GEOLOGIC MAP OF THE CHAPEL HILL 7.5-MINUTE QUADRANGLE, ORANGE AND DURHAM COUNTIES, NORTH CAROLINA

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DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF LAND RESOURCES
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NORTH CAROLINA GEOLOGICAL SURVEY
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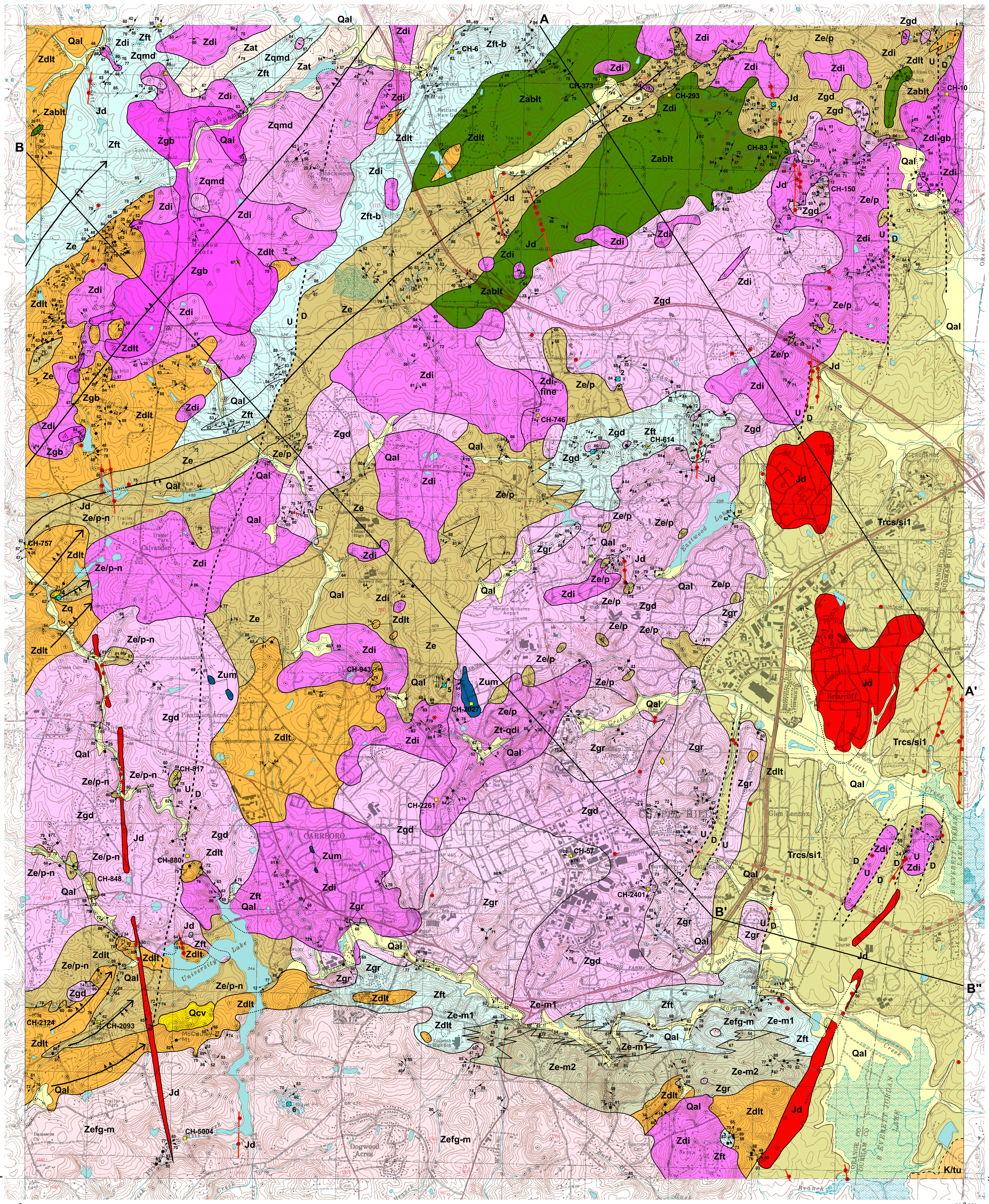
2004



CONTACTS

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

FAULTS

U
D

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

FOLDS

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

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

1 Mines, Prospects, and Pits

1 - Duke Forest Prospect
2 - Weaver-Carr Prospect
3 - Nunn Mountain Mine
4 - Laurel Hill Quartz Prospect
5 - Iron Mine
6 - Gravel Pits

STRUCTURAL SYMBOLS

Observation sites are centered on the strike bar or are at the intersection point of multiple symbols.

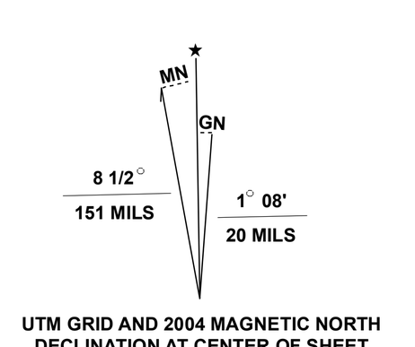
- 31 strike and dip of primary bedding and layering
- 37 strike and dip of primary volcanic compaction and/or welding
- 80 strike and dip of foliation
- 82 strike and dip of foliation S2
- 62 strike and dip of cleavage
- 64 strike and dip of shear foliation
- 28 strike and dip of joint
- 22 strike and dip of quartz vein
- 72 strike and dip of slickenside
- 72 strike and dip of slaty cleavage
- 21 trend and plunge of slickenline
- 16 trend and plunge of crenulation lineation
- station location
- 72 shear zone
- vertical bedding and layering
- vertical welding or compaction foliation
- vertical foliation
- vertical foliation S2
- vertical cleavage
- vertical shear foliation
- vertical joint
- vertical quartz vein
- 37 strike and dip of fault plane
- dike trend
- 13 trend and plunge of lineation
- 19 trend and plunge of fold axis
- Jd - boulder location or outcrop
- 80 fault gouge

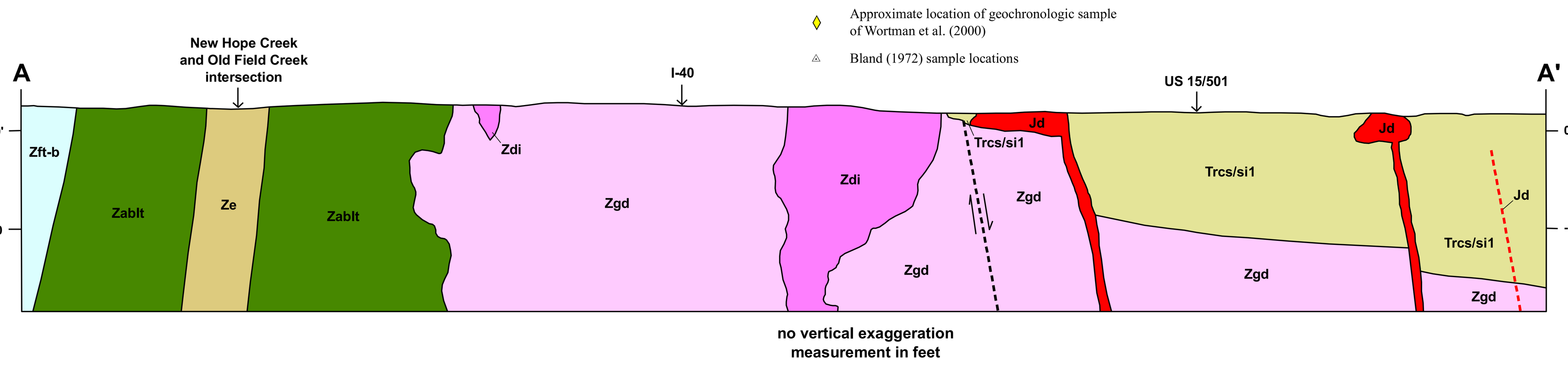
CH-757 Rock sample collected for geochemical analysis
Approximate location of geochronologic sample of Wortman et al. (2000)
Bland (1972) sample locations

0.25 0 0.25 0.5 0.75 1 Miles
1,250 0 1,250 2,500 3,750 5,000 Feet
375 0 375 750 1,125 1,500 Meters

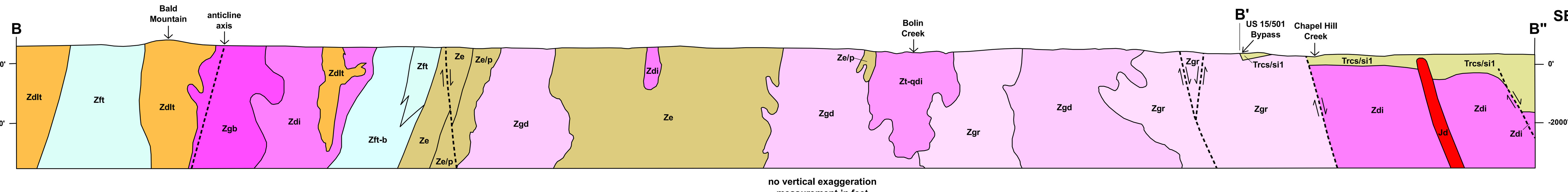
1:24,000 SCALE
CONTOUR INTERVAL 10 FEET

Base topographic map is digital raster graphic image of the Chapel Hill 7.5-minute USGS quadrangle (1993), North Carolina State Plane NAD 83 meters coordinate system.





no vertical exaggeration
measurement in feet



no vertical exaggeration
measurement in feet

EXPLANATION

All pre-Mesozoic rocks of the Chapel Hill quadrangle have been metamorphosed to at least the chlorite zone of the greenschist metamorphic facies. Many of the rocks also display weak to strong metamorphic foliation. Although subjected to metamorphism, the rocks retain relict igneous, pyroclastic, and sedimentary textures and structures that allow for the identification of protolith rocks. As such, the prefix "meta" is not included in the nomenclature of the pre-Mesozoic rocks described in the quadrangle.

The nomenclature of the International Union of Geological Sciences subcommission on igneous and volcanic rocks (IUGS) after Streckeisen (1973 and 1979) is used in classification and naming of the units. The classification and naming of the rocks is based on relict igneous textures, modal mineral assemblages, or normalized mineral assemblages when whole-rock geochemical data is available. Past workers in the Chapel Hill quadrangle (Allen and Wilson, 1968; Black, 1977; Bland, 1972; Butler, 1963 and 1964; Chiulli, 1987; Clark, 1957; Hayes, 1962; Kirstein, 1956; Mann et al., 1965;and Wagener, 1964 and 1965) have used various nomenclature systems for the igneous rocks. The raw data of some of these earlier workers was recalculated and plotted on ternary diagrams and classified based on IUGS nomenclature. Pyroclastic rock terminology follows that of Fisher and Schminke (1984). A review of the area geology is provided in Bradley et al., 2006.

SEDIMENTARY UNITS

Qal Qal – Alluvium: Unconsolidated clay, silt, sand and gravel to cobble-sized clasts, subrounded to angular, deposited in drainages.

Qcv Qcv - Quaternary colluvium: Accumulations of angular cobbles and boulders of unit Zdlt on the north slope of McCauley Mountain. Possibly formed by Quaternary slope movements (rock slide, rockfall, etc.).

K/Tu K/Tu – post-Chatham Group undifferentiated sediments: Yellowish-orange to brownish-yellow to yellowish-gray, unconsolidated to friable unit that consists of distinctive subrounded to well rounded granules, pebbles and small cobbles of white- to rose-colored quartz interlayered with clay, sandy-clay and clayey-sand. Lesser amounts of moderately indurated, yellowish-white, medium- to coarse-grained arkosic sandstone present. Unit is mainly exposed on shores of B. Everett Jordan Lake. Unit is in unconformable contact with Triassic sediments. Distribution of unit in Chapel Hill quadrangle interpreted from edge matching with geologic maps of Green Level (Watson, 1998) and Farrington quadrangles (Bradley et al., 2007) and interpretation from topography.

Trcs/si1 Trcs/si1 – Sandstone with interlayered siltstone of the Chatham Group Lithofacies Association I: Grayish-pink, pinkish-gray, and light-gray; fine- to coarse-grained, micaeous, slightly clayey, moderately poor to moderately well sorted, subangular to subrounded arkose and lithic arkose; dark red to reddish-brown, very silty, micaeous, moderately well sorted, fine-grained sandstone; and dark red to reddish-brown, 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.

INTRUSIVE AND META-INTRUSIVE UNITS

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

Zefg-m Zefg-m – East Farrington pluton main facies: Unfoliated, orange pink to pinkish-gray to gray, medium- to coarse-grained, equigranular to slightly porphyritic, amphibole (va. hornblende?) granite. Amphibole content varies from approximately 5 to 10% by volume and occurs locally as dark green, elongate crystals up to 1.5 cm long and amorphous intergrowths with feldspar and quartz up to 0.5 cm diameter. Dark gray xenoliths/enclaves up to 8 cm in diameter are common. Grain size becomes finer and xenoliths/enclaves larger near the pluton edge. Cavities, <1 mm in diameter, with euhedral terminating crystals are common in some specimens. In thin section the main facies can be separated into two groups: 1) rocks with a porphyritic texture with orthoclase and plagioclase 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. U-Pb zircon geochronologic data (Tadlock and Loewy, 2006) indicate that the East Farrington pluton is ca. 579 Ma.

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

Zgd Zgd – Granodiorite: Leucoractic to mesocratic, fine- to medium-grained, equigranular to porphyritic granodiorite. In the northern portion of the quadrangle, the granodiorite is mainly 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 quadrangle. In the central and southern portions of the 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.

Zdi Zdi – Diorite: Mainly greenish-gray to gray, mesocratic, medium-grained, equigranular diorite. Major minerals include plagioclase and hornblende. Greenish-white plagioclase crystals compose up to 50% of the rock and are typically sericitized and saussuritized. Individual stocks contain varying amounts of tonalite and quartz diorite. Hornblende is typically altered to chlorite and actinolite masses. Weathered cobbles and boulders typically display a "bleached" weathering rind of white to grayish-white.

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

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

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

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

Zgb Zgb – Gabbro: Dark-gray to greenish-gray, mesocratic to melanocratic, medium-grained gabbro. 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.

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

METAVOLCANIC UNITS

Zq Zq - Laurel Hill quartz body: A resistant topographic feature of milky white quartz. Allen and Wilson (1968) described the Laurel Hill quartz body as being composed of a cluster of quartz veins 600 feet in length and 90 feet in width. Float boulders and cobbles of quartz are present over an area of over 300 feet wide.

Zat Zat – Altered tuffs: Very light gray to light greenish gray (whitish in areas) with red and yellow mottling. Alteration consists of silicified 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.

Ze Ze – Epiclastics: Mixed unit of metasedimentary rocks. Includes mudstone, siltstone, sandy siltstone, sandstone, conglomeratic sandstone, and conglomerate. Minor interlayers of fine tuff to vitric tuff are present. Mudstones and siltstones are sometimes phyllitic or silicified, greenish-gray to gray, with continuous, parallel to slightly wavy, thin lamina to very thin beds, occasionally with small-scale loading structures. The mudstones and 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. Conglomerates include matrix supported and clast supported polymictic conglomerate composed of angular to rounded pebble to gravel-size sediment. Sandstone and conglomerate beds often fill scour channels in the siltstones.

Ze-m1 / Ze-m2 Ze-m1 and Ze-m2 – Morgan Creek epiclastics: Contains well bedded, greenish-gray to gray, siltstone, sandy siltstone, sandstone, conglomeratic sandstone, and conglomerate. The unit was divided into two lithofacies, Ze-m1 and Ze-m2: Zme1 is exposed mainly along Morgan Creek; it is mostly well bedded siltstones with lesser sandstone and conglomerate beds; Ze-m2, occurs to the south and southwest of Ze-m1 and is overall coarser, containing mostly sandstones and conglomerates with lesser well bedded siltstones. Siltstones range from thinly laminated to very thinly bedded (<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.

Ze/p Ze/p - Mixed epiclastic-pyroclastic rocks: Grayish-green to greenish-gray; tuffaceous sandstones, conglomeratic sandstones, siltstones and minor phyllite. The siltstones typically are weakly phyllitic. Contains lesser amounts of coarse tuff and lapilli tuff. Abundant silicified and/or sericitized altered rock similar to Zat unit is present near contacts with plutonic rocks.

Ze/p-n Ze/p –n - Mixed epiclastic-pyroclastic rocks of Neville Creek area: Heterogeneous unit of felsic to intermediate composition tuffs and lavas, tuffaceous sandstones and conglomeratic sandstones.

Zft Zft - Felsic tuffs: Greenish-gray, silvery-gray, and gray, massive to foliated, lithic, lithic-crystal, crystal, ash, and minor welded tuffs. Layering ranges from massive to thinly bedded (3 cm to 10 cm).

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

Zdlt Zdlt - Dacitic lavas and tuffs: Distinctive dark-gray to black, siliceous, cryptocrystalline dacite, porphyritic dacite with plagioclase +- quartz phenocrysts, and flow banded dacite. (A distinct quartz + plagioclase porphyritic dacite is present at Bald Mountain.) Tuffs associated with the lavas include welded and non-welded: greenish-gray to grayish-green, coarse plagioclase crystal tuff; lapilli tuff; lithic tuff. The dacites are interpreted to have been coherent magma that were extrusive 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. A sample, identified as a flow-banded rhyolite, collected from a location immediately west of University Lake, yielded an upper intercept date from single zircons of 632.9 +2.6/-1.9 Ma (Wortman et al. 2000).

Zablt Zablt – Andesitic to basaltic lavas and tuffs: Typically unfoliated, green, gray-green, gray, dark gray and black; 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. Tuffs associated with the lavas are weakly foliated to foliated, green to gray to silvery-gray, coarse tuff and lapilli tuff.

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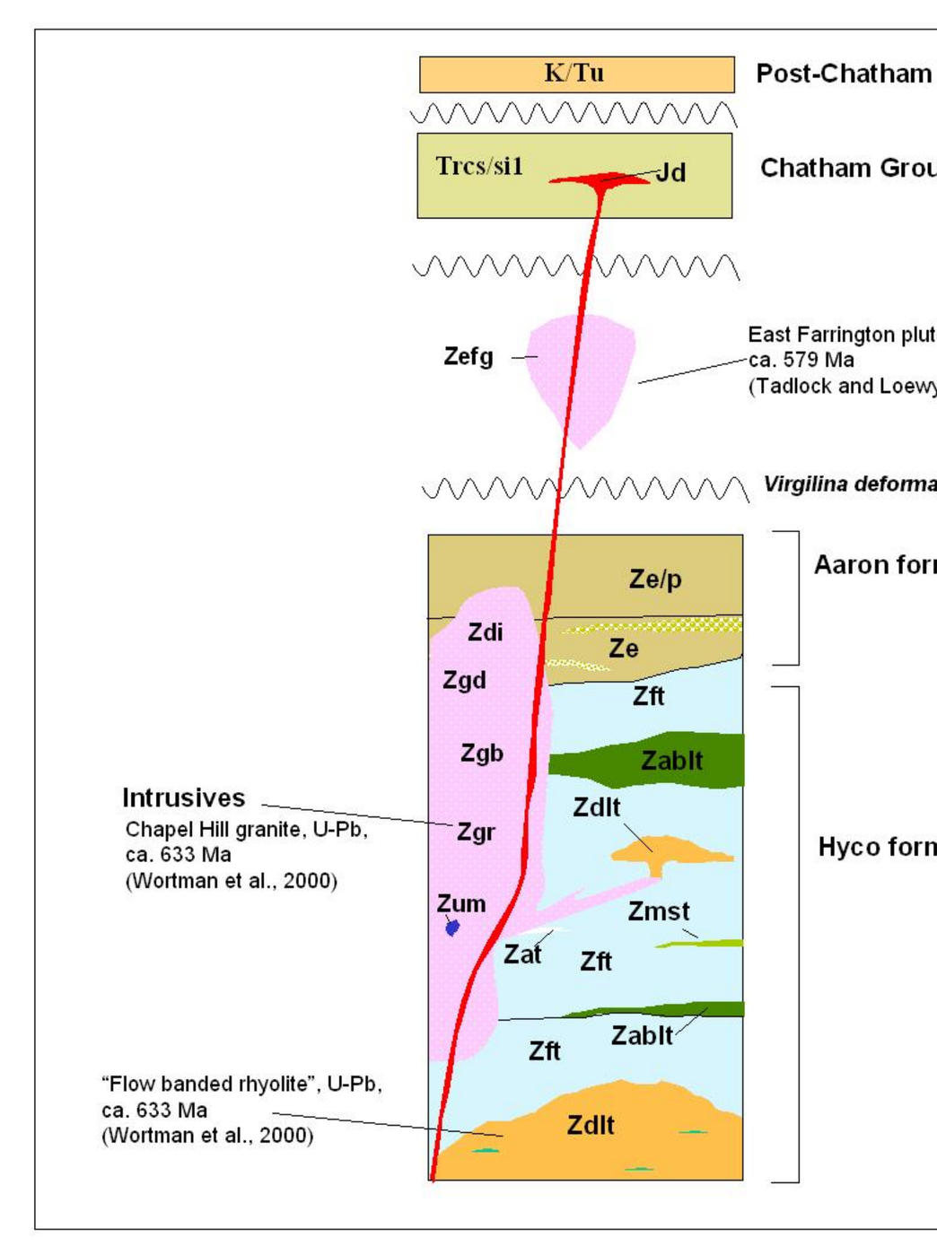
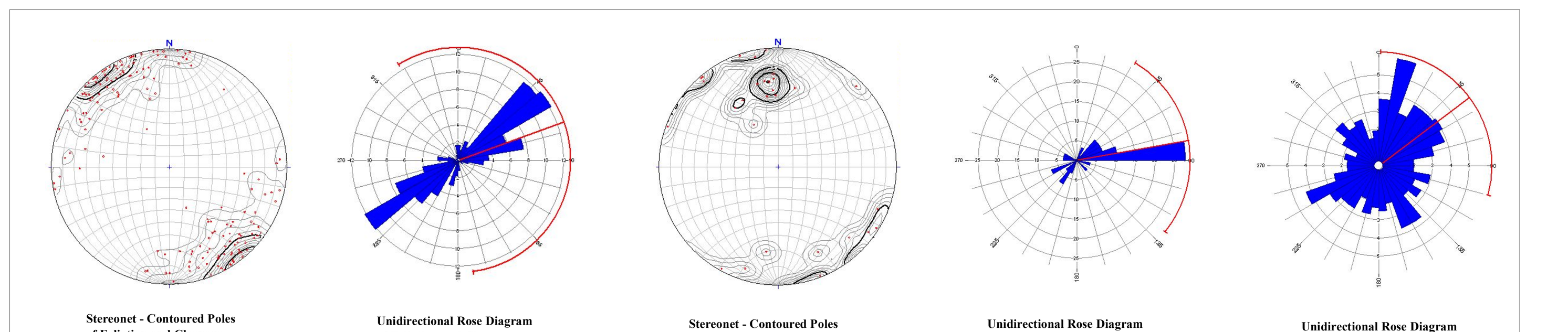


Schematic representation of stratigraphic relationships of geologic units in the Chapel Hill 7.5-minute quadrangle.



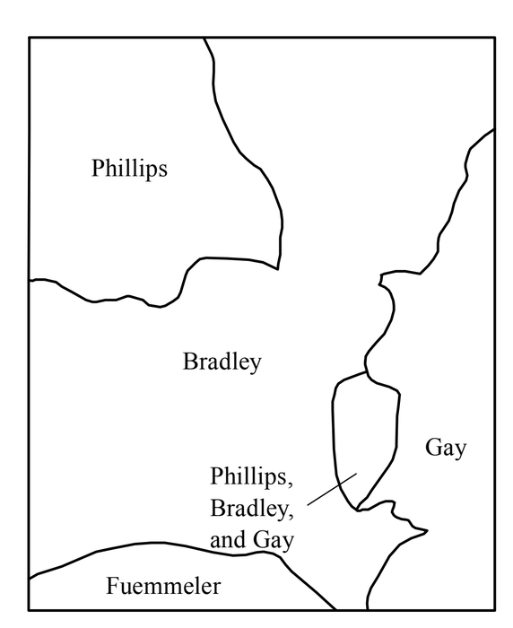
Stereonet - Contoured Poles of Foliation and Cleavage N=173

Unidirectional Rose Diagram of Foliation and Cleavage N=173

Stereonet - Contoured Poles of primary layering and bedding N=29

Unidirectional Rose Diagram of primary layering and bedding N=29

Unidirectional Rose Diagram of Joints N=519



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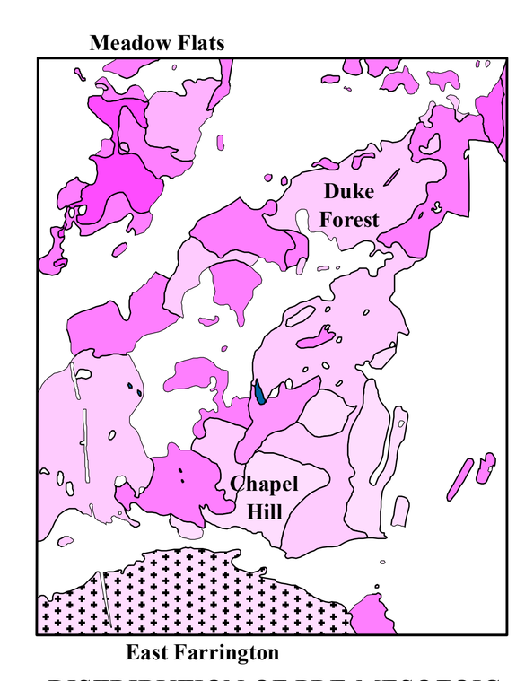

DISTRIBUTION OF PRE-MESOZOIC PLUTONIC ROCKS AND INFORMAL PLUTON NAMES

Scan with smartphone for link to GeoPDF of map. Third party App required.

Plutons

Kirstein (1956), Clark (1957), Hayes (1962), Wagener (1965), and Mann, et. al. (1965) described the intrusive rocks of the Chapel Hill quadrangle in detail. Black (1977) grouped the intrusive rocks of the Chapel Hill area into four plutons: 1) Meadow Flats pluton, 2) Duke Forest pluton, 3) Chapel Hill pluton, and 4) East Farrington pluton.

Meadow Flats pluton

The informally named Meadow Flats pluton, located in the area of the Meadow Flats lowland in the northwest portion of the quadrangle, was originally mapped by Kirstein (1956) and later studied in detail by Bland (1972). The Meadow Flats pluton has been described as a composite pluton of gabbro, diorite, and granodiorite based on the nomenclature used by Kirstein (1965). Whole rock chemical analyses from 57 rock samples collected throughout the Meadow Flats pluton by Bland (1972) were normalized and plotted on QAP diagrams for this study. According to IUGS nomenclature, the rocks previously categorized as granodiorite plot as quartz monzodiorite. In the field, these rocks are similar in appearance to the diorites. The areas previously mapped as granodiorite are designated as quartz monzodiorite in this study.

Duke Forest pluton

The informally named Duke Forest pluton (Black, 1977), is located in the northeast portion of the quadrangle on land partially owned by Duke University. The pluton is composed of diorite with a small amount of gabbro on the east and granodiorite on the west. Cole (1971, unpublished report) produced a geologic map of the area in the vicinity of the Duke Forest pluton based on a determination of rock type from point-count analyses from thin sections. The boundary between the Duke Forest pluton and the Chapel Hill pluton is not distinct and the rocks assigned to the plutons appear to grade into one another. The last appearance of a porphyritic granodiorite, generally restricted to the northern portion of the quadrangle, north of Eastwood Lake, has been arbitrarily selected as the boundary between the Duke Forest pluton and Chapel Hill pluton.

Chapel Hill pluton

The Chapel Hill pluton is composed primarily of granite and granodiorite with several stocks of diorite to the west and northwest. The Chapel Hill pluton underlies UNC campus and the town of Chapel Hill and is bounded on the east by Triassic sediments. Three horsts, one composed of granitic rock and the other two composed of diorite, are present within the Triassic basin.

East Farrington pluton

Rocks assigned to the East Farrington pluton outcrop within the southern portion of the quadrangle. The majority of the East Farrington pluton is located within the Farrington and Bynum quadrangles. Separated from the Chapel Hill pluton by a thin strip of volcaniclastic and volcanosedimentary rocks less than one mile wide, the East Farrington is primarily a granite with minor amounts of granodiorite and diorite.

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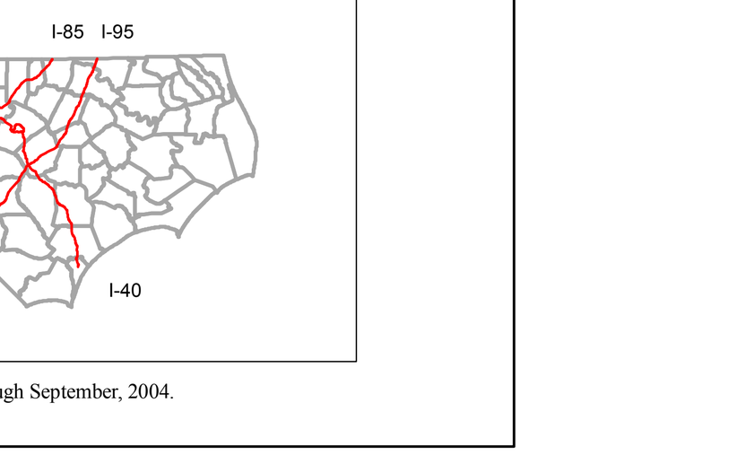
LOCATION OF THE CHAPEL HILL 7.5-MINUTE QUADRANGLE, NORTH CAROLINA



Geology mapped December, 2003, through September, 2004