North Carolina Department of Environmental Quality
Division of Energy, Mineral and Land Resources

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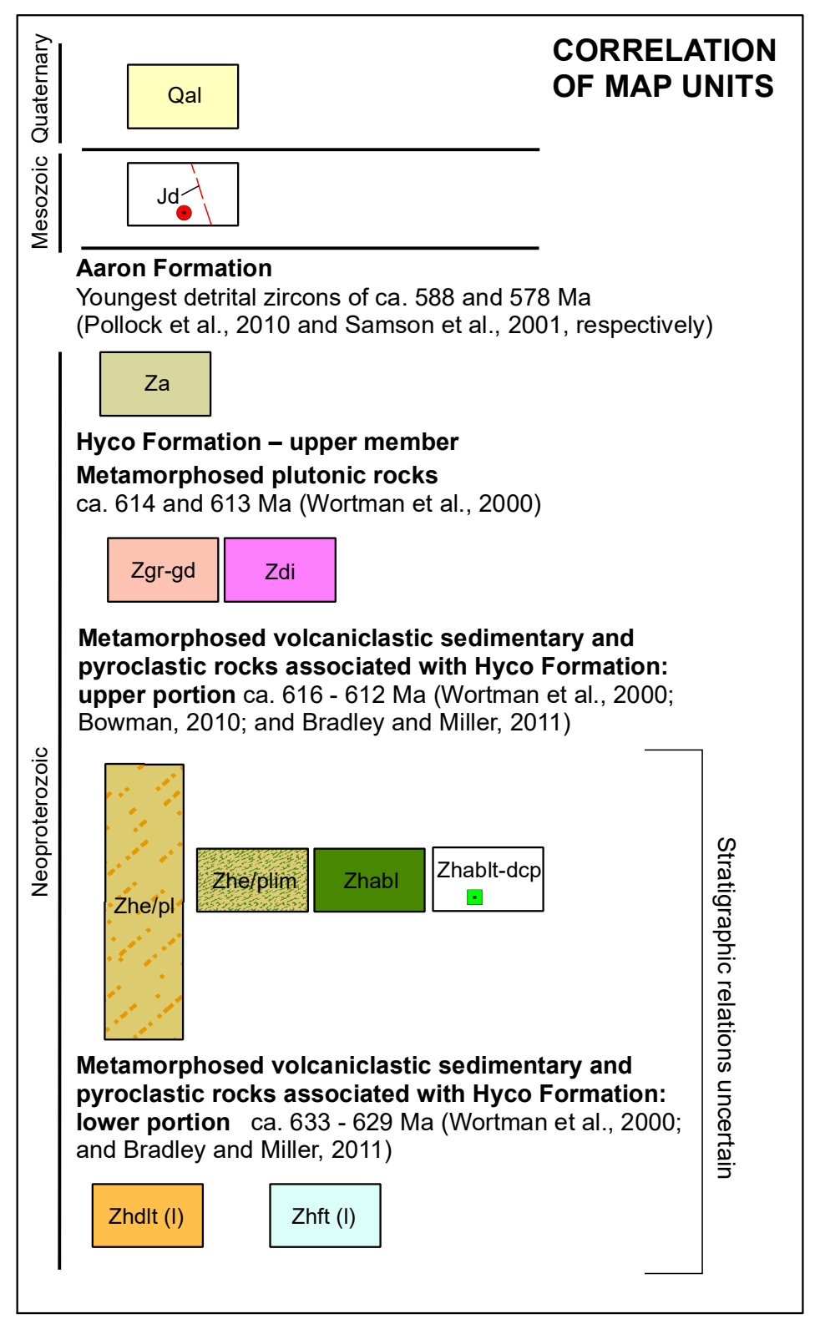
This Geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program

North Carolina Geological Survey
Open File Report 2018-02



CORRELATION OF MAP UNITS

Aaron Formation
Youngest detrital zircons of ca. 588 and 578 Ma
(Pollock et al., 2010 and Samson et al., 2001, respectively)

Hyco Formation – upper member
Metamorphosed plutonic rocks
ca. 614 and 613 Ma (Wortman et al., 2000)

Metamorphosed volcaniclastic sedimentary and pyroclastic rocks associated with Hyco Formation: upper portion ca. 616 - 612 Ma (Wortman et al., 2000; Bowman, 2010; and Bradley and Miller, 2011)

Metamorphosed volcaniclastic sedimentary and pyroclastic rocks associated with Hyco Formation: lower portion ca. 633 - 629 Ma (Wortman et al., 2000; and Bradley and Miller, 2011)

INTRODUCTION

The Liberty 7.5-minute Quadrangle lies in the east central portion of the North Carolina Piedmont. The headwaters of the Rocky River are present in the quadrangle; the Randolph – Chatham County line crosses the quadrangle from north to south. The Chatham – Alamance – Randolph County lines are present in the northeast of the quadrangle. The Town of Liberty (population approximately 2,600) occupies the north-central portion of the quadrangle. The Town of Staley (population approximately 400) is located in the southern portion of the quadrangle. The quadrangle is crossed by northwest-southeast US Highway 421. US Hwy 64, a major east-west corridor for the central Piedmont, is located immediately to the south of the quadrangle and crosses into the quadrangle for approximately 0.75 miles.

Approximately half of the quadrangle drains to the Rocky River along drainages that include the North Rocky River Prong and the unnamed headwater creeks and tributaries of the Rocky River. A small portion of the quadrangle, immediately north of Town of Liberty, drains to the Haw River. The western portion of the quadrangle drains to the Deep River along drainages that include Boodom Creek, Mount Pleasant Creek, Reed Creek, Brush Creek and Reedy Fork. In the southeast 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 exposure at road cuts, ridges, resistant finned-shaped outcrops and pavement outcrops occur locally outside of drainages. The elevations in the map area range from about 810 feet above sea level northeast of the Town of Liberty, to less than 540 feet along Reed Creek and one of it's unnamed tributaries near the southwestern corner of the quadrangle where HWY 64 enters the quadrangle.

GEOLOGIC BACKGROUND AND PAST WORK

Pre-Mesozoic crystalline rocks in the Liberty 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 Virgilina sequence (Hibbard et al., 2013). The Hyco Arc consists of the Hyco Formation which include ca. 633 to 612 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. 615 Ma) portions (informal) with an apparent intervening hiatus of magmatism. In northeastern Chatham County, Hyco Formation units are intruded by the ca. 579 Ma (Tadlock and Loewy, 2006) East Farrington pluton and associated West Farrington pluton. The Aaron Formation consists of metamorphosed layered volcaniclastic rocks with youngest detrital zircons of ca. 588 and 578 Ma (Pollock et al., 2010 and Samson et al., 2001, respectively).

FOLDS

The Hyco Arc and Aaron Formation lithologies were folded and subjected to low grade metamorphism during the ca. 578 to 554 Ma (Pollock, 2007; Pollock et al., 2010) Virgilina 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 tight folds that are locally overturned to the southeast.

Four hundred and seven (407) primary bedding, layering and compaction/welding foliation measurements from this and adjacent quadrangles in the immediate area of the map were used in stereogram analyses to determine the range of fold interlimb angles. Calculated interlimb angles ranged from greater than 120 degrees to less than 30 degrees indicating the presence of gentle to tight folds. Preliminary domain analyses of measurements in Hyco Formation units only, indicate the folds range from tight to open with the majority of the folds likely within the tight to close range. Preliminary domain analyses of measurements in Aaron Formation units only, indicate the folds range from tight to gentle with the majority of the folds within the open range.

Map units of metavolcanic and metavolcaniclastic rocks include various lithologies that when grouped together are interpreted to indicate general environments of deposition. The dacitic lavas and tuffs unit is interpreted to represent dacitic domes and 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 epiclastic deposits. The epiclastic/pyroclastic units are interpreted to represent deposition from the erosion of dormant and active volcanic highlands. Some of the metavolcaniclastic units within the map area display lithologic relationships similar to dated units present in northern Orange and Durham Counties. Due to these similarities, the metavolcanic and metavolcaniclastic 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 and adjacent quadrangles. The brittle faulting and lineaments are interpreted to be associated with Mesozoic extension. The Colon cross-structure (Reinemund, 1955), located to the southeast of the study area, is a constriction 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 area. Additionally, Burt et al. (1978) indicates the presence of a through-going diabase dike inferred from aeromagnetic data or stream patterns in the map area. Quaternary aged alluvium is present in most major drainages.

MINERAL RESOURCES

There are no active mining activities currently in the quadrangle. The central portion of the quadrangle is on strike with a large zone of high-sulfidation alteration as described by Schmidt et al. (2006). This alteration zone has the potential for pyrophyllite and gold resources. The abandoned Staley Pyrophyllite Mine is located in Randolph County, approximately 3.5 miles west of the Town of Staley, on Soapstone Mountain Road. Stuckey (1967) indicates that the Staley pyrophyllite deposit was, at one time, the second largest pyrophyllite mine in the State with an estimate 400,000 tons of material mined. The Staley deposit is also discussed in Broadhurst and Councill (1953) and Espenshade and Potter (1960). According to the USGS MRDS database, the former Staley quartz crushing plant was located within the Town of Staley.

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 or strong metamorphic foliation. Although subjected to metamorphism, the rocks retain relict 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.

A preliminary review of the area geology is provided in Bradley (2013). Unit descriptions common to Bradley et al. (2017 a and b) from the Crutchfield Crossroads 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 subcommission on igneous and volcanic rocks (IUGS) after Le Maitre (2002) is used in classification and naming of the units. The classification and naming of the rocks is based on relict 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 Units

Qal

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 inliers surrounded by alluvium.

Intrusive and Metaintrusive Units

Jd

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 spheriodally weathered boulders with a grayish-brown weathering rind. Red station location indicates outcrop or boulders of diabase.

Zdi

Zdi – Diorite: Mesocratic (CI~50), greenish-gray to grayish-green, fine- to medium-grained, metamorphosed, hypidiomorphic granular diorite. Major minerals include plagioclase and amphibole. Plagioclase crystals are typically sericitized and saussuritized. Amphiboles are typically altered to chlorite and actinolite masses. Gabbro intermingled locally.

Zgr-gd

Zgr-gd – Granite to granodiorite: Leucocratic, fine- to medium- grained, equigranular metamorphosed, granite to granodiorite.

Metavolcanic and Metavolcaniclastic Units

Aaron Formation

Za

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 feldsarenite by Harris (1984)) are distinctive and commonly contain rounded to subrounded clasts of quartz ranging from sand- to gravel-sized. In the sandstones, feldspar is the most prominent mineral grain; 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 et al., (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 date data from an Aaron conglomerate sample collected in the Quadrangle.

Hyco Formation – Upper Portion

Zhabl

Zhabl - Andesitic 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 consisting of angular clasts of andesite and/or basalt occur locally and are interpreted as resedimented hyaloclastite.

Zhablt-dcp

Zhablt-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 50% of the rock; local alignment of plagioclase; lesser pyroxene/amphibole phenocrysts. Green to dark green basalt porphyry with abundant pyroxene (altered to amphibole) phenocrysts with minor plagioclase phenocrysts. Andesite and basalt porphyries locally amygdaloidal (up to 2 cm), amygdules in filling include calcite, quartz, chlorite, and epidote. Same as Dry Creek Porphyry complex of Hauck (1977). Present as isolated outcrops or boulders as designated by green station locations.

Zhe/plim

Zhe/plim - Mixed epiclastic-pyroclastic rocks with interlayered intermediate to basaltic lavas: Grayish-green to greenish-gray, locally with distinctive reddish-gray or maroon to lavender coloration; metamorphosed: conglomerate, conglomeratic sandstone, sandstone, siltstone, mudstone, and felsic fine- to coarse tuff and lapilli tuff. Siltstones are locally phyllitic. Locally contain interbedded andesitic to basaltic lavas identical to Zhabl unit. Silicified and/or sericitized altered rock are locally present. Interpreted to be in gradational contact with unit Zhe/pl and identified by increase in intermediate to mafic lavas and decrease and/or absence of dacites. Fine- to medium-grained diorite is locally present.

Zhe/pl

Zhe/pl - Mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas: Grayish-green to greenish-gray, locally with distinctive reddish-gray or maroon to lavender coloration; metamorphosed: conglomerate, conglomeratic sandstone, sandstone, siltstone and mudstone. Lithologies are locally bedded; locally tuffaceous with a cryptocrystalline-like groundmass. Siltstones are locally phyllitic. Contains lesser amounts of fine- to coarse tuff and lapilli tuff with a cryptocrystalline-like groundmass. Pyroclastics, lavas, and epiclastics are mainly felsic in composition. Locally contain interbedded dacitic lavas identical to Zhdlt unit. 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. Portions of the Zhe/pl unit are interpreted to have been deposited proximal to active volcanic centers represented by the Zhdlt unit but are also interpreted to record the erosion of proximal volcanic centers after cessation of active volcanism.

The deposition of the Zhe/pl unit in the Liberty Quadrangle likely spans the magmatic pulses of the lower and upper Hyco Formation. Felsic tuffs are interlayered with conglomerates and conglomeratic sandstone with angular clasts of dacite similar to the Zhdlt (l) unit.

Hyco Formation – Lower Portion

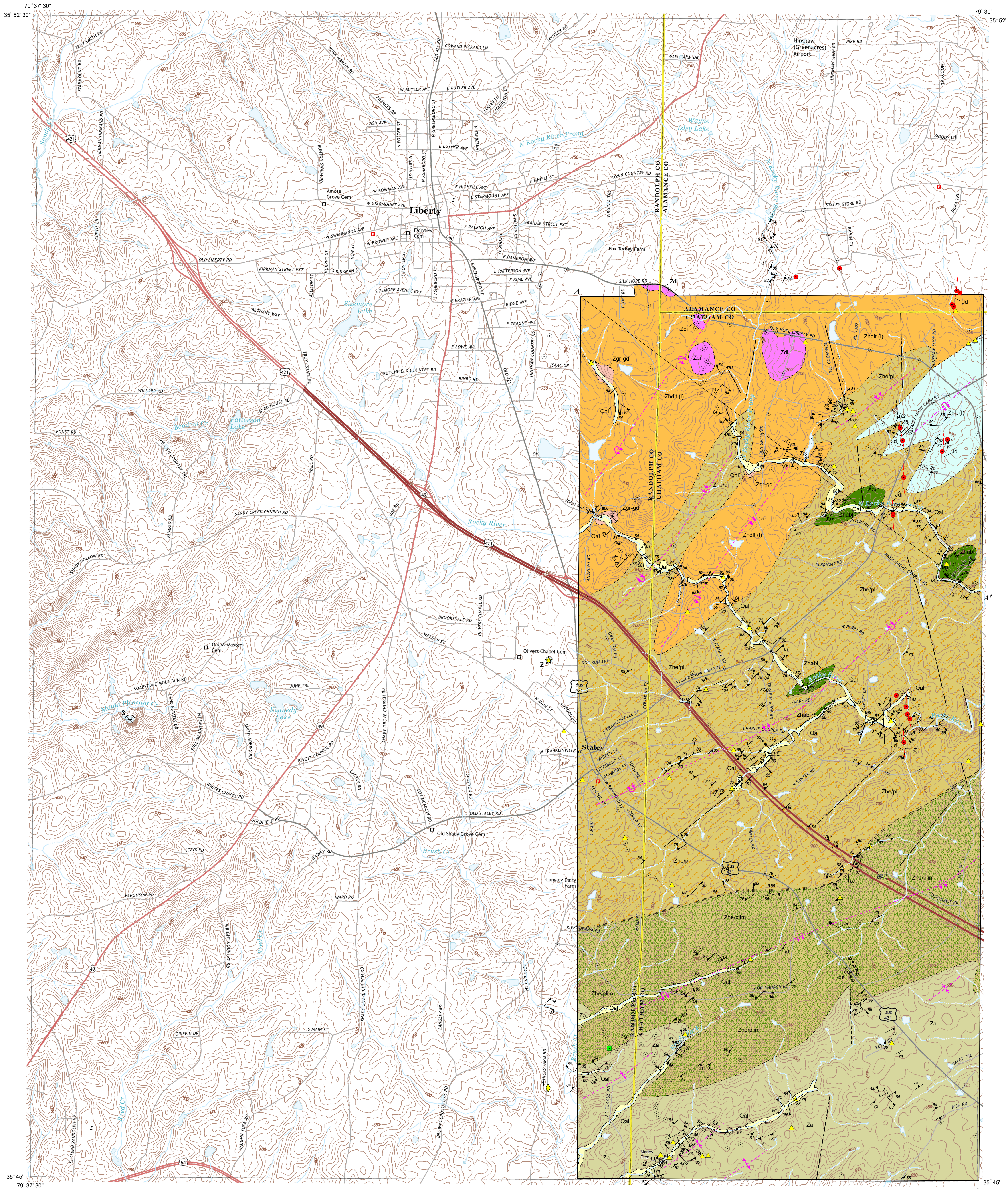
Zhft (l)

Zhft (l) - 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-like fractures in between foliation domains. Layering ranges from massive to thinly bedded. Contains lesser amounts of volcaniclatic sedimentary rocks consisting of volcanic sandstones, and greywackes with minor siltstones and phyllite.

Zhdlt (l)

Zhdlt (l) – Dacitic lavas and tuffs of the lower portion of the Hyco Formation: Distinctive gray to dark gray, siliceous, cryptocrystalline dacite, porphyritic dacite with plagioclase phenocrysts, and flow banded dacite. Welded and non-welded tuffs associated with the lavas include: greenish-gray to grayish-green, fine tuff, coarse plagioclase crystal tuff; lapilli tuff; and tuff breccia. The dacites are interpreted to have been coherent extrusives or very shallow intrusions associated with dome formation. The tuffs are interpreted as episodic pyroclastic flow deposits, air fall tuffs or reworked tuffs generated during formation of dacite domes. Wortman et al. (2000) report a 632.9 +2.6/-1.9 Ma zircon date from a sample within the unit in the Chapel Hill quadrangle generally on strike with this unit.

The Zhdlt unit in the Liberty Quadrangle is partially flanked on the southeast by the Zhft (felsic tuffs) unit. This relationship is typical of dacites assigned to the lower member of the Hyco Formation. As such, the Zhft and Zhdlt of the Liberty Quadrangle are tentatively assigned to the lower member of the Hyco, additional geochronologic data is required to confirm this correlation.

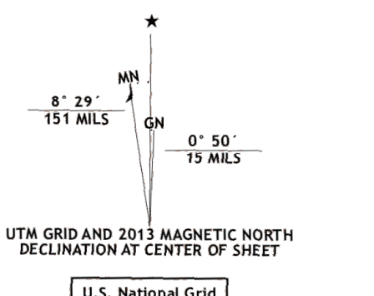


Topographic base produced by the United States Geological Survey.
Altered by the North Carolina Geological Survey for use with map.

North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid: Universal Transverse Mercator, Zone 17S
10 000-foot ticks: North Carolina Coordinate System of 1983

Imagery....NAIP, May 2012
Roads....©2006-2012 TomTom
Names....GNIS, 2012
Hydrography....National Hydrography Dataset, 2012
Contours....National Elevation Dataset, 2008
Boundaries....Census, IBWC, IBC, USGS, 1972 - 2012

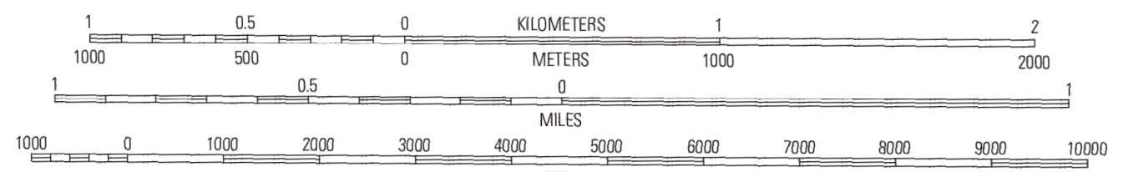
Base map is from USGS 2013 GeoPDF of the Liberty 7.5-minute quadrangle. Air photo, map collar and select features removed. Bounds of GeoPDF based on 7.5-minute grid projection in UTM 17S; North American Datum of 1983 (NAD83).



UTM GRID AND 2013 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000-m Square ID
PV
Grid Zone Designation
17S

SCALE 1:24 000



CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the
National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.11

QUADRANGLE LOCATION

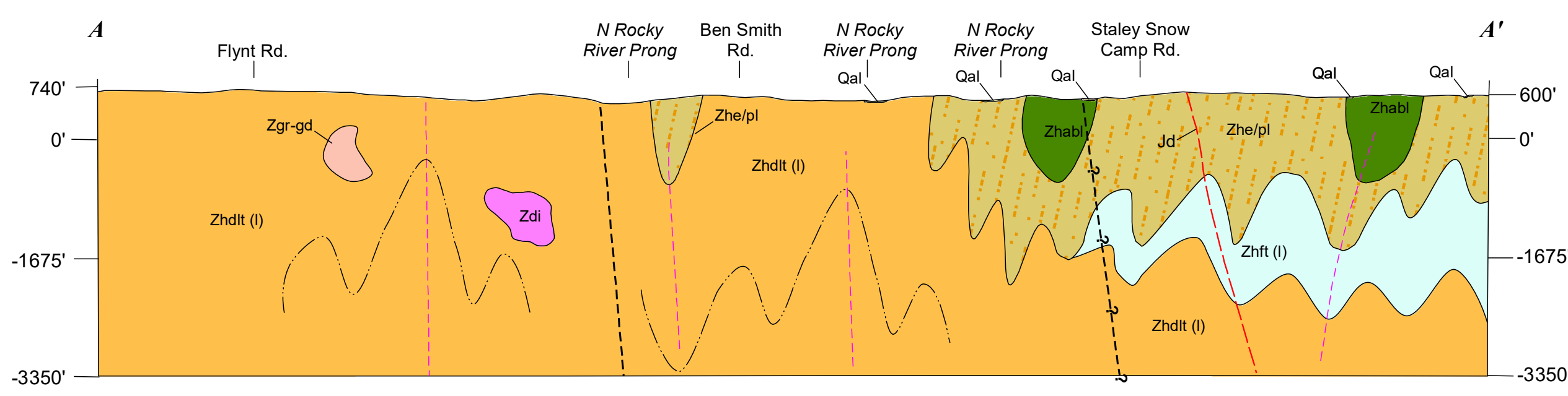
Climax	Kimesville	Snow Camp
Grays Chapel	Liberty	Crutchfield Crossroads
Ramseur	Coleridge	Siler City

ADJOINING 7.5' QUADRANGLES

ROAD CLASSIFICATION

Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

LIBERTY, NC



cross section scale - 1:24 000 no vertical exaggeration

Geologic Map of the Chatham County Portion of the Liberty 7.5-Minute Quadrangle, Chatham, Randolph and Alamance Counties, North Carolina

By

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

Geologic data collected in July 2015 through May 2016 and June through July 2017.

Map preparation, digital cartography and editing by
Michael A. Medina, Philip J. Bradley and Heather D. Hanna
2018

Supersedes Open-file Report 2016-10

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program under StateMap award numbers G15AC00237, 2015 and G17AC00264, 2017.

EXPLANATION OF MAP SYMBOLS

CONTACTS, FAULTS, AND OTHER FEATURES

- Inferred contact
- Concealed contact
- Gradational contact - inferred
- Quaternary alluvium contact
- Inferred brittle fault; dotted where concealed
- Linear geomorphic feature interpreted from hillshade LiDAR - origin uncertain
- Interpreted fold hinge of anticline, 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

IN CROSS SECTION

- inferred contact
- interpretive fold form lines
- Inferred brittle fault. ? indicates identity or existence questionable; inferred from LiDAR lineament.
- inferred fold axis
- diabase dike - inferred

- ⊙ Observation station location
- ● Diabase station location
- △ Indicates location of vuggy quartz or sliceous breccia float
- ▣ Indicates location of Zhablt-dcp boulders or outcrop
- 1 ◊ Detrital zircons date (Pollock et al., 2010)
- 2 ☆ Former Staley quartz crushing plant
- 3 ⚒ Staley Mine (pyrophyllite)

PLANAR AND OTHER FEATURES

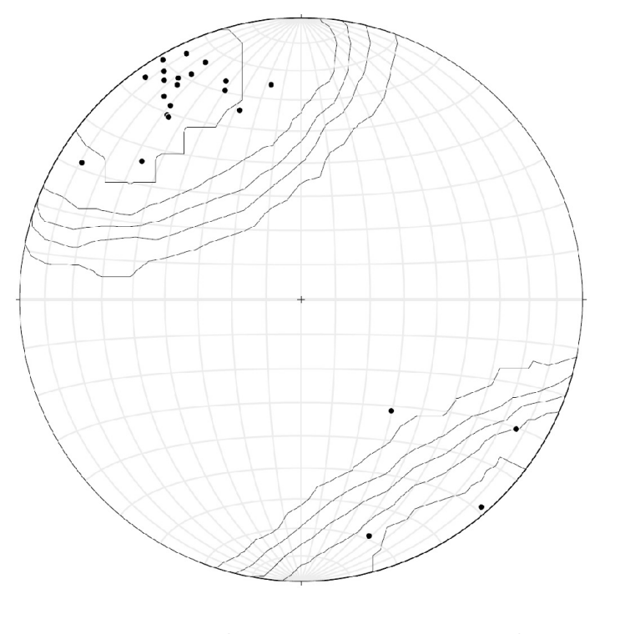
- 68 Strike and dip of primary bedding and/or layering
- 88 Strike and dip of primary bedding and/or layering (multiple observations at one location)
- 71 Strike and dip of inclined regional foliation
- 86 85 Strike and dip of inclined regional foliation (multiple observations at one location)
- 80 Strike and dip of cleavage
- 65 Trend and plunge of mineral lineation
- 86 Strike and dip of cleavage (multiple observations at one location)
- 65 Strike and dip of inclined shear foliation (multiple observations at one location)
- 81 Strike and dip of inclined joint surface
- 71 84 Strike and dip of inclined joint surface (multiple observations at one location)
- Strike of vertical Joint surface (multiple observations at one location)
- 80 Strike and dip of inclined brittle fault surface

REFERENCES:

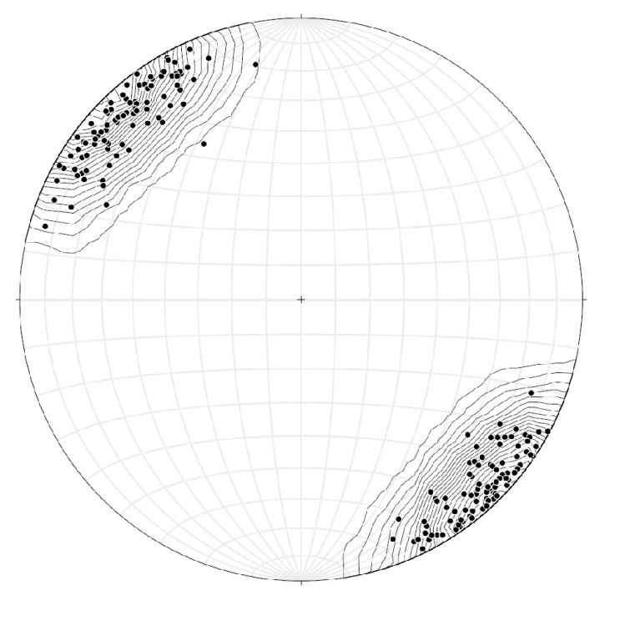
Allmendinger, R. W., Cardozo, N. C., and Fisher, D., 2013, Structural Geology Algorithms: Vectors and Tensors: Cambridge, England, Cambridge University Press, 289 pp.
Bowman, J.D., 2010, The Aaron Formation: Evidence for a New Lithotectonic Unit in Carolinia, North Central North Carolina, unpublished masters thesis, North Carolina State University, Raleigh, North Carolina, 116 p.
Bradley, P.J., and Miller, B.V., 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., Hanna, H.D., Gay, N.K., Stoddard, E.F., Bechtel, R., Phillips, C.M., and Fuemmeler, S. J, 2016, Geologic map of Orange County, North Carolina: North Carolina Geological Survey Open-file Report 2016-05, scale 1:50,000, in color.
Bradley, P.J., Hanna, H.D. and Peach, B.T., 2017a, Geologic map of Chatham County portion of the Crutchfield Crossroads 7.5-Minute Quadrangle, Chatham and Alamance counties, North Carolina: North Carolina Geological Survey Open-file Report 2017-10, scale 1:24,000, in color (Supersedes Open-file Report 2016-09).
Bradley, P.J., Peach, B.T. and Hanna, H.D 2017b, Geologic map of the Siler City 7.5-Minute Quadrangle, Chatham County, North Carolina: North Carolina Geological Survey Open-file Report 2017-07, scale 1:24,000, in color (Supersedes Open-file Report 2016-08).
Broadhurst, S.D., and Councill, R.J., 1953, A preliminary report on high alumina minerals in the Volcanic-Slate series, North Carolina: North Carolina Department of Conservation Development, Division of Mineral Resources, Information Circular 10, 22 p.
Burt, E.R., Carpenter, P.A., III, McDaniel, R.D., and Wilson, W.F., 1978, Diabase Dikes of the Eastern Piedmont of North Carolina: North Carolina Geological Survey Information Circular 23, 12 p. text plus map compilation.
Cardozo, N., and Allmendinger, R. W., 2013, Spherical projections with OSXStereonet: 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, Kyanite, sillimanite, and andalusite deposits of the Southeastern States: U.S. Geological Survey Professional Paper 336, 121 p.
Fisher, R.V., and Schmincke H.-U., 1984, Pyroclastic rocks, Berlin, West Germany, Springer-Verlag, 472 p.
Glover, L., and Sinha, A., 1973, The Virgilina deformation, a late Precambrian to Early Cambrian (?) orogenic event in the central Piedmont of Virginia and North Carolina, American Journal of Science, Cooper v. 273-A, pp. 234-251.
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, L., 1985, The Virgilina deformation: implications of stratigraphic correlation in the Carolina slate belt, Carolina Geological Society field trip guidebook, 36 p.
Harris, C., and Glover, 1988, The regional extent of the ca. 600 Ma Virgilina 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 northwest quarter of the Bynum quadrangle, Carolina slate belt, North Carolina, unpublished M.S. thesis, University of North Carolina at Chapel Hill, 146 p.
Hibbard, J., and Samson, S., 1995, Orogenesis exotic to the Iapetan cycle in the southern Appalachians, In, Hibbard, J., van Staal, C., Cawood, P. editors, Current Perspectives in the Appalachian– Caledonian Orogen. Geological Association of Canada Special Paper, v. 41, pp. 191–205.
Hibbard, J., Stoddard, E.F., Secor, D., Jr., and Dennis, 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, n. 3/4, p. 299-339.
Hibbard, J. P., van Staal, C. R., Rankin, D. W., and Williams, H., 2006, Lithotectonic map of the Appalachian Orogen, Canada-United States of America, Geological Survey of Canada, Map-2096A. 1:1,500,000-scale.
Hibbard, J.P., Pollock, J.C., and Bradley, P.J., 2013, One arc, two arcs, old arc, new arc: An overview of the Carolina terrane in central North Carolina, Carolina Geological Society field trip guidebook, 265 p.
Hughes, E.H., 1987, The geology and alteration centers of the Snow Camp mine-Major Hill area, central Carolina slate belt, Alamance and Chatham Counties, North Carolina: U.S. Geological Survey Open-File Report 87–180, 29 p.
Le Maitre, R.W., Ed., 2002, Igneous Rocks: A Classification and Glossary of Terms: Recommendations of the International Union of Geological Sciences (IUGS) Subcommission on the Systematics of Igneous Rocks: Cambridge, Cambridge University Press, 252 p.
Pollock, J. C., 2007, The Neoproterozoic-Early Paleozoic tectonic evolution of the peri-Gondwanan margin of the Appalachian orogen: an integrated geochronological, geochemical and isotopic study from North Carolina and Newfoundland. Unpublished PhD dissertation, North Carolina State University, 194 p.
Pollock, J.C., Hibbard, J.P., and Sylvester, P.J., 2010, Depositional and tectonic setting of the Neoproterozoic-early Paleozoic rocks of the Virgilina sequence and Albemarle Group, North Carolina: in Tollo, R.P., Bartholomew, M.J., Hibbard, J.P., and Karabinos, P.M., eds., From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region: Geological Society of America Memoir 206, p. 739-772.
Reinemund, J.A., 1955, Geology of the Deep River coal field, North Carolina: U.S. Geol. Survey Prof. Paper 246, 159 p.
Samson, S.D., Secor, D.T, and Hamilton, M.A., 2001, Wandering Carolina: Tracking exotic terranes with detrital Zircons, GSA Abstracts with Programs Vol. 33, No. 6, p. A-263.
Schmidt, R.G., Gumiel, P., and Payas, A., 2006, Geology and mineral deposits of the Snow Camp-Saxapahaw area, Central North Carolina: United States Geological Survey Open-file Report 2006-1259 (http://pubs.usgs.gov/of/2006/1259/index.html).
Stuckey, J.L., 1967, Pyrophyllite deposits in North Carolina: North Carolina Division of Mineral Resources Bulletin 80, 38 p.
Tadlock, K.A., and Loewy, S.L., 2006, Isotopic characterization of the Farrington pluton: constraining the Virgilina orogeny, in Bradley, P.J., and Clark, T.W., editors, The Geology of the Chapel Hill, Hillsborough and Efland 7.5-minute Quadrangles, Orange and Durham Counties, Carolina Terrane, North Carolina, Carolina Geological Society Field Trip Guidebook for the 2006 annual meeting, pp. 17-21.
Wortman, G.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.

Equal-Area Schmidt Net Projections and Rose Diagram

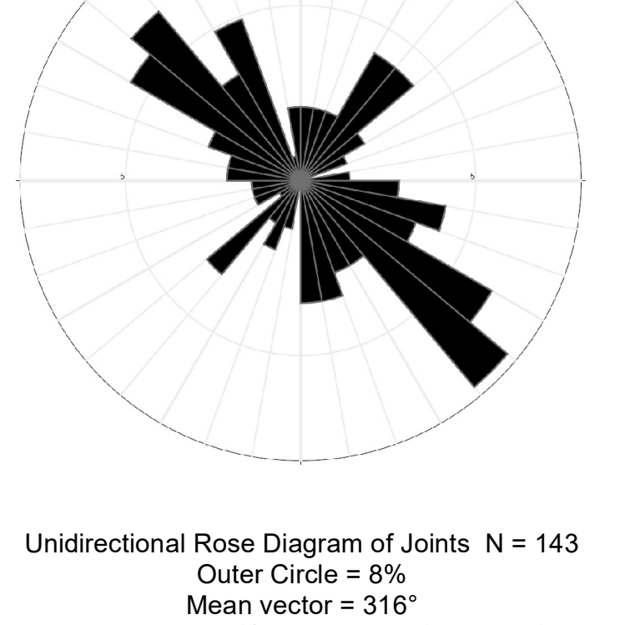
Plots and calculations created using Stereonet v. 8.6.0 based on Allmendinger et al. (2013) and Cardozo and Allmendinger (2013).



Equal Area Schmidt Net Projection of Contoured Poles to Primary Bedding, Layering, and Welding Compaction/Foliation
Contour Interval = 2 sigma N = 25



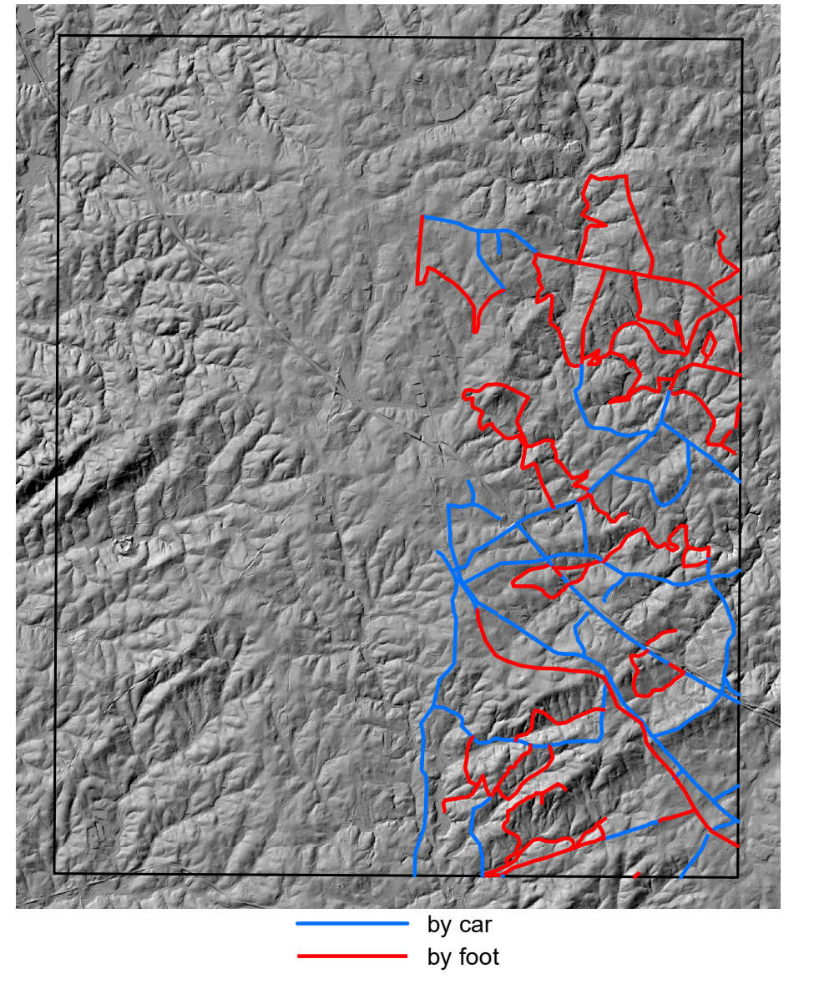
Equal Area Schmidt Net Projection of Contoured Poles to Foliation and Cleavage
Contour Interval = 2 sigma N =197



Unidirectional Rose Diagram of Joints N = 143
Outer Circle = 8%
Mean vector = 316°
Max value = 14% between 131° and 140°

TRAVERSE MAP

Hillshade derived from a 20 foot LiDAR digital elevation model. Red and blue lines show paths of field traverses.



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.

Acknowledgements: Field assistance in January through March 2016 provided by Randy Bechtel and members of the Energy Group - Oil and Gas Program: Ann Shields, Ryan Channell, Katherine Marciniak, and Walt T. Haven.