Geology of the Porter Gap 7.5–minute Quadrangle, Alabama, and Stretched Pebble Analysis Within the Western Blue Ridge of the Southern Appalachians

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GEOLOGY OF THE PORTER GAP 7.5–MINUTE QUADRANGLE, ALABAMA, AND STRETCHED PEBBLE ANALYSIS WITHIN THE WESTERN BLUE RIDGE OF THE SOUTHERN APPALACHIANS

A Master's Thesis

Presented to

The Graduate College of

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In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Geography and Geology

By

Tessa Mills

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GEOLOGY OF THE PORTER GAP 7.5–MINUTE QUADRANGLE, ALABAMA, AND STRETCHED PEBBLE ANALYSIS WITHIN THE WESTERN BLUE RIDGE OF THE SOUTHERN APPALACHIANS

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ABSTRACT

The Porter Gap 7.5–minute quadrangle in eastern Alabama contains portions of the undifferentiated sedimentary Knox Group of the Valley and Ridge province, the metamorphic Talladega Group of the western Blue Ridge, and the metamorphic Ashland Supergroup of the eastern Blue Ridge. Three major faults separate the rock units, including the Talladega-Cartersville fault, the Hillabee thrust fault, and the Hollins Line fault. Deformation and metamorphism of rocks within the Talladega Group occurred during the middle to late Mississippian (~334–320 Ma) recorded by stretched pebbles within the Cheaha Quartzite member of the Lay Dam Formation. Stretched pebbles within the Cheaha Quartzite have been elongated north-south and flattened east-west, suggesting an east-west deformational force acting on the rocks. Elongation was likely during the metamorphism of the Talladega Group. The beginning of deformation can be estimated using the youngest Talladega Group member, the Erin Slate (360-350 Ma), and the faulting of the Hillabee thrust onto the Talladega Group (~350 and 320 Ma). The overall estimate for deformation time is ~359-325 Ma during a Acadian-Alleghanian Transition. Two hypotheses could explain the deformation patterns of the pebble elongation: subregional faulting of the Hollins Line fault and a regional deformation from an Appalachian-wide stress field.

KEYWORDS: Blue Ridge, southern Appalachians, Appalachian-wide stress field, Porter Gap, Talladega Group, Cheaha Quartzite

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This thesis is dedicated to my grandfather, James Perkowski, for giving me the drive to follow my dreams and work to preserve nature. My love of geology started with you and our trips to Carlsbad Caverns.

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OVERVIEW

The Appalachian Mountains formed during three Paleozoic orogenic events and the associated metamorphism and deformation. The Talladega Group of the western Blue Ridge contains the Cheaha Quartzite. Within the Cheaha Quartzite is a metaconglomerate interval at the base of the formation and the pebbles within have been stretched/elongated in a north-south orientation. I present the Porter Gap 7.5–minute geologic mapping and structural measurements of stretched pebble orientation to estimate the timing of deformation in the western Blue Ridge of the southern Appalachian Mountains. To investigate the relationship between metamorphism of the western Blue Ridge and deformation throughout the Appalachian Mountains, this paper presents (1) geologic mapping of the Porter Gap 7.5–minute quadrangle, including lithology descriptions and bedrock structural measurements, and (2) stretched pebble measurements from a marker unit within the western Blue Ridge, the Cheaha Quartzite of the Lay Dam Formation. Deformation and metamorphism happened between 359 and 320Ma, constrained by deposition of the youngest member of the Talladega Group, and the cooling temperatures of muscovite $^{40}Ar/^{39}Ar$ samples (McClellan et al., 2007), however, this timing lies between the known Neoacadian Orogeny (~360-340Ma) and the Alleghenian (320-260Ma). The timing of stretched pebble deformation bridges the temporal gap between two orogenies in an "Acadian-Alleghenian transitional event.

PART 1: GEOLOGY OF THE PORTER GAP 7.5–MINUTE QUADRANGLE, TALLADEGA, AND CLAY COUNTIES, ALABAMA

Cover: View of quartzite beds creating a waterfall, Lake Jogloma, Alabama.

Introduction

The Porter Gap 7.5–minute quadrangle (Fig. 1) is located in Talladega and Clay Counties, Alabama. Residents use this area for recreation, agriculture, and logging within the Talladega National Forest. The Porter Gap 7.5–minute quadrangle is home to the Porter Gap Trailhead of the Pinhoti National Recreation Trail, which provides access along Horn Mountain. Several inactive mines in the area are the Hatchet Creek Copper mine, the Watt Manganese opening, and the Riddles Mill gold mine. In the southeast portion of the quadrangle, several

agricultural operations and tree farms are on private lands. Future residential and industrial development of the Porter Gap 7.5–minute quadrangle is expected due to its proximity to Talladega, Alabama. Geologic mapping of the Porter Gap 7.5–minute quadrangle was completed as part of the U.S. Geological Survey's National Cooperative Geologic Mapping Program (EDMAP component; Award No. G20AC00298) to provide basic geologic information for further planning and development. This report summarizes the geologic investigation of the Porter Gap 7.5–minute quadrangle at the 1:24,000 scale to provide geologic data on the area.

Location

The Porter Gap 7.5–minute quadrangle (longitudes 86°00′00″W to 86°12′50 ″W and latitudes 33°37′50 ″N to 33°25′00 ″N) is located in Talladega and Clay counties, in northeast Alabama. It is located west of the Clairmont Springs quadrangle, mainly within the Talladega National Forest, with access via public roads. The most prominent roadway, Alabama 77, connects Talladega with Ashland to the southeast. Alabama 77 runs through the town of Talladega (north) and Clairmont Springs (east) quadrangles. Clay County 7, the second most traveled trafficway, branches off Alabama 77, heading to the south towards Goodwater and cuts through the Bulls Gap quadrangle (south). An active railroad follows Alabama Highway 77 from the town of Talladega to ~1 mile south of Waldo, where the CSX Transportation railroad turns eastward and carries on towards Lineville, AL. Several Small communities reside on the Porter Gap quadrangle, including Allison Mills, Smelly, Waldo, and Coleta.

The highest elevation on the Porter Gap 7.5–minute quadrangle is Horn Mountain at 1,924 feet above sea level, while the lowest is 580 feet along Swept Creek in the southeast corner. Horn Mountain, the predominant feature on the Porter Gap 7.5–minute quadrangle,

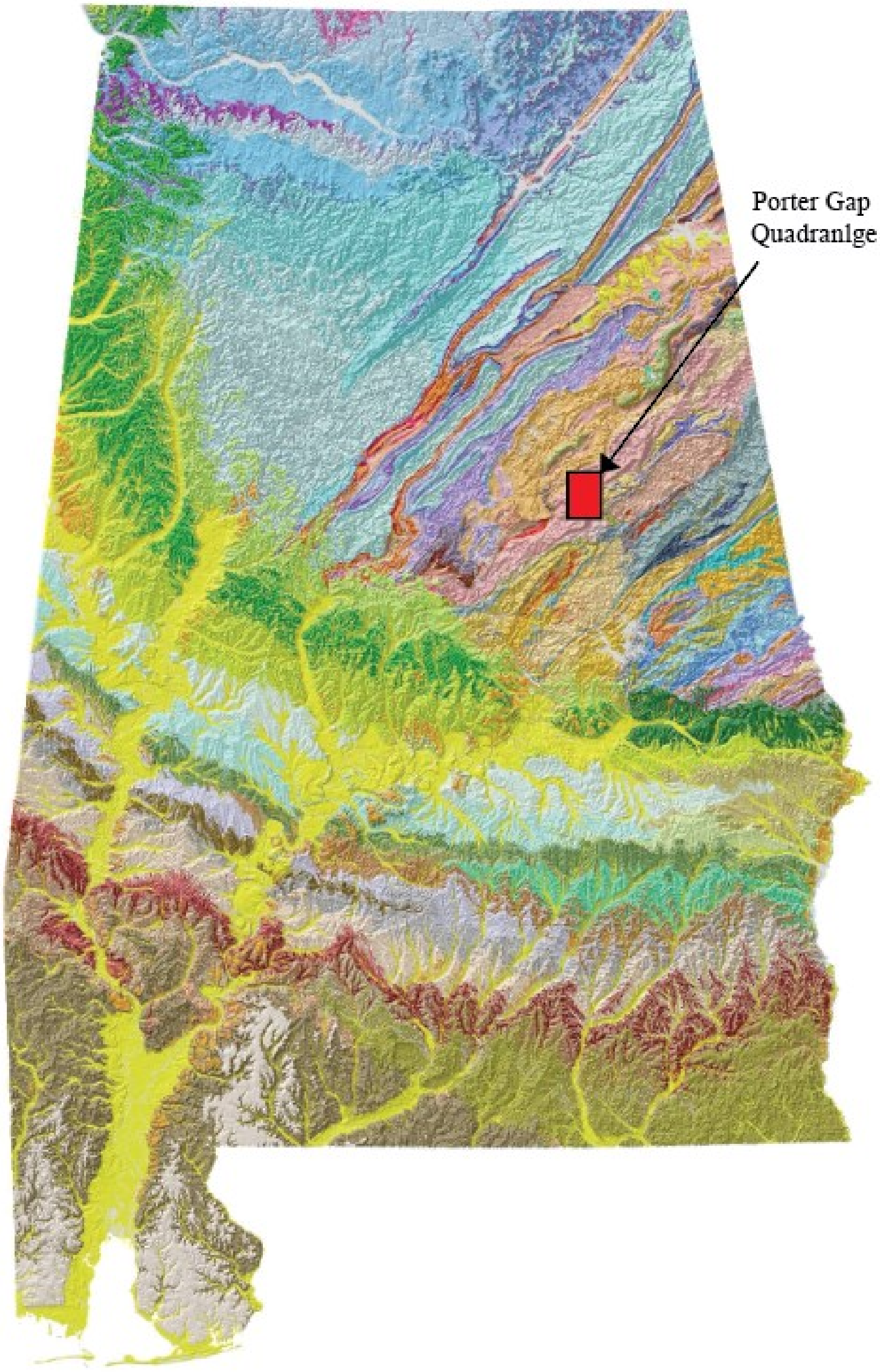

Figure 1. Location of the Porter Gap 7.5–minute quadrangle in the southern Appalachians of Talladega and Clay counties, Alabama (Original map Osborne et al., 1992).

extends from the eastern edge of the map and continues southwest until the strike of the ridge abruptly changes, continuing back towards the south. The southeast slope of the mountain is the dip slope with an average elevation change of .8 ft/m, while the scarp slope to the northwest has an average elevation change of 1.5ft/m.

There are several large creeks in the Porter Gap 7.5–minute quadrangle, including Talladega Creek, Dry Creek, Weeoka Creek, Swept Creek, Smelly Creek, Emuhee Creek, and the East and West Forks of Hatchet Creek. On the southeastern side of Horn Mountain, West Hatchet Creek and East Hatchet Creek flow from the eastern side of the map and converge on the Bulls Gap quadrangle to the south.

Geologic and Tectonic Setting

Geology. Paleozoic rock units, ranging from Ordovician to Mississippian, compose the stratigraphy of the Porter Gap 7.5–minute quadrangle, apart from the slightly older Precambrian-Paleozoic Poe Bridge Mountain Group (Fig. 2). The Porter Gap 7.5–minute quadrangle contains geologic units from the Valley and Ridge, the western Blue Ridge, and the eastern Blue Ridge Provinces (Szabo et al., 1988). The Valley and Ridge rock units are predominantly sedimentary rocks with little to no metamorphism (Szabo et al., 1988; Hatcher et al., 1989). The Valley and Ridge outcrops in the Porter Gap 7.5–minute quadrangle as dolomite and terrace deposits from the undifferentiated Knox Group. The eastern Blue Ridge outcrops on the Porter Gap 7.5–minute quadrangle as the Poe Bridge Mountain Group. The western Blue Ridge, the westernmost metamorphic province of the Appalachians, outcrops as the Talladega Group and the Hillabee Greenstone on the Porter Gap 7.5–minute quadrangle (Sapp and Emplaincourt, 1975; Tull, 1978; Raymond et al., 1988; McClellan et al., 2007; Barineau, 2009; Tull and Barineau, 2012). The

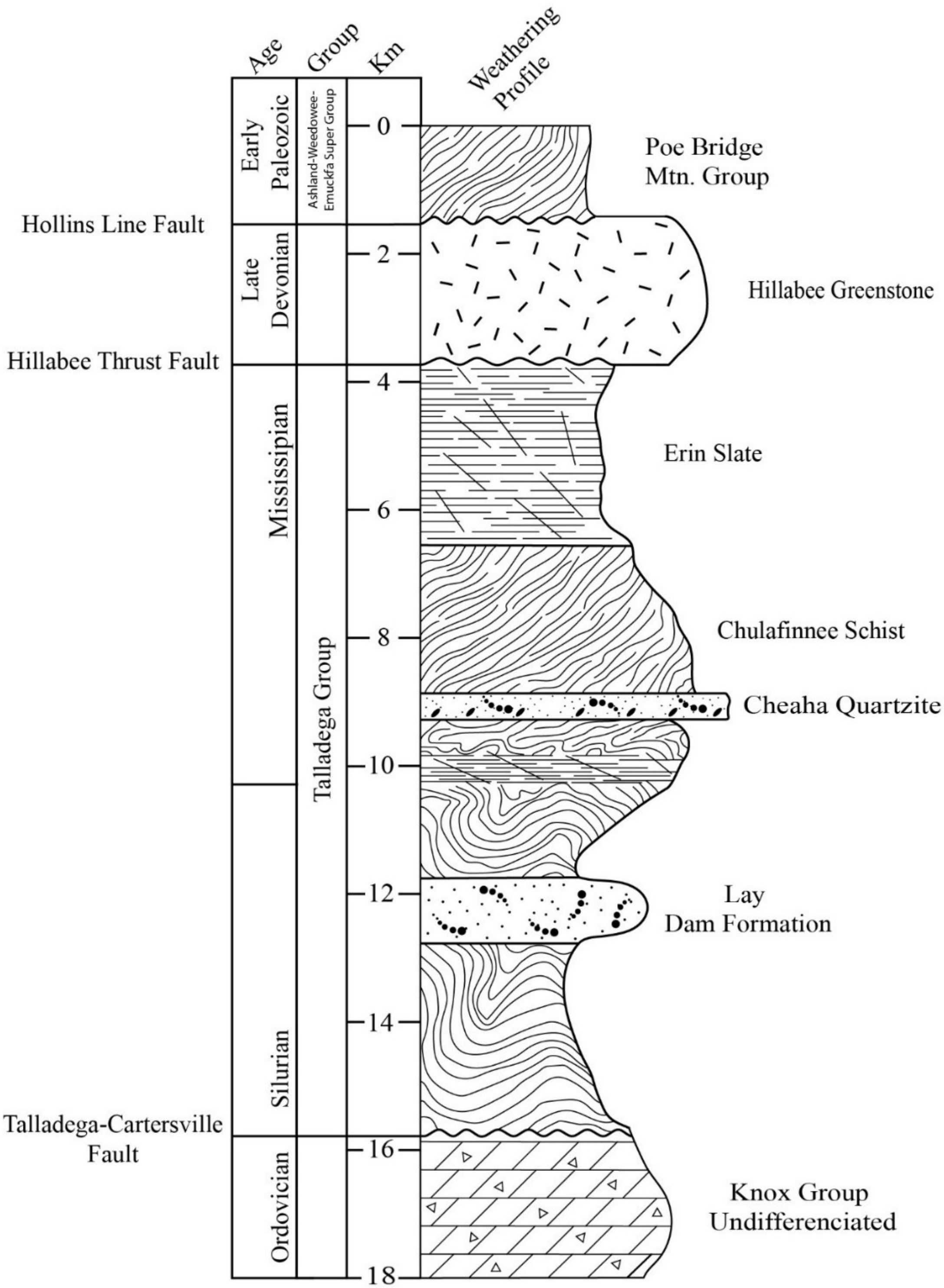

Figure 2. Stratigraphic column of the Porter Gap 7.5–minute quadrangle.

Talladega Group was first deposited between the Silurian(?) and the Mississippian in a shallow marine environment. The youngest unit in the Talladega Group is the Erin Slate of the early Mississippian (Beck, 1978; Szabo et al., 1988).

Tectonics. The Appalachian Mountains were constructed from several Paleozoic orogenic events representing an entire Wilson cycle (Meckel, 1970; Thomas, 1977; Bobyarchick, 1982; Hatcher et al., 1989). The three Paleozoic orogenic events include the Ordovician Taconic orogeny, the Devonian Acadian orogeny with the subsequent Neoacadian orogeny, and the Permian Alleghanian orogeny (Hatcher et al., 1989; Hatcher, 2005). Taconic orogeny is not widely seen in the southern Appalachians because it mainly affects the northern portion of the mountain range (Tull and Barineau, 2012).

The early to middle Devonian (410-380Ma) Acadian orogeny resulted from the collision between fragments of the Avalonia protocontinent and the Laurentian margin (Osberg et al., 1989; Hatcher, 2005; Murphy and Keppie, 2005). Deformation such as crustal thickening, ductile deformation, partial melting, and recrystallization of the Laurentian margin and Avalonia was common during the Acadian orogeny (Osberg et al., 1989; Stowell et al., 2019; Kish, 1990). The Neoacadian orogeny (~360–340) occurred simultaneously with the end of the Acadian orogeny; however, the Neoacadian deformation is limited to the southern Appalachians (Hatcher et al., 1989; van Staal et al., 2009; Hatcher, 2010). The Alleghanian orogeny (325? -260 Ma) resulted from the Laurentian and Gondwanan collision that created the supercontinent of Pangea (Secor et al., 1986; Hatcher et al., 1989; Hatcher, 2005; van Staal et al., 2009; Hatcher, 2010). The Alleghanian orogeny closed in a zipper-like fashion where the present-day northern sections of Laurentia and Gondwana collided directly, and the southern portion collided later at an oblique angle (Secor et al., 1986; Hatcher et al., 1989; Hatcher, 2005).

Previous Investigations

No in-depth mapping has been done on the Porter Gap 7.5–minute quadrangle. All overlapping maps were done on a state-wide or country-wide scale. The first official state geologic map of Alabama was done by Smith (1903). This map was updated by Szabo et al. (1988), then updated again by Osborne et al. (1992). Several local geology maps have been produced, including Talladega County (Causey, 1965; Whiting, 2009), Clay County (Pouty, 1923), and the Sylacauga marble district (Guthrie, 1989). The nearest mapped quadrangle is directly to the north, the Talladega 7.5–minute quadrangle mapped by Irvin and Bearce (2005). Nearby, EdMAPS researchers have mapped geologically similar quadrangles to the Porter Gap 7.5–minute quadrangle, including the Red Hill quadrangle (Sterling, 2006), Beulah quadrangle (Key and Steltenpohl, 2009), Sleeping Giants (Bearce and Irvin, 2003) and Wadley South (VanDervoort and Steltenpohl, 2016). To the east, four quadrangles were mapped as part of a single study by Neathery and Reynolds (1975), the Lineville East, Ofelia, Wadley North, and Mellow Valley quadrangles. Clairmont Springs quadrangle (Ionescu, 2021), directly to the east of the Porter Gap 7.5–minute quadrangle, was mapped in conjunction with this project.

Stratigraphy

The rocks on the Porter Gap 7.5–minute quadrangle look slightly different from their official descriptions. On the Porter Gap 7.5–minute quadrangle, the Poe Bridge Mountain Group can be described as graphitic schist with medium-to-coarse grains of quartz, plagioclase feldspar, and biotite with a white chalky matrix. Secondary growth garnets range in size from sub- 1cm to ~3 cm in diameter and have typically weathered out. The Knox Group undifferentiated is composed of crystalline, white-light grey, massive-bedded, micritic dolomite that is easily

weathered, with interbedded tan, orange, and pink chert nodules. The Hillabee Greenstone outcrops on the Porter Gap 7.5–minute quadrangle as a fine-to-coarse-grained, grey-to-olive green, massive greenstone with interbedded fine-grained, graphitic, green-gray phyllite; some parts grade into grey-green, fine-grained slate/mudstone. The Lay Dam Formation outcrops as gray-green, silver, orange, and red very fine-grained, graphitic phyllite, interbedded with a coarse-grained, dark-grey quartzite; white-tan, medium-grained arkosic schists; a well-consolidated, fine-grained, gray-green, and orange phyllite and metamudstone; and a medium-to-coarse-grained, quartz-rich, arkosic schist. The Cheaha Quartzite is composed of a white-to-light-grey, medium-to-coarse-grained quartzite and metaconglomerate that fines upward. White to gray quartz pebbles are common in the lower section and range from ~3cm to ~22cm long. The Chulafinnee Schist seen on the Porter Gap 7.5–minute quadrangle is described as medium-to-coarse-grained micritic schists with chalky white, crumbly matrix locally iron-rich, with secondary-growth garnets and an interbedded coarse-grained sandstone and grey-green graphitic phyllites. The Erin Slate outcrops as a fine-grained, light-grey slate with interbedded grey, massive mudstone, and phyllite.

Poe Bridge Mountain Group (pbm). The Poe Bridge Mountain Group, part of the Ashland Supergroup, was deposited from the Proterozoic to early Paleozoic and metamorphosed between 448-274 Ma (Allison, 1992; Barineau et al., 2015; Ionescu, 2021). Neathery and Reynolds (1973) initially placed the Poe Bridge Mountain Group into the Wedowee Group as a part of the Ashland Mica Schist but was later divided out by Neathery and Reynolds (1975). Tull (1978) defined the Ashland Supergroup as a separate group apart from the Wedowee Group. Locals have mined the highly graphitic Poe Bridge Mountain Group in Clay County since the 1800s (Prouty, 1926). The protolith of the Poe Bridge Mountain Group is interpreted to be pelitic

sediments interbedded with volcaniclastics (Hayes-Davis, 1979). Szabo et al. (1988) described the Poe Bridge Mountain Group as a coarse- to fine-grained feldspathic graphite schist, ± staurolite ± kyanite ± muscovite schist ± biotite ± garnet schist, with locally common biotite-garnet feldspathic gneiss pegmatites. Poe Bridge Mountain Group outcrops along Hancock Forest Management roads in the southeast corner of the map (Fig. 3) (NW¼SE ¼ sec. 27, T.20 S., R.6 E.).

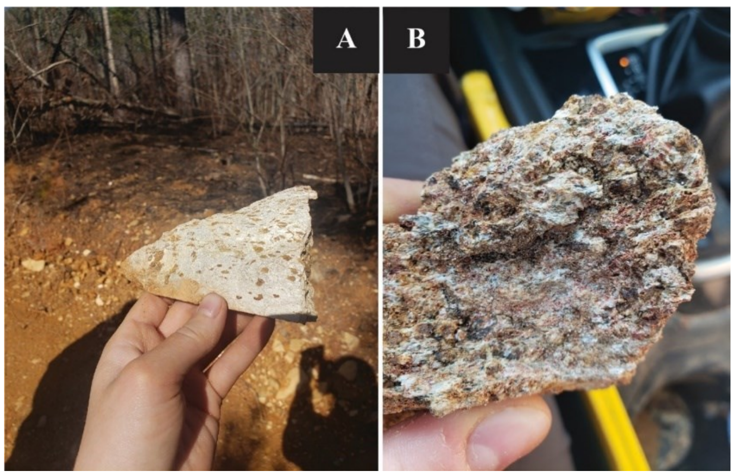

Figure 3. Hand samples of the Poe Bridge Mountain Group were taken along service roads in the Hancock Forest Management Area (NW¼SE ¼ sec. 27, T.20 S., R.6 E.) Porter Gap 7.5–minute quadrangle.

Knox Group Undifferentiated (O\k). The Knox Group undifferentiated (Cambrian to Ordovician) is a part of the sedimentary Valley and Ridge province and makes up a sizable portion of the central Alabama stratigraphy (Szabo et al., 1988). The Szabo et al. (1988) map describes the Knox Group as limestones and dolostones with interbedded chert nodules and is locally fossiliferous. Several members of the Knox Group are the Cooper Ridge Dolomite, the Chepultepec Dolomite, the Longview Limestone, and the Newalla Limestone (Hunter and Moser, 1990). The Knox Group undifferentiated is highly weathered and outcrops poorly on the Porter Gap 7.5–minute quadrangle. Due to these poor outcrops, any subdivision of the Knox

Group was impossible and was mapped as the Knox Group undifferentiated. Highly weathered samples of the Knox Group undifferentiated outcrops along Allison Mills Road (SE¼SW¼ sec. 21, T.19 S., R.5 E.) on the Winterboro 7.5–minute quadrangle and (SW¼SE¼ sec. 21, T.19 S., R.5 E.) the Porter Gap 7.5–minute quadrangle (Fig. 4).

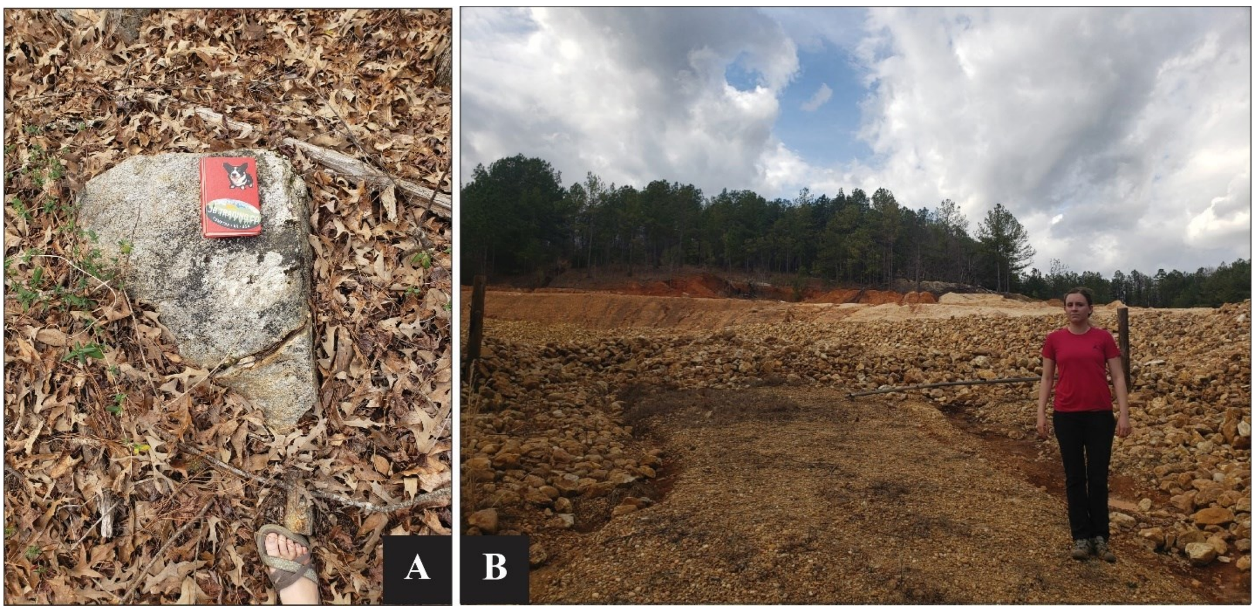

Figure 4. Outcrops of the Knox Group undifferentiated. (A) In place sample of the dolomite member of the Knox Group undifferentiated along Allison Mills Road (SE¼SW¼ sec. 21, T.19 S., R.5 E.) Winterboro 7.5–minute quadrangle. (B) Fellow researcher Adelie Ionescu stands near a gravel quarry along Allison Mills Road (SW¼SE¼ sec. 21, T.19 S., R.5 E.) Porter Gap 7.5–minute quadrangle.

Hillabee Greenstone (hgs). The Hillabee Greenstone likely formed from volcanic rocks filling a back-arc basin due to suprasubduction at the continental margin (Tull et al., 1978; Tull and Stow, 1980; Tull et al., 2007). Some geologists (Prouty, 1926; Neathery and Reynolds, 1973; Tull et al., 1978; Tull and Stow, 1980; Tull et al., 1988) have argued that the contact between the Hillabee Greenstone and the rest of The Talladega Group is stratigraphic. However, muscovite U/Pb and 40Ar/39Ar dating show that the age of the Hillabee is roughly 470-460 Ma, Tull et al., 2007; McClellan et al., 2007). Tull et al. (2007) and Barineau (2009) stated that the Hillabee

thrust fault must be a flat-on-flat ramping fault due to parallel structures within the Hillabee and the underlying Jamison Chert-Erin Slate. making it older than the underlying Talladega Group (Russell, 1978; Russell et al., 1984).

The Hillabee Greenstone is a massive, pale-green, light-olive-brown, fine-grained greenstone interbedded locally with well-foliated phyllite (Szabo et al., 1988). The Hillabee Greenstone is best seen on Flat Top Ridge along Hancock Forest Management roads (sec. 20, T.20 S., R.6 E.) as well as along Chandler Creek Road (Fig. 5) (SE¼NE ¼ sec. 3, T.20 S., R.6 E.). The Hillabee Greenstone has been faulted onto the Porter Gap 7.5–minute quadrangle and changes thickness from its southern to its northernmost point. It ranges from 680m to 2600m thick.

Talladega Group. Lay Dam Formation (tld). The Lay Dam Formation was first defined by Carrington (1973) as a thick clastic wedge composed of metaturbidite, arkosic conglomerate, and thick olistostrome beds. Only one subunit, the Cheaha Quartzite, appears on the Porter Gap 7.5–minute quadrangle. Conodont fossils were used to age the Lay Dam Formation from Silurian to early Devonian (Tull et al., 1988). The Lay Dam Formation is characterized as interbedded dark-green phyllites, medium-gray to light-brown and black metasiltstones, dark-green feldspathic metagraywackes, white to light-gray and dark-gray medium- to coarse-grained arkosic quartzites and metaconglomerates; graphitic phyllite common in the upper part (Szabo et al., 1988). The fine-grained orange and silver phyllite outcrops along Country Road 234 (Fig. 6) (SW ¼ sec. 26, T.20 S., R.6 E.). Lake Jogloma, along the Pinhoti Trail and County Road 621A (SE¼NW ¼ sec. 31, T.19 S., R.6 E.) is the best location to see the quartzite member of the Lay Dam Formation. The dark-gray, well-consolidated, graphitic phyllite outcrops along the

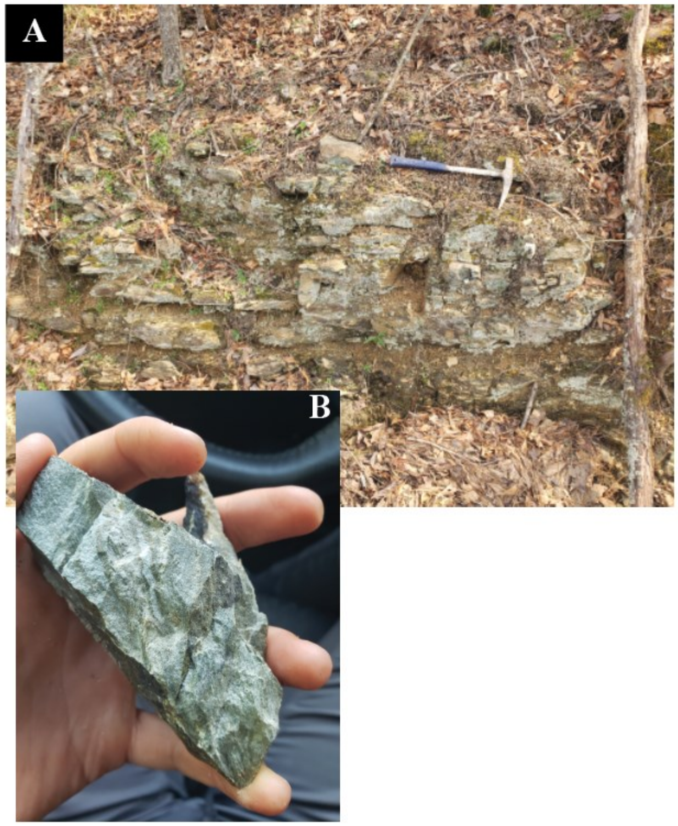

Figure 5. (A) The Hillabee Greenstone seen in roadcut along Chandler Springs Road, (B) Hand sample of the Hillabee Greenstone showing fine-grained texture. (SE¼NE ¼ sec. 3, T.20 S., R.6 E.) Porter Gap 7.5–minute quadrangle.

Alabama 77 roadway (NW ¼NW ¼ sec. 8, T.19 S., R.6 E.). The Lay Dam Formation is the thickest on the quadrangle at 6300m.

Cheaha Quartzite Member of the Lay Dam (tldcq). The Cheaha Quartzite, first named by Butts (1926), is the ridge-forming unit of the Talladega Mountains and is the stratigraphic equivalent to the Butting Ram Sandstone (Cook, 1982; Tull and Barineau, 2012). Locally, the Cheaha Quartzite has a metaconglomerate base with pebbles ranging from 3cm to 22cm in length (Cook, 1982). This unit was first deposited during the Silurian(?) and Devonian (Szabo et al., 1988). Szabo et al. (1988) describe the Cheaha Quartzite as a white to light-gray, medium- to coarse-grained arkosic quartzite, and metaconglomerate. Horn Mountain and County Road 307

(Fig. 7) (SE¼SE¼ sec. 1, T.20 S., R.5 E.) on the Porter Gap 7.5–minute quadrangle is the best locality to find the Cheaha Quartzite. The stratigraphic thickness of the Cheaha Quartzite ranges

Figure 6. The Lay Dam Formation. (A) Fellow researcher Adelie Ionescu on top of the well-consolidated schist/phyllite of the Lay Dam Formation near Skyline Drive (NE¼NE ¼ sec. 25 T.19 S., R.6 E.) Clairmont Springs 7.5–minute quadrangle. (B) A dark-gray Quartzite member of the lower Lay Dam Formation is seen in the waterfall at Jogloma Lake (SE¼NW ¼ sec. 31, T.19 S., R.6 E.) Porter Gap 7.5–minute quadrangle. (C) Road cut of gray-green Phyllite off Alabama 77 (NW ¼NW ¼ sec. 8, T.19 S., R.6 E.) Porter Gap 7.5–minute quadrangle. (D) Gray-green, well-consolidated phyllite/mudstone (NW ¼NW ¼ sec. 8, T.19 S., R.6 E.) Porter Gap 7.5–minute quadrangle.

from 300m to 10m (Tull and Barineau, 2012).

Chulafinnee Schist (Dtjc). According to Bearce (1973), the base of the Erin Slate had a discontinuous quartzite and metachert that is now known as the Chulafinnee Schist or the Tally Mountain Quartzite in Georgia (Bearce, 1973; Heuler, 1993). The Chulafinnee Schist is the

Figure 7. The Cheaha Quartzite member of the Lay Dam Formation. (A) outcrop of Cheaha Quartzite along the Pinhoti Trail near Chandlers Gap (SW¼NE¼ sec. 34, T.19 S., R.6 E.) Porter Gap 7.5–minute quadrangle. (B) outcrop of the Cheaha Quartzite metaconglomerate member on Horn Mountain along County Road 307 (SE¼SE¼ sec. 1, T.20 S., R.5 E.) Porter Gap 7.5–minute Quadrangle.

stratigraphic equivalent to the Jamison chert (Szabo et al., 1988). This unit was deposited from the Silurian to Devonian (Szabo et al., 1988). Szabo et al. (1988) describe the Chulafinnee Schist as a grayish-white to yellowish-orange massive, thick-bedded, fine-grained, locally argillaceous and fossiliferous metachert, with a light- to dark-greenish-gray, fine- to medium-grained fissile quartz-sericite-chlorite phyllite and schist; this locally includes thin chlorite phyllite and quartzose phyllite beds (Fig. 8). It outcrops along County Road 307 (NW¼SW¼ sec. 4, T.20 S., R.6 E.) and County Road 662 (SE¼ sec. 13, T.20 S., R.5 E.). On the Porter Gap 7.5–minute quadrangle, the Chulafinnee Schist averages 1000m thick.

Erin Slate (Dtes). The age of the Erin Slate is late Devonian to early Mississippian (360-350 Ma) (Beck, 1978: Tull and Barineau, 2012) but was first dated to

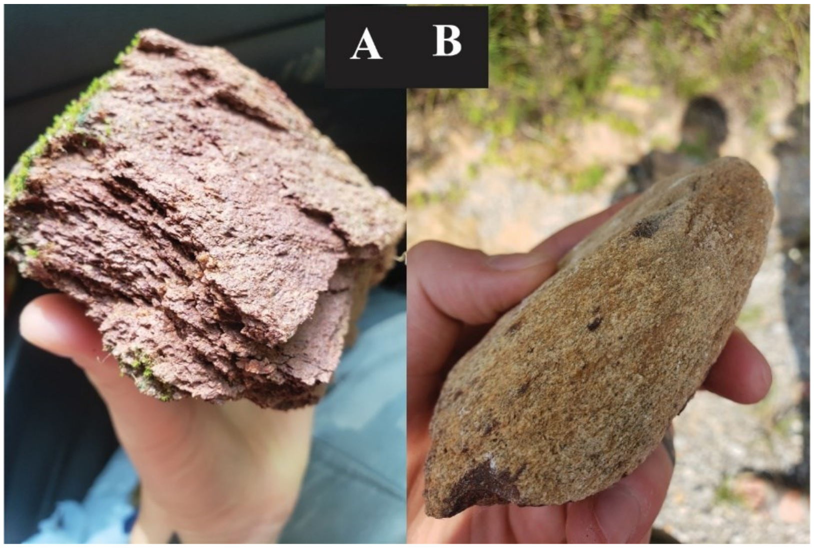

Figure 8. Hand samples of the Chulafinnee Schist (A) a medium-grained, iron-rich hand sample of the Chulafinnee Schist taken from Horn Mountain near Country Road 307 (NW¼SE¼ sec. 12, T.20 S., R.5 E.) Porter Gap 7.5–minute quadrangle. (B) a tan-gray, medium-grained sample of Chulafinnee with some garnets present (NW¼SW¼ sec. 4, T.20 S., R.6 E.) Porter Gap 7.5–minute quadrangle.

the late Carboniferous (Smith, 1903). The miss-aging of the unit led early researchers (Jonas, 1932) to believe it was not a part of the Talladega Group, but a window terrane faulted into the area. It has since been proven to be the youngest member of the Talladega Group. The Erin Slate is described as black graphitic sericite phyllite and slate containing plant fossils (Szabo et al., 1988). The Erin Slate is the stratigraphic equivalent to the Jemison Chert, a fossiliferous, silicious, argillite, phyllite, and metasandstone (Szabo et al., 1988; Tull and Barineau, 2012). The Erin Slate outcrops west of Flat Top Ridge along Horn Valley Road (Fig. 9) (SE¼NW¼ sec. 30, T.20 S., R.6 E.). On the Porter Gap 7.5–minute quadrangle, the Erin Slate is roughly 2000m thick.

Alluvium. Deposits of unconsolidated sand, silt, and gravel are present along streams and creeks on the Porter Gap 7.5–minute quadrangle. Alluvium deposits result from the weathering of surrounding units and consist primarily of chert and quartz. Alluvium grain size ranges from

Figure 9. Outcrop of the Erin Slate seen near Flat Top Ridge along Horn Valley Road (SE¼NW¼ sec. 30, T.20 S., R.6 E.) Porter Gap 7.5–minute quadrangle.

clay to cobble-sized loose rocks. Due to overall thin deposits, the alluvium does not appear on the plate cross-section.

Structural Geology

Major structural features are mapped on the Porter Gap 7.5–minute quadrangle geological map and cross-sections A-A′ and B-B′ (see Plate 1). Three significant faults are present in Porter Gap 7.5–minute quadrangle: The Talladega-Carterville fault, the Hillabee thrust fault, and the Hollins Line fault (Szabo et al., 1988). Faults on the Porter Gap 7.5–minute quadrangle strike southwest-northeast through the northwest corner (Talladega-Cartersville) and southeast (Hillabee thrust and Hollins Line).

Talladega-Cartersville Fault. The regional thrust Talladega-Cartersville fault is located in the northwest corner of the Porter Gap 7.5–minute quadrangle. The Talladega-Cartersville fault strikes northeast-southwest with an average dip of 10° SE (Lim, 1998), as seen in Plate 1. The Talladega-Cartersville fault marks the boundary between the metamorphic rocks of the Talladega Group in the hanging wall and the sedimentary Knox Group undifferentiated in the footwall. Estimates for net slip along the Talladega-Cartersville fault are roughly 23 km with 5–7 km uplift (Lim, 1998; Tull and Barineau, 2012). The Talladega-Carterville fault postdates metamorphism and deformation in the Talladega Group (Connelly and Dallmeyer, 1993; Tull and Barineau, 2012). The most recent movement along the Talladega-Cartersville fault is presumed to be during the Permian (Tull, 1978). The Talladega-Cartersville fault truncates into the Great Smoky fault near Carterville, GA, and may reflect an extension of the Great Smoky fault system to the southwest (Cook et al., 1979; Tull, 1998; Tull and Holm, 2005).

Hillabee Thrust Fault. Located in the central-southeastern portion of the map is the Hillabee thrust fault (Plate 1). The Hillabee thrust fault strikes NE/SW and dips SE at 10°. It enters the Porter Gap 7.5–minute quadrangle on the east and takes a sharp turn to the south before exiting the map, similar to the strike of Horn Mountain (Plate 1). The Hillabee fault runs almost perfectly parallel against the Talladega Group, leading previous researchers thought that the apparent gradation between units could be evidence for the Hillabee Greenstone to be the stratigraphically youngest formation of the Talladega Group (Prouty, 1926; Neathery and Reynolds, 1973; Tull et al., 1978; Tull and Stow, 1980; Tull et al., 1988). The Hillabee Greenstone contains lower greenschist-facies metamorphic rocks that record similar conditions as the adjacent Talladega Group; therefore, movement along the fault is likely pre- or syn-metamorphism (Russell, 1978; Russell et al., 1984; McClellan et al., 2007; Tull et al., 2007;

Barineau, 2009). Barineau and Tull (2001) and Tull et al. (2007) state that the fault is flat-on-flat ramping and a product of thin-skinned deformation.

Hollins Line Fault. Located in the southeast corner of the Porter Gap 7.5–minute quadrangle is the Hollins Line fault. The Hollins Line fault follows a similar strike to the Hillabee thrust fault and strikes NE-SW before bending to exit the map to the south and dips 15–20° SE (Tull, 1995; Tull and Barineau, 2012). Numerous floor and roof faults branch off the main Hollins Line Fault, creating a splay fault. However, only one of these branches is on the Porter Gap 7.5–minute quadrangle (Plate 1). The Hollins Line fault marks the boundary between the Eastern Blue Ridge Poe Bridge Mountain Group and the western Blue Ridge Hillabee Greenstone and the structural and metamorphic change between the two provinces. The ~200 km trace runs along the structurally weak Hillabee Greenstone for >82% of the trace (Tull, 1978; Tull and Barineau, 2012). There is a relatively slight change in the topography at the fault because both units weather at the same rate (Barineau, 2009; Tull and Barineau, 2012). The Hollins Line's most recent deformation is interpreted as Permian due to crustal shortening during the Alleghanian orogeny (Tull et al., 2007; Barineau, 2009; Tull and Barineau, 2012; Tull et al., 2012). However, movement along the Hollins Line fault started as early as 360-345Ma (Stowell et al., 2019).

Timing of Deformation. The Hillabee thrust fault is likely the first deformation seen on the Porter Gap 7.5–minute quadrangle. The youngest member of the Talladega Group, the Erin Slate, has a deposition age of 360-350 Ma (McClellan et al., 2007); thus, the metamorphism of the Talladega Group must be post-deposition of the Erin Slate due to its need to be in place before the Hillabee Greenstone could be faulted on top. The Hillabee Greenstone faulted on top of the Talladega Group, pre-or-syn-metamorphism, evidenced by their similar metamorphic ages

(Tull et al., 2007; McClellan et al., 2007; Barineau, 2009). Muscovite 40Ar/39Ar ages of the Hillabee Greenstone suggest the metamorphism of the Talladega Group and Hillabee Greenstone occurred between 360 to 320 Ma and was likely the second deformation to happen on the Porter Gap 7.5–minute quadrangle (Butts, 1926; Gastaldo et al., 1993; Tull et al., 2007; McClellan et al., 2007; Barineau, 2009).

Third, the Hollins Line fault placed the Poe Bridge Mountain Group on the Hillabee Greenstone during the Alleghanian orogeny. Since the Hollins Line fault cuts through the already metamorphosed Hillabee Greenstone and Talladega Group, we assume the Hollins Line fault happened post-metamorphism of these two units, likely during the Permian (McClellan et al., 2007; Tull et al., 2007; Barineau, 2009; Tull et al., 2012 Tull and Barineau, 2012). Some researchers believe that this fault caused the metamorphism of the Talladega Group and Hillabee Greenstone; However, the timing (Permian) of this fault does not align with the metamorphic age of the Talladega Group (Mississippian).

The last deformation to take place is along the Talladega-Cartersville fault. Slight metamorphism is seen in the footwall (Knox Group undifferentiated), while the hanging wall is metamorphosed (Talladega Group), which suggests that this fault postdates the metamorphism of the Talladega Group. The Talladega Group was deposited in the Silurian-Mississippian, while the Knox Group undifferentiated was deposited in the Cambrian-Ordovician (Szabo et al., 1988); this suggests the fault placed younger rocks on top of older rocks. Due to this, Tull (1998) and Tull and Barineau (2012) do not believe that the Talladega-Cartersville Fault exists, stating that it is an unconformity at the base of the Lay Dam Formation. However, thrust faults can place younger rocks on older rocks, given enough distance between the original deposition locations.

Thus, this fault has moved the Talladega Group considerably, likely a greater distance than the 23km documented by Lim (1998).

Summary

Mapping of the Porter Gap 7.5–minute quadrangle (longitudes 86°00′00″W to 86°12′50′W and latitudes 33°37′50 ″N to 33°25′00 ″N) at the 1:24,000 scale give a better understanding of stratigraphic and structural relationships between the units present. Bedrock units were seen on the Porter Gap 7.5–minute quadrangle, ranging from Precambrian to Mississippian in deposition age (Szabo et al., 1988). The units seen on the Porter Gap 7.5–minute quadrangle are a part of the Valley and Ridge, the western Blue Ridge, and the eastern Blue Ridge provinces. Formal stratigraphic units mapped on the Porter Gap 7.5–minute quadrangle include the Poe Bridge Mountain Group, the Knox Group undifferentiated, the Hillabee Greenstone, and the Talladega Group, which consists of the Lay Dam Formation, the Cheaha Quartzite member of the Lay Dam Formation, the Chulafinnee Schist, and the Erin Slate. The Chulafinnee Schist, the Erin Slate, and the Hillabee Greenstone thin near the east-central portion of the map; however, they do not pinch out entirely.

The only rock unit seen from the Valley and Ridge province on the Porter Gap 7.5–minute quadrangle is the Knox Group undifferentiated. The Knox Group undifferentiated makes up the footwall of the Talladega-Cartersville fault and shows little to no evidence of metamorphism (Connelly and Dallmeyer, 1993; Tull and Barineau, 2012). The Talladega Group is bound in the central portion of the map by the Talladega-Cartersville at the base and the Hillabee thrust fault to the top. The Hillabee thrust fault binds the Hillabee Greenstone at its base

and the Hollins Line fault at its top. The Poe Bridge Mountain Group is faulted on top of the Hillabee Greenstone by the Hollins Line fault.

The Talladega-Cartersville fault's last movement was likely post-metamorphism of the Talladega Group since the underlying Knox Group undifferentiated and contains little evidence of being metamorphosed (Connelly and Dallmeyer, 1993; Tull and Barineau, 2012). The Hillabee thrust fault places Devonian rocks over Mississippian rocks (Tull et al., 2007; McClellan et al., 2007; Barineau, 2009). The tectonic movement that placed the Hillabee above the Talladega Group happened pre-or syn- metamorphism (360–320 Ma) (Tull et al., 2007; McClellan et al., 2007; Barineau, 2009) due to the similar metamorphism and strike of the two units. The faulting geometry of the Hillabee thrust is flat-on-flat ramping (Barineau and Tull, 2001; Tull et al., 2007; Barineau, 2009). The Hollins Line thrust sheet, seen on the Porter Gap 7.5–minute quadrangle as the Poe Bridge Mountain Group, appears on the southeastern corner of the map. The Hollins Line thrust sheet was thrust over the Hillabee thrust sheet and emplaced Precambrian rocks over Devonian rocks during the Permian as a result of the Alleghanian (McClellan et al., 2007; Tull et al., 2007; Barineau, 2009; Tull et al., 2012 Tull and Barineau, 2012).

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PART 2: STRETCHED PEBBLE ANALYSIS OF THE CHEAHA QUARTZITE IN THE SOUTHERN APPALACHIAN MOUNTAINS, ALABAMA

Cover: Outcrop of the Cheaha Quartzite/Metaconglomerate along the Pinhoti Trail and Chandlers Gap near Talladega, Alabama.

Introduction

The timing of metamorphism and deformation of the Talladega Group in the southern Appalachians of Alabama is extraordinarily complex. Two major orogenies and a complete Wilson cycle have deformed the southern Appalachians (Meckel, 1970; Thomas, 1977; Bobyarchick, 1982; Hatcher et al., 1989). Correlating specific events' timing and stress patterns in the southern Appalachian area is difficult due to overprinting metamorphism and uncommon deformation. A stretched pebble analysis gives an insight into the deformation history of the metasedimentary units of the western Blue Ridge by focusing on the pebbles of the Cheaha Quartzite member of the Lay Dam Formation. Similar areas to the western Blue Ridge have been characterized and analyzed by Engelder (2006), Engelder and Whitaker (2006), and Bartholomew and Whitaker (2010). There is currently no stretched pebble analysis on the Cheaha Quartzite, and the cause of the deformation is currently unknown. A stretched pebble analysis was done to investigate the deformational history of the Talladega Group and the southern Appalachians. Linking deformational patterns to specific periods allows future researchers to better understand the tectonic history of the southern Appalachian Mountains.

Data was collected from Porter Gap and Clairmont Springs, 7.5–minute quadrangles of northeastern Alabama (Fig. 10). Porter Gap and Clairmont Springs 7.5–minute quadrangles have been mapped as EdMAP studies (Fig. 11). Talladega Mountain and Horn Mountain are along the same ridge that holds Cheaha Mountain, the highest elevation in Alabama. The Porter Gap 7.5–minute quadrangle holds units from the Valley and Ridge and the Blue Ridge-Piedmont provinces, including the Knox Group undifferentiated, the Talladega Group, and the Ashland Supergroup. Faults on the Porter Gap 7.5–minute quadrangle are the Talladega-Cartersville fault, the Hillabee thrust fault, and the Hollins Line fault.

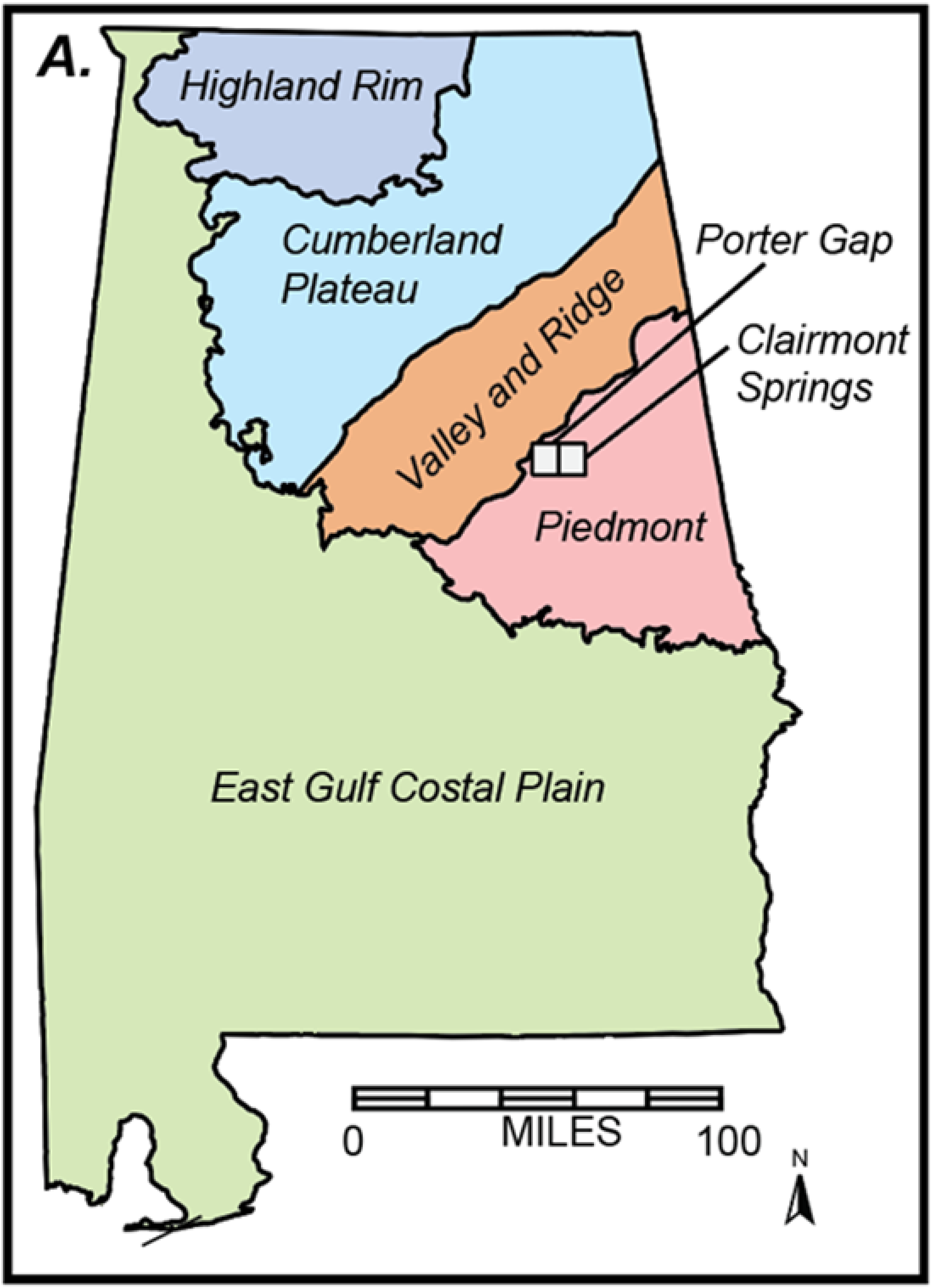

Figure 10. Province map of the southern Appalachians in Alabama showing the location of the Porter Gap and Clairmont Springs 7.5–minute quadrangles. Modified from Sapp and Emplaincourt (1975) and McKay (2015).

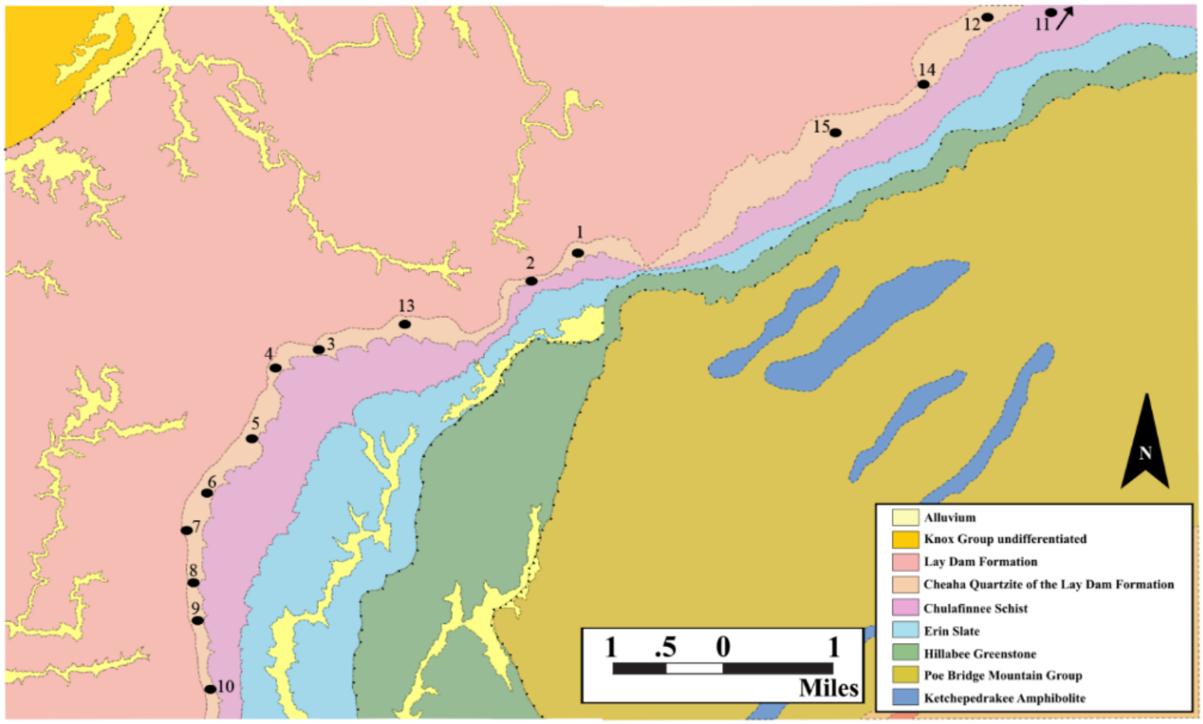

Figure 11. geologic maps of the Porter Gap and Clairmont Springs (Ionescu, 2021) quadrangles show the location of the 15 data stations. Cheaha Quartzite is depicted in light orange along the ridge of the mountain.

Geologic Background

Rock units in this area are part of the western Blue Ridge Province of the Appalachians. The western Blue Ridge is the westernmost metamorphic belt in the Appalachians and was deformed during several mountain-building events. The rocks of the western Blue Ridge originated as sediment deposited off the coast of Laurentia and have since been moved inland and metamorphosed. Units seen in the study area include the Talladega Group and the Hillabee Greenstone. The Talladega Group consists of the Lay Dam Formation, the Cheaha Quartzite of the Lay Dam Formation, the Chulafinnee Schist, and the Erin Slate. The Cheaha Quartzite's stretched pebbles have been deformed so that all pebbles align in a north-south orientation, even along a large bend in the ridge. The Cheaha Quartzite unit (Fig. 12) is a light gray medium-to-coarse-grained, poorly sorted quartzite with a metaconglomerate base (Szabo et al., 1988). The

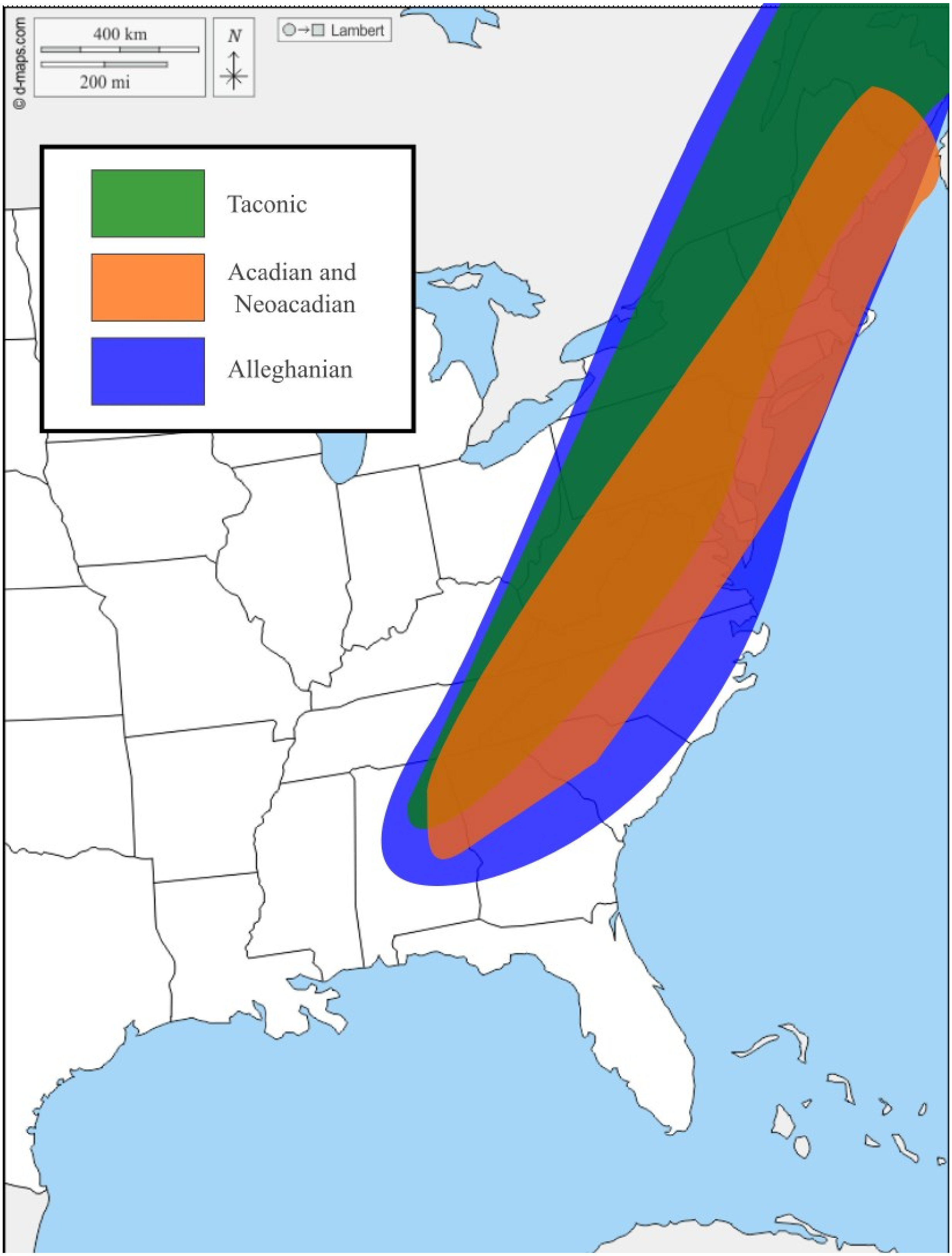

Figure 12. Three orogenic events have shaped the Appalachians, the Taconic, the Acadian/Neoacadian, and the Alleghanian. The green area shows Taconic deformation, the orange shows Acadian/Neoacadian deformation, and the blue shows Alleghanian deformation.

Cheaha Quartzite and metaconglomerate pebbles are primarily made of quartz, with little to no other minerals present in the unit. The pebbles in the metaconglomerate portion align north-south and are present along much of the Horn Mountain ridge. Several major deformational faults are found in the study area, the Talladega-Cartersville fault, the Hillabee thrust fault, and the Hollins Line fault. The Talladega-Cartersville fault places the metamorphosed units of the western Blue Ridge on top of the sedimentary units of the Valley and Ridge. The Hillabee thrust fault places the Hillabee Greenstone on the Talladega Group. Faulting likely occurred before or during the metamorphism of the Talladega Group due to their similar metamorphic ages (375-359 Ma) (Tull et al., 2007; McClellan et al., 2007; Barineau, 2009). The Hillabee thrust fault has a flat-on-flat ramping style, and minor deformation is seen along this fault (Barineau and Tull, 2001; Tull et al., 2007; Barineau, 2009; Barineau et al., 2015). The Hollins Line fault marks the boundary between the Eastern and Western Blue Ridge Provinces (Sapp and Emplaincourt, 1975; Tull, 1984; McClellan et al., 2007; Barineau, 2009; Tull and Barineau, 2012). The Hollins Line fault placed the Ashland Supergroup over the Hillabee Greenstone during the Permian due to the crustal shortening of the Alleghanian (Tull et al., 2007; Barineau, 2009; Tull et al., 2012; Tull and Barineau, 2012). The Hollins Line fault has a normal thrust fault dipping at 15–20° (Tull, 1995; Tull and Barineau, 2012).

Western Blue Ridge Province. The western Blue Ridge is the westernmost metamorphic belt of the Appalachians (Sapp and Emplaincourt, 1975; Raymond et al., 1988). The western Blue Ridge is composed of Laurentian basement gneisses and the overlying metasedimentary, plutonic, and metavolcanic units (Connelly and Dallmeyer, 1993; Massey and Moecher, 2005). Units of the Blue Ridge originated from sediments weathered off the underlying lower Paleozoic rocks and the underlying Grenville gneissic basement (1.1 Ga) (Raymond et al., 1988; Connelly

and Dallmeyer, 1993; Steltenpohl et al., 2004; Tull et al., 2007; Tull and Barineau, 2012). The Western Blue Ridge was deformed during all three major Paleozoic orogenies (Hatcher, 1987; Thomas, 1991; Massey and Moecher, 2005). The rocks in the western Blue Ridge were metamorphosed around 370 Ma but deformed throughout the Acadian and Alleghanian (Stowell et al., 2019; Tull, 2002; Ionescu, 2021). The western Blue Ridge allochthon was transported between 260-500km towards the Laurentian craton dextrally (Cook et al., 1979; Valentino et al., 1994; Tull, 1998; Bartholomew and Tollo, 2004; Barineau, 2009).

On the Porter Gap 7.5–minute quadrangle, the western Blue Ridge rocks outcrops as members of the Talladega Group. The Talladega Group consists of metasedimentary units bound by the Talladega-Cartersville fault and the Hillabee thrust fault (Tull, 1978; Raymond et al., 1988; McClellan et al., 2007; Barineau, 2009; Tull and Barineau, 2012). The rock units of the Talladega Group were deposited on the Laurentian shelf, formed in a marine environment, and deposited between the Silurian(?) and the Mississippian (Szabo et al., 1988). The age of metamorphism of the Talladega Group is bracketed from 350 to 320 Ma (pre- to early Alleghanian) based on 40Ar/39Ar data from McClellan et al. (2007). For this study, we focus on the Cheaha Quartzite and the metaconglomerate at its' base (Fig. 13).

Tectonics. Two significant orogenies deformed rocks in the southern Appalachians; the Acadian/Neoacadian and the Alleghanian orogenies (Fig. 12) (Hatcher, 2010). Between the Acadian/Neoacadian and the Alleghanian, the southern Appalachians were subject to an Appalachian-wide stress field (Engelder and Whitaker, 2006; Bartholomew and Whitaker, 2010). During the early and middle Devonian (410-380Ma), the Acadian orogeny resulted from the collision between fragments of the Avalonia proto-continent and the Laurentian margin (Fig. 14)

Figure 13. Stretched pebbles are found in the Cheaha Quartzite. Figures (A) and (B) are examples of larger pebbles seen within the Cheaha Quartzite at station 10 (NE¼SE ¼ sec. 23, T.20 S., R.5 E.). (C) ~3cm long pebbles seen at station 13 (NE¼SW ¼ sec. 5, T.20 S., R.6 E.). (D) Outcrop of Cheaha Quartzite seen near Pinhoti Trail and station 4 (NW¼SE ¼ sec. 6, T.20 S., R.6 E.), author Tessa Mills for scale.

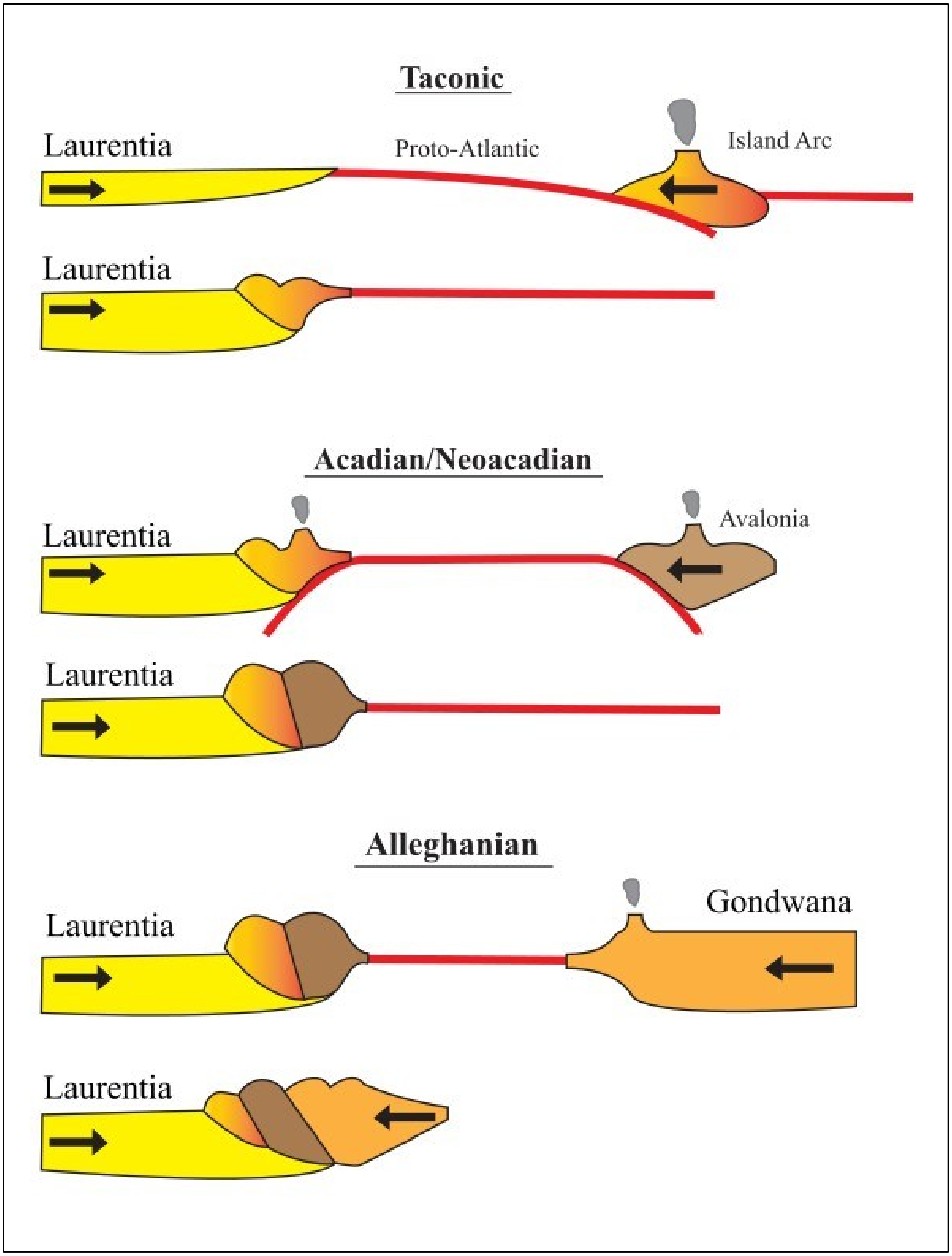

Figure 14. Deformation of the Taconic, the Acadian/Neoacadian, and Alleghanian orogenies affected the Southern Appalachians and the resulting Provinces (modified from Marshak, 2008). 1989).

(Osberg et al., 1989; Hatcher, 2005; Murphy and Keppie, 2005). Crustal thickening, ductile deformation, partial melting, and recrystallization characterize the Acadian orogeny (Osberg et al., 1989; Stowell et al., 2019; Kish, 1990). The late Devonian to middle Mississippian Neoacadian orogeny (360–350) reflects a continuation of volcanism from the Acadian orogeny (Hatcher, 2005; Clark, 2008; Hatcher, 2010). The Neoacadian orogeny happened simultaneously with the end of the Acadian orogeny; however, the Neoacadian deformation is limited to the southern Appalachians (van Staal et al., 2009; Hatcher, 2010).

Between the end of the Neoacadian (~340 Ma) and the onset of the Alleghanian (~325 Ma) orogenies, a tectonic force known as an Appalachian-wide stress field affected the southern Appalachians (Bartholomew and Whitaker, 2010; Engelder, 2006; Engelder and Whitaker, 2006). The Appalachian-wide stress field formed from either (1) traction between Laurentia and Gondwana before the collision or (2) microcontinents and island arcs colliding with Laurentia (Engelder, 2006). These continental fragments moved up to 150-500 km dextrally towards Laurentia (Valentino et al., 1994; Bartholomew and Tollo, 2004), seen in joint sets throughout 1500 km Appalachians (Engelder, 2006; Engelder and Whitaker, 2006). Bartholomew and Whitaker (2010) believed that the onset timing of this Appalachian-wide stress field was migratory, starting first in the present-day north and then later in the south. This Appalachian-wide stress field lasted roughly 10-15 million years (Engelder and Whitaker, 2006).

During the Alleghanian (325? -260 Ma), Laurentia and Gondwana collided to create Pangea (Secor et al., 1986; Hatcher et al., 1989; Hatcher, 2005; 2010; van Staal et al., 2009). This collision was the last deformation event that affected the Appalachians and built the mountains we see today. All three Appalachian provinces deformed and were uplifted towards the northwest during the Alleghanian orogeny (Hatcher et al., 1989). Thrust sheets containing

units from all three Appalachian provinces were stacked on top of each other during the later Carboniferous to Permian (325? -260 Ma) and represent a single major positional cycle related to the Alleghanian orogeny (Meckel, 1970; Thomas, 1977; Bobyarchick, 1982; Hatcher et al.1989). The Alleghanian orogeny occurred in a zipper-like fashion, where the northern section of the continents collided first (Secor et al., 1986; Hatcher et al., 1989). The southern portion of Gondwana then rotated clockwise and collided with the southern portion of Laurentia (Secor et al., 1986; Hatcher et al., 1989; Hatcher, 2005). Deformation collided head-on in the north, while the southern section collided obliquely (Secor et al., 1986; Hatcher et al., 1989).

However, the timing of the Neoacadian and Alleghanian may need to be re-examined. Recent studies have shown that Alleghanian deformation started earlier than previously thought and overlaps with Neoacadian deformation timing (Stowell et al., 2019; McKay et al., 2021; Ionescu, 2021). Hornblende 40Ar/39Ar cooling data from Dallmeyer (1988) gives a cooling age between 362 and 322 Ma for the Blue Ridge province. Dallmeyer's Blue Ridge cooling data overlaps with garnet growth ages between 331-320 Ma (Stowell et al., 2019). These ages give significant overlap between metamorphism and exhumation, suggesting an overlap of deformation. McKay et al. (2021) produced HeFTy thermal history for 4 grains found within the Paleozoic Chilhowee Group, 2 of which showed cooling ages between 385-350 Ma. The Cambrian Chilhowee Group is a Valley and Ridge Province member, and deformation is usually associated with the Alleghanian orogeny (?325-260 Ma). However, this new cooling data suggests that deformation, specifically cooling due to the exhumation of the Chilhowee Group, occurred during the Devonian and before any previously known Alleghanian deformation (McKay et al., 2021). Overlap of the hornblende cooling 40Ar/39Ar (Dallmeyer, 1988), secondary garnet growth (Stowell et al., 2019), and exhumation of Valley and Ridge units

(McKay et al., 2021) suggest that Cambrian through Devonian Valley and Ridge strata were exhumed before the Mississippian strata (Erin Slate) of the Blue Ridge was deposited, suggesting an Acadian-Alleghanian Transition

Previous Investigations

The Cheaha Quartzite and its metaconglomerate base have never been analyzed using a stretched pebble analysis; however, similar kinematic studies have been done on rock units in the southern Appalachians. Engelder (2006), Engelder and Whitaker (2006), and Bartholomew and Whitaker (2010) researched the southern and central Appalachians and a stress field that deformed the western Blue Ridge and Piedmont Provinces. Engelder (2006) researched an Appalachian-wide stress field concerning friction from Laurentia and Gondwana prior to the collision in the Alleghanian. Engelder (2006) measured joint sets over 1500km of the Appalachians in connection with an Appalachian-wide Stress Field. Engelder and Whitaker (2006) looked at early jointing in coal in association with the same Appalachian-wide Stress Field and its associated dextral slip along basement decollements. Bartholomew and Whitaker (2010) expanded on this Appalachian-wide Stress Field by tracking the deformational sequence. Bartholomew and Whitaker (2010) looked at joints, mineral veins, normal and reverse faults, stylolites, and paleoseismicities to distinguish seven deformational events, one of which was the Appalachian-wide Stress Field of Engelder and Whitaker (2006).

Methodology

Stretched pebbles within the Cheaha Quartzite were measured at 15 stations across an area of 16 miles (Fig. 11; Table 1). Four to ten pebbles were measured per station. Pebble length

Table 1. Universal Transverse Mercator (UTM) location of Stations 1 through 15.

Data Station	Northing	Easting
1	592517	3688393
2	591872	3688037
3	587552	3686708
4	586825	3686584
5	586642	3686191
6	585441	3684214
7	585214	3683786
8	585140	3682784
9	585154	3682113
10	585254	3680912
11	604494	3696333
12	600143	3692847
13	589366	3687232
14	599298	3691660
15	597504	3690784

(inch), height (inch), width (inch), trend (degree), and plunge (degree) were measured, as well as the orientation of the sedimentary bedding. The longest side of the pebble is determined as the y-axis, and the x-axis is the perpendicular side. The data is presented in Table 2. Most pebbles have a positive percent flattening, except stations 6, 8, and 13. Length, width, and height data were collected *in situ*, making it difficult to collect precise data. Thus, the negative elongation could

Table 2. Stretched pebble analysis for stations 1 through 15

Station Number	Avg. Trend (°)	Avg. Plunge (°)	Strike (°)	Dip (°)	Dip Direction	Avg. Flattening (%)	Avg. Elongation	Avg. Area (in^2)
1	198	7	041	8	SE	34%	2.60	8.16
2	176	12	051	19	SE	22%	3.24	10.17
3	194	11	094	22	SE	20%	3.40	10.67
4	176	7	154	18	SW	15%	4.13	12.96
5	168	15	045	15	SE	15%	3.50	11.00
6	173	7	349	14	NE	-2%	3.36	10.54
7	190	14	202	11	SE	10%	3.77	11.85
8	174	5	359	30	SE	-5%	5.04	15.81
9	152	13	005	17	NE	8%	3.36	10.54
10	156	10	331	14	SE	11%	2.90	9.09
11	196	27	041	15	SE	10%	1.82	5.73
12	210	21	025	16	SE	27%	1.94	6.10
13	177	16	341	21	NE	-5%	2.61	8.18
14	208	25	083	32	SE	53%	2.32	7.28
15	173	36	355	24	SE	56%	2.77	8.71

be from difficulty accurately measuring pebbles, from misidentified x- and y-axis, or the pebbles not initially being 1 inch in width before deformation. Most of the pebbles had a positive percent flatting which means the pebbles were elongated along the y-axis (length) and compressed along the x-axis (width).

Stereonets were produced based on strikes and dips at each of the 15 stations using the computer program *Stereonet* (Allmendinger, 2020). Each measurement was used to estimate the percent flattening (Price and Cosgrove,1990) using equation 1a.:

$$\text{1a.} \qquad \frac{Width\ (in) - Height\ (in)}{Width\ (in)} * 100$$

Average percent flattening has been calculated for each pebble from all 15 stations. In this study, the y-axis is defined as the width of the pebble, whereas the x-axis is the length of the pebble. A positive percent flattening indicates compression along the y-axis and elongation along the x-axis. In contrast, a negative percent flattening indicates elongation along the Y-axis and flattening along the x-axis. The average elongation for each station was then calculated using equation 1b:

$$\text{1b.} \qquad \frac{Length}{Avg.(Height{:}Width)}$$

A station map and average size/trend map were produced (Fig. 15). Ellipses are used to show the trend and size of pebbles visually. Elongation and flattening were used to produce the average area of pebbles at each station. Pebbles are assumed to initially be one inch in width to standardize size comparison between stations; however, this standardization of pebble size is unlikely over the area. The ellipsis area was calculated using equation 1c:

1c. π*width*Average elongation.

Results

Station 1. A population of four pebbles yielded a mean trend of 197.9° ± 7.0° and an average plunge of 7°. Percent flattening of pebbles averaged 34%. Pebbles had an average elongation of +2.6 and an average area of 8.16in^2. The average pebble dimensions are 1.15in(length), .54in (width), and .35in (height). Strike and dip for station 1 was 041°/8° SE.

Station 1 was taken near Chandler's Gap along the Pinhoti Trail. The outcrop was roughly 3m by 2m, with only the top exposed. Few pebbles were able to be measured.

Station 2. A population of four pebbles yielded a mean trend of 176.3° ± 13.7° and an average plunge of 12°. Percent flattening of pebbles averaged 22%. Pebbles had an average elongation of 3.24x and an average area of 10.17in². The average pebble dimensions are 1.36in

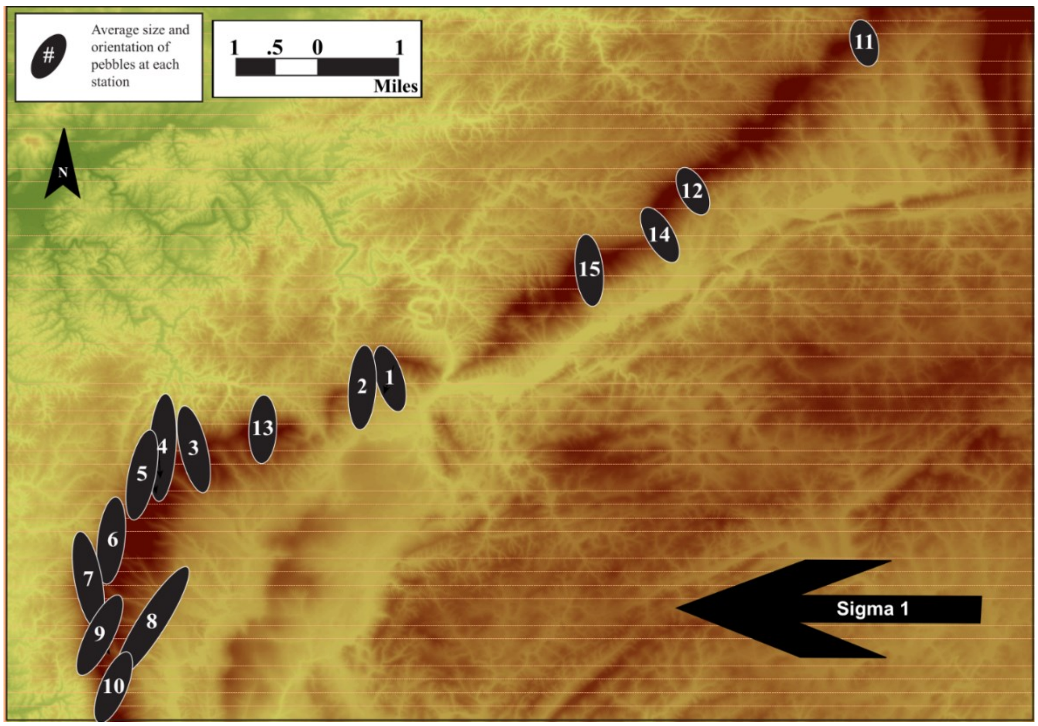

Figure 15: Elevation map of the Porter Gap and Clairmont Springs 7.5–minute quadrangles with black ellipses that depict pebbles' average size and orientation for the 15 stations. Pebbles appear to have a strong north-to-south trend, suggesting an east-west compressional force acting on the pebbles during metamorphism.

(length), .49in (width), and .36in (height). Strike and dip for station 2 was 051°/19° SE. Station 2 was taken at an outcrop along the Pinhoti Trail that was 2m by 2m and only had the top exposed.

Station 3. A population of 10 pebbles yielded a mean trend of 193.7° ± 4.5°and an average plunge of 11°. Percent flattening of pebbles averaged 20%. Pebbles had an average

elongation of 3.36x and an average area of 10.44in^2. The average pebble dimensions are 1.81in (length), .6in (width), and .47in (height). Strike and dip for station 3 was 094°/22° SE. Station 3 was taken along Clay County Road 307, which runs along the Horn Mountain Ridge. The outcrop for Station 3 was roughly 1m by 2m and had exposed sides. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Station 4. A population of 10 pebbles yielded a mean trend of 175.9° ± 1.8° and an average plunge of 17°. Percent flattening of pebbles averaged 15%. Pebbles had an average elongation of 4.30x and an average area of 12.96in^2. The average pebble dimensions are 2.34in (length), .6in (width), and .49in (height). Strike and dip for station 4 was 154°/18° SW. Station 4 outcrops along Clay County Road 307 were roughly 50m long, 20m high, and 15m wide and provided a good campground. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Station 5. A population of 10 pebbles yielded a mean trend of 168.4° ± 4.5° and an average plunge of 15°. Percent flattening of pebbles averaged 25%. Pebbles had an average elongation of 3.50x and an average area of 11.00in^2. The average pebble dimensions are 2.1in (length), .72in (width), and .61in (height). Strike and dip for station 5 was 045°/15° SE. Station 5 outcropped just south of Clay County Road 307 and was roughly 100m long, 10m high, and 5m wide. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Station 6. A population of 10 pebbles yielded a mean trend of 172.5° ± 5.2° and an average plunge of 7°. Percent flattening of pebbles averaged -2%. Pebbles had an average elongation of 3.36x and an average area of 10.52in^2. The average pebble dimensions are 1.13in (length), .37in (width), and .35in (height). Strike and dip for station 6 was 349°/14° NE. Station

6 was on Horn Mountain itself, and the outcrop was roughly 25m long, 10 m high, and 15 m wide. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Station 7. A population of 10 pebbles yielded a mean trend of 190.9° ± 8.3° and an average plunge of 12°. Percent flattening of pebbles averaged 10%. Pebbles had an average elongation of 3.77x and an average area of 11.85in². The average pebble dimensions are 1.45in (length), .45in (width), and .4in (height). Strike and dip for station 7 was 202°/11° SE. Station 7 outcropped along the Sherman Cliffs, a continuous bluff around 2500m long, with varying height and width. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Station 8. A population of six pebbles yielded a mean trend of 174° ± 2.6° and an average plunge of 5°. Percent flattening of pebbles averaged -5%. Pebbles had an average elongation of 5.04x and an average area of 15.81in². The average pebble dimensions are 1.53in (length), .34in (width), and .33in (height). Strike and dip for station 8 was 359°/30° SE. Station 8 outcropped along the Sherman Cliffs, a continuous bluff around 2500m long, with varying height and width. While this station had a large distribution of pebbles, most pebbles were in the rocks, and height data was hard to collect.

Station 9. A population of 10 pebbles yielded a mean trend of 151.6° ± 2.6 and an average plunge of 13°. Percent flattening of pebbles averaged 8%. Pebbles had an average elongation of 3.36x and an average area of 10.54in². The average pebble dimensions are 2.13in (length), .71in (width), and .59in (height).. Strike and dip for station 9 was 005°/17° NE. Station 9 outcropped along the Sherman Cliffs, a continuous bluff around 2500m long, with varying

height and width. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Station 10. A population of 10 pebbles yielded a mean trend of 156.2° ± 3.6° and an average plunge of 10°. Percent flattening of pebbles averaged 11%. Pebbles had an average elongation of 2.90x and an average area of 9.09^2. The average pebble dimensions are 1.25in (length), .49in (width), and .43in (height). Strike and dip for station 10 was 331°/14° SE. Station 10 outcropped along Clay County Road 307 and overhead Power Line. The station 10 outcrop was roughly 90m long, 30m wide, and 7m high. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Station 11. A population of four pebbles yielded a mean trend of 196.3° ± 6.9° and an average plunge of 27°. Percent flattening of pebbles averaged 10%. Pebbles had an average elongation of 1.82x and an average area of 15.73in². The average pebble dimensions are .83in (length), .48in (width), and .49in (height). Strike and dip for station 11 was 041°/15° SE. Station 11 was the only station taken not on Porter Gap or Clairmont Springs 7.5–minute quadrangles but the adjacent Ironaton quadrangle along the Pinhoti Trail. The outcrop at Station 11 was 160m long, 80 m wide, and had poor height at less than 2m. Due to this poor height, station 11 did not have many viable pebbles to collect height data.

Station 12. A population of five pebbles yielded a mean trend of 210.3° ± 9.0° and an average plunge of 14°. Percent flattening of pebbles averaged 27%. Pebbles had an average elongation of 1.94x and an average area of 1.94in². The average pebble dimensions are .66in (length), .95in (width), and .28in (height). Strike and dip for station 12 was 025°/16° SE. Station 12 was taken along the Pinhoti Trail and Talladega Mountain of the Clairmont Springs

quadrangle. The outcrop was roughly 160 m long, 40m wide, and 100m high. Station 12 had relatively poor pebble distribution; thus, only a few pebbles could be measured accurately.

Station 13. A population of 10 pebbles yielded a mean trend of 176.6° ± 3.6° and an average plunge of 16°. The percent flattening of pebbles averages -5%. Pebbles had an average elongation of 2.61x and an average area of 8.18in². The average pebble dimensions are 1.35in (length), .6in (width), and .6in (height). Strike and dip for station 13 was 341°/16° SE. Station 13 was taken just off Clay County Road 307 and along the Pinhoti Trail and was roughly 310m long, 60m wide, and 40m high. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Station 14. A population of eight pebbles yielded a mean trend of 207.6° ± 19.4° and an average plunge of 25°. Percent flattening of pebbles averaged 53%. Pebbles had an average elongation of 2.32x and an average area of 7.28in². The average pebble dimensions are .64in (length), .28in (width), and .28in (height). Strike and dip for station 14 was 083°/32° SE. Station 14 was taken at the intersection of Skyline Drive, Hanging Rock Road, and the Clairmont Springs trailhead of the Pinhoti Trail. This station was roughly 150m long, 20m wide, and 20m high. Station 14 had decent pebble distribution, but not all pebbles could be measured accurately for height.

Station 15. A population of 10 pebbles yielded a mean trend of 173.9° ± 6.4° and an average plunge of 36°. Percent flattening of pebbles averaged 56%. Pebbles had an average elongation of 2.77x and an average area of 8.27in². The average pebble dimensions are 1.61in (length), .62in (width), and .63in (height). Strike and dip for station 15 was 355°/24° SE. Station 15 was taken along the Pinhoti Trail and had an outcrop around 200m long, 70m wide, and 40m

high. Better pebble distribution at this station allowed for more pebbles and pebble heights to be more easily measured.

Discussion

Pebbles at all 15 stations align near-vertical north-south, regardless of where the measurements were taken on the ridge. This is evidenced by the near-perfect 180° average trend from all stations. Only a few stations, 7, 12, and 14, had distinct outliers. These outliers could be due to difficulty taking measurements *in situ*. The average trend for all station averages post tilting is 181.35° ± 4.7°. The stations were then "untilted" in the Stereonet program to give an average trend mean of 186.8° ± 4.7°. All stations have an average standard deviation of 6.7%. Due to the extremely similar data between the tilted and untilted trends, it can be assumed rotation of the pebbles is related to the uplift of the rock units, either happening during uplift, or post uplift.

Average percent flattening fluctuates between stations, with most stations having a positive flattening. Only three stations (6, 8, 13) had negative percent flattening. All other stations (1–5, 7, 9–12, 14, 15) had an average percent flattening of 21%. Due to few negative percent flattening stations, and the negative percent flattening being relatively low, this data is likely erroneous. The negative percent flattening measurements could be due to difficulty taking measurements *in situ.*

The pebbles within the metaconglomerate can range from less than half an inch long to over nine inches long. The average elongation for the pebbles along the straight portion of the ridge was 2.59x, whereas the average elongation along the bend was 3.72x. The most significant elongation was at station 8, with an average of 5.04x. Station 11 had a minor elongation with

only 1.82x. pebbles around the bend in Horn Mountain on average had a larger elongation than pebbles along the strait of the ridge. With this data, we can assume that pebbles along the curve were subject to more strain. Pebble elongation is correlated with the average area, with pebbles with a longer elongation having a larger pebble area. The average area for elongated pebbles was 9.79in^2. The smallest pebble area was calculated from samples at station 11 with an area of 5.73in^2, while the largest pebble area was from station eight at 15.81in^2.

Rose Diagram Analysis. Figure 16 shows the rose diagrams that have been produced. Figure 16A depicts all rose diagrams for the pebble trends for the 15 recorded stations. Station averages were combined into Figure 16B to produce a rose diagram of all pebble trends post-folding and post-uplifting of the Cheaha Quartzite. Figure 16C depicts a rose diagram pre-folding and pre-uplift. These rose diagrams show a similar trend of the pebbles pre- and post-deformation, indicating the pebbles were already in a southern trend before uplift and shifted only slightly during the final deformation of the area. Figure 16D shows pebble lineation for every one of the 124 pebbles collected. Figure 16E shows the untilted data from Figure 16D. For both Figure 16C and 16E, the result of "untilting" the data causes the data to constrain more to the south, indicating rotation post tilting.

Timing Constraints. The deposition of the youngest Talladega Group member, the Erin Slate (360-350 Ma), restricts the start of deformation to the middle Mississippian (Beck, 1978; Tull and Barineau, 2012; Barineau et al., 2015). The Hillabee Greenstone and the Talladega Group share the same metamorphism age (McClellan et al., 2007). The Hillabee thrust sheet was faulted onto the Talladega Group pre- or syn-metamorphism (~375-320 Ma) (Tull et al., 2007; McClellan et al., 2007; Barineau, 2009). McClellan et al. (2007) used 40Ar/39Ar in muscovite samples (with closure temperatures of 350-400°C) to date the metamorphism of the Talladega

Group and the Hillabee Greenstone to ~334–320 Ma. McClellan et al. (2007) stated that the absolute peak was closer to 330 Ma. Pebble elongation and flattening likely occurred during the peak metamorphism of the Talladega Group and after the Hillabee Greenstone was already metamorphosed. A separate strain, pushing east-west, would need to be present during metamorphism to elongate the pebbles in a north-south direction. Due to the pebbles already being in a north-south orientation prior to uplift (Fig. 16C), the pebbles likely finished elongating

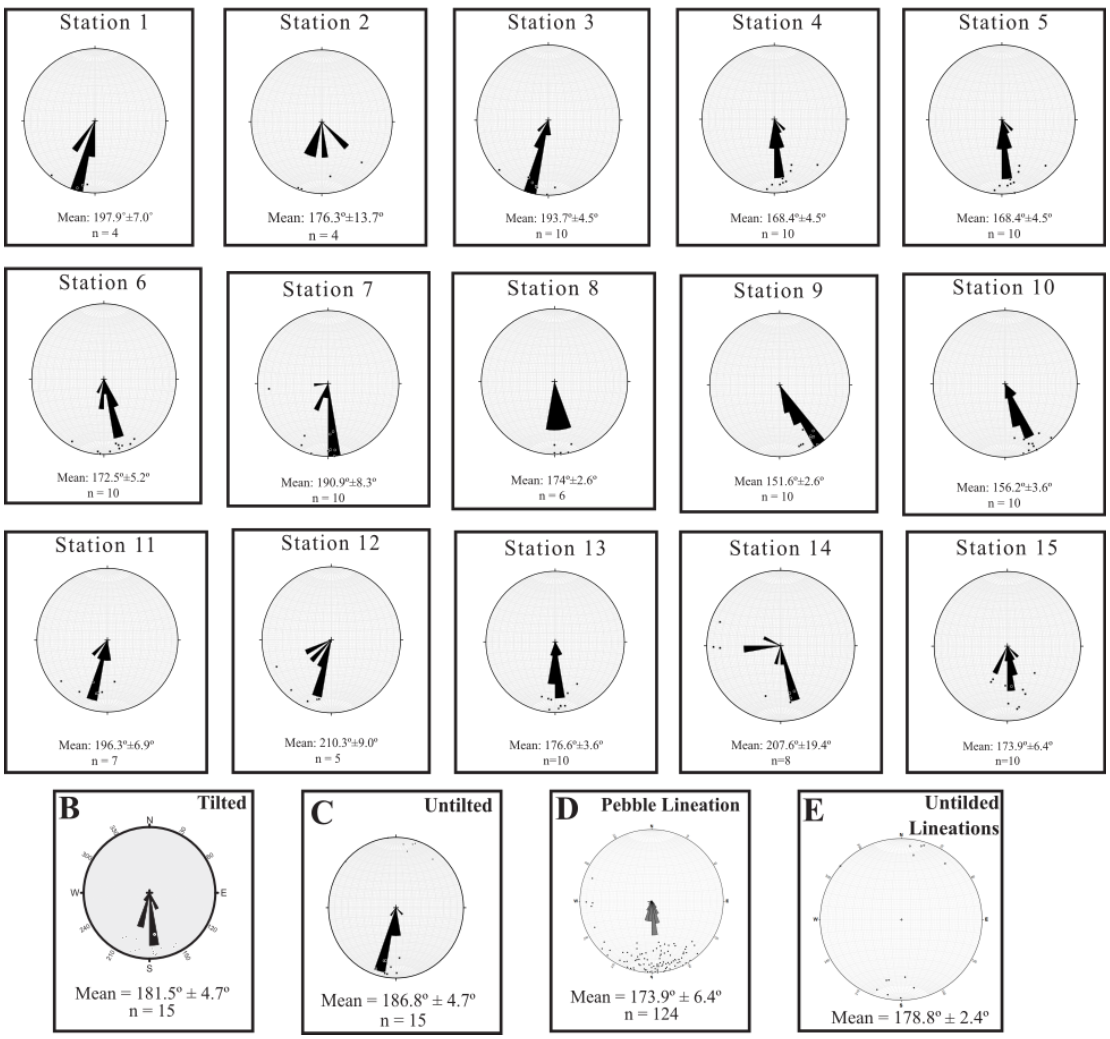

Figure 16. Rose diagrams were created using Stereonet. (A) Station trend and plunge averages, there is an overwhelming trend to the south. (B) station averages of trends and plunges post folding (C) The average trend and plunge of each station used to create an “untilted” rose diagram depicting that the pebbles were trending to the southwest pre uplift. (D) An average Stereonet for all 124 pebbles collected. (E) shows the untilted data for all the pebbles.

before the Alleghanian (~325 Ma) and regional uplift. The timing between the emplacement of the Hillabee thrust sheet on the Talladega Group, combined with the start of the Alleghanian, gives a time range of ~359-325 Ma for flattening and elongation of the pebbles. An age of ~359-325 Ma for deformation of the Cheaha Quartzite overlaps the Neoacadian and Alleghanian orogenies, strengthening the argument for the Acadian-Alleghanian Transition (Dallmeyer, 1988; Stowell et al., 2019; McKay et al., 2021; Ionescu, 2021).

While folding is evident in the softer rocks of the Talladega Group, such as the Lay Dam Formation, the Cheaha Quartzite was more resistant to folding and thickened and broke in a way typical of layer parallel shortening. Layer parallel shortening happens when rocks break due to strain parallel to the rock layers (Fossen, 2016). Layer parallel shortening during plastic deformation of pebble conglomerates could account for the symmetrical stretching of the pebbles observed in the Cheaha Quartzite. Plastic deformation of quartz starts at 300-350°C (Davis and Reynolds, 1996; Fossen, 2016) but can vary due to water content, surrounding minerals, and strain rate (Davis and Reynolds, 1996; Fossen, 2016). Due to the Cheaha Quartzite being entirely quartz, we assumed pure quartz in the area, strain rate was likely uniform throughout the area. Currently, the water content of the Cheaha Quartzite during metamorphism is unknown.

The deformation of the Talladega Group of the western Blue Ridge shows lower-greenschist facies conditions suggesting a temperature of ~350°C (Tull and Stow, 1980; Lim, 1998; Tull, 1998). For this study, we used a minimum of 350°C based on muscovite closure temperatures from McClellan et al. (2007) and the lower greenschist facies seen by Tull and Stow (1980). Based on geothermal data from Blackwell and Richards (2004), an estimate of the geothermal gradient for the southern Appalachians during the Mississippian through the Permian is roughly 35°C/km. If the pebbles needed to reach 350°C, using the geothermal gradient of

35°C/km, a minimum burial depth of 10km would be needed for the Cheaha Quartzite to deform plastically (Fig. 17). However, the metamorphic Talladega Group has likely been buried deeper than 10km, and surrounding minerals and water content could have caused a lower temperature and burial depth.

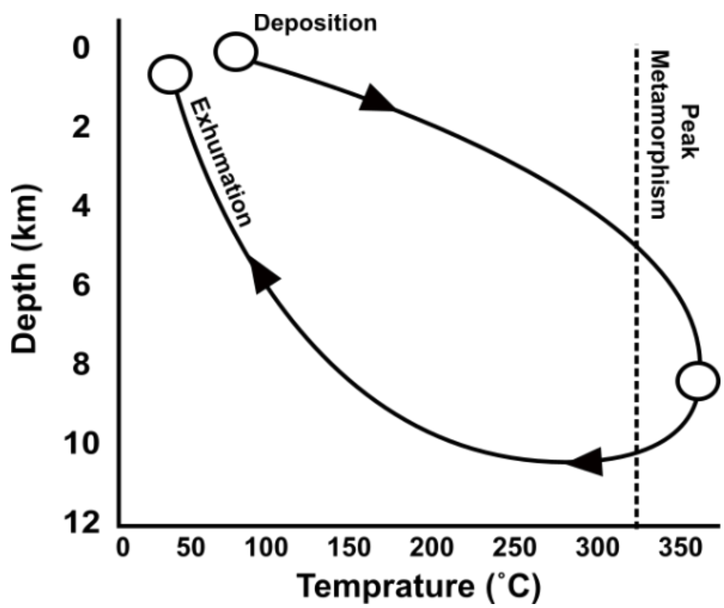

Figure 17. Pressure-Temperature graph for the pure quartz pebbles of the Cheaha Quartzite during metamorphism.

East-to-West Compression During Metamorphism. An east-west flattening of pebbles is needed for a north-south elongation of pebbles. The flattening of pebbles along the X-axis correlates to the elongation along the Y-axis. Flattening and elongation are likely a result of layer parallel shortening of the Cheaha Quartzite. Two possible mechanisms may be responsible for the elongation and flattening of quartz pebbles within the Cheaha Quartzite. The first mechanism might have been localized faulting and folding, creating a subregional deformation trend. The second mechanism might have been a regional deformation trend known as an Appalachian-wide stress field.

The Appalachian's structural features include faults and folds that strike northeast-southwest, ranging from Alabama to Pennsylvania. The fault closest to the Cheaha Quartzite is the Hillabee thrust fault that emplaces the Hillabee Greenstone on top of the Talladega Group. The Hillabee trust fault was transported to the northwest with a flat-on-flat ramping style (Barineau and Tull, 2001; Tull et al., 2007; Barineau, 2009). In this case, the Hillabee Greenstone is placed on the Talladega Group so that there is no change in strike or dip between the two, and the layers appear to be stratigraphically connected when they are in fault contact with each other (McClellan et al., 2007; Tull et al., 2007; Barineau, 2009). Because of this flat-on-flat ramping, minor deformation can be observed along the fault between the Hillabee Greenstone and the Talladega Group (Barineau, 2009; Barineau et al., 2015). Due to the flat-on-flat ramping style, it is unlikely that enough pressure was formed from the Hillabee thrust sheet to deform the pebbles of the Cheaha Quartzite. A more likely explanation would be the Hollins Line fault. The Hollins Line fault is the boundary between the western and eastern Blue Ridge provinces (Tull, 1984; McClellan et al., 2007; Barineau, 2009; Tull and Barineau, 2012). The deformation timing of the Hollins Line fault is middle Mississippian (360-345 Ma) (Stowell et al., 2019), which falls into the proposed elongation age (~359-325 Ma) of the Cheaha Quartzite pebbles. The Hollins Line fault thrusts northwest, which aligns with the northeast-southwest elongation of the Cheaha Quartzite pebbles. One issue with this proposed deformation mechanism is the westward deformation force needed for the pebbles along the curve of Horn Mountain. Figure 18 shows the approximate direction of force needed to elongate the pebbles along the ridge. While the Hollins Line fault movement could account for the elongation of pebbles 1-5 and 11-15, pebbles 6-10 likely needed a more direct east-west force acting upon them for their north-south elongation.

An Appalachian-wide stress field is a regional deformation trend, in this case covering an area from Alabama to New York (>1500 km) (Engelder and Whitaker, 2006). Stress field estimates from the southern and central Appalachians suggest a deformational link to Bartholomew and Whitaker's (2010) A1 Alleghanian deformation sequence event. The pebbles' overall elongation trend is perpendicular to the trend of the A1 event (~085°–265°)

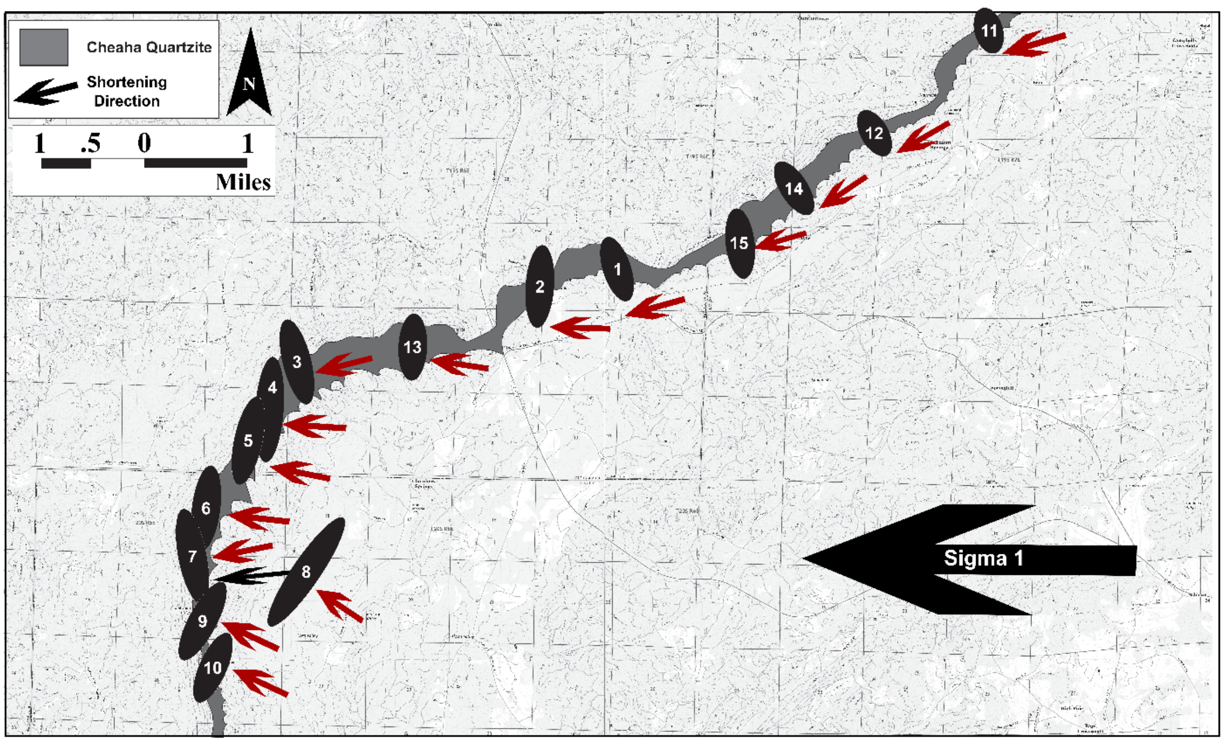

Figure 18: red arrows show interpreted compressional force acting on the Cheaha Quartzite (shown in dark gray). Arrows point perpendicular to the closest pebble station along the ridge, showing interpreted compressional force for the stations. Arrows farther away from the Cheaha Quartzite depict perpendicular force to the average of all pebbles (~182°).

(Bartholomew and Whitaker, 2010); thus, the A1 event may be the deformation force. Bartholomew and Whitaker (2010) correlated their A1 event to the Appalachian-wide stress field of Engelder and Whitaker (2006). The deformation of this Appalachian-wide stress field lasted for 10-15 million years, between ~359 to ~330 Ma (Engelder and Whitaker, 2006; Engelder,

2006). However, Bartholomew and Whitaker (2010) also suggested the timing of deformation of this Appalachian-wide stress field to be migratory, starting in the north and later deforming the southern Appalachians. The Appalachian-wide stress field deformed rock units with a westward force pushing toward the inner continent (Engelder and Whitaker, 2006; Bartholomew and Whitaker, 2010). This Appalachian-wide stress field is parallel to the plate movement of the Laurentia-Gondwanan collision of the Alleghanian (Engelder and Whitaker, 2006; Engelder, 2006; Bartholomew and Whitaker, 2010).

Conclusions

The Cheaha Quartzite of the Talladega Group records a tectonic force responsible for the elongation and flattening of pebbles within the southern Appalachians. The flattening and elongation of these pebbles show deformation associated with layer parallel shortening of the unit. Deformation of the Cheaha Quartzite pebbles can be dated to the middle Mississippian after the Erin Slate was deposited and post emplacement of the Hillabee thrust sheet on top of the Talladega Group (Tull et al., 2007; McClellan et al., 2007; Barineau, 2009). Two deformation forces could be responsible for the elongation and flattening of the Cheaha Quartzite pebbles: subregional fault deformation or a regional deformation force known as an Appalachian-wide stress field. Subregional fault deformation is unlikely from the Hillabee thrust fault but more likely from the Hollins Line fault. The timing of the Hollins Line fault (345-330 Ma) fits into the proposed timeline for elongation of the Cheaha Quartzite pebbles (~359-325 Ma) but does not explain the east-west deformation of pebbles along the bend in Horn Mountain. An Appalachian-wide stress field, the A1 event in Bartholomew and Whitaker (2010), could produce the regional deformation needed to elongate the pebbles (359–330 Ma). This Appalachian-wide stress field

(359 to 330 Ma) also matches the proposed earliest timing for elongating the pebbles (Engelder and Whitaker, 2006; Bartholomew and Whitaker, 2010). This Appalachian-wide stress field produces an east-west deformational force needed to elongate the pebbles north-south. Several quantitative conclusions can be drawn from this research:

1. Using closure temperatures (350°C-400°C) based on 40Ar/39Ar (McClellan et al., 2007) in muscovite samples from the Hillabee Greenstone and an average geothermal gradient of 35°C/km, a burial depth of ~10km would be needed to reach 350°C.
2. Deposition of the Erin Slate (360-350 Ma), the emplacement of the Hillabee Greenstone on top of the Talladega Group (375-359 Ma), and the start of the Alleghanian (325Ma) gives a time constraint of ~359-325 Ma for flattening and elongation of the pebbles.
3. Deformation timing for the Cheaha Quartzite (~359-325) aligns with an overlap of deformation between the Neoacadian and Alleghanian orogenies, referred to as the Acadian-Alleghanian Transition.
4. Pebble elongation (north-south) and flattening (east-west) suggest a tectonic force moving east-west that deformed the pebbles during metamorphism. East-west compression can be seen in the north-south elongation of pebbles at 181.4° along the Horn Mountain ridge.
5. The Hollins Line fault deformation in the middle Mississippian (360-345 Ma) aligns with the earliest proposed timing estimation for the elongation and flattening of the pebbles within the Cheaha Quartzite (~359-325 Ma).
6. The east-to-west compression of the pebbles within the Cheaha Quartzite is compatible with the deformation pattern and timing (359 to 330 Ma) of the A1 event of Bartholomew and Whitaker (2010), considered to be an Appalachian-wide stress field.

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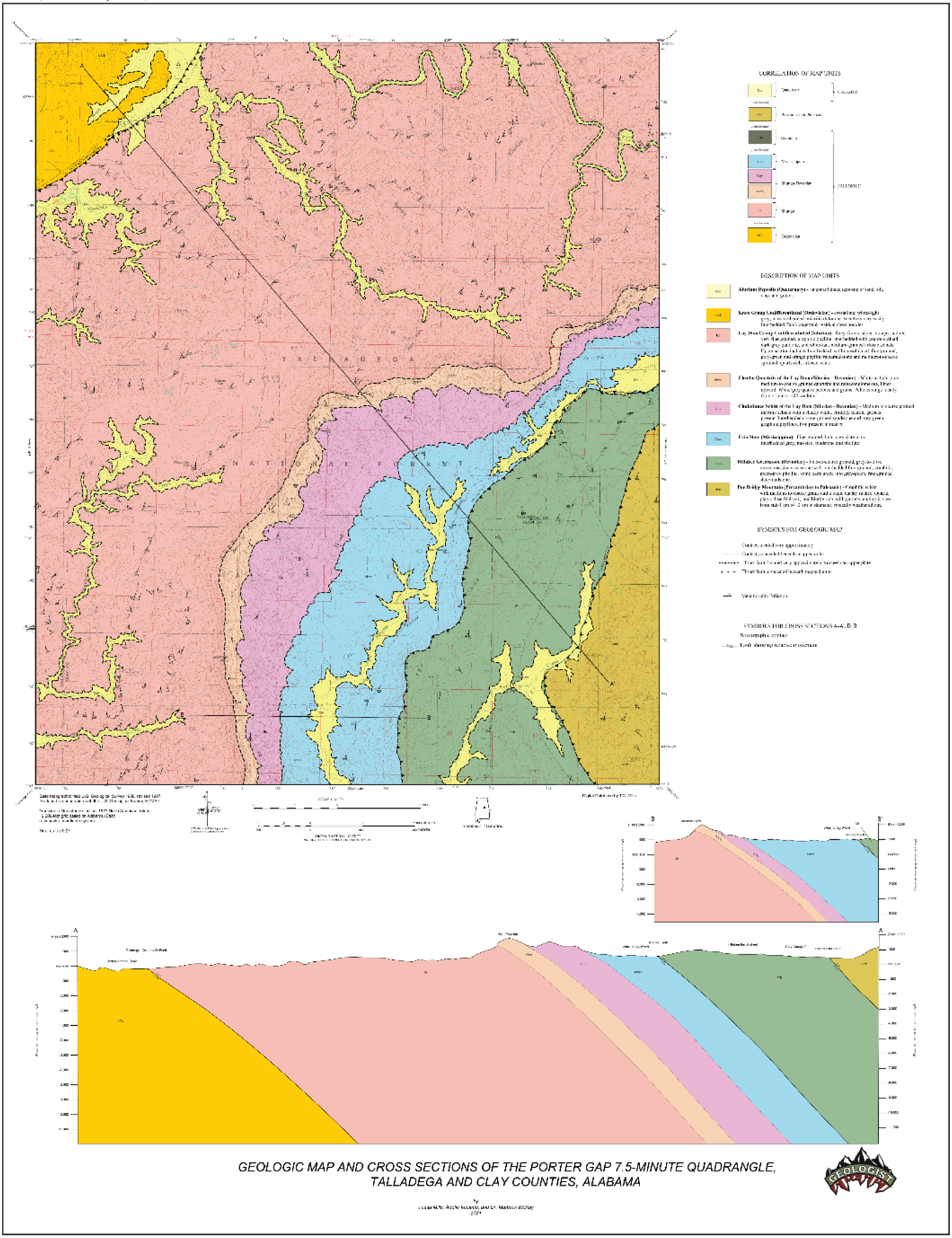
SUMMARY

Geologic mapping of the Porter Gap 7.5–minute quadrangle and a stretched pebble analysis of the Cheaha Quartzite helps us better understand the deformation and timing of the southern Appalachians. Geologic mapping of the Porter Gap 7.5–minute quadrangle aids in describing lithologies and structures in the area. At the same time, the stretched pebble analysis aids in estimating a time frame for the elongation of the Cheaha Quartzite pebbles (~359-325 Ma) (Engelder and Whitaker, 2006; McClellan et al., 2007; Bartholomew and Whitaker, 2010; Tull et al., 2007). Two possible scenarios could account for the deformation of pebbles: a subregional fault deformation or a regional Appalachian-wide stress field. Both deformation of the Hollins Line fault (345-330 Ma) and the A1 event (359 to 330 Ma) of Bartholomew and Whitaker (2010) occur during the earliest estimates for pebble elongation. However, the deformational force of the Hollins Line fault is northwest-southeast, and the A1 event had a more westward deformation pattern.

Further studies will include gathering more stretched pebble data over a broader area to understand the deformation force that stretched the Cheaha Quartzite pebbles and to give a more precise age date for pebble elongation


TALLADEGA
NATIONAL FOREST
CORRELATION OF MAP UNITS
DESCRIPTION OF MAP UNITS
SYMBOLS FOR GEOLOGIC MAP
GEOLOGIC MAP AND CROSS SECTIONS OF THE PORTER GAP 7.5-MINUTE QUADRANGLE,
TALLADEGA AND CLAY COUNTIES, ALABAMA
GEOLOGIST