GEOLOGY OF THE DADEVILLE QUADRANGLE AND THE TALLASSEE SYNFORM IN CHARACTERIZING THE DOG RIVER WINDOW

by

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ABSTRACT

Structural and lithologic observations are reported for southernmost Appalachian shear zones and Blue Ridge and Inner Piedmont metamorphic rocks exposed on the Dadeville 7.5-minute quadrangle map. Brevard fault zone lithologies, called the Jacksons Gap Group, separate the dominantly metasedimentary eastern Blue Ridge from the overlying metavolcanic-metaplutonic Dadeville Complex (Inner Piedmont). The Jacksons Gap Group is sandwiched between the syn-metamorphic Katy Creek fault, above, and the post-metamorphic Abanda fault, beneath. Deformation along the Brevard fault zone is characterized by multiple reactivations through time under varying crustal conditions. Brevard fault zone faulting initiated at near peak-Neoacadian (Late Devonian to Early Carbonifereous) metamorphic (middle-amphibolite facies) conditions yielding mylonites with oblique right-slip and thrust movement indicators. S-C mylonitic fabric along the Abanda fault records Alleghanian (Middle Carboniferous) dextral strike-slip fault reactivation under upper-greenschist to- lower-amphibolite facies conditions. Mylonites reflecting both of these crystal-plastic shearing events were overprinted by Mesozoic subvertical cataclastic faults.

The new geologic map is combined with existing 1:24,000-scale geologic maps and structural analyses conducted on quadrangles framing the hinge zone of the regional northeast plunging Tallassee synform, confirming that lithologies and structures of the eastern Blue Ridge (Emuckfaw Group) on the west limb are continous with those previously assigned to the Inner

Piedmont (Opelika Complex) on the east limb. Aeromagnetic and gravity geophysical signatures are consistent with the surface geology, further indicating closure of the Tallassee synform beneath a thin veneer of Mesozoic Gulf Coastal Plain sediments. U-Pb dating of granites that intruded both limbs of the synform (Kowaliga Gneiss and Farmville Metagranite) confirm similar Late Ordovician-Early Silurian crystallization ages verifying common magmatic histories. U-Pb detrital zircon analyses of distinctive orthoquartzites of the Jacksons Gap Group confirm similar source areas and tectonostratigraphic continuity with regionally distinct marker quartzites along strike in the Blue Ridge and Inner Piedmont of Georgia. Findings document a large (1,029 km^2) tectonic window through the Inner Piedmont allochthon, herein called the Dog River window that exposes a vast area of previously unrecognized Laurentian Blue Ridge rocks spanning most of the Alabama Promontory.

ACKNOWLEDGMENTS

I express my gratitude to the faculty and staff of the Department of Geology and Geography at Auburn University for helping shape me into a geologist through challenging course work and dynamic field studies. I am grateful to my friend and mentor, Dr. Mark Steltenpohl, for inspiring me to become a geologist, for presenting me with unique opportunities for field studies as an undergraduate, for valuable discussion of the geology in the study area, and for technical reviews of the manuscript and geologic map. I would also like to thank my family and friends for their support, and my fiancée, Ruth Yusckat, for her patience and encouragement.

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INTRODUCTION

The format used herein is manuscript style, comprising two papers that have been prepared for journal submission. The first paper, Geology of the Dadeville 7.5-minute Quadrangle, Tallapoosa County, Alabama was prepared as a geologic report for submission to the Geological Survey of Alabama using their manuscript guidelines. The second paper, The Dog River window: confirmation of a first-order eastern Blue Ridge tectonic window in the Inner Piedmont, southern Appalachians, USA has been prepared according to the manuscript guidelines for Geosphere, which is the same as the Bulletin of the Geolgoical Society of America.

The Dadeville 7.5-minute quadrangle is located in a geologically critical area, as it contains one of the largest faults in the Appalachians, the Brevard fault zone, which marks the boundary between the eastern Blue Ridge and the Inner Piedmont terranes. The first paper deals specifically with detailed descriptions of the rock units and metamorphic and structural features found in rocks of the quadrangle. The purpose of this manuscript is to document the polyphase movement history along the Brevard fault zone and its associated change in rheological properties through time and space. This manuscript is the result of a detailed 1:24,000-scale field investigation of 90 km^2 within the Dadeville, Alabama 7.5-minute quadrangle. Standard field mapping techniques (i.e. brunton compass and hand sample collection) were employed during ten weeks of field mapping in the summer of 2012 augmented by numerous day long visits throughout the 2011-2012 academic year. Lithologic and structural data were compiled from 383 stations throughout the map area. Foliation and lineation data was plotted onto overlays and a structural form-line map was constructed. The form-line map then was layered together with the lithologic and topographic information using ArcGIS to generate the geologic map. Laboratory work included petrographic analysis of seventeen thin sections to characterize mineral assemblages, microstructures, fabrics, and lithologies.

The objective of the second paper is to document the presence of the Dog River window, a previously unrecognized tectonic window through the Inner Piedmont into the Laurentian eastern Blue Ridge. Recognition of this large tectonic window stems from detailed geologic mapping conducted as part of several MS-degree thesis projects in the hinge and adjacent flanks of the regional northeast-plunging Tallassee synform in east-central Alabama. Geologic mapping had suggested that lithologies and structures of the eastern Blue Ridge on the west limb correlate with those previously assigned to the Inner Piedmont on the east limb (see Steltenpohl, 2005). The hinge zone of the Tallassee synform, however is obscured by a thin veneer of Mesozoic Coastal Plain sedimentary rock, and thus physical continuity between the limbs was not iron clad. A detailed analysis of four 7.5-minute geologic quadrangle maps in the critical area of the synform's closure along the Coastal Plain onlap therefore is synthesized and presented. Notably, stream drainages cutting through the Coastal Plain unconformity were discovered to be much more numerous and revealing of crystalline bedrock than was previously known. Aeromagnetic and gravity geophysical signatures, presented in Steltenpohl et al. (2013b), are consistent with the observed surface relations and imply closure of the Tallassee synform beneath the Gulf Coastal Plain sediments. U-Pb zircon dating of the Kowaliga Gneiss and Farmville Metagranite, on the west and east limb of the Tallassee synform, respectively, yield Late Ordovician igneous crystallization ages that verify common ages and histories of voluminous magmagenesis and plutonism. U-Pb detrital zircon analysis of the Tallassee Quartzite, which corresponds to a distinctive package of regionally distinct marker quartzite units, suggests that the source area contained a mixture of basement sediments compatible with proposed along strike lithologic correlations. Results document that the Dog River window is a fundamental, first-order structure of the southern Appalachian orogen.

GEOLOGY OF THE DADEVILLE 7.5-MINUTE QUADRANGLE, TALLAPOOSA COUNTY, ALABAMA

Abrahams, J.B.

INTRODUCTION

LOCATION AND PHYSIOGRAPHIC SETTING

The Dadeville 7.5-minute quadrangle (lats. 32°52’30” and 32°52’30”; longs. 85°52’30” and 85°45’) is located in southwestern Tallapoosa County, Alabama (Fig. 1). The quadrangle lies within the Piedmont physiographic province of the Appalachian highlands. Elevation ranges from less than 490 feet (149 m) along the Lake Martin shoreline to more than 780 feet (237 m) on Smith’s Mountain in the central part of the quadrangle. Prominent topographic features generally reflect erosional and weathering resistance of quartzites, amphibolites, and mafic/ultramafic plutonic rocks. Drainage in the quadrangle has a dendritic pattern and is dominated by the Tallapoosa River, several of its tributaries include the Sandy, Chattasofka, Manoy, and Buck creeks, Norrell Branch, and the major recreational and hydropower reservoir Lake Martin. The town of Dadeville and the shoreline adjacent to Lake Martin are predominantly urban, whereas the eastern part of the quadrangle away from Lake Martin is dominantly rural. Many areas of the Dadeville Quadrangle are experiencing rapid development and growth around Lake Martin in the eastern and central parts of the quadrangle and along Hwy. 280 in the northeastern part of the quadrangle.

GEOLOGIC SETTING

Geologically, the Dadeville Quadrangle encompasses an area at the southeastern boundary of the Emuckfaw Group in the eastern Blue Ridge, the Brevard zone, and the northwestern boundary of the Dadeville Complex in the Inner Piedmont (Fig. 1). Rocks of the eastern Blue Ridge in Alabama lie between the Hollins Line fault and the Brevard fault zone (Tull, 1978; Steltenpohl and Moore, 1988; Steltenpohl et al., 2013a and 2013b), and contain three metasedimentary packages, the Ashland, Wedowee, and the Emuckfaw Groups (Neathery, 1975; Tull, 1978). The Ashland Group occupies the lowest structural position, and occurs within two isolated structural salients. The southern salient comprises schist, gneiss, quartzite, and abundant amphibolite layers, whereas the northern salient comprises heterogenous paragneiss, schist, calc-silicate, quartzite and rare amphibolite (Bentley and Neathery, 1970; Tull, 1978; Steltenpohl et al. 2013a). Southeast of the retrogressive, oblique-normal-right-slip Goodwater-Enitachopco fault (Steltenpohl et al. 2013a), rocks of the Wedowee Group are composed of schist, phyllonite, minor quartzite, and amphibolite. The Alexander City fault in most places separates the Wedowee Group from the Emuckfaw Group, the latter group comprises pelitic schist, metagraywacke, and minor amphibolite (Bentley and Neathery, 1970; Steltenpohl et al. 2013a). Compared to the Ashland Group that is characterized by a lack of intrusives, the Wedowee and Emuckfaw Groups are invaded by voluminous felsic plutons (Osborne et al., 1988) of Ordovician-Silurian (~439 Ma and 441+/- 6.6 Ma: Russell, 1978; Tull et al., 2012; Hawkins, 2013), Devonian (~388-370 Ma: Barineau, 2009; Tull et al., 2009; Schwartz et al., 2011; Steltenpohl et al., 2013a), and Carboniferous (~350-330 Ma:

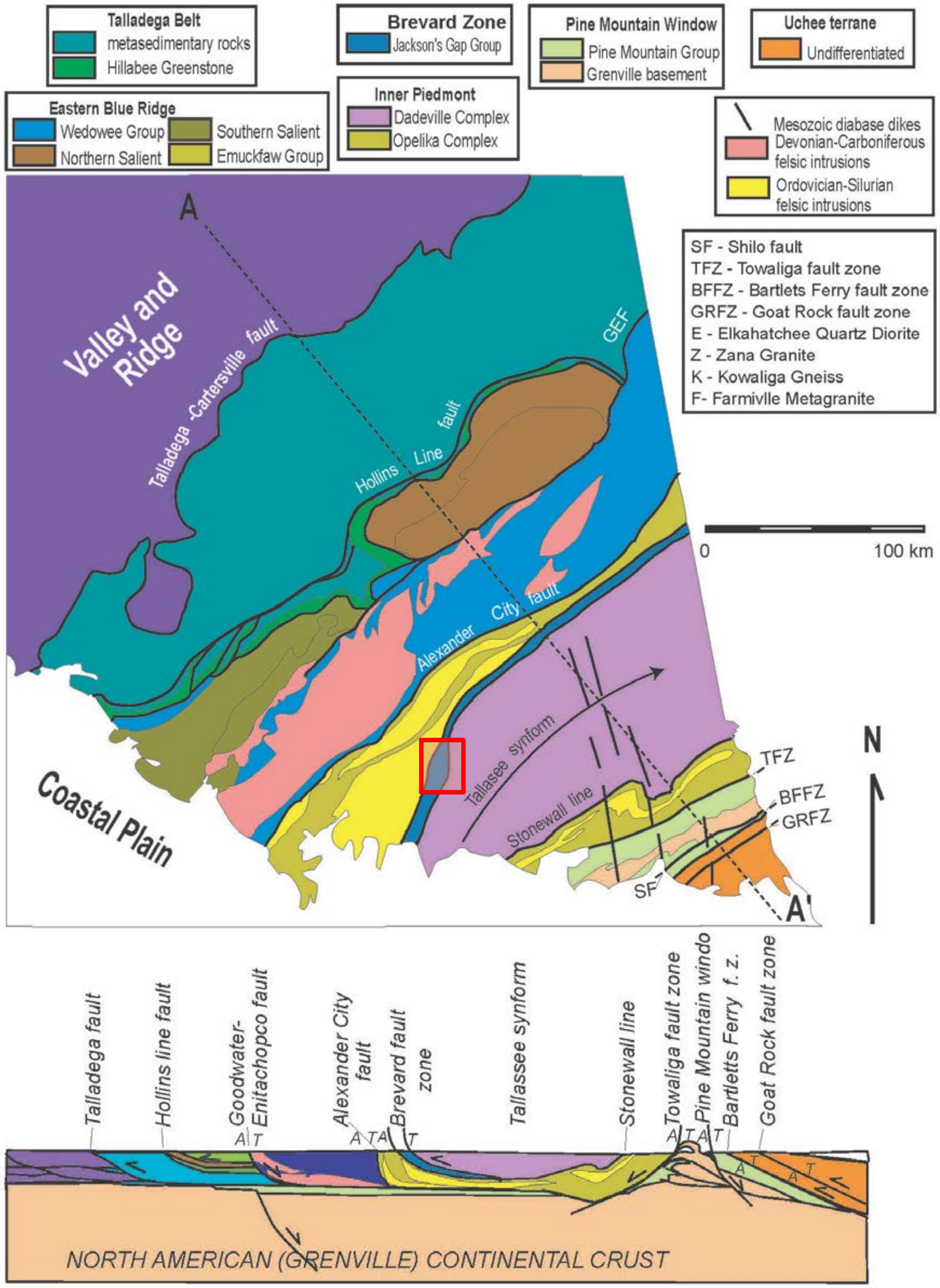

Figure 1. Geologic map and cross- section of the Alabama Piedmont (Modified from Steltenpohl, 2005). The Dadeville Quadrangle is outlined in red.

Schwartz et al., 2011) ages. Most workers consider the eastern Blue Ridge of Alabama to reflect an outboard, slope/rise facies of the ancient Laurentian margin (Drummond et al., 1994, 1997; McClellan et al., 2007; Tull et al., 2007). Alternatively, Steltenpohl (2005), Sterling (2006), and Tull et al. (2012) have proposed that parts of the eastern Blue Ridge exposed in Alabama may have evolved in a back-arc basin outboard of the ancient Laurentian margin.

The Emuckfaw Group is structurally overlain by the Brevard fault zone. The Brevard fault zone is an extensive fault zone that generally marks the boundary between the eastern Blue Ridge and the overlying Inner Piedmont extending in surface exposures from Mt. Airy, North Carolina, to Tallassee, Alabama. In Alabama, the Jacksons Gap Group defines Brevard fault zone lithologies that lie between the Abanda fault, beneath, and the Katy Creek fault, above, and is composed primarily of metasiliciclastics and metapelites. Distinctive orthoquartzites like the Devils Backbone/Tallassee quartzite of the Jacksons Gap Group are rare in the Piedmont; the only other orthoquartzite in this region is the Hollis Quartzite of the Pine Mountain Group, which overlies the Grenville Pine Mountain basement massif (Sears et al., 1981; Steltenpohl et al, 2010).

The Inner Piedmont lies to the southeast and structurally above the Brevard fault zone, the actual contact being the poorly understood Katy Creek fault. Rocks of the Inner Piedmont define the core of the gently northeast-plunging Tallassee synform (Bentley and Neathery, 1970; Abrahams et al., 2014), which is flanked by the Brevard fault zone on the west and the Towaliga fault on the east. The Inner Piedmont in Alabama has been divided into two lithodemic complexes; the metavolcanic-metaplutonic Dadeville Complex overlying the mostly metasedimentary Opelika Complex (Bentley and Neathery, 1970; Osborne et al., 1988). The Dadeville Complex comprises various schists, gneisses, and mafic and ultramafic rocks, with approximately 40% composed of the Ropes Creek Amphibolite (Bentley and Neathery, 1970; Steltenpohl et al., 1990). A probable early Paleozoic arc or back-arc complex (Steltenpohl et al., 1990), the Dadeville Complex is a part of the larger Inner Piedmont terrane. The Inner Piedmont has been interpreted as an exhumed strike-parallel, tectonically forced orogenic channel (Merschat and Hatcher, 2007), which formed from subduction beneath peri-Gondwanan terranes of the Carolina superterrane (Hatcher and Zeitz, 1980: i.e., the Carolina Zone of Hibbard et al., 2006; 2007).

PREVIOUS INVESTIGATIONS

Early investigation of rocks in and adjacent to the Dadeville Quadrangle focused on gold occurrences and included mine location, geologic descriptions, mineralogy and a brief account of the regional geology (e.g. Tuomey, 1858; Phillips 1892; Adams, 1930; Park, 1935; Pardee and Park, 1948). Adams (1926, 1933), describing crystalline rocks of Alabama, first defined the Wedowee formation and interpreted rocks of the Brevard fault zone as correlative with altered Wedowee formation. Significant regional work by Bentley and Neathery (1970) described the geology of the Brevard fault zone and Inner Piedmont, which set the foundation for subsequent geological studies in the area. In their report Bentley and Neathery (1970) designated the Wedowee formation as the Wedowee Group. In addition, rocks between the Wedowee Group and the Brevard fault zone were designated as the Heard Group, with associated felsic intrusives designated as the Kowaliga Gneiss and Zana Granite. In the Brevard fault zone, although Bentley and Neathery (1970) did not define a type section, it was described as a zone of deformation and cataclasis bounded to the north by the Abanda fault and to the south by the Katy Creek fault. Bentley and Neathery (1970) subdivided the Inner Piedmont into the Dadeville Complex and the Opelika Complex and delineated several mappable units (e.g. the Waresville Formation, Agricola Schist, Camp Hill Gneiss, the Ropes Creek Amphibolite, and the Boyds Creek mafic Complex). Bentley and Neathery (1970) suggested that the southern Appalachian Piedmont is allochthonous along a west-directed thrust comprising the Brevard fault zone and faults framing the Pine Mountain basement window (i.e., Towaliga, Bartletts Ferry, and Goat Rock fault zones). The COnsortium for COntinental Reflection Profiling (COCORP) later developed a similar interpretation, the southern Appalachian master décollement, based on their seismic-reflection profiling (Cook et al., 1979).

Subsequent to the work of Bentley and Neathery (1970), Neathery and Reynolds (1973) renamed the Heard Group and designated it as the Emuckfaw formation for exposures along Emuckfaw Creek, Tallapoosa County, which was later formally designated as the Emuckfaw Group by Raymond et al. (1988). Several studies have focused on mapping, geochemistry, and geochronology aimed at better characterizing the magmagenesis and timing of the intrusions in the Emuckfaw Group. Muangonoicharoen (1975) and Stoddard (1983) interpreted their data to indicate that the Zana and Kowaliga are temporally related, with the Zana representing apophyses off a larger Kowaliga intrusion. Russell et al. (1987), using multi-grain U-Pb zircon analytical techniques constrained an apparent age of 461+/-12 Ma for both the Kowaliga Gneiss and Zana Granite, whereas Rb-Sr whole-rock error-chron ages of 437 Ma and 395 Ma for the

Kowaliga Gneiss and Zana Granite, respectively, had analytical uncertainties on the order of +/- 100 Ma. More recently, U/Pb SHRIMP data obtained for the Kowaliga Gneiss and Zana Granite suggest a crystallization age of 430 Ma and 439 Ma, respectively (Tull et al., 2012). Based on U/Pb SIMS data, Hawkins (2013) confirmed an Ordovician-Silurian (441+/- 6.6 Ma) age of igneous crystallization for the Kowaliga Gneiss. Additionally, Hawkins (2013) reported whole-rock major and trace element data for the Kowaliga Gneiss, compared them to previously reported geochemical data for the Zana Granite (i.e., Stoddard, 1983) and documented strong similarities in their geochemical signatures and magmagenesis. Combined with similar crystallization ages and field occurrences, Hawkins (2013) surmised that the granitic plutons are the same unit and formed during one intrusive event.

Subsequent to the work of Bentley and Neathery (1970), Wielchowsky (1983), mapped within and adjacent to the Brevard zone fault zone from the Alabama-Georgia state line southwest to Jacksons Gap, Alabama and described the rocks as a “lithologically distinctive” metasedimentary sequence within a shear zone that flattens with depth. This model was supported by COCORP seismic profiling in Georgia and the Carolinas, which suggested the fault rooted at depth into the southern Appalachian master décollement (Cook et al., 1979).

Further contributions to understanding the geology and gold/precious metal occurrences within the Jacksons Gap Group in the vicinity of the Dadeville Quadrangle were made through detailed 1:24,000 scale geologic mapping, structural analysis, and geochemical analysis conducted as part of several Auburn University student MS-theses between 1988 and 2013 (Johnson, 1988; Keefer, 1992; Grimes, 1993; Reed, 1994; McCullars, 2001; Sterling, 2006; White, 2007; and Hawkins, 2013). Of particular importance, Johnson (1988) and Reed (1994), mapping in the Jacksons Gap Group within the western Dadeville and eastern Jacksons Gap Quadrangles, delineated mappable units that have been slightly modified for this study.

Amphibolites and mafic/ultramafic rocks of the Dadeville Complex in the Inner Piedmont were geochemically analyzed by Neilson and Stow (1986) and Hall and Salpas (1990), and interpreted to have formed in a back-arc basin. Neilson and Bittner (1990) provided a detailed lithologic overview of the mappable units in the Dadeville Complex, previously designated by Bentley and Neathery (1970). In the same guidebook, Bittner and Neilson (1990) structurally analyzed the Dadeville shear zone in the eastern part of the Dadeville Quadrangle, and the Agricola shear zone to the south. Recognizing two deformational phases, Bittner and Neilson (1990) reported the shear zones have similar movement histories of subhorizontal dextral shearing during the second deformational event. In regards to the tectonic affinity of the Dadeville Complex, little is known since the only isotopic date reported for crystallization is a Rb-Sr whole rock isochron age of ~460 Ma (Middle Ordovician) for the Franklin Gneiss that carries large uncertainties (MSWD= 1.9) (Seal and Kish, 1990). Additional geochemical work by Neilson et al. (1997) focused on felsic intrusions indicating that the Camp Hill Gneiss formed in an island arc setting, whereas the Chattasofka Creek Gneiss formed in a collisional setting. Hatcher and Merschat (2006), working in the Carolinas interpreted southwest-northeast aligned mineral stretching lineations reported in the Dadeville Complex (Bentley and Neathery, 1970; Neilson, 1988) to record southwest-directed orogen-parallel extrusion of the Inner Piedmont during the Acadian/Neoacadian event.

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GEOLOGY

The Dadeville quadrangle is divided into the following three geologically distinct areas: eastern Blue Ridge, Brevard fault zone (i.e. Jacksons Gap Group), and the Dadeville Complex. The eastern Blue Ridge lies along the northwestern border of the quadrangle and contains middle-amphibolite facies metasedimentary rocks of the Emuckfaw Group and granitic sill-like plutons of the Kowaliga Gneiss. The eastern Blue Ridge units are separated from the Jacksons Gap Group by the Abanda fault. The Jacksons Gap Group occupies almost one-third of the quadrangle and contains greenschist-to-lower-amphibolite facies metasedimentary rocks. In the eastern portion of the quadrangle, middle-to upper-amphibolite facies rocks of the Dadeville Complex are in sharp contact with the Jacksons Gap Group. Although the contact is cryptic, the discordance of unit boundaries and metamorphic grade suggest that it is a fault, designated by Bentley and Neathery (1970) as the Katy Creek fault.

LITHOSTRATIGRAPHIC UNITS

EASTERN BLUE RIDGE

EMUCKFAW GROUP

Emuckfaw Group, previously known as the Heard Group and the Emuckfaw formation, was named for exposures along Emuckfaw Creek, Tallapoosa County (Bentley and Neathery, 1970; Neathery and Reynolds, 1975). The group occupies a small portion of the eastern Blue Ridge in the study area, forming hilly topography, and comprises coarse grained (up to 2.5 cm long muscovite grains) garnet-muscovite schist with graphitic layers. Where composition allows, porphyroblastic, euhedral, garnets up to 1 cm in diameter occur locally throughout the muscovite schist. Exposures weather to a deep red-maroon color with garnets having been oxidized to a dark brown. Inter-layers of quartzite, amphibolite, metagraywacke, and felsic pegmatite commonly occur within the garnet-mica schist of the Emuckfaw Group (Hawkins, 2013).

KOWALIGA GNEISS

Bentley and Neathery (1970) mapped plutonic bodies of granitic gneiss within the Emuckfaw Group and formally named them the Kowaliga Gneiss for exposures along Kowaliga Creek, Elmore County, Alabama. The Kowaliga Gneiss occurs in the western section of the Dadeville quadrangle, where the intrusive contact with the Emuckfaw Group and fault contact with the Jacksons Gap Group are poorly preserved because of sparse exposure and the saprolitic nature of the rocks. The Kowaliga Gneiss is a medium-to-coarse-grained, well-foliated and lineated quartz monzonite characterized by quartz, potassium feldspar, plagioclase, biotite with accessory muscovite, clinozoisite, epidote, and amphibole. The Kowaliga Gneiss contains conspicuous potassium feldspar augen, 2-3 cm in diameter, set in a matrix of finer-grained quartz, potassium feldspar, biotite, with minor amounts of muscovite. Stretched biotite and quartz grains are commonly observed within the plane of foliation, defining a strong mineral elongation lineation. Regionally penetrative mylonitic foliation, recorded by trains of sigma clasts and pervasive composite S-C and C' fabrics, verify oblique right-lateral and thrust movement (Fig. 2). Saprolitized outcrops are light orange and commonly retain the metamorphic/ mylonitic foliation and lineation. Contact margins of the Kowaliga Gneiss are concordant with the dominant metamorphic schistosity found in the surrounding country rocks indicating that they were likely intruded either prior-to or synchronous-with peak metamorphism and prior to an early phase of mylonitization (see below).

CATACLASITE

Tectonically separating the Kowaliga Gneiss from the Jacksons Gap Group in the northernmost part of Plate 1 is a subvertical, brittle fault characterized by siliceous cataclasite. The cataclasite strikes N40°E along the base of the Jacksons Gap Group and splays obliquely southwestward, striking N60°E, cutting across the Kowaliga Gneiss. The cataclasite is grayish yellow to pale yellowish brown and forms narrow (10 m thick) erosionally resistant ridges. In outcrop, the cataclasite is characterized by angular quartz clasts and cross-cutting veins of medium-to coarse-grained quartz (Fig. 3A). Associated with some of the cataclasite are open vugs containing coarse-grained quartz with pyramidal terminations (Fig. 3A), and rarely double

Figure 2. Typical oblique tops-down-to-the-southwest and dextral shear sense reflected in the composite S-C-C' mylonitic fabric in Kowaliga Gneiss in the eastern Blue Ridge, Alabama. The view of the photograph is looking northeastward along strike (85°52'15.274" W; 32°52'21.726" N).

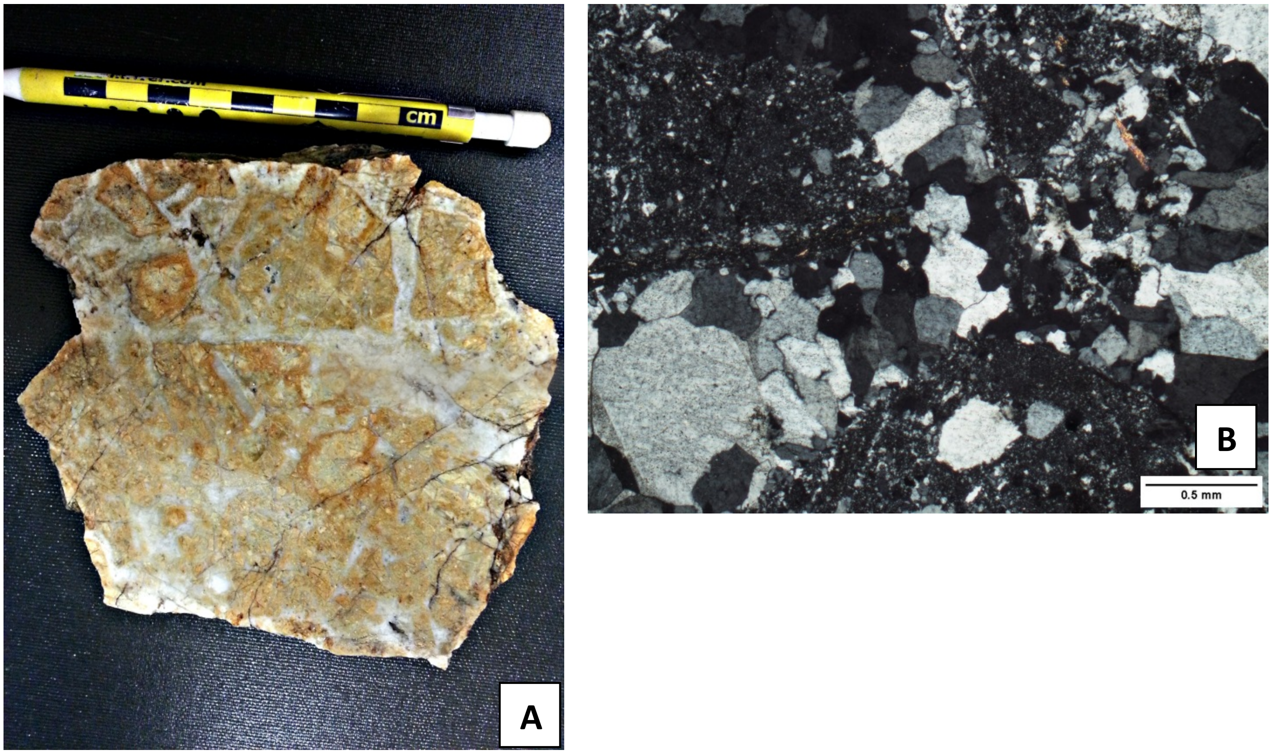


Figure 3. Hand sample photo and photomicrograph of cataclastic rocks associated with the Abanda fault. (A) Slab of cataclasite cut in a random orientation, illustrates the intensely brecciated and vuggy nature of the rock. Note open vugs and terminated quartz crystals in upper left part of the slab. (B) Photomicrograph (plane-polarized light) of siliceous cataclastic rock. Dark, very fine-grain quartz clasts have been fragmented and cut by a vein and filled by subhedral quartz crystals.

terminations. Microscopic analysis indicates angular clasts of ultracataclasite are set in a matrix of fine-grained fragmented and granulated quartz, and cross-cut by veins of coarse grained, tabular quartz with well-equilibrated triple point boundaries (Fig. 3B).

JACKSONS GAP GROUP

Jacksons Gap Group metasiliciclastics and metapelites define the lithologies of the Brevard fault zone and are sandwiched between the Katy Creek fault, above, and the Abanda fault, beneath. Within the study area the Jacksons Gap Group is informally divided into seven lithologies (Plate 1): 1) garnetiferous phyllonite; 2) carbonaceous phyllite; 3) highly carbonaceous phyllite; 4) sericite-chlorite phyllite; 5) quartz-sericite schist; 6) phyllitic quartzite; and 7) massive micaceous quartzite.

GARNETIFEROUS PHYLLONITE

Garnetiferous phyllonite (Fig. 4) is the structurally lowest unit in the Jacksons Gap Group in the Dadeville quadrangle. Exposures of the unit are limited due to dense vegetation and deep weathering but are best seen on the shores of Lake Martin. The garnetiferous phyllonite is composed of fine to medium-grained biotite, quartz, and muscovite, with garnet porphyroblasts and accessory graphite, chlorite, epidote, and unidentified opaque minerals. In outcrop, the unit is a distinctive light olive-gray to light grayish-orange button schist with small to medium-sized (1-5 mm) almandine garnet porphyroblasts. S-C fabrics become locally well-developed near the Abanda fault and indicate oblique-dextral and tops-down-to-the-southeast normal-slip movement (Fig. 4A). In addition, rotated garnets with quartz tails defining sigma

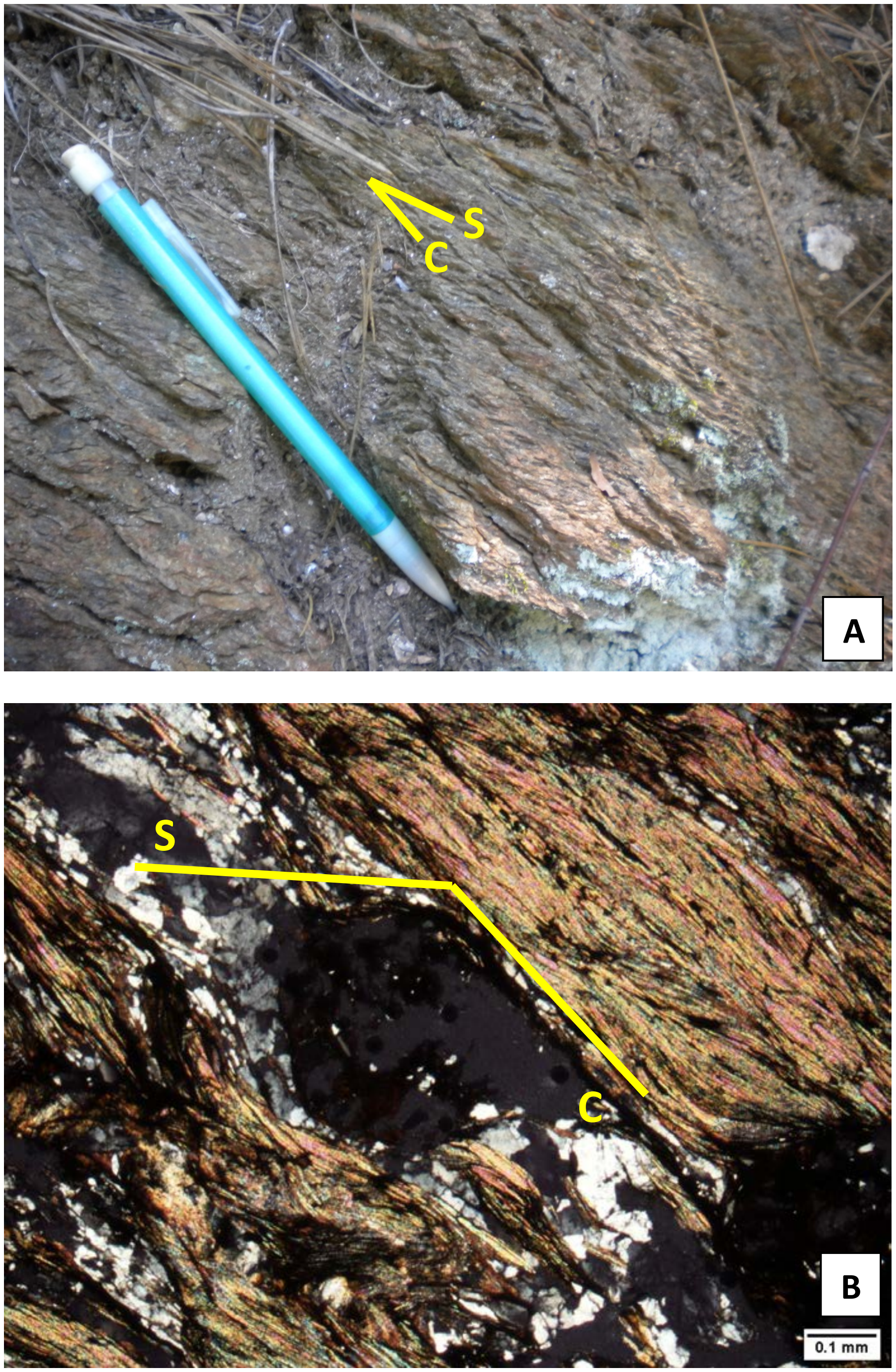


Figure 4. Field photo and photomicrograph of garnetiferous phyllonites associated with the Abanda fault. (A) Typical oblique tops-down-to-the-southeast normal and dextral movement reflected in the composite S-C fabric in the garnetiferous phyllonite. The view of the photograph is looking northeastward along strike (85°50′42.765″ W; 32°51′34.348″ N). (B) Photomicrograph (cross-polarized light) of a garnet sigma-clast and right verging asymmetric fold in muscovite indicating sense of shear is dextral.

clasts are compatible with an oblique dextral and normal sense of shear (Fig. 4B). The Emuckfaw Group phyllonites directly beneath the Abanda fault contain highly sheared, discontinuous felsic pegmatite pods and lenses that are concordant with the composite mylonitic fabric. The absence of pegmatites in the overlying the garnetiferous phyllite is used to arbitrarily mark the base of the Jacksons Gap Group in the study area.

CARBONACEOUS PHYLLITE

Structurally overlying the garnetiferous phyllonite and locally interlayered with quartz-rich schist is carbonaceous phyllite (Fig. 5). It is a dusky-blue to black, well-foliated, very-fine to fine-grained phyllite containing muscovite, quartz, and graphite with accessory biotite, chlorite, epidote, unidentified opaque minerals, and garnet porphyroblasts. Fine-gained quartz, graphite, muscovite bands (~1 mm thick) define the compositional layering with very fine-grained muscovite and biotite forming the dominant cleavage, which is locally deformed by crenulation folds (F_3) and associated crenulation cleavage (S_3) (Fig. 5). Exposures of the carbonaceous phyllite in the southern portion of the Dadeville Quadrangle are more massive and indurated, reflecting higher quartz content, and form ridges. The massive unit locally contains porphyroblastic garnet and foliation is defined by the alignment of very fine-grained graphite intermixed with quartz.

HIGHLY CARBONACEOUS PHYLLITE

Interlayered with carbonaceous phyllite is a dark-gray to black, well-foliated, very-fine to fine-grained, highly graphitic phyllite with minor quartz and muscovite. The highly

Figure 5. Hand sample photograph of carbonaceous phyllite. Notice S_2 is subparallel to and transposes the S_0/S_1 foliation as evidenced from the intrafolial F_2 fold of S_0/S_1, pointed to by the white circle. The late crenulation folds (F_3) and cleavage (S_3) mark a high angle to the $S_0/S_1/S_2$.

carbonaceous phyllite is very distinct and marked by copious amounts of graphite; excellent exposures are found at lat: 85°52’18.13”W, long: 32°45’9.53”N. Locally occurring as isolated lenses within the highly carbonaceous phyllite are distinctive, gray-to dark-gray quartz-pebble-to-cobble clast-supported metaconglomerates (Fig. 6). In addition to well rounded pebbles and cobbles, the metaconglomerate contains angular clasts set in a matrix similar to the massive carbonaceous rock described above. The angular clasts commonly are tabular in nature and reflect reworked orthoquartzite layers. Given the fine-grained carbonaceous mud matrix the metaconglomerate likely reflects debris-flow or turbidite deposits mixed into an anoxic basin.

SERICITE-CHLORITE PHYLLITE

Overlying and in a gradational contact with the carbonaceous phyllite lies the sericite-chlorite phyllite. This unit is a light olive-gray to dark yellowish-green, fine-grained, quartz sericite and chlorite phyllite with localized chloritoid and garnet porphyroblasts, and accessory biotite and graphite. The sericite-chlorite phyllite occupies nearly one-third of the Jacksons Gap Group in the study area, locally forming ridges and weathering to a dusky-red saprolite. Chloritoid porphyroblasts are euhedral (Fig. 7), locally abundant, randomly oriented, and commonly leave divots in the phyllite where they have been plucked or weathered out. Interlayers of phyllitic quartzite and massive quartzite have sharp contacts with the sericite-chlorite phyllite whereas interlayers of quartz-sericite schist have gradational boundaries.

Figure 6. Field photo of quartz-pebble-clast-supported metaconglomerate facies within very-fine carbonaceous mud matrix, locally occurring within the highly carbonaceous phyllite (85°52’17.995” W; 32°45’8.954” N).

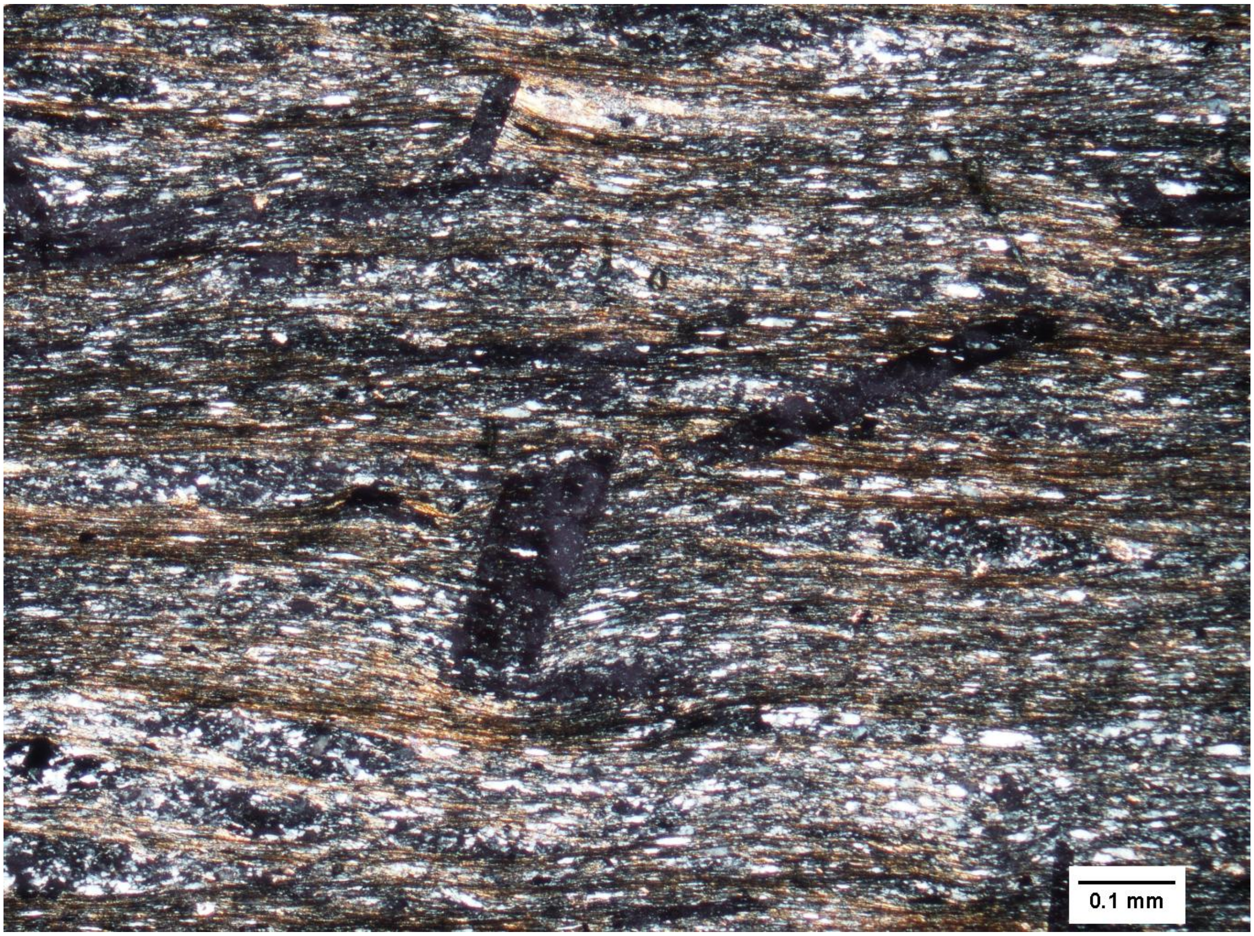


Figure 7. Photomicrograph of sericite- chlorite phyllite (cross-polarized light). Late “static” chloritoid grains occur as randomly oriented, euhedral, and undeformed porphyroblasts with quartz inclusions oriented parallel to layering and foliation.

QUARTZ-SERICITE SCHIST

Occupying the structural highest position in the Jacksons Gap Group is the quartz-sericite schist. This unit is a light-gray to pale-orange, fine-grained, quartz, sericite schist with local porphyroblasts of garnet and accessory epidote and plagioclase. Quartz-sericite schist is interlayered with carbonaceous phyllite, ridge-forming massive micacous quartzite, phyllitic quartzite, and sericite-chlorite phyllite. Where freshly exposed, the rock has a well-developed foliation and contains varying amounts of quartz and white mica, and where slightly-to moderately weathered forms a papery saprolite rich in fine quartz grains.

PHYLLITIC QUARTZITE

Interlayered with phyllites, phyllonites, and schists of the Jacksons Gap Group is phyllitic quartzite. This rock is a light-tan to gray, fine-to medium-grained, well-foliated sericite, muscovite quartzite with porphyroblasts of garnet and accessory epidote, biotite, graphite, and unidentified opaques. Phyllitic cleavage is defined by parallel alignment of muscovite and/or sericite. Commonly a prominent ridge former, the contact between phyllitic quartzite and the underlying phyllitic units is gradational over 5-10 meters and marked by resistant, sheared phyllitic quartzite grading downward into saprolite, whereas the overlying contact is usually eroded away.

MASSIVE QUARTZITE

Interlayered with phyllitic units of the Jacksons Gap Group are massive quartzites that correspond to the Devil's Backbone Quartzite defined by Bentley and Neathery (1970). This unit is a thickly-bedded massive, white to tannish yellow, fine-grained "sugary" texture, weakly to moderately foliated quartzite with accessory muscovite and garnet porphyroblasts (generally flattened and elongated). Massive quartzite is a prominent ridge former, underlying the highest ridge in the area, Smith Mountain, which stands with nearly 100 meters of relief. It commonly occurs adjacent to and has sharp boundaries with saprolitic phyllites/phyllonites (Fig. 8). Within the Dadeville Quadrangle the massive quartzite is discontinuous along strike, likely related to both primary sedimentary facies changes and shearing out.

DADEVILLE COMPLEX

Metasedimentary, metavolcanic, and metaplutonic rocks exposed in Tallapoosa and Chambers County, Alabama were originally called the Dadeville belt by Adams (1926). Bentley and Neathery (1970) modified the name to the Dadeville Complex and designated six mappable units that were subsequently modified (e.g., Sears et al., 1981; Steltenpohl et al., 1990). Lithologic units of the Dadeville Complex in this study correspond to units presented in Steltenpohl et al. (1990), and are as follows: 1) the Agricola Schist; 2) the Ropes Creek Amphibolite; 3) the Waresville Schist; 4) ultramafic and mafic intrusive rocks; 5) Camp Hill Gneiss; 6) and Chattasofka Creek Gneiss.

CAMP HILL GNEISS

Two felsic gneisses, the Camp Hill Gneiss and the Chattasofka Creek Gneiss, were originally called the Sougahatchee granite by Adams (1933), but have subsequently been shown to have

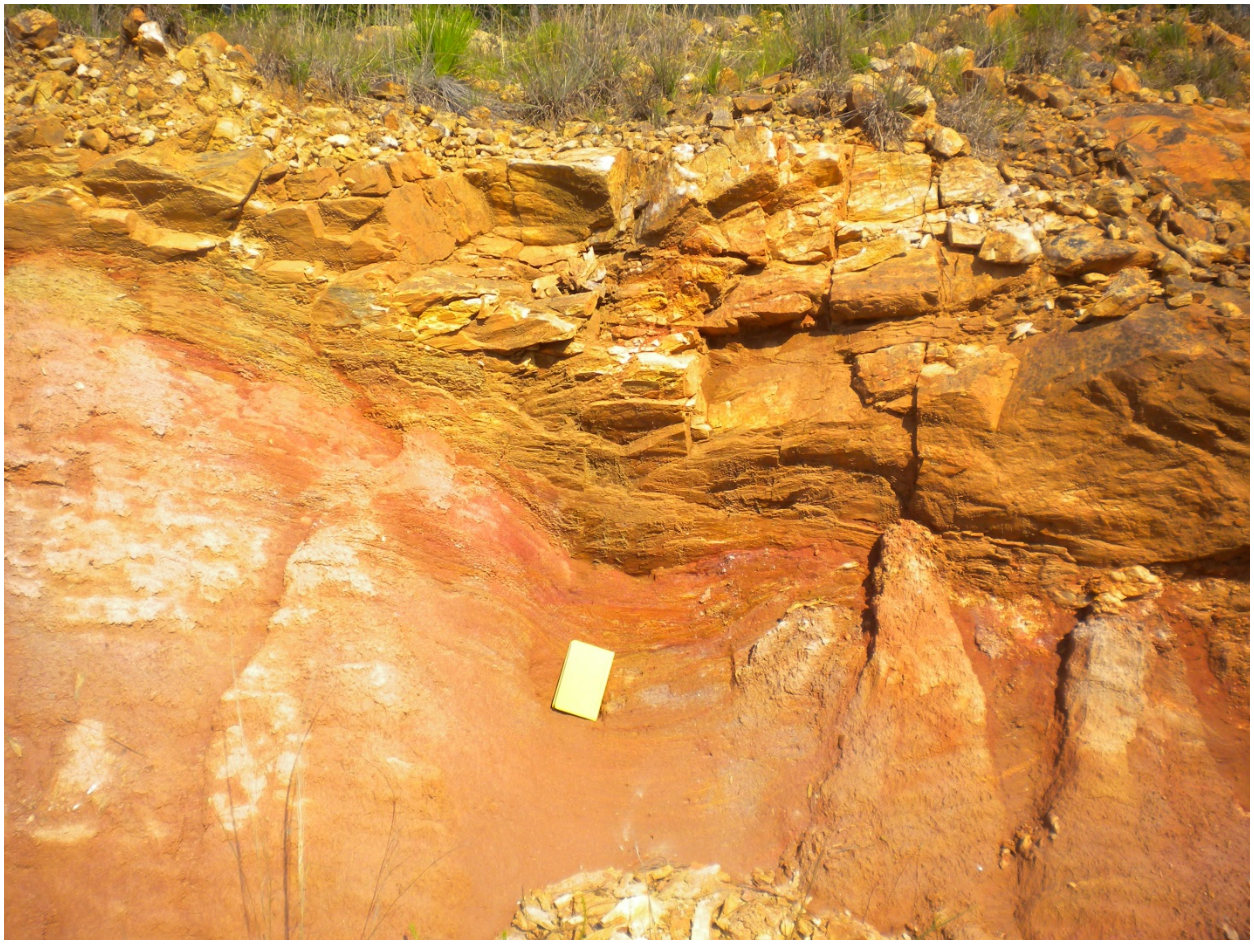


Figure 8. Outcrop photo illustrating the sharp contact between overlying massive quartzite and saprolitized phyllite (85°51’44.597” W; 32°45’20.424” N).

compositions that range from tonalitic to granitic, respectively (Neilson, 1987: see Steltenpohl et al., 1990 for a summary of previous investigations). Reported as felsic orthogneisses, both appear to be rootless plutonic bodies locally containing Ropes Creek Amphibolite and Agricola Schist xenoliths indicating the intrusions post-dated volcanism in the Dadeville Complex (Neilson, 1987). The type locality of the Camp Hill Gneiss was designated as a pavement exposure along a tributary of Sandy Creek, near Camp Hill, Alabama (see Steltenpohl et al., 1990). In the Dadeville Quadrangle, the Camp Hill Gneiss and the Ropes Creek Amphibolite are truncated by the Katy Creek fault to the west. The unit is tonalitic gneiss characterized by medium-to coarse-grained, well-foliated, biotite, muscovite, plagioclase, and quartz with minor amounts of potassium feldspar, epidote, garnet, chlorite, and unidentified opaques. Mylonitic foliation is defined by sheared plagioclase porphyroclasts set in a parallel-aligned matrix of finer-grained quartz, biotite, and feldspar with minor amounts of muscovite. Stretched biotite and quartz grains are commonly observed within the plane of foliation, defining an elongation lineation. Fresh exposures are not abundant in the study area, but pale-orange saprolite commonly retains the mylonitic foliation. Contacts bounding the Camp Hill Gneiss are concordant with the dominant metamorphic schistosity within the unit as well as that found in the surrounding Ropes Creek Amphibolite, indicating it likely intruded prior to or synchronous with peak metamorphism.

CHATTASOFKA CREEK GNEISS

The Chattasofka Creek Gneiss was named from its outcrops in the vicinity of Chattasofka Creek to the northeast of Dadeville, Tallapoosa County (Neilson, 1983, 1987). Exposures of the

Chattasofka Creek Gneiss in the field area are sparse and limited to occurrences in eastern Dadeville (lat: 85°45’5” W; long: 32°50’49” N). The rock is granitic gneiss characterized by medium-grained, well-foliated quartz, plagioclase, potassium feldspar, biotite, muscovite with minor amounts of garnet, and unidentified opaques. Mylonitized varieties display a mortar texture with medium to coarse porphyoclasts of potassium feldspar and plagioclase set in a matrix of fine-grained feldspar, quartz and biotite. Alignment of biotite, muscovite, and quartz ribbons that drape the dextrally rotated potassium feldspar and plagioclase porphyroclasts defines a weak mylonitic foliation. Intrusive contacts and the gneissosity/schistosity are concordant with the dominant metamorphic schistosity found in the surrounding Agricola Schist indicating intrusion either prior-to or synchronous with peak metamorphism. Saprolitized outcrops are light gray-brown to light-orange and commonly retain the metamorphic foliation.

ROPES CREEK AMPHIBOLITE

The Ropes Creek Amphibolite is named for exposures along Ropes Creek, Lee County, Alabama (Bentley and Neathery, 1970), and it is exposed throughout the central portion of the quadrangle. The unit is a distinctive black, medium-to coarse-grained, well-foliated amphibolite comprising plagioclase and hornblende with accessory apatite, augite, biotite, epidote-group minerals, garnet, unidentifiable opaques, quartz, and sphene. Alignment of prismatic hornblende is commonly observed within the plane of foliation, defining a mineral lineation. Fresh exposures of the amphibolite are not abundant in the map area but ellipsoidal masses of moderately indurated and less weathered amphibolite are surrounded by reddish-orange to ochre saprolite.

WARESVILLE SCHIST

The Waresville Schist was named for metavolcanic rocks along the Brevard fault zone in Alabama and correlated with similar exposures that crop out near Waresville, Georgia, however no type locality was reported (Bentley and Neathery, 1970). The unit structurally overlies the Camp Hill Gneiss and is interlayered with the Ropes Creek Amphibolite, and within the Dadeville Quadrangle, it is characterized by homogenous, massive felsic schist comprising potassium feldspar, quartz, and sericite with accessory unidentified opaques. The schist is typically moderately-to-deeply weathered resulting in a light-tan to white, low density, almost spongy saprolite, with relic 0.25-1 cm diameter white-potassium-feldspar porphyroclasts. Johnson (1988) reported that exposures of the Waresville Schist in the northeastern Dadeville Quadrangle and the southeastern Jacksons Gap Quadrangle consisted of highly weathered, interlayered felsic and mafic schist, thinly-bedded amphibolite, and chloritic quartzofeldspathic schist.

AGRICOLA SCHIST

The Agricola Schist was named for exposures of interlayered gneisses and schists that crop out in the vicinity of the community of Agricola, Tallapoosa County, Alabama (Raymond et al., 1988). The schists and gneisses, which are locally migmatitized, comprise mainly quartz, potassium feldspar, muscovite, and biotite with accessory sillimanite, kyanite, garnet porphyroblasts, and unidentified opaques. Migmatites are vein-type migmatites (Mehnert, 1968) and contain a fairly random network of leucosome, comprising coarse-grained quartz and plagioclase, which separate irregular blocks of melanosome, comprising biotite in excess of muscovite (Fig. 9). The dominant schistosity is defined by parallel alignment of prismatic sillimanite, phyllosilicates, and other inequant mineral phases (Figs. 10A and B). Fresh exposures of the Agricola Schist are not abundant in the map area, but its light-to medium-reddish-brown saprolite is common.

MAFIC AND ULTRAMAFIC PLUTONIC ROCKS

Originally mapped as the Smith Mountain and Boyds Creek mafic complexes by Bentley and Neathery (1970), mafic and ultramafic rocks of the Dadeville Complex were later divided by Neilson and Stow (1986) into the Doss Mountain and Slaughters metagabbro. The suites represent two episodes of pre-metamorphic mafic intrusion (Neilson and Stow, 1986). The Doss Mountain suite consists of meta-orthopyroxenite, metanorite, actinolite schist, and massive coarse-grained amphibolite. Exposures of mafic and ultramafic rock in the Dadeville Quadrangle correspond to the Doss Mountain suite and are characterized by dark green to greenish-black, medium to coarse-grained actinolite, epidote, chlorite, amphibole, meta-orthopyroxenite with minor amounts of sphene and unidentified opaques. Primary orthopyroxene defines a relict orthocumulate texture with altered amphibole, chlorite, epidote, and actinolite occupying interstitial areas. Generally the mafic/ultramafic rocks occur near the contact between the Waresville Schist and Ropes Creek Amphibolite. These rocks are relatively resistant to weathering but form ochre colored saprolite.

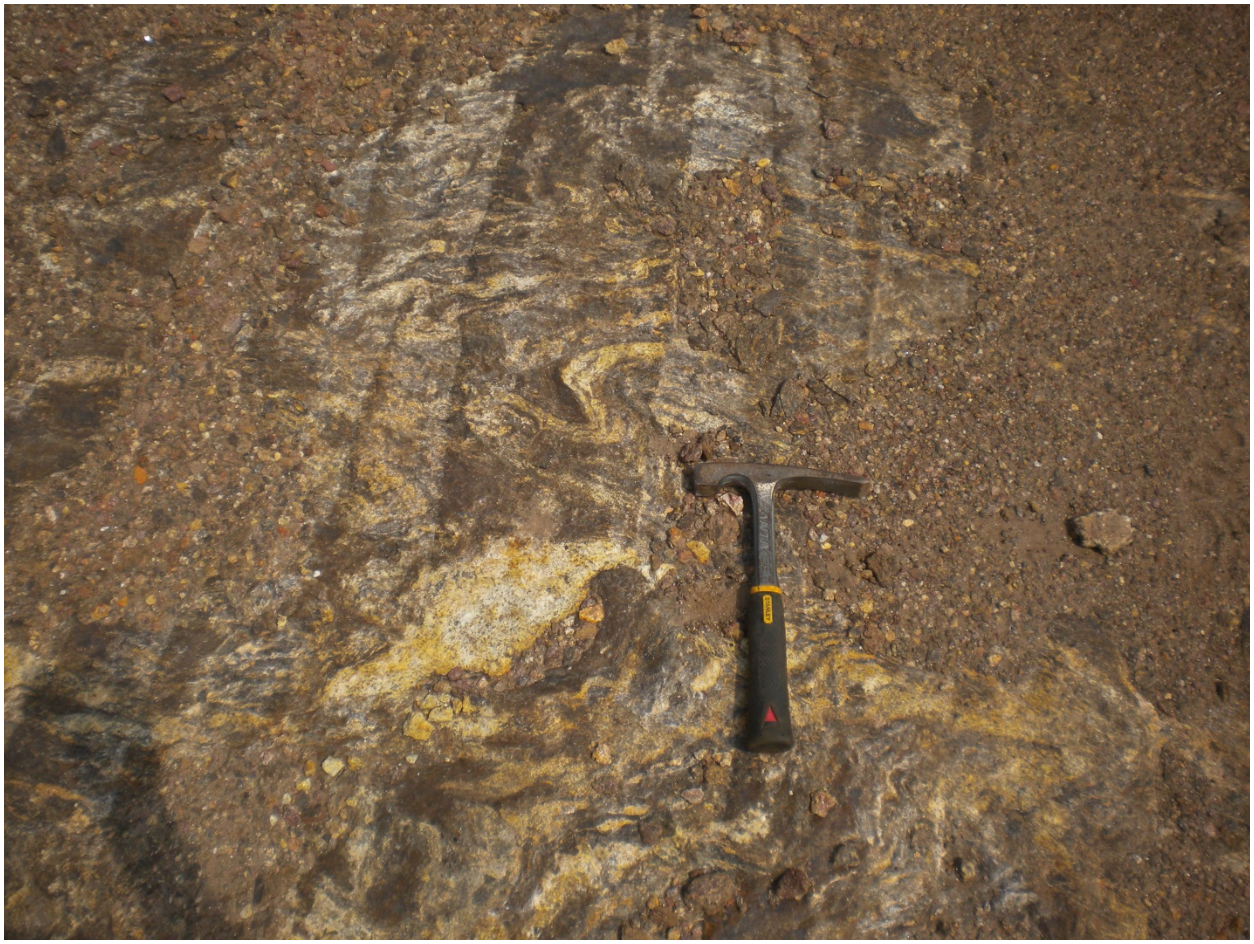
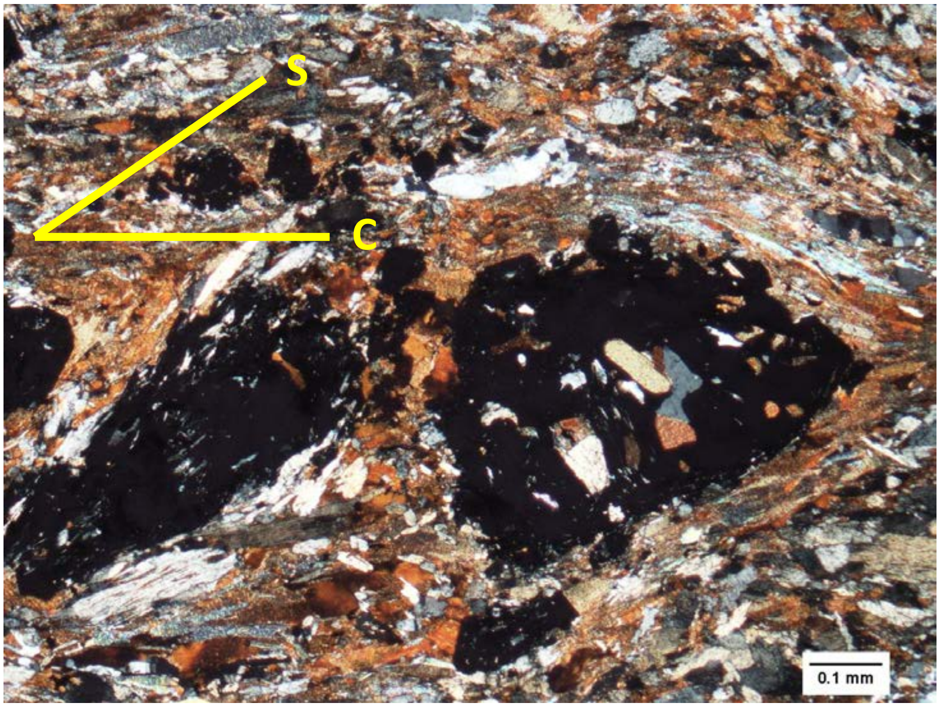


Figure 9. Field photo of vein-type migmatite (Mehnert, 1968) in the Agricola Schist. Leucosomes of coarse-grained quartz and plagioclase are folded and separate irregular blocks of melanosome of biotite in excess of muscovite (85°45’13.833” W; 32°45’13.744” N).



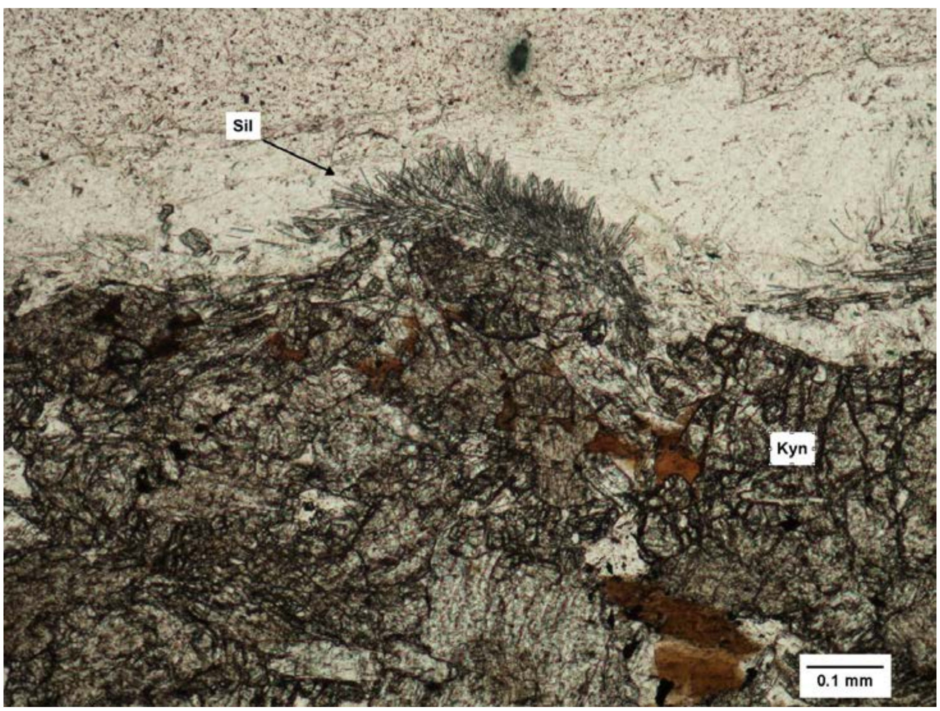


Figure 10. Photomicrographs of Agricola Schist from within the Dadeville shear zone. (A) Subhedral garnet porphyroblasts are rotated and contain abundant inclusions of biotite, quartz, muscovite, and opaques. Asymmetric blasts and clasts indicate sense of shear is dextral (cross-polarized light). (B) Sillimanite occurs as fibrolitic needles, and along with phyllosilicates and other inequant mineral phases defines the metamorphic schistosity (plane-polarized light).

METAMORPHISM

Rocks of the eastern Blue Ridge and Inner Piedmont generally are interpreted to have experienced metamorphism during two events, one in the Devonian (~350 Ma; Neoacadian) and one in the early-to-middle Carboniferous (~330 Ma; early Alleghanian) with localized but intense shearing later in the Carboniferous (~300-285 Ma; late Alleghanian) (Steltenpohl and Moore, 1988; Steltenpohl and Kunk, 1993; Dennis and Wright, 1997; Carrigan et al., 2001; Kohn, 2001; Bream, 2002,2003; Cyphers and Hatcher 2006; Stahr et al., 2006; Hames et al., 2007; McClellan et al., 2007; McDonald et al., 2007). This is compatible with petrological and thermochronological studies of rocks in and around the study area. Rocks of the eastern Blue Ridge contain prograde mineral assemblages that lie within a range from kyanite-sillimanite zone to almandine zones preserving significant lateral variations in metamorphic grade (Steltenpohl and Moore, 1988). Peak-amphibolite-facies metamorphic conditions were followed by a retrogressive middle-to upper-greenschist facies event (Muangnoicharoen, 1975; Wielchowsky, 1983; Johnson, 1988; Steltenpohl et al., 1990; Reed, 1994; Sterling, 2006; Hawkins, 2013).

Within the Emuckfaw Group, Guthrie and Dean (1989) documented prograde mineral assemblages consisting of kyanite ± staurolite ± muscovite ± biotite ± garnet ± plagioclase + quartz, indicating lower- to middle-amphibolite facies metamorphism. Consistent with this interpretation, Emuckfaw Group schist within the study area contain the prograde mineral assemblage garnet ± muscovite ± biotite + quartz, which is compatible with a wide range of metamorphic conditions (from almandine to sillimanite zone). Hawkins (2013) documented deformational microstructures in quartz and feldspar of the Kowaliga Gneiss indicating subgrain rotation, bulging recrystallization, and grain-boundary migration recrystallization consistent with lower-amphibolite facies conditions for dynamic recrystallization. Based on petrogenetic grids, pressure and temperature estimates for the staurolite-kyanite zone are estimated at 525-550°C and 4.2 to 4.8 kb in the Emuckfaw Group (Guthrie and Dean, 1989). Replacement of hornblende by actinolite and chlorite in mafic amphibolite of the Emuckfaw Group was interpreted to have occurred under retrogressive middle-to upper-greenschist facies metamorphism (Guthrie and Dean, 1989).

Rocks of the Jacksons Gap Group within the study area typically contain the peak mineral assemblage garnet ± muscovite ± biotite ± chlorite + quartz, indicating almandine zone metamorphic conditions. The presence of the prograde assemblage garnet + biotite + chlorite in the absence of staurolite suggests upper-greenschist-to lower-amphibolite-facies conditions (Winter, 2010). Johnson (1988) working in the adjacent quadrangle to the north documented the assemblage muscovite ± quartz ± biotite ± garnet ± staurolite ± chlorite in a button schist at the structural top of the Jacksons Gap Group. Sterling (2006) in the adjacent quadrangle to the southwest, similarly reported mineral assemblages with chlorite ± staurolite ± kyanite in phyllitic quartzites at the structural base of the Jacksons Gap Group. These staurolite and staurolite-kyanite zone assemblages indicate a lower-to middle-amphibolite facies metamorphic peak. Preservation of primary sedimentalogical structures such as cross stratification, graded bedding, and conglomerate pebbles, cobbles, and boulders, document low degrees of strain (Bentley and Neathery, 1970; Sterling, 2006, herein). Thus, it appears that lateral and vertical variations in peak metamorphic grade and strain are recorded in the Jacksons Gap Group, but currently are not well understood.

The prograde mineral assemblage in the Jacksons Gap Group is strongly retrograded to a lower-to middle-greenschist-facies mineral assemblage of chlorite ± sericite. M_1 minerals including biotite and garnet are commonly replaced with chlorite, and muscovite is commonly replaced with sericite. Chloritoid porphyroblasts occur as randomly oriented, euhedral, and undeformed porphyroblasts that cross-cut the metamorphic foliation (Fig. 7). This can be interpreted to have resulted from late-static growth following waning of the retrogressive event.

Agricola Schist of the Dadeville Complex contains the prograde assemblage kyanite ± sillimanite ± garnet ± biotite ± muscovite ± plagioclase +quartz reflecting middle- to upper-amphibolite facies conditions of metamorphism. Subhedral garnet porphyroblasts are rotated and contain abundant inclusions of biotite, quartz, muscovite, and opaques (Fig. 10A). Sillimanite generally occurs as fibrolitic mats roughly oriented parallel to the metamorphic schistosity (Fig. 10B), but prismatic blasts are locally observed. P-T conditions of 740° C and 8 kb for the Agricola Schist and 800° C and 10.4 kb for the Ropes Creek Amphibolite were constrained by elemental-partitioning geothermobarometry (Drummond et al., 1997). Prograde mineral assemblages in the Ropes Creek Amphibolite and mafic/ultramafic plutonic rocks are hornblende ± plagioclase ± garnet and confirm middle-to upper-amphibolite metamorphism. Upper-greenschist facies retrogression of the Dadeville Complex is not pervasive, but is observed as the alteration of hornblende to actinolite, and orthopyroxene and biotite to chlorite, and is consistent with Johnson (1988), Steltenpohl et al. (1990), Reed (1994), and Sterling (2006).

Peak metamorphic conditions appear to vary significantly across the tectonstratigraphy of the eastern Blue Ridge and the Jacksons Gap Group in Alabama, whereas the Dadeville Complex is more homogenous. Almandine-grade to local kyanite-staurolite-grade rocks of the Jacksons Gap Group pass structurally upward into kyanite-sillimanite-grade rocks of the Dadeville Complex, which may indicate an inverted metamorphic gradient (Wagner and Srogi, 1987; Peacock 1987, 1988; Duebendorfer, 1988; Hubbard, 1989; Peacock and Norris 1989). The Jacksons Gap Group has more metamorphic variation, and as a consequence bears affinity to the laterally variable kyanite-staurolite to kyanite-sillimanite-grade metamorphic conditions recorded in rocks in the underlying eastern Blue Ridge. The metamorphic evolution of the eastern Blue Ridge, Jacksons Gap Group, and Dadeville Complex in Alabama and west Georgia is only known in a general sense but holds important, yet to be revealed clues about tectonic evolution in the southernmost Appalachians.

STRUCTURE

Rocks of the Dadeville Quadrangle have been multiply deformed, preserving evidence of at least four deformational events (Table 1). The first deformational event (D_1) is characterized by development of a regional metamorphic schistosity and gneissosity (S_1), which formed during peak metamorphic conditions. S_1 strikes N08°E, and dips 30°SE (Fig. 11A), and is defined by parallel alignment of prograde phyllosillicate and inequant mineral phases. Locally within the

Table 1. Summary of Deformational events in the Dadeville Quadrangle.

Deformational Phases	Structural Elements	Description
D_1	M_1	Regional prograde dynamothermal metamorphism
	S_1	Regional foliation (schistosity and gneissosity)
D_{1L}		Early movement along the Brevard fault zone Pre- syn-, or late-peak metamorphic Katy Creek fault, Early movement along the Dadeville shear zone
	S_{1L}	Composite S-C-C' mylonitic fabric indicating right-slip transpressive movement within mylonitized Kowaliga and Zana units
	L_{1L}	Elongation lineations within the mylonitized Kowaliga and Zana units
D_2		Reactivation of the Dadeville shear zone, Spotty development in each terrane
	M_2	Regional retrogressive event
	F_2	Isoclinal, intrafolial folds of S_0/S_1 , Late-F_2 folding of the Tallassee synform
	S_2	Local transposition of S_1 into S_2 in the Jacksons Gap Group, Composite S-C mylonitic fabric indicating oblique dextral-normal movement along the Dadeville shear zone
D_3		Movement along the Abanda fault
	F_3	Asymmetric folds associated with movement along the Abanda fault
	S_3	Composite S-C mylonitic fabric indicating oblique dextral-normal movement along the Abanda fault
D_4		Brittle faults characterized by siliceous cataclasite along the Abanda fault

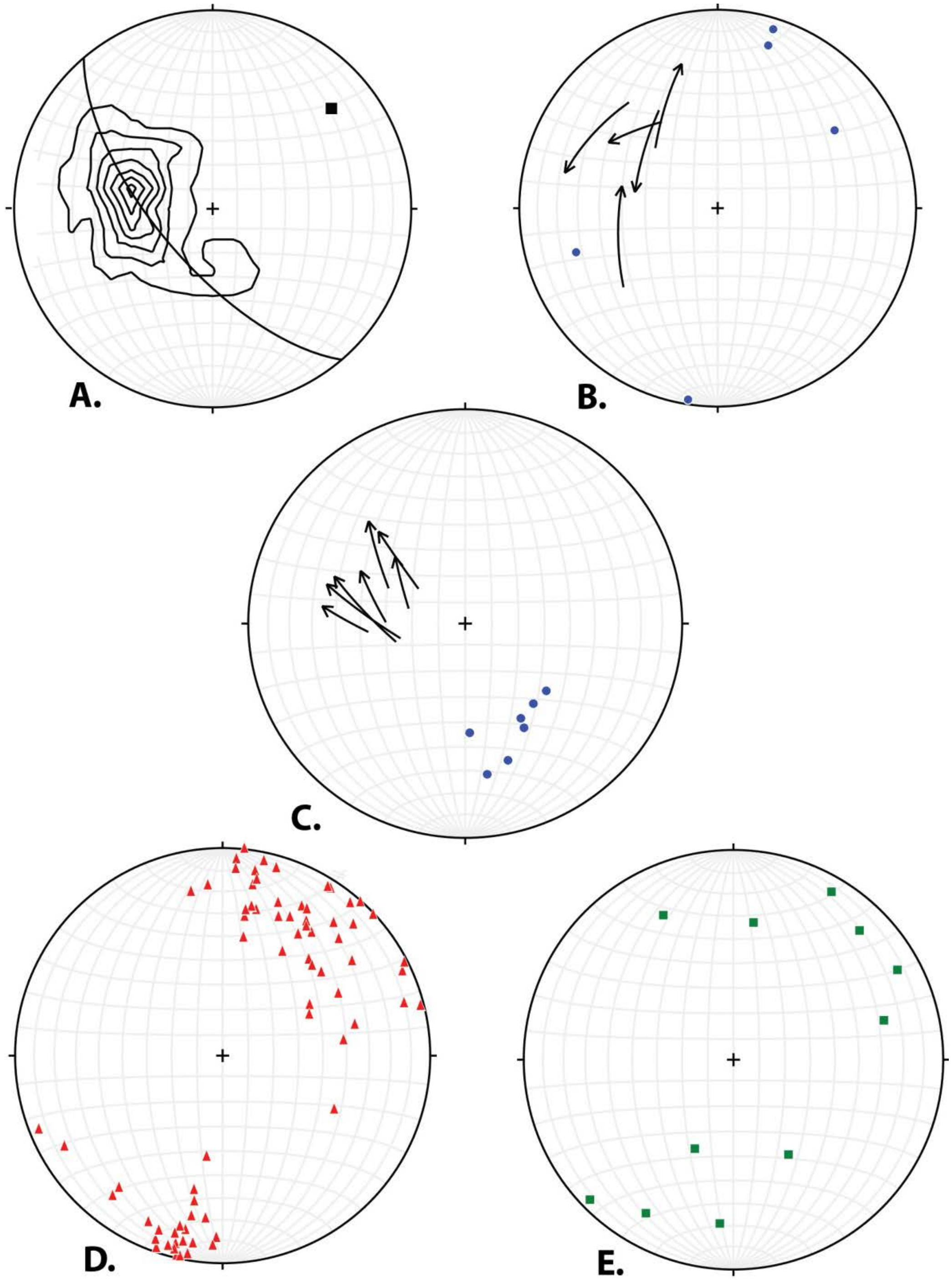


Figure 11. Lower hemisphere equal-area stereoplots of structural measurements made in rocks of the Dadeville quadrangle; north is at the top of each diagram. (A) Contoured plot of poles to S_0/S_1 (n=378). Contours at 2%, 4%, 6%, 8%, 10%, 12%, and 14% per 1% area; the black square is the β-axis, i.e., Tallassee synform, indicating a trend and plunge of N50°E, 23°. (B) Sliplines (blue circles; n=5) recording early-Brevard fault zone movement in the Kowaliga Gneiss. Sliplines are geometrically determined; poles to S planes are the end of the arrow and the C planes are the tip of the arrow. (C) Same elements described in B, but for the Abanda Fault (n=7). (D) Red triangles are elongation lineations (n=74). (E) Green squares are fold axes (n=11).

Jacksons Gap Group compositional banding preserves primary bedding (S_0) that is consistently subparallel to and likely transposed into the S_1 foliation, thus, herein referred to as S_0/S_1.

The Brevard fault zone is well known to have had an early (Devonian) movement history that formed soon after the peak of metamorphism (Vauchez, 1987; Bobyarchick et al., 1988). Mylonitic fabric (S_{1L}) in the Kowaliga Gneiss and Zana Granite of the current study area is interpreted to reflect this early Brevard fault zone movement. Early-Brevard fault zone movement sufficiently transposed S_1 to produce a regionally penetrative mylonitic foliation that is recorded by trains of sigma clasts and a locally well-developed composite S-C, and locally C' mylonitic fabric, verifying top-to-the-northeast-southwest oblique right-lateral and thrust movement (Figs. 2 and 11B). L_{1L} is a mineral stretching lineation defined by elongated phyllosilicates, quartz, and feldspar, and generally plunges shallowly to the northeast and southwest. Petrographic studies indicate that quartz microstructures include subgrain rotation recrystallization, bulging recrystallization, and grain boundary migration. Feldspar microstructures include grain-boundary bulges along rims and core-mantle structures. Combined, the crystal-plastic deformation in the quartz and feldspar indicate temperatures of deformation in excess of ~450° C and up to peak metamorphic conditions within sub-ductile-brittle-transition (sub-DBT) conditions for mylonitization (Passchier and Trouw, 1996). Late Devonian dextral shearing (middle- to upper-amphibolite facies metamorphic conditions) recording early-Brevard fault zone movement is reported in more northern parts of the Brevard fault zone (Vauchez, 1987; Bobyarchick et al., 1988; Davis 1993; Vauchez et al., 1993; Hatcher 2001; Mershcat et al., 2005; Hatcher and Mershcat; 2006). In addition, Devonian (~388-369 Ma) right-lateral strike-slip shearing is documented in the Elkahatchee Quartz Diorite establishing that Neoacadian dextral shearing occurred in the orogen's most southern surface exposures (Steltenpohl et al., 2013a).

In addition to the early-Bevard fault zone fabrics, two map-scale D_1 shear zones have been recognized in the Dadeville Quadrangle, the Dadeville shear zone and the Katy Creek fault. The Dadeville shear zone is a late-D_1, sillimanite-zone, ductile deformational zone within the Agricola Schist that reflects plastic shearing of the M_1 (kyanite-sillimanite zone) assemblage. Rotated garnets and asymmetric microfolds of sillimanite and muscovite layers indicate dextral sense of movement (Figs. 10). Dynamically recrystallized quartz formed by sub-grain rotation are evident with grains having weak shape-preferred orientation in the direction of flow as seen in quartz ribbons surrounding more competent plagioclase and garnet porphyroblasts.

Mapping along the boundary between the Jacksons Gap Group and Dadeville Complex reveals that the Katy Creek fault is a cryptic fault that juxtaposes rocks of different metamorphic grade. Early to syn-peak metamorphic (D_1) structures and lithologic contacts in the hanging wall are sharply truncated along the fault (Plate 1), but with no recognizable retrogressive fabric disruption. Therefore, the Katy Creek fault is interpreted to have formed during or soon after the metamorphic peak. A potential explanation for creating an inverted metamorphic gradient across the Katy Creek fault is downheating of the Jacksons Gap Group from a thrust-emplaced, hot Dadeville Complex synchronous to the metamorphic peak (see, for example: Wagner and Srogi, 1987; Duebendorfer, 1988; Hubbard, 1989).

Deformational event (D_2) deformed and retrograded earlier-formed upper-greenschist to upper-amphibolite facies mineral assemblages, fabrics, and structures. D_2 formed during retrogressive conditions (upper-greenschist to lower-amphibolite-facies), producing a foliation, S_2, defined by parallel alignment of retrogressive chlorite and sericite. S_2 is typically subparallel to and locally transposes the S_0/S_1 foliation (Fig. 5). L_2 is defined by a grain-shape preferred orientation of inequant retrogressive grains, and generally plunges shallowly to the northeast and southwest (Fig. 11D). F_2 folds are characterized by microscopic to mesoscopic, isoclinal (Fig. 5) to open folds in which the hinge surfaces are coplaner with S_2 and fold hinges are colinear with L_1. In addition, late-stage, mesoscale open folds and coincident broad, long-wavelength macroscale synforms and antiforms of S_0/S_1, (or S_1/S_2; beta-axis in Fig. 11A) likely coincide with or *are* a later phase of the D_2 event (Steltenpohl et al., 1990). Folding during D_2 produced the gently northeast-plunging Tallassee synform (Figs. 11A and 11E), in which the Jacksons Gap Group and the rocks immediately adjacent within the eastern Blue Ridge define the west limb, and the Dadeville Complex defines the core. Reactivation of the Dadeville shear zone resulted in the shallow, northwest-dipping fault zone. This reactivation is characterized by a composite S-C fabric defined by retrograde phyllosilicates, indicating oblique dextral-normal movement (Bittner and Neilson, 1990).

Deformational event (D_3) represents prominent retrograde composite S-C mylonitic fabric that indicates oblique dextral-normal movement along the Abanda fault (Figs. 4A, 4B, and 11C) and corresponds to an array of Alleghanian dextral strike-slip shear zones that extend throughout the hinterland to as far west as the Goodwater-Enitachopco fault (Steltenpohl et al., 2013a). Locally developed, mesoscopic and microscopic F_3 crenulation folds are coaxial to cleavage (S_3) (Fig. 5) and plunge moderately northeast and southwest (Fig. 11E). Microscopic analysis of phyllonites from the Abanda fault reveals microstructures including mica fish, raveled muscovite (Fig. 4B) and crystal-plastic deformation of quartz via grain-boundary migration and bulging recrystallization that indicate middle-greenschist facies, sub-DBT conditions for mylonitization (Passchier and Trouw, 1996). Apparent discordance in metamorphic grade between the eastern Blue Ridge and Jacksons Gap Group across the Abanda fault could be interpreted to have resulted from top-down-to-the-east normal and right-lateral-strike-slip post-metamorphic fault displacement. Deciphering the differences in timing of metamorphism and deformation of the Jacksons Gap Group with respect to sandwiching terranes is not aided by existing ^{39}Ar /^{40}Ar muscovite cooling dates that indicate no systematic aging patterns between ~315 to 305 Ma recorded in rocks of each terrane (Steltenpohl et al., 2013a).

Cataclasite along the northwestern side of the Abanda fault overprints earlier-formed fabrics and structures recording evidence for a fourth deformational event, D_4 (Figs. 3A and 3B). This fault is a supra-DBT fault that reactivated the earlier-formed Abanda fault (Steltenpohl et al., 2013a). Similar structures occur throughout the southern Appalachaian hinterland and are interpreted to be post-Appalachian and related to the Mesozoic rifting of Pangea (Garihan and Ranson, 1992; Garihan et al., 1993).

CONCLUSIONS

1. Formation of first generation, D_1, structures was accompanied by Neoacadian upper-amphibolite facies metamorphism in the Inner Piedmont, upper-greenschist to lower-

amphibolite facies metamorphism in the Jacksons Gap Group, and lower-to middle-amphibolite facies metamorphism in the eastern Blue Ridge.

2. Early-syn D_1 fabrics, as well as lithologic contacts, are truncated along the Katy Creek fault, implying juxtaposition of the Dadeville Complex and the Jacksons Gap Group during a syn- to late-metamorphic peak event. An apparent inverted metamorphic gradient associated with the Katy Creek fault potentially formed as the result of down-heating from the thrust emplacement of a hot Dadeville Complex upon the cooler Jacksons Gap Group.
3. Oblique reverse-dextral mylonitic textures within the Kowaliga Gneiss and Zana Granite are interpreted to indicate early fault movement along the Brevard fault zone initiated during the Neoacadian event under metamorphic conditions in excess of ~450° C and up to peak metamorphism.
4. Plastic reactivation of the Brevard fault zone occurred during the Alleghanian event under middle-greenschist facies conditions, as evidenced from retrograde mylonitic overprint along the Abanda fault. Tops-down-to-the-east normal and right-lateral-strike-slip displacement along the Abanda fault apparently juxtaposed rocks of distinctly different metamorphic grade.
5. Cataclasite along the northwest side of the Abanda fault marks the final movement along the Brevard fault zone under supra-ductile-brittle-transition zone conditions during Mesozoic rifting of Pangea.

REFERENCES

Abrahams, J.B., 2014: Geology of the Dadeville quadrangle and the Tallassee synform in Characterizing the Dog River Window [M.S. thesis]: Auburn, Auburn University, 142 p.

Adams, G.I., 1926, The crystalline rocks, in Adams, G.I., et al., eds., Geology of Alabama: Alabama Geological Survey Special Report 14, p. 25-40.

Adams, G.I., 1930, Gold deposits of Alabama, and occurrences of copper, pyrite, arsenic and tin: Alabama Geological Survey Bulletin 40, 91 p.

Adams, G.I., 1933, General geology of the crystalline rocks of Alabama: Journal of Geology, v. 41, p. 159-173.

Barineau, C.I., 2009, Superposed fault systems of the southernmost Appalachian Talladega belt: Implications for Paleozoic orogenesis in the southern Appalachians [Ph.D. dissertation]: Tallahassee, Florida State University, 150 p.

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, 119 p.

Bittner, E.I., and Neilson, M.J., 1990, in Steltenpohl, M.G., et al., eds., Geology of the southern Inner Piedmont, Alabama and southwest Georgia: Geological Society of America Southeastern Section Field Trip Guidebook, Tuscaloosa, Geological Survey of Alabama, p. 101–110.

Bobyarchick, A.R., Edelman, S.H., and Horton, J.W., Jr., 1988, The role of dextral strike-slip in the displacement history of the Brevard fault zone, in Secor, D.T., Jr., ed., Southeastern Geological Excursions: Geological Society of America 1988 Annual Meeting Field Trip Guidebook, p. 53-104.

Bream, B.R., 2002, The southern Appalachian Inner Piedmont: New perspectives based on recent detailed geologic mapping, Nd isotopic evidence and zircon geochronology, in Hatcher, R.D., and Bream, B.R., eds., Inner Piedmont Geology in the South Mountains-Blue Ridge Foothills and the southwestern Brushy Mountains, central western North Carolina: North Carolina Geological Survey, Carolina Geological Society Annual Field Trip Guidebook, p. 45-63.

Bream, B.R., 2003, Tectonic Implications of Geochronology and Geochemistry of Para- and Orthogneisses from the Southern Appalachian Crystalline Core [Ph.D. dissertation]: Knoxville, Tennessee, University of Tennessee, 296 p.

Carrigan, C.W., Bream, B., Miller, C.F., and Hatcher, R.D., Jr., 2001, Ion microprobe analyses of zircon rims from the eastern Blue Ridge and Inner Piedmont, NCSC-GA: Implications for the timing of Paleozoic metamorphism in the southern Appalachians: Geological Society of America Abstracts with Programs, v. 33, p. 7.

Cook, F.A., Albuagh, D.S., Brown, L.D., Kaufman, S., Oliver, J.E., and Hatcher, R.D., Jr., 1979, Thin-skinned tectonics in the crystalline southern Appalachians; COCORP seismic-reflection profiling of the Blue Ridge and Piedmont: Geology, v. 7, p. 563-567.

Cyphers, S.R., and Hatcher, R.D., Jr., 2006, The Chattahoochee- Holland mountain fault: A terrane boundary in the Blue Ridge of western North Carolina: Geological Society of America Abstracts with Programs, v. 38, no. 3, p. 66.

Davis, T.L., 1993, Lithostratigraphy, structure, and metamorphism of a crystalline thrust terrane, western Inner Piedmont, North Carolina [PhD dissertation] University of Tennessee, 245 p.

Dennis, A.J., and Wright, J.E., 1997, Middle and late Paleozoic monazite U-Pb ages, Inner Piedmont, South Carolina: Geological Society of America Abstracts with Programs, v. 29, no. 3, p. 12.

Drummond, M.S., Allison, D.T., and Weslowski, D.J., 1994, Igneous petrogenesis and tectonic setting of the Elkahatchee Quartz Diorite, Alabama Appalachians: Implications for Penobscotian magmatism in the eastern Blue Ridge: American Journal of Science, v. 294, p. 173–236, doi:10.2475/ajs.294.2.173.

Drummond, M.S., Neilson, M.J., Allison, D.T., and Tull, J.F., 1997, Igneous petrogenesis and tectonic setting of granitic rocks from the eastern Blue Ridge and Inner Piedmont, Alabama Appalachians, in Sinha, A.K., et al., eds., The nature of magmatism in the Appalachian orogen: Geological Society of America Memoir 191, p. 147–164, doi:10.1130/0-8137-1191-6.147.

Duebendorfer, E.M., 1988, Evidence for an inverted metamorphic gradient associated with a Precambrian suture, southern Wyoming: Journal of Metamorphic Geology, v. 6, p. 41-63.

Garihan, J.M., and Ranson, W.A., 1992, Structure of the Mesozoic Marietta-Tryon graben, South Carolina and adjacent North Carolina, in Bartholomew, M.J., et al., eds., Basement tectonics 8: Characterization of ancient and Mesozoic continental margins—Proceedings of the 8th International Conference on Basement Tectonics, Butte, Montana, 1988: Dordrecht, Netherlands, Kluwer Academic Publishers, p. 539–555.

Garihan, J.M., Preddy, M.S., and Ranson, W.A., 1993, Summary of mid-Mesozoic brittle faulting in the Inner Piedmont and nearby Charlotte belt of the Carolinas, in Hatcher, R.D., Jr., and Davis, T., eds., Studies of Inner Piedmont geology with a focus on the Columbus Promontory: Carolina Geological Society Field Trip Guidebook, p. 55–66.

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, Auburn University, 129 p.

Guthrie, G.M., and Dean, L.S., 1989, Geology of the New site 7.5-Minute Quadrangle, Tallapoosa and Clay Counties, Alabama: Alabama Geological Survey Quadrangle Map 9, 41 p.

Hall, G.D., Salpas, P.A., 1990, Geochemistry of thin-layered amphibolites of the Ropes Creek Amphibolite, in Steltenpohl, M.G., et al., ed., Geology of the southern Inner Piedmont, Alabama and southwest Georgia: Geological Society of America Southeastern Section Field Trip Guidebook: Tuscaloosa, Geological Survey of Alabama, p. 101–110.

Hames, W.E., Tull, J.F., Barbeau, D.L., Jr., McDonald, W.M., and Steltenpohl, M.G., 2007, Laser 40Ar/39Ar ages of muscovite and evidence for Mississippian (Visean) deformation near the thrust front of the southwestern Blue Ridge province: Geological Society of America Abstracts with Programs, v. 39, no. 2, p. 78.

Hatcher, R.D., Jr., 2001, Rheological partitioning during multiple reactivation of the Paleozoic Brevard fault zone, southern Appalachians, USA, in Holdsworth, R.E., et al., eds., The Nature and Tectonic Significance of Fault Zone Weakening: Geological Society of London Special Publication 186, p. 255–269.

Hatcher, R.D., Jr., and Zietz, I., 1980, Tectonic implications of regional aeromagnetic and gravity data from the southern Appalachians, in Wones, D., ed., Proceedings, The Caledonides in the U.S.A.: Virginia Polytechnic Institute Memoir 2, p. 83–90.

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., et al., eds., Channel Flow, Ductile Extrusion and Exhumation in Continental Collision Zones: Geological Society of London Special Paper 268, p. 517–541.

Hawkins, J.F., 2013, Geology, petrology, and geochronology of rocks in the Our Town, Alabama quadrangle [M.S. thesis]: Auburn, Auburn University, 118 p.

Hibbard, J.P., van Staal, C.R., Rankin, D.W., and Williams, H., 2006, Lithotectonic map of the Appalachian orogen, Canada–United States of America: Geological Survey of Canada Map 2096A, scale 1:1,500,000.

Hibbard, J.P., van Staal, C.R., and Miller, B.V., 2007, Links among Carolinia, Avalonia, and Ganderia in the Appalachian peri-Gondwanan realm, in Sears, J.W., et al., eds., Whence the Mountains? Inquiries into the Evolution of Orogenic Systems: A Volume in Honor of Raymond A. Price: Geological Society of America Special Paper 433, p. 291–311, doi:10.1130/2007.2433(14).

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 230, p. 213-245.

Hubbard, M.S., 1989, thermobarometric constraints on the thermal history of the Main Central Thrust zone and Tibetan Slab, eastern Nepal Himalaya: Journal of Metamorphic Geology 7, p. 19-30.

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

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

Kohn, M.J., 2001, Timing of arc accretion in the southern Appalachians: Perspectives from the Laurentian margin: Geological Society of America Abstracts with Programs, v. 33, no. 6, p. A262.

McClellan, E.A., Steltenpohl, M.G., Thomas, C., and Miller, C., 2007, Isotopic age constraints and metamorphic history of the Talladega belt: New evidence for timing of arc magmatism and terrane emplacement along the southern Laurentian margin: The Journal of Geology, v. 115, p. 541–561, doi:10.1086/519777.

McCullars, J.M., 2001, Geology and trace-element geochemistry of the Bervard zone near Martin Lake, Tallapoosa County, Alabama [M.S. thesis]: Auburn, Alabama, Auburn University, 74 p.

McDonald, W.M., Hames, W.E., Marzen, L.J., and Steltenpohl, M.G., 2007, A GIS database for 40Ar/39Ar data of the southwestern Blue Ridge province: Geological Society of America Abstracts with Programs, v. 39, no. 2, p. 81.

Mehnert, K.R., 1968. Migmatites and the origin of granitic rocks, Developments in Petrology 1: Elsevier, Amsterdam, 393 p.

Merschat, A.J., and Hatcher, R.D., Jr., 2007, The Cat Square terrane: Possible Siluro-Devonian remnant ocean basin in the Inner Piedmont, southern Appalachians, USA, in Hatcher, R.D., Jr., Carlson, M.P., McBride, J.H., and Martínez Catalán, J.R., eds., 4-D Framework of Continental Crust: Geological Society of America Memoir 200, p. 553–565.

Merschat, A.J., Hatcher, R.D., Jr., and Davis, T.L., 2005, The northern Inner Piedmont, southern Appalachians, USA: Kinematics of transpression and SW-directed mid-crustal flow: Journal of Structural Geology, v. 27, p. 1252–1281, doi:10.1016/j.jsg.2004.08.005.

Muangnoicharoen, N., 1975, The geology and structure of a portion of the northern piedmont, east-central Alabama [M.S. thesis]: Tuscaloosa, University of Alabama, 72 p.

Neathery, T.L., 1975, Rock Units of the high-rank belt of the northern Alabama Piedmont, in Neathery, T.L. and Tull, J.F., eds., Geologic profiles of the northern Alabama Piedmont: Alabama Geological Society, 13th Annual Field Trip Guidebook, p. 9-48.

Neathery, T. L., and Reynolds, J. W., 1973, Stratigraphy and metamorphism of the Wedowee Group, a reconnaissance: American Journal of Science, v. 273, p. 723-741.

Neilson, M. J., 1983, Phase equilibria of rock-forming ferromagnesian silicates in granitic systems: American Journal of Science, v. 283, p. 993-1033.

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, Special Publication, p. 9-16.

Neilson, M. J., 1988, The structure and stratigraphy of the Tallassee Synform, Dadeville Belt, Alabama: Southeastern Geology, v. 29, p. 41–50.

Neilson, M.J., Seal, T.L., 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.

Pardee, J.T., and Park, C.F., Jr., 1948, Gold deposits of the southern Piedmont: U.S. Geological Survey Professional Paper 213, 156 p.

Park, C.F., Jr., 1935 Hog mountain gold district, Alabama: American Institute of Mining and Metallurgical Engineers Transactions, Mining Geology, v. 115, p. 209-228.

Passchier, C.W., and Trouw, R.A.J., 1996, Microtectonics: Berlin, Springer, 289 p.

Peacock, S.M., 1987, Creation and preservation of Subduction-related inverted metamorphic gradients: Journal of Geophysical Research, v. 92, p. 12,673-12,781.

Peacock, S.M., 1988, Inverted metamorphic gradients in the westernmost Cordillera, in Ernst, W.G., ed., Metamorphism and Crustal Evolution of the Western United States: Prentice Hall, v. 7, p. 953-974.

Phillips, W.B., 1892, a preliminary report on a part of the lower gold belt of Alabama in the counties of Chilton, Coosa, and Tallapoosa: Alabama Geological Survey Bulletin 3, 97 p.

Raymond, D.E., Osborne, W.E., Copeland, C.W., and Neathery, T.L., 1988, Alabama 1255 Stratigraphy: Geological Survey of Alabama, Tuscaloosa, 97 p.

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., Odom, A.L., and Russell, C.W., 1987, Uranium-lead and rubidium-strontium isotopic evidence for the age and origin of granitic rocks in the northern Alabama Piedmont, in Drummond, M.S., and Green, N.L., eds., Granites in Alabama: Geological Survey of Alabama, Tuscaloosa, p. 239-250.

Seal, T.L., and Kish, S.A, 1990, The geology of the Dadeville Complex of the western Georgia and eastern Alabama Inner Piedmont: Initial petrographic, geochemical, and geochronological results, in Steltenpohl, M.G., et al., eds., Geology of the southernmost Inner Piedmont terrrane, Alabama and southwest Georgia: Southeastern Section of the Geological Society of America Field Trip Guidebook, p. 65-77.

Stahr, D.W., III, Hatcher, R.D., Jr., Miller, C.F., and Wooden, J.L., 2006, Alleghanian deformation in the Georgia and North Carolina eastern Blue Ridge: Insights from pluton ages and fabrics: Geological Society of America Abstracts with Programs, v. 38, no. 3, p. 20.

Steltenpohl, M.G., 1990, Structural development of the Opelika Complex, in Steltenpohl, M.G., et al., eds., Geology of the southern Inner Piedmont terrane, Alabama and southwest Georgia: Southeastern Section of the Geological Society of America Field Trip Guidebook, p. 29-42.

Steltenpohl, M.G., 2005, An introduction to the terranes of the southernmost Appalachians of Alabama and Georgia, in Steltenpohl, M.G., Southernmost Appalachian terranes, Alabama and Georgia: Field trip Guidebook for the Geological Society of America Southeastern Section 2005 Annual Meeting, p. 1-18.

Steltenpohl, M.G., and Kunk, M.J., 1993, 40Ar/39Ar thermochronology and Alleghanian development of the southernmost Appalachian Piedmont, Alabama and southwest Georgia: Geological Society of America Bulletin, v. 105, p. 819–833, doi:10.1130/0016-7606 (1993)105<0819:AATAAD>2.3.CO;2.

Steltenpohl, M.G., and Moore, W.B., 1988, Metamorphism in the Alabama Piedmont: Alabama Geological Survey Circular 138, 29 p.

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

Steltenpohl, M.G., Hatcher, R.D., Jr., Mueller, P.A., Heatherington, A.L., and Wooden, J.L., 2010, Geologic history of the Pine Mountain window, Alabama and Georgia: Insights from a new geologic map and U-Pb isotopic dates, in Tollo, R.P., et al., eds., From Rodinia to Pangea: The lithotectonic record of the Appalachian region: Geological Society of America Memoir 206, p. 837–858, doi:10.1130/2010.1206(32).

Steltenpohl, M.G., Horton, J.W., Hatcher, R.D., Zietz, I., Daniels, D. L., and Higgins, M. W., 2013b, Upper crustal structure of Alabama from regional magnetic and gravity data: Using geology to interpret geophysics, and vice versa: Geosphere, v. 9, no.4, p. 1044-1064, doi:10.1130/GES00703.1.

Steltenpohl, M.G., Schwartz, J.J., and Miller, B.V., 2013a, Late to post-Appalachian strain partitioning and extension in the Blue Ridge of Alabama and Georgia: Geosphere, v. 9; no. 3, p. 647-666, doi:10.1130/GES00738.1.

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

Stoddard, P.V., 1983, A petrographic and geochemical analysis of the Zana Granite and Kowaliga Augen Gneiss: Northern Piedmont, Alabama [M.S. thesis]: Memphis, Memphis State University, 74 p.

Stow, S.H., Neilson, M.J., and Neathery, T.L., 1984, Petrography, geochemistry and tectonic significance of the amphibolites o the Alabama Piedmont: American Journal of Science, v. 284, no. 4 and 5, p. 416-436.

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

Tull, J.F., Barineau, C.I., Mueller, P.A., and Wooden, J.L., 2007, Volcanic arc emplacement onto the southernmost Appalachian Laurentian shelf: Characteristics and constraints: Geological Society of America Bulletin, v. 119, p. 261–274, doi:10.1130/B25998.1.

Tull, J.F., Mueller, P.A., and Barineau, C.I., 2009, Age and tectonic implications of the Elkahatchee Quartz Diorite, eastern Blue Ridge provine, southern Appalachians, USA: Geological Society of America Abstracts with Programs, v. 41, No. 7, p. 288.

Tull, J.F., Barineau, C.I., and Holm-Denoma, C.S., 2012, Characteristics, Extent, and Tectonic Significance of the Middle Ordovician Back-Arc Basin in the Southern Appalachian Blue Ridge, in Barineau, C.I., and Tull, J.F., The Talladega Slate Belt and the eastern Blue Ridge: Laurentian plate passive margin to back-arc basin tectonics in the southern Appalachian orogen: Field Trip Guidebook for the Alabama Geological Society, p. 12-26.

Tuomey, M., 1858, Second biennial report on the geology of Alabama: Alabama Geological Survey Biennial report 2, 292 p.

Vauchez, A., 1987, Brevard fault zone, southern Appalachians: A medium-angle, dextral, Alleghanian shear zone: Geology, v. 15, p. 669–672, doi:10.1130/0091-7613(1987)15<669:BFZSAA>2.0.CO;2.

Vauchez, A., Babaie, H.A., and Babaei, A., 1993, Orogen-parallel tangential motion in the Late Devonian-Early Carboniferous southern Appalachians internides: Canadian Journal of Earth Sciences, v. 30, p. 1297–1305.

Wagner, M.E., and Srogi, L., 1987, Early Paleozoic metamorphism at two crustal levels and a tectonic model for the Pennsylvania-Delaware Piedmont: Geological Society of America Bulletin 99, p. 113-126.

White, T.W., 2008, Geology of the 1:24,000 Tallassee, Alabama, Quadrangle, and its implications for southern Appalachian tectonics [M.S. thesis]: Auburn, Alabama, Auburn University, 74 p.

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

THE DOG RIVER WINDOW: A FIRST-ORDER TECTONIC WINDOW EXPOSING LAURENTIAN BLUE RIDGE ROCKS IN THE SOUTHERNMOST EXPOSED APPALACHIAN HINTERLAND, USA

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ABSTRACT

We report geologic data from the most southern surface exposures of the Appalachians in Alabama confirming the closure of a major shallow-northeast-plunging synform, the Tallassee synform, where along the eastern limb, Laurentian Blue Ridge rocks and structures resurface within the crystalline core. Exposures of the synform's hinge zone skirt the Gulf/Atlantic Coastal Plain onlap where the southward-thickening wedge of Mesozoic sedimentary rocks has hindered geologists' ability to confidently characterize geologic relations and assess their significance for tectonic evolution of the southeastern U.S. Through detailed (1:24,000 scale) geologic mapping we discovered that stream drainages have cut through the veneer of Coastal Plain cover to expose crystalline rocks helping to tie together the east and west limbs of the synform. Mapping confirms continuity of lithologies and structures of the eastern Blue Ridge (EBR) on the west limb with those previously assigned to the Inner Piedmont (Opelika Complex) on the east limb, including a distinctive package of metapelites and metaquartzites (i.e., Saugahatchee Quartzite/Loachapoka Schist, Tallassee Metaquartzite, and Devils Backbone quartzites of the Jacksons Gap Group). Aeromagnetic and gravity geophysical signatures are consistent with surface relations and support closure of the Tallassee synform

beneath the Coastal Plain veneer. We present U-Pb isotopic dates on zircons from metagranites that had intruded metasedimentary rocks along the west (Kowaliga and Zana granites, 441±6.6 Ma) and east (Farmville Metagranite, 454 ± 9 Ma) limbs verifying a common magmatic and metamorphic history. Tracing the distinctive package of metasiliciclastics northeastward out of the hinge zone of the Tallassee synform into Georgia implies regional correlations with the Chattahoochee Palisades Quartzite/Sandy Springs Group. This correlation is supported by analysis of U-Pb detrital zircons from the Tallassee Metaquartzite demonstrating common Grenville (1.0-1.2 Ga) and mid-continent granite/rhyolite province (1.3 to 1.5 Ga) sources; a minor 2.9-2.7 Ga population (mid-continent-superior province, 3.0 to 2.6 Ga) and a single grain at 442 Ma is compatible with siliciclastics reported for other parts of the Blue Ridge in Alabama (Wedowee and Emuckfaw Groups) and Georgia (Dahlonega Gold belt and Cowrock terrane).

Our findings document a large (1,029 km^2) tectonic window, herein called the Dog River window, through the Inner Piedmont (i.e., Dadeville Complex) allochthon and into the Laurentian Blue Ridge that is flanked by the autochthonous Laurentian margin/platform to the west and parauthocthounous Laurentian basement and cover exposed in the Pine Mountain window to the east. Although additional mapping in Georgia will be required to delimit the northern extent of the window, it clearly is a fundamental, first-order structure in the southern Appalachian orogen that roughly corresponds to the Alabama Promontory along the ancient margin of Laurentia prior to Appalachian contraction.

INTRODUCTION

The Brevard fault zone is an extensive retrograde fault zone that extends in surface exposures from Mt. Airy, North Carolina, to Tallassee, Alabama (Fig. 1). Brevard zone lithologies and fault rocks characteristically have a northeast strike and moderate-southeast dip but near Jacksons Gap, Alabama they inexplicably take on a more northerly strike and a shallow eastward dip (Fig. 1). Farther south of Jacksons Gap earlier workers (Stose, 1926; Neathery, 1968) had suggested that strike changes more drastically from north, to northwest, and finally to east-west, with sympathetic shallowing of the dip before becoming covered by Mesozoic sediments of the Gulf Coastal Plain. These relations led to the idea that the southern Appalachian Piedmont is allochthonous along a west-directed thrust system comprising the Brevard fault zone and faults framing Laurentian (Grenville) basement and its stratigraphic cover in the Pine Mountain window (i.e., Towaliga, Bartletts Ferry, and Goat Rock fault zones), the so-called 'mega-nappe' hypothesis of Clarke (1952). Geologic mapping in Alabama by Bentley and Neathery (1970) further supported the mega-nappe hypothesis. Apparently not known by them at the time, COCORP (COnsortium for COntinental Reflection Profiling) was developing a remarkably similar interpretation, the southern Appalachian master décollement, based on their seismic-reflection profiling along strike ~320 km to the northeast (Cook et al., 1979). The structural development of the Brevard fault zone, therefore, figures prominently in the 'mega-nappe' hypothesis but remains the subject of debate (Bobyarchick et al., 1988; Bobyarchick, 1999).

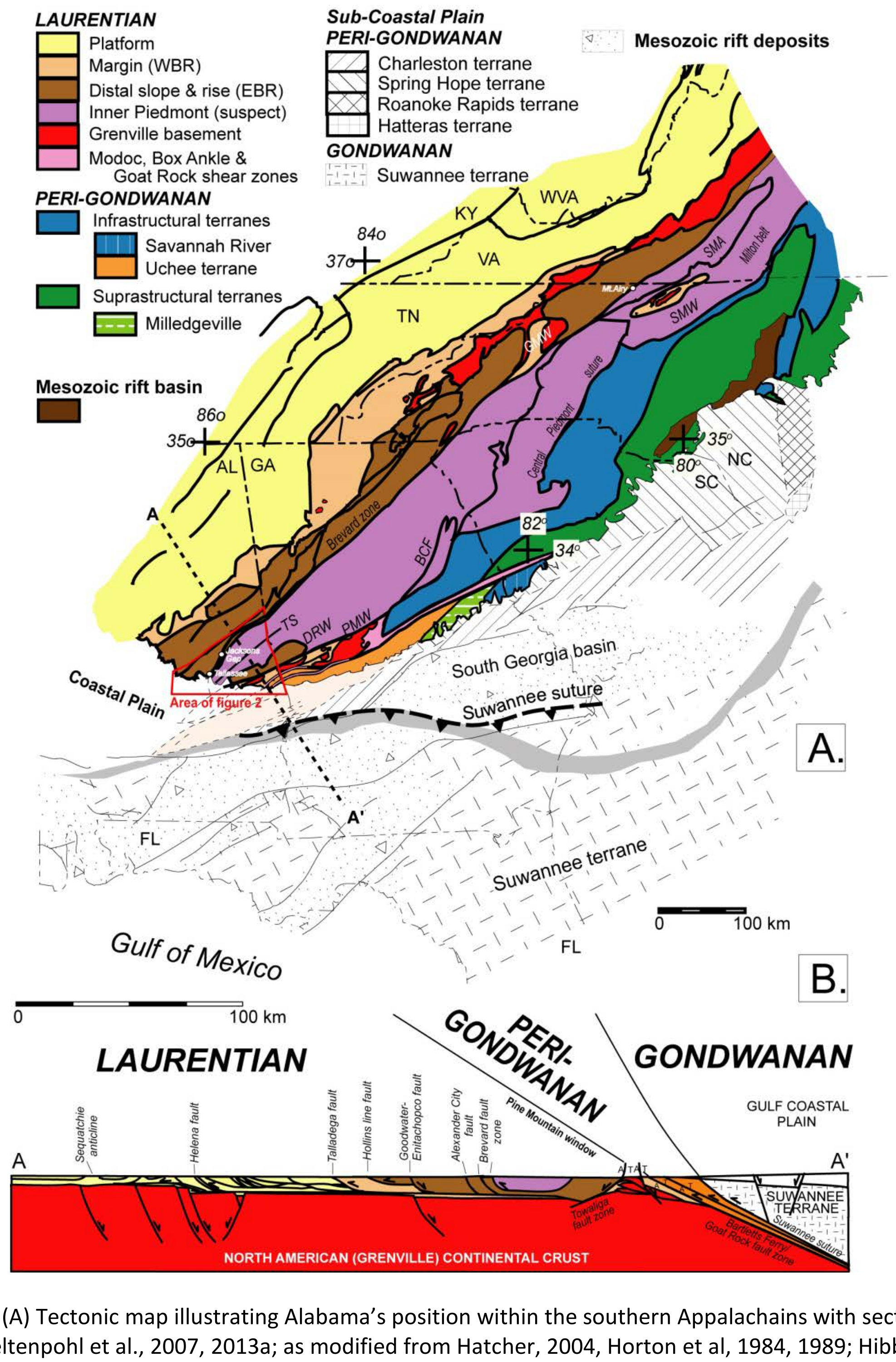

Figure 1. (A) Tectonic map illustrating Alabama's position within the southern Appalachains with section line A-A' (from Steltenpohl et al., 2007, 2013a; as modified from Hatcher, 2004, Horton et al, 1984, 1989; Hibbard et al., 2002, 2006; Steltenpohl, 2005); Alabama is partially outlined in red. Dashed blocks illustrate area of Fig. 2. (B.) Simplified cross section A-A' (modified from W.A. Thomas and coworkers as depicted in Thomas [1989], Thomas et al. [1989], Hatcher et al. [1990], and Steltenpohl [2005]). Map abbreviations: BCF—Brindle Creek fault; CR—Cartersville reentrant; CST—Cat Square terrane; DRW—Dog River window; EBR—eastern Blue Ridge; GMW—Grandfather Mountain Window; PMW—Pine Mountain window; SMW—Sauratown Mountains Window; SRA—Smith River allochthon; TS—Tallassee synform; WBR—western Blue Ridge. Cross Section: A—Away; T—toward; no vertical exaggeration.

Critical to interpretations of the Brevard fault zone is that in its southernmost exposures in Alabama a shallow northeast-plunging synform, the Tallassee synform, appears to fold its lithologies and early-formed fabrics and structures, but a thin veneer of Gulf Coastal Plain cover hides relationships in the area of the hinge zone (Fig. 2). Bentley and Neathery (1970) recognized similarities between metasedimentary lithologies on both limbs of the synform, even plutonic rocks intruding them, yet placed a band of question marks within this critical area, interpreting that the Brevard fault zone continued undeflected southward beneath the Coastal Plain. This has resulted in the traditional interpretation for the Inner Piedmont terrane (i.e., Dadeville and Opelika Complexes in Fig. 2) continuing southward 90 km to the buried suture with Gondwanan crust of the Suwannee terrane (Fig. 1: Horton et al., 1989).

Our investigations indicate however, that lithologic units constituting the eastern Blue Ridge and the Brevard fault zone do not disappear beneath the Coastal Plain but, rather, are mappable eastward around the hinge of the Tallassee synform where along the eastern limb they correspond units previously correlated with the Inner Piedmont (i.e., Opelika Complex). This is indicated by detailed 1:24,000 scale geologic mapping and structural analysis of rocks exposed in the hinge zone where we have found stream drainages that penetrate beneath the Coastal Plain veneer. Critical to the map relations is a distinctive package of interlayered quartzite and metapelites that serve as marker units that we have traced discontinuously along strike into the Blue Ridge of Georgia. Structural and formline analysis of metamorphic fabric independently support continuity around the Tallassee synform’s hinge. Aeromagnetic and gravity maps image structural closure of the Tallassee synform directly beneath the Coastal Plain sedimentary cover. Previously reported U-Pb and Rb-Sr ages for crystallization of

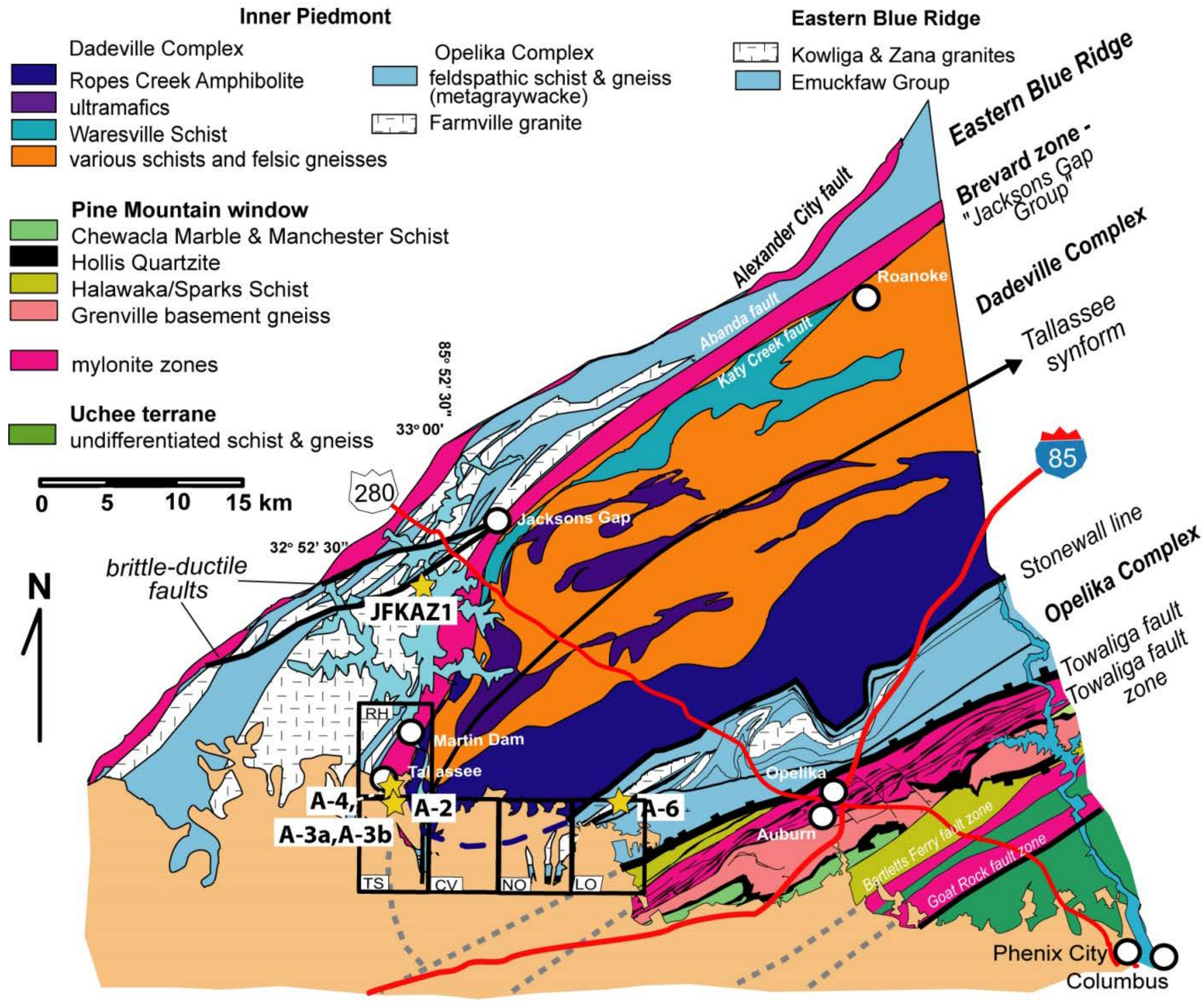

Figure 2. Generalized geologic map of the crystalline rocks along the fall line in Alabama. Map is modified after and compiled from Osborne et al. (1988), Sears et al. (1981) Steltenpohl et al. (1990), Keefer (1992), Grimes et al. (1993), and unpublished contributions from Auburn University Geology students noted in acknowledgements. Heavy dotted lines are aeromagnetic lineaments sourced from beneath the Coastal Plain (Steltenpohl et al., 2013b). Stars represent sample locations for U-Pb igneous and detrital zircon analysis (see text). Dashed block illustratates areas of Figs. 3 and 7(Quadrangle abbreviations: RH---Red Hill; TL---Tallassee; CV---Carrville; NT---Notasulga; LO---Loachapoka).

metagranites that have intruded both limbs of the synform (Russell, 1978; Russell et al., 1987) carry large errors but flavored worker's interpretations against correlating units around the hinge zone. We present U-Pb isotopic dates on zircons from metagranites intruding the metasedimentary rocks along both limbs, however, verifying that the plutons and their fabrics are of the same age. Finally initial U-Pb zircon analyses of detrital zircons from one of the quartzite marker units helps to confirm its Laurentian heritage.

In combination, lithologic correlations and tectonostratigraphic position, structural analyses, aeromagnetic and gravity evidence, and U-Pb igneous and detrital zircon dates document a large tectonic window through the Inner Piedmont that is bracketed by the autochthonous Laurentian margin/platform to the west and the parauthocthounous Pine Mountain window to the east. Recognized in its entirety, the window, herein referred to as the Dog River window, is a fundamental, first-order structure of the southern Appalachian orogen that exposes a huge area of previously unrecognized Laurentian Blue Ridge rocks spanning most of the Alabama Promontory.

REGIONAL GEOLOGY

Rocks lying between the Brevard fault zone and the central Piedmont suture (Fig. 1) with peri-Gondwanan arcs of the Carolina superterrane (Hatcher and Zeitz, 1980; or Carolinia of Hibbard et al., 2007) traditionally have been called the Inner Piedmont (Hatcher, 1987, 2001, 2002; Hopson and Hatcher, 1988; Horton et al., 1989; Hibbard et al., 2002; Hatcher et al., 2007). The Inner Piedmont comprises the Tugaloo and Cat Square terranes (Fig. 1) that are separated by the Brindle Creek fault (Bream et al., 2001, 2004; Bream, 2002, 2003; Merschat et al., 2005). The Tugaloo terrane has an apparent stratigraphy recognizable on either side of the Brevard fault zone, with metasedimentary rocks containing zircons that confirm a Laurentian crustal source (Bream et al., 2001; Bream, 2003). Workers had earlier interpreted the Inner Piedmont to represent either the distal Laurentian slope-rise facies or several amalgamated Laurentian and/or Iapetan suspect terranes (Hatcher, 1987; Horton et al., 1989; Steltenpohl et al., 1990a; Hatcher et al., 2007a) but stratigraphic similarities and Laurentian affinity have recently been interpreted to reflect a basin-plains facies outboard of the Laurentian margin (Huebner et al., *in press*). Hatcher and Merschat (2006), working in the Carolinas interpreted southwest-northeast aligned mineral-stretching lineations found in the Dadeville Complex of Alabama and west Georgia (Bentley and Neathery, 1970) to record southwest-directed orogen-parallel extrusion of the Inner Piedmont during Acadian/Neoacadian oblique transpressive accretion of the overriding Carolina superterrane.

In Alabama and west central Georgia, rocks between the Brevard fault zone and the Towaliga fault have traditionally been assigned to the Inner Piedmont terrane lying in the core of the gently northeast-plunging Tallassee synform (Figs. 1 and 2). The Inner Piedmont in Alabama (Fig. 2) has been divided into two lithodemic complexes; the metavolcanic-metaplutonic Dadeville Complex overlying the mostly metasedimentary Opelika Complex (Bentley and Neathery, 1970; Osborne et al., 1988). The Dadeville Complex, a probable early Paleozoic arc or back-arc complex comprises various schists, gneisses, and mafic and ultramafic rocks, with approximately 40% composed of the Ropes Creek Amphibolite (Bentley and Neathery, 1970; Steltenpohl et al., 1990, Sterling, 2006). Aside from Late Mississippian to Early

Pennsylvanian $^{40}Ar/^{39}Ar$ mineral cooling dates (Steltenpohl and Kunk, 1993), the only isotopic data reported for the Dadeville Complex is a Rb-Sr whole rock age for crystallization of ~460 Ma (Middle Ordovician) for the Franklin Gneiss in Georgia (Seal and Kish, 1990).

On the east limb of the Tallassee synform, the Opelika Complex lies northwest of (structurally above) the Towaliga fault zone and southeast of (structurally below) the Stonewall line (Fig. 2). The Opelika Complex was subdivided into the Loachapoka Schist and underlying Auburn Gneiss (Bentley and Neathery, 1970; Sears et al., 1981). The Loachapoka Schist (Loachapoka Formation of Sears et al., 1981) is predominantly composed of kyanite-staurolite schist (metapelite), graphitic schist, interlayered Saugahatchee Quartzite, and sheared sill-like plutons of Farmville Metagranite (Sears et al., 1981; Steltenpohl et al., 1990). The Auburn Gneiss (Auburn Formation of Sears et al., 1981) mainly comprises feldspathic muscovite-biotite schist (metapelite) and interlayered massive and gneissic banded, locally graded, feldspathic biotite-rich metagraywacke (metaturbidite) also intruded by voluminous sill-like bodies of Farmville Metagranite (Raymond et al., 1988; Steltenpohl et al., 1990). Rare amphibolite layers are locally found.

On the west limb of the Tallassee synform, the Jacksons Gap Group defines Brevard fault zone lithologies and separates the eastern Blue Ridge from the overlying Dadeville Complex (Fig.2). In Alabama, the Jacksons Gap Group comprises mainly metasiliciclastics and metapelites lying between the syn-metamorphic Katy Creek fault, above (Poole et al., 2013), and the post-metamorphic Abanda fault, beneath (Hawkins, 2013; Hawkins et al., 2013). The quartzites, phyllites, and schists of the Jacksons Gap Group and Loachapoka Schist are distinct.

Massive, mappable orthoquartzites like the Devils Backbone/Tallassee quartzite (Jacksons Gap Group) and the Saugahatchee quartzite are rare in this part of the Piedmont in Alabama and Georgia. The only other substantial orthoquartzite unit in this region is the Hollis Quartzite of the Pine Mountain Group, which overlies the Grenville Pine Mountain basement massif (Fig. 2). Abrahams (2014) provides detailed information on lithologies of the Jacksons Gap Group.

Units structurally beneath and northwest of the Jacksons Gap Group have been called the Ashland/Wedowee belt (Adams, 1926; Neathery, 1975) and the northern Piedmont (Bentley and Neathery, 1970; Raymond et al., 1988; Osborne et al., 1988), but are part of the Appalachian eastern Blue Ridge (Tull, 1978; Steltenpohl and Moore, 1988; Steltenpohl et al., 1990; 2013a; 2013b; Steltenpohl, 2005; Hawkins, 2013). The Emuckfaw Group (Bentley and Neathery, 1970) directly underlies the Jacksons Gap Group along the Abanda fault and comprises pelitic schist, metagraywacke, and minor amphibolite that are invaded by voluminous sill-like plutons of Kowaliga Gneiss and the Zana Granite (Osborne et al., 1988; Steltenpohl, 2005; Tull et al., 2012; Hawkins, 2013). Felsic intrusions are not observed in the Jacksons Gap Group. Most workers consider the eastern Blue Ridge of Alabama to reflect an outboard, slope/rise facies of the ancient Laurentian margin (Drummond et al., 1994, 1997; McClellan et al., 2007; Tull et al., 2007). Alternatively, Sterling et al. (2005) and Tull et al. (2012) have suggested that parts of the eastern Blue Ridge exposed in Alabama may have evolved in a back-arc basin outboard of the ancient Laurentian margin.

GEOLOGIC ANALYSIS OF THE TALLASSEE SYNFORM HINGE ZONE

Geologic Mapping

The hinge zone of the Tallassee synform (Fig. 3) is exposed along the fall line, where relatively good exposures of the crystalline Piedmont units are onlapped by less resistant Coastal Plain sediments; historically, water falls along the fall line provided early-American settlements with an important source of hydrologic power. Four 1:24,000-scale quadrangles, from west to east, Tallassee, Carrville, Notasulga, and Loachapoka, straddle the onlap in the hinge area (Fig. 3) and are mostly covered by Coastal Plain and modern alluvial sediments. Detailed 1:24,000-scale geologic mapping and structural analysis were conducted on rocks exposed in the quadrangles with care being placed on mapping drainages that have cut downward through the cover into crystalline bedrock. Mapping of these drainages is tedious and time consuming work but detailed resolution of the drainage inliers is critical to our interpretations. An electronic PDF map has been placed in the repository to allow for careful viewing of lithologic and structural details (Plate 1).

The west limb and most of the core of the Tallassee synform lie within the Tallassee quadrangle (Keefer, 1992; Sterling, 2006; White, 2007). Along the west limb (Fig. 4b), the Katy Creek fault parallels layering within the underlying Jacksons Gap Group but marks a sharp, high-angle discordance with overlying Dadeville Complex units. Sterling (2006) and White (2007) mapped the Tallassee Metaquartzite (Fig. 5b) from its type area in Tallassee northward to Martin Dam (Fig. 2) where it becomes massive micaceous quartzite with localized metaconglomerate layers that correspond to the Devil's Backbone Quartzite (Fig. 5a: Bentley

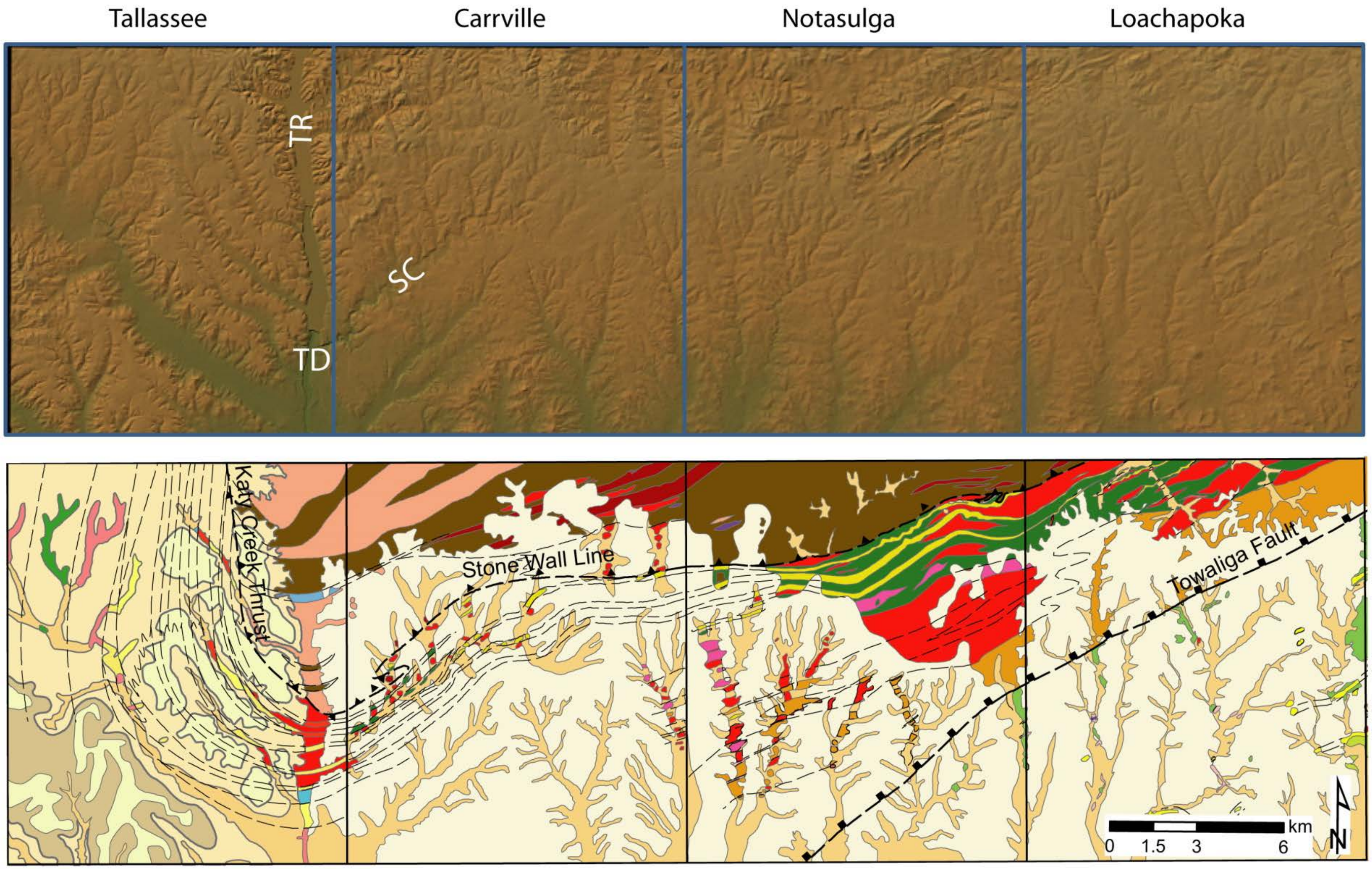

Figure 3. Digital elevation model (DEM) along the hinge zone of the Tallassee Synform (above) and geologic maps of the Tallassee, Carrville, Notasulga, and Loachapoka 1:24,000 quadrangles (below). Katy Ceek Fault/Stonewall line separate Dadeville Complex to the north and Emuckfaw Group and Opelika Complex to the south. Tan shades are Mesozoic Coastal Plains Sediments. Peach is modern alluvium. Note the prominent ridges formed by the resistant layers of muscovite quartzite. Plate 1 (in repository) is and electronic version of the geologic maps complete with structural details and legend. DEM map abbreviations are: TD---Thurlow Dam; TR---Tallapoosa River; SC---Stone Creek.

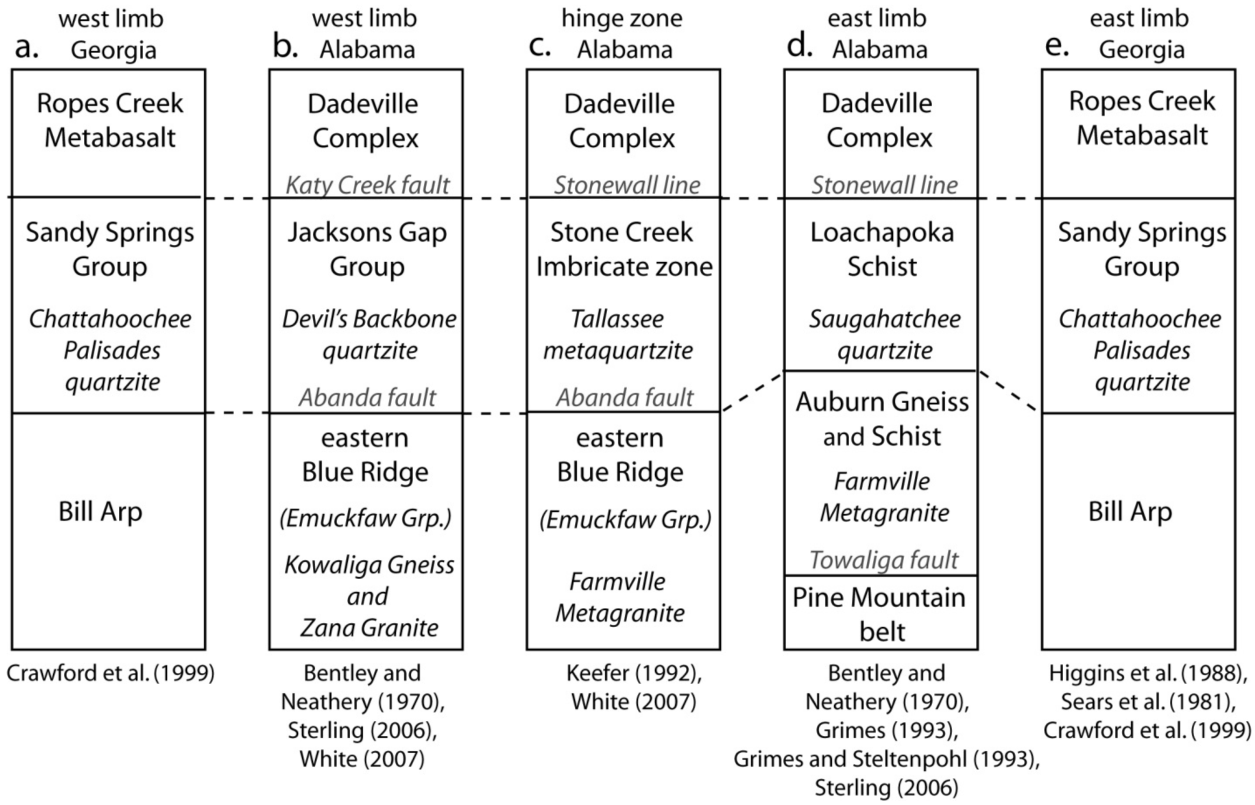

Figure 4. Tectonostratigraphic correlations suggested for crystalline rocks on the hinge of the Tallasse synform along the Alabama fall line with other parts of the southern Appalachians (not to scale). Letters (a-e) key the different stratigraphic sections to geologic/geographic positions in Figure 12.

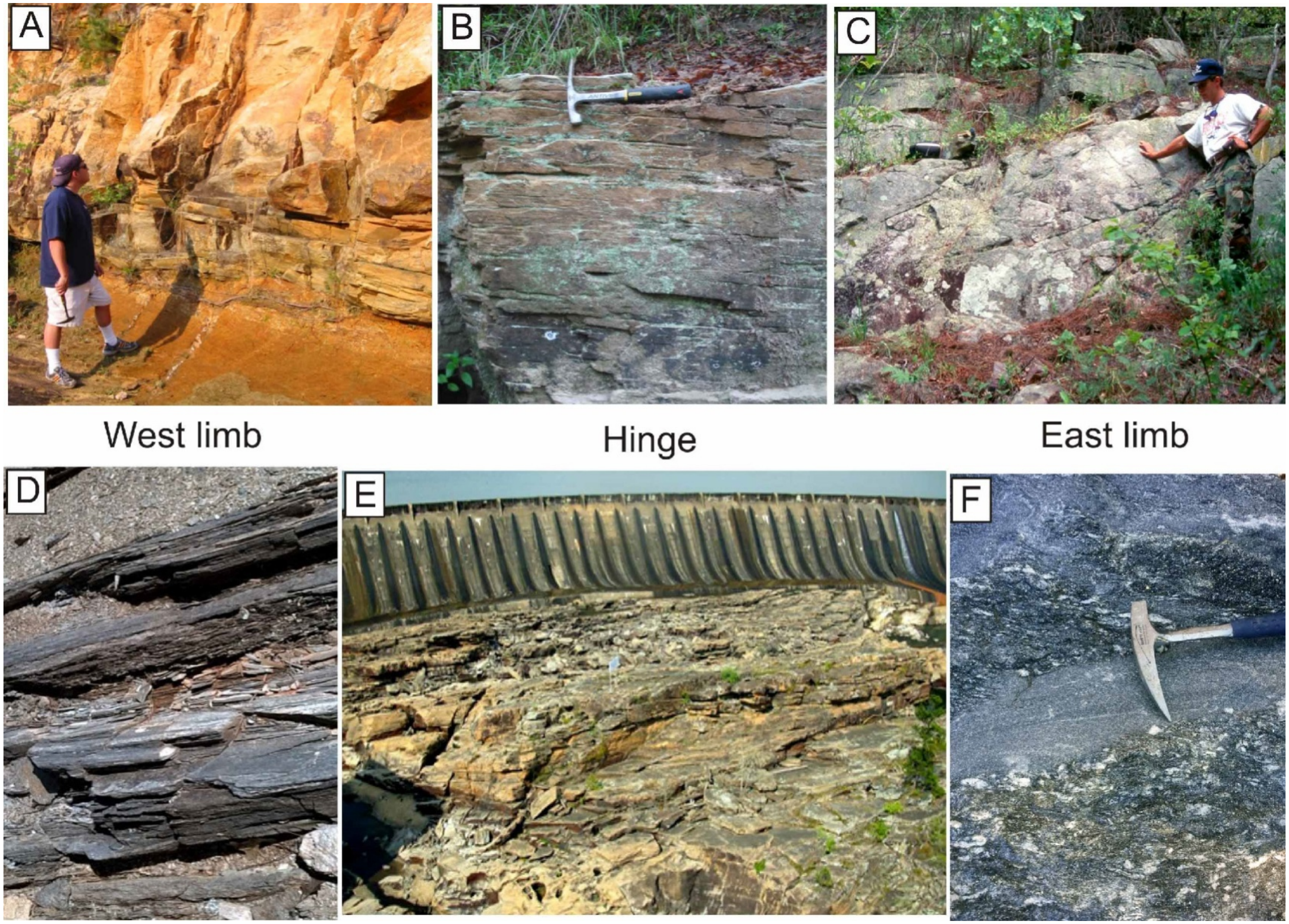

Figure 5. Key lithologies of the study area. (A.) Devil's Backbone Quratzite at Martin Dam. (B.) Tallassee Quartzite at Thurlow Dam. (C.) Saugahatchee Quartzite along Saugahatchee Creek. (D.) Interlayered metagrewacke (ridges) and metapelite (erosionally removed) of the Emuckfaw Group, eastern Blue Ridge. (E.) Subhorizontal Tallassee Metaquartzite of the Stone Creek imbricate zone, Thurlow Dam, Tallassee, Alabama. Dam is approximately 20 m high. (F.) Interlayered metagrewacke (Auburn Gneiss; medium grey, equigranular) and metapelite (Auburn Schist) of the Opelika Complex.

and Neathery, 1970). Mapping of the Jacksons Gap Group metasiliciclastics along the west limb north of Martin Dam to Roanoke, Alabama (Fig. 2) documents numerous exposures of ridge-forming Devil's Backbone quartzites that are generally thin (~4 to 10 meters thick) and discontinuously exposed as lensoidal bodies that are interlayered with and grade in-and-out of papery muscovite/sericite quartzose phyllites. The quartzites range from thin to thick bedded and are massive, with accessory muscovite, garnet (generally flattened and elongated), and rare aluminosilicates (kyanite and/or sillimanite), and they are commonly interlayered with pelitic schist and phyllite. The Abanda fault marks the base of the Jacksons Gap Group beneath which Emuckfaw Group metaturbidites (Fig. 5d) of the eastern Blue Ridge are intruded by sill-like bodies of Kowaliga Gneiss and Zana Granite (Figures 6a and 6b, respectively).

The lithologies and structures of the Brevard zone in the core of the Tallassee synform are subhorizontal, dipping less than 10^{o} toward the north (Fig. 5e). In the hinge zone (Fig. 4c), Keefer (1992) recognized that the Tallassee Metaquartzite is tectonically interleaved with sheared felsic gneiss (Figures 5b and 5e). Given that the Kowaliga Gneiss of the eastern Blue Ridge was reported to be principally an augen gneiss, Keefer (1992) inferred that the gneisses in the core were Zana Granite (c.f., Figs. 6a and 6b, respectively), which reportedly is finer-grained and more homogeneous (Bentley and Neathery, 1970; Raymond et al., 1988). Keefer (1992) called this package of structurally interleaved metasiliciclastics and metagranite the Stone Creek imbricate zone for good exposures that occur as inliers in Stone Creek directly east of the Tallapoosa River (Fig. 3). Thus, contrary to earlier workers' maps that indicate the disappearance of the Jacksons Gap Group beneath the Coastal Plain cover directly southeast of Tallassee (for example, Bentley and Neathery, 1970, and Osborne et al., 1988), Keefer (1992)

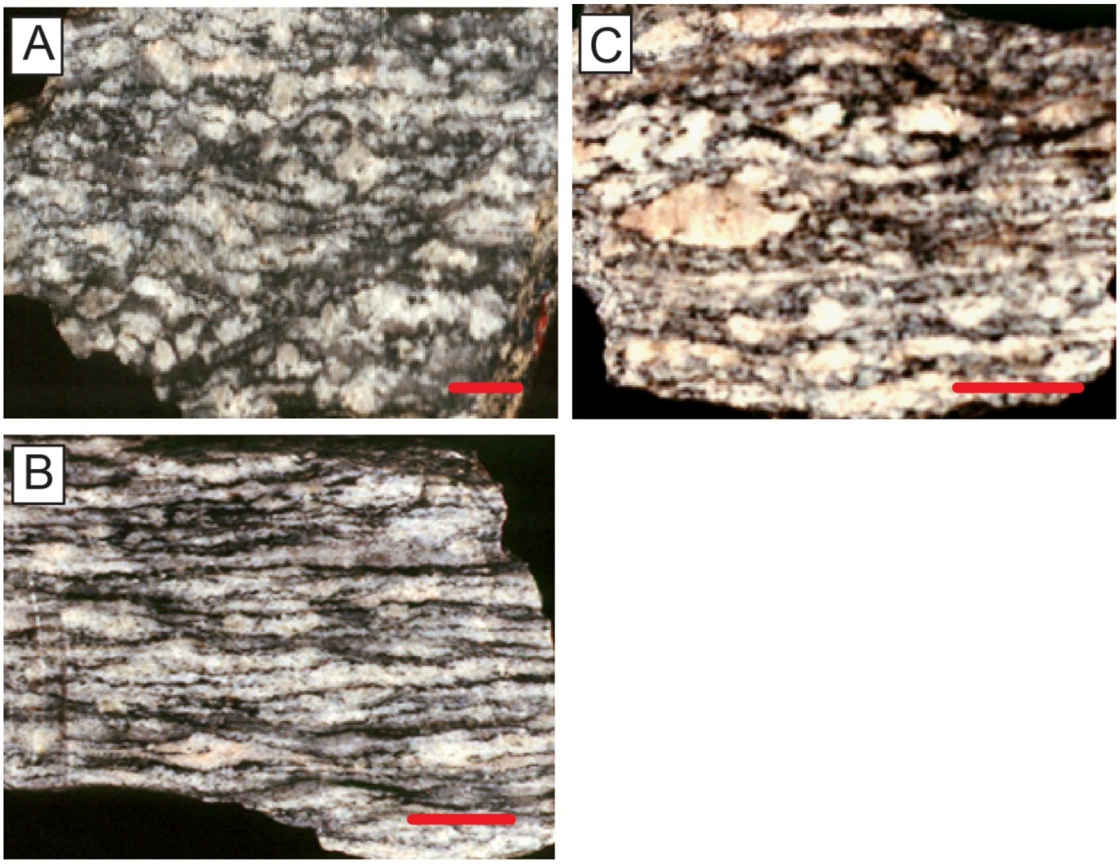

Figure 6. Photographs of polished slabs (A) Kowaliga Gneiss (B) Zana Granite (C) Farmville Metagranite. Red scale bar is 1 cm long in each photo.

interpreted the Tallassee Metaquartzite/Stone Creek imbricate zone to continue eastward around the hinge of the synform (Fig. 3).

Grimes (1993), Grimes and Steltenpohl (1993), and Sterling (2006) traced the Stone Creek imbricate zone out of the Tallassee area eastward along the east limb of the synform (Fig. 4d) across the Carrville, Notasulga, and Loachapoka quadrangles (Fig. 3) where they discovered that the Tallassee Metaquartzite and associated siliciclastics *are* the Saugahatchee Quartzite (Fig. 5c) and Loachapoka Schist, and the sheared Zana Granite *is* the Farmville Metagranite (Fig. 6c: Steltenpohl et al., 1990). The Farmville Metagranite of the Opelika Complex occurs in textural varieties that include augen gneiss, lineated orthogneiss, and metagranite that are indistinguishable petrographically from the Kowaliga and Zana granites within the Emuckfaw Group of the eastern Blue Ridge (Fig. 6: Steltenpohl et al., 1990; Hawkins, 2013). Grimes and Steltenpohl (1993) also reported several thin (<10 m thick) amphibolites within the Auburn Gneiss (see Plate 1). These observations combined with the metapelite/metagraywacke assemblage of the Auburn Gneiss and Schist (Fig. 5f) to lead Grimes and Steltenpohl (1993) to suggest their correlation with the Emuckfaw Group of the eastern Blue Ridge (Figs. 4b, 4c, and 4d). Following the interpretation of Keefer (1992) and Grimes and Steltenpohl (1993), we correlate the Devil's Backbone Quartzite/Tallassee Metaquartzite in the Jacksons Gap Group, and the Emuckfaw Group in the eastern Blue Ridge, with the lithologically-similar and tectonostratigraphically equivalent Saugahatchee Quartzites in the Loachapoka Schist, and the Auburn Gneiss formerly of the Opelika Complex, respectively.

Structural Analysis

Structural mapping and analysis of rocks and their fabrics in the area of Figure 3 appear to document folding and closure of the Tallassee synform, as would be required by the lithologic correlations we propose herein. Eastern Blue Ridge, Jacksons Gap Group, Dadeville Complex, and Opelika Complex units affected by the Tallassee synform have been multiply deformed and preserve evidence of at least three deformational events (Steltenpohl et al., 1990; Keefer, 1992; Grimes, 1993; Sterling, 2006; Hawkins, 2013; Abrahams, 2014). Bedding, S_0, is clearly preserved in some units of the Jacksons Gap Group where metamorphic grade and degree of strain is relatively low (Abrahams, 2014). The dominant regional foliation (S_1) formed during or close to the peak of metamorphic conditions, which varied between allochthons: eastern Blue Ridge – middle-amphibolite facies; Jacksons Gap Group – upper- greenschist- to lower- amphibolite facies; and Dadeville Complex – middle- to- upper- amphibolite facies. Generally, S_0 has been strongly transposed by S_1, and thus the composite foliation is referred to as S_0/S_1.

The Tallassee synform is a major post-peak metamorphic, open-to-tight F_2 fold that is coincident with broad, long-wavelength regional synforms and antiforms in the southernmost Appalachians and likely a counterpart to the northeast-plunging Pine Mountain anticlinorium (Steltenpohl et al., 1990, 2010). Figure 7A is a structural form-line map of 2,236 measurements of the dominant S_0/S_1 foliation within the hinge zone of the synform. Along the west limb of the synform in the Red Hill quadrangle (Fig. 7A), S_0/S_1 in the eastern Blue Ridge and Jacksons Gap Group dips moderately southeast and strikes northeast as is typical for the Brevard fault

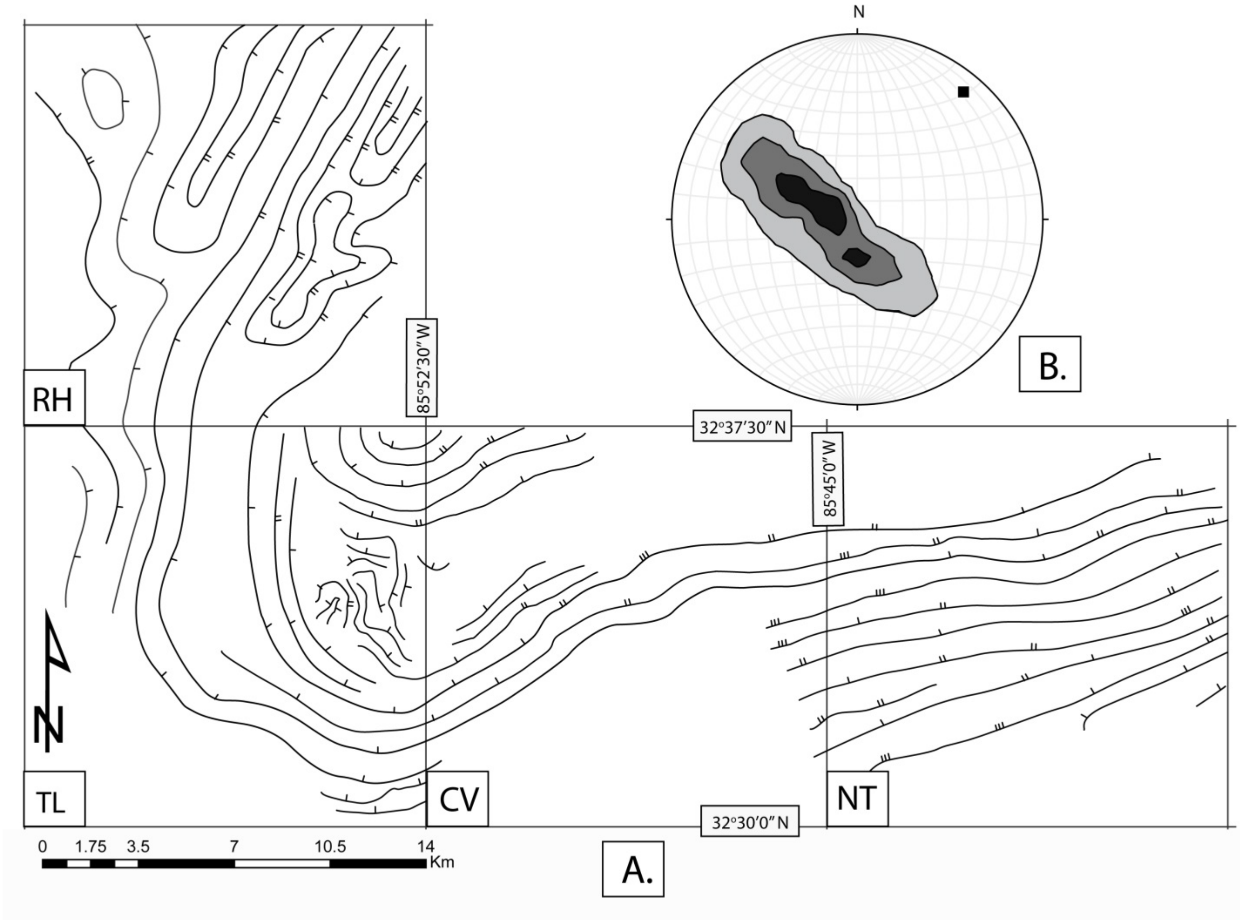

Figure 7. (A) Structural form-line map of the dominant S_0/S_1 foliation along the closure of the Tallassee Synform (Quadrangle abbreviations: RH---Red Hill; TL---Tallassee; CV---Carrville; NT---Notasulga). Tick marks indicate magnitude of dip (one tick mark < 30°, two tick marks 30° <60°, and three tick marks >60°). (B) Lower hemisphere equal-area stereographic projection of contoured poles to S_0/S_1 foliation. Contours at 2%, 4%, and 6% per 1 % area (n=2,236).

zone along most of its ~600 km extent to Mt. Airy, North Carolina (Fig. 1). Dip of S_0/S_1 shallows and strike changes to a northerly orientation in the Tallassee quadrangle (Fig. 7A), however, while D_2 mylonites deviate out of the structural zone to continue on a southerly trend that parallels mylonitic shears in the eastern Blue Ridge and the major Alexander City fault (Fig. 2: Steltenpohl et al. 2013a). Approaching the hinge zone in the Tallasee quadrangle (Fig. 7A), strike of the eastern Blue Ridge and the Jacksons Gap Group units changes from north, to northwest, and finally to east-west, with a shallowing of the dip before becoming subhorizontal at Thurlow Dam (Figs. 3 and 5e). Within the Opelika Complex along the synform's east limb in the Carrville and Notasulga quadrangles, S_0/S_1 dips moderately northwest and strike trends back into a northeastern orientation (Fig. 7A). Figure 7B constrains the geometry of the cylindrical Tallassee synform indicating a β-axis trend and plunge of N40°E, 12°. Aside from some local contortions within the Dadeville Complex, it is clear that S_0/S_1 passes uninterrupted from limb to limb precisely as the lithologic layering does, thus, supporting correlation of the eastern Blue Ridge and Opelika Complex.

Analysis of Remotely Sensed Geophysical Data

Our mapping and structural data gathered from surface exposures are supported by magnetic and gravity anomaly maps that trace surface anomalies beneath the thin veneer of Coastal Plain cover (Fig. 8) around the closure of the Tallassee synform. Domain 2 in Figure 8 is defined by high-frequency, curved and linear magnetic highs that represent amphibolites and local ultramafic bodies of the Dadeville Complex. Broader low-frequency anomalies of Domain

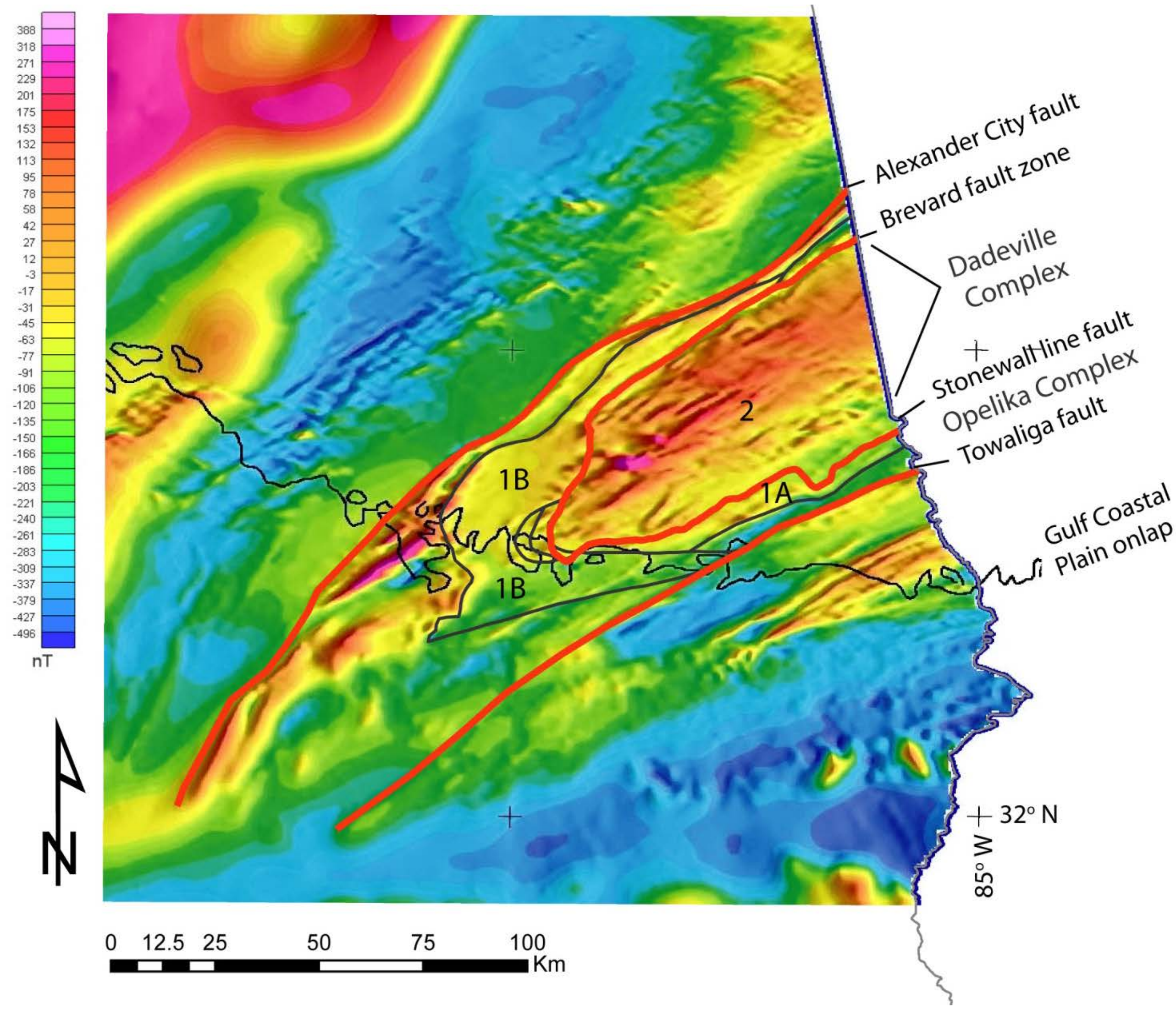

Figure 8. Major crustal features annotated on an aeromagnetic anomaly map of Alabama (from Steltenpohl et al., 2013b). Black lines are geologic interpretations of regional aeromagnetic and gravity anomaly gradients (see Steltenpohl et al., 2013b). Red lines are surface faults from the Alabama state geologic map projected into the subsurface beneath Coastal Plain sediments (Szabo et al., 1988). Subdomains 1A-B and 2 are described in text.

2 are felsic metaplutonic and metavolcanic units. Combined, the overall pattern is consistent with the Dadeville Complex defining the core of the gently northeast-plunging Tallassee synform. Immediately flanking and forming the limbs of the synform is relatively featureless magnetic Domain 1A defined by broad, flat, long-wavelength anomalies corresponding to metasedimentary rocks of the Emuckfaw Group, Auburn Gneiss and Loachapoka Schist. Internal to domain 1A are smaller areas of even lower magnitudes and lacking the moderate-frequency anomalies that define domain 1B and correspond to the intrusive Kowaliga Gneiss, Zana Granite, and Farmville Metagranite. This entire low-frequency domain is bracketed by linear, moderate-frequency anomalies that correspond to the Brevard and Towaliga faults and it is sandwiched by anomalies of the Dadeville Complex. Taken together, the open broad arcuate form of the low intensity domain and its bounding faults mirror the geometry determined from the structural analysis, above, and trace the closure of the Tallassee synform beneath the Coastal Plain.

U-Pb Analysis of Zircons

<u>Kowaliga Gneiss</u>

The Kowaliga Gneiss comprises batholith-scale, granite to granodiorite intrusions into the Emuckfaw Group that extend nearly 65 km along the strike of the west limb of the Tallassee synform (Bentley and Neathery, 1970; Stoddard, 1983; Bieler and Deininger, 1987). Field relations reported for exposures along the shores of Lake Martin (Fig. 2) indicate the Kowaliga Gneiss is inter-leaved as sill-like layers of granitic gneiss within the Emuckfaw Group (Hawkins, 2013). The Kowaliga Gneiss typically carries a mylonitic fabric defined by alignment of biotite, muscovite, and quartz ribbons that drape larger more competent subhedral, primarily microcline and potassium feldspar porphyroclasts. Contact margins of the Kowaliga Gneiss are concordant with the dominant metamorphic schistosity and coplanar mylonitic fabric (S_1/S_2) found in the surrounding country rocks indicating that they were intruded either prior to or synchronous with peak metamorphism and mylonitization. Hawkins (2013) subdivided the Kowaliga Gneiss into the Kowaliga augen gneiss and Kowaliga megacrystic gneiss, the latter being distinguished by the occurrence of euhedral potassium-feldspar megacrysts, interpreting these textural types to reflect varying degrees of shear strain. The megacrystic gneiss clearly is the least texturally modified variety and reflects the primary igneous rock from which the others were derived (Hawkins, 2013).

Traditionally, smaller (~50 km long, ~2.7 km wide), tabular intrusive bodies within the Emuckfaw Group have been mapped as the Zana Granite (Fig.2: Osborne et al., 1988). Muangonoicharoen (1975) and Stoddard (1983) interpreted that the Zana and the Kowaliga are temporally and magmatically related, with the Zana representing apophyses off larger Kowaliga bodies, which is supported by Hawkins (2013). Hawkins (2013) reports strong correlation of whole-rock major and trace element analyses between the Kowaliga Gneiss and Zana Granite. Strong similarities in geochemical signatures, field occurrences, and geochronology presented below indicate that these intrusions should be considered one intrusive suite.

Russell et al. (1987), using multi-grain U-Pb zircon analytical techniques constrained an age of 461±12 Ma for both the Kowaliga Gneiss and Zana Granite based on an upper intercept age and a single concordant point with $^{206}Pb/^{238}U$, $^{207}Pb/^{235}U$, and $^{207}Pb/^{206}U$ ages of 463±3, 462±4, and 459±18 Ma, respectively. In addition, Russell et al. (1987) reported a Rb-Sr whole-rock age of 437 Ma and 395 Ma for the Kowaliga Gneiss and Zana Granite, respectively, but analytical uncertainties were on the order of ±100 Ma. Recent U/Pb SHRIMP data obtained for the Kowaliga Gneiss and Zana Granite were interpreted to suggest a crystallization age of ~430 Ma and ~439 Ma, respectively (Tull et al., 2012). Tull et al. (2012) reported a distinct cluster of ages at 430 Ma for the Kowaliga Gneiss, whereas there was a spread of dates ranging from 480 and 410 Ma for the Zana Granite, with the younger dates interpreted to represent systematic Pb-loss. Using the "zircon age extractor" function in Isoplot v. 3.75 (Ludwig, 2012), an age of ~439 Ma was inferred for the Zana Granite (Tull et al., 2012). In an attempt to more tightly constrain the igneous crystallization age of the Kowaliga Gneiss we attempted the following U-Pb zircon study.

U-Pb isotopes were analyzed in zircons from a sample of megacrystic Kowaliga Gneiss (Sample JFKAZ1; see Figure 2 and Table 1 for location) that was carefully selected based on the lack of structural overprint upon its primary magmatic texture, which included euhedral phenocrysts, thus offered the best potential for dating the time of igneous crystallization. U-Pb zircon analyses for sample JFKAZ1 were performed using facilities at the University of California at Los Angeles SIMS (Secondary Ion Mass Spectrometry) Lab (Table 2) following the methods in Hawkins (2013). A conservative estimate of the concordia age of the intrusion is 441±6.6 Ma (MSWD=0.037; probability of concordance=0.85) based on the 20 $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ zircon ages (Fig. 9).

TABLE 1. SAMPLE LOCALITIES

Samples	Terrane	Rock unit	Location (latitude, longitude)
A-6	Opelika Complex	Farmville Metagranite	32° 37’34.99” N, 85°35’19.46” W
JFKAZ1	Eastern Blue Ridge	Kowaliga Gneiss	32° 50’30.03” N, 85°54’48.97” W
A-4, A-3, A-3b	Jacksons Gap Group	Tallassee Metaquartzite	32° 33’ 5.51” N, 85°51’30.19” W
A-2	Jacksons Gap Group	Tallassee Metaquartzite	32° 32’ 1.56” N, 85°53’11.76” W

TABLE 2. U-Pb DATA FOR ZIRCON ANALYSIS

Kowaliga Gneiss (JFKAZ1)

	206Pb*/ 238U	206Pb*/ 238U	207Pb*/ 235U	207Pb*/ 235U	207Pb*/ 206Pb*	207Pb*/ 206Pb*	Age (Ma) 206Pb/ 238U	Age (Ma) 206Pb/ 238U	Age (Ma) 207Pb/ 235U	Age (Ma) 207Pb/ 235U	Age (Ma) 207Pb/ 206Pb	Age (Ma) 207Pb/ 206Pb
		1 s.e.		1 s.e.		1 s.e.		1 s.e.		1 s.e.		1 s.e.
2012_12_10Dec\ Al_1_core.ais	0.0772	0.00684	0.6	0.0536	0.0563	0.000623	479	40.9	476.9	34	464.6	24.5
2012_12_10Dec\ Al_1_rim.ais	0.0815	0.0143	0.626	0.11	0.0557	0.000504	505	85.2	493.8	68.8	440.8	20.1
2012_12_10Dec\ Al_2_core.ais	0.0711	0.00494	0.554	0.0389	0.0565	0.000423	443	29.8	447.6	25.4	472.5	16.5
2012_12_10Dec\ Al_2_rim.ais	0.0722	0.00545	0.558	0.0422	0.0561	0.000254	449	32.8	450.5	27.5	457.5	10
2012_12_10Dec\ Al_3_core.ais	0.0527	0.00511	0.398	0.0371	0.0548	0.00153	331	31.3	340.2	27	402.8	62.7
2012_12_10Dec\ Al_3_rim.ais	0.0598	0.00599	0.447	0.0467	0.0542	0.00103	375	36.4	375.1	32.8	378	42.6
2012_12_10Dec\ Al_4_core.ais	0.0723	0.00549	0.552	0.0435	0.0553	0.0011	450	33	446	28.5	425.6	44.2
2012_12_10Dec\ Al_4_rim.ais	0.0699	0.0059	0.541	0.046	0.0562	0.000519	435	35.5	439.4	30.3	460.6	20.5
2012_12_10Dec\ Al_5_core.ais	0.084	0.00844	0.644	0.0637	0.0556	0.00076	520	50.2	504.9	39.4	437.7	30.4
2012_12_10Dec\ Al_5_rim.ais	0.0801	0.00857	0.62	0.0653	0.0561	0.00059	497	51.1	490	40.9	457.1	23.3
2012_12_10Dec\ Al_6_core.ais	0.0774	0.00705	0.597	0.0543	0.056	0.000333	481	42.2	475.6	34.5	451.2	13.2
2012_12_10Dec\ Al_6_rim.ais	0.0758	0.00647	0.583	0.0499	0.0558	0.000282	471	38.7	466.6	32	445.7	11.2
2012_12_10Dec\ Al_7_core.ais	0.0776	0.00681	0.608	0.0531	0.0568	0.00121	482	40.7	482.2	33.5	483.1	46.9
2012_12_10Dec\ Al_7_rim.ais	0.0696	0.005	0.539	0.0403	0.0561	0.000731	434	30.1	437.8	26.6	457.7	28.9
2012_12_10Dec\ Al_8_core.ais	0.0748	0.00621	0.581	0.0482	0.0563	0.000464	465	37.2	465.2	31	464.7	18.3
2012_12_10Dec\ Al_8_rim.ais	0.0661	0.00519	0.509	0.0417	0.0559	0.00102	413	31.4	418	28	446.8	40.7
2012_12_10Dec\ Al_9_core.ais	0.0739	0.00614	0.569	0.0479	0.0559	0.00161	460	36.8	457.7	31	448.3	63.8
2012_12_10Dec\ Al_9_rim.ais	0.0735	0.00589	0.57	0.0459	0.0562	0.000217	457	35.4	457.8	29.7	460.8	8.55
2012_12_10Dec\ Al_10_core.ais	0.0779	0.00661	0.606	0.0512	0.0563	0.000234	484	39.5	480.8	32.4	466.2	9.21
2012_12_10Dec\ Al_10_rim.ais	0.0798	0.00679	0.614	0.0527	0.0558	0.000367	495	40.5	486.1	33.2	444.4	14.6
2012_12_10Dec\ Al_10_rim@1.ais	0.0639	0.0042	0.494	0.0325	0.056	0.000285	399	25.4	407.5	22.1	453.1	11.3

Notes: 1 s.e. is the standard error

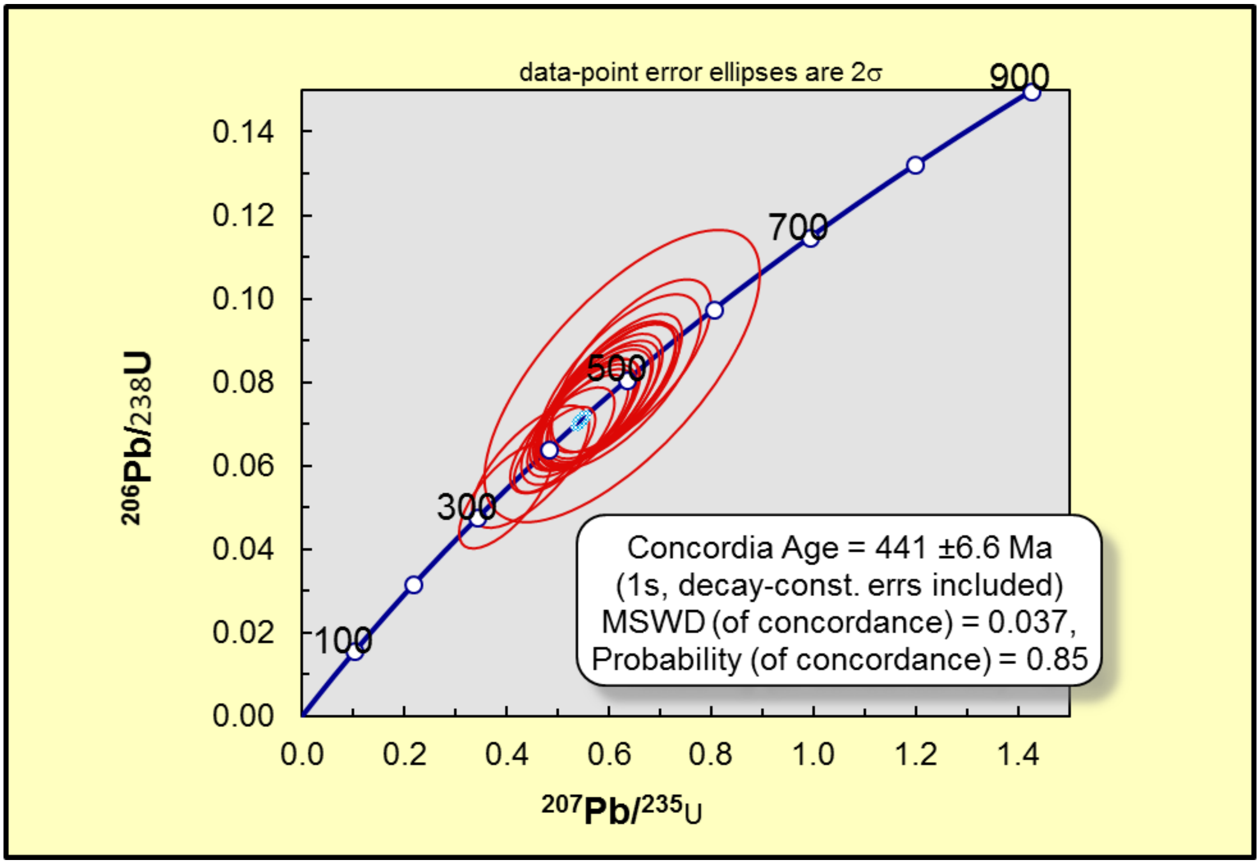

Figure 9. U/Pb isochron plot for zircons from Kowaliga Gneiss sample JFKAZ1 (from Hawkins, 2013). Chart was constructed and ages were determined using Isoplot (Ludwig, 2003).

In summary, the 441±6.6 Ma date for the Kowaliga Gneiss is within the analytical uncertainty of Russell et al.'s (1987) ~460 Ma date and is compatible with the spread of ages ranging from 480-410 Ma and the 439 Ma crystallization age of the Zana Granite reported by Tull et al. (2012). Late Ordovician to Early Silurian magmatism in the Emuckfaw Group, therefore, falls temporally within late Taconic to early Salinic orogenic evolution in this part of eastern Laurentia.

Farmville Metagranite

Along the east limb of the Tallassee synform, metasedimentary rocks of the Opelika Complex (i.e., Auburn Gneiss and Auburn Schist) are intruded by large (~20 km long, ~1.5 km wide) tabular, sill-like bodies of metagranite and granitic gneiss. On earlier maps (e.g., Osborne et al., 1988) these granites were shown as "Bottle Granite," but subsequent work required the name to be revised to Farmville Metagranite (Steltenpohl et al., 1990). The Farmville Metagranite contains the dominant metamorphic schistosity (S_0/S_1) found in the surrounding country rocks, indicating it had intruded either prior to or synchronous with peak metamorphism. Metagranite, orthogneiss, augen gneiss, and migmatitic gneiss are textural variations of the Farmville Metagranite (Steltenpohlet al., 1990; Grimes, 1993; Grimes and Steltenpohl, 1993).

Goldberg and Burnell (1987) reported a Devonian Rb-Sr whole-rock age of 369±5 for the Farmville Metagranite. In light of Grimes et al.'s (1993) suggestion for equivalence of the Auburn Schist and Gneiss with the Emuckfaw Group and hence, the apparent equivalency of the Kowaliga/Zana Gneiss to the Farmville Metagranite, Steltenpohl et al. (2005) suggested that the Farmville Metagranite may similarly have a Middle Ordovician (Taconic) to Devonian (Acadian) history. Initial U-Pb zircon studies bore this out (Grimes et al., 1997) but the isotope systematics were complex with a large range of $^{206}Pb/^{238}U$ ages from 477±20 Ma to 425±18 Ma, with the younger crystallization ages interpreted to result from subsequent heating and metamorphism resulting in partial Pb loss in the Acadian/Neoacadian and/or Alleghanian events. Following the interpretation of Steltenpohl et al. (2005), but in an attempt to provide tighter isotopic age constraints, we report the following U-Pb zircon results.

Thirty-six analyses of 32 zircons separated from a foliated and lineated sample of Farmville Metagranite (Sample A-6; see Fig. 2 and Table 1 for location) were analyzed via SHRIMP-RG at the Stanford-USGS laboratory (Table 3) using methods described in Steltenpohl et al. (2010). Twenty-two of the analyses are 6% or less discordant and between 468 and 420 Ma. These yield an average of 440±7 Ma (2 s.e.m.), only slightly older than the median age of 436 Ma. This difference, however, shows that the ages are not distributed normally about the mean within this interval and suggests that these samples have experienced variable degrees of Pb-loss despite their relative concordance (Fig. 10). Consequently, this average age must be viewed as a minimum age. If Pb-loss is responsible for the dispersion of ages among the <6% discordant group, then the average of the 10 oldest samples may provide a better estimate of the time of crystallization and emplacement. This age remains somewhat arbitrary (choosing 10 rather than 8 or 12), but is more likely to avoid the degradation of $^{206}Pb/^{238}U$ ages inevitably associated with Pb-loss. The resulting age is 454±9 Ma (2 s.e.m.) and likely provides the best estimate of the crystallization age of the Farmville protolith.

TABLE 3. U-Pb DATA FOR ZIRCON ANALYSIS

Farmville Gneiss
Sample A-6

Spot	U/ppm	Th/ppm	Th/U	204Pb/206Pb	206Pb/238U	1 σ %	207Pb/235U	1 σ %	207Pb/206Pb	1 σ %	Age 206/238	1 σ	Age 207/235	1 σ	Age 207/206	1 σ	% D
Set 1																	
A6-1.1	1075	463	0.43	0.0001	0.2327	2.3766	2.9651	2.6468	0.0924	0.8981	1349	29	1399	20	1476	17	4%
A6-2.1	283	175	0.62	0.0012	0.0753	3.1607	0.6947	13.4799	0.0669	12.7167	468	14	536	58	835	290	13%
A6-3.1	511	403	0.79	0.0003	0.0914	2.2543	0.7198	4.6499	0.0571	3.7984	564	12	551	20	497	86	-2%
A6-4.1	729	492	0.67	0.0003	0.0702	2.8917	0.5622	6.9123	0.0581	5.9229	437	12	453	26	533	135	3%
A6-5.1	753	880	1.17	0.0002	0.0753	2.3101	0.5812	6.1686	0.0560	5.4325	468	10	465	23	451	126	-1%
A6-6.1	875	307	0.35	0.0000	0.0769	2.1705	0.6059	3.3899	0.0571	2.3463	478	10	481	13	496	53	1%
A6-7.1	1077	550	0.51	0.0013	0.0682	2.2297	0.5382	8.8492	0.0573	8.2955	425	9	437	32	502	194	3%
A6-8.1	332	300	0.90	0.0002	0.0746	2.6534	0.5876	8.5262	0.0571	7.7745	464	12	469	33	496	181	1%
A6-9.1	1868	1460	0.78	0.0004	0.0731	2.1489	0.5555	3.5102	0.0552	2.5204	455	9	449	13	418	57	-1%
A6-10.1	508	278	0.55	0.0003	0.0714	2.6187	0.5527	6.1628	0.0561	5.2557	445	11	447	23	457	121	0%
Set 2																	
A6-1.1	680	181	0.27	0.0000	0.0694	0.5157	0.5481	1.2383	0.0572	1.1257	433	2	444	5	501	25	2%
A6-2.1	286	139	0.50	-0.0001	0.0680	0.8020	0.5103	2.4530	0.0544	2.3167	424	3	419	10	388	52	-1%
A6-3.1	129	45	0.36	0.0004	0.0585	1.3038	0.4172	6.3462	0.0521	6.2022	364	5	354	22	288	142	-3%
A6-4.1	666	208	0.32	0.0002	0.0710	0.4968	0.5387	1.9927	0.0552	1.9271	441	2	438	9	421	43	-1%
A6-5.1	253	111	0.45	0.0000	0.0649	0.8235	0.5223	2.1549	0.0584	1.9910	405	3	427	9	545	44	5%
A6-6.1	999	699	0.72	0.0004	0.0642	0.4120	0.4605	5.8874	0.0524	5.8612	398	2	385	23	303	134	-4%
A6-7.1	186	131	0.73	0.0001	0.0695	1.0025	0.5115	3.2369	0.0535	3.0753	432	4	419	14	350	70	-3%
A6-8.1	348	172	0.51	0.0000	0.0700	0.7393	0.5526	1.8770	0.0573	1.7253	436	3	447	8	503	38	2%
A6-9.1	482	149	0.32	0.0000	0.0679	0.6120	0.5332	1.6545	0.0570	1.5368	423	3	434	7	491	34	2%
A6-10.1	2068	1969	0.98	0.0000	0.0681	0.2956	0.5237	1.0590	0.0558	1.0162	424	1	428	5	446	23	1%
A6-11.1	200	109	0.56	0.0002	0.0692	0.9612	0.5163	3.5066	0.0543	3.3685	430	4	423	15	382	76	-2%
A6-12.1	68	44	0.68	-0.0002	0.0708	1.6777	0.5737	7.0380	0.0585	6.8225	443	7	460	32	550	149	4%
A6-13.1	44	31	0.72	-0.0006	0.0734	1.9923	0.6204	9.7373	0.0607	9.5091	461	9	490	48	627	205	6%
A6-14.1	1430	1130	0.82	0.0002	0.0612	0.3474	0.4804	2.0190	0.0572	1.9877	381	1	398	8	498	44	4%
A6-15.1	156	57	0.38	0.0001	0.1972	0.8295	2.2506	1.5738	0.0829	1.3365	1159	9	1197	19	1266	26	3%
A6-7.2	221	77	0.36	-0.0001	0.0675	0.9199	0.5280	2.8928	0.0567	2.7406	421	4	430	12	479	61	2%
A6-16.1	286	233	0.84	0.0001	0.0662	0.7672	0.5069	2.9711	0.0556	2.8665	412	3	416	12	438	64	1%
A6-17.1	333	6	0.02	0.0002	0.0559	0.7774	0.3804	3.2983	0.0496	3.2022	349	3	327	11	175	75	-7%
A6-18.1	977	629	0.66	0.0001	0.0713	0.4223	0.5435	1.3161	0.0553	1.2455	444	2	441	6	425	28	-1%
A6-19.1	334	245	0.76	0.0001	0.0699	0.7418	0.5348	2.1507	0.0555	2.0177	435	3	435	9	434	45	0%
A6-20.1R	815	333	0.42	0.0000	0.0700	0.4612	0.5512	1.5334	0.0572	1.4608	436	2	446	7	498	32	2%
A6-21.1R	703	91	0.13	0.0018	0.0575	0.5266	0.4552	12.3728	0.0594	12.3425	349	3	381	47	580	268	8%
A6-22.1R	678	180	0.27	0.0000	0.0674	0.4916	0.5182	1.3039	0.0558	1.2075	420	2	424	6	443	27	1%
A6-7.3R	1112	6	0.01	0.0000	0.0496	0.4250	0.3652	1.4387	0.0534	1.3735	312	1	316	5	345	31	1%
A6-13.2R	1640	22	0.01	0.0001	0.0560	0.3958	0.4011	1.5954	0.0521	1.5445	350	1	342	5	289	35	-2%
A6-17.2R	2919	44	0.02	0.0000	0.0517	0.2817	0.3814	0.7700	0.0535	0.7166	325	1	328	3	348	16	1%

Notes:
r indicates radiogenic (corrected for common Pb based on measured 204Pb counts)
204Pb/206Pb < 0.0000 given as 0.0000
Red entries indicate Th/U < 0.1
Gray entries indicate common 206Pb >1%.
R in label indicates overgrowth
% D idicates discordance of 206/238 and 207/235 ages
All errors are one sigma

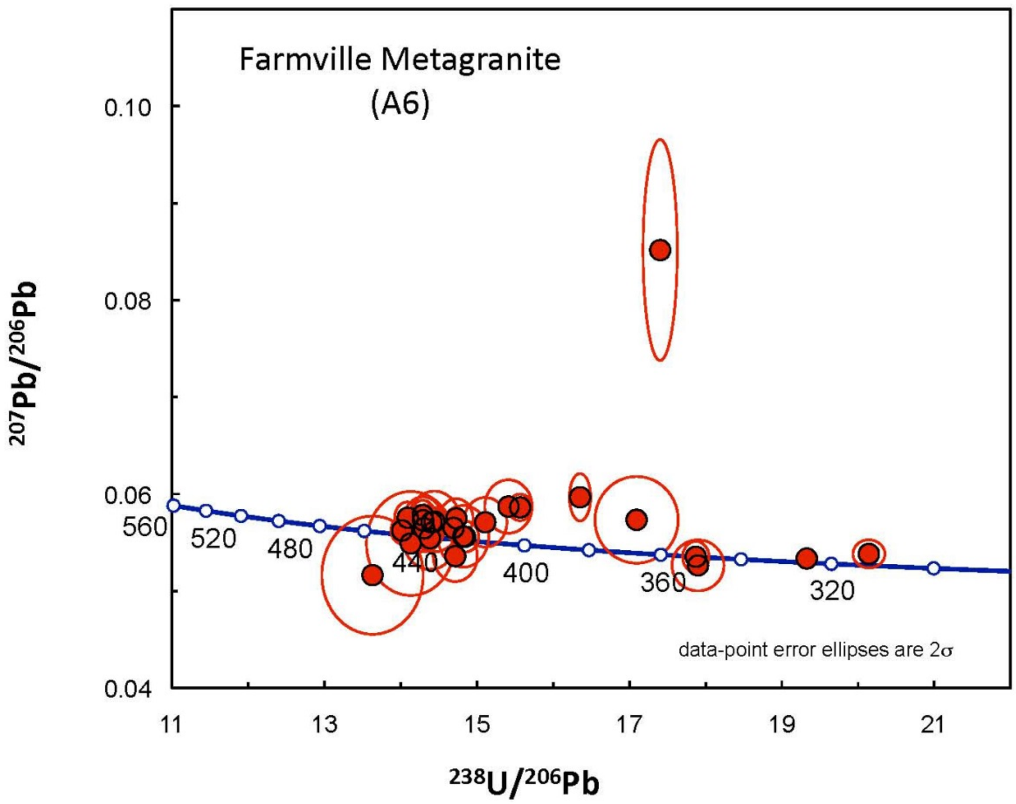

Figure 10. Tera-Wasserburg Concordia plot of U-Pb SHRIMP-RG data from thirty-two zircon grains extracted from Farmville Metagranite sample A-6. Error envelopes are 2-sigma (from Hawkins et al., 2013).

Another group of analyses shows much lower $^{206}Pb/^{238}U$ ages and much lower Th/U than the data discussed above, and supports the argument of age-degradation by Pb-loss. Five analyses with the lowest Th/U (0.01-0.13) range from 350 to 312 Ma with an average of 337Ma. Low Th/U ratios typically indicate hydrothermal growth because of the enhanced mobility of U under oxidizing conditions (Rubatto, 2002; Mueller et al., 2011). These five analyses are a sub-set of 10 analyses that are between 412 and 312 Ma and likely represent cases of Pb-loss generally more severe than the loss experienced among the 22 analyses that yield the minimum age estimate of 440 Ma. For example, these samples show a negative relationship between discordance and age (Table 3). The youngest ages in this group are 325 and 312 Ma (0.01 Th/U) and 1% discordant. Assuming these ages provide the best estimate of the time of disturbance of the U-Pb system, they suggest an early Alleghanian tectonothermal event.

In addition to these probable magmatic grains, this sample also contains three zircons that are likely xenocrysts. Two are Mesoproterozoic and <5% discordant at 1476 and 1266 Ma ($^{207}Pb/^{206}Pb$ ages). The third grain is 3% discordant at 564 Ma ($^{206}Pb/^{238}Pb$ age). Although the older grains correspond to known geologic provinces that may underlie the Farmville area (e.g., Granite-Rhyolite and Grenville respectively), the late Neoproterozoic grain (564 Ma) is more difficult to place. The Farmville formed prior to the Alleghanian collision that sutured Gondwanan crust to Laurentia in the southernmost Appalachians (e.g., Suwannee terrane; Mueller et al., 2013) or the central Appalachians (e.g., Carolinia; Hibbard et al., 2002). It is more likely, therefore, that magmatism of this age was associated with late Iapetan rifting of eastern Laurentia (e.g., Thomas, 2011).

These U-Pb data from single zircons contrast with previous geochronology, such as the ~369 Ma whole-rock Rb-Sr date reported by Goldberg and Burnell (1987) and Goldberg and Steltenpohl (1990), which they interpreted to represent the time of synkinematic intrusion. This interpretation conformed to the arguments of Tull (1980), who proposed that the Acadian event was fundamental in rocks throughout the Alabama Piedmont. In fact, many workers have cited Goldberg and Burnell's (1987) Devonian Rb-Sr date on the Farmville as evidence for widespread Acadian metamorphism (e.g. Goldberg and Steltenpohl, 1990; Drummond et al., 1997). Goldberg and Steltenpohl (1990) also stated that field and petrologic information available at the time of their report did not restrict the Farmville to the interpretation of synmetamorphic crystallization but, rather, the melts could have crystallized prior to kyanite/sillimanite-grade metamorphism. Partial resetting of the Rb-Sr systematics during the Alleghanian as well as during Devonian metamorphism is a viable explanation for the Devonian Rb-Sr date.

In related geochronology, Goldberg and Steltenpohl (1990) also reported a Rb-Sr whole-rock isochron age of 341 ± 10 Ma for Auburn Schist, which they interpreted to reflect prolonged fluid mobility and alteration related to intrusion of the Farmville Metagranite. Steltenpohl and Kunk (1990) remarked, however, that this interpretation requires maintenance of a hydrothermal system about the Farmville pluton for 25-30 m.y., which seems difficult on thermal grounds. More favored is an alternative interpretation of Goldberg and Steltenpohl (1990) for reheating and metamorphism during early Alleghanian activity at ~341 Ma. The ~325–312 Ma ages for zircon rims from the Farmville Metagranite are likely metamorphic and imply reheating and subsequent metamorphism during mid-Carboniferous, early Alleghanian activity. This is consistent with dates on the youngest zircon rims recorded for rocks of the northern Georgia, South Carolina, and North Carolina Inner Piedmont, as reported by Hatcher and Merschat (2006).

Exhumation and cooling from early-Alleghanian metamorphism is recorded by $^{40}Ar/^{39}Ar$ mineral cooling dates reported by Steltenpohl and Kunk (1993). A $^{40}Ar/^{39}Ar$ date of ~320 Ma for hornblende from the Opelika Complex reflects cooling through the ~500 °C (Ar-isotopic closure temperature for hornblende) isotherm. Muscovite from a sample of Auburn Schist is 296±1.5 Ma , and biotite from a sample of Farmville Metagranite is 293.1±1.0 Ma and reflect cooling through the ~350 °C and ~300 °C isotherms (Ar-isotopic closure temperatures for muscovite and biotite), respectively.

In summary, the Farmville Metagranite crystallized at ~450 Ma, was metamorphosed under peak conditions at ~369 Ma (Neoacadian), reheated again between ~341 and ~329 Ma (Early Alleghanian), and then was exhumed and cooled through ~500 °C at ~320-319 Ma and ~350-300 °C at ~296-293 Ma (Fig. 11). This thermochronological record arguably is the most tightly constrained and robust currently reported for any rock from the most southern exposures of the Appalachians, and as such provides important constraints on orogenic evolution, which is discussed below.

Tallassee Metaquartzite

U-Pb isotope analyses on detrital zircons from two samples of Tallassee Metaquartzite of the Jacksons Gap Group, A-2 and A-4, were performed via SHRIMP-RG (Fig. 12; see Figure 2 and Table 1 for locations) at the Stanford-USGS laboratory (Table 4) using methods described in

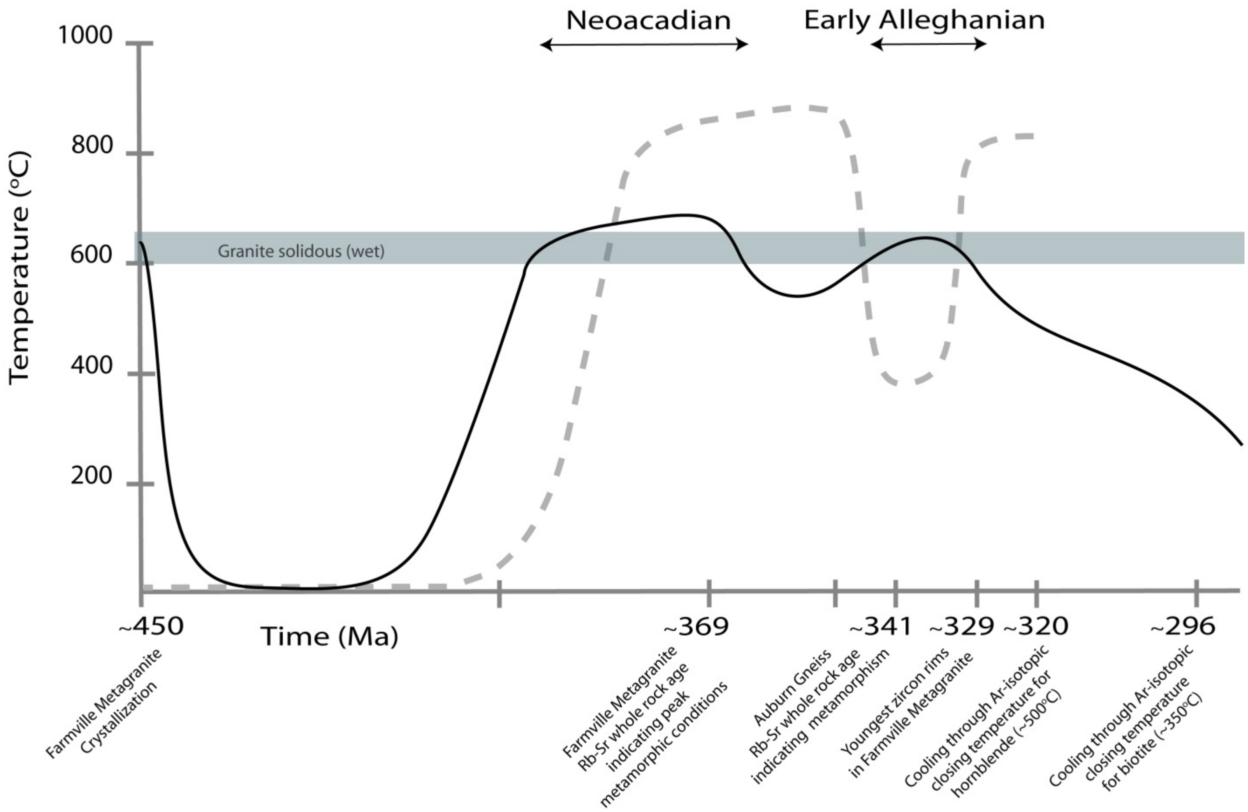

Figure 11. Tectonothermal time line for the Farmville Metagranite (solid-line). Gray, dashed-line represents the tectonothermal time line for the Inner Piedmont of Georgia and the Carolinas (modified after Merschat and Hatcher, 2006). See text.

TABLE 4. U-Pb DATA FOR ZIRCON ANALYSIS

Tallassee Metaquartzite

Sample A-2

Spot	U/ppm	Th/ppm	Th/U	204Pb/206Pb	206Pbr/238U	% 1s	207Pbr/235U	% 1s	207Pbr/206Pbr	% 1s	AGE 6/38	1s	AGE 7/35	1s	AGE 7/6	1s	% D
Set 1																	
A2-1.1	259	267	1.03	0.0001	0.1759	2.728	1.9095	4.378	0.0787	3.100	1045	26	1084	30	1165	63	3.7%
A2-2.1	56	30	0.54	0.0016	0.1569	6.577	1.5263	19.100	0.0706	17.123	940	58	941	125	944	397	0.1%
A2-3.1	298	73	0.25	0.0001	0.2217	2.418	2.7414	3.833	0.0897	2.687	1291	28	1340	29	1419	52	3.7%
A2-4.1	682	311	0.46	0.0000	0.1830	2.815	1.9067	3.380	0.0756	1.548	1083	28	1083	23	1084	31	0.0%
A2-5.1	56	9	0.16	0.0003	0.1873	6.315	1.9715	10.444	0.0763	7.572	1107	65	1106	73	1104	159	-0.1%
A2-6.1	133	199	1.49	0.0000	0.2023	4.796	2.2434	5.599	0.0804	2.350	1187	52	1195	40	1208	47	0.6%
A2-7.1	753	374	0.50	0.0001	0.1703	2.783	1.7067	4.277	0.0727	2.917	1014	26	1011	28	1005	60	-0.3%
A2-8.1	199	174	0.88	0.0003	0.2247	3.609	2.6766	4.984	0.0864	3.010	1307	43	1322	38	1347	59	1.1%
A2-9.1	643	59	0.09	0.0001	0.1655	2.170	1.6459	2.907	0.0721	1.691	987	20	988	19	990	35	0.1%
A2-10.1	198	35	0.18	0.0000	0.1952	7.348	2.2461	7.781	0.0835	1.809	1149	78	1196	56	1280	36	3.9%
A2-11.1	475	162	0.34	0.0000	0.1977	2.428	2.1876	2.819	0.0803	1.159	1163	26	1177	20	1203	23	1.2%
A2-12.1	60	27	0.46	0.0002	0.1923	3.604	2.2361	5.799	0.0844	4.114	1134	38	1192	42	1301	82	4.9%
A2-13.1	292	124	0.43	0.0004	0.2447	2.350	2.8457	3.538	0.0843	2.372	1411	30	1368	27	1300	47	-3.2%
A2-14.1	66	34	0.52	0.0002	0.2738	3.514	3.6159	5.359	0.0958	3.633	1560	49	1553	44	1544	70	-0.4%
Set 2																	
A2-1	84	76	0.93	0.0000	0.5396	0.814	13.4386	1.510	0.1806	0.878	2782	28	2711	101	2659	15	-2.6%
A2-2	352	31	0.09	0.0000	0.2562	1.540	3.1831	0.982	0.0901	0.736	1470	9	1453	214	1428	14	-1.2%
A2-3	1350	332	0.25	0.0000	0.1918	2.903	1.9792	0.566	0.0749	0.449	1131	4	1108	177	1065	9	-2.0%
A2-4	104	43	0.42	0.0001	0.2099	0.818	2.2130	1.987	0.0765	1.565	1228	14	1185	489	1107	31	-3.6%
A2-5	180	99	0.57	0.0001	0.2086	1.098	2.2129	1.810	0.0769	1.564	1221	10	1185	454	1120	31	-3.1%
A2-6	220	65	0.30	0.0001	0.2070	1.186	2.1970	1.395	0.0770	1.111	1213	9	1180	368	1121	22	-2.8%
A2-7	274	90	0.34	0.0001	0.2066	1.323	2.1881	1.401	0.0768	1.179	1210	8	1177	370	1117	24	-2.8%
A2-8	790	34	0.04	0.0001	0.1848	2.620	1.9668	1.111	0.0772	1.043	1093	4	1104	323	1126	21	1.0%
A2-9	91	31	0.35	0.0007	0.1415	0.761	1.2648	6.093	0.0648	5.949	853	10	830	1326	769	125	-2.8%
A2-10	353	156	0.46	0.0003	0.1657	1.621	1.6679	1.704	0.0730	1.588	989	6	996	501	1014	32	0.8%
Set 3																	
A2-1.1	77	80	1.07	0.0000	0.5245	0.953	13.4151	1.345	0.1855	0.840	2718	23	2709	91	2703	14	-0.3%
A2-2.1	407	38	0.10	0.0000	0.2489	1.892	3.1648	0.876	0.0922	0.698	1433	7	1449	194	1472	13	1.1%
A2-3.1	1207	310	0.27	0.0000	0.1848	3.178	1.9376	0.582	0.0760	0.489	1093	3	1094	183	1096	10	0.1%
A2-4.1	107	43	0.41	0.0000	0.1991	0.968	2.1394	1.891	0.0779	1.584	1170	11	1162	479	1146	31	-0.7%
A2-5.1	132	84	0.66	0.0000	0.2073	0.872	2.2730	2.074	0.0795	1.728	1214	13	1204	498	1186	34	-0.9%
A2-6.1	550	314	0.59	0.0001	0.0730	1.462	0.5610	2.075	0.0557	1.959	454	3	452	858	442	44	-0.4%
A2-7.1	358	126	0.37	0.0000	0.1942	1.416	2.1200	1.290	0.0792	1.079	1144	7	1155	351	1176	21	0.9%
A2-8.1	148	35	0.25	0.0001	0.2671	0.948	3.5272	1.773	0.0958	1.425	1526	14	1533	336	1543	27	0.5%
A2-9.1	86	32	0.39	0.0004	0.1486	0.658	1.3808	4.620	0.0674	4.362	893	13	881	1095	850	91	-1.4%
A2-10.1	346	184	0.55	-0.0001	0.1850	1.332	1.9497	1.527	0.0764	1.330	1094	8	1098	424	1106	27	0.4%
A2-21.1	140	37	0.27	0.0000	0.2019	0.895	2.2658	1.920	0.0814	1.562	1186	12	1202	470	1231	31	1.3%
A2-31.1	179	49	0.28	0.0000	0.2251	1.015	2.6776	1.628	0.0863	1.297	1309	12	1322	372	1344	25	1.0%
A2-30.1	477	150	0.33	0.0000	0.1989	1.599	2.2711	1.089	0.0828	0.892	1169	7	1203	292	1265	17	2.8%
A2-40.1	335	99	0.30	0.0000	0.1655	1.331	1.6748	1.423	0.0734	1.209	987	7	999	433	1024	24	1.1%
A2-50.1	530	9	0.02	0.0000	0.1769	1.726	1.7660	1.091	0.0724	0.925	1050	6	1033	338	997	19	-1.6%
A2-11.1	225	79	0.36	0.0000	0.1712	1.086	1.6865	1.674	0.0714	1.398	1019	9	1003	492	970	29	-1.6%
A2-12.1	123	61	0.51	0.0000	0.1847	0.811	1.8989	2.193	0.0746	1.813	1092	12	1081	572	1057	37	-1.1%
A2-13.1	170	57	0.34	0.0001	0.1675	0.928	1.6473	2.202	0.0713	1.920	998	10	988	615	967	39	-1.0%
A2-14.1	120	43	0.37	0.0001	0.2024	0.799	2.1479	2.335	0.0770	1.972	1188	14	1164	563	1120	39	-2.0%
A2-15.1	86	43	0.52	0.0000	0.2548	0.725	3.1813	2.236	0.0906	1.760	1463	18	1453	435	1437	34	-0.7%
A2-16.1	2068	173	0.09	0.0001	0.1351	3.075	1.3002	0.704	0.0698	0.625	817	2	846	271	922	13	3.4%
A2-17.1	160	56	0.36	0.0000	0.2458	0.954	3.0788	1.629	0.0909	1.247	1417	13	1427	341	1444	24	0.8%
A2-18.1	202	25	0.13	0.0000	0.1792	1.039	1.8081	1.713	0.0732	1.417	1063	9	1048	484	1018	29	-1.4%
A2-19.1	242	93	0.40	0.0000	0.2107	1.157	2.3851	1.437	0.0821	1.148	1233	10	1238	359	1248	22	0.4%
A2-20.1	65	15	0.24	0.0001	0.1771	0.586	1.9003	3.223	0.0778	2.734	1051	17	1081	759	1142	54	2.8%
A2-22.1	81	48	0.61	0.0001	0.2333	0.692	2.7502	2.423	0.0855	1.944	1352	18	1342	506	1327	38	-0.7%
A2-23.1	79	41	0.54	0.0000	0.1655	0.640	1.6616	2.867	0.0728	2.405	987	14	994	742	1009	49	0.7%
A2-24.1	767	145	0.20	0.0000	0.1790	2.007	1.8348	0.917	0.0743	0.770	1062	5	1058	284	1050	16	-0.4%
A2-25.1	434	142	0.34	0.0000	0.1786	1.527	1.8049	1.183	0.0733	0.985	1059	6	1047	357	1022	20	-1.1%
A2-26.1	67	43	0.65	0.0000	0.1787	0.605	1.8226	3.027	0.0740	2.535	1060	16	1054	740	1040	51	-0.6%
A2-27.1	485	66	0.14	0.0001	0.1784	0.603	2.4558	2.856	0.0998	2.324	1058	16	1259	612	1621	43	15.9%
A2-28.1	94	25	0.28	0.0000	0.1931	0.709	1.9786	2.497	0.0743	2.061	1138	15	1108	618	1050	42	-2.7%
A2-29.1	608	62	0.10	0.0000	0.1744	1.743	1.7579	1.058	0.0731	0.889	1036	5	1030	330	1017	18	-0.6%
A2-32.1	156	73	0.49	0.0000	0.2605	0.955	3.3875	1.870	0.0943	1.550	1493	14	1501	360	1514	29	0.6%

TABLE 4. U-Pb DATA FOR ZIRCON ANALYSIS *(continued)*

Tallassee Metaquartzite

Sample A-2

Spot	U/ppm	Th/ppm	Th/U	204Pb/206Pb	206Pbr/238U	% 1s	207Pbr/235U	% 1s	207Pbr/206Pbr	% 1s	AGE 6/38	1s	AGE 7/35	1s	AGE 7/6	1s	% D
Set 3 (continued)																	
A2-33.1	73	77	1.09	0.0000	0.1845	0.625	1.9014	2.803	0.0747	2.302	1092	16	1082	686	1061	46	-0.9%
A2-34.1	111	42	0.39	-0.0001	0.2511	0.811	3.2331	2.068	0.0934	1.660	1444	16	1465	404	1496	31	1.4%
A2-35.1	39	46	1.22	0.0001	0.1897	0.450	1.9799	4.030	0.0757	3.364	1120	23	1109	869	1088	67	-1.0%
A2-36.1	81	36	0.46	0.0002	0.1747	0.632	1.6316	3.917	0.0677	3.583	1038	15	982	926	860	74	-5.7%
A2-37.1	209	114	0.56	0.0000	0.2042	1.074	2.2397	1.570	0.0796	1.264	1198	10	1194	401	1186	25	-0.4%
A2-38.1	285	44	0.16	0.0000	0.1804	1.228	1.8843	1.444	0.0758	1.193	1069	8	1076	412	1089	24	0.6%
A2-39.1	480	140	0.30	0.0000	0.1727	1.592	1.7384	1.158	0.0730	0.973	1027	6	1023	358	1014	20	-0.4%
A2-41.1	298	132	0.46	0.0001	0.1639	1.223	1.5787	1.746	0.0699	1.543	978	7	962	525	924	32	-1.7%
A2-42.1	361	168	0.48	0.0000	0.2023	1.388	2.2138	1.228	0.0794	0.994	1187	8	1185	329	1182	20	-0.2%
A2-43.1	78	34	0.45	0.0000	0.2198	0.649	2.4692	2.539	0.0815	2.019	1281	18	1263	558	1232	40	-1.4%
A2-44.1	244	114	0.48	-0.0001	0.1840	1.122	1.8928	1.681	0.0746	1.425	1089	9	1079	465	1058	29	-0.9%
A2-45.1	551	96	0.18	0.0000	0.1940	1.710	2.0788	1.000	0.0777	0.812	1143	6	1142	286	1139	16	-0.1%
A2-46.1	189	90	0.49	0.0001	0.1814	1.000	1.9863	1.842	0.0794	1.546	1075	10	1111	488	1182	31	3.2%
A2-47.1	61	28	0.48	0.0000	0.5281	0.639	13.4492	1.898	0.1847	1.074	2733	35	2712	125	2696	18	-0.8%
A2-48.1	218	23	0.11	0.0000	0.2286	1.081	2.6092	1.506	0.0828	1.188	1327	11	1303	354	1264	23	-1.8%
A2-49.1	103	55	0.55	-0.0001	0.1764	0.719	1.7761	2.774	0.0730	2.400	1047	13	1037	703	1014	49	-1.0%
A2-51.1	104	28	0.28	0.0000	0.1696	0.728	1.7700	2.439	0.0757	2.016	1010	13	1034	641	1087	40	2.4%
A2-52.1	181	164	0.93	0.0001	0.1916	0.977	2.0102	1.993	0.0761	1.710	1130	11	1119	516	1097	34	-1.0%
A2-53.1	532	120	0.23	0.0000	0.1962	1.719	2.2408	1.089	0.0828	0.921	1155	6	1194	294	1265	18	3.3%
A2-54.1	220	78	0.37	0.0000	0.2006	1.104	2.1251	1.569	0.0768	1.281	1179	10	1157	413	1116	26	-1.9%
A2-55.1	372	199	0.55	0.0000	0.2331	1.457	2.7309	1.112	0.0850	0.874	1351	8	1337	265	1315	17	-1.0%
A2-56.1	124	46	0.38	0.0001	0.2461	0.835	3.0458	2.290	0.0898	1.952	1418	15	1419	455	1421	37	0.1%
A2-57.1	225	7	0.03	0.0000	0.1776	1.085	1.8160	1.669	0.0741	1.391	1054	9	1051	473	1045	28	-0.3%
A2-58.1	71	30	0.43	0.0001	0.1687	0.603	1.6899	3.328	0.0727	2.884	1005	15	1005	818	1005	59	0.0%
A2-59.1	255	190	0.77	0.0001	0.1690	1.137	1.7045	1.731	0.0731	1.491	1007	8	1010	502	1018	30	0.3%
A2-60.1	31	28	0.93	0.0006	0.1784	0.397	1.6662	8.070	0.0677	7.666	1058	25	996	1414	861	159	-6.3%

Notes:

r = radiogenic (corrected using Stacey and Kramners (1975) common Pb compositions corresponding to the 206Pb/238U age of the sample and based on measured 204Pb counts)

Red entries indicate analyses with Th/U < 0.1, and may have >1% common 206Pb

Gray entries indicate samples with > 1% common 206Pb

Set 1 = SHRIMP-I, sets 2 and 3 are SHRIMP-RG (single mount, two separate sessions)

% D indicates percentage discordance based on 206/238 vs. 207/235 age

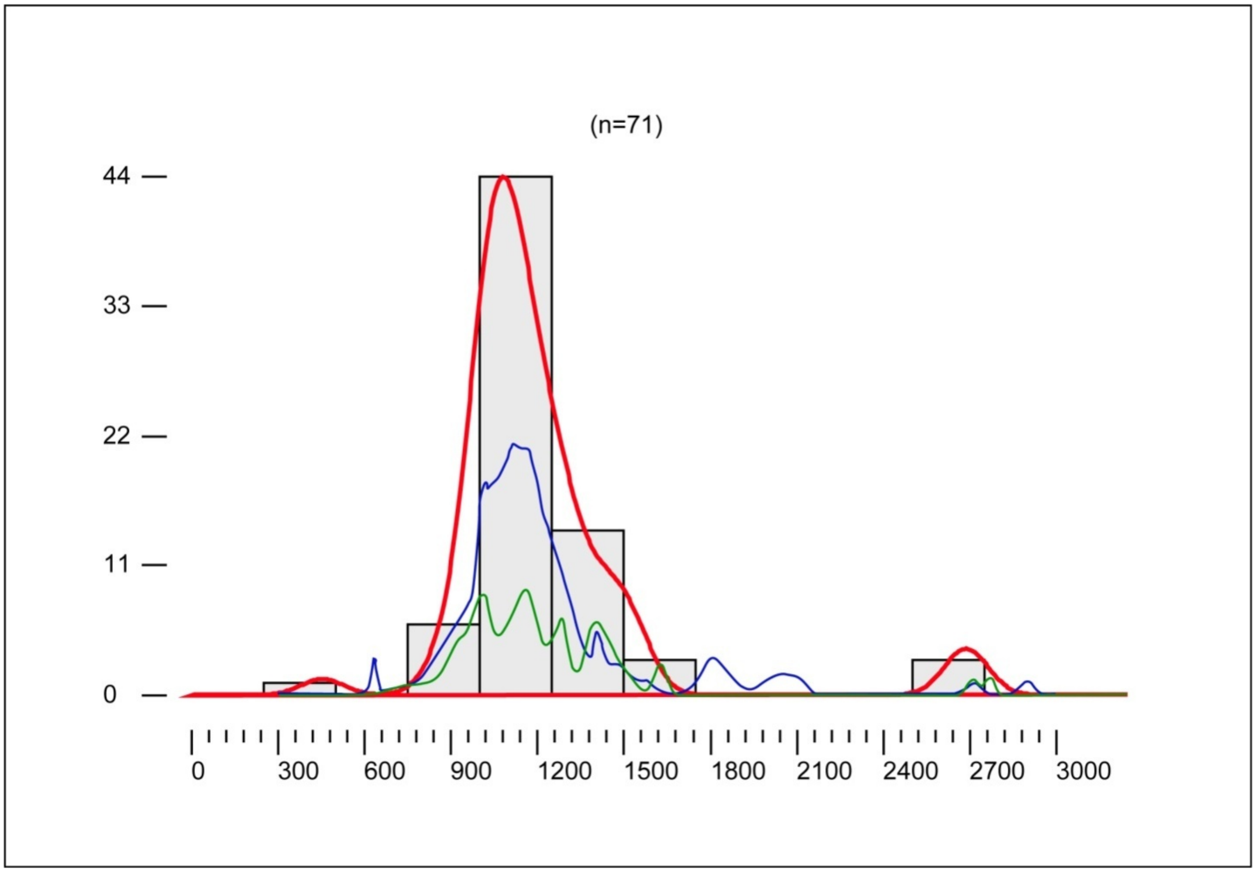

Figure 12. Relative probability plots with histograms of U-Pb ages of detrital zircons. Red population is Tallassee Metaquratzite Sample A-2; light-gray histograms are all Sample A-2 data. Blue population is a metasiliciclastic unit from the Cowrock terrane and the green population is a Dahlonega gold belt unit reported by Merschat et al. (2010). The Y-axis corresponds to the number of analyses per bin and the X-axis is millions of years ago.

Steltenpohl et al. (2010). The objective of this exploratory detrital zircon study was to compare the zircon morphologies and age populations with those reported from the Chattahoochee Palisades Quartzite, Weisner Formation, and the Hollis Quartzite, to which the Tallassee Metaquartzite may correlate (Steltenpohl et al., 2004).

Seventy-one analyses were performed on detrital zircons from sample A-2, from the type locality of the Tallassee Metaquartzite at Thurlow Dam (Fig. 5e). The analyses yielded $^{207}Pb/^{206}Pb$ ages ranging from 2703 Ma to 442 Ma. Sixty-nine of seventy-one analyses are within 5% of Concordia. None of the analyses had Th/U < 0.1, indicating that none of the dates are likely metamorphic. The dates (Fig. 12) suggest that the provenance of the sediment contained a mixture of mid-continent-superior province (3.0 to 2.6 Ga), mid-continent-granite/rhyolite province (1.3 to 1.5 Ga), and Grenville basement lithologies (1.0-1.2 Ga), compatible with a Laurentia provenance signature. The youngest grain, 442 Ma, theoretically sets the maximum age of deposition of the quartzite, but with only one grain and with its age so far from the next closest age it is not an iron-clad indicator of depositional age. It is interesting, however, that Middle Ordovician age populations are reported for Blue Ridge rocks in Georgia (Dahlonega Gold belt; Merschat et al., 2010) and Alabama (Wedowee and Emuckfaw Groups; Tull et al., 2012). Minor Archean populations like sample A-2's are also found in the Dahlonega and Cowrock terranes of the Georgia Blue Ridge (Fig. 12: Merschat et al., 2010).

Fourteen analyses were performed on clear, amber to colorless, rounded zircons from sample A-4. The analyses yielded $^{207}Pb/^{206}Pb$ ages ranging from 1544 Ma to 944 Ma (Fig. 13). Nine of fourteen analyses are within 5% of Concordia; ages for these are 1544, 1347, 1208,

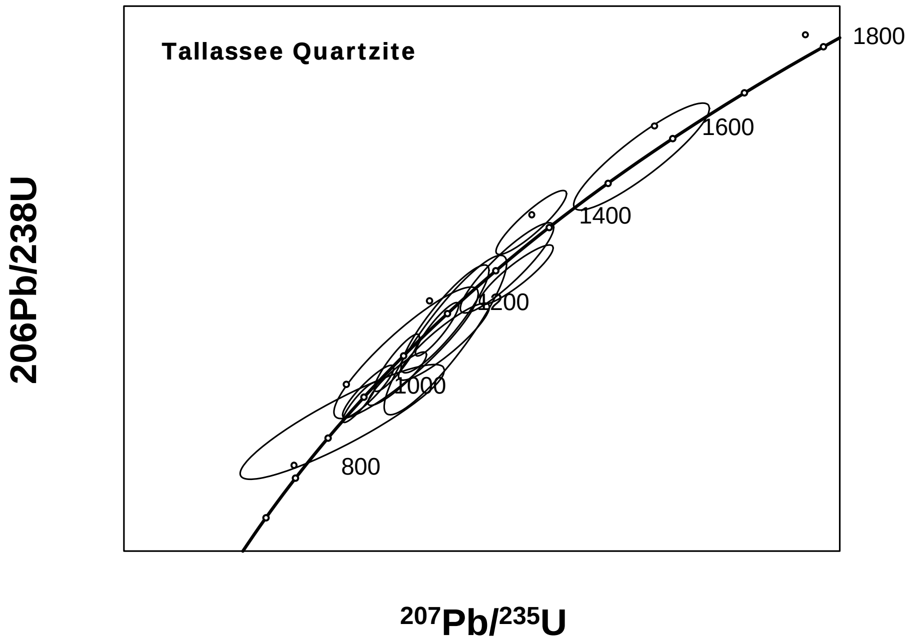

Figure 13. Conventional Concordia plot of U-Pb SHRIMP data from fourteen zircons extracted from Tallassee Quartzite sample A-4. Error envelopes are 2-sigma.

1203, 1104, 1084, 1005, 990, and 944 Ma. These dates suggest that the provenance of the sediment contained a mixture of Grenville-age basement lithologies (1.0-1.2 Ga) and those of the mid-continent granite/rhyolite province (1.3 to 1.5 Ga), a typical eastern Laurentian provenance signature.

A whole-rock Nd isotopic analysis of a metapelite interbedded with the Tallassee Metaquartzite from the same location as Sample A-4 yielded a depleted mantle model age of 1.51 Ga, confirming a component of at least this age is present in the source. Whole-rock Nd isotopic data for two samples of granitic gneiss (Samples A-3a and A-3b) tectonically interleaved with the Jacksons Gap Group (i.e., Keefer's, 1992, Stone Creek Imbricate zone) in the hinge zone of the Tallassee synform, just east of Tallassee, Alabama (Fig. 2), however, yielded depleted mantle model ages of 0.86 and 0.88 Ga. These data indicate that partial melting of a component more juvenile than the sources of zircons recovered from the Jacksons Gap Group sedimentary units was involved in their petrogenesis.

DISCUSSION

The entire tectonostratigraphic package, from structural top to bottom, the Dadeville Complex, Jacksons Gap Group/Loachapoka Schist, and Emuckfaw Group/Auburn Gneiss wraps unbroken around the hinge of the Tallassee synform (Fig. 4). The Opelika Complex thus has been erroneously assigned to the Inner Piedmont and, rather, is an eastward continuation of the Laurentian eastern Blue Ridge. The Dadeville Complex is a very thin allochthonous klippe marking the core of the Tallassee synform and it is in structural contact with this underlying panel of Blue Ridge rocks. A further consequence of these findings is that the base of the eastern Blue Ridge is in direct contact with Laurentian basement/cover units of the Pine Mountain massif along the Towaliga fault, a tectonostratigraphic position equivalent to the Hollins Line/Hayesville fault in more external parts of the orogen. Several regional geologic maps of the southern Appalachians refer to this window of eastern Blue Ridge rocks as the Dog River window (Fig. 1: Higgins and Crawford, 2007; Hatcher et al., 2010) or the Opelika belt (Hibbard et al., 2006). Hatcher et al. (2010) portray the Dog River window as roughly corresponding to the Bill Arp formation (Crawford et al., 1999) in west-central Georgia and extending southwestward across the Alabama-Georgia state line into the Emuckfaw Group. The Dog River window clearly has significance for interpretations of southern Appalachian tectonic evolution but how the window projects northeastward from the area where we have studied it is not yet precisely known.

Along the west limb of the Tallassee synform (Figs. 4a, 4b, and 14), the Jacksons Gap Group defines the Brevard zone lithologies northeastward from Jacksons Gap, Alabama where near Atlanta, Georgia it is known as the Sandy Springs Group (Higgins, 1966, 1968; Medlin and Crawford, 1973; Higgins and McConnell, 1978; Higgins et al., 1988). On many maps, Hatcher and coworkers included these units in the Chauga belt (Hatcher, 1978; Hopson and Hatcher, 1988), and Hatcher (2001) illustrated that the base of the Chauga belt is the western margin of the Brevard fault zone, providing stratigraphic control of the fault. Furthermore, in western North Carolina the Chauga Belt is bounded by a zone of late Alleghanian cataclasite, the Rosman fault, which both the stratigraphic control and the bounding cataclastic zone is similar to what we have observed along the base of the Jacksons Gap Group, that is, the Abanda fault.

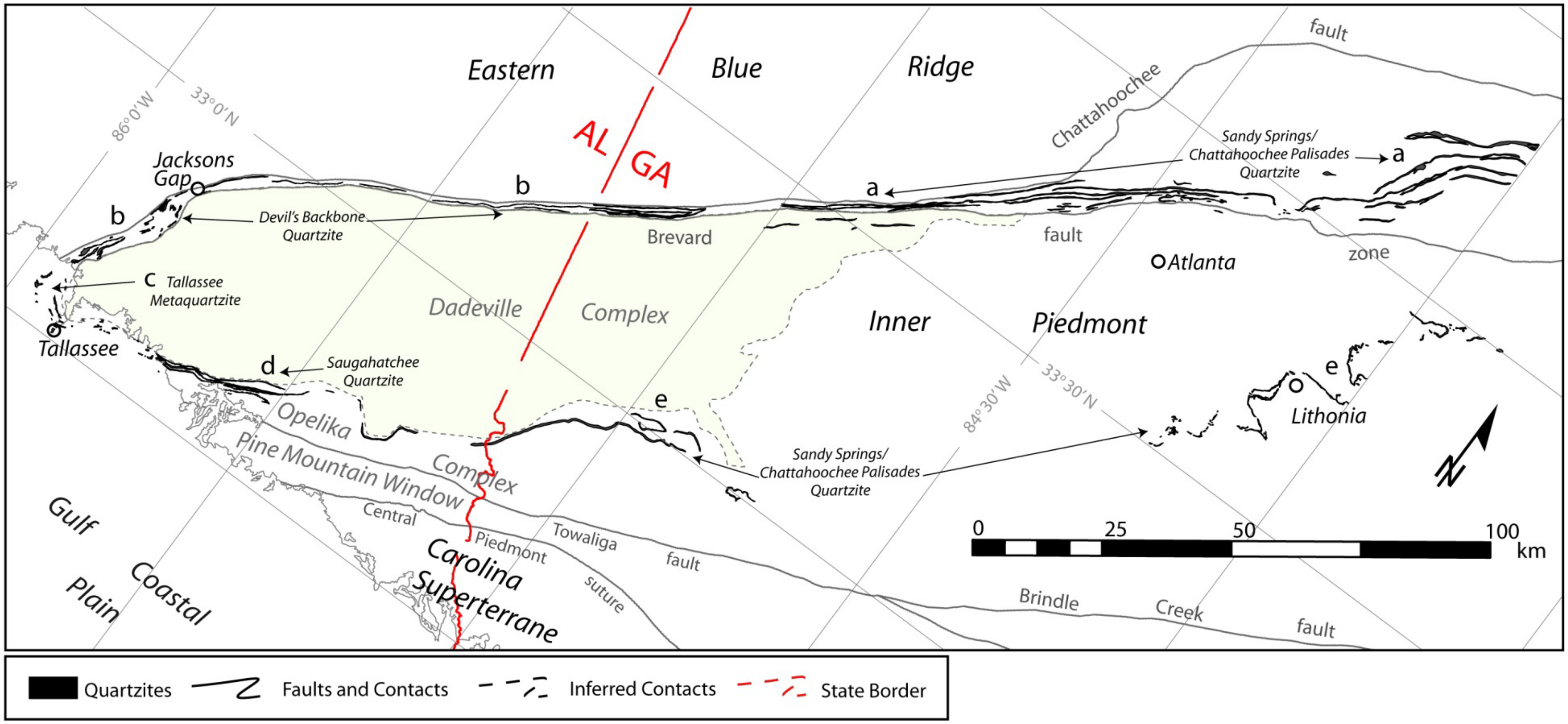

Figure 14. Simplified geologic map illustrating the along strike correlation of Chattahoochee Palisades Quartzite, Devil's Backbone Quartzite, Tallassee Metaquartzite, and Saugahatchee Quartzite. Map is modified after and compiled from Pickering, (1976), Osborne et al. (1988), Sears et al. (1981) Steltenpohl et al. (1990),), Grimes et al. (1993), Higgins and Crawford (2007), and unpublished contributions from Auburn University Geology students noted in acknowledgements. Letters (a-e) key geologic/geographic positions to different stratigraphic sections in Figure 4. See text.

Workers agree that rocks corresponding to Chauga Belt, Sandy Springs Group, and Jacksons Gap Group contain lower-grade metamorphic mineral assemblages than the adjacent units (e.g., greenschist/ lower amphbolite facies vs middle amphibolite facies [kyanite and/or sillimanite grade]); and are interpreted to mostly reflect retrograde metamorphism of the higher-temperature assemblages during the Alleghanian orogeny (Hatcher, 1978; 2001; Hopson and Hatcher, 1988). Locally in Alabama, however, greenschist-to lower-amphibolite facies assemblages are found devoid of evidence for retrogression (Sterling, 2006).   Combined with locally preserved sedimentary structures, which require very low strains (Steltenpohl et al., 2005), and unmetamorphosed limestones (Hatcher, 1978), it is clear that rocks from vastly differing crustal levels are preserved locally along the Brevard zone.

Along the east limb of the Tallassee synform (Figs. 4d, 4e, and 14), Sears et al. (1981) recognized that quartzites and schists of the Loachapoka Schist are discontinuously exposed for nearly 180 kilometers northeastward into central Georgia, where they project into rocks that Higgins et al. (1988) assigned to the Sandy Springs thrust sheet. Higgins et al. (1988) considered the southern Appalachians to comprise thin, west-directed, thrust sheets rather than broader lithotectonic 'belts'. The Sandy Springs Group of Higgins and McConnell (1978) was interpreted by Higgins et al. (1988) to be confined to the Sandy Springs thrust sheet. The Chattahoochee Palisades Quartzite occurs within this group (Figs. 4e and 14) and is associated with an unnamed aluminous schist and an unnamed garnetiferous schist unit (Crawford et al., 1999). Grimes et al. (1993) report that along the Georgia-Alabama border the Saugahatchee quartzite and Loachapoka Schist package is continuous with the Chattahoochee Palisades Quartzite and associated schists (Figs. 4d, 4e, and 14).

Detrital zircon age-populations also support our correlation of the Chattahoochee Palisades Quartzite to the Saugahatchee-Tallassee Quartzites. Crawford et al. (1999) reported discordant U-Pb ages of bulk detrital zircons from a sample of the Chattahoochee Palisades Quartzite north of Lithonia, Georgia (Fig. 14). The ages range from 1.1-1.0 Ga and were interpreted to indicate sediment sourced from Grenville-age basement lithologies (1.0-1.2 Ga). Similarly, our U-Pb isotope analyses on detrital zircons from two samples of Tallassee Metaquartzite indicate that the source contained a mixture of Grenville basement lithologies (1.0-1.2 Ga) and those of the mid-continent granite/rhyolite province (1.3-1.5 Ga) (Hoffman, 1989; Van Schmus et al., 1993). The detrital zircon ages from the Chattahoochee Palisades Quartzite are compatible with the Tallassee metaquartzite, as the absence of the mid-continent granite/rhyolite age population from the former can be explained by temporal differences in sediment transport systems and depositional settings within the crystalline core of Laurentia. In addition, the number and diversity of zircons analyzed preclude the detrital zircon populations from being representative of all possible source areas. The age populations from Tallassee Quartzite sample A-2 (Fig. 12) are much more discriminating, indicating detritus was supplied from the midcontinent-superior province (3.0 to 2.6 Ga), mid-continent granite/rhyolite province (1.3 to 1.5 Ga), Grenville basement lithologies (1.0-1.2 Ga), and a single Middle Ordovician grain, all compatible with a Laurentian source. Middle Ordovician age populations reported for other Blue Ridge rocks in Georgia (see Dahlonega Gold belt analysis in Figure 12; Merschat et al., 2010) and Alabama (Wedowee and Emuckfaw Groups; Tull et al., 2012) are compatible with the interpretation that the Tallassee Quartzite may have a middle Paleozoic age for deposition. Minor Archaen populations like that found in sample A-2 are also found in the Dahlonega and Cowrock terranes of the Georgia Blue Ridge (Fig. 12; Merschat et al., 2010).

In Georgia, existing maps (Higgins et al., 2008; Higgins et al., 1988) indicate that units corresponding to the Sandy Springs Group on the east limb of the Tallassee synform are discontinuously preserved northeast of the state line as klippen. Higgins et al. (2008) depicted the klippen to bend southwest parallel to the Towaliga fault, and also to the north where they trend toward the Brevard fault zone northeast of Atlanta, Georgia. Our lithologic correlation, therefore, suggests that the stratigraphic level of the Jacksons Gap Group and Chattahoochee Palisades quartzites can be continuously traced around the Tallassee synform between Atlanta, Georgia and Tallassee, Alabama even through some lithologies are locally missing (Fig. 4). Based on these correlations we suggest that the name Chattahoochee Palisades Quartzite of Higgins et al. (1988) be applied to the Tallassee Metaquartzite, Devil's Backbone and Saugahatchee quartzites. Similarly, we recommend that the unnamed aluminous schists of the Sandy Springs Group (Crawford et al., 1999) be referred to as the Loachapoka Schist (Bentley and Neathery, 1970).

Grimes et al. (1993) suggested that the Stonewall line may represent a major fault separating the Jacksons Gap Group-Loachapoka Schist from the Dadeville Complex. The position of the Loachapoka Schist is variable due to structural interleaving, and Grimes et al.'s (1993) observations indicate that the actual fault boundary lies along the structural top of the Loachapoka Schist. Keefer (1992) and Grimes and Steltenpohl (1993) reported high-temperature, syn-M_1, annealed mylonitic rocks from along the Stonewall line. These fabrics are only locally overprinted by retrograde, D_2 (the second deformational event), mylonitic shear zones indicating only minor reactivation. The location of the trace of the Stonewall line northeast of the study area is currently not documented. Bentley and Neathery (1970) projected the Stonewall line to continue northeast to merge with the Brevard zone, southwest of Atlanta, Georgia, as depicted in Figure 14. In contrast, Sears et al. (1981) reported that northeast of the Alabama-Georgia state line rocks associated with the Stonewall line become assimilated by granitic plutons and are no longer recognizable but might strike eastward to where it is excised by the Towaliga fault.

On the west limb of the synform, the Katy Creek fault is located in a tectonostratigraphic position equivalent to the Stonewall line. Our mapping indicates that map-scale truncation of lithologic contacts between the Dadeville Complex and that of the Jacksons Gap Group occur along the Katy Creek fault (Fig. 3 and Plate 1). Recognizable retrogressive fabric disruption is only locally observed, however, we interpret the Katy Creek fault to be a pre- or synmetamorphic fault equivalent to the Stonewall line.

Arguably strong evidence supporting equivalence of the eastern Blue Ridge and the Opelika Complex is the distinct pulse of voluminous Ordovician-Silurian (463- 434 Ma) magmatism now documented to intrude both flanks of the Tallassee synform. Ordovician-Silurian granite plutons now are documented throughout the southernmost exposures of the eastern Blue Ridge (Fig. 15A-B). In the Georgia eastern Blue Ridge, Tull and Mueller (2009) determined U-Pb zircon ages of 438±10 Ma from the Mulberry Gneiss, and Higgins et al. (1997) reported an age of 429±4 Ma from the Austell Gneiss. The Lithonia Gneiss can be traced into

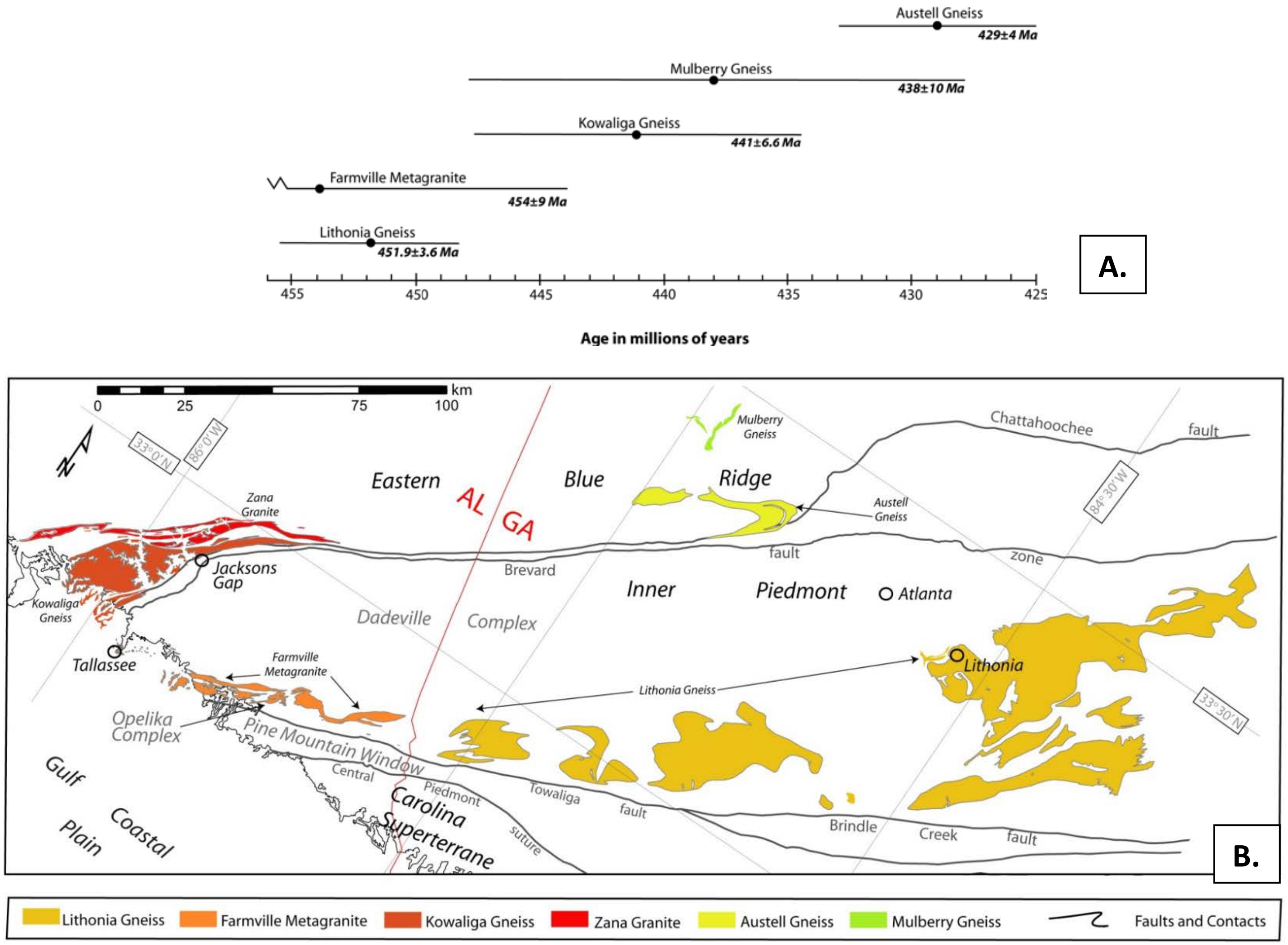

Figure 15. (A.) U-Pb ages of Ordovician-Silurian intrusive rocks of the Austell Gneiss (Higgins et al. 1997), Mulberry Gneiss (Tull and Mueller, 2009), Lithonia Gneiss (Huebner et al., *in press*) compared with that of the Farmville Metagranite and Kowaliga Gneiss (this study). (B.) Simplified geologic map illustrating the Ordovician-Silurian intrusive rocks. Map is modified after and compiled from Pickering, (1976), Osborne et al. (1988), Sears et al. (1981) Steltenpohl et al. (1990),), Grimes et al. (1993), Higgins and Crawford (2007), and unpublished contributions from Auburn University Geology students noted in acknowledgements.

west-central Georgia (Huebner et al., in press) and lies along strike with the Farmville Metagranite, although they are potentially separated by east-trending Stonewall line. Huebner et al. (*in press*) report $^{206}Pb/^{238}U$ ages for the Lithonia Gneiss ranging from 443.8±5.1 Ma to 442.7±5.6 Ma. The Kowaliga and Lithonia Gneisses are arguably the most voluminous plutonic bodies in the southernmost exposures of the crystalline Appalachians, and combined with the Farmville Metagranite, Austell, and Mulberry Gneisses reveal an extensive pulse of Ordovician-Silurian (late Taconian) magmatism.

The Dog River Window clearly represents a large tectonic window of eastern Blue Ridge rocks, through the allochthonous Dadeville Complex. The tectonic affinity of the Dadeville Complex is unknown because the only isotopic date reported for crystallization is a Rb-Sr whole rock isochron age of 462±4 Ma (Middle Ordovician) for the Franklin Gneiss (Seal and Kish, 1990). Clarifying the tectonostratigraphic origin and palinspastic position of the suspect and orphaned Dadeville Complex is easily testable using U-Pb igneous and detrital geochronology and likely will be borne out through future investigations. Hatcher and Merschat (2006), using evidence of southwest-to-northeast aligned mineral stretching lineations in the Dadeville Complex suggested that it was the southwestern extent of a southwest-directed orogen-parallel extruded mid-crustal flow channel during the Acadian/Neoacadian event. In their model, Hatcher and Merschat (2006) argue for a hot Inner Piedmont terrane mobilized to flow through migmatitization. Figure 11 compares Hatcher and Merschat's (2006) temperature-time (T-*t*) path for rocks of the Inner Piedmont (upper plate) in Georgia with the one now tightly established for rocks of the Opelika Complex (lower plate) directly underneath the Dadeville Complex in Alabama, and it demonstrates an antithetic relationship between the two T-*t* curves for the period between ~369 Ma and ~320 Ma. The two curves intersect at ~345 Ma and ~330 Ma, and between these the upper plate had cooled while the lower plate had heated up, consistent with downward heating of the lower plate as suggested by Abrahams (2014). Hence, in addition to supporting southwestward transport of the Dadeville Complex, perhaps by orogen-parallel channel flow, it also accommodates observations for downheating of the eastern Blue Ridge in Alabama.

CONCLUSIONS

Detailed 1:24,000-scale geologic mapping and structural analysis conducted on quadrangles along the west limb, hinge zone, and east limb of the Tallassee synform reveal the entire tectonostratigraphic package, from structural top to bottom, the Dadeville Complex, Jacksons Gap Group/Loachapoka Schist, and Emuckfaw Group/Opelika Complex wraps unbroken around the hinge of the Tallassee synform. Structural and formline analysis constrains the geometry of the cylindrical Tallassee synform indicating a β-axis trend and plunge of N40°E, 12°, clearly demonstrating that S_0/S_1 passes uninterrupted from limb to limb precisely as the lithologic layering does, thus, supporting continuity of the eastern Blue Ridge and Opelika Complex. Aeromagnetic and gravity maps image structural closure of the Tallassee synform directly beneath the Coastal Plain sedimentary cover. Metagranites intruding the metasedimentary rocks along both limbs of the Tallassee synform record a distinct period of Late Ordovician magmagenesis and plutonism, with the 441±6.6 Ma Kowaliga Gneiss to the west and the 454±9 Ma Farmville Metagranite to the east. The new U-Pb dates combine with previously reported geochronology to constrain the most robust thermochronological record currently known for rocks from the most southern exposures of the Appalachians. Finally, initial U-Pb zircon analyses of detrital zircons from the Tallassee Metaquartzite confirms its Laurentian heritage and supports its correlation with the Chattahoochee Palisades Quartzite northeastward along strike in Georgia. The Tallassee/Palisades metasiliciclastics provide a key marker horizon that can be traced discontinuously throughout the Blue Ridge and Inner Piedmont of Alabama and Georgia delimiting a large (1,029 km^2) tectonic window through the Inner Piedmont into the eastern Blue Ridge framed between the autochthonous Laurentian margin/platform to the west and the parauthocthounous Pine Mountain window to the east. Recognized in its entirety, the Dog River window is a fundamental, first-order structure of the southern Appalachian orogen that exposes a huge area of previously unrecognized Laurentian Blue Ridge rocks spanning most of the Alabama Promontory.

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REFERENCES

Abrahams, J.B., 2014: Geology of the Dadeville quadrangle and the Tallassee synform in Characterizing the Dog River Window [M.S. thesis]: Auburn, Auburn University, 140 p.

Adams, G.I., 1926, The crystalline rocks, in Adams, G.I., et al., eds., Geology of Alabama: Alabama Geological Survey Special Report 14, p. 25-40.

Adams, G.I., 1930, Gold deposits of Alabama, and occurrences of copper, pyrite, arsenic and tin: Alabama Geological Survey Bulletin 40, 91 p.

Adams, G.I., 1933, General geology of the crystalline rocks of Alabama: Journal of Geology, v. 41, p. 159-173.

Babaie, H.A., Hadizadeh, J., Babaie, A., and Ghazi, A.M., 1991, Timing and temperature of cataclastic deformation along segments of the Towaliga fault, western Georgia, U.S.A: Journal of Structural Geology, v. 13, p. 579–586, doi:10.1016/0191-8141(91)90044-J.

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, 119 p.

Bieler, D.E., 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 in Alabama, Geological Survey of Alabama, p. 57-72.

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.

Bobyarchick, A.R., Edelman, S.H., and Horton, J.W., Jr., 1988, The role of dextral strike-slip in the displacement history of the Brevard fault zone, in Secor, D.T., Jr., ed., Southeastern Geological Excursions: Geological Society of America 1988 Annual Meeting Field Trip Guidebook, p. 53-104.

Bream, B.R., 2002, The southern Appalachian Inner Piedmont: New perspectives based on recent detailed geologic mapping, Nd isotopic evidence and zircon geochronology, in Hatcher, R.D., and Bream, B.R., eds., Inner Piedmont Geology in the South Mountains-Blue Ridge Foothills and the southwestern Brushy Mountains, central western North Carolina: North Carolina Geological Survey, Carolina Geological Society Annual Field Trip Guidebook, p. 45-63.

Bream, B.R., 2003, Tectonic Implications of Geochronology and Geochemistry of Para- and Orthogneisses from the Southern Appalachian Crystalline Core [Ph.D. dissertation]: Knoxville, Tennessee, University of Tennessee, 296 p.

Bream, B.R., Hatcher, R.D., Jr., Miller, C.F., and Fullagar, P.D., 2001, Geochemistry and provenance of Inner Piedmont paragneisses, NC and SC: Evidence for an internal terrane boundary?: Geological Society of America Abstracts with Programs, v. 33, no. 2, p. 65.

Bream, B.R., Hatcher, R.D., Jr., Miller, C.F., Fullagar, P.D., Tollo, R.P., Corriveau, L., McLelland, J., and Bartholomew, M.J., 2004, Detrital zircon ages and Nd isotopic data from the Southern Appalachian crystalline core, GA–SC–NC–TN; new provenance constraints for part of the Laurentian margin, in Tollo, R.P., et al., eds., Proterozoic tectonic evolution of the Grenville orogen in North America: Geological Society of America Memoir 197, p. 459-475.

Clarke, J.W., 1952, Geology and mineral resources of the Thomaston quadrangle, Georgia: Georgia Geological Survey Bulletin 59, 99 p.

Cook, F.A., Albuagh, D.S., Brown, L.D., Kaufman, S., Oliver, J.E., and Hatcher, R.D., Jr., 1979, Thin-skinned tectonics in the crystalline southern Appalachians; COCORP seismic-reflection profiling of the Blue Ridge and Piedmont: Geology, v. 7, p. 563-567.

Crawford, T.J., Higgins, M.W., Crawford, R.F., Atkins, R.L., Medlin, J.H., and Stern, T.W., 1999, Revision of stratigraphic nomenclature in the Atlanta, Athens, and Cartersville 30’ x 60’ quadrangles, Georgia: Georgia Geological Survey, Bulletin 130, 45 p.

Drummond, M.S., Allison, D.T., and Weslowski, D.J., 1994, Igneous petrogenesis and tectonic setting of the Elkahatchee Quartz Diorite, Alabama Appalachians: Implications for Penobscotian magmatism in the eastern Blue Ridge: American Journal of Science, v. 294, p. 173-236.

Garihan, J.M., and Ranson, W.A., 1992, Structure of the Mesozoic Marietta-Tryon graben, South Carolina and adjacent North Carolina, in Bartholomew, M.J., et al., eds., Basement tectonics 8: Characterization of ancient and Mesozoic continental margins—Proceedings of the 8th International Conference on Basement Tectonics, Butte, Montana, 1988: Dordrecht, Netherlands, Kluwer Academic Publishers, p. 539–555.

Garihan, J.M., Preddy, M.S., and Ranson, W.A., 1993, Summary of mid-Mesozoic brittle faulting in the Inner Piedmont and nearby Charlotte belt of the Carolinas, in Hatcher, R.D., Jr., and Davis, T., eds., Studies of Inner Piedmont geology with a focus on the Columbus Promontory: Carolina Geological Society Field Trip Guidebook, p. 55–66.

Goldberg, SA, 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: Tuscaloosa, Alabama, Alabama Geological Survey, p. 251-257.

Goldberg, S. A., 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.

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, 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 Alabama fall line: Geological Society of America, Southeastern section 42nd Annual Meeting Field Trip Guidebook, 67-94 p.

Grimes, J., Heatherington, A.L., Mueller, P.A., Steltenpohl, M.G., 1997, Tectonic implications of Ordovician U-Pb zircon dates from the Farmville metagranite Geological Society of America Abstracts with Programs, v. 28, p. 21.

Grimes, J.E., Steltenpohl, M.G., Cook. R.B., and Keefer, W.D., 1993, Geology of the southernmost Brevard fault zone, Alabama, and its implications for southern Appalachian tectonostratigraphy, in Hatcher. RD., 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. 91-103.

Hadizadeh, J., Babaie, H.A., and Babaie, A., 1991, Development of interlaced mylonites, cataclasites and breccias: Example from the Towaliga fault, south-central Appalachians: Journal of Structural Geology, v. 13, p. 63–70, doi:10.1016/0191-8141(91)90101-N.

Hatcher, RD., Jr., 1978, The Alto allochthon: A major tectonic feature of the Piedmont of northeast Georgia: Georgia Geologic Survey Bulletin 93, p. 83-86.

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

Hatcher, R.D., Jr., 2001, Rheological partitioning during multiple reactivation of the Paleozoic Brevard fault zone, southern Appalachians, USA, in Holdsworth, R.E., et al., eds., The Nature and Tectonic Significance of Fault Zone Weakening: Geological Society of London Special Publication 186, p. 255–269.

Hatcher, R.D., Jr., 2002, An Inner Piedmont primer, in Hatcher, R.D., Jr., and Bream, B.R., eds., Inner Piedmont geology in the South Mountains-Blue Ridge Foothills and the southwestern brushy Mountains, central-western North Carolina: Carolina Geolgoical Society Field Trip Guidebook, p.1-18.

Hatcher, RD., Jr., 2010, Tectonic map of the Appalachians: in Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region: Boulder Colorado, Geological Society of America Memoir 206.

Hatcher, R.D., Jr., and Zietz, I., 1980, Tectonic implications of regional aeromagnetic and gravity data from the southern Appalachians, in Wones, D., eds., Proceedings, The Caledonides in the U.S.A.: Virginia Polytechnic Institute Memoir 2, p. 83–90.

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., et al., eds., Channel Flow, Ductile Extrusion and Exhumation in Continental Collision Zones: Geological Society of London Special Paper 268, p. 517–541.

Hatcher, R.D., Jr., Bream, B.R., and Merschat, A.J., 2007, Tectonic map of the southern and central Appalachians: A tale of three orogens and a complete Wilson Cycle in Hatcher, R.D., Jr., et al., eds., 4-D Framework of Continental Crust: Boulder, Colorado, Geological Society of America Memoir 200, p. 59-632.

Hawkins, J.F., Steltenpohl, M.G., Zou, H., Mueller, P.A., and Schwartz, J.J., 2013, New constraints on Ordovician magmatism in the southernmost exposures of the eastern Blue Ridge in Alabama: Geological Society of America Abstracts with Programs, v. 45, p. 62.

Hawkins, J.F., 2013, Geology, petrology, and geochronology of rocks in the Our Town, Alabama quadrangle [M.S. thesis]: Auburn, Alabama, Auburn University, 118 p.

Hibbard, J.P., Stoddard, E.F., Secor, D.T., Jr., and Dennis, A.J., 2002, The Carolina zone: Overview of Neo Proterozoic to early Paleozoic peri-Gondwanan terranes along the eastern flank of the southern Appalachians: Earth-Science Reviews, v. 57, p. 299–339, doi:10.1016/S0012-8252(01)00079-4.

Hibbard, J.P., van Staal, C.R., Rankin, D.W., and Williams, H., 2006, Lithotectonic map of the Appalachian orogen, Canada–United States of America: Geological Survey of Canada Map 2096A, scale 1:1,500,000.

Higgins, M.W., 1966, The geology of the Brevard lineament near Atlanta, Georgia: Georgia Geological Survey Bulletin 77, 49 p.

Higgins, M.W., 1968, Geologic map of the Brevard fault zone near Atlanta, Georgia: U.S. Geological Survey Miscellaneous Geologic Investigation Map 1-511, scale 1:50,000.

Higgins, M.W., and McConnell, K.I., 1978, The Sandy Springs Group and related rocks in the Georgia Piedmont; nomenclature and stratigraphy: Georgia Geological Survey Bulletin 93, p. 50-55.

Higgins, M.W., Atkins, R.L., Crawford, T.J., Crawford, R.E, 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, 173 p.

Higgins, M.W., Arth, J.G., Wooden, J.L., Crawford, T.J., Stern, T.W., and Crawford, R.F., 1997, Age and origin of the Austell Gneiss, western Georgia Piedmont–Blue Ridge, and its bearing on the ages of orogenic events in the southern Appalachians, in Sinha, A.K., et al., eds., The Nature of Magmatism in the Appalachian Orogen: Geological Society of America Memoir 191, p. 181–192, doi: 10.1130/0-8137-1191-6.181

Higgins, M.W., Crawford, T.J., Atkins, R.L., and Crawford, R.E, 2003, Geologic map of the Atlanta 30' x 60' quadrangle, Georgia: U.S. Geological Survey Map Miscellaneous Geologic Investigation Map 1-2602, scale 1:100,000.

Higgins, M.W., and Crawford, R.F., 2007, Ongoing compilation of our geologic mapping in the Blue Ridge and Piedmont of Georgia: Geological Society of America Abstracts with Programs, v. 39, no. 2, p. 100.

Hoffman, P.F., 1989, Precambrian geology and tectonic history of North America, in Bally, A.W., and Palmer, A.R., eds., The Geology of North America-An overview: Geological Society of America, The Geology of North America, v. A, p. 447-512.

Hollister, L.S., and Crawford, M.L., 1986, Melt enhanced deformation: A major tectonic process: Geology, v. 14, p. 558-561.

Hopson, J.L., and Hatcher, R.D., Jr., 1988, Structural and stratigraphic setting of the Alto allochthon, northeast 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 230, p. 213-245.

Huebner, M.T., Hatcher, R.D., Jr., and Davis, B.A., 2010, Extent, kinematics, and Mesozoic reactivation of the Alleghanian Towaliga fault, central Georgia Appalachians: Geological Society of America Abstracts with Programs, v. 42, no. 1, p. 128.

Huebner, M.T., Hatcher, R.D., Jr., and Merschat, A.J., 2013, Confirmation of the southwest continuation of the Cat Square terrane, southern Appalachian Inner Piedmont, with implications for middle Paleozoic collisional orogensis: American Journal of Science (in press).

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

Ludwig, K.R., 2012, Isoplot 3.75: A geochronological toolkit for Microsoft Excel: Berkeley Geochronology Center Special Publication no. 5, 75 p.

McClellan, E.A., Steltenpohl, M.G., Thomas, C., and Miller, C., 2007, Isotopic age constraints and metamorphic history of the Talladega belt: New evidence for timing of arc magmatism and terrane emplacement along the southern Laurentian margin: The Journal of Geology, v. 115, p. 541–561, doi:10.1086/519777.

Medlin, J.H., and Crawford, T.J., 1973, Stratigraphy and structure along the Brevard fault zone in western Georgia and Alabama: American Journal of Science, v. 273-A, p. 89-104.

Merschat, A.H., Hatcher, R.D., Jr., and Davis, T.L., 2005, The northern Inner Piedmont, southern Appalachians, USA: Kinematics of transpression and SW-directed mid-crustal flow: Journal of Structural Geology, v. 27, p. 1252–1281, doi:10.1016/j.jsg.2004.08.005.

Merschat, A.J., and Hatcher, R.D., Jr., 2007, The Cat Square terrane: Possible Siluro-Devonian remnant ocean basin in the Inner Piedmont, southern Appalachians, USA, in Hatcher, R.D., Jr., et al., eds., 4-D Framework of Continental Crust: Geological Society of America Memoir 200, p. 553–565.

Merschat, A.J., Hatcher, R.D., Jr., Bream, B.R., Miller, C.F., Byars, H.E., Gatewood, M.P., and Wooden, J.L., 2010, Detrital zircon geochronology and provenance of Southern Appalachian Blue Ridge and Inner Piedmont crystalline terranes, in Tollo, R.P., et al., eds., From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region: Geological Society of America Memoir 206, p. 661–699.

Muangnoicharoen, N., 1975, The geology and structure of a portion of the northern piedmont, east-central Alabama [M.S. thesis]: Tuscaloosa, University of Alabama, 72 p.

Mueller, P. A., Heatherington, A.L., Foster, D.A., Thomas, W.A., and Wooden, J.L., 2013, The Suwannee suture: Significance for Gondwana-Laurentia terrane transfer and formation of Pangaea: Gondwana Research, http://dx.doi.org/10.1016/j.gr.2013.06.018.

Mueller, P. A., Wooden, J.L., Mogk, D.W., and Foster, D.A., 2011, Paleoproterozoic evolution of the Farmington zone: Implications for terrane accretion in southwestern Laurentia: Lithosphere, v. 3, p. 401-408.

Neathery, T.L., 1968, Talc and anthophyllite deposits in Tallapoosa and Chambers Counties, Alabama: Alabama Geological Survey Bulletin 90, 98 p.

Neathery, T.L., 1975, Rock Units of the high-rank belt of the northern Alabama Piedmont, in Neathery, T.L. and Tull, J.F., eds., Geologic profiles of the northern Alabama Piedmont: Alabama Geological Society, 13th Annual Field Trip Guidebook, p. 9-48.

Osborne, W.E., Szabo, M.W., Neathery, T.L., and Copeland, C.W., Jr., compilers, 1988, Geologic map of Alabama, northeast sheet: Alabama Geological Survey Special Map 220, scale 1:250,000.

Pickering, S. M., Jr., 1976, Geologic map of Georgia: Georgia Geological Survey; scale 1:500,000.

Poole, J.D., Hawkins, J.F., Abrahams, J.B., and Steltenpohl, M.G., 2013, Investigations of the Brevard zone, a compilation of 1:24,000 geologic maps tracing the feature through Alabama: Geological Society of America Abstracts with Programs, v. 45, p. 809.

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

Rubatto, D., 2002, Zircon trace element geochemistry: partitioning with garnet and the link between U-Pb age and metamorphism: Chemical Geology, v. 184, p. 123–138, doi:10.1016/S0009-2541(01)00355-2.

Russell, G.S., 1978, U-Pb, Rb-Sr, and K-Ar isotopic data bearing on the tectonic development of the southernmost Appalachian orogen, Alabama [Ph.D. dissertation]: Tallahassee, Florida, Florida State University, 197 p.

Russell, G.S., Odom, A.L., and Russell, C.W., 1987, Uranium-lead and rubidium-strontium isotopic evidence for the age and origin of granitic rocks in the northern Alabama Piedmont, in Drummond, M.S., and Green, N.L., eds., Granites in Alabama: Geological Survey of Alabama, Tuscaloosa, p. 239-250.

Seal, T.L., and Kish, S.A, 1990, The geology of the Dadeville Complex of the western Georgia and eastern Alabama Inner Piedmont: Initial petrographic, geochemical, and geochronological results, in Steltenpohl, M.G., et al., eds., Geology of the southernmost Inner Piedmont terrrane, Alabama and southwest Georgia: Southeastern Section of the Geological Society of America Field Trip Guidebook, p. 65-77.

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. 1-13.

Steltenpohl, M.G., 1990, Structural development of the Opelika Complex, in Steltenpohl, M.G., et al., eds., Geology of the southern Inner Piedmont terrane, Alabama and southwest Georgia: Southeastern Section of the Geological Society of America Field Trip Guidebook, p. 29-42.

Steltenpohl, M.G., 1992, The Pine Mountain window of Alabama: Basement-cover evolution in the southernmost exposed Appalachians, in Bartholomew, M.J., et al., eds., Basement tectonics 8: Characterization of ancient and Mesozoic continental margins: Proceedings of the 8th International Conference on Basement Tectonics, Butte, Montana, 1988: Dordrecht, Netherlands, Kluwer Academic Publishers, p. 491–501.

Steltenpohl, M.G., and Moore, W.B., 1988, Metamorphism in the Alabama Piedmont: Alabama Geological Survey Circular 138, 29 p.

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

Steltenpohl, M.G., and Kunk, M.J., 1993, 40Ar/39Ar thermochronology and Alleghanian development of the southernmost Appalachian Piedmont, Alabama and southwest Georgia: Geological Society of America Bulletin, v. 105, p. 819–833, doi:10.1130/0016-7606 (1993)105<0819:AATAAD>2.3.CO;2.

Steltenpohl, M.G., Heatherington, A., Mueller, P., and Wooden, J.L., 2004, Pre-Appalachian tectonic evolution of the Pine Mountain window in the southernmost Appalachians, Alabama and Georgia, in Tollo, R.P., et al., eds., Proterozoic tectonic evolution of the Grenville orogen in North America: Geological Society of America Memoir 197, p. 633–646, doi:10.1130/0-8137-1197-5.633.

Steltenpohl, M.G., editor, 2005, Southernmost Appalachian terranes, Alabama and Georgia: Geological Society, Southeastern Section of the Geological Society of America Feld Trip guidebook, 162 p.

Steltenpohl, M.G., Hatcher, R.D., Jr., Mueller, P.A., Heatherington, A.L., and Wooden, J.L., 2010, Geologic history of the Pine Mountain window, Alabama and Georgia: Insights from a new geologic map and U-Pb isotopic dates, in Tollo, R.P., et al., eds., From Rodinia to Pangea: The lithotectonic record of the Appalachian region: Geological Society of America Memoir 206, p. 837–858, doi:10.1130/2010.1206(32).

Steltenpohl, M.G., Horton, J.W., Hatcher, R.D., Zietz, I., Daniels, D. L., and Higgins, M. W., 2013b, Upper crustal structure of Alabama from regional magnetic and gravity data: Using geology to interpret geophysics, and vice versa: Geosphere, v. 9, no.4, p. 1044-1064, doi:10.1130/GES00703.1.

Steltenpohl, M.G., Schwartz, J.J., and Miller, B.V., 2013a, Late to post-Appalachian strain partitioning and extension in the Blue Ridge of Alabama and Georgia: Geosphere, v. 9; no. 3, p. 647-666, doi:10.1130/GES00738.1.

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

Stoddard, P.V., 1983, A petrographic and geochemical analysis of the Zana Granite and Kowaliga Augen Gneiss: Northern Piedmont, Alabama [M.S. thesis]: Memphis, Memphis State University, 74 p.

Stose, G.W., 1926, Geologic map of Alabama: Alabama Geological Survey Map, scale 1:500,000.

Thomas W.A., 2011, The Iapetan rifted margin of southern Laurentia: Geosphere, v. 7, p. 97–120, doi:10.1130/GES00574.1.

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

Tull, J.F., Barineau, C.I., Mueller, P.A., and Wooden, J.L., 2007, Volcanic arc emplacement onto the southernmost Appalachian Laurentian shelf: Characteristics and constraints: Geological Society of America Bulletin, v. 119, p. 261–274, doi:10.1130/B25998.1.

Tull, J.F., Mueller, P.A., and Barineau, C.I., 2009, Age and tectonic implications of the Elkahatchee Quartz Diorite, eastern Blue Ridge provine, southern Appalachians, USA: Geological Society of America Abstracts with Programs, v. 41, No. 7, p. 288.

Tull, J.F., Barineau, C.I., and Holm-Denoma, C.S., 2012, Characteristics, Extent, and Tectonic Significance of the Middle Ordovician Back-Arc Basin in the Southern Appalachian Blue Ridge, in Barineau, C.I., and Tull, J.F., The Talladega Slate Belt and the eastern Blue Ridge: Laurentian plate passive margin to back-arc basin tectonics in the southern Appalachian orogen: Field Trip Guidebook for the Alabama Geological Society, p. 12-26.

Van Schmus, W.R., Bickford, M.E., Anderson, J.L., Bender, E.E., Anderson, R.R., Bauer, P.W., Robertson, J.M., Bowring, S.A., Condie, K.C., Denison, R.E., Gilbert, M.C., Grambling, J.A., Mawer, C.K., Shearér, C.K., Hinze, W.J., Karlstrom, K.E., Kisvarsanyi, E.B., Lidiak, E.G., Reed, J.C., Jr., Sims, P.K., Tweto, O., Silver, L.T., Treves, S.B., Williams, M.L., and Wooden, J.L., 1993, Transcontinental Proterozoic provinces, in Reed, J.C., Jr., et al., eds., Precambrian: Conterminous U.S.: Geological Society of America, The Geology of North America, v. C-2, p. 171–334.

White, T.W., 2007, Geology of the 1:24,000 Tallassee, Alabama, quadrangle, and its implications for southern Appalachian tectonics [M.S. thesis]: Auburn, Alabama, Auburn University, 74 p.

CONCLUSIONS

Detailed 1:24,000-scale geologic mapping of the Dadeville 7.5-minute quadrangle reveals new insight into the complex history of the Brevard fault zone in east-central Alabama. The Brevard fault zone originally formed during the Neoacadian (Late Devonian) event under metamorphic conditions in excess of ~450° C and up to peak metamorphism. Initial fault movement, recorded in mylonitic textures verifying top-to-the-northeast-southwest oblique right-lateral and thrust movement within the Kowaliga Gneiss and Zana Granite, occurred under sub-ductile-brittle-transition conditions. During the Alleghanian event (Middle to Late Carboniferous) plastic reactivation of the Brevard fault zone occurred under middle-greenschist facies metamorphic conditions, as evidence from a retrograde mylonitic overprint along the Abanda fault. Top-down-to-the-east normal and right-lateral-strike-slip displacement along the post-metamorphic Abanda fault juxtaposed rocks of distinctly different metamorphic grade. Mesozoic rifting of Pangea, resulted in cataclasite along the northwest side of the Abanda fault and marks the final movement along the Brevard fault zone under supra-ductile-brittle-transition zone conditions for cataclasis. The Brevard fault zone in east-central Alabama, thus, provides an excellent example of a fault undergoing multiple reactivations through time under varying crustal-depths and rheologies.

The new geologic map combined with detailed 1:24,000-scale geologic mapping and structural analysis conducted on quadrangles along the west limb, hinge zone, and east limb of the Tallassee synform reveal the entire tectonostratigraphic package from structural top to bottom, the Dadeville Complex, Jacksons Gap Group/Loachapoka Schist, and Emuckfaw

Group/Opelika Complex wraps unbroken around the hinge of the Tallassee synform. Structural and formline analysis constrains the geometry of the cylindrical Tallassee synform indicating a β-axis trend and plunge of N40°E, 12°, clearly demonstrating that S_0/S_1 passes uninterrupted from limb to limb precisely as the lithologic layering does, thus, supporting correlation of the eastern Blue Ridge and Opelika Complex. Aeromagnetic and gravity maps image structural closure of the Tallassee synform directly beneath the Coastal Plain sedimentary cover. Metagranites intruding the metasedimentary rocks along both limbs of the Tallassee synform reflect a distinct period of Late Ordovician magmagenesis and plutonism, with (441±6.6 Ma) Kowaliga Gneiss to the east and (454±9 Ma) Farmville Metagranite to the west. Our new U-Pb dates combines related geochronology forming arguably the most tightly constrained and robust thermochronological record currently reported in the most southern exposures of the Appalachians. Finally, initial U-Pb zircon analyses of detrital zircons from a distinctive marker unit, the Tallassee Metaquartzite, confirms its Laurentian heritage and combines our mapping to help correlate it with the Chattahoochee Palisades Quartzite along strike in the Blue Ridge and Inner Piedmont of Georgia.

The evidence mentioned above is used to document a large tectonic window through the Inner Piedmont that is bracketed by the autochthonous Laurentian margin/platform to the west and the parauthocthounous Pine Mountain window to the east. Recognized in its entirety, the window, herein referred to as the Dog River window, is a fundamental, first-order structure of the southern Appalachian orogen that exposes a huge area of previously unrecognized Laurentian Blue Ridge rocks spanning most of the Alabama Promontory.

COMBINED LIST OF REFERENCES

Abrahams, J.B., 2014: Geology of the Dadeville quadrangle and the Tallassee synform in Characterizing the Dog River Window [M.S. thesis]: Auburn, Auburn University, 140 p.

Adams, G.I., 1926, The crystalline rocks, in Adams, G.I., et al., eds., Geology of Alabama: Alabama Geological Survey Special Report 14, p. 25-40.

Adams, G.I., 1930, Gold deposits of Alabama, and occurrences of copper, pyrite, arsenic and tin: Alabama Geological Survey Bulletin 40, 91 p.

Adams, G.I., 1933, General geology of the crystalline rocks of Alabama: Journal of Geology, v. 41, p. 159-173.

Babaie, H.A., Hadizadeh, J., Babaie, A., and Ghazi, A.M., 1991, Timing and temperature of cataclastic deformation along segments of the Towaliga fault, western Georgia, U.S.A: Journal of Structural Geology, v. 13, p. 579–586, doi:10.1016/0191-8141(91)90044-J.

Barineau, C.I., 2009, Superposed fault systems of the southernmost Appalachian Talladega belt: Implications for Paleozoic orogenesis in the southern Appalachians [Ph.D. dissertation]: Tallahassee, Florida State University, 150 p.

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, 119 p.

Bieler, D.E., 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 in Alabama, Geological Survey of Alabama, p. 57-72.

Bittner, E.I., and Neilson, M.J., 1990, in Steltenpohl, M.G., et al., eds., Geology of the southern Inner Piedmont, Alabama and southwest Georgia: Geological Society of America Southeastern Section Field Trip Guidebook, Tuscaloosa, Geological Survey of Alabama, p. 101–110.

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.

Bobyarchick, A.R., Edelman, S.H., and Horton, J.W., Jr., 1988, The role of dextral strike-slip in the displacement history of the Brevard fault zone, in Secor, D.T., Jr., ed., Southeastern Geological Excursions: Geological Society of America 1988 Annual Meeting Field Trip Guidebook, p. 53-104.

Bream, B.R., 2002, The southern Appalachian Inner Piedmont: New perspectives based on recent detailed geologic mapping, Nd isotopic evidence and zircon geochronology, in Hatcher, R.D., and Bream, B.R., eds., Inner Piedmont Geology in the South Mountains-Blue Ridge Foothills and the southwestern Brushy Mountains, central western North Carolina: North Carolina Geological Survey, Carolina Geological Society Annual Field Trip Guidebook, p. 45-63.

Bream, B.R., 2003, Tectonic Implications of Geochronology and Geochemistry of Para- and Orthogneisses from the Southern Appalachian Crystalline Core [Ph.D. dissertation]: Knoxville, Tennessee, University of Tennessee, 296 p.

Bream, B.R., Hatcher, R.D., Jr., Miller, C.F., and Fullagar, P.D., 2001, Geochemistry and provenance of Inner Piedmont paragneisses, NC and SC: Evidence for an internal terrane boundary?: Geological Society of America Abstracts with Programs, v. 33, no. 2, p. 65.

Bream, B.R., Hatcher, R.D., Jr., Miller, C.F., Fullagar, P.D., Tollo, R.P., Corriveau, L., McLelland, J., and Bartholomew, M.J., 2004, Detrital zircon ages and Nd isotopic data from the Southern Appalachian crystalline core, GA–SC–NC–TN; new provenance constraints for part of the Laurentian margin, in Tollo, R.P., et al., eds., Proterozoic tectonic evolution of the Grenville orogen in North America: Geological Society of America Memoir 197, p. 459-475.

Carrigan, C.W., Bream, B., Miller, C.F., and Hatcher, R.D., Jr., 2001, Ion microprobe analyses of zircon rims from the eastern Blue Ridge and Inner Piedmont, NCSC-GA: Implications for the timing of Paleozoic metamorphism in the southern Appalachians: Geological Society of America Abstracts with Programs, v. 33, p. 7.

Clarke, J.W., 1952, Geology and mineral resources of the Thomaston quadrangle, Georgia: Georgia Geological Survey Bulletin 59, 99 p.

Cook, F.A., Albuagh, D.S., Brown, L.D., Kaufman, S., Oliver, J.E., and Hatcher, R.D., Jr., 1979, Thin-skinned tectonics in the crystalline southern Appalachians; COCORP seismic-reflection profiling of the Blue Ridge and Piedmont: Geology, v. 7, p. 563-567.

Crawford, T.J., Higgins, M.W., Crawford, R.F., Atkins, R.L., Medlin, J.H., and Stern, T.W., 1999, Revision of stratigraphic nomenclature in the Atlanta, Athens, and Cartersville 30’ x 60’ quadrangles, Georgia: Georgia Geological Survey, Bulletin 130, 45 p.

Cyphers, S.R., and Hatcher, R.D., Jr., 2006, The Chattahoochee- Holland mountain fault: A terrane boundary in the Blue Ridge of western North Carolina: Geological Society of America Abstracts with Programs, v. 38, no. 3, p. 66.

Davis, T.L., 1993, Lithostratigraphy, structure, and metamorphism of a crystalline thrust terrane, western Inner Piedmont, North Carolina [PhD dissertation] University of Tennessee, 245 p.

Dennis, A.J., and Wright, J.E., 1997, Middle and late Paleozoic monazite U-Pb ages, Inner Piedmont, South Carolina: Geological Society of America Abstracts with Programs, v. 29, no. 3, p. 12.

Drummond, M.S., Allison, D.T., and Weslowski, D.J., 1994, Igneous petrogenesis and tectonic setting of the Elkahatchee Quartz Diorite, Alabama Appalachians: Implications for Penobscotian magmatism in the eastern Blue Ridge: American Journal of Science, v. 294, p. 173-236.

Drummond, M.S., Neilson, M.J., Allison, D.T., and Tull, J.F., 1997, Igneous petrogenesis and tectonic setting of granitic rocks from the eastern Blue Ridge and Inner Piedmont, Alabama Appalachians, in Sinha, A.K., et al., eds., The nature of magmatism in the Appalachian orogen: Geological Society of America Memoir 191, p. 147–164, doi:10.1130/0-8137-1191-6.147.

Duebendorfer, E.M., 1988, Evidence for an inverted metamorphic gradient associated with a Precambrian suture, southern Wyoming: Journal of Metamorphic Geology, v. 6, p. 41-63.

Garihan, J.M., and Ranson, W.A., 1992, Structure of the Mesozoic Marietta-Tryon graben, South Carolina and adjacent North Carolina, in Bartholomew, M.J., et al., eds., Basement tectonics 8: Characterization of ancient and Mesozoic continental margins—Proceedings of the 8th International Conference on Basement Tectonics, Butte, Montana, 1988: Dordrecht, Netherlands, Kluwer Academic Publishers, p. 539–555.

Garihan, J.M., Preddy, M.S., and Ranson, W.A., 1993, Summary of mid-Mesozoic brittle faulting in the Inner Piedmont and nearby Charlotte belt of the Carolinas, in Hatcher, R.D., Jr., and Davis, T., eds., Studies of Inner Piedmont geology with a focus on the Columbus Promontory: Carolina Geological Society Field Trip Guidebook, p. 55–66.

Goldberg, SA, 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: Tuscaloosa, Alabama, Alabama Geological Survey, p. 251-257.

Goldberg, S. A., 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.

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, 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 Alabama fall line: Geological Society of America, Southeastern section 42nd Annual Meeting Field Trip Guidebook, 67-94 p.

Grimes, J., Heatherington, A.L., Mueller, P.A., Steltenpohl, M.G., 1997, Tectonic implications of Ordovician U-Pb zircon dates from the Farmville metagranite Geological Society of America Abstracts with Programs, v. 28, p. 21.

Grimes, J.E., Steltenpohl, M.G., Cook. R.B., and Keefer, W.D., 1993, Geology of the southernmost Brevard fault zone, Alabama, and its implications for southern Appalachian tectonostratigraphy, in Hatcher. RD., 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. 91-103.

Guthrie, G.M., and Dean, L.S., 1989, Geology of the New site 7.5-Minute Quadrangle, Tallapoosa and Clay Counties, Alabama: Alabama Geological Survey Quadrangle Map 9, 41 p.

Hadizadeh, J., Babaie, H.A., and Babaie, A., 1991, Development of interlaced mylonites, cataclasites and breccias: Example from the Towaliga fault, south-central Appalachians: Journal of Structural Geology, v. 13, p. 63–70, doi:10.1016/0191-8141(91)90101-N.

Hall, G.D., Salpas, P.A., 1990, Geochemistry of thin-layered amphibolites of the Ropes Creek Amphibolite, in Steltenpohl, M.G., et al., ed., Geology of the southern Inner Piedmont, Alabama and southwest Georgia: Geological Society of America Southeastern Section Field Trip Guidebook: Tuscaloosa, Geological Survey of Alabama, p. 101–110.

Hames, W.E., Tull, J.F., Barbeau, D.L., Jr., McDonald, W.M., and Steltenpohl, M.G., 2007, Laser 40Ar/39Ar ages of muscovite and evidence for Mississippian (Visean) deformation near the thrust front of the southwestern Blue Ridge province: Geological Society of America Abstracts with Programs, v. 39, no. 2, p. 78.

Hatcher, RD., Jr., 1978, The Alto allochthon: A major tectonic feature of the Piedmont of northeast Georgia: Georgia Geologic Survey Bulletin 93, p. 83-86.

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

Hatcher, R.D., Jr., 2001, Rheological partitioning during multiple reactivation of the Paleozoic Brevard fault zone, southern Appalachians, USA, in Holdsworth, R.E., et al., eds., The Nature and Tectonic Significance of Fault Zone Weakening: Geological Society of London Special Publication 186, p. 255–269.

Hatcher, R.D., Jr., 2002, An Inner Piedmont primer, in Hatcher, R.D., Jr., and Bream, B.R., eds., Inner Piedmont geology in the South Mountains-Blue Ridge Foothills and the southwestern brushy Mountains, central-western North Carolina: Carolina Geolgoical Society Field Trip Guidebook, p.1-18.

Hatcher, RD., Jr., 2010, Tectonic map of the Appalachians: in Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region: Boulder Colorado, Geological Society of America Memoir 206.

Hatcher, R.D., Jr., and Zietz, I., 1980, Tectonic implications of regional aeromagnetic and gravity data from the southern Appalachians, in Wones, D., ed., Proceedings, The Caledonides in the U.S.A.: Virginia Polytechnic Institute Memoir 2, p. 83–90.

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., et al., eds., Channel Flow, Ductile Extrusion and Exhumation in Continental Collision Zones: Geological Society of London Special Paper 268, p. 517–541.

Hatcher, R.D., Jr., Bream, B.R., and Merschat, A.J., 2007, Tectonic map of the southern and central Appalachians: A tale of three orogens and a complete Wilson Cycle in Hatcher, R.D., Jr., et al., eds., 4-D Framework of Continental Crust: Boulder, Colorado, Geological Society of America Memoir 200, p. 59-632.

Hawkins, J.F., 2013, Geology, petrology, and geochronology of rocks in the Our Town, Alabama quadrangle [M.S. thesis]: Auburn, Alabama, Auburn University, 118 p.

Hawkins, J.F., Steltenpohl, M.G., Zou, H., Mueller, P.A., and Schwartz, J.J., 2013, New constraints on Ordovician magmatism in the southernmost exposures of the eastern Blue Ridge in Alabama: Geological Society of America Abstracts with Programs, v. 45, p. 62.

Hibbard, J.P., Stoddard, E.F., Secor, D.T., Jr., and Dennis, A.J., 2002, The Carolina zone: Overview of Neo Proterozoic to early Paleozoic peri-Gondwanan terranes along the eastern flank of the southern Appalachians: Earth-Science Reviews, v. 57, p. 299–339, doi:10.1016/S0012-8252(01)00079-4.

Hibbard, J.P., van Staal, C.R., Rankin, D.W., and Williams, H., 2006, Lithotectonic map of the Appalachian orogen, Canada–United States of America: Geological Survey of Canada Map 2096A, scale 1:1,500,000.

Hibbard, J.P., van Staal, C.R., and Miller, B.V., 2007, Links among Carolinia, Avalonia, and Ganderia in the Appalachian peri-Gondwanan realm, in Sears, J.W., et al., eds., Whence the Mountains? Inquiries into the Evolution of Orogenic Systems: A Volume in Honor of Raymond A. Price: Geological Society of America Special Paper 433, p. 291–311, doi:10.1130/2007.2433(14).

Higgins, M.W., 1966, The geology of the Brevard lineament near Atlanta, Georgia: Georgia Geological Survey Bulletin 77, 49 p.

Higgins, M.W., 1968, Geologic map of the Brevard fault zone near Atlanta, Georgia: U.S. Geological Survey Miscellaneous Geologic Investigation Map 1-511, scale 1:50,000.

Higgins, M.W., and McConnell, K.I., 1978, The Sandy Springs Group and related rocks in the Georgia Piedmont; nomenclature and stratigraphy: Georgia Geological Survey Bulletin 93, p. 50-55.

Higgins, M.W., Atkins, R.L., Crawford, T.J., Crawford, R.E, 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, 173 p.

Higgins, M.W., Arth, J.G., Wooden, J.L., Crawford, T.J., Stern, T.W., and Crawford, R.F., 1997, Age and origin of the Austell Gneiss, western Georgia Piedmont–Blue Ridge, and its bearing on the ages of orogenic events in the southern Appalachians, in Sinha, A.K., et al., eds., The Nature of Magmatism in the Appalachian Orogen: Geological Society of America Memoir 191, p. 181–192, doi: 10.1130/0-8137-1191-6.181

Higgins, M.W., Crawford, T.J., Atkins, R.L., and Crawford, R.E, 2003, Geologic map of the Atlanta 30' x 60' quadrangle, Georgia: U.S. Geological Survey Map Miscellaneous Geologic Investigation Map 1-2602, scale 1:100,000.

Higgins, M.W., and Crawford, R.F., 2007, Ongoing compilation of our geologic mapping in the Blue Ridge and Piedmont of Georgia: Geological Society of America Abstracts with Programs, v. 39, no. 2, p. 100.

Hoffman, P.F., 1989, Precambrian geology and tectonic history of North America, in Bally, A.W., and Palmer, A.R., eds., The Geology of North America-An overview: Geological Society of America, The Geology of North America, v. A, p. 447-512.

Hollister, L.S., and Crawford, M.L., 1986, Melt enhanced deformation: A major tectonic process: Geology, v. 14, p. 558-561.

Hopson, J.L., and Hatcher, R.D., Jr., 1988, Structural and stratigraphic setting of the Alto allochthon, northeast 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 230, p. 213-245.

Hubbard, M.S., 1989, thermobarometric constraints on the thermal history of the Main Central Thrust zone and Tibetan Slab, eastern Nepal Himalaya: Journal of Metamorphic Geology 7, p. 19-30.

Huebner, M.T., Hatcher, R.D., Jr., and Davis, B.A., 2010, Extent, kinematics, and Mesozoic reactivation of the Alleghanian Towaliga fault, central Georgia Appalachians: Geological Society of America Abstracts with Programs, v. 42, no. 1, p. 128.

Huebner, M.T., Hatcher, R.D., Jr., and Merschat, A.J., 2013, Confirmation of the southwest continuation of the Cat Square terrane, southern Appalachian Inner Piedmont, with implications for middle Paleozoic collisional orogensis: American Journal of Science (in press).

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

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

Kohn, M.J., 2001, Timing of arc accretion in the southern Appalachians: Perspectives from the Laurentian margin: Geological Society of America Abstracts with Programs, v. 33, no. 6, p. A262.

Ludwig, K.R., 2012, Isoplot 3.75: A geochronological toolkit for Microsoft Excel: Berkeley Geochronology Center Special Publication no. 5, 75 p.

McClellan, E.A., Steltenpohl, M.G., Thomas, C., and Miller, C., 2007, Isotopic age constraints and metamorphic history of the Talladega belt: New evidence for timing of arc magmatism and terrane emplacement along the southern Laurentian margin: The Journal of Geology, v. 115, p. 541–561, doi:10.1086/519777.

McCullars, J.M., 2001, Geology and trace-element geochemistry of the Bervard zone near Martin Lake, Tallapoosa County, Alabama [M.S. thesis]: Auburn, Alabama, Auburn University, 74 p.

McDonald, W.M., Hames, W.E., Marzen, L.J., and Steltenpohl, M.G., 2007, A GIS database for 40Ar/39Ar data of the southwestern Blue Ridge province: Geological Society of America Abstracts with Programs, v. 39, no. 2, p. 81.

Medlin, J.H., and Crawford, T.J., 1973, Stratigraphy and structure along the Brevard fault zone in western Georgia and Alabama: American Journal of Science, v. 273-A, p. 89-104.

Mehnert, K.R., 1968. Migmatites and the origin of granitic rocks, Developments in Petrology 1: Elsevier, Amsterdam, 393 p.

Merschat, A.J., and Hatcher, R.D., Jr., 2007, The Cat Square terrane: Possible Siluro-Devonian remnant ocean basin in the Inner Piedmont, southern Appalachians, USA, in Hatcher, R.D., Jr., et al., eds., 4-D Framework of Continental Crust: Geological Society of America Memoir 200, p. 553–565.

Merschat, A.H., Hatcher, R.D., Jr., and Davis, T.L., 2005, The northern Inner Piedmont, southern Appalachians, USA: Kinematics of transpression and SW-directed mid-crustal flow: Journal of Structural Geology, v. 27, p. 1252–1281, doi:10.1016/j.jsg.2004.08.005.

Merschat, A.J., Hatcher, R.D., Jr., Bream, B.R., Miller, C.F., Byars, H.E., Gatewood, M.P., and Wooden, J.L., 2010, Detrital zircon geochronology and provenance of Southern Appalachian Blue Ridge and Inner Piedmont crystalline terranes, in Tollo, R.P., et al., eds., From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region: Geological Society of America Memoir 206, p. 661–699.

Muangnoicharoen, N., 1975, The geology and structure of a portion of the northern piedmont, east-central Alabama [M.S. thesis]: Tuscaloosa, University of Alabama, 72 p.

Mueller, P. A., Heatherington, A.L., Foster, D.A., Thomas, W.A., and Wooden, J.L., 2013, The Suwannee suture: Significance for Gondwana-Laurentia terrane transfer and formation of Pangaea: Gondwana Research, http://dx.doi.org/10.1016/j.gr.2013.06.018.

Mueller, P. A., Wooden, J.L., Mogk, D.W., and Foster, D.A., 2011, Paleoproterozoic evolution of the Farmington zone: Implications for terrane accretion in southwestern Laurentia: Lithosphere, v. 3, p. 401-408.

Neathery, T.L., 1968, Talc and anthophyllite deposits in Tallapoosa and Chambers Counties, Alabama: Alabama Geological Survey Bulletin 90, 98 p.

Neathery, T.L., 1975, Rock Units of the high-rank belt of the northern Alabama Piedmont, in Neathery, T.L. and Tull, J.F., eds., Geologic profiles of the northern Alabama Piedmont: Alabama Geological Society, 13th Annual Field Trip Guidebook, p. 9-48.

Neathery, T. L., and Reynolds, J. W., 1973, Stratigraphy and metamorphism of the Wedowee Group, a reconnaissance: American Journal of Science, v. 273, p. 723-741.

Neilson, M. J., 1983, Phase equilibria of rock-forming ferromagnesian silicates in granitic systems: American Journal of Science, v. 283, p. 993-1033.

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, Special Publication, p. 9-16.

Neilson, M. J., 1988, The structure and stratigraphy of the Tallassee Synform, Dadeville Belt, Alabama: Southeastern Geology, v. 29, p. 41–50.

Neilson, M.J., Seal, T.L., 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.

Osborne, W.E., Szabo, M.W., Neathery, T.L., and Copeland, C.W., Jr., compilers, 1988, Geologic map of Alabama, northeast sheet: Alabama Geological Survey Special Map 220, scale 1:250,000.

Pardee, J.T., and Park, C.F., Jr., 1948, Gold deposits of the southern Piedmont: U.S. Geological Survey Professional Paper 213, 156 p.

Park, C.F., Jr., 1935 Hog mountain gold district, Alabama: American Institute of Mining and Metallurgical Engineers Transactions, Mining Geology, v. 115, p. 209-228.

Passchier, C.W., and Trouw, R.A.J., 1996, Microtectonics: Berlin, Springer, 289 p.

Peacock, S.M., 1987, Creation and preservation of Subduction-related inverted metamorphic gradients: Journal of Geophysical Research, v. 92, p. 12,673-12,781.

Peacock, S.M., 1988, Inverted metamorphic gradients in the westernmost Cordillera, in Ernst, W.G., ed., Metamorphism and Crustal Evolution of the Western United States: Prentice Hall, v. 7, p. 953-974.

Phillips, W.B., 1892, a preliminary report on a part of the lower gold belt of Alabama in the counties of Chilton, Coosa, and Tallapoosa: Alabama Geological Survey Bulletin 3, 97 p.

Pickering, S. M., Jr., 1976, Geologic map of Georgia: Georgia Geological Survey; scale 1:500,000.

Poole, J.D., Hawkins, J.F., Abrahams, J.B., and Steltenpohl, M.G., 2013, Investigations of the Brevard zone, a compilation of 1:24,000 geologic maps tracing the feature through Alabama: Geological Society of America Abstracts with Programs, v. 45, p. 809.

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

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.

Rubatto, D., 2002, Zircon trace element geochemistry: partitioning with garnet and the link between U-Pb age and metamorphism: Chemical Geology, v. 184, p. 123–138, doi:10.1016/S0009-2541(01)00355-2.

Russell, G.S., 1978, U-Pb, Rb-Sr, and K-Ar isotopic data bearing on the tectonic development of the southernmost Appalachian orogen, Alabama [Ph.D. dissertation]: Tallahassee, Florida, Florida State University, 197 p.

Russell, G.S., Odom, A.L., and Russell, C.W., 1987, Uranium-lead and rubidium-strontium isotopic evidence for the age and origin of granitic rocks in the northern Alabama Piedmont, in Drummond, M.S., and Green, N.L., eds., Granites in Alabama: Geological Survey of Alabama, Tuscaloosa, p. 239-250.

Seal, T.L., and Kish, S.A, 1990, The geology of the Dadeville Complex of the western Georgia and eastern Alabama Inner Piedmont: Initial petrographic, geochemical, and geochronological results, in Steltenpohl, M.G., et al., eds., Geology of the southernmost Inner Piedmont terrrane, Alabama and southwest Georgia: Southeastern Section of the Geological Society of America Field Trip Guidebook, p. 65-77.

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. 1-13.

Stahr, D.W., III, Hatcher, R.D., Jr., Miller, C.F., and Wooden, J.L., 2006, Alleghanian deformation in the Georgia and North Carolina eastern Blue Ridge: Insights from pluton ages and fabrics: Geological Society of America Abstracts with Programs, v. 38, no. 3, p. 20.

Steltenpohl, M.G., 1990, Structural development of the Opelika Complex, in Steltenpohl, M.G., et al., eds., Geology of the southern Inner Piedmont terrane, Alabama and southwest Georgia: Southeastern Section of the Geological Society of America Field Trip Guidebook, p. 29-42.

Steltenpohl, M.G., 1992, The Pine Mountain window of Alabama: Basement-cover evolution in the southernmost exposed Appalachians, in Bartholomew, M.J., et al., eds., Basement tectonics 8: Characterization of ancient and Mesozoic continental margins: Proceedings of the 8th International Conference on Basement Tectonics, Butte, Montana, 1988: Dordrecht, Netherlands, Kluwer Academic Publishers, p. 491–501.

Steltenpohl, M.G., 2005, An introduction to the terranes of the southernmost Appalachians of Alabama and Georgia, in Steltenpohl, M.G., Southernmost Appalachian terranes, Alabama and Georgia: Field trip Guidebook for the Geological Society of America Southeastern Section 2005 Annual Meeting, p. 1-18.

Steltenpohl, M.G., editor, 2005, Southernmost Appalachian terranes, Alabama and Georgia: Geological Society, Southeastern Section of the Geological Society of America Feld Trip guidebook, 162 p.

Steltenpohl, M.G., and Kunk, M.J., 1993, 40Ar/39Ar thermochronology and Alleghanian development of the southernmost Appalachian Piedmont, Alabama and southwest Georgia: Geological Society of America Bulletin, v. 105, p. 819–833, doi:10.1130/0016-7606 (1993)105<0819:AATAAD>2.3.CO;2.

Steltenpohl, M.G., and Moore, W.B., 1988, Metamorphism in the Alabama Piedmont: Alabama Geological Survey Circular 138, 29 p.

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

Steltenpohl, M.G., and Kunk, M.J., 1993, 40Ar/39Ar thermochronology and Alleghanian development of the southernmost Appalachian Piedmont, Alabama and southwest Georgia: Geological Society of America Bulletin, v. 105, p. 819–833, doi:10.1130/0016-7606 (1993)105<0819:AATAAD>2.3.CO;2.

Steltenpohl, M.G., Heatherington, A., Mueller, P., and Wooden, J.L., 2004, Pre-Appalachian tectonic evolution of the Pine Mountain window in the southernmost Appalachians, Alabama and Georgia, in Tollo, R.P., et al., eds., Proterozoic tectonic evolution of the Grenville orogen in North America: Geological Society of America Memoir 197, p. 633–646, doi:10.1130/0-8137-1197-5.633.

Steltenpohl, M.G., Hatcher, R.D., Jr., Mueller, P.A., Heatherington, A.L., and Wooden, J.L., 2010, Geologic history of the Pine Mountain window, Alabama and Georgia: Insights from a new geologic map and U-Pb isotopic dates, in Tollo, R.P., et al., eds., From Rodinia to Pangea: The lithotectonic record of the Appalachian region: Geological Society of America Memoir 206, p. 837–858, doi:10.1130/2010.1206(32).

Steltenpohl, M.G., Horton, J.W., Hatcher, R.D., Zietz, I., Daniels, D. L., and Higgins, M. W., 2013b, Upper crustal structure of Alabama from regional magnetic and gravity data: Using geology to interpret geophysics, and vice versa: Geosphere, v. 9, no.4, p. 1044-1064, doi:10.1130/GES00703.1.

Steltenpohl, M.G., Schwartz, J.J., and Miller, B.V., 2013a, Late to post-Appalachian strain partitioning and extension in the Blue Ridge of Alabama and Georgia: Geosphere, v. 9; no. 3, p. 647-666, doi:10.1130/GES00738.1.

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

Stoddard, P.V., 1983, A petrographic and geochemical analysis of the Zana Granite and Kowaliga Augen Gneiss: Northern Piedmont, Alabama [M.S. thesis]: Memphis, Memphis State University, 74 p.

Stose, G.W., 1926, Geologic map of Alabama: Alabama Geological Survey Map, scale 1:500,000.

Stow, S.H., Neilson, M.J., and Neathery, T.L., 1984, Petrography, geochemistry and tectonic significance of the amphibolites o the Alabama Piedmont: American Journal of Science, v. 284, no. 4 and 5, p. 416-436.

Thomas W.A., 2011, The Iapetan rifted margin of southern Laurentia: Geosphere, v. 7, p. 97–120, doi:10.1130/GES00574.1.

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

Tull, J.F., Barineau, C.I., Mueller, P.A., and Wooden, J.L., 2007, Volcanic arc emplacement onto the southernmost Appalachian Laurentian shelf: Characteristics and constraints: Geological Society of America Bulletin, v. 119, p. 261–274, doi:10.1130/B25998.1.

Tull, J.F., Mueller, P.A., and Barineau, C.I., 2009, Age and tectonic implications of the Elkahatchee Quartz Diorite, eastern Blue Ridge provine, southern Appalachians, USA: Geological Society of America Abstracts with Programs, v. 41, No. 7, p. 288.

Tull, J.F., Barineau, C.I., and Holm-Denoma, C.S., 2012, Characteristics, Extent, and Tectonic Significance of the Middle Ordovician Back-Arc Basin in the Southern Appalachian Blue Ridge, in Barineau, C.I., and Tull, J.F., The Talladega Slate Belt and the eastern Blue Ridge: Laurentian plate passive margin to back-arc basin tectonics in the southern Appalachian orogen: Field Trip Guidebook for the Alabama Geological Society, p. 12-26.

Tuomey, M., 1858, Second biennial report on the geology of Alabama: Alabama Geological Survey Biennial report 2, 292 p.

Van Schmus, W.R., Bickford, M.E., Anderson, J.L., Bender, E.E., Anderson, R.R., Bauer, P.W., Robertson, J.M., Bowring, S.A., Condie, K.C., Denison, R.E., Gilbert, M.C., Grambling, J.A., Mawer, C.K., Shearér, C.K., Hinze, W.J., Karlstrom, K.E., Kisvarsanyi, E.B., Lidiak, E.G., Reed, J.C., Jr., Sims, P.K., Tweto, O., Silver, L.T., Treves, S.B., Williams, M.L., and Wooden, J.L., 1993, Transcontinental Proterozoic provinces, in Reed, J.C., Jr., et al., eds., Precambrian: Conterminous U.S.: Geological Society of America, The Geology of North America, v. C-2, p. 171–334.

Vauchez, A., 1987, Brevard fault zone, southern Appalachians: A medium-angle, dextral, Alleghanian shear zone: Geology, v. 15, p. 669–672, doi:10.1130/0091-7613(1987)15<669:BFZSAA>2.0.CO;2.

Vauchez, A., Babaie, H.A., and Babaei, A., 1993, Orogen-parallel tangential motion in the Late Devonian-Early Carboniferous southern Appalachians internides: Canadian Journal of Earth Sciences, v. 30, p. 1297–1305.

Wagner, M.E., and Srogi, L., 1987, Early Paleozoic metamorphism at two crustal levels and a tectonic model for the Pennsylvania-Delaware Piedmont: Geological Society of America Bulletin 99, p. 113-126.

White, T.W., 2007, Geology of the 1:24,000 Tallassee, Alabama, quadrangle, and its implications for southern Appalachian tectonics [M.S. thesis]: Auburn, Auburn University, 74 p.

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

Geologic Map of the Dadeville Quadrangle

Joel Abrahams and Dr. Mark Steltenpohl

Lithologies

Eastern Blue Ridge

Eem	***Emuckfaw Group***	*Tan color, locally garnetiferous, muscovite schist that weathers to a maroon color; interlayered with metagraywacke; local graded beds.*
Ekg	***Kowaliga Gneiss***	*Biotite rich granite to granodiorite with sheared potassium feldspar grains up to 2 cm in diameter; medium-to coarse-grained, well-foliated, and sheared by discrete shear zones; brown in color and weathers to a tan to reddish-orange saprolite.*
Ect	***Cataclasite***	*Grayish yellow-to pale yelloish-brown cataclasite, characterized by angular quartz clasts and cross-cutting quartz veins. Forms narrow (10 m thick) erosionally resistant ridges.*

Jacksons Gap Group

Jggp	***Garnetiferous Phyllite***	*Fine-grained, strongly foliated, locally phyllonitized, composed of muscovite, biotite, and quartz with abundant 1-3 mm garnet porphyroblasts; locally interlayered with quartzite.*
Jgcp	***Carbonaceous Phyllite***	*Light-gray to dark-gray, fine-to-medium grained, well-foliated graphitic phyllite with interlayered quartz-rich zones.*
Jghcp	***Highly Carbonaceous Phyllite***	*Dark-gray to black, fine grained, well-foliated graphitic phyllite marked by copious amounts of graphite; local quartz pebble clast supported conglomerates.*
Jgscp	***Sericite-Chlorite Phyllite***	*Light olive-gray to dark yellowish-green phyllite composed of fine-grained white mica, chlorite, quartz, and minor graphite and garnet with local chloritoid; unit is locally a ridge former.*
Jgqss	***Quartz-Sericite Schist***	*Light-gray to pale-orange, fine-grained, well-foliated, quartz-rich schist; papery texture where weathered.*
Jgmq	***Massive Quartzite***	*Fine-grained rock with varying amounts of white mica and graphite; unit is blocky, jointed, and a ridge-former.*
Jgpq	***Phyllitic Quartzite***	*Light tan to gray, fine-to coarse grained; has phyllitic cleavage defined by muscovite and/or sericite; unit is a ridge-former.*

Dadeville Complex

Idch	***Camp Hill Gneiss***	*Medium- to coarse-grained, well foliated tonalitic gneiss, locally biotite-rich; weathers to a tan to pink saprolite.*
Idcc	***Chattasofka Creek Gneiss***	*Medium-grained, well-foliated, light gray granitic-gneiss; weathers to light gray-brown to light-orange saporlite.*
Idrc	***Ropes Creek Amphibolite***	*Medium-to coarse-grained,well-foliated, dark green to black amphibolite ; fresh exposures are not abundant but lenses of moderately indurated aphibolite are surrounded by reddish-orange to ochre saprolite.*
Idws	***Waresville Schist***	*Homogenous, massive felsic schist, compising potassium feldspar, quartz, sericite with opaques. Typically, moderately-to-deeply weathered resulting light tan to white low density saprolite.*
Idas	***Agricola Schist***	*Biotite ± garnet ± sillimanite±kyanite+feldspar+quartz schist, locally migmatized. Fresh exposures are not abundant, but its light-to medium-reddish-brown saprolite is common.*
Idmum	***Maific and Ultramafic pods***	*Dark green to greenish-black, medium-to coarse-grained meta-orthopyroxenite. The unit is relatively resistant to weathering but form ochre colored saprolite.*

Legend

- Strike and Dip of Foliation
- Clast Supported Meta-Conglomerate
- Katy Creek Fault
- Abanda Fault

Map supported by a USGS-EDMAP grant to Dr. Mark Steltenpohl

Geologic Map of the 7.5-minute Tallassee, Carrville, Notasulga, and Loachapoka quadrangles

km
0 1.75 3.5 7 10.5 14

Lithologic Units

GULF COASTAL PLAIN

Qt	Quaternary High Terrace deposits
Qal	Quaternary Alluvium
Kg	Upper Cretaceous Tuscaloosa Gordo Formation
K	Upper Cretaceous Gulf Coastal Plain
Kck	Upper Cretaceous Gulf Coastal Plain

EASTERN BLUE RIDGE

Eem	Emukfaw Group
Ekg	Kowaliga Gneiss

JACKSONS GAP GROUP

Jgch	Chlorite-Hornblende-Biotite Schist
Jggp	Garnetiferous Phyllite
Jgpq	Phyllitic Quartzite
Jgtq	Tallassee Quartzite

DADEVILLE COMPLEX

Idum	Ultramafic Rock
Idwg	Waverly Gneiss
Idhc	Camp Hill Gneiss
Idrc	Ropes Creek Amphibolite

OPELIKA COMPLEX

Ioa	Amphibolite
Ioag	Auburn Gneiss
Ioau	Auburn Schist and Gneiss undifferentiated
Iofv	Farmville Metagranite
Iols	Loachapoka Schist
Iomo	Migmatic Orthogneiss
Iosq	Saugahatchee Quartzite
Idcs	Chlorite-Quartz Schist

PINE MOUNTAIN WINDOW

Peg	Pegmatites
Phq	Hollis Quartzite
Phsa	Halawaka Schist - Amphibolite
Phsu	Halawaka Schist undifferentiated
Pms	Manchester Schist

MYLONITE ZONES

My	Mylonite

Thrust Fault
Normal Fault

contact approximate or concealed
Strike and Dip of Foliation
Strike and Dip of Vertical Foliation
Bearing and Plunge of post-metamorphic fold hinge
Elongation Lineation
Intersection Lineation
Mineral Lineation
Mylonitic Elongation Lineation
Mylonitic shear zone primarily right slip

N