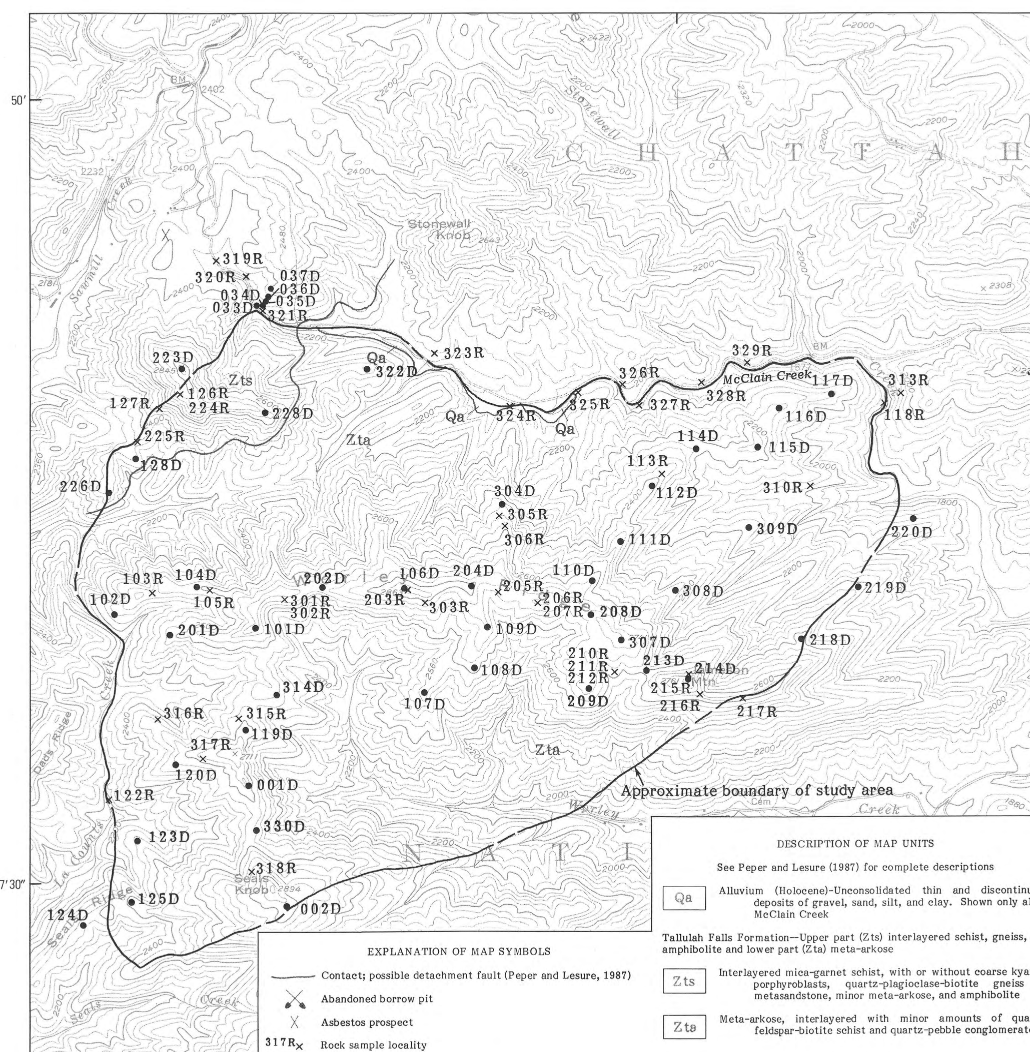
GEOCHEMICAL SURVEY AND MINERAL RESOURCE ASSESSMENT OF THE WORLEY RIDGE ROADLESS AREA, RABUN COUNTY, GEORGIA

By
Frank G. Lesure, John F. D'Agostino, and John D. Peper
1987

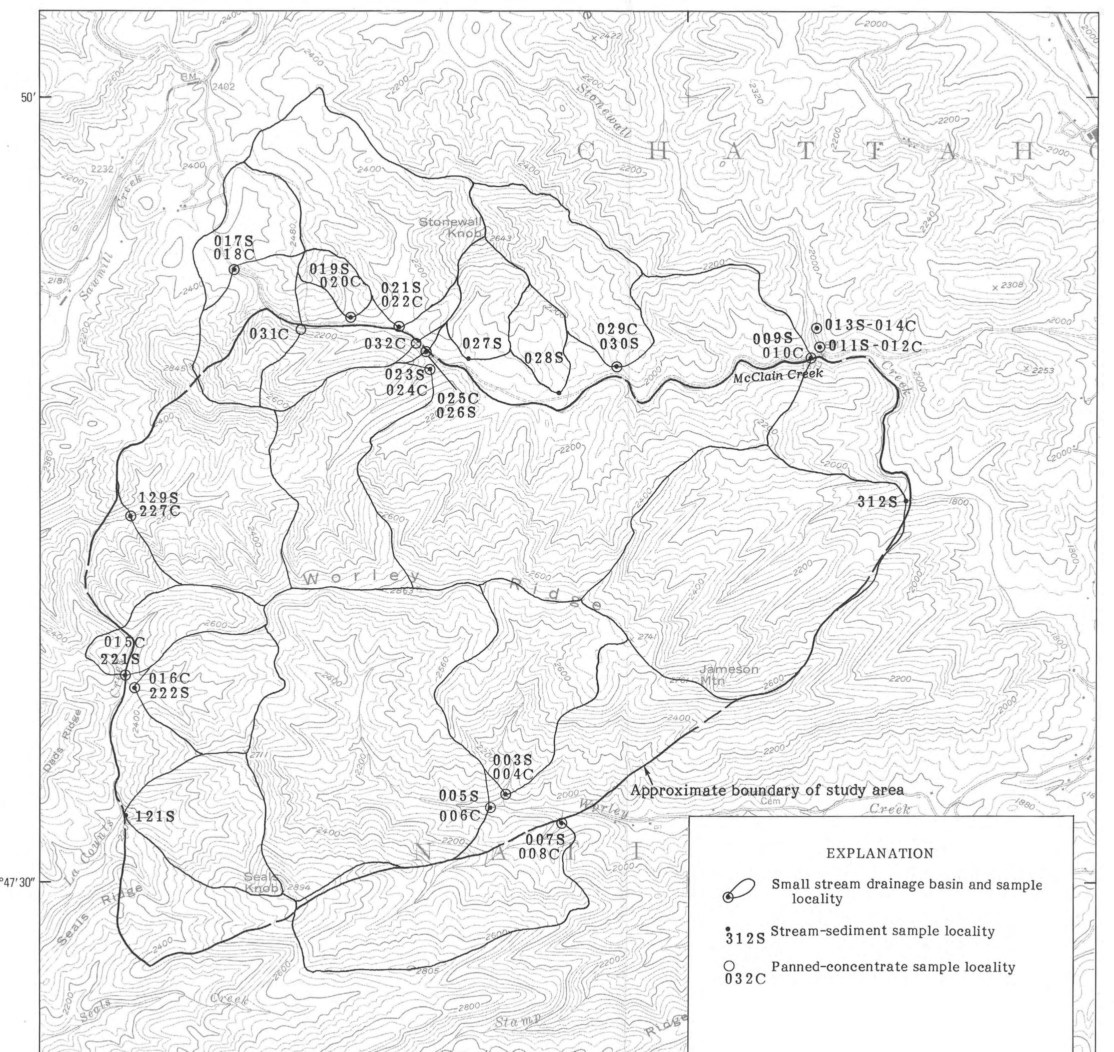


Base from U.S. Geological Survey
Tiger, 1957 (Photorevision as of 1972)

Geology by F.G. Lesure and J.D. Peper, 1985-86
Assisted by J.P. D'Agostino and J.A. Goss

SCALE 1:24 000
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

Figure 1.--Rock and soil sample localities in the Worley Ridge Roadless Area and vicinity, Ga.



Base from U.S. Geological Survey
Tiger, 1957 (Photorevision as of 1972)

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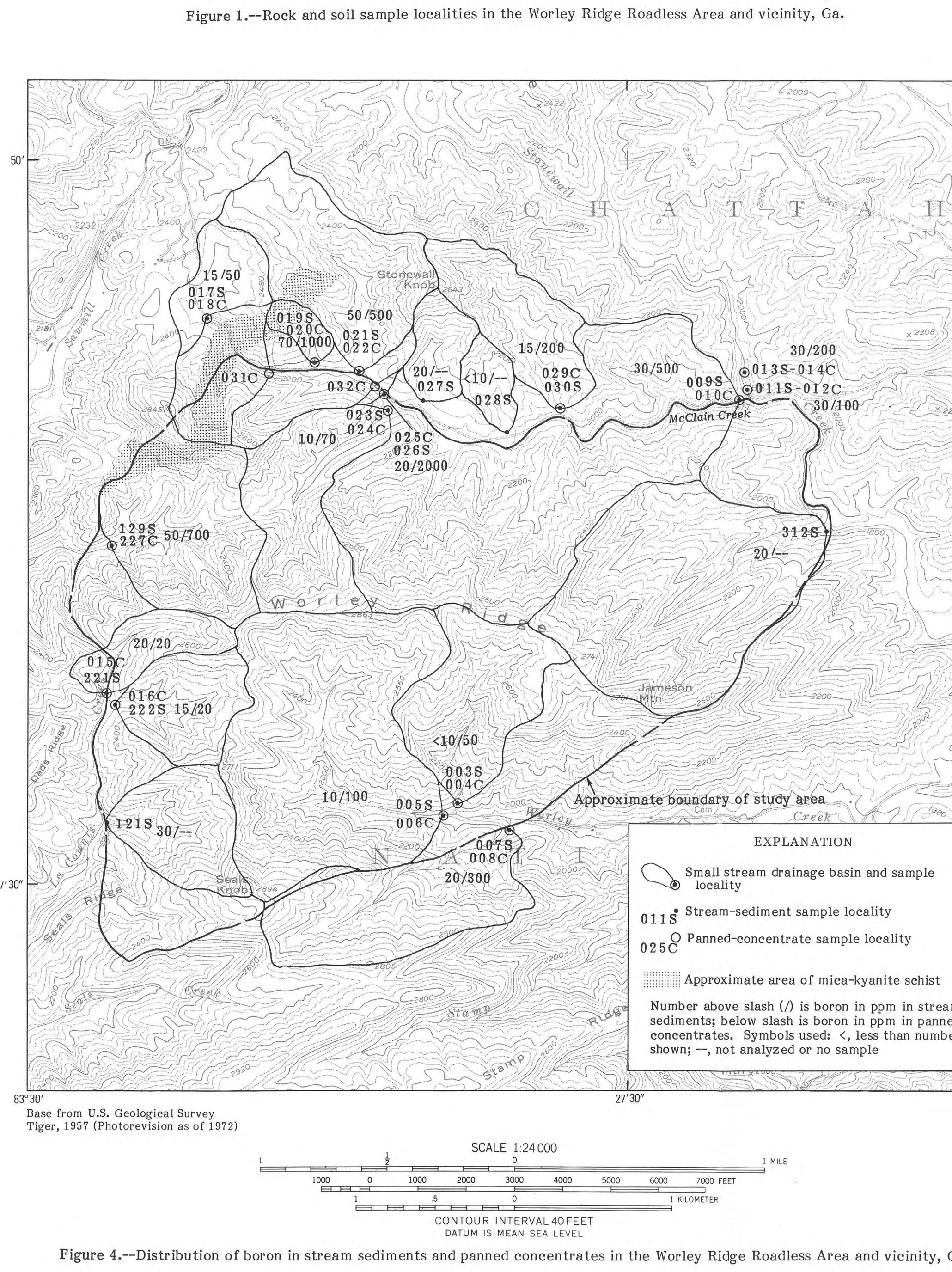
Figure 2.—Stream-sediment and panned-concentrate sample localities in the Worley Ridge Raodless Area and vicinity, Ga.



Base from U.S. Geological Survey
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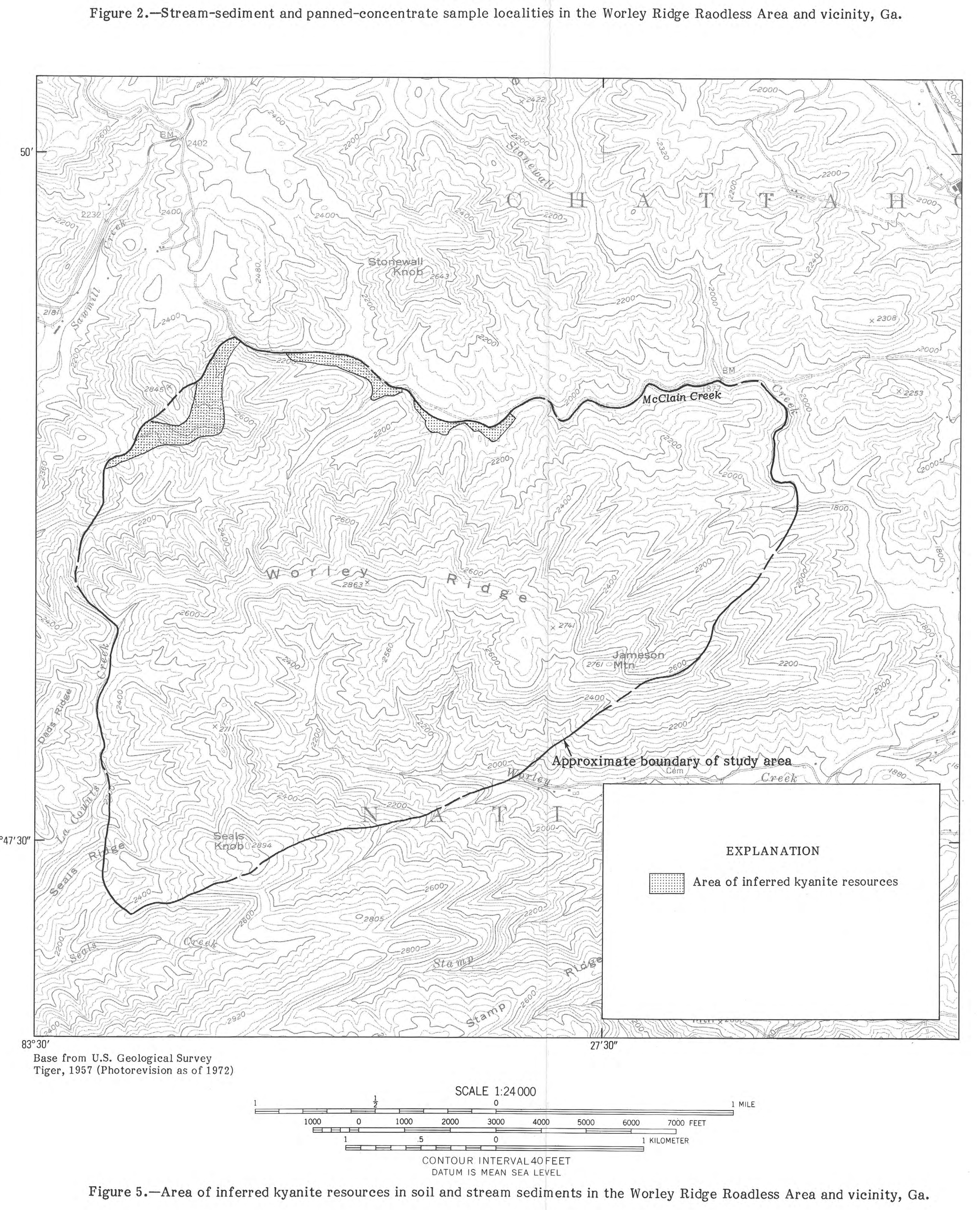
Figure 4.--Distribution of boron in stream sediments and panned concentrates in the Worley Ridge Roadless Area and vicinity, Ga.



Base from U.S. Geological Survey
Tiger, 1957 (Photorevision as of 1972)

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DATUM IS MEAN SEA LEVEL

Figure 5.—Area of inferred kyanite resources in soil and stream sediments in the Worley Ridge Roadless Area and vicinity, Ga.

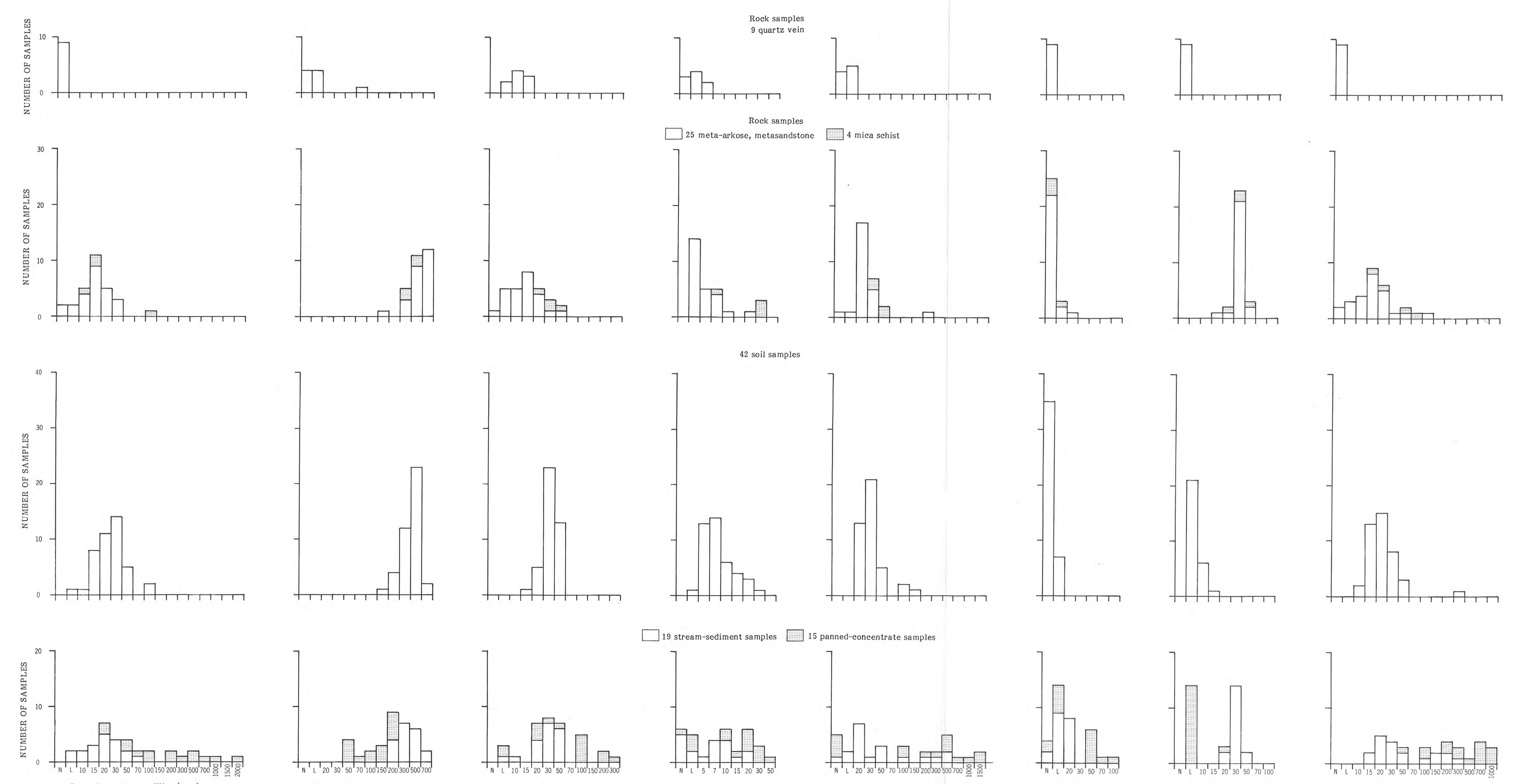

Figure 3.--Histograms showing distributions of selected elements in the Worley Ridge Roadless Area, Ga. Symbols used: N, not detected; L, detected but less than next highest value shown.

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 values, if any, that may be present. 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 and mineral resource assessment of the Worley Ridge Roadless Area (Forest Service number 08-224) in the Chattahoochee National Forest, Rabun County, Georgia. The area was classified as non-wilderness during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979. A multiple use classification was confirmed by the Georgia Wilderness Act of 1984 (Public Law 98-514, October 19, 1984).

ABSTRACT

The Worley Ridge Roadless Area includes about 3,000 acres of Chattahoochee National Forest land in Rabun County, Ga. The area is underlain mosty by meta-arkose of the Tallulah Falls Formation that grades upward into a mixed-rock unit of interlayered mica schist, amphibolite, and metasandstone in the northwest corner. Abundant rock suitable for rough building stone and crushed rock, and an estimated 3,400 short tons (3,000 metric tons) of coarse-grained kyanite in soil and alluvial deposits are the only identified mineral resources. Oil and gas have an unknown potential. All surface and mineral rights are under Federal ownership.

Kyanite, used in refractory linings for metallurgical and other types of furnaces, occurs as large 1 to 2 in. porphyroblasts in several thin 1 to 30 ft layers of mica schist in the northwestern part of the area. The mineral is resistant to weathering and is concentrated in soil and alluvium because it is heavier than most common rock-forming minerals.

The roadless area lies several miles east of the northern part of the Dahlonega gold belt and west of the Hall County gold belt. Rocks of the Dahlonega gold belt may underlie the area at great depth below a regional thrust fault. Although traces of gold are present locally in the mixed rock unit outside the study area and traces of gold have been reported in alluvium derived from this unit within the area, no gold was found in panned-concentrate and vein-quartz samples collected for this study. None of the samples contains anomalous amounts of other metals. The rocks of the study area are apparently unmineralized.

Recent seismic studies in the southeastern United States indicate the presence of a thick sequence of younger, less metamorphosed sedimentary rock beneath layers of older metasedimentary rocks of the Blue Ridge. These younger rocks were once considered a potential source of oil and gas, but their potential is somewhat dubious in view of inferred thermal maturation. Additional seismic studies and exploratory drilling are needed to evaluate the potential. Speculative oil and gas lease applications have been filed for about two-thirds of the study area.

INTRODUCTION

The U.S. Geological Survey (USGS) made a reconnaissance geochemical survey of the Worley Ridge Roadless Area to test for indistinct or unexposed mineral deposits that might be recognized by their geochemical halos or patterns formed by the distribution of trace elements. Geologic mapping and chemical analyses of samples indicate that the study area has a low potential for the occurrence of metallic mineral deposits, but does contain resources of rock suitable for use as construction materials and small deposits of coarse-grained kyanite in rock, soil, and stream sediments. The metal contents of rock, stream-sediment, and soil samples are near or below average abundance for the sample types; no significant enrichments or anomalous amounts are present.

Location

The Worley Ridge Roadless Area comprises about 3,000 acres of Chattahoochee National Forest land 2 mi southwest of Tiger and 4 mi southwest of Clayton in Rabun County, Ga. (Index map). Access to the eastern part of the area is from U.S. Forest Service (USFS) Road 20 which extends west from Rabun County Road 153 south of Tiger. Access to the southern part of the area is by County Road 18 along Worley Creek and USFS Road 25, which extends several miles up Stamp Ridge south of the area and then turns north following the ridge line into the southwest part of the roadless area. This new forest road ends at the southwest corner of Worley Ridge, the highest ridge in the study area. The northern part of the area is reached by County Road 23 and some old forest roads along McClain Creek, which forms the northern boundary of the area.

Worley Ridge is a long digitate crest trending eastward through the center of the study area. Maximum relief is over 1,000 ft; the highest point near the center of Worley Ridge is 2,863 ft above sea level, and the lowest point on Stonewall Creek at the east end of the area is 1,760 ft. Drainage to the north of Worley Ridge is by small streams tributary to McClain Creek, which is a tributary of Stonewall Creek. Drainage along the south side of Worley Ridge is into Worley Creek. The hillsides are steep and thickly wooded with second-growth oak and pine.

Present Work

Lesure and Peper, assisted by J.P. D'Agostino and J.A. Goss (USGS), mapped and sampled the area, March 23-25, 1985, and field checked the northwest corner on April 2, 1986. We collected 39 rock, 42 soil, 19 stream-sediment, and 15 panned-concentrate samples for analysis. All samples were analyzed for 31 elements using semiquantitative six-step spectrographic methods by R.T. Hopkins and M.S. Erickson, USGS laboratories, Denver, Colo. In addition, most of the samples were also analyzed by means of atomic absorption methods for zinc by M.A. Pokorny, USGS laboratories, Denver, Colo. Twelve of the panned-concentrate and ten of the rock samples were also analyzed for gold by atomic absorption methods by T.A. Roemer and D.A. Kelley, USGS laboratories, Denver, Colo. The complete analytical data and sample descriptions are given in Hopkins and others (1987).

Nineteen meta-arkose and metasandstone samples were slabbed, etched with hydrofluoric acid, and stained with sodium cobaltinitrite to estimate the feldspar content. Identification of heavy-minerals suites was done by D'Agostino using a binocular microscope. Some identifications were checked by scanning electron microprobe analysis by E.J. Dwornik, USGS laboratories, Reston, Va. An additional 5 soil and 15 panned-concentrate samples were collected in April 1986 to determine kyanite resources.

Results of the companion U.S. Bureau of Mines mineral investigations of the Worley Ridge Roadless Area are given in Neubert (1986).

SURFACE- AND MINERAL-RIGHTS OWNERSHIP

All surface and mineral rights in the roadless area are owned by the Federal Government. As of March, 1985, about two-thirds of the area was covered by oil and gas lease applications, but no leases had been issued (Neubert, 1986, p. 5-6).

GEOLOGIC SETTING

Worley Ridge is in the northwest part of the Tallulah Falls Dome (Index map) as mapped by Teague and Furcron (1948) and Hatcher (1971). Most of the area is underlain by beds of meta-arkose ranging from fine-pebble conglomerate to fine-grained sandstone. Bedding strikes generally northeast and dips northwest, but swings to a west or northwest strike and north dip in the eastern part of the area (Lesure and Peper, 1987). Graded beds in the conglomeratic layers are present locally and suggest that bedding is upright and tops are to the west. The meta-arkose is cut locally by numerous quartz veins, which are seen as abundant bouldery float. These veins probably range from 1 to 6 ft in thickness and may be as long as 100 ft.

The meta-arkose is overlain to the northwest by an interlayered sequence of quartz-muscovite-biotite schist, metagraywacke, meta-arkose, muscovite-kyanite schist, and amphibolite (fig. 1) containing minor amounts of granitic pegmatite. Bedding criteria for tops are not as convincing in this unit of mixed rock, but right-side-up beds are suggested at several outcrops. These beds are facing to the west, like the bedding in the meta-arkose.

SAMPLING PROCEDURES

Rock samples (fig. 1) consist of a few chips taken across bedding or layering over a measured thickness and are designed to be representative of the major rock units exposed in the area. Most of the rock is partly weathered, but the freshest material available was generally sampled. Rock samples were crushed in a jaw crusher to approximately 0.25 in. (6 mm) and pulverized to minus 140-mesh (0.004 in. or 0.105 mm) in a vertical grinder with ceramic plates.

Soil samples (fig. 1) are from the A_2 or upper B soil zone, just below the dark, organic-rich A_1 surface soil. Soils were dried, sorted in stainless steel sieves to minus 80-mesh (0.007 in. or 0.177 mm), and then pulverized to minus 140-mesh (0.004 in. or 0.105 mm) in a vertical grinder with ceramic plates.

Most of the small drainage basins in the study area were sampled by collecting at random a few handfuls of the finest-grained sediment available at the sample site in the stream (fig. 2). After air-drying in the laboratory, the samples were sorted in stainless steel sieves to minus 80-mesh (0.007 in. or 0.177 mm) and then pulverized to minus 140-mesh (0.004 in, or 0.105) for analysis. In addition to the fine-grained stream-sediment samples, panned heavy-mineral concentrates were made at 15 sample sites (fig. 2). The panned concentrates were further separated into a light and a heavy fraction by using bromoform with a specific gravity of 2.85. The light fraction was discarded. Magnetite was removed from the heavy fraction by use of a hand-held magnet and was not analyzed.

DISCUSSION OF GEOCHEMICAL DATA

The analytical data do not outline any areas of potential metallic mineral resources in the Worley Ridge Roadless Area (table 1). Median values for most elements in the various rock types compare closely with data for the average of the rock type. Most of the meta-arkose samples have slightly more barium, iron, lanthanum, lead, nickel, strontium, titanium, vanadium, and yttrium than the average sandstone, but agree reasonably well with analyses of arkose from the Grandfather Mountain Formation in northwestern North Carolina (table 1). Most of the elements that are enriched in the meta-arkose are present only in trace amounts and are not of economic significance.

Barium, lead, and strontium are minor constituents in potassium feldspar, which forms 30 to 50 percent of the mineral content of the meta-arkose. Iron and titanium can occur in biotite, which forms 5 to 10 percent of the meta-arkose, and in ilmenite, which is common as a heavy mineral in the panned-concentrate samples from streams draining areas of meta-arkose (table 2). Titanium is also the principal constituent of rutile, which is present as a trace mineral in the panned concentrates. Both ilmenite and rutile are trace minerals in the meta-arkose. Vanadium may be a minor constituent of ilmenite, and both vanadium and nickel may be present in biotite. Lanthanum and yttrium may be present in the mineral monazite. Monazite occurs as a trace to 1 percent of the panned concentrates (table 2) but generally in streams that drain areas underlain at least in part by the mixed-rock unit and not in areas underlain by the meta-arkose only. Both lanthanum and yttrium have a wide range of values in stream-sediment and panned-concentrate samples (fig. 3). Only one meta-arkose sample (sample 315R) contains as much as 200 parts per million (ppm) lanthanum, the rest contain 30 ppm or less. One other meta-arkose and vein quartz sample (sample 211R) contains 100 ppm yttrium; the rest contain 50 ppm or less.

The quartz vein samples generally have a low content of all the trace elements looked for (table 1 and fig. 3), which is typical of quartz veins sampled in other areas of metamorphic rocks in the Blue Ridge (Moore and others, in press; Lesure, 1981, 1986). The vein quartz samples contain little or no iron sulfides.

The mica schist samples are similar in composition to an average shale (table 1). The kyanite schist layers contain accessory tourmaline as noted previously by Prindle (1935, p. 19) and Hurst and Crawford (1964, p. 54). Tourmaline is highly resistant to weathering and contains essential boron. Schist sample 127R contains 100 ppm boron, which is six times the amount in the other schist samples. Soil samples from the area of the kyanite schist (samples 128D and 228D) also contain 100 ppm boron. Panned concentrates from streams draining areas underlain by the kyanite schist also contain more boron than similar samples from streams that drain areas underlain by meta-arkose only (fig. 4).

The only amphibolite sampled has a trace element content similar to an average basalt (table 1). Only a few thin 20 to 50 ft amphibolite layers are exposed in the northwest part of the area.

Cobalt, copper, lead, and zinc, which are commonly associated with massive sufide deposits or hydrothermal vein deposits, are present in normal concentrations for the rocks exposed in the study area. Exposed quartz veins from the roadless area are nearly barren of these metals and contain no detectable gold.

MINERAL RESOURCE ASSESSMENT

The Worley Ridge area is underlain mostly by meta-arkose, a rock type that has little potential for mineral resources other than common building stone and crushed rock. A large borrow pit 0.6 mi east of the roadless area is in deeply weathered meta-arkose and has supplied sand and clay for fill. The meta-arkose has no unique features that make it valuable as a building stone. It is abundant in the region and is found in areas more readily accessible.

An asbestos-soapstone prospect pit in a small ultramafic body is 0.4 mi west of the area. This is probably the George Lowell prospect of Teague (1956, p. 7). No other ultramafic bodies are exposed within or near the roadless area.

The only other known mineral resource in the roadless area is a small amount of coarse-grained kyanite in mica schist. Residual deposits of kyanite are in soil over weathered schist and in small alluvial deposits along McClain Creek on the northern border of the area (fig. 5). These deposits are described briefly by Prindle (1935, p. 17-18). Our mapping and sampling indicate an inferred kyanite resource of 3,400 short tons (3,000 metric tons) of kyanite readily available in surficial deposits in the Worley Ridge Roadless Area. Mining of soil in an area of about 40 acres might yield as much as 1,700 short tons (1,500 metric tons) of kyanite, and placering of alluvium an estimated 1,700 short tons (1,500 metric tons). Additional kyanite resources are more extensive in unweathered bedrock, but the average grade will be less than 5 percent kyanite, and the cost of the recovery would not be justified.

Considerable amounts of coarse kyanite are present along the trail on the north side of McClain Creek where the trail crosses the zone of kyanite-bearing schist. Kyanite in the bedrock is present as rod- and lath-shaped crystals in layers of schist 1 to 30 ft thick scattered throughout a zone about 300 to 400 ft thick. The rods and laths are mostly 0.25 to 0.5 in. long, 0.25 to 0.5 in. wide, and less than 0.5 in. thick. The pieces are heavy, moderately soft, and mostly dark gray with parts opaque white, colorless, or tinted blue. Some of the kyanite has specks of rusty-red iron oxides.

Upon the surface in the kyanite-bearing bedrock zone, the kyanite forms patches of surface lag concentrate one crystal thick and about 0.5 yd^2 in area. Beneath the surface within the kyanite zone, it occurs as disseminated rods and laths in the soil and weathered bedrock. Fresh bedrock is usually less than 8 in. from the surface because the muscovite schist is resistant to weathering.

In order to evaluate the kyanite resource potential of the soil from the zone of kyanite-bearing schist we collected one surface lag-concentrate sample and four soil samples from across the zone just north of the trail (table 3 and fig. 1). A level 14-inch gold pan full of soil was the standard amount collected and panned to concentrate the kyanite. The coarse kyanite was hand picked from the concentrate and weighed. The dry weight of each soil sample was 11 to 13 lbs. The volume of the 14-inch gold pan is 0.005 yd^3.

Lag-concentrate sample 033D was taken from two surface scrapings along the main trail, from areas each about 1 ft^2. The amount collected was about a third of a pan (table 3). Soil samples 034D through 037D were taken upslope above the trail (fig. 1). The average amount of kyanite from these four soil samples was 0.4 lb, but the range is large (table 3). The inferred resources of kyanite in the soil from the approximate 40 acres underlain by the kyanite-bearing schist in the northern part of the study area (fig. 5) is 1,700 short tons (1,500 metric tons). This is calculated on an estimated average thickness of soil of 8 in., and an average of 0.4 lb of kyanite per 0.005 yd^3.

Kyanite is also obtainable in appreciable quantities from stream sediment in McClain Creek from where the creek crosses the kyanite schist zone to its juncture with Stonewall Creek, a distance of 2.2 mi. The stream is usually 10 to 16 ft wide and flows on bedrock or on thin and discontinuous alluvium. Nine panned-concentrate samples, four being duplicates (table 3), were taken from McClain Creek (fig. 2). Two samples at site 018C are upstream from the kyanite schist zone and contain what is considered background amounts of kyanite for the general bedrock in the area (table 3). Two samples at 031C (fig. 2) were 500 ft downstream from the kyanite zone; samples 025C and 032C are about 0.56 mi and samples 010C is 2.2 mi downstream from the kyanite zone. The other samples listed in table 3 are from side streams just before their junction with McClain Creek.

The sediment in McClain Creek contains only about 76 short tons (68 metric tons) of kyanite based on a length of 2.2 mi, an average width of 13 ft, an average thickness of 4 in. along 80 percent of the rocky bottom, and an average of 100 lb of kyanite per yd^3 of sediment. Alluvium covers about 20 acres along the south side of McClain Creek within the roadless area. Assuming that most of the recoverable coarse kyanite is in the lower 4 in. of the alluvium similar to the present bed load of the creek, the alluvium in 20 acres contains an inferred resource of an additional 1,600 short tons (1,450 metric tons) of kyanite. Total inferred resources of kyanite in alluvium along and in McClain Creek, therefore, are on the order of 1,700 short tons (1,500 metric tons).

Recent seismic studies indicate that the Blue Ridge of Georgia contains a thick sequence of younger sedimentary rocks beneath the metamorphosed rocks exposed at the surface (Cook and others, 1979). This inverted rock sequence is the result of thrusting of the older metamorphic rocks westward at least 100 mi over the younger rocks, which have an unknown potential for oil and gas (Harris and others, 1981, p. 2504). Speculation on the thermal history of the sedimentary rocks below the thrust fault suggests that only gas might be present in areas along the western Blue Ridge west of Worley Ridge, and that even gas may have been degraded in the central and eastern Blue Ridge in the vicinity of the study area (Hatcher, 1982, p. 980). Further seismic work and deep exploratory drilling are needed to evaluate the oil and gas potential of the buried sedimentary sequence.

The Worley Ridge Roadless Area lies just east of the Dahlonega gold belt (Yeates and others, 1896, p. 80-83) but is separated from the rocks of the gold belt by the Dahlonega thrust fault (Nelson and others, 1987). Rocks of the gold belt may lie beneath that fault below the roadless area but do not offer targets for gold exploration. The Hall County gold belt (Jones, 1909, p. 36) is several miles east of Worley Ridge. The mixed-rock unit contain traces of gold locally. A sample of kyanite schist collected south of Lake Burton 3.5 mi southwest of Worley Ridge contains 0.02 ppm gold, and a sample of metasandstone collected about 3 mi southwest of Worley Ridge contains 0.04 ppm gold (F.G. Lesure, unpub. data). A panned-concentrate sample collected by the Bureau of Mines from a small tributary of McClain Creek in the northwest part of the area contains 0.426 ppm gold (Neubert, 1986, p. 11), but sample 024C, taken from the same drainage, contained no detectable gold at a detection limit of 0.13 ppm. The significance of one anomalous sample is difficult to evaluate. The drainage basin from which the sample came contains a small area underlain by the mixed-rock unit, a possible source of trace amounts of gold. Because no gold was detected in other panned-concentrate samples or in the quartz-vein samples collected from the study area, the potential for gold deposits in the Worley Ridge Roadless Area is deemed low.

Other metallic elements are present in normal concentrations for the rock types present. The potential for metallic resources is low.

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Table 1.--*Range and median concentrations of 21 elements in rock, soil, stream-sediment, and panned-concentrate samples from the Worley Ridge Roadless Area and vicinity compared with the average values for sandstone and shale and median values for similar samples from the Rabun Bald Roadless Area, Rabun County, Ga., and two arkose samples from the Grandfather Mountain Formation, Caldwell and Watauga Counties, N.C.*

All analyses of Worley Ridge samples by semiquantitative, optical-emission, spectrographic methods by R.T. Hopkins and M.S. Erickson, USGS laboratories, Denver, Colo., except zinc, which is by atomic absorption by M.A. Pokorny, USGS laboratories, Denver, Colo. Spectrographic analyses were 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 midpoints of the concentrate ranges, which are 1.2, 0.83, 0.56, 0.38, 0.26, 0.18, 0.12, etc (Matooka and Grimes, 1976). Symbols used: --, not analyzed; N, not detected at limit of detection given after element symbol (first number for rock, soil, and stream sediment; second number for panned concentrate, for Worley Ridge samples only); <, amount detected is below the lower limit of determination, which is number shown; >, amount is greater than number shown. Elements looked for spectrographically but not found and their lower limits of detection in ppm (first number for rock, soil, and stream sediments; second number for panned concentrates): silver (0.5;1), arsenic (200;500), gold (20;20), bismuth (10;20), cadmium (20;50), molybdenum (5;10), antimony (100;200), tin (10;20), thorium (100;200), tungsten (50;100), and zinc (200;500). Exception: zinc was detected in rock sample 319R but below limit of determination (200 ppm).

	VEIN QUARTZ				META-ARKOSE, METASANDSTONE					
	Worley Ridge 9 samples			RB[5] 8 samples	Worley Ridge 25 samples			GMF[4]		Average sandstone[1]
	Low	High	Median	Median	Low	High	Median	GML-8	GML-7	
	Percent									
Ca (0.05;0.1)	N	<0.05	<0.05	N	<0.05	0.7	0.07	0.46	0.29	3.9
Fe (0.05;0.1)	<.05	.3	.05	0.1	.7	3	1.5	1.74	2.0	.98
Mg (0.02;0.05)	<.02	.7	<.02	<.02	.07	.7	.2	.29	.31	.7
Ti (0.002;0.005)	.002	.07	.007	.01	.2	1	.3	.29	.31	.15
	Parts per million									
B (10;20)	N	N	N	10	N	30	15	0	0	35
Ba (20;50)	N	70	<20	70	150	700	500	1,000	700	300[2]
Be (1;2)	N	<1	N	N	<1	3	1	7	3	2[2]
Co (5;10)	N	N	N	N	N	7	N	0	3	.3
Cr (10;20)	<10	15	10	N	N	50	15	10	30	35
Cu (5;10)	N	5	<5	N	<5	20	<5	3	1.5	10-20[2]
La (20;50)	N	<20	<20	N	N	200	20	50	0	7
Mn (10;20)	N	150	<10	15	15	500	200	230	230	500[2]
Nb (20;50)	N	N	N	N	N	20	N	20	15	0.0X[3]
Ni (5;10)	<5	10	7	5	<5	10	7	0	0	2
Pb (10;20)	N	N	N	N	15	50	30	15	<7	7
Sc (5;10)	N	N	N	N	N	10	<5	7	3	1
Sr (100;200)	N	N	N	N	N	200	100	100	70	20
V (10;20)	N	<10	<10	<10	15	70	30	30	15	20
Y (10;20)	N	N	N	N	N	100	15	50	30	10
Zn (5;--)	N	N	N	N(200)	N	45	20	--	--	16
Zr (10;20)	N	<10	N	N	50	700	150	300	300	220

	MICA SCHIST						
	Worley Ridge 4 samples			RB[5] 82 samples	Average shale[1]	Amphibolite 1 sample	Average basalt[1]
	Low	High	Median	Median		No. 225R	
	Percent						
Ca (0.05;0.1)	0.05	0.7	0.5	0.2	2.2	5	7.6
Fe (0.05;0.1)	2	5	3	3	4.7	5	8.65
Mg (0.02;0.05)	.3	1	.7	1	1.5	2	4.6
Ti (0.002;0.005)	.5	.5	.5	.3	.46	.5	1.38
	Parts per million						
B (10;20)	10	100	15	<10	100	N	5
Ba (20;50)	300	500	400	500	580	70	330
Be (1;2)	2	3	2.5	<1	3	<1	1
Co (5;10)	7	10	10	10	19	30	48
Cr (10;20)	30	70	50	30	90	200	170
Cu (5;10)	7	30	30	15	45	50	87
La (20;50)	30	50	40	50	39	N	17
Mn (10;20)	500	700	600	500	850	1,000	1,500
Nb (20;50)	N	<20	N	N	11	N	19
Ni (5;10)	10	30	15	20	68	50	130
Pb (10;20)	20	50	30	15	20	<10	6
Sc (5;10)	5	15	10	10	13	20	30
Sr (100;200)	<100	150	100	150	300	100	465
V (10;20)	70	100	85	50	130	150	250
Y (10;20)	15	70	30	20	35	20	25
Zn (5;--)	20	110	60	N(200)	95	5	105
Zr (10;20)	30	200	150	200	160	50	140

	STREAM SEDIMENTS				PANNED CONCENTRATES				SOIL			
	Worley Ridge 19 samples			RB[5] 57 samples	Worley Ridge 15 samples			RB[5] 51 samples	Worley Ridge 42 Samples			RB[5] 56 Samples
	Low	High	Median	Median	Low	High	Median	Median	Low	High	Median	Median
	Percent											
Ca (0.05;0.1)	<0.05	.1	<0.05	0.15	<0.05	.3	0.15	0.2	<0.05	<0.05	<0.05	N
Fe (0.05;0.1)	1.5	3	2	3	0.15	0.5	0.3	.3	1	3	2	1.5
Mg (0.02;0.05)	.07	.3	.2	.5	.05	.3	.07	<.05	.07	.3	.15	.15
Ti (0.002;0.005)	.5	>1	1	.3	2	>2	>2	2	.15	.7	.5	.3
	Parts per million											
B (10;20)	<10	70	20	<10	20	2,000	200	20	<10	100	25	15
Ba (20;50)	200	700	300	200	50	200	150	70	150	700	500	200
Be (1;2)	<1	1.5	1	<1	N	N	N	N	<1	7	1	<1
Co (5;10)	N	10	5	<5	N	N	N	<10	N	7	N	7
Cr (10;20)	<10	50	30	20	<20	300	100	<20	15	50	30	30
Cu (5;10)	N	20	7	15	N	50	20	N	<5	30	7	10
La (20;50)	N	500	20	150	N	1,500	300	300	20	150	30	70
Mn (10;20)	200	1,000	500	500	30	700	70	70	100	300	150	150
Nb (20;50)	N	20	<20	N	N	100	50	<50	N	<20	N	N
Ni (5;10)	N	10	5	15	10	50	30	10	<5	20	7	15
Pb (10;20)	20	50	30	15	<20	20	<20	N	30	100	50	30
Sc (5;10)	<5	5	5	10	N	<10	N	50	<5	10	5	10
Sr (100;200)	N	150	N	150	N	300	100	<200	N	<100	N	N
V (10;20)	15	70	30	50	20	150	70	70	30	70	50	70
Y (10;20)	15	300	30	50	50	1,000	500	300	10	300	20	30
Zn (5;--)	10	40	20	N(200)	N	140	<10	N(200)	10	60	20	N(200)
Zr (10;20)	500	>1,000	>1,000	300	>2,000	>2,000	>2,000	>2,000	10	1,000	700	200

[1] Turekian (1977, p. 629)
[2] Pettijohn (1963, p. S11)
[3] Order of magnitude, from Turekian (1977, p. 629)
[4] GMF-Grandfather Mountain Formation, two samples, GML-7 and GML-8 (Bryant and Reed, 1970, p. 8 and 80)
[5] RB-Rabun Bald Roadless Area (Moore and others, in press)

Table 2.--*Visual estimate in percent of heavy-mineral content of panned-concentrate samples from the Worley Ridge Roadless Area, Ga.*

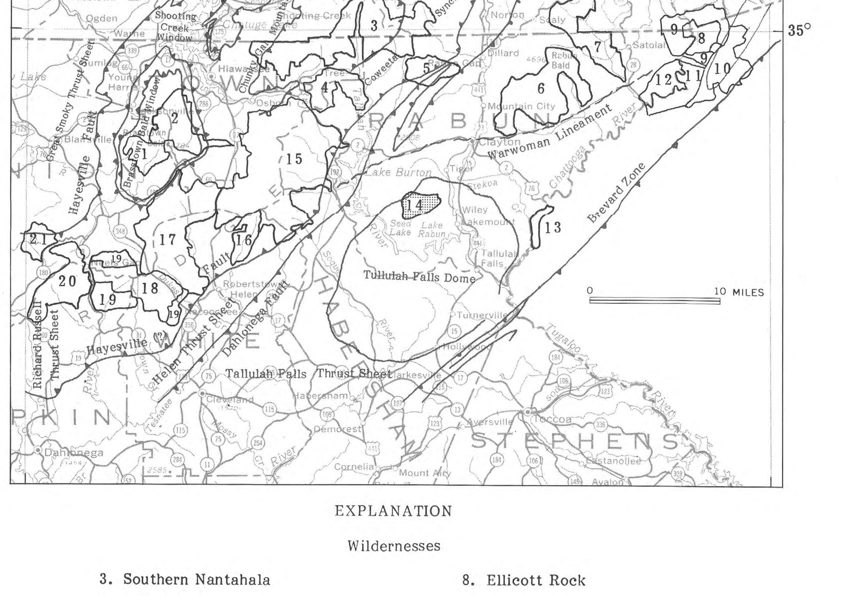
[--, not seen; <, less than; tr, trace, a few grains; columns may not add to 100 because of rounding.]

Mineral	Sample 004C	006C	008C	010C	012C	014C	015C	016C	018C	020C	022C	024C	025C	029C	227C
Epidote	--	--	--	tr	1	2-3	tr	--	<1	1	--	--	tr	--	<1
Gahnite	--	--	--	--	--	tr	--	--	--	--	--	--	--	--	--
Garnet	tr	tr	tr	20	3	55	tr	tr	40	5	25	tr	28	25	13
Hornblende	--	--	--	5	--	--	--	--	--	--	--	--	1-2	--	1
Ilmenite	40	50	50	40	45	20	40	45	25	15	10	50	28	25	45
Kyanite	--	--	--	20	1	5	--	--	2	40	25	tr	28	25	13
Limonite	--	tr	--	--	--	--	--	--	--	15	25	--	2	<1	2
Magnetite	--	tr	tr	tr	tr	<1	tr	tr	tr	tr	--	tr	tr	tr	<1
Monazite	--	--	--	tr	1	1	--	--	1	1	--	--	tr	<1	tr
Muscovite	--	tr	tr	<1	--	<1	--	--	<1	1	--	--	1	--	tr
Rutile	tr	tr	1	<1	tr	1	--	--	<1	1	2	tr	<1	<1	tr
Scheelite	--	--	--	--	--	--	tr	--	--	--	--	--	--	--	--
Spinel	--	--	--	--	2(?)	--	--	--	--	--	--	--	--	--	--
Staurolite	--	tr	--	2-3	1	5	tr	--	2-3	1-2	3	tr	2	1	5
Tourmaline	--	--	tr	2	1	<1	--	--	<1	5	2	tr	1-2	1	2
Zircon	60	50	50	10	45	5-10	60	55	30	20	6	50	7	25	18
Xenotime	--	--	--	tr	--	--	--	--	--	--	--	tr	tr	--	--
	100	100	101	100	100	100	100	100	100	100	98	100	100	102	99

Table 3.--*Kyanite content of soils and stream-sediment samples from the Worley Ridge Roadless Area, Ga.*

[All samples panned from one level 14 in. (35 cm) gold pan full or 0.005 cu yd (0.004 m^3) of soil or alluvium except 033D which was 1/3 as much. Sample locations shown on figure 1.]

Sample number	Kyanite pounds	(grams)
soil		
033D	1.24	(563.9)
034D	.56	(253.7)
035D	.23	(106.0)
036D	.18	(82.6)
037D	.68	(309.4)
Stream sediment		
010C	0.45	(205.1)
010C (duplicate)	.64	(291.8)
014C	.03	(12.1)
018C	.02	(8.0)
018C (duplicate)	.02	(10.0)
020C	.05	(21.0)
022C	.03	(15.1)
024C	.02	(7.5)
025C	.60	(272.1)
025C (duplicate)	.68	(306.7)
027C	.15	(70.0)
029C	.02	(8.0)
031C	.34	(152.7)
031C (duplicate)	.97	(439.2)
032C	.15	(66.5)



EXPLANATION

Wildernesses

3. Southern Nantahala
8. Ellicott Rock

Roadless Areas

1. Wolf Pen 8-149
2. Brasstown 8-146
4. Buzzard Knob 8-223
5. Southern Nantahala B8025
6. Rabun Bald 8-147
7. Overflow 8-026
9. Ellicott Rock Extension A8031
10. Persimmon Mountain L8116
11. Ellicott Rock Expansion 8-112
12. Rand Mountain 8-148
13. Long Creek 8-113
14. Worley Ridge 8-224
15. Tray Mountain 8-030
16. Anna Ruby 8-225
17. Chattahoochee 8-029
18. Raven Cliff A8028
19. Raven Cliff B8028
20. Blood Mountain 8-027
21. Board Camp 8-145

Index map showing locations of wildernesses and roadless areas in northeastern Georgia and adjacent North and South Carolina. The Worley Ridge Roadless Area is stippled. In the explanation, the number after the roadless area names is the Forest Service identification number.

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