UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GEOLOGY AND GEOCHEMISTRY OF THE FLINT MILL ROADLESS AREA, CARTER AND JOHNSON COUNTIES, TENNESSEE

By

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Open-File Report 83-714

1983

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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 geologic and geochemical survey of the Flint Mill Roadless Area, Forest Service number 08176, in the Cherokee National Forest, Carter and Johnson Counties, Tennessee. The Flint Mill Roadless Area was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

SUMMARY

Flint Mill Roadless Area comprises 7,183 acres in the Cherokee National Forest in Carter and Johnson Counties, Tenn. The area consists entirely of Paleozoic sedimentary rocks. Iron and manganese prospects and open-pit mines are scattered throughout the Shady dolomite to the east and south of the study area. The iron and manganese oxides occur in residuum, having been concentrated during weathering of iron and manganese minerals in the bedrock. Panned concentrates were taken from major drainages and analyzed spectrographically for 31 elements to determine the geochemical character and assess the mineral potential of the area. Of the 31 elements determined, copper, lead, zinc, tin, beryllium, and molybdenum were found to occur in significant concentrations in samples that closely coincide with the iron and manganese prospect pits and open-pit mines scattered throughout the Shady dolomite.

INTRODUCTION

In the spring of 1980, K. A. Duttweiler, W. R. Griffitts, and J. W. Whitlow of the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Flint Mill Roadless Area. The purpose of the study was to assess the mineral potential and determine the geochemical nature of the area. This report presents a brief summary of the geology and geochemical anomalies of the Roadless Area.

The Flint Mill Roadless Area comprises 7,183 acres in the Cherokee National Forest in northeastern Tennessee. Its southern boundary is approximately 20 mi north of Elizabethton, Tenn., and it extends 6.5 mi northward. The southern three-quarters of the area lies in Carter County and the northern one-fourth lies in Johnson County. The Roadless Area consists of the northern part of Holston Mountain, which reaches an altitude of 4,145 ft, as much as 2,000 ft above Shady Valley to the east. The mountain is forested.

Access to the area is good. U.S. Route 421 from Mountain City to Bristol crosses Holston Mountain at the north end of the area and State Route 91 runs southwest along the southern border of the area. A branch of the Appalachian Trail follows the mountain crest (fig. 1).

GEOLOGY

The study area is underlain by sedimentary rocks of early Paleozoic age (fig. 2). They include part of the thick basal Chilhowee Group of clastic rocks of Lower Cambrian age followed by a carbonate sequence: the Shady dolomite.

The oldest and lowermost unit of the Chilhowee Group present near the study area is the Unicoi Formation (Ꞓu). On Holston Mountain, beds as much as 2,000 ft thick of the Unicoi Formation overlie the Holston Mountain fault. This formation consists of a thick-bedded quartzite, in part arkosic and conglomeratic, interbedded with thin-bedded arkose. The lower part of the section in this area contains red arkosic shale.

The Hampton Formation (Ꞓh) overlying the Unicoi Formation, is generally thought of as a shaly interval between the more sandy or quartzitic Unicoi Formation (below) and Erwin Formation (above). Locally, the Hampton Formation is composed mainly of gray clay shale, darker than the usual shale of the formation; it weathers to bright orange. Interbedded in the shale are thin to thick layers of arkosic sandstones, which in some areas are several hundred feet thick. The upper part of the Hampton Formation contains beds of white vitreous quartzite.

The Erwin Formation (Ꞓe) is the uppermost unit of the Chilhowee Group and is the most widespread of the formations in the Flint Mill area. It generally lies on the lower slopes of the mountains formed by the Chilhowee Group, next to the lowlands formed by the Shady dolomite. It includes four members which have been grouped together for this report. Together they consist of interbedded layers of white vitreous quartzite, dark ferruginous quartzite, siltstone, and shale. The white quartzitic beds constitute a relatively small part of the formation but serve to distinguish the Erwin Formation from the otherwise similar underlying Hampton Formation. In places, the uppermost member consists of yellow, finely laminated clays and soft arkosic sandstones, some stained red and purple with iron and others greenish due to glauconite grains.

The Shady dolomite, also of Lower Cambrian age, is younger than the Chilhowee Group and overlies it. It consists largely of blue-gray and white dolomite but includes small amounts of limestone and, in the upper part, a few beds of shale. The dolomite has been jointed, brecciated, and recrystallized due to deformation. The Shady dolomite has been thoroughly weathered at and near the valley bottoms, where it underlies the Harrisburg or Valley Floor peneplane. The formation there is represented by wavy, brown-buff residual clay in which relict bedding can still be seen, which testifies to little or no horizontal movement during weathering and accumulation of the clay. In many places, the carbonate minerals have been removed entirely to leave a mass of light-brown or tan sticky clay, locally sandy. Manganese and iron oxides occur in the residuum as concretionary lumps in the clay.

The source minerals of the manganese and iron oxides are probably primary sedimentary, rather than hydrothermal, in origin on the basis of their widespread occurrence (King and Ferguson, 1960). The manganese oxides are probably derived from manganese in carbonate form in the white dolomite of the Shady. The source of the iron is more questionable; it either occurs as disseminated pyrite in the upper quartzite layers of the Erwin Formation, or as carbonate minerals in the lower part of the Shady.

In a few places metal-bearing oxides are underlain by the Erwin Formation, but little or no ore has been produced from such places on Holston Mountain. Instead, the residuum is best developed on and almost entirely restricted to remnants of the Harrisburg peneplane where it is underlain by Shady dolomite. These remnants are on the divides between tributaries of Stoney and Beaverdam

Creeks and at the heads of those creeks. The total area of these remnants of the peneplane is rather small and many of the bodies of residuum under them have already been mined, so there is little terrane left to explore. The report by King and Ferguson (1960) gives information on the geology of the area and should be consulted for further details.

PROCEDURE

Stream sediments and panned concentrates were collected from 32 drainages, each drainage representing an area of about 1 to 2 sq mi. At some sites, more than one sample was taken and the highest value was used.

The panned heavy-mineral concentrates were used in evaluating the Flint Mill area. Concentrates are a good sample medium in that determinations of ore minerals are easier because the common rock-forming minerals (quartz, clays, and feldspar), which tend to dilute the sample, are removed.

Each concentrate was sieved through a 20-mesh screen. The light minerals (quartz and feldspar) still remaining after panning were removed by bromoform (s.g. 2.85). 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 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 before the fraction was analyzed semiquantitatively for 31 elements using a six-step d.c. arc, optical emission spectrographic method (Grimes and Marranzino, 1968). The semiquantitative spectrographic 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) and the values are the approximate midpoints of the concentration ranges.

GEOCHEMISTRY

Of the 31 elements determined, copper, lead, zinc, tin, beryllium, and molybdenum showed significantly high values (Appendix) which coincide with the widespread manganese and iron prospect pits and open-pit mines scattered throughout the Shady dolomite. For each of these elements, the fraction which showed the greatest variation in concentration in the sample population was chosen, and maps were plotted showing the distribution of the metal contents of these elements (figs. 3-5).

The presence of monazite in the M1 fraction in some samples gives consistently high trace-element concentrations of lanthanum, yttrium, and thorium as well as lead. These elements are very closely associated with each other in the M1 fraction and are ubiquitous in the study area; therefore, maps showing their distributions were not plotted.

Copper and Lead

The lower limit of detection for copper when determined spectrographically is 10 ppm, and that for lead is 20 ppm. Average abundance of copper in shales is 50 ppm. In limestones, it is 15 ppm. Lead has an average abundance of 20 ppm in shales and 8 ppm in limestones (Levinson, 1974). Generally, the average abundance in concentrates would be higher than in rocks because of the removal of quartz and feldspar that tend to dilute the values in rocks.

Contamination of the streams by human activities is a common problem in the Flint Mill area. Logging, hunting, and road work, as well as the dumping of trash into streams have added metals and minerals into the streams and soils. Lead shot, bullets, or shavings were commonly found in the NM fraction. Copper wire, though not as common as lead shot, was also found in some places. Care was taken to remove any recognizable artifacts from the samples during microscopic examination before analyzing the samples spectrographically.

High copper values in NM concentrates ranging from 100-1000 ppm and lead values of 100-500 ppm are scattered throughout the area draining the Shady dolomite and Erwin Formations (fig. 3). One sample (80FM4) collected about one-quarter mile north of a iron-manganese strip mine contains 1000 ppm copper and 500 ppm lead (as well as 1000 ppm tin). Similarly, lead and copper occur together to the south. The occurrences are closely associated with the iron and manganese prospects and open-pit mines which are scattered throughout the Shady dolomite. Cuprite was observed in samples 80FM46 and 80FM51, which showed high values of copper when analyzed spectrographically. No lead minerals were observed. Pyrite occurred in trace amounts in several samples.

Lead and copper are interpreted as being weathering products because they are so closely associated with the iron and manganese oxides which are also products of weathering. The M1 fraction of the concentrates contains abundant limonite (as much as 50 percent in some samples); also indicating weathering.

The Shady dolomite (or limestone), the shaly interval at the top of the Erwin Formation, and the upper quartzite layers in the upper part of the Erwin Formation are interpreted as being the host rocks for the lead and copper.

Tin

The lower limit of detection for tin is 20 ppm. Average abundance of tin in shale and limestone is 4 ppm (Levinson, 1974). Values obtained from the NM fraction of concentrates were as high as 1000 ppm, and in many samples tin occurs with lead and copper (fig. 3). Tin-rich concentrates are primarily in the areas draining both the Shady dolomite and the Erwin Formation; closely associated with the iron and manganese prospect pits. No cassiterite or other tin mineral was recognized in the samples when examined microscopically, although many times cassiterite may be difficult to identify.

Beryllium, Molybdenum, and Silver

Lower limits of detection:

Be	2 ppm
Mo	10 ppm
Ag	1 ppm

Average abundance:

	Shale	Limestone
Be	3 ppm	<1 ppm
Mo	3 ppm	<1 ppm
Ag	.05 ppm	<1 ppm

There were no detectable values for silver and molybdenum in the NM and M1 fractions. Those reported for beryllium were insignificant. The M.5 fraction, however, contained beryllium between 10 and 30 ppm in 90 percent of the samples. Molybdenum was detected in four samples; the highest concentration was 20 ppm. Every molybdenum-rich sample also contained beryllium. Silver was detected in only one sample (80FM52) which also contained beryllium and molybdenum (fig. 4).

In the southeast corner of the area, beryllium in the M.5 fraction is associated with tin-rich samples (NM fraction). Beryllium is present in many samples from the Erwin Formation just north of the Cross Mountain fault whereas there is no significant copper, lead, tin, zinc, or molybdenum there. Zinc (M.5 fraction) and beryllium (M.5 fraction) commonly occur together.

No host minerals for these elements were observed. Because beryllium, molybdenum, and silver occur in significant amounts only in the M.5 fraction, it is inferred that they occur as trace elements in iron or manganese oxides or hydroxides, which tend to be scavengers for these and other trace elements. Limonite is ubiquitous throughout the magnetic fractions, and beryllium, molybdenum, and silver probably occur as trace elements in the limonite, having weathered from bedrock containing these elements. The probable source rocks are the shale intervals of the Erwin Formation and the Shady dolomite.

Zinc

The lower limit of detection for zinc is 500 ppm. Because the limit of detection is so high, any detectable zinc is considered significant. However, significant values, between 200 and 500 ppm zinc, are overlooked. Average abundance of zinc in shale is 100 ppm, and in limestone the average is 25 ppm (Levinson, 1974). Zinc was not found in the NM and M1 fractions. The M.5 fraction contained zinc in five samples (fig. 5). Every sample that contained zinc also contained beryllium. Molybdenum, lead, and tin are also present with the zinc and beryllium in some samples.

The occurrence of zinc in the M.5 fraction indicates that it is probably a trace element in iron and manganese oxides or hydroxides, having been weathered from the host shales and limestone units of the Erwin Formation and Shady dolomite.

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

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Appendex. Analytical data for heavy mineral concentrates from the Flint Mill 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
80FM10M1	5.00	.70	.10	.5	500	N	N	N	>2,000	100	<2	N	N	10	200
80FM10M5	50.00	.50	.10	1.0	>10,000	N	N	N	2,000	3,000	20	N	N	100	3,000
80FM10NM	.20	.10	<.10	>1.0	100	N	N	N	500	150	<2	N	N	N	100
80FM11M1	5.00	1.50	.10	.7	500	N	N	N	>2,000	100	<2	N	N	15	1,500
80FM11M5	5.00	.70	.15	.5	3,000	N	N	N	5,000	100	2	N	N	15	5,000
80FM11NM	.20	.05	<.10	>1.0	100	N	N	N	300	150	<2	N	N	N	70
80FM1M1	20.00	1.00	.10	1.0	500	N	N	N	>1,000	100	<2	N	N	20	300
80FM1M5	20.00	.10	.15	.7	2,000	N	N	N	1,500	500	15	N	N	20	500
80FM1NM	.15	.10	<.10	>1.0	70	N	N	N	500	100	<2	N	N	N	150
80FM2M1	20.00	1.50	.10	1.0	700	N	N	N	>1,000	200	<2	N	N	20	500
80FM2M5	30.00	.50	.15	.7	3,000	N	N	N	2,000	1,000	20	N	N	30	700
80FM2NM	.50	.20	<.10	>1.0	100	N	N	N	1,000	100	<2	N	N	N	200
80FM30M1	10.00	.50	<.10	.5	>5,000	N	N	N	>2,000	1,000	N	N	N	50	1,500
80FM30M1	15.00	.70	<.10	.5	>5,000	N	N	N	>2,000	1,500	N	N	N	70	2,000
80FM30M5	50.00	.50	.10	.7	>10,000	N	N	N	2,000	10,000	30	N	N	150	5,000
80FM30M5	50.00	.30	.10	.7	>10,000	N	N	N	1,500	10,000	30	N	N	200	5,000
80FM30NM	.20	.05	<.10	>1.0	300	N	N	N	300	150	<2	N	N	N	100
80FM30NM	.20	<.05	<.10	>1.0	200	N	N	N	200	100	<2	N	N	N	30
80FM31M1	5.00	1.00	.10	1.0	>5,000	N	N	N	>2,000	1,500	<2	N	N	50	300
80FM31M5	30.00	.50	.10	.2	>10,000	N	N	N	2,000	>10,000	30	N	N	300	200
80FM31M5	15.00	.50	.15	.5	>10,000	N	N	N	2,000	>10,000	50	N	N	300	1,500
80FM31NM	.50	.05	<.10	>1.0	100	N	N	N	500	200	2	N	N	N	100
80FM32M1	7.00	1.00	<.10	>1.0	5,000	N	N	N	>2,000	500	N	N	N	20	200
80FM32M1	7.00	1.00	<.10	>1.0	2,000	N	N	N	>2,000	200	N	N	N	30	200
80FM32M5	30.00	.50	.10	2.0	>10,000	N	N	N	2,000	5,000	15	N	N	150	300
80FM32M5	30.00	.30	.10	2.0	>10,000	N	N	N	2,000	5,000	10	N	N	200	200
80FM32NM	.50	.20	<.10	>1.0	150	N	N	N	1,000	150	<2	N	N	N	500
80FM32NM	.50	.10	<.10	>1.0	100	N	N	N	1,000	150	<2	N	N	N	200
80FM33M1	20.00	1.00	<.10	.7	>5,000	N	N	N	>2,000	500	3	N	N	70	200
80FM33M1	15.00	1.00	<.10	1.0	>5,000	N	N	N	>2,000	700	<2	N	N	50	700
80FM33M5	20.00	.30	.10	.3	>10,000	N	N	N	1,500	7,000	30	N	N	200	200
80FM33M5	20.00	.30	.10	.2	>10,000	N	N	N	1,500	10,000	50	N	N	300	300
80FM33NM	.30	.20	<.10	>1.0	150	N	N	N	1,500	300	<2	N	N	N	100
80FM33NM	.20	.10	<.10	>1.0	150	N	N	N	700	200	<2	N	N	N	70
80FM34M1	5.00	.50	<.10	.7	500	N	N	N	>2,000	100	<2	N	N	<10	70
80FM34M5	50.00	.50	.15	1.0	7,000	N	N	N	2,000	700	50	N	N	50	1,000
80FM34NM	.50	.20	<.10	>1.0	150	N	N	N	500	200	3	N	N	N	150
80FM35M1	20.00	.20	<.10	.7	500	N	N	N	2,000	100	7	N	N	10	200
80FM35M5	30.00	.30	.15	1.0	7,000	N	N	N	700	500	15	N	N	50	200
80FM36M1	20.00	.50	.70	1.0	500	N	N	N	>2,000	100	<2	N	N	15	200
80FM36M5	30.00	.50	.50	2.0	5,000	N	N	N	700	500	15	N	N	50	500
80FM36NM	.50	.10	<.10	>1.0	150	N	N	N	700	150	<2	N	N	N	150
80FM37M1	15.00	1.00	.50	>1.0	500	N	N	N	>2,000	100	<2	N	N	20	300
80FM37M5	30.00	1.00	.50	1.5	10,000	N	N	N	3,000	1,500	20	N	N	100	500
80FM37NM	.50	.15	<.10	>1.0	50	N	N	N	1,000	100	<2	N	N	N	200

Appendex. Analytical data for heavy mineral concentrates from the Flint Mill 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
80FM10M1	10	>1,000	N	200	20	50	N	100	N	N	70	N	>2,000	N	>1,000
80FM10M5	50	100	N	50	70	70	N	20	N	N	150	N	1,500	N	>2,000
80FM10NM	500	200	N	N	10	300	N	>100	70	N	150	N	1,500	N	>1,000
80FM11M1	10	>1,000	N	100	20	150	N	100	30	N	100	N	>2,000	N	>1,000
80FM11M5	10	<50	N	N	30	30	N	20	N	<200	100	N	500	N	>2,000
80FM11NM	20	200	N	N	<10	50	N	>100	30	N	100	N	1,500	N	>1,000
80FM1M1	50	>1,000	N	<50	50	70	N	20	N	N	150	N	700	N	>1,000
80FM1M5	20	N	N	50	50	20	N	15	N	N	70	N	500	N	1,500
80FM1NM	30	150	N	<50	10	70	N	>100	200	N	150	N	1,000	N	>1,000
80FM2M1	50	>1,000	N	<50	50	150	N	20	70	N	100	N	500	N	>1,000
80FM2M5	50	70	N	<50	50	50	N	20	N	<200	150	N	500	N	1,000
80FM2NM	30	150	N	<50	10	70	N	>100	200	N	150	N	1,000	N	>1,000
80FM30M1	50	>1,000	N	100	50	100	N	100	70	N	70	N	2,000	N	>1,000
80FM30M1	70	>1,000	N	100	100	100	N	100	30	N	100	N	>2,000	N	>1,000
80FM30M5	100	50	N	<50	150	150	N	20	N	N	200	N	1,500	500	>2,000
80FM30M5	100	100	N	50	200	200	N	20	N	N	200	N	1,000	<500	>2,000
80FM30NM	20	300	N	N	20	70	N	>100	30	N	150	N	2,000	N	>1,000
80FM30NM	15	300	N	<50	<10	70	N	>100	N	N	100	N	1,500	N	>1,000
80FM31M1	30	>1,000	N	100	30	200	N	>100	N	N	100	N	>2,000	N	>1,000
80FM31M5	50	200	N	N	150	500	N	15	N	200	150	N	500	N	500
80FM31M5	30	200	N	N	150	50	N	15	N	<200	200	N	700	N	2,000
80FM31NM	20	200	N	N	<10	70	N	>100	20	N	100	N	1,500	N	>1,000
80FM32M1	30	>1,000	N	100	30	100	N	10	N	N	100	N	500	N	>1,000
80FM32M1	30	>1,000	N	100	50	150	N	10	N	N	100	N	700	N	>1,000
80FM32M5	100	100	10	200	150	100	N	50	N	N	200	N	200	N	2,000
80FM32M5	100	150	N	150	100	70	N	30	N	N	200	N	1,000	N	700
80FM32NM	30	100	N	N	<10	100	N	>100	30	N	150	N	1,500	N	>1,000
80FM32NM	30	70	N	N	<10	70	N	>100	30	N	200	N	1,500	N	>1,000
80FM33M1	30	1,000	N	50	70	70	N	20	N	N	100	N	700	N	>1,000
80FM33M1	50	>1,000	N	100	50	100	N	20	N	N	100	N	1,000	N	>1,000
80FM33M5	50	200	N	N	150	50	N	20	N	<200	150	N	300	N	2,000
80FM33M5	50	150	N	N	200	100	N	15	N	200	150	N	300	N	>2,000
80FM33NM	20	200	N	N	20	50	N	>100	30	N	100	N	1,500	N	>1,000
80FM33NM	15	150	N	N	30	50	N	>100	N	N	100	N	1,500	N	>1,000
80FM34M1	20	>1,000	N	100	20	50	N	20	N	N	100	N	700	N	>1,000
80FM34M5	50	300	N	50	100	300	N	50	500	N	150	N	200	N	>2,000
80FM34NM	15	500	N	N	10	70	N	>100	N	N	100	N	1,500	N	>1,000
80FM35M1	50	>1,000	N	50	20	100	N	10	N	N	100	N	300	N	>1,000
80FM35M5	70	100	N	50	30	300	N	20	N	N	150	N	150	1,000	700
80FM36M1	70	>1,000	N	50	30	70	N	20	70	N	150	N	1,500	N	>1,000
80FM36M5	50	200	N	150	50	50	N	20	100	<200	200	N	150	N	1,500
80FM36NM	15	300	N	N	20	50	N	>100	150	N	100	N	1,500	N	>1,000
80FM37M1	50	>1,000	N	200	50	100	N	10	N	N	150	N	1,500	N	>1,000
80FM37M5	70	70	N	70	70	30	N	30	N	200	200	N	1,000	N	2,000
80FM37NM	50	200	N	N	<10	30	N	100	50	N	200	N	1,000	N	>1,000

Appendex. Analytical data for heavy mineral concentrates from the Flint Mill Area, Tennessee

Sample	S-TH
80FM10M1	700
80FM10M5	N
80FM10NM	N
80FM11M1	2,000
80FM11M5	N
80FM11NM	N
80FM1M1	700
80FM1M5	N
80FM1NM	N
80FM2M1	300
80FM2M5	N
80FM2NM	N
80FM30M1	1,500
80FM30M1	1,500
80FM30M5	N
80FM30M5	N
80FM30NM	N
80FM30NM	N
80FM31M1	2,000
80FM31M5	N
80FM31M5	N
80FM31NM	N
80FM32M1	1,500
80FM32M1	2,000
80FM32M5	N
80FM32M5	N
80FM32NM	N
80FM32NM	N
80FM33M1	200
80FM33M1	1,000
80FM33M5	N
80FM33M5	N
80FM33NM	N
80FM33NM	N
80FM34M1	1,000
80FM34M5	N
80FM34NM	N
80FM35M1	<200
80FM35M5	N
80FM36M1	500
80FM36M5	N
80FM36NM	N
80FM37M1	1,000
80FM37M5	N
80FM37NM	N

Appendex. Analytical data for heavy mineral concentrates from the Flint Mill Area, Tennessee--continued

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
80FM38M1	20.00	.20	<.10	.5	500	N	N	N	>2,000	70	5	N	N	20	300
80FM38M5	30.00	.10	<.10	.5	7,000	N	N	N	500	1,500	20	N	N	70	200
80FM38NM	.20	.10	<.10	>1.0	70	N	N	N	1,000	100	<2	N	N	N	100
80FM39M1	15.00	.50	.10	.7	300	N	N	N	>2,000	50	<2	N	N	15	200
80FM37M5	50.00	.30	.15	1.0	10,000	N	N	N	1,500	500	15	N	N	50	200
80FM39NM	.20	.05	<.10	>1.0	70	N	N	N	500	50	<2	N	N	N	100
80FM3M1	10.00	1.00	.10	>1.0	200	N	N	N	>1,000	50	<2	N	N	20	300
80FM3M1	20.00	1.00	.10	1.0	700	N	N	N	>1,000	700	<2	N	N	50	700
80FM3M5	30.00	.70	.20	>2.0	5,000	N	N	N	2,000	1,000	10	N	N	100	1,000
80FM3M5	50.00	.20	.10	1.0	2,000	N	N	N	700	300	10	N	N	50	150
80FM3NM	.30	.05	<.10	>1.0	50	N	N	N	1,000	500	<2	N	N	N	100
80FM3NM	2.00	.05	<.10	>1.0	300	N	N	N	500	200	<2	N	N	N	200
80FM41M1	20.00	1.00	.10	.5	3,000	N	N	N	>2,000	300	3	N	N	20	300
80FM41M5	20.00	.70	.15	.2	5,000	N	N	N	5,000	500	10	N	N	50	500
30FM41NM	.20	.15	<.10	>1.0	70	N	N	N	2,000	50	<2	N	N	N	100
80FM42M1	20.00	1.00	<.10	1.0	500	N	N	N	>2,000	70	<2	N	N	50	500
80FM42M5	20.00	.50	.15	.3	5,000	N	N	N	2,000	700	15	N	N	30	300
80FM42NM	.20	.15	<.10	>1.0	70	N	N	N	1,500	70	N	N	N	N	100
80FM43M1	20.00	.50	<.10	.2	>5,000	N	N	N	>2,000	500	3	N	N	30	500
80FM43M5	30.00	.20	<.10	.1	>10,000	N	N	N	500	>10,000	20	N	N	200	150
80FM43NM	.20	.05	<.10	>1.0	100	N	N	N	1,000	100	<2	N	N	N	70
80FM44M1	10.00	1.50	.50	1.0	700	N	N	N	>2,000	200	<2	N	N	15	700
80FM44M5	30.00	.50	.20	1.5	>10,000	N	N	N	2,000	3,000	7	N	N	150	2,000
80FM44NM	.20	.05	<.10	>1.0	100	N	N	N	1,000	100	<2	N	N	N	50
80FM45M1	10.00	1.00	.10	1.0	200	N	N	N	>2,000	100	N	N	N	10	1,500
80FM45M5	50.00	.20	<.10	.7	7,000	N	N	N	1,000	1,500	10	N	N	50	3,000
80FM45NM	.20	.05	<.10	>1.0	100	N	N	N	500	100	<2	N	N	N	50
80FM46M1	20.00	.70	<.10	1.0	1,000	N	N	N	>2,000	100	N	N	N	15	100
80FM46M5	50.00	.30	<.10	.5	>10,000	N	N	N	1,500	2,000	15	N	N	70	700
80FM46NM	.20	.05	<.10	>1.0	100	N	N	N	1,000	150	<2	N	N	N	70
80FM47M1	10.00	1.50	.10	.5	>5,000	N	N	N	>2,000	1,500	N	N	N	70	700
80FM47M5	30.00	.50	.10	.5	10,000	N	N	N	2,000	3,000	10	N	N	150	1,500
80FM47NM	.30	.10	<.10	>1.0	100	N	N	N	1,500	200	<2	N	N	N	70
80FM4M1	20.00	.30	<.10	.5	>5,000	N	N	N	>1,000	1,000	<2	N	N	100	700
80FM4M5	20.00	.15	.10	.3	>10,000	N	N	N	1,000	10,000	20	N	N	200	500
80FM4NM	.50	.05	<.10	>1.0	300	N	N	N	500	300	<2	N	N	N	50
80FM50M1	10.00	.10	.10	.3	200	N	N	N	1,000	100	5	N	N	10	150
80FM50M5	30.00	.30	.20	1.0	7,000	N	N	N	200	700	30	N	N	70	300
80FM50NM	.50	<.05	<.10	>1.0	100	N	N	N	150	70	<2	N	N	N	50
80FM51M1	10.00	.20	<.10	.5	500	N	N	N	>2,000	100	2	N	N	10	150
80FM51M5	20.00	.30	.15	.5	7,000	N	N	N	700	700	30	N	N	100	300
80FM51M5	30.00	.20	<.10	.7	>10,000	N	N	N	200	1,500	30	N	N	150	200
80FM51NM	.50	.10	<.10	>1.0	100	N	N	N	1,500	70	<2	N	N	N	70
80FM52M1	20.00	.30	<.10	.2	>5,000	N	N	N	>2,000	5,000	10	N	N	100	100
80FM52M5	20.00	.20	.10	.2	>10,000	2	N	N	700	>10,000	50	N	N	500	70

Appendex. Analytical data for heavy mineral concentrates from the Flint Mill Area, Tennessee--continued

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
80FM38M1	50	1,000	N	<50	50	50	N	10	N	N	150	N	500	N	>1,000
80FM38M5	70	100	N	N	70	70	N	20	N	N	200	N	70	N	1,000
80FM38NM	20	300	N	N	20	20	N	>100	N	N	100	N	1,500	N	>1,000
80FM39M1	50	1,000	N	<50	30	70	N	10	N	N	100	N	700	N	>1,000
80FM39M5	50	200	N	100	30	50	N	30	N	<200	150	N	200	N	>2,000
80FM39NM	20	200	N	N	10	20	N	100	50	N	70	N	1,500	N	>1,000
80FM3M1	50	>1,000	N	N	30	200	N	20	20	N	100	N	1,500	N	>1,000
80FM3M1	70	>1,000	N	50	70	70	N	50	N	N	100	N	1,000	N	>1,000
80FM3M5	50	100	N	100	50	30	N	50	N	N	300	N	500	N	2,000
80FM3M5	30	150	N	<50	50	30	N	20	N	N	300	N	300	<500	>2,000
80FM3NM	20	150	N	<50	<10	70	N	100	200	N	150	N	1,000	N	>1,000
80FM3NM	20	200	N	N	20	100	N	>100	20	N	150	N	1,000	N	>1,000
80FM41M1	50	1,000	N	<50	50	70	N	10	N	N	100	N	700	N	>1,000
80FM41M5	70	<50	N	N	70	50	N	20	N	<200	100	N	150	N	2,000
80FM41NM	20	100	N	N	10	20	N	100	N	N	150	N	1,500	N	>1,000
80FM42M1	50	>1,000	N	50	50	70	N	10	200	N	150	N	700	N	>1,000
80FM42M5	30	50	N	N	30	30	N	30	N	N	100	N	100	N	1,000
80FM42NM	20	150	N	N	10	30	N	100	500	N	150	N	1,500	N	>1,000
80FM43M1	70	>1,000	N	50	70	70	N	20	N	N	100	N	1,000	N	>1,000
80FM43M5	200	<50	20	N	200	200	N	15	N	<200	200	N	100	500	200
80FM43NM	10	100	N	N	10	70	N	>100	700	N	150	N	2,000	N	>1,000
80FM44M1	20	>1,000	N	<50	50	70	N	>100	300	N	150	N	>2,000	N	>1,000
80FM44M5	50	<50	N	100	100	70	N	15	N	<200	100	N	500	<500	>2,000
80FM44NM	15	150	N	N	20	30	N	>100	100	N	150	N	1,500	N	>1,000
80FM45M1	20	>1,000	N	<50	50	70	N	>100	N	N	100	N	2,000	N	>1,000
80FM45M5	50	150	N	<50	50	30	N	70	N	N	100	N	1,500	N	>2,000
80FM45NM	10	150	N	N	20	50	N	>100	N	N	100	N	2,000	N	>1,000
80FM46M1	50	>1,000	N	<50	50	500	N	>100	N	N	100	N	2,000	N	>1,000
80FM46M5	70	50	N	N	100	150	N	20	200	N	150	N	300	<500	2,000
80FM46NM	1,500	150	N	N	20	50	N	>100	500	N	150	N	1,500	N	>1,000
80FM47M1	100	>1,000	N	50	50	100	N	100	N	N	150	N	2,000	N	>1,000
80FM47M5	70	70	N	<50	70	70	N	30	N	N	200	N	700	<500	>2,000
80FM47NM	20	150	N	N	10	30	N	>100	N	N	150	N	1,500	N	>1,000
80FM4M1	50	>1,000	N	50	100	150	N	100	1,000	N	100	N	2,000	N	>1,000
80FM4M5	30	150	N	N	100	70	N	10	N	N	300	N	200	N	500
80FM4NM	>1,000	150	N	N	30	500	N	>100	>1,000	N	150	N	1,500	N	>1,000
80FM50M1	50	1,000	N	50	30	50	N	10	<20	N	100	N	500	N	>1,000
80FM50M5	70	100	N	100	50	30	N	20	N	N	150	N	200	N	1,500
80FM50NM	20	200	N	N	10	50	N	100	N	N	70	N	1,500	N	>1,000
80FM51M1	50	>1,000	N	<50	20	50	N	10	50	N	100	N	1,000	N	>1,000
80FM51M5	150	<50	N	N	70	70	N	30	N	N	200	N	150	N	700
80FM51M5	100	N	N	N	100	100	N	20	N	200	200	N	50	<500	700
80FM51NM	500	150	N	N	10	500	N	100	150	N	100	N	1,500	N	>1,000
80FM52M1	100	>1,000	N	70	150	300	N	10	N	N	100	N	700	N	>1,000
80FM52M5	100	150	20	N	300	200	N	10	N	500	200	N	200	<500	700

Appendex. Analytical data for heavy mineral concentrates from the Flint Mill Area, Tennessee--continued

Sample	S-TH
80FM38M1	<200
80FM38M5	N
80FM38NM	<200
80FM39M1	200
80FM39M5	N
80FM39NM	N
80FM3M1	>2,000
80FM3M1	<200
80FM3M5	N
80FM3M5	N
80FM3NM	N
80FM3NM	<200
80FM41M1	500
80FM41M5	N
80FM41NM	N
80FM42M1	500
80FM42M5	N
80FM42NM	<200
80FM43M1	300
80FM43M5	N
80FM43NM	<200
80FM44M1	500
80FM44M5	N
80FM44NM	<200
80FM45M1	1,000
80FM45M5	300
80FM45NM	<200
80FM46M1	500
80FM46M5	N
80FM46NM	<200
80FM47M1	2,000
80FM47M5	N
80FM47NM	N
80FM4M1	<200
80FM4M5	N
80FM4NM	<200
80FM50M1	N
80FM50M5	N
80FM50NM	<200
80FM51M1	300
80FM51M5	N
80FM51M5	N
80FM51NM	N
80FM52M1	500
80FM52M5	N

Appendex. Analytical data for heavy mineral concentrates from the Flint Mill Area, Tennessee--continued

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
80FM52NM	.30	.05	<.10	>1.0	150	N	N	N	500	300	<2	N	N	N	150
80FM53M1	20.00	.70	<.10	.5	1,500	N	N	N	>2,000	500	N	N	N	30	1,500
80FM53M5	30.00	.20	.10	.7	7,000	N	N	N	1,000	700	10	N	N	50	1,000
80FM53NM	.20	<.05	<.10	>1.0	100	N	N	N	500	100	<2	N	N	<10	70
80FM54M1	20.00	.70	<.10	.3	>5,000	N	N	N	>2,000	1,000	2	N	N	70	700
80FM54M5	30.00	.20	<.10	.5	>10,000	N	N	N	1,000	5,000	15	N	N	150	1,000
80FM54NM	.20	.10	<.10	>1.0	70	N	N	N	1,000	100	<2	N	N	N	50
80FM5M1	20.00	.30	<.10	.5	>5,000	N	N	N	>1,000	500	<2	N	N	30	700
80FM5M5	50.00	.20	<.10	.7	>10,000	N	N	N	1,000	7,000	15	N	N	150	1,000
80FM5NM	.50	.07	<.10	>1.0	300	N	N	N	500	200	<2	N	N	N	30
80FM7M1	7.00	1.50	.10	1.0	1,000	N	N	N	>1,000	150	<2	N	N	20	2,000
80FM7M5	50.00	.50	.10	1.0	5,000	N	N	N	1,500	500	10	N	N	50	7,000
80FM7NM	.20	<.05	<.10	1.0	150	N	N	N	150	100	<2	N	N	N	20
80FM8M1	10.00	.70	<.10	.7	5,000	N	N	N	>1,000	300	<2	N	N	100	2,000
80FM8M5	30.00	.50	.10	1.5	>10,000	N	N	N	2,000	5,000	15	N	N	150	5,000
80FM8NM	.20	<.05	<.10	>1.0	100	N	N	N	200	70	<2	N	N	N	20
80FM9M1	5.00	2.00	.20	.5	500	N	N	N	>2,000	100	<2	N	N	20	3,000
80FM9M5	3.00	.50	.15	1.0	3,000	N	N	N	2,000	100	2	N	N	20	5,000
80FM9NM	.30	.15	<.10	>1.0	150	N	N	N	500	150	<2	N	N	N	150

Appendex. Analytical data for heavy mineral concentrates from the Flint Mill Area, Tennessee--continued

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
80FM52NM	30	150	N	N	20	50	N	>100	70	N	150	N	1,500	N	>1,000
80FM53M1	100	>1,000	N	50	70	100	N	100	200	N	150	N	>2,000	N	>1,000
80FM53M5	70	100	N	300	70	70	N	20	N	N	200	N	1,000	N	>2,000
80FM53NM	300	150	N	N	20	50	N	>100	200	N	100	N	2,000	N	>1,000
80FM54M1	70	700	N	<50	50	100	N	70	N	N	150	N	1,000	N	>1,000
80FM54M5	100	100	N	<50	100	100	N	50	N	N	200	N	500	N	>2,000
80FM54NM	10	100	N	N	<10	20	N	>100	N	N	100	N	1,500	N	>1,000
80FM5M1	30	>1,000	N	150	70	50	N	>100	N	N	100	N	2,000	N	>1,000
80FM5M5	30	200	15	<50	100	50	N	20	N	N	300	N	500	N	>2,000
80FM5NM	100	500	N	N	30	70	N	>100	50	N	150	N	2,000	N	>1,000
80FM7M1	20	>1,000	N	150	30	150	N	>100	500	N	100	N	>2,000	N	>1,000
80FM7M5	30	200	N	200	70	50	N	20	N	N	200	N	1,500	500	>2,000
80FM7NM	10	200	N	N	10	50	N	>100	150	N	100	N	1,500	N	>1,000
80FM8M1	30	>1,000	N	150	30	200	N	>100	700	N	100	N	2,000	N	>1,000
80FM8M5	70	70	N	70	100	70	N	30	200	N	150	N	2,000	500	>2,000
80FM8NM	20	700	N	N	10	300	N	>100	700	N	150	N	1,500	N	>1,000
80FM9M1	10	>1,000	N	200	50	100	N	100	70	N	100	N	>2,000	N	>1,000
80FM9M5	10	150	N	N	50	<20	N	10	N	N	100	N	2,000	N	>2,000
80FM9NM	20	500	N	N	10	100	N	>100	20	N	200	N	2,000	N	>1,000

Appendex. Analytical data for heavy mineral concentrates from the Flint Mill Area, Tennessee--continued

Sample	S-TH
80FM52NM	<200
80FM53M1	500
80FM53M5	N
80FM53NM	<200
80FM54M1	<200
80FM54M5	N
80FM54NM	N
80FM5M1	<200
80FM5M5	N
80FM5NM	<200
80FM7M1	700
80FM7M5	200
80FM7NM	N
80FM8M1	1,000
80FM8M5	N
80FM8NM	N
80FM9M1	2,000
80FM9M5	N
80FM9NM	N