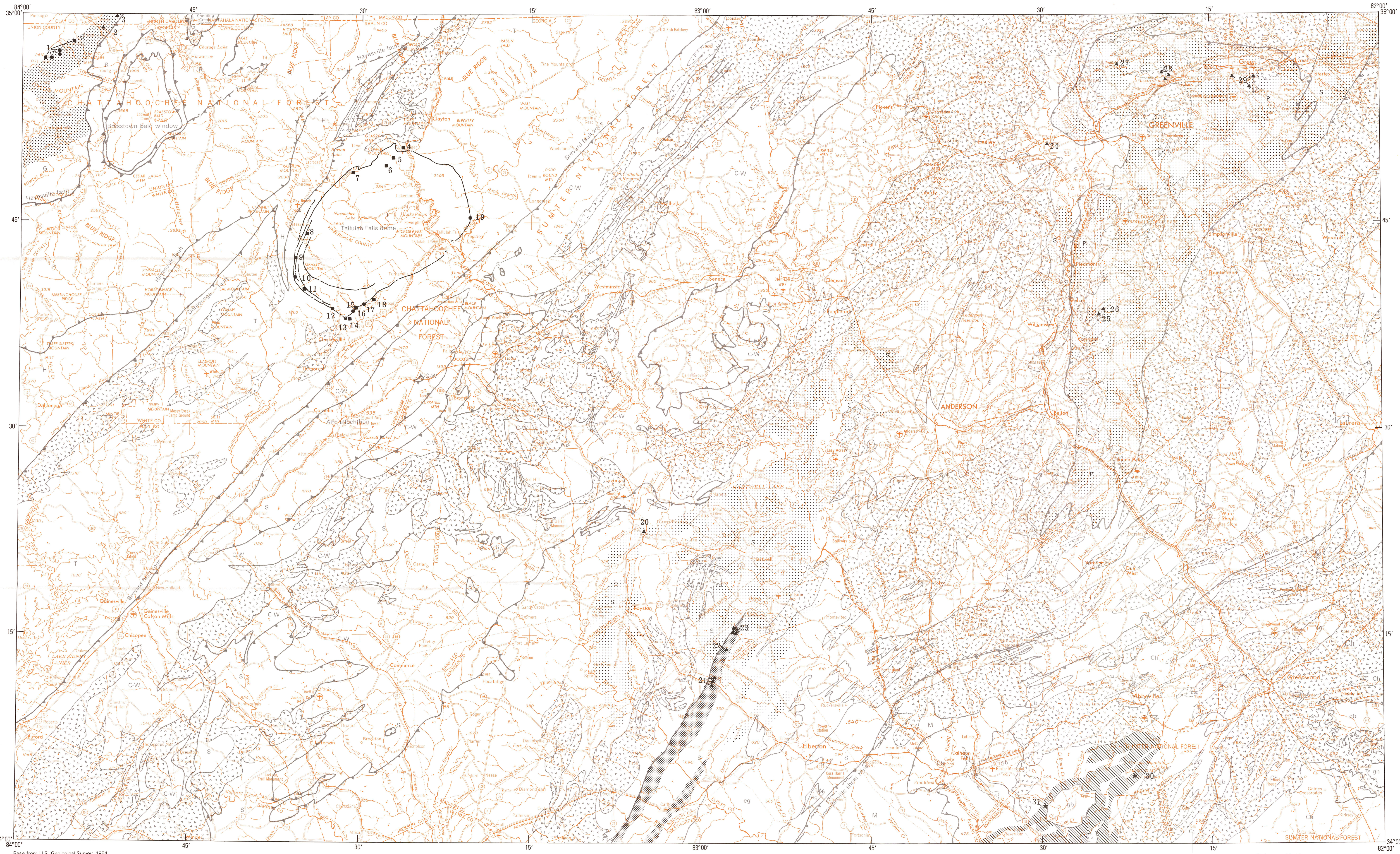

Base from U.S. Geological Survey, 1954, (limited revision, 1964)
Transverse Mercator projection

SCALE 1:250 000
5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 30 35 KILOMETERS
DATUM IS MEAN SEA LEVEL

Geology modified from Nelson and others (1987, 1989)
Manuscript approved for publication March 19, 1992
Revised manuscript received October 1, 1993

MAP SHOWING AREAS THAT CONTAIN KYANITE, SILLIMANITE, AND ANDALUSITE RESOURCES IN THE GREENVILLE 1° × 2° QUADRANGLE, SOUTH CAROLINA, GEORGIA, AND NORTH CAROLINA

EXPLANATION

Great Smoky thrust sheet

Wehutty and Hughes Gap Formations, undivided—Sillimanite more abundant to northeast and south; kyanite more abundant to west

Tallulah Falls thrust sheet

Kyanite schist layers in the Tallulah Falls Formation of Hatcher (1971)—Queried where uncertain. Outcrop pattern generalized from Prindle and others (1935); Teague and Furcron (1948), Hurst and Crawford (1964), and Hatcher (1971, 1974). Soil overlying schist generally contains residual concentration of coarse kyanite crystals as much as 1 to 2 in. long

Six Mile thrust sheet

Megacrystic sillimanite-mica schist—Scattered layers of sillimanite-rich schist 1 to 100 ft thick and more than 1,000 ft long that contain 10 to 20 percent sillimanite in prisms as much as 1 to 2 in. long. Sillimanite-rich layers generally are more resistant and are interlayered with sillimanite-poor schist and granite

S **Sillimanite-mica schist**—Contains scattered layers that contain as much as 12 to 13 percent sillimanite; generally finer grained than megacrystic unit. Has lower potential for mineable deposits

Paris Mountain thrust sheet

P **Sillimanite-mica schist**—Locally contains layers rich in coarse-grained sillimanite similar to the megacrytic unit of the Six Mile thrust sheet. Sillimanite content ranges from 1 to 17 percent

Charlotte thrust sheet

Quartzite, quartz-muscovite schist, crystal-lithic metatuff, mafic volcanic rock of the Carolina slate belt, and muscovite schist and amphibolite of the Charlotte belt, undivided—Two areas of hydrothermal alteration known. Deposits are quartz–andalusite–pyrophyllite. Low to moderate potential for additional high-alumina deposits. Area not thoroughly prospected

Mineral deposit—Number refers to table 1

- ●1 **Kyanite-rich schist**
- ■5 **Kyanite placer**
- ▲21 **Sillimanite-rich schist**
- ★31 **Quartz–andalusite–pyrophyllite rock**

LIST OF MAP UNITS AND SYMBOLS
[Stacking order of thrust sheets]

Blue Ridge thrust stack

- T **Tallulah Falls thrust sheet**
- R **Richard Russell thrust sheet**
- Y **Young Harris thrust sheet**
- H **Helen thrust sheet**
- G **Great Smoky thrust sheet**

Inner Piedmont thrust stack

- L **Laurens thrust sheet**
- P **Paris Mountain thrust sheet**
- S **Six Mile thrust sheet**—Includes the metagabbro at Anderson (Paleozoic?) (ag) and the Elberton Granite (Mississippian) (eg)
- C-W **Chauga–Walhalla thrust complex**

Southeast of Lowndesville shear zone

- Ch **Charlotte thrust sheet**—Includes the Concord Plutonic Suite (Silurian and Devonian) (gb) and the granitic rocks at Coronaca (as used by Fullagar and Butler, 1979; Permian) (cg)
- M **Mafic–ultramafic thrust sheet**

Granite, granodiorite, quartz diorite, and diorite gneiss, undivided (Pennsylvanian to Cambrian)—Shown mostly where rocks cover large areas or where tectonic boundaries are obscured

Contact

Thrust fault—Dashed where inferred; queried where uncertain. Sawteeth on upper plate

Shear zone

Table 1.—Kyanite, sillimanite, and andalusite deposits of the Greenville 1° × 2° quadrangle

Map No.	Name of deposit	Commodity	Description	Reference
			Great Smoky thrust sheet	
1	Gumlog Mountain	Kyanite	Trench 100 ft long, shaft 20 ft deep. Several tons kyanite taken from trench. Massive kyanite in pockets in kyanite schist at several localities.	Prindle and others, 1935, p. 22.
2	Brasstown Church	Sillimanite	Four zones of sillimanite-rich mica schist, each about 200 ft wide, in belt 2,000 ft wide. Schist contains about 4 percent sillimanite.	Furcron and Teague, 1945, p. 26–27; Hash and Van Horn, 1951, p. 20.
3	Davy Mountain	do.	Four or five zones of sillimanite-rich schist, each about 100–200 ft wide, in belt 2,000 ft wide.	Hash and Van Horn, 1951, p. 20–22.
			Tallulah Falls thrust sheet	
4	Tiger Creek	Kyanite	Placer deposit in terrace gravel	Prindle and others, 1935, p. 18.
5	Stonewall Creek	do.	do.	Prindle and others, 1935, p. 17–18.
6	McClain Creek	do.	Small placer deposit, pebble gravel in terrace. Estimated to contain 1,700 tons kyanite.	Prindle and others, 1935, p. 17; Lesure and others, 1987.
7	Sawmill Creek	do.	Placer deposit	Prindle and others, 1935, p. 17.
8	Raper Creek	do.	Placer deposit of 40 acres or more. Partly worked by A.P. Green Firebrick Co., Mexico, Mo., 1939–49.	Espenshade and Potter, 1960, p. 100; Hurst and Crawford, 1964, p. 53.
9	Jackson Estate	do.	Placer deposit of 10–15 acres	Hurst and Crawford, 1964, p. 50.
10	Alec Mountain	do.	Residual deposit of kyanite in soil and weathered schist in area 200 ft wide and 1,500 ft long. Worked by Georgia-Carolina Minerals Co. and Southern Mining and Milling Co., 1932–40.	Prindle and others, 1935, p. 15; Smith, 1938, p. 523–526; Espenshade and Potter, 1960, p. 100.
11	Earnest Nations, Jr.	do.	Residual and alluvial placers in area of 7 acres	Hurst and Crawford, 1964, p. 50.
12	Sutton Mill Creek	do.	Weathered kyanite-rich schist. Worked by Georgia-Carolina Minerals Co. in 1936.	Smith, 1938, p. 526.
13	Kimsey	do.	Residual and alluvial placer area. Worked in 1934–42	Hurst and Crawford, 1964, p. 49.
14	Brown and Smith (formerly W.E. Black?).	do.	Kyanite alluvial placer. Mined 1932–35; 600 tons kyanite recovered from 1.25 acres in 1935. Unworked placer deposits remain north and south of mined area.	Prindle and others, 1935, p. 11–12; Hurst and Crawford, 1964, p. 49.
15	Parkham and N. Georgia Vocational School.	do.	Residual kyanite in soil and limited area of alluvial placer deposits.	Hurst and Crawford, 1964, p. 49, 178.
16	Sleepy Hollow	do.	Residual kyanite in soil. Mined during 1930's in small open pits, in 4- to 5-acre area above Soquee River.	Prindle and others, 1935, p. 13; Hurst and Crawford, 1964, p. 49.
17	Kollock Estate	do.	Residual kyanite in soil. Area 200 ft wide and 7,500 ft long. Estimated to contain 13,000 tons of kyanite to depth of 2 ft.	Prindle and others, 1935, p. 13; Hurst and Crawford, 1964, p. 47–49
18	MacEllen-Inglis	do.	Alluvial placer deposit in area of 4–5 acres	Hurst and Crawford, 1964, p. 47.
19	Unnamed prospect	do.	Residual kyanite in soil and alluvial placer	Teague and Furcron, 1948.
			Six Mile thrust sheet	
20	Bowersville	Sillimanite	Sillimanite-mica schist in 150-ft-wide outcrop; 12–13 percent sillimanite.	Grant, 1958, p. 65.
21	Norman	do.	Sillimanite-rich schist and granite. U.S. Bureau of Mines (USBM) drilled five holes and A.P. Green Firebrick Co. augered 31 holes in belt 200–600 ft wide and 2,700 ft long.	Hudson, 1946, p. 7.
22	Rice	do.	Sillimanite abundant in float	Grant, 1958, p. 69.
23	A.P. Green and Jenkins prospects.	do.	At least four zones of sillimanite-rich schist. Prospected by trenching and drilling by A.P. Green Firebrick Co., Georgia Geological Survey and Tennessee Valley Authority, and USBM in area 1 mi long and 0.5 mi wide. A 4-ton sample tested by USBM averaged 17 percent sillimanite. Resources of sillimanite estimated to be at least 400,000 tons.	Hudson, 1946, p. 7–10; Teague, 1951, p. 787; Grant, 1958, p. 69.
24	Lusk-Moody	do.	Residual boulders of massive crystalline sillimanite scattered in 200-acre area. Not prospected.	Brown, 1966.
			Paris Mountain thrust sheet	
25	Beam	do.	Coarse-grained sillimanite schist in 180-ft-wide zone. USBM tested 7,500-lb sample that contained 17 percent sillimanite, 61 percent biotite, 18 percent quartz, 4 percent garnet and other minerals. Three holes drilled by USBM indicate shallow depth of deposit.	Rampacek and others, 1945, p. 201; Hudson, 1946, p. 5–6.
26	Pearson-Scott	do.	Residual coarse-grained sillimanite in soil in area 200 ft wide and 1,200 ft long. Three holes, drilled by USBM, intercepted schist containing 1–6 percent sillimanite.	Hudson, 1946, p. 5–6.
27	Paris Mountain	do.	Extensive outcrops of sillimanite schist along roads in Paris Mountain State Park. Sillimanite content 13 percent.	Hudson, 1946, p. 5, 11.
28	Taylors	do.	Sillimanite schist. Three areas sampled by USBM contain 6–8 percent sillimanite.	Do.
29	Greer	do.	Sillimanite sampled in three areas. Schist units range in thickness from 150 to 200 ft; sillimanite content ranges from 8 to 20 percent.	Do.
			Charlotte thrust sheet	
30	Parsons Mountain	Andalusite	Quartzose rock containing minor andalusite and pyrophyllite in ridges 100–150 ft wide and 1,000 ft long southwest of fire tower.	Espenshade and Potter, 1960, p. 112.
31	Unnamed	do.	Quartzite and sericite-quartz rock containing minor amounts of andalusite and pyrophyllite(?). Sharp ridge west of Mt. Carmel gabbroic complex, Calhoun Creek quadrangle, S.C.	Espenshade and Potter, 1960, p. 112–113.

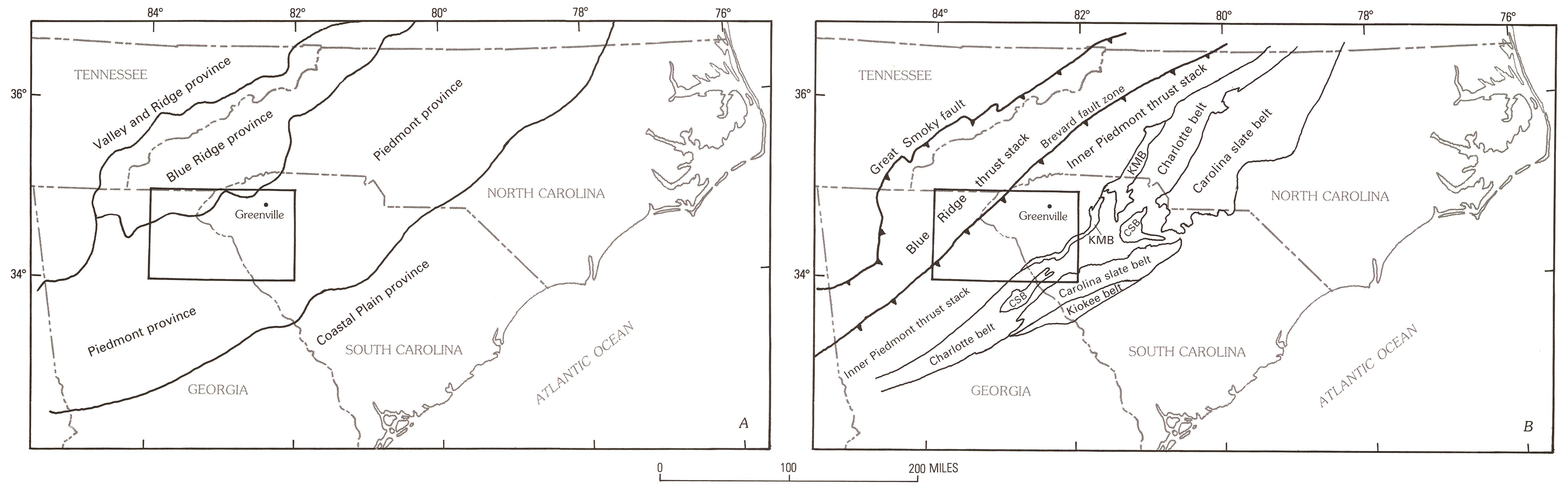

Figure 1.—Maps showing location and setting of the Greenville 1° x 2° quadrangle (box). *A*, Physiographic provinces modified from Fenneman and Johnson (1946). *B*, Previous interpretations of geologic terranes, modified from King (1955), Overstreet and Bell (1965a), and Nelson (1988); CSB, Carolina slate belt; KMB, Kings Mountain belt.

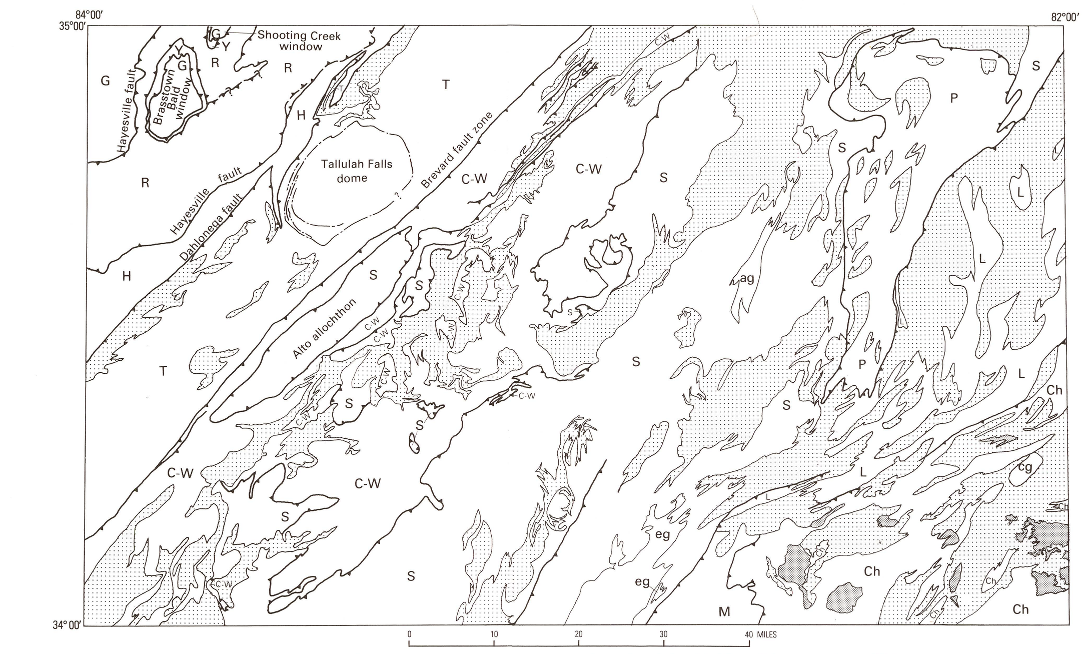

Figure 2.—Generalized tectonic map of the Greenville 1° x 2° quadrangle (modified from Nelson and others, 1990).

EXPLANATION
(Stacking order of thrust sheets)

Blue Ridge thrust stack

- T Tallulah Falls thrust sheet
- R Richard Russell thrust sheet
- Y Young Harris thrust sheet
- H Helen thrust sheet
- G Great Smoky thrust sheet

Inner Piedmont thrust stack

- L Laurens thrust sheet
- P Paris Mountain thrust sheet
- S Six mile thrust sheet—Includes metagabbro at Anderson (ag) and Elberton Granite (eg)
- C-W Chauga–Walhalla thrust complex

Southeast of Lowndesville shear zone

- Ch Charlotte thrust sheet—Includes granite at Coronaca (cg)
- M Mafic–ultramafic thrust sheet

Granitic rocks—Shown where they obscure faults or where extensive

Gabbro and related rocks

Contact

Thrust fault—Dashed where inferred; queried where uncertain. Sawteeth on upper plate

Kyanite schist—Queried where uncertain. Shown around Tallulah Falls dome

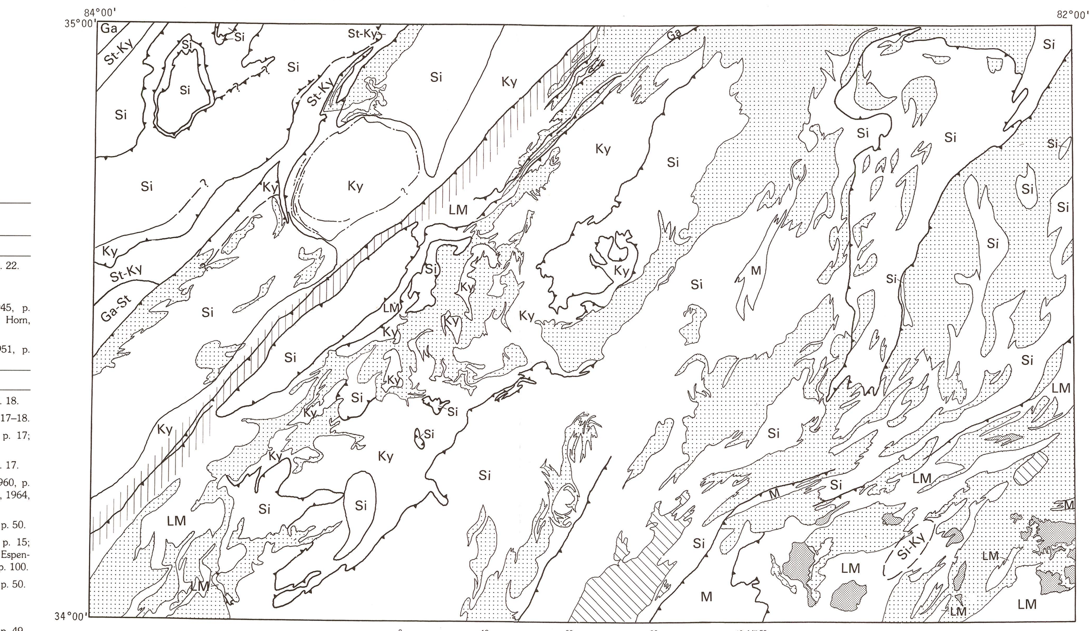

Figure 3.—Generalized tectonic map of the Greenville 1° x 2° quadrangle showing metamorphic grade and metamorphic zones (modified from Nelson, 1988). See figure 2 for explanation of geologic map units.

EXPLANATION

Metamorphic grade

- LM Low to medium
- M Medium

Metamorphic zone—May be shown combined

- Ga Garnet
- St Staurolite
- Ky Kyanite
- Si Sillimanite

Retrograded

Si-Ky Isograd—Dashed where inferred. Letters represent metamorphic zones

Granitic rocks—Shown where they obscure faults or where extensive

Gabbro and related rocks

Contact

Thrust fault—Dashed where inferred; queried where uncertain. Sawteeth on upper plate

Kyanite schist—Queried where uncertain. Shown around Tallulah Falls dome

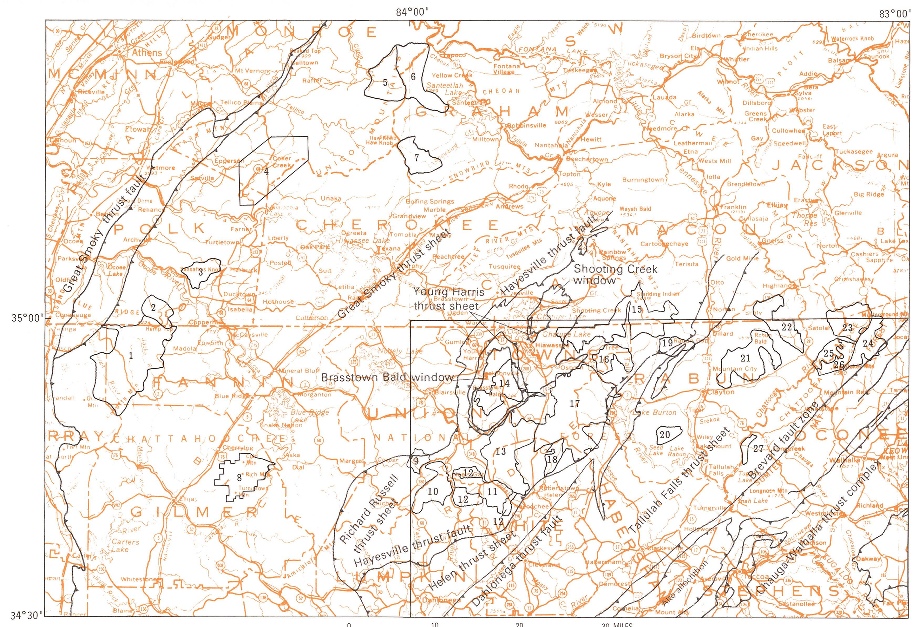

Figure 4.—Location of U.S. Forest Service wildernesses, wilderness study areas, and roadless areas in northern Georgia and adjacent parts of Tennessee, North Carolina, and South Carolina. Northwest corner of Greenville 1° x 2° quadrangle shown by box. Tectonic map generalized from Swingle and others (1966), Georgia Geological Survey (1976), North Carolina Geological Survey (1985), Nelson and others (1989), and Nelson (1991).

EXPLANATION

Thrust Fault—Dashed where inferred. Sawteeth on upper plate

Wildernesses

- 2 Big Frog
- 14 Brasstown
- 5 Citico Creek
- 1 Cohutta
- 24 Ellicott Rock
- 6 Joyce Kilmer–Slickrock
- 11 Raven Cliffs
- 8 Rich Mountain
- 14 Southern Nantahala
- 17 Tray Mountain

Wilderness Study and Roadless Areas

- 18 Anna Ruby
- 10 Blood Mountain
- 9 Board Camp
- 16 Buzzard Knob
- 13 Chattahoochee
- 26 Ellicott Rock
- 3 Little Frog
- 27 Long Creek
- 22 Overflow
- 25 Persimmon Mountain
- 21 Rabun Bald
- 24 Rand Mountain
- 12 Raven Cliff
- 7 Snowbird
- 19 Southern Nantahala
- 20 Worley Ridge

Other

- 4 Coker Creek gold district

DISCUSSION

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. 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 obtained from the literature.

This report is an assessment of the kyanite, sillimanite, and andalusite resources in the Greenville quadrangle and is based heavily on the geology as mapped by Nelson and others (1989). These minerals belong to an aluminosilicate group of minerals that also includes mullite, topaz, and dumortierite.

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 (King, 1955; Overstreet and Bell, 1965a, b; Hatcher, 1972) (fig. 1*B*).

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 separates the Inner Piedmont thrust stack from the Charlotte thrust sheet and a separate mafic–ultramafic thrust sheet.

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 lower 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 synmetamorphic. Exceptions include the Elberton Granite in the Six Mile thrust sheet, which is 350 to 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).

KYANITE GROUP OF MINERALS

The kyanite group of minerals includes kyanite, sillimanite, and andalusite—all with the same chemical composition (Al_2SiO_5)—and the rare mineral mullite ($Al_6Si_2O_{13}$). Topaz and dumortierite, which are closely related aluminosilicate minerals containing fluorine (topaz) and boron (dumortierite), are also members of the group (Espenshade, 1973, p. 307). When heated to high temperatures, these minerals convert to the composition of mullite plus silica glass. Refractories made from these materials are commonly known as mullite refractories. Because of their high alumina content, mullite refractories will withstand high temperatures, abrupt temperature change, and corrosive action, such as occur in metallurgical and glass furnaces and certain types of kilns and boilers (Espenshade and Eilertsen, 1968, p. 307). The United States is self-sufficient in the production of kyanite, but production data have not been published for many years to avoid disclosing company proprietary data. In 1983, the estimated order of magnitude for the demand for kyanite and synthetic mullite made from non-kyanite sources, such as bauxite and kaolin, was 100,000 tons (Potter, 1985, p. 425).

Kyanite, sillimanite, and andalusite are relatively common minerals that are widespread in certain types of metamorphic rocks in many parts of the world; topaz and dumortierite are much less common. In the Southeastern States, members of the kyanite group are found in minable amounts in quartzose rock and in mica schist and gneiss. Because the minerals are resistant to weathering, they are also concentrated in soils and stream and beach placers (Espenshade and Potter, 1960; Espenshade, 1962).

KYANITE, SILLIMANITE, AND ANDALUSITE RESOURCES

A belt of quartzose deposits that contain all the minerals of the kyanite group except dumortierite extends from central Virginia to eastern Georgia, mostly east of the Greenville quadrangle. Kyanite quartzites on Willis Mountain, Va., at the north end of this belt of deposits, is the principal source of the kyanite used in the United States. In addition, a deposit of andalusite-pyrophyllite-quartz rock near Hillsborough, N.C., is being worked for andalusite (McMichael, 1990, p. 32).

Within the Greenville quadrangle, kyanite and sillimanite deposits in mica schist and gneiss and the small placer deposits developed from these rocks are the only deposits found in abundance. The principal deposits are in the Great Smoky, Tallulah Falls, Six Mile, and Paris Mountain thrust sheets.

Two low-grade deposits of quartz-andalusite-pyrophyllite (table 1, Nos. 30 and 31) that contain minor amounts of andalusite are found in the Charlotte thrust sheet in the southeastern part of the quadrangle west of the main belt; these deposits, however, have not been worked (Espenshade and Potter, 1960, p. 112).

Kyanite, sillimanite, and andalusite resources are discussed according to their locations within thrust sheets from northwest to southeast. Concentrations of mullite, topaz, and dumortierite are not found in the Greenville quadrangle.

Great Smoky Thrust Sheet

The Great Smoky thrust sheet in the northwest corner of the quadrangle consists mostly of metamorphosed conglomerate, sandstone, and shale of the Great Smoky Group of Late Proterozoic age (Nelson and others, 1989). Kyanite and sillimanite are found in two formations of the group in the Great Smoky thrust sheet just west of the Hayesville thrust fault. The Wehutty Formation contains interlayered kyanite-sillimanite-graphite-muscovite schist and argillaceous and feldspathic metasandstone, and the overlying Hughes Gap Formation contains sillimanite schist interlayered with conglomeratic metasandstone and abundant thin calc-silicate beds (Nelson and others, 1989). Sillimanite is the more common aluminosilicate mineral in schist of the Wehutty Formation in an area that extends from the north end of Gumlog Mountain, which is about 2 mi southwest of Brasstown, Towns County, Ga., for 4 to 5 mi northeastward to Davy Mountain, Clay County, N.C., which is on the north border of the quadrangle (table 1, Nos. 2 and 3). In this area, four or five zones in the Wehutty Formation have sillimanite-rich layers ranging in thickness from 15 to 200 ft and containing as much as 4 percent sillimanite (Furcron and Teague, 1945, p. 27; Hash and Van Horn, 1951, p. 20). Kyanite becomes the dominant kyanite-group mineral toward the southwest end of Gumlog Mountain (table 1, No. 1) where the A.C. Spark Plug Co. prospected about 1931 (Furcron and Teague, 1945, p. 50). The kyanite is found as massive lumps ranging in size from less than 1 ft in diameter to large masses weighing about 0.5 ton and also is disseminated as coarse crystals, 1 in. or more in length, that are roughly parallel to the schist layers (Prindle and others, 1935, p. 21–23).

Resources of kyanite and sillimanite in these two bedrock formations in the Great Smoky thrust sheet are probably large, but minable thicknesses have not yet been outlined. Additional resources are probably present in small surficial deposits, especially placer deposits formed where streams drain the kyanite or sillimanite zones. No record has been found that such surficial deposits have been prospected in this area.

Tallulah Falls Thrust Sheet

The Tallulah Falls thrust sheet is composed of interlayered and folded metagraywacke, mica schist, amphibolite, aluminous schist, quartzite, biotite gneiss, biotite schist, and quartzofeldspathic gneiss (Nelson and others, 1989). Layers of kyanite-rich mica schist form a nearly complete outcrop pattern around the Tallulah Falls dome in Rabun and Habersham Counties, Ga. (map; Prindle and others, 1935, p. 7–19; Teague and Furcron, 1948; Furcron, 1950; Espenshade and Potter, 1960, p. 99–102; Hurst and Crawford, 1964, p. 46–54; Hatcher, 1974). This schist is part of the garnet-aluminous schist member of the Tallulah Falls Formation of Hatcher (1971, p. 9–12), which ranges in thickness from 100 ft to as much as 800 ft (Prindle end others, 1935, p. 9; Hatcher, 1971, p. 11). Much of the kyanite produced in Georgia up to 1949 came from this belt of rocks (Espenshade and Potter, 1960, p. 99). The total production from the district is not known, but the recorded production from several small deposits worked from 1932 through 1935 is 1,100 tons of kyanite concentrates (Smith, 1938, p. 525). Mining was conducted at several places, mostly in the southern and western parts of the belt. From 1932 to 1935, residual deposits of kyanite crystals in soil and saprolite were mined on Alec Mountain, about 7 mi northwest of Clarkesville, Ga. (table 1, No. 10). Later, from 1935 to World War II, partly weathered rock was mined on Alec Mountain and near Sutton Mill Creek (table 1, No. 12), about 2.5 mi northwest of Clarkesville (Prindle and others, 1935, p. 11–18; Smith, 1938, p. 526; Espenshade and Potter, 1960, p. 100). Stream-placer deposits (table 1, Nos. 13 and 14) were also worked along several small streams about 1 mi northeast of Clarkesville from 1932 to 1942 (Hurst and Crawford, 1964, p. 49–53). Larger stream-placer deposits along Raper Creek (table 1, No. 8), about 0.5 mi north of its junction with Soquee River and about 9 mi northwest of Clarkesville, were worked from 1939 to 1949 (Espenshade and Potter, 1960, p. 100; Hurst and Crawford, 1964, p. 53).

Kyanite is found as coarse blue-gray crystals commonly 1 in. or more long, as much as 0.5 in. wide, and about 0.25 in. thick. The crystals are concentrated within thin layers, 1 to 6 in. thick, in aluminous schist. The kyanite-rich schist layers range in thickness from 1 to 60 ft and are separated by kyanite-poor layers of schist and gneiss of similar thickness. The schist is locally graphitic; in some areas it is mostly a quartz-muscovite-garnet or quartz-biotite-muscovite-garnet schist. The kyanite content ranges from 1 to 15 percent but averages 6 to 8 percent in those few places favorable for mining (Smith, 1938, p. 522). Discontinuous layers of kyanite-rich schist are found outside of the main kyanite schist belt; these layers may be due to folding or faulting of the main schist unit.

Total kyanite resources in this belt are large, but the size of minable deposits is probably small. Coarse kyanite crystals are found in abundance in the soil and colluvium along the schist belt. Similar large crystals can be readily obtained from the weathered schist. In areas where the dip of the foliation and compositional layering is low and the outcrop area is wide, large tonnages of residual kyanite might be available near the ground surface. Small deposits of alluvium along streams crossing the schist belt contain concentrations of kyanite as do some higher terrace deposits along some of the larger streams (Prindle and others, 1935, p. 11–12; Hurst and Crawford, 1964, p. 46–54). About 22 acres of alluvium along McClain Creek (table 1, No. 6) in the Worley Ridge Roadless Area along the northwestern part of the schist belt (fig. 4) is estimated to contain about 1,700 tons of kyanite (Lesure and others, 1987). The larger alluvial deposits along streams like Raper Creek, Sutton Mill Creek and its tributary Beaverdam Creek, and Soquee River probably contain much more kyanite. Details of kyanite content in the schist, thickness of the kyanite-rich layers, and thickness of the schist unit are not known well enough to estimate total resources in rock or saprolite. Similarly, data concerning kyanite content, area, and volume of alluvium and colluvium are also not available, the lack of data precludes quantitative resource estimates of placer deposits.

Hatcher (1974) showed numerous narrow bands of aluminous schist extending northeast of the main belt around the Tallulah Falls dome. In the Ellicott Rock Wilderness and the Overflow and Rabun Bald Roadless Areas (fig. 4), these aluminous schist units contain 2 percent or less kyanite or sillimanite and do not appear to have significant resource potential (Koeppen and others, 1983; Luce and others, 1983; Moore and others, 1988). These aluminous schist units are, therefore, not shown on the resource map.

Six Mile Thrust Sheet

The Six Mile thrust sheet contains extensive areas underlain by sillimanite-bearing schist. Other rock types present include mica schist, manganiferous schist, felsic gneiss, amphibolite, quartzofeldspathic gneiss, megacrystic biotite gneiss, metagraywacke, quartzite schist, and quartzite (Nelson and others, 1989). In Madison, Elbert, and Hart Counties, Ga., one unit containing abundant layers of megacrystic sillimanite-mica schist extends northeastward in an outcrop belt 0.5 to 1.5 mi wide for about 22 mi from the south border of the quadrangle. A smaller, parallel belt of similar rock, 1.5 to 2 mi to the east in Madison and Elbert Counties, Ga., is about 8 mi long and 0.5 to 1 mi wide. Hudson (1946, p. 6) mentioned 126 sillimanite localities in these belts in the three counties. Two areas were extensively prospected just after World War II. The Norman area (table 1, No. 21) contains coarse sillimanite float in an area about 200 to 600 ft wide and more than 0.5 mi long in Elbert County, Ga. (Hudson, 1946, p. 7). One hole drilled by the U.S. Bureau of Mines (USBM) intercepted a layer of sillimanite schist 50 ft thick that contains 7 to 8 percent sillimanite. At the A.P. Green and Jenkins areas (table 1, No. 23) in Hart County, Ga., lenses of hard, less weathered sillimanite schist, 10 to 100 ft thick and as much as 1,000 ft long, are in a zone 0.5 mi wide and 1 mi long (Hudson, 1946, p. 7–8; Teague, 1951, p. 787; Grant, 1958, p. 69; Espenshade and Potter, 1960, p. 108). The schist is composed mostly of quartz, biotite, sillimanite, muscovite, and graphite. Sillimanite content ranges from 2 to 22 percent and averages 17 percent in one bulk sample (Hudson, 1946, p. 7–8). Teague (1951, p. 787) estimated that an area of 0.75 acre at the Jenkins prospect contains 610,000 tons of sillimanite-rich schist, which averages 10 percent sillimanite, above the present drainage level and about 8,500 tons/ft below the drainage level. Teague (1951) further estimated 4 million tons of sillimanite-rich schist for the Jenkins and nearby properties. The sillimanite is readily concentrated by froth flotation, and the concentrate makes a good-quality refractory product (McVay and others, 1945, p. 19–23; Teague, 1951, p. 789).

Other extensive areas of sillimanite-mica schist have been outlined in the Six Mile thrust sheet (Nelson and others, 1989). The sillimanite is generally finer grained than in the megacrystic sillimanite schist and very little, if any, prospecting has been done. Two samples collected near Bowersville, Ga., contained 12 to 13 percent sillimanite from a zone about 150 ft wide (Grant, 1958, p. 65). An isolated area containing boulders of coarse-grained sillimanite, as much as 3 ft across, has been reported in Pickens County, S.C., northeast of most of the outcrop areas of sillimanite schist in the Six Mile thrust sheet (Brown, 1966, p. 5–7).

The deposits of megacrystic sillimanite schist in Elbert and Hart Counties are the most promising sillimanite deposits known in Georgia (Espenshade and Potter, 1960, p. 108), but no further prospecting has been done, and no mining of sillimanite is known to have been done in the region.

Paris Mountain Thrust Sheet

Much of the Paris Mountain thrust sheet is underlain by medium-grained sillimanite schist cut by medium- to coarse-grained granite gneiss. Just east of Pelzer, Greenville County, S.C., the USBM collected a large sample of schist at the Beam property (table 1, No. 25) which contained 17 percent sillimanite and yielded a sillimanite concentrate from which test refractory bricks of high quality were made (Rampacek and others, 1945; Hudson, 1946, p. 5–6). Several diamond drill holes on that property and on the Pearson and Scott properties (table 1, No. 26), about 0.75 mi northeast, intersected sillimanite schist interlayered with granite gneiss. The schist contains 1 to 6 percent sillimanite in layers ranging in thickness from 4 to 120 ft (Hudson, 1946, p. 5–6). Other areas of sillimanite schist in the Paris Mountain thrust sheet were sampled near Paris Mountain, Taylors, and Greer (table 1, Nos. 27–29, respectively) (Hudson, 1946, p. 11). The sillimanite content of the schist was less than that at the Beam area, and the product was finer grained and contained more iron (Espenshade and Potter, 1960, p. 107).

Charlotte Thrust Sheet

The Charlotte thrust sheet contains metamorphosed volcanic and related sedimentary rocks and plutonic rocks that have been traditionally included in the Kings Mountain belt, Charlotte belt, and Carolina slate belt (fig. 1*B*; King, 1955; Overstreet and Bell, 1965a, 1965b). The rocks include metatuff, amphibolite, phyllite, quartzite, greenstone, biotite gneiss and schist, quartzofeldspathic gneiss, mica schist and various types of granitic gneiss and gabbroic intrusive rocks (Nelson and others, 1989). Locally, some of these units have been hydrothermally altered to high-alumina alteration assemblages that contain quartz, pyrophyllite, and andalusite (Espenshade and Potter, 1960, p. 109–112; Schmidt, 1985). The two known deposits of this type in the Greenville quadrangle (table 1, Nos. 30 and 31) seem to contain only minor amounts of andalusite and pyrophyllite (Espenshade and Potter, 1960, p. 112).

RESOURCE POTENTIAL

The productive kyanite mines in Virginia, northeast of the Greenville quadrangle, are all in quartzose deposits that contain as much as 25 to 30 percent kyanite. Kyanite reserves in these quartzose deposits are on the order of 100 million tons (Espenshade and Potter, 1960, p. 34). Within the Greenville quadrangle, the total volume of metamorphic rock within a few hundred feet of the surface that contains kyanite or sillimanite is many times larger than the volume of kyanite quartzite in Virginia, but the average grade of the kyanite or sillimanite rock is only about one-half that of the productive quartzose ores. Although the resources of kyanite and sillimanite in the Greenville quadrangle are enormous, at present they are uneconomic because of their low grade. They do, however, constitute a potential resource. Resources of the known andalusite deposits in the southeastern part of the quadrangle are probably small; however, the area has not been thoroughly explored for its andalusite potential.

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MINERAL RESOURCE ASSESSMENT OF KYANITE, SILLIMANITE, AND ANDALUSITE IN THE GREENVILLE 1° × 2° QUADRANGLE, SOUTH CAROLINA, GEORGIA, AND NORTH CAROLINA

By
Frank G. Lesure
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