THE TECTONIC RELATIONSHIPS OF THE HILLABEE CHLORITE SCHIST AND THE ADJACENT ROCK UNITS IN SOUTHERN CLEBURNE COUNTY, ALABAMA

by

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ABSTRACT

In southern Cleburne County, Alabama, the Coosa block is thrust over the Talladega block along the Hollins Line thrust fault. The Talladega block is composed of low grade metamorphic rocks, and contains evidence for four structural events. The units in the Talladega block indicate a continental origin for the depositional environment. Within the Talladega block, geochemical analyses indicate that the Hillabee Chlorite Schist, known as the Hillabee Greenstone, is associated with island arc volcanic activity and may represent distal lava flows. The Coosa block is composed of a high-grade metasedimentary sequence and amphibolite, and also shows evidence of four structural events. The Poe Bridge Mountain amphibolite of the Coosa block has an unrelated origin to the Hillabee Greenstone. Origin of the Talladega block units is related to subduction associated with an island arc-continental fragment collision of sedimentary-volcanic rock. During this collision, F_1-folds were formed which are found both in the Talladega and Coosa blocks. Continued collision of North America and Africa possibly created the F_2-F_3 folds, the Hollins Line fault, and subsequently the F_4 folds found in both blocks.

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1. INTRODUCTION

Recent studies in the Northern Piedmont of Alabama have distinguished three major lithotectonic blocks: the Talladega, Coosa, and Tallapoosa blocks (Tull, 1977, 1978). The Cartersville-Talladega fault separates the Talladega block from the Valley and Ridge to the northwest and the Hollins Line fault separates the Talladega block from the Coosa block to the southeast. The metasedimentary Talladega Group and the metavolcanic Hillabee Greenstone are the major lithologic units in the portion of the Talladega block investigated in this study. Metasediments and metaigneous lithologies are predominant in the Coosa and Tallapoosa blocks. The Tallapoosa block is bounded structurally by the Coosa block to the northwest and by the Brevard Zone to the southeast.

The Hollins Line fault and segments of the Talladega and Coosa blocks extend through southern Cleburne County, Alabama, into the area investigated in this study (Fig. 1). Although several geologic studies have been conducted in the study area, the geologic history of the area has not been worked out in detail and previous workers have not agreed upon many of the geologic relationships. This study is a comprehensive study of the southern part of Cleburne County which provides new data to allow resolution of some of the unresolved problems, which are elaborated below, in addition to disclosing other problems for future research.

1.1 Purpose and Scope

Previous workers have postulated several different hypotheses dealing with the occurrence and origin of the Hillabee Greenstone. Several maps and descriptions of the regional geology have also been produced by previous workers which differ in important respects. For example, Butts (1926, 1940), in agreement with recent work in this area, mapped a terminus of the Hillabee Greenstone and found no apparent evidence for a major fold but agreed with earlier workers on an intrusive origin of the unit. Recent workers have interpreted the Hillabee Greenstone to be of extrusive volcanic origin (Neathery and Reynolds, 1973; Tull et al., 1978).

The purpose of this study is to determine the structural and metamorphic history of a portion of southwestern Cleburne County, to describe the lithologic units occurring in this region, and to determine the interrelationships among these units. It is the intent of this study to investigate features bearing on the parental nature of the Hillabee Greenstone using field studies, petrography and geochemical analysis. A tectonic history of the area is presented based on these data.

1.2 Geologic Setting

The study area incorporates 166 sq km (65 sq mi.) that includes portions of the Talladega and Coosa lithotectonic blocks and the Hollins Line fault. Three major lithologic units, the Talladega Group and Hillabee Chlorite schist within the Talladega block, and the Poe Bridge Mountain Group in the Coosa block crop out.

Bearce (1973a) divided the northern Talladega Group into the Heflin Phyllite, Abel Gap Formation, and Chulafinnee Schist. The Heflin Phyllite is named for the rock units near Heflin, Alabama, and is a phyllitic metasediment with interlayered quartzite. Stratigraphically, the Heflin Phyllite is postulated to be the lowest unit in the Talladega Group and does not crop out in the study area. Overlying the Heflin Phyllite to the southeast is the Abel Gap Formation. A coarse-grained quartzite found at Abel Gap is distinctive of this unit. The Chulafinnee Schist is restricted to the southeast segment of the Talladega Group and is named for the rock units near the community of Chulafinnee. Bearce (1973a) described the Chulafinnee Schist as a fine-grained schist and phyllite. Rocks of the Chulafinnee Schist and Abel Gap Formation commonly consist of sericite phyllite with interbedded quartzite, and have been subdivided lithologically by the present author.

The Hillabee Greenstone overlies the Chulafinnee Schist to the southeast and defines the southeastern boundary of the Talladega block. The Chulafinnee-Hillabee contact appears to be comformable with possible interlayering of the two units. Recent workers have suggested that the Hillabee Greenstone is of extrusive mafic volcanic origin because it occurs as a discontinuous fault bounded unit along the southeastern boundary of the Talladega block (Tull, 1978).

The Poe Bridge Mountain Group structurally overlies the Hillabee Greenstone to the southeast. Tull (1978) incorporated the Poe Bridge Mountain Group into the northwest segment of the Coosa lithotectonic block. Coarse-grained garnetiferous and graphitic mica schist and quartzite with interlayered amphibolite comprise the Poe Bridge Mountain Group. The parental sequence may have been pelitic sediments intercalated with volcanic and volcaniclastic material.

The Hollins Line fault defines the contact between the Talladega and Coosa blocks. In the study area, this fault represents the contact between the Hillabee Greenstone and the Poe Bridge Mountain Group. Tull (1977) postulated that the Hollins Line fault is a major thrust fault with large displacement that emplaced the high-grade Poe Bridge Mountain sequence over the low-grade Talladega-Hillabee sequence.

1.3 Previous Work

Early geologic interest in the Alabama Piedmont was associated directly with the search for mineral deposits. Smith (1896) studied the crystalline rocks of eastern Alabama and defined the Talladega Series, Hillabee Greenschist and Ashland Mica Schist. Prouty (1923) provided a more comprehensive description of the Ashland Mica Schist and postulated a fault boundary between the Talladega and Ashland sequences. Prouty (1923) also postulated the Hillabee Greenstone to be an intrusive along the fault plane between the Talladega and the Ashland sequences. Butts (1926) divided the Talladega into upper and lower units with the Hillabee Greenstone in the upper unit. In addition, Butts (1926) produced a geologic map of Alabama which indicated a major fold. Adams (1926, 1933) interpreted the Hillabee Greenstone as a sill intruding and lubricating a thrust plane between the Talladega Group and Ashland sequences. Adams (1933) also mapped the terminus of the Hillabee Greenstone in the eastern part, and postulated that the Talladega Group was younger than the Ashland Mica Schist. Huddle (1942) described the occurrence and analysis of limonite ore near the community of Chulafinnee. The ore seam was described as occurring adjacent to a massive quartzite in the Talladega Group and is mappable from Chulafinnee to Dempsey, in Clay County, eastern Alabama.

Griffin (1951) suggested that the Hillabee Greenstone was of igneous origin, interpreting the unit as a sill intruded along the Whitestone fault. Griffin (1951) also divided the Hillabee Greenstone into a mafic border phase and felsic central phase. Lamont and Hastings (1964) described the mineralization within the Hillabee Greenstone near the community of Pyriton, Clay County.

The contact between the Hillabee Greenstone and the Ashland Mica Schist was mapped as gradational by Neathery (1972) and Reynolds (1972). Neathery (1972) also postulated that the Hillabee Greenstone may be interlayered or interfolded with the Chulafinnee Schist of the Talladega Group. Neathery and Reynolds (1973) placed a segment of the Ashland Mica Schist into the Wedowee Group that was further divided into several units including the Poe Bridge

Mountain Formation (Neathery, 1975). Bearce (1973b) subdivided the northern Talladega Group into three units: the Heflin Phyllite, the Abel Gap Formation, and the Chulafinnee Schist. Tull (1977) interpreted the Hollins Line fault as a major thrust fault and included the Hillabee within the Talladega block. Tull et al. (1978) postulated that the Hillabee was of mafic extrusive origin. Tull (1978) divided the Alabama Piedmont west of the Brevard zone into three lithotectonic blocks: Talladega, Coosa, and Tallapoosa, with boundaries that are major thrust faults. Tull (1978) further suggested designating the Ashland as a super-group and the Poe Bridge Mountain as a group distinct from the Wedowee Group.

1.4 Methods of Investigation

This study involved detailed mapping at a scale of 1:12,500 using 7-1/2 minute series U.S. Geological Survey topographic quadrangle maps of Hollis Crossroads and Ross Mountain. In addition, geochemical analysis of 25 samples, petrographic study of approximately 60 thin sections and the statistical and graphic interpretation of geochemical and structural data were performed. The major sampling and structural investigations were undertaken from May 17 to August 10, 1976. Additional sampling and mapping followed the initial work. Road cuts and stream channels provided most of the rock exposures. Both saprolite and fresh rock were investigated. Twenty-five samples were selected for geochemical analysis, and 60 thin sections were analyzed petrographically. Structural data was statistically treated using lower hemisphere equal area projections. A composite geologic map (Plate I) was produced from the field data.

2. METAMORPHIC STRATIGRAPHY

Mappable units within the Talladega and Coosa lithotectonic blocks are differentiated by distinctive mineralogical and textural characteristics. Names applied by previous workers to these mappable units will be used in the descriptions of the units whenever possible. Descriptions and subdivisions of the metamorphic lithologies are based on the classification of Winkler (1976). The textural terminology follows that of Spry (1969). The lithologic units are described below from southeast toward northwest.

2.1 Coosa Block-Poe Bridge Mountain Group

The northwestern fourth of the Coosa block crops out and contains the Poe Bridge Mountain Group (Neathery, 1975; Tull, 1978). The lithologies within the Poe Bridge Mountain Group are subdivided into mica-schist, quartzite, and amphibolite.

2.1.1 Mica-Schist and Quartzite

The southern third of the study area is composed of a high-grade metasedimentary sequence (Plate I). This sequence is represented predominantly by a fine to coarse-grained quartz-feldspathic mica schist, extending continuously along strike for as much as 19 km. Moderate relief, with alternating narrow (0.5 km) ridges, singular hills, and moderately wide (3-5 km) valleys predominate the mica schist terrain. The width of this sequence ranges from 0.25 km to over 7.5 km; however, deformational events have intensely folded the rock obscuring the true stratigraphic thickness (see section 5). Primary sedimentary features, other than compositional layering, have been eliminated either by regional dynamo-thermal events or have not been identified. Therefore, it cannot be determined whether the unit is stratigraphically upright or overturned.

The mica schist is silver-gray to tan in fresh exposure but weathers to tan to red saprolite often containing small (1 mm) relict muscovite flakes. Porphyroblasts of subsidioblastic to idioblastic garnets may comprise as much as 30% by volume of the schist. These garnets may also be very evident in saprolite. Kyanite occurs in the schist in at least one location (NW ¼, Sec. 21, T21S, R9E). Biotite schist occur interbedded with the muscovite schist (Ex. NE 1/4 , Sec. 29, T21S, R8E). Primary sedimentary bedding (S_0) on a scale of 1 m to 1 cm in thickness is noted in the schist. Alternating micaeous, quartz-feldspathic, and highly graphitic layers define compositional layering. Foliation (S_1) formed during regional metamorphism (M_1) and is approximately parallel to compositional layering. Numerous pegmatite veins and quartz dikes 1 to 5 cm thick in the schist are both discordant and concordant to foliation.

Several paraquartzite units are interlayered with the mica schist and are mappable along strike for up to 4 km. The quartzite is composed of quartz grains (0.1-1 mm in size) with thin (1 mm) intermittent mica-rich interlayers. The thickness of the quartzite ranges from 1 cm to 15 m. The contacts between the quartzite units and the mica schist are usually sharp. The thicker (5-15 m) quartzite form resistant ridges which show distinctive topographic trends, such as Ivory Mountain (Sec. 15, 16, 21, 28, 29, and 32, T17S, R9E). Some quartzite displays well developed dimensional planar and linear preferred orientations of quartz grains. Manganese staining commonly occurs in highly weathered quartzite.

2.1.2 Amphibolite

Amphibolite extends continuously for as much as 15 km along strike in the southern third of the study area is interlayered with mica schist (Plate I). The amphibolite is topographically reflected by wide (.5-1.5 km) valleys. Width of the amphibolite varies from 1 m to as much as 1.5 km. The contacts between the amphibolite and mica schist are usually sharp, although interlayering of the amphibolite and mica-rich layers on a scale of less than 1 m is common in the contact zones. Several 50 m wide outcrops show thin (1-20 m) amphibolite, interlayered with mica schist (Ex. E ½, Sec. 21, T21S, R10E). Interlayered within the amphibolite are minor thin (5-15 cm) paraquartzite layers.

Fresh exposures of the amphibolite are gray-green to dark greenish-black. Weathering of the amphibolite produces an orange to ocher saprolite commonly with black manganese stains on the foliation surfaces. Previous workers have mapped some of these amphibolite bodies as Hillabee Greenstone because of their similarity to both fresh and weathered exposures of that unit.

The amphibolite displays compositional layering defined by alternating thin (0.1 cm) light colored felsic-rich bands and dark amphibole-rich bands. The amphibole-rich layers are composed primarily of hornblende whereas the lighter layers are composed dominantly of plagioclase (see section 3). Compositional layering is due to either differentiation of the minerals into distinct layers, or the deformation which accompanied the first metamorphic event straining primary veins approximately parallel to foliation or as the original bedding during formation of the parent material. I propose that metamorphic differentiation is the process which formed the compositional layering. Layering is described as being formed by metamorphic processes in amphibolite with similar regional metamorphic histories (Spry, 1976).

Well developed foliation exists in the amphibolite defined by the preferred orientation of the hornblende and micaeous minerals. The foliated rocks also have well developed mineral lineations defined by the parallel alignment of elongate hornblende grains. Metamorphic foliation is not apparent nor is there preferred orientation of the hornblende in several fine-grained amphibolite samples. Additionally, no deformational textures are noted in several amphibolite samples, which closely resemble basaltic textures. Small (0.1-1 mm) garnets exist within the amphibolite at some localities. At one locality, amphibolite contains ellipsoidal plagioclase porphyroblasts appearing similar to deformed vesicles in basalt.

2.2 Talladega Block

In the footwall of the Hollins Line fault and structurally underlying the Coosa block to the northwest is the Talladega block. The Talladega lithotectonic block is divided into mafic and metasedimentary units. The Hillabee Greenstone comprises the mafic unit, and the Talladega Group is composed of metasedimentary lithologies.

2.2.1 Mafic Lithologies

The Hillabee Greenstone sequence is bounded above and to the southeast by the Hollins Line fault and is underlain by the Talladega Group. Crossbedding, channels, and bedding cleavage relationships in quartzite within the upper Talladega Group in Chilton, Clay, and Cleburne counties indicate that these lithologies are stratigraphically upright (Tull, 1978). This relationship suggests that the Hillabee Greenstone may be the highest stratigraphic unit within the Talladega block.

The Hillabee Greenstone is composed of mafic phyllite and massive greenstone which crop out continuously for 23 km (Plate I). The greenstone and mafic phyllite were not differentiated as separate units on the geologic map (Plate I) as no distinct relationship was noted in the field. The structural thickness of the Hillabee Greenstone ranges from 0-400 m. Because of repetition resulting from imbricate thrusting, a second 100 m thick Hillabee sequence crops out for ~10 km to the East (Plate I).

The Hillabee Greenstone is topographically expressed by narrow (0.5 km) northeast trending valleys containing several isolated small hills. The narrow valleys are generally underlain by the mafic phyllite. The phyllitic units are predominantly weathered because of the foliation surfaces enables groundwater to penetrate this lithology. The greenstone units are more resistant to weathering due to the absence of foliation surfaces, and usually underlie the isolated hills and ridges within the Hillabee Greenstone.

The greenstone units and mafic phyllite are green, grayish-green to gray in fresh or unweathered exposures. Weathering of the greenstone and mafic phyllite produces an ocher saprolite. The weathered mafic phyllite often displays a black manganese stain along the foliation planes. The ocher saprolite and manganese stains in the Hillabee Greenstone are similar to the weathering products previously described in the amphibolite of the Coosa block. Rocks of the Hillabee Greenstone and amphibolite are difficult, if not impossible, to differentiate from one another when highly weathered. In hand specimen, the greenstone is fine-grained (0.1-1 mm), with randomly oriented mineral grains, giving the greenstone a granular appearance similar to basalt. Observable foliation in hand specimen is faint to nonexistent.

The mafic phyllite often display compositional laminae (S_0) and well developed foliation (S_1) in hand specimen. Average orientations of S_0 and S_1 are N45E. Compositional layers are defined by alternating green colored chlorite-epidote-actinolite-rich layers and light colored plagioclase-rich layers. Compositional layering within the mafic phyllite is possibly a primary compositional feature. Low grade metamorphism may produce very thin and lenticular layers (Spry, 1976), compared to the thick (1-10 mm) continuous layers in mafic phyllite. Foliation is defined by parallel arrangement of the micaceous and fibrous minerals. Foliation and compositional layering are essentially parallel. Preferred orientation of actinolite needles defines a mineral lineation.

A 30 m thick zone near the base of the Hillabee Greenstone contains volcanic bombs and lithic ejecta. This zone is mappable for more than 1 km in (Sec. 13 and 14, T17S, R9E). The southeastern corner of Lake Edmond (Se. 14, T17S, R9E) contains a 60 m long, 50 m wide outcrop containing these lithic fragments, which are ellipsoidal and range from approximately 10 to 80 cm in diameter. Foliation wraps around these pods, with the pods showing no directional structures or internal planar features. The pods are green to grayish-green in fresh exposure and weather to tan to ocher residue.

2.2.2 Transitional Lithologies

The contact between the Hillabee Greenstone and the Talladega Group is not sharp but rather is an interlayered zone, and is termed “transitional zone”. This zone between the Hillabee Greenstone and the Talladega Group represents a major change in lithologies during which time intermittent deposition of both lithologic types occurred. The interlayering of the Hillabee Greenstone and Talladega Group lithologies suggests that these units are comformable and that the contact is not a fault or fold. No evidence of mesoscopic F_1 fold repetition of these units is found. Because foliation and compositional layering are parallel across the transitional zone; fold phases later than F_1 cannot have produced the interlayering. Thin slices, breccia or phyllonite indicative of faulting are not present in the transitional zone. Therefore, the interlayering appears to be primary. Transposition can produce interlayering along S_1; however, this normally produced layers that pinch and swell.

Quartz-sericite phyllite, quartz-sericite-chlorite phyllite, and chlorite-sericite phyllite are found in the transitional zone. Quartz-sericite phyllite directly underlies Hillabee Greenstone in sharp contact in the Lake Edmond area and in other areas where the contact of the Hillabee Greenstone and the transitional zone has been studied.

Three distinct lithologic units are found in the Lake Edmond Basin (Sec. 14, T17S, R9E). Figure 1 shows the stratigraphic positions of these units. In knife-sharp, concordant contact with the base of the Hillabee Greenstone is a 50 m thick chlorite-bearing sericite-quartz phyllite. In fresh exposure the chlorite-bearing sericite-quartz phyllite is white to tan and weathers to a splintery gray-brown residue. Foliation within the base of the Hillabee Greenstone and the chlorite-bearing sericite-quartz phyllite are concordant, and the contact of these units parallels the foliations.

In concordant contact and underlying the sericite-quartz phyllite is a mafic phyllite with interlayered greenstone. This mafic unit is ~ 25 m thick, and contains several lithic fragments similar to those described above as occurring in the Hillabee Greenstone.

Directly underlying the interbedded mafic unit is a quartz-sericite-chlorite phyllite ~75 m thick. Foliation and the contact of this unit are concordant with the foliation in the above unit. Although not observable in outcrop, this unit may grade into the sericite phyllite that is exposed 100 m north of the quartz-sericite-chlorite phyllite outcrop. Near the Tallapoosa River (Sec. 1, 2, 3, T17S, R10E; Sec. 5 and 6, T17S, R11E), a repetition of the Hillabee Greenstone and the underlying sericite-quartz phyllite sequence exists (see section 5).

2.2.3 Metasedimentary Lithologies

The lithologic distinctions between the Chulafinnee Schist and the Abel Gap Formation described by Bearce (1973b) are not found; thus, the two units are groups together into the Talladega Group. The Talladega Group extends across the upper fourth of the mapped, area and is composed of sericite phyllite with interbedded quartzite (Plate I). Moderate hills averaging 220 m in elevation with 5 km wide valleys are the predominant topographic features of this sequence. In fresh exposure, sericite phyllite is silver-tan to silver-white, weathering to a reddish-brown saprolite. At several localities the phyllite has a talcose appearance resulting from weathering. Compositional laminae are represented by alternating sericite-rich, graphite-rich and quartz-feldspar rich layers. Foliation is defined by the preferred orientation of the micaceous minerals in the phyllite.

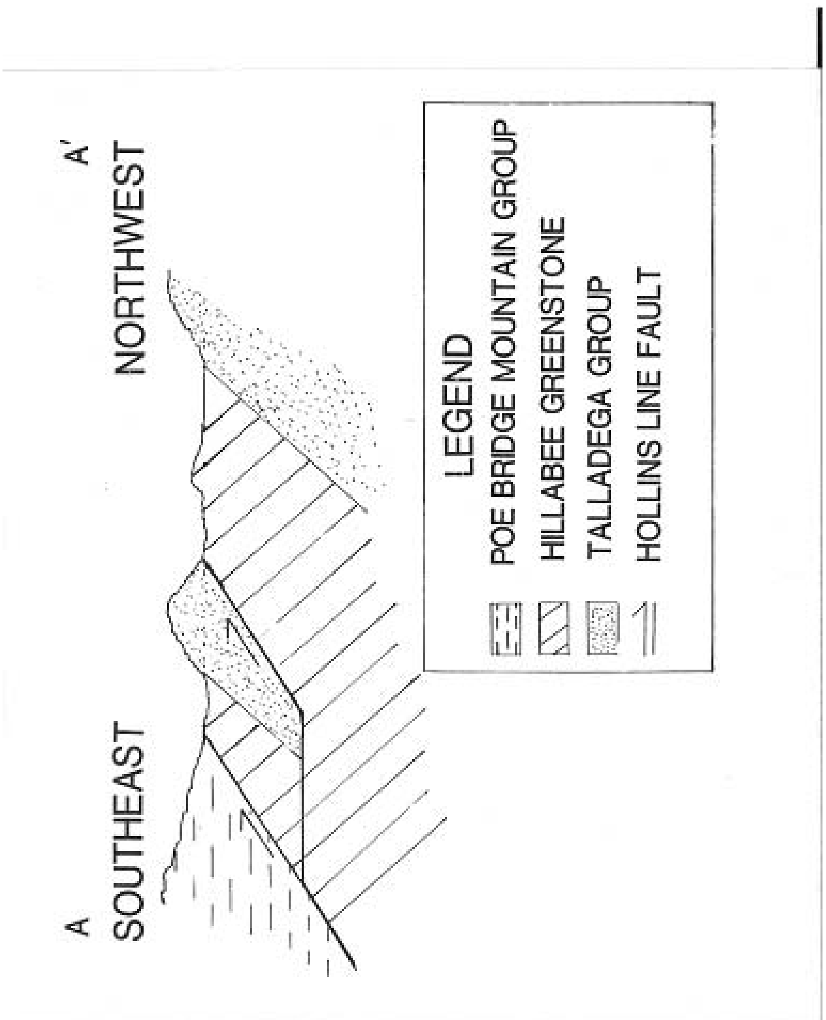

Figure 1. Southeast to Northwest schematic cross section through the Lake Edmond area.

At several localities (Sec. 15 and 16, T12S, R9E; Sec. 5, T12S, R10E), thick (0.5-2 m) massive quartzite crops out and are interbedded with thin sericite phyllite. This quartzite defines thick compositional layers extending continuously for as much as 5 km. The continuous quartzite forms resistant ridges in several localities (Ex. Sec 15 and 16, R17S, R9E).

3. MINERALOGY AND PETROGRAPHY

Approximately 60 thin sections of representative lithologies were examined. Modal percentages of the minerals within the lithiologic units were determined on the basis of point counts of 150 points (Tables 1 and 2). Mineral identification is based on the systematic classification of Kerr (1977). Compositional estimates were made on twinned plagioclase grains using the Michel-Levy Method.

3.1 Coosa Block-Poe Bridge Mountain Group

3.1.1 Mica Schist and Quartzite

Modal abundance of muscovite sericite in the mica schist ranges from 34-80% (Table 1). Small (0.01-0.1 mm) grains of muscovite exist as subidioblastic to xenoblastic porphyroblasts. Larger (0.1-1 mm) grains of muscovite in the coarse-grained schist assume a parallel alignment defining foliation (S_1). Elongate grains of muscovite may also define a mineral lineation (L_1). Post-metamorphic deformation commonly folded the muscovite into crenulation folds, and individual grains of muscovite may form an entire crenulation. Phyllonite is formed from the schist as a result of movement along the Hollins Line fault (see section 5). Fine-grained (0.01 mm) sericite comprises 24-49% of the mode of the phyllonite (Table 1). Muscovite-rich layers (0.1-1 mm thick) alternating with feldspathic and quartz-rich layers define compositional laminae (S_0) in the mica schist. Sericite is also noted as an alteration product of larger (5 mm) plagioclase grains. Red-brown biotite makes up 0-15% of the mica schist (Table 1). The biotite

MINERAL CONTENTS OF THE COOSA BLOCK

		Mica Schists				Phyllonites			Quartzites		Amphibolites			
Sample Number		175	352	373	373B	A	B	C	261	183	369	370	372A	376
Hbl	%	----	----	----	----	----	----	----	----	----	76.600	78.600	61.300	74.000
Plag		7.300	38.700	12.700	5.300	16.000	12.000	4.000	----	----	12.000	17.300	21.300	21.300
Qtz		8.000	12.700	10.000	7.300	20.000	18.700	27.300	91.300	100.000	6.700	1.300	9.300	3.300
Muscovite-sericite		80.000	41.300	34.700	43.300	24.000	48.000	48.700	6.000	----	----	----	0.700	0.700
Biot		----	7.300	15.300	13.300	14.000	8.000	9.300	2.700	----	----	----	----	----
Graphite		2.700	----	6.000	----	13.300	13.300	10.700	----	----	----	----	----	----
Epi		----	----	----	----	----	----	----	----	----	4.600	1.300	6.600	0.700
Sphene		----	----	----	----	----	----	----	----	----	----	1.300	0.700	----
Garnet		2.000	----	21.300	31.300	12.700	----	----	----	----	----	----	----	----

Table 1
Mineral Contents of the Coosa Block
Mica Schists, Phyllonites, Quartzites and Amphibolites
(Percent by Area: 150 Point Counts)

grains are small (0.01-0.1 mm) xenoblastic to idioblastic grains which are interlayered with and assume the preferred orientation of the muscovite.

Garnet constitutes 0-32% of the mode of the mica schist (Table 1). The garnets are subidioblastic to idioblastic porphyroblasts ranging in size from 0.1 to 10 mm. Three to six-sided cross sections of well developed dodecahedral forms are noted in the majority of the garnets. Asymmetric quartz pressure shadows have formed around many highly fractured garnets in the phyllonite. The asymmetric curved appearance of the pressure shadows indicates rotation of the garnets during phyllonitization. Determining the orientation of rotation in the field was not possible. Random quartz inclusions within the garnets form a poikioblastic texture.

The mica schist contains a variety of minerals. Quartz-feldspathic layers (0.1-1 mm thick) are intercalated with the mica schist. Plagioclase may comprise as much as 39% of the mode. Interstitial material is composed mainly of fine-grained (0.01 mm) plagioclase intermixed with quartz and possibly some potassium feldspar. Larger (1-10 mm) xenoblasts of plagioclase are noted. The fine-grained interstitial plagioclase exhibits no twinning and is optically difficult to distinguish from quartz. The twinned plagioclase grains are in the andesine compositional range. Microcline is found within the feldspathic layers; however, the microcline percentage of the mode was not determined. Fine-grained (0.01-0.1 mm) quartz is associated with the plagioclase as interstitial material. The modal percentage of quartz ranges from 0-10%. Larger (0.1-1 mm) quartz grains are also noted as vein fillings. Ribbon structures of quartz are noted in veins as a result of syntectonic recrystallization. Pressure fringes around garnet porphyroblasts are composed of aggregates of strained quartz.

Graphite is a minor constituent of the mica schist, comprising 0-6% of the mode (Table 1). Fine-grained (0.01-0.1 mm) laths of graphite are interlayered with muscovite and have the same preferred orientation as the muscovite. Larger lensoidal graphite aggregates are also interlayered with the muscovite in the mica schist. Graphite-rich layers may define secondary cleavage surfaces (S_2) in the phyllonite. Continuous graphite-rich layers also define compositional layering (S_0) in the mica schist, which parallels the foliation surfaces (S_1).

Paraquartzite ranging in thickness from 1 cm to 10 m are layered with the mica schist and amphibolite in the Poe Bridge Mountain Group. Quartz comprises 90-100% of the mode of the quartzite (Table 1). Coarse (1-2 mm) quartz grains display an elongation which defined foliation (S_1) and mineral lineation (L_1). Undulatory extinction is predominant in the quartz grains. Post-metamorphic deformation has produced a mortar texture of fine (0.01 mm) quartz grains that form a matrix between larger quartz grains. Small (0.1 mm) intercalated muscovite-biotite-rich bands are minor constituents. As much as 6% of the mode is composed of micaceous minerals. The mica-rich layers exhibit a preferred orientation parallel to the foliation (S_1).

3.1.2 Amphibolite

Modal abundance of amphibole ranges from 61-78% (Table 1). Strong pleochroism, x=yellow, y=emerald-green, and z=greenish-blue, indicative of hornblende exists, and hornblende is the dominant amphibole in this unit. However, actinolite and tremolite may also be present but not optically separable from hornblende based on Ernst’s (1966) observations of similar amphibolite.

Hornblende occurs as subidioblastic and xenoblastic prisms 0.1 to 1 mm in diameter. The elongate prisms range from 0.1 to 3 mm in length and have irregular terminations. Parallel orientation of the hornblende laths defines the foliation and the mineral lineation. Randomly oriented porphyroblasts also occur in the amphibolite, ranging from 0.1 to 1 mm in length. Hornblende-rich layers define compositional layering and are usually parallel to foliation.

Twinning is noted in ~5% of the hornblende grains. Primary growth twinning caused the twins observed in the subidioblastic grains because the hornblende grains exhibit very little grain deformation associated with deformational twinning.

Plagioclase comprises 12% to 22% of the mode (Table 1). Xenoblastic to subidioblastic plagioclase grains range in size from 0.01 mm in the matrix to 1 mm twinned grains. Twinning was caused when the plagioclase grew into the subidioblastic shapes because deformational twinning would produce more irregular shape grains with ragged edges, which were not observed in these samples. Interstitial plagioclase occurs between the hornblende prisms, appearing as strained untwinned grains. Larger (1 mm) plagioclase xenoblasts have albite twins, with some pericline twinning also noted. Twinned grains are in the andesine range.

Epidote is a minor constituent that comprises <6% of the mode (Table 1). Fine-grained (0.01 mm) xenoblastic epidote is randomly dispersed in the amphibolite. Larger aggregates (0.1 mm) of epidote are disseminated in the amphibolite. Fine-grained (0.01 mm) quartz is associated with the interstitial plagioclase. Modal abundance of the quartz ranges from 0-9%.

Sphene is present as aggregates of anhedral grains 0.1 to 1 mm in size. Small magnetite and/or ilmenite grains have been noted as random opaque inclusions within the sphene aggregates. Small (0.01-0.1 mm) fibrous masses of subhedral to anhedral muscovite are <1% of the mode. Parallel orientation is noted in the muscovite and hornblende grains.

Winkler (1976) indicates a middle amphibolite facies metamorphic grade for rocks found in the amphibolite. The hornblende-andesine assemblage with minor amounts of epidote and chlorite is similar to the staurolite zone in Precambrian rocks in Michigan (James, 1955). The presence of garnet (almandine?), biotite, muscovite, andesine, and kyanite in the mica schist is also indicative of medium grade metamorphism (Winkler, 1976). The amphibolite and mica schist are of the same metamorphic grade. This relationship suggests that the entire segment of the Coosa block mapped has been subjected to similar metamorphic conditions.

3.2 Talladega Block

3.2.1 Hillabee Greenstone

The mafic phyllite and greenstone have similar mineral assemblages, chemistry and comprise 90% of the Hillabee Greenstone. The differences between the two lithologies will be mentioned in the description of the mafic phyllite.

A major constituent of the greenstone unit is amphibole. Strong pleochroism, x=pale yellow, y=light green, and z=blue-green, is indicative of actinolite which suggests greenschist facies metamorphic grade (Eskola, 1952). Actinolite occurs as fine (0.1-2 mm) xenoblastic prisms, and comprises 29-57% of the mode of the igneous texture of the greenstone (Table 2). The actinolite grains have a subidioblastic equal dimensional shape similar to primary igneous pyroxene. Actinolite is thought to be a one-to-one replacement mineral for an unidentified primary pyroxene. Small (1 mm) imperfectly terminated needles and fibrous aggregates of actinolite are also distributed through the greenstone, with no preferred orientation.

Epidote group minerals (epidote, clinozoisite, and zoisite) constitute 14-29% of the mode (Table 2). Optically, these minerals are distinguished from one another by anomalous birefringence, faint pleochroism and the positive sign of clinozoisite when compared to epidote. Zoisite is differentiated from clinozoisite by a deep blue anomalous interference color and a smaller axial angle. Zoisite is present in quantities <1% of the mode. Epidote is noted as small (0.01-0.1 mm) idioblastic prisms and lath shaped clusters. Plagioclase may display alteration to epidote along grain boundaries. In this case, Ramberg (1952) proposed the following chemical reaction for the formation of the epidote:

$$3\ CaA1_2\ Si\ _2O_8 + 2CaCO_3 + H_20$$

(anorthite)

High Temperature Ca-rich Environment

$$2\ Ca_3Al_3Si3O_{12}\ \ (OH) = 2\ CO_2$$

(epidote)

Low Temperature Environment

The calcite ($CaCo_3$) and water (H_2O) components of the equation were introduced during the metamorphic reactions. The formation of epidote in this reaction is a result of environment in which the temperature is lower than the temperature at which anorthite is stable. This change of environment results in the alteration of calcium-rich plagioclase (anorthite) to epidote and/or sodium-rich plagioclase. Zoisite and clinozoisite comprise 18-30% of the epidote minerals, and are associated with the epidote described previously.

Chlorite comprises as much as 16% of the mode. Chlorite is optically differentiated from actinolite by anomalous weak birefringence. Small (0.01 mm) disseminated grains of chlorite are present in the ground mass in association with actinolite.

In some cases, pyrite comprises as much as 5% of the mode. Pyrite is observed as small (0.1-1 mm) idioblastic to subidioblastic grains, several of which are rimmed with a black opaque. Less than 1% of the mode is a black opaque that is either magnetite or ilmenite. Hematite stain sometimes surrounds the black magnetite/ilmenite grains and may result from oxidation of these minerals.

MINERAL CONTENTS OF THE HILLABEE GREENSTONE

		Greenstones				Mafic Phyllites					Lithic Fragments	
Sample Number		S-116	S-117A	S-118	S-364	S-124	S-125	S151B	S-269	S362C	S-151A	S-198
Qtz	%	8.700	14.000	6.700	16.000	10.700	10.000	14.000	7.300	13.300	2.700	----
Act		40.700	47.300	56.300	29.300	46.000	54.000	34.000	37.300	33.300	2.700	8.000
Chl		6.700	16.000	2.700	10.600	8.700	5.300	16.000	5.300	12.100	1.300	4.000
Epi		14.700	14.700	18.700	28.700	20.700	24.700	24.000	27.300	21.200	86.000	81.300
Plag		20.700	4.700	11.300	11.300	11.300	5.300	12.000	14.000	15.300	1.300	4.000
Sphene		5.300	2.000	3.300	1.300	4.000	0.700	----	2.000	3.300	6.000	2.700
Opagues		4.000	0.700	1.300	2.700	----	----	----	4.000	1.300	----	----
Calcite		----	----	----	----	----	----	----	2.700	----	----	----

Table 2
Mineral Contents of the Hillabee Greenstone
Greenstones, Mafic Phyllites and Lithic Fragments
(Percent by Area: 150 Point Counts)

3.2.1.2 Mafic Phyllite

The mafic phyllite units are the foliated and chemical equivalents of the greenstone unit. Differentiation of the phyllite from the greenstone is based on the recognition of foliation in hand specimen. Actinolite comprises 33-54% of the mafic phyllite mode (Table 2). Small (0.01-1 mm) xenoblastic to subidioblastic grains of actinolite are noted as replacement minerals of primary grains similar to that described above in the greenstone. Elongate fibrous aggregates of actinolite (0.1-2 mm in length) display preferred orientations defining foliation. Actinolite-rich layers (0.1-1 mm thick) alternating with felsic-rich layers define compositional layering. Compositional layering and foliation are essentially parallel.

Modal abundance of epidote group minerals ranges from 20-28%. Small (0.1 mm) grains and aggregates of epidote and zoisite may exhibit a preferred orientation parallel to the actinolite needles and foliation. Epidote is thought to be predominantly formed as a product of the alteration of plagioclase, similar to the situation described in the greenstone. Large xenoblasts of plagioclase may be altered to epidote along grain boundaries and cleavage planes. Epidote-rich layers may also define compositional layering.

Plagioclase may range in size from 0.01 mm in the ground mass to 5 mm xenoblastic grains. The modal percentage of plagioclase ranges from 5-16% in the mafic phyllite. The larger plagioclase grains may display albite twinning, and are in the albite compositional range. Untwinned and strained fine-to-coarse grains of plagioclase are optically difficult to distinguish from strained quartz. Compositional layers rich in fine-grained quartz and plagioclase are parallel to foliation. Sheared plagioclase grains produced by cataclasis of larger (0.1-1 mm) grains commonly have elongated shapes oriented parallel to foliation.

Sphene comprises as much as 4% of the mode (Table 2). Separate highly fractured grains of sphene are noted individually and as aggregates randomly disseminated. Calcite is observed as syn- and post-metamorphic vein infilling and forms large (0.1-2 mm) subhedral polygonal grains. Calcite is also observed as small flaser structures parallel to foliation. Modal abundance of calcite ranges from 0-4%. Fine-grained (0.1 mm) chlorite comprises 5-16% of the mode. Anhedral chlorite growth is observed on the boundaries of actinolite grains, possibly a product of alteration following shearing.

The mineral assemblage actinolite-albite-epidote in the greenstone and mafic phyllite is indicative of the lower greenschist facies of regional metamorphism (Winkler, 1976). The mineral assemblage, actinolite-epidote-chlorite-sphene, noted in the Hillabee Greenstone, has also been reported in the greenschist facies rocks of Japan (Miyashiro, 1961).

3.2.1.3 Lithic Fragments

The lowest horizon of the Hillabee Greenstone contains pod-like masses within a mafic phyllite (Sec. 14, T175, R9E) on the south side of Lake Edmond. The pods may be lithic fragments and volcanic bombs within the Hillabee Greenstone and have a similar mineralogy to that of the Hillabee Greenstone. Granoblastic textures in the pods are distinctly different in comparison to the two major Hillabee Greenstone lithologies, the mafic phyllite and greenstone units, described previously.

Epidote is the major mineral constituent in the two lithic fragments analyzed where the modal percentage ranges from 81-86% (Table 2). Epidote occurs as fine (0.01-3 mm) xenoblastic grains in the ground mass and as a replacement mineral for larger randomly oriented angular mineral grains that may be clinozoisite. Larger zenoblasts of epidote and/or clinozoisite are surrounded by matrix material composed of epidote with fine-grained (0.01 mm) chlorite and actinolite. These epidote-rich rocks are termed epidosites, and may represent large anorthite-rich fragments which have been altered to epidote during low grade metamorphism. Subhedral fibrous aggregates of chlorite (0.1-0.5 mm in diameter) comprise as much as 4% of the mode. No preferred orientation is seen in the aggregates of chlorite. Chlorite is also noted along actinolite grain boundaries as an alteration product of sheared actinolite grains. Modal abundance of actinolite ranges from 3-8%. Xenoblastic grains of actinolite range in size from 1 to 5 mm with the larger grains displaying growth twins.

Plagioclase is a minor mineral constituting 1-4% of the mode. Albite and pericline twins are noted in several of the plagioclase grains. These plagioclase grains are optically identified to be in the albite compositional range.

Grains that are subhedral, highly twinned, moderate birefringence, right angle cleavage, moderate to high relief, inclined extinction, and a negative optic sign exist in one lithic fragment. Based on these properties, this mineral may be clinopyroxene. Grain boundaries are slightly altered and secondary metamorphic overgrowths of actinolite are noted on the clinopyroxene grains.

The mineral assemblage, epidote-actinolite-chlorite-albite, in the lithic fragments is similar to that described in the greenstone and phyllite, indicating once again, a lower greenschist facies of regional metamorphism (Winkler, 1976) for the Hillabee Greenstone. Foliation or preferred orientation is not present, and much larger mineral grains are replaced in the lithic fragments as compared to the phyllite and greenstone. The large percentage of epidote, possibly due to alteration of an anorthite-rich rock, suggests that the lithic fragments were not formed in the same environment as the mafic phyllite and greenstone. The lithic fragments may represent a crystal cumulate that was ejected with the Hillabee Greenstone parental material. The depositional zone near the stratigraphic bottom of the Hillabee sequence may further indicate that the lithic fragments and the enclosing phyllite represent the first phase of continuous volcanism, which produced the Hillabee Greenstone parental material. The lithic fragments are also geochemically distinct from the Hillabee Greenstone samples (see section 4). This further substantiates separate formational environments for the lithic fragments and the Hillabee Greenstone.

3.2.2 Transitional Lithologies

Three transitional lithologies, sericite-chlorite phyllite, quartz-sericite-chlorite phyllite, and sericite-quartz phyllite, occur between the Hillabee Greenstone and the uppermost sericite phyllite of the Talladega Group. Contacts between the three lithologies are gradational in the transitional zone. Sericite and chlorite occur as fine (0.01-1 mm) interfingering lenses, fibrous masses, and distinct compositional layers. The preferred orientation of the fibrous masses defines foliation. Sericite and chlorite comprise essentially equal modal abundances, totaling 50-62% in the sericite-chlorite phyllite (Table 3).

Plagioclase and quartz are usually in association with one another forming compositional layers and interlayering with the sericite-chlorite laminae described above. Modal abundance of the plagioclase ranges from 4-30% and the quartz comprises 16-29% of the mode of the sericite-chlorite phyllite. Strained quartz and untwinned plagioclase are optically difficult to separate in the fine-grained aggregates; thus, modal percentages may be more accurate if the plagioclase and quartz are consolidated.

Quartz comprises 88% of the mode of the sericite-quartz phyllite (Table 3). These rocks are highly fissile and finely foliated; therefore, these quartz-rich rocks are termed phyllite. The

TRANSITIONAL LITHOLOGIES

Sample Number	Transitional lithologies			Sericite phyllites			Quartzites
	S-120	S-197	S-358	S-39	S-82	S-180	S-85
Act (%)	----	----	----	----	----	----	----
Chl	30.700	----	21.800	----	----	----	----
Epi	----	----	2.000	----	----	----	----
Qtz	29.300	88.700	16.700	8.000	8.700	8.700	95.300
Plag	4.700	----	30.000	4.000	7.300	11.300	----
Sphene	2.000	----	----	----	----	----	----
Opagues	0.700	----	1.300	----	----	----	----
Muscovite-sericite	32.700	11.300	28.700	86.000	84.000	78.700	4.700
Graphite	----	----	----	1.300	----	----	----

Table 3
Mineral Contents of the Talladega Group
transitional lithologies, sericite phyllites and quartzites
(percent by area: 150 point counts)

quartz may occur in ribbons. Syntectonic recrystallization has produced elongate quartz grains that define mineral lineation (L_1). Continuous quartz laminae define compositional layering (S_0) and are parallel to foliation (S_1). Sericite occurs in intercalated thin (0.01-0.1 mm) laminae with the phyllite. As much as 11% of the mode of the sericite-quartz phyllite is sericite that has a preferred orientation defining foliation. Sericite-rich layers may also define compositional layers that are parallel to foliation surfaces.

3.2.3 Talladega Group

3.2.3.1 Sericite Phyllite

Fine-grained (0.01 mm) sericite comprises 78-86% of the mode of the sericite phyllite. Preferred orientation of the sericite grains and minute (0.01 mm) partings between the grains define foliation (S_1). Thin (0.1 mm) laminae of fine-grained (0.01 mm) quartz and feldspar comprise 14-22 % of the mode. Layers rich in feldspar and quartz define compositional layering, and are essentially parallel to foliation. Recrystallization of pelitic sediments to form sericite is indicative of low grade metamorphism (Winkler, 1976). The absence of the very low grade minerals lamonite and lawsonite indicates the sericite phyllite is “very low grade” (Winkler, 1976). Recrystallization did not produce a coarse-grained mica or distinctive porphyroblasts indicative of higher metamorphic grades.

3.2.2.2 Quartzite

Quartz constitutes 95% of the quartzite modal abundance (Table 3). Fine-and coarse- (0.1 mm-2 cm) grained granoblastic quartz grains may display an elongation appearing as stretched pebbles. The elongate quartz grains define a mineral lineation (L_1). Sericite is observed as finely intercalated laminae comprising 5% of the mode. Dimensional preferred orientation of the sericite layers defines foliation that is essentially parallel to compositional layering.

4. GEOCHEMISTRY

Geochemical analyses were conducted on 25 samples. Definitive geochemical properties categorize the analyses into groups similar to the lithologic divisions defined previously (see section 3). The Hillabee Greenstone and Poe Bridge Mountain Group amphibolite chemistries are compared and contrasted. Additionally, this study determines original natures and associated tectonic settings of the Hillabee Greenstone and Poe Bridge Mountain Group amphibolite.

4.1 Sample Preparation

Specimens were trimmed of weathered material and crushed in a jaw crusher. Small (100 g) amounts, separated by cone and quartering, were further crushed to minus-150 mesh, and stored in air-tight bottles. A modified form of the fusion procedure of Medlin et al. (1969) was used to prepare triplicate 2500-and 500-fold solutions for each sample. Solutions, without samples, were made for each fusion. A Perkin-Elmer atomic absorption spectrophotometer (Model 303) was used in the chemical determinations. The 2500-fold solutions were analyzed for the major elements: SiO_2, $A1_2 O_3$, Fe_2O_3 (total iron), CaO, MgO, Na_2O, K_2O, and MnO. The 500-fold solutions were used for the determination of TiO_2, Sr, and Zn concentrations. Nitric and hydrofluoric acids were used to prepare 100-fold solutions that were used in the determination of trace element concentrations. Standards, BCR-1 and AGV-1, were used for the analyses. Eight samples were analyzed for Nb, Rb, Y, and Zr by x-ray fluorescence.

Ferrous iron (FeO) was determined colorimetrically using the procedure of Sharpiro (1960). Ferrous iron (Fe_2O_3) was determined by difference of the total iron as Fe_2O_3 and the

PRECISION OF THE ANALYSIS

Major Elements (wt%)

	1	2	3	4	5	6	7	8	9	10	x	s
SiO_2	49.100	49.000	48.900	48.900	48.800	49.100	49.000	48.900	48.900	48.900	48.950	0.100
TiO_2	1.210	1.200	1.210	1.200	1.220	1.200	1.210	1.200	1.200	1.210	1.210	0.010
Al_2O_3	15.000	14.800	14.800	14.900	15.000	15.000	14.800	14.900	14.800	14.800	14.880	0.090
Fe_2O_3	3.930	3.910	3.930	3.920	3.920	3.920	3.930	3.920	3.930	3.920	3.920	0.010
FeO	7.990	8.040	8.060	8.050	8.060	8.060	8.080	8.080	8.070	8.080	8.060	0.030
MgO	6.710	6.700	6.680	6.680	6.710	6.710	6.680	6.690	6.680	6.690	6.690	0.010
CaO	11.700	11.600	11.700	11.800	11.600	11.600	11.700	11.700	11.800	11.700	11.760	0.020
Na_2O	2.910	2.930	2.910	2.900	2.940	2.930	2.910	2.920	2.900	2.940	2.920	0.020
K_2O	0.200	0.200	0.200	0.210	0.200	0.210	0.210	0.200	0.210	0.210	0.210	0.001
MnO	0.196	0.194	0.196	0.196	0.194	0.194	0.195	0.196	0.196	0.195	0.195	0.002
LOI	1.170	1.160	1.180	1.170	1.160	1.160	1.180	1.180	1.160	1.170	1.170	0.001
Fe_2O_3	*13.0	12.900	12.800	12.800	12.900	12.800	12.900	12.800	12.900	12.900	12.880	0.060
Trace Elements (ppm)												
Ba	8.00	8.00	8.00	9.00	7.00	8.00	9.00	8.00	8.00	8.00	7.90	0.06
Cr	196.00	184.00	190.00	203.00	201.00	197.00	204.00	201.00	194.00	196.00	196.00	6.00
Co	41.00	33.00	36.00	42.00	42.00	39.00	42.00	41.00	40.00	40.00	39.60	2.95
Cu	192.00	183.00	187.00	194.00	193.00	190.00	193.00	192.00	191.00	190.00	190.50	3.30
Ni	79.00	73.00	76.00	79.00	76.00	77.00	78.00	77.00	76.00	78.00	77.00	1.70
Pb	18.00	19.00	18.00	18.00	18.00	17.00	19.00	19.00	18.00	18.00	18.20	0.63
Sr	263.00	250.00	251.00	268.00	263.00	257.00	264.00	263.00	261.00	25.00	259.00	6.00
V	259.00	247.00	250.00	260.00	258.00	256.00	256.00	253.00	251.00	250.00	254.00	4.40
Zn	79.00	72.00	76.00	79.00	79.00	78.00	78.00	77.00	76.00	75.00	77.00	2.20

Table 4

ferrous iron (FeO). The percentages of volatile components, predominantly H_2O and CO_2, were determined by heating to constant weight at 1000ºC and are listed in the tables as loss-on-ignition (LOI). Precision of the procedures, reported as the standard deviation of the mean, was ascertained by 10 replicate analyses of 1 sample and are listed in Table 4. The percentage error of the analyses was within 0.3 percent of the amount reported for basaltic compositions.

4.2 General Chemical Characteristics

Tables 5 and 6 contain the averages for the triplicate analyses and illustrate a wide chemical variation due to the lithologic differences of the samples. Silica (SiO_2) content of the Hillabee Greenstone samples ranges between 46.4-52.9% (Table 5), with an average of 48.99% (standard deviation, SD=1.55). Four samples 151B, 364S, 365A, and 360 are not within 1 SD of the mean.

Similarities between the average chemical abundances of TiO_2, Al_2O_3, FeO, MgO, K_2O and MnO for Hillabee Greenstone samples and average basaltic rocks suggest a mafic igneous origin for the Hillabee Greenstone. Minimal alteration is assumed in the samples if low grade metamorphism was the main chemical alteration, however, low grade metamorphism may cause extensive chemical alteration (Winkler, 1976).

Two elemental abundances, CaO and Na_2O, exhibit a direct correlation in the Hillabee Greenstone samples. When the CaO% is larger than the average abundance, Na_2O% is less than the average percent. Mobilization has been reported by Hart (1970) and Pearce (1975) in the alkalis during metamorphism. However, no agreement exists as to the effect, enrichment or depletion, on the alkalis during metamorphism. The variability of Na_2O in the Hillabee Greenstone may be due to weathering after metamorphism, caused by groundwater invasion. Enrichment of CaO may be due to secondary calcite formation within the Hillabee Greenstone or a zone of CaO within the Hillabee Greenstone. Most samples are within 1 SD of the mean in major element abundances suggesting similar mineral alteration depletion or enrichment due to metamorphism.

Differentiation of greenstone and mafic phyllite was not possible on the basis of the geochemical analyses. The absence of separate distinct trends for the greenstone and mafic

CHEMICAL ANALYSIS HILLABEE GREENSTONE

Sample Number		116	117A	117B	118	124	125	129	151B	160	269	364	364S	365A	360	366
SiO_2	wt%	48.800	49.900	48.900	48.800	49.300	49.000	47.600	46.400	48.500	50.300	43.500	52.900	47.100	50.600	48.300
Al_2O_3		14.400	13.700	16.900	16.500	15.100	15.100	14.700	15.100	15.600	14.100	13.800	14.100	15.600	14.100	15.600
TiO_2		1.150	1.310	1.520	1.540	1.540	1.200	1.130	1.150	1.120	1.480	1.600	2.030	0.803	1.110	2.540
Fe_2O_3		4.040	3.090	4.030	3.110	4.010	3.940	3.790	5.620	4.360	3.730	4.690	4.430	3.870	3.930	3.360
FeO		8.860	9.840	4.290	7.860	9.430	8.080	6.870	6.800	6.790	7.410	8.070	8.810	7.110	5.850	10.400
MgO		6.910	6.070	5.070	6.670	5.730	6.730	7.720	6.940	7.300	7.480	6.520	6.290	6.770	6.520	6.940
CaO		11.800	8.900	9.200	9.530	8.940	11.800	12.100	12.300	10.600	9.410	10.500	7.710	12.600	10.600	6.890
Ma_2O		2.420	3.410	3.240	2.640	4.460	2.940	2.080	1.800	2.070	2.440	2.750	8.790	2.560	2.630	3.310
K_2O		0.177	0.551	0.145	0.053	0.203	0.214	1.490	0.132	0.051	0.150	0.006	0.052	0.149	0.077	0.151
MnO		0.200	0.183	0.162	0.172	0.220	0.194	0.182	0.214	0.188	0.190	0.202	0.176	0.176	0.174	0.191
LOI		1.880	2.870	6.260	2.780	1.290	1.180	2.180	2.930	3.140	2.650	3.180	2.370	2.940	2.530	2.630
		100.637	99.824	99.717	99.655	100.223	100.378	99.842	99.386	99.719	99.340	94.818	107.658	99.678	98.121	100.312
Fe as FeO*		12.50	12.62	7.92	10.66	13.04	11.63	10.28	11.86	10.71	10.77	12.29	12.80	10.59	9.39	13.42

Sample Number		116	117A	117B	118	124	125	129	151B	160	269	364	364S	365A	360	366
Pa	ppm	80	83	53	45	10	8	93	76	21	72	93	55	76	80	77
Co		35	40	37	36	43	40	30	38	39	50	40	67	31	37	37
Cr		61	46	34	67	135	200	57	77	93	81	49	38	26	79	19
Cu		211	158	42	114	161	186	70	316	111	141	148	118	53	122	61
Nb		7	----	----	1	----	----	2	----	6	----	----	----	3	----	----
Ni		43	67	41	88	69	76	31	41	30	28	36	43	36	53	29
Rb		3	----	----	2	----	----	2	----	2	----	----	----	2	----	----
Pb		20	18	31	27	41	26	13	21	13	19	13	14	12	13	16
Sr		193	180	175	184	231	255	170	209	206	171	245	311	270	237	190
V		298	315	183	251	307	258	246	323	278	283	303	331	253	251	365
Y		31	----	----	33	----	----	24	----	27	----	----	----	24	----	----
Zn		57	43	54	49	86	77	57	39	44	42	41	65	49	63	58
Zr		80	----	----	100	----	----	65	----	76	----	----	----	72	----	----

Table 5

CHEMICAL ANALYSIS OF LITHIC FRAGMENTS, AMPHIBOLITES, AND TRANSITIONAL ZONE LITHOLOGIES

Sample Number		Lithic Fragments		Transitional Zone			Amphibolites				
		151A	198	120	358	362A	7B	9	369	370	372
SiO_2	wt%	45.300	44.700	50.000	64.300	68.900	51.400	50.600	48.600	47.100	52.900
Al_2O_3		16.800	18.500	17.700	15.100	12.100	14.600	17.700	19.200	15.800	15.500
TiO_2		1.190	0.845	1.370	0.677	1.420	0.690	0.790	1.730	1.350	1.180
Fe_2O_3		8.320	6.540	0.071	2.020	4.000	2.240	2.700	1.990	3.900	1.640
FeO		5.520	4.510	11.600	4.110	3.500	7.840	6.990	6.930	7.820	7.100
MgO		3.990	5.210	4.900	2.750	2.150	10.100	5.740	5.480	8.910	6.350
CaO		15.800	16.400	0.020	2.530	0.020	9.320	8.930	7.710	9.010	7.820
Na_2O		0.600	0.213	8.250	3.010	3.360	2.390	4.140	4.350	3.120	4.030
K_2O		0.149	0.060	2.750	1.830	1.650	0.237	0.163	0.567	0.456	0.196
MnO		0.197	0.164	0.185	0.090	0.062	0.188	0.168	0.123	0.164	0.136
LOI		2.810	2.910	3.700	2.780	2.490	1.630	2.130	2.820	2.870	2.680
Total		100.676	100.052	100.546	99.197	99.652	100.635	100.051	99.500	100.500	99.532
Fe as FeO*		13.010	10.400	11.660	5.930	7.100	9.860	9.420	8.720	11.300	8.580

Sample Number		Lithic Fragments		Transitional Zone			Amphibolites					
		151A	198	120	358	362A	7B	9	369	370	372	376
Pa	ppm	21.000	57.000	675.000	660.000	693.000	105.000	70.000	53.000	75.000	78.000	116.000
Co		35.000	36.000	46.000	31.000	22.000	40.000	37.000	53.000	47.000	52.000	42.000
Cr		83.000	83.000	65.000	24.000	31.000	89.000	88.000	66.000	83.000	91.000	72.000
Cu		229.000	112.000	10.000	5.000	4.000	13.000	68.000	37.000	29.000	27.000	103.000
Nb		5.000	6.000	----	----	25.000	----	----	----	----	----	----
Ni		39.000	37.000	53.000	33.000	51.000	41.000	36.000	41.000	46.000	39.000	28.000
Pb		18.000	26.000	39.000	13.000	18.000	14.000	21.000	17.000	19.000	23.000	18.000
Rb		2.000	5.000	----	----	61.000	----	----	----	----	----	----
Sr		470.000	178.000	231.000	142.000	57.000	171.000	186.000	155.000	168.000	175.000	207.000
V		293.000	323.000	276.000	64.000	58.000	241.000	217.000	204.000	237.000	153.000	235.000
Y		29.000	5.000	----	----	37.000	----	----	----	----	----	----
Zn		33.000	53.000	67.000	48.000	53.000	58.000	61.000	48.000	52.000	63.000	51.000
Zr		78.000	57.000	----	----	870.000	----	----	----	----	----	----

Table 6

phyllite further supports the theory that the greenstone and mafic phyllite are not separate protolithologies within the Hillabee Greenstone.

Average SiO_2 contents are 45%, in the lithic fragments and indicative of basaltic composition (Table 6). High average CaO, 16.2%, and corresponding low average Na_2O, 2.87%, correspond to the previously determined high percentage of epidote in the lithic fragments (see section 3). Assuming negligible Ca metasomatism, this high CaO content in the lithic fragments is suggestive of a large content of CaO-rich primary material (anorthite?). The lithic fragments are surrounded by and are thought to have undergone the same metamorphic alteration as the Hillabee Greenstone but have a higher CaO content; therefore, the primary material of the lithic fragments is thought to have been CaO-rich. No gradational zone is observed between the surrounding Hillabee Greenstone and the lithic fragments which rules out possible migration and concentration of CaO within the lithic fragments due to metamorphism.

High average SiO_2, 61.0%, and K_2O, 2.1%, exist in the transitional zone lithologies (Table 6). As described in section 3, the transitional lithologies have a high amount of interlayered Talladega Group material. The incorporation of the siliceous Talladega Group material particularly the sericite and feldspars, into the ferro-magnesium-rich phyllite of the Hillabee Greenstone is responsible for the enrichment and variability in SiO_2 and K_2O noted in the transitional zone samples.

The Poe Bridge Mountain Group amphibolite of the Coosa block has a geochemical nature similar to the basalts and the Hillabee Greenstone (Table 6). Average SiO_2, 49.7%, Al_2O_3, 16.6%, and MgO, 7.33% of the Coosa block amphibolite compares favorably to the basalt and Hillabee Greenstone averages in Table 5. Two amphibolite samples, 7B and 370, have high MgO contents of 10.1 and 8.91%, respectively, when compared to the average MgO in basalts or

Hillabee Greenstone samples. Aluminum (Al_2O_3) in the Poe Bridge Mountain Group amphibolite samples, 9 and 369, is noted to be far in excess of average Al_2O_3 in the Hillabee Greenstone.

ACF plots (Figs. 2, 3) of the Hillabee Greenstone and Poe Bridge Mountain Group amphibolite indicate the samples cluster in approximately the same area within the ACF diagram, indicating similar ratios for the components Al_2O_3+Fe_2O_3, MgO+FeO, and CaO. Division of the Hillabee Greenstone and Poe Bridge Mountain Group is possible on the basis of the mineralogy, if the ACF diagram is used. Chemical characteristics of the Hillabee Greenstone and Poe Bridge Mountain Group amphibolites verify the mineralogy previously discusses (see section 3).

Separate trends are suggested when the Hillabee Greenstone and Poe Bridge Mountain Group amphibolite samples are plotted on a AFM diagram as show on Figure 4. A possible tholeiitic trend is noted for the Hillabee Greenstone samples, whereas the majority of the Poe

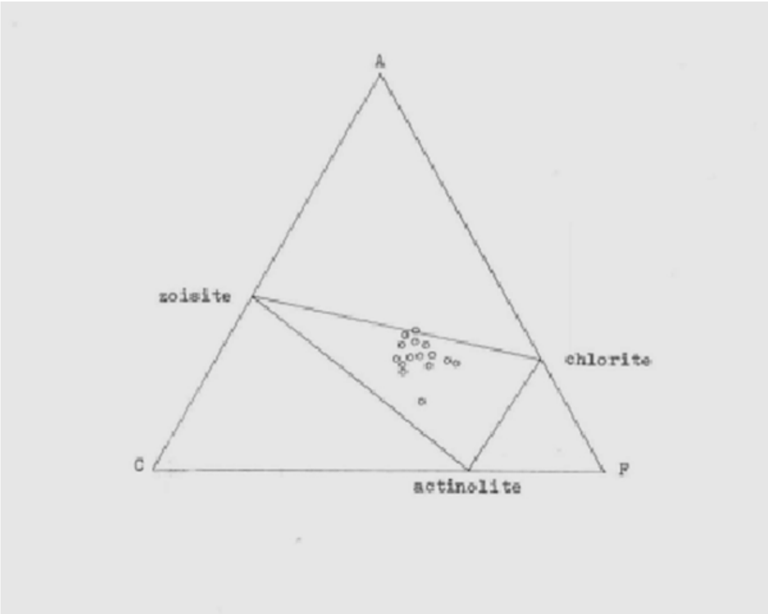

Figure 2. Hillabee Greenstone samples on the low-grade, low temperature mafic green-schist ACF diagram after Winkler (1976).

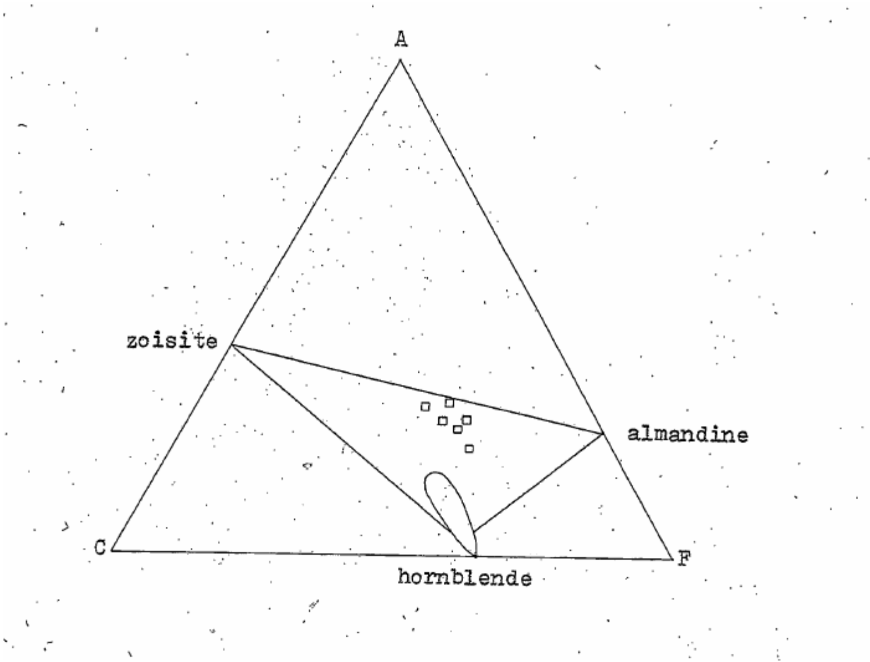

Figure 3. Poe Bridge Mountain Group amphibolite samples on the medium grade ACF diagram after Winkler (1976).

Bridge Mountain Group amphibolite samples plot closer to the calc-alkaline trend. The separate trends suggest separate primary sources. The small number of amphibolite samples does not define a clear trend of the AFM diagram; thus, the diagram is inconclusive in reference to the amphibolite. Selected Hillabee Greenstone samples from areas to the south of the study area indicate a tholeiitic trend when plotted on an AFM diagram (Stow, personal communication), similar to the suggested tholeiitic trend for the Hillabee Greenstone in Figure 4.

Trace element abundances reflect trends similar to the major element abundances for lithologic divisions. Correlations are noted for major elements and the associated trace elements in several cases. Potassium is usually noted correlated with the amount of Rubidium (Rb) and Barium (Ba). Samples with low K_2O (<0.35%) in the Hillabee Greenstone, lithic fragments and amphibolite also have associated low Ba content (61-83 ppm). High average Ba content, 676 ppm, is noted in the transitional zone lithologies, which have a comparatively high, 2.10%,

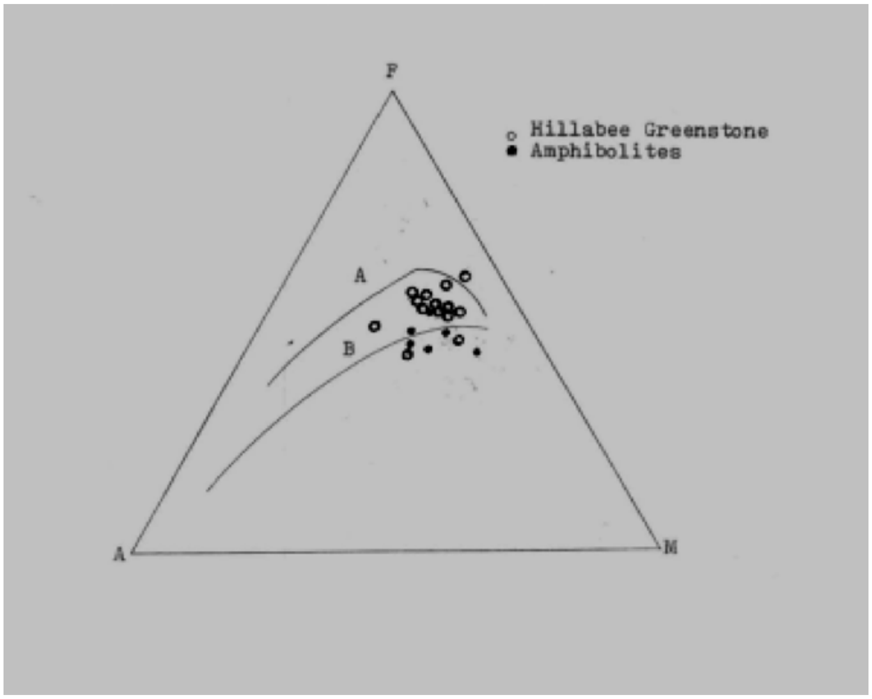

Figure 4. AFM plot showing the relationship of the Hillabee Greenstone and Poe Bridge Mountain amphibolites to the tholeiitic trend (Line A) and calc-alkaline trend (Line B) after Kuno (1968).

average K_2O content. Rubidium content also follows the K_2O content. Average Rb content for the high K_2O transitional zone samples is 61 ppm, as compared to an average Rb content of 2 ppm for the K_2O poor (<0.36 ent) Hillabee Greenstone, lithic fragments, and the Poe Bridge Mountain Group amphibolite.

Strontium (Sr) is associated with CaO and higher values of Sr, 474 ppm, are found in the CaO-rich lithic fragments. Lower average CaO (<11%) in the Hillabee Greenstone, Poe Bridge Mountain Group amphibolite and transitional zone samples have Sr compositions of 215 ppm.

Copper (Cu) values are high, averaging 134 ppm, in the Hillabee Greenstone and lithic fragment analyses, when compared to the other analyses. Mineralized veins of granite and associated cooper minerals were economically mined from the Hillabee Greenstone in Pyriton, Clay County, southwest of the study area. Pyrite exists in small quantities within the Hillabee Greenstone (see section 3).

4.3 Delineation of Tectonic Setting

Average chemical compositions of the Hillabee Greenstone and Poe Bridge Mountain amphibolite are similar to each other and to selected basalt. Basalt has a wide composition range related to the primary formational environments (Miyashiro, 1975). Several geochemical trends have been observed for basalts of different tectonic environments. This study assumes that the Hillabee Greenstone and Poe Bridge Mountain Group amphibolite are derived from similar geochemical systems to the Cenozoic basalt used in the comparisons.

Tholeiitic basalt composition is suggested by the Y/Nb ratios of the Hillabee Greenstone (Fig. 5). Pearce and Cann (1973) indicate that Nb and Y are relatively immobile during alteration and indicate primary basaltic composition. Tholeiitic basalts are found in a variety of tectonic environments, including island arcs and oceanic abyssal plains. Several chemical relationships distinguish the different tholeiitic basalt environments (Jakes and Gill, 1970; Pearce and Cann, 1973; Miyashiro, 1975).

The majority of the Hillabee Greenstone samples are in the low potassium tholeiitic (LKT) field when plotted on a Cr-Ti diagram (Fig. 6). Two Hillabee Greenstone and one Poe

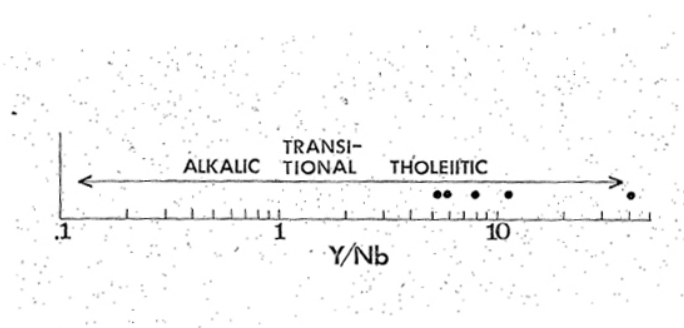

Figure 5. Hillabee Greenstone samples plotted on a Y/Nb diagram after Pearce and Cann (1973).

Bridge Mountain Group amphibolite samples plot in the ocean floor basalt (abyssal tholeiitic) field. An active continental margin origin is also indicated for the Hillabee Greenstone and Poe Bridge Mountain Group amphibolite on a Ni-FeO*/MgO graph (Fig. 7).

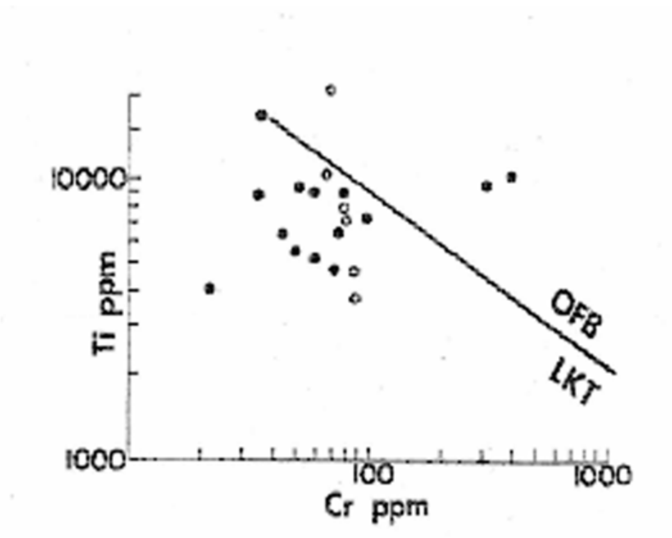

Figure 6. Ti-Cr diagram after Pearce (1975). Hillabee Greenstone samples are designated with a solid circle and the Poe Bridge Mountain Group amphibolite samples are shown with an open circle. Abbreviations: OFB, ocean floor basalt; LKT, low potassium tholeiite field.

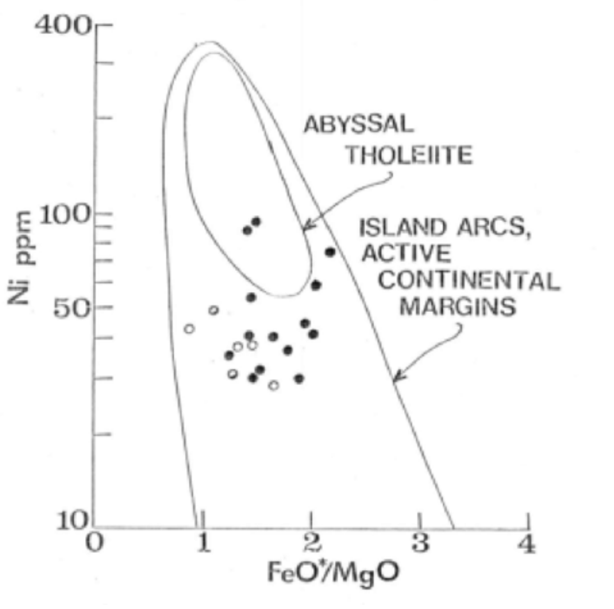

Figure 7. Ni-FeO*/MgO diagram from Miyashiro and Shido (1975). Hillabee Greenstone samples are designated with solid circles, while Poe Bridge Mountain Group amphibolite samples are designated with open circles.

The averages trace element concentrations for the island-arc tholeiitic basalt Hillabee Greenstone and Poe Bridge Mountain Group amphibolite are similar. Chromium is noted to be relatively immobile during alteration (Bloxam and Lewis, 1972). The Cr content (297 ppm) of abyssal tholeiite is very high when compared to the Hillabee Greenstone average chromium content of 70 ppm suggesting that the primary material for the Hillabee Greenstone was not formed in an ocean floor tectonic environment.

Pearce and Cann (1973) have divided basalts into tectonic settings on the basis of Sr, Zr, Y, and Ti concentrations. A triangular Ti-Zr-Yx3 diagram shows that all of the Hillabee samples for which Zr and Y data are available plot within the overlap field between calc-alkaline and low-potassium tholeiite. Figure 8 shows the Hillabee Greenstone samples plotted on a Zr-Ti diagram after Pearce and Cann (1973). The samples are divided between the island-arc and calc-alkaline areas (Fig. 8). Both the Ti-Zr-Y and Zr-Ti diagrams are inconclusive for the delineation of a single tectonic setting for the parental material of the Hillabee Greenstone.

The geochemical data and comparisons discussed above do not give a clear indication of the primary material from which the Hillabee Greenstone and Poe Bridge Mountain Group amphibolite were derived. General characteristics suggest a tholeiitic island-arc formational environment for the Hillabee Greenstone. A basaltic composition is suggested for the Poe Bridge Mountain amphibolite. Chemical differences noted between the Poe Bridge Mountain Group amphibolite and Hillabee Greenstone indicate different primary materials. The Poe Bridge Mountain amphibolite did not derive from an island-arc environment like the Hillabee Greenstone. No definite tectonic environment has been postulated for the Poe Bridge Mountain amphibolite on the basis of these data.

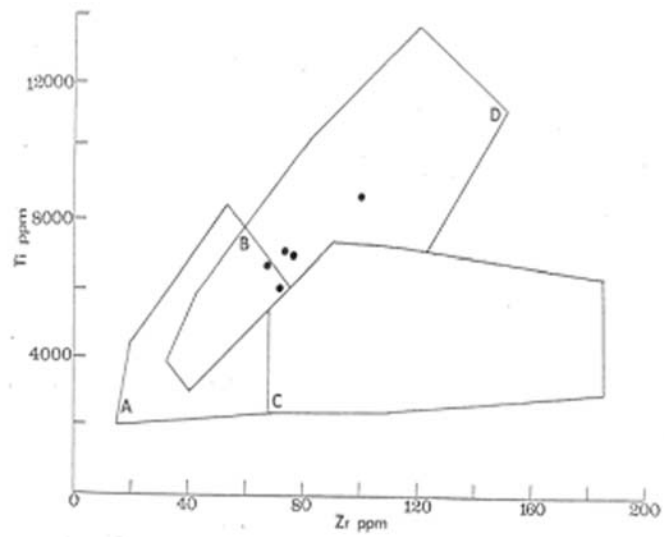

Figure 8. Ti-Zr diagram from Pearce and Cann (1973). Region A represents abyssal tholeiites. Abyssal tholeiites and island-arc basalts plot in area B. Island arc basalts plot in areas B and C. Calc-alkaline basalts plot in area C and D. Hillabee Greenstone samples are indicated by a solid circle.

5. STRUCTURE

Mesoscopic fabric studies and field relationships document at least three folding events and one major thrust faulting event. Similar deformational events affected both the Talladega and Coosa blocks and produced a series of observable folding phases (F_1-F_3). The Hollins Line fault is the major fault that may be a separate event from the folding events. Two sub-areas, I and II, are defined to study the F_4-fold phase. The events are discussed below in the proposed order of occurrence.

5.1 Deformational Phases

5.1.1 F_1-fold Phase

A regional dynamothermal event produced the F_1-fold features observed in both sub-areas. Compositional layering (S_0) is the only pre-F_1 surface and therefore must be observed to identify F_1-folds. Tight isoclinal folds were formed during the F_1-fold phase as shown in Figure 9. Compositional layers thin on the limbs and thicken in the hinges of the F_1-folds. Later deformational events have re-folded the F_1-folds, therefore the original trend of the F_1-folds is unclear.

The regional dynamothermal metamorphic event which produced the F_1-folds may also have produced the primary metamorphic foliation (S_1). Preferred orientation of mineral growth (schistosity) is presumably synchronous with metamorphism and deformation produced foliation surfaces (S_1) which parallel the axial planes of the F_1-folds. Plate 2 shows the regional trends of the foliation surfaces (S_1) to be predominate in the N45E, 45-60º SE in the Talladega block and

Figure 9. Mesoscopic isoclinal fold in the Talledega block formed during the F_1-fold phase. The fold is defined by a quartzite unit.

the N50E, 30º SE in the Coosa block.

Mineral lineation (L_1) has developed in the foliation surfaces (S_1) as a result of preferred mineral growth during syn-metamorphic deformation. Intersection lineations may be formed in the hinge areas of F_1-folds where compositional layers (S_0) and foliation (S_1) are not parallel. Compositional layering (S_0) must be present to produce the intersection lineation. Regional trends of the L_1 lineations are 10º, N50E in the Talladega block and 30º, S50E in the Coosa block (Plate 2). In the limbs of the F_1-folds, foliation and compositional layering are essentially parallel.

5.1.2 F_2 and F_3-Fold Phases

Foliation surfaces (S_1) are refolded by later deformational events producing F_2-folds. Micro-to mesoscopic crenulation and chevron drag folds in the limbs of the F_2-folds are used to define larger F_2-folds. Distinct down plunge symmetries or rotational senses are noted in the small, 0.1-1 cm, crenulation drag folds, which may be used to determine the geometry of larger folds in the area (Billings, 1972). Hinge areas of the F_2-folds display symmetrical profiles (Billings, 1972). Axes of the F_2-folds often form distinctive crenulation lineations (L_2) within the foliation surfaces (S_1). Axial plane cleavage (S_2) is found in several outcrops where the F_2-folds are very tight chevron folds.

A mesoscopic drag fold in the Talladega block with S-symmetry down plunge is shown in Figure 10. Small (1 mm) crenulation folds observed in thin section indicate no changes in the mineralogy described in section 4, and no recrystallization resulted from the F_2-fold phase. The S_0 and S_1 surfaces have been refolded in F_2-folded in the F_2-fold phase. The F_2-folds have a plunge ranging from 0-45º, N45E in the Talladega block. Plunges of 0-30º, S70E are noted in the Coosa block.

Figure 10. Small scale fold showing the F_2-fold phase.

In some localities, a second set of crenulation folds has been noted; the folds formed at angle to the first set of crenulation folds, and are designated as F_3-folds. This set of small, 1 mm to 1 cm, F_3-folds may predate or post-date the above described F_2-folds. Intersection of the F_2

and F_3-fold phases is poorly defined. Angles between the axis trends of the F_2 and F_3-folds are variable ranging between 10-80º. The discontinuous nature of the F_3-folds had made unclear the relationship of the F_3-folds to the other structural features. The F_3-fold features may be large features affecting the regional orientation of S_1, L_1, and F_2 features defined above but this is not clear.

The three fold phases described above are similar features in both the Talladega and Coosa blocks; thus, synchronous deformation affected both blocks producing the F_1, F_2 and F_3-fold phases. Different trends are apparent in the S_1, L_1 and F_2 stereographic plots of data in the Talladega and Coosa block (Plate 2). Thrust faulting is responsible for the different structural trends in the Talladega and Coosa blocks and is described below.

5.1.3 Hollins Line Fault

The Hollins Line fault represents the contact of the Talladega and Coosa blocks. Tull (1978) postulated the Hollins Line fault as a thrust fault of large displacement. An abrupt metamorphic grade change is noted between the lower greenschist facies blocks of the Talladega block, and the middle amphibolite facies rocks in the Coosa block. Specifically, the Hillabee Greenstone abuts against the Poe Bridge Mountain mica-schist along the Hollins Line fault.

Movement along the Hollins Line fault produced a 20 m thick zone of cataclastic rocks within the Poe Bridge Mountain Group mica schist. Phyllonite formed from the coarse-grained mica schist in the Poe Bridge Mountain Group along the contact of the Hollins Line fault. A secondary shear cleavage (S_2) has formed at a shallower angle than the foliation (S_1) producing a "button schist" texture in the phyllonite. Southeastward from the Hollins Line fault contact, the phyllonite grades gradually into a coarser-grained mica schist. Northwestward from the Hollins Line fault no evidence of cataclasis or development of phyllonite is observed within the Hillabee

Greenstone. Cataclasis probably affected the Hillabee Greenstone along the Hollins Line fault; however, the very fine-grained texture of the Hillabee phyllite along this zone makes the results of cataclastic deformation difficult to observe.

When the Hollins Line fault crops out, it is difficult to define, because it exhibits concordance with the rock units on both sides of the fault. However, discordance is noted between the Hollins Line fault and features within the Talladega and Coosa blocks when observed regionally. Plate I shows that stratigraphic units within the Talladega and Coosa blocks truncate against the Hollins Line fault. Quartzite and amphibolite units within the Poe Bridge Mountain Group truncate against the Hollins Line fault to the northeast (Plate 1). Quartzite units and the Hillabee Greenstone in the Talladega block also truncate against the Hollins Line fault to the south (Plate 1).

Structural features foliation (S_1), lineations (L_1) and crenulation axes (F_2) are noted above to be discordant when compared in the Talladega and Coosa blocks and to the trace of the Hollins Line fault (Plate 2). Movement along the Hollins Line fault has emplaced the Coosa block structurally over the Talladega block, creating the angular relationship between the Talladega block, Coosa block and Hollins Line fault. The regional dip of the Hollins Line fault is less than the dip of the Hillabee Greenstone in areas south of the study area (Tull, 1977). Similar stratigraphy and structure are noted in the area to the south of the study area; the Hillabee Greenstone abuts against the Poe Bridge Mountain Group with the Hollins Line fault defining the contact of the two units. Therefore, the Hollins Line fault is thought to have a regional dip less than the dip of the Hillabee Greenstone.

When observed regionally in Alabama, the Hollins Line fault predominantly contacts the Hillabee Greenstone. The Hillabee Greenstone may be controlling the position of the Hollins

Line fault. A decollement zone may exist within the fine grained well foliated phyllite within the Hillabee Greenstone, which is represented by the position of the Hollins Line fault.

Repetition of the Talladega Block stratigraphic sequence in the east is due to imbricate faulting along the Hollins Line fault (Plate 1). A schematic cross-section through the imbricate zone is shown in Figure 1. Two segments of Hillabee Greenstone and the uppermost quartzite of the Talladega Group are observed in the imbricate faulted zone. Stratigraphic positioning of the Hillabee Greenstone is postulated as controlling the position of the imbricate faulting as both fault planes contact the Hillabee Greenstone.

5.1.4 F_4-fold Phase

Lithologic groups within the Talladega and Coosa blocks, and the Hollins Line fault have been further folded by a later F_4-fold phase of folding. Distinct changes are noted for the regional trends of S_1 and L_1-F_2 data using the two subareas. In subarea I, the trends of S_1 are NNE and L_1-F_2 are E-W however in subarea II, the regional trend of S_1 has changed to NE and F_2 axis are trending SE (Fig. 11). A broad northwest-southeast F_4-fold represent the latest deformational event observed.

The spatial relationship of the deformational events reveals the following sequence:

1. A regional dynamothermal metamorphic event produced F_1-folds and associated F_1-structures in the Talladega and Coosa blocks.
2. A regional deformational event refolded the F_1-structures forming F_2-and F_3-folds in the Talladega and Coosa blocks.
3. Movement along the Hollins Line fault resulted in the emplacement of the Coosa lithotectonic block structurally over the Talladega lithotectonic block.

4. A regional deformational event effected the Talladega and Coosa blocks, and the Hollins Line fault produced F_4-folds.

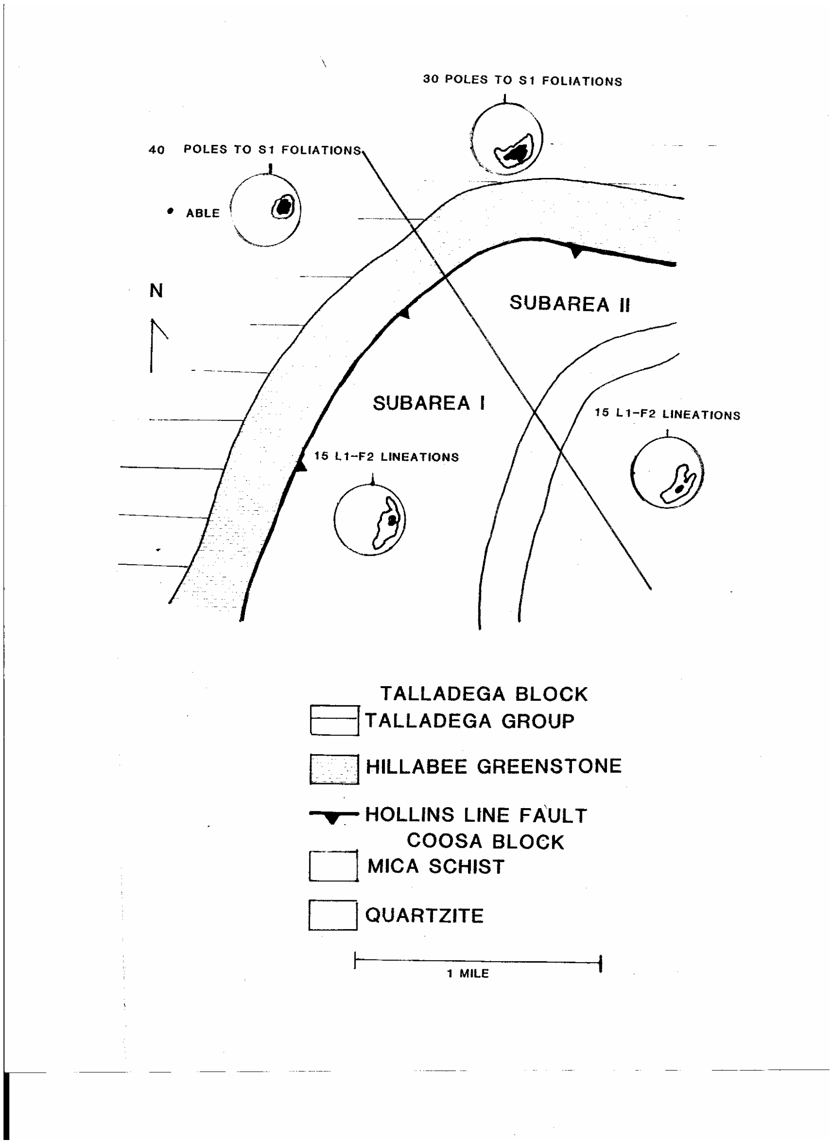

Figure 11. Map showing subareas I and II which delineate a change in the structural components.

6. TECTONIC HISTORY

This study provides the resolution of several conflicting theories regarding the tectonic history providing the interpretive history is correct. Carbon-bearing sericite phyllite with interbedded massive quartzite and isolated stretched pebble conglomerate are the main rock types in the Talladega block. Bearce (1973a) described the lower Talladega Group Able Gap Formation as being a carbonaceous pelite. The parent rocks of the sericite phyllite are postulated to be predominately shale, graywacke and mudstone, some carbonaceous rock with interbedded coarser grain sands and conglomerate. Thickness of the Talladega block parental sediments is unclear. A sub-tidal or lagoonal environment is suggested by the large amount of mudstone and shale parent material and associated carbonaceous layers. Several periods of higher energy fluvial deposition, possibly stream channels, are represented by thin quartzite beds in the Talladega block.

A period of alternating sedimentation and volcanism is indicated by the interlayered nature of the transitional zone lithologies in the Talladega block. The pelitic sediments of the transitional zone are the last periods of sedimentation observed in the Talladega block. Volcanic activity within the Talladega block is first observed as an interlayered unit within the transitional zone (see section 2). Volcanism, possibly of island arc origin, deposited the primary material of the Hillabee Greenstone directly over the sediments of the Talladega Group with some interlaying sequences of Talladega Group sediments. Interlayered ash and basalt are represented by the mafic phyllite and greenstone deposited during the volcanic phases. No time framework is postulated for the volcanism. However, the conformable contact of the Talladega Group and Hillabee Greenstone indicates the Hillabee Greenstone is younger. Volcanic bombs and or ejected particles associated with ash flows and volcanism may be represented by the lithic fragments in the lower youngest Hillabee Greenstone horizon. Clarke (1964) postulated that the parent rock of the Hillabee Greenstone was sedimentary. This study clearly shows that the Hillabee Greenstone has an igneous origin. Some researchers have suggested that the Hillabee Greenstone was intruded as a sill (Griffin, 1951; Carrington and Wigley, 1967). However, this study clearly shows a transitional relationship between the Hillabee Greenstone and the Talladega Group and the presence of lithic ejecta which indicate an extrusive origin. The mafic phyllite may represent ash flows in a volcanic environment where as the greenstone represents basaltic lava flows. This hypothesis is further supported by the presence of compositional layering predominantly in only the phyllite; compositional layering is not commonly observed in the greenstones. The mafic phyllite interlayered with the Talledga Group in the transitional zones is very similar to that of the Hillabee Greenstone described above and is thought to represent the initial pulse of Hillabee volcanism.

At every location, the Poe Bridge Mountain Group is in fault contact with the Hillabee Chlorite Schist along the Hollis Line fault. Deposition of some of the sediments of the Poe Bridge Mountain Group is thought to be earlier than the Talladega Group; Cambrian to Precambrian ages are postulated for the Poe Bridge Mountain Group. Originally, most of the Poe Bridge Mountain Group mica schist was probably fine-grained sediments. Interlayered clastic rocks are represented by the quartzite within the Poe Bridge Mountain Group. Several periods of volcanic activity deposited mafic material within the pelitic sediments of the Poe Bridge Mountain Group. Geochemical data presented above suggests the Poe Bridge Mountain amphibolite was not formed in the same environment as the volcanic Hillabee Greenstone. No definite source rock was determined for the Poe Bridge Mountain amphibolite.

Geochemistry has been used to postulate a subduction zone and associated island-arc volcanism, as the primary source for the Hillabee Greenstone (section 4), Ringwood (1969) presented a subduction zone model and associated rock types shown in Figure 12. The primary Hillabee Greenstone is thought to be represented by the island arc basalts. Geochemical data presented above also suggests that the Poe Bridge Mountain amphibolite was not primarily formed in an island-arc environment. Stow (personal communication) has postulated the geochemistry of the Poe Bridge Mountain amphibolites is similar to volcanics in rift zones.

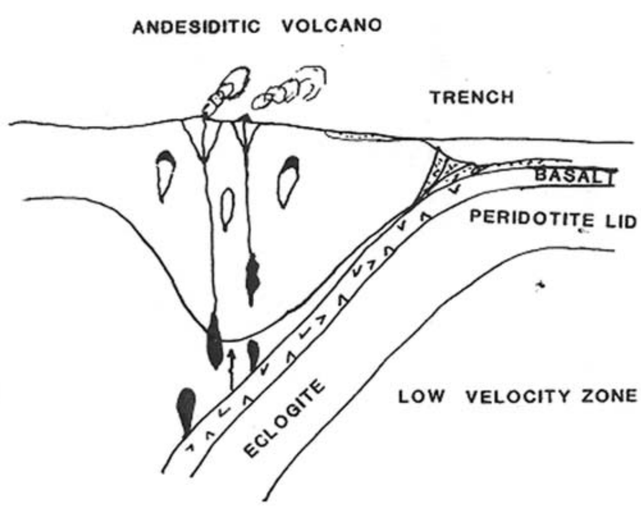

Figure 12. A subduction model with associated volcanic and igneous rocks (Ringwood, 1969)

A single regional dynamothermal metamorphic event (M_1) is thought to have altered the Talladega Group and the Hillabee Greenstone. Similar M_1 metamorphic features, foliation, F_1-folds and lineations, are noted in the low-grade Talladega Group – Hillabee Greenstone sequence and the high-grade Poe Bridge Mountain Group. One dynamothermal metamorphic event altered the Talladega Group, Hillabee Greenstone produced tight isoclinal and Poe Bridge Mountain Group primary rocks. Deformation associated with the event folds resulting in an undetermined amount of regional shortening in the Talladega Group, Hillabee Greenstone and Poe Bridge Mountain Group sequences.

If a Devonian age for the Talladega Group – Hillabee Greenstone complex is correct, the M_1 dynamothermal event may correlate to the Alleghenian orogeny (Rodgers, 1970). Earlier orogenic episodes, Acadian and Taconic, observed in the northern Appalachian region, are not evidenced in the southern Appalachian region. During the Alleghanian orogeny, the Talladega Group – Hillabee Greenstone complex and the Poe Bridge Mountain Group were refolded as a result of the D_2 and D_3 events forming the F_2 and F_3-folds.

A later compressional event resulted in the formation of and movement along the Hollins Line fault. As the Coosa block was thrust to the northwest over the Talladega block, 12 km of displacement occurred (Tull, 1978). The stratigraphic position of the Hillabee Greenstone may have some control of the position of the Hollins Line fault possibly acting as a less competent unit (Tull, 1978). A final compressional event produced large regional north west-southeast cross folding (F_4). The regional outcrop pattern of the Hollins Line Fault, and Talladega and Coosa blocks shows the effect of the last deformation event (Plate 2).

6.1 Comparison to Recent Studies

The study area in Cleburne County, Alabama is entirely within the Blue Ridge of the southern Appalachians, which refers to the area west of the Brevard zone (Hayesville-Fries) and east of the Valley and Ridge. Hatcher (1978) divided the Blue Ridge into 3 subdivisions: 1) a western belt of imbricate thrusts of unmetamorphosed to low-grade rocks; 2) a central core containing high grade and basement rocks; 3) an eastern belt of varying rock types with abundant metavolcanic rocks. The western belt correlates to the Talledega Group rocks including the Hillabee Greenstone and the eastern belt correlates to the Poe Ridge Mountain rocks of the Ashland-Wedowee Sequences.

Odam and Fullagar (1973) proposed that the Blue Ridge and western Piedmont were part of an early Paleozoic island arc separated from the North American continent. An east-dipping subduction zone was present in middle Paleozoic time that closed a small ocean that separated the North American continent from this island arc along the Brevard zone (Odam and Fullagar, 1973). However, similarities in ages of plutons, age of metamorphism and structural sequence on both sides of the Brevard zone necessitate that a subduction zone did not exist at that location (Hatcher, 1978). Hatcher (1978) suggested that an east dipping subduction zone did exist but along the Inner Piedmont-Blue Ridge boundary instead which would to the south of the study region in this paper. Hatcher (1978) suggested that the mafic-ultramafic complexes of the Blue Ridge were emplaced as a marginal sea closed that separated North America from a rifted continental block creating a continental fragment-island arc collision in Devonian time. This event was followed by the continent-continent collision of North America with Africa during Carboniferous and Permian time (Hatcher, 1978). Perhaps this final collision caused the F_4-fold found in the study region and formation of the Hollins Line fault.

Although the geochemistry shows that the Hillabee Greenstone and Talledega Group are associated with island arc volcanism and subduction similar to that in Figure 12, it is unclear which way the subduction zone dipped. Figure 12 is a general sketch, and is not proposing a west dipping subduction zone. Recently, however, Odam and Fullagar (1973) propose an east dipping subduction zone to account for the island arc volcanism as a continental fragment closed with North America. Other rocks in the Talledega block are continental in origin. The volcanism in the Poe Ridge Mountain rocks is not similar geochemically to the Hillabee Greenstone and Talledega Group rocks and suggests a distinct source.

7. CONCLUSIONS

Analyses of the mineralogy, geochemistry and metamorphism indicate a continental origin for the depositional environment for the Talladega block and Hillabee Greenstone with associated island-arc volcanism. The primary depositional sequence for the Talladega units is a near shore environment with shale and sandstone as compositional alternating units. Amphibolite in the upper Talladega units and Hillabee Greenstone indicate that this area was near to an island arc environment possibly as distal lava flows. The island arc volcanic activity represented the primary material for the Hillabee Greenstone as defined by the geochemical analysis. Subduction associated with an island arc-continental fragment collision created this low-grade sequence of sedimentary-volcanic rock. The Coosa block units are higher grade metamorphic rocks and amphibolite, the Poe Bridge Mountain amphibolite. Geochemical analyses reveal that this amphibolite is not related to the Hillabee Greenstone. During the island arc-continental fragment collision, F_1-folds were formed in both the Coosa and Talladega blocks. Continued collision of North America and Africa possibly created the F_2-F_3 folds, the Hollins Line fault, and finally, the F_4 folds.

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PLATE 1

COMPOSITE STRUCTRAL MAP OF SOUTHERN CLEBURNE COUNTY, ALABAMA

PLATE 2

REGIONAL PLOT OF STRUCTURAL TRENDS IN THE TALLADEGA AND COOSA LITHOTECTONIC BLOCKS