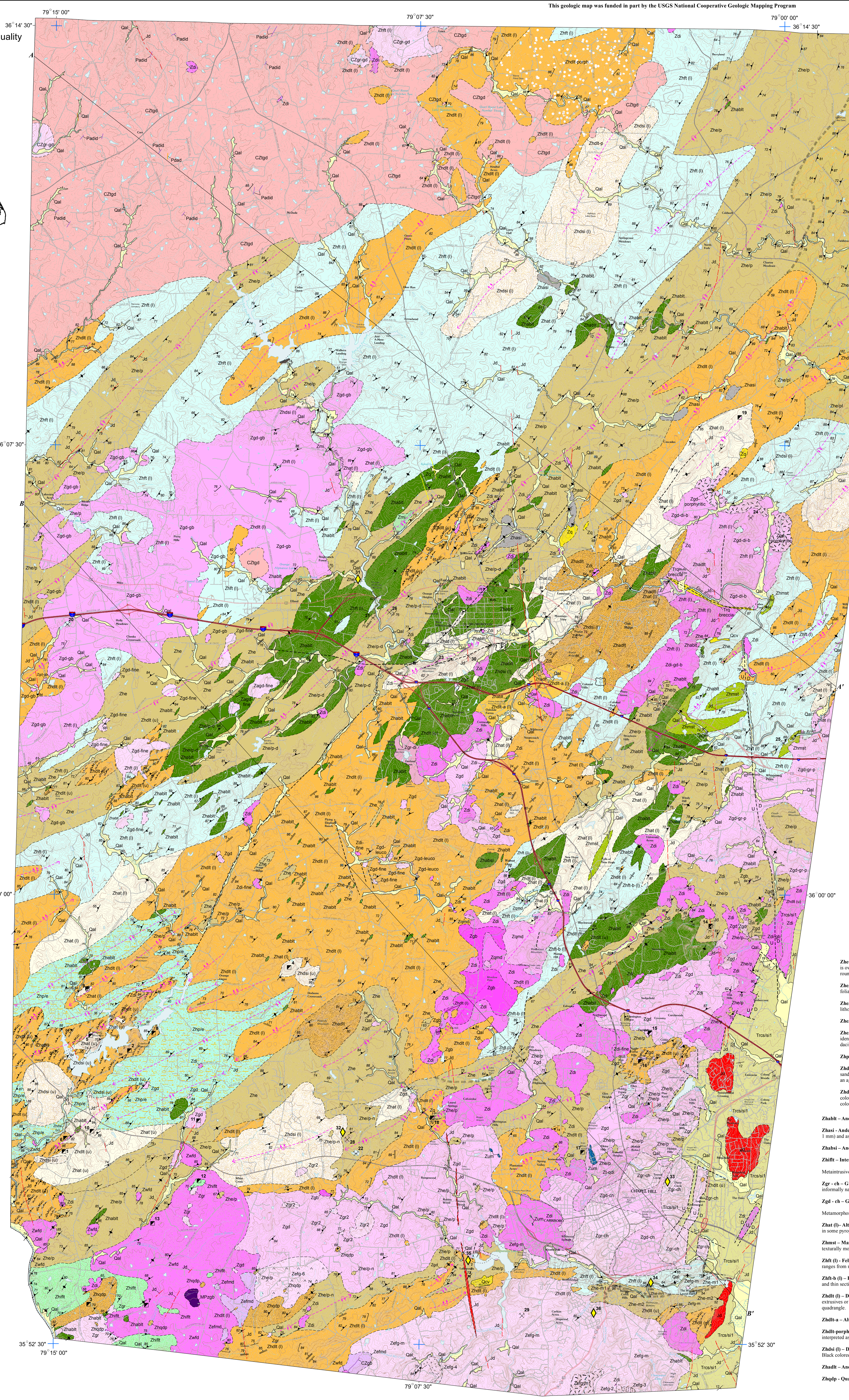
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program

North Carolina Geological Survey
North Carolina Department of Environmental Quality

Kenneth B. Taylor, State Geologist



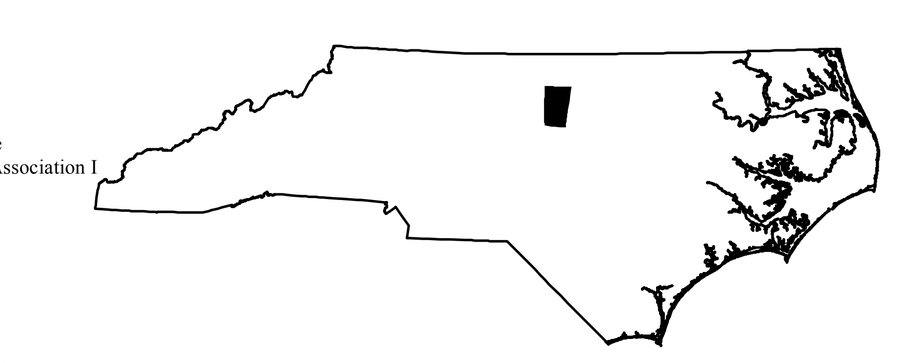
MAP UNITS

QUATERNARY
- Qal / Qcv — alluvium (Qal), colluvium (Qcv)

MESOZOIC
- Jd — diabase
- Trq-breccia — quartz breccia (fault rock)

Triassic Sedimentary Rocks
Deep River Basin: Durham Sub-basin
- Trcs/si1 — sandstone with interlayered siltstone of the Chatham Group Lithofacies Association I

MESOZOIC/ PALEOZOIC (?)
- MPzgb — olivine gabbronorite



LOCATION OF ORANGE COUNTY

Metamorphic Rocks

PALEOZOIC (?)/ NEOPROTEROZOIC
- Pdad / Padid — Dikes present in Prospect Hill Pluton: dacitic dikes (Pdad); andesitic to dacitic dikes (Padid)

Prospect Hill Pluton
metaintrusive rocks

CAMBRIAN (?)/ NEOPROTEROZOIC
- CZtgd / CZgr-gd — tonalitic granodiorite (CZtgd); granite to granodiorite (CZgr-gd) related to ca. 546 ma Roxboro pluton (Wortman et al., 2000)
- CZgb — Dike present in Farrington Pluton: gabbro (CZgb)

East and West Farrington Plutons metaintrusive rocks

NEOPROTEROZOIC
- Zefg-m, Zefg-m1, Zefg-2, Zefg-3, Zefg-4, Zefg-6, Zefmd, Zwfd — East Farrington pluton main facies (Zefg-m); East Farrington pluton main facies variety 1 (Zefg-m1); East Farrington pluton porphyritic granite (Zefg-2); East Farrington pluton fine-grained granite (Zefg-3); East Farrington pluton gray granitoid (Zefg-4); East Farrington pluton satellite granitoid (Zefg-6); East Farrington monzodiorite porphyry of Terrells Creek area (Zefmd); West Farrington pluton diorite (Zwfd). East Farrington pluton is ca. 579 Ma (Tadlock and Loewy, 2006)

Hyco Formation

metaintrusive rocks associated with Hyco Formation: upper portion (stratigraphic relations uncertain) ca. 613 and 614 Ma (Wortman et al., 2000)
- Zgr, Zgr2, Zgr-di, Zgd — granite (Zgr) and (Zgr2); granite to diorite (Zgr-di); granodiorite (Zgd)
- Zgd-fine, Zgd-leuco, Zagd-fine — fine-grained granodiorite (Zgd); fine-grained luecocratic granodiorite (Zgd-leuco); fine-grained altered granodiorite (Zagd-fine)
- Zgd-gr-p — granodiorite to granite of Piney Mountain Creek area (Zgd-gr-p)
- Zgd-di-b, Zdi-gd-b, Zgd-porphyritic — Buckwater Creek Pluton: granodiorite and diorite (Zgd-di-b); diorite and granodiorite (Zdi-gd-b); porphyritic granodiorite (Zgd-porphyritic)
- Zgd-gb, Zt-qdi, Zqmd — granodiorite to gabbro (Zgd-gb); tonalite to quartz diorite (Ztqdi); quartz monzodiorite (Zqmd)
- Zdi, Zdi-fine, Zdi-gb, Zgb — diorite (Zdi); fine-grained diorite (Zdi-fine); diorite to gabbro (Zdi-gb); gabbro (Zgb)
- Zum — ultramafic (Zum)

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, Zhat (u), Zmi — quartz bodies (Zq); altered tuffs (Zhat (u)); porphyritic mafic intrusive (Zmi)
- Zhe, Zhe-m1, Zhe-m2 — epiclastics (Zhe); Morgan Creek epiclastics (Zhe-m1 and Zhe-m2)
- Zhe/p, Zhe/p-n, Zhe/p-d — mixed epiclastic-pyroclastic rocks (Zhe/p); mixed epiclastic-pyroclastic rocks of Neville Creek area (Zhe/p-n); mixed epiclastic-pyroclastic rocks of Duke Quarry area (Zhe/p-d)
- Zhe/pl, Zhiflt — mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas (Zhe/pl); intermediate to felsic lavas and tuffs (Zhiflt)
- Zhablt, Zhasi, Zhabsi — andesitic to basaltic lavas and tuffs (Zhablt); andesitic shallow intrusive (Zhasi); andesitic to basaltic shallow intrusive (Zhabsi)
- Zhp/e, Zhdlt (u), Zhdsi (u) — mixed pyroclastic-epiclastics (Zhp/e); dacitic lavas and tuffs (Zhdlt (u)); dacitic shallow intrusive (Zhdsi (u))

?

metaintrusive rocks associated with Hyco Formation: lower portion (stratigraphic relations uncertain) ca. 630 Ma (Wortman et al., 2000)
- Zgr-ch, Zgd-ch

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 (l), Zhmst — altered tuffs (Zhat (l)); matrix supported tuffs (Zmst)
- Zhft (l), Zhft-b (l) — felsic tuffs (Zhft (l)); felsic tuffs of the Blackwood area (Zhft-b (l))
- Zhdlt (l), Zhdlt-a (l), Zhdlt-porph — dacitic lavas and tuffs (Zhdlt (l)); altered dacitic lavas and tuffs; (Zhdlt-a (l)); porphyritic dacite associated with Zdlt (Zhdlt-porph)
- Zhdsi (l), Zhqdp, Zhadlt — dacitic shallow intrusive (Zhdsi (l)); quartz dacite porphyry (Zhqdp); andesitic to dacitic lavas and tuffs (Zhadlt)

CONTACTS

Lithologic contacts - Distribution and concentration of structural symbols indicates degree of reliability. Contact dashed where inferred. Contact dotted where concealed.

gradational contact

FAULTS

Faults- Dashed where inferred, dotted where concealed. U indicates upthrown block, D indicates downthrown block.

FOLDS

Interpreted fold hinge of large scale overturned anticline. Arrow indicates direction of plunge.

Interpreted fold hinge of large scale overturned syncline. Arrow indicates direction of plunge.

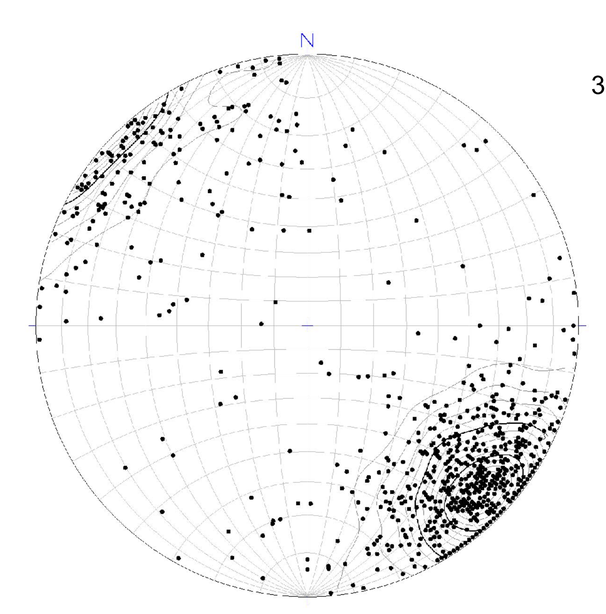
Interpreted fold hinge of large scale doubly plunging syncline.

ASSORTED LINES

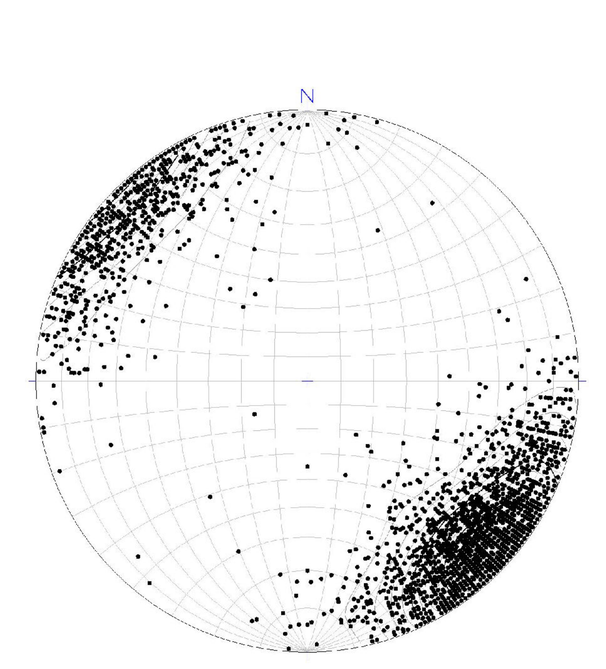
- Diabase dike - Dashed where inferred, dotted where concealed.
- Padid dike - inferred
- Pdad dike - inferred
- gabbro to gabbro porphyry dike - inferred
- quartz vein or zone-inferred
- in cross section - inferred axial trace of large-scale fold
- in cross section - interpreted fold form lines of noncylindrical asymmetric folds
- primary road
- secondary road

STRUCTURAL SYMBOLS

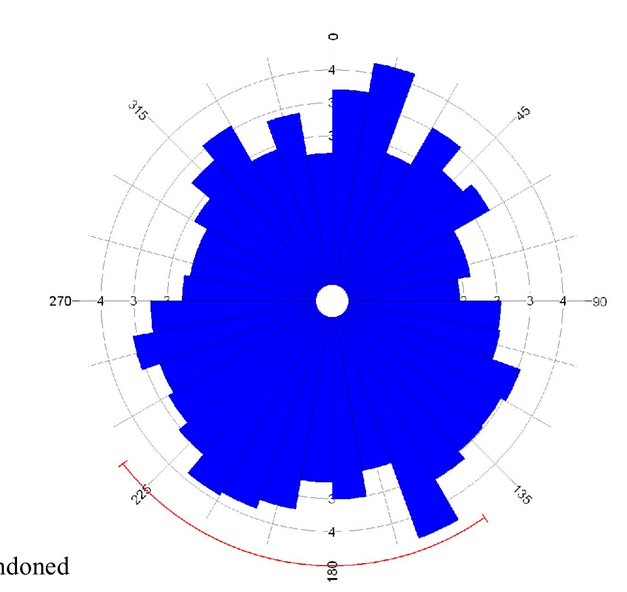
- strike and dip of primary bedding and layering
- strike of vertical bedding and layering
- strike and dip of overturned bedding
- strike and dip of primary volcanic compaction and/or welding
- strike of vertical primary volcanic compaction foliation and/or welding
- strike and dip of foliation
- strike of vertical foliation
- strike and dip of cleavage
- strike of vertical cleavage



Equal Area Schmidt Net Projection of Contoured Poles to Primary Layering, Bedding and Welding/Compaction Foliation. Contour Interval = 1 N = 804



Equal Area Schmidt Net Projection of Contoured Poles to Foliation and Cleavage Contour Interval = 1 N = 2,779



Unidirectional Rose Diagram of Joints N = 3,530 Outer Circle = 4%

OTHER POINTS

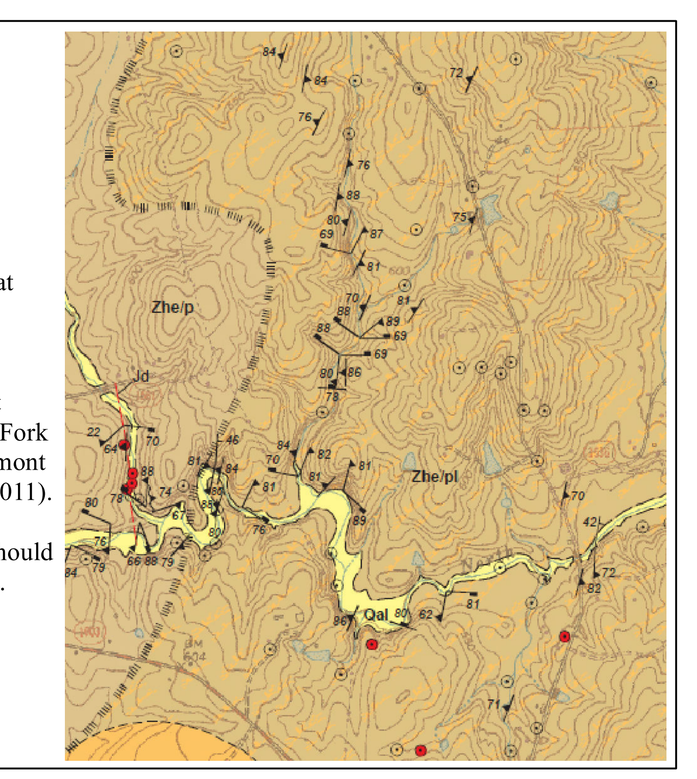
- Mine or Prospect - abandoned
- Quarry-abandoned
- Quarry-active
- U-Pb age date location

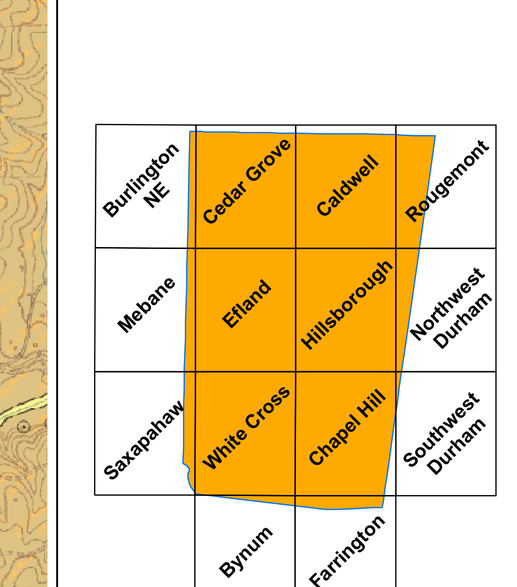
1 - Martin Morrow pyrophyllite mine - abandoned
2 - unnamed prospect - abandoned
3 - Dell Dawson prospect - abandoned
4 - pyrophyllite prospect - abandoned
5 - Teer pyrophyllite prospect - abandoned
6 - Oaks pyrophyllite prospect - abandoned
7 - Stroud copper prospect - abandoned
8 - pyrophyllite prospect - abandoned
9 - Bradshaw pyrophyllite mine - abandoned
10 - North State gold mine - abandoned
11 - Ray gold prospect - abandoned
12 - unnamed prospect - abandoned
13 - unnamed prospect - abandoned
14 - Duke Forest gold prospect - abandoned
15 - Weaver-Carr gold prospect - abandoned
16 - Nunn Mountain gold mine - abandoned
17 - Chapel Hill Iron mine - abandoned
18 - Laurel Hill quartz prospect - abandoned
19 - Murray pyrophyllite prospect - abandoned
20 - Mebane quarry - abandoned
21 - former quarry - abandoned
22 - former quarry - abandoned
23 - Occoneechee Mountain quarry - abandoned
24 - Bacon quarry - abandoned
25 - Coile (Eno) quarry - abandoned
26 - quarry (building stone) - active
27 - quarry (crushed stone) - active
28 - quarry (crushed stone) - active
29 - gravel pit (Chapel Hill grit) - active
30 - mine (pyrophyllite) - active
31 - U-Pb age date ca. 613 Ma (Bradley and Miller, 2011)
32 - U-Pb age date ca. 628 Ma (Bradley and Miller, 2011)
33 - U-Pb age date ca. 633 Ma (Wortman et. al., 2000)
34 - U-Pb age date ca. 630 Ma (Bradley and Miller, 2011)
35 - U-Pb age date ca. 633 Ma (Wortman et. al., 2000)
36 - U-Pb age date ca. 579 Ma (Tadlock and Loewy, 2006)

Example of data density at 1:24,000-scale for 1.5 mile-wide area.

Example from northeast Orange County along North Fork of Little River in the Rougemont Quadrangle (Bradley et al., 2011).

Site-specific investigations should use 1:24,000-scale maps.





ORANGE COUNTY 1:24,000 QUADRANGLES

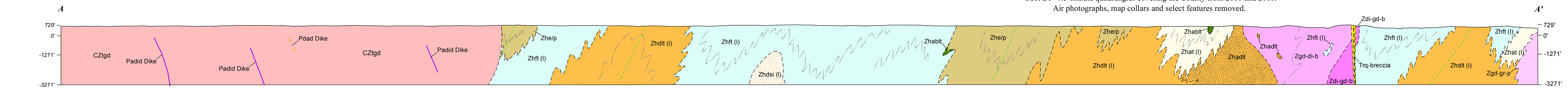
SCALE 1:50 000

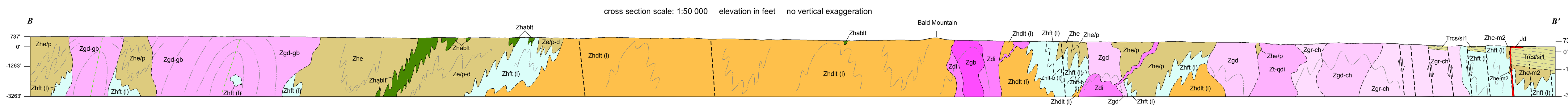
Miles / Feet / Kilometers

North Carolina State Plane NAD 83 meters coordinate system, Lambert Conformal Conic projection

Base Map Information: Base map is a composite of the USGS GeoPDF 7.5-minute quadrangles covering the County from 2010 and 2011. Air photographs, map collars and select features removed.

This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program under StateMap award numbers 02HQAG0043, 2002; 03HQAG0170, 2003; 04HQAG0059, 2004; 05HQAG0082, 2005; 06HQAG0033, 2006; 07HQAG0140, 2007; 08HQAG0100, 2008; G09AC00183, 2009; and G10AC00425, 2010.





cross section scale: 1:50 000 elevation in feet no vertical exaggeration

GEOLOGIC MAP OF ORANGE COUNTY, NORTH CAROLINA

By Philip J. Bradley, Heather D. Hanna, Norman K. Gay, Edward F. Stoddard, Randy Bechtel, Cindy M. Phillips, Stephen J. Fuemmeler

Map preparation and editing by Philip J. Bradley, Heather D. Hanna and Michael A. Medina Digital representation by Michael A. Medina, Philip J. Bradley and Heather D. Hanna

2016

INTRODUCTION

Pre-Mesozoic crystalline rocks in Orange County are part of the Virgilina sequence of the Neoproterozoic to Cambrian Carolina terrane of the Carolina Zone (Harris and Glover, 1988; Hibbard et al., 2002; and Hibbard et al 2006). In the vicinity of the map area, the Virgilina sequence can be separated into two lithotectonic units: 1) the Hyco Formation and 2) the Aaron Formation. The Hyco Formation consists of ca. 615 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 in Orange and Durham Counties may be divided into lower (ca. 630 Ma) and upper (ca. 615 Ma) members (informal) with an apparent intervening hiatus of magmatism. In southern Orange 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 (not present in Orange County) consists of metamorphosed layered volcaniclastic rocks with youngest detrital zircons of ca. 578 and 588 Ma (Samson et al., 2001 and Pollock, 2007, respectively).

The Virgilina sequence was folded and subjected to low grade metamorphism during the ca. 578 to 554 Ma (Pollock, 2007) 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 Virgilina sequence lithologies are interpreted to range from shallowly to steeply dipping due to open to isoclinal folds that are locally overturned to the southeast. The northwest corner of Orange County is underlain by the Prospect Hill pluton. The Prospect Hill pluton intrudes foliated and folded Hyco Formation units and is correlated with the ca. 546 Ma Roxboro pluton (Wortman et al., 2000).

Map units of meta-volcaniclastic rocks include various lithologies that when grouped together are interpreted to indicate general environments of deposition (or lithofacies). The dacitic lavas and tuffs unit is interpreted to represent dacitic domes and proximal pyroclastics. The felsic tuffs units are interpreted to represent air fall tuffs and associated volcanosedimentary rocks deposited distal from a vent. The andesitic to basaltic lavas and tuffs unit is interpreted to represent eruption of intermediate to mafic lava flows and associated pyroclastic deposits. The epiclastic and epiclastic/pyroclastic units are interpreted to represent deposition from the erosion of dormant and active volcanic highlands.

The Vermiforma antiqua fossil locality reported by Cloud et al. (1976) is present within the Zhe/pl unit in adjacent Durham County along the South Fork of the Little River. Seilacher et al. (2000) indicates the fossil may be a tectograph and not a true fossil.

The southeastern corner of the County is underlain by Triassic-aged sedimentary rocks of the Durham sub-basin of the Deep River Mesozoic basin. Sills and dikes of Jurassic aged diabase intrude the Triassic sediments. Diabase dikes also intrude the crystalline rocks of the County. Quaternary aged alluvium is present in most major drainages throughout the County.

All pre-Mesozoic rocks in Orange County 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. Jurassic diabase dikes are unmetamorphosed.

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. Past workers within the County and adjacent areas (Allen and Wilson, 1968; Black, 1977; Bland, 1972; Butler, 1963 and 1964; Chiulli, 1987; Clark, 1957; Hauck, 1977; Hayes, 1962; Kirstein, 1956; Mann et al., 1965; McConnell, 1974; McConnell and Glover, 1982; Newton 1983; Wagener, 1964 and 1965; and Wright, 1974) have used various nomenclature systems for the igneous rocks. The raw data, when available, of these earlier workers was recalculated and plotted on ternary diagrams and classified based on IUGS nomenclature. Pyroclastic rock terminology follows that of Fisher and Schminke (1984). A preliminary review of the area geology is provided in Bradley et al., 2006a and b. This map is a compilation of modified and edited data from the Orange County portions of the Farrington (Bradley et al., 2007), Bynum (Bradley and Stoddard, 2011), Chapel Hill (Bradley et al., 2004), White Cross (Bradley and Stoddard, 2008), Saxapahaw (Bradley et al., 2011a), Northwest Durham (Bradley et al., 2004), Hillsborough (Bradley and Gay, 2005), Efland (Bradley et al., 2006c), Mebane (Bradley, 2011), Rougemont (Bradley et al., 2011b), Caldwell (Bradley et al., 2010), Cedar Grove (Hanna et al., 2010) and Burlington Northeast (Hanna and Bradley, 2010) geologic maps.

DESCRIPTION OF UNITS

Sedimentary Units

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. Structural measurements depicted on the map within Qal represent outcrops of crystalline rock inliers surrounded by alluvium.

Qcv – Colluvium: Accumulations of angular cobbles and boulders . Possibly formed by Quarternary slope movements in some cases (rock slide, rock fall, etc).

Trcs/si1 – Sandstone with interlayered siltstone of the Chatham Group Lithofacies Association I: Grayish-pink, pinkish-gray, and light-gray; fine- to coarse-grained, micaceous, slightly clayey, moderately poor to moderately well sorted, subangular to subrounded arkose and lithic arkose; dark red to reddish-brown, very silty, micaceous, moderately well sorted, fine-grained sandstone; and dark red to reddish-brown, massive, and thickly laminated, bioturbated, micaceous to very micaceous, siltstone and mudstone. Muscovite flakes up 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 and vertical, cylindrical structures often filled with pale-green, fine-grained, quartz sandstone are interpreted 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 and Watson, 1998. The clastic rocks of Lithofacies Association I are interpreted to have been deposited in a braided stream fluvial system.

Mesozoic to Paleozoic(?) Intrusive Units

Jd – Diabase: Black to greenish-black, fine- to medium-grained, dense, consists primarily of plagioclase, augite and may contain olivine. Occurs as dikes up to 100 ft wide. Diabase typically occurs as spheriodally weathered boulders with a grayish-brown weathering rind. Red station location indicates outcrop or boulders of diabase.

MPzgb – Olivine gabbronorite: Unfoliated, black, medium- to coarse-grained gabbronorite. In thin section, olivine, plagioclase, orthopyroxene and clinopyroxene are present with no apparent metamorphic overprint. In field, rock is similar in appearance to coarse-grained diabase.

Fault Rocks

Trq-breccia – Quartz breccia: White; massive to brecciated; vuggy quartz. Typically contains angular clasts of altered volcanic rock suspended in a quartz matrix. Some zones exhibit a lacey pattern of intersecting quartz veins with a matrix of altered wall rock.

Metaintrusive Units

Pdad – Dacitic dikes: Dark gray to gray, finely crystalline, and locally weakly plagioclase porphyritic dacite dikes ranging from less than one foot to several feet wide.

Padid – Andesite to diorite dikes: Melanocratic to Mesocratic (CI ~50 to greater than 50), dark green to green gray, aphanitic to medium-grained, metamorphosed andesite to diorite. Andesites and diorites are locally plagioclase porphyritic. Typically occur in map area as resistant spheroidal boulders. Locally maybe basaltic to gabbroic. Dike trend lines indicated were strike of dike measured in outcrop or interpreted from adjacent stations. Occur as infestation in Ztgd unit and are present in many more locations than displayed on map.

CZtgd – Prospect Hill tonalitic granodiorite pluton: Unfoliated to locally very weakly foliated, leucocratic (CI less than 10), very light gray to yellowish gray, medium- to coarse-grained, hypidiomorphic granular, metamorphosed tonalitic granodiorite to tonalite. Mafic minerals present in rock are most commonly biotite intergrown with chlorite and/or hornblende intergrown with actinolite. Locally muscovite-bearing. Cross cutting pegmatitic dikes of similar mineralogy present in some areas. Locally biotite forms (magmatic?) foliation. Weathering of rock produces distinctive coarse quartz sand grains in soil. Andesite to diorite dikes (Zadid) are common throughout the pluton and typically occur as resistant spheroidal boulders. Pluton map pattern truncates Virgilina sequence volcanics and pluton contains foliated xenoliths of volcanic rocks; as such, the pluton is interpreted to be related to the ca. 546 ma Roxboro pluton (Wortman et al., 2000).

CZgr-gd - Granite to granodiorite of the Prospect Hill pluton: Unfoliated, leucocratic (CI less than 10), pinkish gray hued, very light gray to yellowish gray, fine- to medium-grained, equigranular to locally plagioclase porphyritic, hypidiomorphic granular, metamorphosed granite to grano-diorite. Major minerals include white feldspars, quartz and ± pink feldspars. Mafic minerals consist of fine-grained biotite/chlorite intergrowths that occur as amorphous masses and acicular shaped zones that resemble amphiboles in hand sample. Mafic mineral clots locally are aligned forming a weak (magmatic?) foliation.

CZgb – Gabbro: Dark green to black, melanocratic, medium-grained gabbro to plagioclase porhyritic fine-grained gabbro. Present as a dike.

East Farrington pluton: The East Farrington pluton is composed of several distinct granitoid facies based on mineral and textural characteristics. U-Pb zircon geochronologic data (Tadlock and Loewy, 2006) indicate that the East Farrington pluton is ca. 579 Ma.

Zefg-m – East Farrington pluton main facies: Unfoliated, orange pink to pinkish-gray to gray, medium- to coarse-grained, equigranular to slightly porphyritic, amphibole (va. hornblende?) granite. Amphibole content varies from approximately 5 to 10% by volume and occurs locally as dark green, elongate crystals up to 1.5 cm long and amorphous intergrowths with feldspar and quartz up to 0.5 cm diameter. Dark gray xenoliths/enclaves up to 8 cm in diameter are common. Grain size becomes finer and xenoliths/enclaves larger near the pluton edge. Cavities, less than 1mm in diameter, with euhedral terminating crystals are common in some specimens. In thin section the main facies can be separated into two groups: 1) rocks with a porphyritic texture with orthoclase and plagioclase phenocrysts in a groundmass of intergrown orthoclase, plagioclase and quartz with a granophyric texture (micrographic texture) and 2) porphyritic and equigranular rocks consisting of orthoclase, plagioclase and quartz without a granophyric texture in matrix. The two varieties appear to be intermingled throughout the study area and within the adjacent Farrington Quadrangle (Bradley et al., 2008).

Zefg-m1 – East Farrington pluton main facies variety 1: Identical to main facies but with dark green, chlorite masses up to 4 mm diameter. In thin section, the chlorite masses are intergrowths of chlorite and dark green, fibrous amphibole.

Zefg-2 – East Farrington pluton porphyritic granite: Gray, fine-grained groundmass with pink- and white-colored phenocrysts (1 mm to 4 mm) of orthoclase and plagioclase, granite. Anhedral to acicular-shaped, dark green, amphiboles (less than 1mm to 4 mm long) present in groundmass of quartz and orthoclase and as intergrowths with orthoclase and plagioclase phenocrysts. Present as several map scale bodies and as outcrop scale enclaves surrounded by East Farrington pluton main facies rock.Zefg-3 – East Farrington pluton fine-grained granite: Orange pink, fine-grained granite. Similar texture and mineralogy to East Farrington pluton main facies but with an overall finer-grained texture. White feldspar phenocrysts compose less than 5% of rock.

Zefg-3 - East Farrington pluton fine-grained granite: Orange pink, fine-grained granite. Similar texture and mineralogy to East Farrington pluton main facies but with an overall finer-grained texture. White feldspar phenocrysts compose less than 5% of rock.

Zefg-4 – East Farrington pluton gray granitoid: Unfoliated to foliated, light gray to light greenish-gray, medium-grained granite to granodiorite. White-colored feldspar content is greater than pink feldspars. Foliated specimens have visible white mica growth and less pink feldspars than unfoliated specimens. Foliated rock is present along portions of Pokeberry Creek, Pritchards Mill Creek and Cumbo Branch.

Zefg-6 – East Farrington pluton satellite granitoid: White, creamy, pale pink, or pale greenish; fine- to medium-grained, locally plagioclase-porphyritic granite, granodiorite, leucogranite, leucogranodiorite, and quartz monzodiorite. Contains distinctive prismatic amphibole crystals, locally acicular and up to one cm. Amphibole-rich enclaves to 2 cm are present locally. At western contact in Heron Pond subdivision, contains enclaves of and cuts fine-grained gray diorite and monzodiorite porphyry of the Zefmd unit.

Zefmd – East Farrington monzodiorite porphyry of Terrells Creek area: Light gray to dark grayish-green where fresh, olive drab weathering, plagioclase-phyric monzodiorite and diorite, typically with very low color index. Fine- to medium-grained groundmass, with phenocrysts to 8 mm. Quartz phenocrysts very rare. Commonly has a cloudy, splotchy, or mottled appearance. Locally contains salmon-colored feldspar phenocrysts and/or orange ovoids interpreted as cavity filling or weathered phenocrysts. May have a thin light beige outer weathering rind. Weathered surface may be pitted. Locally sulfide-bearing, saussuritized, or streaked with tiny epidote veins. Fine-grained near margins.

Zwfd – West Farrington pluton diorite: White to cream-colored, unfoliated, medium- to coarse-grained, with dark green amphibole (actinolite after hornblende) diorite. Locally with chlorite/biotite; dominantly equigranular but locally weakly plagioclase porphyritic; includes quartz diorite, grano-diorite, quartz monzodiorite, and onalite; commonly contains ovoid enclaves of green to black microdiorite to 0.5 m; grades to local patches of more mafic diorite and gabbro; fine dense to slabby hornfelsed country rocks occur locally as enclaves and near contacts; locally strongly saussuritized and pale greenish; white weathering with plagioclase occurring in positive relief giving "bumpy" texture.

HYCO FORMATION

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

Zgr – Granite: Light brownish to beige or creamy, and locally pale pink or green; medium- to coarse-grained, equigranular metamorphosed leucocratic granodiorite and granite; locally weakly porphyritic with beta-quartz forms; grades to quartz porphyry in zones of cleavage development; quartz may be bluish; locally reddish weathering; locally contains epidote and/or chlorite clots possibly pseudomorphic after a hornblende; feldspar and quartz grains resist weathering and produce a bumpy surface; plagioclase and quartz phenocrysts sit in a granophyric matrix of alkali feldspar and quartz. Correlative to the Chatham granite of Hauck (1977) in Bynum Quadrangle.

Zgr2 – Granite: Light pink to pink and orange; fine- to coarse-grained granite. May be foliated.

Zgr-di – Granite to diorite: Composite pluton exhibiting a variety of rock types ranging from granite to diorite. Lithologies include grayish pink, medium- to coarse-grained granite; pinkish-white, medium-grained hornblende granodiorite; and dark-gray, fine- to coarse-grained diorite.

Zgd – Granodiorite: Leucocratic to mesocratic, fine- to medium-grained, equigranular to porphyritic granodiorite. May contain quartz diorite and diorite. Typically contains dark green to black less than 1 mm to 4 mm clots of actinolitic (?) amphibole and chlorite masses. Plagioclase grains are often sericitized and saussuritized 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. Medium-grained, with light pink to pinkish white alkali feldspars (up to 5 mm diameter), porphyritic granodiorite is intermingled in the northern portion of the Chapel Hill quadrangle. Locally, map scale xenoliths are present.

Zgd-fine – Fine-grained granodiorite: Light-gray to green; ranges from equigranular fine-grained (less than 1 mm) granodiorite to very fine-grained porphyritic granodiorite with plagioclase phenocrysts (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.

Zgd-lueco – Fine-grained luecocratic granodiorite: Small pods of tan to light-gray, fine-grained (less than 1 mm), luecocratic granodiorite. Mafics present in rock are commonly biotite clusters up to 1 mm in diameter. Plagioglase mineral grains have a light greenish tint from epidote growth.

Zagd fine- Fine-grained altered granodiorite: Light-green, fine-grained (less than 1 mm), altered intrusive rock interpreted as a granodiorite. Rock is primarily a fine-grained mass of heavily saussuritized plagioclase and quartz with no visible mafic minerals in hand sample. Unit occurs as angular boulders in two small map bodies.

Zgd-gr-p – Granodiorite to granite of Piney Mountain Creek area: Composite pluton of dominantly medium-grained hornblende granodiorite with lesser amounts of medium-grained hornblende granite. Typically contains dark green to black less than 1 mm to 4 mm clots of actinolitic (?) amphibole and chlorite masses. Locally contains pinkish-hued feldspars.

Zgd-di-b – Granodiorite and diorite of the Buckwater Creek Pluton: Composite pluton of dominantly medium-grained, hornblende granodiorite; lesser amounts of medium-grained hornblende diorite, fine-grained granodiorite, and diorite. Unit contains abundant xenoliths of volcanic rock and enclaves(?) of fine-grained granodiorite to diorite.

Zdi-gd-b – Diorite and granodiorite of the Buckwater Creek Pluton: Composite pluton of dominantly medium-grained hornblende diorite; lesser amounts of medium-grained hornblende granodiorite, fine-grained granodiorite, porphyritic diorite with plagioclase phenocrysts; minor amounts of porphyritic granodiorite with plagioclase phenocrysts, porphyritic granodiorite with potassium feldspar phenocrysts, and gabbro. Unit contains abundant xenoliths of volcanic rocks and enclaves(?) of fine-grained granodiorite to diorite.

Zgd-porphyritic - Porphyritic granodiorite of the Buckwater Creek Pluton: Greenish-gray with a pinkish-hue; amphibole-bearing; porphyritic granodiorite with plagioclase phenocrysts. Plagioclase phenocrysts are green from saussuritization and range from 2 to 8 mm in a matrix of very fine-grained quartz and alkali-feldspar. Weathered surface exhibit a distinct strongly porphyritic texture. Porphyritic rhyolite of Newton (1983).

Zgd-gb - Granodiorite to gabbro: Composite pluton of dominantly medium-grained, hornblende granodiorite; lesser amounts of medium-grained hornblende diorite, plagioclase porphyritic granodiorite, fine-grained granodiorite, and diorite; minor amounts of fine-grained gabbro. Fine-grained granodiorite and diorite are typically green in hand sample from saussuritization of plagioclase. Hornblende is typically altered to chlorite and actinolite masses.

Zt-qdi – Tonalite to quartz diorite: Light-gray, fine to medium-grained, hornblende tonalite to quartz diorite. Visible quartz content ranges from 5% up to 20%. Outcrops of this unit are typically finer-grained, lighter in color, and have visible quartz in comparison to typical medium-grained diorite.

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

Zdi-fine – Fine-grained diorite: Small plutonic bodies of green, very fine-grained diorite. The rock is green in hand sample from saussuritization of plagioclase.

Zqmd - Quartz monzodiorite: Greenish-gray to gray, mesocratic, medium-grained, equigranular quartz monzodiorite. Major minerals include plagioclase and hornblende. In field, rock is indistinguishable from typical diorite except for rare pinkish alkali feldspar in some samples (specifically on the south side of Blackwood Mountain). Rock type designation based on recalculated whole rock chemical analyses of Bland (1972).

Zdi-gb – Diorite to Gabbro: Greenish-gray to gray, medium-grained, equigranular, hornblende diorite intermingled with dark-gray to greenish-gray, medium-grained gabbro with pyroxene. Plagioclase crystals are typically saussuritized and exhibit a greenish color. Outcrops with heavily saussuritized plagioclase have a high Color Index causing difficulty in distinguishing between gabbro and diorite in the field.

Zgb – Gabbro: Gabbro of the Meadow Flats pluton is Dark-gray to greenish-gray, mesocratic to melanocratic and medium-grained. Major minerals include plagioclase and augite. In outcrop, the diorites and gabbros are very similar in appearance and are difficult to distinguish from each other. According to Mann, et al (1965), the plagioclase crystals are zoned with cores of An53 and An31 at the margins. Augite grains (present up to 3 mm) are fringed with uralite and are sometimes replaced by hornblende, chlorite, or magnetite. The map pattern of gabbro within the Meadow Flats pluton was drawn incorporating the Bland (1972) whole rock data with field data from this study. A small pod of gabbro is present in the southeast corner of the Hillsborough quadrangle that is dark green, melanocratic and fine-grained.

Zum - Ultramafic: Black, coarse-grained (5 mm to 10 mm), ultramafic rock consisting mainly of poikilitic crystals of relict brown hornblende that are partially replaced by actinolite and chlorite. Other minerals include serpentine, talc, chlorite, actinolite, and opaque minerals. Minor relict orthopyroxene is present. Hayes (1962) interpreted the protoliths as olivine-rich wehrlite (with approximately 50% olivine) and clinopyroxenite. Bulter (1989) interpreted the body to be an intrusion of a crystal mush formed by differentiation of gabbroic magma at depth. Normalized whole rock analysis from a sample collected east of Iron Mine Hill (CH-2027) plots within the olivine-clinopyroxenite field on an Ol/Opx/Cpx ternary diagram.

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)

Zmi – Porphyritic mafic intrusive: Grayish-green to dark-green, very hard, plagioclase porphyritic mafic rock. Greenish-white, euhedral, plagioclase phenocrysts (up to 8 mm) and black amphibole/pyroxene? phenocrysts (up to 2 mm) are present in a green and yellow mottled, very fine-grained (less than 1 mm) matrix. Typically weathers to rounded boulders and outcrops. The plagioclase phenocrysts weather in positive relief, creating a distinctive bumpy or pustulate surface. Newton (1983) identified this unit as an amphibole-porphyry lamprophyre dike.

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 is occasionally mixed with sericite and/or pyrophyllite. The addition of sericite and/or pryophyllite gives the otherwise 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.

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 pyrophyllitized rock. Sericite phyllite, pods of pyrophyllite, and quartz + phyrophyllite rock all with less than 1 mm to 2 mm diameter weathered sulfides are common. Relict lithic clasts and kaolinitized 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.

Zhe - Epiclastics: Mixed unit of metasedimentary rocks. Lithologies present include mudstone, siltstone, sandy siltstone, sandstone, pebbly sandstone, and conglomerate. Mudstones are greenish-gray to gray, typically silicified, with continuous, parallel to slightly wavy, very thin to medium lamina occasionally with small-scale loading structures. Siltstones are light green-gray to gray, with continuous, parallel to slightly wavy, thin lamina to very thin beds, occasionally with small-scale loading structures. The siltstones are composed of quartz, sericite, and traces of a black detrital heavy minerals (less than 1 mm in diameter). Siltstones are typically interbedded with the sandstones. Sandstones are dark-gray, gray, greenish-gray, grayish-green, litharenites and feldspathic litharenites composed of volcanic rock fragments, feldspar, quartz, and rare intrusive rock fragments. Textures range from fine-grained, and well sorted to very coarse-grained, and moderately poorly sorted. Bedding in the sandstones is continuous, parallel to inclined, thin lamina to thin beds; also massive bedding and cross-beds are present. Individual beds are sometimes graded from sand-size to silt-size with abrupt upper surfaces. Conglomerates include matrix supported and clast supported polymictic conglomerate composed of angular to rounded, pebbles to large cobbles (up to 30 cm). Conglomerates are generally massive bedded, rarely with any imbrication of the clasts. Clast types include: dark-gray to gray, angular to subangular, microcrystalline volcanic rock fragments; black, subangular to subrounded, plagioclase-porphyritic dacite; black to dark gray, subrounded, flow-banded dacite; and greenish-gray to grayish-green, rounded to well rounded, fine to coarse plagioclase crystal tuff. Rare clast types include: white, subangular to rounded, granite and granodiorite (up to 12 cm); dark-brown, rounded, vesicular basalt (up to 2.5 cm); and gray, angular siltstone (up to 25 cm). Sandstone and conglomerate beds often fill scour channels in the siltstones.

Zhe-m1 and Zhe-m2 – Morgan Creek epiclastics: Contains well bedded, greenish-gray to gray, siltstone, sandy siltstone, sandstone, conglomeratic sandstone, and conglomerate. The unit was divided into two lithofacies, Ze-m1 and Ze-m2: Zme1 is exposed mainly along Morgan Creek; it is mostly well bedded siltstones with lesser sandstone and conglomerate beds; Ze-m2, occurs to the south and southwest of Ze-m1 and is overall coarser, containing mostly sandstones and conglomerates with lesser well bedded siltstones. Siltstones range from thinly laminated to very thinly bedded (less than 1 mm to 10 mm) with individual beds that can be traced continuously in the outcrops. Sandstone and conglomerate beds often fill scour channels in the siltstones. The conglomerates range from matrix-supported to clast-supported, contain subrounded to rounded lithic clasts of porphyritic dacite, aphanitic volcanic rock, and granitoid in a silt to sand matrix. Individual beds are typically graded from sand-size to silt-size with abrupt upper surfaces.

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.

Zhe/p-d – Mixed epiclastic-pyroclastic rocks of the Duke quarry area: Grayish-green to greenish-gray, massive to strongly foliated, tuffaceous sandstones, conglomeratic sandstones, siltstones, phyllite, tuff and lapilli tuff (locally welded). 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 lithologies include interlayers of amygdaloidal basalt and fine-grained mafic tuffs that have been altered to epidote/chlorite. Unit appears to contain more felsic tuffs than Ze/p unit.

Zhe/p –n - Mixed epiclastic-pyroclastic rocks of Neville Creek area: Heterogeneous unit of felsic to intermediate composition tuffs and lavas, mudstone, siltstone, tuffaceous sandstones and conglomeratic sandstones. Unit appears to contain more andesitic to basaltic lavas and tuffs than Ze/p unit.

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; 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. 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 conglomeratic sandstones typically contain subrounded to angular clasts of dacite in a 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 Ze/p. Cloud et al. (1976) fossil locality from unit in Durham County (Bradley et al., 2011b).

Zhp/e – Mixed pyroclastic-epiclastics: Gray to green, felsic tuffs interlayed with mudstone, siltstone, and sandstone and distinctive immature, monomictic, conglomeratic sandstone to conglomerate containing subangular to angular clasts of plagioclase porphyritic dacite. Minor andesitic to basaltic lavas and tuffs. The contact with the Zhdlt (u) unit is interepreted to be gradational.

Zhdlt (u) – Dacitic lavas and tuffs of the upper portion of the Hyco Formation: Greenish-gray to dark gray, siliceous, aphanitic dacite, porphyritic dacite with plagioclase phenocrysts, and flow banded dacite. Welded and non-welded tuffs associated with the lavas include: greenish-gray to grayish-green, fine tuff, coarse plagioclase crystal tuff and lapilli tuff. Locally, interlayers of immature conglomerate and conglomerate 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, air fall tuffs or reworked tuffs generated during formation of dacite domes. The unit occurs as map scale pods surrounded by clastic rocks of Zhe/p, Zhe/pl or Zhe/p units. 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 within the Rougemont quadrangle (Bradley et al., 2011b).

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 fine-grained tuffs. 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 dacite. Contains lesser amounts of dark gray, aphanitic dacite. Interpreted as shallowly emplaced dacite probably co-magmatic with Zdlt (u) unit.

Zhablt – Andesitic to basaltic lavas and tuffs: Green, gray-green, gray, dark gray and black; typically unfoliated, amygdaloidal, plagioclase porphyritic, amphibole/pyroxene porphyritic and aphanitic; andesitic to basaltic lavas and shallow intrusions. Hyaloclastic texture is common and imparts a fragmental texture similar to a lithic tuff on some outcrops. Locally interlayered with meta-sediments identical to the Zhe/pl and Zhe/p unit.

Zhasi - Andesitic shallow intrusive: Grayish-green to light green, plagioclase porphyritic andesite with a granular-textured groundmass to very fine-grained diorite (with intrusive texture visible with 7x hand lens). Contains lesser amounts of fine- to medium grained diorite. Plagioclase phenocrysts typically range from 1 mm to 4 mm. Dark green to black colored amphibole, when present, occurs as phenocrysts (less than 1 mm to 1 mm) and as intergrowths with plagioclase. Screens of volcaniclastic rocks are commonly present.

Zhabsi – Andesitic to basaltic shallow intrusive: Distinctive; very dark-gray to black; aphanitic groundmass; magnetic; andesite to basalt porphyry. In thin section the rock is composed of a very fine matrix of plagioclase laths and apparent relict amygdules in-filled with epidote and quartz. Present in the Currie Hill area on the Hillsborough quadrangle.

Zhiflt – Intermediate to felsic lavas and tuffs: Heterogenous unit of felsic to intermediate composition tuffs and with lesser interlayers of andesitic to basaltic lavas and epiclastic rocks. Porphyritic andesitic to basalatic lithologies may be shallow intrusions. Felsic tuffs are locally phyllitic. Interpreted as equivalent to the Collins Creek and Collins Mountain units of Hauck (1977).

Metaintrusive rocks associated with Hyco Formation: lower portion (stratigraphic relations uncertain) ca. 630 Ma (Wortman et al., 2000)

Zgr - ch – Granite: Typically massive, fine- to medium-grained with dark green amphiboles (commonly rimmed by epidote and chlorite) and +/- biotite. Light-pink to pink, alkali feldspars are prominent and give the rock a pinkish hue. Orange-pink to grayish-orange pink, fine-grained aplite with a sub-graphitic texture is present in dikes ranging from centimeters to meters in width. Rocks of granitic composition occur primarily within the informally named Chapel Hill pluton. Granite of the Chapel Hill pluton has an interpreted U-Pb zircon crystallization age of 633 +2/-1.5 Ma (Wortman et al., 2000). An unpublished U-Pb zircon age of 631.6 +/- 7.9 Ma was also reported by Mehlop (1994) for the Chapel Hill pluton.

Zgd - ch – Granodiorite: Leucocratic to mesocratic, fine- to medium-grained, equigranular to porphyritic granodiorite. In the central and southern portions of the Chapel Hill quadrangle the granodiorite is mainly whitish-gray, fine- to medium-grained, biotite, +/- hornblende granodiorite with minor pink-colored alkali feldspar. Plagioclase grains are often sericitized and saussuritized and exhibit a greenish color throughout the unit.

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 (l)– 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 pyrophyllitized rock. Sericite phyllite, pods of pyrophyllite, 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 lithic clasts and kaolinitized 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.

Zhmst – Matrix supported tuffs: Green-gray to green; weakly foliated to well foliated; matrix supported; polymictic; lapilli tuffs and tuff breccias. Angular to sub-rounded, lithic fragments range from less than 1 mm up to 0.5 m diameter. Unit is interpreted as a resedimented syn-eruptive volcaniclastic deposit in which texturally unmodified volcaniclastic debris and entrained texturally more mature accidental clasts are incorporated into a rapidly resedimented package of sediment. May be emplaced via submarine mass flows, subaerial landslides and/or lahars. Dacitic to andesitic lavas locally present.

Zhft (l) - Felsic tuffs: Grayish-green to greenish-gray and silvery-gray; massive to foliated volcaniclastic pyroclastic rocks consisting of fine- to coarse tuffs, lapilli tuffs and minor welded tuffs. Tuffs are differentiated from other volcaniclastic rocks by the presence of zones of cryptocrystalline texture that exhibit conchoidal-like fractures in between foliation domains. Layering ranges from massive to thinly bedded. Contains lesser amounts of volcaniclastic sedimentary rocks consisting of volcanic sandstones, and greywackes with minor siltstones and phyllite.

Zhft-b (l) – Felsic tuffs of the Blackwood area: Green-gray to gray coarse tuff and lapilli tuff. Plagioclase crystals and crystal fragments are common. Lithic clast types includes dark-gray to black; magnetic; 1 to 70 mm; cryptocrystalline lava, or clasts of porphyritic lava with feldspar phenocrysts. Porphyritic clasts are identical to the porphyritic phases of unit Zdlt. Outcrops and thin sections show a prominent welding and/or compaction foliation with fiamme-shaped clasts. Outcrops typically occur as very resistant fin-like outcrops.

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

Zhdlt-a – Altered dacitic lavas and tuffs: Gray to dark-gray; massive to foliated, aphanitic rocks. Rare plagioclase crystal fragments are present. 5–10% accessory sulfide minerals commonly present. Rock is relatively featureless. Interpreted as dacitic lavas and tuffs. Present in the Cates Creek area southeast of Hillsborough.

Zhdlt-porph - Porphyritic dacite associated with Zdlt: Dominantly light gray to medium dark gray, porphyritic dacite. Acicular shaped zones of mafic mineral phenocrysts resemble amphiboles in hand sample and consist of fine-grained actinolite/chlorite(?) intergrowths under 20 X magnification. Dacites are locally siliceous and flow banded. Unit may contain tuffs and is interpreted as a very shallow intrusive closely associated with Zdlt domes.

Zhdsi (l) – Dacitic shallow intrusive of the lower portion of the Hyco Formation: Gray-green, light green to green; plagioclase porphyritic dacite with a granular-textured groundmass to micro-granodiorite (intrusive texture visible with 7x hand lens). Contains lesser amounts of fine- to medium grained 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.

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 breccia.

Zhqdp - Quartz dacite porphyry: Strongly porphyritic with aphanitic groundmass and sub- to euhedral phenocrysts (2-6 mm) of white to salmon plagioclase and gray to dark gray (beta-) quartz; phenocrysts typically constitute 20 to 25% of the rock; local weak alignment of plagioclase; interpreted as either lava flows or shallow intrusives possibly associated with domes.

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