Geologic Map of the Kings Mountain and Grover Quadrangles, Cleveland and Gaston Counties, North Carolina, and Cherokee and York Counties, South Carolina

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ABSTRACT

This geologic map of the Kings Mountain and Grover 7.5-minute quadrangles, N.C.-S.C., straddles a regional geological boundary between the Inner Piedmont and Carolina terranes. The Kings Mountain sequence (informal name) on the western flank of the Carolina terrane in this area includes the Neoproterozoic Battleground and Blacksburg Formations. The Battleground Formation has a lower part consisting of metavolcanic rocks and interlayered schist, and an upper part consisting of quartz-sericite phyllite and schist interlayered with quartz-pebble metaconglomerate, aluminous quartzite, micaceous quartzite, manganiferous rock, and metavolcanic rocks. The Blacksburg Formation consists of phyllitic metasiltstone interlayered with thinner units of marble, laminated micaceous quartzite, hornblende gneiss, and amphibolite. Layered metamorphic rocks of the Inner Piedmont terrane include muscovite-biotite gneiss, muscovite schist, and amphibolite. The Kings Mountain sequence has been intruded by metatonalite and metatrondhjemite (Neoproterozoic), metadiorite and metagabbro (Paleozoic), and High Shoals Granite (Pennsylvanian). Layered metamorphic rocks of the Inner Piedmont in this area have been intruded by Toluca Granite (Ordovician?), Cherryville Granite and associated pegmatite (Mississippian), and spodumene pegmatite (Mississippian). Diabase dikes (early Jurassic) are locally present throughout the area. Ductile fault zones of regional scale include the Kings Mountain and Kings Creek shear zones. In this area, the Kings Mountain shear zone forms the boundary between the Inner Piedmont and Carolina terranes, and the Kings Creek shear zone separates the Battleground Formation from the Blacksburg Formation. Structural styles change across the Kings Mountain shear zone from steeply-dipping layers, foliations, and folds on the southeast to gently- and moderately-dipping layers, foliations, and recumbent folds on the northwest. Mineral assemblages in the Kings Mountain sequence show a westward decrease from upper amphibolite facies (sillimanite zone) near the High Shoals Granite on the east side of the map to greenschist (epidote-amphibolite) facies in the south-central part of the

area near the Kings Mountain shear zone. Amphibolite-facies mineral assemblages in the Inner Piedmont terrane increase in grade from the kyanite zone near the Kings Mountain shear zone to the sillimanite zone in the northwest part of the map. Surficial deposits include alluvium in the stream valleys and colluvium along ridges and steep slopes. These quadrangles are unusual in their richness and variety of mineral deposits, which include spodumene (lithium), cassiterite (tin), mica, feldspar, silica, clay, marble, kyanite and sillimanite, barite, manganese, sand and gravel, gold, pyrite, and iron.

INTRODUCTION

This geologic map of the Kings Mountain and Grover 7.5-minute quadrangles covers an area in the Piedmont along the North Carolina – South Carolina State line. The map area straddles a regional geological boundary between the Inner Piedmont terrane and the Kings Mountain sequence of the Carolina terrane as discussed below. The Kings Mountain and Grover quadrangles are located along the Interstate Highway 85 corridor. They encompass most of Kings Mountain National Military Park (the site of the October 7, 1780, Battle of Kings Mountain during the American Revolution), Crowders Mountain State Park in North Carolina, and much of Kings Mountain State Park in South Carolina. The area has a remarkable diversity of rock formations and mineral resources, and mining has played a significant role in its history from the 1700s to the present. Field-trip guides are available in Horton and Butler (1977, 1986), Horton and others (1981), and LaPoint (1992).

Intrusive rocks are classified according to IUGS nomenclature using normalized values of modal quartz, alkali feldspar, and plagioclase (Streckeisen, 1976). Mineral modifiers are listed in order of increasing abundance for both igneous and metamorphic rocks. In descriptions, minerals are listed in order of decreasing abundance.

PHYSIOGRAPHY AND EXPOSURE

The Piedmont Province in this area is a moderately dissected upland of low relief. Linear hills and ridges underlain by resistant quartzite and quartz-pebble conglomerate rise abruptly 100 to 800 feet above the surface of low relief. Craggy precipitous cliffs occur at Crowders Mountain and at the Pinnacle.

Outcrop control of bedrock geology ranges from excellent to poor. Rock exposures occur in road cuts, stream beds and banks, quarries, and along the crests and slopes of ridges. Saprolite exposures are common. Thick soils cover most of the bedrock in intervalley areas of low relief. This prevents detailed mapping in some places but residual soil and float furnish significant information about the local bedrock in most areas. Almost all of the roads, trails, streams, ridges, pipelines, power lines, and telephone lines were walked and numerous cross-country traverses were made.

Contacts between rock units are only approximately located and are judged to be accurate within 100 m or more with a few notable exceptions. In areas of poor exposure and little float control, contacts are highly interpretive and certain folded contacts are based solely on extrapolation of the patterns of minor folds seen in outcrop. The beds of quartzite and quartz-pebble conglomerate were walked out and precisely located in most cases. Parts of the manganiferous schist were also walked out. Marble contacts in parts of the Grover quadrangle are known from exploratory drilling by Vulcan Materials Company.

PREVIOUS GEOLOGIC MAPPING

This area lies within the Charlotte 1×2-degree quadrangle, where information on the geologic setting, stratigraphy, structure, and metamorphism is available from Goldsmith and others (1988). In the Kings Mountain area, the early geologic framework of Keith and Sterrett (1931) has served as a foundation for later work. The present geologic map incorporates data from previous geologic mapping in areas of spodumene-bearing pegmatites near the town of Kings Mountain (Kesler, 1942, 1944), kyanite- and sillimanite-bearing quartzites (Espenshade and Potter, 1960), and iron deposits near Yellow Ridge (Nunan, 1983). It builds on, and supersedes, a less complete and less detailed earlier geologic map of the Kings Mountain and Grover quadrangles by Horton (1977, Plate 1).

Geologic maps are available for the Shelby 15-minute quadrangle (Overstreet and others, 1963) at the northwest corner of this map, for the Blacksburg South 7.5-minute quadrangle (Butler, 1981b) at the southwest corner, for the Kings Creek 7.5-minute quadrangle (Murphy and Butler, 1981; Folsom, 1982; Howard, 2004) to the south, and for the Filbert 7.5-minute quadrangle (Nystrom, 2003) to the south. References to other geologic maps in the region are in Goldsmith and others (1988) and Horton and Dicken (2001).

LAYERED AND STRATIFIED METAMORPHIC ROCKS

Metamorphic grades in the area of this map range from greenschist to amphibolite facies, and many of the rocks now consist of metamorphic minerals.

Kings Mountain sequence of the Carolina terrane

The Kings Mountain sequence, as used informally in this report, includes the Battleground and Blacksburg Formations, which are interpreted to be Neoproterozoic in age (Horton, 1984). These rocks, on the western flank of the Carolina terrane (Horton and others (1989), include layered metasedimentary and metavolcanic rocks in the Kings Mountain belt of King (1955). A tectonostratigraphic terrane is a regional, fault-bounded package of rocks characterized by a geologic history different from that of neighboring terranes (Horton and others, 1989 and references therein), and earlier belt terminology is not used in this report for reasons discussed by Horton and Zullo (1991). A separate Gaffney terrane (Horton and others, 1989) is unnecessary, if evidence that the Blacksburg Formation stratigraphically overlies the Battleground Formation is correct. The evidence consists of primary structures in drill cores from the Kings Mountain gold mine (Supplee, 1986; LaPoint, 1992), although relations are complicated by mylonitic fabrics of the Kings Creek shear zone (Horton, 1984; Goldsmith and others, 1988).

The lower part of the Battleground Formation consists of metavolcanic rocks and interlayered schist (Horton, 1984). Metavolcanic facies include metavolcanic hornblende gneiss (Zbht), felsic schist and gneiss (Zbfs), plagioclase-crystal metatuff (Zbct), siliceous metatuff (Zbmps), volcanic metaconglomerate (Zbvc), and mottled phyllitic metatuff (Zbmp). These rocks grade laterally and vertically into biotite-muscovite schist (Zbms) and occur at multiple stratigraphic levels. This schist has a higher quartz content than normal igneous rocks, lacks volcanic textures, and probably formed from epiclastic or sedimentary material and hydrothermally altered volcanic material. The upper part of the Battleground Formation consists of metasedimentary rocks and lesser amounts of interlayered metavolcanic rock. Lithofacies include quartz-sericite phyllite and schist (Zbs) which commonly contains chloritoid, quartz-pebble metaconglomerates (Zbc, Zbd, Zbmc), aluminous quartzites (Zbaq), micaceous quartzite (Zbmq), manganiferous rock (Zbj), and local metavolcanic rocks (Zbmp and part of Zbdt). Stratigraphic interpretations are based on sporadic observations of graded bedding in the metaconglomerates; crossbedding is considered less reliable than graded bedding, because it can be mimicked by cleavage-bedding intersections. Similarities and differences among the metaconglomerate units originally lumped as Draytonville by Keith and Sterrett (1931) are discussed by France and Brown (1981) and France (1983). Two discontinuous units of quartz-pebble metaconglomerate, the Dixon Gap Metaconglomerate Member (Zbc) and the Draytonville Metaconglomerate Member (Zbd) are separated by the intervening Jumping Branch Manganiferous Member (Zbj) as well as quartz-sericite phyllite and schist (Zbs). The Dixon Gap Metaconglomerate Member grades laterally into aluminous quartzite (Zbaq). Aluminous quartzites occur at two stratigraphic levels on the western limb of the South Fork antiform, but their relations to similar rocks on the eastern limb are undetermined. The micaceous quartzite (Zbmq) at Yellow Ridge is interpreted to be stratigraphically higher than the Jumping Branch Manganiferous Member, and the Crowders Creek Metaconglomerate Member (Zbmc) is interpreted to be even higher. Metadacite of the undivided metadacite and metatrondhjemite unit (Zbdt) is interpreted to be the uppermost stratigraphic unit of the Battleground Formation in this area. The Battleground Formation is intruded by metatonalite (Zto) and metatrondhjemite (Ztr, Zts) of Neoproterozoic age (Horton, 1984; Lehuray, 1986; Faggart and Basu, 1987).

The Blacksburg Formation consists mainly of phyllitic metasiltstone (Zbls) and interlayered marble (Zblg, Zblm), laminated micaceous quartzite (Zblq), and hornblende gneiss and amphibolite (Zbla). Minor calc-silicate interlayers are also present. The phyllitic metasiltstone is commonly graphitic and typically more micaceous than schists of the Battleground Formation. The Blacksburg Formation is predominantly metasedimentary, although amphibolites having basaltic composition may be metamorphosed sills or flows (Horton, 1984). Because the Blacksburg Formation is bounded by ductile fault zones, its upper and lower contacts are undetermined. Nevertheless, primary sedimentary structures in drill core suggest that metadacite of the the undivided metadacite and metatrondhjemite unit (Zbdt) at the top of the Battleground Formation is unconformably overlain by the Blacksburg Formation in the vicinity of the Kings Mountain gold mine (LaPoint, 1992) although the contact has been overprinted by mylonitic fabrics of the Kings Creek shear zone. Stratigraphy within the Blacksburg is poorly constrained, and this map follows the interpretation of Horton (1984). In this interpretation, lenses of hornblende gneiss and amphibolite (Zbla) occur in the lower part, and marble (Zblg, Zblm) occurs at two stratigraphic levels. Discontinuous beds and lenses of laminated micaceous quartzite (Zblq) occur in the lower part of the formation, and at three stratigraphic levels in the upper part: (1) below the Gaffney Marble Member (Zblg); (2) equivalent to "Q_1" of Kesler (1944) above the Gaffney Marble Member and below the informally-named marble member at Dixon Branch (Zblm), and (3) equivalent to "Q_2" of Kesler (1944) above the marble member at Dixon Branch. Chloritic phyllonite (Zblc) is present in the Kings Creek shear zone.

Layered metamorphic rocks of the Inner Piedmont terrane

Layered metamorphic rocks of the Inner Piedmont terrane in this area include muscovite-biotite gneiss (ꞒZbg), muscovite schist (ꞒZs), and amphibolite (ꞒZa). No primary structures are preserved in these rocks, and their stratigraphic relations are undetermined. Metamorphic mineral assemblages are typical of the amphibolite-facies kyanite and sillimanite zones, and the layered metamorphic rocks have been intruded by middle to late Paleozoic granites and pegmatites described below.

IGNEOUS INTRUSIVE ROCKS

Igneous intrusive rocks in the Battleground and Blacksburg Formations include metatonalite (Zto) and metatrondhjemite (Ztr, Zts). The metatonalite is most abundant in the lower part of the Battleground, and it may include shallow sills or plugs that intruded their own volcanic ejecta (Horton, 1977; Murphy and Butler, 1981). The metatonalite (Zto) has a nearly concordant U-Pb zircon age of about 570 Ma (Lehuray, 1986), and the metatrondhjemite has a whole-rock Sm-Nd age of 628 Ma (Faggart and Basu, 1987). Metagabbro and metadiorite (Pzgd) occurs as small bodies in the Battleground and locally as dikes cutting the metatonalite, and may be related to similar rocks in Mecklenburg County, N.C. (Goldsmith and others, 1988).

The Toluca Granite (Otg) is found only in the Inner Piedmont terrane, and it occurs as lenticular bodies mostly concordant to the regional foliation in the northwestern part of the Grover quadrangle. The Toluca is not well dated (Horton and McConnell, 1991; Horton and Dicken, 2001) and a provisional Ordovician(?) age is inferred from discordant conventional U-Pb zircon dates ranging from about 540 to 445 Ma (Davis and others, 1962; Odom and Fullagar, 1973; Harper and Fullagar, 1981). The Cherryville Granite (Mc, Mcp) occupies a large area of the Inner Piedmont terrane within the map area. Contacts are mostly concordant but locally discordant with the country-rock foliation. The Cherryville and associated pegmatites (Mp, Ms) have Mississippian Rb-Sr whole rock ages (Kish, 1977, 1983; Kish and Fullagar, 1996). Dikes and concordant sheets of spodumene pegmatite (Ms) are concentrated in a narrow belt along the southeastern flank of the Inner Piedmont terrane near the Kings Mountain shear zone.

The High Shoals Granite (IPhs) along the eastern edge of the map is a coarse-grained, porphyritic, gneissoid biotite granite, which has a Pennsylvanian U-Pb zircon age of 317 Ma (Horton and others, 1987). Maps of regional metamorphic zones (Horton and others, 1987) show a decrease in grade with distance from the High Shoals Granite as discussed below.

Early Jurassic diabase dikes (Jd) in the area are nearly vertical and typically strike N 40°-50°W. Most range from a few centimeters to a few meters in thickness. The largest, near Henry Knob, is about 15 m thick and 13 km long (Butler, 1966). The dikes are concentrated in swarms from Henry Knob to Dixon Gap and beyond, and from the south side of Crowders Mountain through the northeast side of the town of Kings Mountain.

STRUCTURAL GEOLOGY

As many as five episodes of folding and related deformation have been recognized in the Battleground and Blacksburg Formations (Horton, 1981b; Schaeffer, 1981). The distribution of map units is controlled largely by folds of the two earliest episodes, F_1 and F_2. These folds are locally disrupted by ductile faults, which are roughly parallel to the regional schistosity (Butler, 1981b; Horton, 1981b). The largest map-scale fold is the South Fork antiform, which is interpreted as an F_2 structure based on structural relations in the Bessemer City quadrangle to the north (Horton, 1981b). The isoclinal to tight Sherrars Gap synform (Espenshade and Potter, 1960) and Crowders Mountain antiform are map scale folds of the earliest episode, F_1. Both lie on the west limb of the north-plunging South Fork antiform, and are refolded by parasitic F_2 folds which produce the same Z-shaped asymmetry on opposite limbs. Structures younger than F_2 are conspicuous in the shear zones but sporadically distributed elsewhere, and have little influence on the map pattern. The dominant metamorphic foliation or schistosity in the area, S_2, is essentially parallel to axial surfaces of second generation, F_2, folds. A much weaker older schistosity, S_1, is parallel to bedding and layering except in the hinges of mesoscopic F_1 isoclinal folds. The dominant S_2 schistosity transects bedding or compositional layering in many areas of the Battleground Formation. It crosses the older Sherrars Gap synform, for example, and has the same angular relation to bedding on both limbs.

The map shows several ductile shear zones, where mylonitic fabrics overprint earlier structures. The Kings Mountain shear zone forms a major tectonic boundary between the Inner Piedmont and Carolina terranes in this area. Rock units on both sides of the shear zone are clearly truncated by it southwest of this map area (Horton, 1981a; Goldsmith and others, 1988). Spodumene pegmatite of Mississippian age was emplaced during the waning stage of deformation in the Kings Mountain shear zone (Horton, 1981a), and the other zones are inferred to be about the same age. The Kings Creek shear zone separates the Battleground and Blacksburg Formations in these quadrangles. Similar en echelon shear zones lie along the southeast side of the metadacite and metatrondhjemite (Zbdt) unit in the northern part of the map and along the northwest side of the metatrondhjemite and amphibole gneiss (Ztr) in the southern part of the map.

Structural styles change across the Kings Mountain shear zone, from steeply-dipping layers, foliations, and folds in the Battleground and Blacksburg Formations to gently- and moderately-dipping layers, foliations, and recumbent folds in the Inner Piedmont terrane. In the Inner Piedmont an early foliation, which is parallel to gneissic layering except in rare vestigial fold hinges, has been folded by mesoscopic gently-plunging, recumbent, isoclinal folds (Goldsmith and others, 1988). These early folds have been re-folded by minor crenulations and by upright folds into broad synforms and antiforms. The polydeformed rocks of the Inner Piedmont terrane are interpreted to be part of an allochthonous stack of crystalline thrust sheets (Goldsmith and others, 1988 and references therein).

Some northeast-striking faults may be related to folding, and others are younger. An early Jurassic diabase dike in the Kings Mountain quadrangle, near the intersection of Interstate Highway I-85 and Dixon School Road, is offset 1.2 m in a horizontal direction by a subvertical northeast-striking fault (Horton and Butler, 1977). Some northwest-striking faults and joints may be related to the fracture system intruded by early Jurassic diabase dikes. Quartz veins generally dip steeply, strike northeast at varied angles, and locally appear along fault surfaces.

METAMORPHISM

Maps showing the distribution of metamorphic mineral assemblages and isograds in these quadrangles and surrounding areas are presented in Horton and others (1987) and Goldsmith and others (1988). Metamorphic grades within the area of this map range from greenschist to amphibolite facies. In the Battleground and Blacksburg Formations, mineral assemblages show a westward decrease from upper amphibolite facies (sillimanite zone) near the High Shoals Granite to upper greenschist (epidote-amphibolite) facies in the south-central part of the map area near the Kings Mountain shear zone. In the Inner Piedmont terrane, amphibolite-facies mineral assemblages increase in grade from the kyanite zone near the Kings Mountain shear zone to the sillimanite zone in the northwest part of the map. Map relations south of these quadrangles indicate that the Kings Mountain shear zone truncates metamorphic zones on both sides (Horton and others, 1987; Goldsmith and others, 1988). The age of peak metamorphism was late Paleozoic (Alleghanian) in the Battleground and Blacksburg Formations of the Carolina terrane, and middle Paleozoic in nearby parts of the Inner Piedmont terrane in this area (Horton and others, 1987).

Horton and others (1987) show that a north-trending isograd marking the breakdown of chloritoid to produce staurolite lies between the Pinnacle and Crowders Mountain. Significantly, kyanite is present in quartzites (but not in pelitic rocks) on the low-temperature side of this isograd up to four kilometers away to the west, suggesting that the distribution of kyanite is influenced by rock composition in addition to temperature and pressure. The presence of andalusite, in schists both east and west of kyanite quartzite on Crowders Mountain, suggests that rock composition also has an influence on the distribution of these of metamorphic index minerals. Where more than one Al_2SiO_5 polymorph occurs in the same rock, petrographic relations show kyanite replacing andalusite (consistent with increasing pressure) and sillimanite replacing both kyanite and andalusite (consistent with increasing temperature; Horton and others (1987) proposed a clockwise pressure-temperature-time path of increasing pressure followed by increasing temperature of prograde metamorphism to explain these relations.

A lower greenschist-facies metamorphic overprint is present in the shear zones. Contact metamorphism related to spodumene pegmatites was described by Kesler (1961) and Horton (1977).

MINERAL RESOURCES

The Kings Mountain and Grover quadrangles are unusual in their richness and variety of mineral deposits. These include spodumene, cassiterite, mica, feldspar, silica, clay, marble, kyanite and sillimanite, barite, manganese, sand and gravel, gold, pyrite, and iron.

The belt of spodumene pegmatites, described by Kesler (1942) as the “Carolina tin-spodumene belt,” is one of the largest developed reserves of lithium in the world (Kesler, 1976; Evans, 1978). Overviews of the lithium deposits and their resource potential are provided by Horton (1987) and Horton and Gair (1989). Cassiterite is a minor constituent of the spodumene pegmatites and associated greisen, and the pegmatites were first worked for tin. Geology of the Foote Mineral Company’s lithium mine on the south side of the town of Kings Mountain is described by Kesler (1961), Horton and Butler (1977, 1986), Horton and Simpson (1978), and Horton and others (1981). This mine is widely known for its remarkable variety of primary and secondary minerals (Marble and Hanahan, 1978; White, 1981).

Production of mica, feldspar, quartz, and kaolin from weathered Cherryville Granite and associated pegmatites is described by Connor (1990). Griffitts and Olson (1953) described the Herndon mine, the Rice mine, and several mica prospects, and the Moss mine has been described as a field-trip stop (Horton and others, 1981, Stop 3).

Marble from the Blacksburg Formation has been quarried for crushed stone and agricultural limestone by Vulcan Materials Company, in quarries south and southeast of the town of Grover

(Horton and Butler, 1977, Stop 4; Horton and Butler, 1986, Stop 3). Martin Marietta Corporation has produced crushed stone from a quarry in marble on the southeast side of the town of Kings Mountain. The quarries owned by Martin Marietta and Vulcan Materials are in the marble member at Dixon Branch (Zblm). Earlier marble quarries were described by Ruffin (1843, p. 59-69), Sloan (1908), Keith and Sterrett (1931), and Conrad (1960).

Aluminous quartzite (Zbaq) in the Battleground Formation contains large reserves of kyanite and smaller reserves of sillimanite. Espenshade and Potter (1960) estimated that the principal deposits, most of which are in the Kings Mountain quadrangle, contain 40 million tons of rock with 10 to 30 percent kyanite. The most significant mining in the area was at Henry Knob, where kyanite was produced with pyrite as a by-product before 1966 (Smith and Newcome, 1951; Espenshade and Potter, 1960; Butler, 1966; Horton and Butler, 1986). Large deposits of kyanite exist at the Pinnacle, at Crowders Mountain, and at the Shelton properties. Smaller deposits of sillimanite occur at the Will Knox property (Espenshade and Potter, 1960). Those at the Pinnacle and Crowders Mountain lie in and near Crowders Mountain State Park. An overview of the kyanite and sillimanite deposits and their resource potential is available from Horton (1987) and Horton (1989a).

A belt of barite deposits that crosses the map area (Van Horn and others, 1949; Wilson, 1958; McCauley, 1962) lies in the Battleground Formation southeast of the main quartzite and quartz-pebble conglomerate beds. Hand-cobbing operations at the Lawton (Lawson) and Wyatt mines had significant production in the past, and the Lawton and Craig properties may have significant reserves (Van Horn and others, 1949; Horton and Butler, 1977). Barite is not currently mined in the region. Most of the production has been from en echelon, northeast-striking veins of massive barite, but disseminated barite in the surrounding schist reaches concentrations as high as 20 percent (Van Horn and others, 1949). An overview of the barite deposits and their resource potential in the region is available in Horton (1987) and Horton (1989b).

Manganese deposits occur in the Jumping Branch Manganiferous Member (Zbj) of the Battleground Formation on both limbs of the South Fork antiform (Horton, 1987, 1989c). Manganese oxides are derived from weathering of stratabound spessartine-almandine garnet in the schist, and the schist has been prospected for manganese (White, 1944; O'Neill and Bauder, 1962). In recent decades, saprolite and weathered (oxidized) manganiferous rock have been quarried intermittently from elongate pits just west of Kings Mountain National Military Park for use as a dark brown additive in the manufacture of bricks.

Gold mines and prospects in the Battleground Formation of the Kings Mountain and Grover quadrangles were described by Sloan (1908), Keith and Sterrett (1931), Pardee and Park (1948), Butler (1966), and McCauley and Butler (1966). The most significant gold deposit is at the Kings Mountain gold mine, which produced $750,000 to $1,000,000 in gold prior to 1895 (Graton, 1906; Keith and Sterrett, 1931; Pardee and Park, 1948). Descriptions by Supplee (1986) and LaPoint (1992) are based on renewed exploration by Texasgulf Minerals and Metals, Inc. from 1983 to 1988. Other abandoned mines and prospects on gold- and pyrite-bearing quartz veins are part of the Smyrna district (Butler, 1981a).

Stratabound iron deposits are interesting from geologic and historical perspectives (Moss, 1981; Gair, 1989). Those at Yellow Ridge, about 4 km southeast of the town of Kings Mountain, are described by Nunan (1983).

More information on mineral resources is available from Horton and Butler (1981), Posey (1981), and papers in Gair (1989).

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This geologic map incorporates initial data accumulated by Horton (1977, Plate 1), with field assistance from Stephen B. Harper, and substantial unpublished data generated by Horton as a byproduct of U.S. Geological Survey (USGS) geologic mapping in the Charlotte 1_2-degree quadrangle (Goldsmith and others, 1988). Yolanda Fong Sam provided assistance with data tabulation and computer graphics. USGS digital cartography by Boris Barrios, E. Allen Crider, Danielle Denneny, and James Triplett was partly supported by the U.S. National Park Service (NPS) as part of a nationwide Geologic Resources Inventory. The USGS provided additional support through the National Cooperative Geologic Mapping Program.

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