North Carolina Department of Environmental Quality
Division of Energy, Mineral and Land Resources
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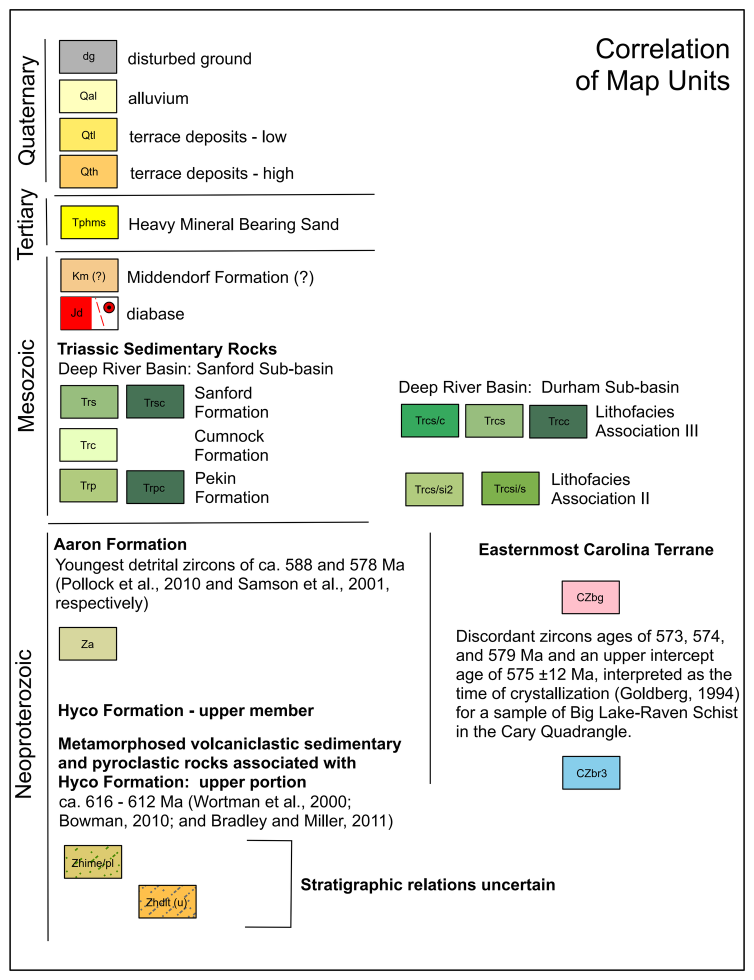
North Carolina Geological Survey
Open File Report 2021-01

Correlation of Map Units



INTRODUCTION

The Moncure 7.5-minute Quadrangle lies in the east central-portion of the North Carolina Piedmont. In Chatham County, the unincorporated communities of Moncure, Haywood and Brickhaven are present within the quadrangle. In Lee County, the unincorporated communities Blacknel and Osgood are present. The local transportation corridor US HWY 1 cuts across the northwest portion of the quadrangle. NC HWY 42 cuts diagonally across the map in the southeast portion of the quadrangle.

The Cape Fear River controls the drainage in the quadrangle. The Deep and Haw Rivers join to form the Cape Fear River in the northern portion of the quadrangle. The smaller tributaries of Shaddox Creek, Gulf Creek, Wombles Creek, Little Shaddox Creek, Lick and Bush Creek flow directly to the Cape Fear. Natural exposures of crystalline and Triassic rocks, as well as younger Quaternary sediments, primarily occur along these named and unnamed creeks. Rock exposure at road cuts, ridges, resistant finned-shaped outcrops and pavement outcrops locally occur outside of drainages. The elevations in the map area range from approximately 470 feet above sea level near the south-central edge of the quadrangle where Coastal Plain sediments cap metamorphic and Triassic-aged rock units, to approximately 160 feet in the Cape Fear River channel on the east-central edge of the quadrangle.

Geologic Background

In the northwestern corner of the Moncure Quadrangle, the crystalline rocks are part of the redefined Hyco Arc and Aaron Formation (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 tentatively 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.

The southeastern corner of the quadrangle is underlain by metamorphosed crystalline rocks of the Cary sequence (Parker, 1979; Farrar, 1985). The Cary sequence is interpreted to be part of the Carolina terrane but separated from the rest of the terrane by the Triassic basin (Hibbard et al., 2002). For this map, related rocks are identified as being part of the Easternmost Carolina terrane. One of the main rock units is the Big Lake-Raven Rock schist. In the Cary Quadrangle, a sample from the unit yielded,

discordant 207Pb/206Pb zircons ages of 573, 574, and 579 Ma and an upper intercept age of 575 ±12 Ma, interpreted as the time of crystallization (Goldberg, 1994). This is a similar age to the Aaron Formation.

The central portion of the quadrangle is underlain by Triassic-aged sedimentary rocks of the Deep River Mesozoic basin which is separated into three sub-basins (Durham, Sanford and Wadesboro). The Colon cross structure (Campbell and Kimball, 1923 and Reinemund, 1955), partially located within the quadrangle, is a constriction zone in the basin characterized by crystalline rocks overprinted by complex brittle faulting. The Colon cross-structure marks the transition between the Durham and Sanford sub-basins. The Colon Quadrangle contains the Triassic-aged units from oldest to youngest of the Pekin, Cumnock and Sanford Formations of the Sanford sub-basin. Detailed descriptions of the Triassic sediments are provided in Reinemund (1955). A detailed comparison of the Durham and Sanford sub-basins is provided in Clark et al. (2001). Dikes of Jurassic aged diabase intrude the Triassic sediments and crystalline rocks of the map area. Coastal Plain sediments are present in the southern portion of the quadrangle. Quaternary aged alluvium is present in most modern river valleys, with at least two levels of fluvial terraces along the major drainages. These terraces, where preserved, mark the location and elevation of ancestral river systems, prior to incision to the modern floodplain levels.

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.

Faults

Abundant evidence of brittle faulting at the outcrop-scale, map-scale and large-scale lineaments (as interpreted from hillshade LiDAR data) are present in the area. The quadrangle includes the eastern portion of the Colon cross-structure that marks the transition between the Durham and Sanford sub-basins. The brittle faulting and lineaments are interpreted to be associated with Mesozoic extension.

A fault bounded block with in the Carolina terrane (in the northwest corner of the Moncure Quadrangle and southwest corner of the Merry Oaks Quadrangle) has been identified with rotated metamorphic foliations up to 70 degrees clockwise. This rotation is speculated to be related to rotation of a breeched relay ramp.

Past Work

Reinemund (1955), is an important work, that has laid the foundation for the geology with in the Triassic basin. For this mapping effort, Reinemund's maps were georeferenced to a digital elevation model from Hillshade LiDAR. Geologic contacts within the Triassic basin were digitized and modified, if needed. Most of the geology south of the Cape Fear River within the Triassic basin was digitized as presented by Reinemund.

The northeast corner of the Moncure Quadrangle is situated in the transition between the Durham and Sanford sub-basins. In the Sanford sub-basin, a three-layer stratigraphy has been identified and formalized from oldest to youngest as the Pekin, Cumnock and Sanford Formations (Campbell and Kimball, 1923 and Reinemund, 1955). In the Durham sub-basin, this three-layer system is not recognized. Previous mapping by North Carolina Geological Survey staff separated the Durham sub-basin into lithofacies associations using the nomenclature of Smoot et al. (1988). Hoffman and Gallaghar (1989) began using the lithofacies association nomenclature and it was subsequently adopted for all mapping in the Durham sub-basin. The formation mapping of Reinemund (1955) in the Sanford sub-basin and the lithofacies association mapping in the Durham sub-basin are incompatible (Clark et al., 2001). These two methods of mapping meet in the Moncure and Merry Oaks Quadrangles. The detailed investigation of the contrasting mapping methods and establishment of a unified stratigraphic nomenclature for the Sanford and Durham sub-basins is out of the scope of this mapping project. As such, the map units from the adjacent Cokesbury Quadrangle (Butler et al., 2016) were extended into Moncure to mark the change of unit nomenclature from the Sanford sub-basin to the Durham sub-basin. Additional work is needed to establish a new stratigraphic nomenclature for the entire Deep River basin.

Heckert et. al (2012) presented the results of a microroinvertebrate fossil analysis of Triassic sediments from a clay pit within the quadrangle. The sediments are interpreted to belong to the Cumnock Formation and extend the eastward extent of the Cumnock Formation map unit compared to that of Reinemund (1955).

Monitoring well boring location data from the Comprehensive Site Assessment Report for the Duke Energy Cape Fear Steam Electric Plant (SynTerra, 2015) is included on the map. Boring data includes bedrock rock type and thickness of surficial material.

Mineral Resources

Clay Products and Crushed Stone

The red claystones of the Pekin and Sanford Formations continue to supply area brick manufactures raw material. In the 1950's, it was reported that multiple brick and tile producers were active in the nearby area (Reinemund, 1955). It has been and continues to be an important location for clay products. Six abandoned and one active clay pits are present in the map and are identified. One active crushed stone quarry is in operation in the northwest corner of the quadrangle.

Coal Deposits

Coal has been mined within the region since before the Revolutionary War – ca. 1750's. Reinemund (1955) estimates the total production in the Deep River Coal Field exceeded 1 million tons. The majority of the production was from two mines with extensive underground workings in the adjacent Colon Quadrangle. Reinemund (1955) identified a limited coal outcrop area and two former coal pits north of the community of Brickhaven within the Moncure quadrangle. Reinemund (1955) provides an extensive review of the coal deposits and geology of the Deep River Coal Field.

Oil and Gas Potential

Natural gas exploration well NCCM-2 was drilled east of the coal outcrop area in 1981 by North American Exploration to a depth of 250 feet. Several other natural gas exploration wells have been drilled in the nearby Goldston Quadrangle. A summary of the natural gas potential of the Sanford sub-basin is provided in Reid et al. (2011). A compilation map showing seismic lines, drill holes and hydrocarbon shows is provided in Reid et al. (2010). An overview of the Triassic rift / lacustrine basins, their hydrocarbon potential in North Carolina, a regulatory framework overview and data access information can be found in Reid et al. (2018).

Quaternary Deposits

Quaternary deposits in the Moncure Quadrangle were previously mapped by Reinemund (1955), along with bedrock mapping; however, the mapping was conducted prior to 1:24,000 topographic map availability. The Quaternary mapping for this project utilized digital county soil survey parent material maps (Soil Survey Staff, 2019), high resolution LiDAR surface topography, data from Reinemund (1955), and new field observations (outcrops and hand augers). The Quaternary fluvial sediments were divided into 3 map units (modern floodplain and two terrace levels). Three terrace levels had been mapped by Reinemund (1955); however, Reinemund's lowest terrace level occurs in large part on the modern floodplain, based on LiDAR and soil survey mapping. Due to practical considerations and mappability at the 1:24,000 scale, we chose to map only two terrace levels (Qth and Qtl), similar in concept to mapping in ...

... deposits themselves are in part reworked from weathered Triassic bedrock. Thus, differentiation of these materials can be difficult within the soil profile, but may be based on the sharpness of the contact, the presence of a basal gravel lag, or an unconformity.

The low terrace deposits (Qtl) contain younger Cape Fear River Basin fluvial deposits, with terrace elevations ranging from 210 feet to 170 feet asl, typically about 10 to 30 feet above the local modern floodplain. The age of deposits within the low terrace unit are speculatively late Pleistocene to early Holocene based on the terrace height above the modern floodplain (Mills, 2000; Suther et al., 2011).

Deposits of the low terrace are generally fine-grained and can be more than 15 feet thick. About 6 feet of low terrace deposits overlie more altered Qth fluvial deposits at a railroad cut east of Corinth Road and south of Brickhaven. At least 20 feet of fine-grained (silty clay, silt and fine sand) deposits occur underneath the low terrace east of the Haw River, near a slight bend in Corinth Road where Reichhold Chemical Superfund site (NC DEQ Site ID NCD049845548) was located.

Alluvial deposits on the modern (Holocene) floodplain (Qal) consist mainly of silt loam to silty clay loam in modern river valleys within in the Triassic Basin. Fine to medium sand occurs in points bars and river channels, along smaller creeks in crystalline terrain (where it can be gravelly) and likely at depth from reworking of Pleistocene and older sediments. Along the Deep-Haw-Cape Fear River valleys, the modern floodplain ranges in elevation from about 190 feet asl (Deep River valley) to 160 feet asl (Cape Fear River valley on eastern edge of quadrangle). This map unit likely also includes very low terraces which are blanketed by modern overbank flood deposits from times of high water levels.

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. Dikes of Jurassic-aged diabase intrude the crystalline rocks and Triassic sediments of the map area. Triassic-aged sediments and Jurassic diabase dikes are not metamorphosed. Quaternary aged alluvium is present in most major drainages.

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).

Crystalline rock unit descriptions common to Bradley et al. (2020) from the Colon geologic map, 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

dg - Disturbed ground: consists of fill in highway embankments, railway embankments, industrial areas and mine spoil piles, as well as areas of removed earth in mined-out-areas (clay pits) and coal ash ponds.

Qal - Modern (Holocene) floodplain deposits: silt loam to silty clay loam, with fine to medium sand deposits in point bars and channels deposits; smaller tributaries in the Carolina terrane can have more sandy or gravelly alluvium; brown to reddish brown to grayish brown; soft; crudely stratified; observed at least 9 feet thick, but maximum thickness unknown. Includes very low terraces that are periodically inundated by modern floods. Contains weak to moderately developed soil profiles. Structural measurements depicted on the map within Qal represent outcrops of crystalline rock inliers surrounded by alluvium.

Qtl – Quaternary low terrace deposits: silt loam to silty clay loam to loamy fine sand; generally does not contain gravel, but may contain a thin lag of gravel near unit base; yellowish brown to brown to light gray; in some areas is difficult to differentiate from high levels of modern floodplain; ranges from 2 feet to more than 20 feet thick

Qth – Quaternary high terrace deposits: sandy clay loam to gravelly loamy sand to gravelly sand; yellowish brown to reddish brown; gravel consists primarily of white, rounded to subrounded quartz pebbles, with rare cobbles; the fluvial depositional sequence generally fines upwards, with gravelly zones typically revealed along eroding slopes; total thickness of map unit is typically 2 to 10 feet; may consist of a lag deposit in strath terraces over a red, silty clay to clay residuum developed into fine-grained Triassic bedrock. Mapped areas may include multiple, undifferentiated high terrace levels. Contains E and Bt horizons of an Ultisol soil profile, with significant alteration extending several feet into the unit. May exhibit crude stratification or cross bedding at depth. [this unit is similar in concept to Qg3 of Reinemund (1955)]

Coastal Plain Deposits

Tphms – Heavy Mineral Bearing Sand: silty and clayey; reddish brown, tan, and gray; fine- to very- coarse grained; poor to moderately poor sorting; subangular to rounded quartz sand. Locally quartz gravel is present. Contains rare heavy minerals (dominantly a suite with staurolite, dravite and rutile); rare mica; rare rose quartz. Massively bedded, rarely laminated. Near surface mottling usually obscures sedimentary structures. Basal contact is erosional. Unit is of probable Pliocene age. Description modified from the adjacent Cokesbury Quadrangle geologic map (Butler et al., 2016).

Km (?) - Middendorf Formation (?): unconsolidated white sand with brown silt and clay. Locally quartz gravel to small cobbles present. Identified as Tertiary-aged high level surficial deposits by Reinemund (1955) and identified as the Middendorf Formation on the Geologic Map of North Carolina (NCGS, 1985).

Intrusive Unit

Jd – Diabase: Black to greenish-black, fine- to medium-grained, dense, consists primarily of plagioclase, augite and may contain olivine. Locally has gabbroic texture. 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.

Triassic Sediments of the Deep River Basin Chatham Group

Trsc – Conglomerate of the Sanford Formation: mainly conglomerates with fragments of metamorphic rock and quartz embedded in and interbedded with red mudstone, siltstone and sandstone (Reinemund, 1955). Equivalent to Trcc of Lithofacies Association III in the Cokesbury Quadrangle.

Trs – Sanford Formation: mainly red to brown, locally purple, coarse-grained, arkosic sandstones and conglomerates. Subordinate amounts of claystone, siltstone and fine-grained sandstone (Reinemund, 1955).

Trcc - Conglomerate of Lithofacies Association III: reddish-brown to dark brown, irregularly bedded, poorly sorted, cobble to boulder conglomerate. Muscovite is rare to absent in the very coarse-grained to gravelly matrix. An arbitrary cut-off of greater than 50 percent conglomerate distinguishes this unit from the Trcs/c facies. Clasts are chiefly miscellaneous felsic and intermediate metavolcanic rocks, quartz, epidote, bluish- gray quartz crystal tuff, muscovite schist, and rare meta-granitic material. Maximum clast diameters are in excess of 2 m locally. Equivalent to Trsc and included in quadrangle to edge-match with the Cokesbury Quadrangle.

Trcs - Interbedded sandstone and pebbly sandstone of Lithofacies Association III

Trcsic - Sandstone with interbedded conglomerate of Lithofacies Association III

Trc – Cumnock Formation

Trcsi/s - Siltstone with interbedded sandstone of Lithofacies Association II

Trcs/si2 - Sandstone with interbedded siltstone of Lithofacies Association II

Trp – Pekin Formation

Trpc – Conglomerate of the Pekin Formation

Metavolcanic and Metavolcaniclastic Units

Aaron Formation

Za – Aaron Formation

Hyco Formation – Upper Portion

Zhime/pl - Mixed intermediate to mafic epiclastic-pyroclastic rocks with interlayered intermediate to mafic lavas

Zhdlt (u) – Dacitic lavas and tuffs of the upper portion of the Hyco Formation

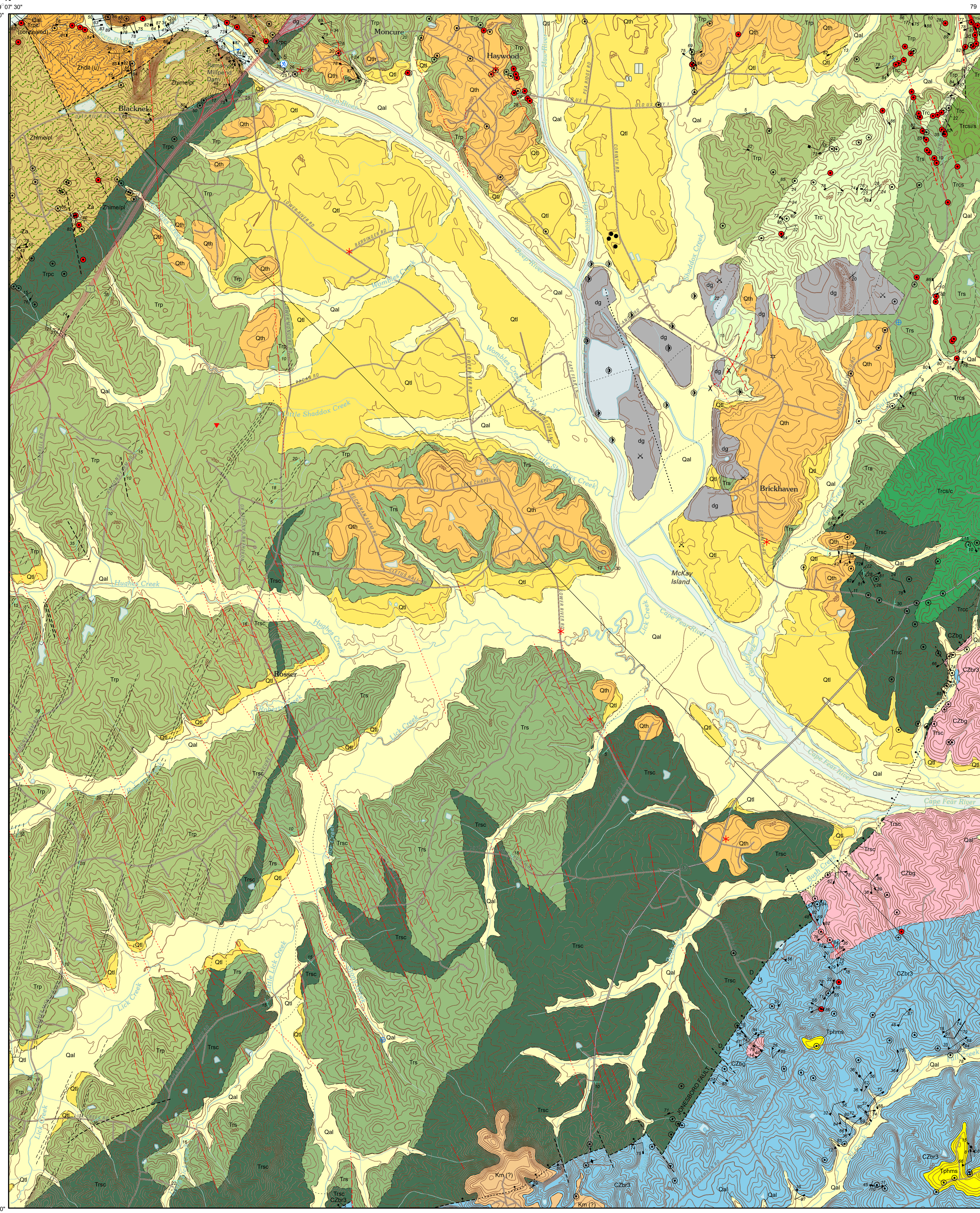
Easternmost Carolina Terrane

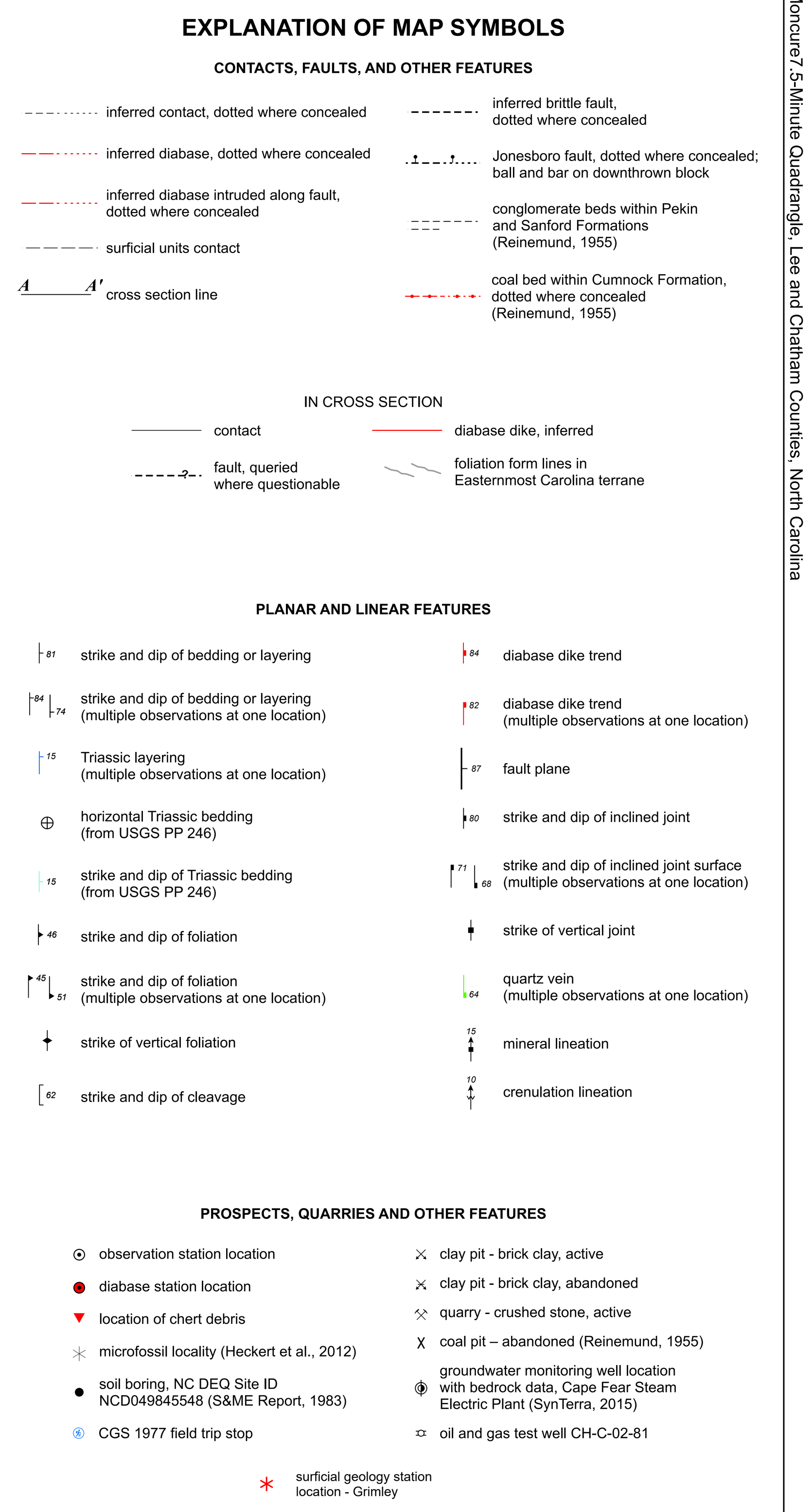
Metaintrusive Units

CZbg - Meta-granitoid rocks of the Buckhorn Dam intrusive suite

Cary Sequence- Cary Metamorphic Suite

CZbr3 – Big Lake-Raven Rock schist 3





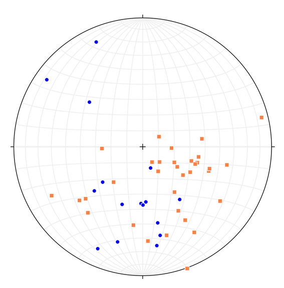
SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

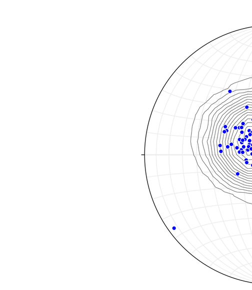
MONCURE, NC

Equal Area Schmidt Net
Projections and Rose Diagram

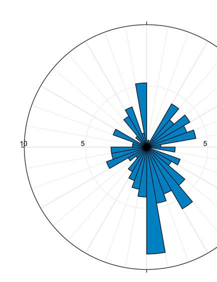
Plots and calculations created using Stereonet v. 10.2.0 based on Allmendinger et al. (2013) and Cardozo and Allmendinger (2013)



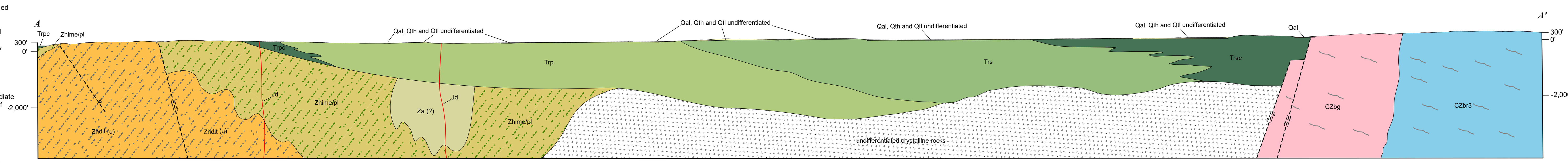
Equal Area Schmidt Net Projection of Contoured Poles to Foliation and Cleavage in Carolina Terrane Rocks (Blue circles), N=16; and Easternmost Carolina Terrane Rocks (Triangle squares), N=34.



Equal Area Schmidt Net Projection of Contoured Poles to Primary Bedding and Layering in Triassic Sediments
Contour Interval =2 sigma; N=96



Unidirectional Rose Diagram
of Joints N=172
Outer Circle = 10%
Mean vector = 354.2°



no vertical exaggeration for bedrock units
Qal and surficial thickness exaggerated to be visible

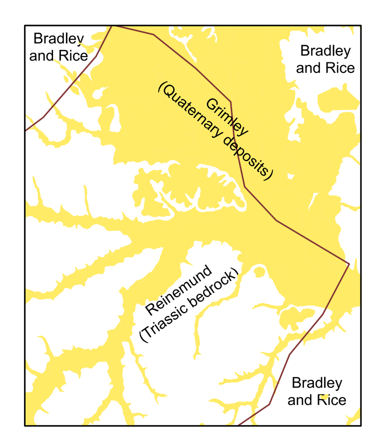
Geologic Map of the Moncure 7.5-Minute Quadrangle, Lee and Chatham Counties, North Carolina

By
Philip J. Bradley, Aaron K. Rice and David A. Grimley

Geologic data collected in June 2020 through May 2021

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

2021



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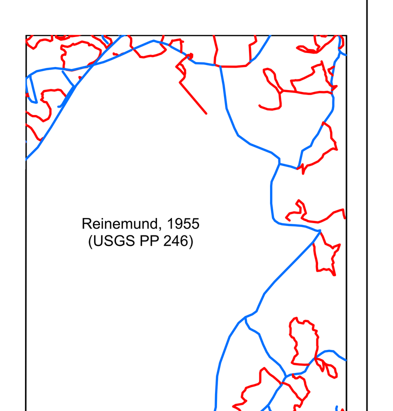

TRAVERSE MAP