UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Geochemical Survey of the Unaka Mountain Roadless Area, Unicoi County, Tennessee

By

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Open-File Report 84-268

1984

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Studies Related to Wilderness

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal Lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geochemical survey of the Unaka Mountain Roadless Area, Forest Service number 08275, in the Cherokee National Forest, Unicoi County, Tennessee. The Unaka Mountain Roadless Area was classified as a non-wilderness area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

SUMMARY

Unaka Mountain Roadless Area comprises 4,700 acres in the Cherokee National Forest, Unicoi County, Tennessee. The area is underlain by a Precambrian-to-Cambrian sequence of gneiss and granite, sandstone, quartzite, and shale. Iron and manganese prospects and mines are scattered throughout a dolomite unit just outside of the Roadless Area. Panned concentrates from major drainages within and just outside of the Roadless Area contained significant values of lead, thorium, copper, tin, zinc, and barium. Concentrations of these elements were plotted showing their distributions. Lead and thorium are ubiquitous and are likely contained in monazite that is reworked from the Precambrian basement rocks. Copper and zinc may be contained in iron oxides after magnetite. Barium and tin-rich concentrates are derived from streams draining clastic rocks and Precambrian granites and gneiss in the northern and northeastern parts of the area.

INTRODUCTION

The Unaka Mountain Roadless Area is in the Cherokee National Forest in the Blue Ridge physiographic province. The area lies entirely in Unicoi County, about 2 1/2 mi south of Stone Mountain. The North Carolina-Tennessee state boundary nearly parallels the southern border of the Roadless Area (plate 1; figure A). Access to the area is primarily by dirt roads and trails. Limestone Cove and Davis Springs along State Route 107 are the nearest towns, about 2 mi north of the area. The town of Erwin, Tennessee, is within 3 mi of the Roadless Area. Rock Creek, Dick Creek, and several other tributaries of North Indian Creek comprise the drainages. Relief is moderate to steep; and vegetation is thick in most places.

In the spring of 1980, K. A. Duttweiler, J. W. Whitlow, and W. R. Griffitts of the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Unaka Mountain Roadless Area. The purpose of this report is to provide a brief summary of the geology and assess the geochemical nature of the area.

GEOLOGY

The general geology of the Roadless Area and adjacent areas is shown in Plate 1 (figure B). The geology was mapped by King and others (1944) and was used in this report to aid in the interpretation of the geochemical data. There was no additional mapping conducted by the authors. A brief description of rock units is provided here. For any additional details on geology or structure, refer to King and others (1944), King and Ferguson (1960), or Rodgers (1952).

The Unaka Mountain Roadless Area lies in the Limestone Cove window bounded by the Limestone Cove and Unaka Mountain thrust faults (King and Ferguson, 1960). Strata strike northeast and dip northwest.

Nearly 98 percent of the study area is underlain by the basal clastic rocks of Lower Cambrian series called the Chilhowee Group. Underlying Precambrian rocks comprise the remaining 2 percent. The Shady Dolomite overlies the Chilhowee Group and occurs only outside of the study area.

The Precambrian rocks that crop out in the far southeast corner of the study area consist of medium-grained granites and fine-grained Cranberry gneiss. The Chilhowee Group includes the Unicoi, Hampton, and Erwin Formations, which for simplicity, were combined as the Chilhowee Group in Plate 1 (figure B). However, descriptions of each of the three formations are included.

The oldest and lowermost formation in the Chilhowee Group is the Unicoi Formation, which is exposed in over 90 percent of the area. The formation consists of thick-bedded quartzite, in part arkosic and conglomeratic, that is interbedded with thin-bedded arkose.

The Hampton Formation, which overlies the Unicoi Formation, is generally thought of as a shaly interval between the more sandy or quartzitic Unicoi and Erwin Formations. The Hampton Formation is composed mainly of dark gray to greenish gray clay shale with interbedded layers of siltstone and arkosic sandstone in the lower part of the formation and vitreous quartzite in the upper part. The Hampton is not exposed in the Unaka Mountain Roadless Area, but the slope break which parallels the northern boundary represents the Unicoi-Hampton contact.

The Erwin Formation is the uppermost unit of the Chilhowee Group and consists of white vitreous quartzite, dark ferruginous quartzite, siltstone, and shale. The white quartzite beds constitute a relatively small part of the formation, but serve to distinguish the Erwin Formation from the otherwise similar Hampton Formation. Based on mapping by Rodgers (1952), small portions of the area are underlain by the Erwin Formation.

The Shady Dolomite, which is also of Cambrian age, crops out 2 to 3 mi west and north of the study area. Numerous iron and manganese prospects and mines are scattered throughout the dolomite. The occurrence of iron and manganese oxides in the Shady Dolomite is common in many parts of northeastern Tennessee (King and others, 1944).

PROCEDURE

Samples were collected from 34 drainages, each drainage representing a 1- to 1.5-sq mi area. Some samples were collected from drainages just outside of the Unaka Mountain Roadless Area boundary. Nevertheless, the samples are important in evaluating the geochemical nature of the area. Sample locations are listed by field number (table 2) and are shown in Plate 1 (figure B). At each sample site, a stream-sediment sample was collected and heavy-mineral-concentrate samples were panned from the same active alluvium as the stream-sediment samples. The heavy-mineral concentrates were used in evaluating the Unaka Mountain area, because the common rock-forming minerals (quartz and feldspar) which tend to dilute the stream-sediment sample are removed, leaving the heavier ore-forming minerals.

Each concentrate was sieved through a 20-mesh screen to remove the coarse material. The light minerals (quartz and feldspar) still remaining after panning were removed by bromoform separation. Magnetite was removed with a hand magnet. Using a Frantz Isodynamic magnetic separator with a 15° side slope and 25° forward slope setting, three fractions were obtained: the magnetic at 0.5 ampere (M.5), the magnetic at 1 ampere (M1), and the nonmagnetic at 1 ampere (NM). The NM fraction generally contains the most common ore-forming sulfide and oxide minerals as well as other nonmagnetic minerals such as zircon, rutile, fluorite, and topaz.

Mineral proportions of each fraction were estimated with a binocular microscope. Many samples contained contaminants such as copper wire or lead shot, which were removed at this stage. Each fraction was subsequently analyzed semiquantitatively by E. F. Cooley for 31 elements using a six-step d.c. arc, optical-emission spectrographic method (Grimes and Marranzino, 1968). The values are reported as one of six steps per order of magnitude: 1, 0.7, 0.5, 0.3, 0.2, 0.15, and multiples of these numbers. These values are the approximate midpoints of the concentration ranges.

GEOCHEMISTRY

Of the 31 elements analyzed, concentrations of lead, thorium, copper, zinc, tin, and barium were significant and their distributions are shown in Plate 1 (figures C-E). The semiquantitative analysis of the samples are listed in the Table 2.

NM fraction

The highest values of tin and copper were found in the NM fraction along with enriched barium values. The three elements were plotted together in Plate 1 (figure C).

The limit of detection for barium by spectrographic analysis is 50 ppm. All of the values in the NM fraction are at or greater than this amount. Barium values ranged from 50 to 3000 ppm. The highest values of 700 to 3000 were found in concentrates obtained from streams draining the northeast section of the Unaka Mountain Roadless Area, an area containing clastic rocks of the Chilhowee Group.

Copper values ranged from 20 to 300 ppm--all above the lower limit of detection of 10 ppm for copper. Sample 80UK33 was taken from a stream draining the Chilhowee Group near the Limestone Cove overthrust and contained 300 ppm copper. Samples 80UK32 and 80UK9 were taken from near the thrust contact in the same drainage basin as 80UK33, and had values of only 50 ppm. Sample 80UK34, also taken from this drainage basin, had 30 ppm.

Tin is detectable down to 20 ppm. Most samples did not contain enough tin to be detectable; the values obtained ranged from 20 to 500 ppm. The highest values occur in the east and northeastern parts of the area. Sample 80UK40 was obtained from a stream outside of the Unaka Mountain Roadless Area boundary, and contained 500 ppm tin. Sample 80UK47 was obtained close to the Unaka Mountain thrust contact between Precambrian rocks and the clastic rocks of the Chilhowee Group just east of the area and contained 300 ppm tin. Furthur downstream in this drainage basin containing 80UK47, however, tin is not present in great enough quantity to be detected. Samples 80UK7 and 80UK8 contained insufficient NM fraction after heavy-liquid separation and magnetic separation for semiquantitative spectrographic analysis.

It was not possible to establish the host minerals for tin, copper, or barium. During examination of the NM fraction with a binocular microscope, no cassiterite nor any recognizable copper or barium minerals were observed.

M1 Fraction

Lead and thorium were ubiquitous in the M1 fraction. The distributions of both elements are shown in Plate 1 (figure D).

Lead is detectable by spectrographic analysis to 20 ppm. All values of lead in the M1 fraction were above this limit and ranged from 50 to 1000 ppm. Generally, the highest values were obtained from concentrates of streams just northeast of the area. Sample 80UK7 is from a stream that drains the Precambrian rocks and contained the highest value of 1000 ppm. Sample 80UK8 contained insufficient sample for analysis. There are six samples which were obtained from drainage basins entirely within the rocks of the Chilhowee Group. The values for these six samples were between 100 and 500 ppm lead. Sample 80UK22 yielded a value of 500 ppm and was from a stream draining Precambrian rocks just north of the area and north of the thrust. The southern and southeastern areas yielded values of 50 to 200 ppm.

Thorium occurred in nearly all M1 samples. By spectrographic analysis, thorium is not detectable below 200 ppm. Values for thorium range from 200 ppm to greater than 2000 ppm. Samples obtained from drainages in both Chilhowee Group rocks in the northern part of the area and Precambrian rocks southeast of the area yielded high values.

Lead and thorium occur together in nearly every sample. Monazite was observed in most M1 samples. Some M1 samples contained 50 to 80 percent monazite, which is the probable source of the lead and thorium. Inasmuch as the monazite is widespread, particularly in the northern and northeastern areas, it is probably reworked from the older Precambrian rocks.

M.5 Fraction

Highest values of zinc occur in the M.5 fraction. Copper and lead are enriched in the M.5 fraction and have a wide range of values. The distributions of the three elements are plotted together in Plate 1 (figure E).

Whenever zinc is detected, it is considered significant because of the very high detection limit of 500 ppm. Ten samples contained 500 ppm zinc.

Samples 80UK46 and 80UK7 were obtained from streams draining both Precambrian gneissic rocks and clastic rocks east of the area. Both samples were close to the Unaka Mountain thrust contact. Other samples containing 500 ppm zinc were obtained from streams in the northern portion of the area, an area underlain by the Chilhowee Group rocks.

Samples 80UK35 and 80UK36 contained 1000 and 500 ppm zinc, respectively. Both were taken from drainages outside of the Unaka Mountain Roadless Area boundary and at the Limestone Cove thrust contact.

Copper and lead are enriched in many samples. Copper values of 10 to 150 ppm are widespread. There are several enriched values near the Limestone Cove thrust southwest of the area. Lead values range from 20 to 100 ppm with the highest values in the northern part.

It is difficult to determine the host minerals for the zinc or copper as no minerals containing them were recognized with a binocular microscope. Because the zinc and copper are enriched in the M.5 fraction, they are most likely contained in iron oxides after magnetite. Monazite was present in small amounts in the M.5 fraction and is the likely source of the lead.

REFERENCES CITED

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

King, P. B., and Ferguson, H. W., 1960, Geology of northeasternmost Tennessee: U.S. Geological Survey Professional Paper 311, 136 p.

King, P. B., Ferguson, H. W., Craig, L. C., and Rodgers, John, 1944, Geology and Manganese Deposits of Northeastern Tennessee: Tennessee Division of Geology Bulletin 52, 275 p.

Rodgers, John, 1952, Geologic map of east Tennessee: Tennessee Division of Geology Bulletin 58, part II, 1:125,000 scale maps, 15 plates.

Table 1.--Limits of determination for the spectrographic analysis of rocks and stream sediments, based on a 10-mg sample

[The spectrographic limits of determination for heavy-mineral-concentrate samples are two reporting units higher than the limits given for rocks and stream sediments.]

Elements	Lower determination limit	Upper determination limit
	Percent	
Iron (Fe)	0.05	20
Magnesium (Mg)	.02	10
Calcium (Ca)	.05	20
Titanium (Ti)	.002	1
	Parts per million	
Manganese (Mn)	10	5,000
Silver (Ag)	0.5	5,000
Arsenic (As)	200	10,000
Gold (Au)	10	500
Boron (B)	10	2,000
Barium (Ba)	20	5,000
Beryllium (Be)	1	1,000
Bismuth (Bi)	10	1,000
Cadmium (Cd)	20	500
Cobalt (Co)	5	2,000
Chromium (Cr)	10	5,000
Copper (Cu)	5	20,000
Lanthanum (La)	20	1,000
Molybdenum (Mo)	5	2,000
Niobium (Nb)	20	2,000
Nickel (Ni)	5	5,000
Lead (Pb)	10	20,000
Antimony (Sb)	100	10,000
Scandium (Sc)	5	100
Tin (Sn)	10	1,000
Strontium (Sr)	100	5,000
Vanadium (V)	10	10,000
Tungsten (W)	50	10,000
Yttrium (Y)	10	2,000
Zinc (Zn)	200	10,000
Zirconium (Zr)	10	1,000
Thorium (Th)	100	2,000

Table 2.--Analytical data for heavy-mineral concentrates from the Unaka Mountain Roadless Area, Tennessee

[N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown]

Sample	S-FE%	S-MG%	S-CA%	S-TI%	S-MN	S-AG	S-AS	S-AU	S-B	S-BA	S-BE	S-BI	S-CD	S-CO	S-CR
80UK1M1	7.0	.70	<.10	>1.0	200	N	N	N	>2,000	150	N	N	N	50	500
80UK1M5	20.0	.50	.10	>2.0	5,000	N	N	N	2,000	700	15	N	N	100	200
80UK1NM	.5	.10	<.10	>1.0	50	N	N	N	500	100	<2	N	N	<10	200
80UK20M5	20.0	.50	<.10	>2.0	2,000	N	N	N	3,000	70	3	N	N	70	500
80UK20NM	.3	.05	<.10	>1.0	50	N	N	N	500	200	<2	N	N	<10	100
80UK20NM	7.0	1.00	<.10	>1.0	150	N	N	N	>2,000	200	<2	N	N	20	500
80UK21M5	20.0	.20	<.10	.5	7,000	2	N	N	1,000	500	15	N	N	100	200
80UK21NM	.5	.10	<.10	>1.0	70	N	N	N	700	150	<2	N	N	<10	150
80UK21NM	15.0	1.00	<.10	>1.0	200	N	N	N	>2,000	200	N	N	N	50	500
80UK22M1	10.0	.70	<.10	>1.0	200	N	N	N	>2,000	200	N	N	N	20	500
80UK22M5	30.0	.15	<.10	>2.0	3,000	N	N	N	500	150	7	N	N	150	200
80UK22NM	.5	.05	<.10	>1.0	70	N	N	N	300	200	<2	N	N	N	200
80UK23M1	10.0	1.00	<.10	>1.0	200	N	N	N	>2,000	200	N	N	N	20	500
80UK23M5	20.0	.10	<.10	>2.0	10,000	N	N	N	1,000	2,000	3	N	N	100	500
80UK23NM	.2	<.05	<.10	>1.0	70	N	N	N	700	100	<2	N	N	N	100
80UK24M1	5.0	.50	<.10	>1.0	100	N	N	N	>2,000	500	N	N	N	10	150
80UK24M5	50.0	.20	.10	.7	700	N	N	N	1,000	300	10	N	N	100	100
80UK24NM	.7	.15	<.10	>1.0	50	N	N	N	1,000	200	<2	N	N	N	200
80UK25M1	5.0	2.00	.10	>1.0	200	N	N	N	>2,000	200	N	N	N	20	500
80UK25M5	20.0	.70	.15	>2.0	2,000	N	N	N	5,000	70	3	N	N	50	3,000
80UK25NM	.2	.05	<.10	>1.0	70	N	N	N	700	200	<2	N	N	N	100
80UK26M1	2.0	.30	.10	>1.0	150	N	N	N	2,000	70	N	N	N	20	300
80UK26M5	30.0	.20	.10	>2.0	5,000	N	N	N	100	50	N	N	N	70	500
80UK26NM	.5	.05	<.10	>1.0	100	N	N	N	700	200	<2	N	N	N	100
80UK27M5	30.0	.15	<.10	>2.0	5,000	N	N	N	500	500	7	N	N	100	500
80UK28M1	5.0	1.00	<.10	>1.0	150	N	N	N	>2,000	300	N	N	N	10	300
80UK28M5	30.0	.30	.10	>2.0	5,000	N	N	N	2,000	700	10	N	N	70	1,000
80UK28NM	.2	.05	<.10	>1.0	70	N	N	N	500	500	<2	N	N	N	150
80UK29M1	5.0	.50	<.10	>1.0	200	N	N	N	>2,000	700	N	N	N	10	500
80UK29M5	20.0	.30	.10	>2.0	5,000	N	N	N	2,000	500	7	N	N	70	1,500
80UK29NM	.2	<.05	<.10	>1.0	70	N	N	N	500	3,000	<2	N	N	N	100
80UK2M1	20.0	1.50	.10	1.0	2,000	N	N	N	>2,000	500	<2	N	N	70	300
80UK2M5	30.0	.50	.10	1.0	>10,000	N	N	N	2,000	5,000	20	N	N	200	700
80UK2NM	.3	.10	<.10	>1.0	70	N	N	N	1,000	150	<2	N	N	<10	100
80UK32M1	5.0	.50	<.10	>1.0	200	N	N	N	>2,000	70	N	N	N	20	200
80UK32M5	30.0	.30	.10	2.0	5,000	N	N	N	2,000	500	10	N	N	70	100
80UK32NM	.5	.05	<.10	>1.0	50	N	N	N	700	150	<2	N	N	<10	200
80UK33M1	5.0	.50	.10	>1.0	200	N	N	N	>2,000	70	N	N	N	10	150
80UK33M5	20.0	1.00	.50	>2.0	1,500	N	N	N	1,500	200	5	N	N	150	150
80UK33NM	.7	.15	<.10	>1.0	70	N	N	N	1,000	500	<2	N	N	<10	200
80UK34M1	5.0	.70	<.10	>1.0	150	N	N	N	>2,000	70	N	N	N	20	500
80UK34M5	20.0	.50	.15	2.0	5,000	N	N	N	2,000	1,000	10	N	N	70	200
80UK34NM	.5	.20	<.10	>1.0	50	N	N	N	700	70	<2	N	N	<10	150
80UK35M1	5.0	.70	.10	>1.0	150	N	N	N	>2,000	100	N	N	N	20	300
80UK35M5	20.0	1.00	.50	>2.0	7,000	N	N	N	2,000	200	5	N	N	100	200

Table 2.--Analytical data for heavy-mineral concentrates from the Unaka Mountain Roadless Area, Tennessee

Sample	S-CU	S-LA	S-MO	S-NB	S-NI	S-PB	S-SB	S-SC	S-SN	S-SR	S-V	S-W	S-Y	S-ZN	S-ZR	S-TH
80UK1M1	50	1,000	N	70	30	70	<200	20	N	N	100	N	500	N	>1,000	200
80UK1M5	100	70	N	150	100	50	N	30	N	N	200	N	1,500	N	1,500	N
80UK1NM	50	100	N	N	10	20	N	50	20	N	100	N	500	N	>1,000	N
80UK20M5	50	N	N	100	50	70	N	30	N	N	300	N	500	<500	2,000	N
80UK20NM	30	150	N	N	10	<20	N	70	N	N	100	N	700	N	>1,000	N
80UK20NM	70	>1,000	N	70	20	150	<200	50	N	N	100	N	500	N	>1,000	500
80UK21M5	100	N	N	N	100	200	N	15	N	N	100	N	100	N	200	N
80UK21NM	30	100	N	N	<10	<20	N	70	N	N	100	N	700	N	>1,000	N
80UK21NM	70	>1,000	N	50	50	100	<200	30	N	N	100	N	500	N	>1,000	200
80UK22M1	70	>1,000	N	70	<10	500	<200	>100	N	N	100	N	2,000	N	>1,000	>2,000
80UK22M5	70	70	N	100	70	100	N	50	N	N	200	N	700	500	300	N
80UK22NM	50	50	N	N	N	<20	N	100	N	N	100	N	700	N	>1,000	N
80UK23M1	70	>1,000	N	100	<10	500	<200	>100	N	N	100	N	2,000	N	>1,000	>2,000
80UK23M5	50	50	N	200	20	70	N	30	N	N	300	N	1,000	500	1,000	N
80UK23NM	20	100	N	N	<10	<20	N	70	N	N	100	N	1,000	N	>1,000	N
80UK24M1	50	300	N	50	20	50	N	20	N	N	100	N	200	N	>1,000	<200
80UK24M5	70	N	N	50	150	70	N	10	N	N	100	N	50	N	1,000	N
80UK24NM	50	70	N	N	10	<20	N	50	N	N	100	N	700	N	>1,000	N
80UK25M1	20	>1,000	N	50	30	200	N	100	20	N	100	N	1,000	N	>1,000	500
80UK25M5	50	150	10	100	50	30	N	50	N	<200	200	N	500	N	>2,000	N
80UK25NM	20	100	N	N	10	<20	N	100	N	N	100	N	1,000	N	>1,000	N
80UK26M1	20	>1,000	N	<50	N	500	N	100	N	N	70	N	2,000	N	>1,000	>2,000
80UK26M5	10	70	N	150	20	20	N	50	N	N	300	N	30	500	500	N
80UK26NM	30	50	N	N	<10	20	N	50	70	N	100	N	700	N	>1,000	N
80UK27M5	100	N	N	100	50	100	N	50	N	N	300	N	300	500	500	N
80UK28M1	30	>1,000	N	50	20	100	N	50	N	N	100	N	2,000	N	>1,000	1,500
80UK28M5	100	300	N	200	100	30	N	30	N	N	200	N	700	<500	2,000	N
80UK28NM	30	150	N	N	10	20	N	100	N	N	100	N	1,500	N	>1,000	N
80UK29M1	50	>1,000	N	<50	20	100	N	50	N	N	100	N	2,000	N	>1,000	1,000
80UK29M5	50	70	N	200	30	30	N	30	N	N	300	N	700	500	2,000	N
80UK29NM	20	150	N	N	10	20	N	100	N	N	70	N	1,500	N	>1,000	N
80UK2M1	100	1,000	N	70	70	100	<200	20	N	N	100	N	1,000	N	>1,000	500
80UK2M5	150	50	N	50	100	50	N	30	N	N	150	N	500	N	>2,000	N
80UK2NM	100	100	N	N	10	20	N	100	N	N	100	N	1,000	N	>1,000	N
80UK32M1	100	>1,000	N	70	20	100	N	20	N	N	100	N	500	N	>1,000	1,000
80UK32M5	100	100	N	50	70	50	N	20	N	N	200	N	1,000	N	1,000	N
80UK32NM	50	150	N	N	<10	<20	N	70	N	N	100	N	500	N	>1,000	N
80UK33M1	100	700	N	70	10	70	N	20	20	N	100	N	300	N	>1,000	500
80UK33M5	50	150	N	150	30	30	N	30	N	200	200	N	200	N	700	N
80UK33NM	300	50	N	N	<10	<20	N	50	N	N	100	N	500	N	>1,000	N
80UK34M1	100	>1,000	N	70	20	100	N	10	N	N	100	N	1,000	N	>1,000	1,000
80UK34M5	100	100	N	100	50	30	N	20	N	N	150	N	700	N	700	N
80UK34NM	30	50	N	N	<10	<20	N	100	N	N	100	N	500	N	>1,000	N
80UK35M1	100	1,000	N	50	20	70	N	10	N	N	100	N	200	N	>1,000	700
80UK35M5	30	100	N	100	30	30	N	30	N	N	200	N	200	1,000	500	N

Table 2.--Analytical data for heavy-mineral concentrates from the Unaka Mountain Roadless Area, Tennessee

Sample	S-FE%	S-MG%	S-CA%	S-TI%	S-MN	S-AG	S-AS	S-AU	S-B	S-BA	S-BE	S-BI	S-CD	S-CO	S-CR
80UK35NM	.7	.20	<.10	>1.0	50	N	N	N	500	100	<2	N	N	<10	200
80UK36M1	15.0	.50	<.10	>1.0	150	N	N	N	>2,000	100	<2	N	N	10	300
80UK36M5	30.0	.50	.15	>2.0	5,000	N	N	N	3,000	300	10	N	N	50	2,000
80UK36NM	.5	.05	<.10	>1.0	50	N	N	N	500	100	<2	N	N	<10	150
80UK40M1	15.0	.20	<.10	>1.0	1,000	N	N	N	1,500	200	N	N	N	30	150
80UK40M5	20.0	.10	N	>2.0	5,000	N	N	N	20	50	3	N	N	70	3,000
80UK40NM	1.0	.07	<.10	>1.0	300	N	N	N	700	2,000	<2	N	N	<10	200
80UK41M1	5.0	1.00	<.10	>1.0	150	N	N	N	>2,000	150	N	N	N	20	300
80UK41M5	30.0	.50	.10	.7	700	N	N	N	2,000	100	15	N	N	70	700
80UK41NM	.5	.05	<.10	>1.0	50	N	N	N	700	200	<2	N	N	<10	200
80UK42M1	10.0	.70	<.10	>1.0	200	N	N	N	>2,000	150	N	N	N	20	500
80UK42M5	30.0	.20	.10	>2.0	3,000	N	N	N	1,000	500	10	N	N	100	1,000
80UK42NM	.5	.07	<.10	>1.0	100	N	N	N	500	700	<2	N	N	<10	200
80UK43M1	3.0	.70	.10	>1.0	150	N	N	N	2,000	100	N	N	N	20	300
80UK43M5	20.0	1.00	.70	>2.0	5,000	N	N	N	1,000	150	<2	N	N	70	200
80UK43NM	.5	.10	<.10	>1.0	100	N	N	N	700	200	N	N	N	<10	150
80UK44M1	7.0	.70	<.10	>1.0	150	N	N	N	>2,000	100	N	N	N	20	500
80UK44M5	20.0	1.00	.20	>2.0	1,500	N	N	N	3,000	200	2	N	N	50	500
80UK44NM	.5	.20	<.10	>1.0	70	N	N	N	1,000	200	N	N	N	<10	200
80UK45M1	5.0	.50	<.10	>1.0	100	N	N	N	>2,000	100	N	N	N	20	200
80UK45M5	15.0	1.00	.10	>2.0	700	N	N	N	3,000	500	2	N	N	20	300
80UK45NM	.5	.10	<.10	>1.0	50	N	N	N	700	2,000	<2	N	N	<10	150
80UK46M1	2.0	1.00	.20	>1.0	300	N	N	N	2,000	70	N	N	N	20	300
80UK46M5	20.0	.50	.30	>2.0	5,000	N	N	N	300	70	N	N	N	50	700
80UK46NM	.5	.05	<.10	>1.0	70	N	N	N	500	150	<2	N	N	<10	200
80UK47M1	15.0	1.00	.20	>1.0	300	N	N	N	1,000	50	N	N	N	30	300
80UK47M5	20.0	.50	.30	>2.0	5,000	N	N	N	100	70	<2	N	N	70	700
80UK47NM	.5	.05	<.10	>1.0	70	N	N	N	500	100	<2	N	N	<10	150
80UK4M1	5.0	2.00	.10	>1.0	200	N	N	N	>2,000	50	N	N	N	30	1,000
80UK4M5	15.0	1.00	.15	>2.0	5,000	N	N	N	5,000	50	2	N	N	50	2,000
80UK4NM	.2	.05	<.10	>1.0	50	N	N	N	700	50	<2	N	N	N	100
80UK5M1	5.0	1.00	<.10	>1.0	150	N	N	N	>2,000	50	N	N	N	20	300
80UK5M5	20.0	1.00	.20	1.5	>10,000	N	N	N	5,000	1,500	20	N	N	50	500
80UK5NM	.5	.20	<.10	>1.0	70	N	N	N	1,000	300	<2	N	N	N	150
80UK61M1	10.0	1.00	.10	>1.0	200	N	N	N	>2,000	200	N	N	N	20	300
80UK61M5	20.0	.70	.20	1.5	5,000	N	N	N	5,000	700	10	N	N	50	1,500
80UK61NM	.5	.05	<.10	>1.0	70	N	N	N	500	150	<2	N	N	<10	200
80UK62M1	5.0	1.00	.10	>1.0	150	N	N	N	>2,000	300	N	N	N	20	700
80UK62M5	20.0	1.00	.20	1.5	2,000	N	N	N	5,000	500	15	N	N	50	1,000
80UK62NM	.5	.10	<.10	>1.0	100	N	N	N	700	200	<2	N	N	<10	200
80UK63M1	5.0	.50	<.10	>1.0	150	N	N	N	>2,000	300	N	N	N	15	500
80UK63M5	15.0	1.00	.50	2.0	2,000	N	N	N	5,000	500	7	N	N	50	150
80UK63NM	.5	.10	<.10	>1.0	100	N	N	N	500	200	<2	N	N	<10	200
80UK6M1	5.0	1.00	<.10	>1.0	200	N	N	N	>2,000	200	N	N	N	20	300
80UK6M5	20.0	.70	.10	>2.0	10,000	N	N	N	3,000	3,000	7	N	N	150	1,000

Table 2.--Analytical data for heavy-mineral concentrates from the Unaka Mountain Roadless Area, Tennessee

Sample	S-CU	S-LA	S-MO	S-NB	S-NI	S-PB	S-SB	S-SC	S-SN	S-SR	S-V	S-W	S-Y	S-ZN	S-ZR	S-TH
80UK35NM	50	50	N	N	<10	<20	N	50	50	N	100	N	300	N	>1,000	N
80UK36M1	70	500	N	100	30	70	N	50	N	N	100	N	500	N	>1,000	<200
80UK36M5	70	300	N	100	70	50	N	30	N	N	150	N	300	500	2,000	N
80UK36NM	30	100	N	N	<10	<20	N	100	100	N	100	N	700	N	>1,000	N
80UK40M1	70	>1,000	N	<50	<10	200	N	100	N	N	100	N	2,000	N	>1,000	>2,000
80UK40M5	50	N	N	100	50	50	N	50	N	N	300	N	20	500	700	N
80UK40NM	30	200	N	N	10	50	<200	>100	500	N	100	N	1,500	N	>1,000	N
80UK41M1	100	>1,000	N	50	20	100	N	20	N	N	100	N	700	N	>1,000	500
80UK41M5	150	70	N	<50	100	100	N	20	N	<200	100	N	500	N	2,000	N
80UK41NM	30	100	N	N	<10	20	<200	100	20	N	100	N	1,000	N	>1,000	N
80UK42M1	70	>1,000	N	50	20	500	N	>100	N	N	100	N	2,000	N	>1,000	>2,000
80UK42M5	70	100	N	100	100	70	N	20	N	N	150	N	500	<500	2,000	N
80UK42NM	30	50	N	N	<10	20	<200	100	200	N	100	N	1,000	N	>1,000	N
80UK43M1	50	>1,000	N	70	10	200	N	10	N	N	100	N	700	N	>1,000	2,000
80UK43M5	20	100	N	150	30	20	N	30	N	<200	200	N	200	<500	700	N
80UK43NM	30	50	N	N	10	20	<200	100	N	N	100	N	1,000	N	>1,000	N
80UK44M1	100	>1,000	N	50	10	70	N	10	<20	N	100	N	500	N	>1,000	500
80UK44M5	70	100	N	200	30	50	N	20	N	N	150	N	300	<500	2,000	N
80UK44NM	30	100	N	N	10	20	<200	100	N	N	100	N	1,000	N	>1,000	N
80UK45M1	70	1,000	N	50	10	50	N	10	N	N	70	N	200	N	>1,000	200
80UK45M5	30	200	N	200	20	30	N	20	N	N	100	N	100	500	>2,000	N
80UK45NM	30	70	N	N	<10	<20	<200	100	N	N	100	N	1,000	N	>1,000	N
80UK46M1	20	>1,000	N	<50	<10	500	N	100	N	N	50	N	2,000	N	>1,000	>2,000
80UK46M5	10	700	N	100	20	30	N	50	N	N	200	N	100	500	500	N
80UK46NM	50	100	N	N	<10	20	<200	100	N	N	100	N	1,000	N	>1,000	N
80UK47M1	20	>1,000	N	<50	N	500	N	100	N	N	50	N	2,000	N	1,000	>2,000
80UK47M5	10	500	N	100	20	20	N	50	N	N	200	N	500	<500	500	N
80UK47NM	50	100	N	N	10	50	<200	100	500	N	100	N	1,000	N	>1,000	N
80UK4M1	10	>1,000	N	70	20	150	<200	50	20	N	100	N	2,000	N	>1,000	2,000
80UK4M5	15	500	N	150	30	70	N	70	N	N	300	N	1,000	N	>2,000	N
80UK4NM	30	1,000	N	N	<10	20	N	100	N	N	100	N	1,000	N	>1,000	N
80UK5M1	20	>1,000	N	100	30	50	<200	20	N	N	100	N	500	N	>1,000	300
80UK5M5	70	300	N	50	50	100	N	30	N	300	100	N	300	N	2,000	N
80UK5NM	50	100	N	N	<10	20	N	70	N	N	100	N	1,000	N	>1,000	N
80UK61M1	20	>1,000	N	50	30	150	N	50	N	N	100	N	700	N	>1,000	1,000
80UK61M5	100	150	N	70	70	30	N	30	N	200	150	N	300	N	>2,000	N
80UK61NM	50	50	N	N	10	20	<200	100	N	N	100	N	1,000	N	>1,000	N
80UK62M1	50	>1,000	N	<50	20	200	N	30	N	N	100	N	700	N	>1,000	1,000
80UK62M5	100	150	N	50	50	30	N	20	N	200	150	N	700	N	>2,000	N
80UK62NM	50	70	N	N	10	20	<200	100	N	N	100	N	1,000	N	>1,000	N
80UK63M1	100	>1,000	N	<50	10	100	N	20	N	N	70	N	300	N	>1,000	200
80UK63M5	30	100	N	150	50	70	N	20	N	<200	100	N	700	N	2,000	N
80UK63NM	50	70	N	N	<10	30	<200	70	30	N	100	N	500	N	>1,000	N
80UK6M1	70	1,000	N	70	10	70	<200	20	N	N	100	N	300	N	>1,000	500
80UK6M5	70	200	N	150	70	50	N	20	N	N	150	N	500	N	2,000	N

Table 2.--Analytical data for heavy-mineral concentrates from the Unaka Mountain Roadless Area, Tennessee

Sample	S-FE%	S-MG%	S-CA%	S-TI%	S-MN	S-AG	S-AS	S-AU	S-B	S-BA	S-BE	S-BI	S-CD	S-CO	S-CR
80UK6NM	.5	.10	<.10	>1.0	50	N	N	N	500	70	<2	N	N	N	100
80UK7M1	1.0	.20	.20	1.0	200	N	N	N	200	70	N	N	N	20	50
80UK7M5	30.0	.50	.15	>2.0	5,000	N	N	N	30	70	<2	N	N	100	1,500
80UK8M5	20.0	.30	.15	>2.0	5,000	N	N	N	20	50	<2	N	N	70	1,000
80UK9M5	20.0	.70	.30	>2.0	1,500	N	N	N	1,000	200	7	N	N	150	100
80UK9NM	.7	.30	<.10	>1.0	100	N	N	N	500	700	<2	N	N	N	200
80UK9NM	5.0	.50	<.10	>1.0	200	N	N	N	>2,000	70	N	N	N	20	200

Table 2.--Analytical data for heavy-mineral concentrates from the Unaka Mountain Roadless Area, Tennessee

Sample	S-CU	S-LA	S-MO	S-NB	S-NI	S-PB	S-SB	S-SC	S-SN	S-SR	S-V	S-W	S-Y	S-ZN	S-ZR	S-TH
80UK6NM	30	50	N	N	<10	50	N	50	N	N	100	N	700	N	>1,000	N
80UK7M1	100	>1,000	N	<50	N	1,000	<200	>100	N	N	20	N	2,000	N	>1,000	>2,000
80UK7M5	20	200	N	200	30	20	N	70	N	N	200	N	300	500	300	N
80UK8M5	15	2,000	N	100	20	70	N	50	N	N	200	N	300	N	1,000	1,500
80UK9M5	30	200	N	200	30	30	N	20	N	200	200	N	200	N	1,000	N
80UK9NM	50	50	N	N	N	20	N	50	N	N	100	N	500	N	>1,000	N
80UK9NM	100	700	N	70	10	50	<200	30	N	N	100	N	200	N	>1,000	300