Pamphlet to accompany:

NCGS Open File Report 2025-06

Compiled bedrock geologic map of the Chapel Hill 30' x 60' Quadrangle (Chapel Hill 100K), North Carolina (version 10/16/2025)

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2025

Reference:

Bradley, P.J., Thompson, G.J. and Pelt, K.E., 2025, Compiled Bedrock Geologic Map of the Chapel Hill 30' x 60' Quadrangle (Chapel Hill 100K), North Carolina, North Carolina Geological Survey Open-file Report 2025-06, scale 1:100,000, in color, with accompanying pamphlet.

BACKGROUND

This compiled geologic map, partially supported by the U.S. Geological Survey (USGS), National Cooperative Geologic Mapping Program under STATEMAP completes a multi-year project to compile the entire bedrock portion of the Chapel Hill 30'x 60' Quadrangle (Chapel Hill 100K) in support of the USGS US Geoframework Initiative's (USGI) vision for a nation-wide, seamless geologic map.

The goal of this compilation effort was to produce a new 1:100,000-scale digital geologic map of the study area using the USGS Geologic Mapping Schema (GeMS). When available, geologic data at scales more detailed than 1:100,000-scale were used (i.e. 1:24,000-scale data). FY21 phase of the compilation effort compiled data from detailed geologic mapping at the 1:24,000-scale in Chatham County. The FY22 phase of the compilation effort, included compilation work and new mapping at the 1:50K scale.

The FY23 phase of the compilation effort compiled legacy data at scales ranging from 125K- to 24K-scale. From July 2023 to June 2024, NCGS staff conducted targeted foot and vehicle traverses to validate contacts from the legacy sources and to collect new field data. Close attention was paid to rectifying edge-match issues between legacy data and recent 24K-scale mapping to allow accurate transitions of map units from areas with detailed data to areas of legacy data collected at smaller scales (e.g. 48K). More detailed and closer spaced traverses targeted areas of structural or stratigraphic complexity. Less detailed and wider spaced traverses were used in areas of less complex structure or rock types (e.g. areas underlain by homogenous plutons received less attention). LiDAR data displayed as hillshade was used to help identify lineaments and possible faults and dikes that may be groundwater sources or preferred pathways for groundwater contaminants. Additional edits were made in FY24 to the map; a few contacts were adjusted and some geologic units were reassigned based on mapping activities in the Southern Pines 100K. Future adjustments to the map and geologic units will occur as geochronology data is made available and refinement of the stratigraphy occurs.

PAST WORKERS

Specific data sources are listed in the DataSources table in the geodatabase. Individual open-file reports include additional references. Major data sources are provided in the index of workers figure on the map layout.

GEOLOGIC SETTING

The Chapel Hill 100K is underlain by five major geologic elements (see figure on map). From west to east they are: the Charlotte terrane, Carolina terrane, Deep River Triassic basin, the Easternmost Carolina terrane and small areas of Coastal Plain sediments. Coastal Plain sediments overlay units within the Deep River Triassic basin and the easternmost Carolina terrane. Older alluvium deposits are present along major drainages in addition to modern floodplain deposits. The map is a compiled bedrock map. Surficial sediments are not displayed but are provided in the GeMS database.

CHARLOTTE TERRANE

The Charlotte terrane (Hibbard et al., 2002) underlies the northwestern portions of the map area. The original contact between the Charlotte and Carolina terranes is obliterated by the intrusion of a granodiorite body (map unit Zgd-CHT and Zgd-CT). The contact is poorly located and is designated on the occurrence of gneissic xenoliths (Charlotte terrane side of contact) and metavolcanic xenoliths (Carolina terrane side of contact) present in the granodiorite. Several map-scale and abundant outcrop-scale xenoliths(?) of metamorphosed basalt, diorite and altered rocks are present throughout the map area in the Charlotte terrane. Intermediate to mafic metavolcanic rocks (Map unit CCv2) in the northwest corner of the map are interpreted to be related to the Albemarle arc of the Carolina terrane and were likely deposited on an already amalgamated, uplifted and eroded Charlotte and Carolina terranes.

CAROLINA TERRANE

The Carolina terrane underlies the largest area within the Chapel Hill 100K. The Carolina terrane is composed of Neoproterozoic to Cambrian metamorphosed volcanic, volcano-sedimentary, sedimentary and intrusive rocks (Hibbard et al., 2002; and Hibbard et al., 2006). The Carolina terrane is separated into three lithotectonic units: 1) the Hyco arc, 2) the Aaron Formation of the redefined Virgilina sequence (Hibbard et al., 2013) and 3) the Albemarle arc (Hibbard et al., 2013).

COMPILED U-Pb GEOCHRONOLOGY DATES FOR THE CAROLINA TERRANE IN THE CHAPEL HILL 100K

As part of the compilation efforts within the Chapel Hill 100K, U-Pb crystallization age and detrital zircon age data was compiled. Additionally, through STATEMAP support (FY23 and FY24), new samples were collected and have been analyzed. Geochronologic data is summarized in Table 1 with references. Sample locations are identified and labeled on the geologic map.

Table 1: Summary of available age dates in the Chapel Hill 100K. Refer to main map for sample locations.

Label	Sample ID	Rock Type	Major Unit	Date	Source	Comments
A-1	UNC Chapel Hill sample DPF-14-02	brecciated rhyolite (dacite)	Hyco Formation	636.0 ± 2.3 Ma with a MSWD of 1.2	U-Pb zircon date (Barefoot, 2015)	Unpublished senior thesis
A-2	UNC Chapel Hill Sample DFP-14-03	gabbro	Hyco Formation intrusive	630.8 ± 3.2 Ma with a MSWD of 3.7	U-Pb zircon date (Barefoot, 2015)	Unpublished senior thesis
B	UNC Chapel Hill Sample WCP-14-02	Porphyritic granodiorite	Hyco Formation intrusive	640.9 ± 2.4 Ma with a MSWD of 0.88	U-Pb zircon date (Barefoot, 2015)	Unpublished senior thesis
C	Chapel Hill Granite	granite	Hyco Formation intrusive	633 ± 2.0/1.5 Ma	U-Pb zircon date (Wortman et al., 2000)	
D	NCGS Station CH-2311	dacitic tuff	Hyco Formation volcanic	630 ± 1 Ma	U-Pb zircon date (Bradley and Miller, 2011)	
E	UNC Chapel Hill Sample FP-AP-05	granodiorite	East Farrington pluton	578.7 +/- 5.5 Ma (MSWD = 1.30, n = 6)	U-Pb zircon date (Tadlock and Loewy, 2006)	
F	Flow banded rhyolite	dacite	Hyco Formation volcanic	632.9 +2.6/-1.9 Ma	U-Pb zircon date (Wortman et al., 2000)	
G	NCGS Station WX-1139	dacite	Hyco Formation volcanic	628.5 ± 1 Ma	U-Pb zircon date (Bradley and Miller, 2011)	
H	UNC-Chapel Hill sample EF19-01	granodiorite	East Farrington Pluton	569.0 ±1.1 Ma	U-Pb zircon date (Goliber and Coleman, 2023)	
I	UNC Chapel Hill Sample TC-14-01 Granodiorite	granodiorite	xenolith of older pluton in West Farrington Pluton	651.0 ± 3.4 Ma	U-Pb zircon date (Barefoot, 2015)	
J	SAX-1	granite	Greensboro Intrusive Suite (?) - Saxapahaw pluton	605 ± 7.4 Ma	U-Pb zircon date (Ingle et al., 2003)	
K	SB-5	dacite	Hyco Formation volcanic	618.1 ± 3 Ma	U-Pb zircon date (Ingle et al., 2003)	
L	NCGS Station CH100K-2962	granodiorite	Greensboro Intrusive Suite (?)	591.2 ± 3.8 Ma (MSWD = 1.9)	U-Pb zircon date by AZ LaserChron with data interpretation by A. Curry (2024), preliminary data	Foliated xenoliths in outcrop area
M	NCGS Station Bear Creek-626	sandstone	Albemarle Arc	Maximum Depositional Ages (MDAs) are between ca. 551 Ma and ca. 560 Ma (T. LaMaskin,	detrital zircon dates (AZ LaserChron). Preliminary report in Pelt and Bradley, 2023. Additional data analysis by T.	No or sparse quartz crystals - possible distal sedimentation off of Albemarle arc

				personal communication, 2025)	LaMaskin, personal communication, 2025	
N	NCGS Station Coleridge-3055	sandstone	Albemarle Arc	Distinct age distribution that is < 600 Ma and all MDAs are between ca. 545 Ma and ca. 549 Ma (T. LaMaskin, personal communication, 2025)	detrital zircon dates (AZ LaserChron). Preliminary report in Pelt and Bradley, 2023. Additional data analysis by T. LaMaskin, personal communication, 2025	Abundant quartz crystals
O	NCGS Station Bennett-710	tuff	Albemarle Arc	548.7 ± 1.1 Ma	U-Pb zircon date (Goliber and Coleman, 2023)	
P	Aaron Formation sample (Pollock et al., 2010)	conglomerate	Aaron Formation (lower portion)	youngest detrital zircon of 588 ± 11 Ma	detrital zircon date (Pollock et al., 2010)	Distinctive conglomerate
Q	NCGS Station Coleridge-472	sandstone	Albemarle Arc	MDA - ca. 554 Ma	detrital zircon dates (USC-Columbia). Data interpretation by A. Curry (2025), preliminary data	
R	UNC Chapel Hill sample NC-18-02 / NCGS Station Coleridge-458	felsic dike or tuff	Albemarle Arc	550.1 ± 2.4 Ma and 550.7 ± 1.3 Ma for two grains	U-Pb zircon date (R. Mills, personal com., 2018)	Adjacent to Coleridge-8005
S	NCGS Station Coleridge-8005	sandstone	Albemarle Arc	MDA - ca. 559 Ma	detrital zircon dates (USC-Columbia). Data interpretation by A. Curry (2025), preliminary data	
T	NCGS Station Bennett-165	sandstone	Albemarle Arc	MDA - ca. 552 Ma	detrital zircon dates (USC-Columbia). Data interpretation by A. Curry (2025), preliminary data	
U	UNC Chapel Hill sample Parks Crossroads Granodiorite / NCGS Sample PCX-1	granodiorite	Parks Crossroads Pluton (Albemarle Arc)	551.86 ± 0.88 Ma	U-Pb zircon date (Morrison and Coleman, 2023)	
V	FB	andesitic tuff	Albemarle or Hyco Arcs (?)	575 ± 27 Ma	U-Pb zircon date (Ingle et al., 2003)	
W	NCGS Station CH100K-3675	sandstone	Albemarle Arc	MDA - ca. 533 Ma	detrital zircon dates (AZ LaserChron). Data interpretation by A. Curry (2025), preliminary data	Abundant quartz crystals
X	NCGS Station CH100K-3839	tuffaceous conglomeratic sandstone	Albemarle Arc	MDA - ca. 523 Ma	detrital zircon dates (AZ LaserChron). Data interpretation by A. Curry (2025), preliminary data	NC Zoo Property

Y	"Uwharrie Formation" sample of Pollock et al. (2010)	pebble conglomerate	Albemarle Arc	youngest detrital zircon of 545 ± 7 Ma	detrital zircon date (Pollock et al., 2010)	Yow Mill area
Z	NCGS Sample ChapelHill100K-Seagrove1	rhyodacite	Albemarle Arc	536.4 ± 6.1 Ma (MSWD = 4.5)	U-Pb zircon date by AZ LaserChron with data interpretation by Bradley et al., 2025	
AA	NCGS Station CH100K-3834	sandstone	Albemarle Arc	MDA - ca. 523 Ma	detrital zircon dates (AZ LaserChron). Data interpretation by A. Curry (2025), preliminary data	North Asheboro Park - Uppermost Uwharrie Formation
BB	NCGS Station CH100K-3838	rhyodacite	Albemarle Arc	548.8 ± 2.8 Ma (MSWD = 1.4)	U-Pb zircon date (AZ LaserChron). Data interpretation by A. Curry (2025), preliminary data	Daves Mountain in Asheboro
CC	SB-7	"dacite" (rhyodacite)	Albemarle Arc	553 ± 20 Ma	U-Pb zircon date (Ingle et al., 2003)	Identified as a dacite in the Tillery Formation (Ingle et al., 2003)
DD	NCGS Sample ChapelHill100K-Caraway Mtn 1	rhyodacite	Albemarle Arc	542.7 ± 5.3 Ma (MSWD = 0.5)	U-Pb zircon date by AZ LaserChron with data interpretation by Bradley et al., 2025	Caraway Mountain
EE	SMG (Stony Mountain Gabbro)	gabbro	Albemarle Arc – Stony Mountain Gabbro	U-Pb TIMS 206Pb/238U date of 544.81 ± 0.55 Ma, and a 207Pb/235U date of 544.73 ± 0.95 Ma	DeDecker et al., 2013	Ridges Mountain
FF	NCGS Station CH100K-3840	rhyodacite	Albemarle Arc	537.4 ± 5.7 Ma (MSWD = 0.86)	U-Pb zircon date (AZ LaserChron). Data interpretation by A. Curry (2025), preliminary data	Luther Place Trail area (Forest Service trail)
GG	DRC-90-1 at 550 to 555 feet	felsic porphyritic dike	Albemarle Arc dike	Two zircon populations 550.27 ± 0.74 Ma and 547.00 ± 0.83 Ma	U-Pb zircon dates (Rapprecht, 2010)	Date from dike intruding Hyco Formation units
GG	DRC-07-6, DRC-07-7, DRC-07-4	molybdenite samples	Albemarle Arc mineralization	539 ± 2 Ma (DRC–07–6), 532 ± 2 Ma (DRC–07–7), 543 ± 2 Ma (DRC–07–4)	Re-Os dates of molybdenite (Rapprecht, 2010)	Same area as GG

HYCO ARC AND THE HYCO FORMATION

In the map area, the Hyco Arc consists of the Hyco Formation which includes ca. 633 to 612 Ma (Wortman et al., 2000; Bowman, 2010; Bradley and Miller, 2011 and Bowman et al., 2013) metamorphosed layered volcaniclastic rocks and plutonic rocks. Dating by Barefoot (2015), indicates that magmatism in the lower portions of the Hyco Formation may be as old as ca. 650 Ma. Available age dates (Wortman et al., 2000; Bradley and Miller, 2011) indicate the Hyco Formation may tentatively be divided into lower (ca. 630 Ma) and upper (ca. 615 Ma) portions with an apparent intervening hiatus of magmatism.

Map units of metavolcanic and metavolcaniclastic rocks include various lithologies that when grouped together are interpreted to indicate general environments of deposition. The dacitic lavas and tuffs unit is interpreted to represent dacitic domes and proximal pyroclastics. The andesitic to basaltic lavas (with tuffs or conglomerates) units are interpreted to represent eruption of intermediate to mafic lava flows and associated pyroclastic and/or epiclastic deposits. The epiclastic/pyroclastic units are interpreted to represent deposition from the erosion of dormant and active volcanic highlands. Deposition of the primary volcanics ranged from subaerial to subaqueous with concomitant deposition of various types and volumes of volcanic-derived sediments. Some of the metavolcaniclastic units within the map area display lithologic relationships similar to dated units present in northern Orange and Durham Counties. Due to these similarities, the metavolcanic and metavolcaniclastic units have been tentatively separated into upper and lower portions of the Hyco Formation; geochronologic data in the map area is needed to confirm this interpretation.

Generally, rock units of the Hyco Formation consist of packages of metamorphosed volcanic rocks and their volcanosedimentary detritus. Hyco Formation volcanic rocks and sedimentary rocks are quartz crystal *poor* or quartz is absent in hand sample. In contrast (discussed in a later section), the Aaron Formation sedimentary rocks and Uwharrie Volcanics and volcanosedimentary rocks range from quartz crystal-rich to having quartz locally present.

HYCO ARC PLUTONS

The best characterized plutons interpreted to be associated with the Hyco arc are present in the northeast corner of the map area within the Chapel Hill 1:24K Quadrangle and include the Chapel Hill Pluton and several unnamed plutons. Granite of the Chapel Hill pluton has an interpreted U-Pb zircon crystallization age of 633 +2/-1.5 Ma (Wortman et al., 2000) and an unpublished U-Pb zircon age of 631.6 +/- 7.9 Ma reported by Mehlop (1994). Barefoot (2015) in an unpublished senior thesis reports U-Pb ages of Ca. 631, 641 and 651 Ma from a diorite (reported as a gabbro), a granodiorite porphyry and a xenolith within the Farrington Pluton; respectively.

FARRINGTON IGNEOUS COMPLEX

The northeastern portion of Chatham County (and adjacent Orange County) is dominated by the Farrington igneous complex. The Farrington igneous complex consists of several map-scale plutons that are grouped into the East and West Farrington plutons. Wagener (1964 and 1965) conducted a study on the modal variation in the Farrington igneous complex. The East Farrington pluton is composed dominantly of granite to granodiorite with several map-scale facies with distinct mineral and textural characteristics. Two age dates are available for the East Farrington pluton: a recent date of 569.0 ± 1.1 Ma from Goliber and Coleman (2023) and a previous date of ca. 579 Ma (Tadlock and Loewy, 2006) in Orange County. The West Farrington pluton is a gradationally zoned composite pluton (Ragland and

Butler, 1972) that is characterized by diorite in the northern portions of the map, diorite to granodiorite along its southwestern margins, and leucogranodiorite in the central portions of the pluton.

The intrusive relationships between the different phases of the East and West Farrington plutons are not well understood. Additional information on the phases of the Farrington igneous complex can be found in the Bynum and Farrington geologic maps (Bradley et al., 2013 and Bradley et al., 2007, respectively).

OTHER PLUTONS

Two age dates from plutons within the Carolina terrane are outside of accepted age ranges for the Hyco (Ca. 610 - 630 Ma) and Albemarle (Ca. 550 - 530 Ma) arcs. The ages are Ca. 591 Ma for a granodiorite (Geochron sample point "L" on map; NCGS Station CH100K-2962) from unit Zgd-CT and Ca. 605 Ma from a granite (Ingle et al., 2003) (geochron sample point "J" on the map; Sax-1) from unit Zsgr. The significance of these ages are unknown.

Discussion about other plutons: The terrane boundary between the Carolina and Charlotte terranes is interpreted to be present in the northwestern portion of the Chapel Hill 100K. The contact between the Charlotte and Carolina terranes is obliterated by the intrusion of a granodiorite body. The granodiorite is mapped as Zgd-CT (in the Carolina terrane) and Zgd-CHT (in the Charlotte terrane). These map units underlay the majority of the northwest portion of the Chapel Hill 100K. Preliminary mapping in the southwest portion of the Greensboro 100K (located immediately north of the Chapel Hill 100K) indicates the pluton continues to the north. The pluton is part of the poorly defined Greensboro Intrusive Suite (Hibbard et al., 2006). The Charlotte and Carolina terranes contact is poorly located and is designated on the occurrence of gneissic xenoliths (Charlotte terrane side of contact) and metavolcanic xenoliths (Carolina terrane side of contact) within the granodiorite. The ca. 591 Ma date is from a granodiorite from this unit and may be a stitching pluton. The ca. 605 Ma date may be a younger Hyco arc pluton or related to the magmatism associated with the Charlotte and Carolina terrane contacts.

AARON FORMATION

Harris (1984) and Harris and Glover (1988) mapped significant areas within the map area as being part of the Aaron Formation. NCGS mapping in the Chatham County portion of the Chapel Hill 100K grouped rocks similar to those sampled for detrital zircon analysis by Pollock et al. (2010) and distinctive quartz-bearing sandstones and other interlayered sedimentary rocks as described by Harris (1984) into the Aaron Formation (Bradley et al., 2017 (Siler City); Bradley et al., 2018 (Coleridge); Bradley et al., 2019a (Bennett) and Bradley et al., 2019b (Bear Creek)).

Results of detrital zircon data collected in 2022 (Bradley, 2023 and Pelt and Bradley, 2023), required the re-evaluation of areas mapped as Aaron Formation since large portions are much younger than previously interpreted. For the compiled Chatham County map (Bradley et al., 2022c) and this compiled 100K map, conglomerates and related rocks proximal to the contact with the Hyco Formation and including the detrital zircon sample location (geochronology data location P) of Pollock et al. (2010) were included in the newly revised Aaron Formation map unit.

Implications on the Aaron Formation for Other Areas in the Carolina Terrane

Geologic compilation work in 2022-2023 in the type area of the Aaron Formation to the south of Virgilina, VA noted the striking resemblance of the abundant quartz-bearing sandstones in the Aaron Formation to those in Chatham County and the Chapel Hill 100K. This is understandable inasmuch as Harris and Glover (1988) extended the Aaron Formation into Chatham and Randolph Counties. The new detrital zircon data from the map area has led to the reassignment of units identified as Aaron Formation to the Albemarle arc (tentatively assigned to the Seagrove formation). To test if portions of the Aaron Formation in the type area of the Virgilina Syncliorium may be Albemarle arc related, a sample of meta-sandstone in the Aaron Formation from the east limb of the Virgilina Syncliorium was collected for detrital zircon analysis and forwarded to the University of Arizona LaserChron Center. Preliminary LA-ICP-MS U-Pb zircon analyses from the meta-sandstone indicates all Maximum Depositional Ages (MDA) are between ca. 540 Ma and ca. 545 Ma (T. LaMaskin, personal communication, 2025). As such, large portions of the Aaron Formation in the type locality may be Albemarle arc related putting the stratigraphic placement of the Aaron Formation in question.

ALBEMARLE ARC UNITS

Age relationships between rocks mapped as Uwharrie Formation (Conley and Bain, 1965; Stromquist and Sundelius, 1969) and the Albemarle Group (Milton, 1984) are unclear. Traditionally, the Uwharrie Formation has been viewed as being the older substrate to the Albemarle Group (e.g. Butler and Secor, 1991); this interpretation is supported by recent models of intra-arc rifting (Moye, 2023). However, radiometric ages from rocks mapped as Uwharrie Formation suggest that rocks of the Uwharrie Formation and Albemarle Group overlap in age, forming a time transgressive sequence (Pollock et al., 2010 and Hibbard et al., 2013). Before the mapping and new geochronology of this study, the stratigraphic relationships of the rocks yielding younger than expected ages to the bulk of the Uwharrie Formation were not confidently established. The goals of this new mapping and compilation work was to compile existing maps, rectify edge-match issues, and to collect rock samples for modern geochronologic analysis to start to better define the Uwharrie Formation and its relationship to adjacent units.

Stratigraphically, the main outcomes of this new study is the elevation of the Uwharrie Formation to Group status, the reassigning of rocks of the Uwharrie Formation to the Uwharrie Volcanics, the establishment of the Seagrove formation and the adoption of the nomenclature of the Morrow Mountain Rhyodacite Suite (discussed below in more detail). Refinement of the stratigraphy is ongoing.

MORROW MOUNTAIN RHYODACITE SUITE

The Morrow Mountain rhyodacite suite is a suite of intrusions with a range of ages and textures that are likely magmatically linked (Boorman et al., 2013 and Moye, 2023b). For this mapping, isolated bodies of rhyodacite surrounded by volcanosedimentary rocks were grouped as part of the suite. Texturally similar bodies are also present in areas mapped as part of the rhyodacitic lavas and tuffs unit of the Uwharrie Volcanics (discussed below).

A summary of existing and new age dates within the Chapel Hill 100K map are provided in Table 1. For a summary of existing and new aged dates in the Southern Pines 100k, see the Open-file report of the Southern Pines 100K.

Ingle et al. (2003) reported TIMS $^{207}Pb/^{206}Pb$ ages of 539±5 Ma for the Morrow Mountain rhyodacite in the Charlotte 100K. Bradley et al. (2025), reported LA-ICP-MS $^{206}Pb/^{238}U$ weighted means ages for two samples in the Chapel Hill 100K: A sample from the Seagrove area yielded an age of 536.4 ± 6.1 Ma (MSWD =4.5) and a sample from Caraway Mountain yielded and age of 542.7 ± 5.3 Ma (MSWD = 0.5).

New and unpublished, LA-ICP-MS $^{206}Pb/^{238}U$ weighted means ages completed in 2025 from samples from the suite include: 548.8 ± 2.8 Ma (MSWD = 1.4) for a sample collected from Daves Mountain in Asheboro (geochronology data location BB); 550.4 ± 4.2 Ma (MSWD = 0.44) for a sample collected from the Robbins area (Southern Pines 100K); and 553.2 ± 2.5 Ma (MSWD = 1.6) for a sample collected near the landfill in the Troy area (Southern Pines 100K). Additionally, two samples were analyzed from the eastern portion of the Charlotte 100K in the vicinity of Dennis Mountain in the Uwharries. LA-ICP-MS $^{206}Pb/^{238}U$ weighted means ages from the samples yielded: 539.4 ± 1.8 Ma (MSWD = 1.6) (sample CLT100k_BoormanE7_CGS6) and 546.0 ± 3.1 Ma (MSWD = 1.6) (sample CLT100k_BoormanE9_CGS7).

The previously existing and new age data indicate that volcanism of the Morrow Mountain Rhyodacite suite spanned from ca. 553 Ma to ca. 536 Ma and was contemporaneous with the Uwharrie Volcanics and deposition in the Albemarle Group.

UWHARRIE GROUP

The Uwharrie Formation has been elevated to Group status and rocks associated with the Uwharrie Formation have been reassigned to the Uwharrie Volcanics general unit. Contemporaneous with the Uwharrie volcanics was the deposition of volcaniclastic debris into an adjacent sedimentary basin; here named the newly defined Seagrove formation (Figure 1 and 2).

New mapping in the Chapel Hill and Southern Pines 100Ks, where the Albemarle arc overlaps the Hyco arc, has confirmed the interpretation of Harris (1984) of the presence of a coarse-grained (sand-rich) submarine fan system that is contemporaneous with felsic and intermediate to mafic volcanism. Large portions of the map area, as depicted by Harris and Glover (1988), were previously assigned to the Aaron Formation. New data suggests the submarine fan system is linked to the Albemarle arc and has been designated as the newly defined Seagrove formation. Recent mapping interprets the source of much the Seagrove formation as the volcanic rocks of the Uwharrie Volcanics.

This study establishes the Uwharrie Group of the Albemarle arc, a stratigraphic package that includes the volcanic and volcaniclastic rocks of the Uwharrie Volcanics and the Seagrove formation units (Figure 1 and 2). The rocks of the Uwharrie Volcanics represents the source area and the Seagrove formation represents the submarine fan deposits. The Uwharrie Group volcanism and sedimentation was likely contemporaneous with the Albemarle Group deposition. Additional work is needed on the nature of the Aaron Formation, if the Aaron Formation turns out to be wholly Albemarle arc related, the Seagrove formation nomenclature can be abandoned.

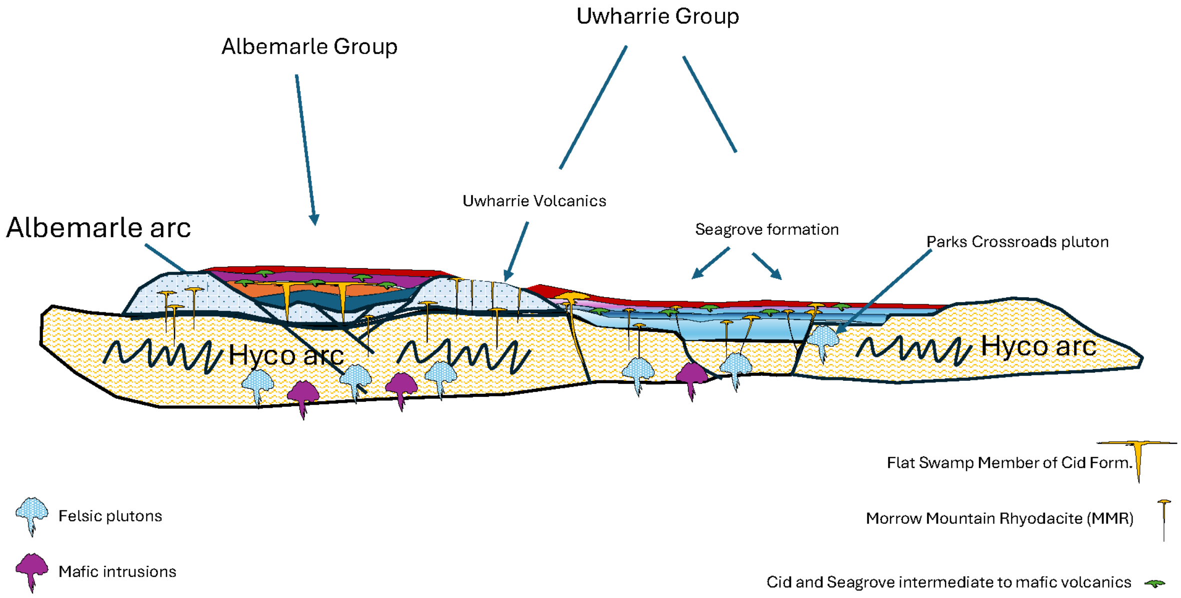

Figure 1: Sketch of proposed Uwharrie Group and relationship to the Albemarle Group. Uwharrie Group includes Uwharrie Volcanics units and newly defined Seagrove formation units – ca. 560 to 523 Ma.

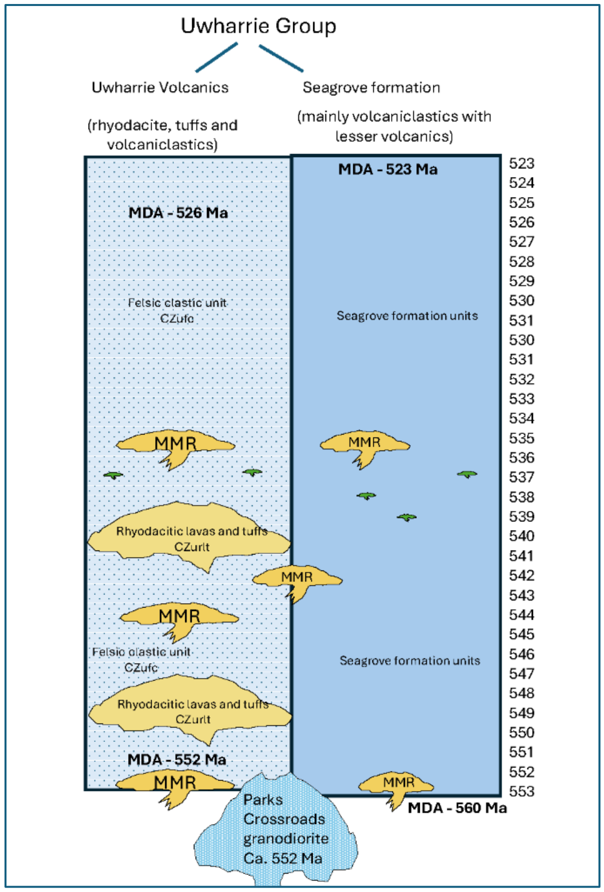

Figure 2: Generalized stratigraphy of the Uwharrie Group consisting of the Uwharrie Volcanics and the Seagrove formation.

SEAGROVE FORMATION (informal name)

Extensive areas identified as Aaron Formation by Harris (1984) and Harris and Glover (1988) have been tentatively assigned to the newly defined Seagrove formation (this map). An overall defining characteristic of the Seagrove formation is the presence of quartz bearing conglomerates, conglomeratic sandstones and sandstones interlayered with varying amounts of finer-grained volcaniclastic sediments that include bedded siltstones and mudstone. Individual units of the Seagrove formation are generally defined by the abundance of coarse-grained clastic sediments with respect to fine-grained clastic sediments. Proximal facies (proximal to Uwharrie Volcanics units) are dominated by immature tuffaceous conglomerates, conglomeratic sandstones and sandstones with abundant clasts of rhyodacite and crystal fragments of plagioclase and quartz. Quartz crystal content locally varies. Medial to distal facies are dominated by conglomeratic siltstones (graywacke), sandy siltstones, siltstones and bedded siltstone and mudstone. Lenses of quartz bearing conglomeratic sandstones and sandstones are locally present (Figure 3).

Data from the Seiders (1981) map in the Asheboro area was utilized in the compilation effort for the Chapel Hill 100K and on-strike units in the Southern Pines 100K. Following accepted regional stratigraphy, Seiders (1981) separated his units, from oldest to youngest, into the Uwharrie Formation and the Tillery and Cid Formations of the Albemarle Group (Stromquist and Sundelius, 1969 and Milton, 1984). The units of Seiders (1981) were maintained for the most part except in areas where new or recent age dates required modifications (ex. portions of the unit CZufc (felsic volcaniclastic rocks) on the east side of the Seiders (1981) map were reassigned to the Seagrove formation and CZups (porphyritic felsite near Seagrove) was reassigned to the Morrow Mountain Rhyodacite).

Seagrove formation new geochronology data

Pollock et al. (2010) reported a youngest detrital zircon of ca. 545 Ma. from the Erect member of the Uwharrie Formation (now included in the Seagrove formation). Recent, LA-ICP-MS U-Pb zircon analyses from sandstones from Seagrove formation units in the Chapel Hill 100K indicate the presence of abundant detrital zircons associated with the Albemarle arc (Bradley, 2023; Pelt and Bradley, 2023). Additionally, a re-evaluation of these zircon analyses yield the following: for NCGS sample Coleridge-3055, there is a distinct age distribution that is < 600 Ma and all Maximum Depositional Ages (MDA) between ca. 545 Ma and ca. 549 Ma; for NCGS sample Bear Creek-626, all MDAs are between ca. 551 Ma and ca. 560 Ma (T. LaMaskin, personal communication, 2025).

New and unpublished, LA-ICP-MS U-Pb zircon analyses from additional Seagrove formation unit samples in the Chapel Hill and Southern Pines 100K map areas include: MDA of 559 Ma for sample COL-8005 in the Chapel Hill 100K; MDA of 554 Ma for sample COL-472 in the Chapel Hill 100K; MDA of 543 Ma for sample SP100K-550363 in the Southern Pines 100K; MDA of 533 Ma for sample CH100K-3675 in the Chapel Hill 100K; MDA of 526 Ma for sample CH100K-3834 in the Chapel Hill 100K; MDA of 524 Ma for sample SP100K-550946 in the Southern Pines 100K; and MDA of 523 Ma for sample CH100K-3839 in the Chapel Hill 100K. A summary of existing and new age dates within the Chapel Hill 100K map are provided in Table 1. For a summary of existing and new aged dates in the Southern Pines 100k, see the Open-file report of the Southern Pines 100K.

The previously existing and new age data indicated that sedimentation of the Seagrove formation spanned from ca. 560 Ma to ca. 523 Ma and was contemporaneous with the Uwharrie Volcanics and deposition in the Albemarle Group.

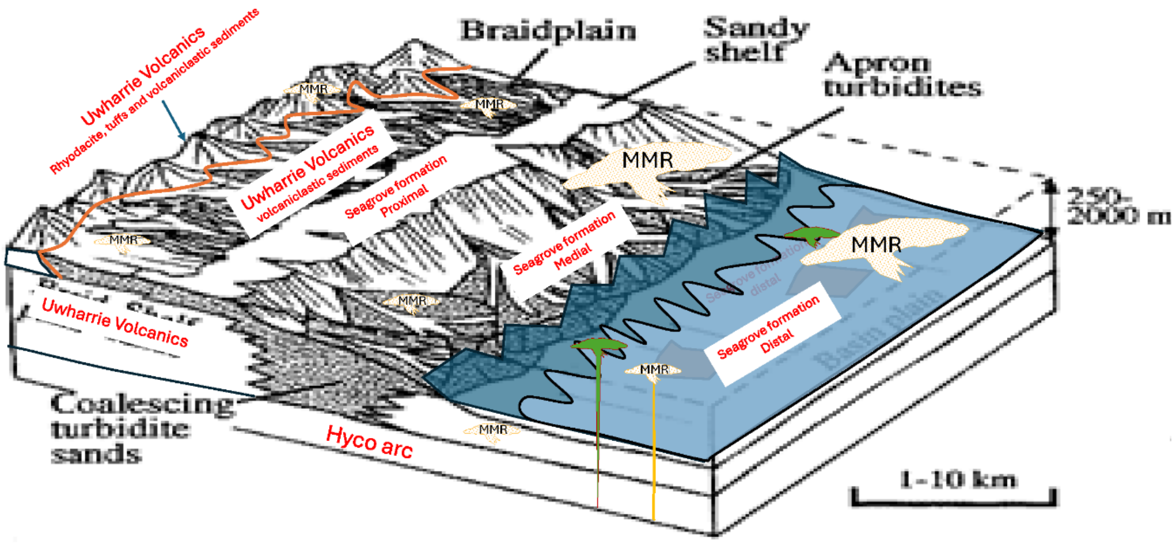

Figure 3: Preliminary interpretation of environment of deposition of the newly defined Seagrove formation. Base figure borrowed from Stow and Mayall (2000) and Reading and Richards (1994) of a sand-rich submarine fan system.

UWHARRIE VOLCANICS (informal name)

Seiders (1981) separated the Uwharrie Formation into multiple units that include metamorphosed felsic lavas, dikes and volcanic necks of varying textures and associated coarse-grained volcaniclastic pyroclastic and sedimentary rocks. The volcaniclastic rocks include metamorphosed tuffaceous sandstones, conglomeratic sandstones, siltstones with lesser amounts of fine- to coarse tuff. Fiamme-like shaped clasts are common in the conglomerates, sandstones and tuffs. Quartz and feldspar crystal fragments are common in the sedimentary components, tuffs and lavas. Subordinate amounts of intermediate to mafic volcanic and volcanosedimentary rocks and find grained clastics (siltstones and mudstones) are present in the Uwharrie Formation units of Seiders (1981).

Previous geochronological data indicated that the Uwharrie Formation was ca. 550 Ma (Ingles et al., 2003). Pollock et al. (2010), reported a youngest detrital zircon age of ca. 545 Ma from a sample reportedly from the oldest portions of the Formation. Hibbard et al. (2013) speculated that the Uwharrie Formation may be time transgressive or previous mapping was in error and that additional geochronologic and mapping work was needed to properly determine the extent and nature of the Uwharrie Formation. Recent geochronologic data from rocks assigned to the Uwharrie Formation indicate that problems exist with the definition of the Formation. Detrital zircon and crystallization ages from this study indicate that units previously interpreted as intrusive into surrounding volcaniclastic units are in disconformable contact (e.g. - Daves Mountain in Asheboro is older than the surrounding clastic unit). Additionally, a sample of rhyodacite from the "core" of the Uwharrie Formation yields a crystallization age of ca. 537 Ma (geochronology data location FF) which is inconsistent with the area being the oldest portions of the Formation. According to the North American Stratigraphic Code, a Formation should have a defined stratigraphic position. Geochronologic data indicates that rocks mapped as part of the Uwharrie Formation are packages of rocks that represents volcanic centers and related volcaniclastic debris that vary in age. As such, portions of the Uwharrie Formation may be better grouped as lithodemic units. While additional investigation into the stratigraphic nomenclature continues, for this map, the Formation nomenclature is dropped for the Uwharrie Formation and Uwharrie Volcanics is used to emphasize the volcanic origin and restricted regional distribution of the package of rocks. Future stratigraphic revisions may include the assigning of areas of intermingled rhyodacitic lavas, volcanic necks, cryptodomes and tuffs into a Uwharrie Volcanic Complex. Volcaniclastic pyroclastic and sedimentary units could be assigned to the Uwharrie Formation or similar name.

Uwharrie Volcanics legacy and new geochronology data

Ingle et al. (2003) reported the weighted average of six $^{206}Pb/^{238}U$ ages for zircon grains by SHIRMP methods of 554±15 Ma for a sample from the Uwharrie Formation (SB-9) in unit Zurlt in the Southern Pines 100K. This location was resampled as part of this study and yielded LA-ICP-MS $^{206}Pb/^{238}U$ weighted means ages of 537.6 ± 2.8 Ma (MSWD = 1.8). Goliber and Coleman (2023) reported a CA-ID-TIMS weighted mean age of 548.7±1.1 Ma from a felsic volcanic rock in the unit on the Chapel Hill 100K (geochronology data location O). A new and unpublished, LA-ICP-MS $^{206}Pb/^{238}U$ weighted means age yielded 537.4 ± 5.7 Ma (MSWD = 0.86) for a sample collected from Luther Place trail area in the Uwharrie Volcanics (geochronology data location FF).

New and unpublished LA-ICP-MS U-Pb detrital zircon ages include: MDA of 533 Ma. for sample CH100K-3675 (geochronology data location W); MDA of 526 Ma for sample CH100K-3834 (geochronology data location AA); and MDA of 552 Ma for sample CH100K-Ben-165 (geochronology data location T).

The previously existing and new age data indicated that volcanism and sedimentation of the Uwharrie Volcanics spanned from ca. 552 Ma to ca. 526 Ma and was contemporaneous with the deposition of the Seagrove formation and deposition in the Albemarle Group.

ALBEMARLE GROUP

CID and TILLERY FORMATIONS

Rock units of the Cid and Tillery Formations are present in the western portion of the map area. These map areas are immediately on strike with mapped units in the Charlotte 250K (Goldsmith et al., 1988) and more detailed-scale map of Stromquist and Henderson (1985).

ALBEMARLE ARC RELATED PLUTONIC ROCKS

The Parks Crossroads pluton (Zagd-p) is located in the west-central part of the Chapel Hill 100K. Morrison and Coleman (2023) reported a new U-Pb zircon age for the Parks Crossroads pluton of ca. 552 Ma (Table 1) (geochronology data location U). Past regional mapping shows the Parks Crossroads pluton truncating units assigned to the Aaron Formation.

Also, a small pluton of diorite and gabbro is present in the southwestern portion of Chatham County in the map area. Informally named the Providence Church Road diorite (Zdi-pcr) (Bradley et al., 2022c), it was described by Green et al. (1982) as a "roughly circular" pluton that cuts the surrounding unit. The apparent truncation of the surrounding units by both the of Parks Crossroads pluton and the Providence Church Road diorite are problematic because detrital zircon data indicate the surrounding volcano-sedimentary units yield MDA ranges from ca. 560 Ma to 523 Ma (see Seagrove formation new geochronology data section).

Moye (2023), presents a new model of intra-arc rifting in the Carolina terrane. Generally, he proposes that Uwharrie magmatism was active ca. 554 – 551 Ma with rifting beginning ca. 547 Ma with the deposition of the Cid Formation. Rifting could have exhumed deeper plutonic rocks associated with the Uwharrie magmatic phase of the Albemarle arc (i.e. Parks Crossroads Pluton and the Providence Church Road diorite) and disconformably deposited sediments with younger MDAs on top of the plutonic units.

FOLDS IN THE CAROLINA TERRANE

Folds in Hyco and Aaron Formations

The Hyco Arc and Aaron Formation lithologies were folded and subjected to low grade metamorphism during the ca. 578 to 554 Ma (Pollock, 2007; Pollock et al., 2010) Virgilina deformation (Glover and Sinha, 1973; Harris and Glover, 1985; Harris and Glover, 1988; and Hibbard and Samson, 1995). In the map area, original layering of Hyco and Aaron Formation lithologies is observed ranging from shallowly to steeply dipping. The range of structural attitude is interpreted to be a result of open to tight folds that are locally overturned. Sterograms and other structural data are provided in Thompson et al. (2023).

Rocks in the map area were also subjected to the ca. 450 Ma Cherokee deformation and low grade metamorphism (Hibbard et al., 2010 and 2012). Outcrop evidence of Cherokee deformation in the map area is scarce. Evidence is best exposed in area pyrophyllite mines where outcrop-scale folds deform an earlier foliation (see field trip stop 7 in Clark et al., 2011). This folding is associated with local deformation along several identified high-angle reverse faults in the map area (e.g. Glendon Fault).

In general, Hyco Formation rock units have been affected by the Virgilina and Cherokee deformations. Both deformations were generally co-planar, as such the metamorphic foliations in most locations are indistinguishable. The typical close to tight fold geometry of Hyco related units may be the result of the tightening of Virgilina deformation folds by the Cherokee deformation.

Folds in Albemarle arc units

Albemarle arc units have been affected by the Cherokee deformation. Folds attributed to the Cherokee deformation are generally open folds and include the well known Silver Valley Syncline, Denton Anticline, New London Syncline and Troy Anticline (located in the western portions of the Albemarle arc). These large folds do not appear to extend into the Chapel Hill 100K, however multiple map scale folds identified by past workers are included on the compiled map.

FAULTS

High-angle reverse faults

Several terrane-internal ductile faults have been recognized in Chatham, Moore and Randolph counties within the Carolina terrane. The best known is the Glendon fault which has long been recognized by past workers (e.g. Stuckey, 1928 and Conley, 1962). The Glendon fault is a high angle reverse fault that is a locus of pyrophyllite alteration for a distance of over 30 km (18 miles) in northeast Moore County and into southern Chatham County. The Glendon fault is interpreted to be parallel to the axial surfaces of regional-scale overturned folds and disrupts an anticline near its crest (Green et al., 1982 and Klein, 1985). In general, the Glendon fault is a zone of intense deformation ranging from 10 to 50 meters wide with abundant small-scale folds, fractures and deformed and undeformed quartz veins indicating a complicated movement history (Klein, 1985). Quartz veins may be folded and high-strain foliations present within the fault zone overprinting and/or transposing primary bedding and regional foliation. Main movement on the Glendon fault is speculated to be related to the Cherokee deformation.

Several other high-angle reverse faults with varying degrees of hydrothermal alteration were identified during mapping. Metamorphic foliation data indicate that the dip of the foliation progressively becomes more shallow to the southeast approaching the high-angle faults. In the immediate area of the faults, sericite (± pyrophyllite) phyllites and schistose phyllites with composite-like fabrics are common. It is interpreted that the older foliation has been transposed to a younger phyllonitic foliation within the fault zones.

Thrust faulting in the Carolina terrane?

In the Erect 7.5-Minute Quadrangle area of the Chapel Hill100K, newly collected structural data by NCGS staff and compiled structural data of Carpenter (1999) and Hibbard (unpublished field data) indicate abundant anomalous shallow dipping foliations and primary beddings consistently dipping northwest. The foliations typically dip less than 54 degrees to the northwest with a significant population with dips between 18-36 degrees. Mineral lineation data is sparse but indicate possible stretching in a northwest to southeast parallel orientation. The nature of these low-lying foliations are not well understood but may be related to thrust faulting and the presence of thrust duplexes(?). Tentatively, a thrust fault has been mapped separating hydrothermally altered volcaniclastic rocks of the Hyco Formation and Seagrove formation rock types. If an accurate interpretation, other un-mapped thrust faults may be present in the surrounding areas.

Other faulting

The historic Clegg Copper Mine (Kerr and Hanna, 1893) located in the Colon Quadrangle is present within a quartz mineralized zone that is interpreted to have been a pre-metamorphic fault – the Copper Mine Fault (Babiker, 1978). The Copper Mine Fault is oriented parallel to later Mesozoic brittle faulting.

Abundant evidence of brittle faulting at the outcrop-scale and map-scale as well as large-scale lineaments (as interpreted from hillshade LiDAR data) are present in the map area. The brittle faulting and lineaments are interpreted to be associated with Mesozoic extension. Major named brittle normal faults include: the Jonesboro Fault, Bonsal-Morrisville Fault, Deep River Fault, Gulf Fault and Indian Creek Fault. The map area includes the Colon cross-structure that marks the transition between the Durham and Sanford sub-basins (Campbell and Kimball, 1923 and Reinemund, 1955). Numerous map-scale relay ramps are present in this area. A fault-bounded block within the Carolina terrane along the Deep River (in the northwest corner of the Moncure Quadrangle and southwest corner of the Merry Oaks Quadrangle) has been identified with metamorphic foliations rotated up to 90 degrees clockwise. This rotation is speculated to be related to rotation of a breeched relay ramp (see Bradley, 2023, field trip stop 8a).

LiDAR LINEAMENTS

Linear geomorphic features interpreted from hillshade LiDAR are included on the map. The inclusion of LiDAR lineaments is an outgrowth of NCGS derivative publication – *Groundwater Features Map of Chatham County and Surrounding Areas* (Bradley and Bolich, 2022).

The Hillshade LiDAR dataset displays a visually striking network of lineaments that are parallel to diabase dikes and known orientations of brittle faults. Some of these lineaments can be traced for multiple miles across the map area. The lineaments are interpreted to be likely fracture zones; however, field observations could not confirm the presence of each potential brittle fault. The map area has hundreds of lineaments when viewed at varying scales. Only the major lineaments that are easily visible at 50,000- to 100,000-scale are identified on the map.

Multiple unmarked geomorphic lineaments are visible when viewed at 24,000- to 50,000-scale on the elevation data from LiDAR. These minor lineaments extend for short distances (100's to 1000's of feet). Minor lineaments are not indicated on the map but can be identified by a close inspection of the LiDAR data. These minor lineaments may have important implications for site-specific investigations. Site specific studies should review lineaments at the 24,000-scale or greater. Like brittle faults, lineaments can widely vary in length and width. Major lineaments extend for miles and have linear topographic expressions that are 100's to greater than 500 feet wide in some locations.

EASTERNMOST CAROLINA TERRANE IN CHATHAM COUNTY

The southeastern corner of the map area is underlain by metamorphosed crystalline rocks of the Cary sequence (Parker, 1979; Farrar, 1985). The Cary sequence is interpreted to be part of the Carolina terrane but separated from the rest of the terrane by the Triassic basin (Hibbard et al., 2002). One of the main rock units is the Big Lake-Raven Rock schist. In the Cary Quadrangle, a sample from the unit yielded discordant 207Pb/206Pb zircons ages of 573, 574, and 579 Ma and an upper intercept age of 575 ± 12 Ma, interpreted as the time of crystallization (Goldberg, 1994). This is a similar age to parts of the Aaron Formation.

DEEP RIVER TRIASSIC BASIN

Portions of the eastern and south-central areas of the map area are underlain by Triassic-aged sedimentary rocks of the Deep River Mesozoic basin. The basin is separated into three sub-basins (Durham, Sanford and Wadesboro). The Colon cross-structure (Campbell and Kimball, 1923 and Reinemund, 1955), located within Chatham and Lee counties, is a constriction zone in the basin characterized by crystalline rocks overprinted by complex brittle faulting. The Colon cross-structure marks the transition between the Durham and Sanford sub-basins.

SANFORD AND DURHAM SUB-BASINS STRATIGRAPHY

The Merry Oaks and Moncure quadrangles within the Chapel Hill 100K are situated in the transition between the Sanford and Durham sub-basins. In the Sanford sub-basin, three stratigraphic units have been identified and formalized from oldest to youngest as the Pekin, Cumnock and Sanford Formations (Campbell and Kimball, 1923 and Reinemund, 1955). In the Durham sub-basin, this three-layer system is not recognized. Previous mapping by North Carolina Geological Survey staff separated the Durham sub-basin into lithofacies associations using the nomenclature of Smoot et al. (1988). Hoffman and Gallagher (1989) began using the lithofacies association nomenclature and it was subsequently adopted for all mapping in the Durham sub-basin. The formation mapping of Reinemund (1955) in the Sanford sub-basin and the lithofacies association mapping in the Durham sub-basin are incompatible (Clark et al., 2001). These two methods of mapping meet in the Moncure and Merry Oaks quadrangles. The detailed investigation of the contrasting mapping methods and establishment of a unified stratigraphic nomenclature for the Sanford and Durham sub-basins was out of the scope of this mapping project. As such, the map units from the adjacent Cokesbury Quadrangle (Butler et al., 2016) were extended into the Moncure Quadrangle to rectify edge-match issues and mark the change of unit nomenclature from the Sanford sub-basin to the Durham sub-basin. Olsen et al. (2015, figure 12), indicates that Lithofacies Association II and III of the Durham sub-basin are younger than units in the Sanford sub-basin. Additional work is needed to establish a new stratigraphic nomenclature for the entire Deep River basin.

POST-TRIASSIC ROCK UNITS

Dikes of Jurassic diabase intrude the Triassic sedimentary and older crystalline rocks of the map area. Coastal Plain sediments are present in the southern portion of the map area. Quaternary alluvium is present in most modern river valleys, with at least two levels of fluvial terraces along the major drainages. These terraces, where preserved, likely mark the location and elevation of ancestral river systems, prior to incision to the modern floodplain levels (see Grimley, 2023 this volume).

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DESCRIPTION OF MAP UNITS

UNMETAMORPHOSED INTRUSIVE BODIES

Jd **Diabase (Jurassic)**—Black to greenish-black, fine- to medium-grained, dense, consists primarily of plagioclase, augite and may contain olivine. Locally has gabbroic texture. Occurs as dikes up to 100 ft wide. Diabase typically occurs as spheriodally weathered boulders with a grayish-brown weathering rind. Red station location indicates outcrop or boulders of diabase. Purple station locations indicate outcrop or boulders of gabbroic textured diabase.

MPzgb **Gabbro (Mesozoic to Paleozoic)**—Melanocratic (CI>50), fine-grained gabbro. Distinctive brown weathering. Occurs as a small map scale body and dike in the Crutchfield Crossroads Quadrangle that is closely associated with a diabase dike. In the Siler City Quadrangle occurs as isolated boulders along the trend of a diabase dike. Appears unmetamorphosed.

MPzgb-wx **Olivine gabbronorite in the White Cross area (Mesozoic to Paleozoic)**—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.

MZlamp **Lamprophyre (?) (Mesozoic to Neoproterozoic)**—Gray to pinkish gray, fine- to medium-grained, exceptionally dense, with alkali-feldspar, plagioclase and amphibole. The groundmass consists of alkali feldspar and plagioclase, with alkali feldspar more abundant than plagioclase. Plagioclase crystals (>1 cm) also occur are subhedral and commonly zoned. Locally, amphibole occurs in elongate slender prismatic habit (1-4 mm) and is randomly oriented. Sparse amygdules of quartz(?) up to 5 mm present locally. The rock is unmetamorphosed but may have magmatic and/or hydrothermal alteration. Occurs as dikes that are coincident with diabase. Outcrop and boulders are typically spheriodally weathered with reddish-brown weathering rind. Red square station locations mark outcrops or boulders.

TRIASSIC SEDIMENTARY ROCKS OF THE NEWARK SUPERGROUP

DEEP RIVER BASIN

DURHAM SUBBASIN

LITHOFACIES ASSOCIATION III

Trcs **Interbedded sandstone and pebbly sandstone of the Chatham Group Lithofacies Association III (Triassic)**—Reddish-brown to dark brown, irregularly bedded to massive, poorly to moderately sorted, medium- to coarse-grained, muddy lithic arkoses, with occasional, matrix-supported granules and pebbles or as 1-5 cm thick basal layers. Muscovite is common to absent. 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.

Trcs/c **Sandstone with interbedded conglomerate of the Chatham Group Lithofacies Association III (Triassic)**—Reddish-brown to dark brown, irregularly bedded, poorly sorted, coarse-grained to pebbly, muddy lithic sandstones with interbedded pebble to cobble conglomerate. Muscovite is rare to absent in the matrix. Well-defined conglomerate beds distinguish this unit from conglomerate basal lags of Trcs. An arbitrary cut-off of less than 50 percent conglomerate distinguishes this unit from the Trcc conglomerate facies. Conglomerate beds are channel-shaped and scour into the underlying sandstone beds. Unit grades eastward into Trcc.

Trcc **Conglomerate of the Chatham Group (Triassic)**—Reddish-brown to dark brown, irregularly bedded, poorly sorted, cobble to boulder conglomerate. Muscovite is rare to absent in the very coarse-grained to gravelly matrix. An arbitrary cut-off of greater than 50 percent conglomerate distinguishes this unit from the Trcs/c facies. Clasts are chiefly miscellaneous felsic and intermediate metavolcanic rocks, quartz, epidote, bluish- gray quartz crystal tuff, muscovite schist, and rare meta-granitic material. Maximum clast diameters are in excess of 2 m locally.

LITHOFACIES ASSOCIATION II

Trcs/si2 **Sandstone with interbedded siltstone of the Chatham Group Lithofacies Association II (Triassic)**—Cyclical depositional sequences of whitish-yellow to grayish-pink to pale red, coarse- to very coarse-grained, trough cross-bedded lithic arkose that fines upward through yellow to reddish-brown, medium- to fine-grained sandstone, to reddish-brown, burrowed and rooted siltstone. Bioturbation is usually surrounded by greenish-blue to gray reduction halos. Coarse-grained portions contain abundant muscovite, and basal gravel lags consist of clasts of quartz, bluish-gray quartz crystal tuff, and mudstone rip-ups.

Trcsi/s **Siltstone with interbedded sandstone of the Chatham Group Lithofacies Association II (Triassic)**—Reddish-brown, extensively bioturbated, muscovite-bearing, siltstone interbedded with tan to brown, fine- to medium-grained, muscovite-bearing, arkosic sandstone, usually less than one meter thick. Siltstones can contain abundant, bedded, calcareous concretions (interpreted as caliche) and iron nodules. Bioturbation is usually surrounded by greenish-blue to gray reduction halos.

Trcsi/sCL **Siltstone with interbedded sandstone of the Chatham Group Lithofacies Association II with chert and limestone (Triassic)**—Mainly siltstone of Lithofacies II with local occurrence of chert and less common limey sediments and nodular and thin limestones. Unit contacts are based on Bain and Harvey (1977) and Wheeler and Textoris (1978).

LITHOFACIES ASSOCIATION I

Trcs/si1 **Sandstone with interbedded siltstone of the Chatham Group Lithofacies Association I (Triassic)**—Pinkish-gray, light-gray, and light-tan; fine- to coarse-grained, micaeous, slightly clayey, moderately poor to moderately well sorted, subangular to subrounded arkose and lithic arkose; maroon, very silty, micaeous, moderately well sorted, fine-grained sandstone; and maroon, massive, and thickly laminated, bioturbated, micaeous to very micaeous, 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.

OTHER UNITS OF THE DURHAM SUBBASIN

Trcc-m **Conglomerate of the Chatham Group in the Merry Oaks Quadrangle (Triassic)**—Reddish-brown to dark brown, irregularly bedded, poorly sorted, cobble to boulder conglomerate. Clasts are chiefly miscellaneous felsic and intermediate metavolcanic rocks and quartz. Typically present adjacent to border faults.

SANFORD SUBBASIN

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

Trsc **Conglomerate of the Sanford Foramation (Triassic)**—Mainly conglomerates with fragments of metamorphic rock and quartz embedded in and interbedded with red mudstone, siltstone and sandstone (Reinemund, 1955). Equivalent to Trcc of Lithofacies Association III in the Cokesbury Quadrangle.

Trc **Cumnock Formation (Triassic)**—Gray and black claystone, shale and siltstone. Gray sandstone. Contains beds of coal and carbonaceous (organic-rich) shale (Reinemund, 1955). Includes coal horizons.

Trp **Pekin Formation (Triassic)**—Gray, Brown to maroon, white mica bearing, interbedded mudstones, siltstones and arkosic sandstones. Outcrops and boulders of float identified as part of Pekin Formation are strongly indurated compared to conglomerates identified as part of Chatham Group. Identified as the Pekin Formation by Reinemund (1955).

Trpc **Conglomerate of the Pekin Formation (Triassic)**—Reddish-brown to dark brown to purplish-red, irregularly bedded, poorly sorted, cobble to boulder conglomerate. Clasts are chiefly miscellaneous felsic and intermediate metavolcanic rocks and quartz. Typically present adjacent to border faults. Outcrops and boulders of float identified as part of Pekin Formation are strongly indurated compared to conglomerates identified as part of Chatham Group. Identified as the Pekin Formation-basal conglomerate by Reinemund (1955).

MISSISSIPPIAN TO PERMIAN INTRUSIVE ROCKS

PzZg **Granite of the Cane Creek Mountains (Paleozoic to Neoproterozoic)**—Distinctively pink to orange-pink, leucocratic, medium-grained hypidomorphic granular granite. Locally silicified. Silicification causes parts of rock to break conchoidally, similar to felsic volcanic rocks. Potassium feldspar minerals are obvious; mafic minerals are composed of aggregates of chlorite. This unit intrudes rocks interpreted to be related to Albemarle Arc. Locally leucocratic, medium-grained granodiorite. Similar in appearance to Zagd. Equivalent to Granite intrusions in the Cane Creek Mountains (Zcg) of Schmidt et al. (2006). Schmidt et al. (2006) interpreted this to be the youngest rock in the study area, a Carboniferous-age pluton, but lacks an age date.

EASTERNMOST CAROLINA TERRANE

METAINTRUSIVE UNITS

BUCKHORN DAM META-INTRUSIVE SUITE

CZbg **Meta-granitoid rocks of the Buckhorn Dam intrusive suite (Cambrian to Neoproterozoic)**—Dark-colored (CI=15-30), medium- to fine-grained, metatonalite, metagranodiorite and metagranite with variably developed foliation; composed mainly of plagioclase, quartz, epidote, microcline, biotite, and opaque minerals, with minor amounts of sericite, sphene, chlorite, and garnet. The more felsic granitoid rocks are mineralogically and chemically similar to the felsic metavolcanic rocks described below, and are probably the intrusive equivalents. The unit includes a number of small granitoid bodies, probably originally dikes and plugs, intruding felsic metavolcanic rocks northeast of the main outcrops of Buckhorn Dam intrusive suite.

CARY METAMORPHIC SUITE

CZbr3 **Big Lake-Raven Rock schist 3 (Cambrian to Neoproterozoic)**—Light tan to orange-brown, fine- to medium-grained, white mica schist, phyllite and gneiss. Locally preserves primary volcanic texture, either fragmental or porphyritic. Inferred to have a dacitic volcanic and/or volcaniclastic protolith. Locally includes intermediate to mafic composition rocks that have been metamorphosed to mica phyllite.

CAROLINA TERRANE

ALBEMARLE ARC

ALBEMARLE ARC PLUTONS

CZagb-sm **Stony Mountain Gabbro (Cambrian to Neoproterozoic)**—Massive, grayish-green to dark-greenish-gray, fine to coarse grained. Composed of secondary amphibole, in part with cores of clinopyroxene, calcic plagioclase, epidote, chlorite, and quartz, with accessory sphene, apatite, calcite, phlogopite, and opaque minerals. Occurs as sheets, dikes, and irregular intrusive bodies; most common within well-bedded sedimentary and volcanic rocks. The sheet exposed west of Back Creek Lake has a basal zone rich in serpentine pseudomorphs after olivine; "comb layering" (Moore and Lockwood, 1973) is well exposed in the quarry at the top of the same sheet (Seiders and Wright, 1977). A sample collected from Ridges Mountain (west of Asheboro) in the unit yielded an age of ca. 545 Ma (DeDecker et al., 2013).

CZgb-e **Gabbro dikes in the Erect Quadrangle (Cambrian to Neoproterozoic)**—Medium- to dark-green, coarse-grained gabbro. Composed of amphibole, epidote, chlorite and uralite. May be related to Stony Mountain Gabbro.

CZdi-e **Diorite dikes in the Erect Quadrangle (Cambrian to Neoproterozoic)**—Medium-gray to pink, fine-grained dike. Contains plagioclase and hornblende with minor quartz, chlorite, epidote and opaque minerals.

CZda-e **Dacite dikes in the Erect Quadrangle (Cambrian to Neoproterozoic)**—Black to greenish-black, fine-grained dacite dikes. Contains plagioclase, quartz and magnetite. Has flow texture locally.

CZmd-r **Mafic porphyry dikes of the Ramseur area (Cambrian to Neoproterozoic)**—Dark greenish-gray to dark gray porphyritic dikes containing phenocrysts of plagioclase and pyroxene (pseudomorphed by actinolite) in an aphanitic matrix. Present in the Ramseur area.

CZfd-r **Felsic porphyry dikes of the Ramseur area (Cambrian to Neoproterozoic)**—Medium to dark gray porphyritic dikes containing phenocrysts of plaqioclase +- quartz +- perthitic alkali feldspar in an aphanitic glassy matrix

Zagd-p **Granodiorite of the Parks Crossroads pluton (Neoproterozoic)**—Leucocratic (CI=5) , fine- to medium- grained, equigranular metamorphosed, granodiorite. Mineral assemblage includes quartz, plagioclase, and green hornblende +/- chlorite, +/- epidote. A sample collected from an abandoned quarry in the unit yielded a weighted mean age of ca. 552 Ma (Morrison and Coleman, 2023).

	Contact with Hyco arc units interpreted as an intrusive contact. Contact with Seagrove formation units is interpreted as unconformatity.
Zagd-pm	**Granodiorite of the Pilot Mountain area (Neoproterozoic)**—Granodiorite, quartz monzonitic and dioritic plutonic rocks, dark greenish-gray; chlorite and epidote rich. Local porphyritic phases, some of which may include volcanic material. Generally foliated. No gradation to hydrothermally altered rocks recognized (Schmidt, 1985 USGS Bulletin 1562)
Zadigdt-pm	**Diorite and granodiorite to tonalite of the Pilot Mountain area (Neoproterozoic)**—Diorite and granodiorite to tonalite, present in small plugs mapped by Harris (1982). Likely related to the Parks Crossroads pluton and granodiorite of the Pilot Mountain area. Interpreted as intrusive into the Hyco an unconformably overlain by younger Albemarle arc related volcaniclastics.
Zdi-pcr	**Diorite of the Providence Church Road area (Neoproterozoic)**—Mesocratic (CI~50), greenish-gray to grayish-green, fine- to medium-grained, metamorphosed, 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. Gabbro intermingled locally.
Zdi-c	**Diorite of the Colon Quadrangle (Neoproterozoic)**—Mesocratic (CI~50), greenish-gray to grayish-green, fine- to medium-grained, metamorphosed, 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. Includes microdiorite textured rock. Locally, amphiboles are acicular up to 1 cm long. Located in the Colon Quadrangle.
Zabsi	**Andesitic to basaltic shallow intrusive (Neoproterozoic)**—Grayish-green to light green, ranges from aphanitic to plagioclase porphyritic and locally amphibole/pyroxene porphyritic, metamorphosed, andesite to basalt. May exhibit a granular-textured groundmass with microdioritic to microgabbroic texture (visible with 7x hand lens). Dark green to black colored amphibole/pyroxene phenocrysts, when present, occurs as masses (up to 4 mm). Interpreted to intrude Hyco and Aaron Formations. May be an apophysis of the Zdi unit in map area. Occurs as spheroid-shaped boulders and massive outcrop in map area.
Zgr-c	**Granite of the Colon Quadrangle (Neoproterozoic)**—Leucocratic, locally pale pink; medium- to coarse-grained, equigranular metamorphosed granite and granodiorite; locally contains epidote and/or chlorite clots possibly pseudomorphic after hornblende. Located in the Colon Quadrangle.
Zhm	**Hunter Mountain dike (Neoproterozoic)**—Distinctive, mesocratic, greenish-gray, plagioclase porphyritic (with plagioclase phenocrysts up to 1 cm long) granodiorite to diorite. Matrix is fine-grained consisting of interlocking plagioclase and amphibole (possibly pyroxene) crystals up to 1 mm. Correlated with the Hunter Mountain dike complex of Hauck (1977).
Zgbp	**Gabbro to gabbro porphyry dike (Neoproterozoic)**—Gabbro to gabbro

porphyry dike: Dark green to black, melanocratic, metamorphosed, medium-grained gabbro to fine-grained, plagioclase porhyritic gabbro porphyry. Present as a dike.

Zdi-porp **Diorite porphry of the Goldston Quadrangle (Neoproterozoic)**—Mesocratic to melanocratic (CI~50-60), greenish-gray to grayish-green, fine- to medium-grained groundmass with euhedral to subhedral phenocrysts (2-12 mm) of white to pale yellow plagioclase. Major minerals include plagioclase and amphibole. Plagioclase crystals are typically sericitized and saussuritized. Amphiboles are present as small clusters and are typically altered to chlorite and actinolite masses. The unit occurs as large boulders and/or outcrop that is nonfoliated and locally it includes aphanitic to porphyritic andesite to basalt. Appears to cut the Aaron Formation. Present in the Goldston Quadrangle.

Zic-z **Igneous complex of the Zachary Mines area (Neoproterozoic)**—Andesite to basalt, diorite to gabbro and granite. Includes microdiorite textured rock. Massive quartz locally present. Whole rock analyses of several rocks provided by Schmidt et al. (2006). Part of the Ztm unit of Schmidt et al. (2006).

MORROW MOUNTAIN RHYODACITE SUITE

CZmmr-ps **Morrow Mountain rhyodacite – porphyritic felsite near Seagrove (Cambrian to Neoproterozoic)**—Gray felsite with phenocrysts of albite and quartz. Occurs in a 3 km-wide belt and in small bodies on both sides of the belt. At the south end of the belt the felsite is flow layered, locally spherulitic, and the phenocrysts are relatively smaller and less abundant. To the north, in Randolph County, phenocrysts are larger (1-3 mm) and more abundant; flow layering and spherulites are generally absent. Both extrusive and shallow intrusive rocks may be represented. A sample collected from the southbound I-73/74 visitor center approximately 1.9 miles southwest of Seagrove in the unit yielded a preliminary concordia age of ca. 536 Ma (NCGS preliminary data).

CZmmr-psa **Altered Morrow Mountain rhyodacite – porphyritic felsite near Seagrove (Cambrian to Neoproterozoic)**—Light gray quartzose sericite phyllite; locally contains pyrite; commonly iron oxide-stained where weathered. Pyrophyllite locally present. Interpreted as hydrothermally altered CZmmr-ps unit.

CZmmr-f **Morrow Mountain rhyodacite – felsite (Cambrian to Neoproterozoic)**—Light- to dark-gray felsite, in part with phenocrysts of albite and quartz. Locally spherulitic and flow layered. May include lava flows, domes, necks, and dikes. The felsic mass that includes Caraway Mountain, in the north-central part of the Seiders (1981) map area, in part has a fine-grained, holocrystalline groundmass and may have solidified at a somewhat deeper level. Select polygons of Ctf and CZuf from Seiders (1981) are reinterpreted as part of Morrow Mountain rhyodacite. A sample collected from Caraway Mountain in the unit yielded a preliminary concordia age of ca. 543 Ma (NCGS preliminary data).

CID FORMATION

Ccv1 **Cid Formation volcanics and epiclastic rocks of northwestern Randolph County**

(Cambrian)—Mixed unit of mainly volcaniclastic sedimentary rocks and andesitic to basaltic lavas: grayish-green to green; metamorphosed non-tuffaceous to tuffaceous conglomerate, conglomeratic sandstone, sandstone, siltstone and bedded mudstone. Interlayed with gray-green, to green; typically unfoliated, amygdaloidal, plagioclase porphyritic, amphibole/pyroxene porphyritic, aphanitic and locally hyaloclastic; metamorphosed andesitic to basaltic lavas and shallow intrusions.

Ccv2 **Cid Formation volcanics and epiclastic rocks of High Point Lake area (Cambrian)**—Mixed unit of mainly andesitic to basaltic lavas and volcaniclastic sedimentary rocks. Area with poor exposure of greenstones and metasedimentary rocks. Alternative interpretation is that area is a map scale xenolith of older Charlotte terrane related rock.

Ccmc **Mafic volcaniclastic rocks and subordinate mudstone (Cambrian)**—Green, calcareous, thin- to very thick-bedded, tuff, lapilli tuff, and tuff breccia; commonly well bedded, poorly sorted, with abruptly alternating beds of tuff and lapilli tuff; local large-scale crossbedding. Mudstone is grayish-green, laminated to thin bedded

Ccml **Mafic lava flows (Cambrian)**—Lens of grayish-green amygdaloidal basaltic lava

SEAGROVE FORMATION (INFORMAL)

CZsfc **Seagrove formation felsic volcaniclastic rocks (Cambrian to Neoproterozoic)**—Thin- to very thick bedded, light- to dark-gray, in part pale-green, tuff, lapilli tuff, and tuff breccia. The most abundant rock types are very thick bedded tuff, lapilli tuff, and tuff breccia, but in many parts of the map unit subordinate amounts of well-bedded, thin- to thick-bedded, in part graded, tuff, tuffaceous sandstones, tuffaceous conglomeratic sandstones and felsic volcanic mudstone are interbedded. In many rocks the principal clasts are dense felsite, like that occurring in the numerous felsite bodies of the formation. Clasts are angular to subrounded, very rarely well rounded. Other rocks have clasts with poorly preserved textures that are strongly suggestive of pumice. Such rocks occur throughout the unit but are especially abundant in a 3 km wide belt, extending from south of Center Cross Church to Purgatory Mountain and located just west of the belt of porphyritic felsite at Seagrove (CZmmr-ps). These rocks generally lack interbeds of well-bedded tuff and may represent thick ashflow deposits. The probable pumice fragments are commonly flattened but the flattening is in the plane of the regional cleavage or foliation and may be tectonic. Textural details are too poorly preserved to record most features that would clearly indicate welding. Modified from Seider, 1981.

CZse-npm **Seagrove formation epiclastic rocks north of Purgatory Mountain (Cambrian to Neoproterozoic)**—Metasedimentary package that ranges from coarse-grained sandstones, pebbly sandstones and conglomerates. The sandstones, pebbly sandstones and conglomerates commonly contain rounded to subangular clasts of quartz ranging from sand- to gravel-sized. In the sandstones, feldspar is the most prominent mineral grain; quartz varies from sparse to abundant in hand sample. Lithic clasts are typically prominent and range from sand- to gravel-size. Local occurrence of felsic and intermediate tuffs and fine-grained volcaniclastic sedimentary rocks.

CZse-em **Seagrove formation epiclastics of the Erect member (Cambrian to Neoproterozoic)**—Metasedimentary package that ranges from coarse-grained sandstones, pebbly sandstones and conglomerates. Locally quartzitic (quartzite-like). The sandstones, pebbly sandstones and conglomerates commonly contain rounded to subangular clasts of quartz ranging from sand- to gravel-sized. In the sandstones, feldspar is the most prominent mineral grain; quartz varies from sparse to abundant in hand sample. Lithic clasts are typically prominent and range from sand- to gravel-size. A sample of sandstone from the unit was collected approximately 1.1 km west of Yow Mill, in the Erect Quadrangle, on a west-northwest trending branch of Fork Creek, for detrital zircon analysis. The youngest grain yielded a date of 545 + 7 Ma (Pollock et al., 2010).

CZsehc **Seagrove formation epiclastic rocks of the Harpers Crossroads area (Cambrian to Neoproterozoic)**—Metasedimentary package that ranges from fine-grained siltstones to coarse-grained sandstones, pebbly sandstones and conglomerates. The sandstones, pebbly sandstones and conglomerates commonly contain rounded to subangular clasts of quartz ranging from sand- to gravel-sized. In the sandstones, feldspar is the most prominent mineral grain; quartz varies from sparse to abundant in hand sample. Lithic clasts are typically prominent and range from sand- to gravel-size. A sample from the unit was collected adjacent to the Siler City Airport for detrital zircon analysis (NCGS sample COL-3055). The four youngest detrital zircons are: ca. 534, 538, 538 and 538. Previously mapped as part of the Aaron Formation on open file maps of western Chatham County.

CZsehc-a **Altered Seagrove formation epiclastic rocks of the Harpers Crossroads area (Cambrian to Neoproterozoic)**—Area of Seagrove formation epiclastic rocks of the Harpers Crossroads area that is mildly to moderately hydrothermally altered. Alteration consists of silicified, sericitized and pyrophyllitized rock. Chloritoid locally present.

CZsebc **Seagrove formation epiclastic rocks of the Bear Creek area (Cambrian to Neoproterozoic)**—Grayish-green to green, locally with distinctive reddish-gray or maroon to lavender coloration, siltstones, sandstones, conglomeratic sandstone, and conglomeratic siltstone (greywacke). Siltstones are locally phyllitic. Siltstones typically display bedding ranging from mm-scale up to 10 cm, bedding layers traceable for several feet locally, may exhibit soft sediment deformation. Locally tuffaceous with a relict vitric texture. Locally contain interbedded intermediate to mafic lavas. Conglomerates and conglomeratic sandstones typically contain rounded to angular clasts. Deposition interpreted as distal from volcanic center. A sample from the unit was collected approximately 0.5 miles southwest of the Bear Creek intersection on a creek adjacent to HWY 902 on the property of Chatham Central High School for detrital zircon analysis (NCGS sample BK-626). The three youngest detrital zircons are: ca. 535, 535 and 536 Ma. Previously Zhesc on Bradley et al. (2019).

CZsmd **Seagrove formation mudstones (Cambrian to Neoproterozoic)**—Grayish-green, light gray to dark gray, locally with distinctive reddish-gray or maroon to lavender coloration, metamorphosed, thinly bedded mudstone, siltstone and sandy siltstone. Mudstone bedding ranges from mm-scale up to 10 cm, bedding layers traceable for several feet locally, may exhibit soft sediment deformation. Locally tuffaceous with a relict vitric texture. When present, crystal fragments are usually plagioclase with rare quartz. Deposition interpreted as distal from volcanic center.

CZsimvc **Seagrove formation intermediate to mafic volcanic and volcaniclastic rocks (Cambrian to Neoproterozoic)**—Map scale bodies of metamorphosed andesitic to basaltic lavas and shallow intrusions with interlayered volcaniclastic rocks consisting of phyllitic siltstone to conglomerate.

CZshar **Seagrove formation hydrothermally altered rocks (Cambrian to Neoproterozoic)**—Areas within the Seagrove formation of moderate to intense hydrothermally altered rock. Alteration consists of silicified, sericitized and pyrophyllitized rock. Chloritoid locally present. Sulfides are common. Primary sedimentary or volcanic textures are commonly obliterated.

TILLERY FORMATION

CZtm **Laminated to thin-bedded graded mudstone (Cambrian to Neoproterozoic)**—Typically grayish-green, less commonly gray, in beds 1 mm to 4 cm thick. Beds grade upward from lighter colored siltstone to darker claystone. Beds are extremely regular, laterally persistent, and show no crossbedding. Thick-bedded mudstone is uncommon. Rare beds of graded sandstone consist of volcanic rock and mineral fragments of diverse composition in an abundant argillaceous matrix. Contains biotite porphyroblasts

CZtpm **Pebbly mudstone and mudstone conglomerate (Cambrian to Neoproterozoic)**—Composed chiefly of angular- to well-rounded pebbles and locally cobbles of Tillery-like mudstone in a mudstone matrix. Locally contains sparse clasts of felsite. Subordinate volumes of laminated- to thin-bedded mudstone are interbedded with the conglomeratic rocks and locally show isoclinal folds of possible penecontemporaneous origin. Unit occurs in lenses near the volcanic neck at Shepherd Mountain in the northwestern part of the map area and may have formed when the neck was emplaced (Seiders and Wright, 1977)

CZtfc **Felsic volcaniclastic rocks (Cambrian to Neoproterozoic)**—Light-gray to pale-green tuff, lapilli tuff, and tuff breccia

CZtfm **Felsite, felsic volcaniclastic rocks and interbedded, laminated- to thin-bedded mudstone (Cambrian to Neoproterozoic)**—Felsite, felsic volcaniclastic rocks, and interbedded, laminated- to thin-bedded mudstone

CZtimv **Intermediate to mafic volcanics in the Tillery Formation (Cambrian to Neoproterozoic)**—Map scale bodies of metamorphosed gray-green, dark green and greenish-gray; typically unfoliated to weakly foliated, amygdaloidal, plagioclase porphyritic and aphanitic; andesitic to basaltic lavas and shallow intrusions. Hyaloclastic texture is common and imparts a fragmental texture on some outcrops and float boulders. Correlated with Ctb (basaltic rocks) of Stromquist and Henderson (1985).

CZtmc **Mafic volcaniclastic rocks (Cambrian to Neoproterozoic)**—Thin- to very thick bedded, grayish-green tuff, lapilli tuff, and tuff breccia. In addition to mafic volcanic debris, many rocks contain subordinate amounts of mudstone and felsic volcanic rock clasts

UWHARRIE VOLCANICS (INFORMAL)

CZue/pl **Uwharrie Volcanics mixed epiclastics, pyroclastics and lavas of the Devils Tramping Ground area (Cambrian to Neoproterozoic)**—Grayish-green to greenish-gray, metamorphosed tuffaceous sandstones, conglomeratic sandstones, siltstones and minor phyllite. The siltstones typically are weakly phyllitic. Contains lesser amounts of fine- to coarse tuff, welded tuff and dacitic lavas. Fiamme-like shaped clasts are common in the conglomerates, sandstones and tuffs. Quartz and feldspar crystal fragments are common in the sedimentary components, tuffs and lavas. Silicified and/or sericitized altered rock and quartz with adularia are locally present. A tuff from the unit yielded an U-Pb zircon age of 548.7 +- 1.1 Ma (Goliber and Coleman, 2023). Contact with unit CZsehc designated at first occurrence of sandstones with angular clasts or primary volcanic rocks.

CZue/pl-A **Uwharrie Volcanics epiclastics pyroclastics and lavas of Alamance County (Cambrian to Neoproterozoic)**—Grayish-green to greenish-gray, metamorphosed tuffaceous sandstones, conglomeratic sandstones, siltstones and minor phyllite. The siltstones typically are weakly phyllitic. Contains lesser amounts of tuff and intermediate to mafic lavas. Quartz and feldspar crystal fragments are common in the sedimentary components, tuffs and lavas. Similar looking rocks in Chatham County yielded an U-Pb zircon age of 548.7 ± 1.1 Ma (Goliber and Coleman, 2023). The unit is interpreted to be in unconformable contact with adjacent Hyco Formation units.

CZurlt **Uwharrie Volcanics rhyodacitic lavas and tuffs (Cambrian to Neoproterozoic)**—Gray to dark gray, siliceous, aphanitic rhyodacites and tuffs, quartz-bearing tuffs and quartz-rhyodacite porphyry. Rhyodacites and tuffs are vitric-like and weakly to moderately foliated. Rhyodacites are locally flow layered and(or) spherulitic. Phenocrysts of albite are generally present, commonly accompanied by quartz. The size and abundance of phenocrysts varies widely. Tuffs locally contain fiamme-shaped clasts. May include lava flows, domes, necks , and dikes. Zuf, Felsite unit, of Seiders (1981).

CZuqdp **Quartz dacite porphyry (Cambrian to Neoproterozoic)**—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. May locally have fine-grained intrusive texture. Interpreted as either lava flows or shallow intrusives possibly associated with domes. Similar to texture to quartz dacite porphyry unit within the Bynum Quadrangle (Bradley et al., 2013)

CZudap **Dacite porphyry (Cambrian to Neoproterozoic)**—Generally light-gray; abundant quartz and plagioclase phenocrysts up to 5 mm across. Generally hydrothermally altered; contains pervasive disseminated pyrite

CZudap-a **Altered dacite (Cambrian to Neoproterozoic)**—Quartz-sericite-pyrite altered dacite. Altered version of unit Zudap

CZufc **Felsic volcaniclastic rocks (Cambrian to Neoproterozoic)**—Thin- to very thick bedded, light- to dark-gray, in part pale-green, tuff, lapilli tuff, and tuff breccia. The most abundant rock types are very thick bedded tuff, lapilli tuff, and tuff breccia, but in many parts of the map unit subordinate amounts of well-bedded, thin- to thick-bedded, in part graded, tuff, tuffaceous sandstones, tuffaceous conglomeratic sandstones and felsic volcanic mudstone are interbedded. In many rocks the principal clasts are dense felsite, like that occurring in the numerous felsite bodies. Clasts are angular to subrounded, very rarely well rounded. Other rocks have clasts with poorly preserved textures that are strongly suggestive of pumice. These rocks generally lack interbeds of well-bedded tuff and may represent thick ashflow deposits. The probable pumice fragments are commonly much flattened but the flattening is in the plane of the regional cleavage or foliation and may be tectonic. Textural details are too poorly preserved to record most features that would clearly indicate welding.

CZupm **Porphyritic felsic volcaniclastic rock (Cambrian to Neoproterozoic)**—Thick bedded, light-gray, tuff and lapilli tuff composed of clasts of felsite with abundant large (1-3 mm) phenocrysts of albite and quartz. The clastic texture is obscure in outcrops but is more easily seen in sawed slabs and thin sections. The unit is exposed in the vicinity of Mechanic Church.

CZupu **Porphyritic felsite east of Ulah (Cambrian to Neoproterozoic)**—Medium-gray felsite with abundant 0.5-2 mm phenocrysts of albite and quartz. Locally flow layered. Includes some volcaniclastic rock of the same composition

CZufb **Felsic volcanic breccia (Cambrian to Neoproterozoic)**—Light- to dark-gray fragments of aphanitic to sparsely porphyritic felsite. In part, the clasts are much flattened and irregularly distorted with vague or wispy margins. In thin section there is little distinction between the microcrystalline texture of the clasts and that of the groundmass. This rock may represent a pumice-rich welded tuff

CZuimcl **Intermediate to mafic volcaniclastic rocks and lavas (Cambrian to Neoproterozoic)**—Thin- to very thick-bedded, grayish-green tuff, lapilli tuff, and tuff breccia. Local occurrence of andesitic to basaltic lavas with hyaloclastic textures. Commonly contains scattered clasts of felsic volcanic rock. Modified equivalent of CZumc of Seiders (1981).

CZuiml **Intermediate to mafic lavas (Cambrian to Neoproterozoic)**—Small bodies of metamorphosed andesite to basalt exposed chiefly in the northeastern part of the Seiders (1981) map area. Commonly amygdaloidal. Pillow lava occurs northeast of Asheboro, along the dead end road 1.5 km east of Oakie Mountain. May include some shallow intrusive rocks. Modified equivalent of CZuml of Seiders (1981).

CZums **Mudstone (Cambrian to Neoproterozoic)**—Laminated to medium-bedded , light-gray mudstone of probable felsic volcanic composition (fine-grained tuff). Subordinate grayish-green mudstone and thin- to thick-bedded felsic and mafic tuff

VIRGILINA SEQUENCE

VIRGILINA SEQUENCE PLUTONS

FARRINGTON IGNEOUS COMPLEX - EAST FARRINGTON

Zefg-m **East Farrington pluton main facies (Neoproterozoic)**—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, <1mm in diameter, with euhedral terminating crystals are common in some specimens. Weakly foliated outcrops are present along Pokeberry Creek and several other locations. In thin section the main facies can be separated into two groups: 1) rocks with a porphyritic texture with orthoclase and plagioclase phenocryts 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. A sample collected from the unit yielded a weighted mean age of ca. 569 Ma (Goliber and Coleman, 2023).

Zefg-m1 **East Farrington pluton main facies variety 1 (Neoproterozoic)**—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 (Neoproterozoic)**—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 (<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 (Neoproterozoic)**—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 <5% of rock.

Zefg-4 **East Farrington pluton gray granitoid (Neoproterozoic)**—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-5 **East Farrington pluton satellite granite (Neoproterozoic)**—Unfoliated, orange pink to pinkish-gray to gray, fine- to medium-grained, equigranular, amphibole (va. hornblende?) granite. Similar to East Farrington pluton main facies but overall finer-grained.

Zefg-6 **East Farrington pluton satellite granitoid (Neoproterozoic)**—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 (Neoproterozoic)**—Leucocratic to mesocratic, light gray to dark grayish-green where fresh, olive drab weathering, plagioclase-phyric monzodiorite and diorite. 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.

FARRINGTON IGNEOUS COMPLEX - WEST FARRINGTON

Zwfd **West Farrington pluton diorite (Neoproterozoic)**—Mesocratic, 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, granodiorite, quartz monzodiorite, and tonalite; 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 a bumpy texture.

Zwfd-gd **West Farrington pluton diorite to granodiorite (Neoproterozoic)**—

Mesocratic to leucocratic, unfoliated, medium- to coarse-grained with dark green amphibole and/or biotite diorite. Quartz content varies locally causing field identification to vary from diorite, quartz diorite, and leucogranodiorite (looks tonalitic locally). Locally with pinkish feldspars. Generally identical to Zwfd but with more intermingled granodiorite with abundant visible quartz.

Zwfgd **West Farrington pluton leucogranodiorite (Neoproterozoic)**—Leucocratic to mesocratic, unfoliated, medium- to coarse-grained, biotite-bearing with dark green amphiboles leucogranodiorite. Quartz content varies locally causing field identification to vary from quartz diorite, leucogranodiorite, to tonalite. Locally with pinkish feldspars. Granophyric texture occurs locally in map area south of Collins Mountain.

AARON FORMATION

Za **Aaron Formation (Neoproterozoic)**—Distinctive metasedimentary package that ranges from fine-grained siltstones to coarse-grained sandstones, pebbly sandstones and conglomerates. Siltstones are similar in appearance to Hyco Formation lithologies. The sandstones, pebbly sandstones and conglomerates (classified as litharenite, feldspathic litharenite and lithic feldsarenite by Harris (1984)) are distinctive and commonly contain rounded to subrounded clasts of quartz ranging from sand- to gravel-sized. In the sandstones, feldspar is the most prominent mineral grain; quartz varies from sparse to abundant in hand sample. Lithic clasts are typically prominent and range from sand- to gravel-size. Harris (1984), performed a detailed sedimentary study of the Aaron Formation to the immediate west of the map area. Harris (1984) interpreted the Aaron Formation to have been deposited by turbidity currents in a retrogradational submarine fan setting.

OTHER PLUTONS (GREENSBORO INTRUSIVE SUITE?)

Zgd-CT **Granodiorite (intrusive into the Carolina terrane) (Neoproterozoic)**—Unfoliated to locally weakly foliated, leucocratic (CI<10), very light gray to yellowish gray, medium- to coarse-grained, hypidiomorphic granular, metamorphosed granodiorite to tonalitic granodiorite. Mafic minerals present in rock are biotite intergrown with chlorite. Weathering of rock produces distinctive coarse quartz sand grains in soil. Resistant, andesitic to basaltic, spheroidal boulders are common throughout the pluton and are interpreted as xenoliths. Cross cutting dikes of similar mineralogy are present in Hyco Formation rock types. Appears to crosscut the Zdi-gb unit. Pluton map pattern truncates Hyco Formation volcanics and pluton contains foliated xenoliths of volcanic rocks. A sample collected from Big Alamance Creek and Alamance Church Road in the unit yielded a preliminary concordia age of ca. 591 Ma (NCGS preliminary data).

Zsgr **Granite to granodiorite of the Saxapahaw pluton (Neoproterozoic)**—Mainly, leucocratic, medium-grained hypidomorphic granular, granite to granodiorite. Quartz grains are conspicuous and weather in positive relief. Mafic minerals are composed of aggregates of chlorite and epidote (likely from the alteration of biotite). Schmidt et al. (2006) interpreted the pluton as being noticeably silicified. Schmidt et al. (2006) reported several whole rock and point count analyses with interpreted rock types included granite, porphyritic granite, granite porphyry, porphyritic granodiorite and quartz monzonite. Based on map pattern and intrusive relationships (high angle truncation of Hyco Formation units), the Saxapahaw pluton may be related to the Farrington pluton family or Albemarle arc plutonism. Ingle (2003) reported a discordant age from the pluton with an upper intercept of 605 +-7.4 Ma.

HYCO ARC

HYCO ARC PLUTONS

Zcgr **Granite of the Chatham pluton (Neoproterozoic)**—Leucocratic, 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). May be genetically related to Zhqdp unit.

Zgr-ccr **Granite of the Crutchfield Crossroads Quadrangle (Neoproterozoic)**—Leucocratic, medium- grained, equigranular metamorphosed, granite or tonalite.

Zgd **Granodiorite (Neoproterozoic)**—Leucoractic to mesocratic, fine- to medium-grained, equigranular to porphyritic granodiorite. May contain quartz diorite and diorite. Typically contains dark green to black <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 <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.

Zgr2 **Granite (Neoproterozoic)**—Light pink to pink and orange; fine- to coarse-grained granite. May be foliated.

Zgr-gd **Granite to granodiorite (Neoproterozoic)**—Leucocratic, fine- to medium-grained, equigranular metamorphosed, granite to granodiorite.

Zgd-ch **Granodiorite of the Chapel Hill pluton (Neoproterozoic)**—Leucoractic 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.

Zgr-ch **Granite of the Chapel Hill pluton (Neoproterozoic)**—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.

Zt-qdi **Tonalite to quartz diorite (Neoproterozoic)**—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 (Neoproterozoic)**—Mesocratic (CI~50), greenish-gray to grayish-green, fine- to medium-grained, metamorphosed, 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 (Neoproterozoic)**—Small plutonic bodies of green, very fine-grained diorite. The rock is green in hand sample from saussuritization of plagioclase. (mircodiorite like)

Zdi-gb **Diorite to gabbro (Neoproterozoic)**—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.

Zdi-porphy **Diorite porphyry of the Silk Hope Quadrangle (Neoproterozoic)**—Mesocratic to almost melanocratic, greenish-gray to gray diorite porphyry with fine- to medium-grained groundmass and euhedral phenocrysts (up to 18 mm) of light gray to white plagioclase. Plagioclase crystals can be saussuritized. Unit locally includes mesocratic, equigranular, plagioclase+amphibole, fine- to medium-grained intrusive diorite to monzodiorite.

Zqmd-sc **Quartz monzodiorite in the Snow Camp area (Neoproterozoic)**—Composite pluton of mesocratic, coarse- to medium-grained, equigranular, quartz monzodiorite, diorite and granodiorite. Major minerals include plagioclase and amphiboles with lesser amounts of quartz. Amphiboles appear altered to chlorite and actinolite masses. Feldspars have a light pinkish-hue locally. Includes a distinctive plagioclase porphyritic granodiorite to diorite on South Fork Cane Creek. Unit identified as the Lindley Farms Quartz Monzonite by

Schmidt et al. (2006). Schmidt et al. (2006) whole rock and modal analyses were replotted on IUGS ternary diagrams and plot in the quartz monzodiorite field.

Zqmd-mf **Quartz monzodiorite in the Meadow Flats area (Neoproterozoic)**—Greenish-gray to gray, mesocratic, medium-grained, equigranular metamorphosed 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).

Zgb-mf **Gabbro in the Meadow Flats area (Neoproterozoic)**—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 (Neoproterozoic)**—Black, coarse-grained (5 mm to 10 mm), metamorphosed 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.

HYCO FORMATION - UPPER PORTION

Hydrothermally altered units

Zq **Quartz body (Neoproterozoic)**—White, beige, red, and tan; sugary to porcelaneous; very fine- to medium-grained massive quartz rock to quartzite-like rock. Outcrops are usually massive. May contain vugs with crystal shaped terminations. Map areas contain boulders (up to several feet in diameter) and/or outcrops of white colored massive quartz.

Zhat-f **Altered tuffs within the Farrington Pluton (Neoproterozoic)**—Very light-gray, light-greenish-gray to white, mottled red and yellow, hydrothermally altered rock interpreted to be silicified and/or sericitized tuffs. Unit occurs as map scale xenoliths within the East Farrington pluton.

Zhat **Altered tuffs (Neoproterozoic)**—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 <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. Chloritoid and staurolite present locally.

Zhat (u) **Altered tuffs of the upper portion of the Hyco Formation (Neoproterozoic)**—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 <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.

Zhhar **Hydrothermally altered rocks (Neoproterozoic)**—Mixed unit of hydrothermally altered rocks consisting of: dense siliceous cryptocrystalline rock; quartz-pyrophyllite rocks, +- kaolinite, andalusite, chloritoid, sericite, paragonite and iron oxides; quartz-sericite rocks, +- paragonite, k-feldspar and iron oxides; and quartz-chloritoid-chlorite rocks, +- sericite and hematite. Described in detail by Hughes (1987) and Schmidt et al. (2006).

Zhat/vcs **Altered tuffs and volcaniclastic sedimentary rocks (Neoproterozoic)**—Mixed unit of altered volcaniclastic rocks and volcaniclastic sedimentary rocks. Alteration consists of silicified, sericitized and pyrophyllitized rock. Chloritoid locally present. Volcaniclastic sedimentary rocks include conglomeratic siltstone to conglomerate that may be variably altered. Includes area of quartz-sericite-paragonite rock (Zvqs) of Schmidt et al. (2006). Andesitic to basaltic lavas and massive quartz locally present.

Zhhar-sg **Silica granofels hydrothermally altered rock (Neoproterozoic)**—Moderately to intensely silicified rock; quartz content commonly over 80 percent, especially on Pilot Mountain and Pine Hill.

Zhhar-ag **Advanced argillic hydrothermally altered rock (Neoproterozoic)**—Generally contains sparse pyrophyllite and a few percent of disseminated sulfide. Encloses unknown amount of silicified argillite and quartz-sericite-pyrite schist which does not commonly form outcrops. Includes pods containing abundant pyrophyllite, andalusite, topaz, and pyrite. Textural features of protolith mostly obliterated except for quartz phenocrysts

Zhhar-qsp **Quartz-sericite-pyrite schist (Neoproterozoic)**—Includes small pods of quartz granofels and lenses of chloritic volcanic rocks. Pyrite content generally 2-10 percent. Gradational to unaltered andesitic and dacitic volcanic rocks

Volcanoclastic-sedimentary units

Zhe **Epiclastics (Neoproterozoic)**—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 (<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 **Morgan Creek epiclastics 1 (Neoproterozoic)**—Mixed unit of metasedimentary rocks that contains well bedded, greenish-gray to gray, siltstone, sandy siltstone, sandstone, conglomeratic sandstone, and conglomerate. The unit was divided into two lithofacies, Zhe-m1 and Zhe-m2: Zhme1 is exposed mainly along Morgan Creek; it is mostly well bedded siltstones with lesser sandstone and conglomerate beds. Siltstones range from thinly laminated to very thinly bedded (<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-m2 **Morgan Creek epiclastics 2 (Neoproterozoic)**—Mixed unit of metasedimentary rocks that occurs to the south and southwest of Zhe-m1 and is overall coarser, containing mostly sandstones and conglomerates with lesser well bedded siltstones.

Zhel **Epiclastic rocks and lavas (Neoproterozoic)**—Conglomerate, conglomeratic sandstone, sandstone, siltstone and mudstone. Siltstones and mudstones typically display bedding ranging from mm-scale up to 10 cm, bedding layers traceable for several feet locally, may exhibit soft sediment deformation. Locally tuffaceous with a relict vitric texture. Locally contain interbedded dacitic to basaltic lavas. Conglomerates and conglomeratic sandstones typically contain subrounded to angular clasts of dacite in a clastic matrix. Deposition interpreted as distal from volcanic center, in deep water(?), and via turbidite flows.

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

Zhp/e **Mixed pyroclastic-epiclastics (Neoproterozoic)**—Gray to green, metamorphosed 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 unit is interepreted to be gradational.

Zhe/p **Mixed epiclastic-pyroclastic rocks (Neoproterozoic)**—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/pl **Mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas (Neoproterozoic)**—Mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas: Grayish-green to greenish-gray, locally with distinctive reddish-gray or maroon to lavender coloration; metamorphosed: conglomerate, conglomeratic sandstone, sandstone, siltstone and mudstone. Lithologies are locally bedded; locally tuffaceous with a cryptocrystalline-like groundmass. Siltstones are locally phyllitic. Locally contain interbedded dacitic lavas identical to Zhdlt unit. Contains lesser amounts of fine- to coarse tuff and lapilli tuff with a cryptocrystalline-like groundmass. Pyroclastics, lavas, and epiclastics are mainly felsic in composition. Minor andesitic to basaltic lavas and tuffs present. Silicified and/or sericitized altered rock are locally present. Conglomerates and conglomeratic sandstones typically contain subrounded to angular clasts of dacite in a clastic matrix. Portions of the Zhe/pl unit are interpreted to have been deposited proximal to active volcanic centers represented by the Zhdlt unit but are also interpreted to record the erosion of proximal volcanic centers after cessation of active volcanism.

Zhe/pl-c **Conglomerate dominated mixed epiclastic-pyroclastic rocks**

(Neoproterozoic)—Grayish-green to greenish-gray, metamorphosed, conglomerate and conglomeratic sandstone. Contains abundant subangular to angular clasts of dacite in a strongly tuffaceous (with a cryptocrystalline-like groundmass) clastic matrix. Interpreted as a resedimented hyaloclastite body likely sourced from a nearby dacite dome.

Felsic to intermediate volcanic units

Zhft **Felsic tuffs (Neoproterozoic)**—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.

Zhdlt (u) **Dacitic lavas and tuffs of the upper portion of the Hyco Formation (Neoproterozoic)**—Greenish-gray to dark gray, siliceous, aphanitic dacite, porphyritic dacite with plagioclase phenocrysts, and flow banded dacite. Dacite with hyaloclastic textures are common. 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 conglomeratic sandstone with abundant 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/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 in the Rougemont quadrangle.

Zhdlt-Q **Quartz dacite lavas and tuffs (Neoproterozoic)**—Interlayered light-gray to white, unfoliated quartz and hornblende porphyritic dacite and foliated quartz crystal tuff. Quartz phenocrysts are distinctive with di-pyramidal form ranging from 1 mm up to 4 mm diameter. Hornblende phenocrysts are brown with a vitreous luster and are present up to 4 mm diameter. In hand sample, the groundmass is light-gray to white on weathered and fresh surfaces. Unfoliated varieties are interpreted to be lava or shallow intrusive bodies; foliated varieties are interpreted to be tuff. Quartz dacite porphyry unit of Eligman (1987).

Zhqdp **Quartz dacite porphyry (Neoproterozoic)**—Micro-granitic to 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. May locally have fine-grained intrusive texture. Interpreted as either lava flows or shallow intrusives possibly associated with domes. Present as boulders in the northeast of the Siler City NE Quadrangle and within the Bynum Quadrangle.

Zhdsi (u) **Dacitic shallow intrusive of the upper portion of the Hyco Formation**

(Neoproterozoic)—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. Interpreted as shallowly emplaced dacite probably co-magmatic with Zdlt (u) unit.

Zhdasi **Dacitic to andesitic shallow intrusive (Neoproterozoic)**—Gray to greenish-gray; dacite to andesite. Aphanitic groundmass with plagioclase and acicular amphibole phenocrysts. Weak relict cryptocrystalline texture present (less than dacites). Aphanitic dacite to andesite clasts present locally likely indicating hyaloclastic texture.

Zhadlt (u) **Andesitic to dacitic lavas and tuffs of the upper portion of the Hyco Formation (Neoproterozoic)**—Black to dark gray, gray-green to green; aphanitic andesite to dacite and porphyritic andesite to dacite with plagioclase phenocrysts. Hyaloclastic textures are common. Interlayed with the lavas are gray to black; welded and non-welded; coarse tuff, lapilli tuff, and tuff breccia. Rocks interpreted as andesites have distinct interior weathering rind of light brown to gray and fresh surfaces exhibit non-vitric like textures in contrast to dacites.

Zhdlt-absi **Dacitic lavas and tuffs of the Hyco Formation infested by andesitic to basaltic dikes (Neoproterozoic)**—Mixed unit of metamorphosed dacitic lavas and tuffs of the Zhdlt unit intruded by plagioclase porphyritic andesite to basalt.

Intermediate to mafic volcanoclastic-sedimentary units

Zhime/pl **Mixed intermediate to mafic epiclastic-pyroclastic rocks with interlayered intermediate to mafic lavas (Neoproterozoic)**—Grayish-green to green, locally with distinctive reddish-gray or maroon to lavender coloration; metamorphosed: conglomerate, conglomeratic sandstone, sandstone, siltstone and mudstone. Lithologies are locally bedded; locally tuffaceous with a cryptocrystalline-like groundmass. Siltstones are locally phyllitic. Locally contain interbedded intermediate to mafic lavas identical to Zhablt, Zhabl, and Zhablc units. Contains lesser amounts of fine- to coarse tuff and lapilli tuff with a cryptocrystalline-like groundmass. Pyroclastics, lavas, and epiclastics are mainly intermediate to mafic in composition. Minor dacitic lavas and tuffs present. Silicified and/or sericitized altered rock similar to Zhat unit are locally present. Conglomerates and conglomeratic sandstones typically contain subrounded to angular clasts of andesite and basalt in a clastic matrix. Generally interpreted to have been deposited proximal to active intermediate to mafic composition volcanic centers and/or record the erosion of proximal intermediate to mafic composition volcanic centers after cessation of active volcanism. May be related to Green et al. (1982) unit C - Intermediate to Mafic Volcanics and Graywacke.

Zhe/plim **Mixed epiclastic-pyroclastic rocks with interlayered intermediate to basaltic**

lavas (Neoproterozoic)—Grayish-green to greenish-gray, locally with distinctive reddish-gray or maroon to lavender coloration; metamorphosed: conglomerate, conglomeratic sandstone, sandstone, siltstone, mudstone, and felsic fine- to coarse tuff and lapilli tuff. Siltstones are locally phyllitic. Locally contain interbedded andesitic to basaltic lavas identical to Zhabl unit. Silicified and/or sericitized altered rock are locally present. Interpreted to be in gradational contact with unit Zhe/pl and identified by increase in intermediate to mafic lavas and decrease and/or absence of dacites.

Zhfit-bw **Felsic to intermediate tuffs of the Big Woods area (Neoproterozoic)**—Heterogenous unit of felsic to intermediate composition tuffs and with lesser interlayers of andesitic to basaltic lavas and epiclastic rocks. Abundant dacitic lavas and tuffs, identical to Zdlt unit lithologies, are interlayered within unit.

Intermediate to mafic volcanic units

Zhabl **Andesitic to basaltic lavas (Neoproterozoic)**—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 on some outcrops and float boulders. Conglomeratic rocks consisting of angular clasts of andesite and/or basalt occur locally and are interpreted as resedimented hyaloclastite.

Zhablc **Andesitic to basaltic lavas and conglomerate (Neoproterozoic)**—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 on some outcrops and float boulders. Interlayers of conglomeratic rocks consisting of angular clasts of andesite and/or basalt are common and are interpreted as resedimented hyaloclastite. Locally interlayered with pyroclastic rocks and meta-sediments identical to the Zhime/pl units.

Zhable **Andesitic to basaltic lavas with interlayered epiclastic rocks (Neoproterozoic)**—Light green, gray-green, gray, and dark gray; typically unfoliated, amygdaloidal, plagioclase porphyritic, amphibole/pyroxene porphyritic and aphanitic; metamorphosed: andesitic to basaltic lavas and shallow intrusions. Hyaloclastic texture is common and imparts a fragmental texture on some outcrops and float boulders. Contains lesser amounts of grayish-green, light green, and light gray to white; metamorphosed conglomerate, conglomeratic sandstone, sandstone, siltstone and mudstone.

Zhablt **Andesitic to basaltic lavas and tuffs (Neoproterozoic)**—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 pyroclastic rocks and meta-sediments identical to the Zhe/pl and Zhime/pl units.

Zhabsi **Andesitic to basaltic shallow intrusive of the Hyco Formation**

(Neoproterozoic)—Grayish-green to light green, metamorphosed: plagioclase porphyritic andesite to basalt with a granular-textured groundmass to very fine-grained diorite and gabbro (with intrusive texture visible with 7x hand lens – microdiorite/microgabbro). Contains lesser amounts of fine- to medium grained diorite and gabbro. 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.

Zhablt-dc **Andesitic to basaltic lavas and tuffs of the Dry Creek area (Neoproterozoic)**—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. Locally interlayered with meta-sediments identical to the Zhel unit. Clasts of Zhablt-dcp locally occur in conglomerates of the unit adjacent to outcrop area of Zhablt-dcp. Includes rocks of the Dry Creek unit of Hauck (1977).

Zhablt-dcp **Andesite to basalt porphyry of the Dry Creek area (Neoproterozoic)**—Distinctive, green to dark green, andesite porphyry with aphanitic groundmass and euhedral phenocrysts (up to 10 mm) of greenish-white plagioclase; phenocrysts typically constitute 20 to 50% of the rock; local alignment of plagioclase; lesser pyroxene/amphibole phenocrysts. Green to dark green basalt porphyry with abundant pyroxene (altered to amphiboles) phenocrysts with minor plagioclase phenocrysts. Andesite and basalt porphyries locally amygdaloidal (up to 2 cm), amygdules in filling include calcite, quartz, chlorite, and epidote. Same as Dry Creek Porphyry complex of Hauck (1977).

HYCO FORMATION - LOWER PORTION

Felsic to intermediate volcanic units

Zhat (l) **Altered tuffs of the lower portion of the Hyco Formation (Neoproterozoic)**—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 <1 mm to 2 mm diameter weathered sulfides are common. Fine-grained chloritoid porphyroblasts (<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.

Zhft (l) **Felsic tuffs (Neoproterozoic)**—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 volcaniclatic sedimentary rocks consisting of volcanic sandstones, and greywackes with minor siltstones and phyllite.

Zhft-b (l) **Felsic tuffs of the Blackwood area (Neoproterozoic)**—Green-gray to gray, metamorphosed, 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 Zhdlt. 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 (Neoproterozoic)**—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 directly on strike with this unit.

Zhdsi (l) **Dacitic shallow intrusive of the lower portion of the Hyco Formation (Neoproterozoic)**—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 (<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.

CHARLOTTE TERRANE

PLUTONS (INTRUSIVE INTO CHARLOTTE TERRANE)

Zgd-CHT **Granodiorite (intrusive into the Charlotte terrane) (Neoproterozoic)**—Unfoliated to locally weakly foliated, leucocratic (CI<10), very light gray to yellowish gray, medium- to coarse-grained, hypidiomorphic granular, metamorphosed granodiorite to tonalitic granodiorite. Mafic minerals present in rock are biotite intergrown with chlorite. Weathering of rock produces distinctive coarse quartz sand grains in soil. Resistant, gabbro, diorite and andesitic to basaltic, spheroidal boulders are common throughout the pluton and are interpreted as xenoliths. Xenoliths of gneissic rock present. Same pluton as Zgd-CT but interpreted as intrusive into the Charlotte terrane. May be associated with the Greensboro Intrusive Suite

Zbda-CHT **Xenoliths of basalt, diorite and altered rocks of the Charlotte terrane**

(Neoproterozoic)—Map scale bodies of metmorphosed basalt, diorite and hydrothermally altered rock.

Zdi-CHT **Diorite of the Charlotte terrane (Neoproterozoic)**—Mesocratic (CI~50), greenish-gray to grayish-green, fine- to medium-grained, metamorphosed, 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. Locally foliated. Granodiorite locally present.

REFERENCES:

Babiker, H.M., 1978, Geology of the Clegg Copper Mine and Vicinity, Lee and Chatham County, North Carolina: unpublished MS thesis, North Carolina State University, Raleigh, North Carolina, 67 p.

Bain, G.L., and Harvey, B.W., eds., 1977, Field guide to the geology of the Durham Triassic basin: Carolina Geological Society Fortieth Annual Meeting, 7-9 October 1977: North Carolina Department of Natural Resources and Community Development, Division of Earth Resources, Geology and Mineral Resources Section, 83 p.

Barefoot, J., 2015, Chronological and Mineralogical Comparison of Gold Prospect Host Rock with Known Gold Horizon Host Rock - Orange and Chatham Counties, North Carolina, unpublished senior thesis, University of North Carolina at Chapel Hill, 18 pages.

Bland, A.E., 1972, Geochemistry of the Meadow Flats Complex, Orange County, North Carolina, M.S. thesis, University of North Carolina at Chapel Hill, 49 p.

Bowman, J.D., 2010, The Aaron Formation: Evidence for a New Lithotectonic Unit in Carolinia, North Central North Carolina, unpublished M.S. thesis, North Carolina State University, Raleigh, North Carolina, 116 p.

Bowman, J.D., Hibbard, J.P. and Miller, B.V. 2013, The Virgilina Sequence Redefined, North Central North Carolina, *in* Hibbard, J.P., and Pollock, J.C., eds., One arc, two arcs, old arc, new arc: the Carolina terrane in central North Carolina, Carolina Geological Society field trip guidebook, p. 127-138.

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., 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., Hanna, H.D., Stoddard E.F., and Bechtel, R., 2013, Geologic map of the Bynum 7.5-minute quadrangle, Orange, Chatham and Alamance Counties, North Carolina: North Carolina Geological Survey Open-file Report 2013-03, scale 1:24,000, in color (supersedes NCGS OFR 2011-07).

Bradley, P.J., Peach, B.T. and Hanna, H.D 2017, Geologic map of the Siler City 7.5-Minute Quadrangle, NCGS Open-file Report 2017-07, scale 1:24,000

Bradley, P.J, Peach, B.T. and Hanna, H.D., 2018, Geologic map of the Chatham County portion of the Coleridge 7.5-minute Quadrangle, NCGS Open-file Report 2018-03, scale 1:24,000

Bradley, P.J., Rice, A.K. and Peach, B.T., 2019a, Geologic map of the eastern portion of the Bennett 7.5-Minute Quadrangle, NCGS Open-file Report 2019-05, scale 1:24,000

Bradley, P.J., Rice, A.K. and Peach, B.T., 2019b, Geologic map of the Bear Creek 7.5-Minute Quadrangle, NCGS Open-file Report 2019-06, scale 1:24,000

Bradley, P.J. (with contributions in alphabetical order from : Bechtel, R.; Blocher, W .B.; Butler, R.J.; Clark, T.W .; Gay, N.K.; Grimley, D.A.; Hanna, H.D.; Malaska, M .J.; Peach, B.T.; Rice , A.K.; Stoddard , E.F.; and Watson, M.E.), 2022c, Compiled Geologic map of Chatham County and surrounding areas, North Carolina: North Carolina Geological Survey Open-file Report 2022-03, scale 1:50,000, in color. https://deq.nc.gov/energy-mineral-and-land-resources/geological-survey/ofrs-geological-survey/geologic-map-chatham-county-and-surrounding-areas-north-carolina

Bradley, P.J. and Bolich, R.E., 2022, Groundwater features map of Chatham County and surrounding areas, North Carolina: North Carolina Geological Survey Open-file Report 2022-04, scale 1:50,000, in color. https://deq.nc.gov/energy-mineral-and-land-resources/geological-survey/ofrs-geological-survey/groundwater-features-map-chatham-county-and-surrounding-areas-north-carolina

Bradley, P.J., 2023, Geology of Chatham County and Surrounding Areas, North Carolina, *in* Bradley, P.J., ed., The geology of the Carolina terrane in Chatham County, North Carolina, Carolina Geological Society annual meeting field trip guidebook for 2023, p. 1-26.

Bradley, P.J., Curry, A.C., Thompson, G.J. and Zhang, Q., 2025, New problems from new data - an example from the Carolina terrane in North Carolina and bearing on interstate correlation, Geological Society of America Abstracts with Programs., Vol. 57, No. 2, 2025, doi: 10.1130/abs/2025SE-407549

Butler, J.R., 1989, Review and classification of ultramafic bodies in the Piedmont of the

Carolinas, p. 19-31, in Mittwede, S.K. and Stoddard, E.F., editors, Ultramafic Rocks of the Appalachian Piedmont, Geological Society of America Special Paper 231, 103 p.

Butler, J.R., and Secor, D.T., Jr., 1991, The central Piedmont, *in* Horton, W., and Zullo, V., eds., The Geology of the Carolinas: Knoxville, University of Tennessee Press, p. 59–78.

Butler, J.R., Clark, T.W. and Gay, N.K., 2016, Geologic map of the Cokesbury 7.5-minute quadrangle, NCGS Open-file Report 2016-22, scale 1:24,000

Campbell, M.R., and Kimball, K.W., 1923, The Deep River coal field of North Carolina: North Carolina Geological and Economic Survey Bulletin 33, 95 p.

Carpenter, P.A., 1999, Bedrock Geologic map of the Erect 7.5-minute Quadrangle, Randolph County, North Carolina, North Carolina Geological Survey, NCGS Open-file Report 1999-01, scale 1:24,000.

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., ed. Field Trip Guidebook for the 50th Annual Meeting of the Southeastern Section, Geological Society of America, Raleigh, North Carolina, p. 27-50. (re-printed in Carolina Geological Society Field Trip Guidebook 2011)

Clark, T.W., Taylor, K.B., Bradley, P.J., 2011, Geology, natural gas potential and mineral resources of Lee, Chatham and Moore counties, North Carolina, Carolina Geological Society field trip guidebook for 2011, 49 p.

Conley, J.F., 1962, Geology and mineral resources of Moore County, North Carolina: Division of Mineral Resources, North Carolina Department of Conservation and Development, Bulletin 76, 40 p.

Conley, J.F., and Bain, G.F., 1965, Geology of the Carolina Slate belt west of the Deep River-Wadesboro Triassic basin, North Carolina, Southeastern Geology v. 6, no. 3, p. 117-138

DeDecker, J., Coleman, D.S., Hibbard, J.P., and Pollock, J.C., 2013, Preliminary U-Pb TIMS zircon ages from the Stony Mountain gabbro at Ridges Mountain, North Carolina: timing of the birth of the Rheic Ocean? *In*, Hibbard, J.P. and Pollock, J., (Eds.). One arc, two arcs, old arc, new arc: The Carolina terrane in central North Carolina. Carolina Geological Society Guidebook, p. 239-244.

Eligman, D., 1987, Volcanic stratigraphy in the Carolina slate belt near Chapel Hill, North Carolina, unpublished M.S. thesis, University of North Carolina at Chapel Hill, 51 p.

Farrar, S.S., 1985, Stratigraphy of the northeastern North Carolina Piedmont: Southeastern Geology, v. 25, no. 3, p. 159-183.

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., eds., Geology and Field Trip Guide, Western Flank of the Raleigh metamorphic belt, North Carolina, Raleigh, North Carolina Geological Survey, Carolina Geological Society Guidebook for 1994, p. 13-17.

Goldsmith, Richard, Milton, D.J., and Horton, J.W., 1988, Geologic map of the Charlotte 1 degree x 2 degree quadrangle, North and South Carolina: U.S. Geological Survey, Miscellaneous Investigations Series Map I-1251-E, scale 1:250000.

Goliber, S.F.B. and Coleman, D.S., 2023, Assessment of the Timing of the Virgilina Deformation with U-Pb Ages of Plutonic and Volcanic Rocks in the Carolina Terrane, *in* Bradley, P.J. editor, 2023, The Geology of the Carolina terrane in Chatham County North Carolina, Carolina Geological Society field trip guidebook. 57-76.

Glover, L., and Sinha, A., 1973, The Virgilina deformation, a late Precambrian to Early Cambrian (?) orogenic event in the central Piedmont of Virginia and North Carolina, American Journal of Science, Cooper v. 273-A, pp. 234-251.

Green, G., Cavaroc, V., Stoddard, E., Abdelzahir, A., 1982, Volcanic and volcaniclastic facies in a part of the slate belt of North Carolina, In: Bearce, D., Black, W., Kish, S., Tull, J. (Eds.), Tectonic studies in the Talladega and Carolina slate belts, Southern Appalachian Orogen. Geological Society of America Special Paper, vol. 191, pp.109– 124.

Grimley, D.A., 2023, Quaternary terraces and deposits in Chatham County area, North Carolina, *in* Bradley, P.J., ed., The geology of the Carolina terrane in Chatham County, North Carolina, Carolina Geological Society annual meeting field trip guidebook for 2023.

Hayes, L.D., 1962, A petrographic study of the crystalline rocks of the Chapel Hill, North Carolina quadrangle, M.S. thesis, University of North Carolina at Chapel Hill, 67 p.

Harris, C., 1982, An unconformity in the Carolina slate belt of central North Carolina: New evidence for the areal extent of the ca. 600 Ma Virgilina deformation. Unpublished MS Thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 90 p.

Harris, C.W., 1984, Coarse-grained submarine-fan deposits of magmatic arc affinity in the late Precambrian Aaron Formation, North Carolina, U.S.A., Precambrian Research, 26, pp. 285-306.

Harris, C., and Glover, L., 1985, The Virgilina deformation: implications of stratigraphic correlation in the Carolina slate belt, Carolina Geological Society field trip guidebook, 36 p.

Harris, C., and Glover, 1988, The regional extent of the ca. 600 Ma Virgilina deformation: implications of stratigraphic correlation in the Carolina terrane, Geological Society of America Bulletin, v. 100, pp. 200-217.

Hauck, S.A., 1977, Geology and petrology of the northwest quarter of the Bynum quadrangle, Carolina slate belt, North Carolina, unpublished M.S. thesis, University of North Carolina at Chapel Hill, 146 p.

Hibbard, J., and Samson, S., 1995, Orogenesis exotic to the Iapetan cycle in the southern Appalachians, In, Hibbard, J., van Staal, C., Cawood, P. editors, Current Perspectives in the Appalachian– Caledonian Orogen. Geological Association of Canada Special Paper, v. 41, pp. 191–205.

Hibbard, J., Stoddard, E.F., Secor, D., Jr., and Dennis, A., 2002, The Carolina Zone: Overview of Neoproterozoic to early Paleozoic peri-Gondwanan terranes along the eastern flank of the southern Appalachians: Earth Science Reviews, v. 57, n. 3/4, p. 299-339.

Hibbard, J. P., van Staal, C. R., Rankin, D. W., and Williams, H., 2006, Lithotectonic map of the Appalachian Orogen, Canada-United States of America, Geological Survey of Canada, Map-2096A. 1:1,500,000-scale.

Hibbard, J.P., van Staal, C.R., and Rankin, D.W., 2010, Comparative analysis of the geological evolution of the northern and southern Appalachian orogen: Late Ordovician-Permian: in Tollo, R.P., Bartholomew, M.J., Hibbard, J.P., and Karabinos, P.M., eds., From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region: Geological Society of America Memoir 206, p. 51-69.

Hibbard, J.P., Miller, B.V., Allen, J.S., Standard, I.D., Hames, W.E., Lavallee, S.B., and Boland, I.B., 2012, Kinematics, U-Pb geochronology, and 40Ar/39Ar thermochronology of the Gold Hill shear zone, North Carolina: the Cherokee orogeny in Carolinia, southern Appalachians. Geological Society of America Bulletin, v. 124, p.643-656.

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 and Southwest Durham 7.5 minute quadrangles, North Carolina: North Carolina Geological Survey Bulletin 92, 34 p.

Hughes, E.H., 1987, The geology and hydrothermal alteration centers of the Snow Camp Mine-Major Hill area, central Carolina slate belt, Alamance and Chatham Counties, North Carolina: U.S. Geological Survey, Open-File Report OF-87-180, scale 1:24000.

Ingle, S., Mueller, P., Heatherington, A., and Kozuch, M., 2003, Isotopic evidence for the magmatic and tectonic histories of the Carolina terrane: implications for stratigraphy and terrane affiliation, Tectonophysics, 371, p. 187-211.

Kerr, W.C. and Hanna, G.B., 1893, Ores of North Carolina, North Carolina Geological Survey, Volume II, Chapter 2, 359 p.

Klein, T.L., 1985, Glendon Pyrophyllite deposits – Stops 2-10, *in* Feiss, P.G., editor, Volcanic-hosted gold and high-alumina rocks of the Carolina slate belt, guidebook for the field trip held in conjunction with the 1985 fall meeting of the Society of Economic Geologists and the 1985 annual meeting of the Geological Society of America, Orlando, Florida, p. 48-72.

Mann, V.I., Clark, T.G., Hayes, L.D., and Kirstein, D.S., 1965, Geology of the Chapel Hill Quadrangle, North Carolina, North Carolina Division of Mineral Resources Special Publication 1, 35 p.

Mehlhop, A., 1994, U-Pb age for the Chapel Hill pluton – Implications for the Carolina slate belt history, unpublished senior thesis, University of North Carolina, Chapel Hill, 13 p.

Milton, D., 1984, Revision of the Albemarle Group, North Carolina: U.S. Geological Survey Bulletin 1537-A, p. A69–A72.

Moore, J. G. and Lockwood, J. P., 1973, Origin of comb layering and orbicular structure, Sierra Nevada batholith, California: Geological Society of America Bulletin, v. 84, p. 1-19.

Morrison, D.J., and Coleman, D, 2023, Absolute age determination of the Parks Crossroads granodiorite of the Carolina terrane, *in* Bradley, P.J., ed., The geology of the Carolina terrane in Chatham County, North Carolina, Carolina Geological Society annual meeting field trip guidebook for 2023.

Moye, R.J., 2023a, Introduction to: The Albemarle Sequence of the Carolina Terrane in Central North Carolina: Geologic and metallogenic Analysis with an alternative model, *in* Bradley, P.J., ed., The geology of the Carolina terrane in Chatham County, North Carolina, Carolina Geological Society annual meeting field trip guidebook for 2023.

Moye, R.J., 2023b, The Albemarle Sequence of the Carolina Terrane in Central North Carolina: Geologic and metallogenic analysis with an alternative model, *in* Supplemental Papers, Carolina Geological Society Annual Meeting 2023, p. 1-82.

Olsen, Paul E.; Reid, Jeffrey C.; Taylor, Kenneth B.; Whiteside, Jessica H.; Kent, Dennis V., 2015, Revised Stratigraphy of Late Triassic Age Strata of the Dan River Basin (Virginia and North Carolina, USA) Based on Drill Core and Outcrop Data, Southeastern Geology, V. 51, No. 1, p. 1-31.

Parker, J.M., 1979, Geology and mineral resources of Wake County: North Carolina Geological Survey Bulletin 86, 122 p., 1:100,000-scale map.

Pelt, K.E. and Bradley, P.J., 2023, Preliminary detrital zircon data from Chatham County, NC, *in* Bradley, P.J., ed., The geology of the Carolina terrane in Chatham County, North Carolina, Carolina Geological Society annual meeting field trip guidebook for 2023.

Pollock, J. C., 2007, The Neoproterozoic-Early Paleozoic tectonic evolution of the peri-Gondwanan margin of the Appalachian orogen: an integrated geochronological, geochemical and isotopic study from

North Carolina and Newfoundland. Unpublished PhD dissertation, North Carolina State University, 194 p.

Pollock, J.C., Hibbard, J.P., and Sylvester, P.J., 2010, Depositional and tectonic setting of the Neoproterozoic-early Paleozoic rocks of the Virgilina sequence and Albemarle Group, North Carolina: in Tollo, R.P., Bartholomew, M.J., Hibbard, J.P., and Karabinos, P.M., eds., From Rodinia to Pangea: The Lithotectonic Record of the Appalachian Region: Geological Society of America Memoir 206, p. 739-772.

Ragland, P.C. and Butler, J.R., 1972, Crystallization of the West Farrington pluton, North Carolina, U.S.A., Journal of Petrology, vol. 13, No. 3, pp. 381-404.

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

Reading, H. G., and Richards, M., 1994, Turbidite systems in deep-water Basin margins classified by grain size and feeder system, Bulletin American Association Petroleum Geologists, 78, 792-822.

Reinemund, J.A., 1955, Geology of the Deep River coal field, North Carolina: U.S. Geol. Survey Prof. Paper 246, 159 p.

Schmidt, R., 1985, High-alumina hydrothermal systems in volcanic rocks and their significance to mineral prospecting in the Carolina slate belt. U.S. Geological Survey Bulletin 1562, 59 p.

Schmidt, R.G., Gumiel, P., and Payas, A., 2006, Geology and mineral deposits of the Snow Camp-Saxapahaw area, Central North Carolina: United States Geological Survey Open-file Report 2006-1259 (http://pubs.usgs.gov/of/2006/1259/index.html).

Seiders, V. M., and Wright, J. E., 1977, Geology of the Carolina volcanic slate belt in the Asheboro, North Carolina, area, p. 1-34, *in* Burt, E. R., ed., Field guides for Geological Society of America, Southeastern Section Meeting, Winston-Salem, North Carolina Department of Natural and Economic Resources, Geology and Mineral Resources Section, 149 p.

Seiders, V., 1981, Geologic map of the Asheboro Quadrangle, North Carolina, and adjacent areas. US Geological Survey, Miscellaneous Investigations Map I-1314, scale 1:62,500.

Stow, D.A.V. and Mayall, M., editors, 2000, Deep-water Sedimentary Systems: Thematic Set, Marine and Petroleum Geology, Volume 17, No. 2.

Smoot, J.P., Froelich, A.J., and Luttrell, G.W., 1988, Uniform symbols for the Newark Supergroup, in Froelich, A.J., and Robinson, G.R., Jr., eds., Studies of the early Mesozoic basins of the eastern United States, US Geological Survey Professional Paper 1776, p. 1-6.

Stromquist, A.A., and Sundelius, H.W., 1969. Stratigraphy of the Albemarle Group of the Carolina slate belt in central North Carolina: U.S. Geological Survey Bulletin 1274-B, p. 1-22.

Stromquist, A., and Henderson, J., 1985, Geologic and geophysical maps of south-central North Carolina: U.S. Geological Survey Miscellaneous Investigation Series Map I-1400.

Stuckey, J.L., 1928, Pyrophyllite deposits of North Carolina: North Carolina Department of Conservation and Development, Bulletin 37, 62 p.

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

Thompson, G.J., Michael, E.K., Rice, A.K. and Bradley, P.J., 2023, Updated compiled structural data from Chatham County, North Carolina – Utilizing GIS to unravel structural geology problems, *in* Bradley, P.J., ed., The geology of the Carolina terrane in Chatham County, North Carolina, Carolina Geological Society annual meeting field trip guidebook for 2023, p. 27-40.

Wagener, H.D., 1964, Areal modal variation in the Farrington igneous complex, Chatham and Orange counties, North Carolina, unpublished M.S. thesis, University of North Carolina at Chapel Hill, 51 p.

Wagener, H.D., 1965, Areal modal variation in the Farrington igneous complex, Chatham and Orange Counties, North Carolina, Southeastern Geology, v. 6, no. 2, p. 49-77.

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.

Wheeler, W.H. and Textoris, D.A., 1978, Triassic limestone and chert playa origin in North Carolina, Journal of Sedimentary Geology, v. 48, p. 765-776.

Wortman, G.L., Samson, S.D., and Hibbard, J.P., 2000, Precise U-Pb zircon constraints on the earliest magmatic history of the Carolina terrane, Journal of Geology, v. 108, pp. 321-338.