is the same as that of the pods of Corbin Metagranite in the Mulberry Rock structure (fig. 2). Therefore, the Gothards Creek is tentatively assigned an age of Middle Proterozoic(?) to Early Silurian(?).

The Austell Gneiss is truncated along its southeastern side by the Chattahoochee fault (Medlin and Crawford, 1973; Hurst, 1973) at the northwestern edge of the Brevard fault zone, along its northeastern side by the Olley Creek fault, and along its northern side by faults of the Oak Mountain fault zone. The Chattahoochee fault bounds the southeastern side of the Olley Creek fault zone (German, 1985, p. 15) which is bounded on the northwest by the Olley Creek fault (named for Olley Creek, which it follows for several kilometers), and we propose the name Olley Creek fault zone for the whole zone of fault rocks. Kinematic indicators, although sparse (outcrops are also sparse in the highly urbanized area of the fault zone), indicate that the Olley Creek fault zone is a dextral strike-slip fault zone. Because the strike-slip faults cut the Early Silurian Austell Gneiss, some of the strike-slip faulting must be younger than Early Silurian, but earlier strike-slip faulting is not precluded and the early thrusting may have accompanied early strike-slip faulting.

The major metamorphic event that produced the Austell Gneiss must have taken place during and (or) after the Early Silurian. The foliation in the Austell Gneiss is defined by aligned potassium-feldspar megacrysts and biotite laths and by elongated quartz domains and is the same foliation as that in the parautochthonous assemblage country rocks. Therefore, this foliation and the early folds and wrench folds, both of which fold the Austell Gneiss foliation, must be younger than the Early Silurian Austell Gneiss. However, the parautochthonous assemblage foliation may not be the same foliation as the isocline-bearing foliation in the allochthonous assemblage, although it is likely that it is the same. The allochthonous assemblage foliation may be older than the parautochthonous assemblage foliation, but this is indeterminate because the allochthonous assemblage is everywhere in fault contact with the parautochthonous assemblage. Nevertheless, the time of metamorphism of the Austell Gneiss is probably also the time of metamorphism of the Corbin Metagranite (see below).

Carboniferous Ben Hill and Palmetto Granites

The Ben Hill and Palmetto Granites, which have been tentatively dated by Stern (unpub. data) as Carboniferous (about 325 Ma), lack foliation except near the Rivertown fault at the southeastern edge of the Brevard fault zone. The granites are interpreted to have been intruded during strike-slip faulting because they occur as retort-shaped plutons having "tails" that extend to the northeast along the Rivertown fault (Higgins and Atkins, 1981; Higgins and others, in press); their shapes are interpreted to be the result of an en echelon folding in the sense of Wilcox and others (1973) and Dibblee (1977) during dextral movement along the zone (Higgins and Atkins, 1981; Vauchez, 1987).

Stratigraphic Nomenclature

Stratigraphic nomenclature in this report follows the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature, 1983). The nomenclature established here concentrates on the Atlanta, Athens, and Cartersville 30'X60' quadrangles as well as contiguous areas of the Georgia Piedmont-Blue Ridge.

Contacts and Thicknesses

The North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature, 1983) emphasizes the desirability of detailed descriptions of contact relations when naming or revising stratigraphic units. However, a paradigm of Southern Appalachian geology is that contacts are seldom seen. If no mention is made of contact relations, then the reader may assume that the contact is generally unexposed and cryptic.

The North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature, 1983) emphasizes the desirability of giving thicknesses of units when naming them. However, thicknesses are meaningless in metamorphic rocks that have been folded several times (at least once isoclinally), or have experienced thrust or strike-slip faulting so that many outcrop areas of a formation are fault slices.

Thicknesses of the quartzites in the Sandy Springs Group, for example, vary from less than half a meter to several hundred meters. The thickness variation is due to 1) thickening in the apical regions of folds and thinning in the limbs of folds, especially isoclinal folds; 2) thickening due to isoclinal folds that lie within the foliation; 3) probable original differences in thicknesses of individual quartzite bodies; 4) probable original lensoidal shape of most of the quartzite bodies; 5) possible thickening due to thrust faulting within the quartzite and to overthrust doubling, tripling, and so on, of quartzite bodies; and 6) thinning due to attenuation during faulting. Therefore, we only give thickness estimates where we feel they have some meaning.

Lithologic Nomenclature

In this report, we use the fault-rock terminology of Higgins (1971), as modified by Sibson (1977), Berthé and others (1979), Lister and Snoke (1984), Simpson (1986), and Tanaka (1992). Mélange is a nongenetic term for a body of rock characterized by the inclusion of fragments, and (or) blocks, and (or) slabs, native and (or) exotic in a matrix; this usage follows that of Greenly (1919), Berkland and others (1972, p. 2296), and Bates and Jackson (1980, p. 388; 1987, p. 404).

Acknowledgments

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PARAUTOCHTHONOUS CONTINENTAL-MARGIN ASSEMBLAGE

The stratigraphically lowest assemblage of rocks in the Piedmont-Blue Ridge in northern Georgia is the parautochthonous assemblage of Laurentian continental-margin rocks. This assemblage includes the Appalachian basement, consisting of Middle(?) to Late Proterozoic metagranites, Middle(?) Proterozoic and (or) older metasedimentary, metavolcanic, and metaplutonic rocks intruded by the Middle(?) to Late Proterozoic metagranites; and the cover sequence over the basement, consisting of Early Cambrian(?) to Early Ordovician(?) metasedimentary rocks derived from and deposited unconformably upon the basement rocks. Many of the cover-sequence rocks have previously been assigned to or correlated with the Ocoee Supergroup. We assign rocks of the Chilhowee Group ages of Early Cambrian(?) and Early Cambrian. Trace fossils in the Pinelog Formation on Henderson Mountain, west of Jasper, Ga., suggest an age of Early Cambrian (Martin and Crawford, 1996). However, there is little evidence of the age of most of these rocks. For example, some of the rocks that had previously been mapped as Early Cambrian Weisner Quartzite (Butts, 1926; Butts and Gildersleeve, 1948) were shown by Cressler (1970) to be Devonian Frog Mountain Sandstone. Because of the doubts about the Weisner, and the difficulty of identifying it without fossils, Cressler (1970; Cressler and Crawford, in Cressler and others, 1979) mapped the quartzites in the Cartersville area that had previously been mapped as Weisner as Chilhowee Group divided into a shale and phyllite facies with quartzite and a quartzite facies with shale and phyllite. We follow the assignment of these rocks to the Chilhowee Group, but we also accept their assignment to the Weisner and Wilson Ridge Formations, following Mack (1980). Moreover, we have mapped the rocks to the east that Crawford (Cressler and Crawford, in Cressler and others, 1979) mapped as belonging to the Ocoee Supergroup rocks as belonging instead to the Chilhowee Group because they differ from some of the rocks he mapped as

Chilhowee only in metamorphic grade (Higgins and others, 1996). These rocks are assigned to the Early Cambrian(?) and Early Cambrian Pinelog Formation. More detailed study of their sedimentary characteristics will probably show that they are metamorphosed correlatives of, or belong to, the Cochran, Nichols, and Wilson Ridge Formations, as described by Mack (1980), with the bulk of the Pinelog being, or being equivalent to, the Cochran Formation (Higgins and others, 1996).

In the Atlanta and Cartersville 30'X60' quadrangles and adjacent areas, the basement rocks of the Allatoona Complex basement consist of the Corbin Metagranite and rocks intruded by the Corbin. Rocks intruded by the Corbin are the Rowland Spring Formation (named below) and the Red Top Mountain Formation (name revised below).

The cover sequence over the Allatoona Complex consists of (generally in ascending order) the following units: 1) the Chilhowee Group, which includes the Pinelog Formation and its more distal "tidal flat-beach-barrier island" facies, the Weisner Formation (Mack, 1980, p. 512–513), the Crawfish Creek Formation (named below), and the Nantahala Formation with its Laffingal Member (named below), which generally overlies the Pinelog Formation, but in many places rests directly upon the basement in place of the Pinelog Formation; 2) the Sweetwater Creek and Illinois Creek Formations, which lie between the Nantahala Formation of the Chilhowee Group and the Bill Arp Formation in many places; 3) the Bill Arp Formation, which overlies the Nantahala Formation where the Sweetwater Creek and Illinois Creek Formations are absent, and is composed of metapelite (phyllite and schist) and metagraywacke; 4) the informally named schist of Hulett, which is interpreted to belong to the Bill Arp Formation and to lie between the phyllite and schist and metagraywacke of the undivided Bill Arp Formation and the underlying Sweetwater Creek Formation; and 5) the unnamed northern facies of the Bill Arp Formation (Higgins and others, 1996), consisting of metapelite (phyllite and schist) and metagraywacke that contains amphibolite and scattered pods of meta-ultramafic rocks. The Bill Arp and its unnamed amphibolite- and meta-ultramafic-bearing northern facies are interpreted to be slope-rise deposits. All of these rocks must be younger than the basement because they overlie the basement unconformably and (or) contain blue quartz granules or pebbles and microcline granules or pebbles derived from the Corbin Metagranite and, locally and rarely, pebbles, cobbles, or boulders of the Corbin. Also included in the cover sequence is the Sandy Springs Group which, as revised in this report, includes an unnamed aluminous schist unit, an unnamed garnetiferous schist unit, and the Chattahoochee Palisades Quartzite. Neither rock fragments nor blue quartz and potassium-feldspar fragments derived from the basement have been found in these rocks, but zircons from the Chattahoochee Palisades Quartzite east of Atlanta have yielded a bulk zircon sample age of about 1.1 Ga, indicative of a basement source.

Middle(?) to Late Proterozoic Corbin Metagranite

Hayes (1901) named the Corbin Granite for the crossroads of Corbin, on Georgia Highway 20 in the Allatoona Dam 7.5-min quadrangle (fig. 2). The Corbin consists of coarse-grained megacrystic granite that intrudes older metasedimentary and metaigneous rocks of the Rowland Spring Formation in the area now around Allatoona Lake,

In his description of the Cartersville mining district, La Forge (1919, p. 40) stated,

> Nearly half of the Piedmont Plateau part of the district is occupied by a crushed, sheared, and altered granite to which Hayes gave the name Corbin granite. It is typically a coarsely porphyritic augite-biotite granite, most of which has been so much sheared that it is now characteristically an augen gneiss. In places it displays a fine-grained, non-porphyritic phase which has suffered less from crushing than the porphyritic rock and in other places has been so greatly crushed that it is altered into biotite-sericite schist without a semblance of the original rock. It is believed to be of Archean age, as it is manifestly one of the oldest formations of the region and has furnished much of the material for the overlying metamorphosed sediments.
>
> The granite is overlain and nearly surrounded by a conglomerate gneiss that Hayes called the Pinelog conglomerate. This is a rather heterogeneous formation composed of conglomerate, arkose, quartzite, siliceous phyllite, and graphitic slate, all much sheared and largely altered to sericitic schist and gneiss. Its base is in places an arkose, composed chiefly of granitic debris of all degrees of coarseness from sand to boulders. Much of this arkose

is composed wholly of granitic material and shows little evidence of transportation and sorting. In such places it is believed to be a sedimentary arkose formed by the reconsolidation of the debris derived from the weathering and disintegration, without much washing about, of an anciently exposed surface of the granite.

> The conglomerate is overlain, along most of its west side, by interbedded graphitic slate and sericitic schist that Hayes regarded as a distinct formation, equivalent to his Wilhite slate of Tennessee. He also believed that this slate and conglomerate beneath are distinct from the quartzite he regarded as the lowest Cambrian formation and are separated from that formation by a great thrust fault. More recent field work, however, has thrown doubt on the existence of a great regional fault along the contact of these formations. It now seems not improbable that the slate and conglomerate conformably underlie the quartzite and constitute the base of the Cambrian strata and that the whole section from the basal arkose to the top of the quartzite is equivalent to Safford's Chilhowee group of Tennessee.

Hayes (1895, 1901) and La Forge (1919) described the Corbin as a granite, rather than a metamorphic rock. Kesler (1950) followed Hayes' usage and called the rock the Corbin granite. Bentley and others (1966, p. 3) referred to the Corbin as "the granite," and as "Corbin gneiss." Morgan (1966, p. 26) stated, "The Corbin gneiss is a coarse-grained, sheared rock with exceptionally large porphyroclasts of white microcline, coarse-grained, blue quartz; and a fine grained, highly sheared matrix consisting of these minerals as well as biotite, muscovite, garnet, and others. Banding in the rocks, defined by stringers and segregations of blue quartz, is usually either weakly present or entirely absent." The outcrops Morgan described are at Cooper Branch Landing, about 0.8 km north of Allatoona Dam. We have mapped these rocks as part of the massive phase of Corbin Metagranite, but the massive phase is cut by innumerable shear zones. The appearance of the massive unfoliated phase of the Corbin Metagranite caused Hadley (1970, fig. 1) to consider the Corbin to be a "Paleozoic intrusive." Cressler and Crawford (in Cressler and others, 1979) called the unit Corbin Granite. Costello (1978) and McConnell and Costello (1980, p. 246–247) called the unit Corbin gneiss and McConnell and Costello (1984, p. 267) proposed changing the name of the Corbin Granite to Corbin Gneiss Complex, referring to their earlier publication (McConnell and Costello, 1980, p. 246) in which they stated, "The Corbin gneiss (Corbin Granite of Hayes, 1900 [1901]) is a complex association of ortho- and paragneisses." Higgins and others (1988, p. 125–126) followed McConnell and Costello (1984) and stated,

> McConnell and Costello (1984) suggested calling these rocks the Corbin Gneiss Complex to accentuate the lithologic variability of what had previously been called Corbin Gneiss. Their suggestion was good one, but they apparently included in their complex the basement schists that have been intruded by the plutonic rocks that had previously been called Corbin Gneiss. This inclusion is proper for the basement complex, which must include the Grenville-age or older country rocks that have been intruded by the plutonic gneisses, but it allows confusion between the names Corbin Gneiss and Corbin Gneiss Complex. We, therefore, propose that the name Corbin Gneiss be retained for the metaplutonic rocks in the basement complex east and northeast of Cartersville, whereas we propose that the entire assemblage of rocks in the basement complex in northern Georgia be called the Allatoona Complex.

However, detailed geologic mapping of the Allatoona Dam 7.5-min quadrangle has shown that the lithologic variability in the massive phase of the Corbin Metagranite is due to variable shearing and mylonitization and that in many areas the massive phase of the Corbin has no perceptible foliation, is only very rarely layered (see quote from Morgan, 1966, above) and therefore rarely a gneiss, and is best described as metagranite. Therefore, we here revise the name from Corbin Gneiss to Corbin Metagranite, modifying slightly the original usage by Hayes (1901). The Corbin Metagranite also includes a small outcrop area of finer grained, mica-poor quartz-feldspar rock that generally lacks foliation, a large area underlain by rocks intermediate between the mica-poor rocks and the massive megacrystic Corbin, and a mappable biotite-rich sheared phase that ranges from mylonite gneiss to mylonite schist and phyllonite. As recognized by La Forge (1919, p. 40) and Costello (1978), the final product of shearing of the Corbin Metagranite is a biotite-sericite schist or phyllonite.

Several authors have cited the presence of pyroxene in the Corbin Metagranite as evidence for pyroxene-granulite facies metamorphism. La Forge (1919) described the Corbin as an augite-biotite granite following Watson (1908), who stated (p. 41), "The granite is a coarse-grained porphyritic rock presenting a distinct augen-gneiss facies in the border portion. It is composed of large microcline phenocrysts, embedded in a ground-mass of blue quartz, plagioclase, augite and mica." Watson (1908, p. 42) presented a chemical analysis and petrographic description of granite samples from "one mile east of Rowland," by A.H. Brooks, stating,

> Mr. Brooks has given the following petrographic data on the granite from this locality: 'Contains microcline, some plagioclase, abundant pyroxene partly altered into chiefly uralite and chlorite, some biotite with frequent inclusions of rutile, much blue vitreous quartz, apatite, zircon and magnetite.'

The rock analyzed and described was probably from the large outcrop of high-grade metamorphosed mafic rocks of the Red Top Mountain Formation located about a mile east of Rowland Spring in the Allatoona Dam, Ga., 7.5-min quadrangle (Higgins and others, unpub. data). We have mapped the Allatoona Dam and South Canton, Ga., 7.5-min quadrangles in detail and have not found augite anywhere in any phase of the Corbin Metagranite; nor did Martin (1974) who studied the petrography of the Corbin. Pyroxene is only present in the Rowland Spring (Kath and Higgins, 1996) and Red Top Mountain Formations (Higgins and others, unpub. data) that have been intruded by the Corbin Metagranite; this includes a phase of the Red Top Mountain that has been "granitized" by the Corbin to form altered metamorphosed mafic rocks with "porphyroblasts" of potassium-feldspar and a composition much like that described by Brooks (Watson, 1908, p. 42—see quote above). The Rowland Spring and Red Top Mountain Formations were probably metamorphosed to pyroxene-granulite grade before being intruded by the Corbin, but metamorphism of the Corbin probably took place much later during the Paleozoic and was at much lower grade. The metamorphic grade of the Corbin Metagranite in the Corbin massif is probably the same as that of its low-grade cover rocks, and is therefore a "retrogressive metamorphism" of its high-grade igneous minerals. The Corbin intruded granulite-facies rocks, but was probably not itself metamorphosed until the Paleozoic.

Dallmeyer's (1975, p. 1740–1743) conclusion that the "undisturbed $^{40}Ar/^{39}Ar$ release spectra with total-gas ages of 735 Ma and 732 Ma, both ±15 Ma from biotite in the Corbin date the time of cooling below temperatures required for argon retention following Grenville metamorphism" is probably not correct. The length of time between the end of Grenville metamorphism, generally placed at about 1 Ga (Bartholomew, 1984, p. v–vii), and the maximum age of 750 Ma (735±15 Ma), is equal to nearly half the length of the Paleozoic, during which there were supposedly several orogenies, and seems too long to have maintained temperatures above biotite grade. Secondly, as outlined above, the Corbin Metagranite in the Corbin massif was probably not metamorphosed during Grenville pyroxene-granulite facies metamorphism, but during a much lower grade Paleozoic metamorphic event at the same time its cover rocks were metamorphosed. This was probably either at the same time as or after crystallization of the Austell Gneiss in the Early Silurian (see above). The Corbin has crosscutting intrusive relations to the Rowland Spring Formation, which does appear to have been metamorphosed under pyroxene-granulite facies conditions. The contact between the Corbin and the Red Top Mountain Formation is a shear zone in many places, but in roadcuts along Vulcan Materials Company's new quarry road, the Corbin can be seen to have intruded the Red Top Mountain. That the original contact was everywhere intrusive is supported by the following observations: 1) the Red Top Mountain Formation occurs as many bodies with a wide range of sizes, surrounded by Corbin Metagranite; 2) in some of the bodies, the Red Top Mountain appears to have had its mafic constituents converted or partly converted to biotite and hornblende and to have grown porphyroblasts of plagioclase feldspar; and 3) in the area of the Corbin massif, neither the cover sequence nor the allochthonous assemblage includes rocks similar to the Red Top Mountain Formation. The Red Top Mountain is generally poorly foliated except within a meter or so of its contact with the Corbin.

In 1994, before vegetation covered the roadcuts, the Red Top Mountain could be seen to intrude the Rowland Spring Formation along the new road from Georgia Highway 20 to Vulcan Materials Company's new quarry just north of Allatoona Lake in the Allatoona Dam 7.5-min quadrangle, although the contact between the two is also faulted in some of these exposures. Cuts along the quarry road also showed that the Corbin intruded the Rowland Spring Formation. The Corbin can also be seen intruding the Rowland Spring along the lakeshore west of Bethany Bridge near Red Top Mountain State Park in the Allatoona Dam quadrangle (Higgins and others, 1996, p. 18–19, pl. 2), and in many other places.

The metamorphic grade of the Corbin is probably no higher than garnet grade and is probably as low as greenschist facies. During the same Paleozoic metamorphic event that metamorphosed the Corbin, the older Red Top Mountain Formation, which was intruded by the Corbin, had its pyroxenes partly uralitized and chloritized, as described by Brooks (p. 42 in Watson, 1908—see quote above).

Important questions are as follows: 1) How old is the Corbin and when did the event that metamorphosed the Corbin take place? Is the metamorphism dated as during or younger than the Early Silurian by the age of the Austell Gneiss? Is the Corbin dated by ages obtained from bulk samples or zircons analyzed by Odom and others (1973) and by Stern (unpub. data) that can be interpreted to indicate an age of about 1.1 to 1 Ga? Or were the zircon ages obtained forced to appear too old by the presence of older inherited detrital zircons? As recognized by Morgan (1966, p. 27), rounded zircons are common in the Corbin and may once have been detrital grains. 2) If the Corbin is younger than 1 Ga, is it roughly dated by the ~735±15 Ma $^{40}Ar/^{39}Ar$ release spectra total-gas ages of biotite obtained by Dallmeyer (1975)? This could only be true if the later Paleozoic metamorphism of the Corbin and its cover rocks never reached high enough temperatures to reset biotite. On the other hand, if the Corbin is older than ~735±15 Ma, the biotites may have been partly reset to that age during the Paleozoic metamorphism. Not enough data are available to answer most of these questions. However, the Corbin, whatever its age, must be younger than the high-grade metamorphic rocks it intruded; so, if the Corbin is ~1 Ga, then the Red Top Mountain and Rowland Spring Formations must be older.

Age Changed

We tentatively assign the Corbin Metagranite an age of Middle(?) to Late Proterozoic; the intruded Red Top Mountain and Rowland Spring Formations are assigned an age of Middle(?) Proterozoic; the lower part of the cover sequence that we interpret to belong to the Chilhowee Group is assigned an age of Early Cambrian(?) and Early Cambrian; and the units above the Chilhowee Group rocks are assigned ages of Cambrian and Cambrian to Early Ordovician(?). More detailed radiometric dating of fractions of zircon populations from the Corbin Metagranite Rb-Sr dating of whole rocks and biotite from the Corbin, and Rb-Sr and $^{40}Ar/^{39}Ar$ dating of muscovite and whole-rock samples from rocks of the cover sequence is needed before more definitive age assignments can be made.

Rowland Spring Formation, Allatoona Complex, Named

Around the shore of Allatoona Lake and in the area north and northeast of the lake in the Allatoona Dam, Ga., 7.5-min quadrangle, the Corbin Metagranite contains large xenoliths and (or) roof pendants of a unit of gneiss and granofels of probable metavolcanic origin that was metamorphosed to pyroxene-granulite grade during Grenville metamorphism. This unit of high-grade gneiss and granofels is here named the Rowland Spring Formation for Rowland Spring Branch, which cuts through one of the formation's largest outcrop areas in the Allatoona Dam quadrangle (fig. 3). The type section is designated as the fresh road cuts along the quarry road to Vulcan Material Company's new quarry from approximately 135 m to approximately 595 m south of the juncture of that road with Georgia Highway 20 in the Allatoona Dam, Ga., 7.5-min quadrangle (fig. 3).

The Rowland Spring is a streaky, gray to tan to greenish-gray gneiss and granofels. It commonly and characteristically contains clots of red and purplish-red garnet, generally 2 to 3 cm in diameter, but as large as 5 cm in diameter, and small crystals (<1 mm) of graphite. Dark-green pyroxene and red to red-brown biotite can be seen in hand samples and most rocks in the unit can be described as pyroxene-graphite-biotite-garnet-quartz-feldspar gneiss or granofels. In most outcrops, the gneiss and granofels contain elliptical lenses of fine-grained mafic rocks with diabasic texture in hand samples that are commonly zoned and were probably concretions. The gneiss and granofels of the Rowland Spring Formation weathers to a chalky, mostly foliation free, quartz-poor saprolite with red clots of weathered garnet and with crystals of graphite. Because it has only been mapped as xenoliths and (or) roof pendants in Corbin Metagranite, the thickness of the Rowland Spring Formation is unknown. Its stratigraphic

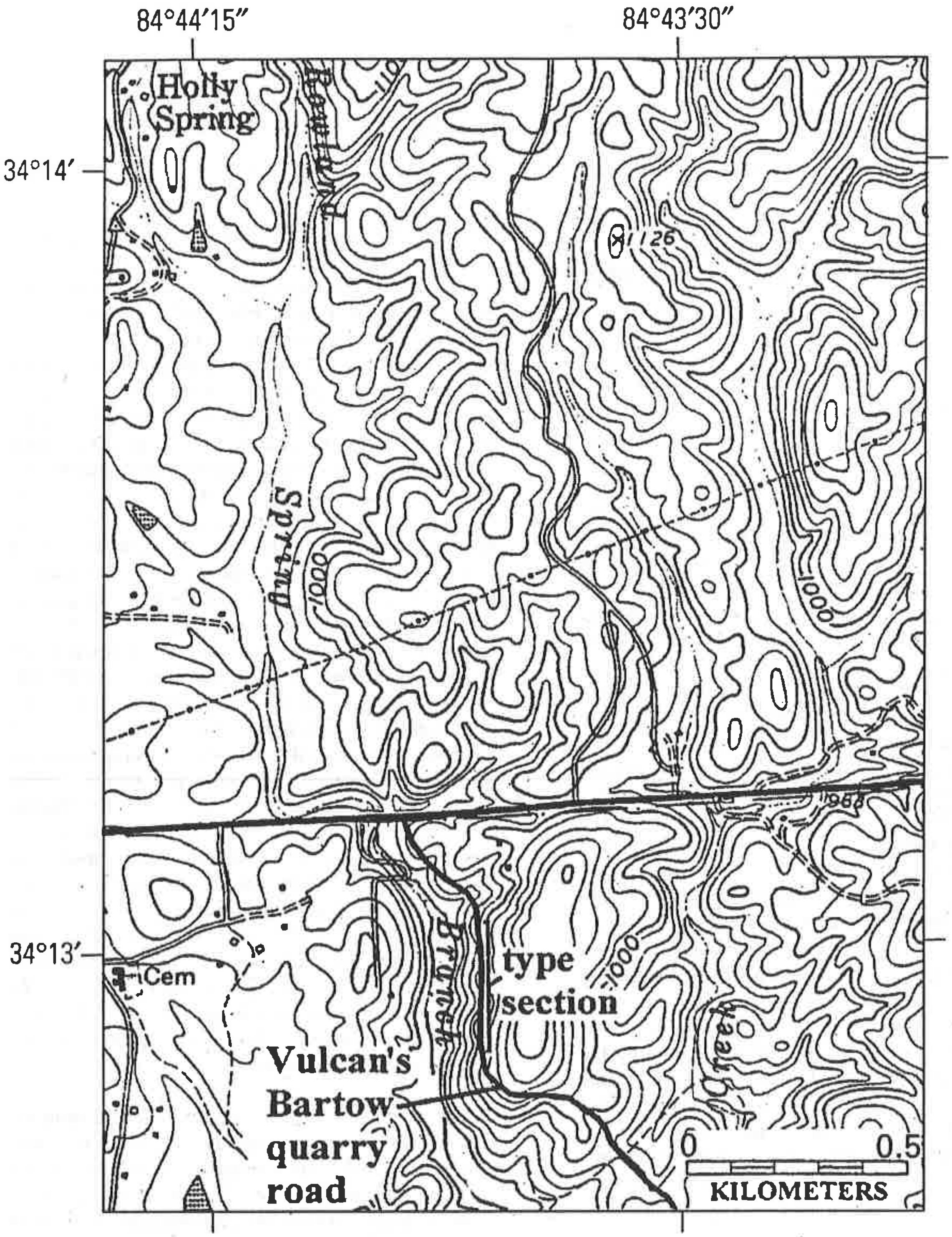

Figure 3: Topographic map of part of the Allatoona Dam, Ga., 7.5-min quadrangle showing the type locality (Rowland Spring Branch) and type section of the Rowland Spring Formation.

placement is also unknown. It is intruded by the Corbin Metagranite and by the Red Top Mountain Formation, so it must be one of the oldest rock units in Georgia. We here assign the Rowland Spring Formation an age of Middle(?) Proterozoic, recognizing that it could be even older than Middle Proterozoic.

Red Top Mountain Formation, Allatoona Complex, Revised

Based on the unpublished mapping of T.J. Crawford and on the work of Costello (1978) and McConnell and Costello (1980), Higgins and others (1988) named small bodies of rock surrounded by Corbin Metagranite along the shore of Allatoona Lake the Red Top Mountain Schist and suggested that it is an older rock intruded by the Corbin. Detailed mapping in the Allatoona Dam, Ga., quadrangle during 1993-1994 has shown that the rocks we earlier assigned to the Red Top Mountain Schist are intruded by the Corbin, but are not schist except where they are sheared. The most prevalent rocks exposed in Red Top Mountain State Park and on the peninsula into Allatoona Lake north of the park, and the rock that weathers to the dark-red soil that gives Red Top Mountain and the park their names, is a high-grade metamorphosed mafic metaigneous rock intruded by the Corbin Metagranite and exposed as xenoliths and roof pendants. Because it occurs as xenoliths and roof pendants in the Corbin Metagranite, its stratigraphic position and thickness are unknown. The Red Top Mountain intruded the Rowland Spring Formation and was intruded by the Corbin Metagranite. Therefore, we change the name Red Top Mountain Schist to Red Top Mountain Formation and tentatively assign it an age of Middle(?) Proterozoic because it must be older than the Middle(?) to Late Proterozoic Corbin Metagranite.

Cover Sequence

The cover sequence above the Allatoona Complex in northern Georgia consists of rocks of the Chilhowee Group, including the Crawfish Creek Formation (named below), the Pinelog Formation, and the Nantahala Formation and its Laffingal Member (named below); and the rocks overlying the Chilhowee Group, including the Sweetwater and Illinois Creek Formations (accepted below), and the Bill Arp Formation and its informal schist of Hulett (named below).

Pinelog Formation, Chilhowee Group

The Pinelog Formation is a coarse-grained, relatively clean quartzite composed chiefly of clear and milky quartz grains, but containing blue quartz grains like those in the Corbin, and minor amounts of microcline in granules and pebbles large enough to have been derived from the microcline in the Corbin. In addition, the Pinelog contains lenses of quartz-granule and quartz-pebble metaconglomerate composed mostly of clear and milky quartz granules and pebbles but also containing blue quartz and microcline granules and pebbles, and rare pebbles of Corbin Metagranite. Locally within the metaconglomerates in the Pinelog, there are tabular pebbles of graphitic pelite like that of the Nantahala Formation and similar to the tabular graphitic pebbles in the Sweetwater Creek Formation; locally, there are lenses of graphitic pelite within the quartzites and metaconglomerates. In many outcrops, the quartzites and metaconglomerates of the Pinelog are crossbedded. Quartzites of the Pinelog Formation contain trace fossils that suggest an Early Cambrian age for the formation (Martin and others, 1996). Metaconglomerates and quartzites of the Pinelog Formation can be seen directly overlying Corbin Metagranite along the unnamed road across The Basin near the western margin of The Basin in the Ludville, Ga., 7.5-minute quadrangle. The contact between the Corbin and the quartzites and metaconglomerates of the Pinelog Formation is interpreted to be an unconformity and to be stratigraphic in these outcrops. In other places, it may be either an unconformity or an unconformity that has been thrust faulted.

The Pinelog Formation is here removed from the Ocoee Supergroup and its age changed to Early Cambrian(?) and Early Cambrian. In the Cartersville 30'X60' quadrangle, the Corbin Metagranite is overlain in some places by the Nantahala Formation and in others by low-grade quartzite and metaconglomerate of the Pinelog Formation. Hayes (1895, 1901) first used the name Pinelog conglomerate; it was also described by La Forge (1919, p. 40–41—see above). As recognized by Hayes (1901, p. 406), the Pinelog Formation is composed of debris weathered from the Corbin Metagranite. Like the metaconglomerate lenses in the Nantahala Formation, the metaconglomerate lenses in the Pinelog Formation contain microcline and blue quartz granules and pebbles that are identical to the microcline megacrysts and blue quartz grains in the Corbin Metagranite and, rarely, but importantly, pebbles and cobbles of Corbin Metagranite. Moreover, the Pinelog Formation quartzites contain lenses and thin layers of graphitic phyllite identical to the graphitic phyllite of the Nantahala Formation. Therefore, the metaconglomerate and graphitic phyllite lenses in the Pinelog link it to the Nantahala as well as to the Corbin and it is likely that the Nantahala and Pinelog Formations are partly facies of one another, with the Nantahala stratigraphically overlying the Pinelog in most of the Corbin massif.

Age and Reassignment

Hayes (1901) thought the Pinelog lay beneath his Wilhite Slate (the only context he had at the time) and was separated from the Cambrian rocks to the west by a great thrust fault. La Forge (1919, p. 40–41) thought "the whole section from the basal arkose to the top of the quartzite is equivalent to Safford's Chilhowee group of Tennessee." He was referring to the Pinelog Formation and the quartzite and quartzite and metapelite that we have mapped as part of the Chilhowee Group. Hadley (1970, fig. 1) depicted the rocks above the Corbin Metagranite (which he designated as a Paleozoic intrusive rock) as Walden Creek Group. McConnell and Costello (1984, p. 269) followed Hayes (1901) and Hadley (1970) and assigned the Pinelog Formation to the Snowbird Group of the Ocoee Supergroup and assigned rocks previously mapped as Nantahala Formation above it to the Wilhite Formation of the Walden Creek Group of the Ocoee Supergroup. Assignment to the Ocoee Supergroup was followed by Higgins and others (1988). The rocks we have shown to be the Nantahala Formation were called Nantahala Schist by Bayley (1928) and Nantahala Formation by Fairley (1965).

The age of the Pinelog Formation is unknown. However, as pointed out by Higgins and others (1989), the Pinelog is lithologically identical to parts of the sequences of Chilhowee Group rocks exposed on Chilhowee Mountain in Tennessee (Keith, 1895), as recognized by La Forge (1919). The Pinelog is in approximately the same structural position in the orogen, has the same relations to the same Lower Cambrian units in the Rome Valley to the west, and is gradational with the rocks Cressler (in Cressler and others, 1979) called Chilhowee Group west of Allatoona Dam. The Pinelog contains trace fossils that suggest an Early Cambrian age (Martin and others, 1996; Martin and Crawford, 1996). Therefore, following La Forge (1919) and Higgins and others (1989, 1996), we assign the Pinelog Formation to the Chilhowee Group and assign it an age of Early Cambrian(?) and Early Cambrian.

Thickness and Contacts

The thickness of the Pinelog Formation is undetermined because of lack of complete exposure and because of faulting; it must be at least 300 m thick, but could be as thick as 1000 m. In roadcuts near The Basin, in the Ludville, Ga., 7.5-min quadrangle, the Pinelog is unconformable upon the Corbin Metagranite, and McConnell and Costello (1984, p. 271) report the same relations at two other localities. The upper contact has not been observed, but is probably paraconformable. The presence of metaconglomerates in the Nantahala Formation that are identical to those in the lower part of the Pinelog support a stratigraphic contact. The Nantahala and Pinelog Formations may be partly facies equivalents so that the Nantahala may in places lie unconformably upon Corbin Metagranite. However, mylonitic textures are pervasive in rocks adjacent to the contacts between the Nantahala and the Corbin and between the Pinelog and the Nantahala and there may be no unfaulted contacts between these units.

Crawfish Creek Formation, Named, Assigned to Chilhowee Group

Underlying the Nantahala Formation in many places is the Crawfish Creek Formation, here named for Crawfish Creek in the Villa Rica, Ga., 7.5-min quadrangle (fig. 4) where the schist is exposed in and along the creek and along the hillsides above the creek. The type section is designated as the nearly continuous outcrops along Pool Road from its western intersection with Tyson Road to its eastern intersection with Tyson Road in the Villa Rica, Ga., 7.5-min quadrangle (fig. 5A).

Crawford and Medlin (1974) included the Crawfish Creek Formation in their Frolona Formation (abandoned below), along with rocks now assigned to the Nantahala, Sweetwater Creek, and Illinois Creek Formations, and the informal schist of Hulett of the Bill Arp Formation. Abrams and McConnell (1981, p. 63–64) recognized that the Sweetwater Creek and Illinois Creek Formations are separate from the Frolona Formation of Crawford and Medlin (1974), and proposed the name Andy Mountain Formation. However, the Andy Mountain

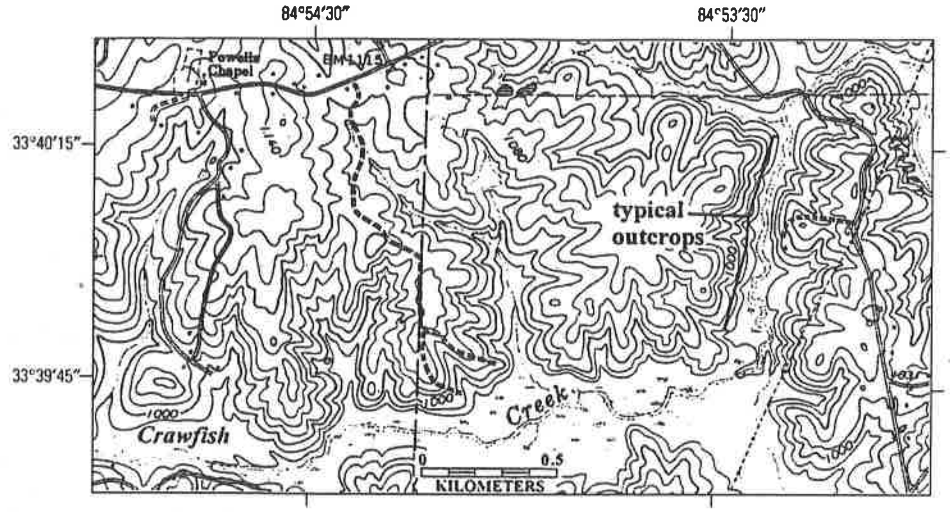

Figure 4: Topographic map of part of the Villa Rica, Ga., 7.5-min quadrangle showing the type locality and typical outcrops of the Crawfish Creek Formation.

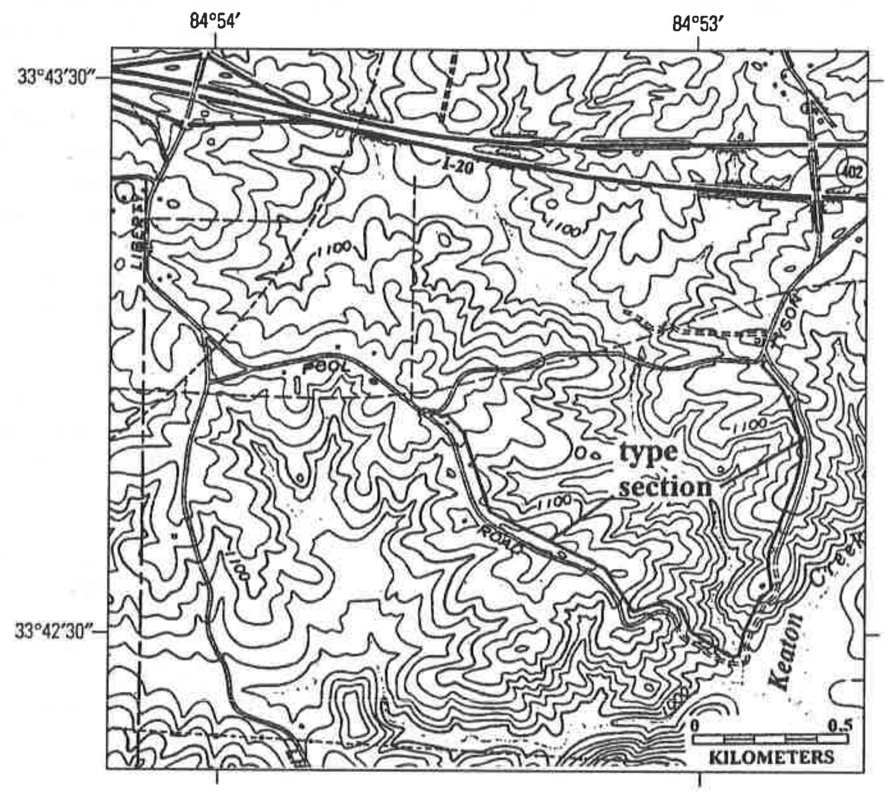

Figure 5A: Topographic map of part of the Villa Rica, Ga., 7.5-min quadrangle showing the type section of the Crawfish Creek Formation is underlain by the Nantahala Formation, which contains lenses of relatively clean quartzite and blue-quartz granule- and pebble-bearing metaconglomerate.

At the type locality, where it is at kyanite grade, and in other areas where it is at high metamorphic grade (staurolite, kyanite, or sillimanite), as in the Crawfish Creek and Mulberry Rock structures, the Crawfish Creek Formation is garnetiferous to very garnetiferous schist that contains numerous stringers and lenses as thick as several meters, but more commonly less than 2 m thick and, locally, mappable clean quartzites as much as tens of meters thick. Garnets in the Crawfish Creek Formation are commonly ~0.5 mm to ~1 cm in size, but locally are larger; in many outcrops, some of the garnets are elongated. Locally, garnets are so abundant that they cover the ground along unpaved roads and trails. In most places, the Crawfish Creek Formation contains small crystals of staurolite or kyanite; locally, these are abundant, and, less commonly, large. Garnetites are also locally common. The high-grade Crawfish Creek Formation is generally resistant to weathering and erosion because of the high quartz and garnet content and commonly holds up high, steep ridges.

Where the Crawfish Creek Formation is at lower metamorphic grade, as in the outcrop belt northwest of the Allatoona Dam fault and southwest of the Emerson fault in the Cartersville 30'X60' quadrangle (fig. 2) and in places along the Murphy marble belt duplex window (Higgins and others, 1996), it is a greenish and green-flecked, silver-gray phyllite that is commonly slightly to moderately calcareous and generally has many lumps, stringers, and veins of clear to milky quartz, and locally, mappable clean quartzites. The phyllite is intensely folded in most outcrops and roadcuts. Despite its calcareous nature, the low-grade Crawfish Creek is generally resistant to erosion, possibly because it also contains a fair percentage of quartz; it commonly holds up fairly high irregular hills with steep stream valleys. Typical outcrops of low-grade Crawfish Creek Formation can be seen along Georgia Highway 293 north of its northernmost crossing of Pumpkinvine Creek in the northwestern corner of the Acworth, Ga., 7.5-min quadrangle; about 450 m of long the highway at this location (fig. 5B) Crawfish Creek Formation is exposed in roadcuts. The stratigraphic placement of the Crawfish Creek Formation is based on circumstantial evidence and repetition of occurrences in stratigraphic or structural position. La Forge and Phalen (1913, p. 6; see quote in this report) included "a considerable thickness of banded garnetiferous and staurolitic quartz schists" in the basal part of the Nantahala Formation, but stated that the "basal beds" are best developed northeast of the Ellijay 15-min quadrangle, and are inconspicuous southeast of Cherrylog in that quadrangle. They considered the Crawfish Creek Formation to be at the base of the Nantahala Formation. High-grade garnetiferous, kyanite-bearing schist of the Crawfish Creek Formation underlies the graphitic Laffingal Member of the Nantahala Formation in the Crawfish Creek structure, where no basement has been found. In the Mulberry Rock structure (fig. 2), the Crawfish Creek directly overlies the Corbin Metagranite in nearly as many places as does the Laffingal Member. Between Allatoona Lake and U.S. Highway 41 in the Acworth 7.5-min quadrangle, about 30 to 300 m of calcareous, chloritic phyllite of the low-grade Crawfish Creek Formation structurally overlies the Laffingall Member and structurally underlies about 15 to 30 m of the calcareous, chloritic phyllite that is in turn overlain by muscovite phyllite and schist and sheared metagraywacke of the Bill Arp Formation. However, the contact between the northwestern outcrop belt of the Laffingal Member graphite phyllite and schist and the northwesternmost calcareous, chloritic phyllite and schist of the Crawfish Creek Formation is the North Canton high-angle fault (Costello, 1988; Higgins and others, 1996, p. 48), and the contact between the quartz-rich phyllite/schist and the southernmost outcrop belt of graphitic phyllite and schist of the Laffingal Member is probably a thrust fault; in fact, the base of the graphitic Laffingal Member nearly everywhere is a thrust fault. The structural succession (lowest to highest) would appear to be Nantahala Formation, chloritic phyllite and schist, quartzite, quartz-rich schist with layers and lenses of mylonitized quartzite, and quartzite. However, there is a small sliver of mylonitized Corbin Metagranite at the base of the second outcrop belt of Nantahala graphitic phyllite and schist and structurally above, quartz-rich schist about 91 m southwest of the power line southwest of Interstate 75, and slivers of mylonitized Corbin Metagranite along the southernmost contact of the quartz-rich schist to the northeast at several places.

We interpret the section given above to be overturned, with the stratigraphic section as follows (lowest to highest): mylonitized Corbin Metagranite; mylonitized, quartz-rich phyllite and schist grading up into quartzite (representing the Pinelog Formation); calcareous, chloritic phyllite and schist

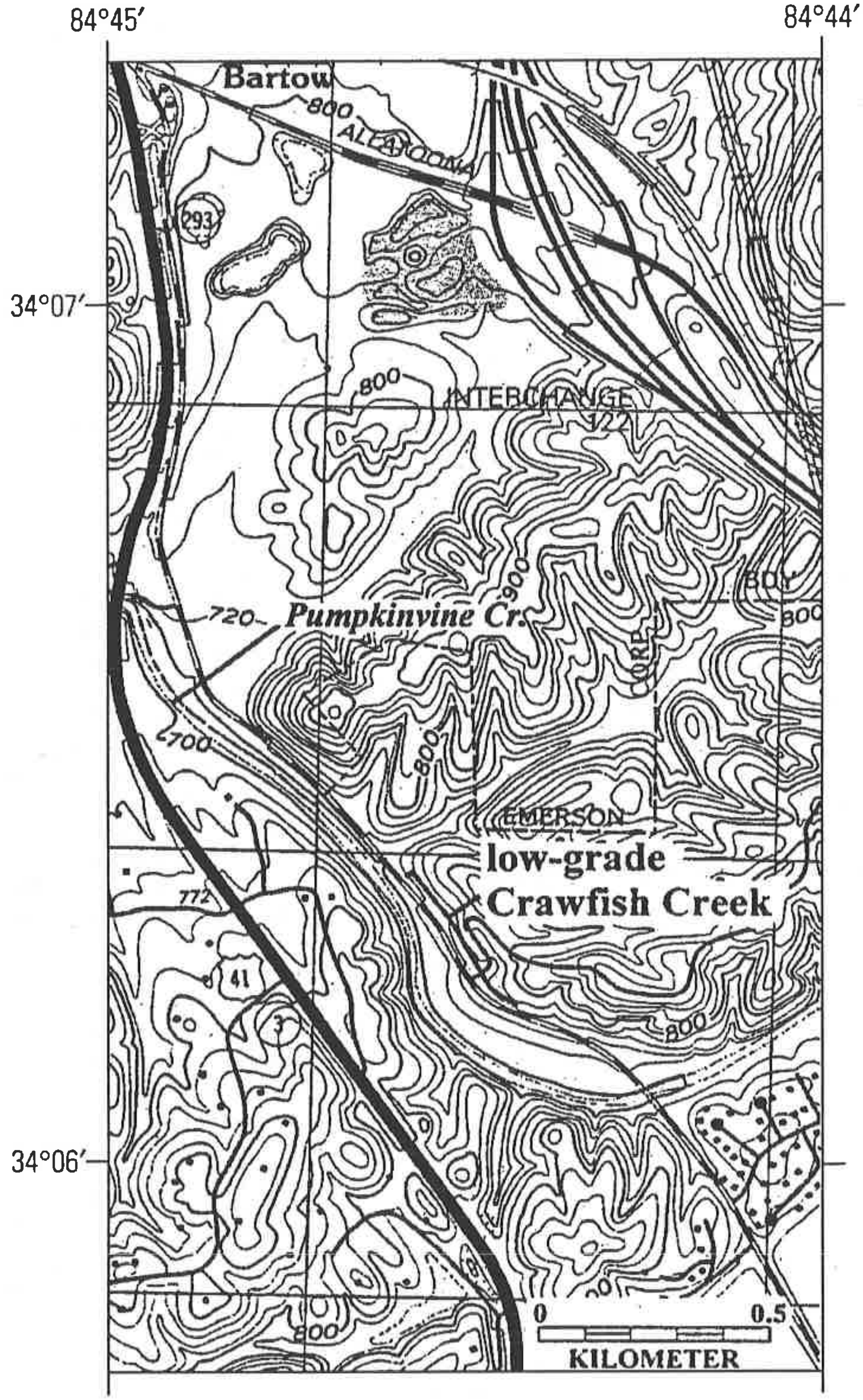

Figure 5B: Topographic map of part of the Acworth, Ga., 7.5-min quadrangle showing typical outcrops of low-grade Crawfish Creek Formation along Georgia Highway 293.

of the Crawfish Creek Formation; and graphitic phyllite and schist of the Laffingal Member. The chloritic phyllite and schist of the Crawfish Creek Formation along the stretch of the old road that parallels Georgia Highway 293 (Higgins and others, 1996, pl. 2) is structurally overlain by a sliver ~6 m long and ~2 m thick of dolomite (strongly resembling Shady Dolomite) that is structurally overlain by the quartzite and quartz-rich schist unit. A possible explanation is that the dolomite is a remnant of Shady Dolomite along the top of the overturned quartzite and quartzite-rich schist unit (which is probably equivalent to the Weisner Formation of the Chilhowee Group) and that the calcareous, chloritic phyllite and schist of the Crawfish Creek Formation is equivalent to part of the Pinelog Formation of the Chilhowee Group (Higgins and others, 1996, pl. 2). Therefore, we assign the Crawfish Creek Formation to the Chilhowee Group and suggest that it may be a facies of the Pinelog Formation, and perhaps equivalent to the tidal-flat deposits of the Wilson Ridge Formation (Mack, 1980, p. 512–513).

Northeastern Facies of the Bill Arp Formation

In western Georgia, the Bill Arp Formation is a clastic metapelite-metagraywacke unit that lacks amphibolite or other metavolcanic rocks, locally contains blue-quartz granules and microcline granules in its metagraywackes, contains ilmenite and is therefore high in titanium oxide like the Middle(?) to Late Proterozoic Corbin Metagranite, and lies structurally and probably stratigraphically above the Illinois Creek Formation in the Corbin massif, in the Mulberry Rock structure, in the Crawfish Creek structure, and in the Austell-Frolona anticlinorium (fig. 2). The Bill Arp Formation is considered part of the cover sequence over basement. However, like the Nantahala Formation (see above), the Bill Arp Formation changes facies in northern Georgia (fig. 2). North and east of the vicinity of Canton, Ga., the Bill Arp Formation contains lenses, pods, and layers of amphibolite; the percentage of amphibolite increases to the east and northeast, so that it is sparse in the Bill Arp near Canton, and accounts for a small percentage of rock in the formation 16 to 24 km northeast of Canton, whereas across strike, amphibolite constitutes a small percentage of the Bill Arp only a few miles east of Canton where the formation has been telescoped and repeated by thrust faulting. In addition, at about the same place the Bill Arp Formation starts to contain amphibolite, it also starts to contain pods and small lenses of metamorphosed ultramafic rocks, chiefly metapyroxenite, which, like the amphibolite, become more prevalent to the northeast along the regional strike and across regional strike to the southeast.

Nantahala Formation, Chilhowee Group

Keith (1907, p. 4) named the Nantahala Formation for outcrops along the Nantahala River in western North Carolina, in the Fontana Lake, N.C.-Tenn.-S.C.-Ga., 30'X60' quadrangle; he placed it with units of the Chilhowee Group. From its type locality to southeast of Tate, Ga., in the Cartersville, Ga., 30'X60' quadrangle, the Nantahala Formation is mostly at staurolite-grade and is mostly a (±staurolite)-(±garnet)-pyrite-graphite-muscovite-quartz-feldspar schist that is interbedded with thin feldspathic quartzites and commonly and characteristically contains thin lenses of orthoclase and blue quartz granule and pebble metaconglomerate. In many outcrops it can be called a rhythmite. We have mapped the Nantahala from the Cartersville quadrangle through the Dalton, Ga., 30'X60' quadrangle and into the type locality in the Fontana Lake quadrangle, so there is no doubt that the graphitic rocks in the Cartersville and Atlanta, Ga., 30'X60' quadrangles deserve the name Nantahala Formation.

As recognized by La Forge and Phalen (1913, p. 6), the Nantahala Formation undergoes a facies change south of Ellijay, Ga.:

> As far south as the neighborhood of Ellijay the Nantahala slate is composed principally of blackish or dark-gray banded clay slate containing considerable finely disseminated graphite and iron oxide, which give the rock its color. It contains a few thin beds of white or light-gray quartzite and, at its base, a considerable thickness of banded garnetiferous and staurolitic quartz schists. These basal beds are best developed farther northeast; they are inconspicuous south of Cherrylog. From Ellijay southward the formation is of somewhat different character, being chiefly graphitic schist with more or less staurolite throughout its thickness and containing few or no siliceous beds.

> Because of its uniform character throughout very thick beds and of the

homogeneity of its texture the Nantahala slate does not show deformation so extensive as that of the underlying formations. In the northern part of the quadrangle the amount of alteration it has undergone appears to be comparatively small, being confined to the formation of some metamorphic minerals. Farther south, with the increase in proportion of foliaceous minerals, schistosity has been strongly developed and the metamorphic minerals are more widely distributed.

Our mapping confirms the facies change described by La Forge and Phalen (1913), and we also find that the change that takes place south of Ellijay, Ga., also takes place across strike. From the Nantahala River to south of Ellijay, the easternmost outcrop belt of the Nantahala Formation is a rhythmite in most outcrops. Southeast of Tate, Ga., and west of Jasper, Ga., the facies change is complete. Between Ellijay and Tate, graphite content increases and the thin beds of feldspathic quartzite disappear over a strike distance of a few tens of kilometers until the Nantahala becomes a graphitic schist with quartzite and metaconglomerate lenses; feldspathic quartzite is again found in the Nantahala along the southern shore of Allatoona Lake in the Acworth, Ga., quadrangle, where it occurs as layers 15 to 46 cm thick. In the Corbin massif and on its flanks, in the northwesternmost outcrop belts, northwest of the Dahlonega fault zone, as far southwest as the Georgia-Alabama State Line, the Nantahala is a very graphitic schist that only rarely contains index minerals higher than garnet and in most places lacks garnet. In places, especially where highly sheared, the Laffingal Member of the Nantahala Formation contains so much graphite that it has been widely prospected for minable graphite. It is possible that the change in character of the Nantahala is due to a change in metamorphic grade and (or) to shearing. Nevertheless, it is a mappable distinction and although its stratigraphic position is the same, we believe this more schistose non-rhythmite facies of the Nantahala deserves a different name. This graphitic phase contains scattered metaconglomerate lenses composed of pebbles of blue, clear, and milky quartz and potassium feldspar.

The Laffingal Member of the Nantahala Formation, which directly, but probably structurally, overlies Corbin Metagranite in many places in the Corbin massif and in the Mulberry Rock structure, is a very dark gray to black, graphitic to very graphitic phyllite and schist that locally contains small garnets and commonly contains small pyrite cubes. The Laffingal also commonly contains lenses of blue-quartz- and microcline-granule-, pebble-, and locally, cobble-, and boulder-metaconglomerate identical to those in undivided Nantahala Formation and in the Pinelog Formation. Where it is not highly sheared, the graphitic phyllite and schist is interbedded and interlaminated with thin, fine-grained, iron-rich, quartzose beds and laminae like those of the undivided Nantahala Formation to the north and northeast. In most outcrops in the Atlanta and Cartersville, Ga., 30'X60' quadrangles, the Laffingal Member is sheared to button schist or buttony phyllite and its quartzose laminae have been mobilized into folded quartz lenses and stringers. The Nantahala button schist contains shear bands and would be classified as an S-C mylonite using the nomenclature of Berthé and others (1979) and Lister and Snoke (1984). However, the kinematics of the button schist have not yet been studied in detail, so the term button schist is used instead of S-C mylonite as suggested by Simpson (1986, p. 250). A wide outcrop belt of Nantahala button schist occurs around (over) the Corbin Metagranite in the Corbin massif in the Cartersville quadrangle. Offield and Higgins (1991) interpreted the repetition of the Nantahala on the flanks of the Corbin massif to be due to thrust faulting.

Laffingal Member, Named

We here name the graphitic phase of the Nantahala Formation the Laffingal Member for exposures around the crossroads of Laffingal (fig. 6), in the Allatoona Dam, Ga., 7.5-min quadrangle (Cartersville, Ga., 30'X60' quadrangle). The type section of the Laffingal Member is designated as those exposures along the unpaved road leading northeast from Laffingal (fig. 6) for approximately 750 m. The contact between the Nantahala and the Corbin Metagranite is interpreted to be nearly everywhere thrust faulted as it is in the few places it has been seen. The stratigraphic position of the Nantahala may be seen in roadcuts and outcrops along the road past Padgett Falls in the Jasper, Ga., 7.5-min quadrangle (Cartersville, Ga., 30'X60'quadrangle), where the Nantahala rests above the Pinelog Formation. Despite some shearing at the contact, we believe the Nantahala at this locality is in "parautochthonous" or paraconformable stratigraphic contact with the underlying Pinelog. The presence of metaconglomerates with blue quartz and feldspar derived from the Corbin Metagranite in both the

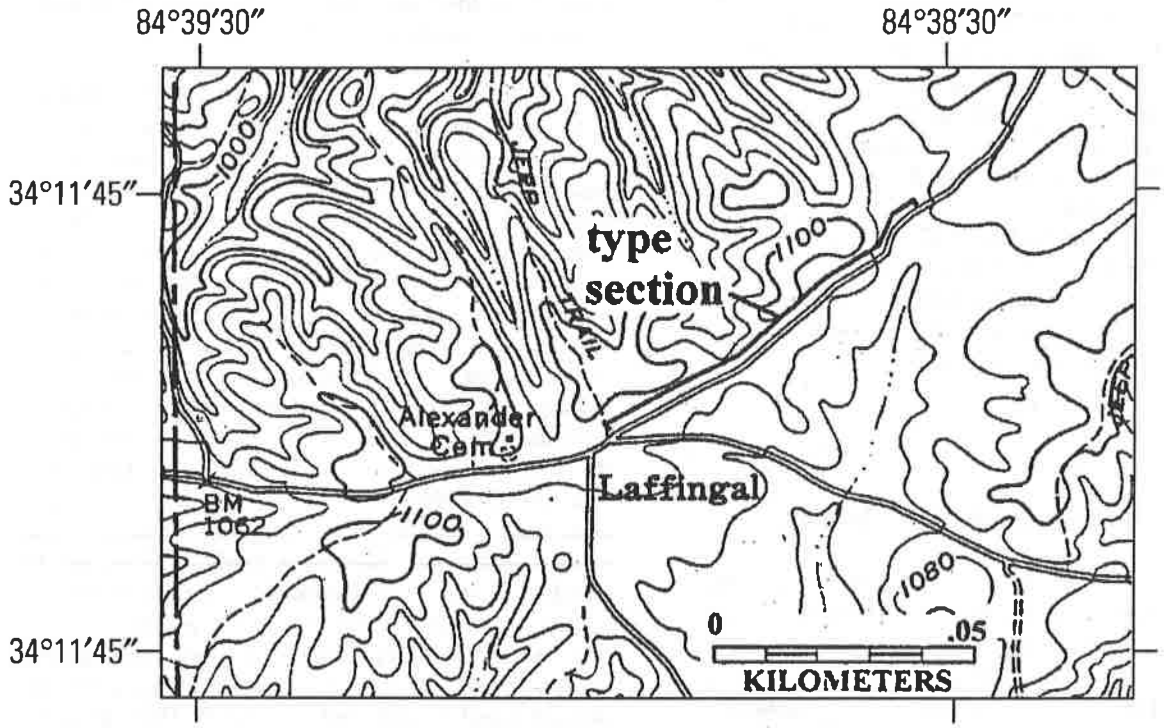

Figure 6: Topographic map of part of the Allatoona Dam, Ga., 7.5-min quadrangle showing the type locality and type section of the Laffingal Member of the Nantahala Formation.

Pinelog and Nantahala Formations indicates that these two formations belong together; we follow La Forge (1919) and interpret the Nantahala to generally overlie (but partly to be a facies of) the Pinelog. The Nantahala, with its rarer and finer grained metaconglomerates is probably a distal facies of the coarser grained, more conglomeratic Pinelog. The Laffingal Member of the Nantahala Formation, which structurally both underlies and overlies the pods of Corbin Metagranite in the Mulberry Rock structure, structurally and probably stratigraphically underlies the Bill Arp Formation. The Nantahala is linked to the Corbin Metagranite basement by its stratigraphic position unconformably above the Corbin, by the blue-quartz and microcline-feldspar granules and pebbles, by the rare presence of pebbles of Corbin Metagranite in its metaconglomerate lenses, and because it has high titanium and high barium contents like the Corbin (Higgins and others, 1988, p. 137, 140–149).

Age and Stratigraphic Assignment

Keith (1907, p. 4) assigned the Nantahala Formation a Cambrian age because "it appears to be less metamorphosed than the surrounding kyanite and (or) staurolite schists." Tull, Thompson, Groszos, and others (1991, p. 81) assigned the Nantahala Formation to their newly named Hiwassee River Group. Aylor (1991, p. 94) correlated the siliciclastic portion of the Hiwassee River Group with the Chilhowee. However, the sequence of units in the Hiwassee River Group depends on acceptance of an unfaulted stratigraphy and acceptance of a synclinal interpretation of the "Murphy syncline" and ignores the presence of mylonites and faults within the sequence. The sequence of units in the Hiwassee River Group of Tull, Thompson, Groszos, and others (1991) also ignores field relations that suggest that the "Murphy structure" is basically antiformal, extensively faulted, and can be interpreted to be exposed in antiformal duplexes that expose the lower part of the regional section near the basement rather than the upper part (Higgins and others, 1989, 1996), as recognized by La Forge and Phalen (1913) and Stose and Stose (1944). Therefore, we do not recognize the Hiwassee River Group. However, because we think the stratigraphy and structure of the critical areas is still not absolutely deciphered, we prefer not to abandon or alter the name Hiwassee River Group. The name is certainly an improvement over previous terms such as "Murphy series" (Furcron, 1953), "Murphy belt group" (Hurst, 1955; Mohr, 1973; Costello, 1988), "Murphy sequence" (Forrest, 1969), "Murphy Group" (Hatcher, 1972; Dallmeyer and others, 1978; Tull and Groszos, 1988; Higgins and others, 1988), "Murphy syncline group" (Nesbitt and Essene, 1982), and "Murphy succession" (Thomas and Hatcher, 1988), and we agree with their abandonment by Tull, Thompson, Groszos, and others (1991, p. 79–81).

McConnell and Costello (1980, p. 248; 1984, p. 271) assigned the Nantahala Formation graphitic phyllites and schists in the Corbin massif (their Salem Church anticlinorium) to the Wilhite Formation of the Walden Creek Group of the Ocoee Supergroup partly because Hayes (1895; see quote from La Forge (1919) in section on Corbin Metagranite) considered them correlative with his Wilhite and because the Nantahala in the Corbin massif is a dark (graphitic) siltstone and schist and is structurally adjacent to exposures of carbonate rocks. Published descriptions of the Wilhite Formation in the western Great Smoky Mountains in Tennessee (Hamilton, 1961) depict it as being dark and containing lenses of carbonate rock and metaconglomerate. Moreover, Hadley (1970, fig. 1) had depicted the rocks around the Corbin Metagranite basement (which he thought was a younger granite that had intruded the metasedimentary rocks in the Corbin massif of this report) as belonging to the Walden Creek Group, and had stated (1970, p. 251), "The Walden Creek Group is the only part of the Ocoee Series that contains important amounts of carbonate rocks. These consist of dark, silty, sandy or argillaceous limestone, and dolomitic limestone, thin to thick bedded, occurring in units 1-150 ft (45 m) thick interbedded with feldspathic sandstone and various pelitic rocks." Our detailed mapping in the Allatoona Dam, South Canton, Ludville, White East, and Jasper, Ga., 7.5-min quadrangles indicates that the carbonate rocks exposed along the southeastern flank of the Corbin massif are unlike the metamorphosed carbonate rocks in the Wilhite Formation in eastern Tennessee. The carbonate rocks in contact with the Nantahala Formation in the Corbin massif are interpreted to belong with lower Paleozoic units of the Valley and Ridge province carbonate shelf sequence rather than with the Wilhite Formation. The carbonate rocks on the southeastern flank of the Corbin massif are interpreted to be exposed in structural windows that also exposed other units of the Valley and Ridge sequence (Higgins and others, 1989) and the Nantahala

Formation rocks in contact with the carbonate rocks are mylonitized. In addition, the Wilhite where we have seen it in its type locality does not have the conspicuous graphite that is ubiquitous in the Nantahala in the Corbin massif and to the east near Jasper, Ga. (fig. 2)

There is little direct evidence bearing on the age of the Nantahala Formation. It must be younger than the Middle(?) to Late Proterozoic Corbin Metagranite because its metaconglomerates contain detritus from the Corbin. It is probably older than the Middle Ordovician Rockmart Slate because it has locally been thrust upon the Rockmart. It is thought to reside stratigraphically above the Early Cambrian(?) to Early Cambrian Pinelog Formation and to belong to the Chilhowee Group. Therefore, we assign the Nantahala and its Laffingal Member an age of Early Cambrian and place it in the Chilhowee Group.

Thickness

In the Atlanta, Ga., 30'X60' quadrangle, the maximum outcrop width of the Nantahala Formation is about 300 m, but the unit is everywhere isoclinally folded and in many outcrops it is a button schist (mylonite) or phyllonite (phyllite mylonite) characterized by shear bands. To the northeast, in the Cartersville, Ga., 30'X60' quadrangle, on the flanks of the Corbin massif, the Nantahala reaches an outcrop width of more than 3 km, but is nearly everywhere isoclinally folded and mylonitized. In its type area in the gorge of the Nantahala River in North Carolina, Keith (1907, p. 4) estimated the thickness of the Nantahala to be 427 to 549 m. Aylor (1991) measured sections of the Nantahala along the Hiwassee River near Murphy, N.C., and gave a thickness of 1550 m. In our opinion, faulting and folding (including layer-parallel foliation) indicative of isoclinal folding, and common tight to isoclinal folding of that foliation make measured sections unusable. Structural features were not taken into account in measurements of thickness by either Aylor (1991) or by Tull and Groszos (1988), who negate faulting and deformation in the whole area (see Tull, Thompson, and Groszos, 1991) and treat the rocks as a stratigraphic stack of barely deformed sedimentary rocks.

Sweetwater Creek and Illinois Creek Formations, Adopted

On the southeastern flanks of the Corbin massif, the Nantahala Formation is overlain by the Sweetwater Creek Formation (McConnell and Costello, 1980; McConnell and Abrams, 1984), which is composed of interlayered tan, slightly graphitic metapelite (phyllite and schist); tan to cream-colored, nongraphitic sericite phyllite; and scattered lenses of metagraywacke, arkosic metagraywacke, and metaconglomerate. The metaconglomerate contains blue-quartz granules that link its provenance to the Corbin Metagranite and flattened clasts of graphitic slate and phyllite that link its provenance to the underlying Nantahala Formation; it is locally very feldspathic. Locally, metagraywacke in the Sweetwater Creek contains calc-silicate nodules and lenses similar to those found locally in metagraywacke in the Bill Arp Formation. McConnell and Costello (1980, p. 248–249) called this unit the Sweetwater Creek Formation of the Great Smoky Group, but did not give a type locality or type section. The name Sweetwater Creek Formation was formalized by McConnell and Abrams (1984, p. 16–18), who designated a type locality at the confluence of Sweetwater Creek and Allatoona Lake, in the South Canton, Ga., 7.5-min quadrangle, but did not define a type section. The type section for the Sweetwater Creek Formation is here defined, based on the type locality of McConnell and Abrams (1984, p. 16–18), as the section exposed along Sweetwater Creek, in the South Canton quadrangle, from the confluence of Sweetwater Creek and Allatoona Lake to opposite benchmark 859 (fig. 7). The upper contact of the Sweetwater Creek Formation with the Bill Arp Formation is approximately 305 m southeast of the upper end of the type section under Allatoona Lake; the upper part of the formation is truncated by the North Canton fault.

McConnell and Costello (1980, p. 249) used the name Illinois Creek Formation for a unit that they considered to be above the Sweetwater Creek and, therefore, interpreted to be the uppermost formation of the Great Smoky Group. The Illinois Creek Formation was characterized by McConnell and Costello (1980, p. 249) as containing a quartz-pebble conglomerate that differed "from that in the Sweetwater Creek Formation in that it contains lesser amounts of dark minerals and is somewhat better sorted. The most significant difference is the lack of slate chips." In later reports, they abandoned use of the Illinois Creek and considered it to be the Dean Formation of Hurst (1955), mainly because of what they interpreted to be its stratigraphic position and membership in the Great Smoky Group (Costello and others, 1982, p. 9; McConnell and Costello, 1982, p. 24; McConnell and Abrams, 1984, p. 19).

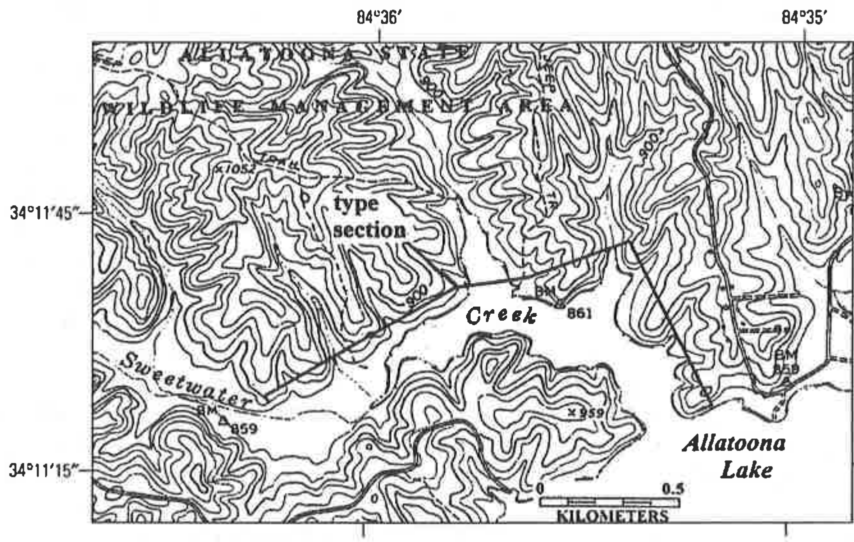

Figure 7: Topographic map of part of the South Canton, Ga., 7.5-min quadrangle showing the type locality (after McConnell and Abrams, 1984, p. 16-18) and type section (this report) of the Sweetwater Creek Formation.

McConnell and Abrams (1984, p. 19) correlated these rocks with the Dean Formation, a unit about 97 km to the northeast in the Murphy marble belt that Hurst (1955) named and included in the Great Smoky Group. We here accept the Illinois Creek Formation and the localities shown by McConnell and Abrams (1984, p. 19, fig. 10) as the type locality. The type section is here defined as the section exposed along the southeastern bank of the southwest-running stretch of Illinois Creek, in the Allatoona Dam quadrangle, from where the creek turns from southeast-trending to southwest-trending near the Bartow County-Cherokee County line, to where the creek turns southeastward again to enter Allatoona Lake (fig. 8). The lower contact of the Illinois Creek Formation with the Sweetwater Creek Formation is eaxposed along both sides of Allatoona Lake southeast and southwest of Illinois Creek; the contact appears to be gradational. The lower part of the formation is truncated by the North Canton fault.

Because they equated the Nantahala Formation on the flanks of the Corbin massif with the Wilhite Formation, and therefore considered it to be a different unit from the Nantahala Formation west of Jasper, Ga., that was considered to be a part of the Murphy marble belt, McConnell and Costello (1980), McConnell and Abrams (1984), and Costello (1988) interpreted the Sweetwater Creek Formation to lie above the Bill Arp Formation (their Etowah Formation) and below the Illinois Creek Formation. We consider the Illinois Creek Formation to overlie the Sweetwater Creek Formation, and the Bill Arp Formation (Etowah Formation of McConnell and Costello, 1980; Costello and others, 1982) to overlie the Illinois Creek. That is the sequence empirically derived at the many localities in northern Georgia (Higgins and others, 1996; Higgins and others, in press). We interpret the graphitic slate chips in metaconglomerates in the Sweetwater Creek to have been derived from the underlying Nantahala Formation. The fact that the graphitic slate chips become less common in metaconglomerates as one proceeds away from the Sweetwater Creek-Nantahala contact supports the interpretation that the Sweetwater Creek stratigraphically overlies the Nantahala Formation, rather than underlying it.

Rocks here called the Sweetwater Creek and Illinois Creek Formations together were previously mapped as part of the Frolona Formation by Crawford and Medlin (1973, 1974; Medlin and Crawford, 1973) along with the Nantahala Formation and schist of Hulett. Therefore, because the lower part of their Frolona Formation, and the part that is present at the type locality is here identified as Nantahala Formation, albeit at higher grade than the Nantahala in the northern part of the Murphy marble belt, and the upper part of their Frolona is here assigned to the Sweetwater Creek and Illinois Creek Formations, we have abandoned the name Frolona Formation in favor of Keith's (1907) Nantahala Formation (see below).

Frolona Formation, Abandoned

The Frolona Formation was informally named by Crawford and Medlin (1974) for outcrops around the crossroads of Frolona, Ga., in the Anniston, Ala.-Ga. 30'X60' quadrangle. Higgins and others (1988, p. 126–127) accepted the name Frolona Formation for use by the U.S. Geological Survey, assigned it to the Great Smoky Group of the Ocoee Supergroup, and designated a type section. The Frolona Formation of Crawford and Medlin (1974) and Higgins and others (1988) consists of at least four different units. At the type locality and in the type section, the Frolona Formation is a graphitic to very graphitic schist containing small crystals of kyanite and fairly abundant discontinuous clean quartzite lenses; less common, but important, are discontinuous lenses of metaconglomerate that contain blue quartz granules and pebbles, microcline-feldspar granules and pebbles, and chips of dark, graphitic schist. This unit is now recognized as the Nantahala Formation at a high metamorphic grade; moreover, it is the Laffingal Member of the Nantahala Formation. Because the Frolona Formation at its type locality is now identified as the Nantahala Formation, we here abandon the Frolona Formation.

Bill Arp Formation, Removed from Great Smoky Group

Higgins and others (1988, p. 127) assigned the Bill Arp Formation to the Great Smoky Group because it is a clastic metapelite-metagraywacke unit that lacks metavolcanic rocks, it locally contains blue-quartz granules in its metagraywackes, and it contains ilmenite and is therefore high in titanium dioxide like the Middle(?) to Late Proterozoic Corbin Metagranite. However, the Bill Arp Formation lies structurally and probably stratigraphically above the Nantahala Formation and (or) Sweetwater Creek Formation and (or) Illinois Creek Formation in the Corbin massif, in the Mulberry Rock structure, in the

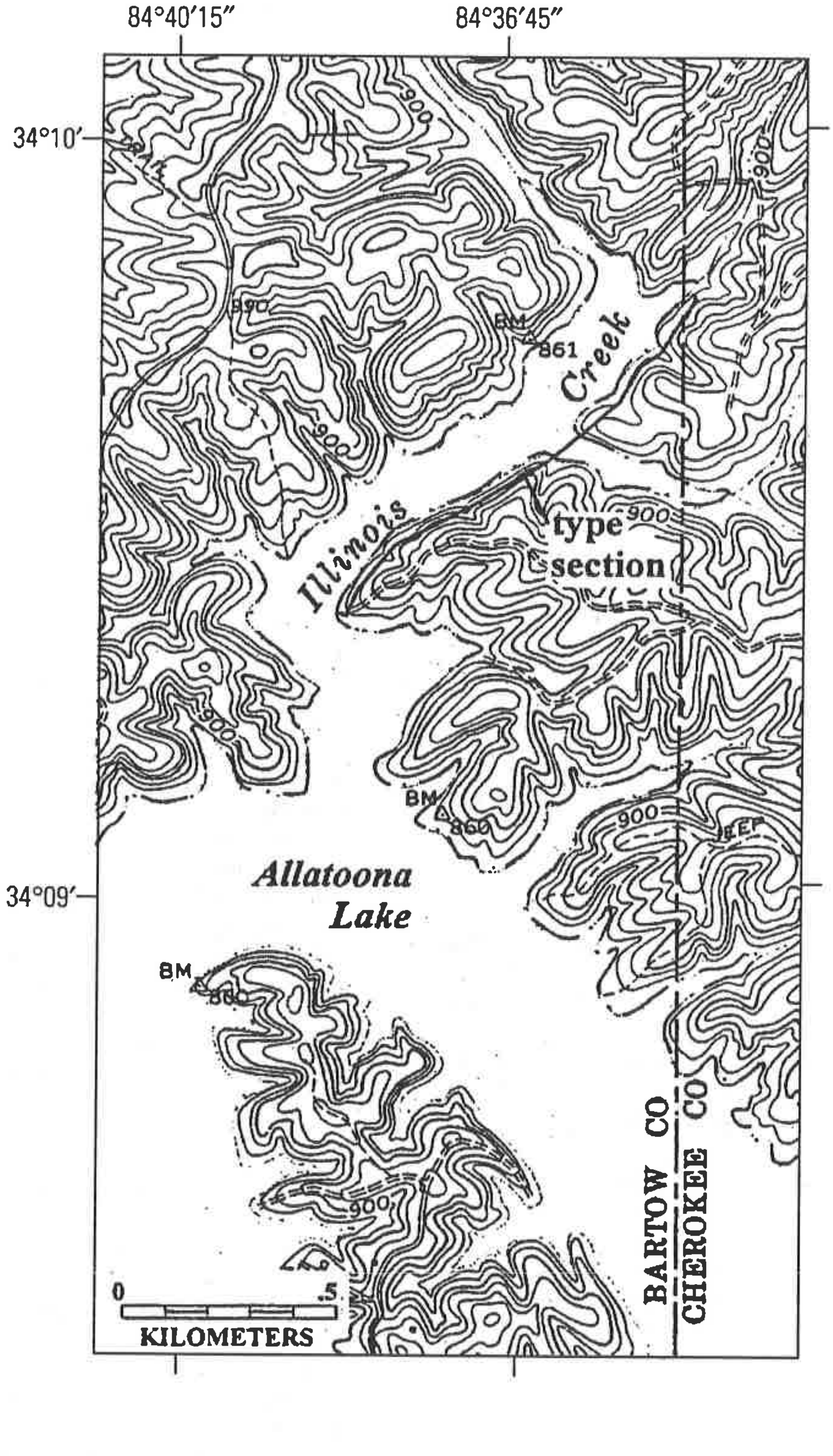

Figure 8: Topographic map of part of the Allatoona Dam, Ga., 7.5-min quadrangle showing the type locality (after McConnell and Abrams, 1984, p. 19) and type section (this report) of the Illinois Creek Formation

Crawfish Creek structure, and in Austell-Frolona anticlinorium. Therefore, the Bill Arp Formation is probably not older than the Nantahala and Sweetwater Creek Formations and is here removed from the Great Smoky Group and the Ocoee Supergroup. It is considered part of the cover sequence over basement and lies stratigraphically above the Chilhowee Group and Sweetwater Creek and Illinois Creek Formations.

The age of the Bill Arp can only be established by bracketing. It is younger than the Middle(?) to Late Proterozoic Corbin Metagranite because its metaconglomerates contain blue quartz and potassium-feldspar granules and pebbles probably derived from the Corbin, and because the basement and Nantahala Formation have commonly been thrust upon it. It is probably younger than the Nantahala Formation which has been thrust upon it in the Mulberry Rock structure, but which underlies it, apparently conformably or paraconformably, in other places. Otherwise, the age of the Bill Arp Formation is poorly constrained and is tentatively inferred to be Cambrian to Early Ordovician.

Schist of Hulett, Informally Named

Immediately overlying the Sweetwater Creek Formation in the axial area of the Austell-Frolona anticlinorium is a biotite-muscovite schist that contains small (~1-3 mm) red garnets in many outcrops and lacks garnet in nearly as many outcrops. The two types of schist were not separately mapped in 1:24,000-scale detailed mapping of the Hulett, Ga., 7.5-min quadrangle. A persistent secondary characteristic of the schist is the presence of closely spaced schistosity planes that gives it a finely cleaved, "pin-striped" appearance. The schist underlies the Bill Arp Formation southwest of the Atlanta 30'X60' quadrangle, in the axial area of complex Austell-Frolona anticlinorium, but the nature of the contact between them is unknown. It is unknown whether the schist belongs with the Sweetwater Creek Formation or the Bill Arp Formation, but it is likely that the schist may be part of the Bill Arp Formation and may be garnetiferous Bill Arp Formation mapped to the northeast (from the northwestern edge of the Brevard fault zone nearly to Interstate 20) in the northeastern part of the Austell-Frolona anticlinorium (fig. 2; Higgins and others, in press). The schist is here informally called the schist of Hulett for outcrops in the Hulett, Ga., 7.5-min quadrangle around the town of Hulett. Typical schist of Hulett can be seen in cuts along the unnamed, unpaved road that runs south-southeast from Georgia Highway 166 about 320 m southeast of Hulett for approximately 2130 m south of Georgia Highway 166 in the Hulett, Ga., 7.5-min quadrangle (fig.9).

We name the schist informally because future mapping in the Cartersville, Ga., and Anniston, Ala.-Ga., 30'X60' quadrangles may reveal the correct placement of the schist. We tentatively assign the schist of Hulett an age of Cambrian to Early Ordovician.

Sandy Springs Group, Revised, Assigned to Cover Sequence; Powers Ferry Formation, Rank Reduced and Reassigned; Mableton Amphibolite Member and Factory Shoals Formation, Abandoned

Higgins (1966, 1968) mapped a sequence of rocks in the Brevard fault zone that he informally called the Sandy Springs sequence. The lithologic units in the Sandy Springs sequence recognized by Higgins (1966, 1968) in the Brevard fault zone were mapped to the southwest along strike by Crawford and Medlin (1973, 1974; Medlin and Crawford, 1973) who further subdivided them, and to the northeast by Murray (1973). Based on these works and on further mapping by McConnell, Higgins and McConnell (1978) formalized the Sandy Springs sequence of Higgins (1966, 1968) as the Sandy Springs Group and defined four formations (ascending): the Powers Ferry Formation (gneiss, schist, and amphibolite unit of Higgins, 1966, 1968), the Chattahoochee Palisades Quartzite (lower quartzite unit of Higgins, 1966, 1968), the Factory Shoals Formation (aluminous schist unit of Higgins, 1966, 1968), and the Rottenwood Creek Quartzite (upper quartzite unit of Higgins, 1966, 1968). Higgins and others (1988) abandoned the Rottenwood Creek Quartzite, believing it to be the same as the Chattahoochee Palisades Quartzite.

The Powers Ferry Formation was previously considered to be the lowest unit of the Sandy Springs Group. However, detailed mapping has shown that the Powers Ferry is a facies of the Stonewall Gneiss and is in fault contact with other units of the Sandy Springs Group. The Powers Ferry consists of biotite gneiss interlayered with biotite-muscovite-feldspar-quartz schist (~20-35 percent) and minor scattered amphibolite. We here remove the Powers Ferry Formation from the Sandy Springs Group, reduce its rank to member, and reassign it to the Stonewall

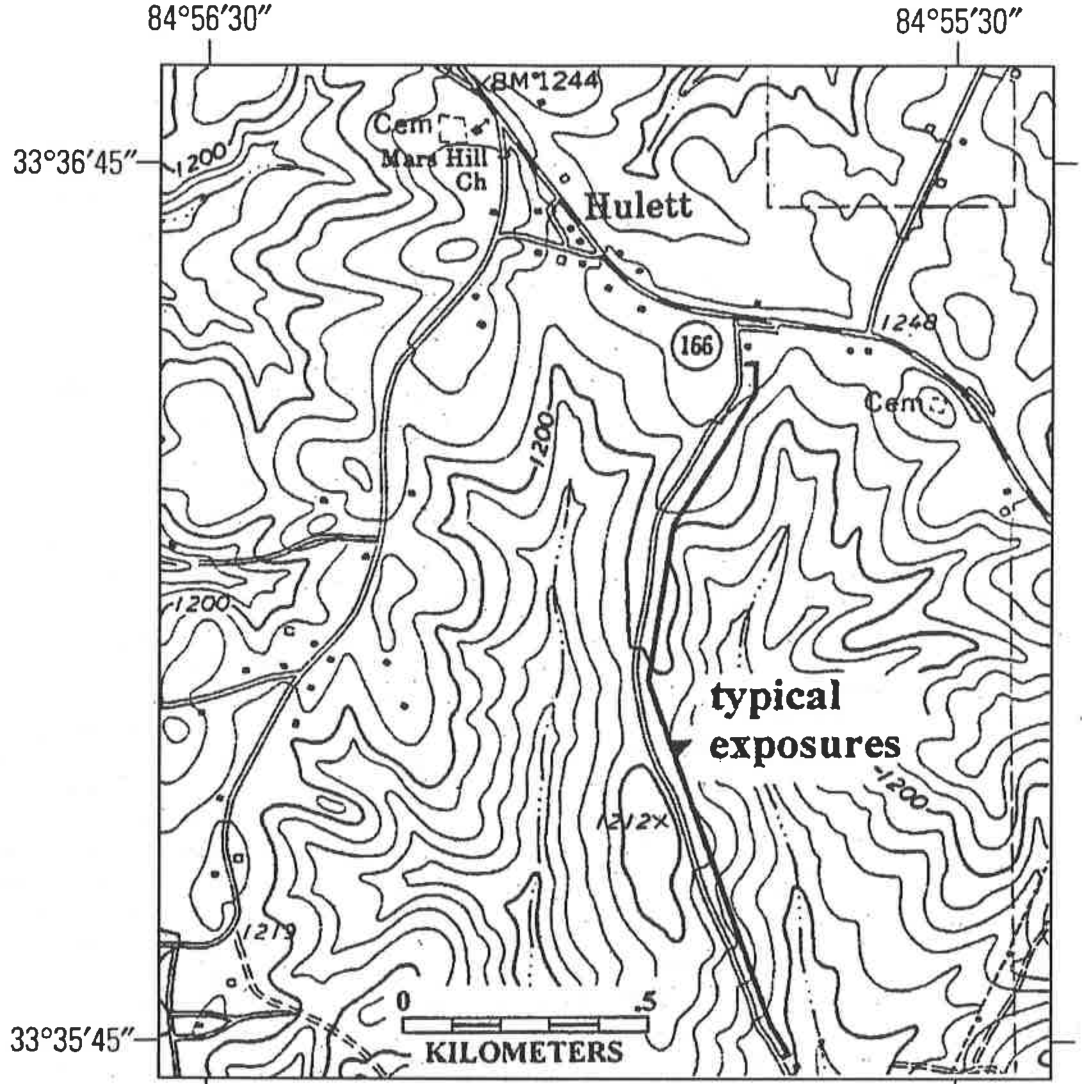

Figure 9: Topographic map of part of the Hulett, Ga., 7.5-min quadrangle showing the type locality and type section (this report) of the informally named schist of Hulett of the Bill Arp Formation.

Gneiss of the allochthonous assemblage. Detailed mapping also has shown that the Mableton Amphibolite Member of the Powers Ferry Formation is actually part of the Ropes Creek Metabasalt, complete with magnetite quartzite, and is thus abandoned.

Based on mapping by McConnell, Higgins and McConnell (1978) named the Factory Shoals Formation for Factory Shoals in the gorge of Sweetwater Creek, a tributary of the Chattahoochee River west of Atlanta. Outcrops in the gorge of the creek were designated as the type section. Remapping of the area has shown that the rocks designated Factory Shoals Formation cannot be mapped away from the type locality and type section and are instead inseparable from the aluminous schist unit of the Sandy Springs Group. The rocks in the gorge of Sweetwater Creek are deceptive because they are exceptionally fresh and therefore have a different appearance from slightly weathered "fresh" rocks away from the gorge. Because it is not a mappable unit at the scale of a quadrangle, the Factory Shoals Formation is here abandoned and the rocks designated part of the informal aluminous schist unit of the Sandy Springs Group.

The Sandy Springs Group, as redefined here, consists of an aluminous schist unit (containing one or more unnamed quartzites and local metagraywacke), the Chattahoochee Palisades Quartzite, and an unnamed garnetiferous schist unit; it is not known if the unnamed quartzites in the aluminous schist unit are the Chattahoochee Palisades Quartzite. The Chattahoochee Palisades Quartzite everywhere appears to overlie the aluminous schist unit and as far as we know is in stratigraphic contact with it; this is also true of the Chattahoochee Palisades Quartzite that occurs as roof pendants (and (or) infolds?) in the Lithonia Gneiss in the eastern part of the Atlanta 30'X60' quadrangle and the western parts of the Athens and Commerce, Ga., 30'X60' quadrangles. Higgins and Atkins (1981) interpreted the Sandy Springs Group in its eastern outcrop area to rest either unconformably or in thrust contact upon the Lithonia Gneiss because where streams cut across the Sandy Springs ridges, they appear to have cut through the Sandy Springs Group rocks exposing the Lithonia Gneiss. New deep roadcuts in the southwestern part of the Athens, Ga., 30'X60' quadrangle show that the Sandy Springs Group rocks there are in the Lithonia Gneiss, not on it. Therefore, the stream courses in that area were probably determined by the absence of Sandy Springs Group xenoliths and roof pendants rather than by the streams having cut through and eroded the xenoliths and roof pendants.

A characteristic of the Sandy Springs Group is that its rocks are everywhere at high metamorphic grade and partly granitized or migmatized, and though these features are secondary, they are ubiquitous and serve as one of its characteristic features. Dikes and sills of "sweat-out" pegmatite pervade the schists and gneisses and small bodies of granitoid are common. The quartzites are granular, thoroughly recrystallized, and commonly contain garnet and aluminosilicate minerals.

The continuity of the quartzites in the Sandy Springs Group in the Brevard fault zone west and southwest of Atlanta is an enigma. Mappable quartzite units a few meters thick, mostly assigned to the Chattahoochee Palisades Quartzite or to mylonitized Chattahoochee Palisades Quartzite, are continuous for as much as 70 km along strike. West and southwest of Atlanta, two quartzite units less than 0.1 km thick run parallel to each other with a separation of less than 0.5 km for about 70 km. A reasonable conclusion is that the thinness and continuity of the quartzites is due to attenuation without dismemberment during ductile shearing and folding in the Brevard fault zone.

Zircons from the Chattahoochee Palisades Quartzite north of Lithonia, Ga., dated by Stern (unpub. data) yielded discordant Pb-U ages of bulk zircon samples consistent with an age of about 1.1 to 1 Ga. The ages are interpreted to indicate that the detrital zircons were derived from the Grenvillian basement and that the Chattahoochee Palisades Quartzite and probably also the rest of the Sandy Springs Group (as revised) were derived from the basement and are part of the parautochthonous continental-margin assemblage. The Chattahoochee Palisades Quartzite is not presently considered to be the same rock unit as the Hollis Quartzite of the Pine Mountain Group in the Pine Mountain window, located 50 km to the south of the Atlanta quadrangle, but we speculate that future mapping in the Pine Mountain window will show that correlation.

Age

There is no conclusive evidence upon which to base the age of the Sandy Springs Group. It is younger than the basement because the Chattahoochee Palisades Quartzite contains zircons probably derived from the basement. If it is part of the cover sequence, as we speculate, it is probably Early Cambrian(?) and Early Cambrian and that is the tentative age assigned to the Sandy Springs.

ALLOCHTHONOUS OCEANIC ASSEMBLAGE

Structurally overlying the parautochthonous assemblage is the allochthonous oceanic assemblage (fig. 2), which consists of the Ropes Creek Metabasalt, the informal mixed unit of Goldmine Branch, the Villa Rica Gneiss, the informally named migmatite of Kennesaw Mountain, the Wahoo Creek Formation, the Crider Gneiss, the Stonewall Gneiss with its Kalves Creek and Powers Ferry Members and its informal schist and gneiss member, the Clairmont Formation, an informal mixed unit, the Clarkston Formation, the Ison Branch Formation, and the Paulding Volcanic-Plutonic Complex. Names abandoned in this report are the Soapstone Ridge Complex, the Ola Formation, the Apalachee Formation, the Big Cotton Indian Formation, the Promised Land Formation, and the Wolf Creek Formation.

Higgins and others (1988) assigned the rocks of the allochthonous assemblage a Cambrian age based on interpretations of their paleotectonic settings. We now adopt a more conservative position and reassign these rocks an age of Late Proterozoic(?) to Early Ordovician(?). The assignment of a Late Proterozoic age is uncertain because they are probably not part of the Grenvillian basement. They could be as young, but not younger than, the time of beginning of closure of the ocean they originated in, as set by the slope reversal marked by the deposition of the Middle Ordovician Rockmart Slate upon the unconformity at the top of the Upper Cambrian to Middle(?) Ordovician Knox Group and Middle Ordovician Lenoir Limestone.

Migmatite of Kennesaw Mountain, Informally Named

Hurst (1952) named the Kennesaw Mountain gneiss after Kennesaw Mountain, in the Marietta, Ga., 7.5-min quadrangle, for rocks he included in his migmatite category. McConnell and Abrams (1984) proposed formalizing the name Kennesaw Gneiss Member of their Laura Lake Mafic Complex for the migmatite. We here informally name the unit the migmatite of Kennesaw Mountain because we don't think it belongs with the Laura Lake Mafic Complex of McConnell and Abrams (1984). As recognized by Hurst (1952), the migmatite of Kennesaw Mountain is a massive, light-gray to whitish-gray biotite-quartz-plagioclase gneiss that has the same general mineralogic composition as the nearby metatrondhjemite gneisses except that it contains abundant xenoliths of amphibolite that is lithologically identical to amphibolite in Ropes Creek Metabasalt. The migmatite is interpreted to be the result of intrusion of a trondhjemitic magma into amphibolite of the Ropes Creek Metabasalt, and is assigned an age of Late Proterozoic(?) to Early Ordovician(?).

Crider Gneiss, Named

The Crider Gneiss is here named for Crider Creek in the New Georgia, Ga., 7.5-min quadrangle (fig. 10). A complete section of the Crider Gneiss is not exposed. Therefore, the saprolite outcrops marked "T" in figure 8 are designated a composite type section. The Crider Gneiss is a gray to nearly white, massive to slabby, medium- to coarse-grained, poorly to well-foliated biotite-muscovite-quartz-plagioclase gneiss that is locally contorted and generally weathers to a light-tan to dark-yellowish-tan soil containing corestones of gneiss. The presence of muscovite in excess of biotite in the Crider Gneiss is one of the features that distinguishes it from other biotite gneisses such as the Stonewall Gneiss. The Crider Gneiss is commonly found as residual boulders where the unit is deeply weathered. Crider Gneiss containing beds and lenses of finely laminated to massive calc-silicate rock containing diopside and locally diopside and garnets underlies a 5-km-long belt northwest of Villa Rica, Ga., in the Atlanta 30'X60' quadrangle (Higgins and others, in press); this calc-silicate-bearing gneiss is similar to some calc-silicate-bearing gneisses in the Wahoo Creek Formation (Higgins and Atkins, 1981; Higgins and others, in press). Map relations indicate that the Crider Gneiss, like the metatrondhjemites, intrudes the Ropes Creek Metabasalt.

Mixed Unit of Goldmine Branch, Informally Named

Overlying the Ropes Creek Metabasalt southeast of Yorkville, Ga., in the Yorkville, Ga., 7.5-min quadrangle (northwestern corner of Atlanta, Ga., 30'X60' quadrangle) is a poorly exposed unit that is a mixed unit of feldspathic gneiss, garnetiferous schist,

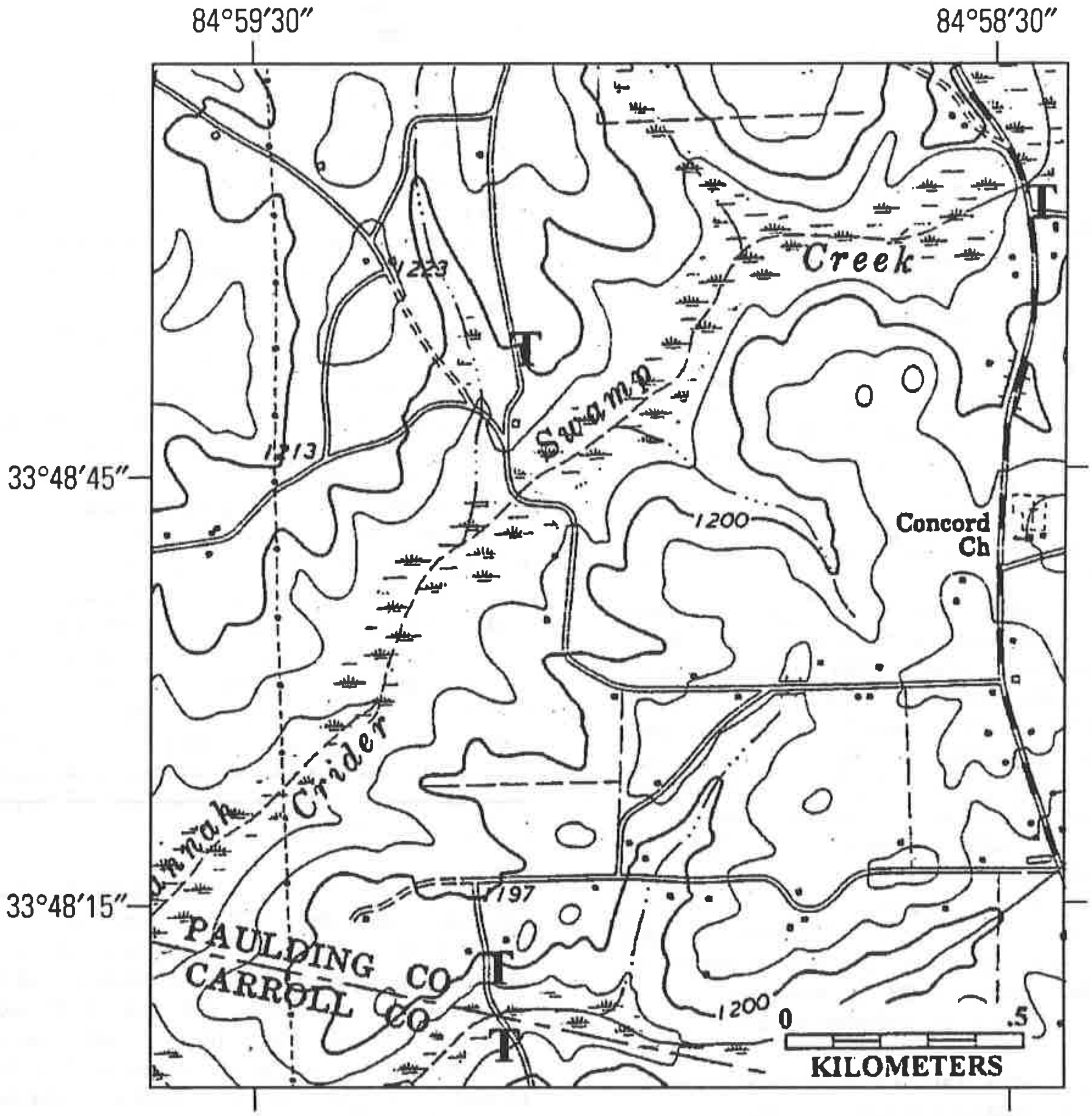

Figure 10: Topographic map of part of the New Georgia, Ga., 7.5-min quadrangle showing the type locality (Crider Creek) and outcrops (T) that constitute a composite type section of the Crider Gneiss.

nongarnetiferous schist, amphibolite, and scattered thin quartzite, manganiferous schist, and manganiferous quartzite that has only been mapped in the Yorkville and adjoining Taylorsville and Burnt Hickory Ridge, Ga., 7.5-min quadrangles. The unit is here informally named the mixed unit of Goldmine Branch for Goldmine Branch in the Yorkville quadrangle. The informal type section is designated as the saprolite outcrops in the roadside ditches along the first unpaved road to the east from Georgia Highway 101/113, south of the Yorkville microwave towers in the Yorkville, Ga., 7.5-min quadrangle, to where that road forks (fig. 11). The unit is poorly exposed even in streams because of its tendency to weather deeply, causing low stream gradients. The thickness is unknown and the age is assigned as Late Proterozoic(?) to Early Ordovician(?).

Promised Land Formation, Abandoned

Higgins and Atkins (1981) gave the name Promised Land Formation to a gray, massive to thinly layered, medium-grained, hornblende-bearing biotite granite gneiss containing thin, dark-green to greenish-black, fine-grained, ocher-weathering hornblende-plagioclase amphibolite layers. Hornblende-plagioclase and plagioclase-hornblende amphibolite, commonly containing epidote and sphene, are locally mappable within the unit. Remapping in the area of the Promised Land Formation indicates that the Promised Land is a variety of Lithonia Gneiss. Therefore, we here abandon the name Promised Land Formation and assign the rocks to the informal gneiss with amphibolite facies of the Lithonia Gneiss.

Stonewall Gneiss, Name Changed from Stonewall Formation, Members Assigned

Higgins and Atkins (1981, p. 16–17) named the Stonewall Formation for the community of Stonewall in the Fairburn, Ga., 7.5-min quadrangle, for biotite gneiss with amphibolite and ultramafic rocks that are exposed south of the Ben Hill Granite in the Fairburn and Palmetto, Ga., 7.5-min quadrangles. However, subsequent and more detailed mapping of large areas of the Georgia Piedmont-Blue Ridge has shown that gneiss that is commonly laced with pegmatite generally makes up more than 98 percent of the unit and, whereas amphibolite and ultramafic rocks are an important part of the Stonewall unit, in many places the amphibolite and ultramafic rocks are rare or absent. Therefore, because the designation "formation" is not as informative as a lithic modifier, especially in the many areas where gneiss is the only lithology, we here change the name Stonewall Formation to Stonewall Gneiss. The Stonewall Gneiss is a gray to grayish-brown to dark-gray, medium- to coarse-grained, commonly schistose, generally pegmatitic (biotite-muscovite-quartz-potassium-feldspar pegmatites), biotite-rich gneiss with generally rare but locally fairly common layers, lenses, and pods of hornblende-plagioclase amphibolite. Locally the Stonewall Gneiss contains small red garnets. Stonewall Gneiss characteristically and commonly contains small pods and lenses of altered ultramafic rocks, now mostly soapstones and serpentinites, but originally probably pyroxenites, dunites, and peridotites. Some have original crystal textures of pyroxenites, but the crystals of pyroxene have been completely serpentinized and (or) uralitized, and many rocks are now soapstones. Stonewall Gneiss is intensely deformed in most outcrops. Fresh outcrops are relatively rare because the unit weathers deeply; fresh rock is exposed along some large streams such as the Chattahoochee River, but in general, hillsides along small streams show no outcrop. The Stonewall Gneiss weathers to a uniform, slightly micaceous, dark-red saprolite and clayey dark-red soil; vermiculitic mica is characteristic in soils formed from the gneiss. Lack of outcrops and the dark-red soil are also characteristic.

The Stonewall Gneiss as now defined includes the Kalves Creek Member, Powers Ferry Member, an unnamed schist and gneiss member, and rocks previously assigned to the Ola, Apalachee, and Big Cotton Indian Formations. The Stonewall Gneiss appears to be in stratigraphic contact with the underlying Ropes Creek Metabasalt and in fault contact with the overlying Paulding Volcanic-Plutonic Complex.

Ola Formation, Abandoned

Higgins and others (1988, p. 127) gave the name Ola Formation to "a sequence of medium- to coarse-grained schists with lensoidal units of biotite-plagioclase gneiss," correlated the unit with the Bill Arp Formation, and assigned it to the Great Smoky Group. Our more detailed mapping of the Ola Formation type area and especially of the area to the east in the Athens 30'X60' quadrangle, as well as study of thin sections, has shown that most of the schist of the Ola is schistose biotite gneiss of the Stonewall Gneiss. Therefore, in order to avoid having multiple names for the same unit, we here abandon the Ola Formation, remove it from the Great

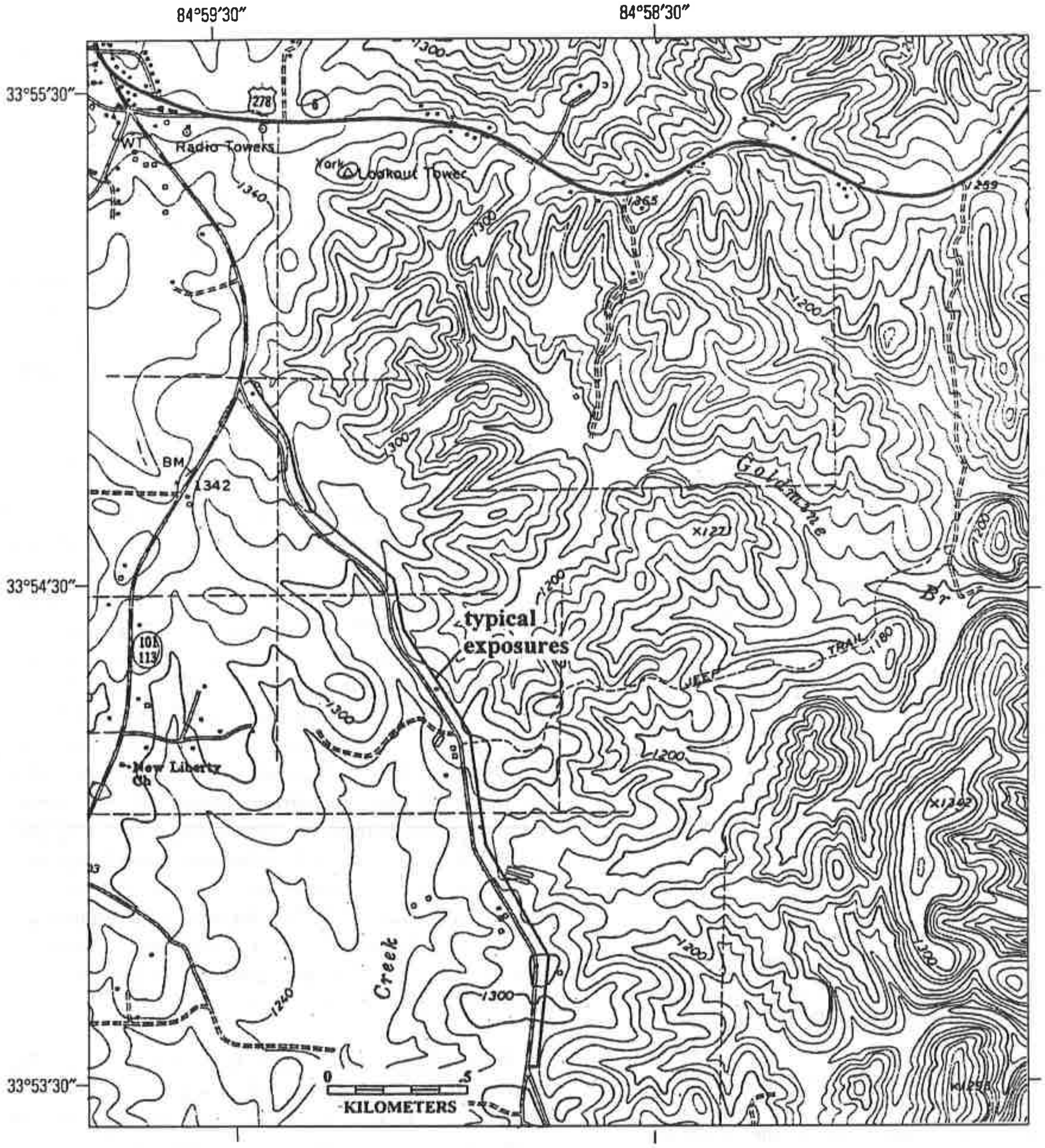

Figure 11: Topographic map of part of the Yorkville, Ga., 7.5-min quadrangle showing the type locality (Goldmine Branch) and the locality of typical exposures of the informally named mixed unit of Goldmine Branch.

Smoky Group, and assign its rocks to the Stonewall Gneiss.

Apalachee Formation, Abandoned

Higgins and others (1988, p. 126) gave the name Apalachee Formation to "coarse-grained, granitized, greatly deformed, schistose, generally reddish garnet-sillimanite-K-feldspar-plagioclase-biotite (and biotite-plagioclase) gneiss with scarce amphibolite that weathers to a chocolate-covered soil" and assigned the unit to the Middle Proterozoic Wacoochee Complex. Our more detailed mapping of the Apalachee type area and other areas in the Athens, Ga., 30'X60' quadrangle, as well as study of thin sections, have shown that the Apalachee Formation is the Stonewall Gneiss. Therefore, in order to avoid having multiple names for the same unit, we here abandon the Apalachee Formation and assign its rocks to the Stonewall Gneiss.

Schist and Gneiss Member, Informally Named

The unnamed schist and gneiss member of the Stonewall Gneiss consists of ("garnet)-biotite-muscovite-feldspar-quartz schist with lesser amounts of typical Stonewall Gneiss biotite gneiss and very rare amphibolite. Typically, the gneiss is in layers and lenses 0.5 m to about 1.5 m thick interlayered with biotite-rich schist layers about 3 to 6 m thick. Locally, the schist contains rare kyanite, staurolite, or sillimanite. The unit characteristically contains much pegmatite in dikes and sills like the undivided Stonewall Gneiss. Typical exposures of the schist and gneiss member can be seen in the Yorkville, Ga., 7.5-min quadrangle in roadcuts along the unpaved, unnamed road that runs southwest from near the eastern edge of the quadrangle toward McPherson, for about 1830 m from where that road leaves an unnamed southeast-running road (fig. 12).

Kalves Creek Formation, Rank Reduced and Reassigned

Higgins and others (1988, p. 127) gave the name Kalves Creek Formation to "a unit composed of Ola lithologies, but with significant amounts of white-weathering, graphite-sillimanite schist (graphite in tiny blebs and flakes on the surfaces of fibrous sillimanite) that commonly breaks into spindles upon weathering. In drill core, the Kalves Creek has blebs of pyrite that make up as much as 10 percent of the rock. The "Ola lithologies" have now been recognized as schistose Stonewall Gneiss. Therefore, the Kalves Creek is removed from the Great Smoky Group and reduced in rank to the Kalves Creek Member of the Stonewall Gneiss. The rest of the original description for the Kalves Creek remains unchanged except as follows: in saprolite outcrops, the schist of the Kalves Creek Member generally shows voids and iron stains where sulfide minerals have weathered out. In fresh core, the schist contains as much as 20 percent pyrite. Generally thin, granular quartzite is locally present in the Kalves Creek.

Big Cotton Indian Formation, Abandoned

Higgins and Atkins (1981, p. 19) named the Big Cotton Indian Formation for exposures near Big Cotton Indian Creek and its tributaries in the Jonesboro, Ga., 7.5-min quadrangle. They defined the Big Cotton Indian Formation as "composed of biotite-plagioclase gneisses (locally porphyritic), hornblende-plagioclase amphibolites, and smaller amounts of biotite-muscovite schist" and stated that biotite gneiss is more abundant in the formation north of Soapstone Ridge, whereas granite gneisses make up more of the formation south of the ridge. Manganiferous quartzites (gondites), which Higgins and Atkins (1981) thought were a separate formation, the Intrenchment Creek Quartzite (abandoned by Higgins and others, 1988), were shown within the Big Cotton Indian Formation and also along its contact with the Clarkston Formation (Higgins and Atkins, 1981, p. 4–5, fig. 1).

Remapping of the area that includes the Big Cotton Indian Formation of Higgins and Atkins (1981) has shown that the Big Cotton Indian Formation in most of the northern area north of Soapstone Ridge is the mixed unit of the allochthonous assemblage, which includes the manganiferous quartzites (gondites); that the Big Cotton Indian Formation around Soapstone Ridge Complex (abandoned) is Stonewall Gneiss; and that the Big Cotton Indian Formation south of Soapstone Ridge, which includes the type locality and type section of the Big Cotton Indian, is Stonewall Gneiss that has been intruded by a light-colored metagranite (the "granite gneisses" in the Big Cotton Indian in Higgins and Atkins' (1981, p. 190) original description). Therefore, to avoid multiple names for the same rock unit, we here abandon the Big Cotton Indian Formation and assign part of its rocks to the mixed unit of the allochthonous assemblage, and part to the Stonewall Gneiss.

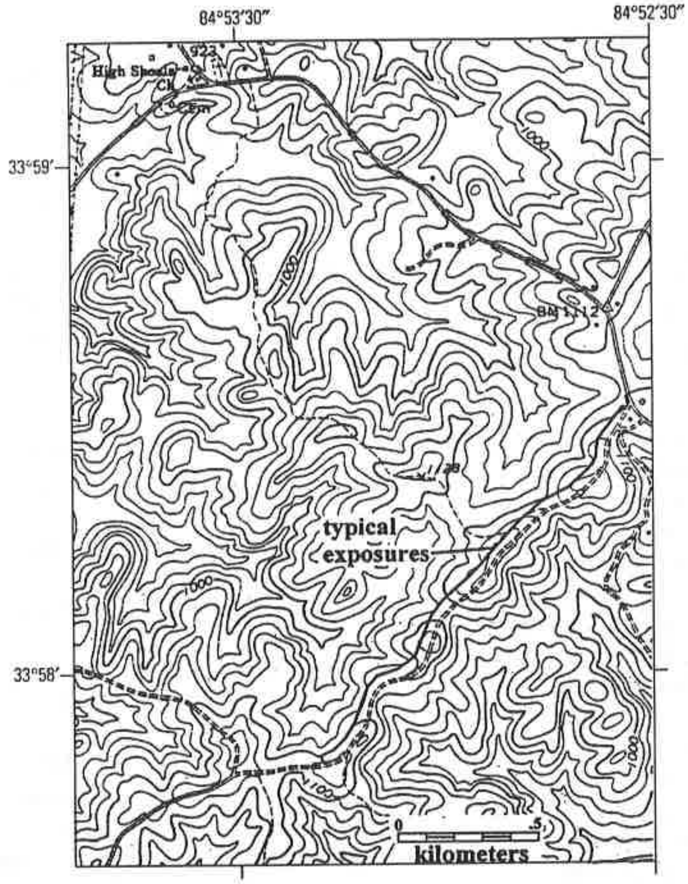

Figure 12: Topographic map of part of the Yorkville, Ga., 7.5-min quadrangle showing the location of typical exposures of the informally named schist and gneiss member of the Stonewall Gneiss.

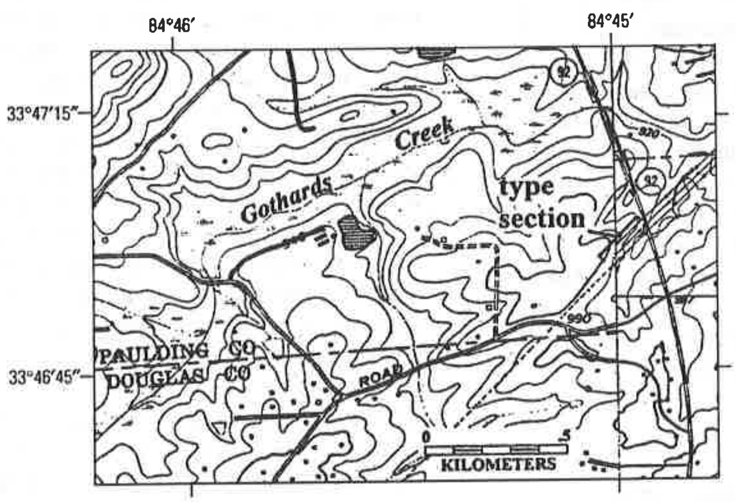

Figure 13: Topographic map of part of the Nebco, Ga., and Austell, Ga., 7.5-min quadrangles showing the type locality and type section of the Gothards Creek Gneiss.

Clairmont Formation, Relation to Stonewall Gneiss

The name Clairmont Formation was given (Higgins and Atkins, 1981) to a high-grade granitized mélange (interpreted to be mid-crustal ductile fault mélange) consisting of light-gray to bluish-gray, medium- to coarse-grained, generally porphyroblastic, locally porphyroclastic, generally highly tectonized, streaky to finely layered to granitic biotite-plagioclase potassium-feldspar gneiss containing fragments, chips, blocks, and slabs ("exotic blocks") of amphibolite; amphibolite and light-gray granofels; light- to medium-gray, equigranular biotite granitic gneiss; epidosite; light-gray granofels; metagranite; clean quartzite; and rare ultramafic rocks. Autoclastic chips, blocks, and slabs ("native blocks") are common in the mélange. The matrix of the mélange is pervasively penetrated by innumerable anastomosing, recrystallized shear planes that do not pass into or through the clasts. Foliation and folds within all types of clasts (including the autoclastic clasts) terminate abruptly against the surrounding matrix. The mélange has a granitized look as if it were on the verge of melting, but under the right pressure-temperature conditions so as not to complete the process. The Clairmont paleosome is a tectonic mélange probably composed chiefly of Stonewall Gneiss and the Clairmont locally has gradational contact with undivided Stonewall Gneiss. The Clairmont Formation is considered to be partly a facies of the Stonewall Gneiss. The neosome of the Clairmont is interpreted to be Devonian(?) anatectic granite similar to Lithonia Gneiss neosome. Weathered Clairmont that has the appearance of Stonewall Gneiss, with characteristic Clairmont exotic and native blocks, can be seen in roadcuts along dirt roads south, east, and southeast of Millers Mill in the southeastern corner of the Atlanta, Ga., 30'X60' quadrangle (Stockbridge, Ga., and Kellytown, Ga., 7.5-min quadrangles).

Wolf Creek Formation, Abandoned

Higgins and Atkins (1981) named button schists, sheared amphibolites, and phyllonites mapped by Atkins and L.M. Joyce in the area north of Norcross, Ga., the Wolf Creek Formation. Parts of the area have since been remapped in more detail. The presence of spessartine quartzites in the Wolf Creek and the overall makeup of the unit indicates that these rocks belong to the mylonitized mixed unit of the allochthonous assemblage. Therefore, the Wolf Creek Formation is abandoned and its rocks assigned to the mixed unit of the allochthonous assemblage.

Paulding Volcanic-Plutonic Complex

Higgins and others (1988, p. 131) named the Paulding Volcanic-Plutonic Complex for Paulding County, Ga., where thick sections of the unit are well exposed. The Paulding is a widespread unit in the Piedmont-Blue Ridge of Georgia and eastern Alabama and may be one of the "key" or "marker" units that will allow reassembly of wrench-fault separated areas. The Paulding is a mostly chaotic mixture of mafic and felsic rocks marked by an overall metaigneous, veined, faulted, disrupted, gray to epidote-green appearance. Pods of ultramafic rocks are common in and characteristic of the Paulding.

Soapstone Ridge Complex, Abandoned

Higgins and Atkins (1981) gave the name Soapstone Ridge Complex to what they thought was a large ophiolitic sheet of mostly ultramafic rocks in southeastern Atlanta. However, the Soapstone Ridge area is underlain by Paulding Volcanic-Plutonic Complex rocks with an abundance of mafic and ultramafic blocks and slabs. Rocks of the Paulding Volcanic-Plutonic Complex are surrounded by Stonewall Gneiss, appearing to be a sheath of rocks around the Paulding (Higgins and others, in press). Plunges of minor fold axes, mineral elongations, crenulations, and other lineations are consistently eastward at 20° to 30° in both the Paulding and the Stonewall Gneiss. Therefore, the Paulding Volcanic-Plutonic Complex in the Soapstone Ridge appears to occupy the "knife" in a large sheath fold (the Soapstone Ridge fold) that has the geometry of a folded tubular fold (terminology of Skjernaa, 1989). The remapping also showed that the Soapstone Ridge fold ends against a high-angle fault that truncates the Clarkston Formation west of Stone Mountain, Ga. (Higgins and others, in press). Because rocks previously designated Soapstone Ridge Complex belong to the Paulding Volcanic-Plutonic Complex, we here abandon the name Soapstone Ridge Complex.

Gothards Creek Gneiss, Named

The name Gothards Creek Gneiss is here given to a generally highly sheared and schistose, light- to dark-gray biotite granitic gneiss that is completely bounded by faults in the Oak Mountain fault zone on the northern side of the northeastern end of the Austell-Frolona anticlinorium. The gneiss is named for Gothards Creek where it can be seen in large bare "whale-back" outcrops under the powerline and cuts along Georgia Highway 92 just north of where it crosses Gothards Creek, about 4 km north of Douglasville, Ga., in the Nebo, Ga., 7.5-min quadrangle; the section exposed for about 150 m west of the highway along the powerline is designated as bounded by faults, the stratigraphic thickness of the Gothards Creek Gneiss is indeterminable. The outcrop width at the type section is about 1.7 km, but the outcrop width of the Gothards Creek ranges from less than 100 m to over 4 km in fault slices in the Atlanta, Ga., 30'X60' quadrangle. The Gothards Creek contains tight isoclinal folds parallel to layering and foliation that effectively double the layering, and has been folded after the isoclinal folding. The age of the Gothards Creek is unknown and therefore is assigned as Middle Proterozoic(?) to Late Ordovician(?) because the oldest basement in the region is possibly Middle Proterozoic and the unit is intruded by Austell Gneiss, which is Early Silurian.

Lithonia Gneiss

Large areas of the Piedmont-Blue Ridge in Georgia and eastern Alabama are underlain by the Lithonia Gneiss, a light-gray to whitish-gray, medium-grained, muscovite-biotite-microcline-oligoclase-quartz gneiss (Herrmann, 1954) that generally contains xenoliths of amphibolite, locally contains garnet segregations, commonly forms pavement outcrops, and, where deeply weathered, forms light-whitish-yellow, sandy soils. The gneiss has been given different names in different places: Lithonia Gneiss around Lithonia, east of Atlanta, in the Athens, Ga., 30'X60' quadrangle (Herrmann, 1954; Grant and others, 1980; Higgins and Atkins, 1981); Mount Arabia Migmatite within the Lithonia Gneiss around Mount Arabia north of Lithonia (Grant and others, 1980; Covert, 1986; Size and Khairallah, 1989); "Odessadale Gneiss" north of the Towaliga fault zone in central Georgia (R.L. Atkins, unpublished map), and Farmville Metagranite of the Opelika Complex in eastern Alabama (Bentley and Neathery, 1970; Steltenpohl and others, 1990). Geologic mapping (Higgins and Atkins, unpublished mapping of the Griffin, Ga., 30'X60' quadrangle; Steltenpohl and others, 1990; Higgins and others, in press), petrographic and geochemical studies (Grant and others, 1980; Steltenpohl and others, 1990), and some geochronological data (Higgins and Atkins, 1981; Goldberg and Burnell, 1987) have shown that 1) these gneisses are part of the same complex unit; 2) several textural varieties are common to all of the separated outcrop areas of the gneisses; 3) all of the gneisses occupy the same structural and (or) approximately the same mineral and chemical compositions; and 5) all of the gneisses are about 380 to 360 Ma (Goldberg and Burnell, 1987), or Middle to Late Devonian. We therefore assign the gneisses a Devonian age.

Textures in the Lithonia Gneiss range from massive to finely laminated, with the most characteristic texture being intensely swirled and sheared, finely layered gneiss such as that exposed in the large pavement outcrop at Mount Arabia, a few kilometers northeast of Lithonia, Ga. (Herrmann, 1954; Grant and others, 1980; Covert, 1986; Size and Khairallah, 1989). Grant and others (1980) gave this swirled gneiss the name Mount Arabia Migmatite. This variety of Lithonia Gneiss is one of several in the large body of gneiss that extends northeast and south of the type locality at Lithonia. In many outcrops, the Lithonia is massive and locally has scattered megacrysts of potassium feldspar, some of which may be relict phenocrysts, whereas others are porphyroblasts that may have seeded on relict phenocrysts, as suggested by their zoning. Structural features and textures in the Lithonia Gneiss also range from those with characteristics of a melt to those indicative of varying degrees of granitization.

Arabia Mountain Migmatite Facies

A common variety of Lithonia Gneiss is exposed at Arabia Mountain, a bare monadnock in Arabia Mountain State Park, 2.5 km northeast of Klondike in the southeastern part of the Atlanta, Ga., 30'X60' quadrangle (Redan, Ga., 7.5-min quadrangle). This variety exhibits well-defined, contorted, 5-mm- to 1-cm-scale gneissic layering. The rock was named Arabia Mountain Migmatite by Grant and others (1980); the name was also used by Covert (1986) and Size and Khairallah (1989). In this report, we call it the Arabia Mountain migmatite facies of the Lithonia Gneiss.

Norcross Gneiss, Abandoned

Higgins and Atkins (1981) gave the name Norcross Gneiss to a light-gray to whitish-gray, medium-grained, poorly to well-foliated muscovite-biotite-potassium-feldspar-quartz-plagioclase gneiss, with xenoliths of amphibolite ranging from less than a meter to hundreds of meters long; locally, the unit forms pavement outcrops, but more commonly forms corestones in thick saprolite. The gneiss weathers to a characteristic orange-pink clayey soil with quartz grains. More recent mapping in the Athens, Ga., 30'X60' quadrangle has shown that Norcross Gneiss is a facies of Lithonia Gneiss; the two gneisses can be mapped into one another. Lithonia Gneiss is a well-established name and takes precedence over Norcross Gneiss, so we here abandon Norcross Gneiss.

Age

The Lithonia Gneiss is tentatively assigned an age of Devonian, although that is probably the age of the neosome; the paleosome of the Lithonia Gneiss may be as old as Middle Proterozoic or as young as Early Ordovician.

Long Island Creek Gneiss, Age Changed

The Long Island Creek Gneiss, which was first mapped and described by Higgins (1966, 1968), is a light-gray to dark-gray, well-layered (layers generally about 8 to 40 cm thick), medium-grained epidote-biotite-plagioclase-quartz gneiss with tiny crystals of sphene, interlayered with biotite-epidote-muscovite-quartz-plagioclase-microcline (and microcline-plagioclase) gneiss, with quite a variable microcline content, that also contains tiny crystals of sphene. In many outcrops, the Long Island Creek is a mylonite gneiss with porphyroclasts of potassium feldspar. The Long Island Creek Gneiss is characteristically cut by numerous thick (6 to 20 cm) quartz veins and sills and aplite dikes and sills. The Long Island Creek weathers to a characteristic yellowish soil and locally forms pavement outcrops.

Higgins and McConnell (1978) assigned an age of late Precambrian and (or) early Paleozoic to the Long Island Creek Gneiss because it is bounded by faults and there is little evidence of its age. Sinha and Higgins (1987) reported a Rb-Sr isochron age of 460 Ma for the gneiss. We regard that age as preliminary because it has not yet been supported by U-Pb ages from zircon. Therefore, we assign the Long Island Creek Gneiss an age of Middle Proterozoic(?) to Devonian(?) until further radiometric dating can define a better age.

Yellow Dirt Gneiss, Abandoned

Crawford and Medlin (1974) used the name "Yellow Dirt gneiss" informally, from the community of Yellow Dirt in Heard County, for a rock that is mostly mylonite gneiss and that weathers to a distinctive yellow soil. The name was formalized as the Yellow Dirt Gneiss by Higgins and McConnell (1978). However, more recent mapping shows that the Yellow Dirt is the Long Island Creek Gneiss. Therefore, we here abandon Yellow Dirt Gneiss.

GRANITES

Five late-metamorphic to postmetamorphic plutons have intruded the metamorphic rocks southeast of the Brevard fault zone in the Atlanta, Ga., 30'X60' quadrangle. These plutons have not been well dated, despite preliminary ages reported by Atkins and Higgins (1980); those ages were based on preliminary U-Pb dates on bulk zircon samples. We have assigned the Ben Hill and Palmetto Granites a Carboniferous(?) age based on the preliminary ages and because they lack metamorphic foliation, except near the Brevard fault zone. This changes the age of the Union City Granite (revised below) from Paleozoic(?) as assigned by Higgins and others (1988) to Carboniferous(?). We have assigned the Stone Mountain Granite (quartz monzonite) a Carboniferous(?) age because of 1) the lack of metamorphic foliation, 2) the lack of appreciable contact effects indicating that the country rocks were under about the same temperature-pressure conditions as the pluton, and 3) the zircon ages, although preliminary, suggest a Carboniferous age. Whitney and others (1976) reported a whole-rock Rb-Sr isochron age of 291 Ma (Carboniferous) for the Stone Mountain and Dallmeyer (1978) reported $^{40}Ar/^{39}Ar$ spectra for biotite and muscovite in the granite as 281±5 Ma and 283±5 Ma, respectively (Permian); the argon ages are probably cooling ages. We have also assigned an age of Carboniferous to the Panola Granite because of the preliminary zircon ages and the lack of foliation in the Panola.

Union City Granite, Name Revised, Age Changed

Higgins and Atkins (1981) gave the name Union City Complex to a granitic complex composed of porphyritic granite identical to the Ben Hill and Palmetto Granites that has intercalated lenses of gneiss. More recent mapping has shown that the intercalated lenses of gneiss in the Union City

Complex granite are probably large xenoliths, roof pendants, or floor cupolas of Crider Gneiss country rock. Therefore, we here change the name Union City Complex to Union City Granite and interpret the age to be about the same as the Ben Hill and Palmetto Granites, but with large a margin for error (Carboniferous(?)).

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