





COMPILED GEOLOGIC MAP OF DURHAM COUNTY, NORTH CAROLINA

Jd Trcs/si1

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Pre-Mesozoic crystalline rocks in northeastern and northern Durham County are part of the redefined Virgilina sequence (Hibbard et al., 2013). Within the map area, the Carolina terrane of the redefined Hyco Arc (Hibbard et al., 2013). Within the map area, the Carolina terrane of the redefined Hyco Arc (Hibbard et al., 2013). Within the map area, the Carolina terrane of the redefined Virgilina sequence (Hibbard et al., 2013). have differentiated the Hyco Formation into a ca. 633-629 Ma lower member (Wortman et al., 2000; and Bradley and Miller, 2011) and a ca.616-612 Ma upper member (Wortman et al., 2000; and Bradley and Miller, 2011). In Durham County, the Hyco Formation consists of layered meta-volcaniclastic rocks, vields detrital zircon ages as young as 578 and 588 Ma (Samson et al., 2000; and Bradley and Miller, 2011). In Durham County, the Hyco Formation consists of layered meta-volcaniclastic rocks. The Aaron Formation, which is composed of meta-volcaniclastic rocks. The Aaron Formation, which is composed of meta-volcaniclastic rocks. The Aaron Formation, which is composed of meta-volcaniclastic rocks. respectively). Deformation and low-grade metamorphism of both the Hyco Arc and the Aaron Formation (Glover, 1985; Harris and Glover, 1985; Harris Hyco Formation units of meta-volcaniclastic rocks include various lithologies that are grouped together to represent interpreted to be distally deposited air fall tuffs unit is interpreted to represent and tuffs unit is interpreted to represent dacitic domes and proclastics. The epiclastic/pyroclastic units are interpreted to be deposits of active volcanics and eroded volcanic highlands. The Vermiforma antiqua fossil locality reported by Cloud et al. (1976) is present within the Hyco Formation (upper member) along the South Fork of the Little River. Seilacher et al. (2000) indicates the feature may be a tectograph instead of a true fossil. A small section of the map. A since that the Easternmost Carolina terrane is equivalent to the Aaron Formation of the map. A zircon age date of ca. 575 Ma was reported by Goldberg (1994) for the Big Lake-Raven Rock schist unit. This date may indicate that the Easternmost Carolina terrane is equivalent to the Aaron Formation of the map. A zircon age date of ca. 575 Ma was reported by Goldberg (1994) for the Big Lake-Raven Rock schist unit. The central and southern portions of Durham County are part of the Triassic-aged Durham sub-basin of the Deep River Mesozoic basin. Lithologies in the basin is dominated by interlayered mudstones, sandstones, and conglomerates. Generally the basin is dominated by interlayered mudstones, sandstones, and conglomerates. Durham sub-basin lacks marker beds, making the identification of formal formations difficult (Clark et al., 2001). Instead, an alternate method of lithofacies Associations I and II contact in the Northeast Durham sub-basin based on lithofacies associations is used to group sedimentary rocks of the Durham and Gallagher. (1989) contacts. This contact was extended into the Lake Michie Quadrangle to edge-match with the Northeast Durham Geologic map (Phillips et al., 2004 (revised 2010)). Extent of diabase sills in the Northwest Durham Quadrangle were modified from Spencer (1987). The former Triangle Brick pit in southeast Durham County is a world-class Triassic fossil locality in the Tresi/s unit. Recovered specimens include plants, invertebrates, and vertebrates, and vertebrates related to fossils recovered from the Triangle Brick site. All pre-Mesozoic rocks in Durham County have been metamorphised to at least the chlorite zone of the greenschist metamorphise, and sedimentary textures and structures that allow for the identification. Although subjected to metamorphised. As such, the prefix "meta" is not included in the nomenclature of the pre-Mesozoic rocks described in the quadrangle. Jurassic diabase is not metamorphosed. 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, normalized mine Spencer, 1987; Wright, 1974) have used various nomenclature of Clark et al. (2001) and Hoffman and Gallagher (1989). Triassic units follow the nomenclature of Clark et al. (2001) and Hoffman and Gallagher (1989).

A preliminary review of the area geology is provided in Bradley et al., 2012), Chapel Hill (Bradley et al., 2004), Northwest Durham (Hoffman and Gallagher, 1989), Southeast Durham (Rodley et al., 2004), Northwest Durham (Bradley et al., 2004), Northwest Durham (Bradley et al., 2004), Southwest Durham (Bradley et al., 2004), Northwest Durham (Bradley et al., 2004), Southwest Durham (Bradley et al., 2004), Northwest Durham (Bradley et al., 2004), Northwest Durham (Bradley et al., 2004), Southwest Durham (Bradley et al., 2004), Northwest Durham (Bradley et al., 2004), Southwest Durham (Bradley et al., 2004), Northwest Durham (Bradley et al., 2004), Southwest Durham (Bradley et al., 2004), Southwest Durham (Bradley et al., 2004), Northwest Durham (Bradley et al., 2004), Southwest Durham (Bradley et al., 2004), Northwest Durham (Bradley et al., 2004), Southwest Durham (Bradley et al., 2004) al., 2004), Farrington (Bradley et al., 2007), and Green Level (Watson, 1998) geologic maps.

Qal - Alluvium: Unconsolidated poorly sorted and stratified deposits of angular to subrounded clay, silt, sand and gravel- to cobble-sized clasts, in stream drainages. May include point bars, terraces and natural levees along larger stream floodplains. Qt – Quaternary terrace deposits: Unconsolidated clay, silt, sand and pebbles on flat plain above current floodplain level; cobble and boulder float (up to 40 cm diameter) consisting of diabase, granodiorite and various volcanics (tuffs and lavas). K/Tu – post-Chatham Group undifferentiated sediments: Yellowish-white, medium- to coarse-grained arkosic sandstone present. Unit is mainly exposed on shores of B. Everett Jordan Lake. Unit is in unconformable contact with Triassic sediments. Unit outcrops in few locations at or above approximately 250 feet elevation. As such, unit extent interpreted from topography when station location data are sparse. Distribution of unit in the Southwest Durham and Chapel Hill Quadrangles of the County were interpreted from topography when station location data are sparse. Distribution of unit in the Southwest Durham and Chapel Hill Quadrangles of the County were interpreted from topography when station location data are sparse. Distribution of unit in the Southwest Durham and Chapel Hill Quadrangles of the County were interpreted from topography when station location data are sparse.

Tres/si1 – Sandstone with interbedded siltstone of the Chatham Group Lithofacies Association I: Gravish-pink, pinkish-gray, and light-gray; fine- to coarse-grained, micaeous, silghtly clayey, moderately well sorted, subangular to subrounded arkose and lithic arkose; dark red to reddish-brown, massive, and thickly laminated, bioturbated, micaeous, silghtly clayey, moderately well sorted, fine-grained sandstone; and dark red to reddish-brown, massive, and thickly laminated, bioturbated, micaeous, silghtly clayey, moderately well sorted, fine-grained sandstone; and dark red to reddish-brown, massive, and thickly laminated, bioturbated, micaeous, silghtly clayey, moderately well sorted, fine-grained sandstone; and dark red to reddish-brown, massive, and thickly laminated, bioturbated, micaeous, silghtly clayey, moderately well sorted, fine-grained sandstone; and dark red to reddish-brown, massive, and thickly laminated, bioturbated, micaeous, silghtly clayey, moderately well sorted, fine-grained sandstone; and dark red to reddish-brown, massive, and thickly laminated, bioturbated, micaeous, silghtly clayey, moderately well sorted, fine-grained sandstone; and dark red to reddish-brown, massive, and thickly laminated, bioturbated, micaeous, silghtly clayey, moderately well sorted, fine-grained, micaeous, silghtly clayey, moderately well sorted, fine-gray, fine-to coarse-grained, micaeous, silghtly clayey, moderately well sorted, fine-gray, fine-to coarse-grained, micaeous, silghtly clayey, moderately well sorted, fine-gray, fine-to coarse-grained, micaeous, silghtly clayey, moderately well sorted, fine-gray, fine-to coarse-grained, micaeous, silghtly clayey, moderately well sorted, fine-gray, fine-to coarse-grained, micaeous, silghtly clayey, moderately well sorted, fine-gray, fine-to coarse-gray, fine-to coars to 3 mm diameter are common especially in the siltstone. Fine-grained flakes of biotite in the arkose and lithic arkose is a distinctive accessory. Randomly oriented as burrows. Bedding, when observed, is parallel to slightly wavy, occurring as thick laminations to thinly bedded (0.5 cm to 5 cm). These rocks are assigned to the Lithofacies Association I of Hoffman and Gallagher (1989), Watson (1998), and Clark et al. (2001). Trcs/si2 - Sandstone with interbedded siltstone of the Chatham Group Lithofacies Association II: Cyclical depositional sequences of whitish-yellow to gray reduction halos. Coarse- to very co consist of clasts of quartz, bluish-gray quartz crystal tuff, and mudstone rip-ups. These rocks are assigned to the Lithofacies Association II of Hoffman and Gallagher (1989) and Clark et al. (2001). In the conception of the conce Triangle Brick fossil locality from unit in Durham County with location indicated on map. See Clark et al. (2001) and Peyer et al. (2001). These rocks are assigned to the Lithofacies Association II of Hoffman and Gallagher (1989) and Clark et al. (2001). Trcs – Interbedded sandstone/pebbly sandstone of the Chatham Group Lithofacies Association III: Reddish-brown to dark brown, irregularly bedded to massive, poorly to moderately sorted, medium- to coarse-grained, muddy lithic arkoses, with occasional bioturbation is usually surrounded by greenish-blue to gray reduction halos. Beds are tabular, 1-3 meters thick, with good lateral continuity. Unit grades eastward into Trcs/c. This unit description from Clark et al. (2001) combines the Trcs and Trcsc units of Hoffman and Gallagher (1989). Tres/c - Sandstone with interbedded conglomerate of the Chatham Group Lithofacies Association III: Reddish-brown to dark brown, irregularly bedded, poorly sorted, coarse-grained to pebbly, muddy lithic sandstones with interbedded pebble to cobble conglomerate basal lags of Tres. An arbitrary cut-off of less than 50 percent conglomerate basal lags of Tres. An arbitrary cut-off of less than 50 percent conglomerate basal lags of Tres. An arbitrary cut-off of less than 50 percent conglomerate basal lags of Tres. beds are channel-shaped and scour into the underlying sandstone beds. Unit grades eastward into Trcc. Unit described by Clark et al, (2001) and Hoffman and Gallagher (1989). Trese - Pebbly sandstone of the Chatham Group Lithofacies Association III: Reddish-brown, pebbly, poorly sorted, coarse-grained, lithic, feldspathic sandstone; locally contains laterally discontinuous pebble and cobble trains and conglomeratic channel lags. Description from Hoffman and Gallagher (1989). Trcc – Conglomerate of the Chatham Group 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. Muscovite is rare to absent in the very coarse-grained to gravelly matrix. An arbitrary cut-off of greater than 50 percent conglomerate. Muscovite is rare to absent in the very coarse-grained to gravelly matrix. An arbitrary cut-off of greater than 50 percent conglomerate. Muscovite is rare to absent in the very coarse-grained to gravelly matrix.

maximum clast diameters are in excess of 2 m. These rocks are assigned to the Lithofacies Association III of Hoffman and Gallagher (1989) and Clark et al. (2001). Trccw – Conglomerates of the western border of the Chatham Group: Reddish-brown to dark brown, matrix to clast supported, pebble to cobble conglomerate; clasts are subrounded to rounded consisting of primarily of quartz and foliated and unfoliated felsic volcanic rocks; matrix consists of coarse- to very coarse-sand.

Jd-recon - Diabase reconnaissance: Jurassic diabase from reconnaissance and geophysical data as depicted in Gottfried et al. (1991).

Trfb - Fault breccia: Silicified and/or hematite-stained fault breccia containing angular clasts of Triassic and pre-Triassic rock material along Jonesboro fault.

Arg - Reedy Creek metagranodiorite: leucocratic (CI less than 10) light tannish-gray, medium-grained to porphyritic, foliated and lineated to massive, metagranodiorite. Locally white mica rich and or contains blue quartz phenocrysts and clots of biotite and epidote.

Zbdi - Beaverdam diorite: Grayish-white to greenish-white, coarse-grained, unfoliated to well-foliated, mesocratic (CI less than 40) biotite hornblende metagranodiorite to metadiorite. Zbgb - Beaverdam gabbro and metapyroxenite: Black and white to greenish black, fine- to medium-grained, unfoliated to well-foliated, melanocratic (CI greater than 40) gabbro to metapyroxenite.

Zbr1 - Big Lake-Raven Rock schist 1: light tan to white, fine- to medium-grained white mica quartzitic schist containing abundant relict phenocrysts of blue quartz/and plagioclase or local white to gray lapilli and rock clasts. A zircon age date of ca. 575 Ma was obtained by Goldberg (1994). CAROLINA TERRANE

Aaron Formation

Za – Aaron Formation: Brown, gray to grayish green or light gray; typically foliated, arkosic sandstones, silty sandstones and phyllitic siltstones. Hyco Formation

Metaintrusive rocks associated with Hyco Formation: upper portion ca. 613 and 614 Ma (Wortman et al., 2000)

Plutonic rocks associated with the Flat River complex area of Glover and Sinha (1973), McConnell (1974), and McConnell and Glover (1982). Wortman et al. (2000) report a 613.4 +2.8/-2 Ma U-Pb zircon date from a granite and a 613.9 +1.6/-1.5 Ma U-Pb zircon date from a diorite collected in the northeast of the County. Zmpf – Moriah Pluton felsic phase: Dominantly leucocratic (CI 10-30) light pinkish gray to gray, fine- to medium-grained quartz diorite to diorite present. Locally, melanocratic (CI 40-50), grayish-green, fine- to medium-grained quartz diorite to diorite present. Mpf - Granodiorite and granite of the Moriah Pluton from McConnell (1974) and McConnell and Glover (1982).

Zgms – Granodiorite tonalite of the Stem and Moriah plutons: Leucocratic (CI=5-15), light tan-gray white, or pinkish-white, medium to coarse phaneritic, hypidiomorphic to xenomorpohic granular granodiorite and the Moriah plutons of the Lake Michie Quadrangle. Major minerals include plagioclase, alkali feldspar, and quartz with lesser amounts of biotite and amphibole, interpreted to be hornblende. Plagioclase is highly sericitized and in lesser amount sources. Alkali feldspar typically displays granophyric texture in thin section. If present, biotite is commonly recrystallized to chlorite, epidote, and actinoliteopaque mineral. Metamorphosed trondhjemite and monzonite pods are present and may represent dikes or differentiated portions of the pluton. Locally, mm- to cm-scale granitic in the western portion surrounding Lake Michie. Outcrops locally contain enclaves of microdiorite. Aggregates of white mica, quartz, plagioclase, and orthoclase highlight steeply dipping foliation and dipparallel lineation domains inferred to be highly fractured and/or phyllonitic and protomylonitic high strain zones (**Zfgms**). This unit is correlative to the Zmpf unit of Bradley et al. (2011) in the adjacent Rougemont 7.5-minute Quadrangle. Zagms – altered granodiorite and granite of the Moriah pluton: Leucocratic (CI=10-30), light pinkish gray to gray, fine- to medium-phaneritic texture likely included plagioclase, alkali feldspar, and quartz that are now combinations of fine to medium crystalline, foliated and non-foliated domains of white mica and recrystallized feldspar and quartz. Outcrops, and more commonly float cobbles and boulders display apparent silicification, while other samples display feldspar and altered portion of Zgms. Domains of highly foliated rocks additionally display recrystallized and altered portion of Zgms.

of this unit are separated as (Zfagms). Mpm – Tonalite, quartz dacite, and minor gabbro of the Moriah Pluton from McConnell (1974) and McConnell and Glover (1982).

Mpd – Dacite of the Moriah Pluton from McConnell (1974) and McConnell and Glover (1982).

Other plutonic rocks:

Zgd – Granodiorite: Leucoractic to mesocratic, fine- to medium-grained, equigranular to porphyritic granodiorite. May contain quartz diorite and chlorite masses. Plagioclase grains are often sericitized and may exhibit a greenish color. Locally, granodiorite is pinkish hued, fine- to medium-grained with dark green to black less than 1 mm to 4 mm clots of mafic minerals interpreted to be biotite and amphibole masses. Chlorite growth on biotite and amphibole is present. Metamorphosed volcaniclastic sedimentary and pyroclastic rocks associated with Hyco Formation: upper portion (stratigraphic relations uncertain) ca. 613 - 616 Ma (Wortman et al., 2000; Bowman, 2010; and Bradley and Miller, 2011) Zq – Quartz bodies: White, beige, red, and tan; sugary to porcelaneous; very fine- to medium-grained massive quartz rock to quartzite-like rock. Outcrops are usually massive. Quartzite-like rock a foliation. Pyrite is present as cubic crystals and empty cubic molds of crystals (up to 12 mm). Map areas contain boulders (up to several feet in diameter) and outcrops of white colored massive quartz. feldspar crystal shards are visible in some exposures. Relict structures are obliterated in heavily altered rocks. Map area contains boulders (up to several feet in diameter) and outcrop of massive milky quartz and quartz + sericite rock.

white mica and quartz highlight steeply dipping and plunging foliation and lineation domains inferred to be highly fractured and/or phyllonitic and protomylonitic high strain zones (Zhfdlt-a).

fractured and/or phyllonitic and protomylonitic high strain zones (**Zhfdlt**).

white mica and quartz highlight steeply dipping and plunging foliation and lineation domains inferred to be highly fractured and/or phyllonitic and protomylonitic high strain zones (**Zhfdsi**). Zhadlt – Andesitic to dacitic lavas and tuffs: Distinctive black to dark gray; porphyritic lava with plagioclase phenocrysts (up to 4 mm), and flow banded lava with local amygdules. Interlayed with the lavas are gray to black; welded and non-welded; coarse tuff, lapilli tuff, and tuff breccias. Zhablt – Andesitic to basaltic lavas and tuffs: Green, gray-green, gray, dark gray and black; typically unfoliated, amygdaloidal, plagioclase porphyritic, amphibole/pyroxene porphyritic, amp sediments identical to the Zhe/pl and Zhe/p unit.

A1 – Intermediate volcanic rocks from McConnell (1974) and McConnell and Glover (1982). Z – Felsic pyroclastic rocks from McConnell (1974) and McConnell and Glover (1982)

Metamorphosed volcaniclastic sedimentary and pyroclastic rocks associated with Hyco Formation: lower portion (stratigraphic relations uncertain) ca. 629 - 633 Ma (Wortman et al., 2000 and Bradley and Miller, 2011) Zhat (1) – Altered tuffs of the lower portion of the Hyco Formation: Very light gray to light greenish gray (whitish in areas) with red and yellow mottling. Alteration consists of silicified, sericitized and pyrophyllite, and quartz + phyrophyllite, and quartz + phyrophyllite rock all with less than 1 mm to 2 mm diameter weathered sulfides are common. Fine-grained chloritoid porphyroblasts (less than 1 mm) are present in some pyrophyllite bearing rocks. Relict structures are obliterated in heavily altered rocks. Relict structures are obliterated in heavily altered rocks. Relict structures are obliterated in heavily altered rocks. Zhft (1) - Felsic tuffs: Grayish-green to greenish-gray and silvery-gray; massive to foliated volcaniclastic pyroclastic 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 (I) – 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 prevents, 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; 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. The tuffs are interpreted as episodic pyroclastic flow deposits, air fall tuffs or reworked tuffs generated during formation. Zhdsi (1) – Dacitic shallow intrusive of the lower portion of the Hyco Formation: Gray-green, light green to green; plagioclase porphyritic dacite with a granular-texture displayed granodiorite. Plagioclase phenocrysts typically range from 1 mm to 4 mm. Black colored amphibole, when visible, occurs as phenocrysts (less than 1 mm to 1 mm) and as intergrowths with plagioclase. Amphibole intergrowths distinguish rock from fine-grained tuffs. Enclaves of dark gray, plagioclase porphyritic dacite are common and at times give rock a psuedo-clastic appearance. Bradley and Miller (2011) report an age of 628.5 ±1 Ma for a dacite from this unit in southern Orange County. REFERENCES Allmendinger, R. W., Cardozo, N. C., and Fisher, D., 2013, Structural Geology Algorithms; Vectors & Tensors; Cambridge, England, Cambridge University Press, 289 p. Bain, G.L., and Harvey, B.W., 1977, Field guide to the geology of the Durham Triassic basin: Carolina Geological Society, Fortieth Annual Meeting, October 7-9, 1977, Geology and Mineral Resources Section, Raleigh, 84 p. Blake, D.E., Schronce, A.G., Smith, B.C., and Kendall, J.M., 2009, Geologic map of the Stem 7.5-minute quadrangle, Granville County, North Carolina: North Carolina Geological Survey Open file Report 2009-02, scale 1:24,000, in color. Blake, D.E., Stoddard, E.F., Bradley, P.J., and Clark, T.W., 2012, Neoproterozoic to Mesozoic petrologic and ductile-brittle structural relationships along the Alleghanian Nutbush Creek fault zone and Deep River Triassic basin in North Carolina, in Eppes, M.C., and Bartholomew, M.J., editors., From the Blue Ridge to the Coastal Plain: Field Excursions in the Southeastern United States: Geological Society of America Field Guide 29, p. 219–261, doi:10.1130/2012.0029(07). Bowman, J.D., 2010, The Aaron Formation: Evidence for a New Lithotectonic Unit in Carolinia, North Central North Carolina, unpublished master's thesis, North Carolina State University, Raleigh, North Carolina, 116 p. Bradley, P.J., Phillips, C.M., Witanachchi, C., Ward, A.N., and Clark, T.W., 2004, Geologic map of the Northwest Durham 7.5-minute quadrangle, Durham and Orange Counties, North Carolina: North Carolina Geological Survey Open-file Report 2004-03a Revision-01 (2010), scale 1:24,000, in color.

Bradley, P.J., Phillips, C.M., Gay, N.K., and Fuemmeler, S.J., 2004, Geologic map of the Chapel Hill 7.5-minute quadrangle, Orange and Durham Counties, North Carolina: North Carolina Geological Survey Open-file Report 2004-01 Revision-02 • • (2008). scale 1:24.000. in color. Bradley, P.J., Gay, N.K., Bechtel, R., and Clark, T.W., 2007, Geologic map of the Farrington 7.5-minute quadrangle, Chatham, Orange and Durham Counties, North Carolina: North Carolina Geological Survey Open-file Report 2007-03, scale

1:24,000. in color. Bradley, P.J., Hanna, H.D., and Bechtel, R, 2011, Geologic map of the Rougemont 7.5-minute quadrangle, Orange, Durham and Person Counties, North Carolina: North Carolina Geological Survey Open-file Report 2011-08, scale 1:24,000, in 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 Triassic Basin in the northern Piedmont of North Carolina – a status report in central North Carolina, in Hibbard, J.P. and Pollock, J. editors, One arc, two arcs, old arc, new arc - The Carolina terrane in central North Carolina, 2013 Carolina Geological Society field trip guidebook, Salisbury, North Carolina, p.139-151. Cardozo, N., and Allmendinger, R. W., 2013, Spherical projections with OSXStereonet: Computers & Geosciences, v. 51, no. 0, p. 193 - 205, doi: 10.1016/j.cageo.2012.07.021. Clark, T.W., Gore, P.J., and Watson, M.E., 2001, Depositional and structural framework of the Deep River Triassic basin, North Carolina, in Hoffman, C.W., editor, Field Trip Guidebook for the 50th Annual Meeting of the Southeastern Section, Geological Society of America, Raleigh, North Carolina, p. 27-50. Clark, T.W., Phillips, C.M., and Blake, D.E., 2016, Geologic Map of the Creedmoor 7.5-minute quadrangle, Granville, Wake and Durham Counties, North Carolina: North Carolina Geological Survey Open File Report 2016-18, scale 1:24,000 Clark, T.W., Blake, D.E., Stoddard, E.F., Carpenter, III, P.A., and Carpenter, R.H., 2004, Preliminary Bedrock Geologic Map of the Raleigh 30' x 60' Quadrangle, North Carolina: North Carolina Geological Survey Open-file Report 2004-02, scale 1:100.000. in color.

Cloud, P., Wright, J., and Glover, L., 1976, Traces of animal life from 620-million-year-old rocks in North Carolina: American Scientist, v. 64, p. 396-406. Farrar, S., 1985, Stratigraphy of the northeastern North Carolina Piedmont, North Carolina, Southeastern Geology 25, p.159–183. 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, p. 234-251. Goldberg, S.A., 1994, U-Pb geochronology of volcanogenic terranes of the eastern North Carolina Piedmont: Preliminary results, in Stoddard, E.F. and Blake, D.E., editors., Geology and Field Trip Guide, Western Flank of the Raleigh Metamorphic Belt, North Carolina, Raleigh, North Carolina, p. 13-17 Gottfried, D., Froelich, A.J., and Grossman, J.N., 1991, Geochemical data for Jurassic diabase associated with early Mesozoic basins in the Eastern United States: Durham and Sanford Basins, North Carolina, USGS Open-File Report 91-322-I, 21 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, L., 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, p. 200-217.

Canada Special Paper, v. 41, p. 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. Hoffman, C.W., and Gallagher, P. E., 1989, Geology of the Southeast Durham and Southwest Durham 7.5-minute quadrangles, North Carolina Geological Survey Bulletin 92, 34 p. Horton, J.W., Jr., Blake, D.E., Wylie, A.S., Jr., and Stoddard E.F., 1992, Geologic map of the Falls Lake-Wake Forest area, north-central North Carolina: U.S. Geological Survey Open File Report 92-269, scale 1:24,000. LeMaitre, 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.

McConnell, K.I., 1974, Geology of the late Precambrian Flat River Complex and associated volcanic rocks near, Durham, North Carolina, unpublished masters thesis, Virginia Polytechnic and State University, Blacksburg, Virginia, 64 p. McConnell, K.I., and Glover, L., 1982, Age and emplacement of the Flat River complex, an Eocambrian sub-volcanic pluton near Durham, North Carolina: Geological Society of America Special Paper 191, p. 133-143. Parker, J., 1979, Geology and mineral resources of Wake County. North Carolina Geological Survey Bulletin 86, 122 p. Peyer, K., Carter, J.G., Sues, H.D, Novak, S.E., and Olsen, P.E., 2008, A new Suchian Archosaur from the Upper Triassic of North Carolina, Journal of Vertebrate Paleontology 28 (2): p. 363–381. Phillips, C.M., Witanachchi, C., Ward, A.N., and Clark, T.W., 2004, Geologic map of the Northeast Durham 7.5-minute quadrangle, Durham, Granville, and Wake Counties, North Carolina: North Carolina Geological Survey Open-file Report 2004-03a Revision-01 (2010), 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. Rhodes, D.L., Blake, D.E., Marrow, R.H., April, J.D., Gross, A.L., and Kendall, J.M., 2012, Geologic map of the Eastern and Central Portions of the Lake Michie 7.5-minute quadrangle, Durham, Granville, and Pearson Counties, North Carolina:

North Carolina Geological Survey Open-file Report 2012-01, scale 1:24,000, in color. Samson, S.D., Secor, D., and Hamilton, M.A., 2001, Wandering Carolina: Tracking exotic terranes with detrital Zircons, GSA Abstracts with Programs Vol. 33, No. 6, p. A-263. Seilacher, A., Meschede, M., Bolton, E.W., and Luginsland, H., 2000, Pecambrian "fossil" Vermiforma is a tectograph: Geology, v. 28, p. 235-238. Spencer, R.J., 1987, Geology of the Northeast Durham 7.5-minute Quadrangle, North Carolina, manuscript map, cross section and report in the files of the North Carolina Geological Survey, unpublished data. Watson, M.E., 1998, Geologic map of Green Level 7.5-minute quadrangle, Chatham, Wake and Durham Counties, North Carolina: North Carolina Geological Survey Open-file Report 98-3, scale 1:24,000, in color. Wilson, W.F., and Carpenter, P. A., 1997, Superconducting Super Collider: Location, geology, and road log. Open-file report 97-2. North Carolina Geological Survey: Raleigh. 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, p. 321-338. Wright, J.E., 1974, Geology of the Carolina slate belt in the vicinity of Durham, North Carolina, unpublished M.S. thesis, Virginia Polytechnic Institute and State University, 78 p.





Disclaimer:

this preliminary map may occur.

addressed during future mapping.

Lambert Conformal Conic projection

Jd – Diabase: Black to greenish-black, melanocratic, fine- to medium-grained, dense, consists primarily of plagioclase, augite, and may contain olivine. Occurs as dikes up to 100 ft wide and sills. Locally occurs as dikes up to 100 ft wide and sills. Locally occurs as dense, spheriodally weathered boulders with a grayish-brown weathering rind. Whole rock geochemistry data for several samples in the Durham area are presented in Gottfried et al. (1991).



Zdim –diorite of the Moriah pluton: Mesocratic to melanocratic (CI=40-70), greenish-gray to grayish-green to green, fine- to medium-phaneritic diorite, microdiorite and amphibole, interpreted to represent to green, fine- to medium-phaneritic diorite, microdiorite and amphibole, interpreted to be hornblende. Plagioclase crystals are highly saussuritized and in lesser amounts sericitized. Hornblende may be recrystallized to chlorite, epidote, and actinolite-opaque mineral. Locally contains 5-10% quartz highlighting differentiated outcrops of quartz highlighting differentiated outcrops of quartz highlighting. Texturally and mineralogically equivalent to Zdib in Granville County portions of the Lake Michie Quadrangle.

> Zgd-gr-p – Granodiorite to granite of Piney Mountain Creek area: Composite pluton of dominantly medium-grained hornblende granodiorite with lesser amounts of medium-graned hornblende graned hornblende granodiorite with lesser amounts of medium-graned hornblende graned hornblende g Zdi – Diorite: Mesocratic (CI~50), greenish-gray to grayish-green, fine- to medium-grained, hypidiomorphic granular diorite. Major minerals include plagioclase and amphibole. Plagioclase and amphibole. Plagioclase and amphibole.

Zhat (u) – Altered tuffs: Very light gray to light greenish gray (whitish in areas) with red and yellow mottling, altered volcaniclastic rocks. Alteration consists of silicified, sericitized and pyrophyllite, and kaolinitized Zhdlt-a- altered dacitic lavas and tuffs: White to red to tan, silicecious, hydrothermally altered aphanitic dacite, porphyritic dacite, porphyritic dacite, and plagioclase phenocrysts ranging from 2 to 5 mm in size. Commonly siliceous concentrations give the rock a "chunky" appearance. Localized pyrophyllite mineralization occur as radiating crystals that range from 0.25 mm to 1cm in size. Commonly Fe-oxide mineralization gives the rock a red color. Equivalent to the Zadlt unit of Blake et al. (2009) in the Stem Quadrangle to the West. Silicification, sulfide mineralization, and aggregates of Zhe/p - Mixed epiclastic pyroclastic rocks: Grayish-green to greenish-gray, tuffaceous sandstones, conglomeratic sandstones, siltstones and minor phyllite. The siltstones typically are weakly phyllitic. Contains lesser amounts of fine- to coarse tuff and lapilli tuff. Tuffs are differentiated from other volcaniclastic rocks by the presence of zones of cryptocrystalline texture that exhibit conchoidal-like fractures in between foliation domains. Minor andesitic to basaltic lavas and tuffs present. Silicified and/or sericitized altered rock similar to Zhat unit are locally present. Unit is interpreted to grade into Zhe/pl unit. Contact with Zhe/pl designated at first occurrence of dacitic lavas. Domains of highly foliated rocks of this unit are separated as Zhfe/p. Zhe/pl - Mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas: Gravish-green to greenish-gray, locally with distinctive reddish-gray or maroon to lavender coloration; conglomerate, conglomerate, sandstone, substone, substant, substa contain interbedded dacitic lavas identical to Zhdlt unit. Contains lesser amounts of fine- to coarse tuff and lapilli tuff with a cryptocrystalline-like groundmass. Minor andesitic to basaltic lavas and tuffs present. Silicified and/or sericitized altered rock similar to Zhat unit are locally present. Conglomerates and conglomerates and conglomerates and tuffs present. clastic matrix. Zhe/pl distinguished from Zhe/p by presence of dacites and is interpreted to represent a facies change to an area more proximal to the active volcanic centers compared to Zhe/p. Cloud et al. (1976) fossil locality from unit in Durham County with location indicated on map. Zhdlt (u) – Dacitic lavas and tuffs of the upper portion of the Hyco Formation: Greenish-gray to dark gray, siliceous, aphanitic dacite, porphyritic dacite, porphyrit conglomerate and 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 to have been coherent extrusives or very shallow intrusions associated with dome formation. Zhe/pl unit. Wortman et al. (2000) reports an age of 615.7+3.7/-1.9 Ma U-Pb zircon date for a dacitic tuff from the unit. Red Mountain, a prominent topographic feature of the Rougemont quadrangle is underlain by this unit. Zhdsi (u) – Dacitic shallow intrusive of the upper portion of the Hyco Formation: Gray-green, light green to green, greenish-gray to light gray; dacite, plagioclase porphyritic dacite with a granular-textured groundmass to micro-granodiorite (intrusive texture visible with 7x hand lens). Locally fine- to medium grained granodiorite present. Plagioclase phenocrysts, when present, range from less than 1 mm to 4 mm. Black colored amphibole, when visible, occurs as phenocrysts (less than 1 mm to 1 mm) and as intergrowths with plagioclase. Amphibole intergrowths distinguish rock from the active quarry includes greenish-gray to light gray; aphanitic to weakly plagioclase porphyritic dacite to micro-granodiorite. Relict plagioclase phenocrysts are sausseritized in a matrix of recrystallized feldspar and quartz with dark colored clots (less than 1 mm to 4 mm) interpreted in hand sample as chlorite(?) masses and/or relict enclaves of dark gray, aphanitic dacite. Interpreted in hand sample as chlorite(?) masses and/or relict enclaves of dark gray, aphanitic dacite.

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



Example of data density at 1:24,000-scale for 1 mile-wide area. Example from northerr Durham County along the Little Rive in the Rougemont Quadrangle (Bradley et al., 2011) Site-specific investigations should use 1:24,000-scale maps



Equal Area Schmidt Net Projection of Contoured Poles to Primary Bedding, Layering, and Welding/Compaction Foliation in Metamorphic Rocks. Contour Interval = 2 sigma N = 91



MAJOR GEOLOGIC FEATURES

Equal Area Schmidt Net Projection of Contoured Poles to Bedding in Triassic Sediments

Unidirectional Rose Diagram of Joints N = 1107Outer Circle = 9%Mean vector = 325 degrees