STUDIES RELATED TO WILDERNESS

MINERAL RESOURCES OF THE BIG FROG WILDERNESS STUDY AREA AND ADDITIONS, POLK COUNTY, TENNESSEE AND FANNIN COUNTY, GEORGIA

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

By John F. Slack, U.S. Geological Survey,
and by Gertrude C. Gazdik and Maynard L. Dunn, Jr., U.S. Bureau of Mines

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An evaluation of the mineral potential of the area

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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 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 National Forest lands in the Big Frog Wilderness Study Area and Further Planning Additions, Tennessee-Georgia, in the Cherokee and Chattahoochee National Forests in Polk County, Tennessee, and Fannin County, Georgia. Big Frog was established as a Wilderness Study Area by Public Law 93–622, January 3, 1975. The Big Frog Additions were designated for further planning during the second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

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

By John F. Slack, U.S. Geological Survey,
and
Gertrude C. Gazdik and Maynard L. Dunn, Jr., U.S. Bureau of Mines

SUMMARY

The proposed Big Frog Wilderness and Additions comprise approximately 2,041 hectares (20.4 square kilometers) of mountainous terrane 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, metaarkose, metagraywacke, and dark slate of the Ocoee Supergroup of Proterozoic Y(?) and Z age. A major thrust fault, correlated with the Greenbrier fault, separates fine-grained slaty rocks probably 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 copper, zinc, and arsenic that are slightly higher than background in samples of rock, soil, and stream sediment. 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 currently of value because similar resources exist closer to markets outside the study area; these deposits, therefore, would have only marginal use in the region. A possibility also exists for the presence of natural gas at great depths.

INTRODUCTION

LOCATION AND DESCRIPTION

The proposed Big Frog Wilderness and Further Planning Additions comprise about 2,041 ha (9,047 acres or 20.4 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

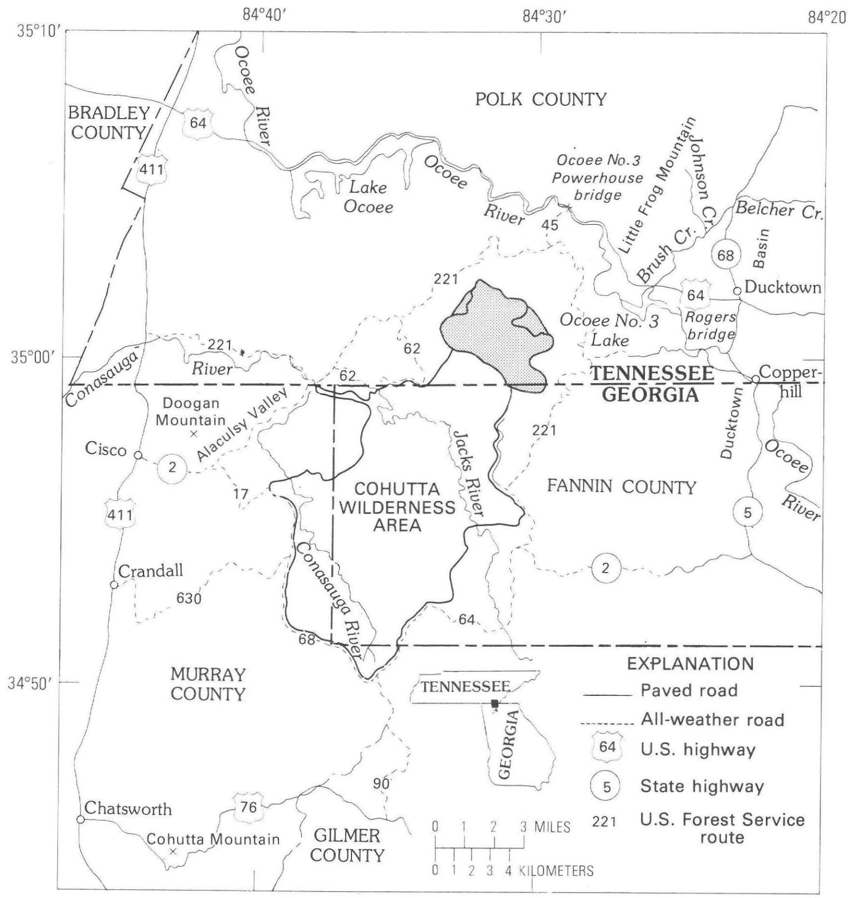

FIGURE. 1.–Index map showing the location of the Big Frog Wilderness Study Area and Additions (shaded), Tennessee and Georgia.

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, Tenn., 10 km to the east. Topographic features of the proposed Wilderness consist of a series of long ridges which converge at the 1,282-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 part which adjoins the Cohutta Wilderness. The Forest Service roads are reached from the

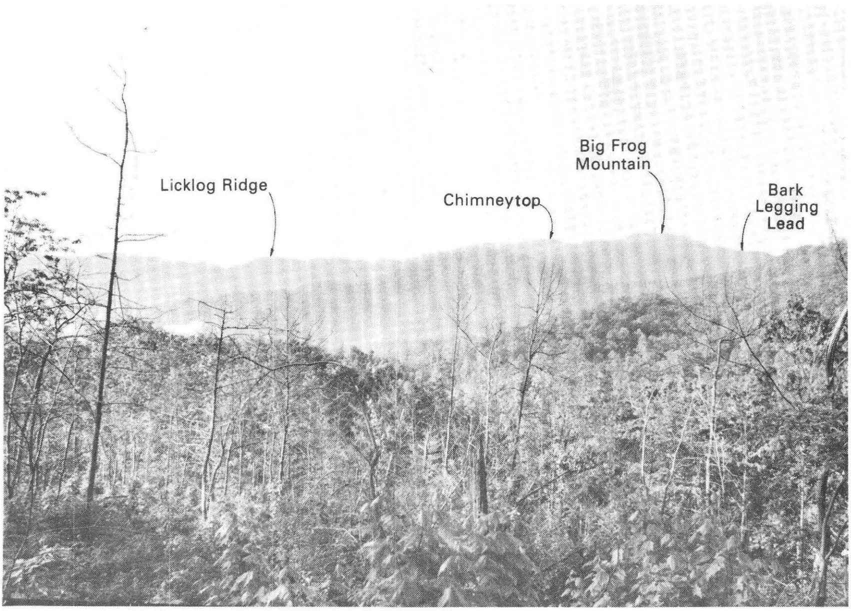

FIGURE 2.–View of Big Frog Wilderness Study Area from Low Gap, looking south.

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 No. 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.

The 2,041 ha 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, 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 G. C. Gazdik and M. L. Dunn, Jr., of the U.S. Bureau of Mines. Geologic mapping and sample collection were done by J. F. 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.

ACKNOWLEDGMENTS

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 greenschist-facies metasedimentary rocks of the Ocoee Supergroup of Proterozoic Y(?) and Z 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 units of the Ocoee, the Great Smoky Group and the Snowbird Group. Within the Great Smoky Group, a generally eastward-facing sequence of metasedimentary strata, composed of varying proportions of fine and coarse clastic rocks, has been designated the Buck Bald, Boyd

[1]Revised and updated in 1978.

Gap, Farner, and Copperhill Formations by Wiener and Merschat (1978b). Detailed mapping during the present study has also subdivided the Ocoee, as shown on the geologic map (fig. 3); the accompanying legend describes more fully specific lithologies of individual map units.

East and southeast of the Greenbrier fault, a rock sequence dominated by metasiltstone and metasandstone is similar to lithologies within parts of the adjacent Cohutta Wilderness (fig. 1) newly designated as the Panther Bluff Formation (Gair and Slack, in press). The crests of Big Frog Mountain and Peavine Ridge, and the drainage basins of Rough Creek, Silvermine Creek, and Indian Creek to the east contain interbedded sulfidic metasandstone, metagraywacke, and dark (locally graphitic) slate. These rocks are assigned to the Boyd Gap Formation of Wiener and Merschat (1978b), based on similarities to roadcut exposures in the type area along U.S. Highway 64 to the north. In the Big Frog area, graded beds and cleavage-bedding relations consistently indicate an upright geometry for the Panther Bluff Formation and a stratigraphic position beneath the Boyd Gap Formation. These relationships thus preclude any correlation between the Panther Bluff and Buck Bald Formations because the latter is interpreted to be stratigraphically above the Boyd Gap Formation (Wiener and Merschat, 1978b).

STRUCTURE

Structural elements 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, having numerous tight folds and at least one major fault, the Greenbrier.

FOLDS

Open and closed folds are common within the study area. The most prominent fold, which can be seen along the west side of the map, 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 complete 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 terrane of more complex

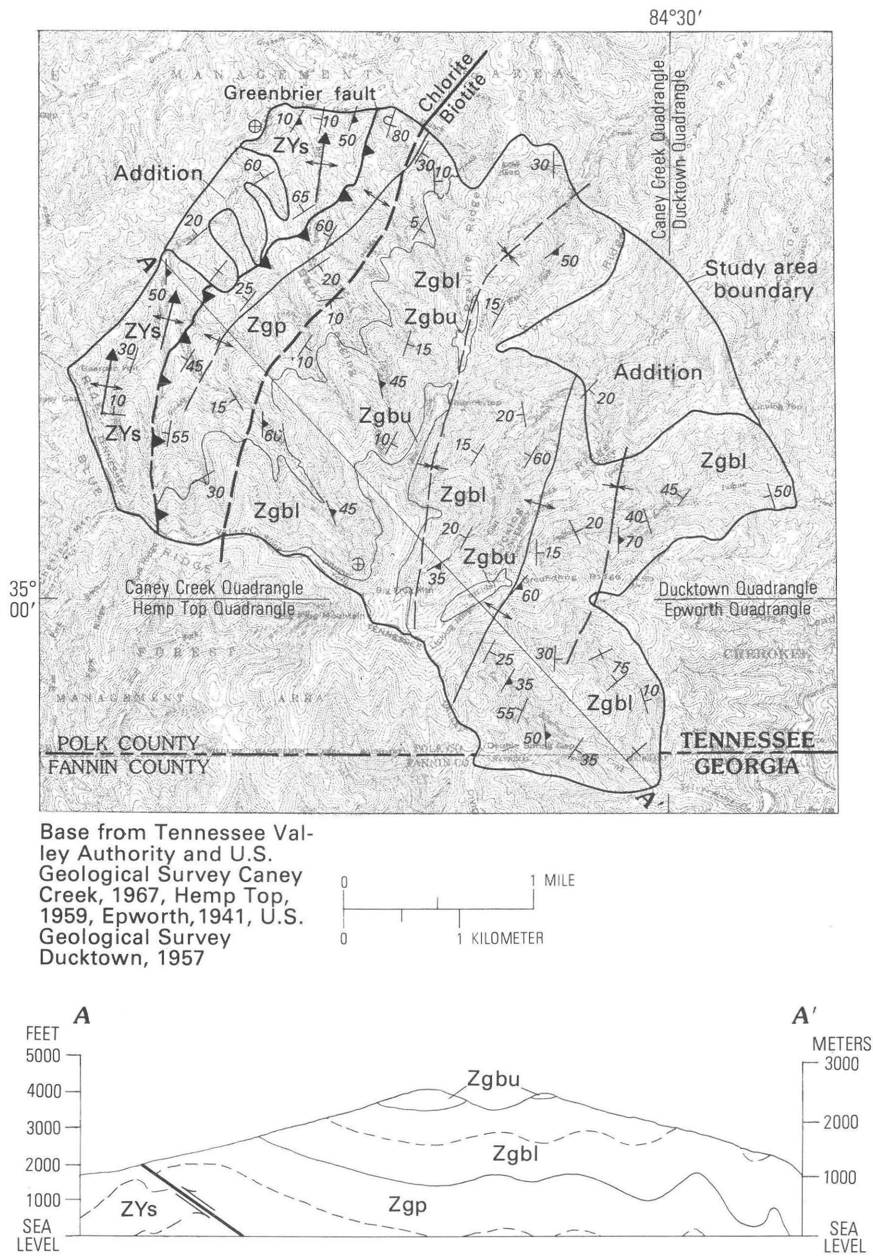

FIGURE 3.—Geologic map and cross section of the Big Frog Wilderness Study Area and Additions.

EXPLANATION

Contact

Thrust fault—Dashed where approximately located; sawteeth on upper plate

Anticline—Showing axial trace and direction of plunge; dashed where approximately located

Syncline—Showing axial trace; dashed where approximately located

Strike and dip of beds

25 Inclined

80 Overturned

Vertical

Horizontal

70 Strike and dip of slaty cleavage

Chlorite / Biotite Metamorphic isograd—Metamorphic zones indicated by mineral names

DESCRIPTION OF MAP UNITS

UNIT NORTHWEST OF GREENBRIER FAULT

ZYs 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 GREENBRIER FAULT

Great Smoky Group

Zgbu Boyd Gap Formation[1], upper part—Fine to coarse metasandstone, metagraywacke, and quartz pebble metaconglomerate (base) overlain by dark slate.

Zgbl Boyd Gap Formation[1], lower part—Interbedded gray to black fissile sulfidic slate (locally graphitic) and buff sulfidic metasiltstone and metasandstone. Sands partly arkosic; sulfides mainly pyrrhotite.

Zgp Panther Bluff Formation —Fine to coarse arkosic metasiltstone and metasandstone and minor interbedded gray slate.

[1]Name designated by Wiener and Merschat (1978b)

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 part of the study area. It separates fine-grained slaty rocks probably 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. This is interpreted to be 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 fine-grained siltstone and slate. Two types of cleavage have been recognized; one, a major penetrative slaty cleavage, and the other, a local fracture cleavage that deforms the older slaty cleavage. The younger fracture cleavage, visible as a herringbonelike parting in slates and phyllites, is defined in thin section by linear concentrations of dark, possibly organic, material.

The slaty cleavage generally strikes north, although a few readings range from northwest to northeast. The cleavage orientations generally are not parallel to the axial planes of folds, and their pattern is not consistent with models of simple strain from one period of folding. The orientations probably reflect 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 assigned to the greenschist facies of regional metamorphism (Swingle and others, 1966; Carpenter, 1970). Rocks within the almandine garnet metamorphic zone and higher grade (staurolite, kyanite) rocks of the Ducktown basin are exposed several kilometers east of the eastern boundary of the study area. Petrographic examination of clastic rocks from the study area shows abundant sericite and local chlorite and biotite as a matrix surrounding detrital grains of quartz and feldspar. The distribution of biotite-bearing rocks suggests that the chlorite-biotite isograd trends northeastward on the northwest side 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 65 km northeast of Big Frog in greenschist-facies metasedimentary rocks of the Joyce Kilmer–Slickrock Wilderness (Lesure and others, 1977) and in the adjoining Citico Creek Wilderness Study Area (Slack and others, 1979). Nearly colorless spessartine (manganese-rich garnet) is present in all of these areas and apparently is a common product of the low-grade Ocoee metamorphism. However, pink detrital garnets, including one found at Big Frog, are pyrope (magnesium)-rich almandines probably derived from higher metamorphic-grade pre-Ocoee basement rocks (Slack and others, 1980).

GEOCHEMICAL SURVEY

SAMPLING AND ANALYTICAL TECHNIQUES

More than 200 samples of rock, soil, stream sediment, and vein quartz were collected from throughout the Big Frog Study Area; several samples were also collected from the two Further Planning Additions. 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 −80 mesh prior to analysis. Stream sediments

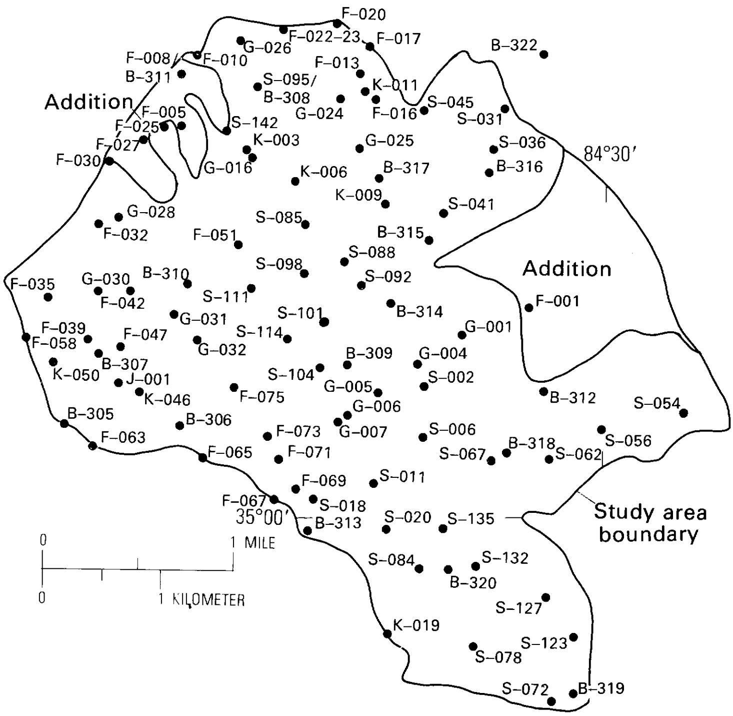

FIGURE 4.–Map of the Big Frog Wilderness Study Area and Additions showing localities of rock-chip and quartz-vein samples.

(fig. 6) were collected from active and large intermittent drainages. Organic-rich samples were ashed prior to analysis to avoid spectral interference. Stream-sediment samples were sieved to –80 mesh. Heavy-mineral concentrates, collected by standard panning techniques, were taken from major streams draining radially away from the summit of Big Frog Mountain. Minerals in the panned concentrates were separated by bromoform and methylene iodide, and the heavy (nonmagnetic) fraction submitted for analysis.

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, 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 concentra-

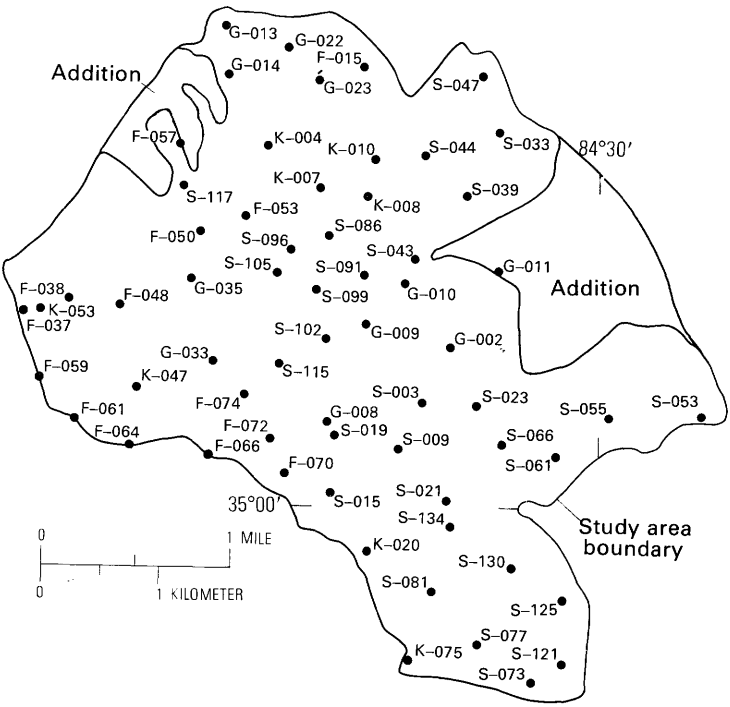

FIGURE 5.—Map of the Big Frog Wilderness Study Area and Additions showing localities of soil samples.

tion ranges. The precision is 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 and southwest in lithologically similar rocks of the Great Smoky Group (Lesure and others, 1977; Slack and others, 1979; Gair, in press) and with samples collected from areas of known mineralization at the nearby Hazel Creek and Fontana copper mines, western North Carolina. In their study of these mines, Lesure and others (1977) used a cumulative frequency plot for copper in stream sediment and determined a threshold for anomalous values of about 100 ppm copper, with higher values restricted to the immediate mine areas. More recently, J. E. Gair has evaluated geochemical data for the adjoining Cohutta Wilderness (fig. 1) and determined threshold values for copper and zinc of 70 and 190 ppm, respectively, based on values two standard deviations above the mean; for soil samples, thresholds of 100 ppm copper and 165 ppm zinc

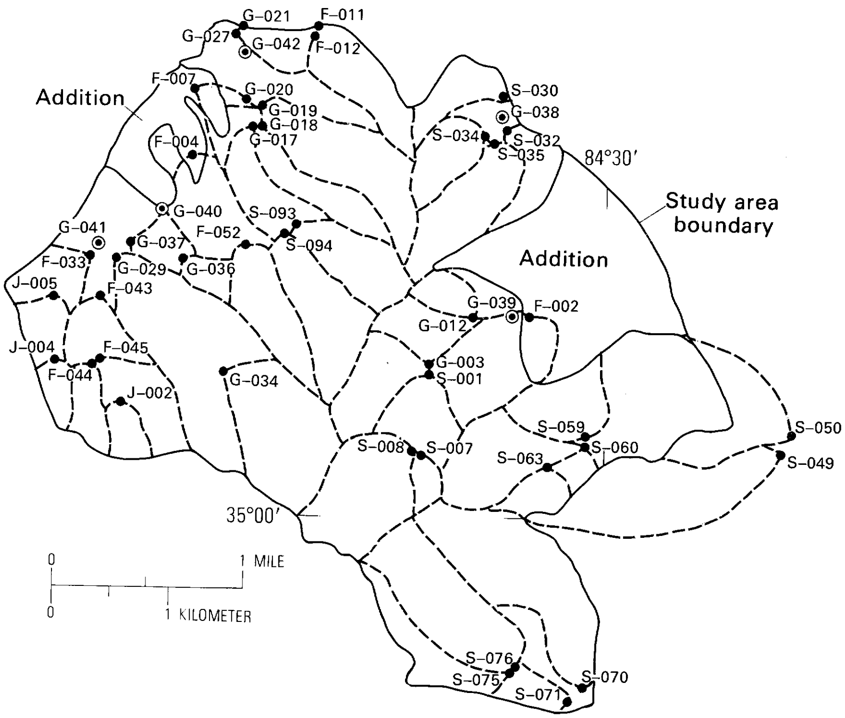

FIGURE 6.—Map of the Big Frog Wilderness Study Area and Additions showing localities of stream-sediment samples (single dots) and panned concentrates (circled dots). Dashed lines outline drainage basins for each sample site.

were found for that area (Gair, in press). In the present study area, anomalous samples are similarly identified as those having metal concentrations at or higher than two standard deviations above the arithmetic mean.

In the tabulation and discussion of the geochemical data, selected elements of particular economic interest (for example, Au, Ag, Pb, Cu, and 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, and Zr) are 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 showed no significant metal anomalies (table 1). Concentrations of most metals were within expected background ranges; no gold or silver was detected. Slightly high amounts of zinc and copper were found locally in some streams, as determined by comparison with threshold values of 243 ppm zinc and

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 semiquantitave 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, and so forth, which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins and A. L. Meier, U.S. Geological Survey, 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).]

Elements	Soil (65 samples)			Stream sediment (43 samples)			Panned concentrate (5 samples)		
	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

57 ppm copper (fig. 7). Anomalous values for copper and zinc are distributed in three drainage basins, including the coincidence of 70 ppm copper and 290 ppm zinc in one small drainage area near the headwaters of the East Fork of Rough Creek (fig. 8). The highest copper value (70 ppm) is clearly anomalous (fig. 7) but is too far 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. Lithologically similar rocks constituting part of the Great Smoky Group also have high background concentrations of base and precious metals in stream-sediment samples from areas to the northeast of the Big Frog area (Lesure and others, 1977; Slack and others, 1979).

SOIL SAMPLES

Emission spectrographic and atomic absorption analyses of 65 soil samples showed few anomalously high metal values (table 1). Gold and silver were found at the limit of detection (0.5 ppm) in two samples, one from the ridge north of Penitentiary Branch, and the other, from the drainage of Silvermine Creek (fig. 4). Anomalous zinc values (≥ 200 ppm) were found for 11 samples collected from widely scattered sites throughout the study area. Concentrations of zinc above threshold (277 ppm, fig. 7) are from three different areas (fig. 8) where the bedrock (generally metasiltstone) contains as much as 5 to 7 percent disseminated sulfides, including trace amounts of sphalerite and chalcopyrite; high copper values, above a threshold of 58 ppm, are coincident with two of these areas. These 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 known to be associated with ore deposits (Mitchell, 1964, fig. 8.1).

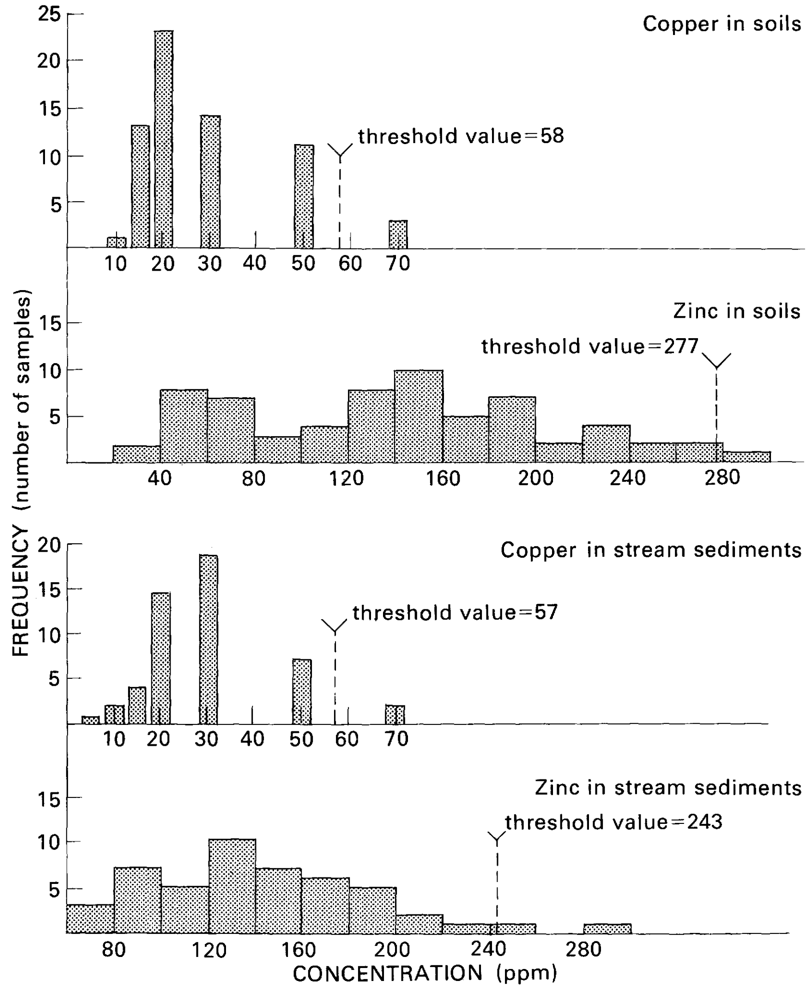

FIGURE 7.–Ranges of concentration of copper and zinc in soil and stream-sediment samples from the Big Frog Wilderness Study Area and Additions.

PANNED CONCENTRATES

Heavy minerals panned from stream sediments were concentrated by heavy-liquid methods in the laboratory, and splits of five samples were analyzed by spectrographic and atomic-absorption techniques (table 1). No elements were present in anomalously high concentrations. Microscopic study of heavy minerals showed major amounts of hematite, limonite, magnetite, tourmaline, epidote, ilmentite, 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.

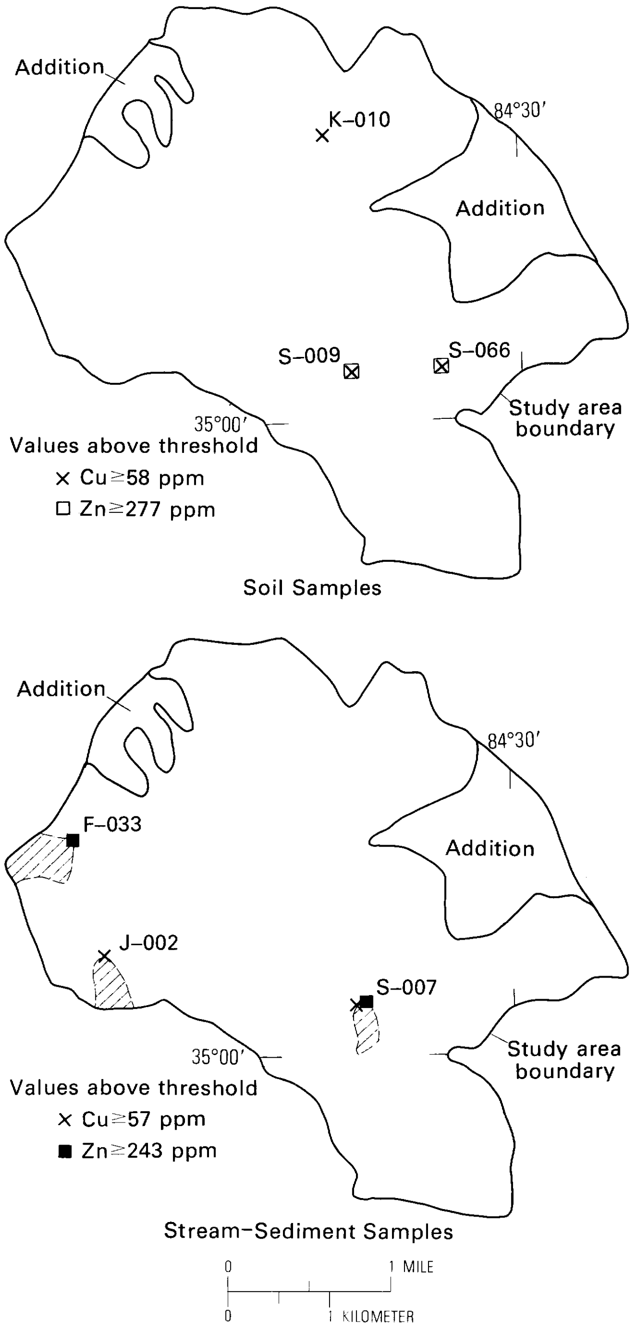

FIGURE 8.–Maps of the Big Frog Wilderness Study Area and Additions showing the distribution of anomalous values of copper and zinc in soil and stream-sediment samples.

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 determinated 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 copper; one sample from the headwaters of the East Fork of Rough Creek has 500 ppm arsenic (table 2).

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, and so forth, which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins and A. L. Meier, U.S. Geological Survey, 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).

The slightly high concentrations of copper, zinc, and arsenic apparently are caused by trace amounts of base-metal sulfides intergrown with the principal sulfide minerals, pyrite and pyrrhotite. The iron sulfides may constitute as much as 10 volume percent of some rocks. East of the Greenbrier fault, pyrrhotite and locally pyrite form streaked aggregates as much as 1 cm long oriented parallel to the major slaty cleavage of fine-grained rocks and contain accessory chalcopyrite and sphalerite. West of the fault, porphyroblastic cubes of pyrite (as large as 2 cm) occur in slates (fig. 3). Similar occurrences of disseminated base-metal sulfides in rock of the Ocoee Supergroup 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 widespread distribution of these sulfides, they have not been found in enough quantity to be of current commercial interest. Concentrations of zinc, for example, are at least two orders of magnitude lower than present economic grades; copper values are even lower. It seems apparent from this and other recent studies that geochemical surveys of terranes underlain by rocks of the Ocoee Supergroup commonly yield characteristic high background values for base metals such as copper and zinc, as well as arsenic and locally cobalt (Slack and others, 1979).

QUARTZ VEINS

Numerous massive quartz veins throughout the area of the proposed Wilderness are 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 slate and metasiltstone; 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 to 5 m wide in Silvermine Creek (fig. 3) suggest the presence of very large veins upstream there, 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 seven U.S. Bureau of Mines' samples of outcrops and float of vein quartz (table 4). No economically important metal concentrations, including gold, 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 emmission spectropgraphic 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, and so forth, which represent approximate midpoints of group data on a geometric scale (see text). Analyses by R. T. Hopkins and A. L. Meier, U.S. Geological Survey, 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)]

Elements	Sample numbers					
	5-092	5-095	5-135	F-027	K-003	K-011
Percent:						
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
Parts per million:						
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 in the Big Frog Wilderness Study Area*

[Analyses by fire assay, U.S. Bureau of Mines, Reno Metallurgy Research Center, Reno, Nev., 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-m-long quartz vein exposure.
B–307	.41	Composite of chips from quartz float.
B–308	.27	Random chip sample, 6 m-long quartz vein exposure.
B–313*	.31	Composite of chips from quartz float.
B–316	.34	Do.
B–318	.45	Random chip sample, 7.6 m-long quartz vein exposure.
B–319	.31	Random chip sample, 2-m-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, and iron and manganese and on several nonmetallic commodities including slate and phyllite, stone, sand and gravel, and oil and gas. 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 panned 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, Tenn. Gold, in amounts generally less than 0.5 ppm, 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 gold). 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 U.S. Bureau of Mines quartz samples and in one sample of panned stream sediment (table 4). The highest concentration, 0.4 ppm (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 Wilderness 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). Mineralized rock occurs both as massive and disseminated sulfides that conform to the general structure of the enclosing host rocks. Such 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, 1980) to have formed by syngenetic processes contemporaneously with the deposition of the enclosing sediments. The Ducktown deposits comprise approximately 80 million tons of ore (Gair and Slack, 1979) and are confined to the Copperhill Formation as used by Hernon (1968) and Magee (1968) of the Great Smoky Group. Merschat and Wiener (1973) show the Copperhill trending, 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 suggests a low potential for massive sulfides of the Ducktown type in the Big Frog area. Nevertheless, the possibility does exist for additional hidden stratabound deposits within other stratigraphic units of the Ocoee Supergroup, but the present study cannot adequately evaluate this possibility. Known occurrences of base-metal sulfide minerals that are disseminated in trace amounts in many rocks of the Ocoee Supergroup (Merschat and Larson, 1972; Slack and others, 1979), including those of the Big Frog area, are too sparse and low grade to be of current economic interest.

Iron and Manganese

Iron concentrations, associated with rocks of the Ocoee Supergroup (Salisbury, 1961), occur as iron oxides (primarily limonite) in veins and 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; locally it is found as the cementing material for quartzite breccia (Watson, 1908, p. 174-179; Hull and others, 1919, p. 197-201; Haseltine, 1924, p. 74-83). 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 prospected extensively near Doogan Mountain in northern Murray County, Ga., approximately 15 km southwest of the study area. Records of the U.S. Bureau of Mines 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 manganese, 8.52 percent iron, 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 manganese, 26.00 percent iron, 4.8 percent SiO_2, and 1.12 percent phosphorous; 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 several 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 analyses recorded by the U.S. Bureau of Mines. However, the analyses consistently indicate the deposits to be too high in silica and (or) in phosphorous 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 Proterozoic Z Walden Creek Group and partly by the Chilhowee Group and Sandsuck Formation of Proterozoic Z and 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 manganese, was found in several soils and stream sediments; rock samples contain much less manganese. 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, which has 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, but, 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 thus 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 this sand and gravel is low.

Oil and Gas

Recent seismic and aeromagnetic studies (Cook and others, 1979; Hatcher and Zeitz, 1979) indicate that the Blue Ridge in northern Georgia and southeastern Tennessee contains a thick sequence (1–5 km thick) of sedimentary rocks below an overlying layer of metamorphic rocks (6–15 km thick). These metamorphic rocks, of which those of the proposed Big Frog Wilderness are a part, have apparently been moved northwestward 100 km or more up and over the younger sedimentary rocks. These sedimentary rocks have an unknown potential for hydrocarbons, but 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 such 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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