# GEOLOGY OF THE 1:24,000 TALLASSEE, ALABAMA, QUADRANGLE, AND ITS IMPLICATIONS FOR SOUTHERN APPALACHIAN TECTONICS

Except where reference is made to the work of others, the work described in the thesis is my own or was done in collaboration with my advisory committee. This thesis does not include proprietary or classified information.

Thomas West White

Certificate of Approval:

| | |
|---|---|
| Robert B. Cook<br>Professor<br>Geology | Mark G. Steltenpohl, Chair<br>Professor<br>Geology |
| Willis E. Hames<br>Professor<br>Geology | Philip L. Chaney<br>Associate Professor<br>Geography |

Joe F. Pittman
Interim Dean
Graduate School

# GEOLOGY OF THE 1:24,000 TALLASSEE, ALABAMA, QUADRANGLE, AND ITS IMPLICATIONS FOR SOUTHERN APPALACHIAN TECTONICS

Thomas West White

A Thesis

Submitted to

the Graduate Faculty of

Auburn University

in Partial Fulfillment of the

Requirements for the

Degree of

Master of Science

Auburn, Alabama
May 10, 2008

# GEOLOGY OF THE 1:24,000 TALLASSEE, ALABAMA, QUADRANGLE, AND ITS IMPLICATIONS FOR SOUTHERN APPALACHIAN TECTONICS

Thomas West White

Signature of Author

Date of Graduation

# VITA

Thomas West White was born on May 17, 1980, in Jackson, Mississippi, to Mary A. Blair and Billy D. White. He graduated in May of 1998 from Florence High School in Florence, Mississippi. He then attended Copiah-Lincoln Junior College, Wesson, Mississippi, where he obtained his Associates of Science degree in May of 2001. West then went on to obtain his Bachelor of Science degree from the University of Southern Mississippi, Hattiesburg, Mississippi, in August of 2004. During his undergraduate studies he worked as a field research assistant on the National Guard Resource Management Grant Project. In January 2006, West was accepted into the graduate program for Geology at Auburn University. While in graduate school at Auburn, he was a teaching assistant and a field research assistant. On September 5, 2006, West and his wife Heather were blessed with their first daughter, Kathryn Pyper.

# THESIS ABSTRACT

# GEOLOGY OF THE 1:24,000 TALLASSEE, ALABAMA, QUADRANGLE, AND ITS IMPLICATIONS FOR SOUTHERN APPALACHIAN TECTONICS

Thomas West White

Master of Science, May 10, 2008
(B.S., University of Southern Mississippi, 2004)
(A.S., Copiah Lincoln Junior College, 2000)

89 Typed Pages

Directed by Mark G. Steltenpohl

The 1:24,000 scale Tallassee, Alabama, Quadrangle, was mapped to characterize lithologies and structures in the southernmost exposures of the southern Appalachians. Four deformation events are recognized. $D_1$ was associated with prograde amphibolite-facies metamorphism that produced the dominant schistosity and gneissosity, $S_1$, isoclinal folds of compositional layering, $S_0$, and a mineral lineation, $L_1$. $D_2$ was a lower amphibolite- to upper greenschist-facies event that occurred during late $M_1$ metamorphism. $D_2$ resulted in $F_2$ isoclinal folds of $S_0$/ $S_1$ and conical folds, extensional shear bands ($S_2$), $L_2$ elongation lineation, and foliation boudinage. $D_3$ was a greenschist-facies event that produced $F_3$ kink folds and the map scale Tallassee synform and $S_3$ crenulation cleavage. $D_4$ resulted in tension gashes and small cataclastic zones.

The base of the Dadeville Complex is marked by the pre- or syn-metamorphic Stonewall Line shear zone on the southeast limb, through the hinge zone, and on the northwest limb of the Tallassee synform. North of the Tallassee Quadrangle, late, post-$M_1$ reactivation of the Katy Creek fault cut $D_1$ fabrics and $S_0/S_1$ layering of the Dadeville Complex and excised a segment of the Stonewall Line shear zone. The Stonewall Line shear zone is interpreted to be a segment of the early stage of development of the Brevard zone. Within the study area, Jacksons Gap Group metasedimentary rocks are interleaved with quartzofeldspathic gneisses interpreted as mylonitized Farmville Metagranite, the latter becoming more abundant as the hinge zone is approached from along the synform's southeast limb. Middle Ordovician Kowaliga, Zana, and Farmville granitoids are interpreted to continue through the buried parts of the Tallassee hinge zone, supporting correlation of the eastern Blue Ridge with portions of the Opelika Complex. The base of the Opelika Complex, i.e., the Towaliga fault, should be considered to be a segment of the Hayesville-Fries fault since it emplaces eastern Blue Ridge rocks upon Laurentian units (i.e., the Pine Mountain terrane). The presence of a voluminous mass of granitoids and migmatites at the base of the Dadeville Complex in this area is compatible with the concept of a 'super migmatite' zone, supporting Hatcher and Merschat's (2006) interpretation for mid-crustal level channelized flow of the Inner Piedmont terrane. The Opelika Complex is not related to the Inner Piedmont, as is traditionally thought, but is continuous with the eastern Blue Ridge around the hinge zone of the Tallassee synform as originally suggested by Grimes et al. (1993a).

# ACKNOWLEDGMENTS

The author would like to thank the United States Geological Survey Education Mapping Program (EDMAP) for providing funds in support of this research.  Thanks are extended to David Keefer for providing valuable insight and data for map development. The author thanks his wife Heather and daughter Pyper for all of the love and support provided throughout his education process.

Style manual used: Suggestions to Authors of the Reports of the United States Geological Survey

Computer software used: Microsoft Office XP, Corel® Designer 12.0, Rockware® Utilities 3.0, and Adobe Photoshop 6.0

## TABLE OF CONTENTS

## LIST OF FIGURES

# LIST OF TABLES

# LIST OF PLATES

# INTRODUCTION

## General Statement

The 1:24,000 Tallassee Quadrangle contains the southernmost exposures of crystalline bedrock of the Appalachian Mountain chain in east-central Alabama (Figs. 1, 2, and 3). Outcrops are primarily found along the banks of the Tallapoosa River and its tributaries where they have cut deeply through the veneer of Gulf Coastal Plain sediment cover. The Tallassee Quadrangle covers an area in southeastern Elmore and southwestern Tallapoosa counties, between latitudes 32º 30’ 00” N and 32º 37’ 30” N and longitudes 85º 52’ 30” W and 86º 00’ 00” W. This area lies north of Interstate 85, the major thoroughfare connecting Montgomery, Alabama, with Atlanta, Georgia. Auburn, Alabama, lies twenty-four kilometers east of the quadrangle.

Located within the Tallassee Quadrangle is the hinge zone of the Tallassee synform, a regional synform that plunges shallowly to the north-northeast (Figs. 2 and 3; Bentley and Neathery, 1970). Several unusual geological features related to the Tallassee synform are not yet understood but have major significance for interpretations of how the southern Appalachians tectonically evolved. Major shear zones associated with the synform are, from west to east, the Brevard fault zone, Stonewall Line shear zone, and Towaliga fault zone. Unfortunately, the closure of

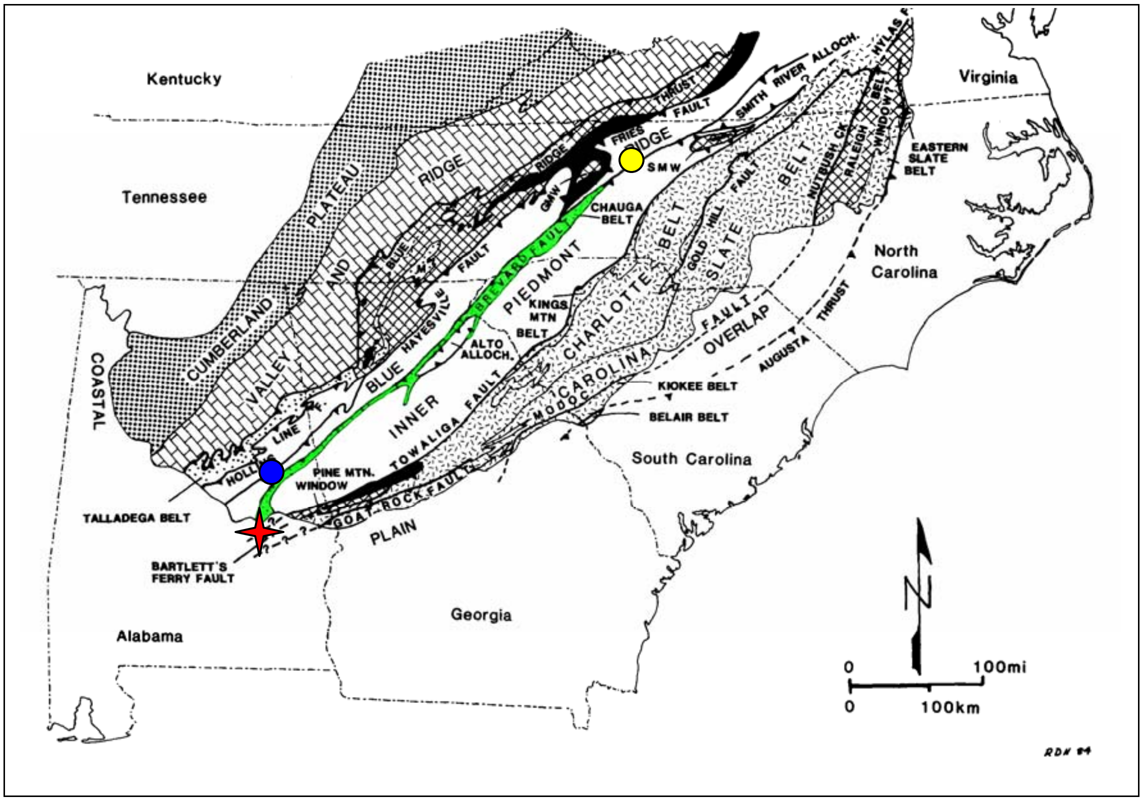


**Figure 1.** Generalized tectonic map of the southern Appalachians showing major tectonostratigraphic subdivisions and fault zones (modified from Hopson and Hatcher, 1988). Brevard fault zone is highlighted in green. Locations: Mt. Airy, North Carolina - yellow circle; Jacksons Gap, Alabama - blue circle; and study area - red star.

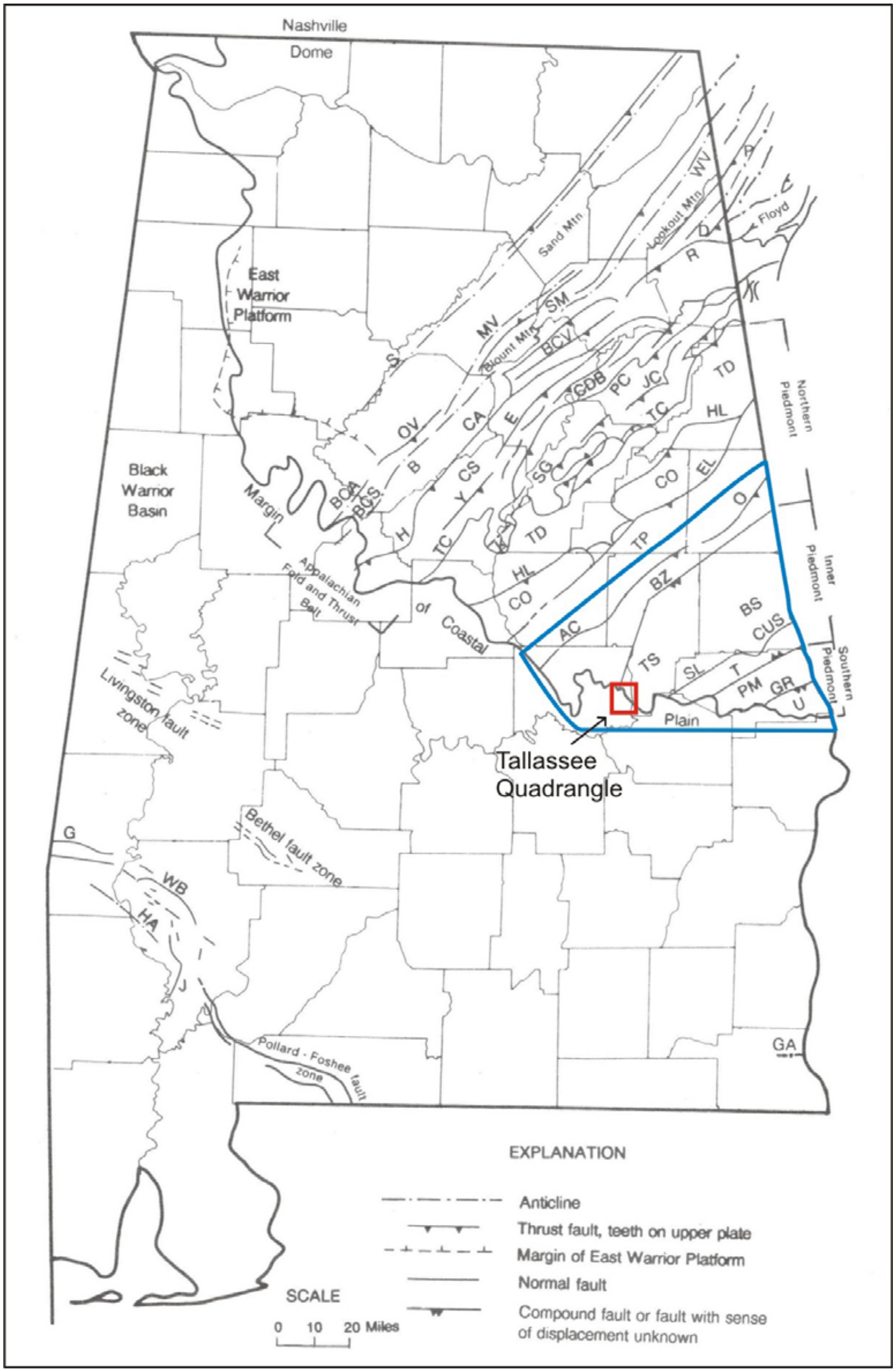
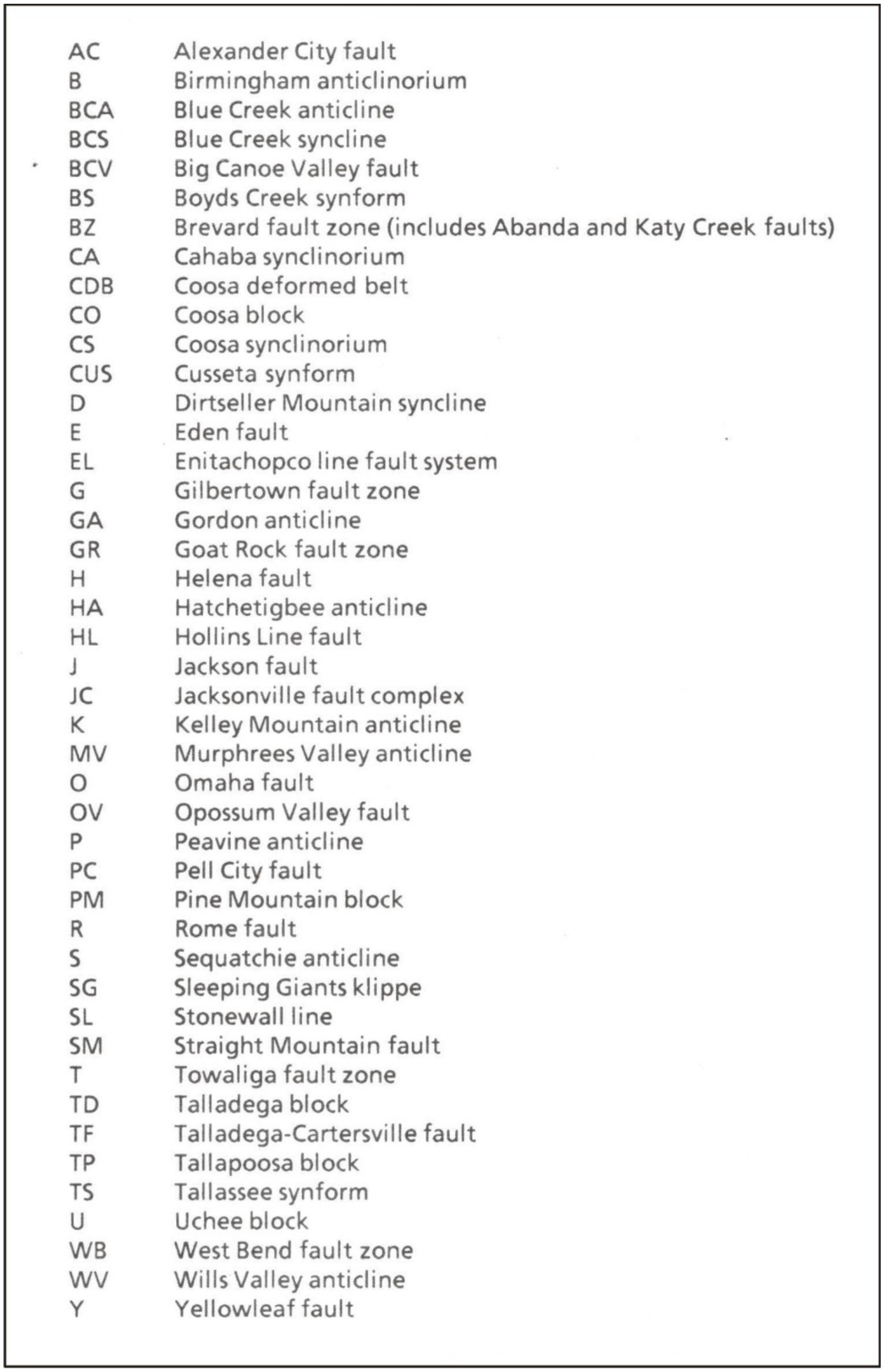


**Figure 2**. Study area location index map (modified from Raymond et al., 1988). Area of Figure 3 outlined in blue.



| | |
|---|---|
| AC | Alexander City fault |
| B | Birmingham anticlinorium |
| BCA | Blue Creek anticline |
| BCS | Blue Creek syncline |
| BCV | Big Canoe Valley fault |
| BS | Boyds Creek synform |
| BZ | Brevard fault zone (includes Abanda and Katy Creek faults) |
| CA | Cahaba synclinorium |
| CDB | Coosa deformed belt |
| CO | Coosa block |
| CS | Coosa synclinorium |
| CUS | Cusseta synform |
| D | Dirtseller Mountain syncline |
| E | Eden fault |
| EL | Enitachopco line fault system |
| G | Gilbertown fault zone |
| GA | Gordon anticline |
| GR | Goat Rock fault zone |
| H | Helena fault |
| HA | Hatchetigbee anticline |
| HL | Hollins Line fault |
| J | Jackson fault |
| JC | Jacksonville fault complex |
| K | Kelley Mountain anticline |
| MV | Murphrees Valley anticline |
| O | Omaha fault |
| OV | Opossum Valley fault |
| P | Peavine anticline |
| PC | Pell City fault |
| PM | Pine Mountain block |
| R | Rome fault |
| S | Sequatchie anticline |
| SG | Sleeping Giants klippe |
| SL | Stonewall line |
| SM | Straight Mountain fault |
| T | Towaliga fault zone |
| TD | Talladega block |
| TF | Talladega-Cartersville fault |
| TP | Tallapoosa block |
| TS | Tallassee synform |
| U | Uchee block |
| WB | West Bend fault zone |
| WV | Wills Valley anticline |
| Y | Yellowleaf fault |

**Figure 2, continued**. Legend to study area location map in Figure 1 (Raymond et al., 1988).

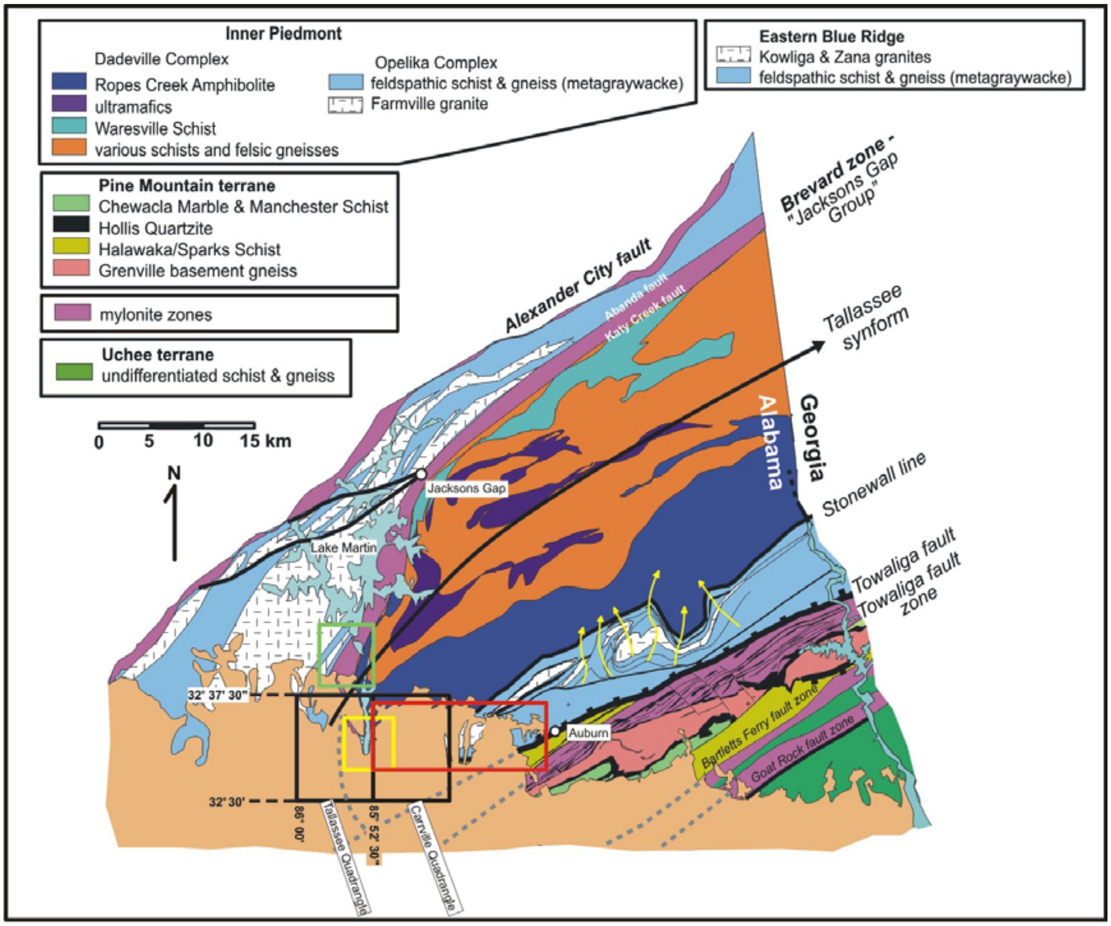


**Figure 3**. Geologic map of the Alabama Piedmont modified from Osborne et al. (1988). Light gray dashed lines are inferred from aeromagnetic linaments projected beneath Coastal Plain sediments (Horton et al., 1984). Black rectangles represent the Tallassee and Carrville Quadrangles. Colored rectangles represent areas of previous geologic mapping studies (Green - Sterling, 2006; Red - Grimes, 1993; and Yellow - Keefer, 1992). Yellow arrows represent macroscopic late-phase cross folds (Steltenpohl et al., 1990).

the synform is almost entirely covered by Gulf Coastal Plain sedimentary rocks leaving geologists with an incomplete understanding of how, or if, these major Appalachian shear zones are related, and how they terminate (if they do). The Tallapoosa River and its tributaries, however, provide partial exposure of the crystalline bedrock beneath the Coastal Plain unconformity.

The Brevard fault zone is perhaps the most controversial structure in the Appalachians. As many as forty-two different interpretations have been offered to explain the fault zone, yet its origin remains uncertain (Bobyarchick, 1999). It is known to be a polyphase, steeply-southeast dipping zone of mylonite, up to 3 km wide, that has a remarkably linear, N $55^o$ E-striking trace from Mt. Airy, North Carolina to Jacksons Gap, Alabama (Figs. 1, 2, and 3). The nature and kinematics of the 'early-stage' (Ordovician or Devonian?), syn-metamorphic history has been obscured by intense 'late-stage' right-slip overprinting during the Carboniferous, but few isotopic dates and no fossil data are reported (Hatcher, 1987; Vauchez, 1987; Dallmeyer, 1988; Cook and Thompson, 1995a). What is certain, however, is that the Brevard is a fundamental Appalachian fault zone that separates Laurentian slope-rise facies rocks of the eastern Blue Ridge from outboard 'suspect' terranes of the Inner Piedmont (Hatcher, 1987; Horton et al., 1989).

At Jacksons Gap, Alabama, the lithologies that characterize the Brevard zone in Alabama, the Jacksons Gap Group, change from steeply dipping to shallowly dipping and they make a sharp bend to the south, reflecting their position along the northwestern limb of the Tallassee synform (Figs. 2 and 3). Also at Jacksons Gap, the 'late-stage' right-slip shear zones that bound the top and bottom of the Brevard shear zone diverge from the Jacksons Gap Group and their ‘early-stage’ structures, with the latter features continuing southward to the Coastal Plain onlap (Fig, 3; Bentley and Neathery, 1970). This segment of the Brevard zone south of Jacksons Gap appears to be the only place in the orogen where the ‘early-stage’ history is exposed without the obliterating affects of the ‘late-stage’ overprint seen elsewhere in the orogen.

Bentley and Neathery (1970) and Raymond et al. (1988) describe the Jacksons Gap Group as containing graphitic-sericite-(muscovite)-quartz schist, quartzite, metaconglomerate, sericite-quartz phyllonite, sericite phyllonite, and chlorite-sericite phyllonite at the type locality near Jacksons Gap, Alabama (Figs. 1, 2, and 3). On the Geologic Map of Alabama, Osborne et al. (1988) depict the Jacksons Gap Group as defining the northwest limb and hinge zone of the Tallassee synform, projecting it to the east bank of the Tallapoosa River within the Tallassee Quadrangle.

Reed (1994) and McCullars (2001) mapped the Jacksons Gap Group along the northwest limb of the Tallassee synform between Jacksons Gap, Alabama, and Martin Dam. They describe this unit as a structurally interleaved sequence of metasedimentary lithologies locally interlayered with amphibolite, which structurally overlie the Kowaliga Gneiss and underlie the Dadeville Complex and typically in fault contact with both. Recent mapping by Sterling (2006) within the Red Hill Quadrangle focused on characterizing the lithologies and depositional environments of Jacksons Gap Group rocks exposed near Martin dam, directly north of the Tallassee Quadrangle (Fig. 3). Sterling (2006) recognized structurally repeated packages of lithologies within the Lake Martin duplex, a syn-metamorphic (amphibolite-facies) transpressional duplex. The Jacksons Gap Group near Martin Dam is distinctly metasedimentary in origin, with preserved primary structures (cross beds and conglomerates, see Figs. 7 and 8 in Sterling, 2006).

Keefer (1992) investigated the Jacksons Gap Group lithologic units and structures along the Coastal Plain onlap in the east-central parts of the Tallassee and the west-central parts of the Carrville quadrangles (Fig. 3). Keefer (1992) recognized repeated packages of rocks that he interpreted to reflect structural duplication within the 'Stone Creek imbricate zone'. The present study will help determine whether the Lake Martin duplex is the northern extension of the Stone Creek imbricate zone and what significance this structure has for southern Appalachian tectonic evolution.

Sears et al. (1981) and Steltenpohl et al. (1990) report a distinct package of pelites and orthoquartzites, the Loachapoka Schist and Saugahatchee Quartzite, at the structural top of the Opelika Complex on the southeast limb of the Tallassee synform. Subsequent mapping led Grimes (1993) to suggest lithologic correlation of the Stone Creek imbricate zone (Jacksons Gap Group) in Keefer's area with the Saugahatchee Quartzite and the Loachapoka Schist, implying connectivity and symmetry between rock sequences on opposing limbs of the Tallassee synform (Fig. 4). A problem with this interpretation, however, is that feldspathic gneisses generally characterize units that Osborne et al. (1988) assigned to the Jacksons Gap Group along the Tallapoosa River (M. G. Steltenpohl, personal communication, 2006). Though the Jacksons Gap Group is described and depicted as a package of metasedimentary rock (Raymond et al., 1988, and Osborne et al., 1988, respectively), these feldspathic gneisses along the

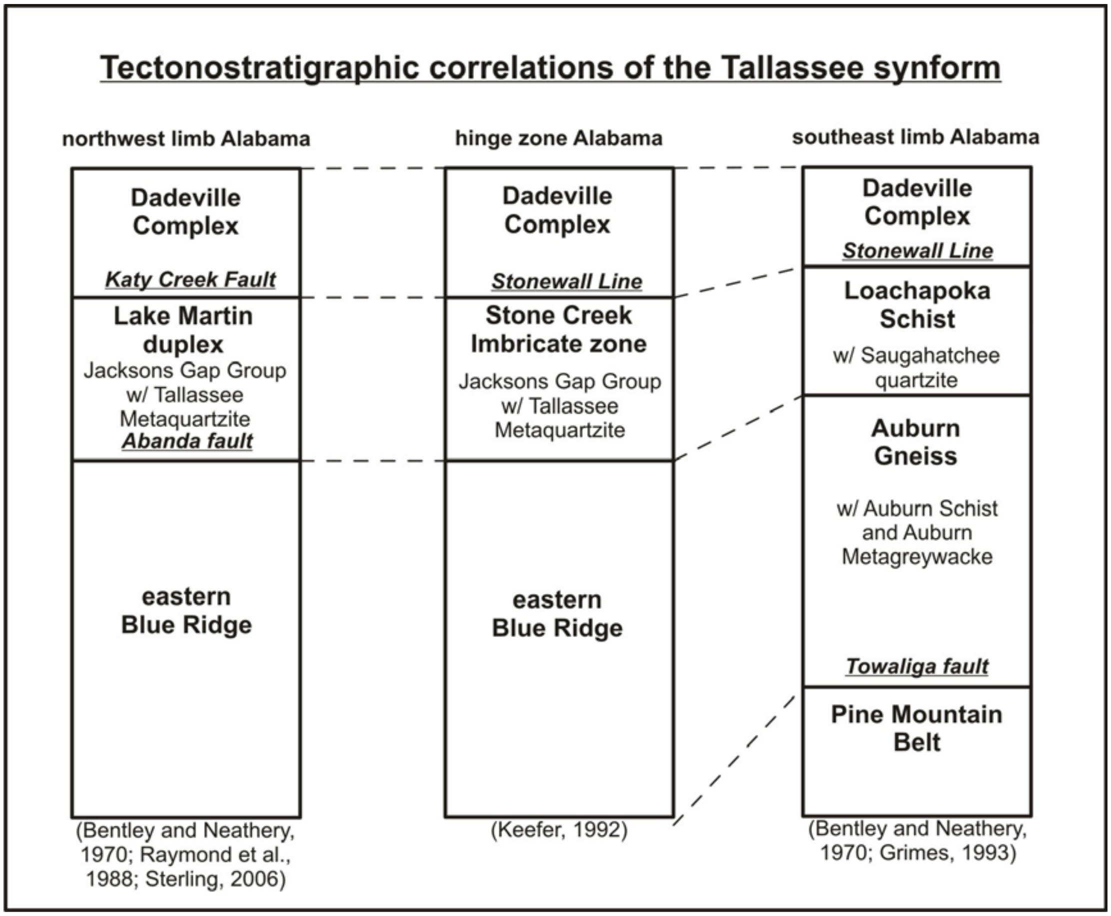


**Figure 4**. Tectonostratigraphic correlations suggested for the Tallassee synform within Alabama (not to scale). Modified after Grimes (1993).

Tallapoosa River have the appearance of orthogneisses. Feldspathic gneisses have been observed within the Jacksons Gap Group along the northwest limb of the Tallassee synform near Jacksons Gap, Alabama (Johnson, 1988; Cook and Thompson, 1995a, and 1995b; and Thompson and Cook, 1995). A major objective of the present study was to map the area between that mapped by Sterling (2006) and that by Keefer (1992) to clarify how the drastically different looking gneisses described by the latter correspond or relate to the metasedimentary rocks of the Jacksons Gap Group described by the former.

Mapping for the current study was conducted to fulfill some of the objectives outlined in a United States Geological Survey EDMAP project grant awarded to Dr. Mark G. Steltenpohl. The Tallassee Quadrangle and its surrounding areas have been designated by the Alabama State Geological Mapping Advisory Board to have a high priority for geologic mapping within the state mainly because of socio-economic concerns (Osborne, 2005; Steltenpohl, 2005). Detailed geologic mapping is needed to delineate possible sources for aggregate stone production, as these are the southernmost exposures of crystalline bedrock available to serve a large part of the United States lying to the south. Mapping is also needed for future Source Water Protection studies as required by the Alabama Department of Environmental Management (Steltenpohl, 2005).

## Methods of Investigation

The objectives of this study of the geology of the 1:24,000 Tallassee Quadrangle are fourfold: (1) to map and describe lithologies, fabrics, and structures; (2) to statistically evaluate geometric relationships of fabrics and structures present; (3) to generate a detailed digital geologic map and cross section of the quadrangle; and (4) to use the results to synthesize the geologic history of the rocks and propose correlations with broader tectonostratigraphic packages and structures elsewhere in the southern Appalachians.

Geologic mapping of the 1:24,000 Tallassee Quadrangle was conducted using standard field mapping methods (e.g., traverse mapping, establishing field stations, collecting structural data using a Brunton compass, hand sample collection and identification, etc.). All primary and secondary roads with open access and private roads where permission was obtained were mapped. The Tallapoosa River and its tributaries, along with power line and gas pipeline right of ways were also mapped. Mapping was accomplished by kayak and by foot along the river and its tributaries.

The Tallassee, Alabama, 7.5 minute U.S.G.S. topographic quadrangle map was used as a base map. Continuous outcrops of crystalline rock were limited to the northeastern quadrant of the quadrangle along the Tallapoosa River and within its low-lying tributaries. Two-hundred-and-one field stations were established, where lithologic, structural, and fabric observations were recorded. Data collected at these stations were combined with data from one-hundred-and-eighty-one field stations reported by Keefer (1992) and plotted on this base map. A structural form-line map then was constructed from foliation data. The form-line map was layered with a lithologic data map to generate the geologic map. Topography locally was useful for projecting lithologic units and their contacts in parts of the map area.

Laboratory work involved petrographic analysis of 27 thin sections and stereographic analysis of structural geometries and kinematics. Thin sections were examined to characterize metamorphic mineral assemblages and microstructures. Thin sections were cut perpendicular to the dominant metamorphic foliation and parallel to mineral or elongation lineations. Petrographic results were then compared with those reported by Keefer (1992) and Sterling (2006), requiring re-examination of 47 of their thin sections. Structural geometries and kinematics were investigated via lower-hemisphere stereographic projections produced using Rockware® software.

Corel Designer 9.0® was used to create the 1:24,000 digital geologic map and cross section (Plate 1) of the Tallassee Quadrangle. The final digital map was submitted to the State Geological Survey of Alabama in Tuscaloosa, Alabama, and the United States Geological Survey in Reston, Virginia, as a deliverable to fulfill requirements for Dr. Mark G. Steltenpohl's United States Geological Survey EDMAP grant.

# TECTONOSTRATIGRAPHY AND LITHOLOGIC DESCRIPTIONS

## General Statement

Roughly eighty percent of the Tallassee Quadrangle is covered by Gulf Coastal Plain sedimentary rocks and Quaternary sediments (Plate 1). This veneer of sediment posed a major problem in mapping the crystalline bedrock that lies beneath it. Gulf Coastal Plain sediments in the area of the quadrangle consist of the Gordo and the Coker Formations of the Tuscaloosa Group. Quaternary alluvial deposits and the Quaternary High terrace deposits were deposited atop Gulf Coastal Plain sediments.

Appalachian Piedmont rocks belong to, from west to east, the eastern Blue Ridge, the Jacksons Gap Group, and the Dadeville Complex (Fig. 3). The Piedmont units have been strongly deformed and transposed during amphibolite-facies metamorphism and subsequent retrograde events. Depositional ages for many of these metasedimentary and metavolcanic units are not well constrained because no fossils and few absolute age dates are reported. Ascending tectonostratigraphic and structural order is eastern Blue Ridge, Jacksons Gap Group, and Dadeville Complex, and this is how these terranes are described below. Under individual terrane subheadings, rock unit descriptions are ordered in decreasing volumetric abundance. Likewise, listings of minerals in all descriptions are in order of decreasing volumetric abundance.

## Gulf Coastal Plain and Quaternary Sediments

### Quaternary Alluvial Deposits

Quaternary alluvial deposits are varicolored, fine-to coarse-grained quartz sand and gravel deposits. Gravels comprise quartz, chert, and rock fragments derived from various metamorphic rocks in the surrounding area. In the study area, alluvium is primarily found in stream drainages, especially in the southern half of the quadrangle.

### Quaternary High Terrace Deposits

The Quaternary "High terrace" deposits are varicolored beds of poorly-sorted quartz, sand, silt, clay, and gravelly sand (Osborne et al., 1988). This unit stratigraphically overlies the Gordo formation in the southwestern quadrant of the Tallassee Quadrangle and overlies the Coker Formation in the eastern half. In outcrops within the Tallassee Quadrangle, the terrace deposits are red-orange, medium-to course-grained sands with siliceous gravels composed of quartz and quartzite.

### Gordo Formation

The Upper Cretaceous Gordo Formation of the Tuscaloosa Group is cross-bedded sand deposited in massive beds, with local gravel and intermixed gray to moderate-red and pale-red-purple, partly mottled clay lenses, and is carbonaceous in some areas (Raymond et al., 1988). Within the Tallassee Quadrangle the Gordo Formation is exposed on hillsides in the southwestern quadrant. Outcrops along road cuts are composed of light brown-orange, medium- to course-grained sand with abundant quartz and chert gravel. The Gordo Formation stratigraphically overlies the Coker Formation and underlies Quaternary High terrace deposits.

### Coker Formation

Raymond et al. (1988) described the Upper Cretaceous Coker Formation as a light-colored, fine-to medium-grained micaceous sand, cross-bedded sand, and multicolored clay, containing a few thin beds of gravel, that locally contains marine sediments consisting of glauconitic, fossiliferous, fine-to medium-grained quartz sand and medium-gray carbonaceous silty clay. It is exposed over about fifty percent of the Tallassee Quadrangle and outcrops in the study area consist of red-orange poorly sorted sand with abundant quartz gravel lenses. The Coker Formation has a nonconformable contact with the crystalline bedrock of the southern Appalachians and underlies either the Gordo Formation or the Quaternary high terrace deposits.

## Eastern Blue Ridge

The eastern Blue Ridge of Alabama, part of the northern Piedmont of Osborne et al. (1988), contains various phyllites, schists, gneisses, and amphibolites formed from the regional metamorphism of sedimentary, volcanic, and plutonic rocks (Steltenpohl and Moore, 1998). The eastern Blue Ridge is bounded by the Hollins Line fault to the northwest and the Abanda fault of the Brevard fault zone to the southeast (Bentley and Neathery, 1970; Tull, 1978: Figs. 1 and 2). Two eastern Blue Ridge units occur in the study area, the Kowaliga Gneiss and the Emuckfaw Group (Raymond et al., 1988).

### Kowaliga Gneiss

The Kowaliga Gneiss is a large metaplutonic unit of course-grained quartz-monzonite gneiss that trends northeast in the southeastern part of the eastern Blue Ridge (Bentley and Neathery, 1970; Russell, 1978; Sterling, 2006). Within the study area, the Kowaliga Gneiss is interlayered with Emuckfaw Group rocks and structurally underlies units of the Jackson Gap Group. Keefer (1992) describes a lithologic unit he called 'porphyroclastic gneiss' that occurs along the southern portions of the Tallapoosa River in the Tallassee Quadrangle. The present author correlates this unit with the Kowaliga Gneiss in the present study on the basis of similar lithologies, especially the strong gneissic foliation with large (several centimeters) K-feldspar augen, and its structural position at the base of the Jacksons Gap Group (Plate 1). The Kowaliga is best exposed within stream drainages in the northwest quadrant of the Tallassee Quadrangle, and along the southernmost portion of the Tallapoosa River. Russell (1978) reports the age of the Kowaliga Gneiss is ~460 Ma (Middle Ordovician) based on U/Pb dating of zircons and Rb/Sr whole rock isotopic studies.

In outcrop, the Kowaliga Gneiss is either a light-red-brown-to-gray saprolite, or a light gray, medium- to course-grained, well-foliated, biotite-rich, banded augen gneiss (Fig. 5). Augen are composed of 2-3 cm feldspar grains with quartz and

(a)

(b)

**Figure 5.** (a) Weathered and scraped outcrop of Kowaliga Gneiss along the southern portions of the Tallapoosa River (NAD 27, location 32º 30’ 02” N, 85º 53’ 26” W). (b) Typical outcrop of Kowaliga Gneiss seen in streams west of the Tallapoosa River near the contact with the Jacksons Gap Group (NAD 27, location 32º 36’ 17” N, 85º 57’ 32” W).

muscovite inclusions and these are surrounded by a quartz, feldspar, and biotite forming the matrix (Fig. 6). The Kowaliga Gneiss becomes finer grained, more mica rich, and more tabular and strongly foliated as the contact between the gneiss and rocks of the Jackson Gap Group is approached (Fig. 5b).

Petrographic analysis reveals the Kowaliga Gneiss is a porphyroclastic rock with a moderate-to-well-developed foliation defined by muscovite and biotite. Mineralogy consists of quartz, microcline, plagioclase, biotite, muscovite, epidote, and chlorite with minor amounts of opaque minerals. Augen are primarily composed of microcline with tartan twinning and inclusions of quartz and fine-grained muscovite and biotite. Detailed petrographic descriptions of thin sections of porphyroclastic gneiss, which likely corresponds to the Kowaliga Gneiss, are provided by Keefer (1992) and Sterling (2006), respectively.

Mapping and thin section analysis during the present study documents the fining of the Kowaliga Gneiss structurally upward toward the boundary with the Jacksons Gap Group, interpreted as the result of more intense degrees of mylonitization. The rock becomes more micaceous, and porphyroclasts decrease in abundance and size. The mylonitic fabric is recrystallized and metamorphic rather than preserving nonrecovered elastic strain, indicating synamphibolite facies shearing. This ductile shear zone is in the correct structural position to be the Abanda fault (Bentley and Neathery, 1970) although no ductile-brittle fault like that described by Sterling (2006) along strike to the north was observed.

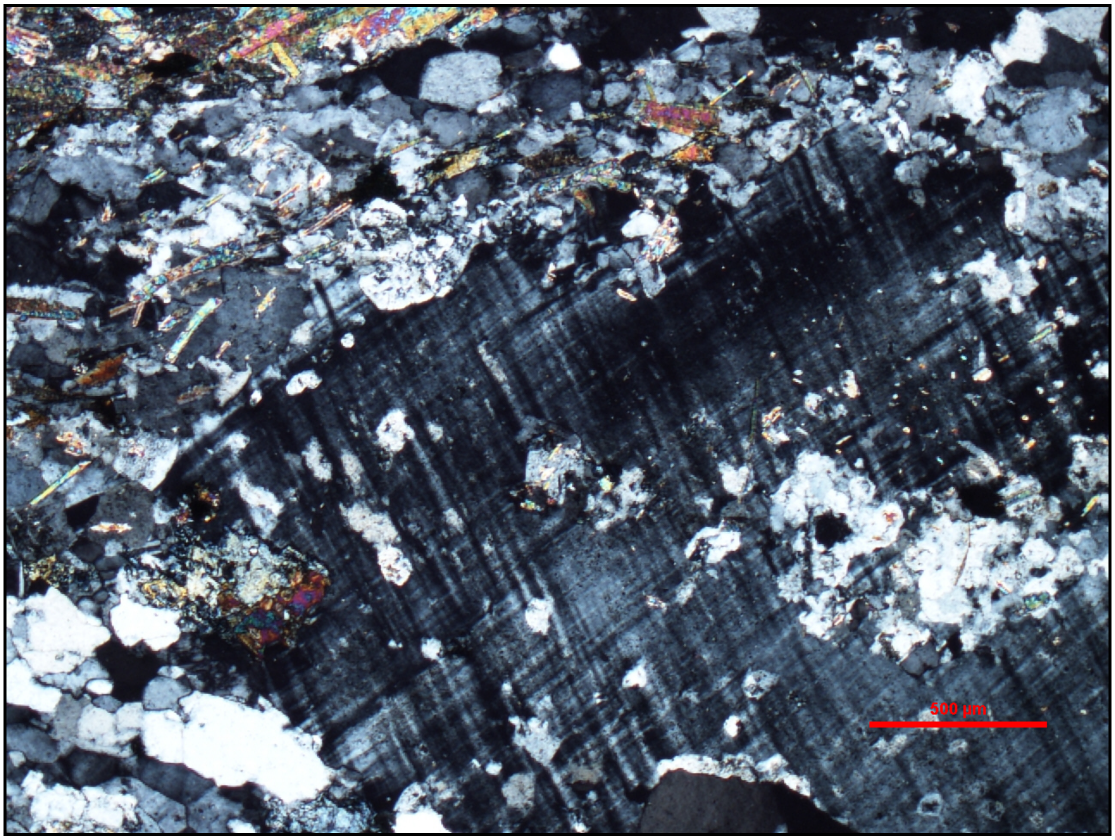


**Figure 6**. Microcline porphyroclast (with tartan twins) in the Kowaliga Gneiss collected from near contact with the Jacksons Gap Group. Porphyroclast contains inclusions of quartz and muscovite. 4x in crossed polars.

## Emuckfaw Group

Rocks of the Emuckfaw Group are metasedimentary in origin, composed of medium-grained muscovite-quartz-feldspar gneiss (or 'metagreywacke'), schist, and quartzite (Bentley and Neathery, 1970; Russell, 1978; Raymond et al., 1988). The Kowaliga Gneiss is interpreted to have intruded the Emuckfaw Group (Bieler and Deininger, 1987). Within the study area the Emuckfaw Group is best exposed in stream channels within the northwest quadrant of the Tallassee Quadrangle, especially approximately one mile north of Neman, Alabama. In outcrops the Emuckfaw Group is primarily a light tan-orange saprolite found in stream channels and at the base of the stream banks. Where the rock is less saprolitic, metagreywacke is the primary rock type and it has a roughly parallel, continuous foliation primarily defined by biotite and muscovite.

Petrographic analysis of foliated metagraywacke reveals light-colored bands (several millimeters thick) of fine- to medium-grained quartz and plagioclase alternating with medium-grained, platy biotite. The rock is composed of quartz, plagioclase, biotite, and muscovite with minor amounts of garnet, chlorite, and opaque minerals. Quartz and plagioclase grains are subhedral in shape with interlobate grain boundaries, exhibit undulose extinction, and have a grain-shape preferred orientation parallel to the foliation. Biotite primarily defines the foliation and has been retrograded to chlorite in some areas. Garnets range from one to two millimeters in diameter, are fractured, and partially flattened into the foliation.

## Brevard Zone Lithologies / Jacksons Gap Group

The Jacksons Gap Group (Bentley and Neathery, 1970) is an assemblage of metasedimentary rocks in Alabama and Georgia that is composed of lithologies characterizing the Brevard fault zone in this area. Jacksons Gap Group is bounded to the northwest by the Abanda fault and to the southeast by the Katy Creek fault north of the study area (Fig. 3). These units have been variably described by different workers investigating various areas along the Tallassee synform (see Figure 3) resulting in seemingly different packages of rocks that simply do not correlate around the hinge of the synform. Unit terminology along the northwest limb of the Tallassee synform was established by Sterling (2006), along the hinge zone by Keefer (1992), and along the southeast limb as in by Grimes (1993) and Steltenpohl et al. (1990). Within the study area, the present author has subdivided the Jacksons Gap Group into five mappable units, described below, following the terminology of Sterling (2006) although with slight modifications to accommodate some formal rock unit names that are entrenched in the literature.

Within the Jacksons Gap Group in the hinge zone of the Tallassee synform, the axial trace of which projects roughly parallel to the Tallapoosa River (Plate 1), the foliated granitic rocks of Keefer (1992) are herein interpreted to correspond to the Farmville Metagranite of Steltenpohl et al. (1990) seen along the southeast limb of the synform. The Farmville Metagranite occurs within the Saugahatchee Group, of the Opelika Complex, along strike to the east along the southeast limb of the Tallassee synform (Steltenpohl et al., 1990; Grimes, 1993). In the hinge zone area, rocks of the Jacksons Gap Group are more strongly foliated, having a more gneissic appearance with distinctive phyllitic cleavage. The foliated Farmville Metagranite in the hinge zone does not continue more than four miles west of the axis of the synform along strike of the northwest limb (Plate 1). This latter finding has important tectonic implications described below in the discussion section.

### Farmville Metagranite

The most voluminous unit in the Jacksons Gap Group exposed within the hinge zone of the Tallassee synform is a package of strongly foliated quartzofeldspathic gneisses interpreted herein to correspond to the 'Farmville Metagranite' of Steltenpohl et al. (1990; Plate 1). Farmville Metagranite in this area is a medium-gray to brownish-tan, fine- to medium-grained, foliated gneiss/metagranite that forms large pavement exposures at the base of Thurlow dam (Fig. 7). These rocks are characteristically tabular and strongly foliated, with a distinct, spaced phyllitic parting. Thin quartz veins (<6 cm thick) with large muscovite books (<3 cm) cut across the gneissosity at a high angle. Petrography indicates primary minerals are quartz, microcline, plagioclase, muscovite, and biotite with minor amounts of clinozoisite and opaque minerals. The relatively fine grain size and homogenous fabric of the gneisses is attributed to high-temperature mylonitization that appears to have thoroughly recrystallized the original igneous fabric. This interpretation is supported also by locally preserved feldspar augen as

**Figure 7**. Pavement exposure of Farmville Metagranite at base of Thurlow dam looking north. Note the shallow dip of the unit toward the north.

well as the platy, phyllitic cleavage. In this area, Farmville Metagranite bodies are clearly interleaved with metasedimentary units that are much more typical of the Jacksons Gap Group (e.g., quartzites, phyllitic quartzite, garnetiferous phyllite, and chlorite-hornblende-biotite schist; see Plate 1).

Intensely deformed, gneissic units like those assigned herein to the Farmville Metagranite may or may not correlate with any units reported within in the Jacksons Gap Group at the type locality at Jacksons Gap, Alabama, or along the west limb of the Tallassee synform outside of the hinge zone, approximately four miles northwest from the Tallapoosa River (see dashed boundary on Plate 1). Near the type locality in Jacksons Gap, Alabama, Johnson (1988), Cook and Thompson (1995a and 1995b), and Thompson and Cook (1995) described a feldspathic gneiss, which is interpreted as a metavolcanic unit. Farmville Metagranite on Plate 1 appears to be distinctly metaplutonic and corresponds to two gneissic units that Keefer (1992) called ‘quartzofeldspathic gneiss’ and ‘quartzitic/quartz- microcline gneiss’. The granitic composition of these orthogneisses, based on visual percentage estimates, distinguish them from the tonalitic Camp Hill Gneiss of the Dadeville Complex, and the tonalites near Martin Dam described by Sterling (2006), but it is compatible with that of the Chattasofka Creek granite (Neilson, 1987; Neilson et al., 1997). However, the orthogneisses in question cannot be Chattasofka Creek granite *sensu stricto* because they intrude characteristic Jacksons Gap Group metasedimentary rocks and they occur structurally beneath the Dadeville Complex. These rocks might be strongly metamorphosed and mylonitized metagraywacke of the Auburn Gneiss of the Opelika Complex or the Emuckfaw Group of the eastern Blue Ridge but their mineralogy implies that they are less aluminous than would be expected.

Correlation of these orthogneisses with the Farmville Metagranite is favored for several reasons. First, east of study area along the southeast limb of the Tallassee synform, the Farmville Metagranite intrudes rocks of the Saugahatchee group of the Opelika Complex, which Grimes et al. (1993) and Steltenpohl (2005) have suggested might lithologically correlate with the Jacksons Gap Group; particularly notable are the shallow marine siliciclastics (Tallassee and Saugahatchee orthoquartzites), which are rare in the southern Appalachian Piedmont. Along the southeast limb the Farmville Metagranite occurs as sills that intruded between the Saugahatchee quartzite units, which Sears et al. (1981) (see also Goldberg and Burnell, 1987, and Steltenpohl et al., 1990) attributed to magmas that favored injection along lithologic boundaries. It is remarkable that the granites are not reported to cut across any of the quartzite bodies, which partly led Higgins et al. (1988) to interpret these same contacts along strike in northeast Georgia (i.e., between the Lithonia Gneiss and the Pallisades Quartzite) as thrust faults. There is also a distinct increase in the volume and variety of granite, granitic gneiss, and migmatite within the Opelika Complex as one traverses to the southwest along strike of the southeast limb of the Tallassee synform toward the hinge zone (Grimes, 1993; Grimes et al., 1993b; Steltenpohl, 2005).

## Tallassee quartzite

In Plate 1 the Tallassee quartzite is locally interleaved with garnetiferous phyllite, phyllitic quartzite, and the Farmville Metagranite. Outcrops in the Tallassee Quadrangle are found along the banks of the Tallapoosa River in the southeastern quadrant of the quadrangle and sporadically along strike to the west within the tributaries of the Tallapoosa River. In hand sample the quartzite is a light-tan to light-gray, coarse- to medium-grained, and massive quartzite. Locally, this unit contains garnet and rounded detrital zircons (Keefer, 1992).

The quartzite is primarily composed of quartz (up to 85% of the mode) and muscovite with accessory garnet, biotite, chlorite, magnetite, epidote, and graphite (see also, Keefer, 1992; Sterling 2006). Quartz is fine- to coarse-grained, and exhibits undulose extinction. Parallel alignment of muscovite/sericite defines foliation.

On Plate 1 the term ‘Tallassee quartzite’ (Keefer, 1992) is used for the ‘Tallassee Metaquartzite’ as is seen on the Geologic map of Alabama, which is described as “bedded” quartzite interbedded with thin graphitic units and sandy-schistose units at its type locality south of Thurlow Dam (Bentley and Neathery, 1970; Raymond et al., 1988; Osborne et al, 1988), though at this location the Tallassee quartzite is not the rock unit present. The best exposures recognized in this area are south of Thurlow Dam at the intersection of Stone Creek and River Road. The present author suggests that these exposures be used to represent the type locality, as did Keefer (1992).

Quartzites flanking the Tallassee synform have been referred to by many different names depending on workers and location along the synform. For example, along the northwest limb Cook and Thompson (1995) used the term ‘Devil’s Backbone quartzite’, and Sterling (2006) used ‘massive micaceous quartzite’, in the hinge zone Keefer (1992) used ‘Tallassee quartzite’, and along the southeast limb Sears et al. (1981), Steltenpohl et al. (1990), and Grimes (1993) used ‘Saugahatchee quartzite’. In the current study, the term ‘Tallassee quartzite’ is adopted to emphasize its elevated level as equivalent to the Saugahatchee quartzite and to separate the term from the former (misnomer) ‘Metaquartzite’. The present author, thus, interprets the Tallassee quartzite as being lithologically equivalent to the ‘massive micaceous quartzite’, ‘Tallassee Metaquartzite’, and ‘Saugahatchee quartzite’.

### Phyllitic Quartzite

Sterling (2006) described a map unit called ‘phyllitic quartzite’ in the Red Hill Quadrangle that preserves primary sedimentary structures (cross-beds and conglomerates). The term phyllitic quartzite is adopted for the present study, and the garnet-quartz-muscovite schist of Keefer (1992) is correlated with it due to its similar appearance in the field, tectonostratigraphic position above the garnetiferous phyllite and below the Tallassee quartzite, and mineralogical composition.

In outcrop the phyllitic quartzite is a light tan-gray to dark-gray, fine- to medium-grained sericite phyllite. The best exposures are in Wallahatchee Creek in the central portions of the quadrangle and along southern portions of the Tallapoosa River (Plate 1). Contacts between the phyllitic quartzite and the underlying garnetiferous phyllite and with the overlying Tallassee quartzite were observed to be sharp to gradational over 1-3 m. Garnet porphyroblasts become more abundant as the contact with the garnetiferous phyllite is approached (Sterling, 2006). This unit is also intruded by K-feldspar, quartz, and muscovite pegmatite bodies, which range from 3-5 m thick and 10-15m in strike length, along the Tallapoosa River.

In thin section the phyllitic quartzite exhibits an inequigranular porphyroblastic texture (Sterling, 2006) with a continuous foliation defined by muscovite. Primary minerals observed were quartz, muscovite, kyanite, and staurolite. Accessory minerals include epidote, clinozoisite, chlorite, tourmaline, biotite, garnet, and opaques. Quartz grains have interlobate grain boundaries and undulose extinction (Sterling, 2006; present study). Muscovite grains are fine to medium in size and wrap around kyanite and staurolite porphyroblasts. Coexistence of kyanite and staurolite porphyroblasts (Fig. 8) indicates conditions of prograde metamorphism being within the amphibolite-facies. Chlorite is observed to have replaced biotite, which indicates greenschist facies retrogression.

## Garnetiferous Phyllite

On Plate 1, the term ‘garnetiferous phyllite’ is adopted after Sterling (2006), and it is also used to refer to the garnet-muscovite schist and the garnet-two mica gneiss reported by Keefer (1992). This terminology is based mainly on tectonostratigraphic position above the chlorite-hornblende-biotite schist and below

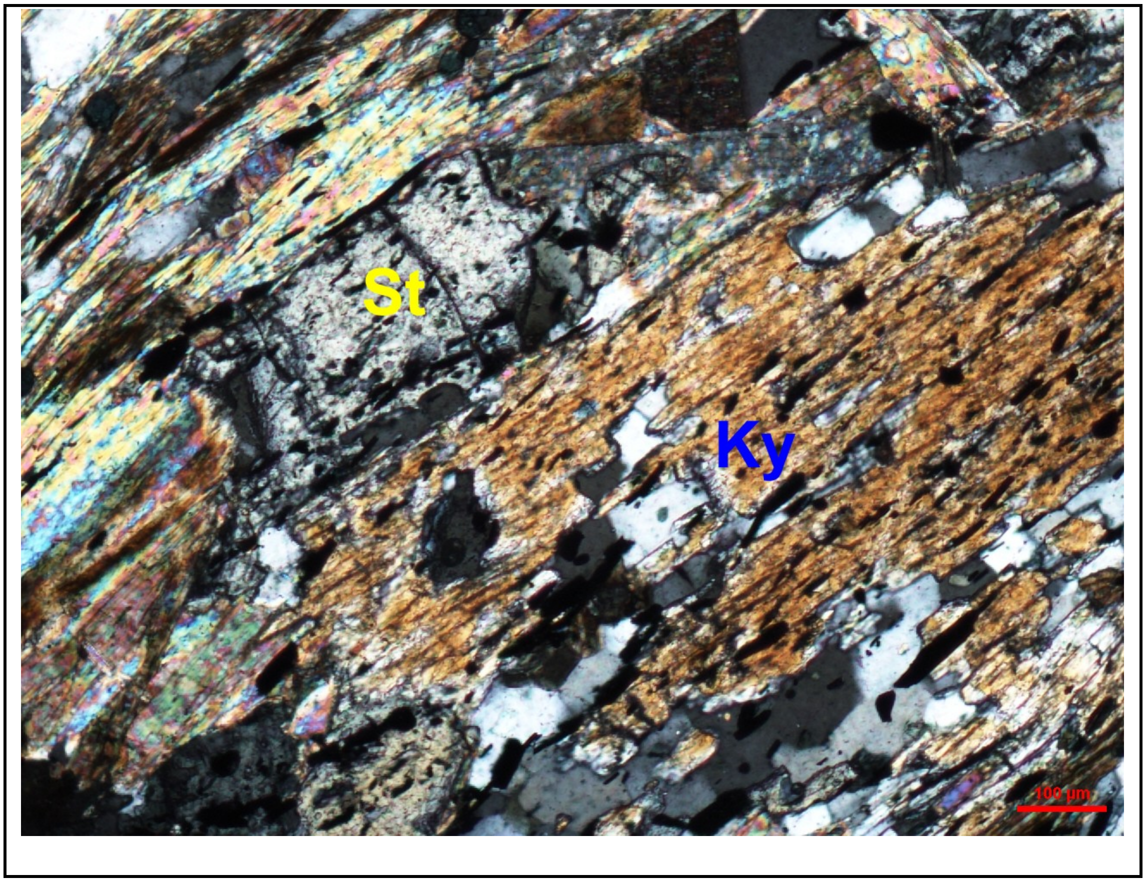


**Figure 8**. Phyllitic quartzite showing co-existence of kyanite (Ky) and staurolite (St). 10x in crossed polars.

the phyllitic quartzite along the west limb of the Tallassee synform combined with projection of structural form-lines into the hinge zone. The correlation of these units of Sterling (2006) and Keefer (1992) is also supported by mineralogical features such as abundant 1-5 mm garnet porphyroblasts that are wrapped by the dominant foliation formed by biotite, muscovite, and chlorite (Fig. 9). Garnetiferous phyllite in the Tallassee Quadrangle is in contact with the chlorite-hornblende-biotite schist and the phyllitic quartzite west of the Tallapoosa River (plate 1). Along the river it appears to be interleaved with the Farmville Metagranite. In the study area, this unit is primarily saprolitized and poorly exposed, due to its high susceptibility to weathering, extensive Coastal Plain cover, and vegetation cover. The best exposures of this unit are found along the banks of theTallapoosa River. Where fresh, the garnetiferous phyllite is a light gray to grayish-brown, garnet-bearing, fine- to medium-grained, muscovite and biotite phyllite and schist.

Sterling (2006) separated the garnetiferous phyllite into four subunits: 1) garnet phyllite, 2) chloritoid-sericite-chlorite phyllite/schist, 3) quartz-muscovite schist, and 4) kyanite-pyrophyllite schist. During the present study the author did not observe rock types that fit all of these subunits, but quartz-muscovite schist and garnet phyllite were observed. The quartz-muscovite schist is usually identifiable as a gray to light-orange saprolite, whereas the garnet phyllite is dark-gray phyllite to schist depending on coarseness of micas.

**Figure 9.** Polished slab of garnetiferous phyllite showing dominant foliation wrapping $M_1$ porphyroblasts.

The highly weathered state of the garnet-muscovite schist did not allow the present author to make any new thin sections of this unit.  Detailed petrographic descriptions of correlative rocks (i.e., garnet-muscovite schist and garnet-two mica gneiss), however, can be found in Keefer (1992) and Sterling (2006).  These other authors report primary minerals to be biotite, garnet, muscovite, quartz, chlorite, chloritoid, with accessory tourmaline, epidote, sericite, and graphite.  Muscovite is the primary foliation-forming phase.

### Chlorite-Hornblende-Biotite Schist

Chlorite-hornblende-biotite schist is the structurally lowest unit in the Jacksons Gap Group (Sterling, 2006).  In the present study, the garnet-amphibole gneiss of Keefer (1992) is correlated with the chlorite-hornblende-biotite schist of Sterling (2006) on the basis of similar petrographic and mineralogic character and tectonostratigraphic position.  Both rock units are described petrographically by Keefer (1992) and Sterling (2006) as having a dominant foliation with light bands of fine- to medium-grained quartz and/or plagioclase and dark bands primarily composed of amphibole.  These previous authors also describe the mineralogical make up of both rocks as having primarily garnet, plagioclase, amphibole (hornblende and/or tremolite), and quartz. There is limited exposure of the chlorite-hornblende-biotite schist within the Tallassee Quadrangle.  Most exposures are along the banks of the Tallapoosa River in its southern parts, and in the headwaters of the unnamed creek south of Yates Dam flowing from the west (Plate 1). In outcrops it is a fine-to-medium-grained, grayish-green to grayish-brown schist and/or gneiss with garnet porphyroblasts.

Detailed petrographic analyses of the chlorite-hornblende-biotite schist and the garnet-amphibole gneiss are reported in Sterling (2006) and in Keefer (1992), respectively. The primary mineral assemblage is garnet, plagioclase, hornblende, tremolite, and quartz with accessory amounts of epidote, clinozoisite, opaques, chlorite, and biotite. Chlorite ranges from coarse- to fine-grained and defines primary foliation. Given the poor quality of exposure of this unit within the study area no new petrographic information resulted in this report. Based on mineral assemblage and location within the Jacksons Gap Group this unit could possibly be retrograded equivalents of the amphibolites described by Johnson (1988) near Jacksons Gap, Alabama.

## Dadeville Complex

The Dadeville Complex is mostly a sequence of amphibolites, feldspathic gneisses, and schists interpreted as a metaplutonic/metavolcanic complex with minor metasedimentary rock (Bentley and Neathery, 1970; Osborne et al., 1988; Steltenpohl et al., 1990). Along the southeast limb of the Tallassee synform, the Dadeville Complex is separated from the Opelika Complex by the Stonewall Line shear zone (Steltenpohl et al. 1990; Grimes, 1993). Units of the Dadeville Complex exposed within the study area are the Camp Hill Gneiss, the Ropes Creek Amphibolite, and chlorite-quartz schist (Plate 1). Unlike the correlation problems in the Jacksons Gap Group units produced by the Coastal Plain onlap around the hinge of the Tallassee synform, the units of the Dadeville Complex are continuously exposed through the synform's closure.

### Camp Hill Gneiss

The "Camp Hill Granite Gneiss" is described by Raymond et al. (1988) as a tan to gray colored fine- to medium-grained, granite to quartz diorite (tonalite). The present author prefers the term 'Camp Hill gneiss' because it is not true granite based on Raymond et al.'s (1988) description. Nielson (1987) also points this out in his subdivision of the Camp Hill Granite Gneiss (Camp Hill gneiss) into the tonalitic Camp Hill gneiss and the granitic Chattasofka Creek gneiss. In the present study area, Camp Hill gneiss is a moderate-to-well foliated granitic gneiss with quartz, plagioclase, and K-feldspar composing light-colored bands and mostly biotite defining the dark bands, which would indicate that this unit likely is the granitic Chattasofka Creek gneiss of Neilson (1987). Outcrops of the Camp Hill gneiss are primarily found along the shores of the Tallapoosa River and its tributaries in the northeastern quadrant of the Tallassee Quadrangle (Plate 1).

Keefer (1992) recognized a similar granitic gneiss within the Dadeville Complex that he named the 'Yates granitic gneiss'. Based on similar lithologies and its tectonostratigraphic position in the hanging wall block of the Stonewall Line shear zone, together with additional mineralogic observations described below, the current author correlates the Yates granitic gneiss of Keefer (1992) with the Camp Hill gneiss of the Dadeville Complex in Plate 1.

Keefer (1992) provides detailed descriptions of the Yates granitic gneiss. In thin section, the general texture ranges from heteroblastic in well-foliated samples to granoblastic in weakly foliated ones. Primary minerals are quartz, plagioclase, microcline, muscovite, and biotite with accessory tourmaline, garnet, zoisite, clinozoisite, and opaques. Biotite grains (3-5 mm) define the foliation and muscovite occurs as cross foliation overgrowths (Fig. 10).

### Ropes Creek Amphibolite

The Ropes Creek Amphibolite is a distinctive package of delicately layered to massive amphibolite comprising mostly hornblende and plagioclase with lesser amounts of apatite, augite, biotite, epidote, garnet, opaques, quartz, and sphene (Hall, 1991; Keefer, 1992; Sterling, 2006). This unit composes approximately forty percent of the volume of the Dadeville Complex (Bentley and Neathery, 1970) and was the focus of several petrological and geochemical studies (Neilson and Stow, 1986; Higgins et. al., 1988; Hall, 1991; Cook and Thompson, 1995). Within the study area the Ropes Creek Amphibolite is exposed as brown to reddish-brown saprolite. In fresh samples it is dark-greenish-black to dark-gray well indurated amphibolite. The best outcrops are found primarily along the shores of the Tallapoosa River and Saugahatchee Creek, and their tributaries within the northeastern quadrant of the Tallassee quadrangle.

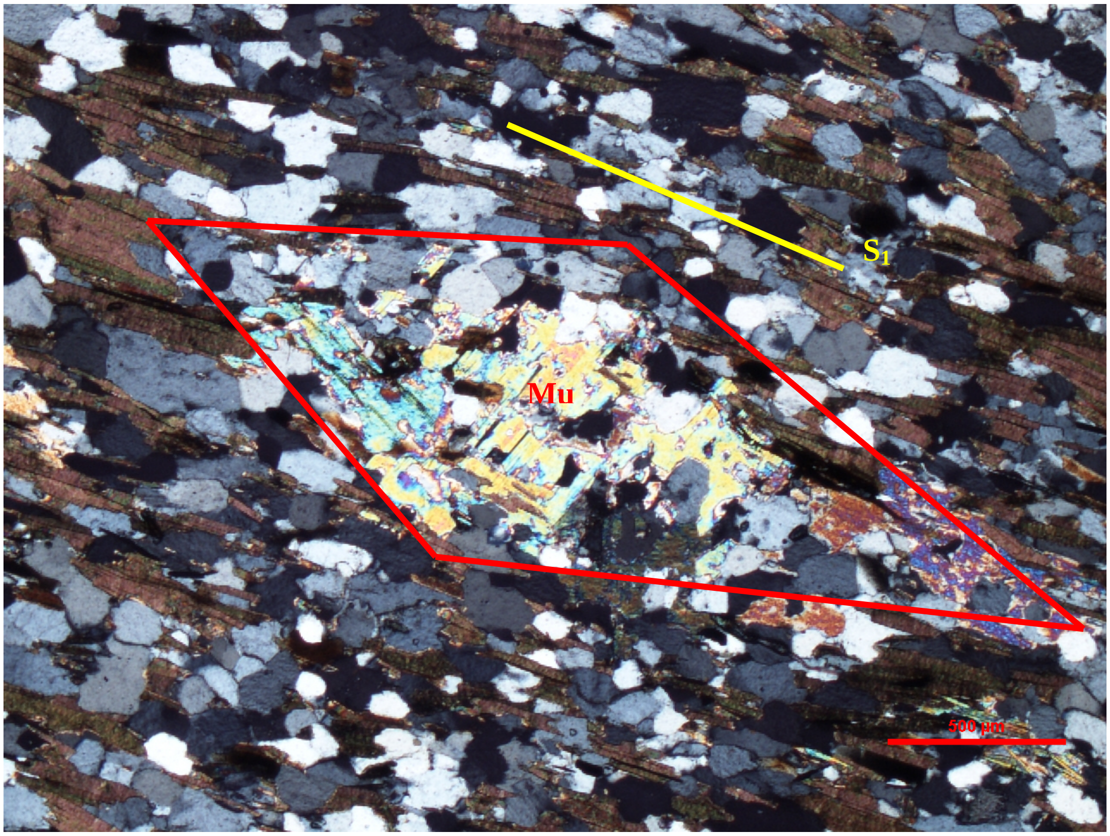


**Figure 10**. Biotite defining gneissic foliation ($S_1$) with muscovite outlined in red as cross foliation overgrowth in the Camp Hill Gneiss (NAD 27, location 32º 31’ 47” N, 85º 53’ 17” W). Scale bar is 500 µm; 4x in crossed polars.

In their study areas, Keefer (1992) and Sterling (2006) report that the Ropes Creek Amphibolite is a fine- to medium-grained, equigranular or granoblastic, massive to thinly layered amphibolite. Well-developed dark bands are rich in hornblende and biotite and alternate with light-colored bands rich in quartz and plagioclase producing a gneissic foliation. Hornblende occurs as (1-3 mm) grains with dark-green to greenish-brown pleochroism. These grains have a grain-shape preferred orientation that defines the primary foliation.

### Chlorite Quartz Schist

Chlorite quartz schist appears to define a ductile deformation zone at the base of the Ropes Creek Amphibolite within the study area (Plate 1). This medium- to course-grained, olive-gray, chlorite-quartz schist weathers to a yellowish-green color (Keefer, 1992). The rock contains hornblende, plagioclase, chlorite, biotite, tremolite, sphene, and opaques. Locally this unit contains radially oriented sprays of hornblende (up to 1 cm in length) lying in the plane of schistosity, giving it a ‘garben schiefer’ appearance. Hornblende porphyroblasts are sheathed in fine-grained chlorite, indicating retrogression of the former Ropes Creek Amphibolite. For more detailed petrographic descriptions of this rock refer to Keefer (1992). It is likely that this rock formed due to retrogressive shearing along the Stonewall Line shear zone.

# STURCTURE AND METAMORPHISM

## General Statement

Rocks underlying the area of the Tallassee Quadrangle have experienced multiple deformational and metamorphic events. Keefer (1992) reports detailed structural and metamorphic data along the Tallapoosa River in the eastern half of the quadrangle. These data sets have been incorporated with data collected in the present study to help refine our understanding of the structural and metamorphic history of rocks in the Tallassee Quadrangle.

The Stonewall Line shear zone is a major structural feature seen on Plate 1. It separates the units of the Jacksons Gap Group from those of the Dadeville Complex. It is truncated by the Katy Creek fault of the Brevard fault zone, north of the present study area, where the Brevard zone fabrics diverge from the Jacksons Gap group and continue southwest to the Coastal Plain onlap.

## Structure

Geologic mapping of the Tallassee Quadrangle indicates that the rocks experienced four deformational events: $D_1$ prograde amphibolite-facies deformation; $D_2$ retrogressive green-schist-facies deformation; $D_3$ folding and cleavage forming event; and $D_4$ brittle caticlasis (Table 1). These deformational episodes are recognized on the basis of structural style, geometry, deformational fabrics, and their mutual crosscutting relationships.

**Pre- $D_1$**

$S_0$ – original compositional layering

**$D_1$**

$F_1$ – tight-isoclinal folds, helicitic folds, $S_0$, quartz inclusion trails observed in garnet porphyroblasts

$S_1$ – metamorphic foliation (phyllitic cleavage, schistosity, and gneissosity)

$L_1$ – mineral lineation, grain shape preferred orientation

**$D_2$**

$F_2$ – tight-isoclinal folding of $S_0$ / $S_1$; steep plunging conical folds

$S_2$ – extensional shear bands and parallel aligned mica defining distinct phyllitic parting cleavage; Stonewall Line / Katy Creek shear zone

$L_2$ – elongation lineation

Boudinage development

**$D_3$**

$F_3$ – open kink folds folding $S_0$ / $S_1$ and $S_2$, and $F_1$ and $F_2$ folds, map scale Tallassee synform

$S_3$ – crenulation cleavage

**$D_4$**

Tension gashes

Cataclastic zones

**Table 1.** Relative chronology of metamorphic and deformational structures and fabrics recognized in the rocks of the Tallassee Quadrangle. Modified from Keefer (1992) and Sterling (2006).

The study area was subdivided into three sub-areas for structural analysis (Fig. 11). Subarea boundaries were chosen based on recognized lithologic and structural features. Subarea I covers the west limb of the Tallassee synform, subarea II is in the hinge zone, and subarea III also is in the hinge zone but is separated from subareas I and II by the Stonewall Line shear zone. The structural nomenclature in the Tallassee Quadrangle is described using the following convention: $S_1$, $L_1$, and $F_1$ resulted from $D_1$ deformation; $S_2$, $L_2$, and $F_2$ resulted from $D_2$ deformation; and so forth. Nomenclature for metamorphic events ($M_n$) deviates from this convention as described below.

## Deformation Phase One ($D_1$)

The first recognizable deformational event, $D_1$, affected all of the crystalline rocks within the study area and was a prograde amphibolite-facies event. Original bedding, $S_0$, is reported by Sterling (2006) as coarsening upward sequences, cross beds, and pebbly layers in the Tallassee quartzite and phyllitic quartzite (see for example, Figures 7 and 8 of Sterling, 2006) within the Jacksons Gap Group on the Red Hill Quadrangle. In the present study, $S_0$ is the compositional layering that is interpreted as strongly transposed original bedding. $S_0$ is folded into rare tight-to-isoclinal $F_1$ fold hinges (Keefer, 1992). Keefer (1992) also described $M_1$ garnet porphyroblasts containing helitic folds ($F_1$) of inclusion trails of quartz interpreted as $S_0$. These $M_1$ garnets have discontinuous relations to the encapsulating $S_1$ continuous cleavage. These observations of $S_0/S_1$ imply that most everywhere the dominant metamorphic foliation is a transposed into a composite $S_0/S_1$ , which is depicted as "metamorphic foliation" in Plate 1.

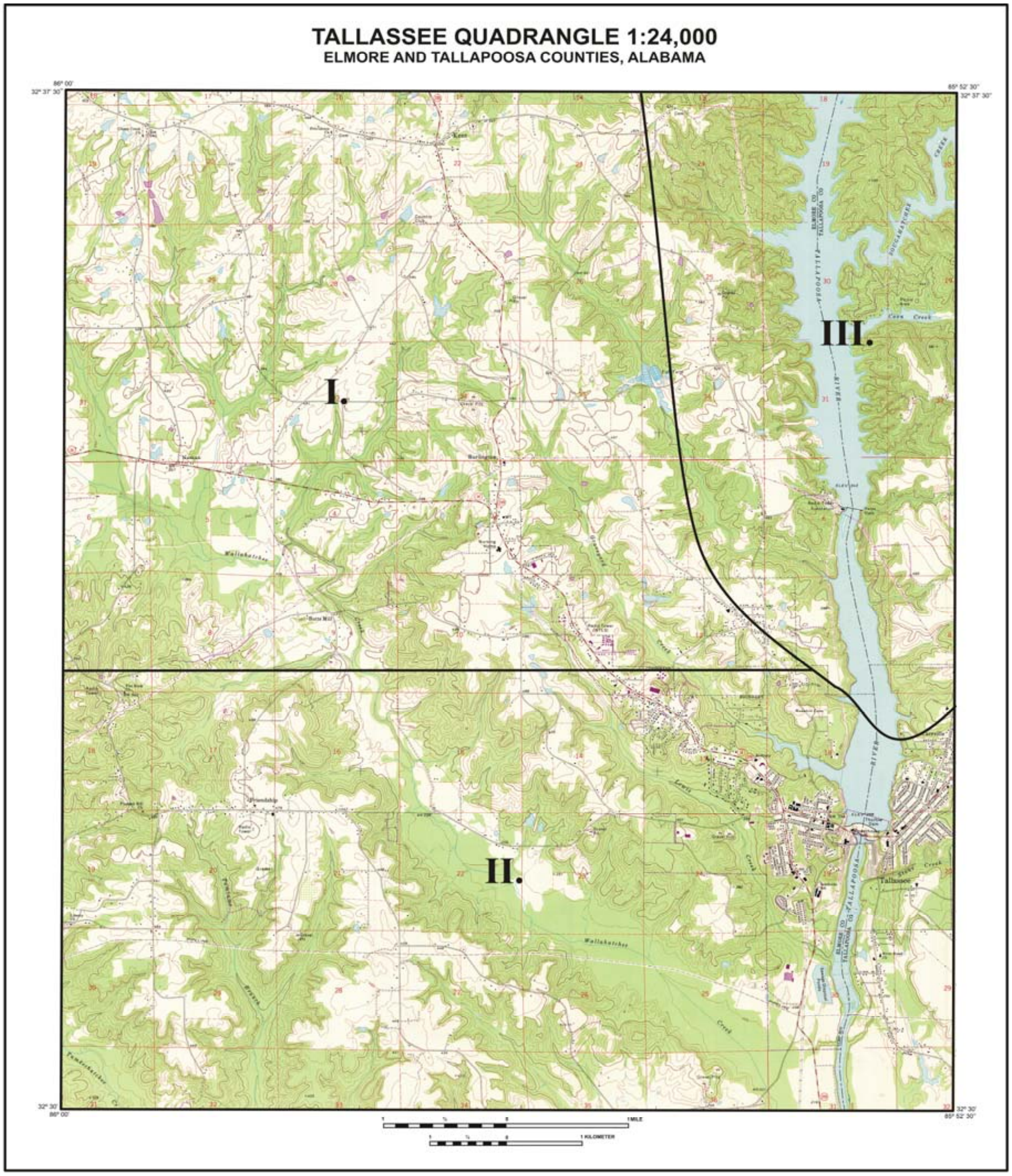


**Figure 11**. Subarea distribution map used for structural analysis.

Dominant foliation as reflected on the form-line map (Fig. 12) represents $S_1$ schistosity that is defined by aligned biotite and/or muscovite, and $S_1$ gneissosity that is defined by light bands of quartz and feldspar alternating with dark bands of biotite and/or hornblende. $S_0/S_1$ foliation surfaces (Fig. 13) within the study area range in attitude from north-northwest striking to west-northwest striking, and dip shallowly toward the northeast (Fig. 14). The west limb of the Tallassee synform (subarea I) has an average strike and dip of N 21º W, 17º NE, the hinge zone (subarea II) N 54º W, 15º NE, and the Dadeville Complex (sub-area III) N 54º W, 16º NE. Minor partial-great circles (Fig. 14) provide evidence for a change in orientation from northeast strikes along the west limb (c.f., Sterling, 2006) to more east-west trends as the hinge zone is approached. Figure 15 depicts the best-fit estimate for the orientation of Tallassee synform based on $S_0/S_1$ data from the Tallassee Quadrangle – N 42º E, 12º NE. Mineral lineations, $L_1$, are defined by grain-shape preferred orientations of quartz, feldspar, and/or hornblende, observed in subareas I, II, and III, which generally plunge gently to the north-northeast (Fig. 16)

### Deformation Phase Two ($D_2$)

The second deformational event to affect rocks in the study area, $D_2$, is characterized by extensional shear bands and phyllitic cleavages/partings ($S_2$), elongation lineations ($L_2$), tight and conical folds of $S_0/S_1$ ($F_2$), and foliation boudinage. Sterling (2006) observed all of these features in the Red Hill Quadrangle, except for the conical folds and foliation boudinage, and similarly interpreted them to have occurred during $D_2$. Prograde $M_1$ mineral assemblages were retrograded under

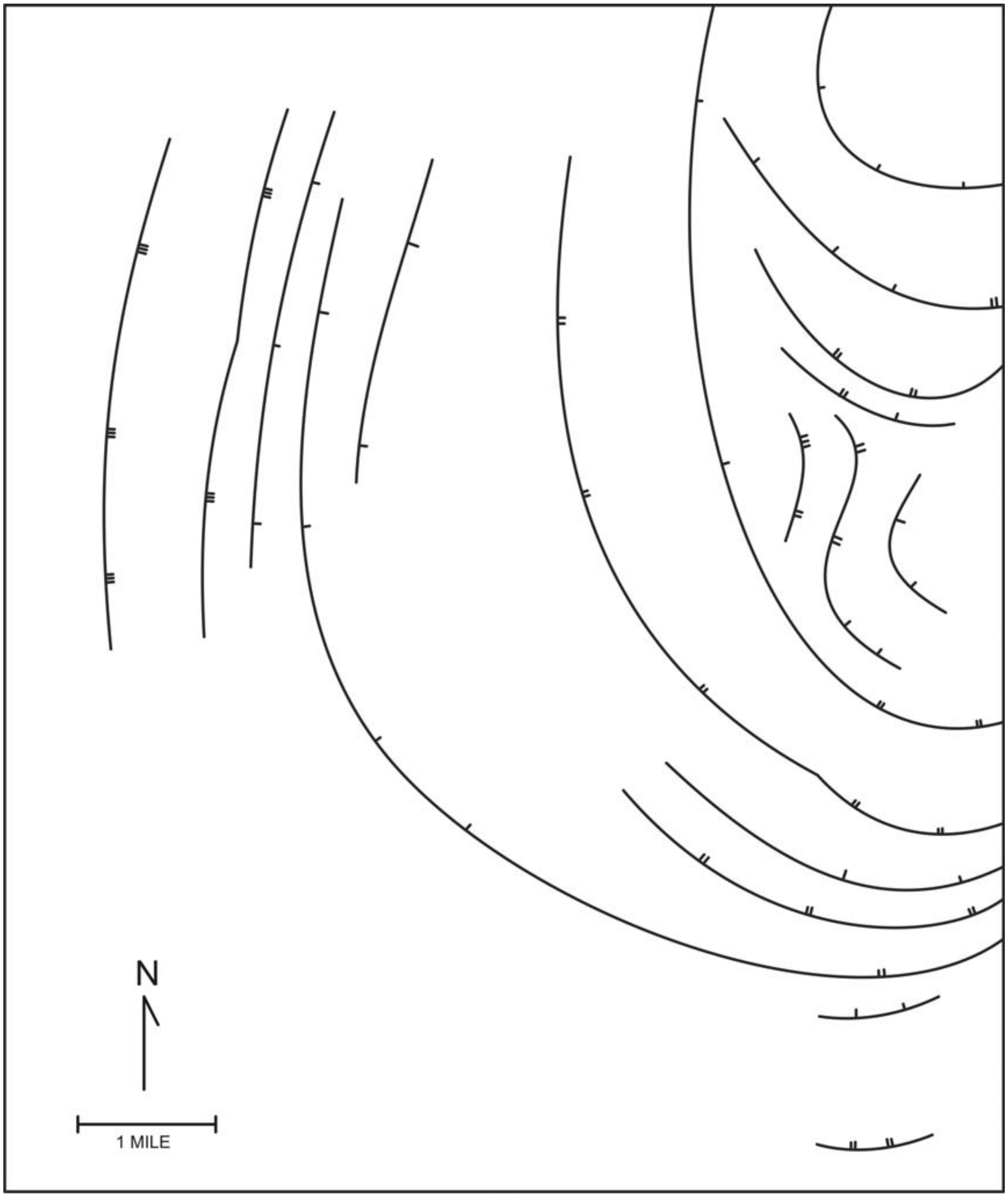
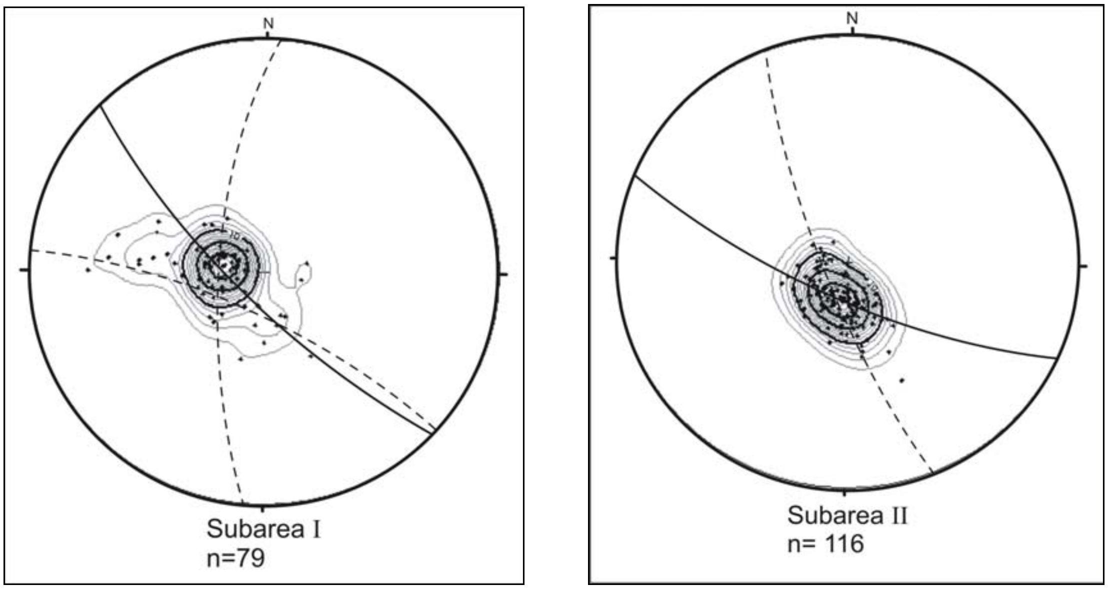


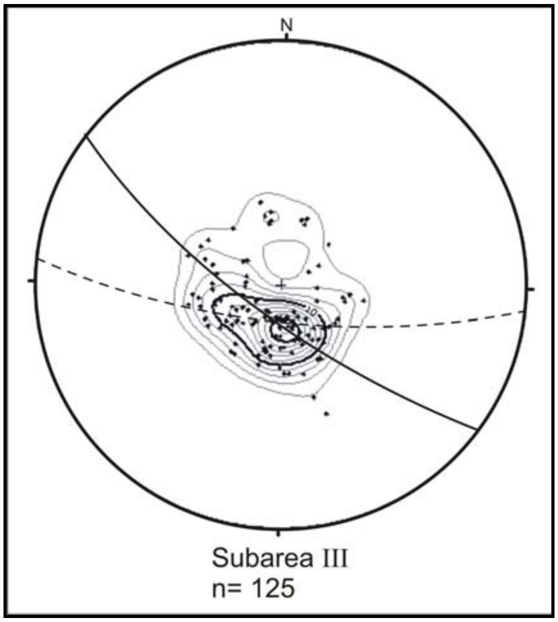
**Figure 12.** Form-line map of the dominant foliation ($S_1$) in the Tallassee Quadrangle. Hatchers represent dips from 0º-20º (single), 20º-40º (double), and >40º (triple). Used for controls to generate geologic map (Plate 1).

**Figure 13.** Tabular slabs of $S_0/S_1$ in the Farmville Metagranite south of Thurlow Dam along the Tallapoosa River, facing east.



Subarea I
n=79

Subarea II
n= 116



Subarea III
n= 125

**Figure 14**. Best-fit estimates of great-circle distributions of poles to $S_0/S_1$ measured in rocks of the study area using contoured lower hemisphere stereographic projections for subareas I, II, and III (see Fig. 10 for subarea distribution map).

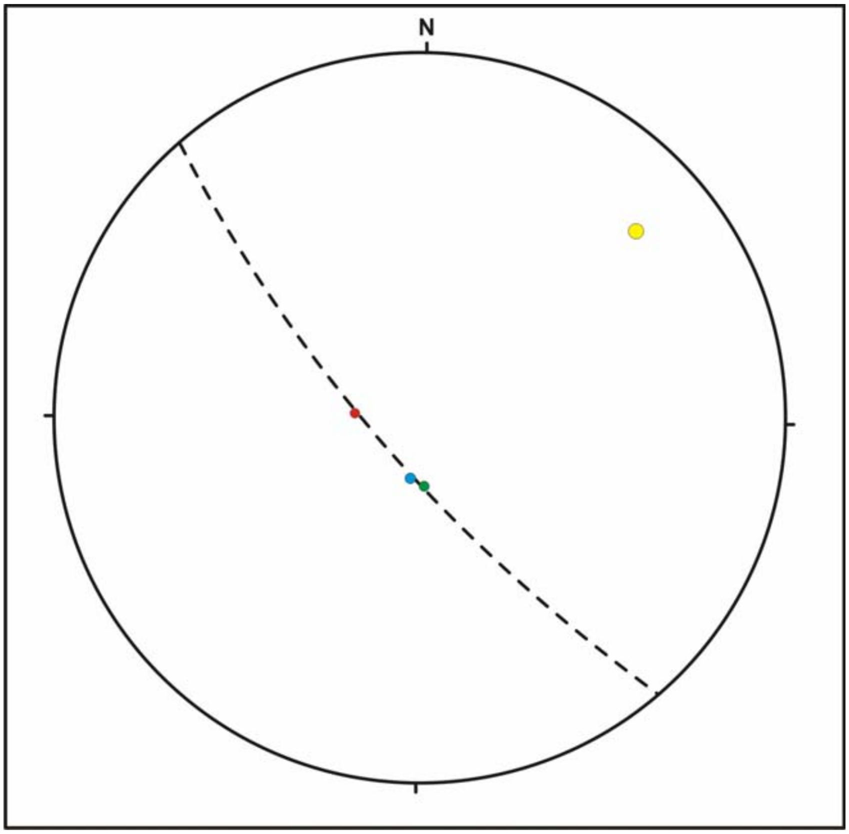
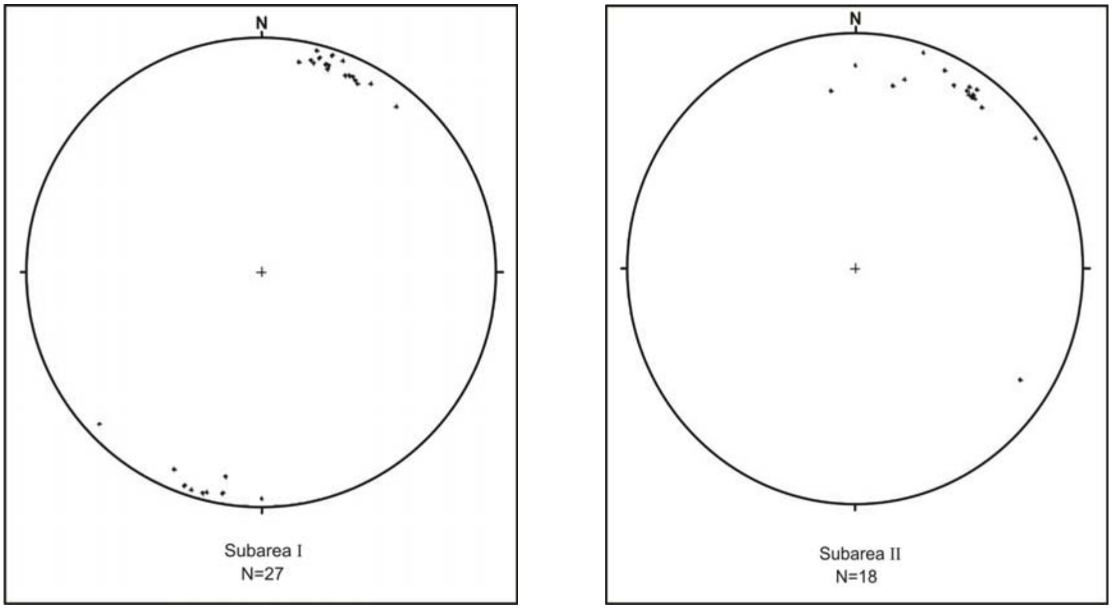
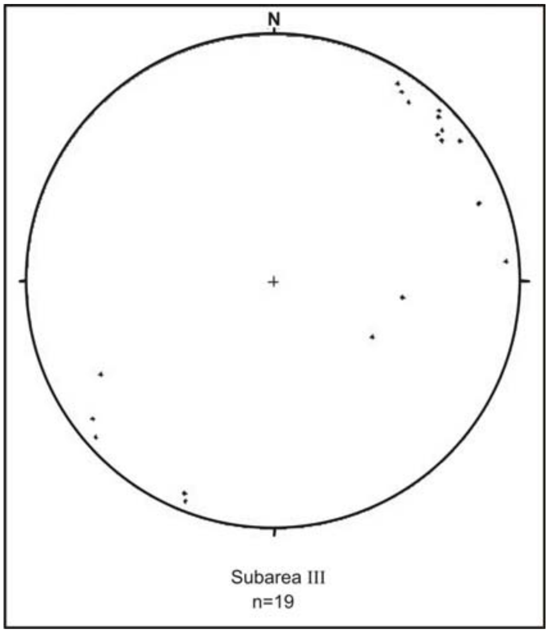


**Figure 15.** Lower hemisphere stereographic projection of point maxima of poles to planes of $S_0/S_1$ (red dot - subarea I, blue dot - subarea II, and green dot - subarea III) with a girdle indicating the best-best fit orientation (yellow – dot) of N 42º E, 12º NE of the Tallassee synform.



Subarea I
N=27

Subarea II
N=18



Subarea III
n=19

**Figure 16.** Lower hemisphere stereographic projections of $L_1$ for subareas I, II, and III.

lower amphibolite- to upper greenschist-facies metamorphic conditions during $D_2$. $D_2$ retrogression followed the reactions hornblende → biotite → chlorite and plagioclase → white mica + epidote minerals.

$S_2$ corresponds to a local spaced phyllitic cleavage or parting foliation, and extensional shear bands. Shear bands are common in medium- to coarse-grained micaceous rocks of the Camp Hill gneiss and the chlorite quartz schist. Phyllitic parting in the phyllitic quartzite and the Farmville Metagranite south of Thurlow dam is also interpreted as an $S_2$ fabric. This parting is defined by a phyllitic sheen of very fine-grained (0.1-0.5 mm) muscovite along surfaces that are at low to moderate angles to $S_1$. In some rocks (e.g., the phyllitic quartzite) this parting truncates and encapsulates $S_0/S_1$ as rootless isoclinal folds (see Sterling, 2006).

Keefer (1992) reported that $F_2$ folds are the most abundant type of folds seen in the field area, primarily along the Tallapoosa River. These folds deform $S_0/S_1$and $L_1$, as well as $F_1$ folds (Fig 17). An elongation lineation, $L_2$, is developed sub-parallel to $F_2$ fold hinge planes and plunges shallowly to the north-northeast (Fig. 18), and was only observed within subareas I and II of the study area. $L_2$ is typically parallel to, or subparallel to $L_1$ and can be distinguished in the field from the latter where $L_2$ is observed to be folded around $F_2$ fold hinges (see Fig. 16 of Keefer, 1992).

One of the most striking structures on Plate 1 is the truncation of the Dadeville Complex along the Stonewall Line shear zone. This truncation, which is consistent with studies by Sears et al. (1981) and Steltenpohl et al. (1990), is interpreted to have resulted from a reactivation of the Stonewall Line shear zone. $S_0/S_1$ fabrics and lithologic layering within the units of the Dadeville Complex clearly are cut by this

**Figure 17.** Example of $F_2$ folds of the $S_0/S_1$ foliation in a non-oriented sample of mylonitized chlorite-hornblende-biotite schist.

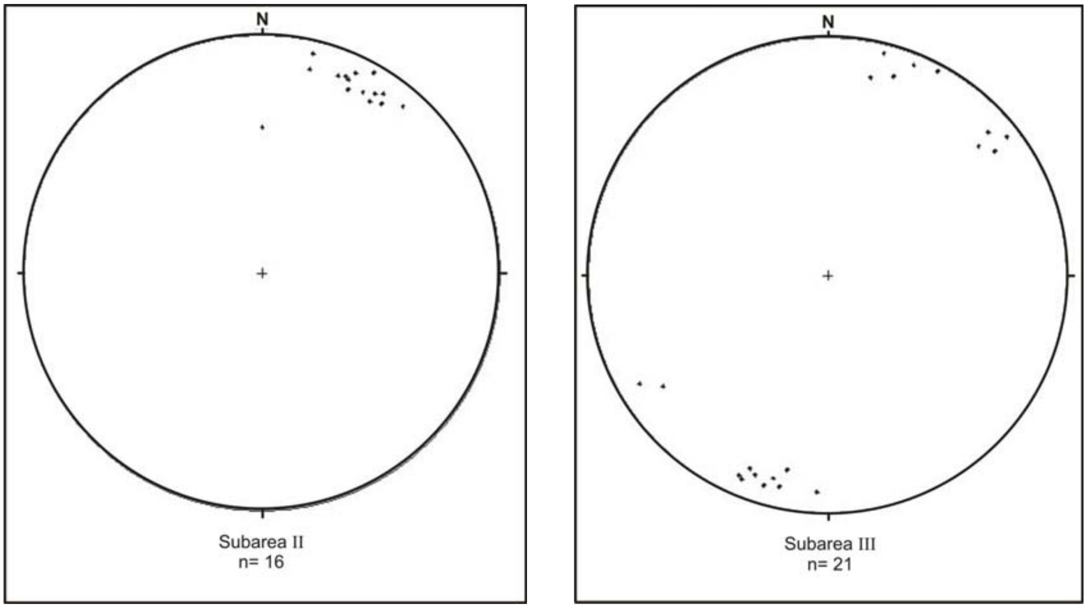


**Figure 18.** Lower hemisphere stereographic projections of $L_2$ for subareas II and III.

truncation indicating post-$D_1$ reactivation. Movement along the shear zone also produced steep-plunging conical folds, which are clear in the map pattern on Plate 1 as well, further supporting right-slip movement. This is consistent with right-slip movement reported along the Katy Creek fault of the Brevard fault zone in the Red Hill Quadrangle (Sterling, 2006). Lower hemisphere stereographic projections of $S_0/S_1$ measured in sub-area III document the conical fold developed within the Dadeville Complex (Fig. 19). The axis of the cone trends N 3º E and plunges 80º N. This steep axis orientation indicates that the development of the conical fold resulted from dextral movement along the Stonewall Line shear zone.

Foliation boudinage is observed in the homogenous gneissic rocks south of Thurlow Dam in subarea I. It is developed within, but also deforms $S_1$, and the boudin axes lie parallel to the $S_1$ plane. Necked volumes of foliation boudinage are primarily injected with quartz, feldspar, and mica. Keefer (1992) reports that boudin axes lie within $S_1$ and plunge shallowly to the northwest, forming a weak girdle with a best-fit orientation of the pole to the girdle at N 68º E, 24º NW.

### Deformation Phase Three ($D_3$)

The third stage of deformation, $D_3$, is evidenced by $F_3$ folds and $S_3$ axial planar crenulation cleavage. $D_3$ was a greenschist-facies retrogressive event that formed white mica and chlorite at the expense of biotite, plagioclase, and hornblende. This deformational episode is interpreted to have been synchronous with the latter parts of $M_2$. It is also the event that formed the map-scale Tallassee synform, which controls the structural configuration of the western Inner Piedmont (Keefer, 1992).

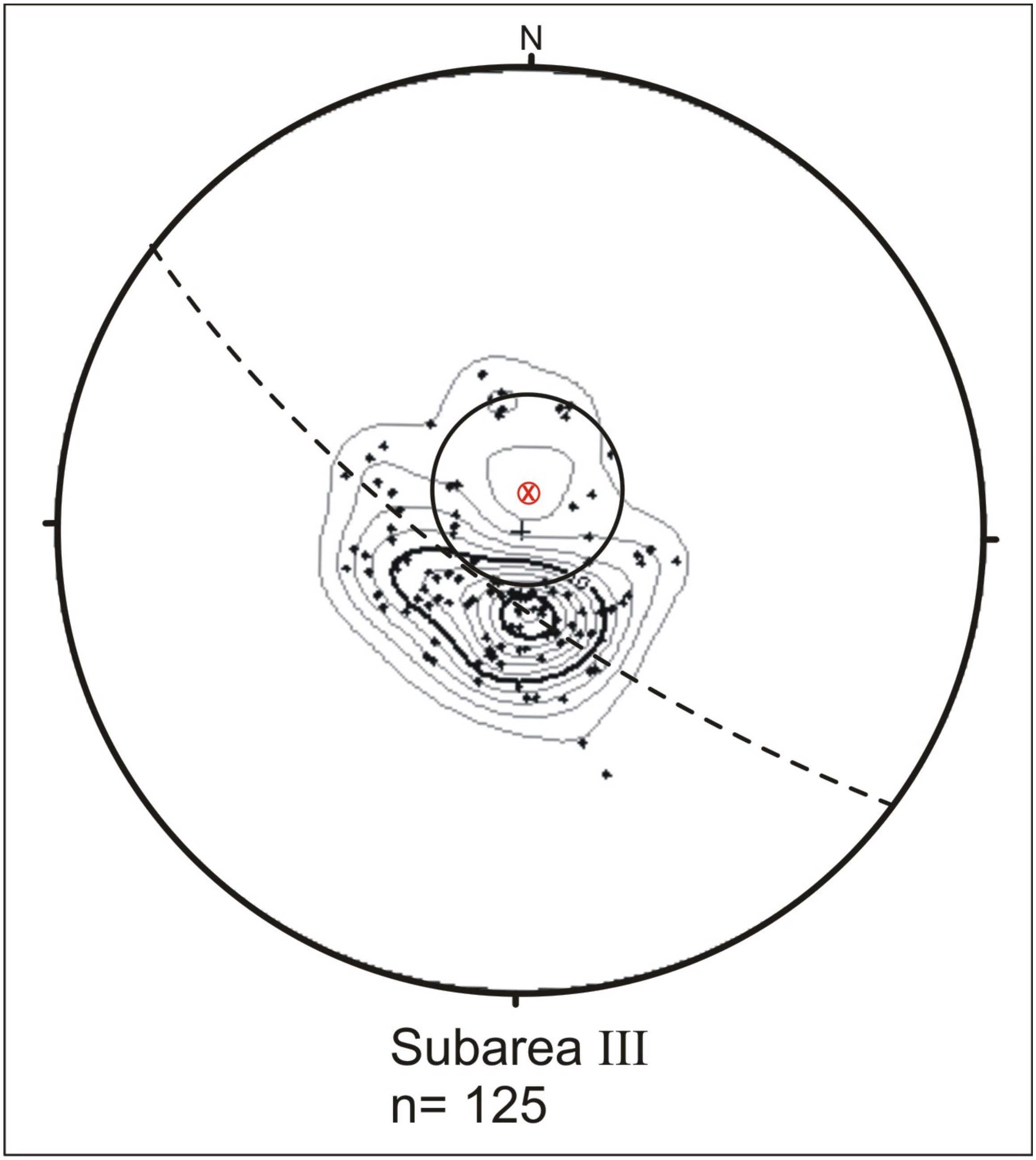


**Figure 19**. Lower hemisphere stereographic projection of poles to $S_0/S_1$ for subarea III illustrating a best-fit great circle (dashed line) and closed small circle (heavy solid line), the latter defining a conical fold distribution.

$F_3$ folds, which deform $S_0/S_1$ and $S_2$ and $F_1$ and $F_2$ folds, exhibit three distinct geometries; (1) centimeter-scale kink folds, (2) meter- to kilometer-scale, close to open folds, and (3) superposed folds (Keefer, 1992). Kink folds formed at high angles to $S_0/S_1$ and produced distinct kink bands bounded by the $S_3$ axial planar crenulation cleavage. Superposed $F_3$ folds result in Ramsay type III interference patterns where they were observed to fold previously formed $F_1$ and $F_2$ folds. Folding during $D_3$ produced the Tallassee synform and other kilometer-scale, close to open folds that likely correspond to the set of cross-folds that deform the Stonewall Line shear zone along the southeast limb of the Tallassee synform (see Fig. 3) described by Steltenpohl et al. (1990).

Figure 20 illustrates a construction that constrains the geometry of the regional Tallassee synform. The axial trace, N 10º E, was determined from Plate 1 using the line separating $S_0/S_1$ strikes and dips on opposed limbs of the synform. Using the axial trace as the strike of the axial surface, and projecting the dip to contain the axis of the synform (from Fig. 14), the dip of the axial surface is 48º SE.

$S_3$ is a weakly developed crenulation cleavage that is generally axial planar to $F_3$ folds (Keefer, 1992). This cleavage may be only a weak axial planar parting or a spaced cleavage where folds are not present. It usually forms at moderate to high angles to $S_0/S_1$ and $S_2$.

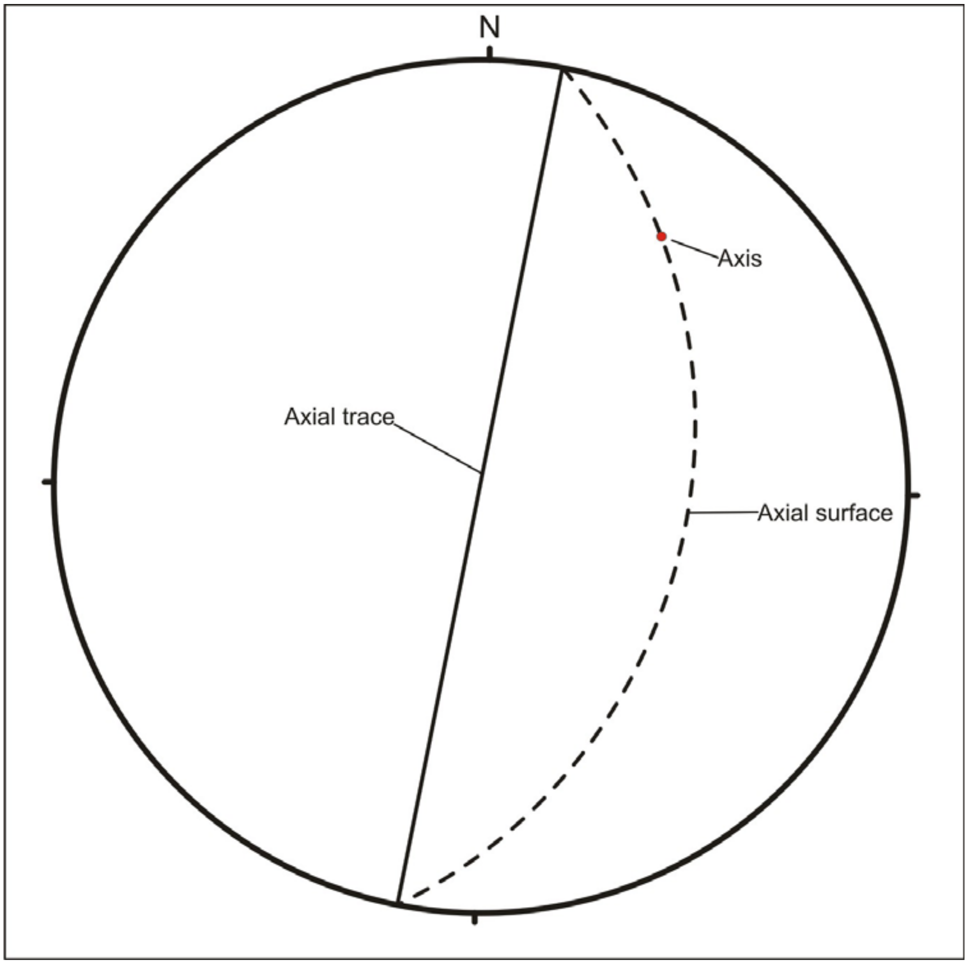


**Figure 20**. Lower hemisphere stereographic projection of axial trace (solid line), orientation of the axial plane (dashed line), and the axis of the Tallassee synform derived from lower hemisphere stereographic projections of poles to $S_1$ within subareas I and II of the Tallassee Quadrangle.

### Deformational phase four ($D_4$)

Keefer (1992) described brittle deformation structures, mainly small tension gashes and cataclastic zones to characterize $D_4$ deformation. Tension gashes truncate the dominant schistosity with little to no offset across them and are infilled with mostly chlorite. Keefer (1992) also described a single, narrow zone of fault breccia in a chlorite-rich matrix within an amphibolite inclusion within the Yates granite gneiss (Camp Hill gneiss). During the present study the author did not observe any $D_4$ structures. The present author interprets features that formed during $D_4$ within the present study area to be associated with latest $D_5$ movement along the Katy Creek and Abanda faults (Steltenpohl et al., 1990).

## Metamorphism

Field observations and petrographic analysis of the rocks from the eastern Blue Ridge, Jacksons Gap Group, and Dadeville Complex indicate metamorphism related to two events. The first metamorphic event, $M_1$, was a prograde amphibolite-facies, Barrovian-type regional metamorphic event. A second event, $M_2$, occurred under greenschist-facies metamorphic conditions and retrograded the pre-existing prograde $M_1$ assemblages. $M_2$ occurred simultaneously with the third deformational event ($D_3$). Prograde ($M_1$) and retrograde ($M_2$) metamorphic events will be described for the eastern Blue Ridge, Jacksons Gap Group, and Dadeville Complex separately because the prograde mineral assemblages ($M_1$) differ between these rock groups.

Prograde ($M_1$) mineral assemblages in eastern Blue Ridge rocks directly west and north of the present study area reflect middle-to upper-amphibolite facies (kyanite and sillimanite zones); grade decreases toward the northeast into Georgia through the staurolite and garnet zones (Steltenpohl and Moore, 1998). Within the study area the Kowaliga Gneiss has the $M_1$ assemblage quartz + orthoclase + plagioclase + muscovite ± biotite, which is not definitive of metamorphic pressure-temperature conditions. Metagraywackes in the Emuckfaw Group in the Tallassee Quadrangle have an $M_1$ assemblage of quartz + orthoclase + muscovite + biotite + plagioclase ± garnet, which also is not diagnostic but is compatible with amphibolite facies conditions. The lack of kyanite and/or sillimanite in these Emuckfaw Group rocks in the present study area, therefore, is interpreted to be due to bulk compositional differences rather than true differences in metamorphic grade. This is compatible with kyanite-zone assemblages and pressure-temperature estimates for rocks of the Opelika Complex, which herein are equated to those of the eastern Blue Ridge, directly east of the area of the Tallassee Quadrangle (Goldberg and Steltenpohl, 1990; Fig. 21). Retrograde $M_2$ assemblages occur in both the Kowaliga Gneiss and Emuckfaw Group rocks. Biotite and plagioclase are retrograded to chlorite and white mica/muscovite, respectively, indicating greenschist-facies conditions for $M_2$ retrogression.

Within the study area, pelitic rocks of the Jacksons Gap Group contain the index minerals biotite, garnet, staurolite, and kyanite. Johnson (1988), Reed (1994), McCullars (2001), and Sterling (2006) all report chloritoid assemblages along the

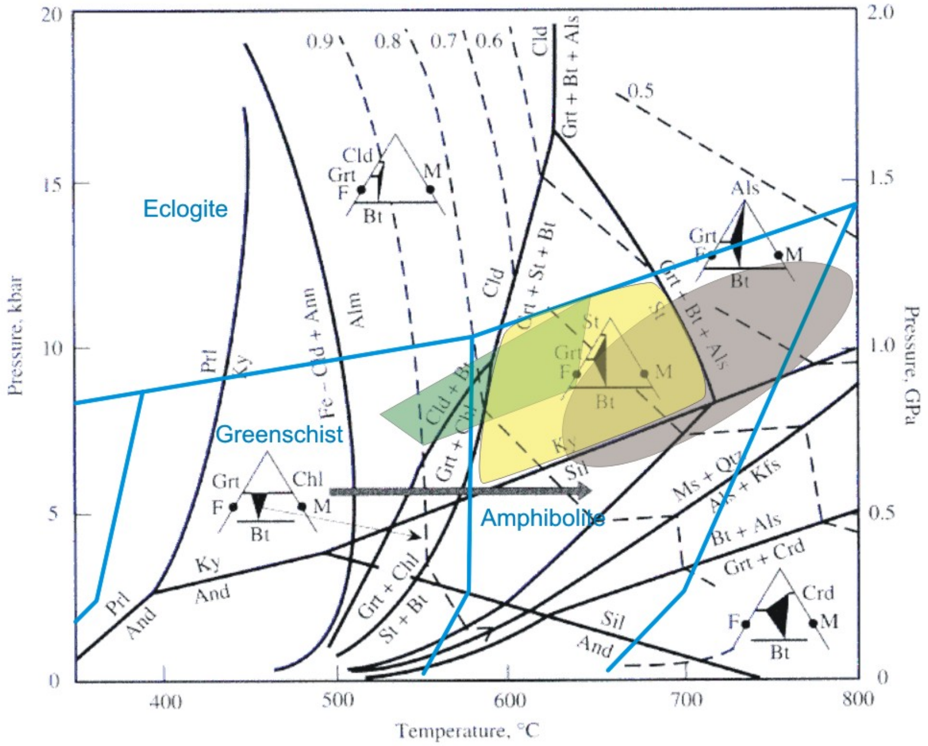


**Figure 21.** Petrogenetic grid with discontinuous reaction boundary curves and metamorphic conditions of temperature and pressure related to rocks of the study area. Yellow shaded area - Jacksons Gap Group, brown shaded area - Dadeville Complex (Drummond et al., 1997), and green area - Opelika Complex (Goldberg and Steltenpohl, 1990). Modified after Blatt and Tracy (1996).

west limb of the Tallassee synform but none were observed in the area of the present investigation. This observation may indicate a progressive change in metamorphic conditions from chloritoid → staurolite → kyanite from north to south toward the hinge zone of the Tallassee synform. The highest-grade metamorphic conditions in the pelitic rocks from the Jacksons Gap Group are recorded by kyanite + sillimanite + staurolite assemblages (see also Weilchowsky, 1983, and Sterling, 2006). Within the present study area the assemblage kyanite + staurolite requires metamorphic pressure-temperature conditions of 5 - 10 kb and 575º - 725º C (Fig. 21). Felsic gneisses (Farmville Metagranite) within the study area contain biotite, garnet, plagioclase, and orthoclase, which do not constrain definite conditions of metamorphism. Rocks of the Jacksons Gap Group, both pelitic and granitoidal, thus, appear to have experienced the same kyanite and staurolite zone amphibolite-facies metamorphic conditions, which are supported by common deformational fabrics throughout these rocks exposed in the study area. Jacksons Gap Group rocks were also retrograded during $M_2$, greenschist-facies metamorphism, as indicated by chlorite and/or white mica having replaced biotite, plagioclase, and/or hornblende.

$M_1$ in rocks of the Dadeville Complex (Fig. 21) achieved upper amphibolite-facies (sillimanite zone) conditions (Steltenpohl and Moore, 1988; Drummond et. al., 1997). The peak mineral assemblage in pelitic rocks is biotite + garnet + sillimanite, whereas the mafic rocks contain garnet + amphibole or garnet + clinopyroxene. In the area of the Tallassee Quadrangle, mafic rocks contain amphibole + garnet. $M_2$

retrogression within rocks of the Dadeville Complex also occurred under greenschist-facies conditions, following the reactions amphibole +/- clinopyroxene → clinozoisite +/- epidote, and biotite + plagioclase +/- hornblende → chlorite + white mica.

To summarize, rocks of the Tallassee Quadrangle experienced different metamorphic conditions, which are retained and recorded in the metamorphic mineral assemblages. The Jacksons Gap Group experienced the lowest temperature conditions based on the assemblage kyanite + staurolite. Pressure and temperature conditions ranged from 5 - 10 kb and 575º - 725º C (Fig. 21). Peak conditions of metamorphism within rocks of the Opelika Complex along the southeast limb of the Tallassee synform (Goldberg and Steltenpohl, 1990), and by extrapolation those of the eastern Blue Ridge, appear to be similar in temperature and pressure (6.5 - 10 kb and 550º - 650º C; Fig. 21). Metamorphic conditions in rocks of the Dadeville Complex appear to be the highest, estimated at approximately 6 - 11 kb and 640º - 780º C (Drummond et al., 1997).

# DISCUSSION

Results from mapping of the Tallassee Quadrangle illustrate many geological relations in the hinge zone of the Tallassee synform. The cartoon diagram in Figure 22 illustrates broad-scale relationships interpreted for this area as would be seen if the Coastal Plain sedimentary cover was removed. The most obvious finding is that the base of the Dadeville Complex is marked by the Stonewall Line shear zone on both the southeast and the northwest limbs of the synform. In the Tallassee Quadrangle ,along the Tallapoosa River, locating rocks within the Stonewall Line shear zone is extremely difficult due to the sparsity of outcrops, weathering, and vegetative cover. Therefore, this contact is inferred on Plate 1to lie between the differing Camp Hill gneiss and the Farmville Metagranite. Steltenpohl et al. (1990) reported that the Stonewall Line shear zone along the southeast limb of the Tallassee synform is a cryptic pre- or syn-metamorphic shear zone that contains parallel rock layers and metamorphic fabrics in both the hanging wall and footwall blocks. Within the northwest limb of the synform, the Stonewall Line shear zone roughly parallels rocks in the footwall but marks a sharp, high-angle truncation with the Dadeville Complex units in the hanging wall and is truncated by the Katy Creek fault north of the present study area (see Fig. 21 of Reed, 1994). Retrogressive mylonites and phylonites along the Katy Creek fault within the northwest limb of the synform (north of the present study area)

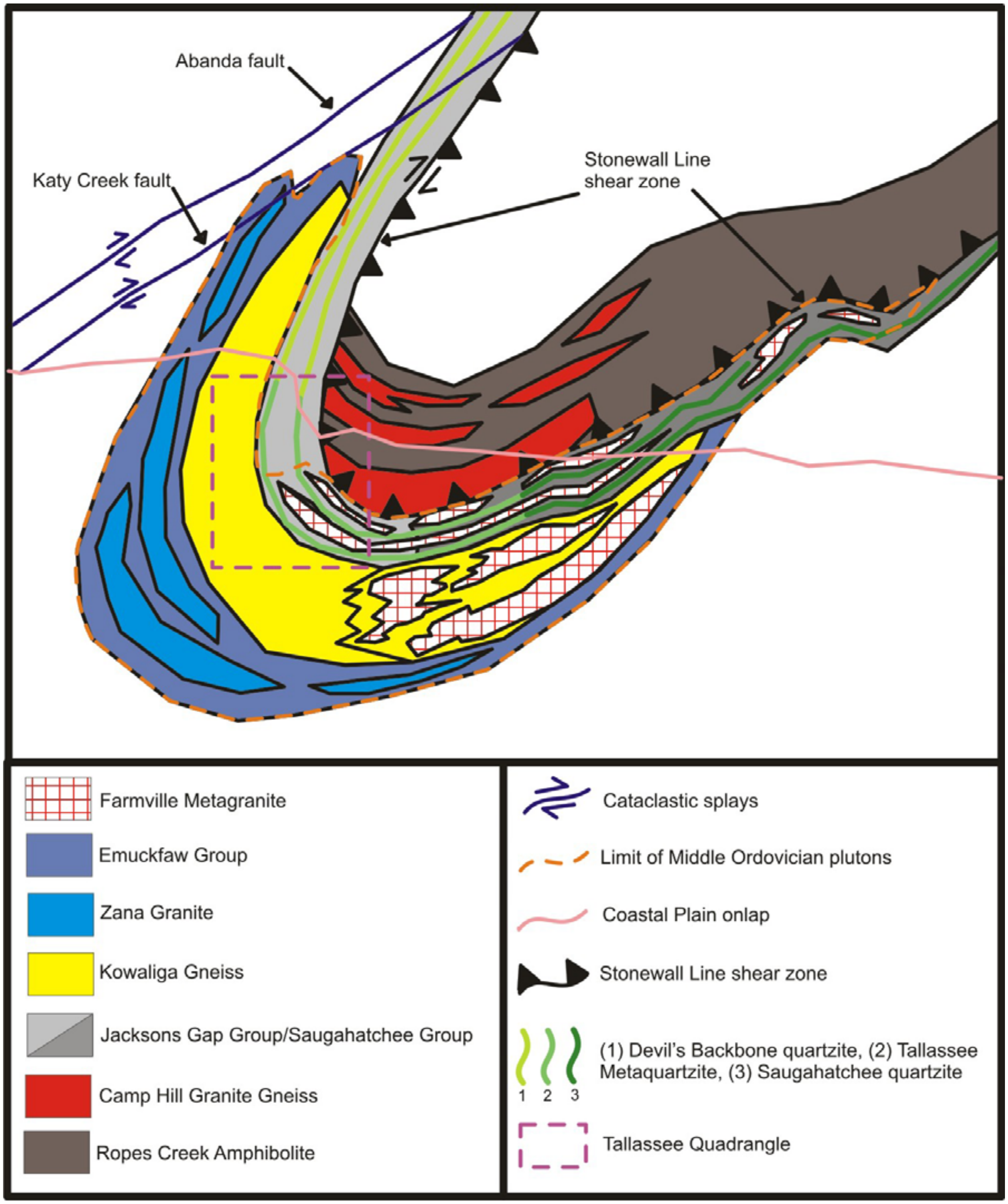


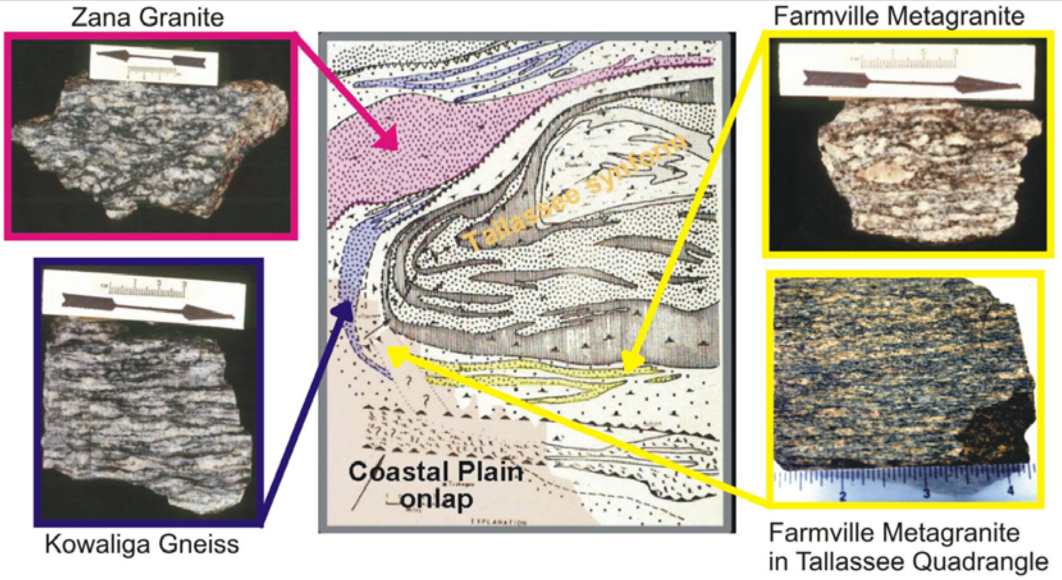
**Figure 22.** Schematic map of the closure of the Tallassee synform, illustrating broad-scale relationships of the rock on opposing limbs of the synform, if the Coastal Plain cover was removed. (not to scale; after Reed, 1994, fig. 21, p. 91)

clearly cut the $D_1$ fabrics and $S_0/S_1$ layering in the Dadeville Complex as does the Stonewall Line shear zone within the present study area. This requires post-$M_1$ juxtaposition and that the earlier Stonewall Line shear zone was later reactivated and partially excised, together with some volume of Dadeville Complex rocks prior to the last movement along the Katy Creek fault. The Stonewall Line shear zone therefore, likely is a segment of the early Brevard zone, as suggested by Grimes et al. (1993) and Steltenpohl (2005).

The Jacksons Gap Group rocks are bounded by the Abanda and Katy Creek faults (below and above, respectively) northeast of Jacksons Gap, Alabama, along strike of the Brevard Zone. Higgins et al. (1988) correlate the Jacksons Gap Group rocks with the Sandy Springs Group in Georgia, which are bounded by the Sandy Springs thrust fault below and the Paulding thrust fault above. Reed (Fig. 21; 1994) and Grimes et al. (1993b) suggested that the late Abanda and Katy Creek faults diverge from the Jacksons Gap Group rocks near Jacksons Gap, Alabama, where the Jacksons Gap Group lithologies make a turn to the south. The late Abanda and Katy Creek fault fabrics should continue southwest along strike to the Coastal Plain onlap. Since the Stonewall Line shear zone is a fault contact between the Jacksons Gap Group and its proposed equivalents and the Dadeville Complex, it correlates with the Paulding thrust fault of Higgins et al. (1988) in the Atlanta, Georgia, area. However, projecting the various thrust slices into the Dadeville Complex in Alabama suggests that the Stonewall Line shear zone is equivalent to segments of the Ropes Creek thrust of Higgins et al. (1988). Petrographic evidence from the Kowaliga Gneiss in the western part of the Tallassee Quadrangle near the contact suggests that this contact is an unnamed fault. The structural position of this possible fault between the Jacksons Gap Group and the eastern Blue Ridge rocks places it in the correct location to possibly be the Sandy Springs thrust fault of Higgins et al. (1988). A similar divergence of thrusts bounding the Sandy Springs Group from the trend of the Brevard zone proper north of Atlanta, Georgia, is shown on the regional map of Higgins et al. (1988).

Plate 1 also appears to verify tectonostratigraphic correlations presented in Figure 4. From east to west, the Loachapoka Schist/Saugahatchee Quartzite correlate with the Jacksons Gap Group (schists)/Tallassee quartzite. Although earlier workers suggested such correlations (Bentley and Neathery, 1970; Keefer, 1992; Grimes et al. 1993; Steltenpohl, 2005), the limited mapping of geological features in the area of the Tallassee Quadrangle left this idea a hypothesis to be further explored. A principal difference between these authors' interpretations and those presented herein, is how one reconciles the fact that within the Tallassee Quadrangle the quartzites are interleaved with highly resistant quartzofeldspathic gneisses instead of schists and phyllites. The present author has demonstrated that this interleaving of quartzite and orthogneiss is exactly what one should expect, since Farmville Metagranite bodies become more and more abundant southwestward along the southeast limb of the Tallassee synform as the hinge zone is approached (Steltenpohl et al., 1990; Grimes, 1993; Grimes et al., 1993; Steltenpohl, 2005). Not only do the tabular sheets of granite become more abundant, but so do augen gneisses and migmatitic rocks (Grimes, 1993; Grimes et al., 1993). Such interleaving of the Farmville and apparently equivalent plutonic bodies in Georgia with the Saugahatchee Quartzite and correlative Chattahoochee Palisades and Tallulah Falls quartzites farther north has been known since the early 1980's (Hatcher, 1978; Sears et al., 1981; Higgins et al., 1988). As described above, authors debated whether this interleaving was structural (Higgins et al., 1988) or intrusive (Sears et al., 1981; Steltenpohl et al., 1990; Goldberg and Steltenpohl, 1993). The present author suggests that the correlative quartzites should be further examined to place a single formalized name on the quartzites that are seen both in the northwest and southeast limbs of the Tallassee synform in both Alabama, and Georgia.

A true revelation from the present mapping effort was the recognition that there is a near mirror-image disappearance of these granitic and migmatitic units across the axis of the Tallassee synform along its west limb (Figure 22). Steltenpohl (2005) reports that the Kowaliga, Zana, and Farmville plutons have strikingly similar field, petrographic, and geochemical signatures. They now are mapped projecting through the covered parts of the synform's hinge zone (Fig. 23). The Kowaliga Gneiss and the Zana Granite of the eastern Blue Ridge have, respectively, ~458 Ma and ~460 Ma U-Pb dates (total zircon populations) of crystallization (Russell, 1978). The Farmville metagranite had been interpreted to have intruded and crystallized in the Devonian based on an Rb-Sr whole-rock isochron of 369 Ma (Goldberg and Burnell, 1987) but Steltenpohl et al. (2005) report a TIMS U-Pb date on zircons documenting igneous crystallization at 460+/-16 Ma. These dates further support correlation of rocks of the Emuckfaw and Jacksons Gap Group with those of the Auburn Gneiss and the Loachapoka Schist/Saugahatchee Quartzite of the Opelika



ISOTOPIC DATING

| Rock Unit | Rb/Sr | Source |
|---|---|---|
| Zana Granite | 395 +/- 56 m.y. | Russell, 1978 |
| Kowaliga Gneiss | 437 +/- 47 m.y. | Russell, 1978 |
| Farmville Metagranite | 369 +/- 5 m.y. | Goldberg & Burnell, 1987 |
| **Rock Unit** | **U/Pb** | **Source** |
| Zana Granite | 460 m.y. | Russell, 1978 |
| Kowaliga Gneiss | 458 m.y. | Russell, 1978 |
| Farmville Metagranite | 460 +/- 16 m.y. | Steltenpohl, 2005 |

**Figure 23.** Diagram illustrating similarities between various granitic rocks across the hinge of the Tallassee synform. Map modified after Bentley and Neathery (1970).

Complex, respectively, and also indicates that Middle Ordovician magmatism is more extensive in the Alabama Piedmont than was previously thought. Results of the present study clearly indicate the presence of a Ramsay type II, ‘boomerang’-shaped fold interference pattern containing this distinct mass of Middle Ordovician plutonic and migmatitic rock. These findings are compatible with the ‘super migmatite’ phenomenon recognized at the base of the Inner Piedmont terrane in South Carolina (Griffin, 1969). They are also consistent with Hatcher and Merschat’s (2006) interpretation for middle-crustal level channelized flow within the migmatized portion of the Inner Piedmont, which would be directed southwestward along the Tallassee synform.

Several fabric observations imply that the interleaving of the Farmville Metagranite and Tallassee quartzite in the core of the Tallassee synform has been at the least modified by subsequent mylonitization processes. First, the finer grained, homogenous nature of the gneisses in the present study area implies that mylonitization may have largely recrystallized the Farmville Metagranite. The texture of the gneisses is well homogenized in comparison with the granitoids farther northeast along the southeast limb of the synform. Likewise, the difficulty in separating textures in the gneisses from those in the quartzites suggests mylonitic homogenization. The well-developed phyllitic parting in these units recognized in this study also is consistent with structural modification of lithologic units and their contacts.

Finally, relationships in Plate 1 support the suggestion that the Opelika complex is not related to the Inner Piedmont, as it is traditionally interpreted (Bentley and Neathery, 1970; Osborne et al., 1988; Hatcher; 1987), but rather is continuous with the eastern Blue Ridge around the hinge of the Tallassee synform (Grimes et al., 1993; Steltenpohl, 2005). This has important tectonic implications. First, the fault at the base of the Opelika Complex, i.e., the Towaliga fault (Figs. 1, 2, and 3), now must be considered a segment of the Hayesville-Fries fault (suture; Hatcher, 1987) since it emplaces eastern Blue Ridge rocks upon Laurentia (i.e., the Pine Mountain terrane). Second, the interleaving of orthoquartzites with Middle Ordovician plutonic rocks is an unusual relationship in the southern Appalachians. The fact that the immediate footwall block to the Stonewall Line shear zone hosts large Middle Ordovician plutons (Kowaliga Gneiss, Lithonia Gneiss, Elkahatchee Quartz Diorite) may indicate that these acted as a footwall buttress for incoming Appalachian allochthons. Future work along the margins of the Dadeville Complex should help to further our understanding of the significance that these findings have for southern Appalachian tectonic evolution.

# CONCLUSIONS

Mapping of the Tallassee quadrangle reveals that the contact between the Dadeville Complex and the Jacksons Gap Group is the Stonewall Line shear zone on the southeast limb, through the hinge zone, and on the northwest limb of the Tallassee synform, to near Jacksons Gap where it is truncated by the Katy Creek fault (Reed, 1994). The Katy Creek fault cuts $D_1$ fabrics and $S_0/S_1$ layering of the Dadeville Complex (north of the present study area) requiring post-metamorphic juxtaposition that reactivated and excised the Stonewall Line shear zone. The author suggests that the Stonewall Line shear zone is a segment of the early Brevard zone where it coinsides with the present Katy Creek fault.

Within the study area, the Tallassee quartzite of the Jacksons Gap Group is interleaved with quartzofeldspathic gneisses instead of the typical schists and phyllites observed along the northwest limb of the Tallassee synform. As the hinge zone is approached from along the southeast limb, Farmville Metagranite bodies become more abundant and become the quartzofeldspathic gneisses within the Tallassee Quadrangle. The Kowaliga, Zana, and Farmville granitoids have strikingly similar field, petrographic, and geochemical signatures that support their continuance through the buried parts of the Tallassee hinge zone, supporting the correlation of the eastern Blue Ridge with portions of the Opelika Complex (Grimes et al., 1993; Steltenpohl, 2005). Middle Ordovician magmatism is much more extensive in the

Alabama Piedmont than was previously thought. The Towaliga fault should be considered a segment of the Hayesville-Fries fault (suture; Hatcher, 1987), because it emplaces eastern Blue Ridge rocks upon Laurentian units of the Pine Mountain terrane. The presence of a Ramsay type II ‘boomerang’-shaped fold interference pattern at the base of the Inner Piedmont in this area is compatible with the concept of a ‘super migmatite’ zone, supporting Hatcher and Merschat’s (2006) interpretation for mid-crustal level channelized flow.

Future studies along the Tallassee synform need to address two areas of interest. First, investigations into the faults bounding the Jacksons Gap Group between Jacksons Gap, Alabama, and the axis of the Tallassee synform need to be conducted to determine equivalency and the correct name of the ‘Stonewall Line shear zone’ and to formalize a name for the unnamed fault between the Jacksons Gap Group and the eastern Blue Ridge. Second, the correlative quartzites along both limbs of the Tallassee synform in Alabama and Georgia, need to be further examined so that one formal name can be applied to them. These names need to be established according to the most recent version of the North American Stratigraphic Code provided by the North American Commission on Stratigraphic Nomenclature (2005).

# REFERENCES

Bentley, R. D., and Neathery, T. L., 1970, Geology of the Brevard fault zone and related rocks of the Inner Piedmont of Alabama: Alabama Geological Society 8th Annual Field Trip Guidebook, p. 119.

Bieler, D. B., and Deininger, R. W., 1987, Geologic setting of the Kowaliga augen gneiss and the Zana Granite, northern Alabama Piedmont, *in* Drummond, M. S., and Green, N. L., eds., Granites of Alabama: Geological Survey of Alabama, p. 57-72.

Blatt, H., and Tracy, R. J., 2001, Petrology: igneous, sedimentary, and metamorphic (second ed.): New York, W. H. Freeman and Company, 529 p.

Bobyarchick, A. R., 1999, The history of investigation of the Brevard fault zone and evolving concepts in tectonics: Southeastern Geology, v. 38, no. 3, p. 223-238.

Cook, R. B., and Thompson, I., 1995, Characteristics of Brevard zone gold mineralization in the sessions vicinity, Tallapoosa county, Alabama, *in* Guthrie, G. M., ed., The timing and tectonic mechanisms of the Alleghanian orogeny: Alabama Piedmont, v. Geological Society of Alabama 32nd Annual Field Trip Guide, p. 43-51.

Cook, R. B., and Thompson, I., 1995, Character of Brevard Zone-Inner Piedmont boundary mineralization at the Sessions prospect. Eagle Creek District, Tallapoosa County, Alabama: Geological Society of America Abstracts with Programs, v. 27, no. 6, p. A-117.

Dallmeyer, R. D., 1988, Late Paleozoic tectonothermal evolution of the western Piedmont and eastern Blue Ridge, Georgia: Control on the chronology of terrane accretion and transport in the southern Appalachian orogen: Geological Society of America Bulletin, v. 100, p. 702-713.

Drummond, M. S., Nielson, M. .J., Allison, D. T., and Tull, J. F., 1997, Igneous petrogenisis and tectonic setting of granitic rocks from the eastern Blue Ridge and Inner Piedmont, Alabama Appalachians, *in* Sinha, A. K., Whalen, J. B., and Hogan, J. P., eds., The Nature of Magmatism in the Appalachian Orogen: Geological Society of America, p. 147-164.

Goldberg, S. A., and Burnell, J. R., 1987, Rubidium-strontium geochronology of the Farmville granite, Alabama Inner Piedmont, *in* Drummond, M. S., and Green, N. L., eds., Granites of Alabama: Geological Survey of Alabama, p. 251-258.

Goldberg, A. R., and Steltenpohl, M. G., 1990, Timing and characteristics of Paleozoic deformation and metamorphism in the Alabama Inner Piedmont: American Journal of Science, v. 290, p. 1169-1200.

Griffin, V. S., Jr., 1969, Migmatitic Inner Piedmont belt of northwestern South Carolina: South Carolina Division of Geology, Geologic Notes, no. 13, p. 87-104.

Grimes, J. E., 1993, Geology of the Piedmont rocks between the Dadeville Complex and the Pine Mountain window in parts of Lee, Macon, and Tallapoosa Counties, Alabama [M.S. thesis]: Auburn, Alabama, Auburn University, 129 p.

Grimes, J. E., and Steltenpohl, M. G., 1993, Geology of the crystalline rocks along the fall line, on the Carrville, Notasulga, and Loachapoka quadrangles, Alabama, *in* Steltenpohl, M. G., and Salpas, P. A., eds., Geology of the southernmost exposed Appalachian Piedmont rocks along the fall line: Geological Society of America, Southeastern Section 42nd Annual Meeting Field Trip Guidebook, p. 67-94.

Grimes, J. E., Steltenpohl, M. G., Cook, R. B., and Keefer, W. D., 1993a, New geological studies of the most southern part of the Brevard zone, Alabama, and their implications for southern Appalachian tectonostratigraphy, *in* Hatcher, R. D., Jr., and Davis, T. L., eds., Studies of Inner Piedmont geology with a focus on the Columbus Promontory: Carolina Geological Society Annual Field Trip Guidebook, p. 95-116.

Grimes, J. E., Steltenpohl, M. G., Keefer W. D., and Cook R. B., 1993b, New geological studies of the most southern part of the Brevard zone, Alabama: Tectonic implications: Geological Society of America Southeastern Section, Abstracts with Programs, v. 25, n. 4, p. 19.

Hall, G. D., 1991, A comparative geochemical study of differing amphibole types within the Ropes Creek Amphibolite, western Lee County, Alabama [M.S. thesis]: Auburn, Alabama, Auburn University, 131 p.

Hatcher, R. D., Jr., 1978, Tectonics of the western Piedmont and Blue Ridge, southern Appalachians: Review and speculation: American Journal of Science, v. 278, p. 276-301.

Hatcher, R. D., Jr., 1987, Tectonics of the southern and central Appalachian Internides: Annual Review of Earth and Planetary Sciences, v. 15, p. 337-362.

Hatcher, R. D., Jr., 1993, Perspective on the tectonics of the Inner Piedmont, Southern Appalachians, *in* Hatcher, R. D., Jr., and Davis, T., eds., Studies of the Inner Piedmont geology with a focus on the Columbus Promontory: Carolina Geological Society Annual Field Trip Guidebook, p. 1-16.

Hatcher, R. D., Jr., and Merschat, A. J., 2006, The Appalachian Inner Piedmont: an exhumed strike-parallel tectonically forced orogenic channel, *in* Law, R. D., Searle, M. P., and Godin, L., eds., Channel flow, ductile extrusion and exhumation in continental collision zones: Geological Society, London, Special Publications, Geological Society of London, p. 517-541.

Higgins, M. W., Atkins, R. L., Crawford, T. .J., Crawford, R. F., Brooks, R., and Cook, R. B., 1988, The structure, stratigraphy, tectonostratigraphy, and evolution of the southernmost part of the Appalachian orogen: U.S. Geological Survey Professional Paper 1475, p. 173.

Hopson, J. L., and Hatcher, R. D., Jr., 1988, Structural and stratigraphic setting of the Alto allochthon, northwest Georgia: Geological Society of America Bulletin, v. 100, p. 339-350.

Horton, J. W., Jr., Avery, A. D., Jr., and Rankin, D. W., 1989, Tectonostratigraphic terranes and their Paleozoic boundaries in the central and southern Appalachians: Geological Society of America Special Paper, v. 230, p. 213-245.

Horton, J. W., Jr., Zietz, I., and Neathery, T. L., 1984, Truncation of the Appalachian Piedmont beneath the Coastal Plain of Alabama: Evidence from new magnetic data: Geology, v. 12, p. 51-55.

Johnson, M. J., 1988, Geology of the gold occurrences near Jacksons Gap, Tallapoosa County, Alabama [M.S. thesis]: Auburn, Alabama, Auburn University, 156 p.

Keefer, W. D., 1992, Geology of the Tallahassee synform hinge zone and its relationship to the Brevard zone, Tallapoosa and Elmore Counties, Alabama [M.S. thesis]: Auburn, Alabama, Auburn University, 195 p.

McCullars, M. J., 2000, Geology and trace-element geochemistry of the Brevard zone near Martin Lake, Tallapoosa County, Alabama [M.S. thesis]: Auburn, Alabama, Auburn University, 113 p.

Neilson, M. J., 1987, The felsic gneisses of the Inner Piedmont, *in* Drummond, M. S., and Green, N. L., eds., Granites of Alabama: Tuscaloosa, Alabama, Geological Survey of Alabama, p. 9-15.

Nielson, M. J., and Stow, S. H., 1986, Geology and geochemistry of the mafic and ultramafic intrusive rocks, Dadeville belt, Alabama: Geological Society of America Bulletin, v. 97, p. 296-304.

Neilson, M. J., Thomas, L. S., and Kish, S. A., 1997, Two high-silica gneisses from the Dadeville Complex of Alabama's Inner Piedmont: Southeastern Geology, v. 36, no. 3, p. 123-132.

North American Commission on Stratigraphic Nomenclature, 2005, North American stratigraphic code: AAPG Bulletin, v. 89, no. 11, p. 1547-1591.

Osborne, W. E., 2005, Letter to Dr. Randall C. Orndorff, EDMAP Project Officer: Reston, VA, U.S. Geological Survey, p. 2, *in* Steltenpohl, M. G., Geology of the 1:24,000 Tallassee, Alabama, Quadrangle (Digital Geologic Map of Tallassee Quadrangle, Alabama ed.): Tallassee, Alabama, U.S. Geological Survey EDMAP proposal, p. 8.

.

Osborne, W. E., Szabo, M. W., Neathery, T. L., and Copeland, C. W., Jr., 1988, Geologic map of Alabama, northeast sheet: Tuscaloosa, Alabama Geological Survey.

Raymond, D. E., Osborne, W. E., Copeland, C. W., Jr., and Neathery, T. L., 1988, Alabama stratigraphy: Alabama Geological Survey Circular, v. 140, p. 1-97.

Reed, A. S., 1994, Geology of the western portion of the Dadeville 7.5’ Quadrangle, Tallapoosa County, Alabama [M.S. thesis]: Auburn, Alabama, Auburn University, 108 p.

Russell, G. S., 1978, U-Pb, Rb-Sr, and K-Ar isotopic studies bearing on the tectonic development of the southernmost Appalachian Orogen, Alabama [Ph.D. dissertation]: Tallahassee, Florida, Florida State University, 196 p.

Sears, J. W., Cook, R. B., and Brown, D. E., 1981, Tectonic evolution of the western part of the Pine Mountain Window and adjacent Inner Piedmont province, *in* Sears, J. W., ed., Contrasts in tectonic style between the Inner Piedmont Terrane and the Pine Mountain Window: Alabama Geological Society 18th Annual Field Trip Guidebook, p. 1-61.

Steltenpohl, M. G., 2005a, Geology of the 1:24,000 Tallassee, Alabama, Quadrangle (Digital Geologic Map of Tallassee Quadrangle, Alabama ed.): Tallassee, Alabama, USGS EDMAP, p. 8.

Steltenpohl, M.G., 2005b, A Primer on terranes of the southernmost Appalachians of Alabama and Georgia., *in* Steltenpohl, M. G., ed., New perspectives on southernmost Appalachian terranes, Alabama and Georgia: Geological Society of Alabama 42nd Annual Field Trip Guide, p. 1-18.

Steltenpohl, M. G., and Moore, W. B., 1988, Metamorphism in the Alabama Piedmont: Alabama Geological Survey Circular, v. 138, p. 1-27.

Steltenpohl, M. G., Neilson, M. J., Bittner, E. I., Colberg, M. R., and Cook, R. B., 1990, Geology of the Alabama Piedmont terrane: Geological Survey of Alabama Bulletin, v. 139, p. 1-80.

Sterling, J. W., 2006, Geology of the southernmost exposures of the Brevard zone in the Red Hill Quadrangle, Alabama [M. S. thesis]: Auburn, Alabama, Auburn University, p. 118.

Thompson, I., and Cook R. B., 1995, Structural and lithological controls to gold mineralization, Eagle Creek district, Tallapoosa County, Alabama: Geological Society of America, Abstracts with Programs, v. 27, no. 6, p. A-117.

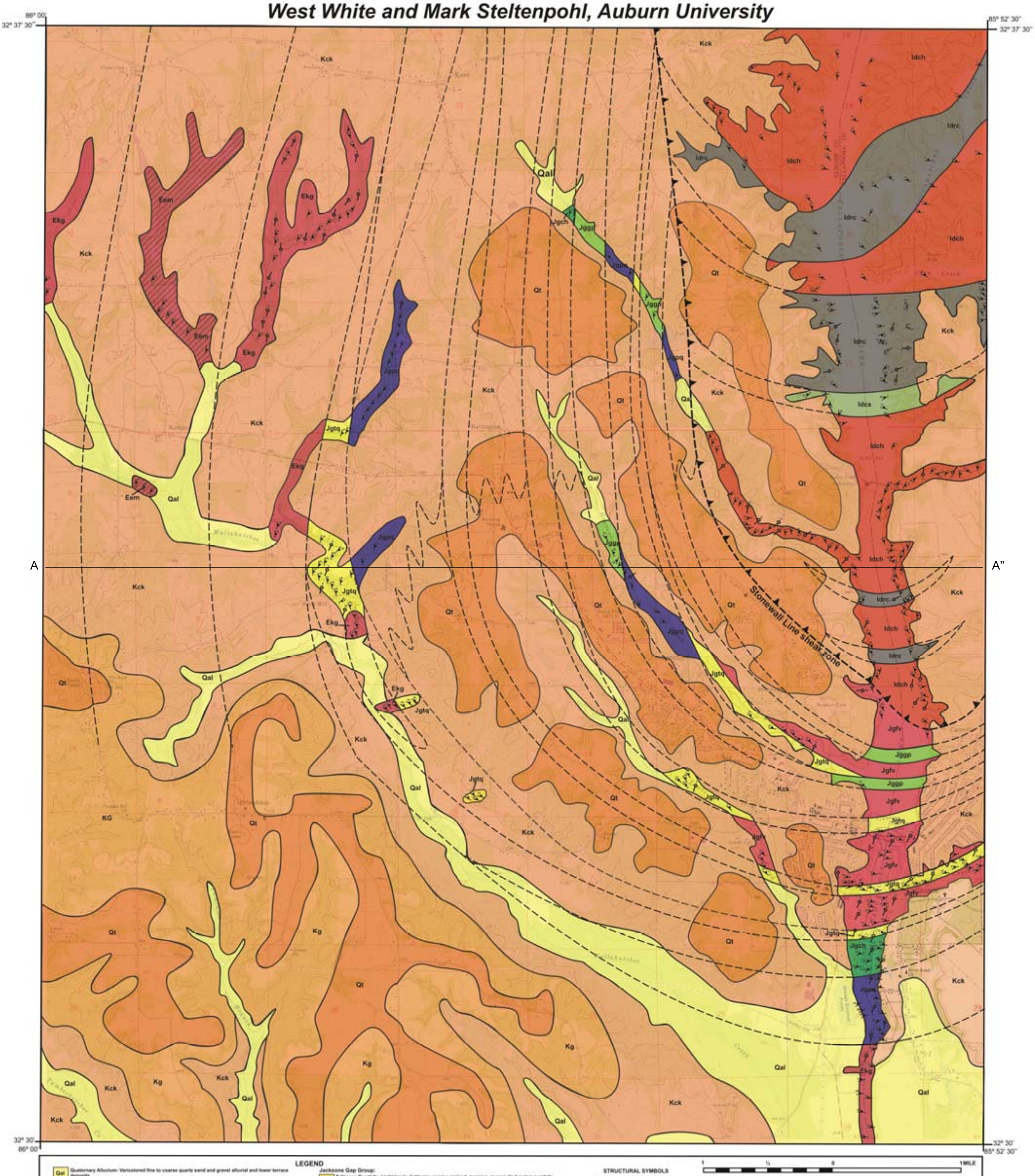
Tull, J. F., 1978, Structural development of the Alabama Piedmont northwest of the Brevard zone: American Journal of Science, v. 278, p. 442-460.

Vauchez, A., 1987, Brevard fault zone, southern Appalachians: A medium-angle, dextral, Alleghanian shear zone: Geology, v. 15, p. 669-672.

Wielchowsky, C. C., 1983, The geology of the Brevard zone and adjacent terranes in Alabama [Ph.D. dissertation]: Houston, Texas, Rice University, 237 p.

# GEOLOGIC MAP OF THE TALLASSEE QUADRANGLE ELMORE AND TALLAPOOSA COUNTIES, ALABAMA

*West White and Mark Steltenpohl, Auburn University*



LEGEND

| | |
|---|---|
| Qal | Quaternary Alluvium- Varicolored fine to coarse quartz sand and gravel alluvial and lower terrace deposits. |
| Qt | Quaternary High Terrace deposits- Varicolored, poorly sorted, coarse quartz sand, and quartzite gravel with lenses of clay. |
| Kg | Upper Cretaceous Tuscaloosa Gordo Formation- Light brown-orange, med- to coarse-grained cross-bedded gravelly sand. |
| Kck | Upper Cretaceous Tuscaloosa Coker Formation- Red-orange poorly sorted sand, containing lenses of quartz and chert gravel. |

INNER PIEDMONT:

DADEVILLE COMPLEX:

| | |
|---|---|
| ldrc | Ropes Creek Amphibolite- Layered and massive amphibolite, locally tonalitic layers and migmatite, with rare calcsilicates. |
| ldcs | Chlorite-Quartz Schist- Green-yellow medium- to coarse-grained schist, defining a zone of ductile deformation. |
| ldch | Camp Hill Gneiss- Tan- to gray colored, fine- to medium-grained, granitic to quartz diorite gneiss. Locally migmatic and well foliated, resembling Farmville Metagranite. |

Jacksons Gap Group:

| | |
|---|---|
| Jgtq | Tallassee Quartzite- Light tan to light gray coarse-grained, massive, muscovite bearing quartzite, locally containing garnet. |
| Jgpq | Phyllitic Quartzite- Light tan-gray to dark gray, fine- to coarse-grained sericite phyllite with lenses and isoclinally folded layers of quartz,coarse grained garnet porphyroblasts. Contains large pegmatite bodies along Tallapoosa River South of Tallassee, AL. |
| Jggp | Garnetiferous Phyllite- Light gray to grayish-brown, fine- to medium-grained muscovite, biotite, phyllite/schist |
| Jgch | Chlorite-Hornblende-Biotite Schist- Fine- to medium-grained, grayish-green to grayish-brown schist with garnet porphyroblasts |
| Jgfv | Farmville Metagranite- Medium gray to brownish tan, fine- to medium-grained, foliated and or lineated quartz-monzonite metagranite. |

Eastern Blue Ridge:

| | |
|---|---|
| Ekg | Kowaliga Gneiss- Medium gray coarse-grained granodiorite to quartz monzonite with large feldspar augen. |
| Eem | Emuckfaw Group- Tan to gray, medium-grained muscovite-biotite-feldspar schist |

STRUCTURAL SYMBOLS

- Metamorphic Foliation
- Syn-metamorphic fold & hinge surface
- Post-metamorphic fold & hinge surface
- Elongation lineation
- Mineral lineation
- Lithologic contact
- Inferred contact
- Thrust fault

1 ½ 0 1 MILE

1 ½ 0 1 KILOMETER

N

QUADRANGLE LOCATION

TALLASSEE, AL.

Mapping was supported by an EDMAP grant to Mark Steltenpohl, 2006-2007.