MINERAL RESOURCE ASSESSMENT OF MAFIC AND ULTRAMAFIC ROCKS IN THE GREENVILLE 1° × 2° QUADRANGLE, SOUTH CAROLINA, GEORGIA, AND NORTH CAROLINA

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INTRODUCTION

Mineral resources of the Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina, were assessed between 1984 and 1990 under the Conterminous United States Mineral Assessment Program (CUSMAP) of the U.S. Geological Survey (USGS). The mineral resource assessments were made on the basis of geologic, geochemical, and geophysical investigations and on the distribution of mines, prospects and mineral occurrences reported in the literature.

This report is an assessment of the mineral resources associated with mafic and ultramafic rocks in the Greenville quadrangle. It is based on the geology as mapped by Nelson and others (1987, 1989), on geochemistry of rock samples collected for this and other studies, on data available for known mines and prospects, and on the published geologic literature.

GEOLOGIC SETTING

The Greenville 1° × 2° quadrangle extends from the Blue Ridge province in the northwest corner to the Piedmont province in the southeast corner (fig. 1*A*). In the Valley and Ridge province of the southern Appalachians west of the Greenville quadrangle, it has long been known that westward-transported thrust sheets are the dominant structural elements (Rodgers, 1970, p. 39–59). Recent work has shown, however, that the same structural style also dominates the crystalline rocks east of the Valley and Ridge (Cook and others, 1979; Harris and others, 1981). Previously, the rocks of the Greenville quadrangle were described as parts of the Blue Ridge, Inner Piedmont, Kings Mountain, Charlotte, and the Carolina slate belts (fig. 1*B*; King, 1955; Overstreet and Bell, 1965a, b; Hatcher, 1972).

The Greenville quadrangle contains metamorphosed crystalline rocks of mostly Late Proterozoic to Paleozoic age in 11 westward-transported thrust sheets (fig. 2), each having a characteristic rock assemblage (Nelson and others, 1989). In ascending stacking order, the Great Smoky, Helen, Young Harris, Richard Russell, and Tallulah Falls thrust sheets form the Blue Ridge thrust stack northwest of the Brevard fault zone. The Inner Piedmont thrust stack, southeast of the Brevard fault zone, contains, in ascending order, the Chauga–Walhalla thrust complex and the Six Mile, Paris Mountain, and Laurens thrust sheets. The Lowndesville shear zone in the southeastern part of the quadrangle separates the Inner Piedmont thrust stack from the Charlotte thrust sheet and a separate mafic–ultramafic thrust sheet.

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Rocks of all the thrust sheets are polydeformed and polymetamorphic (Nelson, 1988, p. 11). Many rocks of the Blue Ridge and Inner Piedmont thrust stacks are at medium to high metamorphic grade in the kyanite or sillimanite zone (fig. 3). The Charlotte and mafic–ultramafic thrust sheets are generally of low to medium grade. Nelson (1988, p. 9–11), in summarizing the timing of regional metamorphism, recognized separate metamorphic events at 470 to 430 million years ago (Ma) for the thrust sheets west of the Dahlonega thrust fault, about 365 Ma for the Tallulah Falls and Six Mile thrust sheets, about 365 or possibly 430 to 410 Ma for the Chauga–Walhalla thrust complex, about 344 Ma for the Paris Mountain and Laurens thrust sheets, and 338 to 312 Ma for the Charlotte and mafic–ultramafic thrust sheets. Granitic masses in most of these thrust sheets appear to be generally pre- or syn-metamorphic. Exceptions include the Elberton Granite in the Six Mile thrust sheet, which is 350–320 Ma (Ross and Bickford, 1980, p. 52; Whitney and others, 1980, p. 63), and the granite at Coronaca in the Charlotte thrust sheet, which is 278 Ma (Fullagar and Butler, 1979, p. 169).

Rocks of the Blue Ridge Thrust Stack

Great Smoky Thrust Sheet

The Great Smoky thrust sheet in the northwest corner of the Greenville quadrangle consists chiefly of metamorphosed conglomerate, sandstone, and shale of the Great Smoky Group, which is part of the Ocoee Supergroup of Late Proterozoic age (Nelson and others, 1989). These rocks are overlain in a small area of a few acres in the farthest northwest corner of the quadrangle by the Nantahala Slate of Cambrian age. Farther southeast, rocks of the Great Smoky thrust sheet are also exposed below the Hayesville fault in the Brasstown Bald and Shooting Creek windows, which are areas eroded through the Richard Russell and Young Harris thrust sheets (fig. 2). Unlike the other thrust sheets to the southeast, the Great Smoky thrust sheet lacks recognizable igneous or metaigneous rocks in the Greenville quadrangle other than a few small mica-pegmatite bodies of metamorphic origin that are found in areas of kyanite or sillimanite metamorphic grade.

Helen Thrust Sheet

The Helen thrust sheet contains a variety of metamorphosed interlayered sedimentary and volcanic rocks of Late Proterozoic and (or) early Paleozoic age (Nelson and others, 1989). These rocks include siltstone, sandstone, shale, and chemically deposited sedimentary rocks and mafic to felsic tuffs, flows, and intrusive bodies that are now micaceous and quartzofeldspathic gneiss and schist, quartzite, iron- and manganese-rich quartz schist, amphibolite, metagabbro, granitic to dioritic gneiss, and metatrondhjemite (Cook and Burnell, 1986). Rocks of the Helen thrust sheet overlie rocks of the Great Smoky thrust sheet along an unnamed fault zone southwest of the Greenville quadrangle (Nelson, 1991). The Dahlonega fault forms the boundary between the Helen thrust sheet and the Tallulah Falls thrust sheet to the southeast.

Young Harris Thrust Sheet

A complex of mafic and ultramafic rocks makes up the relatively thin Young Harris thrust sheet, which lies between the Great Smoky and the Richard Russell thrust sheets and is only exposed in narrow belts around the Brasstown Bald and Shooting Creek windows (fig. 2) in the northwestern part of the quadrangle (Nelson and others, 1989). The complex includes masses of gabbro, troctolite, pyroxenite, talc schist, eclogite, wehrlite, and amphibolite; it may, in part, represent a tectonic melange. The age of these rocks, which may be Late Proterozoic or early Paleozoic, is not well established. All of the other thrust sheets above the Great Smoky thrust sheet also contain a variety of rare ultramafic and mafic rocks, commonly as small discontinuous pods but locally as larger mappable units.

Richard Russell Thrust Sheet

Metasandstone, quartzofeldspathic gneiss, metagraywacke, biotite gneiss, mica schist, and lesser amounts of amphibolite, together with granitic gneiss, granodiorite gneiss, and granitic pegmatite make up most of the Richard Russell thrust sheet (Nelson and Gillon, 1985). The metamorphic rocks are mostly Middle Proterozoic in age, but some metagabbro and dioritic to tonalitic gneiss in this thrust sheet may be of early Paleozoic age (Nelson, 1988; Nelson and others, 1989). This thrust sheet overlies parts of the Helen and Great Smoky thrust sheets along the Hayesville thrust fault.

Tallulah Falls Thrust Sheet

The Tallulah Falls thrust sheet contains interlayered and folded metagraywacke, mica schist, amphibolite, aluminous schist, quartzite, biotite gneiss, biotite schist, quartzofeldspathic gneiss, and amphibolite, together with several types of granitoid rock (Nelson and others, 1989). Most of the rocks are of Late Proterozoic to early Paleozoic age except for two masses of Middle Proterozoic rocks. This thrust sheet is bounded to the southeast by the Brevard fault zone.

Rocks of the Inner Piedmont Thrust Stack

Chauga–Walhalla Thrust Complex

The Chauga–Walhalla thrust complex of Nelson and others (1987), which contains smaller thrust sheets separated by poorly defined thrust faults or tectonic slides, trends northeastward across the quadrangle immediately southeast of the Brevard fault zone. This thrust complex includes rocks assigned by Hatcher (1972) to the Chauga belt and by Griffin (1969) to his Walhalla nappe. Abundant amphibolite, especially in the Walhalla nappe, is interlayered with various types of quartzofeldspathic and micaceous gneiss and schist, metasandstone, metasiltstone, carbonate rocks, quartzite, phyllonitic schist, and pegmatite of Late Proterozoic to early Paleozoic age in the complex.

Six Mile Thrust Sheet

Rock units consisting of various combinations of mica schist, sillimanite schist, manganiferous schist, felsic gneiss, amphibolite, quartzofeldspathic gneiss, megacrystic biotite gneiss, metagraywacke, quartzose schist, and quartzite of Late Proterozoic to early Paleozoic age are widespread in the Six Mile thrust sheet (Nelson and others, 1989). A distinctive quartz-garnet rock (gondite) and various types of mostly Paleozoic plutonic gneiss, pegmatite, and quartz veins also are found in this thrust sheet, which structurally overlies the Chauga–Walhalla thrust complex.

Paris Mountain Thrust Sheet

The Paris Mountain thrust sheet consists chiefly of sillimanite schist, quartzite, and amphibolite of Late Proterozoic to early Paleozoic age and granite gneiss of Paleozoic age (Nelson and others, 1989). It has been thrust over the Six Mile thrust sheet.

Laurens Thrust Sheet

The principal rock types of the Laurens thrust sheet are layered biotite gneiss, amphibolite, hornblende gneiss, mica schist, sillimanite schist, marble, and magnetite-bearing quartzite, all of Late Proterozoic to early Paleozoic age (Nelson and others, 1989). Also included are Paleozoic granitic and granodioritic gneiss. The Laurens thrust sheet structurally overlies the Six Mile and Paris Mountain thrust sheets (Art Nelson, USGS, written commun., 1990).

Rocks Southeast of the Lowndesville Shear Zone

Mafic–Ultramafic Thrust Sheet

A melange of probable Late Proterozoic to early Paleozoic age that contains fragmental ultramafic and mafic rocks in a quartzofeldspathic matrix, together with several different-sized granitic bodies of Paleozoic age, is near the south border of the Greenville quadrangle southeast of the Lowndesville shear zone (Nelson and others, 1989). This melange, which is at least partly equivalent to the Juliette melange of Higgins and others (1989), may be a separate thrust sheet. To the northeast, these rocks are bordered by the volcanic-arc assemblage of the Charlotte thrust sheet. The boundary between the melange and the volcanic arc has not been observed but is inferred to be a thrust fault.

Charlotte Thrust Sheet

Metamorphosed volcanic and related sedimentary rocks of Late Proterozoic to early Paleozoic age, together with plutonic rocks of Paleozoic age make up a volcanic-arc assemblage, which may or may not represent a distinct thrust sheet or thrust complex (Nelson and others, 1989). These rocks have been traditionally included in the Kings Mountain belt, Charlotte belt, and Carolina slate belt (fig. 1*B*; King, 1955; Overstreet and Bell, 1965a, b). The rocks include metatuff, amphibolite, phyllite, quartzite, greenstone, biotite gneiss, biotite schist, quartzofeldspathic gneiss, mica schist, and various types of granitoid gneiss. The Charlotte thrust sheet also has relatively unmetamorphosed mafic igneous complexes of Paleozoic age, which range in composition from gabbro to syenite and diorite (Butler and Ragland, 1969). The Charlotte volcanic-arc assemblage and adjacent melange complex overlie rocks of the Six Mile and Laurens thrust sheets along the Lowndesville shear zone.

MINERAL RESOURCES RELATED TO MAFIC AND ULTRAMAFIC ROCKS

Mineral resources related to mafic and ultramafic rocks in the Greenville quadrangle that have been mined, or which might be present, include asbestos, chromite, corundum, nickel, olivine, platinum-group elements (PGE's), pyrite–pyrrhotite, soapstone, talc, titanium, and vemiculite. Of these, chromite, olivine, and pyrite–pyrrhotite are generally considered to be primary minerals, and the PGE's and titanium are usually in primary minerals; asbestos, corundum, soapstone, talc, and vermiculite are postmagmatic and related to secondary processes, either metamorphism or weathering, or both. At present, the only commodity of interest is vermiculite, a small deposit of which has recently been prospected on the east edge of the quadrangle just south of Laurens, S.C.

Asbestos, corundum, pyrite, soapstone, and vermiculite have been mined in the Blue Ridge thrust stack of the Greenville 1° × 2° quadrangle (table 1) but generally on a small scale. It is doubtful that any of these commodities, other than possibly pyrite, will again be of economic importance in that area, although limited resources are present. Information is available on 101 deposits in mafic, ultramafic, or related rocks that may contain some of these commodities (table 2; fig. 4; map).

The mafic and ultramafic rocks of the Blue Ridge and Piedmont provinces have been the subject of extensive study by many geologists. The early and comprehensive studies of the ultramafic rocks by King (1894), Pratt and Lewis (1905), and Hopkins (1914) are still the definitive works. Later studies by Hunter (1941), Hartley (1973), and other investigators (see table 2) are generally concerned with only one deposit or one commodity. In the last 15 years, renewed study by several university professors and their students has focused on various aspects of the origin of both mafic and ultramafic rocks. Summary articles by Misra and Keller (1978), Misra and McSween (1984), and Butler (1989) are useful guides to the problems concerning origin and history of these rock types.

Mafic Rocks

Amphibolite and hornblende gneiss and schist are the most common mafic metaigneous rocks in the quadrangle. They are present as layers, lenses, and irregular masses interlayered in various proportions with more felsic gneiss and schist in all the thrust sheets except the Great Smoky. They range in composition from basalt to diorite and represent several types of altered volcanic rocks or igneous intrusions.

In addition to amphibolite and other metamorphosed mafic igneous rocks, the Charlotte thrust sheet also contains many relatively unmetamorphosed mafic igneous complexes that range in composition from gabbro to syenite and diorite (Butler and Ragland, 1969). The Mount Carmel Complex (fig. 5), in Abbeville and McCormick Counties, S.C., and the mafic complex at Buffalo, 12 mi to the east in Union County, S.C., in the Spartanburg 1° × 2° quadrangle have been studied in detail (figs. 6 and 7) (Medlin, 1968; Medlin and others, 1972). Rocks of the Mount Carmel Complex range from gabbro to syenite, and those of the Buffalo complex range from gabbro to quartz monzonite. In a comparison of the two complexes (table 3), gabbro from the Mount Carmel Complex is characterized by greater content of TiO_2 and alkalies (Na_2O+K_2O) and lower content of SiO_2 than the gabbro at Buffalo. The Mount Carmel Complex appears to have an alkalic affinity and the complex at Buffalo, a calc-alkalic or tholeiitic affinity (Medlin, 1968).

Ultramafic Rocks

The most common ultramafic rock is peridotite composed mostly of olivine and various amounts of pyroxene, amphibole, or mica. The larger peridotite masses are dunite consisting of 90 percent or more olivine that has a composition of about 92 percent forsterite (Carpenter and Phyfer, 1975). Enstatite and chromite are the other common primary accessory minerals. In most rock units, the chromite constitutes less than 1 percent of the rock and is fine grained and disseminated. In a few deposits, chromite is concentrated in small lenses, thin veins, or pods, but these concentrations are not common and are generally not economic. Relatively unaltered dunite bodies are restricted to the Blue Ridge thrust stack and are found in the Young Harris, Helen, and Tallulah Falls thrust sheets in the Greenville quadrangle (map) and also the Richard Russell thrust sheet in the adjoining Knoxville quadrangle to the north.

Olivine is susceptible to alteration and weathering, and most of the dunite contains olivine that is partly altered to serpentine, talc, vermiculite, chlorite, or anthophyllite. Such alteration is found mainly in the outer parts of the deposits along contacts with country rock, along internal fractures, and adjacent to pegmatite or quartz veins cutting the dunite. Other minerals commonly associated with dunite include magnetite, actinolite, phlogopite, garnierite, magnesite, corundum, spinel, antigorite, limonite, chalcedony, sepiolite(?), and occasionally tourmaline (King, 1894; Pratt and Lewis, 1905, p. 270–333; Hopkins, 1914, p. 48–70).

Dunite bodies are neither large nor abundant in the quadrangle. The several dunite deposits in the Young Harris thrust sheet (Hartley, 1973) may have areas as large as 250 to 300 acres but are poorly exposed. The dunite at Lake Burton in the Helen thrust sheet has a surface exposure of 21 acres (Chatman, 1985), and the dunite at Laurel Creek in the Tallulah Falls thrust sheet covers about 155 acres (Petty, 1982).

Drilling and geophysical studies show that dunite bodies in the Blue Ridge province are ellipsoid or irregular podlike masses that have well-defined bottoms (Honeycutt and others, 1981; Chatman, 1985; Hirt and others, 1987) . Most of them are roughly concordant with the regional foliation of the enclosing gneiss and schist, but some may be locally discordant.

Harzburgite, a peridotite containing olivine and significant amounts of orthopyroxene, is found as individual bodies or, more commonly, as variants of a larger dunite body. The harzburgite may be in contact with or completely enclosed by dunite (Conrad and others, 1963, p. 9). Wehrlite, a peridotite containing clinopyroxene, has been reported in the Young Harris thrust sheet by Hartley (1973, p. 31–32) but is not a common rock type in the area.

Pyroxenite, composed mostly of pyroxene, may be as common as peridotite in the Greenville quadrangle. The most abundant type present is orthopyroxenite, composed chiefly of enstatite. The orthopyroxenite bodies, which are smaller than most of the dunite bodies, commonly are found in groups of small separate bodies, generally enclosed by an envelope of altered rock that consists of talc, chlorite, vermiculite, and anthophyllite.

Most of the smaller ultramafic bodies are completely altered to soapstone, talc schist, chlorite schist, or serpentinite. In general, these bodies seem to have been mostly pyroxenite or harzburgite; a few may have been dunite. Many of the soapstone or chlorite schist bodies are closely associated with larger masses of amphibolite.

Mafic or ultramafic rocks are not found in the Great Smoky thrust sheet in the Greenville quadrangle. In the other thrust sheets in the Blue Ridge and Inner Piedmont thrust stacks, the most common mafic rocks are amphibolite and hornblende gneiss, which are generally interlayered with the more felsic gneiss and schist. Some of the thrust sheets also contain a few small masses of metagabbro, the largest of which is the metagabbro at Anderson (Griffin, 1970) in the Six Mile thrust sheet. Most of the ultramafic bodies in the Blue Ridge thrust stack are in the Young Harris, Helen, and Tallulah Falls thrust sheets near major thrust faults such as the Hayesville and Dahlonega faults (fig. 4). The thrust sheets of the Inner Piedmont thrust stack contain fewer ultramafic bodies (fig. 4) but have abundant interlayered amphibolite. Only a few ultramafic bodies in the Inner Piedmont thrust stack have been described (Byran and Griffin, 1981; Warner and others, 1986, 1989; Butler, 1989). Griffin (1974, p. 1130) reported that altered ultramafic rocks ranging in size from a few feet to several hundred feet across are widely dispersed in the Walhalla thrust sheet and that a few are included in the Six Mile sheet. None have been reported from the Paris Mountain thrust sheet.

In addition to amphibolite and a few bodies of ultramafic rock, the Charlotte thrust sheet also contains many small to large masses of gabbro and related syenite and diorite (Medlin, 1968; Medlin and others, 1972).

The origin of the mafic and associated ultramafic rocks has been the subject of much speculation. Recently, several writers have proposed that these rocks represent parts of ophiolites, complex plutons, or melange terranes (Misra and Keller, 1978; McElhaney and McSween, 1983; Abbott and Raymond, 1984; Hatcher and others, 1984; Misra and McSween, 1984). Shaw and Wasserburg (1984), using isotopic data, pointed out that some of the large dunite bodies and associated mafic complexes, like the Young Harris thrust sheet, have a depleted mantle signature and may be fragments of oceanic crust. Other ultramafic bodies, like the Webster–Addie body in North Carolina, are not isotopically similar to oceanic crust or to other ultramafic bodies analyzed from the Blue Ridge province. They inferred diverse origins for the Appalachian mafic rocks. Lipin (1984), who studied chromite in dunite in the Blue Ridge province of North Carolina, concluded that the Blue Ridge dunite bodies are probably remnants of ophiolites emplaced before or during peak metamorphism. Later, metamorphism dehydrated the serpentine-bearing rocks to form olivine and altered the chromite compositions and textures. Butler (1989, p. 23–24), in a brief discussion of ultramafic bodies of the Inner Piedmont province, stressed that the occurrences are small and scattered and generally do not follow recognized tectonic features. All these ultramafic rocks are metamorphosed and their emplacement predated the main episodes of regional deformation and metamorphism. Protoliths were predominantly dunite and peridotite.

Asbestos

Asbestos deposits in the Greenville quadrangle are associated with metaperidotite and metapyroxenite bodies, many of which are so altered that they are classified as chlorite schist, serpentinite, soapstone, or just altered ultramafic rock (table 2). Hopkins (1914) studied many of the more promising deposits in Georgia, and Sloan (1908, p. 122–125) listed seven asbestos occurrences in South Carolina, four of which are in the Greenville quadrangle. The asbestos of commercial value in Georgia and South Carolina is the fibrous form of anthophyllite, an amphibole mineral, that has characteristically short and only slightly flexible fibers of low tensile strength. It has been used extensively in fireproofing, roofing shingles, pipe-covering materials, wall board, and floor tile; it has better resistance to heat and acid than chrysotile, the more commercially important type of asbestos.

Anthophyllite is found in three principal forms: cross-fiber veins, slip-fiber veins, and mass-fiber deposits. Most of the production is from mass-fiber deposits. Most of the Georgia deposits are small because the ultramafic bodies are small. Development of the fibrous, or asbestos, form of anthophyllite seems largely dependent on the degree of weathering (Conrad and others, 1963, p. 20), and most deposits cannot be expected to extend very far underground.

Demand for asbestos is down because of environmental concerns. The last recorded asbestos production in the quadrangle was from Rabun County, Ga., in 1951 to 1954. Resources of asbestos in the quadrangle are probably equal to or possibly a little more than past production, which was less than 20,000 tons of mass-fiber anthophyllite. This is about 20 percent of the estimated anthophyllite resources of the United States but less than 1 percent of the chrysotile asbestos resources (Shride, 1973, p. 69–70). Chrysotile asbestos is the type most commonly used; anthophyllite production in the United States may have been as much as 5 percent of the total United States asbestos production (Bowles, 1955, p. 56; Clifton, 1985, p. 64).

Most of the known asbestos deposits in the Greenville quadrangle are in the Tallulah Falls and Helen thrust sheets, which have a moderate to high potential for additional asbestos resources (fig. 8). In the Young Harris thrust sheet, small deposits of anthophyllite that have been prospected (Hopkins, 1914, p. 149–153) and the abundance of ultramafic rocks suggest a high potential for asbestos resources. The part of the Richard Russell thrust sheet that contains more abundant amphibolite and ultramafic bodies has a moderate potential for asbestos resources. The presence of some slip-fiber asbestos in ultramafic rocks in the mafic–ultramafic thrust sheet (Hopkins, 1914, p. 295) also suggests a moderate potential for asbestos resources. The other thrust sheets in the quadrangle that contain few or no ultramafic rocks have little potential for asbestos resources.

Chromite

Chromite, which is present in small quantities in most of the peridotite in the Greenville quadrangle, is found as massive or segregated chromite in ultramafic rocks, as sand or disseminated chromite, and as chromite sand in colluvium or alluvium (Hunter, 1938; Hunter and others, 1942, p. 4; Lipin, 1983 and 1984, p. 510–511). Massive chromite forms small lenses and irregular seams, pods, and veins, commonly near the contact of the peridotite and the country rock (Lewis, 1922, p. 114–115; Hunter, 1938, p. 18). Sand chromite is the name applied to disseminated chromite crystals in peridotite that are found generally in layers separated by peridotite containing much less chromite. Chromite sand, on the other hand, consists of crystals and fragments of chromite in clay or alluvium derived from weathered peridotite. Only a minor amount of prospecting for chromite has been done in the quadrangle. Chatman (1985) listed the Barnett Denton prospect (table 2, No. T7) as a chromite prospect on the basis of unpublished data in Tennessee Valley Authority files. This prospect, which is in rocks of the Richard Russell thrust sheet, appears to be the same one shown on a mineral resources map of some counties in northern Georgia (Georgia Dept. of Mines, Mining, and Geology, 1951) as a magnetite prospect. Hopkins (1914, p. 152) mentioned chromite prospecting by W.M. Scott in a dunite body in the Young Harris thrust sheet (table 2, No. T3).

Resources of chromite, if any, in the quadrangle are small. Residual placers and alluvial resources might be found along streams draining two large areas underlain by dunite in the Young Harris thrust sheet; if present, such deposits would probably be small and low grade. Although unexposed dunite bodies are probably present in the metamorphic rocks of the Richard Russell, Tallulah Falls, and Young Harris sheets, the chances of finding them are poor. The known deposits are generally small and have no known geochemical halo except for a few feet of alteration at the contact with country rock. Detailed ground geophysical methods have been used to determine the shape and size of known deposits in North Carolina (Hunter and others, 1942, p. 18–28; Honeycutt and others, 1981; Hirt and others, 1987) and might be useful in the search for unexposed bodies in Georgia. The rewards, however, are probably not worth the cost of such exploration.

Corundum

Corundum is generally found associated with alteration zones along the margins of peridotite or pyroxenite deposits or along internal fractures, especially where the deposits have been cut by granite or pegmatite. Corundum also is found in lesser amounts in amphibolite and in felsic gneiss or schist.

Systematic mining of corundum for abrasive use began at the Corundum Hill deposit, Macon County, N.C., in the fall of 1871 and at Laurel Creek, Rabun County, Ga., in 1873 (King, 1894, p. 77). From then until 1898, the deposits in North Carolina and, until 1893, the deposits in adjacent Georgia supplied most of the Nation's demand for corundum (Pratt and Lewis, 1905, p. 361–362). Corundum mining in the United States ceased in 1905 but was reactivated briefly during World War I (1917–19), and again during World War II (1943–44) (French and Eilertsen, 1968, p. 263). Total production figures are not available, but the mines in the Greenville quadrangle (table 2) probably produced only a little more than 3,000 tons of cleaned corundum. The largest production was 3,000 tons from the Laurel Creek or Lucas mine in Rabun County (table 2, No. R1), which is followed by several tons from the Track Rock mine in Union County (table 2, No. U1), and a few tons from the Hog Creek mine in Towns County (table 2, No. T2).

Because most of the abrasive needs in the Nation are now supplied by artificial materials, there is little or no commercial demand for corundum. Continued ruby and sapphire collecting by mineral collectors and tourists can be anticipated. The Young Harris and the northern parts of the Helen and Tallulah Falls thrust sheets have a moderate to high potential for additional corundum resources (fig. 9). The isolated corundum occurrences in the Six Mile, Laurens, and Charlotte thrust sheets in South Carolina (McCauley and McCauley, 1964, p. 5) are too poorly known to be evaluated as potential resources.

Nickel

Dunite deposits in the Blue Ridge thrust stack contain 0.1 to 0.4 percent nickel, mostly in olivine (Ross and others, 1928, p. 545). During weathering, this nickel is released and forms the hydrous nickel silicate minerals collectively called garnierite. Nickel silicates tend to migrate through the soil and saprolite and concentrate near the base of the saprolite or weathered material. A minor occurrence of nickel of this type was prospected near the Hog Creek corundum mine in 1890 (table 2, No. T2), but the results were discouraging and the prospect abandoned (Ballard, 1946, p. 2). Concentrations of nickel in mafic and ultramafic rocks collected in the quadrangle during our studies range from 4 to 4,000 parts per million (ppm) (table 3). Four samples of soil and rock from the gabbro of the Mount Carmel Complex (fig. 5) contain from 790 to 3,940 ppm Ni (Worthington, 1964, p. 106).

Worthington (1964) made a geochemical survey of ultramafic rocks in the Blue Ridge province looking for areas that might have lateritic nickel ore similar to deposits in Cuba. Worthington's (1964) minimum target for development was 1 mi^2 of nickeliferous ultramafic rock overlain by at least 25 ft of lateritic soil that has a nickel content averaging more than 1 percent, which would contain 25 million tons of usable material. Estimates of the nickel resources at Webster, N.C., are 2.5 million tons of soil and saprolite containing 1 percent nickel (Stuckey, 1965, p. 329), well below the minimum requirement. Because the Webster deposit is one of the larger known in the Blue Ridge, the potential for economic nickel deposits is nil. Even if larger dunite deposits are found that are unexposed or not fully exposed, the only possibility for nickel deposits is in deeply weathered material or in partly weathered and fractured bedrock just below deeply weathered rock. The less surface area that is available for weathering, the smaller the potential deposit will be. The Young Harris thrust sheet, which is composed largely of mafic and ultramafic rock, has the largest known exposed surface area of dunite in the quadrangle and has a low potential for nickel resources. Further prospecting might be done using the geophysical methods used to study the shape and size of known dunite bodies in the Blue Ridge province of North Carolina (Honeycutt and others, 1981; Hirt and others, 1987) and the geobotanical prospecting methods that have been used to locate nickeliferous areas (Milton and Purdy, 1988).

Olivine

Olivine, for use in refractories, foundry sand, and even sand blasting, has been produced for many years from several of the dunite bodies in the Blue Ridge province of North Carolina. Resources of olivine in two dunite bodies in Rabun County, Ga. (table 2, Nos. R1 and R16), total more than 8 million tons of relatively unaltered olivine (Hunter, 1941, p. 116; Chatman, 1985). The potentially larger dunite bodies in the Young Harris thrust sheet have not been sampled adequately to determine whether the rock is suitable as a source of olivine. Resources of olivine in the adjoining Knoxville 1° × 2° quadrangle north of the Greenville quadrangle are nearly 100 times greater (Hunter, 1941).

The Young Harris thrust sheet has a high potential for additional dunite bodies. The northern parts of the Helen and Tallulah Falls thrust sheets have a moderate potential for additional dunite bodies; the northern part of the Richard Russell thrust sheet has a low potential for dunite bodies (fig. 9). There is little potential for dunite bodies in the other thrust sheets.

Platinum-Group Elements (PGE's)

To help assess the PGE potential of the area, 182 mafic (MgO <16 weight percent) and 51 ultramafic (MgO >16 weight percent) rock samples were analyzed for palladium (Pd) and platinum (Pt) (table 3). The Pd and Pt contents of the samples were determined by graphite-furnace atomic-absorption spectrometry after preconcentration by classic fire assay using lead collection as described by Aruscavage and others (1984). An estimate of the precision of this technique was given by Gottfried and Froelich (1988), who concluded that for concentrations of Pd and Pt greater than 5 parts per billion (ppb) differences of about 20 percent were geochemically significant. At concentrations from 0.5 to 2 ppb, the relative deviations are on the order of 50 to 100 percent. A summary of the analytical results is given in table 4.

Economic deposits of PGE's have not been found in the Greenville quadrangle. A few grains of native platinum have been reported in 17 stream-sediment samples from Habersham and White Counties, Ga., in streams that drain parts of the Richard Russell, Helen, Tallulah Falls, and Six Mile thrust sheets (Hurst and Crawford, 1964, p. 17; Hurst and Otwell, 1964, p. 14), but PGE's were not detected geochemically in resampling of many of these reported occurrences during our studies. Whole-rock analyses of samples of dunite, amphibolite, gabbro, and metapyroxenite from the quadrangle show uniformly low values for Pt and Pd (table 3). The higher values are mostly in metapyroxenite, but are still 1 or 2 orders of magnitude lower than minimum ore grade, which is currently about 2 ppm. On the basis of these analyses and the lack of layered or concentric mafic–ultramafic intrusive complexes, which are generally the source of most PGE deposits (Page and others, 1973), the ultramafic rocks of the quadrangle have little potential for PGE deposits.

Pyrite–Pyrrhotite

Massive sulfide deposits closely related to mafic igneous rocks are a type of volcanogenic deposit that has recently received much study (Fox, 1984; Lydon, 1984, 1988). Several massive sulfide deposits composed mostly of pyrite–pyrrhotite and spatially related to amphibolite have been mined or prospected in the Greenville quadrangle, the largest of which are the Chestatee mine (table 2, No. L6), the Tom Coward prospect (No. R15), and the Saluda mine (No. A1). These deposits are probably the so-called Besshi type of volcanogenic massive sulfide deposit, which is a tabular, stratiform body formed subaqueously in a thick sequence of continentally derived clastic sediments that generally encloses oceanic or interplate mafic volcanic rocks (Fox, 1984, p. 57). The largest of the three deposits is the Chestatee mine in the Helen thrust sheet (Shearer and Hull, 1918, p. 182–198). This deposit is a tabular mass of pyrite and minor amounts of chalcopyrite that ranges from 4.5 to 40 ft in thickness, is as much as 3,500 ft long, and has been explored to a depth of 200 ft. This ore body lies between amphibolite on the footwall and quartzitic mica schist on the hanging wall. The Tom Coward prospect, a similar but much smaller deposit, was prospected in the Richard Russell thrust sheet (Shearer and Hull, 1918, p. 205–206; Peper and others, 1991).

The Saluda mine, in Abbeville County, S.C., is in a series of interlayered amphibolite, siliceous mica schist, marble, and banded quartz-magnetite rock in the Laurens thrust sheet (Bynum, 1982, p. 61). The sulfide minerals are in several thin layers or lenses, 0.5 to 9 ft thick, which contain as much as 70 percent pyrrhotite, 5 percent pyrite, and 15 percent chalcopyrite (Bynum, 1982, p. 61). Some layers of amphibolite and mica schist contain disseminated sulfides. The Tennessee Copper Co. and its successors drilled 28 drill holes at the Saluda mine between 1928 and 1967, before abandoning the area and donating some of the drill core to Furman University, Greenville, S.C. The drilling covered an area 2,000 ft by 4,500 ft. The sulfide-bearing zone ranges from 1 to 60 ft thick and dips 20° to 30° to the southeast. Weighted averages of analyses of sulfide-rich layers in the core are 21 percent Fe, 1.1 percent Cu, 0.5 percent Zn, 0.007 oz/ton Au, and 0.4 oz/ton Ag (Henry Bell, III, USGS, written commun., 1989). The mineralized zone is too thin and low grade to be mined at current metal prices.

A related type of massive sulfide occurrence is disseminated pyrite in amphibolite, which is found in a belt of mafic rock that has been prospected in several places in Hall and Banks Counties, Ga. (table 2, Nos. HL2 and B1). The belt, located in the Chauga–Walhalla thrust complex, is about 7 mi long and as much as 1 mi wide (Shearer and Hull, 1918, p. 202–204). Much of the rock in the belt contains disseminated pyrite, and some layers contain as much as 10 to 25 percent pyrite. This belt is a large, low-grade sulfide resource.

Assessment of the potential for massive sulfide deposits in the various thrust sheets is difficult because there are so few known deposits and these known deposits have ambiguous geochemical signatures. Iron is the principal metallic element, and only minor amounts of base metals are present. The three known deposits appear to be related to the presence of amphibolite interlayered with felsic gneiss and schist.

We propose a moderate potential for massive sulfide deposits for the Helen thrust sheet on the basis of the presence of the Chestatee deposit and the widespread distribution of amphibolite similar to that which forms the footwall of the Chestatee deposit (fig. 9). Much of the Richard Russell thrust sheet has little potential for massive sulfide deposits because of the small amount of amphibolite present. The potential increases somewhat from the area of the Tom Coward prospect toward the northeast because of the increase in interlayered amphibolite in the gneiss and schist (fig. 9). The Tallulah Falls thrust sheet also has little potential for volcanogenic massive sulfide deposits. Although amphibolite is a common rock type in this thrust sheet, there are no reported occurrences of massive sulfides. The Chauga–Walhalla thrust complex may have a moderate potential on the basis of widespread and locally abundant amphibolite and on the presence of disseminated pyrite in amphibolite. The Six Mile and Paris Mountain thrust sheets contain some amphibolite but no known sulfide deposits and probably have little potential. The Laurens thrust sheet contains the Saluda mine deposit and favorable host rocks. It has a moderate potential for additional deposits. The mafic–ultramafic and Charlotte thrust sheets have a variety of mafic rock types but no known sulfide deposits and have, therefore, little potential.

Soapstone

Soapstone was probably one of the earliest used rock types in the Greenville quadrangle. Small, impure soapstone deposits were the source for soapstone vessels commonly used by Late Archaic to Early Woodland cultures, 2000 to 500 B.C. (Coe, 1964). European pioneers in the 18th century used the same rocks as sources of easily cut dimension stone for making door lintels and sills, tombstones, and fireplace hearths. Minor use in this manner has continued into the present; the deposits are too small or too impure except for local use.

Titanium

The gabbro of the Mount Carmel Complex (Medlin, 1968), Abbeville and McCormick Counties, S.C., contains from 2 to almost 9 percent TiO_2 (table 3) and would be a low-grade titanium resource if it contained minerals from which titanium could be extracted. The titanium, however, is present mostly in titanaugite and in titaniferous magnetite (Medlin, 1968, p. 136–151), neither of which can be used economically as a source of titanium. Although the whole rock is too low grade to be of interest, saprolite developed on the rock might be enriched locally in titanium. Analyses of soil samples from four soil profiles (fig. 5) on the weathered gabbro, however, do not show the expected enrichment in titanium and offer little hope for any resource potential. Heavy-mineral concentrates taken from the soil samples contain from 2.2 to 9.7 percent TiO_2, and the fresh rock nearby contains from 3.2 to 6.2 percent TiO_2 (G.C. Curtin, USGS, unpub. data, 1992). Streams draining the outcrop area of the gabbro are rich in black sands, which contain ilmenite, but still have a relatively low TiO_2 content of 2 to 3 weight percent in the heavy-mineral concentrate (G.C. Curtin, USGS, unpub. data, 1992). Unweathered ilmenite contains various amounts of iron, which makes it less desirable as a commercial source of titanium than thoroughly weathered ilmenite or leucoxene, which contains little iron (Klemic and others, 1973). Williams (1967) estimated that more than 150,000 tons of ilmenite reserves are present in four placer deposits within the Greenville quadrangle in Anderson and Laurens Counties, S.C. The heavy-mineral placer deposits outlined in the South Carolina part of the Greenville quadrangle by Overstreet and others (1968), Caldwell and White (1973), and Cuppels and White (1973) represent a large but low-grade titanium resource (Lesure and others, in press).

Vermiculite

Vermiculite, a micaceous mineral produced by the weathering of biotite, chlorite, and phlogopite, is used to make light-weight aggregate, soil conditioners, insulation, and mineral filler (Bush, 1976). Two different types of vermiculite deposits are present in the Greenville quadrangle: the Blue Ridge type and the Piedmont type (Hunter, 1950). In the Blue Ridge type, vermiculite deposits are found along the serpentinized contacts of the ultramafic bodies and enclosing country rock and along fractures within the ultramafic body where intruded by granite and pegmatite (Murdock and Hunter, 1946, p. 9; Hunter, 1950; Bush and Sweeney, 1968, p. 222; Bush, 1976, p. 148–152). These deposits are generally small and discontinuous and are more abundant in the North Carolina part of the Blue Ridge province north of the Greenville quadrangle than in the Georgia and South Carolina parts of the Blue Ridge. They range in thickness from less than 1 ft to as much as 20 ft and in length from less than 50 ft to as much as 1,000 ft. At most, they contain only a few thousand tons of material and are generally worked by pick and shovel in narrow trenches or small open cuts.

There has been little production of vermiculite from the Blue Ridge type of deposit in the Greenville quadrangle. Two deposits have been prospected (Prindle and others, 1935, p. 44–46) in the Richard Russell thrust sheet (table 2, Nos. T5 and T6), and, in the Tallulah Falls thrust sheet, the Hicks mine (table 2, No. R2) produced about 10 tons of vermiculite in 1946. Annual production from the small Blue Ridge-type deposits in North Carolina was probably a few thousand tons between 1946 and 1955 (Bush and Sweeney, 1968, p. 224), and total production was probably about 25,000 tons. The deposits in the quadrangle in the Richard Russell, Helen, and Tallulah Falls thrust sheets have little potential for economic development.

In contrast, the Piedmont-type deposit is a product of deep weathering of a large lenticular mass of biotite-rich schist or biotite covering a few to many acres. These deposits may have developed by metamorphic or metasomatic alteration of pyroxenite or other mafic rock by granitic or syenitic intrusions (Bush, 1976, p. 152–153) or by metamorphism of potassium-rich ultramafic rocks related to a type of igneous rock called lamproite (Libby, 1975; Bergman, 1987; Butler, 1989). One deposit of this type was mined at Tigerville, Greenville County, S.C., 4.5 mi north of the Greenville quadrangle, and several are being mined in Laurens and Spartanburg Counties, S.C., east of the Greenville quadrangle. Three small deposits of this type have been prospected just south of Laurens along the east edge of the Greenville quadrangle (table 2, Nos. La1 and La2), and several other deposits are reported in the Laurens thrust sheet north of Laurens (McClure, 1963). This type of deposit, which can contain 20,000 to 100,000 or more tons of ore (Bush, 1976, p. 153), is mined in large open cuts using large earth-moving equipment.

Production of vermiculite from the Piedmont-type deposits is much larger than that from the Blue Ridge type. Greenville County, S.C., has a recorded production of nearly 20,000 tons of vermiculite for 3 years between 1956 and 1969, most of which must have come from Tigerville, S.C. Laurens County, S.C., had a recorded production of more than 1.5 million tons from 1959–77 and Spartanburg County, a production of nearly 4,000 tons from 1959–62. All of this production is from an area 10 mi by 40 mi that is 2 to 8 mi east of the Greenville quadrangle. Resources of the Piedmont-type deposits in the Spartanburg 1° × 2° quadrangle east of the Greenville quadrangle are large. Several deposits are known to have been prospected in the Greenville quadrangle, and there is a moderate to high potential for additional resources in this type of deposit in the Greenville quadrangle, mostly in the Laurens thrust sheet (fig. 8). Recent studies show the usefulness of geochemical prospecting methods in the search for additional vermiculite deposits of this type (Maybin and Carpenter, 1990).

Some lamproites contain diamonds. The biotite of Laurens and Spartanburg Counties, S.C., has whole-rock chemistry that falls within the range of the diamond-bearing lamproites (Bergman, 1987, p. 118–120). Only one diamond has been reported from South Carolina (Kunz, 1885, p. 730), but interestingly this find has been tentatively located in Spartanburg County (McCauley, 1964, p. 22) possibly downstream from the area of the Tigerville vermiculite deposit, which is probably similar to the deposits of Laurens and Spartanburg Counties.

REFERENCES CITED

Abbott, R.N., Jr., and Raymond, L.A., 1984, The Ashe metamorphic suite, northwest North Carolina; Metamorphism and observations on geologic history: American Journal of Science, v. 284, nos. 4–5, p. 350–375.

Aruscavage, P.J., Simon, F.O., and Moore, R., 1984, Flameless atomic absorption determination of platinum, palladium, and rhodium in geologic materials: Geostandards Newsletter, v. 8, no. 1, p. 36.

Ballard, T.J., 1946, Exploration of the Hog Creek corundum mine, Towns County, Georgia: U.S. Bureau of Mines Report of Investigations 3855, 3 p.

———1948, Investigation of Track Rock corundum mine, Union County, Georgia: U.S. Bureau of Mines Report of Investigations 4309, 5 p.

Bergman, S.C., 1987, Lamproites and other potassium-rich igneous rocks: a review of their occurrence, mineralogy and geochemistry, *in* Fitton, J.G., and Upton, B.J., eds., Alkaline igneous rocks: Geological Society [of London] Special Publication 30, p. 103–190.

Bowles, Oliver, 1955, The asbestos industry: U.S. Bureau of Mines Bulletin 552, 122 p.

Bryan, J.G, and Griffin, V.S., Jr., 1981, Ultramafic bodies in the Piedmont of northwestern South Carolina: South Carolina Geology, v. 25, no. 2, p. 69–78.

Bush, A.L., 1976, Vermiculite in the United States, *in* Forum on the geology of industrial minerals, 11th, Proceedings: Montana Bureau of Mines and Geology Special Publication 74, p. 145–155.

Bush, A.L., and Sweeney, J.W., 1968, Lightweight aggregates, *in* Mineral resources of the Appalachian region: U.S. Geological Survey Professional Paper 580, p. 210–224.

Butler, J.R., 1989, Review and classification of ultramafic bodies in the Piedmont of the Carolinas, *in* Mittwede, S.K., and Stoddard, E.F., eds., Ultramafic rocks of the Appalachian Pied-

mont: Geological Society of America Special Paper 231, p. 19–31.
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.
Bynum, F.J., Jr., 1982, The geology of the south one-half of the Ware Shoals West quadrangle, S.C.: Athens, University of Georgia, M.S. thesis, 81 p.
Caldwell, D.W., and White, A.M., 1973, Fluvial monazite deposits in the drainage basins of the Savannah and Saluda Rivers, South Carolina: South Carolina Division of Geology Mineral Resource Series no. 2, 75 p.
Carpenter, J.R., and Phyfer, D.W., 1975, Olivine compositions from southern Appalachian ultramafics: Southeastern Geology, v. 16, no. 3, p. 169–172.
Chatman, M.L., 1985, Maps showing mines, prospects, and mineral sites in the Tray Mountain Roadless Area and vicinity, northern Georgia: U.S. Geological Survey Miscellaneous Field Studies Map MF–1347–C, scale 1:30,000.
Clifton, R.A., 1985, Asbestos, *in* Mineral facts and problems (1985 ed.): U.S. Bureau of Mines Bulletin 675, p. 53–64.
Coe, J.L., 1964, The formative cultures of the Carolina Piedmont: Transactions of the American Philosophical Society, new ser., v. 54, pt. 5, 130 p.
Conrad, S.G., Wilson, W.F., Allen, E.P., and Wright, T.J., 1963, Anthophyllite asbestos in North Carolina: North Carolina Division of Mineral Resources Bulletin 77, 61 p.
Cook, F.A., Albaugh, D.S., Brown, L.D., Kaufman, Sidney, Oliver, J.E., and Hatcher, R.D., Jr., 1979, 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.
Cook, R.B., 1978, Minerals of Georgia, their properties and occurrences: Georgia Department of Natural Resources, Geologic and Water Resources Division Bulletin 92, 189 p.
Cook, R.B., Jr., and Burnell, J.R., Jr., 1986, The trace metal signature of some major lithologic units, Dahlonega district, Lumpkin County, Georgia, *in* Misra, K.C., ed., Volcanogenic sulfide and precious metal mineralization in the southern Appalachians: Knoxville, University of Tennessee Studies in Geology 16, p. 206–219.
Cuppels, N.P., and White, A.M., 1973, Fluvial monazite deposits in the drainage basins of the Enoree, Tyger, and Pacolet Rivers, South Carolina: South Carolina Division of Geology Mineral Resource Series no. 1, 74 p.
Fenneman, N.M., and Johnson, D.W., 1946, Physical divisions of the United States: U.S. Geological Survey, scale 1:7,000,000.
Fox, J.S., 1984, Besshi-type volcanogenic sulphide deposits—A review: CIM (Canadian Institute of Mining and Metallurgy) Bulletin, v. 77, no. 864, p. 57–68.
French, A.E., and Eilertsen, N.A., 1968, Abrasives, *in* Mineral resources of the Appalachian region: U.S. Geological Survey Professional Paper 580, p. 261–268.
Fullagar, P.D., and Butler, J.R., 1979, 325 to 265 m.y.-old granitic plutons in the Piedmont of the southeastern Appalachians: American Journal of Science, v. 279, no. 2, p. 161–185.
Gazdik, G.C., 1985, Map showing mines, prospects, and mineral sites in the Ellicott Rock Wilderness and additions, South Carolina, North Carolina, and Georgia: U.S. Geological Survey Miscellaneous Field Studies Map MF–1287–E, scale 1:48,000.
Georgia Department of Mines, Mining, and Geology, 1951, Mineral resources of Union, Towns, Lumpkin, and White Counties, Georgia: Georgia Department of Mines, Mining, and Geology, scale 1:125,000.
Gillon, K.A., 1982, Stratigraphic, structural, and metamorphic geology of portions of the Cowrock and Helen, Georgia, 7 1/2′ quadrangles: Athens, University of Georgia, M.S. thesis, 236 p.
Gottfried, David, and Froelich, A.J., 1988, Variations of palladium and platinum contents and ratios in selected early Mesozoic tholeiitic rock associations in the eastern United States, *in* Froelich, A.J., and Robinson, G.R., Jr., eds., Studies of the early Mesozoic basins of the eastern United States: U.S. Geological Survey Bulletin 1776, p. 332–341.
Griffin, V.S., Jr., 1969, Migmatitic Inner Piedmont belt of northwestern South Carolina: South Carolina Division of Geology Geologic Notes, v. 13, no. 4, p. 87–104.
———1970, A probable pre-Triassic mafic intrusive in the Anderson 15-minute quadrangle, South Carolina: South Carolina Division of Geology Geologic Notes, v. 14, no. 4, p. 97–104.
———1974, Analysis of the Piedmont in northwest South Carolina: Geological Society of America Bulletin, v. 85, no. 7, p. 1123–1138.
Harris, L.D., Harris, A.G., de Witt, Wallace, Jr., and Bayer, K.C., 1981, Evaluation of southern eastern overthrust belt beneath Blue Ridge–Piedmont thrust: American Association of Petroleum Geologists Bulletin, v. 65, no. 12, p. 2497–2505.
Hartley, M.E., III, 1973, Ultramafic and related rocks in the vicinity of Lake Chatuga: Georgia Geological Survey Bulletin 85, 61 p.
Hatcher, R.D., Jr., 1970, Geology of the Long Creek Soapstone body, Oconee County, South Carolina: South Carolina Division of Geology Geologic Notes, v. 14, no. 2, p. 49–55.
———1971, The geology of Rabun and Habersham Counties, Georgia: Georgia Geological Survey Bulletin 83, 48 p.
———1972, Developmental model for the southern Appalachians: Geological Society of America Bulletin, v. 83, no. 9, p. 2735–2760.
Hatcher, R.D., Jr., Hooper, R.J., Petty, S.M., and Willis, J.D., 1984, Structure and chemical petrology of three southern Appalachian mafic–ultramafic complexes and their bearing upon the tectonics of emplacement and origin of Appalachian ultramafic bodies: American Journal of Science, v. 284, nos. 4–5, p. 484–506.
Higgins, M.W., Crawford, R.F., III, Atkins, R.L., and Crawford, T.J., 1989, The Macon complex; An ancient accretionary complex in the southern Appalachians, *in* Horton, J.W., Jr., and Rast, Nicholas, eds., Melanges and olistostromes of the U.S. Appalachians: Geological Society of America Special Paper 228, p. 229–246.
Hirt, S.M., Heimlich, R.A., and Palmer, D.F., 1987, Geophysical study of a small ultramafic body near Newfound Gap, Buncombe County, North Carolina: Southeastern Geology, v. 27, no. 4, p. 229–244.
Honeycutt, F.M., Heimlich, R.A., and Palmer, D.F., 1981, Magnetic survey of the Balsam Gap dunite, Jackson County, North Carolina: Southeastern Geology, v. 22, no. 4, p. 223–231.
Hopkins, O.B., 1914, A report on the asbestos, talc, and soapstone deposits of Georgia: Georgia Geological Survey Bulletin 29, 319 p.

Hunter, C.E., 1938, Chromite in western North Carolina and north Georgia: Tennessee Valley Authority Water Control Planning Department Geologic Bulletin 10, p. 18–20.
———1941, Forsterite olivine deposits of North Carolina and Georgia: North Carolina Division of Mineral Resources Bulletin 41, 117 p.
———1950, Vermiculite of the Southeastern States, *in* Snyder, F.G., ed., Symposium on mineral resources of the Southeastern United States: Knoxville, Tennessee University Press, p. 120–127.
Hunter, C.E., Murdock, T.G., and MacCarthy, G.R., 1942, Chromite deposits of North Carolina: North Carolina Division of Mineral Resources Bulletin 42, 39 p.
Hurst, V.J., and Crawford, T.J., 1964, Exploration of mineral deposits in Habersham County, Georgia: Washington, D.C., U.S. Department of Commerce Area Redevelopment Administration, 180 p.
Hurst, V.J., and Otwell, W.L., 1964, Exploration of mineral deposits in White County, Georgia: Washington, D.C., U.S. Department of Commerce Area Redevelopment Administration, 166 p.
King, F.P., 1894, A preliminary report on the corundum deposits of Georgia: Georgia Geological Survey Bulletin 2, 137 p.
King, P.B., 1955, A geologic section across the southern Appalachians: An outline of the geology in the segment in Tennessee, North Carolina, and South Carolina, *in* Russell, R.J., ed., Guides to southeastern geology: Geological Society of America, Annual Meeting, Field Trip Guidebook, p. 332–373.
Klemic, Harry, Marsh, S.P., and Cooper, Margaret, 1973, Titanium, *in* Brobst, D.A., and Pratt, W.P., eds., United States mineral resources: U.S. Geological Survey Professional Paper 820, p. 653–665.
Kline, M.H., and Beck, W.A., 1949, Investigation of Chestatee copper and pyrite deposit, Lumpkin County, Ga.: U.S. Bureau of Mines Report of Investigations 4397, 12 p.
Kunz, G.F., 1885, Precious stones, *in* Mineral resources of the United States, 1883 and 1884: U.S. Geological Survey, p. 723–782.
Larrabee, D.M., 1966, Map showing distribution of ultramafic and intrusive mafic rocks from northern New Jersey to eastern Alabama: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–476, scale 1:500,000.
Lesure, F.G., Curtin, G.C., Daniels, D.L., and Jackson, J.C., in press, Mineral resource assessment of rare-earth elements, thorium, titanium, and uranium in the Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina: U.S. Geological Survey Miscellaneous Field Studies Map MF–2198–E, scale 1:250,000.
Lewis, J.V., 1922, Deposits of chrome ore in North Carolina: U.S. Geological Survey Bulletin 725–B, p. 101–139.
Libby, S.C., 1975, The origin of potassic ultramafic rocks in the Enoree "Vermiculite" district, South Carolina: University Park, Pennsylvania State University, Ph.D. dissertation, 117 p.
Lipin, B.R., 1983, Low-grade chromium resources, *in* Shanks, W.C., III, ed., Cameron volume on unconventional mineral deposits: New York, Society of Mining Engineers, p. 47–60.
———1984, Chromite from the Blue Ridge province of North Carolina: American Journal of Science, v. 284, nos. 4–5, p. 507–529.
Lydon, J.W., 1984, Ore deposit models—8. Volcanogenic massive sulphide deposits, pt. 1: A descriptive model: Geoscience Canada, v. 11, no. 4, p. 195–202.
———1988, Ore deposit models—14. Volcanogenic massive sulphide deposits, pt. 2: Genetic models: Geoscience Canada, v. 15, no. 1, p. 43–65.
Maybin, A.H., III, and Carpenter, R.H., 1990, Geochemistry: A new approach for vermiculite exploration in South Carolina, *in* Zupan, A.W., and Maybin, A.H., III, eds., Forum on the geology of industrial minerals, 24th, Greenville, S.C., May 2–5, 1988, Proceedings: South Carolina Geological Survey, p. 57–69.
McCallie, S.W., 1926, A preliminary report on the mineral resources of Georgia; revised edition: Georgia Geological Survey Bulletin 23, 164 p.
McCauley, C.K., 1964, Gem stone resources of South Carolina: South Carolina Division of Geology Bulletin 30, 34 p.
McCauley, C.K., and McCauley, J.F., 1964, Corundum resources of South Carolina: South Carolina Division of Geology Bulletin 29, 9 p.
McClure, W.C., 1963, Geology of the Enoree area, South Carolina: Columbia, University of South Carolina, M.S. thesis, 39 p.
McElhaney, M.S., and McSween, H.Y., Jr., 1983, Petrology of the Chunky Gal Mountain mafic–ultramafic complex, North Carolina: Geological Society of America Bulletin, v. 94, no. 7, p. 855–874.
McSween, H.Y., Jr., 1970, Petrology of Charlotte and Kings Mountain Belt rocks in northern Greenwood County, South Carolina: South Carolina Division of Geology Geologic Notes, v. 14, no. 3, p. 57–84.
Medlin, J.H., 1968, Comparative petrology of two igneous complexes in the South Carolina Piedmont: University Park, Pennsylvania State University, Ph.D. dissertation, 328 p.
Medlin, J.H., Thornton, C.P., and Gold, D.P., 1972, Petrology of the mafic igneous complexes in the southeastern U.S. Piedmont: II. The Buffalo mafic igneous complex, Union County, South Carolina: Southeastern Geology, v. 14, no. 2, p. 73–106.
Milton, N.M., and Purdy, T.L., 1988, Response of selected plant species to nickel in western North Carolina: Castanea, v. 53, no. 3, p. 207–214.
Misra, K.C., and Keller, F.B., 1978, Ultramafic bodies in the southern Appalachians; A review: American Journal of Science, v. 278, nos. 4–5, p. 389–418.
Misra, K.C., and McSween, H.Y., Jr., 1984, Mafic rocks of the southern Appalachians; A review: American Journal of Science, v. 284, nos. 4–5, p. 294–318.
Mittwede, S.K., and Zupan A.W., 1985, The Soapstone Hill ultramafic body, Oconee County, South Carolina: Southeastern Geology, v. 25, no. 4, p. 241–248.
Murdock, T.G., and Hunter, C.E., 1946, The vermiculite deposits of North Carolina: North Carolina Department of Conservation and Development Bulletin 50, 44 p.
Nelson, A.E., 1988, Stacked crystalline thrust sheets and episodes of regional metamorphism in northeastern Georgia and northwestern South Carolina—A reinterpretation: U.S. Geological Survey Bulletin 1822, 16 p.
———1991, Geologic map of the Campbell Mountain quadrangle, Lumpkin County, Georgia: U.S. Geological Survey Miscellaneous Field Studies Map MF–2148, scale 1:24,000.

Nelson, A.E., and Gillon, K.A., 1985, Stratigraphic nomenclature in the Richard Russell and Helen thrust sheets, Georgia and North Carolina, *in* Stratigraphic notes, 1984: U.S. Geological Survey Bulletin 1605–A, p. A59–A62.

Nelson, A.E., Horton, J.W., Jr., and Clarke, J.W., 1987, Generalized tectonic map of the Greenville 1° × 2° quadrangle, Georgia, South Carolina, and North Carolina: U.S. Geological Survey Miscellaneous Field Studies Map MF–1898, scale 1:250,000.

———1989, Geologic map of the Greenville 1° × 2° quadrangle, Georgia, South Carolina, and North Carolina: U.S. Geological Survey Open-File Report 89–9, scale 1:250,000, 11 p.

Nelson, A.E., Horton, J.W., Jr., Lesure, F.G., Bell, Henry, III, and Curtin, G.C., 1990, Thrust sheets and mineral resources in the Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina, *in* Zupan, A.W., and Maybin, A.H., III, eds., Forum on the geology of industrial minerals, 24th, Greenville, S.C., May 2–5, 1988, Proceedings: South Carolina Geological Survey, p. 83–93.

Overstreet, W.C., and Bell, Henry, III, 1965a, The crystalline rocks of South Carolina: U.S. Geological Survey Bulletin 1183, 126 p.

———1965b, Geologic map of the crystalline rocks of South Carolina: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–413, scale 1:250,000.

Overstreet, W.C., White, A.M., Whitlow, J.W., Theobald, P.K., Jr., Caldwell, D.W., and Cuppels, N.P., 1968, Fluvial monazite deposits in the southeastern United States, *with a section on* Mineral analyses, by Jerome Stone: U.S. Geological Survey Professional Paper 568, 85 p.

Page, N.J, Clark, A.L., Desborough, G.A., and Parker, R.L., 1973, Platinum-group metals, *in* Brobst, D.A., and Pratt, W.P., eds., United States mineral resources: U.S. Geological Survey Professional Paper 820, p. 537–545.

Peper, J.D., Lesure, F.G., Cox, L.J., and D'Agostino, J.P., 1991, Geology, geochemistry, and mineral resource assessment of Southern Nantahala Wilderness and adjacent roadless areas, Rabun and Towns Counties, Georgia, and Clay and Macon Counties, North Carolina: U.S. Geological Survey Bulletin 1883, 30 p.

Petty, S.M., 1982, The geology of the Laurel Creek mafic–ultramafic complex in northeast Georgia: Intrusive complex or ophiolite?: Tallahassee, Florida State University, M.S. thesis, 147 p.

Pratt, J.H., and Lewis, J.V., 1905, Corundum and the peridotites of western North Carolina: North Carolina Geological Survey Report, v. 1, 464 p.

Prindle, L.M., and others, 1935, Kyanite and vermiculite deposits of Georgia: Georgia Geological Survey Bulletin 46, 50 p.

Robinson, G.R., Jr., Lesure, F.G., Marlowe, J.I., II, Foley, N.K., and Clark, S.H., 1992, Bedrock geology and mineral resources of the Knoxville 1° × 2° quadrangle, Tennessee, North Carolina, and South Carolina: U.S. Geological Survey Bulletin 1979, 2 pls., scale 1:250,000, 73 p.

Rodgers, John, 1970, The tectonics of the Appalachians: New York, John Wiley and Sons, 271 p.

Roper, P.J., and Dunn, D.E., 1970, Geology of the Tamassee, Satolah, and Cashiers quadrangles, Oconee County, South Carolina: South Carolina Division of Geology Map Series MS–16, scale 1:24,000.

Ross, C.R., II, and Bickford, M.E., 1980, The U-Pb age of zircons from the Elberton Granite, Piedmont of Georgia, *in* Stormer, J.C., Jr., and Whitney, J.A., eds., Geological, geochemical, and geophysical studies of the Elberton batholith, eastern Georgia: Georgia Geologic Survey Guidebook 19, p. 52–62.

Ross, C.S., Shannon, E.V., and Gonyer, F.A., 1928, The origin of nickel silicates at Webster, North Carolina: Economic Geology, v. 23, no. 5, p. 528–552.

Shapiro, Leonard, 1975, Rapid analysis of silicate, carbonate, and phosphate rocks—Revised edition: U.S. Geological Survey Bulletin 1401, 76 p.

Shaw, H.F., and Wasserburg, G.J., 1984, Isotopic constraints on the origin of Appalachian mafic complexes: American Journal of Science, v. 284, nos. 4–5, p. 319–349.

Shearer, H.K., and Hull, J.P.D., 1918, A preliminary report on a part of the pyrites deposits of Georgia: Georgia Geological Survey Bulletin 33, 229 p.

Shride, A.F., 1973, Asbestos, *in* Brobst, D.A., and Pratt, W.P., eds., United States mineral resources: U.S. Geological Survey Professional Paper 820, p. 63–73.

Sloan, Earle, 1908, A catalogue of the mineral localities of South Carolina: South Carolina Geological Survey, ser. 4, Bulletin 2, 505 p. [Reprinted 1958 by South Carolina Division of Geology.]

Stuckey, J.L., 1965, North Carolina: Its geology and mineral resources: Raleigh, North Carolina Department of Conservation and Development, 550 p.

Teague, K.H., 1956, Georgia [asbestos] occurrences described: Georgia Mineral Newsletter, v. 4, no. 1, p. 4–7.

Teague, K.H., and Furcron, A.S., 1948, Geology and mineral resources of Rabun and Habersham Counties, Georgia: Georgia Department of Mines, Mining, and Geology, scale 1:125,000.

U.S. Bureau of Mines, 1927–34, Mineral resources of the United States [1924–31]: Washington, D.C., U.S. Government Printing Office. [Annual publication.]

———1933–88, Minerals yearbook [1932–86]: Washington, D.C., U.S. Government Printing Office. [Annual publication.]

U.S. Geological Survey, 1883–1927, Mineral resources of the United States [1882–1923]: Washington, D.C., U.S. Government Printing Office. [Annual publication.]

Warner, R.D., Griffin, V.S., Jr., Hoover, R.C., Bryan, J.G., Poe, S.H., and Steiner, J.C., 1986, Mineralogy of ultramafic chlorite-amphibole schists, Inner Piedmont belt, South Carolina: Southeastern Geology, v. 27, no. 2, p. 107–120.

Warner, R.D., Griffin, V.S., Steiner, J.C., Schmitt, R.A., and Bryan, J.G., 1989, Ultramafic chlorite-tremolite-olivine schists: Three bodies from the Inner Piedmont belt, South Carolina, *in* Mittwede, S.K., and Stoddard, E.F., eds., Ultramafic rocks of the Appalachian Piedmont: Geological Society of America Special Paper 231, p. 63–74.

Whitney, J.A., Hess, J.R., and Mose, Douglas, 1980, Geochronology and cooling history of the Elberton Granite, *in* Stormer, J.C., Jr., and Whitney, J.A., eds., Geological, geochemical, and geophysical studies of the Elberton batholith, eastern Georgia: Georgia Geologic Survey Guidebook 19, p. 63–79.

Williams, Lloyd, 1967, Heavy minerals in South Carolina: South Carolina Division of Geology Bulletin 35, 35 p.

Worthington, J.E., 1964, An exploration program for nickel in the southeastern United States: Economic Geology, v. 59, no. 1, p. 97–109.

TABLES 1–4

Table 1.—Production of mineral commodities related to mafic and ultramafic rocks in or near the Greenville 1° × 2° quadrangle by counties

[Commodity symbols: A, asbestos; C, corundum; O, olivine; P, pyrite; T, talc and soapstone; V, vermiculite. Production symbols: x, production reported by U.S. Bureau of Mines, Minerals Yearbook (1946–86); z, production reported before 1945 by McCallie (1926), Sloan (1908), U.S. Bureau of Mines (1927–34, 1933–88) or U.S. Geological Survey (1883–1927); ?, uncertain production]

	Commodity					
State and county[1]	A	C	O	P	T	V
Georgia:						
Habersham	z				z	
Lumpkin (50)				z	z	
Rabun	x	z	x[2]		z	x
Towns		x				
Union (50)		x				
White	z				z	
South Carolina:						
Abbeville				z?		
Greenville (71)						x[3]
Laurens (50)					z	x[3]
Oconee		z?			z	
Pickens (75)	z					
Spartanburg (60)						x[3]
North Carolina:						
Clay (5)		z[3]				
Macon (1)	x[3]	z[3]			x[3]	x[3]

[1]Number in parentheses indicates percentage of county area in Greenville quadrangle (see fig. 4).

[2]Produced dunite for road fill and not for olivine.

[3]Most of this production probably from outside Greenville quadrangle.

Table 2.—Summary of known ultramafic and mafic deposits that have been mined or prospected for various mineral commodities, exclusive
[Commodity symbols: A, asbestos; Ch, chromite; C, corundum; N, nickel; P, iron sulfides; O, olivine; T, talc and soapstone; V, vermiculite.

Map No.	Deposit	Rock type	A	Ch	C	N	P	O	T	V
		Georgia								
Banks County:										
B1	Roberts prospects	Epidote-hornblende rock					X			
Elbert County:										
E1	J.E. Calhoun	Chlorite schist							X	
E2	T.P. Jones	Soapstone	X						X	
Habersham County:										
H1	Robert McMillan property	Chlorite schist and hornblende gneiss							*	
H2	C.W. Stambaugh property	Soapstone and chlorite schist	*						X	
H3	Hollywood mine	Metaperidotite and metapyroxenite(?)	*	X				X	X	
H4	J.J. Holcomb property	Soapstone and talcose-asbestos rock	X						X	
H5	Blalock Lumber property (was J.J. Holcomb property).	Chlorite schist	*						X	
H6	John Tatum property (was A.E. Berong property).	Serpentinite	*							
H7	John Tatum property (was A.E. Berong property).	do.	X							
H8	Ruel White property (was G.L. Lyon property).	Chloritic and talcose soapstone and serpentinite	*		X				X	
H9	John Martin prospects	Chlorite schist and soapstone	X					X	X	
H10	Mack Mountain prospects	Soapstone and partly altered ultramafic dikes	X		X				X	
H11	Wolfpit Mountain prospects	Soapstone; partly altered peridotite	X						X	
H12	Wykle property	Soapstone							X	
H13	Mrs. W.T. Arrendale property	do.	X						X	
H14	Lovell prospect	Serpentinite	X						X	
H15	Stamie or Wood prospect	do.	X		X					

of crushed stone, in the Greenville 1° × 2° quadrangle
Production symbols: X, commodity present; *, commodity mined; ?, possible resource but data lacking]

Remarks	References
Georgia—Continued	
Several prospects in amphibolite that has layers of epidote-hornblende-pyrite rock. Pyrite mostly disseminated but is as much as 10–25 percent in some layers.	Shearer and Hull, 1918, p. 202–203.
Rock too hard for use as soapstone. Outcrop trends NNE.	Hopkins, 1914, p. 295–296.
Minor slip-fiber asbestos; outcrop trends NE.	Hopkins, 1914, p. 295.
Small amount of soapstone quarried for tombstones from opening 6 ft wide in chlorite schist. Strikes N. 20° E., dips 30° E. Location approximate.	Hopkins, 1914, p. 271.
Soapstone exposed at street in front of residence.	Hopkins, 1914, p. 271; Hurst and Crawford, 1964, p. 167–168.
Upper part of metaperidotite altered to asbestos. Curved body 540 ft long and 20–85 ft wide strikes N. 20° E. Opening 60 ft long at south end. Later work suggests five separate lenses 50–250 ft long and 25–50 ft wide. Mined and milled 1907 and 1913–28. Best ore removed.	Hopkins, 1914, p. 154–156; Teague, 1956, p. 5; Hurst and Crawford, 1964, p. 166.
Largest and best exposure on bank of Chattahoochee River. Area 8 by 10 ft shows mass-fiber asbestos in radiating form. Prospected but not mined.	Hurst and Crawford, 1964, p. 155.
Mined extensively in early 1950's by Powhatan Mining Co., Baltimore, Md. Mining along ridge, near crest for about 150 ft, 50–75 ft wide. Trend N. 25° E. Considerable quantity of mass-fiber asbestos boulders present.	Hurst and Crawford, 1964, p. 156.
On north side of Sautee Creek, altered dike at least 30 ft wide and 50–75 ft long. It strikes north and dips at a moderate angle to west. South end is massive serpentine; east edge has considerable quantity of coarsely crystalline, high-grade, mass-fiber asbestos. Some mining about 1900. Mined area 100 by 100 ft.	Hopkins, 1914, p. 158; Hurst and Crawford, 1964, p. 152.
On south side of Sautee Creek. Original rock probably peridotite or dunite. Serpentinite, possibly altered pyroxenite. Prospected 1962 by Powhatan Mining Co., Baltimore, Md. Open trench along hillside at elev. 1,480 ft. Considerable quantity of mass-fiber asbestos boulders on slope and in trench. Minor amount of cross-fiber asbestos in veins as much as 1.5 in. wide cutting mass-fiber asbestos.	Hopkins, 1914, p. 158–159; Hurst and Crawford, 1964, p. 152.
Two small pits 80 ft apart. East pit exposes 15 ft of decomposed chloritic and talcose soapstone associated with minor slip-fiber veins of asbestos. Fibers 8–10 in. long exposed for 5 ft vertically along small fault 3–3.5 in. wide. At bottom of pit, 15-ft adit follows vein. Mined about 1895 or 1900 with small production. Hard serpentinite exposed in west pit. Ultramafic body at least 15–20 ft thick and 300 ft long. Moderately large amounts of poorly fibrous talcose soapstone. Originally prospected for corundum.	Hopkins, 1914, p. 159; Hurst and Crawford, 1964, p. 154–155.
Asbestos found on Lots 64, 65, and 66, 6th District. Small deposits scattered over a north-trending direction for 1.5 mi. On Lot 64 mass-fiber asbestos on crest of small hill covers an area 150 ft long and 50 ft wide. Has 8 pits exposing talcose anthophyllite, 30 ft thick and dipping west. Estimated volume of asbestos ore present is 50,000 tons. Fresh enstatite-olivine rock nearby. For 1 mi north of locality H10 scattered outcrops of altered peridotite.	Hopkins, 1914, p. 159–161; Hurst and Crawford, 1964, p. 155.
On south slope of Mack Mountain, tunnel 100 ft long for corundum. Cut on ridge crest exposes ultramafic body 75 ft wide altered to soapstone and asbestos. Asbestos veins as much as 2 ft thick. Small hexagonal corundum crystals on dump. Another tunnel on western slope. Numerous pits on different intrusive rocks. Mostly soapstone. Veins of long-fibered asbestos cut soapstone and partly altered peridotite. Major vein 75 ft wide.	Hopkins, 1914, p. 161–162; Hurst and Crawford, 1964, p. 157.
East slope has 6 intrusive bodies, each 2 ft wide, of schistose soapstone. Several dikes on north slope, largest covers an area 150 by 25 ft. Trench exposes long-fibered asbestos vein 2 ft wide. Pure foliated talc with asbestos. Large amounts of impure soapstone and partly altered peridotite. Location approximate.	Hopkins, 1914, p. 162, 163.
Soapstone associated with green amphibolite crops out on both sides of highway.	Hurst and Crawford, 1964, p. 158.
Small dike of soapstone containing small amount of soft cross-fiber asbestos. Several dikes in area.	Hopkins, 1914, p. 165. Hurst and Crawford, 1964, p. 159.
Dike 30–40 ft wide. Cut 20 ft long exposes hard serpentinite that has some cross- and slip-fiber asbestos. Some surface soapstone fragments.	Hopkins, 1914, p. 165; Hurst and Crawford, 1964, p. 157–158.
Dike of altered mafic rock 40 ft wide on east bank of creek. Most hard serpentinite with small amount of cross- and slip-fiber asbestos. Prospected for corundum; data not given. Prospect pit 30 ft long, 5 ft wide, and 4 ft deep; trends N. 35° W.	Hopkins, 1914, p. 165; Hurst and Crawford, 1964, p. 158–159.

Table 2.—Summary of known ultramafic and mafic deposits that have been mined or prospected for various mineral commodities, exclusive

Map No.	Deposit	Rock type	A	Ch	C	N	P	O	T	V
		Georgia—Continued								
Habersham County—Continued:										
H16	Jackson estate and Frenchman Carson.	Fuchsite schist		X						
H17	Terrell Barron	Soapstone	X						*	
H18	Jim Kinsey prospect	Hornblende gneiss			X				X	
H19	Earnest Nations prospect	Amphibolite and chlorite schist			X					
H20	Worley prospect	Serpentinite and talcose schist	X		X				X	
H21	Ivy Branch, Rogers Creek deposit	Soapstone	X							
H22	Buford Elrod property	do.	X						X	
H23	V.L. Lovell, Jr., property, southwest of Raper Creek.	do.	X						X	
H24	Lyon and Davis prospects	do.	*		X				X	
Hall County:										
HL1	Soapstone Hill	Metaperidotite	X	X					X	
HL2	Miller/Abernathy properties	Epidote-hornblende rock					X			
Jackson County:										
J1	M.L. Carter	Altered, ultramafic, rock	X							
J2	J.P. Johnson	Soapstone (altered peridotite)							?	
J3	Estes Place	Amphibolite and soapstone	?						?	
J4	Cabin Branch	Soapstone							X	
J5	Curry Creek	do.						X		
J6	Southern Railway	Soapstone (altered peridotite)							X	
Lumpkin County:										
L1	East side of Chestatee River	Chloritic soapstone							*	
L2	Soapstone Ridge	Soapstone							*	
L3	J.R. Dowdey	do.							X	
L4	One mile NE. of New Bridge(?)	do.	X						X	
L5	Charles Cain property	Amphibolite(?)			X					
L6	Chestatee mine	Amphibolite and mica gneiss					*			

Remarks	References
Georgia—Continued	
Trench 15 ft long, 6 ft wide, and 4 ft deep. Bright, grass-green fuchsite schist that has grains of chromite concentrated in small pods.	Hurst and Crawford, 1964, p. 175.
Old quarry pit 30 ft long, 20 ft wide, and 5 ft deep for soapstone blocks. Small amount of poor-quality cross- and mass-fiber asbestos in narrow veins in soapstone.	Hurst and Crawford, 1964, p. 159.
Prospected about 1890–95. No commercial production. Small crystals of ruby corundum, wrapped in green margarite, in hornblende gneiss interlayered with quartz-mica schist; all thoroughly weathered. Several float pieces of talc noted.	Hurst and Crawford, 1964, p. 165.
Trench in mafic rock, primarily amphibolite and chlorite. No corundum found in pit but 15-lb corundum block of sub-gem-quality ruby found downslope.	Hurst and Crawford, 1964, p. 169.
Tunnel and trench dug about 1890. Between forks of upper Amos Creek, bouldery outcrop of weathered serpentinite and talcose schist. Gray, speckled with dark-blue, corundum; brown garnet, possibly andradite; and minor amounts of chalcopyrite and malachite associated with green hornblende. Hard, very short mass-fiber asbestos and green foliated talc also present. Similar rocks exposed 500 ft to west.	Hurst and Crawford, 1964, p. 169–170.
South of Sautee Creek. Large boulders of mass-fiber asbestos over an area 10 by 35 ft on steep, heavily vegetated north slope of east-trending ridge.	Hurst and Crawford, 1964, p. 178.
West of Alec Mountain and Amos Creek. Fragments of mass-fiber asbestos and soapstone over area of 10 ft diameter in open field on gentle slope.	Hurst and Crawford, 1964, p. 179.
Fragments of soapstone and talc and small amount of mass-fiber asbestos over area of about 15 by 30 ft.	Do.
Several small bodies of altered ultramafic rock prospected for asbestos and one near Ivy Branch prospected for corundum. Powhatan Mining Co. mined asbestos from Davis prospect in 1962.	Hurst and Crawford, 1964, p. 153.
Ultramafic body traceable several hundred yards. Trends north; maximum width about 300 ft. Deeply weathered peridotite that has soapstone layers alternating with clay. Weathered asbestos slip- and cross-fiber veins as much as 5 in. in width. Location approximate.	Hopkins, 1914, p. 171.
Minor prospecting for pyrite and copper in areas of disseminated pyrite in epidote-hornblende rock. Location approximate.	Shearer and Hull, 1918, p. 202.
Poor-quality, short-fiber asbestos in area 12 by 40 ft. Location approximate.	Hopkins, 1914, p. 174.
Elongate lens, 200 by 700 ft. Poorly exposed. Poor-quality soapstone. Location approximate. Lot 253, Newton District.	Hopkins, 1914, p. 175–176.
Poorly exposed, elongate body 150 by 250 ft. Poor-quality asbestos and soapstone along contact of amphibolite and mica schist. Location approximate.	Hopkins, 1914, p. 174.
Poorly exposed. Soapstone fragments scattered over 1 acre. Location approximate.	Hopkins, 1914, p. 175.
Several boulders of soapstone at edge of river marsh. Possibly used by Indians for bowls. Location approximate.	Do.
Dike, 40 by 200–300 ft, exposed in railroad cut. Location approximate.	Hopkins, 1914, p. 174.
Soapstone 30–200 ft wide. Quarried for local use. Location approximate.	Hopkins, 1914, p. 274–275.
Soapstone found as parallel bands, widest is several hundred feet. Strikes slightly E. of N. and traced at least 1 mi. Quarried in several places. Location approximate.	Hopkins, 1914, p. 275.
Soapstone similar to Soapstone Ridge. Location approximate.	Do.
Two small openings 300 ft apart. Probably two small deposits; one strikes N. 32° E., dips NW. in direction of other. South opening exposes 3–4 ft of talcose rock. Asbestos largely altered to talc, and talc much decomposed. Location approximate.	Hopkins, 1914, p. 170.
Low outcrop 60–70 ft wide and 200–300 ft long of massive hornblende containing corundum. A child picked several pounds of grayish-white, blue, and pink blocks of corundum. Location approximate.	King, 1894, p. 96; Hopkins, 1914, p. 276.
Adit, two shafts, and some underground workings in moderate-sized massive sulfide deposit. Ore consists mostly of pyrite and minor chalcopyrite. Mica gneiss hanging wall; amphibolite in footwall. Produced 48,835 tons of ore 1918–19.	Shearer and Hull, 1918, p. 182–198; Kline and Beck, 1949.

Table 2.—Summary of known ultramafic and mafic deposits that have been mined or prospected for various mineral commodities, exclusive

Map No.	Deposit	Rock type	A	Ch	C	N	P	O	T	V
		Georgia—Continued								
Stephens County:										
S1	E.H. Russell property	Soapstone in hornblende rocks							X	
S2	Bird Yearwood property	Chloritic soapstone	X						X	
S3	C.F. Anderson property	do.							X	
S4	Meckline property	Chloritic soapstone and hornblende schist.							X	
S5	J.E. Brady property	Chloritic soapstone							X	
S6	Glen Davis property	Soapstone							X	
S7	Perry Farrow property	Chloritic soapstone							X	
S8	T.R. Yow property	do.							X	
Rabun County:										
R1	Laurel Creek mine	Dunite, partly serpentinized	*		*			X	X	X
R2	Hicks mine	Peridotite and serpentinite	*							*
R3	Reid mine	Soapstone and peridotite	*							X
R4	Nicholson mine	Soapstone, pyroxenite, and amphibolite.	*						X	
R5	Chatooga River prospect (probably Nicholson estate).	Soapstone	*							
R6	Gennett prospect	do.	*						X	
R7	Frank Kelly property	Soapstone and peridotite	X							
R8	Soapstone Mountain deposit, L.D. Garland property.	Soapstone	X						X	
R9	Beavett prospect	Altered ultramafic rock	X		X				X	
R10	A.A. Darnell property(?)	Soapstone	X						*	
R11	R.H. Lamb property	Variety of ultramafic rocks, partly altered.	X		X				X	
R12	McCoy mine	Soapstone	*						X	X
R13	Dillard prospect	do.	*		X				X	X

Remarks	References
Georgia—Continued	
Large amount of very inferior grade of soapstone. On bank of Tugaloo River opposite Fort Madison, S.C. Location approximate. Covered by Hartwell Lake?	Hopkins, 1914, p. 273.
Ten-ft cut exposes chloritic soapstone, some slip-fiber asbestos, and moderately pure talc. Fragments extend to the NE. Location approximate.	Do.
Chloritic soapstone of very inferior grade. Location approximate.	Do.
Rock outcrops on small knoll 0.25 acre in size. Derived from hornblende schist. Prospected, little worked. Location approximate.	Hopkins, 1914, p. 272–273.
Chloritic soapstone of very inferior grade. Location approximate.	Hopkins, 1914, p. 273–274.
Soapstone in hill exposure 6 ft thick that contains almost pure chlorite layer 4 ft thick, all enclosed by hornblende gneiss. Can be traced for 0.25 mi NE. Location approximate.	Hopkins, 1914, p. 272.
Chloritic soapstone of very inferior grade. Location approximate.	Hopkins, 1914, p. 274.
Chloritic soapstone of very inferior grade. Location approximate.	Do.
North bank of Laurel Creek. Intrusion 1,700 ft long and 750 ft wide is partly serpentinized dunite. Along west contact, bands of hard, poorly fibrous anthophyllite, talc schist, and altered mass-fiber asbestos between peridotite and mica gneiss country rock. Some soapstone along east contact. Worked for asbestos about 1880. Prospected for corundum 1873–74, mined for corundum 1880–92. Minor vermiculite. Olivine resources estimated by Hunter to be 1,440,000 tons.	King, 1894, p. 77–83; Hopkins, 1914, p. 143–144; Hunter, 1941, p. 114–117; Petty, 1982.
Intrusion 150 ft wide and 300 ft long forms crest between two branches. Strikes N. 30° E. and dips E. Workings include adit, cut, and numerous pits. Numerous veins of cross- and slip-fiber asbestos and bodies of mass-fiber asbestos in hard peridotite or serpentinite. Original rock varied from dunite to pyroxenite. Large amount of short- and long-fiber asbestos present. Production more than 50 tons of asbestos and 10 tons of vermiculite.	King, 1894, p. 83–84; Hopkins, 1914, p. 144; Teague, 1956, p. 7.
Cut 35 ft long, 15 ft wide, and 12 ft deep. Mined for asbestos 1900 and 1941. Vermiculite zone 2 ft thick along hanging wall. Ultramafic body 150 ft long and 40 ft wide.	Teague, 1956, p. 7; Petty, 1982, p. 8–9; Gazdik, 1985.
Intrusion 50 ft wide and at least 200 ft long. Most of surface weathered mass-fiber asbestos. Small production of asbestos in 1936 and 1946.	Hopkins, 1914, p. 145; Teague, 1956, p. 7; Gazdik, 1985.
On Lots 27 and 28, 3d District. Ultramafic body 200 ft long and 40–60 ft thick. About 20 tons asbestos mined in 1946.	King, 1894, p. 84; Hopkins, 1914, p. 145; Teague, 1956, p. 6.
Trench 125 ft long and 4–10 ft deep; circular pit 40 ft diameter and 20 ft deep; 6 tons of asbestos mined in 1946.	Hopkins, 1914, p. 145–146; Teague, 1956, p. 6.
Small opening 6 ft^2 exposes a peridotite (harzburgite) that contains veins of both cross- and slip-fiber asbestos.	Hopkins, 1914, p. 146–147; Teague, 1956, p. 7; Cook, 1978, p. 126.
Ultramafic body 200 ft long and 30 ft wide. Mass-fiber asbestos largely altered to talc, which has been used locally for building stone. Several large outcrops in area; second site 0.35 mi west on upper mountain slope.	King, 1894, p. 86; Hopkins, 1914, p. 147.
Thoroughly decomposed mafic rock 15 ft wide, containing some asbestos and soapstone. Layer of 6–10 in. of chlorite around asbestos core. Country rock hornblende gneiss. Small intrusion strikes N. 50° E., dips 80° SE. Some corundum present. About 0.25 mi west of McCoy mine. Location approximate.	King, 1894, p. 84; Hopkins, 1914, p. 147; Teague, 1956, p. 6.
Ultramafic body 100 ft wide and 600 ft long. Strikes N. 30° E., dips 30° NW. Site of Indian quarry for soapstone pots. May be site described by Hopkins as dunite but no dunite seen in 1987 visit.	Hopkins, 1914, p. 147–148(?); Peper and others, 1991.
Number of small intrusions in area 2,000 ft long and as much as 450 ft wide in vicinity of Lamb Creek in Lot 188, 2d District. Asbestos and soapstone found on two separate ridges. Some very coarsely crystalline mass-fiber asbestos altered to talc; some masses of light-green, somewhat fibrous soapstone also found. Along one contact, 18-in. vein with pockets of corundum crystals found. Peridotite dike present southward toward Betty Creek; probably dunite, somewhat serpentinized, that contains small amount of asbestos and soapstone; dike about 35 ft wide and traceable for several hundred yards. Other dunite dikes reported to the west and to the east by Lamb Creek. Location approximate.	King, 1894, p. 84, 85; Hopkins, 1914, p. 148–149.
Two cuts, east one 50 ft deep but backfilled. About 450 tons asbestos produced in 1944.	Teague, 1956, p. 7.
Prospect in northwest corner of Lot 177, 2d District. May be area described by King. Openings on both sides of Burrell(?) Branch on separate ultramafic bodies. Southwest body 800 ft long and 150 ft wide; northeast body 200 ft long and 75 ft wide; 25 tons asbestos produced by Powhatan Mining Co. in 1940.	King, 1894, p. 84–85; Teague, 1956, p. 6.

Table 2.—Summary of known ultramafic and mafic deposits that have been mined or prospected for various mineral commodities, exclusive

Map No.	Deposit	Rock type	A	Ch	C	N	P	O	T	V
		Georgia—Continued								
Rabun County—Continued:										
R14	George Lovell prospect	Soapstone	X						X	
R15	Tom Coward prospect	Amphibolite and mica schist					X			
R16	Lake Burton dunite (N.V.M. Miller Mine).	Dunite	X	X				X		
Towns County:										
T1	Bell Creek corundum	Troctolite; metaperidotite	X		*?					
T2	Hog Creek corundum mine	Dunite and troctolite			*?					
T3	W.M. Scott property, chromite prospect	Dunite		X	X	X		X		
T4	Hamilton mine property	Altered ultramafic rock			X					
T5	Lemon Gap prospect	Ultramafic rock and amphibolite								X
T6	Jethro Burrell prospect	Ultramafic rock								X
T7	Barnett Denton	Ultramafic rock(?)		X						
Union County:										
U1	Track Rock corundum mine	Altered peridotite		X	*			X	X	
U2	Stone mine	Probably altered peridotite			*					
White County:										
W1	A.M. Allison property	Chloritic soapstone							*	
W2	Castleberry or Elliot property	do.							*	
W3	Asbestos mine	Soapstone(?)	*						X	
W4	H.H. Dean prospect	Soapstone							X	
W5	Calhoun Mining Co., prospect	do.	X						X	
W6	Sal Mountain mine	Soapstone and peridotite(?)	*							
W7	Camp Echoee prospect	Soapstone	X						X	
W8	Wolfpit Mountain or Wykle prospects	Soapstone, metaperidotite, and metapyroxenite.	X						X	

Remarks	References
Georgia—Continued	
Small ultramafic body poorly exposed in old prospect pit.	Teague, 1956, p. 6.
Shaft 60 ft deep and short, caved adit. Five drill holes by Tennessee Copper Co. totaled 2,850 ft of coring. Small amount of massive sulfides along contact between amphibolite and schist.	Shearer and Hull, 1918, p. 205–206; Chatman, 1985, p. 10; Peper and others, 1991.
Dunite body about 1,300 ft long and 700 ft wide. Open cuts made about 1890 in southwestern part of intrusive body in hard olivine, in places serpentinized and showing veins of slip- and mass-fiber asbestos. Foliated talc also present in small amounts. Olivine resources greater than 7 million tons.	King, 1894, p. 86; Hopkins, 1914, p. 146; Hunter, 1941, p. 112–113; Chatman, 1985.
Shaft, several pits, and a trench in ultramafic body several hundred feet long. Central core is altered peridotite, probably a troctolite, that has a band of chlorite and soapstone forming the contact zone. Some long-fibered asbestos in small amounts. Identified minerals include olivine, serpentine, amphibole, and magnetite. No report on corundum production.	King, 1894, p. 87–88; Hopkins, 1914, p. 150; Hartley, 1973, p. 50.
Troctolite a few feet wide and more than 100 ft long, striking NE. and dipping SE., in country rock hornblende gneiss and olivine gabbro. Pink and blue corundum on mine dump. Shaft 45 ft deep and trench 190 ft long.	King, 1894, p. 88–89; Hopkins, 1914, p. 151–152; Ballard, 1946; Hartley, 1973, p. 50.
Dunite probably 300 ft wide and more than 600 ft long in olivine gabbro grading to troctolite. Five trenches and pits for chromite. Abundant chromite grains in dunite. Corundum present. Small area of dunite with corundum on surface to NE. Genthite (garnierite), hydrous nickel silicates, present as pale-green crusts in cracks of dunite at north end of intrusion. Location approximate.	Hopkins, 1914, p. 152.
Bedrock similar to talcose schist at Track Rock mine and other altered ultramafic rock units. Several pits and a 100-ft shaft sited on spur top where rock unit is widest. Location approximate.	King, 1894, p. 91.
Several small prospect pits for vermiculite north of Lemon Gap.	Prindle and others, 1935, p. 45.
Prospecting shows disseminated vermiculite for 1 mi along strike.	Prindle and others, 1935, p. 44.
May be same prospect shown as a magnetite prospect on Georgia Dept. of Mines, Mining, and Geology map (1951).	Chatman, 1985.
Largely chlorite, talc, and actinolite of metamorphosed peridotite. Much olivine; also includes chlorite, magnetite, chromite, and talc. Minor production of corundum.	King, 1894, p. 92–95; Hopkins, 1914, p. 269–270; Ballard, 1948.
Adjacent to Track Rock mine and similar rock type. Has 20-ft tunnel into hillside from road; exposed rock is talc and chlorite schist grading into completely altered material containing corundum.	King, 1894, p. 95.
Trench 175 ft long and 7 ft wide; worked in 1914. Mass of chloritic soapstone 12 ft wide and 100 ft long. Fair grade of soapstone. Used for local construction.	Hopkins, 1914, p. 270.
Five feet of chloritic schist or soapstone exposed. Fair grade of soapstone; quarried in 1914 for local construction. Trench 100 ft long and 25 ft wide.	Hopkins, 1914, p. 270; Hurst and Otwell, 1964, p. 65–66, 109.
Cut 175 ft long, 100 ft wide, and 50 ft deep. Sal Mountain Asbestos Co. produced good-quality asbestos as late as 1930(?). Production figures not available but produced several hundred tons by 1914 (Hopkins).	Hopkins, 1914, p. 169–170; Hurst and Otwell, 1964, p. 108.
Soapstone body at least 40 ft thick; strikes N. 40° E., dip vertical. Exposed near crest of small ridge. Good cleavage allows blocks of any size; quarried. Two trenched areas: intermittent trenching for 200 ft in southwest area; northeast area trenched for 80 ft.	Hopkins, 1914, p. 270–271; Hurst and Otwell, 1964, p. 65, 109.
Two contour trenches, each 50 ft long, 6 ft wide, and 5 ft deep, expose mass of anthophyllite and talc 125 ft long and probably 15 ft wide, bordered by laminated soapstone. Some cross-fiber asbestos veins 0.5 to 3 or 4 in. wide.	Hopkins, 1914, p. 166–167; Hurst and Otwell, 1964, p. 23–24, 111.
West cut 200 ft long, 75 ft wide, and 50 ft deep; east cut 100 ft long, 50 ft wide, and 30 ft deep. Poorly exposed. Ore was mass-fiber anthophyllite; fibers 0.25 to 1.5 in. long. Worked 1894–1930; production estimated to be 15,000 tons asbestos (Gillon).	Hopkins, 1914, p. 167–169; Teague, 1956, p. 3; Gillon, 1982, p. 214–216; Hurst and Otwell, 1984, p. 23, 110.
Pit 50 ft long, 15 ft wide, and 25 ft deep.	Hurst and Otwell, 1964, p. 24, 71, 121–122.
Deposits on west-trending ridge west of Wolfpit Mountain largely talc and soapstone with cross- and slip-fiber asbestos. To the west are conspicuous outcrops of peridotite and pyroxenite.	Hopkins, 1914, p. 163–165.

Table 2.—Summary of known ultramafic and mafic deposits that have been mined or prospected for various mineral commodities, exclusive

Map No.	Deposit	Rock type	A	Ch	C	N	P	O	T	V
		South Carolina								
Abbeville County:										
A1	Saluda mine	Amphibolite, banded iron formation; massive sulfide deposit.					X			
Greenwood County:										
G1	Unnamed occurrence	Serpentinite							X(?)	
Laurens County:										
La1	Monore and Powers prospects	Biotite-rich schist or lamproite(?)								X
La2	Patterson prospect	do.								X
La3	Reedy Fork occurrence	Soapstone							*	
Oconee County:										
O1	Soapstone Hill deposit	Soapstone and amphibolite-metapyroxenite.			X				*	
O2	Kuhtman(?) property	Peridotite			*?					
O3	Soapstone occurrence	Soapstone							*	
O4	Bee Cove Creek prospect	Altered ultramafic rock	X							
O5	Old Pickens	Chlorite schist							*	
O6	Fair View Church deposit; S.O. Haynes property.	do.							*	
O7	Seneca	do.							X	
O8	Walhalla	do.							X	
O9	Long Creek	do.							X	
Pickens County:										
P1	Unnamed prospect	Ultramafic rock in amphibolite	X							
P2	Woodall Mountain	Aphanitic hornblende schist	X							
P3	Hendrix property	Soapstone							X	
P4	Twelve-mile Creek	do.							X	
P5	Clemson	Chlorite schist							X	

Remarks	References
South Carolina—Continued	
Shaft and several adits. Worked by Donalds family early 1900's. Tennessee Copper Co. drilled 28 holes in area. Massive sulfides contain 70 percent pyrrhotite, 5 percent pyrite, and 15 percent chalcopyrite. Some disseminated sulfides.	Bynum, 1982, p. 61–63.
Altered ultramafic dike, 20–30 ft wide and as much as 1 mi long.	McSween, 1970, p. 74–77.
Two small open cuts in deeply weathered biotite-rich schist.	Libby, 1975, map; Henry Bell, III, written commun., 1989.
Small open cut in deeply weathered biotite-rich schist.	Henry Bell, III, written commun., 1989; field observations, this study.
Bold outcrop of amphibolite altered to soapstone. Sawed for local use.	Sloan, 1908, p. 119–120, No. 5245.
Old pit exposes green talc schist, locally designated soapstone. Near contact are green mica, corundum, and tremolite. Rock sawed for local use.	Sloan, 1908, p. 118, No. 1440; Gazdik, 1985; Mittwede and Zupan, 1985.
Large outcrop of peridotite containing corundum. Location approximate.	Sloan, 1908, p. 151, No. 1460; McCauley and McCauley, 1964, p. 5; Roper and Dunn, 1970.
Massive, gray-mottled soapstone. Blocks have been sawed for local use.	Gazdik, 1985.
Altered ultramafic body 20 ft wide. Limited trenching for asbestos by Powhatan Mining Co. in 1971.	Gazdik, 1985.
Altered ultramafic body, 300 by 1,400 ft.	Bryan and Griffin, 1981.
Bed quarried for local use. Fair grade of soapstone. Dark-green chlorite schist, fine uniform grain. Abundant secondary tremolite. Location approximate.	Sloan, 1908, p. 118–119.
Altered ultramafic body 300 by 600 ft.	Bryan and Griffin, 1981; Warner and others, 1986, 1989.
Altered ultramafic body 150 by 600 ft.	Warner and others, 1989.
Soapstone partly exposed in area 300 by 700 ft.	Hatcher, 1970.
A few shallow prospect pits.	Sloan, 1908, p. 124, No. 1610.
Small amount of asbestos in hornblende schist on projected line of chlorite schist or altered peridotite. Location approximate.	Sloan, 1908; p. 124–125, No. 1570.
Fair grade of soapstone observed by Sloan. Location approximate.	Sloan, 1908, p. 119, No. 1645.
Prominent body of soapstone. Location approximate. (Might be same as No. P5.)	Sloan, 1908, p. 119, No. 1530.
Chlorite schist in area 400 by 1,100 ft along shore of Lake Hartwell.	Bryan and Griffin, 1981; Warner and others, 1986, 1989.

Table 3.—Selected chemical components in mafic (MgO <16 weight percent), ultramafic (MgO >16 weight percent), and related rocks from selected thrust sheets, Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina, and northwestern part of the Spartanburg 1° × 2° quadrangle, South Carolina and North Carolina

[All analyses done in USGS laboratories. MgO and TiO_2 by X-ray spectroscopy or single-solution methods (Shapiro, 1975) by Hezekiah Smith, F.W. Brown, Norma Rait, J.E. Taggart, J.R. Evans, A.V. Bartel, D.F. Siems, M.G. Kavulok, Herbert Kirschenbaum, W.B. Crandell, Roosevelt Moore; Co, Cu, and Ni by emission or optical spectroscopy by J.D. Fletcher, J.S. Kane, W.M. d'Angelo, M.W. Doughten, B.J. Libby, K.E. Slaughter; Cr by instrumental neutron activation analysis by J.N. Grossman, G.A. Wandless, J.S. Mee; Pd and Pt by graphite-furnace atomic-absorption spectrometry by Hezekiah Smith, Norma Rait, Roosevelt Moore, B.J. Libby, J.M. Allingham. %, weight percent; ppm, parts per million; ppb, parts per billion; —, not analyzed or not calculated. Sample localities shown on map and figs. 5–7]

Map No.	Field No.	MgO (%)	TiO_2 (%)	Co (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pd (ppb)	Pt (ppb)	Pd/Pt	Rock type
					Richard Russell thrust sheet[1]						
10	GA03–302	9.6	0.88	45	955	126	202	3.6	15	0.24	Amphibolite.
14	GA04–197	8.2	.97	54	13	110	130	<.5	3.3	—	Do.
14	GA04–267	7.0	3.1	46	143	170	82	14.0	3	4.67	Do.
15	GA04–210	6.0	1.0	51	259	29	86	1.8	5	.36	Do.
16	GA04–241	7.7	.98	52	168	140	82	1.9	4	.48	Do.
17	GA04–147	8.1	1.04	51	47	110	100	.5	<1	—	Do.
21	GA04–183	8.0	.99	58	14	100	88	<.5	<1	—	Do.
21	GA04–184	7.9	.95	48	33	39	90	<.5	<1	—	Do.
10	GA03–301	26	.66	126	1,740	71	1,160	3.7	3.6	1.03	Soapstone.
11	GA04–272	28.6	.56	110	2,170	18	1,100	6.8	32	.21	Do.
12	GA04–268	30.7	.45	110	2,350	49	1,200	7.8	17	.46	Metapyroxenite.
13	GA04–150	29.4	.53	130	2,080	27	1,100	4.2	18	.23	Do.
19	ANG–539	27.9	.38	110	2,140	51	1,500	2.7	5	.54	Do.
20	GA04–275	25.5	.66	120	1,850	26	894	17	13	1.31	Do.
20	ANG–433	26.5	.60	110	1,750	42	970	12	32	.38	Do.
					Young Harris thrust sheet[2]						
01	GB02–202	7.4	1.9	35	175	71	65	.5	<1	—	Amphibolite.
02	GB02–201B	7.3	.94	37	95	78	110	<.5	<1	—	Do.
04	KNG85–2	6.4	1.2	33	232	69	54	.8	2	.4	Do.
05	GA02–903	8.5	.81	42	334	84	56	<.5	<1	—	Do.
05	KNG85–1	7.9	1.0	35	306	86	110	1.3	1	1.3	Do.
06	GA02–904	6.0	1.4	45	31	22	21	2.1	2.2	.95	Do.
07	GA03–252	7.4	1.3	35	309	97	65	1.5	3	.5	Do.
08	GA02–901	9.2	.55	38	985	86	130	<.5	<1	—	Do.
09	GA02–902	9.2	.19	37	632	170	180	<.5	<1	—	Do.
02	GA02–201A	28.0	.19	120	999	56	1,100	3.2	6	.53	Do.
03	GA02–204	31.1	.13	95	1,580	53	1,100	4.4	5	.88	Olivine gabbro.
					Helen thrust sheet[3]						
18	GA04–225	5.3	1.2	27	22	120	18	2.8	2	1.4	Amphibolite.
23	BL1	7.63	.93	46	126	144	71	5.3	4.3	1.23	Do.
24	TA200	8.45	1.34	55	164	26	81	<.5	<1	—	Do.
25	H24	4.95	1.35	39	168	73	88	1.2	<1	—	Do.
27	C35	7.9	1.32	46	159	18	87	<.5	<1	—	Do.
28	CL22	5.28	1.55	41	45	207	25	<.5	<1	—	Amphibolite.
29	D36	2.68	.28	14	43	39	12	1.3	1.3	1	Hornblende-diorite.
30	GD01–250	7.9	.42	49	15	42	26	12	7.2	1.67	Amphibolite.
30	GD01–252	9.6	.62	42	315	632	106	1.0	.99	1.01	Amphibolite, minor iron sulfide.
31	DL9	4.40	1.63	29	87	289	58	2.1	1.3	1.6	Biotite-hornblende-garnet schist.
32	M40	7.23	.82	56	185	87	88	<.5	1.7	—	Amphibolite.
22	GB04–003	40.1	.09	211	5,250	<2	1,500	2.5	1.8	1.39	Dunite.
22	GB04–004	46.6	.03	173	4,350	<2	3,260	13	6.6	1.97	Dunite, minor iron sulfides.
22	KNG82–2	46.1	.01	130	3,990	1.4	1,500	1.4	9	.15	Dunite.
30	GD01–251	.22	.32	88	180	7	41	<.5	<1	—	Massive sulfide (Chestatee mine).

Table 3.—Selected chemical components in mafic (MgO <16 weight percent), ultramafic (MgO >16 weight percent), and related rocks from selected thrust sheets, Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina, and northwestern part of the Spartanburg 1° × 2° quadrangle, South Carolina and North Carolina—Continued

Map No.	Field No.	MgO (%)	TiO_2 (%)	Co (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pd (ppb)	Pt (ppb)	Pd/ Pt	Rock type
Tallulah Falls thrust sheet[4]											
26	TA199	7.5	1.34	58	148	63	63	0.9	1.1	0.82	Amphibolite.
33	KOC078	4.5	5.0	45	14	100	37	6.4	4	1.6	Do.
34	GA06–665	6.3	2.25	44	124	74	67	—	—	—	Do.
35	GA06–711	8.1	1.04	42	271	18	69	<.5	<1	—	Do.
36	GA06–628	6.2	1.04	37	64	5	25	<.5	<1	—	Do.
37	KOC326	7.1	.90	30	153	82	44	<.5	<1	—	Do.
38	GA07–010	7.6	1.5	55	94	150	51	2.1	2.5	.84	Do.
40	GA07–012	6.2	1.4	45	50	75	80	<.5	<1	—	Do.
41	GA07–001	9.3	.71	44	185	76	74	1.1	1	1.1	Do.
41	GA07–002	11.2	1.8	52	520	91	130	1.4	3.2	.44	Do.
41	GA07–003	12.4	.97	55	617	94	200	2.4	3.5	.69	Do.
41	GA07–004	7.1	2.4	43	156	98	65	1.0	1.9	.53	Do.
42	TA201	7.5	1.8	57	86	4	43	<.5	<1	—	Do.
43	TA203	5.3	4.13	50	80	260	65	5.3	3.7	1.43	Do.
39	GA07–008	46.2	<.01	98	4,200	4	2,900	5.4	6.5	.83	Dunite.
39	GA07–009	45.8	<.01	97	2,870	3	4,000	<.5	2	—	Do.
39	GA07–011	17.6	.25	63	1,580	9	450	6.7	8.2	.82	Peridotite.
44	TA202	28.5	.07	82	1,740	8	1,600	2.5	1.7	1.47	Soapstone.
Chauga–Walhalla thrust complex[5]											
46	OP1R1	8.41	1.24	39	254	21	120	.6	<1	—	Amphibolite.
49	CO99R1	4.15	1.68	34	169	27	89	.7	1	.7	Do.
49	CO99R2	6.78	1.76	46	79	46	37	<.5	<1	—	Do.
50	CO271R1	6.68	1.13	23	174	<1	66	<.5	<1	—	Do.
45	OP2R1	25.1	.74	110	2,400	78	940	.7	<1	—	Soapstone.
45	OP3R1	26.7	.59	120	3,100	56	1,000	<.5	<1	—	Do.
Six Mile thrust sheet[6]											
51	P2R1	5.63	.73	40	8	87	13	<.5	1.8	—	Amphibolite.
51	P2R2	8.32	.28	43	69	98	51	<.5	1	—	Do.
52	P3R1	6.56	.67	79	30	210	42	.6	<1	—	Gabbro.
53	P1R1	9.10	.24	52	91	100	73	8.1	5.1	1.59	Amphibolite.
54	P6R1	5.51	.37	35	39	13	33	3.1	2.0	1.55	Do.
54	P6R2	14.2	.19	61	1,070	1	270	5.2	5.2	1	Do.
54	P6R3	7.73	.40	45	11	70	40	<.5	<1	—	Do.
55	P7R1	4.89	.52	35	47	21	22	1.1	<1	—	Do.
56	P5R1	9.64	.34	55	160	110	69	13	5.3	2.45	Gabbro.
57	P4R1	4.11	.61	32	18	28	7	.8	<1	—	Do.
58	AN4R1	5.26	3.82	57	89	160	69	8.4	7.0	1.2	Amphibolite.
59	AN3R1	5.33	.45	41	16	65	23	<.5	<1	—	Gabbro.
59	AN3R2	5.73	.59	50	7	110	17	<.5	<1	—	Do.
59	AN3R3	5.22	.41	40	28	56	43	<.5	<1	—	Do.
59	GASW12	5.9	.61	52	7	120	17	<.5	<1	—	Do.
60	GASW5	11.7	1.9	61	513	99	160	2.5	4.6	.54	Do.
61	AN1R1	6.45	.31	42	62	140	38	6.2	2.6	2.38	Do.
61	AN1R2	7.1	.35	51	38	58	35	6.3	1.9	3.32	Do.
61	AN1R3	5.89	.27	34	143	32	36	7.7	3.2	2.4	Mafic dike.
62	GASW3	5.5	.44	47	11	250	19	1.3	<1	—	Gabbro.
62	GASW4	6.9	.63	64	28	260	46	1.0	2.8	.36	Do.
63	AN2R1	3.14	.42	28	24	23	12	2.7	1.1	2.45	Quartz diorite.
63	AN2R2	7.4	.39	35	81	12	42	1.4	7.3	.19	Amphibolite.
47	CL1R1	27.5	.27	120	1,500	26	810	.8	1	.8	Chlorite schist.
47	CL1R2	27.7	.37	130	1,700	19	840	1.1	1.4	.79	Ultramafic rock.

Table 3.—Selected chemical components in mafic (MgO <16 weight percent), ultramafic (MgO >16 weight percent), and related rocks from selected thrust sheets, Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina, and northwestern part of the Spartanburg 1° × 2° quadrangle, South Carolina and North Carolina—Continued

Map No.	Field No.	MgO (%)	TiO_2 (%)	Co (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pd (ppb)	Pt (ppb)	Pd/Pt	Rock type
Six Mile thrust sheet[6]—Continued											
48	SE1R1	31.5	0.19	140	1,900	14	950	0.8	1	0.8	Ultramafic schist.
48	SE1R2	29.9	.31	110	1,800	35	670	<.5	1.1	—	Chlorite schist.
Laurens thrust sheet[7]											
65	WSW1R1	7.41	.93	52	292	120	94	<.5	<1	—	Amphibolite.
65	WSW1R6	4.86	1.87	17	183	290	82	<.5	<1	—	Biotite gneiss.
65	WSW1R7	7.13	.83	52	263	42	55	<.5	<1	—	Amphibolite.
65	HB87–11	7.37	.88	53	333	118	113	—	—	—	Do.
65	HB87–12	9.0	.90	55	353	26	120	—	—	—	Do.
65	HB87–13	8.73	.86	53	333	23	125	—	—	—	Do.
66	WSE1R6	5.36	1.03	27	80	32	30	<.5	<1	—	Biotite gneiss.
66	WSE1R7	5.64	1.86	40	37	17	14	<.5	<1	—	Amphibolite.
64	WSW4R1	21.2	.51	76	1,940	99	910	5.6	3.6	1.56	Metapyroxenite(?).
65	WSW1R4	—	—	100	17	>1,000	75	1.1	1.5	.73	Massive sulfide.
65	WSW1R5	—	—	5	39	>1,000	9	<.5	1.2	—	Gossan.
65	WSW1R8	—	—	11	4	160	8	<.5	3.6	—	Magnetite quartzite.
Mafic–ultramafic thrust sheet[8]											
86	AB218	5.44	.96	42	80	114	41	<.5	<1	—	Gabbro.
87	AB217R1	8.83	3.01	69	135	50	99	<.5	<1	—	Do.
87	AB217R2	12.3	3.06	51	515	72	101	<.5	<1	—	Mafic rock.
88	AB231R1	4.38	.85	25	99	13	25	.9	<1	—	Mafic dike.
88	AB231R3	8.86	.09	39	600	73	130	4.9	3.2	1.53	Gabbro.
89	AB232R1	8.86	.84	41	660	4	130	<.5	<1	—	Do.
89	AB232R2	6.91	.69	32	370	3	82	<.5	<1	—	Do.
91	AB214R1	7.0	.68	34	43	120	55	<.5	3.2	—	Do.
92	AB215R3	14.1	1.25	63	1,000	2	250	1.9	3.3	.58	Do.
95	AB211R2	6.82	1.02	35	37	110	36	<.5	1.0	—	Do.
96	AB210	9.33	1.19	50	79	93	77	<.5	1.0	—	Do.
84	AB220	20.4	.28	140	5,060	191	663	18	9.5	1.89	Ultramafic rock.
85	AB219	20.7	.11	91	320	<2	660	<.5	<1	—	Do.
88	AB216R1	19.9	.08	102	695	152	421	40	33	1.21	Do.
88	AB216R2	24.0	.11	114	1,067	87	573	61	22	2.77	Do.
88	AB231R2	25.8	.06	110	930	77	510	13	8.6	1.51	Do.
90	AB208	23.8	.43	101	1,086	31	861	4.3	4.9	.88	Do.
91	AB214R2	22.6	<.02	93	861	<2	809	5.7	1.3	4.38	Do.
92	AB215R1	27.5	.34	109	2,270	16	1,060	2.5	1.8	1.39	Do.
92	AB215R2	26.0	.38	104	1,297	10	1,330	2.8	4.5	.62	Do.
92	AB215R4	27.7	.32	110	2,900	30	1,000	1.3	2.2	.59	Soapstone.
93	AB213R1	21.4	.39	91	1,473	57	556	2.6	2.4	1.08	Ultramafic rock.
93	AB213R2	27.7	.26	123	1,177	40	802	1.7	2.2	.77	Do.
94	AB212R1	23.3	<.02	186	95	10	255	<.5	<1	—	Do.
94	AB212R2	27.8	.22	173	45	11	292	<.5	<1	—	Do.
95	AB211R1	33.1	.06	170	68	4	631	8.2	1.2	6.83	Do.
97	AB209	22.4	.26	86	2,050	98	423	3.1	5.2	.6	Do.
Charlotte thrust sheet[9]											
67	86ABE1D	3.35	2.42	24	10	12	18	<.5	<1	—	Tonalite.
67	AB186–R1	4.91	2.95	27	80	<10	44	<.5	<1	—	Gabbro.
67	AB186–R2	3.89	3.24	34	9	45	20	<.5	<1	—	Do.
67	AB186–R3	7.41	3.20	36	202	<10	89	<.5	<1	—	Do.
68	AB227	7.48	.47	34	410	57	170	<.5	<1	—	Do.
69	GKSC87–4A	3.6	.6	27	5	20	4	<.8	.9	—	Do.

Table 3.—Selected chemical components in mafic (MgO <16 weight percent), ultramafic (MgO >16 weight percent), and related rocks from selected thrust sheets, Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina, and northwestern part of the Spartanburg 1° × 2° quadrangle, South Carolina and North Carolina—Continued

Map No.	Field No.	MgO (%)	TiO_2 (%)	Co (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pd (ppb)	Pt (ppb)	Pd/Pt	Rock type
					Charlotte thrust sheet[9]—Continued						
69	GKSC87–4B	5.66	2.39	31	19	29	80	<0.8	<0.5	—	Gabbro.
69	GKSC87–4C	5.67	3.0	44	24	57	40	<.8	1.6	—	Do.
70	GKSC87–5	8.72	1.71	79	213	90	114	<.8	<.5	—	Do.
71	GKSC87–6	5.66	3.77	65	38	50	20	<.8	<.5	—	Diabase.
72	86BR7	5.8	3.97	14	23	13	20	<.5	<1	—	Gabbro.
73	86BR6	5.8	3.99	27	33	18	19	<.5	<1	—	Do.
74	86BR5A	5.6	4.01	22	18	8	19	<.5	<1	—	Do.
74	86BR5B	7.2	.75	34	90	47	78	<.5	<1	—	Do.
75	GKSC87–7	12.4	.73	60	247	45	328	<.8	<.5	—	Do.
75	GKSC87–8	6.63	1.15	49	7	288	29	50	29	1.67	Do.
75	SC87–9	11.7	.87	73	765	138	424	17	14	1.21	Diabase.
75	86BR1	7.9	.95	47	53	220	53	12	8.5	1.41	Gabbro.
76	86BR4	7.8	1.03	52	50	130	47	7.6	5.8	1.31	Do.
77	86BR2	9.8	1.41	57	349	76	260	<.5	<1	—	Do.
77	86BR3	8.6	.79	33	81	43	56	1	4.9	2.24	Do.
77	88BR2	12.6	.44	62	380	55	100	11	6.3	1.75	Do.
78	88BR1	8.5	.68	48	140	66	74	7.3	4.9	1.49	Do.
79	88BR4	7.45	1.49	54	230	67	170	<.5	<1	—	Mafic rock.
79	88BR5	9.51	.56	51	580	16	110	2.8	3.1	.9	Gabbro.
80	88BR3	6.87	1.55	52	200	72	150	<.5	<1	—	Do.
81	AB230	4.38	1.79	26	12	29	9	<.5	<1	—	Do.
83	AB229	6.58	3.0	36	27	49	25	<.5	<1	—	Do.
82	AB228	21.0	1.25	94	1,500	33	840	<.5	<1	—	Pyroxenite.
					Mt. Carmel Complex (Charlotte thrust sheet)[10]						
	AB169	5.13	5.12	49	18	47	35	<.5	<1	—	Gabbro.
	AB170R1	6.78	5.41	35	35	20	11	<.5	<1	—	Do.
	AB170R2	5.6	4.44	36	30	23	14	<.5	<1	—	Do.
	AB171R	6.39	4.23	33	66	28	39	<.5	<1	—	Do.
	AB171R1	5.66	3.79	33	49	31	41	<.5	<1	—	Do.
	AB172R	4.99	3.89	29	20	29	35	<.5	<1	—	Do.
	AB172R1	5.32	3.62	24	25	20	11	<.5	<1	—	Do.
	AB173R	7.39	7.95	61	5	340	83	<.5	<1	—	Do.
	AB173R1	9.35	8.91	54	9	55	16	<.5	<1	—	Do.
	AB174	7.22	6.17	57	22	47	26	<.5	<1	—	Do.
	78–1	5.5	4.28	57	66	47	22	<.5	<1	—	Do.
	124–20	5.29	5.08	54	7	28	3	<.5	<1	—	Do.
	124–37	5.1	4.54	53	24	107	67	<.5	<1	—	Do.
	126–1	5.31	3.17	40	117	53	129	<.5	<1	—	Do.
	126–5	3.38	3.36	34	5	19	8	<.5	<1	—	Do.
	126–8	5.18	4.77	49	21	30	36	<.5	<1	—	Do.
	126–17	5.88	4.44	45	50	35	22	<.5	<1	—	Do.
	126–18	5.0	3.90	47	29	85	21	<.5	<1	—	Do.
	126–23	6.9	4.86	65	74	86	53	<.5	<1	—	Do.
	126–25	3.3	2.98	34	4	53	7.1	.6	<1	—	Do.
	126–27	6.16	5.37	55	17	37	7	<.5	<1	—	Do.
	126–29	6.49	2.62	58	94	35	45	<.5	<1	—	Do.
	126–32	6.1	5.36	36	35	65	26	<.5	<1	—	Do.
	180–18	3.51	2.27	40	13	70	39	<.5	<1	—	Do.
	GKSC–1	2.45	1.81	16	12	15	4	<2	<1	—	Diorite.
	GKSC–2	.17	.1	.8	1.2	2	<2	<2	<1	—	Rhyolite.
	GKSC–3A	4.37	4.1	36	19	29	44	<2	1	—	Diorite.
	GKSC–3B	.13	.05	.1	<3	4	<2	<2	<1	—	Rhyolite.
	86CAR1A	7.34	7.43	66	10	60	34	<.5	<1	—	Gabbro.

Table 3.—Selected chemical components in mafic (MgO <16 weight percent), ultramafic (MgO >16 weight percent), and related rocks from selected thrust sheets, Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina, and northwestern part of the Spartanburg 1° × 2° quadrangle, South Carolina and North Carolina—Continued

Map No.	Field No.	MgO (%)	TiO_2 (%)	Co (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pd (ppb)	Pt (ppb)	Pd/ Pt	Rock type
					Mt. Carmel Complex (Charlotte thrust sheet)[10]—Continued						
	86CAR1B	6.85	5.86	61	21	62	44	<0.5	<1	—	Gabbro.
	86CAR2A	5.72	4.69	27	28	11	19	<.5	<1	—	Do.
	86CAR2B	5.87	5.24	35	7	27	38	<.5	<1	—	Do.
	86CAR2C	5.59	4.44	28	15	20	20	<.5	<1	—	Do.
	86CAR2D	5.13	3.87	32	19	24	15	<.5	<1	—	Do.
	86CAR2E	.11	.06	3	2	<10	6	<.5	<1	—	Aplite.
					Spartanburg 1° × 2° quadrangle (Charlotte thrust sheet)						
					Mafic complex at Buffalo[11]						
	U125–1	19.7	.5	100	593	114	437	1.8	<1	—	Gabbro.
	U125–6	7.9	1.24	54	237	120	115	<.5	<1	—	Norite.
	U125–8	14.7	.72	61	990	8	188	<.5	<1	—	Gabbro.
	U125–14	12.7	.65	61	362	<1	211	8.4	1.2	7	Do.
	U125–29	14.6	1.26	94	451	152	341	3.8	4.4	.86	Norite.
	U125–31	23.2	.4	101	2,410	91	682	7.8	5.7	1.37	Do.
	U125–32	13.2	.77	53	1,300	297	312	1.2	2.3	.52	Gabbro.
	U127–1	13.5	.49	75	337	233	338	<.5	<1	—	Do.
	U127–3	9.70	.60	60	203	124	169	<.5	<1	—	Do.
	U127–4	6.94	.97	41	93	74	105	<.5	<1	—	Do.
	U127–5	9.8	1.0	57	223	89	180	<.5	<1	—	Do.
	U127–7	21.0	.47	100	1,123	48	734	1.3	2	.65	Do.
	U127–9	15.7	.50	88	264	57	405	1.8	<1	—	Norite.
	U127–13	18.5	.45	92	953	85	720	1.3	<1	—	Gabbro.
	U127–15	15.1	1.0	74	605	132	411	.7	<1	—	Norite.
	U127–16	14.9	.36	64	477	238	248	<.5	<1	—	Gabbro.
	U127–17	12.2	.31	53	385	148	374	.8	2.4	.33	Do.
	U127–18	17.6	.44	92	545	112	478	1.2	<1	—	Gabbro.
	U127–22	8.1	1.0	46	222	88	175	<.5	<1	—	Do.
	U127–23	8.7	.28	34	318	99	179	1.3	<1	—	Do.
	U127–25	16.0	.44	82	531	144	473	<.5	<1	—	Do.
	U127–27	12.1	.87	57	307	97	298	<.5	<1	—	Do.
	U127–29	19.3	.67	81	1,690	68	520	9.4	1.0	9.4	Do.
	U127–30	9.0	.46	38	143	134	165	<.5	<1	—	Do.
	U185–1	13.2	.37	56	574	303	395	7.1	1.2	5.92	Do.
	U185–7	15.7	1.32	73	248	31	285	<.5	<1	—	Norite.
	U185–9	12.8	.4	83	235	233	239	<.5	<1	—	Gabbro.
	U185–13	8.8	.28	37	94	19	110	<.5	<1	—	Do.
	U185–30	8.3	.28	46	203	137	189	<.5	<1	—	Do.
	U185–32	9.4	.42	48	97	96	167	<.5	<1	—	Do.
	U185–34	10.8	.56	62	234	124	186	<.5	1.4	—	Do.
	U185–36	13.3	.34	58	882	190	440	.9	2.6	.35	Do.
	U185–37	11.5	.4	62	219	98	230	<.5	<1	—	Do.
	U185–41	12.7	.32	58	630	227	270	<.5	<1	—	Do.
	86BC–1	7.94	1.74	61	117	340	160	<.5	<1	—	Diabase.
	86BC–2	8.24	1.69	74	110	180	150	<.5	<1	—	Do.
	86BC–3	7.66	1.79	57	24	160	120	<.5	<1	—	Gabbro.
	86BC–4	16.8	.66	64	884	93	530	.6	1.3	.46	Do.
	86BC–5	10.5	.56	49	176	92	210	<.5	<1	—	Do.
	86BC7B	19.3	.44	73	1,547	280	600	2.6	1.8	1.44	Do.
	86BC7A	19.2	.46	71	1,710	290	580	2.5	2.1	1.19	Do.
	86BC6	16.1	.3	74	366	110	420	.7	1.5	1.13	Do.
	GKSC–11	14.1	.98	70	619	96	412	<2	1	—	Do.

Table 3.—Selected chemical components in mafic (MgO <16 weight percent), ultramafic (MgO >16 weight percent), and related rocks from selected thrust sheets, Greenville 1° × 2° quadrangle, South Carolina, Georgia, and North Carolina, and northwestern part of the Spartanburg 1° × 2° quadrangle, South Carolina and North Carolina—Continued

Map No.	Field No.	MgO (%)	TiO_2 (%)	Co (ppm)	Cr (ppm)	Cu (ppm)	Ni (ppm)	Pd (ppb)	Pt (ppb)	Pd/Pt	Rock type
				Spartanburg 1° × 2° quadrangle (Charlotte thrust sheet)—Continued							
				Mafic complex at Buffalo[11]—Continued							
	GKSC–12	5.99	2.42	40	5	141	29	3.5	<1	—	Gabbro.
	GKSC–13	9.67	.36	45	313	45	221	<.8	.5	—	Do.
				Broad River locality (Charlotte thrust sheet)[12]							
	GKSC–14A	8.52	1.49	44	416	72	121	2.2	1.7	1.29	Amphibolite.
	GKSC–14B	7.27	.26	38	411	170	86	73	30	2.4	Gabbro.
	GKSC–14C	3.62	1.57	13	19	104	30	<.8	2.9	—	Altered rock.
	GKSC–14D	16.5	.28	101	116	47	221	39	16	2.44	Gabbro.

[1]Samples collected by F.G. Lesure, J.A. Goss, and David Gottfried, USGS, in 1985–87 and by A.E. Nelson, USGS, in 1979–80.
[2]Samples collected by R.P. Koeppen, USGS, in 1985 and by F.G. Lesure and David Gottfried, USGS, in 1986.
[3]Samples collected by F.G. Lesure, USGS, in 1966–69 and 1985–88 and by R.P. Koeppen, USGS, in 1982.
[4]Samples collected by R.P. Koeppen, USGS, in 1978; W.J. Moore and J.D. Peper, USGS, in 1985; F.G. Lesure and David Gottfried, USGS, in 1986–88; and G.C. Curtin, USGS, in 1987–88.
[5]Samples collected by G.C. Curtin, David Gottfried, and F.G. Lesure, USGS, in 1988.
[6]Samples collected by J.W. Horton, Jr., USGS, in 1984 and by G.C. Curtin, David Gottfried, and F.G. Lesure, USGS, in 1988.
[7]Samples collected by Henry Bell, III, USGS, in 1987 and by G.C. Curtin, David Gottfried, and F.G. Lesure, USGS, in 1988.
[8]Samples collected by G.C. Curtin, David Gottfried, and F.G. Lesure, USGS, in 1986–88.
[9]Samples collected by G.C. Curtin, David Gottfried, R.P. Koeppen, and F.G. Lesure, USGS, in 1986–88.
[10]Sample sites shown on figure 5. Samples collected by J.H. Medlin (1968) in 1966 and by G.C. Curtin, David Gottfried, and R.P. Koeppen, USGS, in 1986–87.
[11]Sample sites shown on figures 6 and 7. Samples collected by J.H. Medlin (1968) in 1966 and by G.C. Curtin, David Gottfried, and R.P. Koeppen, USGS, in 1986–87.
[12]Sample site shown on figure 6. Samples collected by David Gottfried and R.P. Koeppen, USGS, in 1987.

Table 4.—Summary of platinum-group elements in mafic (MgO <16 weight percent) and ultramafic rocks (MgO >16 weight percent) in the Greenville 1° × 2° quadrangle and northwestern part of the Spartanburg 1° × 2° quadrangle (table 3) compared to similar data from the North Carolina Blue Ridge province in the Knoxville 1° × 2° quadrangle (Robinson and others, 1992)

[ppb, parts per billion; —, not applicable]

Thrust sheet and rock type[1]	Palladium (Pd) (ppb)			Platinum (Pt) (ppb)		
	Low	High	Median	Low	High	Median
Greenville quadrangle						
Richard Russell thrust sheet:						
MgO 6.0–9.6 wt. pct. (8)	<0.5	14	1.5	<1	15	3
MgO >16 wt. pct. (7)	2.7	17	6.8	3.6	32	17
Young Harris thrust sheet:						
MgO 6.0–9.2 wt. pct. (9)	<.5	2.1	<.5	<1	3	<1
MgO >16 wt. pct. (2)	3.2	4.4	—	5	6	—
Helen thrust sheet:						
MgO 4.4–9.6 wt. pct. (11)	<.5	12	1.2	<1	7.2	1.3
MgO >16 wt. pct. (3)	1.4	13	2.5	1.8	9	6.6
Tallulah Falls thrust sheet:						
MgO 4.5–12.4 wt. pct. (13)	<.5	6.4	1.0	<1	4	1.1
MgO >16 wt. pct. (4)	<.5	6.7	4	1.7	8.2	4.3
Chauga–Walhalla thrust complex:						
MgO 4.15–8.41 wt. pct. (4)	<.5	.7	<.5	<1	1	<1
MgO >16 wt. pct. (2)	<.5	.7	—	<1	<1	—
Six Mile thrust sheet:						
MgO 3.14–14.2 wt. pct. (23)	<.5	13	1.3	<1	7.3	1.8
MgO >16 wt. pct. (4)	<.5	1.1	.8	1	1.4	1.1
Laurens thrust sheet:						
MgO 4.86–7.41 wt. pct. (5)	<.5	<.5	<.5	<1	<1	<1
MgO >16 wt. pct. (1)	—	5.6	—	—	3.6	—
Mafic–ultramafic thrust sheet:						
MgO 4.38–14.1 wt. pct. (11)	<.5	4.9	<.5	<1	3.3	<1
MgO >16 wt. pct. (16)	<.5	61	3.1	<1	33	2.2
Charlotte thrust sheet:						
MgO 3.35–12.6 wt. pct. (31)	<.5	73	<.5	<.5	30	<1
MgO >16 wt. pct. (2)	<.5	39	—	<1	16	—
Charlotte thrust sheet—Mt. Carmel Complex:						
MgO 2.45–9.35 wt. pct. (35)	<.5	<2	<.5	<1	1	<1
Spartanburg quadrangle						
Charlotte thrust sheet—Mafic complex at Buffalo:						
MgO 5.99–16.0 wt. pct. (35)	<.5	8.4	<.5	<1	4.4	<1
MgO >16 wt. pct. (10)	.6	9.4	1.55	<1	5.7	1.2
Knoxville quadrangle						
North Carolina Blue Ridge thrust stack[2]:						
MgO 4–12.5 wt. pct. (23)	<.5	36	3.6	<1	24	4
MgO 19–28 wt. pct. (12)	1.6	82	14	4.2	150	15
MgO >40 wt. pct. (17)	.1	39	.4	<1	24	3

[1]Number in parentheses is number of samples.

[2]Data from Robinson and others (1992).