

INTRODUCTION

The Littleton 7.5-minute quadrangle lies in the northeastern Piedmont, partly along the south shore of Lake Gaston and within 1.5 miles of the Virginia state line. The Warren-Halifax County line runs nearly north-south through the quadrangle, except for a jog around the western edge of the town of Littleton, which itself lies entirely in Halifax County. The majority of the quadrangle lies within Warren County to the west of the town. US Highway 158 runs approximately west to east across the quadrangle, following the southern drainage divide of the Roanoke River basin. NC Highway 4, which runs north to Rocky Mount, has its northern terminus at US 158 at Littleton. NC 903 runs south, ending the northern edge of the quadrangle before crossing Lake Gaston at Eaton's Ferry Bridge and terminating at the Virginia state line. The old Seaboard Coast Line Raleigh and Gaston railway spur runs parallel to US 158 across the quadrangle, but it is now defunct and the tracks have been removed. Aside from the town of Littleton, the Warren County portion of the quadrangle contains the unincorporated communities of Enterprise, Fowling, and part of Vaughan, while the unincorporated community of Cooleys Crossroads lies in Halifax County. Panacea Springs, a former resort hotel featuring mineral waters, is located in the upper reaches of Beech Creek in the southeastern part of the quadrangle. It burned during the latter part of the 19th century, and its ruins are still visible. North of US 158, streams draining north into Lake Gaston (formerly the Roanoke River) have incised relatively deep channels. The three most significant of these, Mill Creek and Big and Little Stone House Creeks, have NNE trends that are at least partly controlled by the structure of the bedrock geology. South of the US 158 drainage divide, Butterwood Creek, Little Fishing Creek, and Little Fishing Creek drain eastward and southward, eventually emptying into the Roanoke River in the Halifax-Halifax County line. Tidal relief in the quadrangle is less than 200 feet, with a high just about 390 feet above sea level just east of the town of Littleton, while the low point is Lake Gaston at 200 feet. Despite the low relief, bedrock exposure is fairly good along creeks and the lake shore; in addition, the granitic rocks are well exposed on ridges and slopes.

GEOLOGICAL FRAMEWORK

Three major groups of rocks underlie the quadrangle: from west to east they include late Proterozoic to Cambrian metamorphic rocks of the Raleigh terrane, similar-age metamorphic rocks of the Spring Hope terrane, and a number of late Paleozoic granitoid plutons in the eastern part of the quadrangle. Two major late Paleozoic faults also lie within the quadrangle. The Macon fault separates the Raleigh terrane from the Spring Hope terrane. The Hollister fault, which separates the Spring Hope terrane from the Triplet terrane, tracks through younger granitic rocks in the eastern part of the quadrangle. Metamorphic rocks of the Triplet terrane occur east of the Littleton Quadrangle in the Thomas Quadrangle. The Raleigh terrane consists of gneiss and schist, and is interpreted as an infrastructural component of a Neoproterozoic volcanic arc (Holland and others, 2002). The suprastructural Spring Hope terrane comprises metamorphic and igneous rocks. All metamorphic rocks of the quadrangle have been subjected to mid- to upper-amphibolite facies conditions. Late Paleozoic granitic rocks in the quadrangle range from medium-grained and equigranular to strongly megacrystic, and from some undeformed granites to those strongly deformed and mylonitized. Nearly all of the granitic rocks are divided into five separate bodies; they are the Butterwood Creek, Airline, Panacea Springs, Lawrenceville, and Enterprise plutons. The Butterwood Creek and Airline plutons intrude metamorphic rocks of the Triplet terrane, while the other three intrude the Spring Hope terrane. An age of 292 ± 31 Ma was reported by Russell and others (1985) for the Butterwood Creek pluton, but subsequent mapping, shown on this geologic map, indicates that some of the samples analyzed in their study are from the Panacea Springs pluton. Nevertheless, all of the granitic rocks are likely for all five granitic plutons in the Littleton Quadrangle. Intrusive rocks of Jurassic age cut the older rocks of the quadrangle. These are of two types: olivine diabase and rhyolite porphyry. Both types occur as NNW-trending, steeply dipping dikes; the porphyries comprise a swarm of dikes in the western half of the quadrangle. The unusual rhyolite porphyry has been dated at 198–200 Ma by several methods (Stoddard and others, 1986; Gungul and others, 1995). In the eastern part of the quadrangle, several high and flat areas, underlain by sedimentary deposits of the Atlantic Coastal Plain, are not shown on the geologic map.

PREVIOUS WORK

Previous geologic investigations pertinent to the Littleton Quadrangle include several regional and reconnaissance studies. Parker (1968) defined the structural framework of the region. McDaniel (1980) mapped a multi-county region, including Warren County, at a scale of 1:100,000. Farrar (1985a, b) mapped the entire eastern Piedmont of North Carolina, defined map units for the region, and proposed a model for the tectonic evolution of the region. Bolin (1985) mapped the Hollister Quadrangle immediately to the south of the Littleton Quadrangle. The Hollister Quadrangle was updated with new data concurrently with the Littleton Quadrangle (Sacks and others, 2011). Sacks (1996a, b and others, 2011) mapped a strip of four 7.5-minute quadrangles along the Virginia-North Carolina border. One of these, the Gasburg Quadrangle (Sacks, 1996c), lies immediately to the north of the Littleton Quadrangle. Additional mapping by Sacks (1999 and unpublished manuscript map), in a study of the Hollister fault zone, constitutes the eastern portion of the geologic map and served as the impetus for this study. Other research pertinent to the geology of the Littleton Quadrangle includes two studies involving mapping and chemical analyses of some of the granitic rocks of the area (Kochler, 1982; Grundy, 1983), investigations of Mesozoic dikes (Deberry, 1983; Stoddard and others, 1986; Stoddard, 1992), and metamorphic studies (Bolin and Stoddard, 1987; Stoddard, 1992). Two published field trip guides include stops within the quadrangle (Stoddard and others, 1987; Sacks and others, 1999).

DESCRIPTION OF MAP UNITS

INTRUSIVE ROCKS

- Jp - rhyolite porphyry:** Dark gray to black, strongly porphyritic dike rocks containing phenocrysts of alkali feldspar (sanidine-anorthoclase) and quartz, and locally microphenocrysts of Fe-Ti oxide minerals, ferropargasite, and amphibole. Commonly with a weak, locally aligned amphibole fabric, silica, or a green swelling clay mineral. Occurs in steeply dipping, NNW-trending dikes that correlate with linear magnetic highs. Weathers phylloitic. Described more fully elsewhere (Deberry, 1983; Stoddard and others, 1986; Stoddard, 1992). Blue dots indicate outcrop or float occurrences.
- Jd - diabase:** Fine to medium-grained, dark gray to black, equigranular to locally plagioclase porphyritic diabase, typically olivine-bearing. Commonly weathers to tan-gray, spheroidal boulders and cobbles. Occurs in vertical to steeply dipping dikes. The bases of the larger dikes correlate with and may be partly interfused on the basis of linear magnetic highs. In the Littleton quad, nearly all diabase dikes trend NW to NNW. Red dots indicate outcrop or float occurrences.
- PPpc, PPpn - Panacea Springs granite:** Medium-grained, megacrystic, weakly foliated biotite ± hornblende monzonite to quartz monzonite (PPpn) composed of megacrysts of microcline in a matrix of coarse-grained plagioclase, microcline, quartz, biotite, opaque minerals, and minor white mica; microcline megacrysts are as long as 5 cm. A chemical analysis (Grundy, 1983, sample 27-1) yields norms falling in the quartz monzonite field. See Table. Medium-grained, coarse-grained, porphyritic, foliated biotite monzonite to quartz monzonite (PPpc), composed of plagioclase, microcline, quartz, biotite, opaque minerals, and minor white mica, locally contains microcline phenocrysts as long as 3 cm. Locally mylonitic along eastern margin (Sacks, 1996c). Apparently sampled from the Littleton quad and analyzed by Voth and McSwain (1990) as their "undeformed Butterwood Creek" granite.
- PPm - Lawrenceville granite:** Medium-grained, megacrystic, weakly foliated biotite quartz monzonite to megacrystic (PPm) composed of megacrysts of microcline in a matrix of coarse-grained plagioclase, microcline, quartz, biotite, opaque minerals, and minor white mica; microcline megacrysts are as long as 5 cm (Sacks, 1996c). A chemical analysis (Grundy, 1983, sample 84-1) yields norms falling in the quartz monzonite to leucogranite range. See Table.
- Ppa - Airline granite:** Light gray to beige, fine- to medium-grained, dominantly equigranular muscovite, muscovite-biotite, and muscovite-biotite-garnet monzonite and leucogranite. Generally massive, but locally weakly to moderately foliated. Mylonitic along western margin (Sacks, 1999). Cuts and locally contains enclaves of megacrystic Butterwood Creek granite. A chemical analysis (Grundy, 1983, sample 73-1) yields norms falling in the monzonite field. See Table.
- PPb - Butterwood Creek granite:** Medium gray to tan, megacrystic biotite ± hornblende monzonite or quartz monzonite with accessory titanite. Generally massive, locally with a weak magmatic affinity of K-feldspar megacrysts. At its western and northeastern margin, where it is intruded by granite of the Airline pluton within the Hollister fault zone, the Butterwood Creek granite carries a strong deformational fabric. There, megacrysts are strongly aligned, quartz ribbons are developed, and the foliation is composite with both a mylonitic foliation defined by aligned feldspars, biotite and quartz ribbons, and shearward of that, a deformed zone defined by the main foliation (Sacks, 1999). Sampled from the Hollister Springs quad by Voth and McSwain (1990) as their "undeformed Butterwood Creek granite".
- Ppe - Enterprise granite:** Light- to medium-gray, porphyritic to megacrystic biotite granitoid. Typically gneissic and mylonitic. Salmon, pink, or beige K-feldspar porphyroclasts 0.5-2.0 cm in length in a quartzofeldspathic matrix consisting of alternately biotite-rich and biotite-poor 1 to 3-mm-thick layers. Cf-10-15.
- PPgm - mylonitic granite:** Medium-gray, medium- to fine-grained biotite and muscovite-biotite granite in the Hollister fault zone; locally contains feldspar porphyroclasts as long as 1.2 cm; variably mylonitic or gneissic; commonly lineated (Sacks, 1996c).

METAMORPHIC ROCKS OF THE SPRING HOPE TERRANE

- CZm - intermediate-mafic metapelite rocks:** Dark green to greenish-black, medium- to coarse-grained weakly foliated to massive metabasite or metadiabase consisting of amphibole, plagioclase, and clinopyroxene, with local quartz and epidote; and quartz, epidote, and opaque minerals.
- CZnmv - mafic metavolcanic rocks:** Green to dark green, fine to medium grained, weakly to moderately foliated amphibole, amphibole gneiss, greenschist, phyllite, and quartz-epidote rock containing various mixtures of hornblende, plagioclase, quartz, chlorite, and opaque minerals.
- CZmv - felsic metavolcanic rocks:** Light grayish-tan, biotite, or gray, thin to medium-grained weakly foliated to massive felsic gneiss consisting predominantly of a very strongly recrystallized mosaic matrix of very fine quartz + sodic plagioclase ± microcline. Sparse relict phenocrysts of plagioclase and rare quartz are present. Biotite and white mica may be present but are sparse. Microcline layering is locally defined by biotite and/or megacrysts. Biotite is distinctly biotitic in contact aureoles and where occurring as orthoclase within granitic plutons. Common metamorphic minerals, especially in hornblende gneiss, include quartz, epidote, and magnetite; these minerals may occur in clusters, suggesting they are pseudomorphous after mafic phenocrysts or possibly pyroclasts. Interpreted to be pyroclastic or lava in origin. Includes thin K-feldspar leucosomes of Farrar (1985a,b) and quartzites of McDaniel (1980), also believed to be correlative with "diabase blueschist" mapped to the southwest (Stoddard, 1991; Stoddard and others, 2010). Major-element chemical data (Sacks, 1999, Table 1, specimen LT-8) from a thin, abnormally quartz in the western Littleton Quadrangle indicate that the rock has a diacidic protolith. Analysis from Grundy (1983) of samples north of the town of Littleton (35-1, 39-4, and 80-1) are rhyolitic in composition. See Table.
- CZmpa - metagraywacke and metasilstone:** Light greenish to medium-brown or gray, fine- to medium-grained metagraywacke and fine, typically phyllitic metasilstone. Consists of quartz, plagioclase, white mica, biotite, and opaque minerals. Locally displays relict clastic texture and sedimentary bedding or laminae. Commonly foliated. Includes minor metavolcanic rocks, including felsic varieties with possible phenocrysts of plagioclase and quartz, and chlorite-actinolite phyllite likely derived from a mafic protolith.
- CZps - muscovite-garnet schist:** Silver to gray white mica schist and phyllite commonly containing porphyroblasts of staurolite and garnet. May also contain quartz, chlorite, tourmaline, sodic plagioclase, and opaque minerals. Garnet is typically well crystallized, with crenulation cleavage overprinting the schistosity. Unit also includes rare interlayers of fine-grained micaceous quartzite, one quartzite specimen contains biotite, muscovite, chlorite, staurolite, garnet and opaque minerals.
- CZs - metavolcanic rocks undivided:** Mixed fine- to medium-grained metavolcanic rocks of felsic, mafic, or intermediate composition, including with volcanoclastic metasedimentary rocks. Includes phyllitic, schist, gneiss, greenschist, amphibolite, and metagraywacke.

METAMORPHIC ROCKS OF THE RALEIGH TERRANE

- CZms - muscovite gneiss:** Silvery gray to greenish-gray, medium- to coarse-grained schist containing white mica, quartz, and commonly sillimanite and sodic plagioclase; may also contain chloritoid, tourmaline, garnet, or rarely biotite. Sillimanite may be fibrous or prismatic. Commonly displays mylonitic fabric, and a biotite schist appearance and commonly shows retrograde metamorphic effects, with white mica, chlorite and chloritoid replacing earlier minerals. Typically interlayered with quartzofeldspathic gneiss. Includes rare soapstone and talc schist. Likely equivalent to Mason Formation of Farrar (1985a,b).
- CZg - biotite gneiss:** Predominantly interlayered medium-gray to greenish-gray, fine- to medium-grained biotite gneiss and grayish-tan muscovite-biotite gneiss composed of plagioclase and amphibole, and local biotite, quartz, clinopyroxene, magnetite and epidote. Also contains minor interlayers of muscovite schist.
- CZgp - granitic gneiss:** Light tan, light gray, and light brown, fine- to medium-grained quartzofeldspathic gneiss and foliated metagranitoid, consisting of quartz, sodic plagioclase, microcline, white mica, and locally biotite. May show retrograde effects including chlorite and sericite.
- CZmg - mylonitic biotite gneiss:** Interlayered, variably mylonitic biotite gneiss, muscovite-biotite gneiss, muscovite schist, amphibole gneiss, and quartzofeldspathic gneiss.
- CZsa - talc-actinolite schist:** Light grayish-green, green, or dark green, foliated to massive talc schist, soapstone, and talc-actinolite schist composed of talc, serpentine, actinolite, and chlorite, with sparse granules of black, rusty-weathering oxide minerals.

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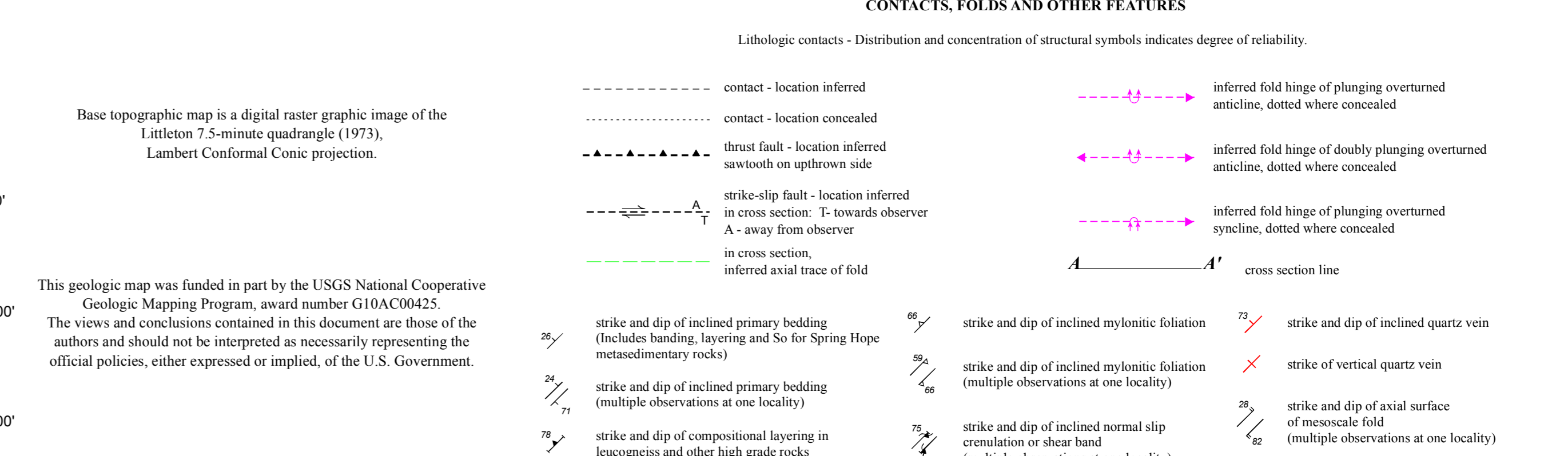
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Base topographic map is a digital raster graphic image of the Littleton 7.5-minute quadrangle (1973), Lambert Conformal Conic projection.

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Disclaimer: This Open-File report is preliminary and has been reviewed internally for conformity with the North Carolina Geological Survey editorial standards. Further revisions or corrections to this preliminary map may occur.

Symbol	Description	Symbol	Description
---	contact - location inferred	---	inferred fold hinge of plunging overturned anticline, dotted where concealed
---	contact - location concealed	---	inferred fold hinge of doubly plunging overturned anticline, dotted where concealed
---	thrust fault - location inferred upsouth an upflow side	---	inferred fold hinge of plunging overturned anticline, dotted where concealed
---	strike-slip fault - location inferred in cross section, T-toward observer	---	inferred fold hinge of plunging overturned anticline, dotted where concealed
---	A - away from observer	---	cross section
---	inferred axial trace of fold	---	strike and dip of inclined mylonitic foliation (includes banding, layering and so for Spring Hope mesosedimentary rocks)
---	strike and dip of inclined primary bedding (includes banding, layering and so for Spring Hope mesosedimentary rocks)	---	strike and dip of inclined mylonitic foliation (multiple observations at one locality)
---	strike and dip of inclined primary bedding (multiple observations at one locality)	---	strike and dip of vertical quartz vein
---	strike and dip of inclined normal slip (includes observations at one locality)	---	strike and dip of axial surface of mesoscale fold (multiple observations at one locality)
---	strike and dip of compositional layering in leucogranites and other high grade rocks (multiple observations at one locality)	---	bearing and plunge of mesoscale fold hinge
---	strike and dip of vertical normal slip (multiple observations at one locality)	---	bearing and plunge of lineation
---	strike and dip of compositional layering in leucogranites and other high grade rocks	---	bearing and plunge of mineral lineation
---	strike and dip of vertical joint surface	---	bearing and plunge of slickensite
---	strike and dip of inclined regional foliation (includes mylonitic foliation of Sacks (1996c))	---	bearing and plunge of slickensite lineation
---	strike and dip of inclined regional foliation (includes mylonitic foliation of Sacks (1996c))	---	strike and dip of inclined joint surface (multiple observations at one locality)
---	horizontal regional foliation	---	strike and dip of vertical joint surface
---	strike of vertical regional foliation (includes mylonitic foliation of Sacks (1996c))	---	abandoned quarry
---	strike of vertical regional foliation (includes mylonitic foliation of Sacks (1996c))	---	observation station location
---	strike of vertical joint surface (multiple observations at one locality)	---	geochronological sample ID

BEDROCK GEOLOGIC MAP OF THE LITTLETON 7.5-MINUTE QUADRANGLE, WARREN AND HALIFAX COUNTIES, NORTH CAROLINA

By Edward F. Stoddard, Paul E. Sacks, Timothy W. Clark and Randy Bechtel

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

