North Carolina Department of Environmental Quality
Division of Energy, Mineral and Land Resources
S. Daniel Smith, Director
Kenneth B. Taylor, State Geologist

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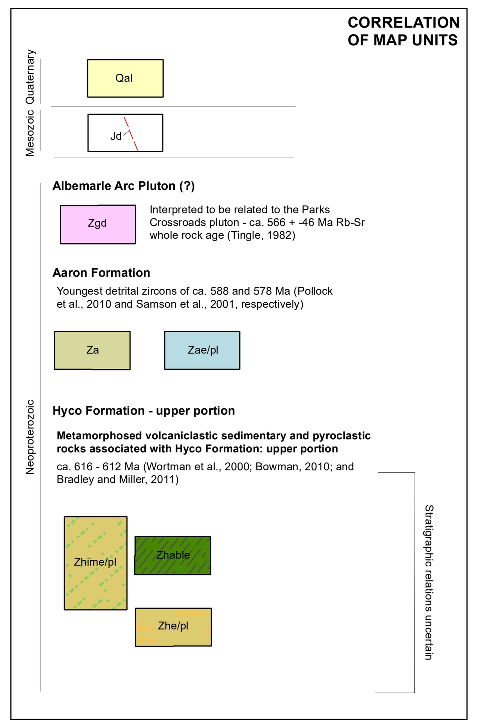
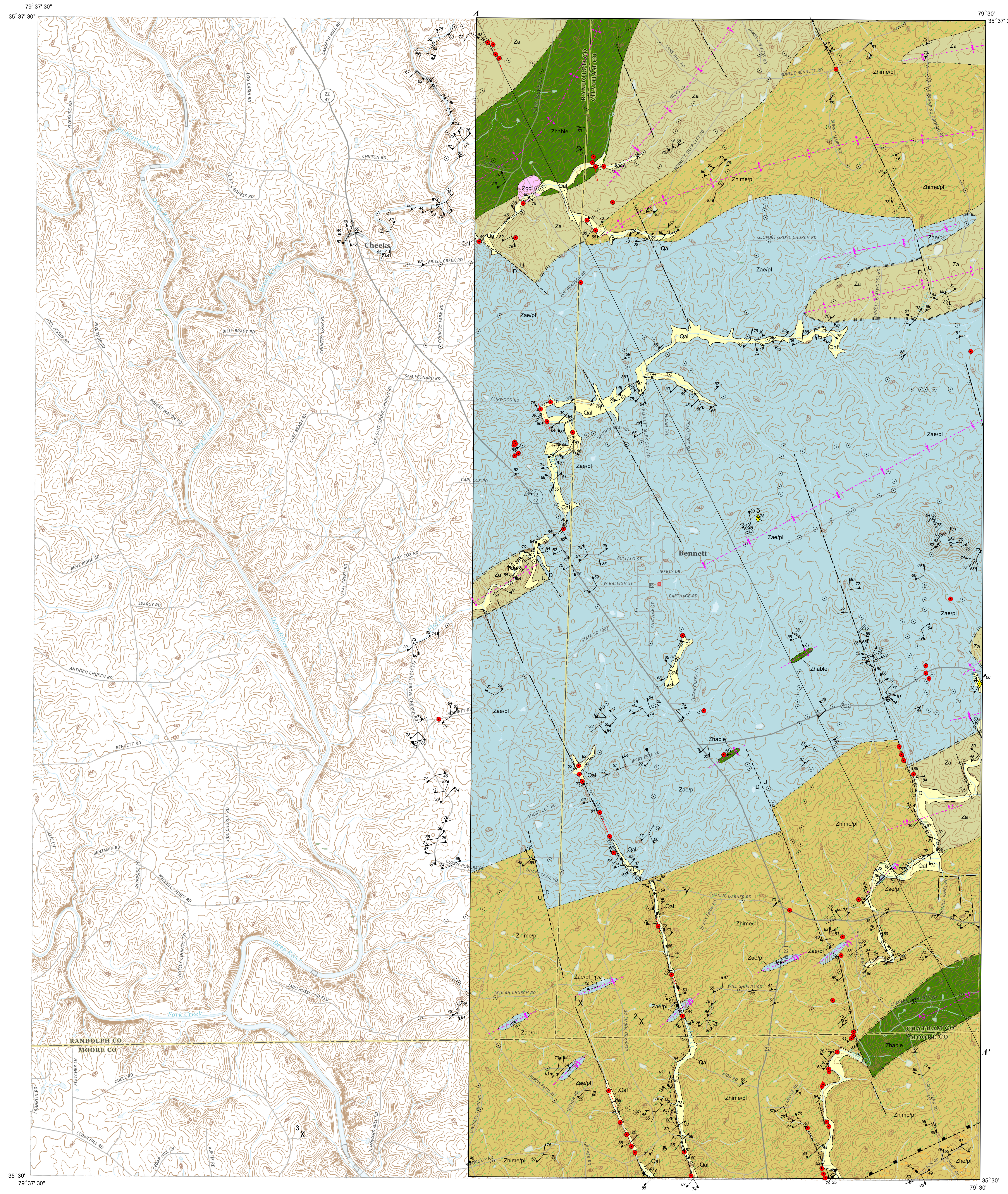
North Carolina Geological Survey
Open File Report 2019-05





INTRODUCTION

The Bennett 7.5-minute Quadrangle lies in the east central portion of the North Carolina Piedmont. The Randolph – Chatham County line crosses the quadrangle from north to south and intersects with the Moore County line (trending east-west) in the southern portion of the quadrangle. The unincorporated community of Bennett is present in Chatham County near the center of the quadrangle. The quadrangle is bisected diagonally by State Hwy 22/42. State HWY 902 intersects HWY 22/42 in the southeast of the quadrangle.

The quadrangle drains to the Deep River along drainages that include Richland Creek, Brush Creek, Fork Creek, Flat Creek, Cedar Creek, and Falls Creek. 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 600 feet above sea level east of the community of Bennett near the eastern edge of the quadrangle (the high point is identified by a horizontal control marker named Paul Beck 2 on historical topographic maps), to less than 300 feet along Cedar Creek near the southern edge of the quadrangle.

GEOLOGIC BACKGROUND AND PAST WORK

Pre-Mesozoic crystalline rocks in the Bennett Quadrangle are part of 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. 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. 615 Ma) portions 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). Hibbard et al. (2013) interprets an at least 24 million year unconformity between the Aaron and underlying Hyco Formation.

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 observed ranging from shallowly to steeply dipping and are interpreted to be a result of open to tight folds that are locally overturned.

Preliminary stereogram analyses of data from two map scale synclines in the nearby Coleridge Quadrangle (Bradley et al, 2018), appears to indicate the presence of folds ranging from gentle to open. Subsequent domain analyses of primary bedding and layering in Hyco Formation and Aaron Formation units outside of the two synclines, indicate folds range from tight to open with the majority of the folds within the tight to close range. In general, it appears that the Hyco Formation and older portions of the Aaron Formation are more tightly folded compared to the Aaron Formation in the identified synclines in the Coleridge Quadrangle. This apparent range from gentle to tight folds is not well understood and may indicate: 1) normal disharmonic folding due to competency differences between units or 2) indicate that the younger units within the synclines in Coleridge are more appropriately assigned to the Albemarle Arc lithologies and were deposited above an angular unconformity. More investigation is needed.

MINERAL RESOURCES

There are no active mining activities currently in the quadrangle. The quadrangle has 2 identified historic mineral prospects for copper: the Cassana Kidd Prospect and the W.H. Purvis Prospect (Carpenter, 1976). Both prospects consist of one pit each, opened in iron stained quartz in association with felsic to intermediate tuffs (Carpenter, 1976).

The Deep River gold-copper-molybdenum prospect is located in the southwest portion of the quadrangle. Exploration activities have been carried out at the Deep River prospect from 1989 intermittently to 2008. Exploration activities identified significant gold mineralization with associated molybdenum and copper enrichment (Rapprecht, 2010).

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.

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 east 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. Quaternary aged alluvium is present in most major drainages.

A preliminary review of the area geology is provided in Bradley (2013). Unit descriptions common to Bradley et al. (2017), Bradley et al. (2018) and Peach et al. (2018) from the Siler City, Coleridge and Bear Creek 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 spheroidally weathered boulders with a grayish-brown weathering rind. Red station location indicates outcrop or boulders of diabase.

Zgd — **Zgd – Granodiorite:** (CI=5) Leucocratic, fine- to medium- grained, equigranular metamorphosed, granodiorite. Mineral assemblage includes quartz, plagioclase, and green hornblende +/- chlorite, +/- epidote. Likely correlative to the Parks Crossroads pluton of Tingle (1982).

Metavolcanic and Metavolcaniclastic Units

Aaron Formation

Zae/pl — **Zae/pl – Aaron Formation (Virgilina member) mixed epiclastics, pyroclastics and lavas of the Devils Tramping Ground area:** Grayish-green to greenish-gray, metamorphosed tuffaceous sandstones, conglomeratic sandstones, siltstones and minor phyllite. The siltstones typically are weakly phyllitic. Contains lesser amounts of fine- to coarse tuff, welded tuff and dacitic lavas. Fiamme-like shaped clasts are common in the conglomerates, sandstones and tuffs. Quartz and feldspar crystal fragments are common in the sedimentary components, tuffs and lavas. Silicified and/or sericitized altered rock and quartz with adularia are locally present. Unit is interpreted to be in gradational contact with unit Za. Contact with unit Za designated at first occurrence of sandstones with angular clasts or primary volcanic rocks.

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 northwest of the map area. Harris (1984) interpreted the Aaron Formation to have been deposited by turbidity currents in a retrogradational submarine fan setting.

Hyco Formation – Upper Portion

Zhime/pl — **Zhime/pl - Mixed intermediate to mafic epiclastic-pyroclastic rocks with interlayered intermediate to mafic lavas:** Grayish-green to green, 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. Locally contain interbedded intermediate to mafic lavas identical to Zhable. Contains lesser amounts of fine- to coarse tuff and lapilli tuff with a cryptocrystalline-like groundmass. Pyroclastics, lavas, and epiclastics are mainly intermediate to mafic in composition. Minor dacitic lavas and tuffs present. Silicified and/or sericitized altered rock are locally present. Conglomerates and conglomeratic sandstones typically contain subrounded to angular clasts of andesite and basalt in a clastic matrix. Generally interpreted to have been deposited proximal to active intermediate to mafic composition volcanic centers and/or record the erosion of proximal intermediate to mafic composition volcanic centers after cessation of active volcanism.

Zhable — **Zhable – Andesitic to basaltic lavas with interlayered epiclastic rocks:** Light green, gray-green, gray, and dark gray; 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. Contains lesser amounts of grayish-green, light green, and light gray to white; metamorphosed conglomerate, conglomeratic sandstone, sandstone, siltstone and mudstone.

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. Locally contain interbedded dacitic lavas identical to Zhdlt unit (not present in quadrangle). 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. Minor andesitic to basaltic lavas and tuffs present. Silicified and/or sericitized altered rock are locally present. 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.

EXPLANATION OF MAP SYMBOLS

CONTACTS, FAULTS, AND OTHER FEATURES

- inferred contact
- concealed contact
- gradational contact
- inferred brittle fault
- concealed brittle fault
- high-angle reverse fault - rectangles on upthrown block
- quaternary alluvium contact
- inferred diabase dike, 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; dotted where concealed
- interpreted fold hinge of overturned anticline
- interpreted fold hinge of overturned syncline

A — A' cross section

IN CROSS SECTION

- inferred contact
- inferred gradational contact
- fold form line
- inferred fold axis
- inferred diabase dike
- inferred brittle fault
- linear geomorphic feature interpreted from hillshade LiDAR - origin uncertain

PLANAR AND LINEAR FEATURES

- strike and dip of primary bedding and/or layering
- strike and dip of primary bedding and/or layering (multiple observations at one location)
- strike and dip of primary volcanic compaction and/or welding foliation
- strike and dip of inclined regional foliation
- strike and dip of inclined regional foliation (multiple observations at one location)
- strike and dip of cataclastic foliation
- strike and dip of cleavage
- strike and dip of cleavage (multiple observations at one location)
- strike and dip of inclined joint surface
- strike of vertical joint surface
- strike and dip of inclined joint surface (multiple observations at one location)
- strike of vertical joint surface (multiple observations at one location)
- trend and plunge of clast lineation

PROSPECTS AND QUARRIES

X prospect (pit or small open cut)

prospect - abandoned
1 Cassana Kidd Prospect – copper (USGS, MRDS; Carpenter, 1976); approximate location; not confirmed by NCGS
2 W.H. Purvis Prospect – copper (USGS, MRDS; Carpenter, 1976); approximate location; not confirmed by NCGS

prospect
3 Deep River Gold Prospect – gold, copper and molybdenum (Rapprecht, 2010)

U-Pb age date location
4 U-Pb age date location - Bennett station 710 (BT-710) (analysis pending)
5 U-Pb age date location - Bennett station 162 (BT-162) (analysis pending)

OTHER FEATURES

- diabase station location
- observation station location

REFERENCES:

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

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., Peach, B.T. and Hanna, H.D 2017, 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).

Bradley, P.J, Peach, B.T. and Hanna, H.D., 2018, Geologic map of the Chatham County portion of the Coleridge 7.5-minute Quadrangle, Chatham and Randolph Counties, North Carolina: North Carolina Geological Survey Open-file Report 2018-03, scale 1:24,000, in color. (Supersedes Open-file Report 2016-11).

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.

Carpenter, P. Albert III., 1976 (reprinted 1993), Metallic mineral deposits of the Carolina Slate Belt, North Carolina Geological Survey, Bulletin 84, 89p.

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.

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.

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.

Peach, B.T and Bradley, P.J., 2018, Geologic map of the northern half of the Bear Creek 7.5-Minute Quadrangle, Chatham and Moore counties, North Carolina: North Carolina Geological Survey Open-file Report 2018-08, scale 1:24,000, in color.

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.

Rapprecht, R.M., 2010, A study of Late–Proterozoic host rocks, the style of mineralization and alteration and their timing at the Deep River Gold Prospect, central North Carolina, unpublished masters thesis, University of North Carolina, Chapel Hill, North Carolina, 117 p.

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.

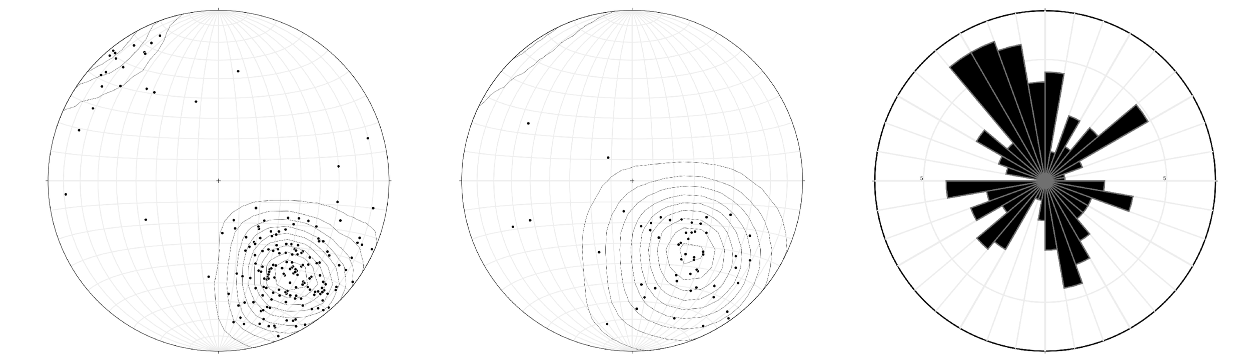
Tadlock, K.A., and Loewy, S.L., 2006, Isotopic characterization of the Farrington pluton: constraining the Virgilina orogeny, in Bradley, P.J., and Clark, T.W., editors, The Geology of the Chapel Hill, Hillsborough and Efland 7.5-minute Quadrangles, Orange and Durham Counties, Carolina Terrane, North Carolina, Carolina Geological Society Field Trip Guidebook for the 2006 annual meeting, pp. 17-21.

Tingle, T.N., 1982, Geology and geochronology of the Parks Crossroads granodiorite near Siler City, central North Carolina Piedmont. Southeastern Geology, vol. 23, p. 117- 122.

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. 10.2.9 based on Allmendinger et al. (2013) and Cardozo and Allmendinger (2013).



Equal Area Schmidt Net Projection of Contoured Poles to Foliation and Cleavage
Contour Interval =3 sigma; N=193

Equal Area Schmidt Net Projection of Contoured Poles to Primary Bedding, Layering and Welding/Compaction Foliation
Contour Interval =2 sigma; N=53

Unidirectional Rose Diagram of Joints N=246
Outer Circle = 7%
Mean vector = 338.8° ± 23.0°

Produced by the United States Geological Survey
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

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Bennett Base Map Information:
Base map is from USGS 2016 GeoPDF of the Bennett 7.5-minute quadrangle. Air photo, map collar and select features removed by the North Carolina Geological Survey for use with map.

UTM GRID AND 2016 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

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 0.6.19

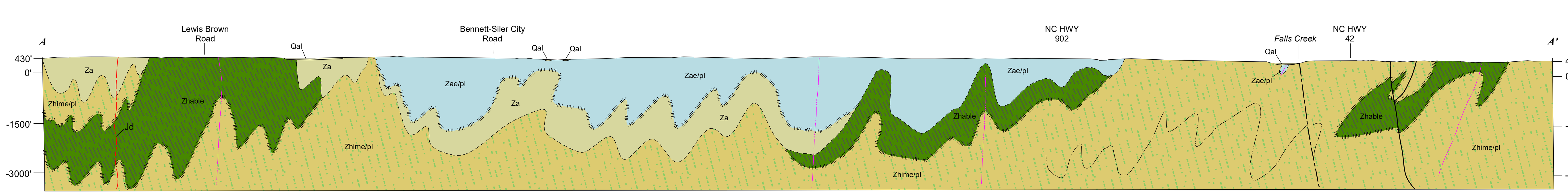
ROAD CLASSIFICATION
Expressway — Local Connector
Secondary Hwy — Local Road
Ramp — 4WD
Interstate Route — US Route — State Route

QUADRANGLE LOCATION

1 Ramseur
2 Coleridge
3 Siler City
4 Erect
5 Bear Creek
6 Eves
7 Robbins
8 Putnam

ADJOINING QUADRANGLES

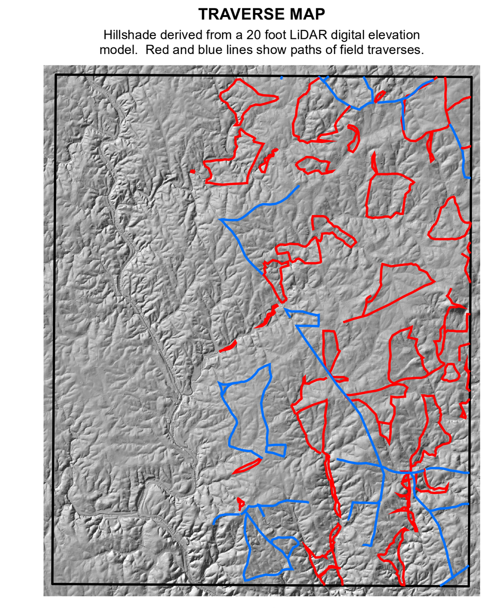
BENNETT, NC
2016



cross section scale - 1:24000 no vertical exaggeration

TRAVERSE MAP

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



This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program under StateMap award number G18AC00205, 2018.

Geologic Map of the Chatham County portion of the Bennett 7.5-Minute Quadrangle, Chatham, Randolph and Moore Counties, North Carolina

By
Philip J. Bradley, Aaron K. Rice and Brandon T. Peach

Geologic data collected in May 2018 through May 2019.

Map preparation, digital cartography and editing by
Michael A. Medina, Philip J. Bradley and Aaron K. Rice

2019