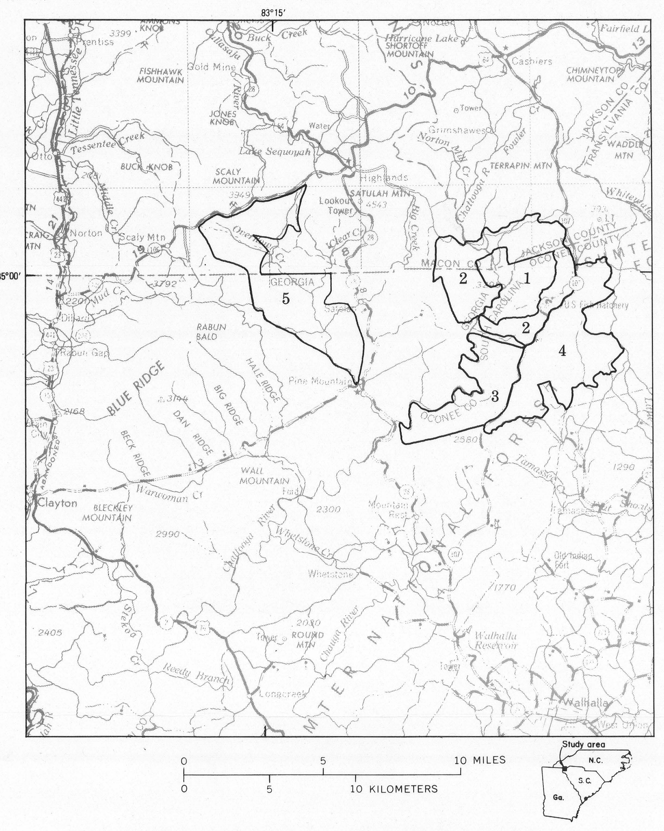

Figure 1.--Index map showing location of the Ellicott Rock Wilderness and additions: 1. Ellicott Rock Wilderness; 2. Ellicott Rock Extension (A8031); 3. Ellicott Rock Expansion (08112); and 4. Persimmon Mountain Area (L8116). The nearby Overflow Roadless Area (5) is also shown.

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 the 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 of the Ellicott Rock Wilderness and additions in South Carolina, North Carolina, and Georgia. The Ellicott Rock Wilderness was established by Public Law 93-622, January 3, 1975. The Ellicott Rock Extension (A8031) is a roadless area that was recommended for wilderness, and the Ellicott Rock Expansion (08112) and Persimmon Mountain Area (L8116) are roadless areas that were classified as further planning areas, during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979. These areas are in the Sumter National Forest, Oconee County, S.C., the Nantahala National Forest, Macon and Jackson Counties, N.C., and the Chattahoochee National Forest, Rabun County, Ga.

INTRODUCTION

The Ellicott Rock Wilderness comprises 3,332 acres in parts of Sumter, Nantahala, and Chattahoochee National Forests. The Ellicott Rock Extension would expand wilderness boundaries in these national forests by 5,600 acres. The Ellicott Rock Expansion, 5,512 acres, and the Persimmon Mountain Area, 6,678 acres, are both in Sumter National Forest.

COLLECTION OF SAMPLES AND EVALUATION OF DATA

For the geochemical survey of the Ellicott Rock Wilderness and additions (fig. 1), samples of rock and alluvium were collected from small streams and analyzed by means of chemical and microscopic techniques. The results are summarized in this report. Figures 2 and 3 show sample localities, and table 1 summarizes the chemical analyses reported in Siems and others (1981). That report contains a complete description of sampling methods, rock samples, and analytical techniques. Also included herein is a discussion of geochemical anomalies that may indicate the presence of significant ore deposits in the study area.

Stream sediments

Two types of sediment samples were collected: a fine-grained type (stream sediment) and a coarse-grained type (panned concentrate). The geochemical composition of the Ellicott Rock area is most easily characterized on the basis of the chemical composition of fine-grained sediment eroded from the local rocks by small streams. Because stream-sediment samples are mainly clay- and silt-size alluvium, commonly containing some organic matter, elements such as copper, lead, zinc, and uranium are concentrated by being adsorbed from water onto sediment in areas where the rocks contain these elements in abundance.

Drainage basins and the stream-sediment sample locality in each basin are shown in figure 2. Gaps in sample number sequences in figure 2 result from duplicate or replicate samples, all of which are included in the data of Siems and others (1981). Table 1 gives the range and median values for the concentrations of elements in the stream-sediment samples. Most elemental concentrations in stream-sediment samples from the study area are the same as or slightly lower than those from similar samples collected in the Shining Rock Wilderness (Lesure, 1981) and the Craggy Mountain Wilderness Study Area and Extension (Lesure and others, 1982); only the median concentration of zirconium is slightly higher in the Ellicott Rock area. The other areas are in a geological environment in the Blue Ridge province of North Carolina that is similar to the geologic setting of the Ellicott Rock area. Localities of 18 colluvium samples from small intermittent streams are shown in figure 2. The range and median concentrations of elements in these samples are nearly identical to the stream-sediment samples and are not included in table 1. However, the coordinates of location and analytical results for the colluvium samples are included in Siems and others (1981).

Panned concentrates

Coarse-grained sediment samples were collected from the drainage basins shown in figure 2 and were panned on location to produce concentrates. This sample type is particularly useful for the detection of heavy elements such as gold, chromium, iron, titanium, and zirconium in heavy, insoluble, and abrasion-resistant minerals. The range and median concentrations of elements in the panned concentrates from the Ellicott Rock area (table 1) are generally the same as or slightly lower than those from the geologically similar Craggy Mountain area (Lesure and others, 1982). Niobium, yttrium, and zirconium are found in slightly greater concentrations in the Ellicott Rock samples.

Rocks

Analytical results for samples of the rocks in the Ellicott Rock Wilderness and additions are summarized in table 1. The samples are grouped according to major rock units in the area. These are: garnet aluminous schist (garnet-kyanite or garnet-sillimanite schist), metagraywacke, amphibolite, and gneiss and biotite schist (all of the Tallulah Falls Formation); Toxaway Gneiss; and veins and metamorphic segregations. The distribution of most of these rock units and the rock sample localities are shown in figure 3. The petrography of these rock units is described in Bell and Luce (1983).

The garnet aluminous schist is probably metamorphosed shale. Comparison of the range and median concentrations of elements in this schist with a worldwide compositional average for shale shows that barium and manganese are found in slightly greater than average concentrations in the garnet aluminous schist.

The metagraywacke samples in the Ellicott Rock area have significantly higher median concentrations of barium, cobalt, chromium, nickel, lead, scandium, strontium, vanadium, yttrium, and zinc than average for graywacke worldwide.

Median elemental concentrations for amphibolite samples from the Tallulah Falls Formation are very close to those for an average basalt, the presumed pre-metamorphic rock.

The gneisses and biotite schists of the Tallulah Falls Formation and the Toxaway Gneiss can be compared to an average composition for granite. Table 4 of Siems and others (1981) gives X-ray fluorescence analyses of selected rocks from the Ellicott Rock area which indicate a granitic composition for these rocks. The Tallulah Falls Formation gneisses and biotite schists have substantially greater median concentrations of chromium, nickel, and vanadium, and slightly greater concentrations of barium, manganese, lead, and yttrium than an average granite; whereas the Toxaway Gneiss contains notably higher-than-average concentrations of lanthanum, nickel, and lead. Uranium was determined in only 16 of the rock samples; therefore, meaningful computation of medians for different rock types was not possible. However, high concentrations of uranium in the Tallulah Falls Formation gneisses and biotite schists, the Toxaway Gneiss, and in veins and metamorphic segregations, are noteworthy.

Two ultramafic rock samples (318 and 362) have compositions that are very similar to Turekian and Wedepohl's (1961) average for ultrabasic rocks. One sample (369) of mylonite gneiss from the Brevard fault zone has a composition similar to the median for the gneisses and biotite schists of the Tallulah Falls Formation. These three samples were not included in table 1.

ASSESSMENT OF GEOCHEMICAL ANOMALIES

The chemical analyses of rock, stream-sediment, and panned-concentrate samples have been evaluated by several means in order to recognize geochemical anomalies that may indicate the presence of mineral deposits in the study area. Geochemical anomalies are concentrations of one or more elements that are higher than background concentrations.

Rock samples

The rock samples collected were selected mainly to be typical of rock units in the study area, thereby allowing them to be compared chemically with rocks elsewhere having similar lithologies. However, a small number of mineralized samples were collected where they were evident. Analytically detected concentrations of silver, arsenic, bismuth, molybdenum, tin, and thorium are considered anomalous simply because most samples had concentrations of these elements below the lower detection limits. The sample numbers of these geochemically anomalous rocks are given in the heading for table 4 in Siems and others (1981). Rock-sample localities are shown in figure 3 of this report. The distribution of these samples is generally scattered, but bismuth and tin anomalies cluster near the gold prospect at the south end of the study area (fig. 4), whereas molybdenum and tin anomalies cluster near the uranium-thorium prospect at the east side of the study area (fig. 5). Some rocks from the uranium-thorium prospect area were analyzed for uranium; results show concentrations up to twice those normally found in the rock types involved, but none of the rocks sampled had exceptionally high anomalous concentrations.

Stream-sediment and panned-concentrate samples

Histograms were made for each element in stream-sediment and panned-concentrate samples. Lognormal frequency distribution plots were constructed for those elements that showed a bimodal distribution. Next, three categories of anomalous values were chosen: low (LA--upper 16 percent of all values, which corresponds to one standard deviation above the mean); intermediate (IA--upper 4 percent of all values, approximately two standard deviations above the mean); and high (HA--the highest one or two values). A map showing drainage basins containing anomalous concentrations was then made for each element. Low, intermediate, and high categories were distinguished. Usually the anomaly distributions were similar for stream-sediment and panned-concentrate sample types. Finally, the elemental anomaly distribution maps were compared in several ways. Patterns that indicated an influence of the underlying geological features--rock type, faults, fold axes, and mining prospects--were noted. Elements having similar distribution patterns were grouped together; calculation of correlation coefficients aided this. The most significant results of these comparisons are shown in figures 4-7.

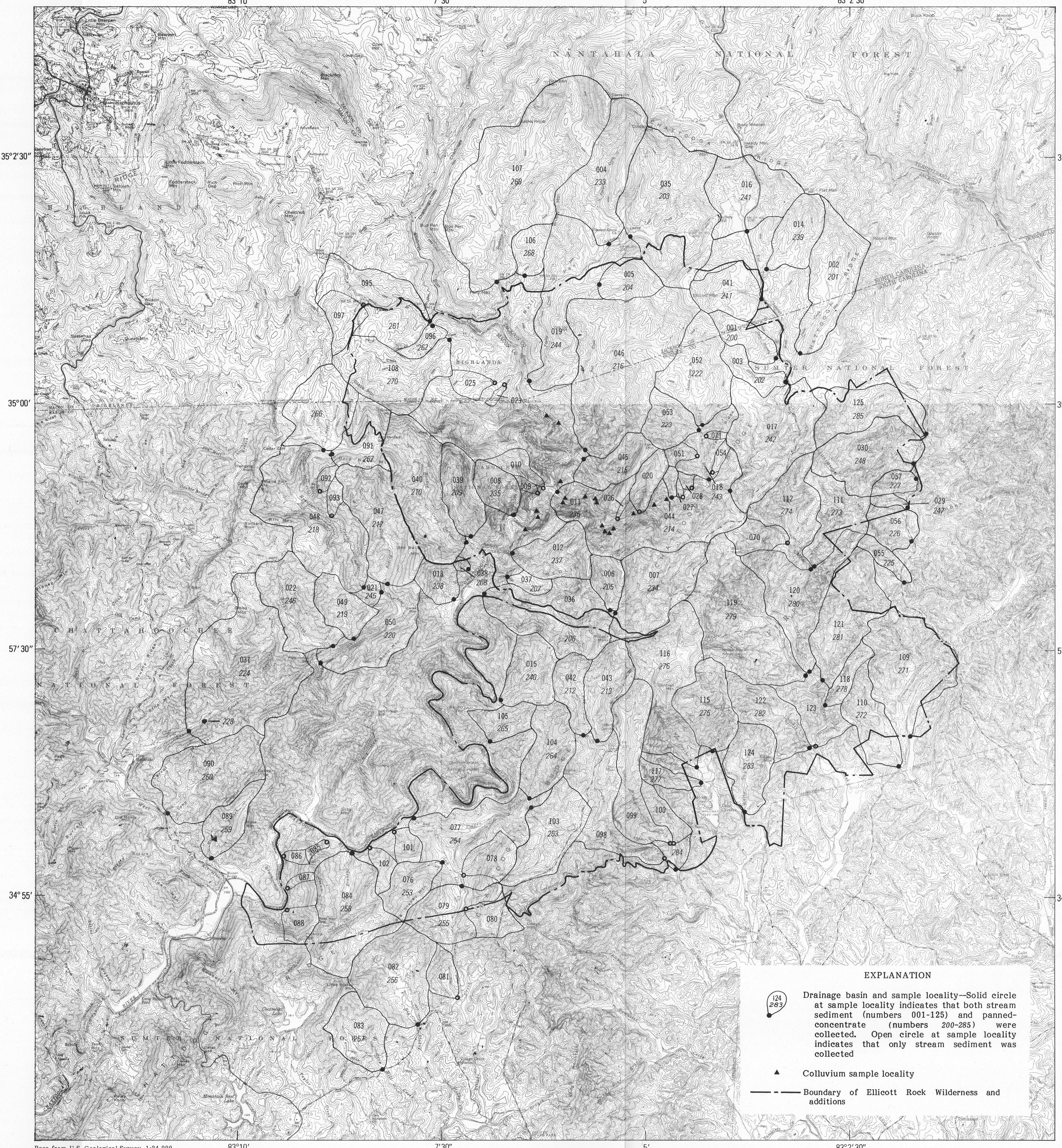

Figure 2.--Map showing stream-sediment, panned-concentrate, and colluvium sample localities. Colluvium sample localities are shown unnumbered to avoid overcrowding the map. Latitude and longitude for all sample localities are given in Siems and others (1981). Numbers are not consecutive; see text.

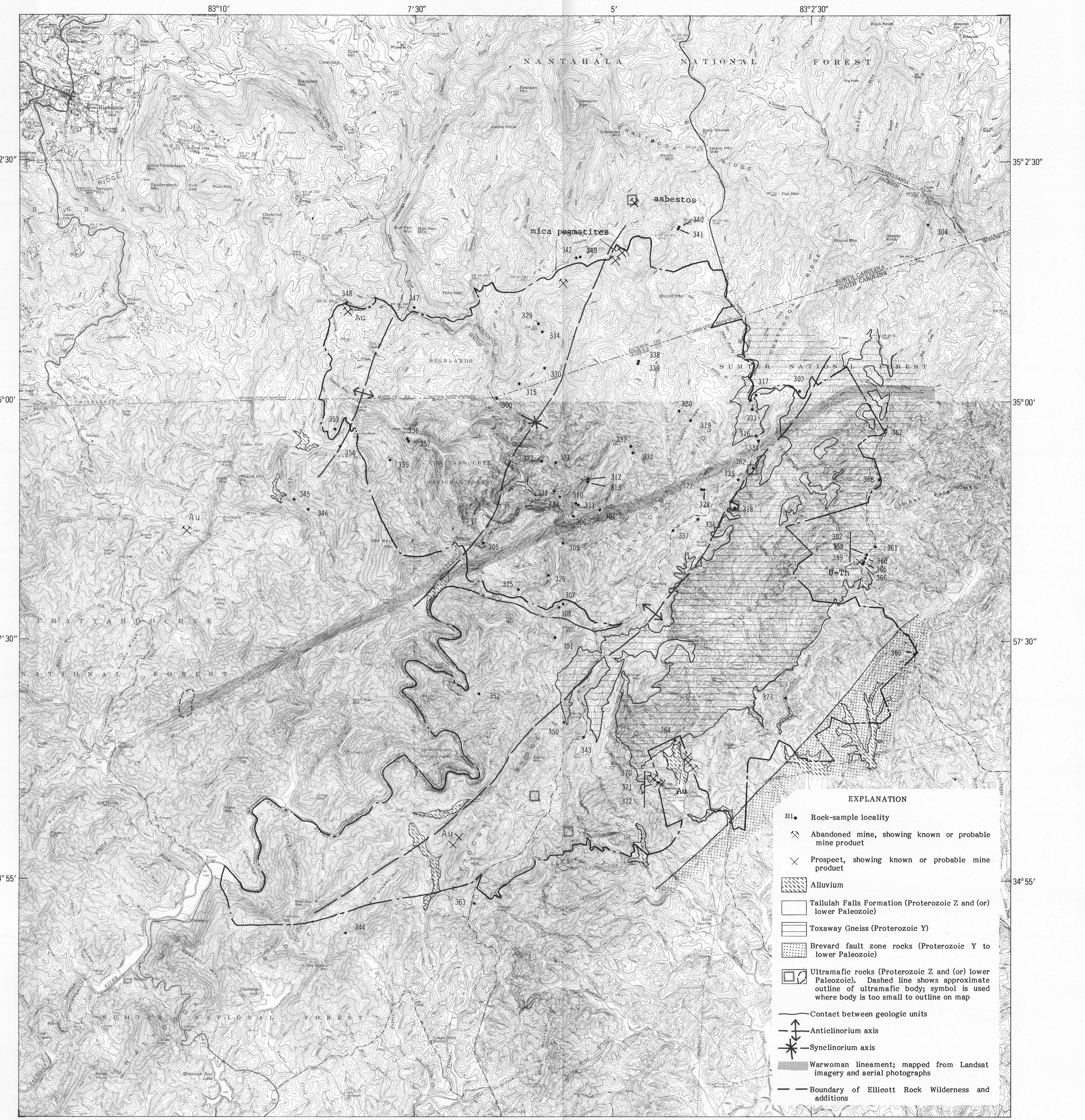

Figure 3.--Map showing rock-sample localities. Geology is generalized from Bell and Luce (1983).

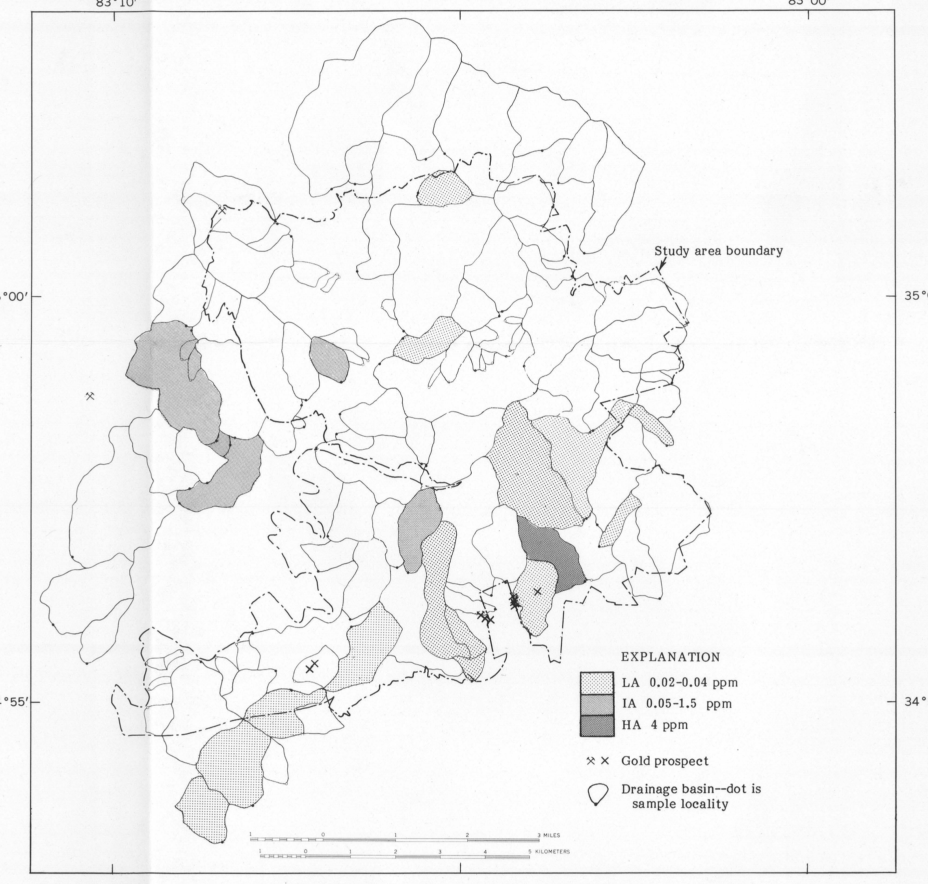

Figure 4.--Gold anomalies in panned-concentrate samples.

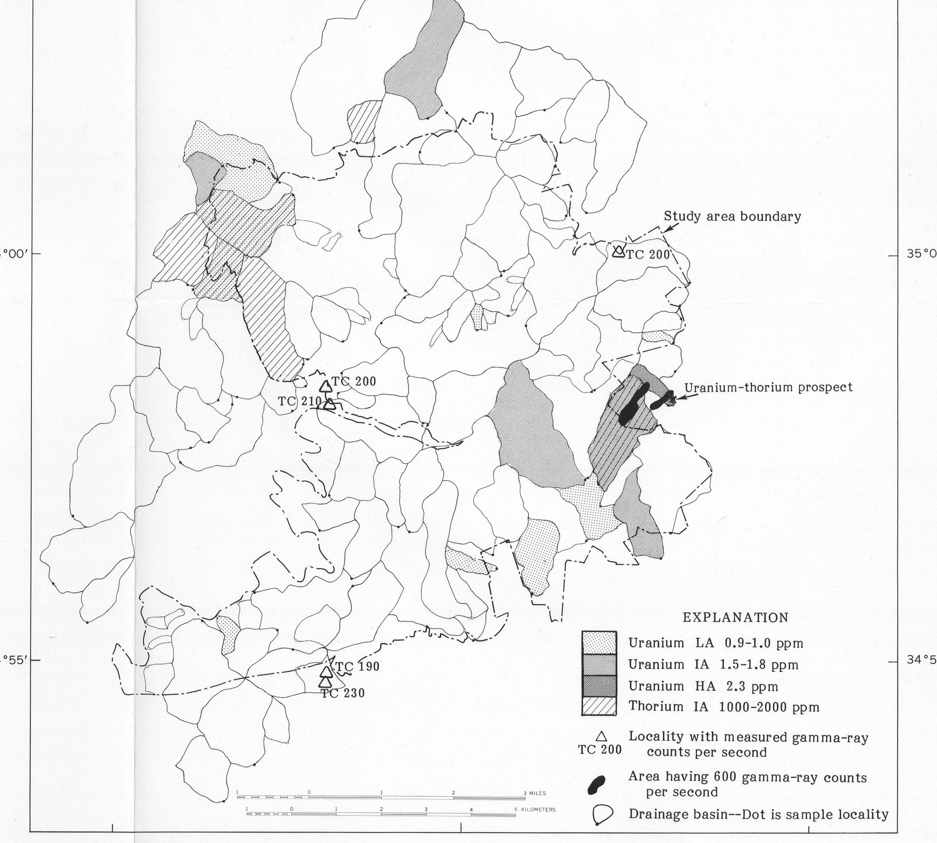

Figure 5.--Uranium anomalies in stream-sediment samples and thorium anomalies in panned-concentrate samples.

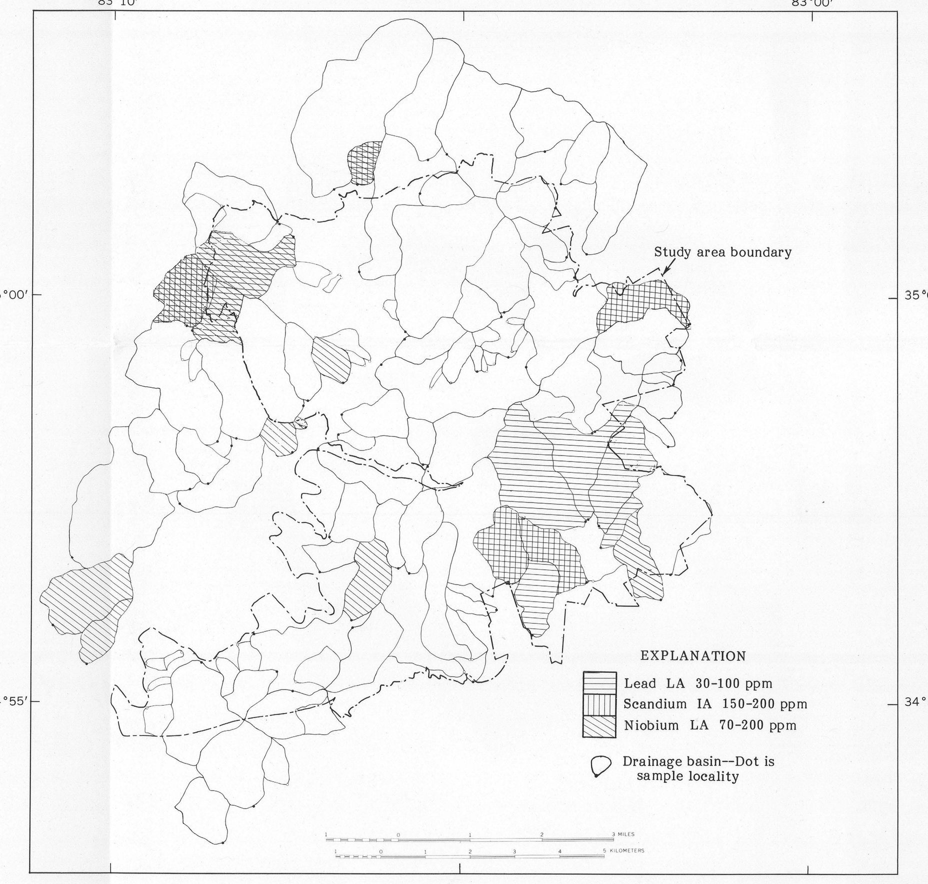

Figure 6.--Lead, scandium, and niobium anomalies in panned-concentrate samples.

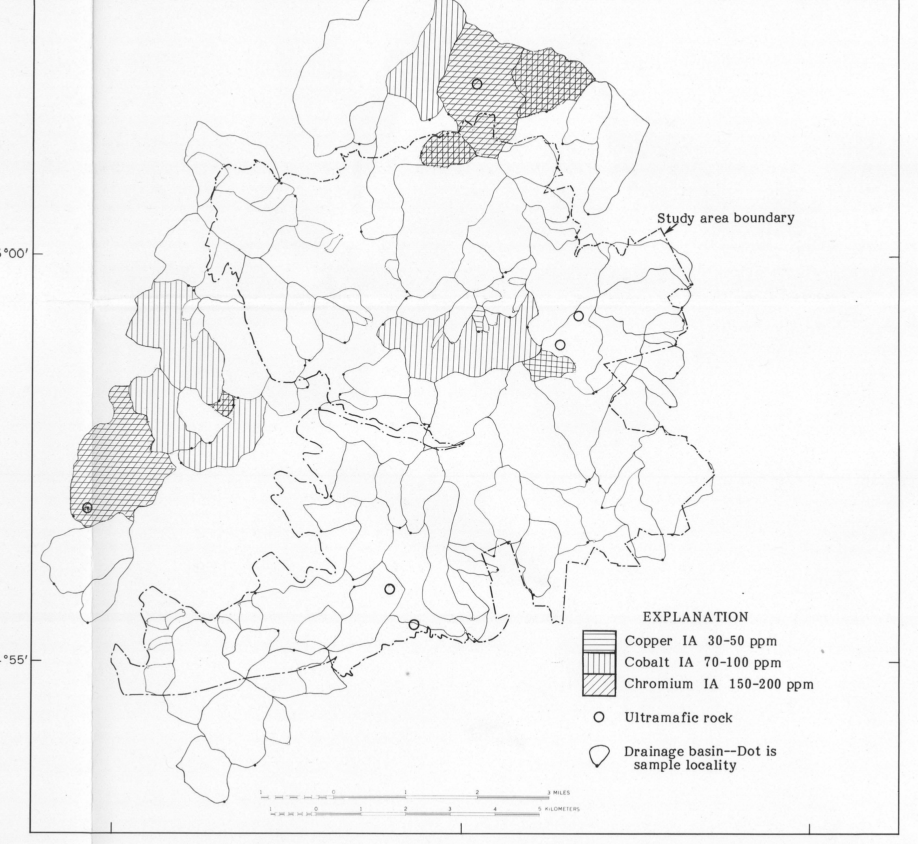

Figure 7.--Copper, cobalt, and chromium anomalies in stream-sediment samples.

Gold anomalies

Gold was found in trace amounts throughout the study area. Figure 4 shows the distribution of gold in panned-concentrate samples having concentrations equal to or greater than 0.02 parts per million (ppm). The very sensitive (0.002 ppm detection limit) flameless atomic absorption analytical method was used to detect gold in many other stream-sediment samples from drainage basins within and southwest of the Toxaway Gneiss outcrop area (fig. 3) and also in three drainage basins in the northwestern part of the study area. Reasonable analytical results are expected even though some analytical error may have been introduced in grinding and splitting the samples because of the particulate, high-density, malleable, and low-concentration nature of gold in panned-concentrate and stream-sediment samples (Fischer and Fisher, 1968). High and intermediate anomalies are located in two areas: (1) near the Tallulah Falls Formation-Toxaway Gneiss contact, and (2) in three west-central drainage basins. The concentration range of 0.05 to 4 ppm in these two areas corresponds with that found by Fischer and Fisher (1968) for streams draining weakly gold-mineralized areas. In the Tallulah Falls-Toxaway contact area, the elements lead, tin, strontium, and vanadium, plus the percent magnetic fraction of panned-concentrate samples, show anomaly patterns similar to that of gold.

Uranium and thorium anomalies

Figure 5 shows the location of anomalous-radioactivity sites and the drainage basins having stream-sediment samples containing anomalous concentrations of uranium. These basins are in three clusters: (1) in the outcrop area of the Toxaway Gneiss near its contact with the overlying Tallulah Falls Formation; (2) in the northwest corner of the study area; and (3) at the northern end of the area sampled. Traverses with a portable gamma-ray spectrometer along most roads and major trails in the study area showed that several localities have higher-than-background radioactivity. Background is 125 gamma-ray counts per second (originating from uranium, thorium, and potassium, but mainly uranium) in the Tallulah Falls Formation, and 150 in the Toxaway Gneiss. Radioactivity is highest at the uranium-thorium prospect outside the study area boundary in the east-central part of the area mapped (fig. 5). There the count reached 1,958 per second, which equals approximately 0.039 percent equivalent uranium (uranium and thorium, geometry corrected).

Autoradiographs of rock samples (Siems and others, 1981, sample numbers 358-360) show that the greatest radioactivity originates in the mineral thorite (ideally $ThSiO_4$ but containing uranium, iron, lead, zirconium, and rare-earth elements), which was identified by E. J. Dwornik of the U.S. Geological Survey (USGS) using a scanning electron microscope equipped with an energy-dispersive X-ray analyzer. A thorium/uranium ratio of 33 for separated grains (Vaneaton Price, written commun., 1980) supports the thorite identification (Staatz and others, 1979, p. 11).

Price (1976) shows a similar distribution of stream-sediment uranium anomalies in the eastern third of the study area, but an exact comparison of his and our data cannot be made because of the different sampling and analytical techniques used (see Gazdik, 1985). Penley and others (1978) give uranium and thorium analyses for some rock samples from the Tallulah Falls Formation and the Toxaway Gneiss in the study area.

Lead, scandium, and niobium anomalies

Drainage basins having panned-concentrate samples containing anomalous lead, scandium, and niobium form clusters and have a similar distribution to the uranium and thorium anomalies (fig. 5). Lanthanum in panned concentrates is found at or above 1500 ppm in almost all drainage basins patterned in figure 6. A granitic, probably pegmatitic, origin is suggested by the grouping of these six elements. Thorite is a primary mineral in pegmatites (Frondel, 1958).

Copper, cobalt, and chromium anomalies

Drainage basins having anomalous copper, cobalt, and chromium concentrations form three tight clusters around ultramafic rocks (fig. 7). The stream-sediment samples from these drainage basins contain, with few exceptions, anomalous concentrations of iron, lanthanum, niobium, and vanadium.

Summary of the geochemical anomalies

Stream-sediment and panned-concentrate samples yield coherent geochemical anomalies for (1) gold, (2) uranium, thorium, and related metals, and (3) copper, cobalt, and chromium. Weak gold mineralization occurs throughout the study area but is highest in the southeast near the Tallulah Falls Formation-Toxaway Gneiss contact. Uranium and thorium anomalies also are highest near the Tallulah Falls-Toxaway contact. The overall coincidence of anomaly patterns for uranium, thorium, lead, scandium, niobium, and lanthanum suggests that granitic, probably pegmatitic, solutions deposited these metals. Copper, cobalt, and chromium anomalies cluster around small ultramafic pods in the Tallulah Falls Formation.

REFERENCES CITED

Bell, Henry, III, and Luce, R. W., 1983, Geologic map of the Ellicott Rock Wilderness and additions, South Carolina, North Carolina, and Georgia: U.S. Geological Survey Miscellaneous Field Studies Map MF-1287-B, scale 1:48,000.

Fischer, R. P., and Fisher, F. S., 1968, Interpreting pan-concentrate analyses of stream sediments in geochemical exploration for gold: U.S. Geological Survey Circular 592, 9 p.

Frondel, Clifford, 1958, Systematic mineralogy of uranium and thorium: U.S. Geological Survey Bulletin 1064, 400 p.

Gazdik, G. C., 1985, Map showing mines, prospects, and mineral sites in the Ellicott Rock Wilderness and additions, South Carolina, North Carolina, and Georgia: U.S. Geological Survey Miscellaneous Field Studies Map MF-1287-E, scale 1:48,000.

Krauskopf, K. B., 1967, Introduction to geochemistry: New York, McGraw-Hill, 721 p.

Lesure, F. G., 1981, Geochemical survey of Shining Rock Wilderness, Haywood County, North Carolina: U.S. Geological Survey Miscellaneous Field Studies Map MF-1290-B.

Lesure, F. G., Grosz, A. E., Williams, B. B., and Gazdik, G. C., 1982, Mineral resources of the Craggy Mountain Wilderness Study Area and Extension, Buncombe County, North Carolina: U.S. Geological Survey Bulletin 1515, 27 p., maps.

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

Penley, H. M., Schot, E. H., and Sewell, J. M., 1978, Preliminary report of the uranium favorability of shear zones in the crystalline rocks of the southern Appalachians: Grand Junction, Colo., Bendix Field Engineering Corporation report GJBX-128 (78), 24 p.

Pettijohn, F. J., 1963, Chemical composition of sandstones--excluding carbonate and volcanic sands, *in* Fleischer, Michael, ed., Data of geochemistry, sixth edition: U.S. Geological Survey Professional Paper 440-S, p. S1-S21.

Price, Vaneaton, 1976, Raw data from orientation studies in crystalline rock areas of the southeastern United States: U.S. Energy Research and Development Administration report GJBX-9 (76), 117 p.

Siems, D. F., Meier, A. L., Luce, R. W., and Bell, Henry, III, 1981, Analyses and descriptions of geochemical samples, Ellicott Rock Wilderness and additions, South Carolina, North Carolina, and Georgia: U.S. Geological Survey Open-File Report 81-594, 37 p.

Staatz, M. H., Armbrustmacher, T. J., Olson, J. C., Brownfield, I. K., Brock, M. R., Lemons, J. F., Jr., Coppa, L. V., and Clingan, B. V., 1979, Principal thorium resources in the United States: U.S. Geological Survey Circular 805, 42 p.

Turekian, K. K., and Wedepohl, K. H., 1961, Distribution of the elements in some major units of the earth's crust: Geological Society of America Bulletin, v. 72, no. 2, p. 175-191.

Table 1.--*Range and median values for stream-sediment, panned-concentrate, and rock samples*

[This table summarizes the results given in Siems and others (1981). The lower detection limit of the analytical technique for each element follows the element symbol (in parentheses). Gold and zinc were determined by means of atomic absorption; the lower detection limit for gold was 0.05 parts per million (ppm) for ordinary atomic absorption and 0.002 ppm for flameless atomic absorption. Arsenic was determined by means of colorimetry and uranium by means of fluorimetry. The remaining elements were determined by means of semiquantitative emission spectroscopy. The spectrographic results are reported in six steps per order of magnitude in the series 1, 0.7, 0.5, 0.3, 0.2, and 0.15 (or multiples of 10 thereof). The precision of this method has been shown to be within one adjoining interval on each side of the reported value 83 percent of the time and within two adjoining intervals 96 percent of the time (Motooka and Grimes, 1976). Elements looked for but not found and their lower detection limits (ppm) are: cadmium (20), antimony (100), and tungsten (50). Bismuth (10) was found only in rock sample 371, where it is 15 ppm. Symbols are: N, not detected; L, present but below limit of detection; G, greater than; ---, not determined.]

Element	Stream sediments, 103 samples			Panned concentrates, 76 samples			Rocks: Tallulah Falls Formation: Garnet aluminous schist, 13 samples			Metagraywacke, 10 samples			Amphibolite, 6 samples			Gneisses and biotite schists, 23 samples			Rocks: Other units: Toxaway Gneiss, 8 samples			Veins and metamorphic segregations, 13 samples			Worldwide average rock compositions			
	Low	High	Median	Low	High	Median	Low	High	Median	Low	High	Median	Low	High	Median	Low	High	Median	Low	High	Median	Low	High	Median	Shale[1]	Graywacke[2,3]	Basalt[1]	Granite[1]
Semiquantitative spectrographic analysis — Percent																												
Ca(0.05)	L	1	0.3	0.07	7	0.5	0.07	2	0.7	N	2	1	3	10	3	0.5	2	1	L	1	0.3	N	1	0.3	2.5	1.8	6.7	1.6
Fe(0.05)	0.7	7	2	2	G20	15	2	10	5	2	7	5	5	10	9	0.3	10	5	0.7	15	2	0.3	G10	2	4.7	3.8	8.8	2.7
Mg(0.02)	0.07	5	0.3	0.02	0.5	0.15	0.2	2	1	0.2	15	1	0.7	7	3	0.1	2	1	0.02	0.5	0.4	L	0.7	0.2	1.3	1.3	4.5	0.16
Ti(0.002)	0.1	1	0.3	0.2	G1	G1	0.2	0.7	0.5	0.3	0.5	0.5	0.3	1	0.4	0.02	0.7	0.5	0.07	0.7	0.2	0.007	G0.3	0.2	0.45	0.4	0.9	0.23
Parts per million																												
Ag(6.5)	N	N	N	N	N	N	N	N	N	N	1	N	N	N	N	N	N	N	N	N	N	N	0.5	N	0.1	0.1	0.1	0.04
B(10)	L	50	10	N	1500	20	N	30	15	N	10	L	N	15	10	N	50	10	L	15	10	N	15	L	100	20-30	5	15
Ba(20)	150	1500	500	N	500	100	N	1000	1000	N	1500	700	N	200	100	100	1500	1000	30	700	300	L	2000	200	580	300	250	600
Be(1)	L	3	L	N	2	N	1	3	2	1	2	1	L	2	1	1	5	2	N	5	2	N	5	1	3	2	0.5	5
Co(5)	N	100	7	N	50	15	7	50	15	5	15	7	10	100	30	N	30	10	N	15	6	N	50	N	20	0.3	48	1
Cr(10)	N	200	20	10	3000	100	20	200	100	30	100	60	70	700	185	N	150	100	N	15	L	N	30	L	100	10-20	200	4
Cu(5)	N	50	7	N	100	L	N	100	20	N	20	10	N	100	15	N	150	15	N	30	N	N	30	L	57	10-20	100	10
La(20)	N	500	30	30	G1000	500	20	150	70	N	100	50	N	70	40	N	150	50	N	1000	85	N	700	L	40	30	10	40
Mn(10)	50	1000	300	1000	G5000	5000	30	1500	1000	70	1000	500	1000	2000	1500	150	2000	700	200	1500	300	70	2000	200	850	500	1500	400
Mo(5)	N	L	N	N	N	N	N	N	N	N	N	N	N	15	N	N	20	N	N	5	N	N	10	N	2	0.2	1	2
Nb(20)	N	20	L	N	200	50	N	20	L	N	20	L	N	20	L	N	20	20	N	20	20	N	50	N	20	0.0X	20	20
Ni(5)	L	150	10	N	30	N	10	70	30	7	30	10	30	200	60	5	70	20	L	20	5	L	30	5	95	2	150	0.5
Pb(10)	N	50	20	N	100	L	15	50	50	10	70	40	10	20	10	15	70	50	30	150	85	N	100	20	20	9	5	20
Sc(5)	N	100	7	N	200	30	5	50	10	7	15	10	15	50	20	L	30	10	5	10	7	N	20	5	10	1	38	5
Sn(10)	N	N	N	N	100	N	N	10	N	N	N	N	N	L	N	N	10	N	N	20	N	N	30	N	6	0.X	1	3
Sr(100)	N	200	L	N	700	N	100	300	150	N	300	150	100	1000	100	100	300	150	N	200	100	N	500	100	450	35	465	285
Th(100)	N	N	N	N	2000	N	N	N	N	N	N	N	N	N	N	N	N	N	N	500	N	N	N	N	11	1-2	2.2	17
V(10)	10	100	50	50	1000	150	70	150	100	70	150	85	70	300	250	10	200	100	15	150	40	L	300	30	130	10-20	250	20
Y(10)	L	300	30	30	5000	700	15	150	30	L	50	20	15	50	25	10	100	30	15	200	30	N	50	10	57	4	100	10
Zr(10)	150	G1000	500	500	G2000	G1000	50	300	150	200	500	300	20	300	85	N	500	200	15	700	85	N	150	L	200	200-250	150	180
Other analytical techniques — Parts per million																												
As(10)	N	N	N	N	10	N	N	10	N	N	N	N	N	L	N	N	L	N	N	N	N	N	20	N	6.6	1	2	1.5
Au(0.002 and 0.05)	N	0.004	N	N	4	N	N	L	L	N	N	N	N	N	N	N	0.02	N	N	N	N	N	L0.05	N	L0.05	0.00X	L0.05	L0.05
U(0.1)	0.2	2.3	0.6	---	---	---	---	0.8	---	---	0.6	---	---	---	---	---	11	---	---	8	---	---	11	---	3.2	0.5	0.6	4.8
Zn(5)	10	100	40	L	130	20	30	180	70	L	170	60	L	35	10	10	220	65	5	80	40	N	75	20	80	16	100	40

[1]Krauskopf (1967)
[2]Pettijohn (1963)
[3]Turekian and Wedepohl (1961)

GEOCHEMICAL MAPS OF THE ELLICOTT ROCK WILDERNESS AND ADDITIONS, SOUTH CAROLINA, NORTH CAROLINA, AND GEORGIA

By
Robert W. Luce and Henry Bell III, U.S. Geological Survey
and
Gertrude C. Gazdik, U.S. Bureau of Mines

1985

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1985
For sale by Branch of Distribution, U.S. Geological Survey,
1200 South Eads Street, Arlington, VA 22202