ASSOCIATION OF ENVIRONMENTAL & ENGINEERING GEOLOGISTS

- **Carolinas Chapter**

Field Trip Guide

Geological Hike of the White Pines Nature Preserve, Chatham County, NC

Spring Field Trip

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This field trip guide includes a geologic hike along the trail system of White Pines Nature Preserve and an additional stop at an abandoned quarry on the edge of Jordan Lake in Chatham County, NC. The field trip stops are draft versions of stops to be included in the planned 2023 Carolina Geological Society field trip.

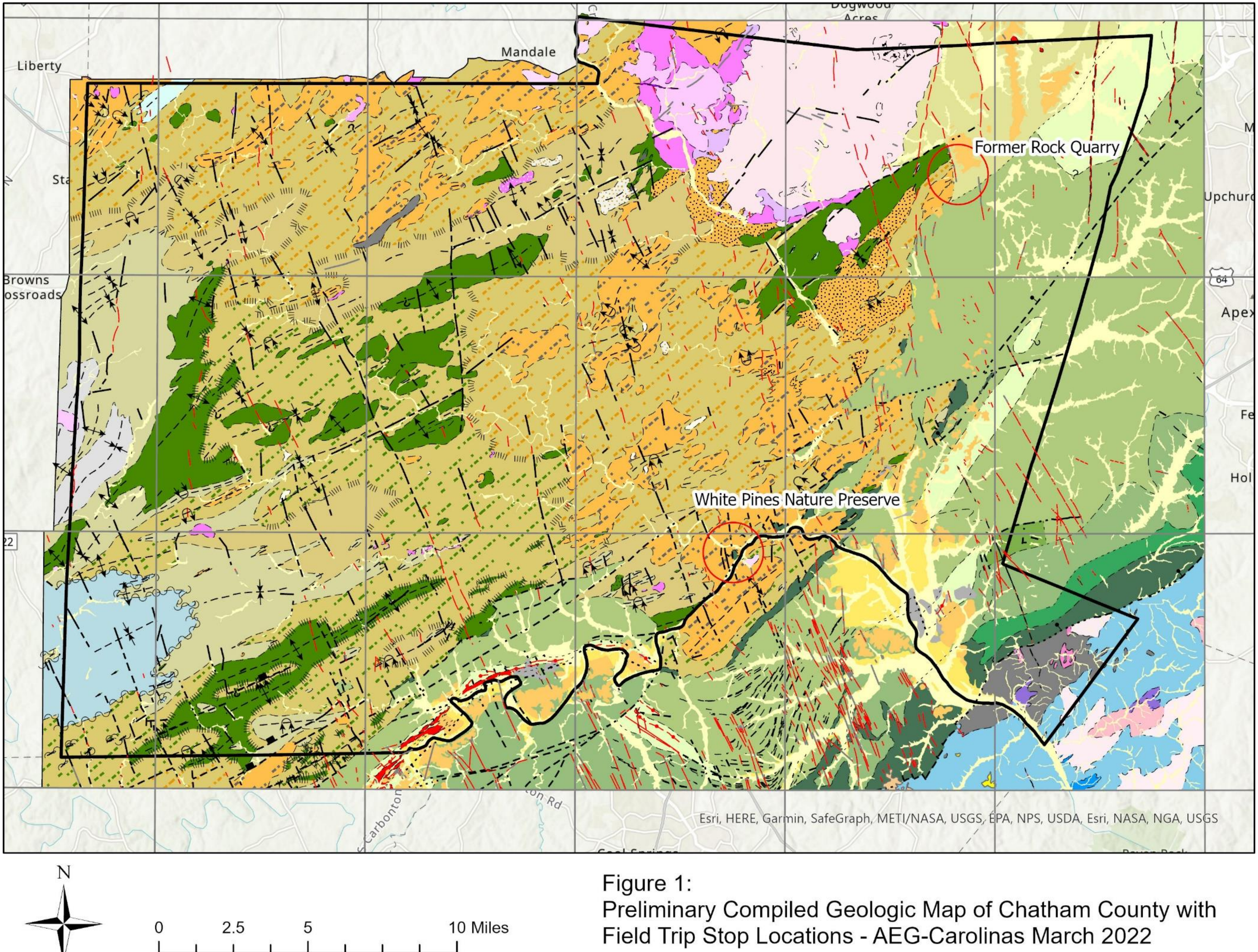


Figure 1:
Preliminary Compiled Geologic Map of Chatham County with Field Trip Stop Locations - AEG-Carolinas March 2022

STOP 1:
GEOLOGIC HIKE OF THE WHITE PINES NATURE PRESERVE – NEWLY DISCOVERED OUTLIER OF TRIASSIC SEDIMENTS WITHIN THE CAROLINA TERRANE. (35.6144°N, --79.1604°W), WHITE PINES NATURE PRESERVE, TRIANGLE LAND CONSERVANCY LAND, ROCKY AND DEEP RIVERS CONFLUENCE, CHATHAM COUNTY, NC.
STOP LEADER: PHIL BRADLEY

Figure 2: From the Colon 7.5' quadrangle with White Pines trail system and points of geologic interest.

Background:

The White Pines Nature Preserve is located at the confluence of the Rocky and Deep Rivers in Chatham County. It is a 275-acre nature preserve owned by the Triangle Land Conservancy. The preserve has a rare stand of White Pine trees that are more common at higher elevations and/or latitudes. The White Pine and Mountain Laurel were common in the Pleistocene in the Piedmont, they remain due to the microclimates of the shady north-facing slopes and cooling effect of the confluence of the Rocky and Deep Rivers. North Carolina Geological Survey detailed geologic mapping in 2019 identified a previously unknown small portion of Triassic sediments surrounded by Carolina terrane rock units (Bradley et al., 2020) in the preserve.

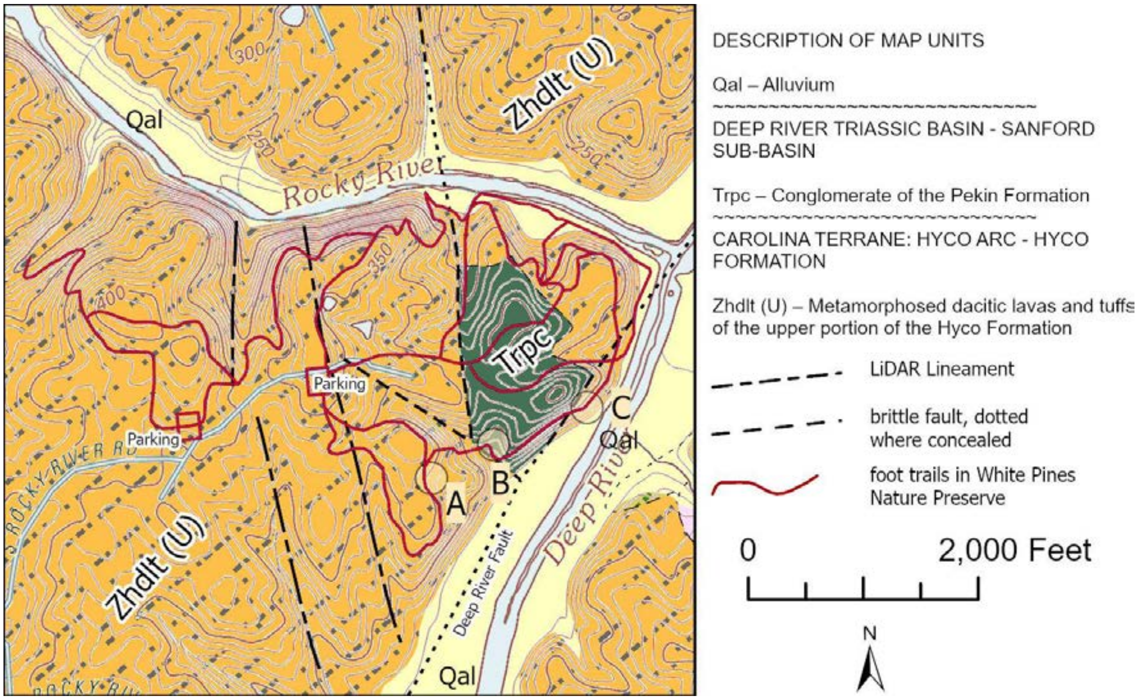


Figure 3: Portion of the Geologic Map of the Colon 7.5' quadrangle with White Pines trail system and geologic points of interest: A, B and C.

Geologic Hike Description:

This stop is an approximate 2 miles round trip hike along trails in the White Pines Nature Preserve. The hike will present results of detailed geologic mapping by the NC Geological Survey in Chatham County (Figure 1) and interpretations of various outcrops and landforms within the Preserve.

The sparse rock debris present in the first part of this hike (from the parking areas to Geologic Point of Interest A – Figures 2 and 3) is an example of typical upland rock debris that is encountered in the Piedmont. Detailed geologic mapping within the Piedmont relies heavily on sparse outcrop and rock debris (as long as interpreted as being representative of the underlying rock) to help determine the type and extent of geologic units in an area. As you walk from the parking area, take notice of sparse cobbles and boulders and tree throws from downed trees (which often contain rock debris). These cobbles, boulders and other rock debris encountered along areas like these provide useful data in the outcrop-poor Piedmont.

Two main rock types are present in the preserve: 1) metamorphosed volcanic rocks of dacitic lavas and tuffs of the Hyco Formation of the Carolina terrane and 2) Triassic sedimentary rocks of the Sanford sub-basin of the Deep River Triassic basin.

The outcrops of the metamorphosed volcanic rocks are not very impressive, but the float has interesting textures of flow banding and auto brecciation in the dacitic lavas and lithic clasts, plagioclase crystal shards and welding and compaction features in the welded tuffs. The outcrop of Triassic sediments are substantial. The steep slopes from relatively recent stream incision are also note-worthy.

Geologic Points of Interest on the Hike:

Point A

Point A is a small boulder pile and outcrop of white weathered rocks. If on a self-guided walk, the location can be easily overlooked (especially when the trees and shrubs have leaves). The boulder pile is most easily found in the winter when vegetation is at its minimum.

Point A: Boulder pile and small outcrop of metamorphosed dacitic tuffs of the Hyco Formation of the Carolina terrane. The boulders display a pronounced light-colored weathered rind typical of felsic volcanic rocks. Lithic clasts and crystals are visible on weathered surfaces. The main rock type is interpreted as a metamorphosed welded lithic crystal tuff. This location is a good example of the primary volcanic features (lithic clasts, fiamme and crystal shards) still visible in the Hyco Formation rocks. The white weathering rind is indicative of the felsic volcanics chemically weathering to kaolinitic clays with resulting clay-rich soils.

Continuing on the trail toward Geologic Point of Interest B, take note of the several tree throws that have weathered rock chips of white weathered felsic volcanic rock – likely felsic tuffs. When you reach a small foot bridge, pause and notice the jointed small outcrop in the creek. A few boulders are also present in and around the outcrop. This outcrop is a metamorphosed dacitic lava with flow banding. The small creek occupies a prominent LiDAR lineament on the Hillshade LiDAR image. Many of these lineaments are occupied by diabase dikes or are brittle faults.

Continue over the small foot bridge, soon you will enter another small drainage with a foot bridge. This location and the slope to the east is Geologic Point of Interest B.

Point B

Walking toward Point B, a brittle fault is crossed separating the ca. 615 Ma Hyco Formation rocks from the ca. 220 Ma Triassic sedimentary rocks. As you walk east along the trail, look closely at the cobble and boulder debris and small outcrops. Multiple examples of quartz pebble-rich Triassic conglomerate and conglomeratic sandstone are present. Continuing along the trail to the east, several large outcrops of the Triassic sediments with sub-horizontal bedding are visible. The Triassic rocks are interpreted to be part of the Pekin Formation of the Sanford sub-basin of the Deep River Basin.

The floodplain of the Deep River occupies the lowland to the immediate east. A major Mesozoic fault (the Deep River fault) is interpreted to occupy the Deep River valley in this location (Figure 3).

Continue along the trail toward Geologic Point of Interest C. Note the steep slopes with the occasional rock ledge of Triassic sediments.

Point C

An outcrop of metamorphosed volcanic rock occurs at Geologic Point of Interest C. This rock is interpreted as a metamorphosed tuff and shows intense fracturing. Triassic rocks are above your head in the hanging wall of the fault with the metamorphosed volcanic rocks in the footwall. Continuing along the trail, an additional outcrop and rock debris of the metamorphosed volcanic rocks are present.

Discussion of the steeply incised Rocky and Deep River valleys

The steeply incised banks of the Rocky and Deep River within the preserve are impressive for the Piedmont but not uncommon. The cliffs at Raven Rock State Park are a well-known example of deeply incised riverbank in the Piedmont. Generally, this incision was thought to have occurred gradually over many million years as the Piedmont slowly uplifted differentially at different times over the multiple millions of years. It is generally understood that the majority of the more recent uplift and subsequent erosion occurred during the later stages of the Miocene epoch approximately 10 to 5 million years ago (Pavich, 1989; and Pazzaglia and Brandon, 1996; Poag and Sevon, 1989). So, very generally, the consensus was that the landscape we see today had been forming over the last 5 million years. In that 5 million year span, erosion has worn away the land, resulting in hills and topographic highs where more resistant rocks occur.

Recent research along the Potomac River at the Maryland-Virginia border (Reusser et al., 2004), the Mississippi River valley (Wickert et al., 2019) and the mid-Atlantic region (Pico et al., 2019) has indicated that some incision may be relatively recent in timing (less than 100,000 years old). The incision of the Potomac River to form 30- to 60-feet (10- to 20-meter) gorges is thought to have occurred ~35,000 years ago based on cosmogenic dating of fluvially eroded bedrock surfaces on a terrace level that has since been abandoned (Reusser et al., 2004). Along the Mississippi River valley, Wickert et al. (2019) documented 2.5 to 0.8 million year old incision of the Mississippi River valley to at least 200 feet (65 meters) at latitude N37^0 (the latitude of White Pines is approximately N35.6^0). The Mississippi River Valley incision is correlated with the deep subsidence under the Laurentide Ice Sheet coupled with induced positive vertical displacement in the immediate periphery of the ice sheet – named the glacial forebulge. According to Pico et al. (2019), the glacial forebulge (or peripheral bulge) on the east coast extended from Pennsylvania and New Jersey (near the ice margin) to the Carolinas, generally decreasing in effect to the south but still significant. Pico et al. (2019) shows that, during the last glaciation, the peripheral bulge of the Laurentide Ice Sheet affected the gradient, drainage basins, and pathways of several rivers in the mid-Atlantic. Taken together, these three studies show that differential glacial isostatic adjustments (including the peripheral forebulge), through their effect on river gradients and stream power, can have significant effects on river incision or aggradation over millennial timescales.

The extent of the induced uplift from the Laurentide Ice Sheet in the southeastern US is poorly understood but may have contributed to periods of incision along particular segments of North Carolina Piedmont rivers, such as the Deep River and Rocky River at White Pines Nature Preserve. David Grimley (Illinois State Geological Survey), in collaboration with the NC Geological Survey, mapped terrace deposits originally identified by Reinemund, (1955) along the Deep, Haw and Cape Fear Rivers in the Colon, Merry Oaks and Moncure Quadrangles (Bradley et al., 2020, Bradley et al., 2021a and Bradley et al., 2021b). The terrace deposits mark deposition on the ancestral floodplains of the rivers, prior to the incision which formed the terrace landforms. Additionally, preliminary results from a numerical model of the Laurentide Ice Sheet isostatic effects, indicates that, theoretically, there could have been up to 8 mm/yr (or 8 m per thousand years) of uplift in the White Pines area during the last glaciation ca. 26,000 years ago (Tamara Pico, personal communication to David Grimley, 2022). Grimley plans to age date material from the higher level terraces to help determine timing of aggradation and incision and test the forebulge hypothesis (Grimley, personal communication, 2022). Other possible factors that may control river erosion and aggradation include climate (especially precipitation) and vegetation cover in the drainage basin (Leigh, 2008).

STOP 2:
DACITIC TUFFS AND ANDESITIC TO BASALTIC ROCKS OF THE HYCO FORMATION, HYCO ARC (35.7984°N, -79.0258°W) ROCK QUARRY PUBLIC FISHING AREA, NORTH CAROLINA WILDLIFE RESOURCES COMMISSION, B. EVERETT JORDAN LAKE, CHATHAM COUNTY, NC.
STOP LEADER: PHIL BRADLEY

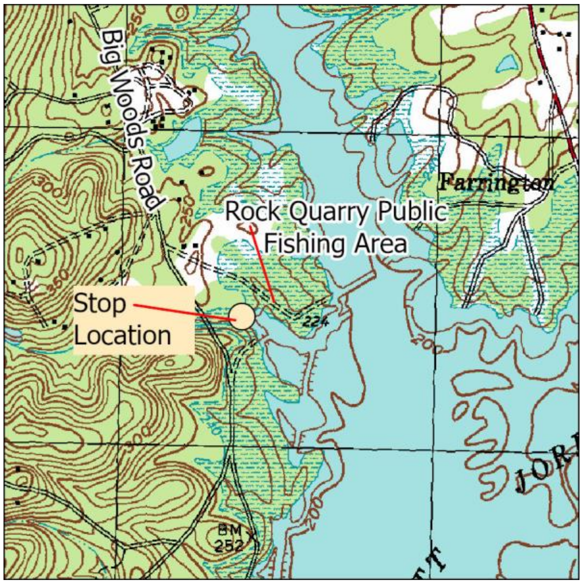
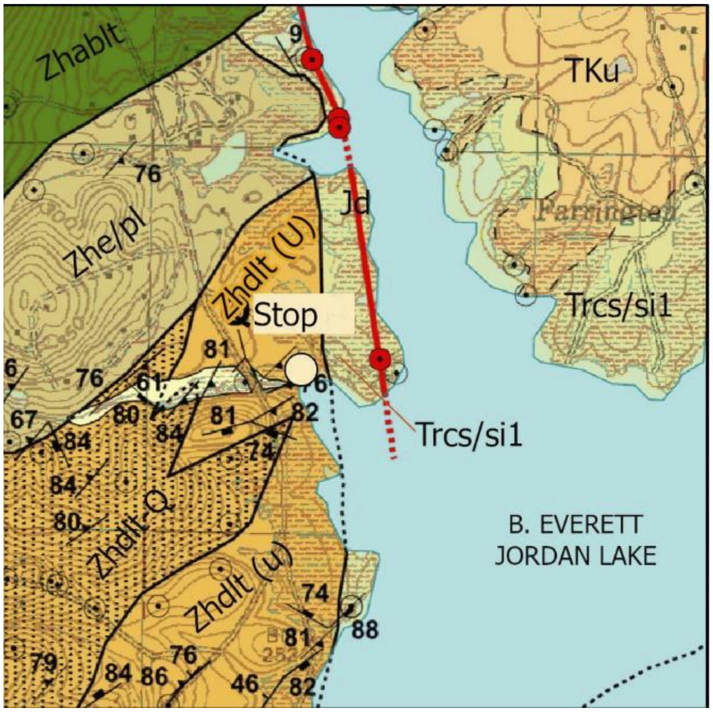


Figure 4: from the Farrington 7.5' Quadrangle

Purpose:
To examine examples of weakly metamorphosed volcanic rocks in an abandoned quarry within the Hyco Formation of the Carolina terrane. This stop is located in a partially flooded abandoned quarry at the NC Wildlife Resources Commission – Rock Quarry Public Fishing Area.



DESCRIPTION OF MAP UNITS

TKu - Post-Chatham Group undifferentiated sediments

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Jd – Diabase dike

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DEEP RIVER TRIASSIC BASIN - DURHAM SUB-BASIN

Trcs/si1 – Triassic sediments: Sandstone with interbedded siltstone of the Chatham Group Lithofacies Association I

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CAROLINA TERRANE: HYCO ARC - HYCO FORMATION

Zhablt – Metamorphosed andesitic to basaltic lavas and tuffs

Zhe/pl – Metamorphosed mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas

Zhdlt-Q – Metamorphosed quartz dacite lavas and tuffs

Zhdlt (U) – Metamorphosed dacitic lavas and tuffs of the upper portion of the Hyco Formation

N 0 2,000 Feet

Figure 5: from the Geologic Map of the Farrington Quadrangle (Bradley et al, 2007 and compiled Chatham County Geology)

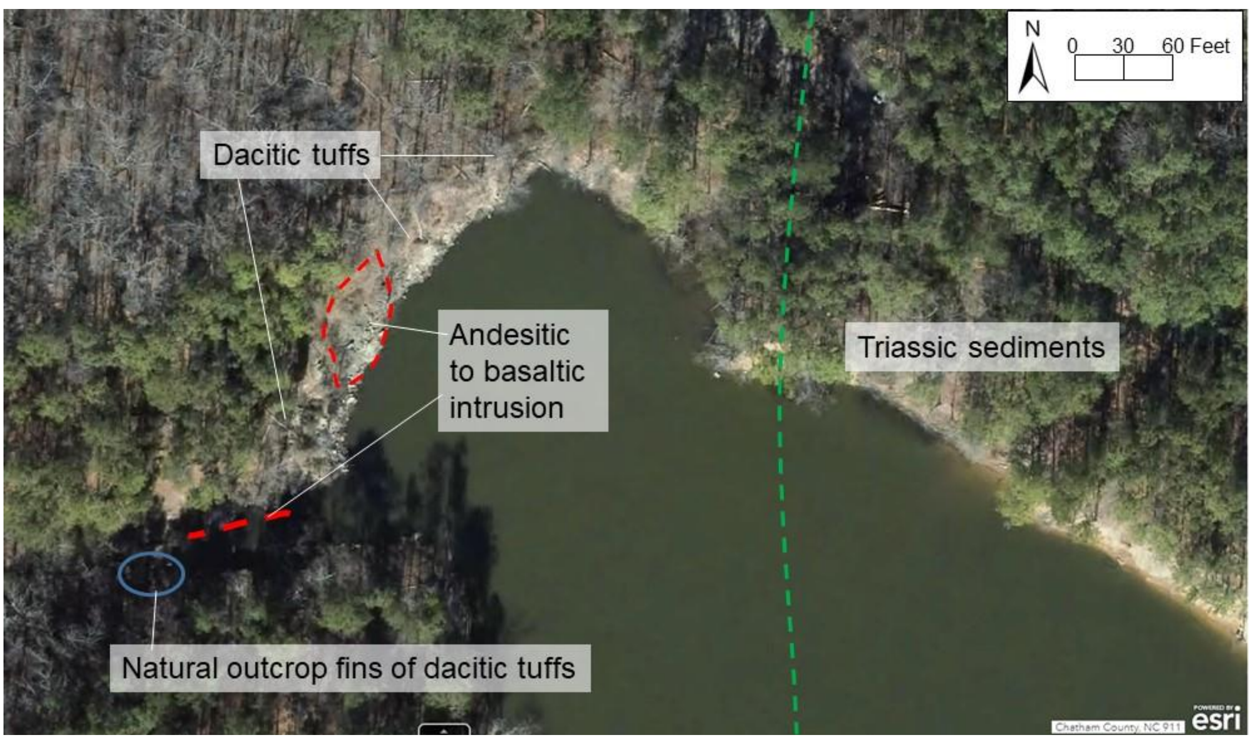

Figure 6: Sketch of approximate locations of rock types at Rock Quarry Public Fishing Area. Aerial photograph base (2017) from Chatham County GIS.
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Rock Types:

The majority of the area is interpreted to be underlain by the Carolina terrane unit - *dacitic lavas and tuffs of the upper portion of the Hyco Formation (Zhdlt (U))* (Bradley et al., 2007) (Fig. 5). The contact with the Durham sub-basin of the Deep River Triassic basin is located immediately east of the abandoned quarry.

The main rock type in the quarry is metamorphosed dacitic tuffs. An intrusion of metamorphosed andesitic to basaltic composition rock is present near the center of the worked areas of the abandoned quarry. Natural exposures of dacitic tuffs are present on the south bank of a small tributary near the south side of the quarry.

In worked areas of the abandoned quarry, the dacitic tuffs have a light-colored weathering rind, are gray to greenish-gray on the fresh surface and contain varying amounts of plagioclase crystal shards and lithic clasts. Lithic clasts are typically angular clasts of aphanitic dacite and/or plagioclase porphyritic dacite. Locally, elongated and wispy black-colored clasts are interpreted as compacted pumice (a typical volcanic texture present in tuffs called *fiamme*).

The andesitic to basaltic rocks are green, range in texture from aphanitic to containing plagioclase phenocrysts, abundant lithic clasts of felsic rock and infilled vugs(?). Small vesicles are present locally in the aphanitic groundmass. Distinct clast boundaries are visible surrounding the felsic clasts. Amorphous clast-like areas, ranging from a few millimeters to several centimeters, exhibit indistinct boundaries and may be mineralized vugs with quartz and epidote infill. Reaction halos are present encircling some clasts. The felsic clasts may be plucked from local wall rock. The andesitic to basaltic intrusion may be related to the map scale body of andesitic to basaltic lavas and tuffs of unit Zhablt present to the northwest of the stop (Figure 5).

Walking toward the south, through the abandoned quarry, natural outcrops are visible in the creek. Natural outcrops on the south bank of the creek include tall fins of metamorphosed dacitic tuffs. A low outcrop, in the center of the creek, of an andesitic to basaltic dike is present. The fin-shaped outcrops of tuff exhibit typical Hyco Formation structure of nearly vertical fins.

The natural outcrops consist of crystal- and clast-rich tuffs that are interpreted to show evidence of welding. Plagioclase crystal shards are abundant. Lithic clasts are angular, dark gray to black colored fragments of dacitic lavas ranging from millimeters to several centimeters in size. Some clasts appear to display a relict pumice-like texture. The rock exhibits a distinct planar fabric defined by aligned clasts and thin fiamme-like lenticular-shaped clasts that are interpreted as flattened pumice. Weathered-out lithic fragments and fiamme-shaped clasts (1-10 mm long) give the surface of rock perpendicular to the cleavage a pock-marked appearance and define the primary welding/compaction foliation.

The welding/compaction foliation trends approximately 204/84NW (right-hand rule). A metamorphic cleavage is also present with a strike and dip generally parallel to welding/compaction foliation. This steep (sub-vertical) metamorphic cleavage is typical of Hyco Formation lithologies. The andesitic to basaltic dike in the bottom of the adjacent creek displays a similar oriented metamorphic cleavage.

In hand samples of the dacitic tuffs, crystals are dominantly plagioclase crystal fragments. With the unaided eye or with hand lens, the groundmass is cryptocrystalline and display conchoidal-shaped fractures whose flake-like terminations may be weakly translucent. We interpret this texture to be a relict vitric texture that was originally volcanic glass – now devitrified and recrystallized by metamorphism. Thin sections of rocks with cryptocrystalline groundmass show a completely recrystallized groundmass consisting of a mosaic of primarily quartz and feldspar. Relict vitric texture is common in felsic tuffs, lavas and tuffaceous sedimentary rocks in the Hyco Formation.

Elsewhere in the unit, metamorphosed dacites ranging from aphanitic to porphyritic texture and interlayered welded and non-welded tuffs are common. Locally, interlayers of immature conglomerate and conglomeratic sandstone with 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 episodic pyroclastic flow deposits and air fall tuffs generated during formation of dacite domes. Conglomerates and sandstones are interpreted as reworked tuffs and eroded pyroclastic debris. The dacitic lavas and tuffs unit occurs as map scale pods surrounded by clastic rocks of the *Mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas* (Zhe/pl) unit (Figure 5).

Wortman et al. (2000) reported that single zircons from a similar rock type in the Rougemont Quadrangle yielded an upper intercept age of 615.7+3.7/-1.9 Ma. This date and others (Wortman et al., 2000; Bowman, 2010; and Bradley and Miller, 2011), coupled with lithologic relationships from detailed mapping in Orange and Durham Counties led to the tentative interpretation that the Hyco Formation may be divided into lower (ca. 630 Ma) and upper (ca. 615 Ma) portions. Subsequent U-Pb zircon LA-ICPMS ages indicate that magmatism in the lower member of the Hyco Formation may be as old as ca. 650 Ma (Barefoot, 2015 and Bradley et al., 2016).

Triassic Sedimentary Rocks and Diabase

If the water level is low in Jordan Lake, you may be able to see weathered outcrops of Triassic sediments and boulders of diabase along the lakeshore (Figure 5).

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