UNITED STATES DEPARTMENT OF INTERIOR

GEOLOGICAL SURVEY

Mineral Resources of the Big Frog Wilderness Study Area, Polk County, Tennessee, and Fannin County, Georgia

by

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STUDIES RELATED TO WILDERNESS

STUDY AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, and as specifically designated by PL 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 National Forest lands in the Big Frog study area, Tennessee-Georgia, that is being considered for Wilderness designation (PL 93-622, January 3, 1975). The area studied is in the Cherokee and Chattahoochee National Forests in Polk County, Tennessee, and Fannin County, Georgia.

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SUMMARY

The proposed Big Frog Wilderness is comprised of approximately 1820 hectares (18.2 km^2) of mountainous terrain in the Cherokee and Chattahoochee National Forests south of the Ocoee River in Polk County, Tennessee, and Fannin County, Georgia. Rocks of the study area are greenschist-facies metasandstone, meta-arkose, metagraywacke, and dark slate of the Ocoee Supergroup of late Precambrian age. A major thrust fault, correlated with the Greenbrier Fault, separates fine-grained slaty rocks of the Snowbird Group on the northwest side, from coarse clastic sediments and interbedded slates of the Great Smoky Group on the southeast. North- and northeast-trending folds are common in the map area. Minor deposits of Quaternary sand and gravel occur locally in the lower parts of large streams.

Semiquantitative spectrographic, atomic absorption, and selected fire assay analyses were done on more than 200 samples of rock, soil, and stream sediment. No significant metal anomalies were found for 31 major, minor, and trace elements. In many places, metasiltstone and metasandstone contain trace amounts of chalcopyrite and sphalerite as microscopic intergrowths with the chief sulfide minerals, pyrite and pyrrhotite. Sulfides make up as much as 5 to 10 percent of some rocks and provide concentrations of Cu, Zn, and As slightly higher than background in samples of rock and soil. Rocks containing these disseminated base-metal sulfides are of insufficient grade to have current economic potential, however.

No metallic mineral resources are known within the proposed Big Frog Wilderness. Nonmetallic resources, including slate and phyllite, stone, and sand and gravel are present locally, but are not presently o value because similar resources exist closer to markets outside the study area. These deposits therefore would have only marginal use in the region.

INTRODUCTION

Location and description

The proposed Big Frog Wilderness comprises about 1820 hectares (4500 acres or 18.2 km^2) in parts of the Cherokee and Chattahoochee National Forests in southeastern Tennessee and northernmost Georgia (fig. 1). The study area lies within the western part of the Blue Ridge physiographic province, just south of the Ocoee River gorge. The Cohutta Wilderness borders the Big Frog area on the south and southwest. The nearest town is Ducktown, Tennessee, 10 km to the east. Topographic features of the proposed Wilderness consist of a series of a long ridges which converge at the 1282 m summit of Big Frog Mountain (fig. 2). Maximum relief is 830 m. Drainage has developed in a radial pattern around Big Frog summit. The streams have short, steep courses and within 10 km discharge into the westward-flowing Ocoee River.

Access to the study area is by secondary Forest Service roads from the north, east, or west (fig. 1). Routes 62 and 221 encircle the area at a distance of 2 to 5 km on all but the southern portion which adjoins the Cohutta Wilderness. The Forest Service roads are reached from the east by crossing the Ocoee River at Rogers Bridge off state route 68 near Copperhill, Tenn., and from the north by crossing the Ocoee No. 3 Powerhouse bridge from U.S. highway 64. On the northeast, two jeep roads penetrate further into the high mountains and terminate at the study area boundary; one parallels the East Fork of Rough Creek and the other, the West Fork. These are the only roads that provide direct entry into the study area; all other access is by Forest Service foot trails.

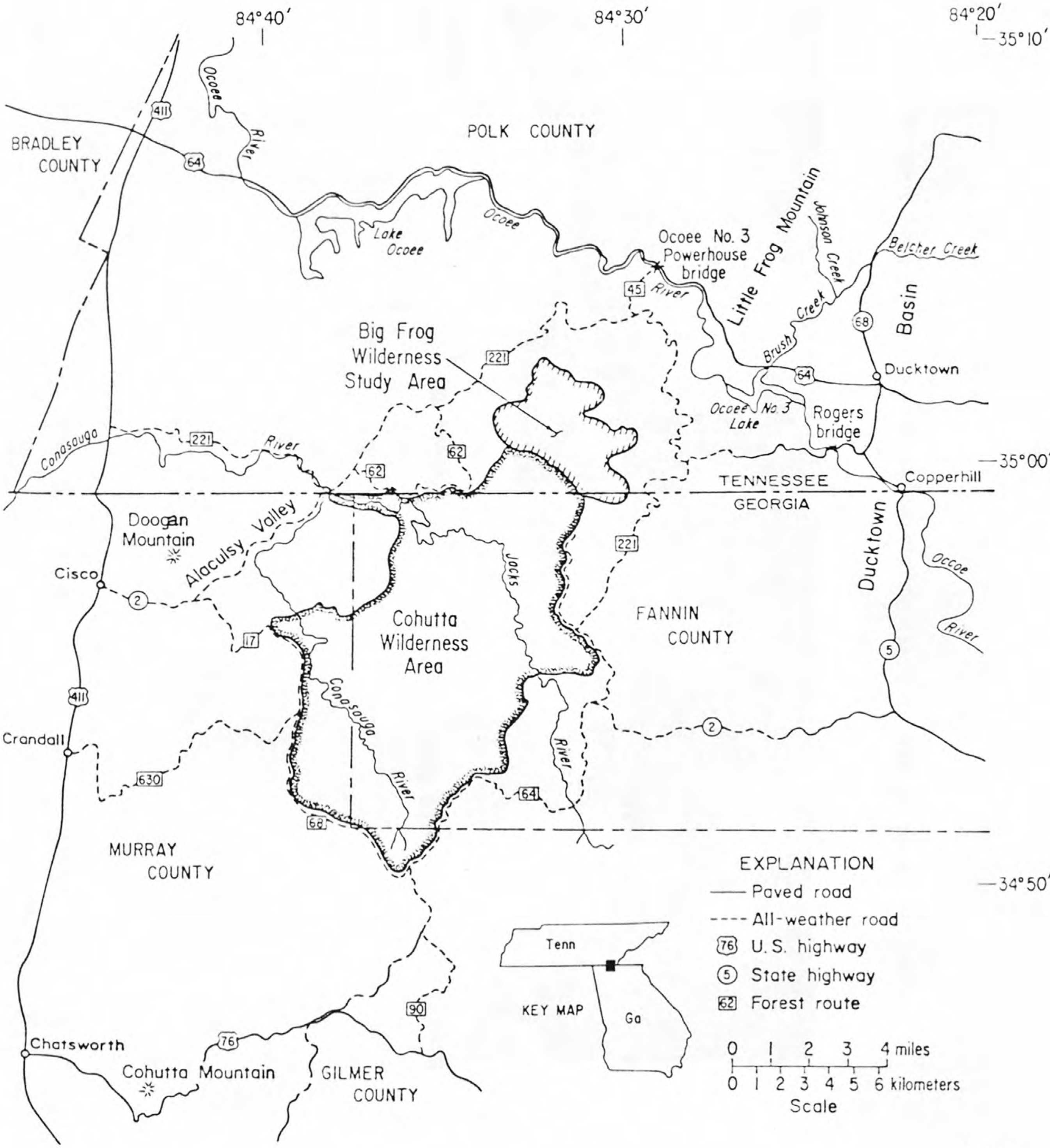

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FIGURE 1. - Index map, Big Frog Wilderness Study Area

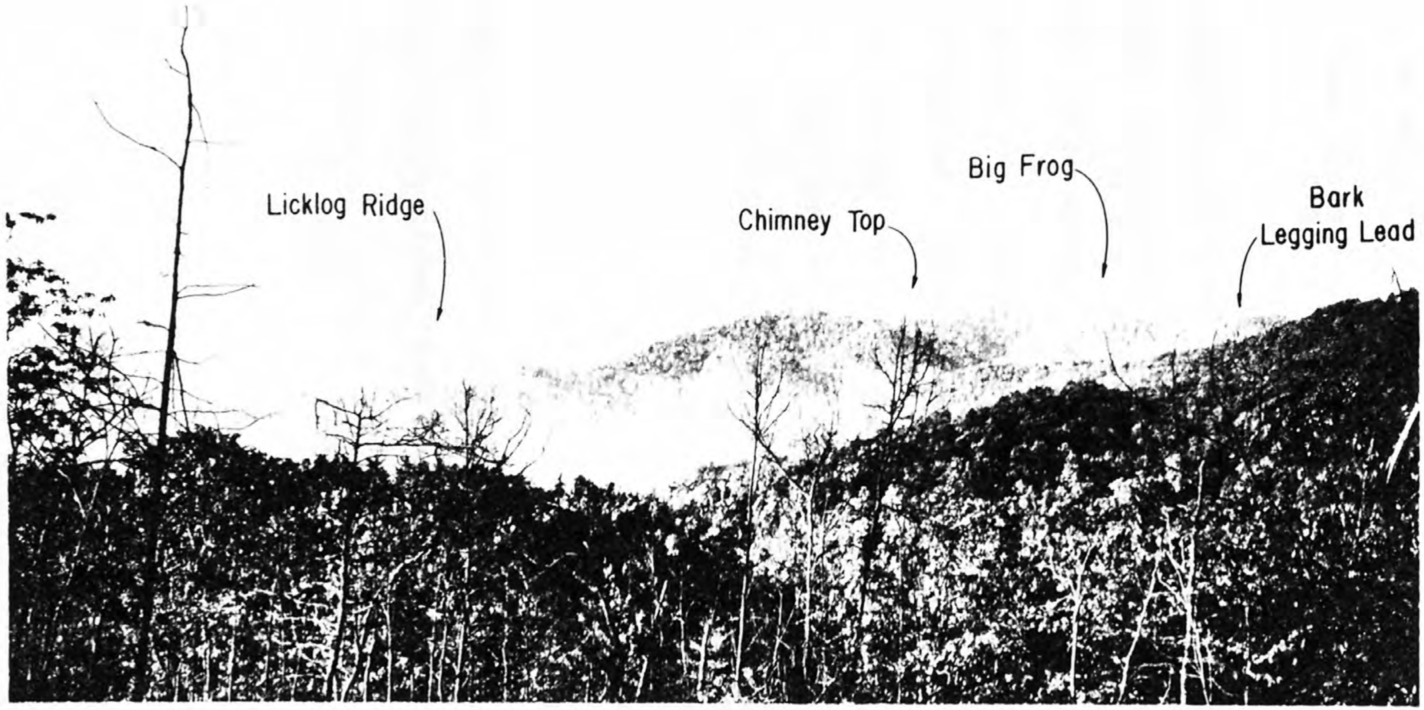

Figure 2. View of Big Frog Wilderness Study Area from Low Gap, looking south.

The 1820 hectares included in the proposed wilderness are owned in their entirety by the U.S. Government and are under Forest Service administration. There are no outstanding mineral rights.

Previous work

Geologic studies in the southern Great Smoky Mountains were pioneered by Safford (1856; 1869) in his early reconnaissance of the state of Tennessee. More recently, Hurst (1973) has provided an overview of the geology of the southern Blue Ridge province. Merschat and Wiener (1973) compiled a geologic map of the southern Great Smoky Mountains from the National Park southwestward to just south of the Big Frog area. Excellent exposures along the Ocoee River gorge, 4 km to the north, have fostered guidebook chapters for field trips in 1962 (Hurst and Schlee, 1962) and in 1978 (Wiener and Merschat, 1978b). More detailed studies near the proposed Big Frog Wilderness include the work of Salisbury (1961) on the Cohutta Mountain quadrangle to the southwest, and geologic mapping by Hernon (1968) of the nearby Ducktown, Isabella, and Persimmon Creek quadrangles east of the study area.

Present investigations

Field investigations were begun in the spring of 1977 by Gazdik and Dunn of the Bureau of Mines. Geologic mapping and sample collection were done by Slack and other personnel of the U.S. Geological Survey in October, 1977. Samples of rock, soil, and stream sediment were collected and submitted for geochemical analysis. Petrographic and x-ray studies and writing of the report were carried out in the spring and early summer of 1978.

Acknowledgements

Assistance in geologic mapping was given by E.R. Force, R.H. Ketelle, and A.E. Grosz. Grosz also collected panned stream sediment concentrates, made heavy liquid separations, and identified minerals.
C.E. Merschat and L.S. Wiener of the North Carolina Division of Mineral Resources discussed with us the structure and stratigraphy of the study area. Appreciation is also extended to C.G. Hagegorge, former Chief Geologist of the Copperhill Operation of Cities Service Company; to Helmuth Wedow, Jr., of the U.S. Geological Survey; to geologists of the Tennessee Division of Geology; and to personnel of the U.S. Forest Service.

GEOLOGY

Stratigraphy and lithology

The Big Frog Wilderness Study Area is underlain by low-grade (greenschist-facies) metasedimentary rocks of the Ocoee Supergroup of probable late Precambrian age. Minor deposits of Quaternary sand and gravel occur locally in some stream drainages. The bedrock is composed of massive quartzite, metagraywacke and arkosic metasandstone interbedded with thick sequences of slate and phyllite. Regional correlations by Merschat and Wiener (1973)[1] show the Big Frog area to contain two of the major subdivisions of the Ocoee, the Great Smoky Group and the Snowbird Group. Within the Great Smoky Group, a generally eastward-facing sequence of metasedimentary strata, comprised of varying proportions of fine and coarse clastic rocks, has been designated the Buck Bald, Boyd Gap, Farner, and Copperhill Formations (Wiener and Merschat, 1978b). More detailed mapping during the present study has further subdivided these units, as shown on the geologic map (fig. 3). The accompanying legend describes more fully specific lithologies of individual map units.

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[1] Revised and updated in 1978.

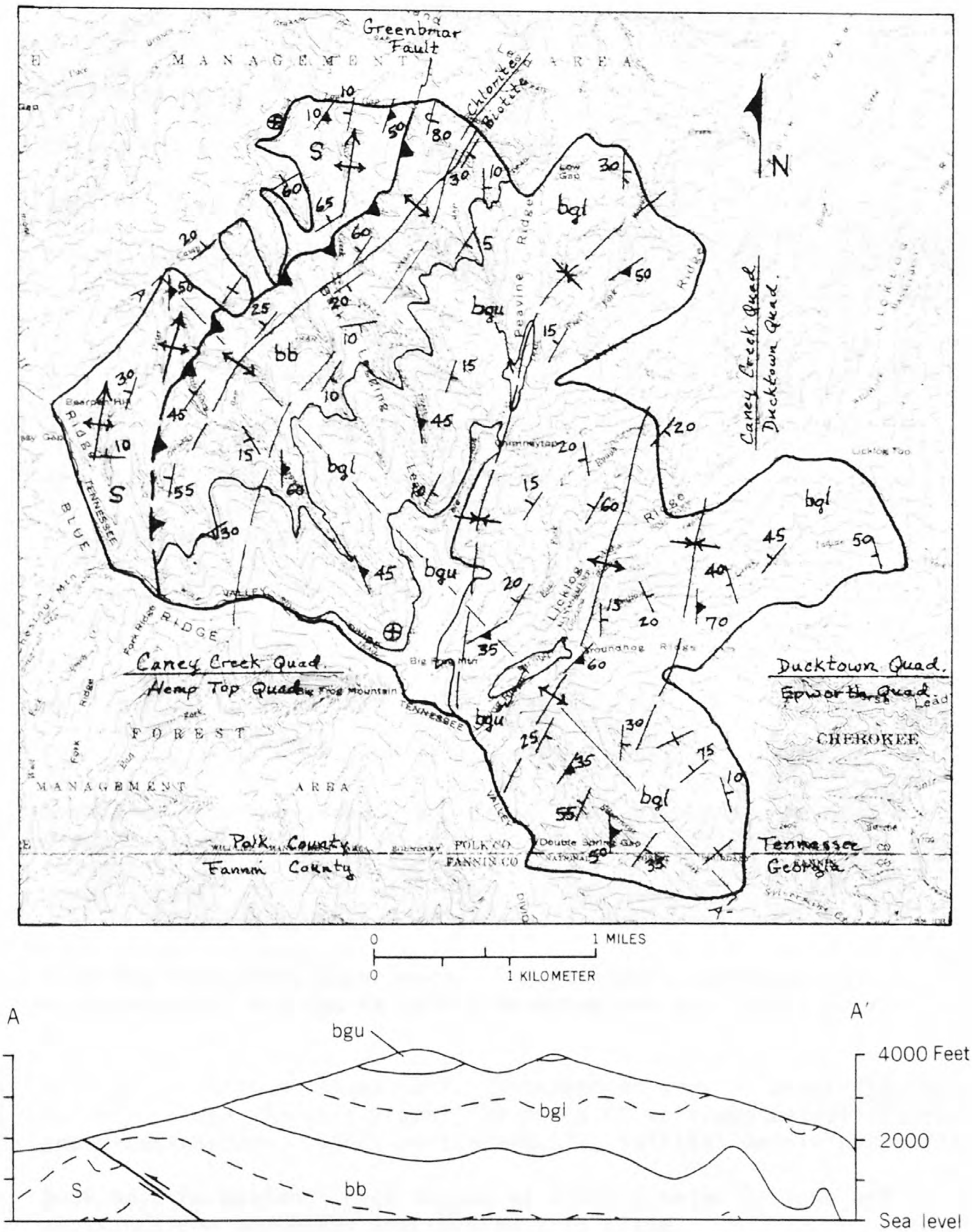

FIGURE 3. **Geologic map and section of the Big Frog Wilderness Study Area**

EXPLANATION

Symbol	Explanation
	Geologic contact
	Thrust fault; saw teeth on upper plate
30	Inclined bedding (upright)
80	Overturned bedding
	Vertical bedding
	Horizontal bedding
45	Strike and dip of slaty cleavage
	Anticline, showing direction of plunge
	Syncline
Chlorite / Biotite	Metamorphic Isograd

Description of Map Units

Units northwest of Greenbriar Fault

s — Snowbird Group undivided. Laminated gray, blue-gray, or gray-black pyritic slate and slaty metasiltstone. Pyrite cubes (or molds) 1-2 cm common in silty beds.

Units southeast of Greenbriar Fault

Great Smoky Group

bgu — Boyd Gap Formation, upper part. Fine to coarse metasandstone, metagraywacke, and quartz pebble metaconglomerate (base) overlain by dark slate.

bgl — Boyd Gap Formation, lower part. Interbedded gray to black fissile sulfidic slate (locally graphitic) and buff sulfidic metasiltstone and metasandstone. Sands partly arkosic; sulfides mainly pyrrhotite.

bb — Buck Bald Formation. Fine to coarse arkosic metasiltstone and metasandstone and minor interbedded gray slate.

Largely coarse-grained metasandstone and pebble metaconglomerate exposed southeast of the Greenbrier Fault are lithologically similar to the Buck Bald Formation as described by Wiener and Merschat (1978b). The crest of Big Frog Mountain, Peavine Ridge, and the drainage basins of Rough Creek, Silvermine Creek, and Indian Creek to the east (fig. 3) contain interbedded sulfidic metasandstone, metagraywacke, and dark slate (locally graphitic); these rocks are assigned to the Boyd Gap Formation of Wiener and Merschat (1978b). Consistent eastward-dipping, upright beds, the tops of which have been determined by graded bedding and cleavage-bedding relations, suggest that the Buck Bald Formation, as here correlated from exposures along the Ocoee River Gorge 4 km to 5 km to the northeast (Merschat and Wiener, 1973), is older than the Boyd Gap Formation. This proposed stratigraphic order is inverted from that of Wiener and Merschat (1978b) who, on the basis of exposures northeast of the Gorge, suggested a younger age for the Buck Bald Formation. More detailed mapping between the two areas will be needed to resolve this conflict.

Structure

Structural elements present in the Big Frog region include open and closed folds, faults, and a prominent axial planar slaty cleavage. In a central area, the metasedimentary rocks commonly have gentle dips, including strata on and near Big Frog Mountain. The western and eastern parts of the proposed Wilderness are more structurally complex, with numerous tight folds and at least one major fault, the Greenbrier Fault.

Folds.--Open and closed folds are common within the study area. The most prominent fold occurs along the west side of the map. It is a broad, open, northeast-trending anticline that appears to be nearly symmetric. Its location is accurately fixed by excellent exposures in several streams; one unnamed stream allows a completely exposed traverse from one limb, across the crest, and down the other limb. To the west, finer-grained slaty rocks of the Snowbird Group show three minor folds whose axes trend nearly north. These anticlines are well-exposed in small drainages on the west side of the Greenbrier Fault, and contrast in orientation with the northeast-trending anticline on the east side.

East and northeast of Big Frog Mountain, the nearly flat strata of the central part of the map area change to a terrain of more complex structure. Here, moderate to steep opposing dips are common, suggesting tight, closed folds similar to those described in correlative rocks at Boyd Gap, about 5 km along strike to the northeast (Wiener and Merschat, 1978a).

Faults.--One major fault passes through the northwest portion of the study area. It separates fine-grained slaty rocks of the Snowbird Group on the west and northwest, from coarser metasandstone and minor interbedded slate of the younger Great Smoky Group on the southeast. We believe this is the Greenbrier Fault described by King (1964) and Hadley and Goldsmith (1963) farther to the northeast in the central and eastern parts of the Great Smoky Mountains, and extended southwestward through the Ocoee River gorge area by Wiener and Merschat (1978b). Evidence for the presence of the Greenbrier Fault, in addition to the regional lithologic considerations, includes sharp changes in bedding attitudes, topography, and fold orientations. The broad, northeast-trending anticline on the southeast side of the fault (fig. 3) may have developed by drag during thrusting; drag on the hanging wall is suggested by overturned bedding along Low Gap Branch. The more northerly strike of minor folds on the northwest side of the thrust suggests deformation prior to movement along the Greenbrier Fault.

Cleavage and jointing.--Cleavage and jointing are both well-developed throughout the study area. Jointing is especially prominent in coarser clastic rocks, particularly in outcrops of massive metasandstone and metagraywacke. Cleavage is common in most fine-grained siltstones and slates. Two types have been recognized, one a major penetrative slaty cleavage, the other a local fracture cleavage that deforms the slaty cleavage. The younger fracture cleavage is visible as a herringbone-like parting in slates and phyllites. In thin section, it is defined by linear concentrations of dark, possibly organic material and appears to be a transposed cleavage.

Orientation of the slaty cleavage generally is north-striking, although a number of readings range from northwest to northeast. The pattern of cleavage orientations is not consistent with models of simple strain from one period of folding, and probably reflects polyphase deformation like that recognized in the Ducktown basin 10 km to the east (Holcomb, 1973; Addy and Ypma, 1977).

Metamorphism

Rocks of the proposed Big Frog Wilderness are within the greenschist facies of regional metamorphism (Swingle and others, 1966; Carpenter,1970). The almandine garnet isograd, and higher grade (staurolite, kyanite) rocks of the Ducktown basin, are several kilometers east of the eastern boundary of the study area. Petrographic examination of clastic rocks shows abundant sericite, and local chlorite and biotite, as a matrix surrounding detrital grains of quartz and feldspar. Biotite was identified in only 6 of 78 thin sections. The distribution of biotite-bearing rocks suggests that the chlorite-biotite isograd lies just west of Big Frog Mountain (fig. 3).

Garnet was identified in two samples of panned stream sediment, but was not found in thin section. A similar situation occurs in greenschist-facies rocks of the Joyce Kilmer-Slickrock Wilderness (Lesure and others, 1977) and in the adjoining Citico Creek Wilderness Study Area (Slack and others, 1979), 65 km northeast of Big Frog. Nearly colorless spessartines are indigenous to the low-grade Ocoee metamorphism. However, pink detrital garnets, including one found in the Big Frog area, probably are second cycle pyrope-rich almandines resulting from the higher grade metamorphism of pre-Ocoee basement rocks (Slack, Wiggins, and Grosz, unpub. data).

GEOCHEMICAL SURVEY

Sampling and analytical techniques.--Over 200 samples of rock, soil, stream sediment, and vein quartz were collected from throughout the Big Frog Study Area. For each type of material an attempt was made to provide a uniform sample coverage. Rock samples (fig. 4) were collected by a composite chip method from different parts of each outcrop. Fresh, unweathered samples were taken wherever possible. The rock chip samples are representative of all major rock types in the study area, as well as all major map units shown on the geologic map. Chip samples of quartz veins also were collected. Soil samples (fig. 5) were taken below surficial organic material from the lower to middle parts of the A horizon, but locally from the upper part of the B horizon. Soil samples were routinely sieved to minus 80-mesh prior to analysis. Stream sediments (fig. 6) were collected from active and intermittent drainages. Organic-rich samples were ashed prior to analysis in order to avoid spectral interference. Stream sediment samples were sieved to minus 80-mesh. Heavy mineral concentrations, collected by standard

panning techniques, were taken from major streams draining radially away from the summit of Big Frog Mountain.

FIGURE 4. Location map for rock chip and quartz vein samples, Big Frog Wilderness Study Area

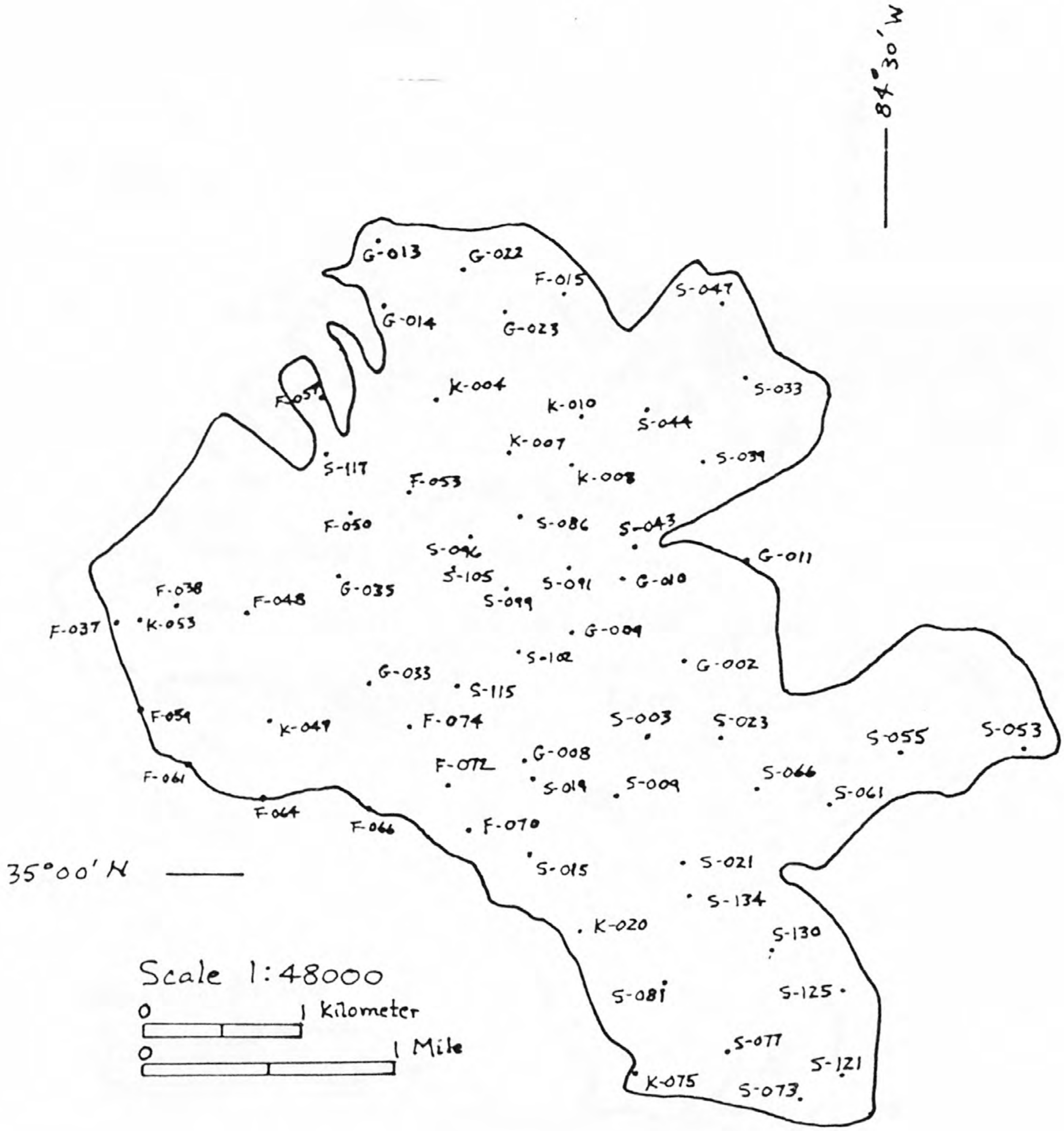

FIGURE 5. Location map for soil samples, Big Frog Wilderness Study Area

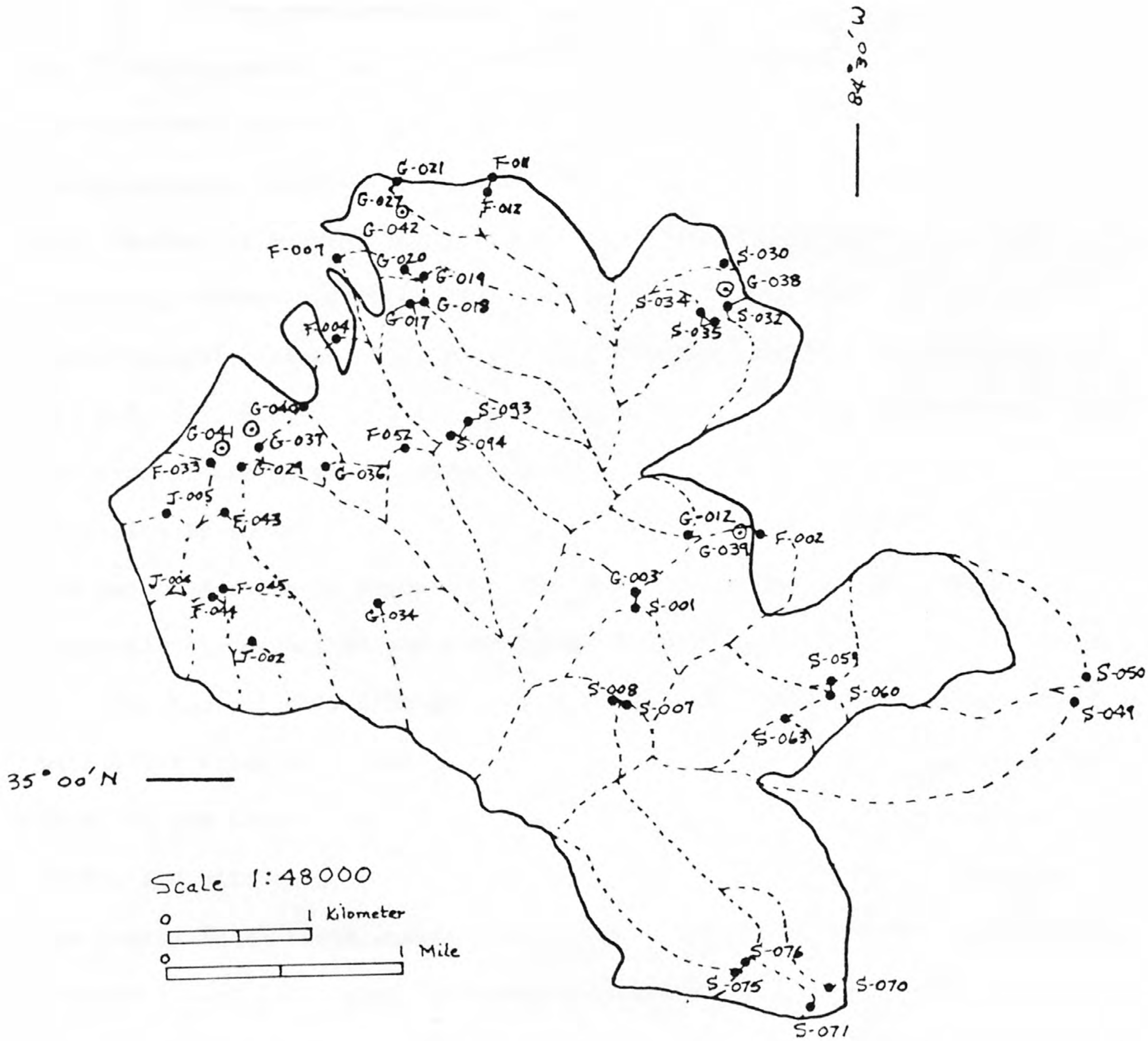

FIGURE 6. Location map for stream sediment samples (single dots) and panned concentrates (circled dots) Big Frog Wilderness Study Area. Light dashed lines outline drainage basins for each sample site.

All samples were analyzed by semiquantitative spectrographic methods for 31 major, minor, and trace elements. Concentrations of gold, silver, and zinc were determined more accurately by atomic absorption and fire assay methods. Analyses were made in the laboratories of the U.S. Geological Survey, Denver, Colorado, and the U.S. Bureau of Mines Metallurgy Research Center, Reno, Nevada. 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 shown 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).

Geochemical data from the Big Frog area are evaluated by comparison with other Wilderness studies to the northeast in lithologically similar rocks of the Great Smoky Group (Lesure and others, 1977; Slack and others, 1979), and with samples collected from areas of known mineralization at the nearby Hazel Creek and Fontana copper mines. For example, a cumulative frequency plot for copper in stream sediment (Lesure and others, 1977, fig. 9) shows a threshold for anomalous values of about 100 ppm Cu, with higher values restricted to the immediate mine areas. In the tabulation and discussion of the geochemical data, selected elements of particular economic interest (for example, Au, Ag, Pb, Cu, Zn) are emphasized. Concentrations of other major, minor, and trace elements (Fe, Mg, Ca, Ti, Mn, B, Ba, Be, Cr, La, Nb, Sc, Sr, V, Y, Zr) fall within expected background ranges and are not discussed. Complete analyses for rock, soil, and stream sediment are available in Hopkins and others (1979).

Stream sediment samples.--Analyses of 43 stream sediment samples show no significant metal anomalies (table 1). Concentrations of most metals fall within expected background ranges; no Au or Ag was detected. Slightly high amounts of Zn and Cu occur locally in some streams; one sample of stream sediment from the East Fork of Rough Creek contains 70 ppm Cu and 290 ppm Zn. Lithologically similar rocks, also comprising part of the Great Smoky Group, yield high background concentrations of base- and precious-metals in stream sediments from areas northeast of the Big Frog area (Lesure and others, 1977; Slack and others, 1979). The high value of 70 ppm Cu is below the threshold of 100 ppm found by Lesure and others (1977) to be characteristic of areas surrounding known mineral deposits at the Fontana and Hazel Creek mines.

Soil samples.--Emission spectrographic and atomic absorption analyses of 65 soil samples show no anomalously high metal values (table 1). Concentrations above background include individual samples for Co (70 ppm), Cu (70 ppm), Ni (70 ppm), Pb (70 ppm), and Zn (300 ppm); Au and Ag were found at the limit of detection (0.5 ppm) in two samples, one from the ridge north of Penitentiary Branch, the other from the drainage of Silvermine Creek (fig. 4). Slightly anomalous Zn values ($\geq$ 200 ppm) were found for 11 samples collected from widely scattered sites throughout the study area. Soil samples containing over 250 ppm Zn are from 5 different areas where the bedrock (generally metasiltstone) contains as much as 5 to 7 percent disseminated sulfides. These Zn concentrations, although much higher than background or median values, are still within the upper part of the range of abundances common to soils that are not associated with ore deposits (Mitchell, 1964, fig. 8.1).

Table 1.--Range and median values (in ppm) for selected elements in soil, stream sediment, and panned concentrate samples collected in 1977 from the Big Frog Wilderness Study Area, Polk County, Tennessee, and Fannin County, Georgia. All analyses are by semiquantitative spectrographic methods except 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, etc., which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins and A. L. Meier, Branch of Exploration Research, 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), Bi (10), Cd (20), Sb (100), W (50), Sn (10), Th (100). Au found only in two soil samples at limit of detection (0.05 ppm); Ag (0.5 ppm) in one soil sample (see text).

	Soil (65 samples)			Stream Sediment (43 samples)			Panned Concentrate (5 samples)		
Elements	Low	High	Median	Low	High	Median	Low	High	Median
Co (5)	5	70	10	7	70	15	7	15	7
Cu (5)	10	70	20	10	70	30	5	30	15
Mo (5)	N	5	N	N	10	N	N	N	N
Ni (5)	7	70	30	10	70	30	10	20	15
Pb (10)	20	70	30	20	70	30	20	30	20
Zn (5)	35	300	150	75	290	150	80	140	130

Table 2.--Range and median values (in ppm) for selected elements in 73 rock chip samples collected in 1977 from the Big Frog Wilderness Study Area, Polk County, Tennessee, and Fannin County, Georgia. All analyses by semiquantitative spectrographic methods except 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, etc., which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins and A. L. Meier, Branch of Exploration Research, 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 (0.05), Ag (0.5), Bi (10), Cd (20), Sb (100), Sn (10), W (50), Th (100).

	Metasandstone, metagraywacke, metaconglomerate (40 samples)				Slate (33 samples)			
Elements	Low	High	Median	Average Sandstone[1,2]	Low	High	Median	Average Shale[3]
As (200)	N	N	N	1	N	500	N	6.6
Co (5)	N	15	7	0.3	N	20	10	20
Cu (5)	N	30	15	10-20	N	70	20	57
Mo (5)	N	15	N	0.2	N	7	N	2
Ni (5)	L	70	15	2	L	50	15	95
Pb (10)	N	50	20	9	N	50	20	20
Zn (5)	15	220	75	16	10	150	100	80

[1] Pettijohn (1963); [2] Turekian and Wedepohl (1961); [3] Krauskopf (1967, Appendix III).

Panned concentrates.--Heavy minerals panned from stream sediments were concentrated by heavy liquid methods in the laboratory. Splits of 5 samples were analyzed by spectrographic and atomic absorption techniques (table 1). No elements are present in anomalously high concentrations. Microscopic study of heavy minerals shows major amounts of hematite, "limonite," magnetite, tourmaline, epidote, ilmenite, and zircon. Gold was found only in one sample (B-321: 0.31 ppm) collected from Tumbling Creek (fig. 6), which also drains areas outside of the proposed Wilderness.

Rock samples.--Composite rock chips of metasandstone, metagraywacke, and metaconglomerate (40 samples), and slate and phyllite (33 samples) were submitted for 31-element spectrographic analysis. Selected ranges and median values, as determined from these analyses, are reported in table 2. No significant concentration of metals was found. Samples of sulfidic siltstone and slate locally contain as much as 70 ppm Cu; one sample from the headwaters of the East Fork of Rough Creek has 500 ppm As (table 2).

The slightly high concentrations of Cu, As, and Zn are apparently caused by trace amounts of base-metal sulfides intergrown with the principal sulfide minerals, pyrite and pyrrhotite. These iron sulfides may comprise as much as 10 volume percent of some rocks. Porphyroblastic cubes of pyrite (to 2 cm) are characteristic of slates west of the Greenbrier Fault (fig. 3). Chalcopyrite and sphalerite are common as accessory intergrowths with pyrrhotite, and locally pyrite, which form streaked aggregates as much as 1 cm long oriented parallel to the major slaty cleavage of fine-grained rocks east of the fault. Similar occurrences of base-metal sulfides disseminated in Ocoee Supergroup rocks have been described by Merschat and Larson (1972) and by Slack and others (1979) for strata of the Great Smoky Group northeast of the Big Frog area. Despite the apparently widespread distribution of these sulfides, they have not been found in enough quantity to be of current commercial interest. Concentrations of Zn, for example, are at least two orders of magnitude lower than present economic grades; copper values are even lower.

Quartz veins.--Numerous quartz veins occur throughout the area of the proposed Wilderness. They form massive white veins generally 1 m or less thick in slate or, less commonly, in metasandstone or metagraywacke. Veins are localized along the principal cleavage of fine-grained slates and metasiltstones; most are milky white to grayish white and barren except for trace amounts of pyrite in a few places. The largest vein discovered during geologic mapping crops out along the lower part of Big Creek, where it forms a northeast-trending body nearly 5 m wide containing abundant inclusions of dark gray slate. Boulders of quartz 4 m to 5 m wide in Silvermine Creek (fig. 3) suggest the presence of very large veins upstream, on the southeast side of Big Frog Mountain.

Six quartz veins were sampled by a composite chip method and analyzed for 31 major, minor and trace elements (table 3). Trace amounts of gold (0.3-0.4 ppm) were detected by fire assay methods in 7 Bureau of Mines samples of outcrops and float of vein quartz (table 4). No economically important metal anomalies, including Au, are associated with any of the samples.

Table 3.--Partial analyses of selected vein quartz collected in 1977 from the Big Frog Wilderness Study Area, Polk County, Tennessee, and Fannin County, Georgia. All analyses are by semiquantitative emission spectrographic methods except 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, etc., which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins and A. L. Meier, Branch of Exploration Research, 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 (0.05), Ag (0.5), As (200), Bi (10), Cd (20), Mo (5), Nb (20), Sb (100), Sn (10), Sr (100), W (50), Th (100).

	Sample Numbers					
Elements percent	5-092	5-095	5-135	F-027	K-003	K-011
Ca (0.05)	N	L	L	L	L	N
Fe (0.05)	0.7	0.3	1.5	0.2	0.7	0.3
Mg (0.02)	.02	.02	.02	.02	.02	.05
Ti (0.002)	.03	.03	.02	.005	.01	.05
Elements ppm						
B (10)	N	N	20	N	L	10
Ba (20)	100	100	70	50	50	100
Be (1)	N	N	N	N	1	1
Co (5)	N	N	5	N	5	N
Cr (10)	10	L	N	N	L	10
Cu (5)	5	L	7	L	L	L
La (20)	N	N	N	L	20	20
Mn (10)	20	30	700	20	150	50
Ni (5)	L	L	5	5	5	5
Pb (10)	L	N	L	N	N	L
Sc (5)	N	N	N	N	L	L
V (10)	10	10	L	L	L	10
Y (10)	N	N	20	N	N	N
Zn (5)	20	40	25	10	15	10
Zr (10)	15	50	100	N	L	20

Table 4.--Distribution of gold in quartz veins, quartz float, and panned concentrate, Big Frog Wilderness Study Area.

[Analyses by fire assay, U.S. Bureau of Mines, Reno Metallurgy Research Center, Reno, Nevada, Conversion factors: 1 ppm = 0.0001 percent = 0.0291667 ounces troy per short ton = 1 gram per metric ton.]

Sample number	Gold (ppm)	Sample description
B-306	0.34	random chip sample, 1 meter long quartz vein exposure
B-307	.41	composite of chips from quartz float
B-308	.27	random chip sample, 6 meter long quartz vein exposure
B-313*	.31	composite of chips from quartz float
B-316	.34	composite of chips from quartz float
B-318	.45	random chip sample, 7.6 meter long quartz vein exposure
B-319	.31	random chip sample, 2 meter long quartz vein exposure
B-321	.31	panned concentrate

* Sample containing trace of silver.

MINERAL APPRAISAL

No economic concentration of minerals was found within the boundaries of the study area. Evaluation of possible resources is focussed on gold, base-metal sulfides, iron and manganese, and on several non-metallic commodities, including slate and phyllite, stone, and sand and gravel. Persistent local rumor insists on the occurrence of a silver deposit, but only one sample tested by fire assay (B-313) had detectable silver. Legend also reports a tin deposit on Silvermine Creek (Furcron, 1960), but pan samples from this stream show no measurable (10 ppm) tin.

Metallic resources

Gold.--A small gold mining district which centered around Coker Creek and several of its tributaries is about 24 km northeast of the study area in Monroe County, Tennessee. Gold, in amounts generally less than 0.5 parts per million, occurs near Coker Creek (Hale, 1974) disseminated in rocks that have been mapped locally as units of the Ocoee Supergroup (Merschat and Wiener, 1973). Mining there has been restricted to gold concentrations in saprolitic and alluvial materials derived from the gold-bearing units and from a few quartz veins (Ashley, 1911; Rove, 1926; Hale, 1974). These deposits were most actively worked from their discovery in 1827 to the Civil War. Sporadic mining has taken place since then with the Annette Mining Company's mid-1920 placer operation being the most recent serious attempt. Hale (1974, p. 3) reports "the total production from the Coker Creek district from 1831 to 1972 was about 9,000 ounces" (280,000 grams of Au). Gold deposits of the Coker Creek district seem to be restricted to southern Monroe County. Although gold-bearing quartz veins on Johnson's Creek and Little Frog Mountain are reported by Ashley (1911) and Rove (1926), these occurrences have not been substantiated.

Gold was detected by atomic absorption analysis in only two soil samples at the limit of detection (0.05 ppm). Low concentrations were found by fire assay in all Bureau of Mines quartz samples and in one sample of panned stream sediment (table 4). The highest concentration, 0.4 parts per million (Samples B-318 and B-307), is well below the lower limit for economic recovery.

Base-metal sulfides.--Massive sulfide deposits in the Ducktown mining district, 11 km east of the Big Frog Study Area, are among the largest in the United States. The Ducktown district has produced almost continuously since 1850, yielding copper, zinc, iron, sulfuric acid, gold, and silver (Kinkel and others, 1968; Magee, 1968). Mineralization occurs both as massive and disseminated sulfides that conform to the general structure of the enclosing hostrocks. The stratabound deposits, previously interpreted as epigenetic, that is, younger than the surrounding rocks, are now considered by many workers (Addy and Ypma, 1977; Gair and Slack, 1979) to have formed by syngenetic processes contemporaneously with the deposition of the enclosing sediments. The Ducktown deposits, comprising approximately 80 million tons of ore, are confined to the Copperhill Formation of the Great Smoky Group (Hernon, 1968; Magee, 1968). Merschat and Wiener (1973) show the Copperhill to trend, at its closest point, about 3.4 km east of the eastern boundary of the Big Frog area. The absence of this formation within the proposed Wilderness, and the lack of any anomalously high values of Cu, Zn, or Pb in samples of rock, soil, or stream sediment suggests a low potential for similar massive sulfide deposits in the Big Frog study area. Base-metal sulfide minerals, including chalcopyrite, sphalerite, arsenopyrite, and galena, that are disseminated in trace amounts in many rocks of the Ocoee Supergroup (Merschat and Larson, 1972), including those of the Big Frog area, are too sparse to be of current economic interest.

Iron and Manganese.--Iron concentrations, associated with rocks of the Ocoee Supergroup (Salisbury, 1961), are found as iron oxides (primarily limonite) in veins and in pockets southwest of the study area. Manganese, when present, is associated with the limonite either as nodules in the iron ore or as manganiferous iron; it is locally found as the cementing material for quartzite breccia (Watson, 1908; Hull and others, 1919; Haseltine, 1924). These deposits probably result from the weathering and subsequent concentration of the minor amounts of iron and manganese found disseminated throughout rocks of the Ocoee Supergroup.

In the early 1900's, deposits of iron with associated manganese were extensively prospected near Doogan Mountain in northern Murray County, Georgia, approximately 15 km southwest of the study area. Bureau of Mines statistical records show that 216 metric tons of ore were shipped from two Doogan Mountain properties during 1917 and 1918. In 1917, 26 metric tons containing 43.61 percent Mn, 8.52 percent Fe, and 2.49 percent SiO_2 were shipped from the Powell property. The following year, the Southern Manganese Corporation shipped 190 metric tons from the Green property. Shipments from the Green property had a composition of 18.85 percent Mn, 26.00 percent Fe, 4.8 percent SiO_2, and 1.12 percent P. No further production or shipments are recorded. However, numerous workings are found over these properties and probably small quantities of ore were shipped sporadically over a number of years. Analyses of samples from the Powell and Green properties published by Hull and others (1919) and by Haseltine (1924) vary widely and differ from ore analyses recorded by the Bureau of Mines. However, the analyses consistently show the deposits to be too high in silica and/or phosphorus to compete with other available ores.

Reconnaissance geologic mapping by Merschat and Wiener (1973) show the Doogan Mountain area to be underlain by rocks of the late Precambrian Walden Creek Group, and partly by the Chilhowee Group and Sandsuck Formation, of Cambrian age. Neither of these stratigraphic units are known within the proposed Big Frog Wilderness. No limonite deposits like those of Doogan Mountain were seen in the study area and no anomalous amounts of iron or manganese were reported from any of the samples analyzed. Manganese contents are uniformly low for samples of rock, soil, and stream sediment (Hopkins and others, 1979). The highest value, 0.3 percent Mn, was found in several soils and stream sediments; rock samples contain much less Mn. Of bedrock samples collected during the field examination, B-311, a highly pyritic phyllite from Peter Camp Branch, 0.2 km west of the study area boundary, had the highest iron content, 8.7 percent. Sample B-305, with an iron content of only 5.6 percent, is from the sole ferruginous quartzite outcrop found during the field examination.

Nonmetallic Resources

Slate and phyllite.--Slate and phyllite are major rock types of the study area. Various physical properties, including sulfide and carbonate contents, color irregularities, and rod-shaped fracturing, make these rocks generally useless as dimension slate, roofing granules, or mineral filler. One bulk sample of phyllite (B-322) was submitted for ceramic testing. Because of its short-firing characteristics, it was found to be only marginally acceptable in the manufacture of structural clay products such as building brick or tile. Several phyllite outcrops appeared to be graphitic, but testing revealed less than 1 percent graphite. Phyllites and slates in the study area have low resource potential because of the abundance of higher quality rock nearer markets.

Stone.--Coarse clastic rocks in the study area such as metasandstone and metagraywacke could be used as riprap, railroad ballast, or as road material. Requirements for stone or stone aggregate commonly are local, however, so that it is unlikely that distant markets would obtain stone from within the proposed Wilderness.

Sand and gravel.--Sand and gravel form minor deposits in the lower drainages of a few major streams around the periphery of Big Frog Mountain. These deposits are thin and not easily accessible. The presence of more easily recovered larger deposits outside the study area indicates that the economic potential of sand and gravel is low.

REFERENCES CITED

Addy, S. K., and Ypma, P.J.M., 1977, Origin of massive sulfide deposits at Ducktown, Tennessee: an oxygen, carbon, and hydrogen isotope study: Econ. Geol., v. 72, p. 1245-1268.

Ashley, G. H., 1911, The gold fields of Coker Creek, Monroe County, Tennessee, in The Resources of Tennessee: Geol. Survey of Tennessee, p. 79-107.

Carpenter, R. H., 1970, Metamorphic history of the Blue Ridge Province of Tennessee and North Carolina: Geol. Soc. America Bull., v. 81, p. 749-761.

Furcron, A. S., 1960, Some lost mineral localities in Georgia: Georgia Miner, Newsletter, Georgia Geol. Survey, v. XIII, no. 3, p. 124-125.

Gair, J. E., and Slack, J. F., (in press), Stratabound massive sulfide deposits of the U.S. Appalachians: Irish Geol. Survey Spec. Vol., IGCP-CCSS, Proj. no. 60.

Hadley, J. B., and Goldsmith, Richard, 1963, Geology of the eastern Great Smoky Mountains, North Carolina and Tennessee: U.S. Geol. Survey Prof. Paper 349-B, 118 p.

Hale, R, C., 1974, Gold deposits of the Coker Creek district, Monroe County, Tennessee: Tenn. Div. Geology Bull. 72, 96 p.

Haseltine, R. H., 1924, Iron ore deposits of Georgia: Georgia Geol. Survey Bull. 41, p. 74-83.

Hernon, R. M., 1968, Geologic maps and sections of the Ducktown, Isabella, and Persimmon Creek quadrangles, Tennessee and North Carolina: U.S. Geol. Survey Open-File Rept., 71 p.

Lesure, F. G., Force, E. R., Windolph, J. F., and Hill, J. J., 1977, Mineral resources of the Joyce Kilmer-Slickrock Wilderness, North Carolina-Tennessee: U.S. Geol. Survey Bull. 1416, 89 p.

Magee, Maurice, 1968, Geology and ore deposits of the Ducktown district, Tennessee, in Ore deposits of the United States, 1933-1967 (Graton-Sales Volume): New York, Amer. Inst. Mining Metall. Engineers, v. 1, p. 207-241.

Merschat, C. E., and Larson, L. T., 1972, Disseminated sulfides in late Precambrian Ocoee rocks (abs.): Geol. Soc. Am., Abstracts with Programs, v. 4, no. 2, p. 92-93.

Merschat, C. E., and Wiener, L. S., 1973, Provisional geologic map of the Ocoee Supergroup, southwestern North Carolina and southeastern Tennessee (abs.): Geol. Soc. Am., Abstracts with Programs, v. 2, no. 3, p. 420.

Mitchell, R. L., 1964, Trace elements in soils, in Bear, F. E., ed., Chemistry of the soil, 2nd ed.: New York, Reinhold, p. 320-368.

Motooka, J. M., and Grimes, D. J., 1976, Analytical precision of one-sixth order semiquantitative spectrographic analyses: U.S. Geol. Survey Circ. 738, 25 p.

Pettijohn, F. J., 1963, Chemical composition of sandstone excluding carbonate and volcanic sands, in Fleischer, M., Ed., Data of Geochemistry, Chap. 5: U.S. Geol. Survey Prof. Paper 440-S, p. 511.

Rove, O. N., 1926, Reconnaissance of gold deposits of eastern Tennessee (M.S. Thesis): Madison, Wisc., Univ. of Wisconsin, 92 p.

Safford, J. M., 1856, A geological reconnaissance of the state of Tennessee: Tenn. State Geologist, 1st Bienn. rept., 164 p.

Safford, J. M., 1869, Geology of Tennessee, 550 p.

Salisbury, J. W., 1961, Geology and mineral resources of the northwest quarter of the Cohutta Mountain quadrangle: Georgia Geol. Survey Bull. 71, 61 p.

Slack, J. F., Force, E. R., Behum, P. T., and Williams, B. B., 1979, Mineral resources of the Citico Creek Wilderness Study Area, Monroe County, Tennessee: U.S. Geol. Survey Open-File Rept. 79-231.

Swingle, G. D., and others, compilers, 1966, Geologic map of Tennessee--East-central sheet: Tenn. Div. Geology, scale 1:250,000.

Turekian, K. K., and Wedepohl, K. H., 1961, Distribution of elements in some major units of the Earth's crust: Geol. Soc. America Bull., v. 72, p. 175-192.

Watson, T. L., 1908, A preliminary report on the manganese deposits of Georgia: Georgia Geol. Survey Bull. 14, p. 174-179.

Wiener, L. S., and Merschat, C. E., 1978a, Structure of Boyd Gap, _in_ Milici, R. C., ed., Field trips in the southern Appalachians, April, 1978, Stop 6: Tenn. Div. Geology, Rept. Invest. No. 37, p. 39-40.

____________, 1978b, Summary of geology between the Great Smoky Fault at Parksville, Tennessee and basement rocks of the Blue Ridge at Glade Gap, North Carolina, _in_ Milici, R. C., ed., Field trips in the southern Appalachians, April, 1978: Tenn. Div. Geology, Rept. Invest. No. 37, p. 23-29.

hbury, J. W., 1953, Geology and mineral resources of the northeast quarter of the Cohutta Mountain quadrangle: Georgia Geol. Survey Bull. 71, 61 p.

k, J. F., Bosse, R. [illegible], Brown, [illegible], and [illegible], [illegible], 197[illegible], Mineral resources of the Citico Creek Wilderness Study Area Monroe County, Tennessee: U.S. Geol. Survey Open-File Rept. 79-[illegible].

[illegible], [illegible], and others, compilers, 1966, Geologic map of Tennessee-- East-central sheet: Tenn. Div. Geology, scale 1:250,000.

[illegible]ins, K. K., and Hedenquist, [illegible] H., 1961, Distribution of elements in some major units of the earth's crust: Geol. Soc. America Bull., v. 72, p. 175-192.

[illegible]on, T. L., 1908, A preliminary report on the manganese deposits of Georgia: Georgia Geol. Survey Bull. 14, p. 174-179.

[illegible]ar, L. S. and Harsmann, G. E., 1978a, Structure of Boyd Gap, in Milici, R. C., ed., Field trips in the southern Appalachians, April, 1978, Stop [illegible]: Tenn. Div. Geology, Rept. Invest. No. 37, p. 39-40.

_____, 1978b, Summary of geology between the Great Smoky Fault at Parksville, Tennessee and basement rocks of the Blue Ridge at Glade Gap, North Carolina, in Milici, R. C., ed., Field trips in the southern Appalachians, April, 1978: Tenn. Div. Geology, Rept. Invest. No. 37, p. 25-29.