GEOLOGIC MAP OF THE CHARLOTTE 1° x 2° QUADRANGLE, NORTH CAROLINA AND SOUTH CAROLINA

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INTRODUCTION

The Charlotte 1° x 2° quadrangle extends across four lithotectonic belts of the Piedmont from the Coastal Plain and Wadesboro Triassic basin on the east to the Blue Ridge belt in the vicinity of the Grandfather Mountain window on the west (see tectonic map). Because these belts differ in geologic character, the geology of each is described separately.

WADESBORO BASIN

The southeast corner of the Charlotte quadrangle lies within the Wadesboro basin, which is filled with Upper Triassic continental sedimentary rocks: fanglomerates, conglomerates, arkosic sandstones, and siltstones. Beds dip gently toward a major normal fault on the southeast margin of the basin. Within the Charlotte quadrangle the northwest margin of the basin is marked by a series of minor faults bounding small sediment-filled troughs and grabens. A basal conglomerate at the updip northwest margin of the basin contains debris from a granite pluton cut by the southeast marginal fault. These relations indicate that faulting and tilting were at least in part postdepositional. Poorly consolidated sands of the Upper Cretaceous Middendorf (?) Formation (**Km**) form outliers of the Coastal Plain unconformably overlying Triassic strata (**₮ss** and **₮cg**) in the Wadesboro basin. The Upper Triassic Davie County basin barely extends across the northern border into the quadrangle, between the Charlotte and Inner Piedmont belts.

Diabase dikes (**J₮d**) of Triassic and Jurassic age, generally with north-northwesterly trends, occur throughout the quadrangle, but are particularly abundant in the Wadesboro basin and the nearby Carolina slate belt. Another swarm crosses the Charlotte and Kings Mountain belt between Charlotte, N.C., and Gaffney, S.C., and extends into the Inner Piedmont in Cleveland, Gaston, and Lincoln Counties. One of these dikes crosses the Brevard fault zone into the Blue Ridge.

CAROLINA SLATE BELT

The Carolina slate belt consists of weakly metamorphosed sedimentary and volcanic rocks. The lowest stratigraphic unit, the Uwharrie Formation (**Zu**), of which only the upper part crops out near the eastern edge of the quadrangle, is composed primarily of rhyolitic volcanics. The overlying Albemarle Group is a mostly sedimentary sequence five or six kilometers thick (Stromquist and Sundelius, 1969; Milton, 1984). The grain sizes of this sequence show a general increase upward from the argillite of the Tillery Formation (**Zt**), at the base, through the mudstone and siltstone of the Cid Formation (**Zcm**), the siltstone of the Floyd Church Formation (**Zf**), to the graywacke sandstone of the Yadkin Formation (**Zy**) at the top. A quarter to a third of the volume of the Albemarle Group consists of metavolcanic rocks (**mvf, mvm**, and **mv**) which, together with the metavolcanics of the Uwharrie Formation, compose a chemically bimodal calc-alkaline suite, in which rocks of basaltic and rhyolitic compositions predominate over those of intermediate composition (Seiders, 1978). There are several volcanic centers in the Albemarle Group, at Flat Swamp (High Rock) Mountain west of Denton, tn the Mt. Morrow-Badin area, and elsewhere. These are thick piles of tuffs, agglomerates, and hypabyssal intrusives that extend distally into thinner and finer grained tuff beds. The Flat Swamp Member of the Cid Formation (**Zcf**), makes a conspicuous marker bed that can be traced for 150 km. The Carolina slate belt may have formed in an island-arc environment, in which slow deep-water deposition of sediments, largely of distant volcanic derivation (although there is evidence of some material of continental provenance; Milton and Reinhardt, 1980) was locally and intermittently interrupted by massive deposition of volcanic material from nearby volcanoes.

Recent finds (Gibson, 1984) in the Floyd Church Formation of *Pteridinium* (or a closely related form), a metazoan fossil diagnostic of the Ediacaran or Vendian fauna of latest Precambrian age, and reinterpretation as *Pteridinium* of fossils earlier identified as Cambrian *Paradoxides* (St. Jean, 1973) indicate a Late Proterozoic age for the Albemarle Group. This dating is supported by a U-Pb date of 586 ± 10 m.y. for zircon from the uppermost Uwharrie Formation (**Zu**) (Wright and Seiders, 1980).

Most of the rocks in the slate belt in the Charlotte quadrangle describe open folds about northeast-southwest-trending axes, forming two major anticlines, two major synclines, and many smaller folds. Beds dip gently to moderately, less commonly steeply, and are rarely overturned. Widely spaced axial plane cleavage is generally present. In contrast, a zone 3–5 km wide on the west edge of the slate belt (the "Gold Hill shear zone") consists largely of phyllite (**Zp**) with cleavage vertical or dipping steeply west-northwest. The phyllite, and tuffaceous interbeds within it, are probably strongly sheared and recrystallized beds of the Tillery or Cid Formations. Earlier detailed maps (Stromquist and others, 1971; Stromquist and Sundelius, 1975; Sundelius and Stromquist, 1978) portray the shear zone as bounded by the Silver Hill fault on the east and Gold Hill fault on the west. Some units (notably the Flat Swamp Member) are truncated abruptly along the Silver Hill line which indicates that it is indeed a fault. Nevertheless, the Denton anticline extends across the Silver Hill fault, and changes from a gently plunging fold on the east to a steeply plunging fold in the shear zone; thus, any major displacement on the Silver Hill fault must antedate the folding. There is some evidence that the fault itself is folded by the Denton anticline which suggests that shearing in the Gold Hill shear zone and folding to the east were roughly contemporaneous. No brecciation or other evidence of brittle deformation has been observed anywhere in the Gold Hill zone. The Gold Hill line is, in general, a contact between metasedimentary rocks on the east and metavolcanic rocks on the west, with no apparent angular discordance. In contrast to the Silver Hill line, it appears to be a stratigraphic contact, perhaps an unconformity, with the sequence on the east side presumably younger. The cumulative effect of shearing and unmapped small-scale faulting within the shear zone may have significantly reduced the thickness of the sequence from the original stratigraphic thickness.

CHARLOTTE BELT

The Charlotte belt, to the west of the slate belt, is dominated by plutonic rocks with some large areas of metavolcanic rocks, but very few metasedimentary rocks. Varying degrees of development of metamorphic fabric and reconstitution of mineral assemblages indicate a range of ages for the igneous rocks, which may be divided into pre-, syn-, and post-tectonic-metamorphic suites, although assignments of many plutons are uncertain. The pretectonic suite, a metamorphosed volcanic-plutonic complex that forms the major part of the Charlotte belt, ranges in composition from ultramafic to felsic and from coarse-grained plutonic rocks through porphyritic hypabyssal rocks to include extrusive volcanic flows and tuffs. The Charlotte belt may represent the axial part of an island arc eroded to a deep level, whereas the Uwharrie Formation and Albemarle Group of the Carolina slate belt may represent an off-axis facies richer in sediment. Alternatively, the Charlotte belt metavolcanic rocks (and older metaplutonic rocks) may correlate with the 600–700 m.y. series of volcanics of the Carolina slate belt exposed in the Roxboro-Durham area (Glover and Sinha, 1973; Seiders and Wright, 1977). Radiometric dating of the pretectonic Charlotte belt rocks has only been attempted on metagranodiorite (**mgd**) from York County, S.C., from which zircons yielded a U–Pb concordia age of 532 ± 15 m.y. (Law Engineering Testing Co., 1976). The metamafic complex of the eastern and northern parts of the Charlotte belt could include ophiolitic associations. The syntectonic Salisbury Plutonic Suite (**DSsr** and **DSsg**) is composed of leucocratic nonporphyritic granites which are generally weakly foliated and recrystallized. These have been dated at about 400 m.y. (Butler and Fullagar, 1978). The gabbroic rocks present particularly complex problems in age assignment, as gabbros commonly intrude older metagabbros (McSween, 1981). Gabbros (**DScgb**) and associated syenites (**DScs**) of the Concord Plutonic Suite have been dated at about 405 m.y. by Rb-Sr (Fullagar, 1971), Nd/Sm (Olsen and others, 1983), and $^{40}Ar/^{39}Ar$ (Sutter and others, 1983) methods. The youngest major intrusive bodies of the Charlotte belt are the large post-tectonic porphyritic granites of the Churchland Plutonic Suite (**PPc**), which have been dated at between 280 and 320 m.y. (Fullagar and Butler, 1979; Speer and others, 1979).

Hornblende gneiss and diopside gneiss (**hgn**) that crop out along the Yadkin River, near the northern boundary of the quadrangle, resemble Inner Piedmont more than Charlotte belt rock types. These may actually mark the southwestern extremity of the Milton belt of recent workers to the north and east.

The paucity of metasedimentary or stratified rocks makes the structural and metamorphic patterns of the Charlotte belt obscure. Trends of rock units, foliation and magnetic anomalies have the common Appalachian northeast-southwest orientation in the northern half of the quadrangle, but curve to east-west near Charlotte and to northwest-southeast near Lake Norman. This suggests a large fold open to the northeast, involving most of the Charlotte belt within the quadrangle. Regional metamorphism reaches amphibolite grade, and appears to be of lower grade on either flank than in the center of the belt. Metamorphic aureoles of hornfels facies enclose some intrusives. Hornblendes from amphibolite give $^{40}Ar/^{39}Ar$ plateau ages of 425–430 m.y. which indicate a Taconic age for regional metamorphism (Sutter and others, 1983).

The boundary between the Charlotte belt and the Inner Piedmont in the north-central part of the quadrangle, unlike the Gold Hill shear zone, is marked by brecciation and cataclasis, apparently superimposed on earlier mylonitized rocks. This zone, which we have named the Eufola fault (Milton, 1981), is continuous with the boundary faults of the Davie County basin, thereby indicating that some movement occurred at least as late as Triassic. The character of displacement on the Eufola fault is unknown, but it must be compatible with the broad curve of the fault trace from north-south to east-west. The Charlotte and Kings Mountain belts may have been thrust northward over the Inner Piedmont in the southern segment of the Eufola fault, implying right-lateral strike slip in the northern segment.

KINGS MOUNTAIN BELT

The Kings Mountain belt is characterized by distinctive metasedimentary and metavolcanic rocks, steep dips, and metamorphic grades which are commonly lower than in nearby parts of adjacent belts. The latter two features vary from place to place within and across the lithostratigraphic units (Horton, 1981b).

Lithostratigraphic units of the Kings Mountain belt are divided into the Blacksburg Formation, which lies west of the Kings Creek and Blacksburg shear zones, and the Battleground Formation, which lies east of these shear zones. Both are inferred to be of Late Proterozoic age (Horton, 1981b). The lower part of the Battleground Formation consists mostly of metavolcanic rocks interlayered with quartz-sericite schist. Metavolcanic facies include fine-grained hornblende gneiss (**Zbvm**), felsic metavolcanic rocks (**Zbvf**), and phyllitic or schistose metavolcaniclastic rocks (**Zbp**). These rocks grade laterally and vertically into quartz-sericite schist (**Zbs**). The high quartz content and lack of volcanic textures and mineralogy, except for minor plagioclase, in the quartz-sericite schist suggest that it originated from epiclastic or sedimentary materials and possibly, at least in part, from hydrothermally altered volcanic materials which may or may not have been reworked by sedimentary processes. The upper part of the Battleground Formation consists of quartz-sericite schist (**Zbs**) interbedded with high-alumina (kyanite or sillimanite) quartzite (**Zbkq, Zbsq**), quartz-pebble metaconglomerate (**Zbc**), spessartine-quartz rock (**Zbj**), and quartzite (**Zbq**).

The Blacksburg Formation consists of sericite schist or phyllite (**Zbls**) with beds or lenses of marble and calc-silicate rock (**Zblm**), micaceous quartzite (**Zblq**), and amphibolite (**Zbla**). The sericite schist is commonly graphitic and contains more white mica and less quartz and plagioclase than quartz-sericite schist of the Battleground Formation. The Blacksburg Formation is predominantly metasedimentary in origin, but the amphibolite lenses have basaltic compositions and may be metamorphosed sills or flows. The stratigraphic relationship between the Blacksburg and Battleground Formations is uncertain because of intervening faults and plutons.

Metatonalite (**Zto**) and metatrondhjemite (**Ztr**) intrusions of Late Proterozoic? age in the Kings Mountain belt are most abundant in the stratigraphically lower part of the Battleground Formation. The metatonalite bodies may represent shallow sills and plugs that intruded their own volcanic ejecta (Horton, 1977; Murphy and Butler, 1981). They are similar to metatonalite along the western side of the Charlotte belt. The Kings Mountain belt also contains bodies of metagabbro and metadiorite (**gdi**) similar to those of the Charlotte belt. Metagabbro dikes cut the metatonalite in places.

Lenticular bodies of ultramafic rock (**u**), including metapyroxenite and soapstone, occur on the western side of the Kings Mountain belt just southwest of Gaffney, S.C. The High Shoals Granite (**IPhs**), a coarse-grained, porphyritic, gneissoid biotite granite or granitic gneiss, occupies an area of batholithic size within the Kings Mountain belt. U-Pb data from zircons indicate a Pennsylvanian age of 317 m.y. for this intrusion (Horton and Stern, 1983). The undeformed porphyritic biotite granite at Gastonia, N.C., part of the batholith that includes the High Shoals Granite, resembles other Pennsylvanian and Permian age plutons of the Churchland Plutonic Suite (**PIPc**) in composition and texture.

As many as five episodes of folding and related deformation have been recognized in the Kings Mountain belt (Horton, 1981b). The pattern of rock units on the map is controlled largely by folds of the two earliest episodes, F_1 and F_2. These folds are locally disrupted by tectonic slides or ductile faults which are roughly parallel to the regional schistosity (Butler, 1981; Horton, 1981b). The largest map-scale folds are the South Fork antiform and Cherokee Falls synform, which are interpreted as F_2 structures (Horton, 1981b). Structures younger than F_2 are conspicuous in the major shear zones but are sporadically distributed elsewhere and rarely affect the map pattern.

Ductile shear zones occur both along the margins of the Kings Mountain belt and within it. The most significant of these, the Kings Mountain shear zone, separates the Kings Mountain and Inner Piedmont belts. Rock units and metamorphic isograds on both sides of the zone are truncated against it (Horton, 1981a). The shear zone which marks the eastern boundary of the Kings Mountain belt near Gastonia, N. C., does not extend northward into Lincoln County where the boundary between the Kings Mountain and Charlotte belts is defined, in part, by intrusive contacts. We have no lithostratigraphic criteria to distinguish rocks in the lower part of the Battleground Formation from similar, possibly correlative metavolcanic and metasedimentary rocks in the Charlotte belt. Some rock units have been assigned arbitrarily to one belt or the other.

Metamorphic grade within the Kings Mountain belt ranges from greenschist to amphibolite facies. The areas of greenschist facies or epidote-amphibolite facies metamorphism are lower in grade than nearby parts of the adjacent belts. A well-defined zone of Alleghanian-age sillimanite-grade metamorphism surrounds the High Shoals Granite. Regional metamorphism of this age, which overprints an older but lower grade Paleozoic metamorphic event, extends beyond the immediate vicinity of the granite (Horton and Stern, 1983; Sutter and others, 1984).

Similarities among the Kings Mountain belt, Charlotte belt, and Carolina slate belt suggest that they are parts of a single terrane, perhaps a Late Proterozoic volcanic arc-basin complex. If so, the Charlotte belt may represent a deeply eroded zone in which more plutonic rocks are exposed than in the Kings Mountain and Carolina slate belts.

INNER PIEDMONT BELT

The Inner Piedmont lies between the Charlotte and Kings Mountain belts to the east and the Blue Ridge to the west. It is separated from the Charlotte and Kings Mountain belts by the Kings Mountain and Eufola fault zones and from the Blue Ridge by the Brevard fault zone.

Stratified rocks of the Inner Piedmont consist predominantly of thinly layered mica schist and biotite gneiss which are interlayered with lesser amounts of amphibolite, calc-silicate rock, hornblende gneiss, quartzite, and some rare marble. Protoliths of these rocks were largely sedimentary and in part volcanic. Much of the biotite gneiss was probably graywacke, but some layers could have been intermediate volcanic flows or tuffs. Some of the mica schist is feldspathic and may have had a tuffaceous component. A thin gondite or quartzite rich in manganese garnet (**ЄZgq**) was probably a manganiferous chert.

Two stratigraphic suites seem to be present. A mostly mafic lower suite (**ЄZbg, ЄZbga, ЄZa ЄZpg**), mainly biotite gneiss and amphibolite, with layers of mica schist and layered granitoid gneiss that might be felsic metavolcanic material, structurally underlies a metasedimentary upper suite (**ЄZss, ЄZs, ЄZbg, ЄZbgs, ЄZgs, ЄZsq**) of interlayered mica schist, biotite paragneiss, and minor calc-silicate rock. Distinctive strata mark the top of the lower suite and the bottom of the upper suite. At the top of the lower suite is an inequigranular biotite gneiss (**ЄZpg**) resembling a diamictite that lies physically below amphibolite (some **ЄZa**). Overlying the amphibolite is a locally conglomeratic quartzite and quartz schist (**ЄZsq**) or, in places, a feldspathic mica schist not mapped separately that constitute the base of the upper suite. The complexity of structure within the Inner Piedmont, the lack of recognizable indicators of facing direction and of primary features except layering, and the paucity of distinctive marker units make recognition of a more detailed stratigraphic sequence uncertain. The upper suite occupies the high-grade central core of the Inner Piedmont and the lower suite flanks the central core to the northwest and east. The upper suite is at medium metamorphic grade in a belt southeast of the Brevard zone and in a belt northwest of the Kings Mountain shear zone. Lenses of marble (**ЄZm**) occur along the Brevard zone, and one outcrop of marble was observed on the southeastern flank of the Inner Piedmont in Cherokee County, S.C. The age of the stratified rocks in the Inner Piedmont is unknown but, because they are intruded by granite which is probably as old as Cambrian (see Correlation of Map Units), they are probably of Proterozoic age, but no younger than Cambrian.

Many large and small masses of granite and granodiorite, and a few masses of quartz diorite, are scattered through the Inner Piedmont. The Toluca Granite (**OЄtg**), a gray, medium-grained biotite granite grading into granodiorite is widely distributed in the central core of the Inner Piedmont. The Toluca forms concordant to semiconcordant masses, some of which are gneissic and appear to be relatively older than a poorly foliated to nonfoliated facies. A porphyritic granite informally called here the granite of Sandy Mush (**OЄsg**) and probably related to the Toluca, forms semiconcordant masses from Sandy Mush, N.C., to Cowpens, S.C. Along the western flank of the Inner Piedmont are elongate masses of porphyritic granitoid Henderson Gneiss (**Єh**), probably projections from larger masses in the type area to the southwest (Hadley and Nelson, 1971). Tabular masses of dark-colored, nonlayered, garnetiferous, porphyritic biotite gneiss (**Єhp**), considered to be a phase of the Henderson, are aligned on both sides of the central core of the Inner Piedmont. An extensive mass of migmatitic granitoid gneiss (**OЄgm**), which resembles the gneissic Toluca Granite, occupies a zone west of the central core and east of the marginal belt containing the Henderson Gneiss. This migmatitic granite contains inclusions of biotite gneiss and amphibolite and masses of granite similar to the non-gneissic part of the Toluca. Similar migmatitic granite is exposed in the lower suite on the northeast side of the central core, but most masses are small. The Henderson and the Toluca are considered to be of Cambrian age on the basis of somewhat ambiguous isotopic data (Davis and others, 1962; Odom and Fullagar, 1973; Odom and Russell, 1975; Kish, 1983), but ages as young as Ordovician have been determined by Harper and Fullagar (1981) from other Inner Piedmont granites which may be, in part at least, equivalent to the Toluca.

Late- to post-metamorphic two-mica Cherryville Granite (**Mc, Mcs**) of Mississippian age (Kish, 1983) intrudes mica schist and gneiss southeast of the central belt of Toluca Granite. Sills and dikes of two-mica granite elsewhere in the Inner Piedmont may be a late phase of the Toluca or they may be related to the Cherryville. A few gneissic and non-gneissic masses of quartz diorite (**qd**) intrude the stratified rocks in the eastern and western sides of the central core. Small, apparently rootless, ultramafic masses (**u**), most altered to soapstone or serpentinite, are scattered along the east and west sides of the Inner Piedmont. The largest of these are located along the northeast side of the Inner Piedmont within the lower suite in Iredell and Catawba Counties, N.C. One less-altered ultramafic mass lies in the central core of the Inner Piedmont in Burke County, N.C.

Rocks of the central core of the Inner Piedmont are in the sillimanite-muscovite zone of regional Barrovian metamorphism. The flanks are mostly in the staurolite-kyanite zone. Both zones contain many areas where alumino-silicate minerals have been altered to sericite and locally to muscovite which indicates a period of hydration following the main dynamothermal peak. Butler (1972) considered the main period of regional metamorphism in the Inner Piedmont of the Carolinas and Georgia to have been about 410–430 m.y. ago; some evidence exists for an Acadian event (Hatcher and others, 1979). The complex deformational and intrusive history of the Inner Piedmont remains to be documented.

The Inner Piedmont is probably allochthonous and the rocks are polydeformed (Cook and others, 1979a, 1979b; Harris and Bayer, 1979; Goldsmith, 1981). Their original position is unknown. Ductile and locally brittle faults flank the Inner Piedmont on its northwest and southeast sides. The structural style changes abruptly across the Kings Mountain shear zone from tightly appressed, steeply-dipping folds in the Kings Mountain belt to flat dips and recumbent folding in the Inner Piedmont. Basement rocks of the Sauratown Mountains, 15–20 km north of the quadrangle boundary, plunge southward under the rocks of the Inner Piedmont beneath the Yadkin fault.

The Inner Piedmont has been extensively folded and faulted. An early-formed foliation is parallel to layering, except around vestigial early fold hinges. This foliation has been tightly to isoclinally folded about gently plunging axes and moderately inclined to recumbent axial surfaces (Goldsmith, 1981). Vergence is generally west to northwest. Sheared-off limbs of folds and anastomosing shear surfaces are common. Small granite dikes have been emplaced along shears, and the position of some larger granite masses in the central core appears to coincide with discordances (probably major shears) suggested by the map pattern of foliation. Later upright folds have refolded the earlier folds about gently plunging subhorizontal axes and moderately to steeply dipping axial surfaces that strike east-northeast, northeast, and north. These folds have produced broad synforms and antiforms across the earlier structures.

The overall structural pattern of the Inner Piedmont belt is an asymmetric synform, although the high-grade metamorphic core suggests an antiformal structure. Alternative explanations include a difference in metamorphic grade between flanks and core, inversion of a nappe, and stacking of thrust sheets (Goldsmith, 1981). Foliations and axial surfaces of the earlier folds dip moderately southeast near the Brevard zone, but flatten toward the core of the Inner Piedmont and locally dip west. Moderate dips to the west prevail along the eastern side of the Inner Piedmont belt but dips steepen abruptly near the Kings Mountain belt. In the Gaffney area, however, the dip is east into the Kings Mountain fault. The overall map pattern suggests the presence of nappe structures such as those described by Griffin (1974) to the southwest and suggested by the map of the Shelby quadrangle (Overstreet and others, 1963). This interpretation is supported by gently dipping anastomosing faults and sheared-off recumbent folds seen in many outcrops. Specific boundaries for such nappes, if present, have not been identified in the Charlotte quadrangle.

If the Inner Piedmont is allochthonous, then the linear northeast-trending ridges and valleys and repetition of units in the Inner Piedmont near the Brevard zone suggest that unrecognized subsidiary thrusts and normal faults may be present in this part of the Inner Piedmont. Such faults are indicated by patterns in seismic profiles across the belt in the Winston-Salem quadrangle to the north (L. D. Harris and K.C. Bayer, written commun., 1981). The Eufola fault (Milton, 1981), which bounds the Inner Piedmont on the east, projects into the Inner Piedmont and swings southward north of Lincolnton, N.C. Here it may connect with a fault which strikes into the western edge of the Cherryville Granite and coincides with the boundary between the sillimanite and kyanite metamorphic zones. However, no evidence for such faulting has been seen in the Cherryville. A few high-angle faults have been observed in outcrop and deduced from map patterns within the Inner Piedmont, particularly in the area of the South Mountains and Cherry Mountain. The South Mountains may be an uplifted block tilted toward the southeast. En echelon masses of silicified breccia (**sb**) trend north-northeasterly near Sunshine, N.C., and may define a fault system of Mesozoic or younger age (Snipes and others, 1979). No offset can be discerned along the prominent lineament coinciding with the Catawba River in Caldwell, Burke, and Alexander Counties, N.C., although a minor fault was seen in one outcrop. A fault of minor displacement was observed along the linear Henry Fork in Burke County.

BLUE RIDGE BELT

The oldest rocks in the Blue Ridge belt in the Charlotte quadrangle are the Elk Park Plutonic Suite of Middle Proterozoic age (1 b.y.) (Davis and others, 1962) which consists of the Cranberry Gneiss (**Yec**), a composite of massive stratiform granite; the Wilson Creek Gneiss (**Yew, Yewm**) a granite to granodiorite gneiss containing enclaves of paragneiss and schist; and the Blowing Rock Gneiss (**Yebr**), a gneissic porphyritic granite to granodiorite. The Late Proterozoic Grandfather Mountain Formation (**Zga, Zgs, Zgw, Zgf**) lies unconformably over the Wilson Creek Gneiss. This formation consists of weakly metamorphosed arkose, arkosic conglomerate, siltstone (now in part phyllitic), and felsic to mafic metavolcanic rocks. Unconformably overlying the Cranberry Gneiss is the Ashe Formation (**Za, Zaa**), inferred to be about the same age as the Grandfather Mountain Formation. It consists of metawacke, pelitic schist and gneiss, and zones of amphibolite. The Alligator Back Formation (**ЄZab**) appears to overlie the Ashe Formation conformably (Rankin and others, 1973, p. 17) and consists of thinly layered to laminated silicic schist and gneiss. The upper age limit of the Alligator Back is uncertain but it could be as young as early Paleozoic (Espenshade and others, 1975). The youngest sedimentary rocks of known age in the Blue Ridge belt in the Charlotte quadrangle consist of the Late Proterozoic to Early Cambrian Chilhowee Group and the overlying Early Cambrian Shady Dolomite (**Єs**). The Chilhowee Group here consists of a lower and an upper quartzite (**ЄZcl, ЄZcu**) and an intervening phyllite unit (**ЄZcp**).

The Blue Ridge belt contains elements of two suites of intrusive rocks. The Brown Mountain Granite (Zcb) of the Crossnore Complex of Late Proterozoic age intrudes the Wilson Creek Gneiss, and the Spruce Pine Alaskite (DOs) of Late Ordovician to Early Devonian age (Kish, 1976), a two-mica granite, intrudes the Ashe Formation in the Spruce Pine area in the extreme northwest corner of the quadrangle. A sliver of granite similar to Spruce Pine Alaskite is located in the Brevard zone at the north edge of the quadrangle.

During the Paleozoic, metasedimentary and metavolcanic rocks within the Grandfather Mountain window underwent prograde metamorphism to the greenschist facies, Grenville-age rocks were retrograded, and the Ashe Formation and other rocks now outside the window were metamorphosed to amphibolite-facies assemblages. Rocks in and immediately west of the Brevard fault zone are variably sheared and blastomylonitic. Butler (1973a) has postulated three phases of Paleozoic metamorphism and deformation in the Blue Ridge belt. The main episode of regional metamorphism probably occurred during the early Paleozoic Taconic orogeny, about 450 m.y. ago.

The Blue Ridge belt consists of a series of thrust sheets stacked above a sole thrust (Cook and others, 1979a). The uppermost sheet in the Charlotte quadrangle and adjacent Winston-Salem quadrangle has been breached to produce the Grandfather Mountain window. Within the window two lower thrust sheets are exposed. The lowest sheet contains the Wilson Creek Gneiss, Blowing Rock Gneiss, and the Grandfather Mountain Formation. The Table Mountain thrust sheet, in an intermediate position, contains rocks of the Chilhowee Group and the Shady Dolomite. The Cranberry Gneiss and Ashe Formation in the uppermost sheet form the bounding rocks of the window above the Linville Falls fault. Subsidiary faults are recognized in places.

The Brevard zone forms the boundary between the Blue Ridge and the Inner Piedmont in the Charlotte quadrangle. It is a zone of ductile faulting in which the fault surfaces dip moderately southeast (Bryant and Reed, 1970) but are inflected and probably flatten to the southeast (Cook and others, 1979b). Horton (1979) has described brittle faulting in the Brevard zone southwest of the quadrangle. The Brevard is, in part at least, a splay off the southern Appalachian sole thrust (Harris and Bayer, 1979; Cook and others, 1979a), and represents a higher level décollement surface beneath the Inner Piedmont rocks. The Brevard zone encompasses faults in and bounding the Sauratown Mountains window north of the quadrangle (Espenshade and others, 1975).

REFERENCES

References marked with asterisk are shown on the index map of sources of geologic data.

*1. Bates, R. G., and Bell, Henry, III, 1965, Geophysical investigations in the Concord quadrangle, Cabarrus and Mecklenburg Counties, North Carolina: U.S. Geological Survey Geophysical Investigations Map GP–522, scale 1:48,000.

*2. Bell, Henry, III, unpublished mapping, 1957–63.

*3. Bowerman, J. N., 1954, The geology and mineral resources of the Pasour Mountain area, Gaston County, North Carolina: Raleigh, N.C., North Carolina State University, unpublished M.S. thesis, 56 p.

*4. Bowman, F. O., Jr., 1954, The Carolina slate belt near Albemarle, North Carolina: Chapel Hill, University of North Carolina, unpublished Ph.D thesis, 85 p.

*5. Bryant, Bruce, and Reed, J. C., Jr., 1970, Geology of the Grandfather Mountain window and vicinity, North Carolina and Tennessee: U.S. Geological Survey Professional Paper 615, 190 p.

*6. Burt, E. R., Carpenter, P. A., III, McDaniel, R. D., and Wilson, W. F., 1978, Diabase dikes of the eastern Piedmont of North Carolina: North Carolina Division of Land Resources, Geological Survey Section, Information Circular 23, 12 p.

7. Butler, J. R., 1972, Age of Paleozoic regional metamorphism in the Carolinas, Georgia, and Tennessee, southern Appalachians: American Journal of Science, v. 272, no. 4, p. 319–333.

8. _________ 1973a, Paleozoic deformation and metamorphism in part of the Blue Ridge thrust sheet, North Carolina: American Journal of Science, v. 273–A, (Byron N. Cooper Volume), p. 72–88.

9. _________ 1973b, Orbicular rocks from Davie County, North Carolina Piedmont: Southeastern Geology, v. 15, p. 127–139.

10. _________ 1978, Generalized geologic map of the Charlotte quadrangle, North Carolina and South Carolina, *in* Heffner, J. D., and Ferguson, R. B., Savannah River Laboratory hydrogeochemical and stream sediment reconnaissance, preliminary raw data release, Charlotte 1° x 2° NTMS area, North Carolina and South Carolina, National Uranium Resource Evaluation Program: U.S. Department of Energy, Grand Junction Office, GJBX–40(78).

*11. _________ 1981, Geology of the Blacksburg South quadrangle, South Carolina, *in* Horton, J. W., Jr., and others, eds., Geological investigations of the Kings Mountain belt and adjacent areas in the Carolinas, Carolina Geological Society, field trip guidebook, 1981: Columbia, South Carolina Geological Survey, p. 65–71.

12. Butler, J. R., and Fullagar, P. D., 1978, Petrochemical and geochronological studies of plutonic rocks in the southern Appalachians, III, Leucocratic adamellites of the Charlotte belt near Salisbury, North Carolina: Geological Society of America Bulletin, v. 89, p. 460–466.

13. Butler, J. R., and Ragland, P. C., 1969, A petrochemical survey of plutonic intrusions in the Piedmont, southeastern Appalachians, U.S.A.: Contributions to Mineralogy and Petrology, v. 24, no. 2, p. 164–190.

*14. Butler, J. R., and Siple, G. E., 1966, Geology and mineral resources of York County, South Carolina: South Carolina Division of Geology Bulletin 33, 65 p.

*15. Conley, J. F., 1962, Geology of the Albemarle quadrangle, North Carolina: North Carolina Department of Conservation and Development, Division of Mineral Resources Bulletin 75, 26 p.

16. Cook, F. A., Albaugh, D. S., Brown, L. D., Kaufman, Sidney, Oliver, J. E., and Hatcher, R. D., Jr., 1979a, Thin-skinned tectonics in the crystalline southern Appalachians, COCORP seismic-reflection profiling of the Blue Ridge and Piedmont: Geology, v. 7, no. 12, p. 563–567.

17. Cook, F. A., Albaugh, D. S., Brown, L. D., Oliver, J. E., Kaufman, Sidney, and Hatcher, R. D., Jr., 1979b, The Brevard Fault: a subsidiary thrust fault to the southern Appalachian sole thrust, *in* Wones, D. R., ed. The Caledonides in the USA: International Geologic Correlation Program, Project 27, Caledonide Orogen: Blacksburg, Va., Virginia Polytechnic Institute, Department of Geological Sciences Memoir 2, p. 205–213.

18. Davis, G. L., Tilton, G. R., and Wetherill, G. W., 1962, Mineral ages from the Appalachian Province in North Carolina and Tennessee: Journal of Geophysical Research, v. 67, no. 5, p. 1987–1996.

19. Duke Power Company, 1975, Preliminary safety analysis report, section 2.5, Perkins Nuclear Station: Docket Nos. STN 50–488, STN 50–489, STN 50–490, Table 2C–2.

*20. Espenshade, G. H., and Potter, D. B., 1960, Kyanite, sillimanite, and andalusite deposits of the southeastern states: U.S. Geological Survey Professional Paper 336, 121 p.

21. Espenshade, G. H., Rankin, D. W., Shaw, K. W., and Neuman, R B., 1975, Geologic map of the east half of the Winston-Salem quadrangle, North Carolina – Virginia: U.S. Geological Survey Miscellaneous Investigatons Map I–709–B, scale 1:250,000.
22. Fullagar, P. D., 1971, Age and origin of plutonic intrusions in the Piedmont of the southeastern Appalachians: Geological Society of America Bulletin, v. 82, no. 10, p. 2845–2862.
23. Fullagar, P. D., and Butler, J. R., 1979, 325–265 m.y.-old granitic plutons in the Piedmont of the southeastern Appalachians: American Journal of Science, v. 279, no. 2, p. 161–185.
24. Fullagar, P. D., and Kish, S. A., 1981, Mineral age traverses across the Piedmont of South Carolina and North Carolina, *in* Horton, J. W., Jr., and others, eds., Geological investigations of the Kings Mountain belt and adjacent areas in the Carolinas, Carolina Geological Society, field trip guidebook, 1981: Columbia, South Carolina Geological Survey, p. 155–165.
25. Gibson, G.G., 1984, Ediacaran fossils from Stanly County, North Carolina: new evidence of the age of the Carolina slate belt terrane: Geological Society of America, Abstracts with Programs, v. 16, no. 1, p. 18.
26. Glover, L. G., III, and Sinha, A. K., 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, v. 273–A (Byron N. Cooper Volume), p. 234–251.
*27. Godfrey, P. E., 1981, Geology of the southern half of the Kings Creek quadrangle, South Carolina: Athens, University of Georgia, unpublished M.S. thesis, 46 p.
28. Goldsmith, Richard, 1981, Structural patterns in the Inner Piedmont of the Charlotte and Winston-Salem 2° quadrangles, North Carolina and South Carolina, *in* Horton, J. W., Jr., and others, eds., Geological investigations of the Kings Mountain belt and adjacent areas in the Carolinas, Carolina Geological Society, field trip guidebook, 1981: Columbia, South Carolina Geological Survey, p. 19–27.
*29. Goldsmith, Richard, reconnaissance mapping, 1976–80.
30. Griffin, V. S., Jr., 1974, Analysis of the Piedmont in northwest South Carolina: Geological Society of America Bulletin, v. 85, no. 7, p. 1123–1138.
31. Griffitts, W. R., and Overstreet, W. C., 1952, Granitic rocks of the western Carolina Piedmont: American Journal of Science, v. 250, no. 11, p. 777–789.
*32. Hadley, J. B., reconnaissance mapping, 1973–74.
33. Hadley, J. B., and Nelson, A. E., 1971, Geologic map of the Knoxville quadrangle, North Carolina, Tennessee, and South Carolina: U.S. Geological Survey Miscellaneous Investigations Map I–654, scale: 1:250,000.
34. Harper, S. B., and Fullagar, P. D., 1981, Rb-Sr ages of granitic gneisses of the Inner Piedmont belt of northwestern North Carolina and southwestern South Carolina: Geological Society of America Bulletin, v. 92, no. 11, part I, p. 864–872.
35. Harris, L. D., and Bayer, K. C., 1979, Sequential development of the Appalachian orogen above a master décollement, a hypothesis: Geology, v. 7, no. 12, p. 568–572.
36. Hatcher, R. D., Jr., Butler, J. R., Fullagar, P. D., Secor, D. T., and Snoke, A. W., 1979, Geologic synthesis of the Tennessee – Carolinas – northeast Georgia southern Appalachians, *in* Wones, D. R., ed., The Caledonides in the USA; International Geologic Correlation Program, Project 27, Caledonide Orogen, Proceedings: Blacksburg, Virginia Polytechnic Institute, Department of Geological Sciences Memoir 2, p. 83–90.
*37. Hermes, O. D., 1968, Petrology of the Mecklenburg gabbro – metagabbro complex, North Carolina: Contributions to Mineralogy and Petrology, v. 18, no. 3, p. 270–294.
*38. Horton, J. W., Jr., reconnaissance mapping, 1979–81.
*39. Horton, J. W., Jr., 1977, Geology of the Kings Mountain and Grover quadrangles, North and South Carolina: Chapel Hill, University of North Carolina, unpublished Ph.D. dissertation, 174 p.
40. ________ 1979, Post-mylonitic deformation in the Brevard fault zone, North Carolina [abs.], *in* Wones, D. R., ed., The Caledonides in the USA; International Geologic Correlation Program, Project 27, Caledonide Orogen, Proceedings: Blacksburg, Virginia Polytechnic Institute, Department of Geological Sciences Memoir 2, Appendix, p. A17.
41. ________ 1981a, Shear zone between the Inner Piedmont and Kings Mountain belts in the Carolinas: Geology, v. 9, no. 1, p. 28–33.
42. ________ 1981b, Geologic map of the Kings Mountain belt between Gaffney, South Carolina and Lincolnton, North Carolina, *in* Horton, J. W., Jr., and others, eds., Geological investigations of the Kings Mountain belt and adjacent areas in the Carolinas, Carolina Geological Society, field trip guidebook, 1981: Columbia, South Carolina Geological Survey, p. 6–18.
43. ________ 1984, Stratigraphic nomenclature in the Kings Mountain belt, North Carolina and South Carolina: U.S. Geological Survey Bulletin 1537–A, p. A59–A68.
44. Horton, J. W., Jr., and Stern, T. W., 1983, Late Paleozoic (Alleghanian) deformation, metamorphism, and syntectonic granite in the central Piedmont of the Southern Appalachians [abs.]: Geological Society of America, Abstracts with Programs, v. 15, no. 6, p. 599.
45. Hunter, C. E., and Mattocks, P. W., 1936, Geology and kaolin deposits of Spruce Pine and Linville Falls quadrangles, North Carolina: Tennessee Valley Authority, Water Control Planning Department, Geology Division, Bulletin 4, p. 10–23.
*46. Keith, Arthur, and Sterrett, D. B., 1931, Gaffney-Kings Mountain, South Carolina-North Carolina: U.S. Geological Survey Geologic Atlas, Folio 222, 13 p.
*47. Kesler, T. L., 1942, The tin-spodumene belt of the Carolinas, a preliminary report: U.S. Geological Survey Bulletin 936–J, p. 245–269.
48. Kish, S. A., 1976, Paleozoic plutonic activity in the Blue Ridge of North Carolina [abs.]: Geological Society of America, Abstracts with Programs, v. 8, no. 2, p. 211–212.
49. ________ 1983, A geochronological study of deformation and metamorphism in the Blue Ridge and Piedmont of the Carolinas: Chapel Hill, University of North Carolina, unpublished Ph.D. thesis, 220 p.
50. Law Engineering Testing Company, 1976, Catawba Nuclear Station, Units 1 and 2, Final geologic report on brecciated zones: Duke Power Company, Docket Nos. 50–413, 50–414, March 1, 1976.
51. McSween, H. Y., Jr., 1981, Gabbro-metagabbro complexes: a mechanism for magma ascent? [abs.]: Geological Society of America, Abstracts with Programs, v. 13, no. 7, p. 508.
*52. Milton, D. J., reconnaissance mapping, 1977–81.
53. ________ 1981, The northern termination of the Kings Mountain belt, *in* Horton, J. W., Jr., and others, eds., Geological investigations of the Kings Mountain belt and adjacent areas in the Carolinas, Carolina Geological Society, field trip guidebook, 1981: Columbia, South Carolina Geological Survey, p. 1–5.
54. ________ 1984, Revision of the Albemarle Group, North Carolina: U.S. Geological Survey Bulletin 1537–A., p. A69–A72.
55. Milton, D. J., and Reinhardt, Juergen, 1980, Turbidites in the Albemarle Group, Carolina Slate Belt [abs.]: Geological Society of America, Abstracts with Programs, v. 12, no. 4, p. 202.