North Carolina Department of Environmental Quality
Division of Energy, Mineral, and Land Resources
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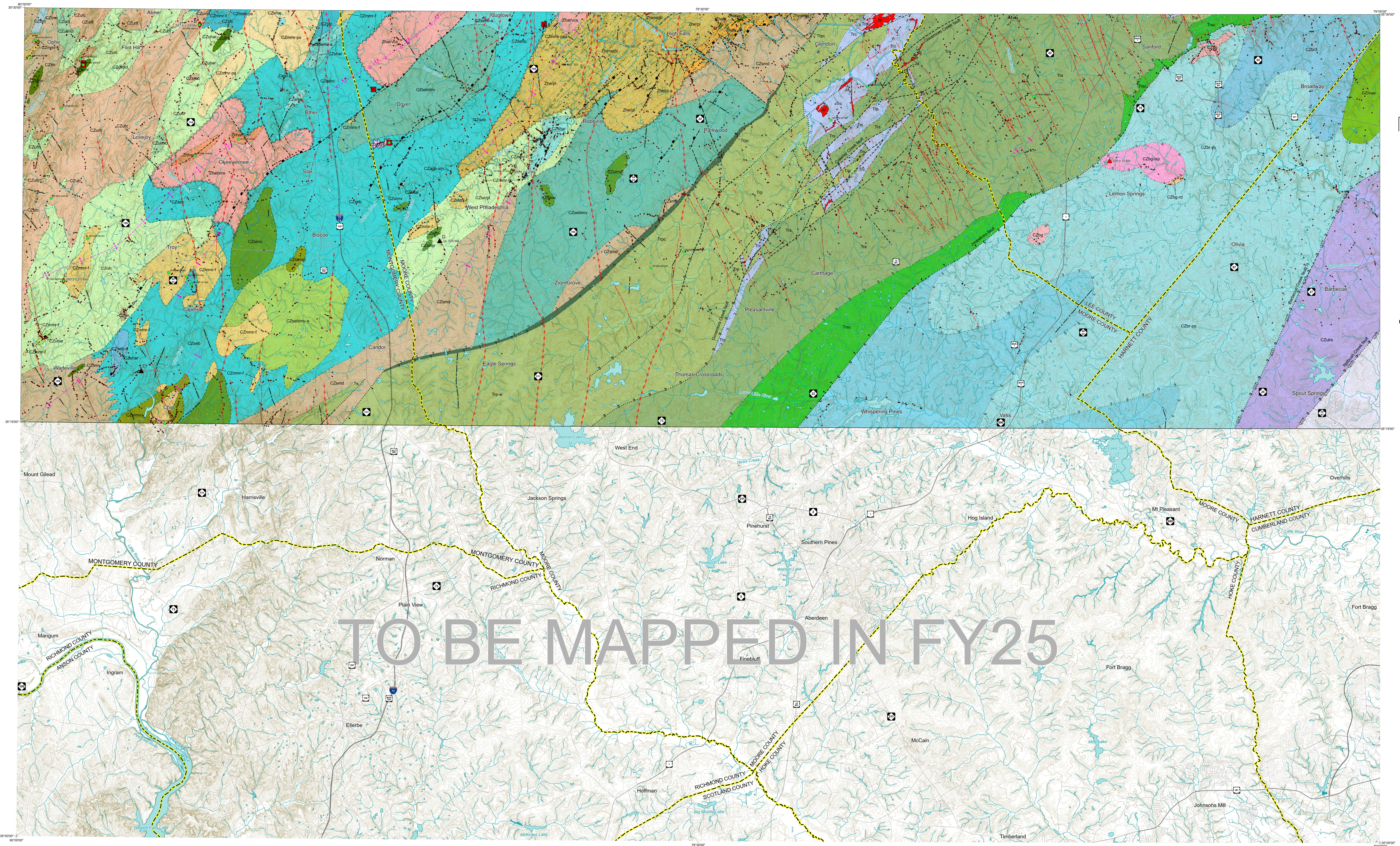
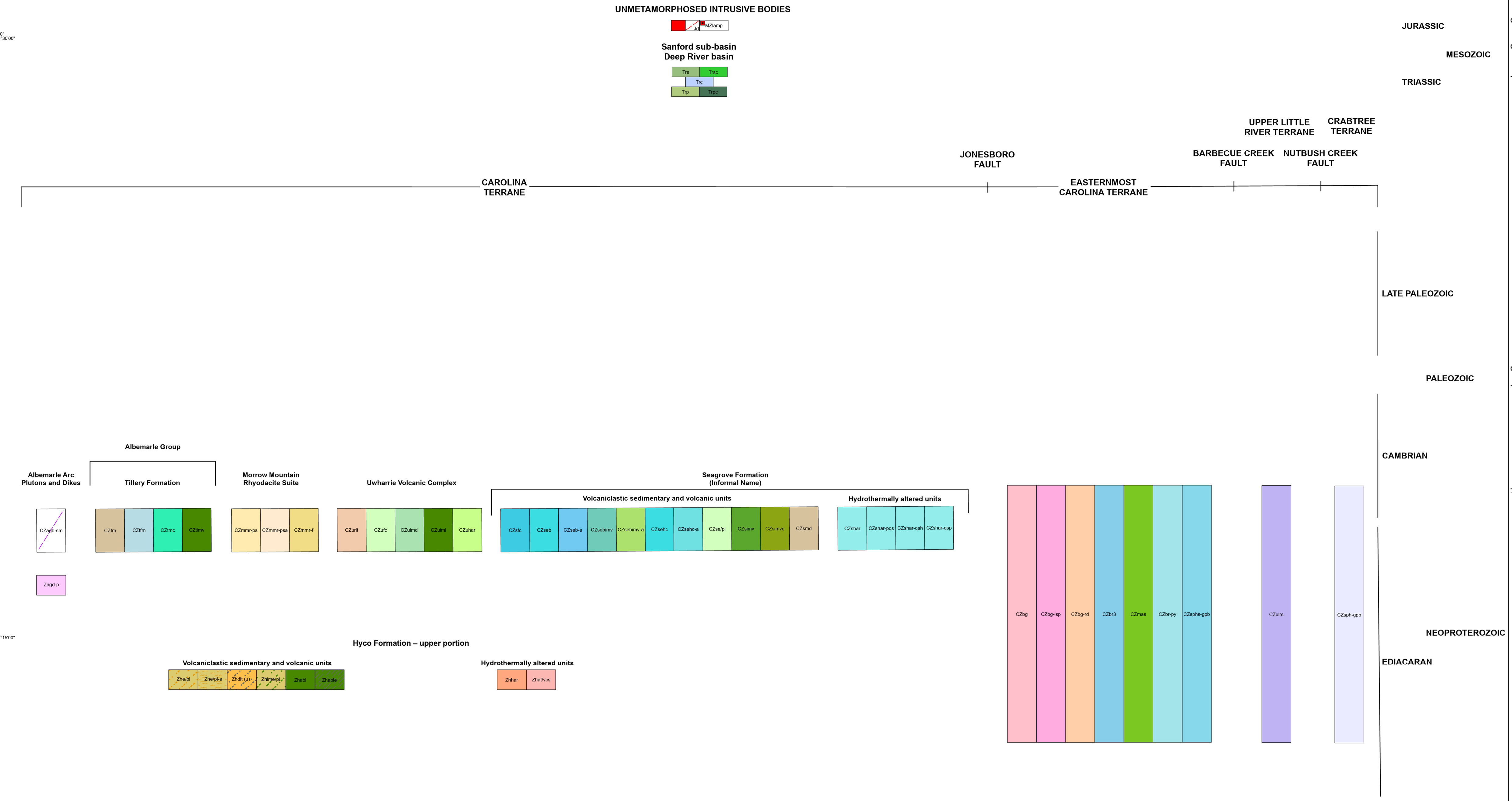


CORRELATION OF MAP UNITS



LIST OF MAP UNITS

[See Description of Map Units (in pamphlet) for complete unit descriptions and age information]

UNMETAMORPHOSED INTRUSIVE BODIES

- Jd — Diabase
- MZlamp — Lamprophyre (?)

Triassic Sedimentary Rocks: Newark Supergroup - Chatham Group of the Deep River Basin

Deep River Basin: Sanford Sub-basin

- Trs — Sanford Formation
- Trsc — Conglomerate of the Sanford Formation
- Trc — Cumnock Formation
- Trp — Pekin Formation
- Trpc — Conglomerate of the Pekin Formation

CAROLINA TERRANE

ALBEMARLE ARC

Albemarle Arc Plutons and Dikes

A sample of Stony Mountain Gabbro from Ridges Mountain, west of Asheboro in the Chapel Hill 100K, yielded a $^{206}Pb/^{238}U$ date of 544.81±0.55 Ma and a $^{207}Pb/^{235}U$ date of 544.73±0.95 Ma (DeDecker et al., 2013). Morrison and Coleman (2023) reported a CA-ID-TIMS weighted mean age of 551.86±0.9 Ma (MSWD=3.5) from a sample from an abandoned quarry in the Chapel Hill 100K.

- CZagb-sm — Stoney Mountain Gabbro
- Zagd-p — Granodiorite of the Parks Crossroads Pluton

Morrow Mountain Rhyodacite Suite

Suite of intrusions with a range of ages and textures that are likely magmatically linked (Boorman et al., 2013 and Moye, 2023). 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 from 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 an age of 542.7±5.3 Ma (MSWD = 0.5). New and unpublished LA-ICP-MS $^{206}Pb/^{238}U$ weighted mean ages from the suite includes: 548.8±2.8 Ma (MSWD = 1.4) for a sample collected from Daves Mountain in Asheboro in the Chapel Hill 100K; 550.4±4.2 Ma (MSWD = 0.44) for a sample collected from the Robbins area (geochronology data location G); and 553.2±2.5 Ma (MSWD = 1.6) for a sample collected near the landfill in the Troy area (geochronology data location C). 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 mean 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).

- CZmmr-ps — Porphyritic felsite near Seagrove
- CZmmr-psa — Altered porphyritic felsite near Seagrove
- CZmmr-f — Felsite

ALBEMARLE GROUP

Tillery Formation

Pollock et al. (2010) reported a youngest LA-ICP-MS U-Pb zircon age of 541±9 Ma for the Tillery Formation from a sample from the Charlotte 100K.

- CZtlm — Laminated to thin-bedded graded mudstone
- CZtfm — Felsite, felsic volcaniclastic rocks and interbedded, laminated- to thin-bedded mudstone
- CZtmc — Mafic volcaniclastic rocks
- CZtimv — Intermediate to mafic volcanics

Uwharrie Volcanic Complex

Ingle et al. (2003) reported the weighted average of six $^{206}Pb/^{238}U$ ages for zircon grains by SHRIMP methods of 554±15 Ma for a sample from the Uwharrie Volcanics (SB-9) in unit Zurlt (geochronology data location A). This location was resampled as a 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)(geochronology data location B). 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 in the Chapel Hill 100K. A new and unpublished, LA-ICP-MS $^{206}Pb/^{238}U$ weighted mean age yielded 537.4±5.7 Ma (MSWD = 0.86) for a sample collected from Luther Place trail area in the Uwharries in the Chapel Hill 100K.

New and unpublished detrital zircon ages include: Maximum Depositional Ages (MDA) of 533 Ma. for sample CH100K-3675; MDA of 526 Ma for sample CH100K-3834; and MDA of 552 Ma for sample CH100K-Ben-165.

- CZurlt — Uwharrie Volcanics rhyodacitic lavas and tuffs
- CZufc — Felsic volcaniclastic rocks
- CZuimcl — Intermediate to mafic volcaniclastic rocks and lavas
- CZuiml — Intermediate to mafic lavas
- CZuhar — Uwharrie Volcanics hydrothermally altered rocks

Seagrove Formation (Informal Name)

Pollock et al. (2010) reported a youngest LA-ICP-MS U-Pb zircon age of 545±7 Ma from a sample from the unit near Yow Mill in the Chapel Hill 100K. Recent preliminary LA-ICP-MS U-Pb zircon analyses from two samples from the unit in the Chapel Hill 100K yield the following: for NCGS sample Coleridge-3055, there is a distinct age distribution that is <600 Ma and all MDAs are 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 detrital LA-ICP-MS U-Pb zircon analyses from additional Seagrove formation samples in the Chapel Hill 100K include: MDA of 559 Ma for sample COL-8005; MDA of 554 Ma for sample COL-472; and MDA of 523 Ma for sample CH100K-3839.

Also in the Chapell Hill 100K, two zircon grains from a felsic dike or tuff (UNC Chapel Hill sample NC-18-02 / NCGS Station Coleridge-458) from the unit yielded crystallization ages of 550.1±2.4 Ma and 550.7±1.3 Ma (R. Mills, personal com., 2018).

Additionally, two new and unpublished detrital LA-ICP-MS U-Pb zircon analyses from samples in the Southern Pines 100K include: MDA of 543 Ma for sample SP100K-550363 (geochronology data location E) and an MDA of 524 Ma for sample SP100K-550946 (geochronology data location D).

Hydrothermally altered units

Map units CZshar-qsp, CZshar-pqs, CZshar-qsh are surrounded by CZshar in the Robbins area and are very small at 100K-scale and are unlabeled on map. See GeMS database for detailed locations of units.

- CZshar — Seagrove formation hydrothermally altered rocks
- CZshar-pqs — Pyrophyllite-quartz±sericite hydrothermally altered rock
- CZshar-qsh — Quartz-sericite±hematite hydrothermally altered rock
- CZshar-qsp — Quartz-sericite±pyrite hydrothermally altered rock

Volcaniclastic sedimentary and volcanic units

- CZsfc — Seagrove formation felsic volcaniclastic rocks
- CZseb — Seagrove formation epiclastic rocks of the Biscoe area
- CZseb-a — Altered Seagrove formation epiclastic rocks of the Biscoe area
- CZsebimv — Seagrove formation epiclastic rocks of the Biscoe area with local intermediate to mafic volcanics
- CZsebimv-a — Altered Seagrove formation epiclastic rocks of the Biscoe area with local intermediate to mafic volcanics
- CZsehc — Seagrove formation epiclastic rocks of the Harpers Crossroads area
- CZsehc-a — Altered Seagrove formation epiclastic rocks of the Harpers Crossroads area
- CZse/pl — Seagrove formation epiclastic and pyroclastic rocks with rhyodacitic domes of the Robbins area
- CZsimv — Seagrove formation intermediate to mafic volcanic rocks
- CZsimvc — Seagrove formation intermediate to mafic volcanic and volcaniclastic rocks
- CZsmd — Seagrove formation mudstones

HYCO ARC

Hyco Formation - upper portion

Wortman et al. (2000) reported a TIMS $^{207}Pb/^{206}Pb$ age of 615.7+3.7/-1.9 Ma (MSWD = 0.44) from a metamorphosed tuff from unit Zhdlt (u) in the Henderson 100K. Bowman (2010) reported a CA-TIMS $^{207}Pb/^{206}Pb$ ages of 616.5±1.2 Ma (MSWD = 0.027) from unit Zhf in the southern portion of the South Boston 100K. Bradley and Miller (2011) reported a CA-TIMS $^{207}Pb/^{206}Pb$ age of 613±1 Ma from a felsic tuff in Orange County in the Greensboro 100K.

Hydrothermally altered units

- Zhhar — Hydrothermally altered rocks
- Zhat/vcs — Altered tuffs and volcaniclastic sedimentary rocks

Volcaniclastic sedimentary and volcanic units

- Zhe/pl — Mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas
- Zhe/pl-a — Altered mixed epiclastic-pyroclastic rocks with interlayered dacitic lavas
- Zhdlt (u) — Dacitic lavas and tuffs of the upper portion of the Hyco Formation
- Zhime/pl — Mixed intermediate to mafic epiclastic-pyroclastic rocks with interlayered intermediate to mafic lavas
- Zhabl — Andesitic to basaltic lavas
- Zhable — Andesitic to basaltic lavas with interlayered epiclastic rocks

EASTERNMOST CAROLINA TERRANE

Plutonic Rocks

Buckhorn Dam Meta-intrusive Suite

- CZbg — Meta-granitoid rocks of the Buckhorn Dam intrusive suite
- CZbg-lsp — Lemon Springs pluton of the Buckhorn Dam intrusive suite
- CZbg-rd — Rhyodacite to dacite of the Buckhorn Dam intrusive suite

Layered and Stratified Rocks

Cary Metamorphic Suite

A sample from Big Lake-Raven Rock schist (CZbr1) in the Raleigh 100K sheet contains discordant zircon fractions that yield TIMS $^{207}Pb/^{206}Pb$ crystallization ages of ca. 579-573 Ma and an upper intercept age of 575±12 Ma (Goldberg, 1994).

- CZbr3 — Big Lake-Raven Rock schist 3
- CZmas — Mafic schist, phyllite, and sericite phyllite
- CZbr-py — Phyllite and argillite
- CZsphs-gpb — Sericite phyllite and metamorphosed sedimentary rocks interpreted by geophysical methods and boring data

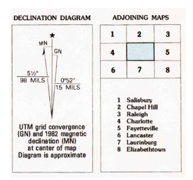
UPPER LITTLE RIVER TERRANE

- CZulrs — Upper Little River schist

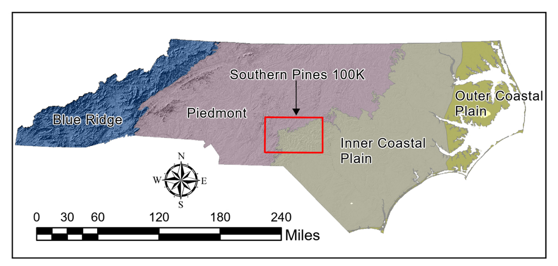
CRABTREE TERRANE

The Crabtree Creek gneiss (CZccg) in the Raleigh 100K sheet yields TIMS U-Pb zircon ages of ca. 566-554 Ma (Goldberg, 1994). Horton and Stern (1994) reported TIMS $^{207}Pb/^{206}Pb$ ages of ca. 542 Ma for CZccg. A sample of Middle Creek gneiss (Zmca) in the Henderson 100K yields an LA-ICP-MS zircon age of 562±14 Ma (Fishel et al., 2024). A sample of Horse Creek schist (Zhcs) in the Raleigh 100K sheet yields a unimodal population of monazite U-Pb concordia ages ca. 300 Ma; rutile ages are ca. 335 Ma and 263 Ma (lower intercept isochron ages; Burgess et al., 2024). Two additional samples of Zhcs produce an LA-ICP-MS zircon lower concordia intercept metamorphic age of 287.09±1.39 Ma, and a muscovite $^{40}Ar/^{39}Ar$ cooling age of 251.45±1.6 Ma, respectively (Blake et al., 2021).

- CZsph-gpb — Sericite phyllite interpreted from geophysical methods and boring data



Magnetic north declination 8.78° W
(NOAA National Centers for Environmental Information Website, March 12, 2025)



Miles: 0 2.5 5 10 15 20
US Feet: 0 12,500 25,000 50,000 75,000 100,000
Kilometers: 0 2.5 5 10 15 20

CONTACTS, FAULTS, AND OTHER FEATURES

dashed where inferred, dotted where concealed, ? where questionable

- contact
- gradational contact
- unconformable contact
- fault
- normal fault
- high angle reverse fault
- thrust fault
- lidar lineament
- anticline
- syncline
- overturned anticline
- overturned syncline
- coal bed (Reinemund, 1955)
- conglomerate beds (Reinemund, 1955)
- county boundary
- Trpwpp, zone of wind polished and faceted pebbles in the Pekin Formation (Reinemund, 1955)

DIKES

solid where known, dashed where inferred, dotted where concealed, ? where questionable

- Jd, diabase
- Jd, diabase intruded along fault (Reinemund, 1955)
- Jd, diabase located via magnetic data (Burt et al., 1978)
- CZabg-sm, Stony Mountain gabbro
- CZq, quartz veins

GEOCHRONOLOGY DATA LOCATIONS

(see pamphlet for detailed table)

- U-Pb zircon crystallization age
- detrital zircon age as maximum depositional age (MDA)
- Rb-Sr whole rock isochron date

OBSERVATION STATION POINTS

Distribution and concentration of observation stations indicates degree of reliability of geologic mapping.

- Observation station location
- Diabase observation station location

GEOCHEMICAL DATA LOCATIONS

(see pamphlet for detailed table)

SP100K-550187
Geochemical data location

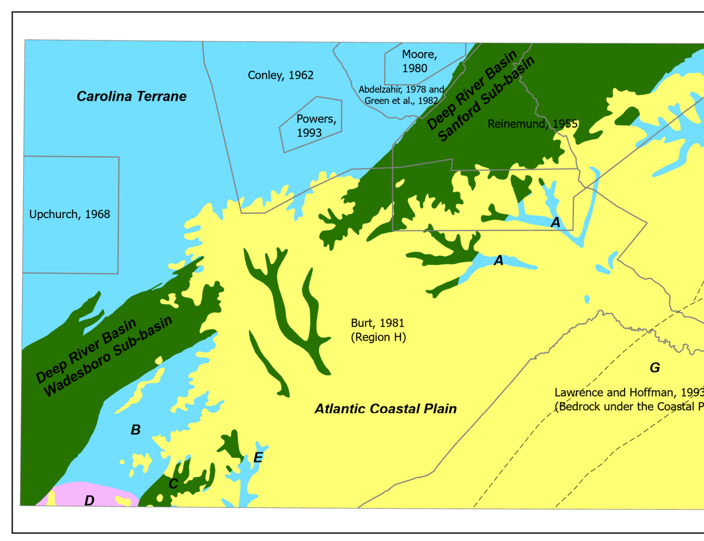
Declination diagram and map of adjoining 100K quadrangles is from the USGS 1982 GeoTiff of the Southern Pines 30' x 60' quadrangle. Basemap contours provided courtesy of the USGS National Elevation Dataset. Other data provided courtesy of NC One Map.

Research supported by the U.S. Geological Survey, National Cooperative Geologic Mapping Program under STATEMAP (Award 2024, G24AC00339).

This map and explanatory information is submitted for publication with the understanding that the United States Government is authorized to reproduce and distribute reprints for governmental use. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

Acknowledgments: Many thanks to James P. Hibbard for the discussions, guidance, and continued assistance with enhancing the understanding of the Carolina terrane.

Thanks to Joe Moye for reviving discussions of the stratigraphy in the Carolina terrane with his paper *The Albemarle Sequence of the Carolina Terrane in Central North Carolina: Geologic and metallogenic analysis with an alternative model* (Moye, 2023).



Major geologic elements and terrane map with an index of legacy maps used in this compilation. New field work was conducted in 2024 and 2025 to rectify internal edge-match issues. A - Easternmost Carolina terrane, B - Carolina terrane east of Triassic basin, C - Ellerbe basin, D - Lilesville pluton, E - Millstone Lake pluton, F - Upper Little River terrane, G/H - Crabtree/Spring Hope terranes (both completely covered by Atlantic Coastal Plain). Dashed lines represent interpreted terrane boundaries.

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

The goal of this compilation effort is 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). Data from the more detailed maps were preserved at the scale originally mapped. As such, some map unit polygons are very small on this 100,000-scale map and are unlabeled. The unit name of the unlabeled polygon can typically be interpreted from nearby labeled polygons. The GeMS digital database should be utilized in conjunction with this layout version of the map.

This compilation effort compiled legacy data at scales ranging from 125K- to 24K-scale. From June 2024 to June 2025, NCGS staff conducted targeted foot and vehicle traverses to validate contacts from 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 elevation 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.

Large portions of the Southern Pines 100K are overlain by Atlantic Coastal Plain sediments – see inset map. For areas in which the bedrock is covered by Coastal Plain sediments, data from the NC Department of Transportation Geotechnical Engineering Unit, boring data (NCDOT, 2026) and Lawrence and Hoffman (1993) - Geology of basement rocks beneath the North Carolina Coastal Plain - were utilized. The sub-Coastal Plain geology of Lawrence and Hoffman (1993) was based on widely spaced drilled data and geophysical data that included aeromagnetic maps (Zietz et al., 1984) and Bouguer gravity maps (Black, 1986; Daniels and Leo, 1985). Additionally, the locations of some diabase dikes and terrane boundaries were modified from Lawrence and Hoffman (1993) after review of the preliminary magnetic survey map from the Piedmont Bridge South Magnetic and Radiometric Survey (USGS Piedmont Bridge, 2025). Additional edits to the sub-Coastal Plain geology in the map area will likely occur after the official release and review of the new Piedmont Bridge data.

See accompanying pamphlet for detailed unit descriptions and additional information.

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Compiled Bedrock Geologic Map of the Northern Half of the Southern Pines 30' x 60' Quadrangle (Southern Pines 100K), North Carolina

New data collection and compilation work by: Philip J. Bradley, Garett J. Thompson, Qingxin Zhang, Douglas B. Hill, Ezra T. Becker, and Katherine E. Pelt

Cartographic representation by: Garett J. Thompson, Philip J. Bradley, and Michael A. Medina

Version 04/24/2026