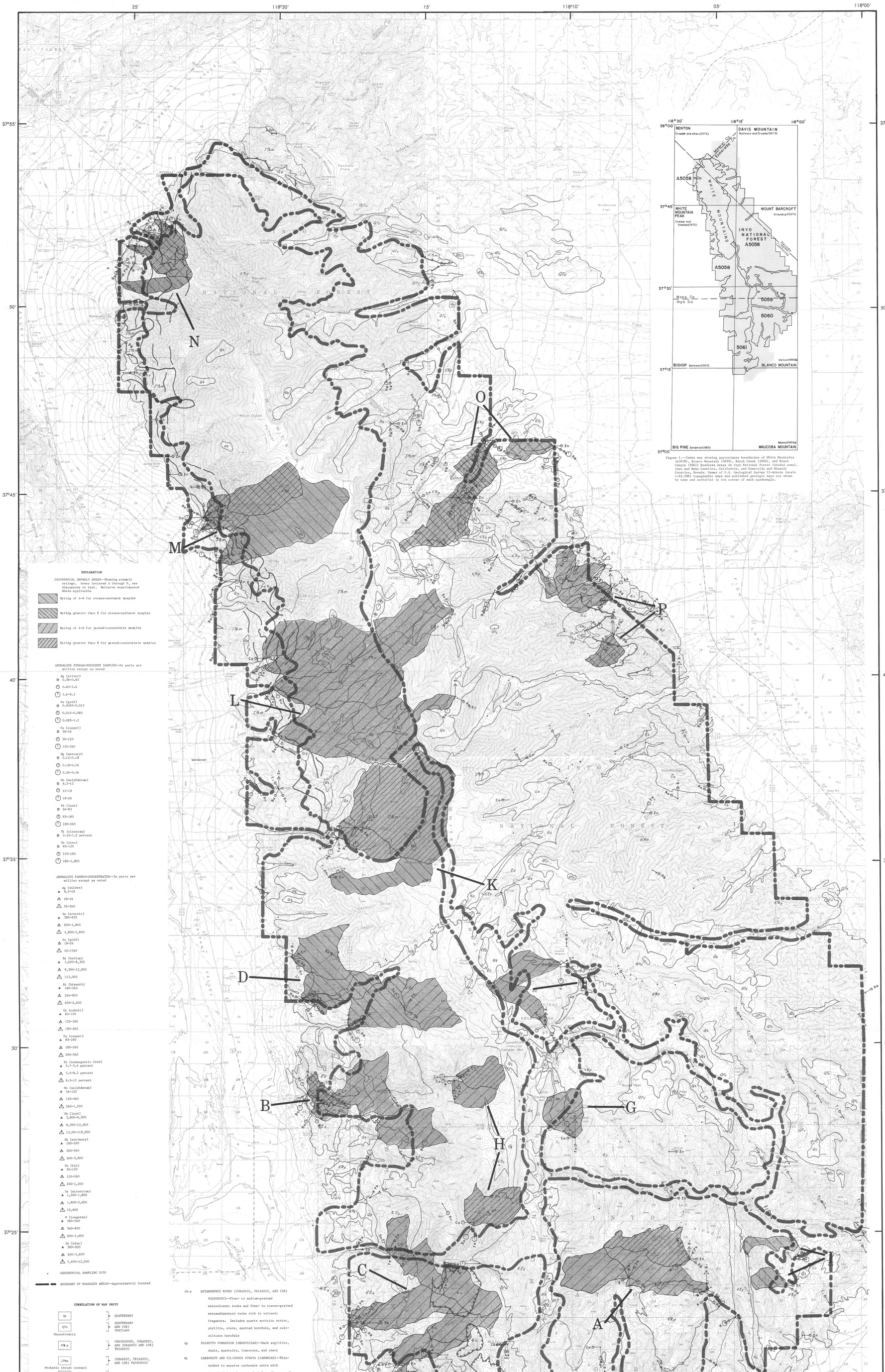

Figure 1.--Index map showing approximate boundaries of White Mountains (A5058), Blanco Mountain (5059), Birch Creek (5060), and Black Canyon (5061) Roadless Areas in Inyo National Forest (shaded area). Inyo and Mono Counties, California, and Esmeralda and Mineral Counties, Nevada. Names of U.S. Geological Survey 15-minute (scale 1:62,500) topographic maps and published geologic maps are shown by name and author(s) in the corner of each quadrangle.

Table 1.--Threshold determination results
[All values are in parts per million except as indicated; (s), semiquantitative spectrographic analysis; (aa), atomic absorption spectrometry; $\bar{x}_G$, geometric mean; S_G, geometric deviation. Underlined values are those chosen for the map and table 2]

Element and analysis type	Cohen's method			Upper 5 to 10 percent		Natural brake		GAMAP		Sinclair	
	$\bar{x}_G+2S_G$	Indicated threshold	Percent anomalous	Indicated threshold	Percent anomalous	Indicated threshold	Percent anomalous	Indicated threshold	Percent anomalous	Indicated threshold	Percent anomalous
STREAM-SEDIMENT SAMPLES											
Ag (s)	16	--	0	0.38	7.0	--	--	*	--	****	****
Au (aa)	11	--	0	.0083	6.5	0.0038	1.8	*	--	0.083	1.0
Cu (s)	18	18	33.4	38	3.9	--	--	38	3.9	****	****
Hg (aa)	4.3	--	0	.12	4.4	.083	6.2	*	--	.26	4.3
Mo (s)	6.5	8.3	3.9	8.3	3.9	12	.78	*	--	12	.78
Pb (s)	30	38	19.7	56	3.1	56	3.1	56	3.1	83	1.3
Ti (s) (percent)	3.9	--	0	.56	11.1	--	--	.56	11.1	****	****
Zn (aa)	49	56	24.6	83	8.0	180	.78	73	12.7	180	.78
DENSE-MINERAL CONCENTRATE SAMPLES											
Ag (s)	[41	180	.55	8.3	6.6	8.3	6.6	*	--	18	1.1
As (s)[1]	1,000	1,200	.27	380	1.1	380	1.1	*	--	***	***
Au (s)[1]	**	--	--	<18	.11	38	.05	*	--	***	***
Ba (s)	**	--	--	>12,000	6.9	5,600	15.4	4,000	17.6	3,800	17.6
Bi (s)	**	--	--	180	6.9	180	6.9	*	--	830	1.4
Co (s)	18	18	45.0	83	7.2	83	7.2	60	9.9	****	****
Cu (s)	18	18	30.8	83	6.1	83	6.1	60	9.9	180	1.7
Fe (s) (percent)	5.5	5.6	11.8	5.8	7.7	--	--	28	7.1	****	****
Mo (s)	18	18	28.4	56	4.1	56	4.1	40	7.4	83	3.0
Pb (s)	**	--	--	3,800	5.0	3,800	5.0	850	14.0	3,800	.5.0
Sb (s)[1]	500	560	.27	180	1.1	--	--	*	--	****	****
Sn (s)	24	26	33.1	56	6.9	56	6.9	85	5.0	260	.83
Sr (s)[2]	**	--	--	830	8.0	1,200	1.1	1,200	1.1	830	7.7
W (s)	54	56	33.3	380	6.1	380	6.1	*	--	260	7.2
Zn (s)	35	38	3.3	380	3.3	--	--	*	--	****	****

*More than 50 percent qualified values, no computations.
**Cohen's method cannot be used when any value is qualified as greater than the upper limit of detection.
***Too few unqualified samples to apply Sinclair's method.
****Not sufficiently polymodal to apply Sinclair's method.
[1]The threshold for samples with fewer than 2 percent unqualified values was set at the lower limit of detection.
[2]The threshold for strontium was chosen based on earlier work by M. A. Chaffee (written commun., 1982) as discussed in the text.

Table 2.--Anomaly thresholds and priority ranges for selected elements
[All values are in parts per million except as indicated; (s), semiquantitative spectrographic analysis; (aa), atomic absorption spectrometry]

Element and analysis type	Anomalous samples			Low priority		Moderate priority		High priority	
	Threshold value	Number anomalous	Percent anomalous	Range of values	Number of samples	Range of values	Number of samples	Range of values	Number of samples
STREAM-SEDIMENT SAMPLES									
Ag (s)	0.38	27	7.0	0.38–0.83	15	0.83–2.6	9	2.6–8.3	3
Au (aa)	.0083	25	6.5	.0083–.012	11	.012–.083	10	.083–1.2	4
Cu (s)	38	15	3.9	38–56	10	56–120	3	120–260	2
Hg (aa)	.12	17	4.4	.12–.18	7	.18–.26	8	.26–.56	2
Mo (s)	8.3	15	3.9	8.3–12	12	12–18	1	18–26	2
Pb (s)	56	12	3.1	56–83	7	83–180	4	180–260	1
Ti (s) (percent)	.56	43	11.1	.56–1.2	43	--	--	--	--
Zn (aa)	83	31	8.0	83–120	21	120–180	7	180–1,800	3
DENSE-MINERAL CONCENTRATE SAMPLES									
Ag (s)	8.3	24	6.6	8.3–18	14	18–56	5	56–560	5
As (s)	380	4	1.1	380–830	1	830–1,800	2	1,800–2,600	1
Au (s)	18	3	.8	--	--	18–26	1	26–>560	2
Ba (s)	5,600	56	15.4	5,600–8,300	7	8,300–12,000	24	>12,000	25
Bi (s)	180	25	6.9	180–260	10	260–830	9	830–2,600	6
Co (s)	83	26	7.2	83–120	14	120–180	7	180–260	5
Cu (s)	83	22	6.1	83–180	10	180–260	8	260–560	4
Fe (s) (percent)	3.8	28	7.7	3.7–5.6	14	5.6–8.3	10	8.3–12	4
Mo (s)	56	15	4.1	56–120	9	120–560	4	560–1,200	2
Pb (s)	3,800	24	6.6	3,800–8,300	15	8,300–12,000	6	12,000–>18,000	3
Sb (s)	180	4	1.1	180–260	2	260–560	1	560–3,800	1
Sn (s)	56	24	6.9	56–120	15	120–260	6	260–1,200	3
Sr (s)	1,200	4	1.1	1,200–1,800	2	1,800–2,600	1	>2,600	1
W (s)	380	22	6.1	380–560	8	560–830	8	830–2,600	6
Zn (s)	380	12	3.3	380–830	5	830–5,600	5	5,600–12,000	2

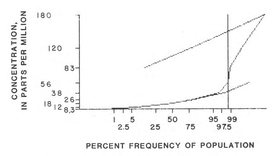

Figure 2.--Log-logprobability plot for cobalt, showing line fits after being treated with program SPA2, Sinclair Population Analysis. See discussion in text.

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 White Mountains (A5058), Blanco Mountain (5059), Birch Creek (5060), and Black Canyon (5061) Roadless Areas in the Inyo National Forest, Inyo and Mono Counties, California, and Esmeralda and Mineral Counties, Nevada. White Mountains, Blanco Mountain, Birch Creek, and Black Canyon Roadless Areas were classified as further planning during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

INTRODUCTION

The geochemical results show the most anomalous part of the study area to be the White Mountain Fault zone along the northwestern range front. Silver, lead, and zinc mineralization in calcareous rocks, porphyry copper in dikes, gold-arsenic quartz vein deposits, tungsten and molybdenum tactite mineralization, and argillic alteration zones are indicated. Titanium and molybdenum were detected in Jeffery Mine Canyon, an area known for rutile deposits.

GEOGRAPHIC SETTING

The roadless areas are in Mono and Inyo Counties, California and Esmeralda and Mineral Counties, Nevada. They are all within the Inyo National Forest and constitute an area of about 301 mi^2 (987 km^2). With the addition of the White Mountain Wilderness, about 484 mi^2 (1,254 km^2) is covered by this study. The terrain is rugged and steep, with relief of about 9,000 ft (2,438 m) along most of the west side of the White Mountains. Elevation ranges from 14,242 ft (4,341 m) above sea level at White Mountain Peak to about 4,500 ft (1,372 m) in Owens Valleyto the west and in Fish Lake Valley to the east. The climate is arid to semiarid, and, because of the great range in elevation, at least two climatic life zones are represented. Most of the vegetation is typical of the Upper Sonoran and Transition zone. It ranges from sage brush, rabbit brush, and sparse grasses at lower elevations to pinon pine, juniper, and mountain mahogany on mountain slopes. At higher elevations the mountains support limber pine and bristlecone pine. Large portions of the range are above timberline. Perennial vegetation includes willow, aspen, wild rose, lush grasses and wildflowers.

Access to the region is from the south by several roads that merge into a single road (near the Bristle Cone Nature Preserve) running northward along the crest into the center of the range. The north half of the range has no roads, but undeveloped trails extend part way up some of the canyons. The northern part of the White Mountain Roadless Area in Nevada has a number of old unimproved mining roads, some of which are passable in four-wheel-drive vehicles.

GEOLOGY

The rocks of the White Mountains and northern part of the Inyo Mountains range in age from Proterozoic to Holocene. They can be divided into the following major groups: (1) late Proterozoic through Ordovician strata with all but the Ordovician consisting of a carbonate-sandstone-shale sequence deposited in a shallow-marine continental-shelf environment. The Ordovician rocks, that occur only in the northern part of the White Mountains, are dark argillite, chert, and shale deposited in a deep-water marine environment and thrust into their present location from sites of deposition 40 mi (64 km) or more to the northwest. (2) Metavolcanic and metasedimentary rocks of uncertain age but lithologically similar to late Paleozoic and early Mesozoic rocks of western Nevada. The metamorphic rocks occur in a belt about 3 mi (5 km) wide that crosses the White Mountains near White Mountain Peak. The separation of these rocks from lithologically similar rocks found tens of miles to the northeast, suggests that they are allochthonous. (3) Mesozoic plutonic rocks of the Inyo batholith, an eastern part of the Sierra Nevada batholith. These are predominantly granodiorite to quartz monzonite in composition but include monzonite and granite as well. About half of the roadless area is underlain by granitic rock; 14 discrete Mesozoic plutons have been mapped. Most of these are Jurassic or Cretaceous in age; Triassic and (or) Jurassic plutons are present (Crowder and others, 1973), but small in volume. (4) late Tertiary (mainly late Miocene and (or) Pliocene) volcanic and sedimentary rocks are especially abundant in the northern part of the White Mountains The volcanic rocks include rhyolitic lava flows, ash flows, ash-fall tuffs, and hypabyssal dome-complex rocks. Most of the sedimentary rocks contain a large proportion of rhyolitic ash as well. Andesitic lava flows and lahars are common, and olivine basalt is found at scattered locations throughout the White and Inyo Mountains.

At least four distinct periods of deformation have been recognized in the White Mountains. The oldest structures are found only in the Proterozoic and Paleozoic strata and record two major periods of thrusting before emplacement of the Inyo batholith. The older event occurred during late Devonian and Early Mississippian time and corresponds to the Antler orogeny of central Nevada; it displaced Ordovician strata from western Nevada to the White Mountains. The younger event, that thrust the metavolcanic and metasedimentary rocks at White Mountain Peak south from western Nevada, is related to the late Paleozoic Sonoma orogeny of western and central Nevada. The third major period of deformation is related to the emplacement of the Mesozoic (Snyder and Kistler, 1970, McKee and Nash, 1967) batholith. Local deformation is related to the various plutons. The fourth major period of deformation, Tertiary through Holocene basin-and-range faulting, is responsible for the present topography. The White and Inyo Mountains are one of the best examples of a block-faulted range in the basin and Range physiographic province. Figure 1 is an index to the detailed geologic mapping in the study area. A compilation of the geology of roadless areas within the White Mountains was published in McKee and others (1982), which is the source for the generalized geology shown on the accompanying map.

GEOCHEMICAL STUDY

The geochemical sampling for this study was conducted during the summer of 1980. Rock, stream sediment, and (or) bulk sediment samples for concentration of nonmagnetic dense minerals were collected at 386 sampling sites. The samples were analyzed for 31 elements by six-step semi-quantitative spectrography, and for zinc and gold by atomic absorption spectrometry. Forty-seven selected stream-sediment samples from the silicic volcanic area in the northern part of the area were also analyzed for mercury by a variation of the atomic-absorption technique. In this process, mercury is vaporized by heating, passed through the lamp beam on the atomic-absorption instrument, and measured. Eighteen selected rock and 42 stream-sediment samples were analyzed for uranium by fluorometry. The samples selected for analysis for mercury and uranium were collected from areas with favorable geologic conditions for their occurrence. Stream sediments on the west side of the study area are primarily the products of periodic storms, while the drainages on the eastern, more gently sloping valleys, contain annual creeks. The analytical results were entered into the U.S. Geological Survey Rock Analysis Storage System (RASS) from which a standard binary STATPAC (Statistical Package) file was generated (Van Trump and Miesch, 1976). A complete listing of analytical and geographic data along with a sample-site location map, summary statistics, frequency tables, and histograms are included in Diggles and others (1982).

Geochemical anomalies

For a geochemical sampling program to be effective, the data must be considered in ways that will resolve multiple populations. Some samples will be related to background while others near mineral deposits will form a second population. Data for key elements related to mineralization are most useful if they exhibit at least some separation of populations. Discrimination of background and mineralized areas is never completely satisfactory, but a number of methods can be used to most effectively identify anomalous samples.

Identification of anomalous limits

Of the 35 elements determined in the stream-sediment samples, 8 (silver, gold, copper, mercury, molybdenum, lead, titanium, and zinc) were selected as having possible association with hydrothermal alteration and mineralization. Of the 31 elements determined in the samples of nonmagnetic dense-mineral concentrate, 15 (silver, arsenic, gold, barium, bismuth, copper, cobalt, nonmagnetic iron, molybdenum, lead, antimony, tin, strontium, tungsten, and zinc) were selected for the same reason. Forty seven samples were analyzed by fluorometry for uranium; all samples contained only amounts consistent with normal background values for that element. The data were processed and the results analyzed in several ways in order to identify anomalous populations of samples.

Resolution of bimodal populations

Populations of geological materials in nature tend to be distributed lognormally (Ahrens, 1957, Siegel, 1974). In a simple case, where the data set shows this type of distribution, it is useful to note the value that is two geometric deviations above the geometric mean and set this value as the threshold above which samples can be considered anomalous. This technique is used with some reservations, however, because any normally distributed population can have individuals in the high end of the distribution curve and these samples quite likely represent high background for that element rather than being representative of metallic enrichment.

Many of the elements have bimodal or polymodal distributions, thereby lending themselves to methods of determining thresholds in ways that present fewer doubts as to their significance. When the sampling program was conducted, samples from barren regions as well as samples from undiscovered, resource-bearing mineralized zones were gathered together, analyzed, and the results entered into the same data sets. The curves produced by statistical treatment of these data reflect the fact that two separate populations are represented by polymodality. The anomalous limit in cases like these is at a break in the curve. The background values occur below the break; a population of potentially anomalous samples falls above the break. A first approximation of thresholds defined by breaks between modes was made by considering the histograms in Diggles and others, (1982). Where a natural break or a second peak was observed on the histograms, the level of concentration at that point was noted and values above this break were considered anomalous.

A further treatment of the datasets was made using the program CAPMAP written by A. T. Miesch (written commun., 1981) of the U.S. Geological Survey. This program reads a STATPAC (file and normalizes the data using a 3-parameter lognormal transformation and makes adjustments for the expected frequency at the position of each gap to prevent bias toward the tails. It then searches for statistically significant discontinuities in each variable. The output file contains the position of the gap and information regarding the transformation and its effectiveness. The program also identifies lesser gaps that are significant at the 80 percent of higher level, divides the data into as many as five classes according to the four most significant gaps, and prints a page-sized map showing the relative geographic positions of each sample in each class. For elements where the data lent itself to treatment by this method, anomalous levels were identified. The program often identifies more than one gap. In those cases, the value selected for this study was one which fell in the upper 10 percent of the population and at a gap that the program showed as having a probability of under 0.001 of occurring if no anomaly is present. The value chosen, if more

For certain of the elements considered in the mineral resource evaluation, the use of probability graphs provided a good method of choosing thresholds between anomalous and background geochemical data. This technique is described by Sinclair (1973) and was carried out with the aid of the program SPA2 (Sinclair Population Analysis) written by G. I. Selner and modified by N. A. Dellinger (written commun., 1981) for use with a Hewlett-Packard 85 computer. This method is based on partitioning a cumulative probability plot of the data in Diggles and others (1982) and producing a fundamental grouping of data values. The output graph is a plot of the logarithm of the analytical values plotted against the logprobability plot of the cumulative frequency. The distribution of a logsorally distributed population plots as a straight line on such a graph. Bimodally distributed populations plot as curves with inflection points. The program breaks the data into two sets and plots the subsets as lines which, when added, give the original curve. The degree to which any trial solution is a good approximation of the two populations is indicated by the extent to which the plots of the subsets approximate straight lines. The best-fit solution gives plots of hypothetical background and mineralized populations and the associated threshold value. The upper curve is a computer model of the distribution of samples that were collected from stream drainages with significantly higher than normal concentrations of elements that relate to metallic deposits. These drainages are geochemically anomalous. Figure 2 is an example of the results of this population analysis treatment.

The threshold values for the White Mountains area were also compared to those determined in other studies being conducted in the same general region (Dellinger and others, 1982, Chaffee and others, 1980). Rose and others (1979) also gave a general listing of average concentrations of different elements in geologic materials. Table 1 includes information on thresholds using the different methods, the method used, and the final threshold value assigned based on all of these considerations.

Locating anomalous drainages

The goal in all of the methods of threshold determination discussed above, is to define and locate sampling sites in mineralized areas. The anomalous samples are divided into priority groups (usually three) where the lower group has the highest chance of containing samples that are merely high background. There is a similar likelihood that the highest value in the background population contains samples that are actually the low end of the mineralized population. The low priority group requires many times as much work to check each anomalous sample than is required for the higher priority groups; it also contains the least important levels of the element being considered, thus, the reason for assigning priorities to the groups. In practice, some of the anomalous samples in the low range can be recognized with a fair degree of certainty. For example, a number of samples with low-priority anomalous values might be expected to occur downstream from higher-priority anomalous samples. Samples in this group might also be anomalous in associated elements.

Pathfinder elements

The elements considered in this study include both indicator elements that are economically valuable components of the mineralization being studied and pathfinder elements, which are associated with possible mineral deposits. Pathfinder elements are useful both for indicating presence of commodity elements and the type of mineral deposit. The following are pathfinder elements that are associated with geochemical environments in the White Mountains.

Iron.--The dense-mineral concentrate samples were prepared by removing the magnetic fractions as well as the less-dense fraction of each original panned-concentrate sample. This final product was analysed for iron by semi-quantitative spectrography. Iron that is detected in this manner is derived from pyrite and indicates that other sulfide minerals may be present.

Bismuth.--Bismuth is an associated element in some tungsten skarn deposits, notably the Pine Creek mine in the Bishop tungsten district (Rose and others, 1979). Molybdenum is also a major component of this ore type. The combination of bismuth and molybdenum, even in the absence of tungsten, is an indication of a potential for this type of deposit, particularly in drainages where other stations produced samples anomalous in tungsten. The lower limit of detection for tungsten in this study is fairly high, which makes bismuth a valuable pathfinder.

Molybdenum.--Where copper is present in anomalous amounts, other elements indicative of sulfide deposits are present (such as non-magnetic iron, lead, or zinc), and where bismuth is absent, molybdenum may be an indicator of porphyry copper hydrothermal deposits. Also, as mentioned above, molybdenum is associated with tungsten skarns.

Arsenic.--Vein-type gold deposits often have associated arsenic in wallrock, residual soils, and stream sediment. Arsenic is contained in high levels even in fairly cool ore-forming fluids, which makes it useful in detecting nearby gold deposits.

Cobalt and (or) Strontium.--Hydrothermally altered areas have been identified in the Walker Lake 1:250,000 quadrangle in California and Nevada (M. A. Chaffee, oral commun., 1982) by noting the occurrence of cobalt, strontium, nonmagnetic iron, and barium in dense-mineral concentrate samples. Anomalous samples tend to have greater than 1,000 to 1,500 ppm strontium and greater than 30 ppm cobalt. This group of elements is concentrated in rocks that have been bleached, argillized, silicified, and otherwise altered.

Barium.--In addition to the association with strontium and cobalt, noted above, barium is an indicator for bedded barite deposits in the Walker Lake quadrangle. Dense-mineral concentrate samples from streams underlain by the Palmetto Formation in the southeast corner of the quadrangle show barium plus or minus strontium, but no cobalt nor nonmagnetic iron. These rocks crop out in the northern part of the White Mountains as well.

GEOCHEMICALLY ANOMALOUS AREAS

Sixteen areas within the White Mountains were identified as being anomalous with regard to geochemical samples of stream sediment. The map shows the location of each area and information regarding the degree to which the area showed anomalous concentrations of various elements. It also shows the outlines of drainages that rated from 4 through 8 and greater than 8 when all indicator elements at a site are considered.

Computer files of data for anomalous samples were searched for groups of elements that are known to occur as suites in various ore deposit models. Five ore deposit models that seem applicable to the White Mountains were developed. These are: 1) lead, zinc, silver in carbonate rocks, 2) copper and lead in copper porphyry deposits, 3) tungsten, molybdenum, and bismuth in skarns, 4) arsenic and gold in mineralized vein deposits, and 5) strontium, nonmagnetic iron, cobalt, and barium in rocks that have been argillized and (or) silicified. This information has helped interpret the geologic control of each anomalous area.

Area A

Nine drainages in and adjacent to the quartz monzonite of Birch Creek showed anomalous levels of tungsten and (or) bismuth. Tungsten tends to concentrate in later-crystallizing phases such as granites and quartz monzonites (Levinson, 1980). Bismuth is a useful associated element in identifying hydrothermal deposits of tungsten and molybdenum (Rose and others, 1979). The tungsten anomaly in area A may be due to deposits of sheelite in skarns that are associated with the carbonate-quartz monzonite contact zones. Carbonate formations that may act as host rocks include the limestone and dolomite of the lower part of the Wyman Formation, the Reed Dolomite, and the Deep Spring Formation. Silver and lead occur at anomalous levels in nine of the samples. Four samples show iron in the nonmagnetic dense-mineral concentrate samples, which indicates pyrite and perhaps other sulfide mineralization.

Area B

Samples that yield the highest anomalies in the geochemical study are from the mouth of Goldwater Canyon. This area showed high amounts of gold in stream-sediment and panned-concentrate samples, possibly derived from quartz veins in the surrounding Campito and Poleta Formations. The sample at the south of the canyon contained tungsten and bismuth, which are indicative of tactite mineralization. Sheelite in tactite may be present in small amounts in contact zones between diabase dikes and carbonate rocks of the Poleta Formation. Silver and copper were present in anomalous amounts in two of the samples in the canyon and may be derived from sulfide-bearing diabase dikes that are common in the country rock.

Area C

The mouth of Bedding Canyon and a small drainage that is north of Poleta Canyon and south of Silver Canyon showed relatively anomalous amounts of tungsten, gold, silver, antimony, lead, and barite. The silver, lead, and antimony are possibly derived from carbonate rocks of the Poleta Formation. The gold may be from quartz veins in the stratified silicic rocks of the area. Tungsten may be derived from older fan deposits as no contact zones conducive to skarn formation are known. A single dense-mineral concentrate sample in lower Silver Canyon showed anomalies in lead, zinc, nonmagnetic iron, and copper. A sample taken farther downstream showed minor lead as well. This anomaly possibly is due to sulfide deposits associated with dikes in quartzite and shale of the Campito Formation.

Area D

Five anomalous geochemical samples were collected from the area of Sacramento Canyon and Piute Creek. Gold and arsenic were detected in four samples in fairly high amounts and may be derived from quartz veins from the granodiorite of Mount Barcroft. Copper and nonmagnetic iron suggest a copper sulfide source. Deposits of this type are present at the mines in Sacramento and Piute Canyons in diabase dikes.

Area E

Three drainages on the south side of Black Canyon produced anomalies in lead, silver, and gold. Most of the rocks in Area E are quartzite and shale. The source of the anomalies probably is limited to beds of limestone 0.5 mi (0.8 km) wide in the immediate area or thin beds of carbonate rocks in the Deep Spring Formation at the west end of Area E. Gold occurred in small amounts in three samples from the area and may be derived from quartz veins in shear zones.

Areas F and G

Stream sediments near the contact between the quartz monzonite of Beer Creek and the Reed Dolomite west of Cottonwood Basin showed bismuth, tungsten, and copper in geochemical samples that are indicative of skarn deposits. The Eva Belle mine at the north end of the Area F contains copper in contact metamorphosed zones. These two deposits types are generally mixed in shear zones.

Area H

The two parts of Area H in upper Silver Canyon display the iron, cobalt and, in the north part, barium group of metals that indicates bleached silicified, argillized and otherwise altered zones. The north part also showed a moderate tungsten anomaly. The anomalous drainages in the north coincide with the Harkless quartzite and shale, which may be argillically altered.

Area I

Three standard stream-sediment samples in this area had minor anomalies of copper, silver and zinc. There was also a gold anomaly in the northern drainage. This area is underlain by quartz monzonite of Beer Creek and contains at least one prospect shaft. The anomaly may be derived from veins in the quartz monzonite.

Area J

This area has two drainages within the quartzite and shale of the Campito Formation that showed anomalous amounts of both copper and nonmagnetic iron in the dense-mineral concentrate samples. The iron is indicative of pyrite; the copper probably is also derived from sulfide minerals.

Area K

Located in the Milner Creek drainage, Area K has two of the more anomalous samples in the study area. Tungsten, molybdenum and bismuth were present in relatively high amounts indicating possible tactite mineralization. Silver, zinc, and copper were also detected in anomalous amounts. Cobalt, barium, and iron elements commonly associated with argillic alteration, were measured at fairly high levels. The area is underlain by the granodiorite of Mount Barcroft, granite of Pellister Flats, and metasedimentary and metavolcanic rocks of Permian and (or) Jurassic age. The metasedimentary rocks include a few lenses of clastic limestone up to 3 ft (0.9 m) thick that are seen as discontinuous ledges among shale layers on the slope of the canyon. Tactite mineralization may be present at contacts between the calcareous lenses in the metasedimentary rocks and the plutons or dikes and veins. The silver and zinc as well as the nonmagnetic iron were possibly derived from sulfide-bearing diabase dikes cutting both the plutonic rocks and the metamorphic units. The Copper Queen mine between Sables and Milner Creeks is in such a deposit.

Area L

The range-front fault shear zone between Willow Creek and Jeffery Mine Canyon produced three samples anomalous in tungsten, molybdenum, copper, zinc, nonmagnetic iron, and gold. Two of the samples exhibited cobalt and barium as well, which indicate possible argillic alteration. The tungsten and copper probably are from altered areas in the shear zone near contacts between calcareous metamorphic rocks and the granite of Pellister Flats. The copper and zinc may be due to sulfide mineralization in similar zones or in dikes.

Area M

The area along the White Mountains fault zone between Rock Creek and Middle Canyon produced samples anomalous in silver, bismuth, cobalt, nonmagnetic iron, molybdenum, lead, strontium, tungsten, and zinc, suggesting the presence of tactite and argillic alteration with accompanying tungsten-molybdenum and lead-zinc-silver sources. Anomalous copper and nonmagnetic iron was measured in stream-sediment samples. The copper and iron, seen at levels above 50 ppm and 0.3 percent respectively, suggest that a copper porphyry-type source (Cox, 1981) may be present in dikes in the calcareous rocks.

Area N

This area is also within the White Mountains fault zone. Geochemical samples had anomalous lead, copper, and (or) zinc, possibly from quartz stringers and veinlets in marble of possible Paleozoic age. Molybdenum was detected in moderately anomalous amounts and may be derived from small veins in the batholithic and dike rocks. Silver was detected in six samples in Area N. The Black Warrior mine contains surface silver in quartz veins, but underground there is very little visible mineralization (S. W. Schmuck, unpub. data, 1982). There are no pertatant structures in the range-front shear zone, making it impossible to trace controlling features for more than short distances.

Area O

Lead, zinc, and silver were present in anomalous amounts in four samples in Indian and Marble Creeks. Two types of mineralization are indicated. In the northern part of the area, igneous dikes cut sedimentary rocks of the Wyman Formation. The Green Monster mine at the head of Indian Creek produced argentite and argentiferous galena in marble of the Bishop tungsten district (Rose and others, 1979). Molybdenum is also a major component of this ore type. The combination of bismuth and molybdenum, even in the absence of tungsten, is an indication of a potential for this type of deposit, particularly in drainages where other stations produced samples anomalous in tungsten. The lower limit of detection for tungsten in this study is fairly high, which makes bismuth a valuable pathfinder.

The contact between the quartz monzonite of Marble Cre