STUDIES RELATED TO WILDERNESS

MINERAL RESOURCES OF THE CITICO CREEK WILDERNESS STUDY AREA, MONROE COUNTY, TENNESSEE

GEOLOGICAL SURVEY BULLETIN 1552

Mineral Resources of the Citico Creek Wilderness Study Area, Monroe County, Tennessee

By JOHN F. SLACK *and* ERIC R. FORCE, U.S. GEOLOGICAL SURVEY, *and*
PAUL T. BEHUM *and* BRADFORD B. WILLIAMS, U.S. BUREAU OF MINES

STUDIES RELATED TO WILDERNESS—WILDERNESS AREAS

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An evaluation of the mineral potential of the area

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STUDIES RELATED TO WILDERNESS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts and as specifically designated by Public Law 93-622, January 3, 1975, the U.S. Geological Survey and U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild," or "canoe" when the Act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The Act provided that areas under consideration for Wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of the Citico Creek Wilderness Study Area, in the Cherokee National Forest, Monroe County, Tenn., that is being considered for wilderness designation (PL 93-622, January 3, 1975).

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STUDIES RELATED TO WILDERNESS

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SUMMARY

The proposed Citico Creek Wilderness comprises about 14,000 acres (56.7 km^2) in the Cherokee National Forest south of the Little Tennessee River in easternmost Monroe County, Tenn. Principal drainages are Citico Creek and Doublecamp Creek. Rocks of the study area include greenschist-facies arkosic metasandstone, metagraywacke, slate, and metaconglomerate of the Great Smoky Group of Proterozoic Z age. Minor deposits of unconsolidated Quaternary alluvium locally mantle the bedrock. Deformation is expressed by asymmetric and overturned folds and by several major faults.

More than 500 samples of soil, rock, and stream sediment were collected and analyzed for 31 major, minor, and trace elements by spectrographic, atomic-absorption, and fire-assay methods. No significant metal anomalies were detected. Concentrations of Cu, Co, As, Pb, and Zn slightly higher than background were found within sulfidic parts of a distinctive stratigraphic unit composed of graphitic slate and metagraywacke. Within this unit, pyrite and pyrrhotite are the chief sulfide minerals; traces of accessory sphalerite, chalcopyrite, galena, and arsenopyrite form microscopic intergrowths. A reconnaissance ground radiometric survey and subsequent neutron-activation analysis of selected radioactive rock samples show that the sulfidic parts of the graphitic slate unit also have a relatively high content of Th but have no resource potential.

No metallic mineral resources appear to exist within the Citico Creek Wilderness Study Area. Resources of slate, silica, and stone are present, but they display no special qualities to differentiate them from other such material throughout the region. Anomalous concentrations of Ba in some rock samples suggest local potential for barite. Ceramic evaluation tests on selected samples of slate indicate that the slate would have only marginal use for structural clay products such as brick and tile. Minor sand and gravel deposits occur along a few streams but are present in larger quantities and are more easily recovered in other areas. A possibility also exists for the presence of natural gas at great depths.

INTRODUCTION

LOCATION AND DESCRIPTION

The proposed Citico Creek Wilderness comprises approximately 14,000 acres (56.7 km²) of national forest land south of the Little Tennessee River in easternmost Monroe County, Tenn. (fig. 1). The study area is entirely within the Cherokee National Forest, along the southern continuation of the Great Smoky Mountains in the Blue Ridge physiographic province. Surface and mineral rights are entirely owned by the U.S. Government, with the 177-acre (0.72 km²) Falls Branch Scenic Area being the only easement. The Joyce Kilmer-Slickrock Wilderness and the North Carolina State Line together form the eastern border of the area. Principal drainages are Citico Creek (fig. 2) and one of its major tributaries, Doublecamp

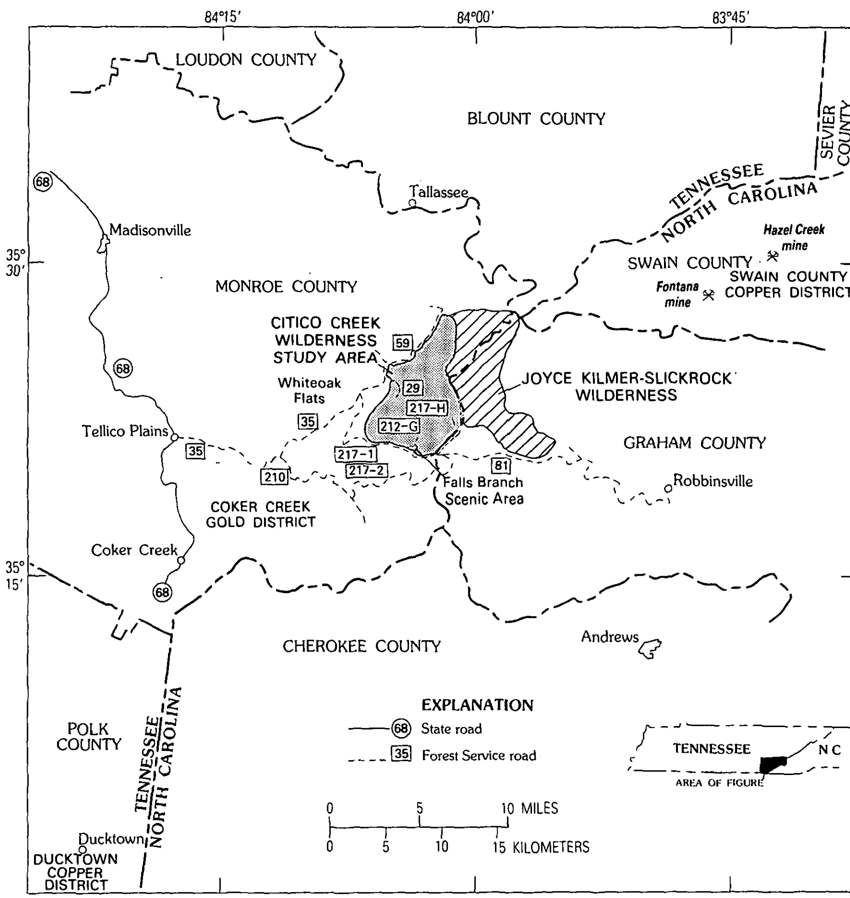

FIGURE 1.—Index map of Citico Creek Wilderness Study Area (shaded) and vicinity.

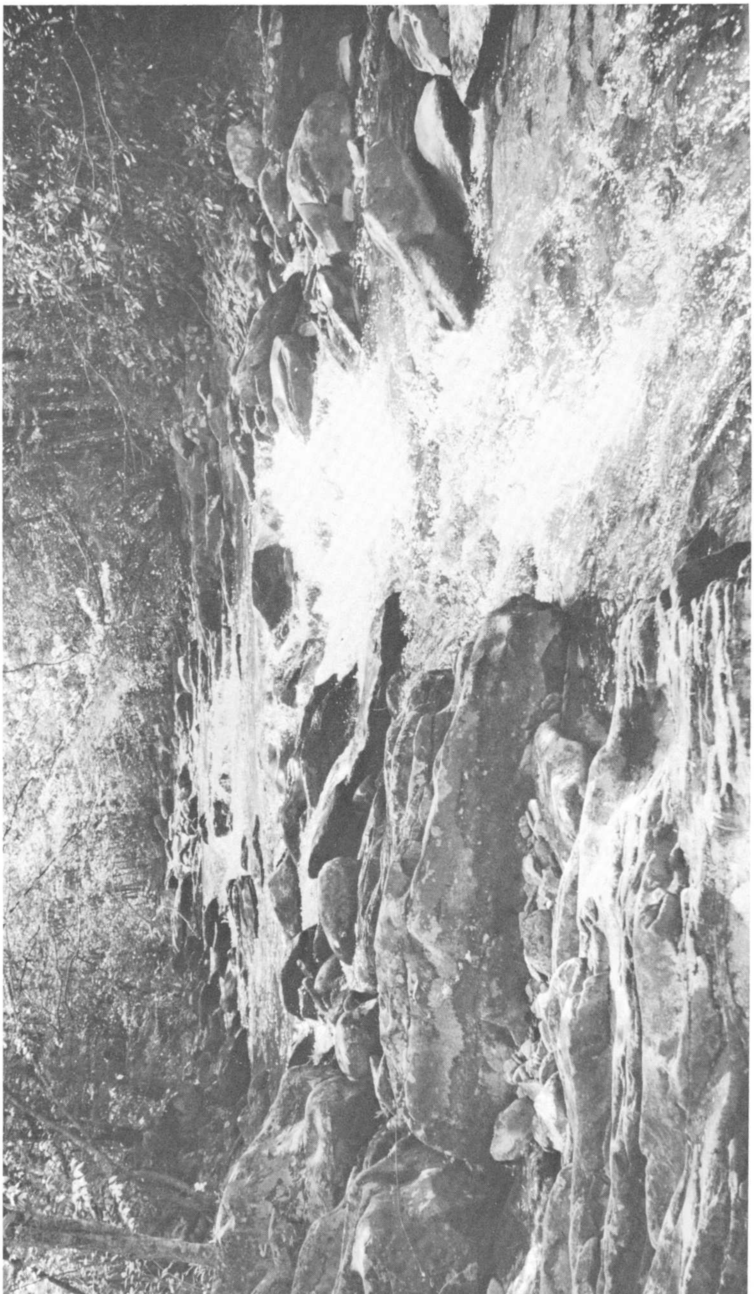

FIGURE 2.—Typical view along Citico Creek, showing outcrops (left foreground) of metasandstone and metaconglomerate of unit III.

Creek, the latter forming the northwestern boundary of the study area. Total relief is about 3,780 ft (1,150 m). The lowest elevation, 1,411 ft (430 m), is at the confluence of Doublecamp and Citico Creeks; the highest, about 5,190 ft (1,580 m), is astride the Tennessee-North Carolina border near Brush Mountain. The topography is typical of much of the Great Smoky Mountains, with narrow valleys, steep slopes, and sharp ridge crests.

Principal access is from the southwest along Tennessee State Route 68 from Madisonville and Tellico Plains. U.S. Forest Service Road 217–I continues from Route 68 to the northeast along Sassafrass Ridge, where it forms the southern border of the study area. Roads 217–H and 217–G extend into the southeastern interior. Forest Service Road 35 provides entry from Citico Beach and other northwest locations, with Road 59 extending up Doublecamp Creek to Farr Gap, and Road 29 a short distance up Citico Creek. Road 81, along Santeetlah Creek, allows access from the North Carolina (eastern) side to Beech Gap, from where a dirt road (217–H) heads northward along the Tennessee-North Carolina border for about a mile. The area has been heavily logged in the past, and many hiking trails follow old railroad grades along major stream valleys.

LAND STATUS

The Citico Creek Wilderness Study Area comprises portions of two tracts of land purchased by the Forest Service under the authority of the Weeks Act of 1911. Surface and mineral rights were purchased from Babcock Lumber and Land Company and the Tellico River Lumber Company. The 177-acre (0.72-km^2) Falls Branch Scenic Area near the south-central boundary is the only easement within the study area. The southern boundary of the area will be slightly modified to accommodate a new scenic highway, U.S. Forest Service Road 217–I.

PREVIOUS WORK

Early geologic studies in the southern Great Smoky Mountains were made by Safford (1856; 1869) and Keith (1907), who reported on the reconnaissance mapping of both eastern Tennessee and western North Carolina. King and others (1950) described the geology of the Murphy quadrangle, which includes the Citico Creek Wilderness Study Area. More detailed investigations of the western Great Smoky Mountains were published by Neuman and Nelson (1965). Merschat and Wiener (1973)[1] compiled a provisional geologic map of the Ocoee Supergroup in this region from available data and their

[1] Revised and updated in 1978.

own reconnaissance. Hale (1974) studied the nearby Coker Creek gold district. The most recent geologic work in the area, by Lesure and others (1977), describes the geology and mineral resources of the Joyce Kilmer-Slickrock Wilderness, which borders the present study area on the east (fig. 1).

PRESENT INVESTIGATIONS

Field work during October 1976, was done by J. F. Slack, E. R. Force, and F. G. Lesure, assisted by A. E. Grosz, M. P. Foose, and C. E. Brown, all of the U.S. Geological Survey (USGS). Several additional days of mapping were done in October 1977, by Slack and Force, assisted by R. H. Ketelle and A. E. Grosz. P. T. Behum and B. B. Williams of the U.S. Bureau of Mines conducted field reconnaissance in April 1977. Samples of soil, rock, and stream sediment were collected by USGS personnel and submitted for geochemical analysis. Radiometric surveys were made along major roads with a hand-held scintillometer and subsequently checked by a gamma-ray spectrometer.

ACKNOWLEDGMENTS

Field radiometric measurements and panning of heavy-mineral concentrates from stream sediments were made by A. E. Grosz, USGS. Mineral identification by X-ray diffraction was done in the laboratory by P. J. Loferski and M. E. Mrose, USGS; R. B. Finkelman, USGS, assisted in electron microprobe work. Grosz also separated minerals from panned concentrates, using heavy liquids, and identified the minerals. M. P. Foose, USGS, helped during our prolonged attempts to unravel the geologic structure of the study area and provided insight into possible solutions. C. E. Merschat and L. S. Wiener of the North Carolina Division of Mineral Resources provided a preliminary map compilation of the geology of the southern Great Smoky Mountains and discussed with us the general stratigraphy of the region. Merschat also lent polished sections of sulfide-rich rock collected from the Farner (N.C.-Tenn.) quadrangle southwest of the Citico Creek area. R. C. Hale and the late J. M. Fagen, Tennessee Valley Authority, Knoxville, Tenn., provided unpublished information and mine locations. R. A. Laurence, USGS, Knoxville, also supplied information about former mines. U.S. Forest Service personnel from the Watershed and Minerals Branch, Atlanta, Ga., furnished maps and tabulations on mineral and surface ownership and prospect data. Additional prospect information was obtained from the U.S. Bureau of Land Management, Washington, D.C.

GEOLOGY

STRATIGRAPHY AND LITHOLOGY

The Citico Creek Wilderness Study Area is underlain by greenschist-facies metasedimentary strata of the Proterozoic Z Great Smoky Group, which is part of the Ocoee Supergroup. Unconsolidated alluvial deposits of Quaternary age are found locally in some major stream drainages. Precambrian rocks northeast of the map area and just north of the Little Tennessee River in the western part of the Great Smoky Mountains National Park have been subdivided by Neuman and Nelson (1965). More recently, Merschat and Wiener (1973) compiled a reconnaissance geologic map of the southern part of the Great Smoky Mountains, including both the Citico Creek Wilderness Study Area and the Joyce Kilmer-Slickrock Wilderness. Merschat and Wiener were unable to project lithologic units for long distances southwestward from the National Park and used different subdivisions and nomenclature as earlier established by Hernon (1968) near Ducktown, Tenn. Merschat and Wiener (1973) extended Hernon's slaty unit 1 and Hernon's unit 2 northeastward to the area of the proposed Citico Creek Wilderness and recently (Wiener and Merschat, 1978) designated them the Farner, Boyd Gap, and Buck Bald Formations, respectively. To portray as detailed a stratigraphic and structural picture as possible, Hernon's units are here subdivided into more specific lithologic types, designated by Roman numerals. Because of a different structural interpretation, we are unable to correlate our subdivisions completely with those in the adjacent Joyce Kilmer-Slickrock Wilderness (Lesure and others, 1977), but those units which are correlative are so indicated on the map explanation (pl. 1). Lithologic descriptions of individually mapped units are given on the geologic map.

STRUCTURE

The metasedimentary rocks of the Citico Creek area are deformed by open and closed folds and by several major faults. The Nichols Cove fault (Lesure and others, 1977) divides the map area into two stratigraphic sequences that display different fold styles. Northwest of the fault, on and near Pine Ridge, the structures are extremely complicated. Selected contacts have been carefully traced here, but as yet the exact nature of the structure is uncertain. The geology of this particular area is complex and adds uncertainty to interpretations of structural and stratigraphic features.

FOLDS

Northwest of the Nichols Cove fault, open folds that have long subhorizontal east limbs and short, steeply dipping west limbs (with respect to anticlines) are characteristic (fig. 3). These folds, here termed "step folds," form a generally eastward-rising flight of steps that range in scale from mesoscopic (outcrop) to megascopic (major Pine Ridge syncline, pl. 1). Along Citico Creek, between the former Warden Station and Doublecamp Creek, an enveloping surface of such folds can be traced using the upper boundary of unit III, which dips gently to the northwest. A hinge of the major syncline shown within unit III is exposed where it crosses the North Fork of Citico Creek.

Southeast of the Nichols Cove fault, the deformation style is characterized by inclined or upright closed folds. These folds differ from the step folds on the northwest side of the fault in that they commonly are symmetric having either gentle or steep limbs; some small folds are isoclinal. Several larger folds of this type strongly influence the topography, as indicated by major anticlines on either side of Grassy Gap (pl. 1) coincident with linear ridges trending north (Hampton Lead) and northeast (Brushy Ridge). To the north along the south fork of Citico Creek, another anticlinal axis coincides with a northeast-

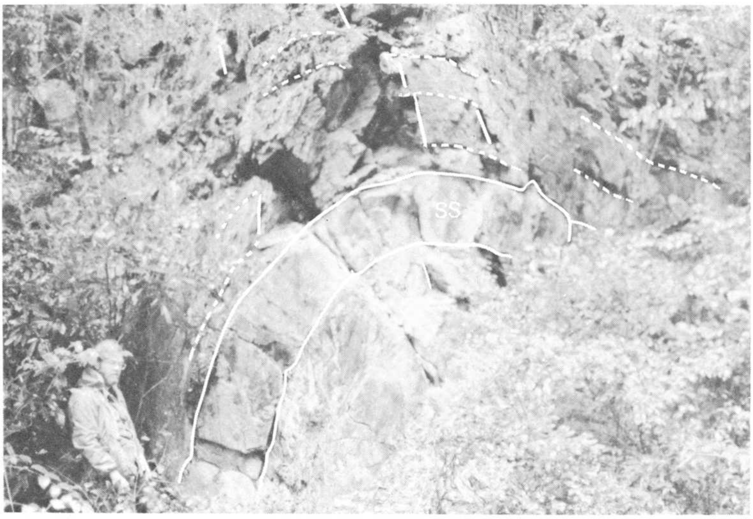

FIGURE 3.—Small step-fold exposed along Doublecamp Creek, within metasandstone and slate of unit II, north of Nichols Cove fault. Bedding and cleavage annotated. View looking north. Note man for scale.

trending ridge that forms a spur on the southwest side of Brush Mountain, near the headwaters of Ike Camp Branch.

In some areas, complex folding and transposition of beds are evident. Along the new Sassafrass Ridge road, excellent exposures show abrupt local terminations of coarse clastic beds in a sequence of interlayered metagraywacke and graphitic slate. At one location, highly contorted beds of metagraywacke are found within a simple homoclinal section (fig. 4); other exposures show intensely folded slate between unfolded beds of more competent metasandstone or metagraywacke. These features are most reasonably interpreted as reflecting processes of preconsolidation (soft-sediment) slumping.

Plunges of fold axes and of lineated structures such as cleavage-bedding intersections appear to be shallow throughout the study area. Axes of minor folds that have amplitudes less than a few feet typically plunge 10° to 20° northeast, parallel to the axes of major folds of the region.

FAULTS

The major fault recognized within the study area is the Nichols Cove fault, previously described by Lesure and others (1977) to the northeast. We have interpreted this fault as a thrust, although locally it may be a high-angle reverse fault. It divides the Citico

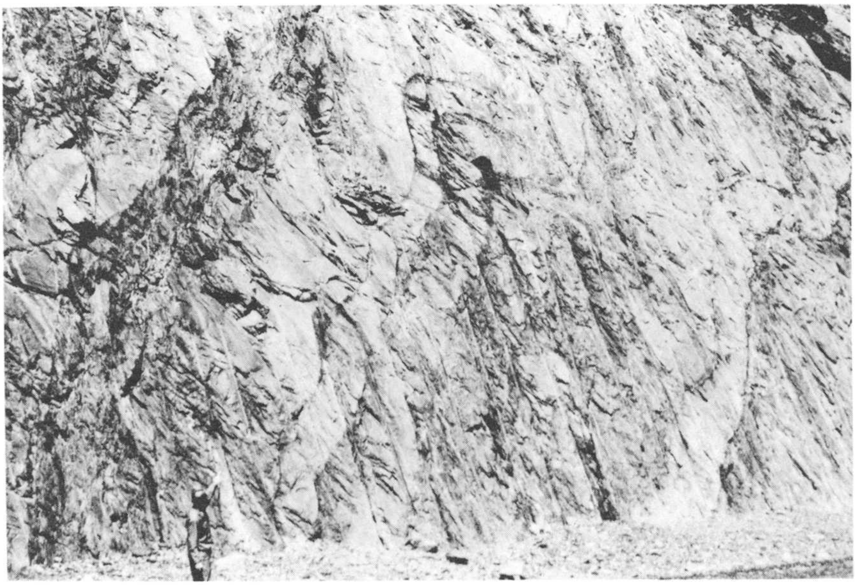

FIGURE 4.—Contorted beds of metagraywacke and thin interbeds of dark slate exposed along new roadcut at Sassafrass Ridge, south of Nichols Cove fault. Note man for scale.

Creek area into two different stratigraphic sequences. The fault separates gray slate and arkosic metasandstone and metaconglomerate to the northwest from dark graphitic slate and metagraywacke to the southeast. In general, strata on both sides of and close to the fault are moderately to strongly overturned to the southeast. The fault crosses the Sassafrass Ridge road at Eagle Gap (pl. 1), where rocks of the upper plate are crushed, mylonitized, and in places display transposed bedding. The dip of the fault is not determinable except near Harrison Gap, where its position on adjacent ridges and in valleys suggests a dip of about 45° southeast.

Tear faults, formed probably synchronously with folding, strike north-northwest on the north side of Pine Ridge. These faults separate two blocks where the lower and upper contacts of the same unit (III) are juxtaposed. They thus separate areas where unit III is in contact with lower slates of unit II, from areas where unit III is in contact with upper slates of unit IV. Younger faults in this same region strike east-west and offset lithologic boundaries and fold axes. The largest of these east-west faults is traceable from the lower parts of Rocky Flats Branch to Big Stack Gap. On aerial photographs, this fault is expressed by a strong lineament visible at least 3 mi (5 km) eastward to beyond Big Fat Gap, at the eastern edge of the Joyce Kilmer-Slickrock Wilderness. In the Citico Creek area, the magnitude and direction of fault movement are not determinable, but offsets of rock formations on the map suggest measurable movement. However, geologic contacts mapped by Lesure and others (1977) to the east are not offset by the fault, indicating little or no displacement within that map area.

Another fault is recognized on the south and east sides of Pine Ridge. It strikes northeast from Flats Mountain to just west of Big Fodderstack and is a conspicuous lineament on aerial photographs. Strata on both sides of this fault dip steeply southwest and in places are overturned. The northward bend of the fault trace near Big Fodderstack suggests a west-dipping fault plane, but the direction and amount of movement are unknown.

CLEAVAGE AND JOINTING

Cleavage and jointing are well developed throughout most of the Citico Creek map area. Slaty cleavage is prominent in fine-grained rocks and is characteristically at an angle to bedding (fig. 5). It strikes uniformly northeast and dips moderately to steeply southeast. Most of the slate outcrops show both bedding and cleavage. We have inferred that bedding is overturned where cleavage dips less than bedding. Various sedimentary structures (chiefly graded beds and cross-laminations) support this inference.

FIGURE 5.—Typical view of bedding-cleavage relations within unit IV slates. Bedding here is nearly horizontal; cleavage is inclined. Note hammer for scale.

Cleavage in slates appears to be parallel to the axial planes of step folds northwest of the Nichols Cove fault and to closed folds southeast of the fault. Quartz veins are oriented along cleavage directions in many slaty rocks. Near Hemlock Knob, on the southern border of the study area, a new roadcut exposes a group of parallel quartz veins that are preferentially alined within the axial-plane cleavage of a prominent anticline.

A second and younger, more widely spaced cleavage commonly deforms the earlier slaty cleavage of fine-grained rocks. It is visible locally in outcrops as dark, herringbonelike partings. In some slate outcrops, this parting or fracture cleavage forms minor crenulations on the earlier cleavage surfaces and is associated with chevron folds of small amplitude (less than 4 in. or 10 cm). The strike of the fracture cleavage generally parallels the fold axes, and the dip is steep or vertical. As seen in thin section, the older penetrative slaty cleavage is kinked and in places transposed by the younger cleavage. The younger fracture cleavage is marked by concentrations of organic material. The origin of this secondary fracture cleavage is unclear. Stereonet plots demonstrate that it is not a simple bedding-cleavage intersection. It may be a minor axial-plane cleavage developed during or after the main period of regional deformation. However, no mappable folds seem to be associated with it.

METAMORPHISM

The entire study area appears to be within the greenschist facies of regional metamorphism (Tennessee Division of Geology, 1966; Carpenter, 1970). The chlorite-biotite isograd, determined mainly by petrographic study, extends west-southwest from near Big Fodderstack to the northern part of Flats Mountain (pl. 1). The biotite-almandine garnet isograd passes through the central part of the Joyce Kilmer Memorial Forest, about 2 mi (3 km) east of the southeast corner of the present study area. These isograds cannot be correlated with mappable rock units (designated by Roman numerals, pl. 1), either in the Citico Creek area or in the adjacent Joyce Kilmer-Slickrock Wilderness (Lesure and others, 1977, pl. 1).

Minor amounts of chlorite and muscovite form the matrix of much of the metasandstone and metasiltstone of units I–IV. Megascopic biotite is restricted to the southern part of the study area, where it forms porphyroblastic flakes as much as 1 mm in diameter in schistose metagraywacke of units V and VI. Finer grained biotite was noted in thin sections from several metasandstone and metagraywacke units south of Pine Ridge. Biotite is also common in most rocks of the upper plate southeast of the Nichols Cove fault, except in highly graphitic slate of unit V, where bulk compositions (or graphite) may have prevented its formation. The apparently greater deformation of lower plate rocks near the Nichols Cove fault and the distribution of biotite on the north side of and close to the fault suggest that the biotite isograd may be related to the proximity of this major thrust.

Garnet was identified by optical and X-ray methods in 8 of 14 heavy-mineral concentrates from panned stream sediment. Two types of garnet were found, one a lavender or pale pink, the other pale clove brown. The latter type corresponds to the "colorless" garnet described by Lesure and others (1977) from the adjacent Joyce Kilmer-Slickrock Wilderness. Preliminary X-ray powder-camera studies indicate that the pink garnet is similar to rhodolite, a magnesium-iron variety; the brownish type has d-spacings almost identical to spessartine, a manganese-rich garnet. Recent detailed electron-microprobe analyses (Slack and others, 1980) confirm these chemical classifications. The garnets were collected in streams that drain small basins, but thin sections of rocks from the same basins do not contain garnet. Garnets were also noted in a panned concentrate from the mouth of Crowder Branch (pl. 1), well within the chlorite zone as determined by petrographic study. Whereas manganiferous garnet may be a common product of lower greenschist-facies metamorphism (Turner, 1968, p. 72), magnesium-rich garnet is known to be more characteristic of high-grade metamorphic terranes. Possible explanations for the apparent conflict between data from thin sections and panned stream sediments are that either the hand-specimen coverage has been too sparse (about 200 samples) or that bulk compositions of most local rocks are inappropriate for the formation of garnet, so that only a few selected (unsampled) horizons provided the detrital garnets found by panning. Alternatively, the magnesium-rich garnets could be inherited second-cycle detritus from an older, more highly metamorphosed basement source for rocks of the Great Smoky Group (Slack and others, 1980).

GEOCHEMICAL SURVEY

SAMPLING AND ANALYTICAL TECHNIQUES

Samples of rock, soil, stream sediment, and vein quartz were collected throughout the Citico Creek Wilderness Study Area (pl. 2). An attempt was made to uniformly sample each type of material. However, full coverage was limited by dense vegetation in some areas, especially in the south near Jeffrey Hell.

Rock samples were taken by a composite-chip method from several parts of each sampled outcrop. The chip samples are representative of all major rock types of the area including vein quartz, as well as all the rock units shown on the geologic map. Soil samples were taken below surficial organic material, generally from the lower to middle parts of the A horizon but in some places from the upper part of the B horizon. Soil samples were sieved to minus 80-mesh prior to analysis. Stream sediment was sampled from active and a few small intermittent tributaries draining into Citico Creek and Doublecamp Creek. Additional samples were collected from outside the study area from drainage basins that are partly within the study area. Stream-sediment samples were sieved to minus 80-mesh; some samples rich in organic material were ashed before analysis to avoid spectral interference. Panned concentrates of heavy minerals were collected from major streams by using standard gold-panning techniques. Samples were taken either from loose gravel in or near a stream or from potholes where streams flow over bedrock, especially from lower Citico Creek and its tributaries.

A semiquantitative spectrographic analysis for 31 elements was made for every sample. Concentrations of gold, silver, and zinc were determined more accurately by atomic-absorption and fire-assay methods. Samples were analyzed in the laboratories of the USGS, Denver, Colo., and the U.S. Bureau of Mines Metallurgy Research Center, Reno, Nev. The semiquantitative spectrographic values are reported as six steps per order of magnitude (1, 0.7, 0.5, 0.3, 0.2, 0.15, or multiples of 10 of these numbers) and are approximate geometric midpoints of the concentration ranges. The precision is expected to be within one adjoining interval on each side of the reported value 83 percent of the time and within two adjoining intervals 96 percent of the time (Motooka and Grimes, 1976).

In their study of the adjacent Joyce Kilmer-Slickrock Wilderness, Lesure and others (1977) compared geochemical data from their area with those from the nearby Hazel Creek and Fontana copper mines. Comparisons were made by plotting data on cumulative frequency-distribution diagrams to determine which wilderness samples contained anomalously high values. Geochemical data from the Citico Creek area have been evaluated by similar comparisons with these known mineralized areas and with data from the Joyce Kilmer-Slickrock Wilderness. In the tabulation and discussion of the geochemical data, selected elements of particular economic interest, especially Au, Ag, Ba, Cu, Pb, Zn, Ni, Co, and Sn, are emphasized. Concentrations of other major, minor, and trace elements (Fe, Mg, Ca, Ti, Mn, B, Be, Cr, La, Nb, Sc, Sr, V, Y, Zr) are within expected ranges of background values and are not further discussed. Complete analyses for rock, soil, and stream sediment are available in Hopkins and others (1979).

STREAM-SEDIMENT SAMPLES

Analyses of 119 stream-sediment samples collected in 1976 and 25 samples collected in 1973 (Lesure and others, 1977) show no significant metal anomalies. Silver and gold were not detected in any samples. Other elements of major economic interest (Ba, Co, Cu, Ni, Pb, Sn, Zn) were generally found to have concentrations within expected ranges (table 1). Tin was detected in three samples, but with a high value of only 15 ppm. The sediment in a few streams contains slightly anomalous concentrations of zinc, with a high value of 145 ppm; no systematic geographic distribution exists for these occurrences, however. One sample collected by Lesure and others (1977, table 2, sample no. 2355) from just west of Bob Bald contains 180 ppm lead. A second sample from the same drainage basin, collected in 1976, yielded only 30 ppm lead.

PANNED CONCENTRATES

Splits of 14 panned-concentrate samples were analyzed by spectrographic and atomic-absorption methods (table 1). No elements are present in anomalously high concentrations. A heavy-mineral fraction was separated from the remainder of each sample by standard

TABLE 1.—*Range and median values (in ppm) for selected elements in samples of soil, stream sediment, and panned concentrate collected in 1976 from the Citico Creek Wilderness Study Area, Monroe County, Tenn.*

[All analyses by semiquantitative spectrographic methods except those for gold and zinc, which are by atomic absorption. Spectrographic data are reported to the nearest number in the series 1, 1.5, 2, 3, 5, 7, 10, and so on, which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins, C. A. Curtis, and J. Sharkey, USGS, Denver, Colo. Letter symbols: L, detected but below limit of determination (value in parentheses); N, not detected. Elements looked for but not found and their lower limits of detection, in ppm: Ag(0.5), As(200), Bi(10), Cd(20), Mo(5), Sb(100), W(50). Au found only in two soil samples at limit of detection (0.05 ppm)]

	Soil (128 samples)			Stream sediment (119 samples)			Panned concentrate (14 samples)		
Element	Low	High	Median	Low	High	Median	Low	High	Median
Ba (20)	70	700	500	150	700	500	200	500	300
Co (5)	N	30	5	N	50	15	N	20	N
Cu (5)	7	70	20	5	30	15	L	30	7
Ni (5)	L	50	15	L	70	15	L	20	5
Pb (10)	10	70	30	10	70	30	10	30	15
Sn (10)	N	N	N	N	15	N	N	20	N
Zn (5)	10	140	50	30	145	70	N[1]	N[1]	N[1]

[1]Determined by emission spectrographic methods only; detection limit 200 ppm.

heavy-liquid methods. Principal heavy minerals are epidote, tourmaline, zircon, hematite, magnetite, "limonite," garnet, and ilmenite. One 0.5-mm ribbon-shaped grain of gold was found in a sample from the mouth of Flint Branch of Doublecamp Creek. The Flint Branch drainage basin is outside the boundaries of the present study area, however.

SOIL SAMPLES

Soil samples collected in 1976 (128) were analyzed and showed no anomalously high metal values (table 1). Gold and zinc are the only elements that have local concentrations slightly higher than background that might be of possible interest. Gold is at the limit of detection (0.05 ppm) in two samples. Zinc concentrations of 140 ppm occur in two areas, but neither area correlates geographically with areas where similar values of zinc are found in rock or stream sediment.

Of 19 soil samples collected in 1973 within the Citico Creek area, only 1, a dark silty loam, is considered anomalous. That sample contains 0.5 ppm Ag, 410 ppm Cu, and 300 ppm Pb (Lesure and others, 1977, table 3, sample no. 1391). This soil sample was taken near Farr Gap in the northernmost part of the study area along the eastern boundary with the Joyce Kilmer-Slickrock Wilderness.

ROCK SAMPLES

Spectrographic analyses (table 2) of rock chips of metasandstone, metagraywacke, and metaconglomerate (113 samples) and of slate (79 samples) reveal no metal anomalies having resource potential. Seventeen rock-chip samples collected in 1973 along the common (eastern) boundary with the Joyce Kilmer-Slickrock Wilderness (Lesure and others, 1977) similarly show no anomalously high values. Barium is high in some samples of slate and metasandstone (table 2), and concentrations of As, Co, Pb, Cu, and Zn slightly higher than background are distributed within sulfidic and graphitic parts of unit V.

Rock samples containing high concentrations of barium are mainly from the southern part of the study area, within units southeast of the Nichols Cove fault (fig. 6). Rocks containing 1,000 ppm Ba are common, and eight samples, mainly slate, contain 1,500 to as much as 3,000 ppm Ba (Hopkins and others, 1979). Some of the highest concentrations are from samples collected along Sassafrass Ridge east of Hemlock Knob (sample nos. 5011, 8024, 4107, pl. 2). No correlation exists between high barium values and high base-metal values, except for sample nos. 4245 and 5139, each containing 1,500 ppm Ba and (respectively) 150 and 100 ppm Pb. Overall, the high barium con-

TABLE 2.—*Range and median values (in ppm) for selected elements in 192 rock-chip samples collected in 1976 from the Citico Creek Wilderness Study Area, Monroe County, Tenn.*

[All analyses by semiquantitative spectrographic methods except those for gold and zinc, which are by atomic absorption. Spectrographic data are reported to the nearest number in the series 1, 1.5, 2, 3, 5, 7, 10, and so on, which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins, J. Sharkey, and C. A. Curtis, USGS, Denver, Colo. Letter symbols: L, detected but below limit of determination (value in parentheses); N, not detected. Elements looked for but not found and their lower limits of detection, in ppm: Au(0.5), Bi(10), Cd(20), Sn(10), Sb(100), W(50); other elements discussed in text]

	Metasandstone, metagraywacke, metaconglomerate (113 samples)				Slate (79 samples)			
Element	Low	High	Median	Average sandstone[1 2]	Low	High	Median	Average shale[3]
Ag (0.5)	N	N	N	[4]0.0X	N	1	N	0.1
As (200)	N	N	N	1	N	700	N	6.6
Ba (20)	70	2,000	700	300	70	3,000	700	580
Co (5)	N	20	5	0.3	N	100	10	20
Cu (5)	N	30	10	10–20	5	70	20	57
Mo (5)	N	L	N	0.2	N	7	N	2
Ni (5)	L	70	10	2	L	70	15	95
Pb (10)	L	70	20	9	L	150	30	20
Zn (5)	N	120	40	16	L	200	90	80

[1]Pettijohn (1963).
[2]Turekian and Wedepohl (1961).
[3]Krauskopf (1967, Appendix III).
[4]Order of magnitude estimated by Turekian and Wedepohl (1961).

tents clearly are anomalous with respect to other rocks in the study area and as compared with average values for shales (table 2).

Sulfide minerals locally constitute as much as 10 percent by volume in rocks of unit V. Particularly good exposures of sulfidic rocks within this unit can be observed in roadcuts at Eagle Gap and Hemlock Knob. Metagraywacke rarely contains more than 2 to 3 percent sulfides; laminated graphitic slate and metasiltstone may contain as much as 10 percent sulfides, typically concentrated along lenses and microlaminations of the coarser silty beds (fig. 7). In most outcrops of slate or metasiltstone, the sulfide minerals are transposed into the major slaty cleavage and show a strong, preferred lineation. Pyrrhotite and pyrite are the chief sulfide minerals, pyrrhotite forming disseminations in the metagraywacke, and pyrite porphyroblastic cubes (to 3 cm) or streaked aggregates (with minor pyrrhotite) in graphitic slate.

Microscopic studies of selected sulfide-rich samples reveal the presence of very minor amounts of other sulfides of economic interest, principally sphalerite and chalcopyrite, plus traces of arsenopyrite and galena. These accessory sulfides generally form marginal inter-

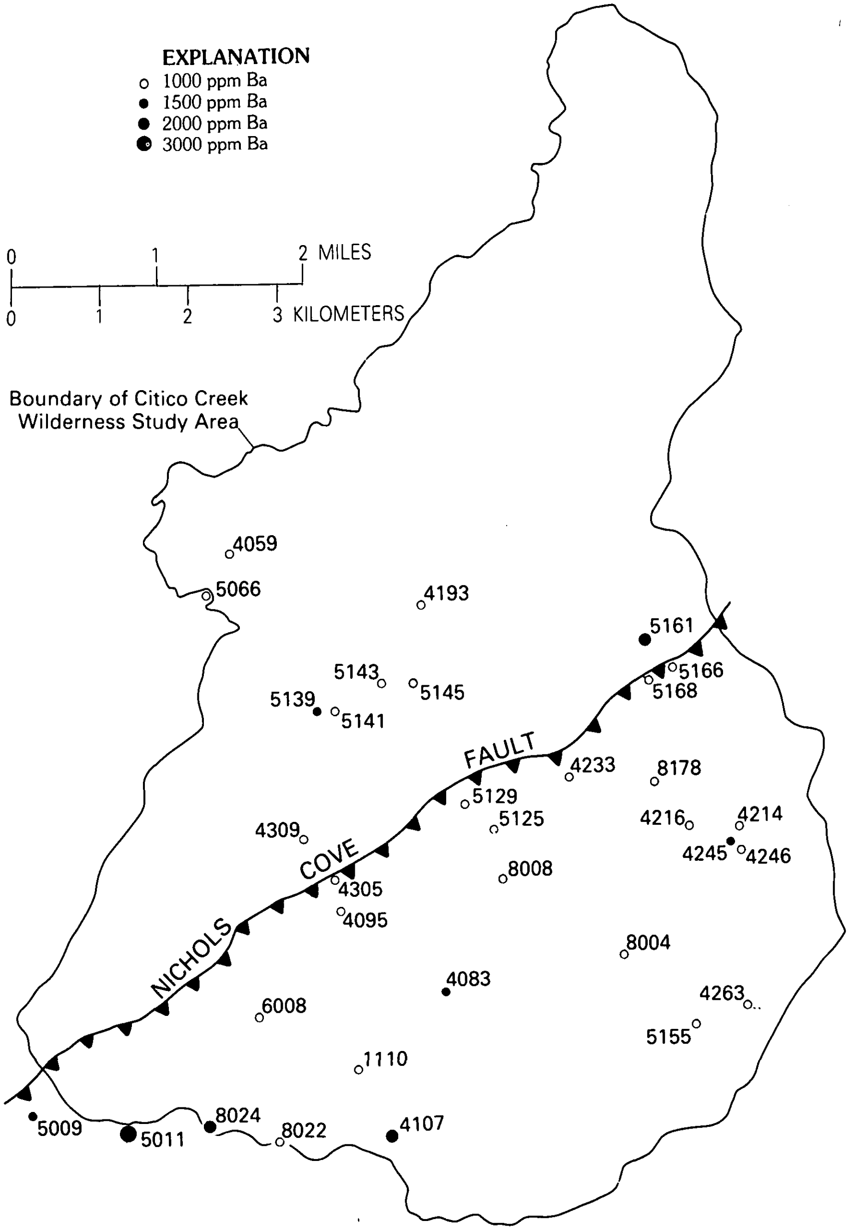

FIGURE 6.—Locations of barium-rich rocks. Numbers refer to samples listed by Hopkins and others (1979).

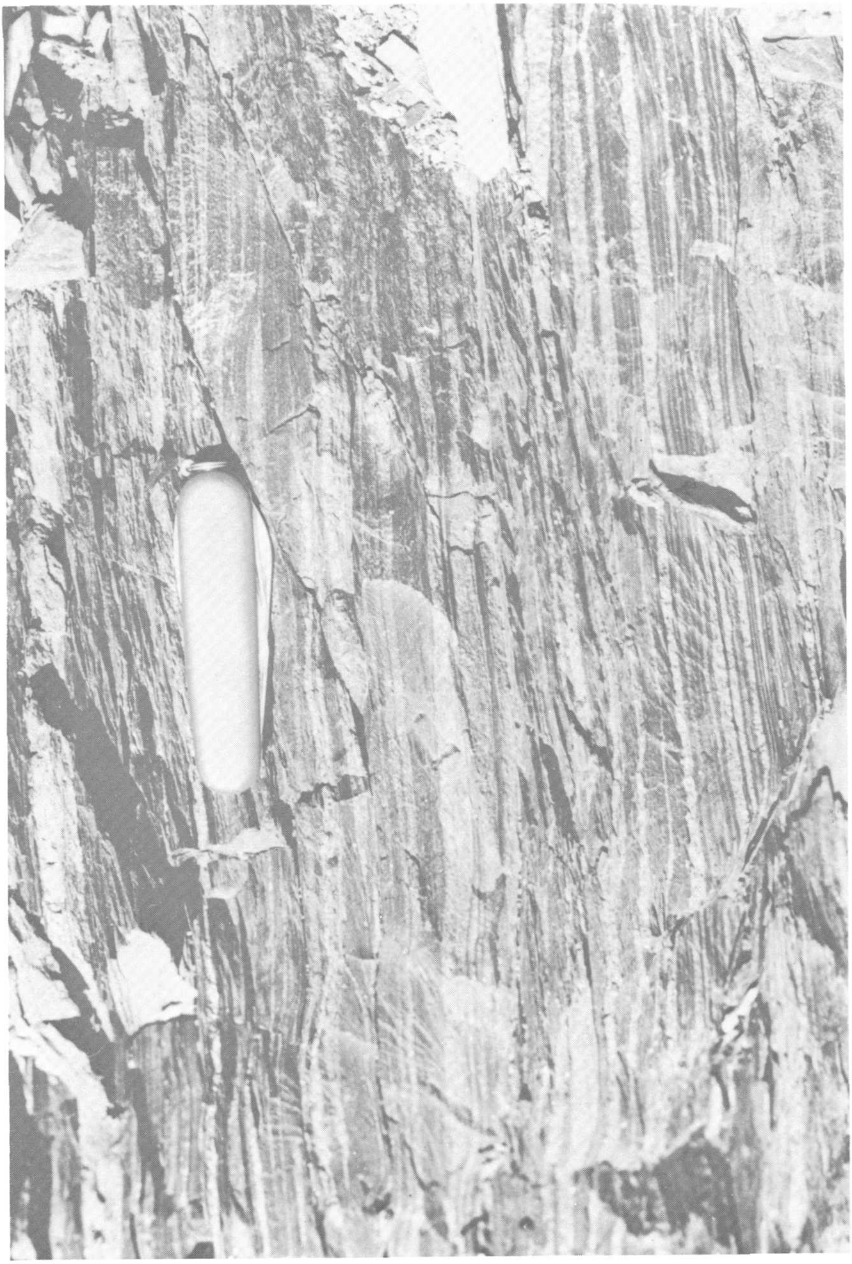

FIGURE 7.—Thin laminations of sulfide minerals (mainly pyrite) within dark graphitic slate of unit V, at Eagle Gap roadcut. Note pocketknife for scale.

growths with pyrrhotite (partly altered to marcasite) in either metagraywacke or slate. Their presence readily explains the high background concentrations of Cu, Zn, As, and Pb in these rocks (table 2). Similar occurrences of minor base-metal sulfides were found by Merschat and Larson (1972) in correlative rocks in the Farner quadrangle about 20 mi (30 km) southwest of the Citico Creek area.

Because of the unusual concentration of sulfide minerals in this area, the rocks were resampled in more detail. Composite-chip samples were taken at approximately 3-ft (1-m) spacings for each lithologic unit. A composite sample weighing at least 22 lb (10 kg) was taken of each of six units containing different proportions of graphitic slate, metagraywacke, and laminated graphitic metasiltstone and slate. No anomalous metal concentrations were found in these samples or in four other sulfide-rich specimens, except for slightly high values (200–300 ppm) for Zn.

Sulfide concentrates from two bulk samples of metagraywacke and graphitic slate collected near Eagle Gap were separated by density (heavy liquids), grain size, and magnetic susceptibility. Eleven concentrates from the two bulk samples, mainly pyrite and pyrrhotite, were analyzed for 31 major, minor, and trace elements. Anomalously high metal values were found for several elements in some (not all) sulfide concentrates. A few samples, particularly finer grained splits, contain as much as 20 ppm Ag, 50 ppm Sn, 500 ppm Pb, 500 ppm Ni, 2,000 ppm Co, 2,000 ppm Cu, 3,000 ppm Zn, and greater than 1 percent As.

QUARTZ VEINS AND GOSSAN

Quartz veins occur throughout the study area. They are most common in slate, typically are a few feet wide, and are traceable for tens to hundreds of feet along strike. Locally some quartz veins are folded or deformed into pods or boudins, particularly near the Nichols Cove fault. Most veins are barren milky quartz, although a few contain minor amounts of pyrite. One unusual vein from the Hemlock Knob roadcut contains quartz, albite, and minor pyrite and siderite.

Four of 32 samples of vein quartz collected in 1976 (table 3) and one collected in 1973 contain slightly anomalous metal concentrations. Silver is present in three samples, the highest value being 5 ppm (0.15 oz/ton) in sample no. 5021. A minor amount of gold (0.3 ppm) is present in a quartz vein from Crowder Branch in the northern part of the study area (sample no. 6041); three other veins contain traces of gold at the limit of detection, 0.17 ppm (sample nos. TCC–2, 10, 12; table 6). Weak lead anomalies (100–150 ppm) occur in the same samples with detectable silver, suggesting a common host mineral such as galena. A lead concentration of 550 ppm is present in a sample of iron-stained quartz collected on Rockstack, along the common boundary with the Joyce Kilmer-Slickrock Wilderness (Lesure and others, 1977, table 1, sample no. 1438). One sample of a gossan-cemented breccia from the Sassafrass Ridge road just west of Eagle Gap contains 15 percent Fe, 3,000 ppm Mn, 200 ppm Zn, and 100 ppm each of Co and Cu (table 3, sample no. 5003). This sample, although indicating anomalous base-metal mineralization, does not contain sufficient metal to be of resource interest.

TABLE 3.—*Partial analyses of selected samples of vein quartz and gossan collected in 1976 from the Citico Creek Wilderness Study Area, Monroe County, Tenn.*

[All analyses by semiquantitative emission spectrographic methods except those for gold and zinc, which are by atomic absorption. Spectrographic analyses are reported to the nearest number in the series, 1, 1.5, 2, 3, 5, 7, 10, and so on, which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins, J. Sharkey, and C. A. Curtis, USGS, Denver, Colo. Letter symbols: L, detected but below limit of determination (value in parentheses); N, not detected. Elements looked for but not found and their lower limits of detection, in ppm: As(200), Cd(20), Mo(5), Nb(20), Sb(100), Sn(10), Sr(100), W(50)]

	Sample numbers				
Elements (percent)	4165	4239	5003[1]	5021	6041
Ca (0.05)	N	L	0.05	N	0.1
Fe (0.05)	1.5	0.3	15	0.1	0.7
Mg (0.02)	0.15	L	0.1	L	0.02
Ti (0.002)	0.1	0.02	0.15	0.07	0.03
Elements (ppm)					
Ag (0.5)	1.5	2	N	5	N
Au (0.05)	N	N	N	N	0.3
B (10)	150	15	300	N	N
Ba (20)	700	70	500	50	100
Be (1)	5	L	7	N	L
Bi (10)	N	10	N	N	N
Co (5)	N	N	100	N	N
Cr (10)	20	L	20	N	L
Cu (5)	50	7	100	7	N
La (20)	50	L	200	N	N
Mn (10)	100	70	3,000	500	500
Ni (5)	7	L	50	7	5
Pb (10)	150	150	10	100	L
Sc (5)	10	N	15	N	N
V (10)	30	10	30	10	L
Y (10)	15	N	70	N	N
Zn (5)	20	10	200	220	10
Zr (10)	70	N	150	15	50

[1]Sample of gossan-cemented breccia.

RADIOMETRIC SURVEY

Radiometric readings were made at 152 separate stations on rock exposures along the new Sassafrass Ridge road that forms the southern boundary of the study area and along the Doublecamp-Farr Gap road. Readings were taken with a hand-held scintillometer at spacings of about 500 ft. Graphitic and sulfidic rock of unit V yielded the highest radioactivity values (table 4). Selected samples from areas of high radioactivity were analyzed quantitatively by neutron activation and contain from 15 to more than 36 ppm Th and 3 to 5 ppm U (table 5). Anomalously high radioactivity readings within unit V are believed to be caused by minor concentrations of monazite in metagraywacke, slate, and metasandstone. Thin-section study indicates that most of these rocks contain at least traces of monazite, and some

TABLE 4.—*Radioactivity ranges and mean values in rocks of the Citico Creek area, grouped by lithologic map unit (pl. 1)*

[Radioactivity determined by hand-held scintillometer and checked by gamma-ray spectrometer]

Map unit(s)	Lithology	Radioactivity range (ur)[1]	Approximate mean value of radioactivity (ur)[1]
I–IV	Metasandstone and metaconglomerate.	20–30	23
I–IV	Slate	27–43	33
V	Graphitic metagraywacke and slate.	27–60	42
VI	Metasandstone, metagraywacke, and slate.	17–50	28

[1]One ur (radioelement unit) is the radioactivity produced by 1 ppm U in radioactive equilibrium with all daughter products.

TABLE 5.—*Concentrations of U and Th in selected rock samples of unit V, Citico Creek area (see pl. 1)*

[Analyses by delayed neutron activation by H. T. Millard, Jr., C. M. Ellis, and V. C. Smith, USGS, Denver, Colo.]

Field no.	Radioactivity (ur)	Th (ppm)	U (ppm)	Th/U
S3	40	21.9	5.1	4.3
S4	60	19.2	4.4	4.4
S5	50	17.5	5.0	3.5
S10	40	19.0	3.0	6.3
S24	40	36.6	3.8	9.6
S30	30	15.1	4.3	3.5
S33	30	16.9	4.6	3.7

samples contain as much as 1 percent. Laminated silty argillite or slate from unit V locally contains thin (1 mm) detrital(?) bands rich in zircon, epidote, and monazite. Semiquantitative microprobe scans of two such monazite grains reveal high concentrations of rare-earth elements and a high Th:U ratio, in agreement with the whole-rock analyses (table 5). However, neither the uranium nor thorium content of these rocks appears high enough to have resource potential.

MINERAL APPRAISAL

METALLIC RESOURCES

Proterozoic Y(?) and Z metasedimentary rocks of the Ocoee Supergroup locally contain important metallic mineral deposits, chiefly of copper and gold. The only metal anomalies within the Citico Creek Wilderness Study Area are associated with minor amounts of sulfide minerals in graphitic slate and metagraywacke of unit V (pl. 1). These strata contain as much as 10 percent pyrite and (or) pyrrhotite, minor amounts of intergrown chalcopyrite and sphalerite, and rare galena and arsenopyrite. Concentrations of As, Co, Pb, Cu, and Zn slightly higher than background values are evident from spectrographic analysis. No potential resource value appears to be associated with this sulfide mineralization, however.

COPPER

Copper sulfide deposits occur in rocks of the Ocoee Supergroup in several places near the study area. The Ducktown copper district, containing some of the largest massive sulfide deposits in the United States, is about 30 mi (50 km) southwest of the study area in southeastern Polk County, Tenn. (fig. 1). Primary ore now being mined there consists of pyrrhotite and pyrite with associated minor chalcopyrite, sphalerite, and magnetite (Magee, 1968). Sulfuric acid is the major product of value, but copper, iron (as pellets), zinc, and minor amounts of gold and silver also are recovered.

Another region of similar sulfide mineralization is in western Swain County, N.C., at the former Fontana and Hazel Creek mines (fig. 1). The Fontana mine, about 15 mi (25 km) northeast of the study area, was mined between 1926 and 1944, producing more than 37,800 long tons of copper (Espenshade, 1963). The Hazel Creek mine, also known as the Everett or Adams mine, is about 22 mi (35 km) northeast of the wilderness study area. Mining there began about 1900 and continued intermittently until 1944. Reserves at the Hazel Creek property were estimated in 1942 to be 15,500 long tons of high-grade ore (3–3.5 percent each of copper and zinc), of which about 2,700 tons have since been mined. Approximately 29,000 long tons of low-grade ore containing 1 to 1.7 percent combined copper and zinc also is reported (Espenshade, 1963). Both mines were permanently closed in 1944, when rail and road access was blocked by the rising waters of Fontana Reservoir.

No major gossans nor abundance of copper minerals was identified within the wilderness study area. Regional geologic studies such as that by Merschat and Wiener (1973) suggested that the host rocks for the Ducktown and Fontana-Hazel Creek deposits are stratigraphically higher than rocks of the Citico Creek area. Merschat and Wiener (1973) showed that strata probably correlative with these massive sulfide terranes are exposed several miles southeast of the wilderness area boundary. Within the present study area, the potential for occurrence of significant copper mineralization is therefore judged to be low.

GOLD

The proposed wilderness is about 8 mi (13 km) northeast of the Coker Creek district, a gold-producing area of approximately 12,000 acres (50 km^2) in southern Monroe County. At Coker Creek, gold originating from quartz veins and fine-grained, ankeritic country rock of the Ocoee Supergroup was discovered in 1827 and worked periodically through the 1920's (Hale, 1974). Most production came from placer deposits and terrace gravels along main streams and their tributaries. Several attempts at underground mining, all unsuccessful, were made between 1869 and the mid-1920's. Total production of Au from the district has been estimated to be about 9,000 ounces (Hale, 1974).

Gold in or near the study area has been known for more than a century and a half, since Troost (1837) reported small amounts of gold in the Tellico River. Safford (1869, p. 489–490) cited the occurrence of gold "on the waters of Coker Creek" and projected the trend of gold-bearing rocks of the district into the Whiteoak Flats area, about a third of a mile west of the present study area. Gold in Whiteoak Flats was later reported between Ballplay and Citico Creeks by Ashley (1911) and along Flats Creek and Gold Branch by Rove (1926). Rove also mentioned "vague rumors" of gold-bearing quartz veins "on the headwaters of Citico Creek."

During this study, measurable quantities of gold were detected in four rock samples, and traces were found in four others. Two soil samples also contain detectable gold. All major streams of the area were panned for gold, but analyses of the stream sediment samples show none.

In addition to the gold in samples from the present study, gold was found previously in or near the Citico Creek area by Lesure and others (1977) and by the Tennessee Valley Authority (TVA, R. C. Hale, written commun., 1977). Table 6 lists gold-bearing samples, and figure 8 illustrates the distribution of gold occurrences in and near the Citico Creek Wilderness Study Area.

Traces of gold were found along Doublecamp Creek and the Unicoi Mountain highlands in gray pyritic slates and in thin quartz veins. Lesure and others (1977, p. 26) reported 0.3 ppm gold in a sample of pyrite porphyroblasts from slate (sample no. 3202) on Little Fodderstack Mountain on the eastern boundary. A similar porphyroblast sample (TCC–42) from a roadcut along the lower reaches of Doublecamp Creek contains a trace of gold (< 0.17 ppm). Three samples of vein quartz (TCC–2, 10, 12) have detectable gold; a sample of quartz (6041) from the area of Crowder Branch contains 0.3 ppm gold. One

TABLE 6.—*Gold content of samples from the Citico Creek Wilderness Study Area and vicinity*

[All values are listed in parts per million (ppm), where 1 ppm=0.0001 percent=.035 oz per long ton. Sample locations are shown in figure 7. TCC prefixed numbers from present investigation, fire-assay tests; 1,000, 2,000, 3,000 numbers from Lesure and others, 1977, atomic-absorption analyses; 4953 numbers from Robin C. Hale, Tennessee Valley Authority, Geologic Branch, Knoxville, Tenn., written commun., 1977, atomic-absorption analyses; 4014, 4022, and 6041 samples from this study, atomic-absorption analyses. L( )=detected but below limit of determination or below value shown]

Sample no.	Au content (ppm)	Sample description
TCC–1	0.21	Dark-gray slate.
TCC–2	L(0.17)	Vein quartz.
TCC–7	0.31	Dark-gray slate.
TCC–10	L(0.17)	Vein quartz.
TCC–12	L(0.17)	Do.
TCC–24	0.34	Dark-gray slate.
TCC–42	L(0.17)	Pyrite concentrate.
1414	L(0.1)	Soil.
2222	0.3	Interlayered pale and medium gray slate.
2230	0.1	Arkosic metaconglomerate.
2237	0.1	Dark-gray slate.
2240	0.1	Sheared light-olive-gray arkosic metasandstone.
2244	L(0.12)	Forest litter.
2355	L(0.05)	Stream sediment.
2356	L(0.05)	Do.
3202	0.3	Pyrite concentrate.
4953–1–1	0.03	Metagraywacke.
4953–2–2	0.02	Coarse metasandstone.
4014	L(0.05)	Soil.
4022	L(0.05)	Do.
6041	0.3	Vein quartz.

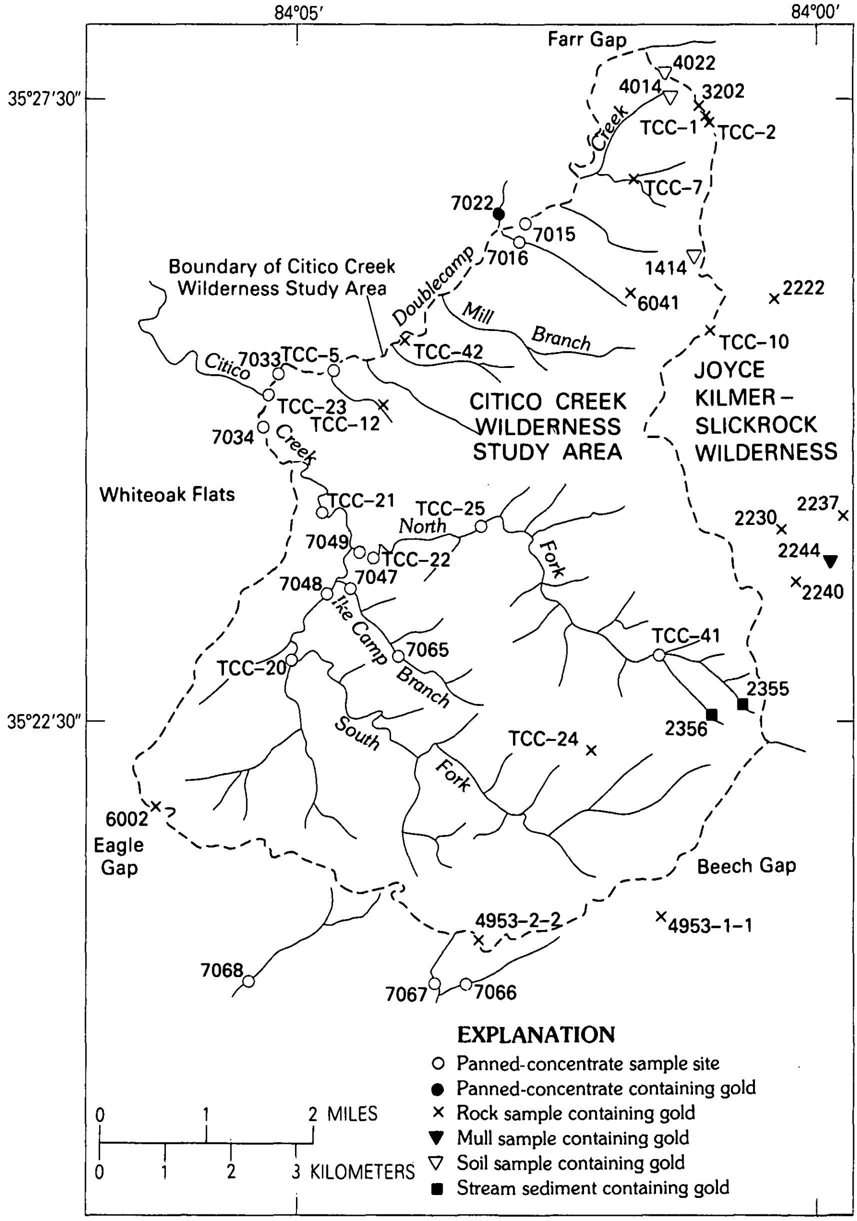

FIGURE 8.—Gold distribution in the Citico Creek Wilderness Study Area and vicinity. Numbers refer to samples listed by Hopkins and others (1979).

panned-concentrate sample collected from Flint Branch along the northwest boundary of the study area yielded a 0.5-mm ribbon-shaped grain of gold.

Minor amounts of gold also were found in the highlands surrounding the headwaters of the north and south forks of Citico Creek; this coincides with the "vague rumors" of gold mentioned by Rove (1926, p. 67). Here, traces of gold occur in dark-gray slate, metasandstone, metaconglomerate, and thin quartz veins of units IV and V. Lesure and others (1977, p. 23) reported gold in the same area, from two stream-sediment samples (2355 and 2356), four rock samples (2222, 2230, 2237, and 2240), a soil sample (1414), and a mull sample (2244). The gold-bearing TVA samples (4953–1–1 and 4953–2–2) are also from this region. Hale (1974, p. 16) stated that unit 2 (of Merschat and Wiener, 1973; unit III of this study) in the Great Smoky Group contains the so-called "Unaka veins," but gold was not detected in two quartz veins sampled from this unit during the present study. Rove (1926, p. 28) reported gold in similar veins in the Unicoi Mountains east of Coker Creek, Tenn. In the present study, gold was not detected in samples of conglomerate from unit II, which Rove (1926, p. 26) indicated to be gold bearing in the Coker Creek area. Because of the low tenor of gold-bearing rocks in the study area and the lack of large alluvial deposits, it is doubtful that commercial quantities of gold exist.

IRON

Troost (1837) first noted traces of iron in Citico Creek, north of the study area, possibly as pyrite altered to limonite. Safford (1869) later included the general area in the Eastern (Tennessee) Iron Region, which, in 1854, had nine operating furnaces. One of the largest operations, the Tellico Iron Works, was about 9 mi (15 km) west of the study area on the Tellico River. Much of the ore was mined from ferruginous sandstone of the Ocoee Supergroup, and most of the iron was siliceous and high in phosphorous. In the Ducktown copper district, gossan was mined for iron until depletion in 1907. Since that time, iron sinter and pellets have been produced at Ducktown as a byproduct of sulfuric acid manufacture from primary iron sulfides.

Neither highly ferruginous sandstone nor major gossan deposits were found in the study area. One small exposure of gossan-cemented breccia contains 15 percent iron (table 3); another red oxidized metasandstone (sample no. TCC–36) contains only 4 percent iron. Most rocks in the study area have traces of pyrite or pyrrhotite, containing as much as 10 percent locally. However, these concentrations of iron in sulfides, as well as in the gossan, are too low to be of current resource interest.

NONMETALLIC RESOURCES

Known nonmetallic resources within the Citico Creek study area include slate, graphite, stone, silica, and sand and gravel. Some slate might find marginal use for structural clay products but, like the other nonmetallic resources, is present in larger quantities and is more easily recovered outside of the proposed wilderness. A low potential for barite may also exist in the study area.

SLATE

Units of slate generally do not crop out in the study area but are exposed along roadcuts and streambeds. Slates are commonly gray to black, are in many areas pyritic, and also are locally graphitic. Variegated yellow, red, violet, blue, and brown slate is also present, typically with cleavage at a high angle to bedding (fig. 5), creating attractive banded slabs. Some of the slate could probably be crushed for use as roofing granules and pulverized for mineral filler. However, for these uses, color uniformity and rock purity (lack of carbonate and sulfides) would be necessary, although many slate granules are artificially colored (Bates, 1960).

None of the varieties of slate would be suitable for dimension slate that might be competitive with other products. Detrimental factors include (1) pyrite porphyroblasts forming "knots," which would weather and stain; (2) lack of color uniformity (in the variegated variety) required of dimension stone (Pennsylvania State College, 1947); and (3) cleavage typically at a high angle of bedding (fig. 5), which, where present, creates rod-shaped pieces making the rock useless as dimension stone.

Ceramic evaluation tests of three slate samples (TCC–13, 14, and 15) by the U.S. Bureau of Mines Metallurgy Research Center, Tuscaloosa, Ala., showed that all would have only marginal use for structural clay products such as building brick or tile (see table 7). The lack of a nearby market area in the foreseeable future suggests a low resource potential for these rocks.

GRAPHITE

Dark slate of unit V in places is sooty black and shiny surfaced, especially near Eagle Gap along the Sassafrass Ridge road. This material, which in hand specimen appears graphitic, is typically very fine grained, occurring either disseminated throughout the rock or concentrated in irregular flattened chips, 1 to 5 cm across. No high-quality flake graphite was seen in any of these rocks, presumably because of the low metamorphic grade of the area.

TABLE 7.—*Ceramic evaluation of slates*

Sample no.	Sample interval	Raw properties[1]	Slow firing test: Temperature[2] (°C)	Munsell color	Mohs' hardness	Total shrinkage (percent)	Absorption (percent)	Apparent porosity (percent)	specific gravity	Potential use
TCC-13------	25 ft	Water plasticity: 20.0 percent	1000	5 *YR* 7/6	2	2.5	25.6	41.1	1.61	Marginal for structural clay products.
	(7.6 m)	Color: gray	1050	2.5 *YR* 7/6	2	2.5	24.6	40.1	1.63	
		Drying shrinkage: 2.5 percent	1100	2.5 *YR* 5/8	2	2.5	17.8	32.4	1.82	
		pH: 7.2	1150	10 *R* 5/6	3	7.5	10.6	22.1	2.09	
			1200	10 *R* 4/4	4	10.0	7.2	16.2	2.24	
			1250	-	—	Melted	—	—	—	
TCC-14------	15 ft	Water plasticity: 22.0 percent	1000	5 *YR* 7/6	2	2.5	24.7	40.1	1.63	Marginal for structural clay products.
	(4.6 m)	Color: gray	1050	2.5 *YR* 6/8	2	2.5	24.1	39.9	1.65	
		Drying shrinkage: 0.0 percent	1100	2.5 *YR* 5/8	3	2.5	17.4	32.1	1.84	
		pH: 5.6	1150	10 *R* 5/6	3	5.0	12.7	25.2	1.98	
			1200	2.5 *YR* 4/6	4	7.5	8.0	17.2	2.14	
			1250	—	—	Melted	—	—	—	
TCC-15------	15 ft	Water plasticity: 27.7 percent	1000	5 *YR* 7/6	2	2.5	27.3	42.9	1.57	Marginal for structural clay products.
	(4.6 m)	Color: tan	1050	2.5 *YR* 6/8	2	2.5	25.4	40.8	1.61	
		Drying shrinkage: 0.0 percent	1100	2.5 *YR* 5/8	3	2.5	17.6	32.4	1.83	
		pH 6.4	1150	10 *R* 5/6	3	7.5	13.3	26.1	1.96	
			1200	2.5 *YR* 4/6	4	7.5	7.5	16.2	2.16	
			1250	10 *YR* 4/2	5	10.0	0.0	0.0	2.38	

[1]Tests indicate the following for all samples: Working properties—short; dry strength—fair; no HCl effervescence; preliminary bloating tests—negative.
[2]Abrupt vitrification for all samples below 1250°C.

Qualitative X-ray-emission tests revealed the presence of major graphite peaks in unit V slate samples TCC–24 and TCC–31. Special chemical tests were performed in which residues from HCl- and HF-treated samples were burned to determine total carbon and organic carbon content. Sample TCC–24 contains 1.5 percent total carbon and 0.95 percent organic carbon, leaving 0.55 percent inorganic carbon, which probably is graphite. Similarly, TCC–31 contains 0.92 percent total carbon, 0.62 percent organic carbon, and 0.30 percent inorganic carbon or graphite. Additional X-ray studies of several shiny black specimens of slate from near Eagle Gap failed to show any characteristic graphite peaks, suggesting an amorphous rather than crystalline state. Five analyzed samples from this same locality contain less than 2 percent noncarbonate carbon. These fine-grained deposits of graphitic rock cannot compete with higher grade flake graphite mainly in foreign deposits (Mexico), or from more easily worked deposits in Alabama and Pennsylvania (Pallister and Thoenen, 1948; Sanford and Lamb, 1949).

STONE

Metasandstone, metagraywacke, and metaconglomerate in the area may be suitable as riprap, railroad ballast, and road material. A small quarry on the south side of Citico Creek, about 9 mi upstream of the confluence with Doublecamp Creek, removed massively bedded metasandstone and metaconglomerate of unit III, presumably for use as road metal. Stone has been used only locally, however, and there is no reason to believe that a wider market will exist in the future.

Some units of attractive blue-quartz metagraywacke and metaconglomerate also have potential use as dimension stone. They have low porosity and high strength due to recrystallization and commonly are massively bedded. However, in many areas they contain disseminated iron sulfides (pyrite and (or) pyrrhotite), which would form unsightly stains upon weathering. The presence of iron sulfides and variable grain size in some beds would considerably restrict use of the stone.

SILICA

Thick, relatively pure quartz veins occur in slate and metasiltstone along Doublecamp Creek and near Beehouse Gap. Outcrops of veins as much as 6 ft (2 m) thick were found at several locations, and some float blocks suggest that thicker veins may exist. Quartz veins possibly could be used as a source of fluxstone, silica flour, or ferrosilicon. In the past, a small amount of vein quartz from nearby areas has been used as a fluxstone in copper smelting in the Ducktown copper district (Hurst, 1955). However, the cost of working, crushing, and transporting the quartz would not be competitive with that from other sources.

SAND AND GRAVEL

Minor amounts of sand and gravel occur as alluvium along a few streams, especially the lower parts of Doublecamp Creek and Citico Creek. Because larger and more easily recovered deposits are found in other regions, the resource potential of the deposits in the study area is judged to be low.

BARITE

Anomalous contents of barium determined for many fine-grained clastic rocks in the Citico Creek area suggest a potential for stratabound barite. Deposits of stratabound barite are of economic importance in many parts of the world, principally as a source for high-density drilling muds. Barite is also of exploration interest because of its common association with sediment-hosted, stratabound Pb-Zn deposits (Large, 1980). Some rocks in the study area contain 2,000 to 3,000 ppm Ba (table 2), mainly slates from southeast of the Nichols Cove fault (fig. 6). In the absence of obvious veins, stratabound barite or Ba-rich feldspar or mica is suggested. A large deposit of stratabound barite, celsian (Ba-feldspar), Ba-rich muscovite, and sphalerite has recently been described from the Dalradian of the Scottish Highlands (Coats and others, 1980), where the metasedimentary rocks are of similar age and lithology to those of the Ocoee Supergroup. In the Citico Creek area, barium contents of stream sediments and panned concentrates do not exceed 700 ppm (table 1), and Ba-rich rocks apparently are not confined to a restricted stratigraphic interval (fig. 6). The potential for stratabound barite (and associated Pb-Zn) is thus judged to be low within the present study area. However, barium is anomalously high in slaty rocks in the adjacent Joyce Kilmer-Slickrock Wilderness, where some stream-sediment samples contain 1,000 to 1,500 ppm Ba (Lesure and others, 1977, tables 2, 5). Other metasedimentary terranes of the Great Smoky Mountains, including the Joyce Kilmer-Slickrock Wilderness, therefore, may have a higher potential for stratabound barite.

OIL AND GAS

Recent seismic and aeromagnetic studies (Cook and others, 1979; Hatcher and Zeitz, 1978) indicate that the Blue Ridge in North Carolina contains a thick sequence (0.6–3 mi or 1–5 km thick) of sedimentary rocks, below an overlying layer of metamorphic rocks 4 to 10 mi (6–15 km) thick. These metamorphic rocks, of which those of the proposed Citico Creek Wilderness are a part, have apparently been moved northwestward about a hundred miles up and over the younger sedimentary rocks. These sedimentary rocks have an unknown potential for hydrocarbons. The depths at which they occur and the implied degree of metamorphism suggest that any hydrocarbons present would be in the form of natural gas and not oil (Cook and others, 1979). The chances of finding concentrations of this gas are problematical; until some deep drilling is done to test the results of the seismic studies, no reasonable estimate of the gas potential can be made, but the presence of gas cannot be totally discounted.

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