

**INTRODUCTION**

The Crutchfield Crossroads 7.5-minute Quadrangle lies in the east central portion of the North Carolina Piedmont. The Rocky River crosses the southwestern corner of the quadrangle. The Chatham - Alamance County line crosses the quadrangle from west to east. Portions of the Town of Siler City (population approximately 8,200) occupies the southwest corner of the quadrangle. Impounded portions of the Rocky River within the quadrangle serve as the water supply source for the Town of Siler City. The quadrangle is crossed by northwest-southeast US Highway 421. Hwy 421, a major east-west corridor for the central Piedmont, is located northeast to the south of the quadrangle.

The majority of the quadrangle drains to the Rocky River along drainages that include Lucy's Creek, Nick Creek, North Prong, Greenbrier Creek, Johnson Creek, Mud Lick Creek, Varnell Creek, and unnamed creeks. The northeast portion of the quadrangle drains to the Haw River along drainages that include South Fork, Reedy Branch, and Pine Hill Branch. A small fork of the Rocky River is located in the southwest corner of the quadrangle. The drainage divide between the Rocky and Deep Rivers is locally controlled by a ridge that marks a major geologic contact (Hyco and Aaron Formations). Natural exposures of crystalline rocks occur mainly along these and numerous unnamed creeks. Rock exposures at road cuts, ridges, resistant finned-shaped outcrops and pavements occur locally outside of drainages. The elevations in the map area range from about 740 feet above sea level north of the intersection of Piney Grove Church road and Fellowship Church Road (on US92) that follows the drainage divide between the Rocky and Deep Rivers) in the southwest corner of the quadrangle, to less than 500 feet along Pine Hill Branch near the northeastern corner of the quadrangle.

**Geologic Background and Past Work**

Pre-Mesozoic crystalline rocks in the Siler City Quadrangle are part of the redefined Hyco Arc (Hibbard et al., 2013) within the Neoproterozoic to Cambrian Carolina terrane (Hibbard et al., 2002; and Hibbard et al., 2006). In the region of the map area, the Carolina terrane can be separated into two lithotectonic units: 1) the Hyco Arc and 2) the Aaron Formation of the redefined Virginia sequence (Hibbard et al., 2013). The Hyco Arc consists of the Hyco Formation which include ca. 612 to 633 Ma (Wortman et al., 2000; Bowman, 2010; Bradley and Miller, 2011) metamorphosed layered volcaniclastic rocks and plutonic rocks. Available age dates (Wortman et al., 2000; Bradley and Miller, 2011) indicate the Hyco Formation may be divided into lower (ca. 630 Ma) and upper (ca. 612 Ma) members (informal) with an apparent intervening hiatus of magmatism. In northeastern Chatham County, Hyco Formation units are intruded by the ca. 579 Ma (Lock and Loney, 2006) East Farmington pluton and associated West Farmington pluton. The Aaron Formation consists of metamorphosed layered volcaniclastic rocks with youngest detrital zircons of ca. 578 and 588 Ma (Samson et al., 2001 and Pollock, 2010, respectively).

The Hyco Arc and Aaron Formation lithologies were folded and subjected to low grade metamorphism during the ca. 578 to 584 Ma (Pollock, 2007; Pollock et al., 2010) Virginia deformation (Glover and Sinha, 1973; Harris and Glover, 1985; Harris and Glover, 1988; and Hibbard and Samson, 1995). In the map area, original layering of Hyco and Aaron Formation lithologies are interpreted to range from shallowly to steeply dipping due to open to isoclinal folds that are locally overturned to the southeast.

Map units of metamorphic and metavolcanic rocks include various lithologies that when grouped together are interpreted to indicate general environments of deposition. The diachronous and tuff units are interpreted to represent proximal pyroclastics. The andesitic to basaltic lavas (with tuffs or conglomerates) units are interpreted to represent eruption of intermediate to mafic lava flows and associated pyroclastic and/or sedimentary deposits. The epistatocyclic units are interpreted to represent deposition from massive to thin bedded, dominant and active volcanic highlands. Some of the metamorphic units within the map area display lithologic relationships similar to dated units present in northern Orange and Durham Counties. Due to these similarities, the metamorphic and metavolcanic units have been tentatively separated into upper and lower portions of the Hyco Formation, geochronologic data in the map area is needed to confirm this interpretation. A review of the regional lithologies is summarized in Bradley (2013).

Abundant evidence of brittle faulting at the outcrop scale and large-scale lineaments (as interpreted from hillshade LIDAR data) are present in the map area. The brittle faulting and lineaments are interpreted to be associated with Mesozoic extension. The Cotton cross-structure (Rehmer, 1955), located to the southeast of the study area, is a contraction zone in the Deep River Mesozoic basin and is characterized by crystalline rocks overprinted by complex brittle faulting. Dikes of Jurassic aged diabase intrude the crystalline rocks of the map area. Quaternary aged alluvium is present in most major drainages.

**Mineral Resources**

There are no active mining activities currently in the quadrangle. One historic flagstone quarry associated with an abandoned gravel mill site was identified along the Rocky River in the south of the quadrangle. The northern portion of the quadrangle was mapped at reconnaissance scale as part of the Schmidt et al. (2006) study. The area was identified as containing large zones of high sulfidation alteration with the potential for pyrophyllite and gold resources. The quadrangle has 4 identified prospect and/or mine areas including: 1) "Ore Hill", 2) Hinshaw pyrophyllite prospect, 3) Snow Camp Pyrophyllite Mine, and the 4) Snow Camp South pyrophyllite prospect.

Schmidt et al. (2006) identified "Ore Hill" as a location of a small shaft at the top of a knob. The rock is magnetite bearing and it is speculated that the shaft was sunk in search of iron ore. A site visit to "Ore Hill" in 2016 did not encounter the shaft, several shallow (prospector-like) openings are present. The reported shaft may have collapsed. The Hinshaw pyrophyllite prospect is described by Stuckey (1967) and Schmidt et al. (2006). The Snow Camp Pyrophyllite Mine is abandoned. Schmidt (1985) described the mine as an important former producer of high-grade pyrophyllite in North Carolina active from the mid-1950's to the mid-1960's. Additional descriptions of the Snow Camp Mine are provided in Broadhurst and Council (1953), Espenshade and Potter (1960), Stuckey (1967), and Hughes (1987). The Snow Camp South pyrophyllite prospect is located on the southern end of the ridge that includes the Snow Camp Mine location.

**DESCRIPTION OF MAP UNITS**

All pre-Mesozoic rocks in the map area have been metamorphosed to at least the chlorite zone of the greenschist metamorphic facies. Many of the rocks display a weak to strong metamorphic foliation. Although subjected to metamorphism, the rocks retain relic igneous, pyroclastic, and sedimentary textures and structures that allow for the identification of protolith rocks. As such, the prefix "meta" is not included in the nomenclature of the pre-Mesozoic rocks described in the quadrangle. Jurassic diabase dikes are unmetamorphosed.

A preliminary review of the area geology is provided in Bradley (2013). Unit descriptions common to Hanna et al. (2014) and Bradley et al. (2017) from the Silk Hope and Siler City geologic maps, respectively, were used for conformity with on strike units in neighboring quadrangles. Unit descriptions and stratigraphic correlations were maintained from adjacent mapping in Orange County (Bradley et al., 2016). The nomenclature of the International Union of Geological Sciences (IUGS) subcommission on igneous and metamorphic rocks (Le Maître (2002)) is used in classification and naming of the units. The classification and naming of the rocks is based on relic igneous textures, modal mineral assemblages, or normalized mineral assemblages when whole-rock geochemical data is available. Pyroclastic rock terminology follows that of Fisher and Schminke (1984).

**SEDIMENTARY UNIT**

**Qal - Alluvium:** Unconsolidated poorly sorted and stratified deposits of angular to subrounded clay, silt, sand and gravel to boulder-sized clasts, in stream drainages. May include point bars, terraces and natural levees along larger stream floodplains. Structural measurements depicted on the map within Qal represent outcrops of crystalline rock rivers surrounded by alluvium.

**INTRUSIVE AND METAINTRUSIVE UNITS**

**Jd - Diabase:** Black to greenish-black, fine- to medium-grained, dense, consists primarily of plagioclase, augite and may contain olivine. Occurs as dikes up to 100 ft wide. Diabase typically occurs as sporadically weathered boulders with a grayish-brown weathering rind. Red stain location indicates outcrop or boulders of diabase.

**MPzgb - Gabbro:** Melanocratic (C1 greater than 50), fine-grained gabbro. Distinctive brown weathering. Occurs as a small map scale body closely associated with a diabase dike, and as isolated boulders along the trend of a diabase dike. Appears unmetamorphosed. Purple stain location indicates outcrop or boulders of MPzgb.

**Zqmz - Quartz monzonite:** Composite suite of mesocratic, coarse- to medium-grained, equigranular, quartz monzonite, diorite and granodiorite. Major minerals include plagioclase and amphiboles with lesser amounts of quartz. Amphiboles appear altered to chlorite and actinolite masses. Feldspars have a light pinkish-tan locality. Includes a distinctive plagioclase porphyritic granodiorite to diorite on South Fork Cary Creek. Unit identified as Lindley Farms Quartz Monzonite by Schmidt et al. (2009). Schmidt et al. (2006) whole rock and modal analyses were reported on IUGS ternary diagrams and plot in the quartz monzonite field.

**Zdl - Diorite:** Mesocratic (C1=50), greenish-gray to grayish-green, fine- to medium-grained, metamorphosed, hydromorphic granular diorite. Major minerals include plagioclase and amphibole. Plagioclase crystals are typically unzoned and saussuritized. Amphiboles are typically altered to chlorite and actinolite masses. Gabbro intermingled locally.

**Zgr - Granite:** Leucocratic, medium-grained, equigranular metamorphosed, granite or tonolite.

**METAVOLCANIC AND METAVOLCANIC-LIKE UNITS**

**Aaron Formation**

**Za - Aaron Formation:** Distinctive metasedimentary package that ranges from fine-grained siltstones to coarse-grained sandstones, pebbly sandstones and conglomerates. Siltstones are similar in appearance to Hyco Formation lithologies. The sandstones, pebbly sandstones and conglomerates (classified as litharenite, feldspathic litharenite and lithic tuffarenite by Harris (1984)) are distinctive and commonly contain rounded to subrounded clasts of quartz ranging from sand to gravel in size. In the sandstone, the clasts are typically prominent mineral grains, quartz varies from sparse to abundant in hand sample. Lithic clasts are typically prominent and range from sand- to gravel-size. Harris (1984), performed a detailed sedimentary study of the Aaron Formation to the immediate west of the map area. Harris (1984) interpreted the Aaron Formation to have been deposited by turbidity currents in a retrogradational submarine fan setting. Pollock (2010) interprets an approximate 35 million year unconformity between the Aaron and underlying Hyco Formation. This interpretation is based in part on detrital zircon age data from an Aaron conglomerate sample collected in the adjacent Liberty Quadrangle.

**Hyco Formation - Upper Portion**

**Zht (u) - Altered tuffs:** Very light gray to light greenish gray (whitish in areas) with red and yellow mottling, altered volcaniclastic rocks. Alteration consists of silicified, sericitized and pyrophyllitized rock. Sericite phylite, pods of pyrophyllite, and quartz + pyrophyllite rock all with less than 1 mm to 2 mm diameter abundant in the matrix. Red stain location indicates outcrop or boulders of Zht (u). Zht (u) is visible in some exposures. Relic structures are obliterated in heavily altered rocks. Map area contains boulders (up to several feet in diameter) and outcrop of massive milky quartz and quartz + sericite rock.

**Zhe - Epilastic rocks and lavas:** Metamorphosed conglomerate, conglomeratic sandstone, sandstone, siltstone and mudstone. Siltstones and mudstones typically display bedding ranging from mm-scale up to 10 cm, bedding layers, traceable for several feet locally, may exhibit soft sediment deformation. Locally tuffaceous with a relic tuff texture. Locally contain interbedded dacitic to basaltic lavas. Conglomerates and conglomeratic sandstones typically contain subrounded to angular clasts of dacite in a clastic matrix. Deposition interpreted as distal from volcanic center, in deep water (?) and via turbidites.

**Zheplm - Mixed epilastic-pyroclastic rocks with interlayered intermediate to basaltic lavas:** Grayish-green to greenish-gray, locally with distinctive reddish-gray or maroon to lavender coloration, metamorphosed, conglomeratic, conglomeratic sandstone, sandstone, siltstone, and mudstone, and felsic fine-grained tuff. Siltstones are locally phylitic. Locally contain interbedded dacitic to basaltic lavas identical to Zht (u) unit. Silicified and/or sericitized altered rock are locally present. Interpreted to be in a gradational contact with unit Zheplm and identified by increase in intermediate to mafic lavas and decrease and/or absence of dacites.

**Zhepl - Mixed epilastic-pyroclastic rocks with interlayered dacitic lavas:** Grayish-green to greenish-gray, locally with distinctive reddish-gray or maroon to lavender coloration, metamorphosed, conglomeratic, conglomeratic sandstone, sandstone, siltstone and mudstone. Lithologies are locally bedded, locally siliceous with a cryptocrystalline-like groundmass. Siltstones are locally phylitic. Locally contain interbedded dacitic lavas identical to Zht (u) unit. Contains lesser amounts of fine- to coarse tuff and lapilli tuff with a cryptocrystalline-like groundmass. Pyroclastics, lavas and epilastics are mainly felsic in composition. Minor andesitic to basaltic lavas and tuffs present. Silicified and/or sericitized altered rock are locally present and increase in occurrence toward the north. Conglomerates and conglomeratic sandstones typically contain subrounded to angular clasts of dacite in a clastic matrix. Fine- to medium-grained diorite is locally present. Portions of the Zhepl unit are interpreted to have been deposited proximal to active volcanic centers represented by the Zht (u) unit but are also interpreted to record the erosion of proximal volcanic centers after cessation of active volcanism.

**Zhd (u) - Dacitic lavas and tuffs of the upper portion of the Hyco Formation:** Greenish-gray to dark gray, siliceous, metamorphosed, granitic dacite, porphyritic dacite with plagioclase phenocrysts, and flow banded dacite. Dacite with hyaloclastic textures are common. Welded and non-welded tuffs associated with the lavas include: greenish-gray to grayish-green, fine tuff, coarse plagioclase crystal tuff and lapilli tuff. Locally, siltstones of immature conglomerates and conglomeratic sandstone with abundant dacite clasts are present. The dacites are interpreted to have been coherent extrusives or very shallow intrusions associated with dome formation. The tuffs are interpreted as epiclastic pyroclastic deposits, air-fall tuffs or reworked tuffs generated during eruption of dacite domes. The unit occurs as map scale rock surrounded by classic rocks of Zhepl unit. Wortman et al. (2000) reports an age of 615.7-7.7 ± 1.8 Ma U-Pb zircon date for a dacite tuff from the unit in the Rougemont quadrangle.

**Zhdal - Dacite to andesitic shallow intrusive:** Gray to greenish-gray, dacite to andesite. Aphanitic groundmass with plagioclase and calcic amphibole phenocrysts. Weak relic cryptocrystalline texture present (less than dacites). Aphanitic dacite to andesite clasts present locally indicating hyaloclastic texture.

**Zhbl - Andesite to basaltic lavas:** Green, gray-green, gray, dark gray and black, typically unfoliated, amygdaloidal, plagioclase porphyritic, amphibole/pyroxene porphyritic and aphanitic, metamorphosed andesitic to basaltic lavas and shallow intrusions. Hyaloclastic texture is common and imparts a fragmental texture on some outcrops and float boulders. Conglomeratic rocks containing angular clasts of andesite and/or basalt occur locally and are interpreted as resedimented hyaloclastite. Map-scale body within Sheepshead alteration zone is siliceous and magnetic.

**Zhblm - Andesite to basaltic lavas with interlayered epilastic rocks:** Light green, gray-green, gray, and dark gray, typically unfoliated, amygdaloidal, plagioclase porphyritic, amphibole/pyroxene porphyritic and aphanitic, metamorphosed, andesite to basaltic lavas and shallow intrusions. Hyaloclastic texture is common and imparts a fragmental texture on some outcrops and float boulders. Contains lesser amounts of grayish-green, light green, and gray to light gray, metamorphosed conglomerate, conglomeratic sandstone, sandstone, siltstone and mudstone.

**Zhqdp - Quartz dacite porphyry:** Porphyritic with aphanitic groundmass and sub- to euhedral phenocrysts (2-6 mm) of white to salmon plagioclase and gray to dark gray (delta) quartz; phenocrysts typically constitute 20 to 25% of the rock. Foliated and likely altered. Present in a few outcrops and boulders in the vicinity of Johnson Creek. Similar to quartz dacite porphyry unit within the Byrum Quadrangle (Bradley et al., 2013).

**Zhsl - Andesitic shallow intrusive:** Grayish-green to light green, metamorphosed plagioclase porphyritic andesite with a granular-textured groundmass to very fine-grained drifite (with intrusive texture visible with 7x hand lens - microlite-like). Contains lesser amounts of fine- to medium grained diorite. Plagioclase phenocrysts typically range from 1 mm to 4 mm. Dark green to black colored amphibole, when present, occurs as phenocrysts (less than 1 mm to 1 mm) and as intergrowths with plagioclase.

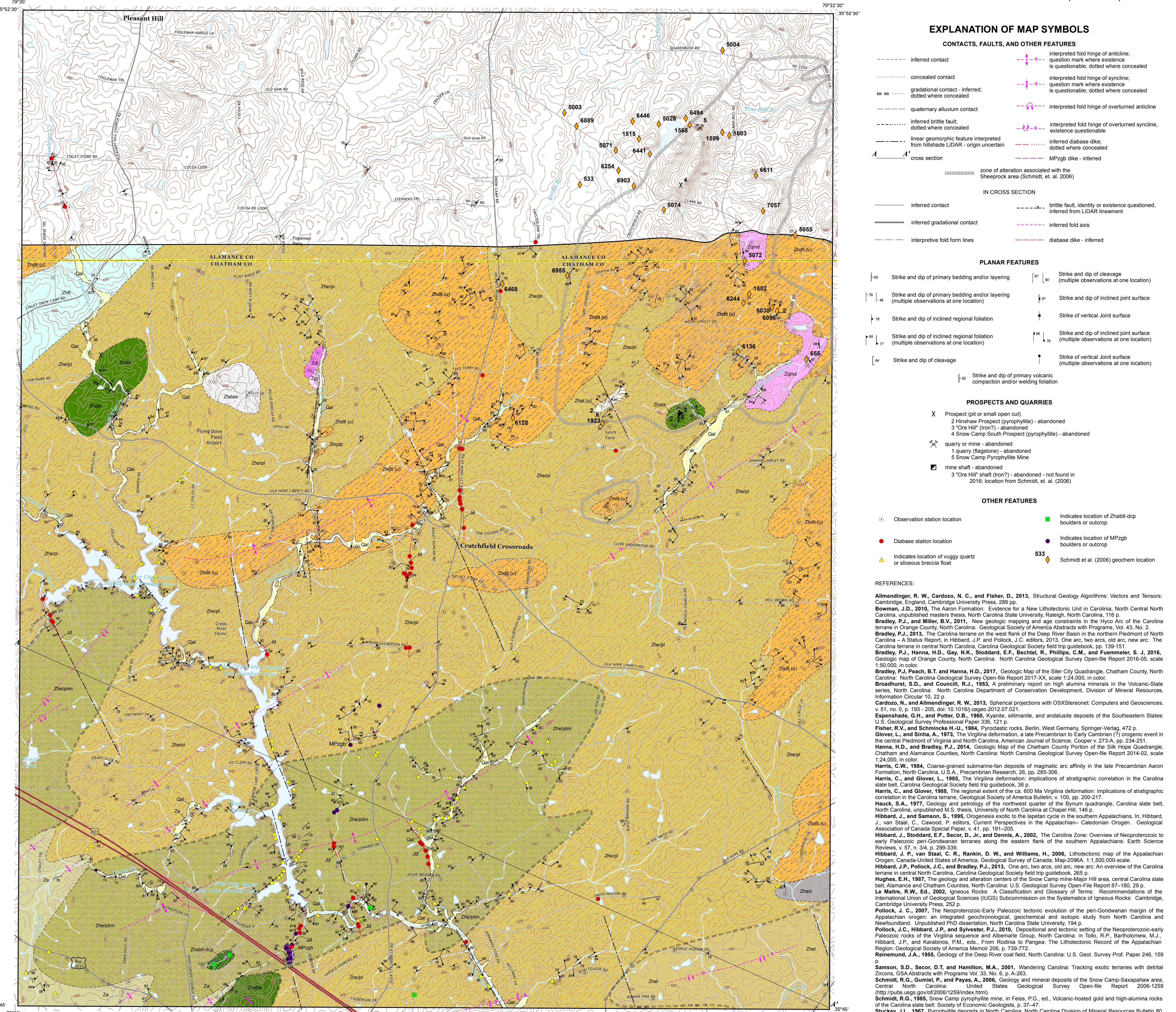
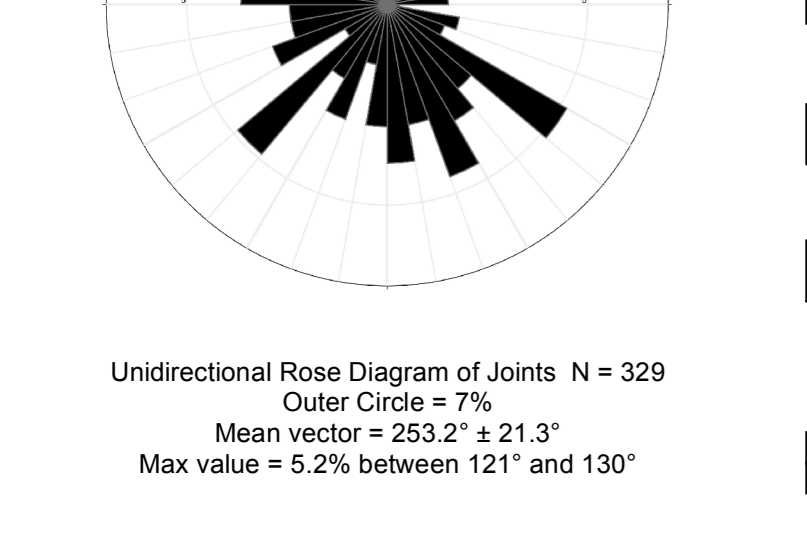
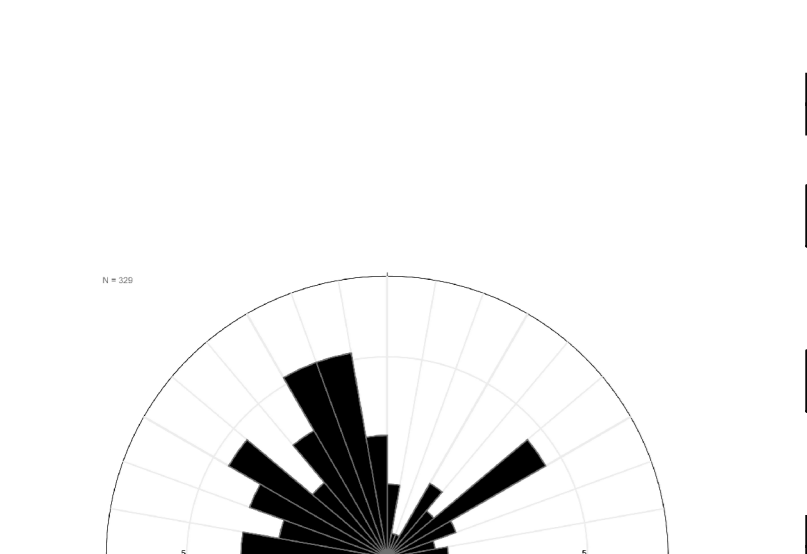
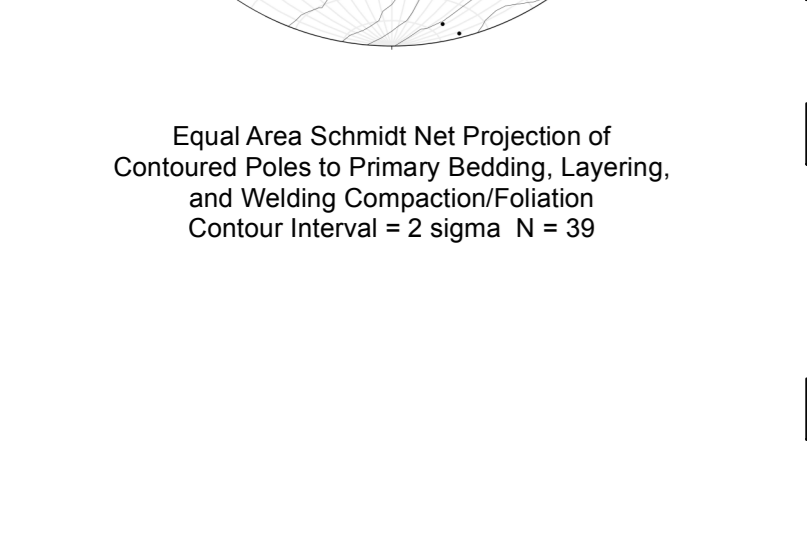
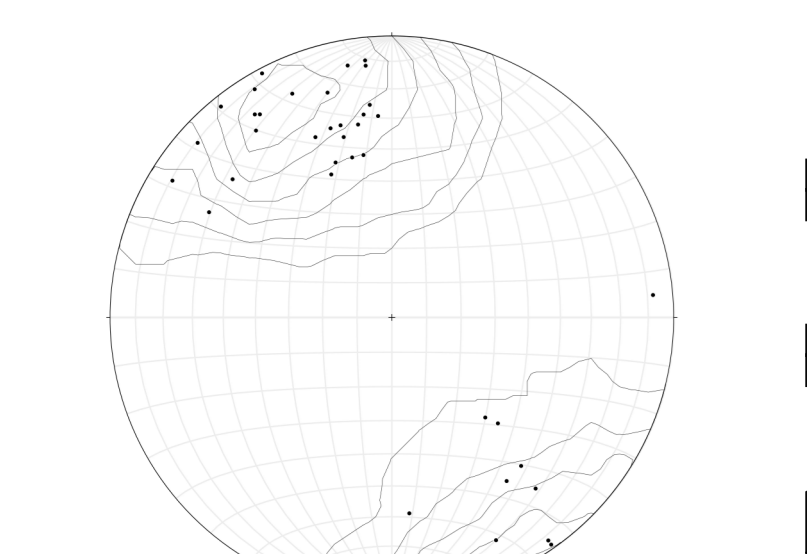
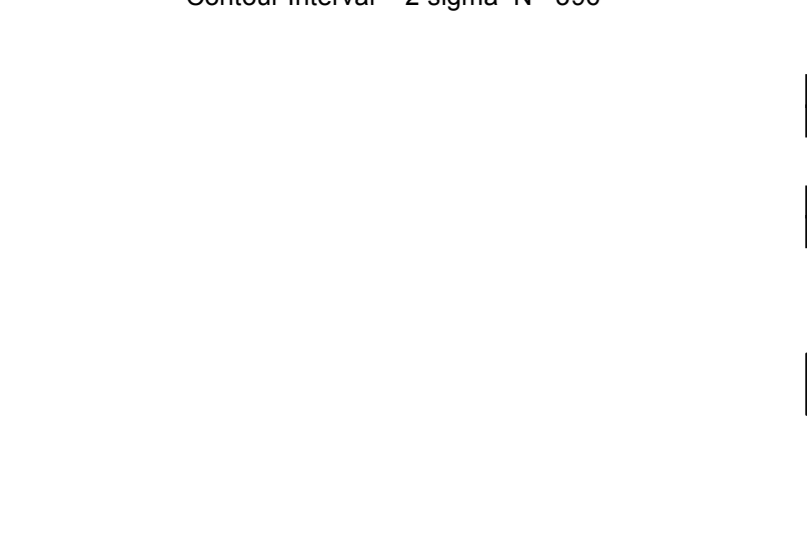
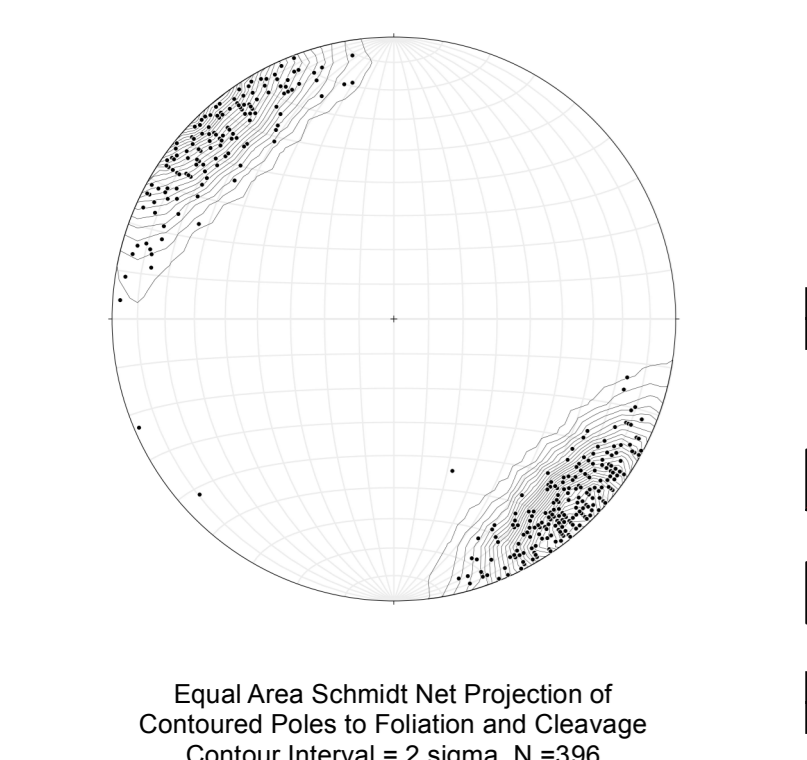
**Zhbl-dcp - Andesite to basalt porphyry of the Dry Creek area:** Distinctive, green to dark green, metamorphosed andesite porphyry with aphanitic groundmass and euhedral phenocrysts (up to 10 mm) of greenish-white plagioclase. Phenocrysts typically constitute 20 to 25% of the rock, local alignment of plagioclase, lesser phenocrysts. Green to dark green basaltic porphyry with abundant pyroxene (altered to amphibole) phenocrysts with minor plagioclase phenocrysts. Andesite and basalt porphyries locally amygdaloidal (up to 2 cm), amygdaloid filling includes calcite, quartz, chlorite, and epidote. Same as Dry Creek Porphyry complex of Hauck (1977). Present as isolated outcrops or boulders as designated by green stain locations.

**Zhf - Felsic tuffs:** Grayish-green to greenish-gray and silvery-gray, massive to foliated volcaniclastic pyroclastic rocks consisting of fine- to coarse tuffs, lapilli tuffs and minor welded tuffs. Tuffs are differentiated from other volcaniclastic rocks by the presence of zones of cryptocrystalline texture that exhibit conchoidal fracture in between foliation domains. Layering ranges from massive to thin bedded. Contains lesser amounts of volcanic sedimentary rocks consisting of volcanic sandstones, and graywackes with minor siltstones and phyllite.

**ABUNDANT EVIDENCE OF BRITTLE FAULTING AT THE OUTCROP SCALE AND LARGE-SCALE LINEAMENTS (AS INTERPRETED FROM HILLSHADE LIDAR DATA) ARE PRESENT IN THE MAP AREA. THE BRITTLE FAULTING AND LINEAMENTS ARE INTERPRETED TO BE ASSOCIATED WITH MESOZOIC EXTENSION. THE COTTON CROSS-STRUCTURE (REHMER, 1955), LOCATED TO THE SOUTHEAST OF THE STUDY AREA, IS A CONTRACTION ZONE IN THE DEEP RIVER MESOZOIC BASIN AND IS CHARACTERIZED BY CRYSTALLINE ROCKS OVERPRINTED BY COMPLEX BRITTLE FAULTING. DIKES OF JURASSIC AGED DIABASE INTRUDE THE CRYSTALLINE ROCKS OF THE MAP AREA. QUATERNARY AGED ALLUVIUM IS PRESENT IN MOST MAJOR DRAINAGES.**

**Equal-Area Schmidt Net Projections and Rose Diagram**

Plots and calculations created using Stereonet v. 6.6.0 based on Allmendinger et al. (2015) and Cardozo and Allmendinger (2013).



**EXPLANATION OF MAP SYMBOLS**

**CONTACTS, FAULTS, AND OTHER FEATURES**

- inferred contact
- concealed contact
- gradational contact - inferred: dotted where concealed
- quaternary fault
- inferred brittle fault: dotted where concealed
- linear geologic feature interpreted from hillshade LIDAR - origin uncertain
- cross section
- zone of alteration associated with the Sheepshead area (Schmidt, et al., 2006)
- inferred contact
- inferred gradational contact
- interpreted fold form lines
- interpreted fold hinge of anticline; question mark where existence is questionable; dotted where concealed
- interpreted fold hinge of syncline; question mark where existence is questionable; dotted where concealed
- interpreted fold hinge of overturned anticline
- interpreted fold hinge of overturned syncline; existence questionable
- inferred diabase dike; dotted where concealed
- MPzgb dike - inferred
- brITTLE fault, identify or existence questioned, inferred from LIDAR treatment
- inferred fold axis
- diabase dike - inferred

**IN CROSS SECTION**

- Strike and dip of primary bedding and/or layering (multiple observations at one location)
- Strike and dip of primary bedding and/or layering (multiple observations at one location)
- Strike and dip of inclined regional foliation
- Strike and dip of inclined regional foliation (multiple observations at one location)
- Strike and dip of cleavage (multiple observations at one location)
- Strike and dip of primary volcanic compaction and/or welding foliation

**PLANAR FEATURES**

- Strike and dip of primary bedding and/or layering (multiple observations at one location)
- Strike and dip of inclined joint surface (multiple observations at one location)
- Strike of vertical joint surface
- Strike and dip of inclined joint surface (multiple observations at one location)
- Strike and dip of vertical joint surface (multiple observations at one location)

**PROSPECTS AND QUARRIES**

- Prospect (pit or small open cut)
- Hinshaw Prospect (pyrophyllite) - abandoned
- Ore Hill (iron?) - abandoned
- Snow Camp South Prospect (pyrophyllite) - abandoned
- quarry (flagstone) - abandoned
- quarry (pyrophyllite) - abandoned
- mine shaft - abandoned
- Ore Hill shaft (iron?) - abandoned - not found in 2016; location from Schmidt, et al. (2006)

**OTHER FEATURES**

- Observation station location
- Diabase station location
- Indicates location of vuggy quartz or siliceous breccia foot
- Indicates location of Zhtbl-dcp boulders or outcrop
- Indicates location of MPzgb boulders or outcrop
- Schmidt et al. (2006) geochron location

**REFERENCES:**

Allmendinger, R. W., Cardozo, N. C., and Fisher, D., 2013, Structural Geology Algorithms: Vectors and Tensors. Cambridge, England: Cambridge University Press, 289 pp.

Bradley, J.D., 2010, The Aaron Formation: Evidence for a New Lithotectonic Unit in the Carolina Terrane, North Carolina, unpublished masters thesis, North Carolina State University, Raleigh, North Carolina, 116 p.

Bradley, P.J., and Miller, B.M., 2011, New geologic mapping and age constraints in the Hyco Arc of the Carolina terrane in Orange County, North Carolina. Geological Society of America Abstracts with Programs, Vol. 43, No. 2.

Bradley, P.J., 2013, The Carolina terrane on the west flank of the Deep River basin in the northern Piedmont of North Carolina - a Status Report, in Hibbard, J.P. and Pollock, J.C. editors, 2013, One arc, two arcs, old arc, new arc: The Carolina terrane in central North Carolina. Carolina Geological Society field trip guidebook, pp. 139-151.

Bradley, P.J., Harris, E.H., Gay, N.C., Bechtel, E.F., Bechtel, R., Phillips, C.M., and Fuemmeler, S., 2016, Geologic map of Orange County, North Carolina. North Carolina Geological Survey Open-File Report 2016-05, scale 1:24,000, in color.

Bradley, P.J., Peach, B.T., and Hanna, H.D., 2017, Geologic Map of the Siler City Quadrangle, Chatham County, North Carolina. North Carolina Geological Survey Open-File Report 2017-XX, scale 1:24,000, in color.

Broadhurst, S.D., and Cowling, R.L., 1983, A preliminary report on high alumina minerals in the Volcano-Stratovolcanic Series, North Carolina. North Carolina Department of Conservation Development, Division of Mineral Resources, Information Circular 10, 22 p.

Cardozo, N., and Allmendinger, R. W., 2013, Spherical projections with QGIS/Stereonet. Computers and Geosciences, v. 51, no. 0, p. 193-205. doi: 10.1016/j.cageo.2012.07.021.

Espenshade, G.H., and Potter, D.B., 1960, Kovarite, sillimanite, and andalusite deposits of the Southeastern States. U.S. Geological Survey Professional Paper 336, 121 p.

Fisher, R.V., and Schminke, H.-U., 1984, Pyroclastic rocks. Berlin, West Germany: Springer-Verlag, 472 p.

Glover, L., and Sinha, A., 1973, The Virginia deformation, late Precambrian to Early Cambrian (?) orogenic event in the central Piedmont of Virginia and North Carolina. American Journal of Science, Cooper v. 73-A, pp. 234-259.

Hanna, H.D., and Bradley, P.J., 2014, Geologic Map of the Chatham County Portion of the Silk Hope Quadrangle, Chatham and Alamance Counties, North Carolina. North Carolina Geological Survey Open-File Report 2014-02, scale 1:24,000, in color.

Harris, C.W., 1984, Coarse-grained submarine-fan deposits of magmatic arc affinity in the late Precambrian Aaron Formation, North Carolina. U.S.A. Precambrian Research, 26, pp. 285-306.

Harris, C., and Glover, 1985, The regional extent of the ca. 600 Ma Virginia deformation: implications of stratigraphic correlation in the Carolina terrane. Geological Society of America Bulletin, v. 100, pp. 200-217.

Hauck, S.A., 1977, Geology and petrology of the northwestern quarter of the Byrum quadrangle, Carolina state belt, North Carolina, unpublished M.S. thesis, University of North Carolina at Chapel Hill, 146 p.

Hibbard, J., and Samson, S., 1985, Progression exotic to the Appalachian cycle in the southern Appalachians. In Hibbard, J., van Staal, C., Coward, F. editors, Current Perspectives in the Appalachians - Caledonian Orogen. Geological Association of Canada Special Paper, v. 41, pp. 191-205.

Hibbard, J., Steidinger, E.F., Secor, D. Jr., and Daniels, A., 2002, The Carolina Zone: Overview of Neoproterozoic to early Paleozoic peri-Gondwanan terranes along the eastern flank of the southern Appalachians. Earth Science Reviews, v. 57, no. 3, pp. 229-338.

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

Hibbard, J.P., Pollock, J.C., and Bradley, P.J., 2015, One arc, two arcs, old arc, new arc: An overview of the Carolina terrane in central North Carolina. Carolina Geological Society field trip guidebook, 205 p.

Hibbard, J.P., and Karason, P.M., eds., From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region. Geological Society of America Memoir 206, p. 739-772.

Rehmer, J.L., 1955, Geology of the Deep River coal field, North Carolina. U.S. Geol. Surv. Prof. Paper 246, 159 p.

Samson, S.D., Secor, D.T., and Hamilton, M.A., 2001, Wandering Carolina: Tracking exotic terranes with detrital Zircon. CSA Abstracts with Programs, Vol. 33, No. 6, p. A-263.

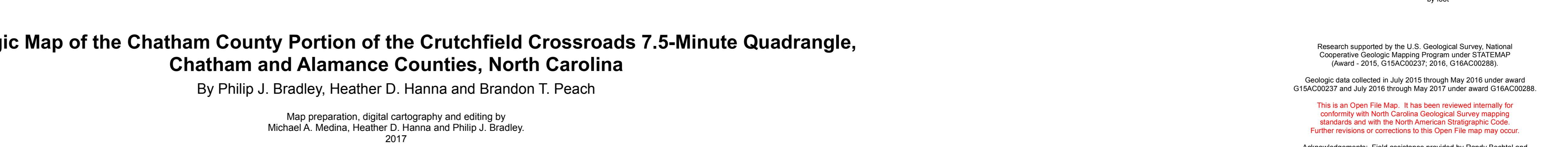
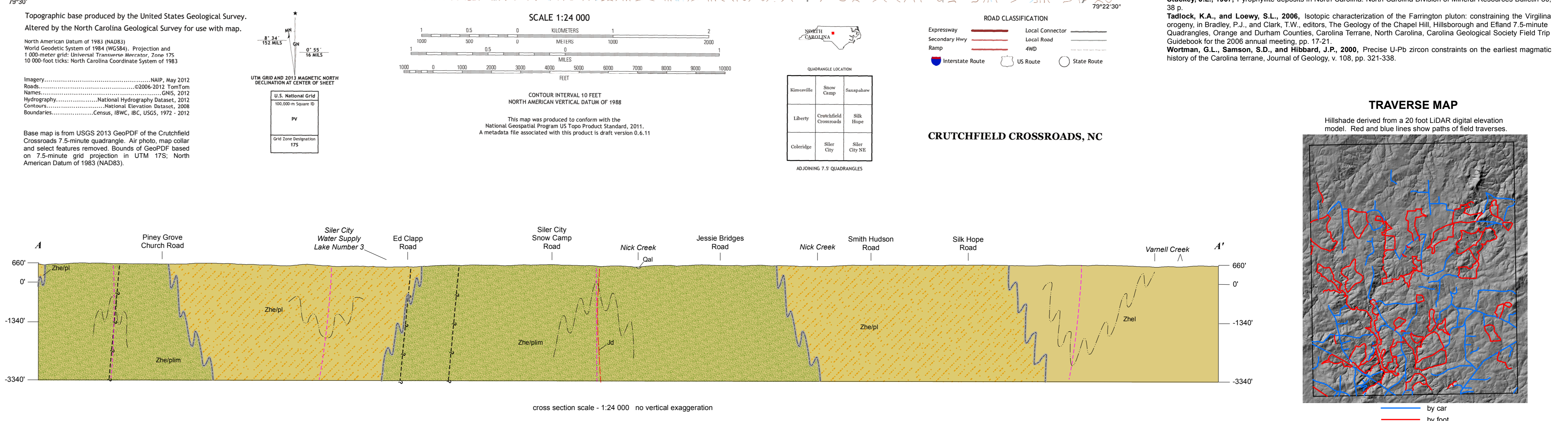
Schmidt, R.G., Gumiel, P., and Payne, A., 2006, Geology and mineral deposits of the Snow Camp-Saxapahaw area, North Carolina. United States Geological Survey, Open-File Report 2006-1059 (http://pubs.usgs.gov/of/2006/1059/index.html).

Schmidt, R.G., 1985, Snow Camp pyrophyllite mine, in Felt, G.P., ed., Volcanic-hosted gold and high-alumina rocks of the Carolina state belt. Society of Economic Geologists, p. 37-47.

Stuckey, J.L., 1967, Pyrophyllite deposits in North Carolina. North Carolina Division of Mineral Resources Bulletin 80, 38 p.

Tatlock, K.A., and Loney, S.L., 2006, Isotopic characterization of the Farmington pluton: constraining the Virginia orogeny in Bradley and Clark, 2011, editors, The Geology and Geochronology of the Eiland 7.5-minute Quadrangle, Orange and Durham Counties, Carolina Terrane, North Carolina. Carolina Geological Society Field Trip Guidebook for the 2006 annual meeting, pp. 17-21.

Wortman, R.L., Samson, S.D., and Hibbard, J.P., 2000, Precise U-Pb zircon constraints on the earliest magmatic history of the Carolina Terrane. Journal of Geology, v. 108, pp. 321-338.

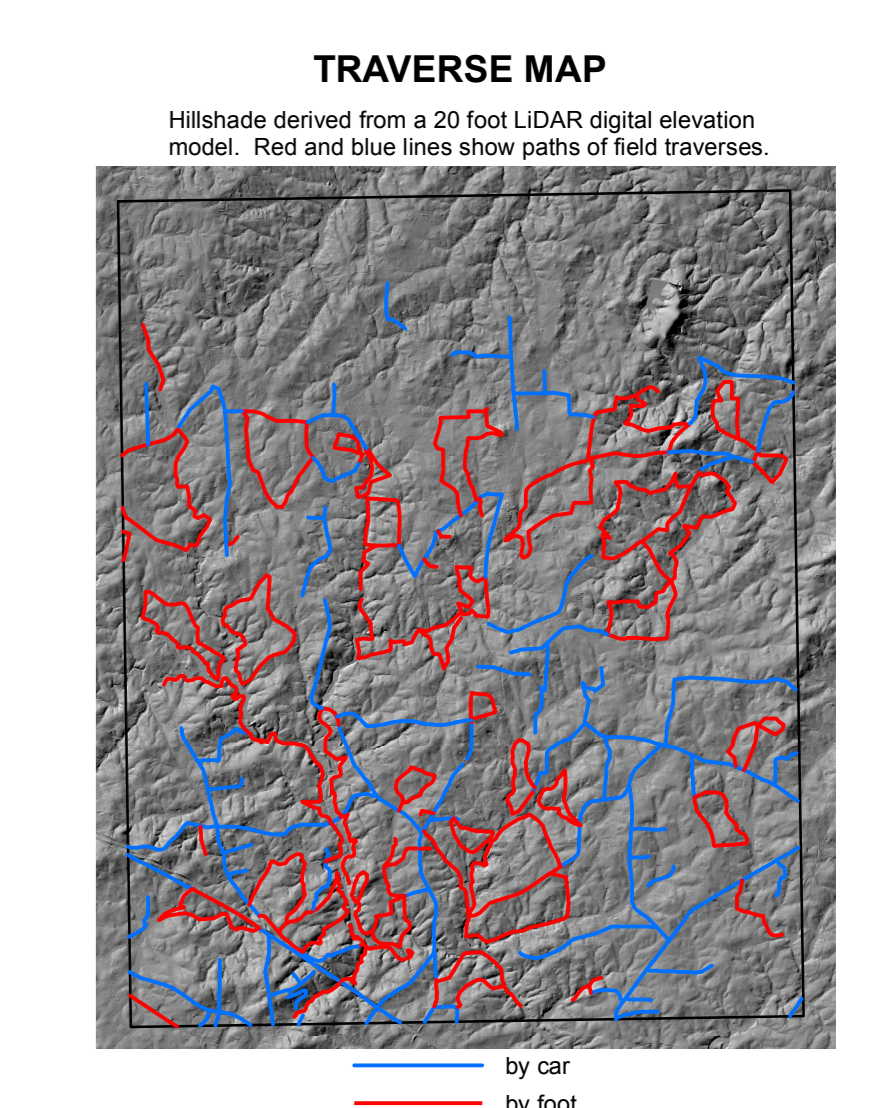


**Geologic Map of the Chatham County Portion of the Crutchfield Crossroads 7.5-Minute Quadrangle, Chatham and Alamance Counties, North Carolina**

By Philip J. Bradley, Heather D. Hanna and Brandon T. Peach

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This is an Open File Map. It has been reviewed internally for conformity with North Carolina Geological Survey mapping standards and with the North American Stratigraphic Code. Further revisions or corrections to this Open File map may occur.

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