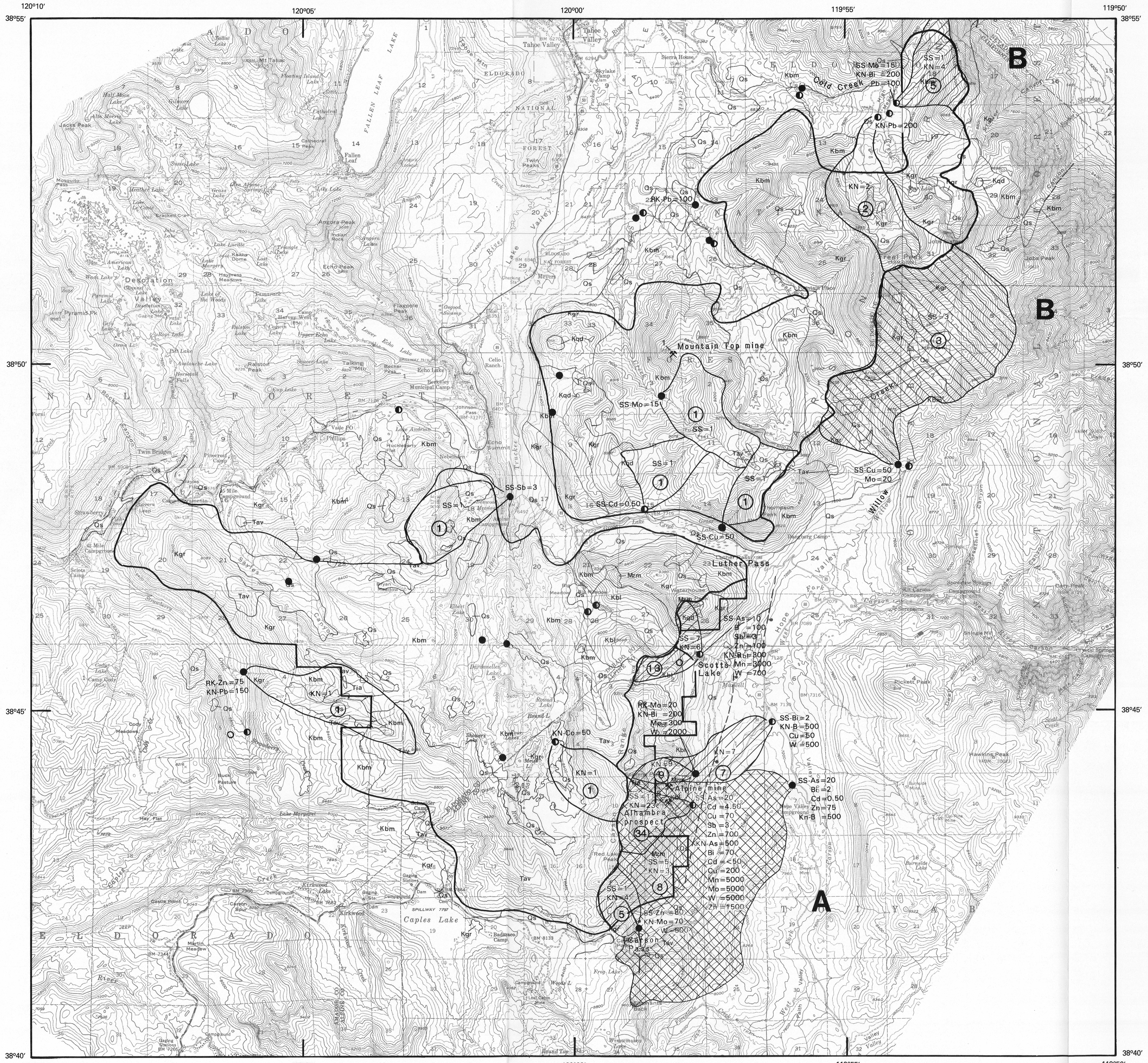


Base from U.S. Geological Survey Fallen Leaf Lake, 1955; Freel Peak, Markleeville, Silver Lake, 1956

Geochemical sampling, 1978-79; geology simplified from John and others (1981)

SCALE 1:62 500

CONTOUR INTERVAL 120 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

CORRELATION OF MAP UNITS

Unit	Age	Period
Qs	Holocene and Pleistocene	QUATERNARY
Tia	Pliocene and (or) Miocene	TERTIARY
Tav	Miocene and Oligocene	TERTIARY
Kbm, Kbl (Kgr), Kqd	Upper Cretaceous	CRETACEOUS
Mzm		PRE-UPPER CRETACEOUS

LIST OF MAP UNITS

Qs SURFICIAL DEPOSITS, UNDIVIDED (QUATERNARY)

Tia INTRUSIVE ANDESITE (PLIOCENE AND (OR) MIOCENE)

Tav ANDESITIC VOLCANIC ROCKS (MIOCENE AND OLIGOCENE)

Kbm BRYAN MEADOW GRANODIORITE (UPPER CRETACEOUS)

Kbl BURNSIDE LAKE ADAMELLITE OF PARKER (1961) (UPPER CRETACEOUS)

Kgr GRANITIC ROCKS, UNDIVIDED (UPPER CRETACEOUS)

Kqd DIORITE AND GABBRO (UPPER CRETACEOUS)

Mzm METASEDIMENTARY AND METAVOLCANIC ROCKS (PRE-UPPER CRETACEOUS)

EXPLANATION

APPROXIMATE BOUNDARY OF ROADLESS AREA

CONTACT--Dashed where approximately located

FAULT--Dashed where approximately located; dotted where inferred; bar and ball on downthrown side

MINE OR PROSPECT (5)

1 Mountain Top mine

4 Alpine mine

5 Alhambra prospect

SAMPLE LOCALITY

- Only rock sample collected
- Only stream-sediment and concentrate samples collected
- Rock, stream-sediment, and concentrate samples collected

ANOMALOUS SAMPLE--Showing element and concentration in ppm

RK Zn=75 Rock

SS Cu=50 Stream sediment

KN Bi=200 Concentrate

SCORESUM

SS=1 For one or more of the elements As, B, Bi, Cd, Cu, Mo, Sb, or Zn in stream-sediment samples

KN=2 For one or more of the elements As, B, Bi, Cd, Co, Cu, Mn, Mo, Pb, W, or Zn in concentrate samples

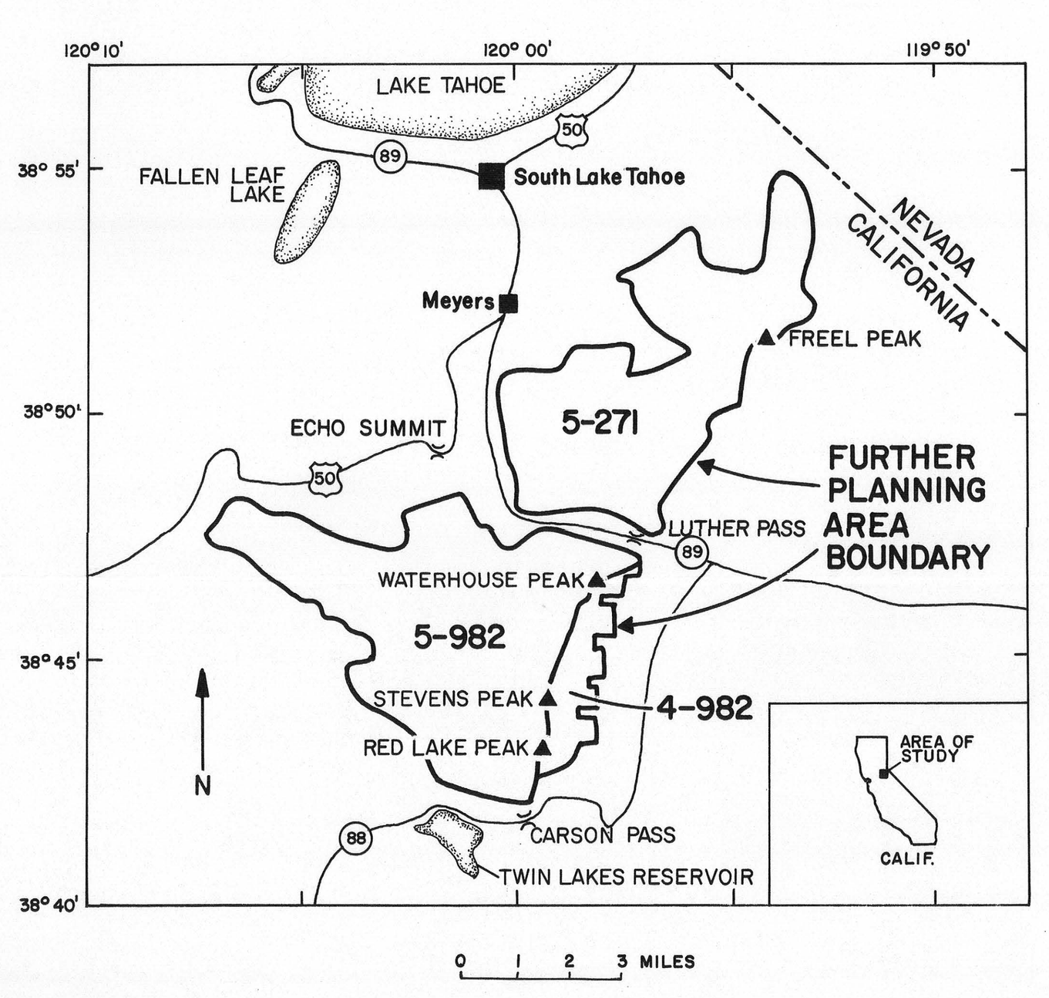
(5) TOTAL SCORESUM--Sum of stream-sediment and concentrate SCORESUMS for each outlined drainage basin

SAMPLE LOCALITY AND OUTLINE OF DRAINAGE BASIN

For stream-sediment samples that have SCORESUMS ≥ 3

For concentrate samples that have SCORESUMS ≥ 3

A AREA DISCUSSED IN TEXT



INDEX MAP SHOWING GEOGRAPHIC LOCATION OF THE FREEL (5-271) AND DARDANELLES (4-982, 5-982) ROADLESS AREAS, CALIF.

SUMMARY GEOCHEMICAL MAP FOR SAMPLES OF ROCK, STREAM SEDIMENT, AND NONMAGNETIC HEAVY-MINERAL CONCENTRATE, FREEL AND DARDANELLES ROADLESS AREAS, ALPINE AND EL DORADO COUNTIES, CALIFORNIA

By
M. A. Chaffee

1985

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 of the Freel (5271) and Dardanelles (4982 and 5982) Roadless Areas in the Eldorado and Toiyabe National Forests and in the Lake Tahoe Basin Management Unit, Alpine and El Dorado Counties, California. These roadless areas were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

INTRODUCTION

The Freel and Dardanelles Roadless Areas lie near the crest of the central Sierra Nevada south of Lake Tahoe in California. The roadless areas (the study area) encompass approximately 51 sq mi in Eldorado and Toiyabe National Forests and in the Lake Tahoe Basin Management Unit, in Alpine and El Dorado Counties, California.

The study area is dominated by rugged topography; elevations range from about 6,000 ft along the extreme western boundary of the Dardanelles Roadless Area to 10,881 ft at Freel Peak in the northern part of the Freel Roadless Area.

Geochemical sampling was conducted during 1978 and 1979. This report summarizes the results of that investigation and provides details of the geochemical evaluation used in producing the final mineral resource assessment of the study area (John, Armin, Plouff, Chaffee, Peters, and others, 1983).

GEOLOGY

The geology of the study area has been described in detail in John and others (1981) and in articles cited in that publication. Only a brief summary, based mainly on John and others (1981) and on John, Armin, Plouff, Chaffee, Peters, and others (1983) is included here.

The oldest rocks exposed in the study area comprise metasedimentary and metavolcanic rocks of pre-Late Cretaceous age. These rocks, which were derived from siltstone, calcareous siltstone, feldspathic sandstone, marl, impure limestones, and andesite flows, now consist of calcareous hornfelses and marble.

Most outcrops in and around the study area are Late Cretaceous plutonic rocks. These rocks include a number of different units that are all part of the Sierra Nevada batholith. Granodiorite is the most common rock type; however, quartz monzonite, quartz diorite, and diorite have also been mapped.

Remnants of Tertiary andesitic volcanic rocks, comprising an interbedded sequence of (1) andesitic lahars, (2) fluvially stratified tuffaceous sandstone and conglomerate, and (3) minor andesitic flow rocks and dikes, are present in scattered localities, mainly in the Dardanelles Roadless Area. Several andesite plugs are also present in the Dardanelles Roadless Area.

Quaternary units, including glacial moraine and outwash deposits, as well as lacustrine and fluvial deposits, are also present throughout the study area.

Carbonate-rich lenses within some of the metasedimentary roof-pendant rocks have locally been converted to tungsten-bearing skarns. The Alpine mine, just outside the southeastern part of the Dardanelles Roadless Area, was developed for tungsten in such an environment. Prospects along the eastern side of the Dardenelles Roadless Area contain copper, silver, molybdenum, tungsten, and (or) zinc, also in skarns. The only other known mineralization in the study area is at the Mountain Top mine where a small copper-silver-molybdenum-bearing quartz vein is exposed across a ridge in the Bryan Meadow Granodiorite about 4 miles southwest of Freel Peak in the Freel Roadless Area.

GEOCHEMICAL INVESTIGATIONS

This geochemical report is based on chemical analysis of 21 rock samples, 35 minus-60-mesh stream-sediment samples (stream sediment), and 35 nonmagnetic heavy-mineral-concentrate samples processed from active stream alluvium (concentrate).

Rock samples were collected as composite chips from outcrops in the vicinity of many of the sites shown on the map. These samples were of fresh rock and provide background geochemical information on elements in rocks that have not been affected by alteration or mineralization. The samples were selected to represent the chemistry of the rocks exposed in the vicinity of the sample site; however, the actual areal extent represented by a specific sample is not known. Thus, the rock-sampling program was designed only to provide some general information on the geochemical nature of the rock units present.

The stream-sediment samples consisted of active alluvium collected primarily from first-order (unbranched) and second-order (below the junction of two first-order) streams. Each sample was composited from several localities within an area that may extend as much as 100 ft from the center of each plotted site. The samples were sieved, and the minus-60-mesh material was retained for analysis. The chemical analyses of the stream-sediment samples reflect the chemistry of rock material eroded from the drainage basin upstream from each sample site and may reveal unusually high concentrations of elements related to mineral deposits.

The concentrate samples were prepared from the same active alluvium used to make the stream-sediment samples. The bulk sediment was panned and dried, and the resulting heavy-mineral fraction was treated with bromoform. The grains that were heavier than the bromoform were saved and separated into magnetic and relatively nonmagnetic fractions in a Frantz Isodynamic Separator[1]. The nonmagnetic fraction was analyzed for this study.

The analyses of the concentrate samples provide information about the chemistry of a limited number of minerals present in rock material eroded from the drainage basin upstream from each sample site. The concentrating procedures may produce a sample rich in heavy minerals commonly associated with many types of mineral deposits. The selective concentration of ore-related minerals permits determination of some elements, such as tungsten, that are not easily detected in bulk stream-sediment samples. The chemical composition of a nonmagnetic heavy-mineral concentrate may also indicate specific minerals. For example, the cobalt content in a stream-sediment sample may be related to a number of different minerals, many of which normally have no relation to hydrothermal mineralization. Anomalous cobalt concentrations in a concentrate sample, however, often indicate the presence of minerals such as pyrite, or possibly other iron-rich minerals, commonly associated with mineralization.

All the samples were analyzed for 31 elements (Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, La, Mg, Mn, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, and Zr) by six-step semiquantitative emission spectroscopy. All of the rock and stream-sediment samples were also analyzed for arsenic by colorimetry and for bismuth, cadmium, antimony, and zinc by atomic-absorption spectrometry.

Further details concerning the collection, preparation, and analysis of the samples, as well as a tabulation of the analyses, are published in Sutley, Chaffee, Fey, and Hill (1983).

EVALUATION PROCEDURES

On the basis of analyses of samples collected in both mineralized and unmineralized localities in this and other roadless and wilderness areas in the Sierra Nevada region, a suite of 12 elements (As, B, Bi, Cd, Co, Cu, Mn, Mo, Pb, Sb, W, and Zn) was selected as being indicative of mineral deposits expected to be present in or near the study area. Within this area, anomalous concentrations of copper, molybdenum, lead, tungsten, and zinc are most commonly associated with the ore minerals chalcopyrite, molybdenite, galena, scheelite, and sphalerite (or their oxidation products), respectively. The mineral residences for the other selected elements were not positively identified. Arsenic is commonly present in arsenopyrite or associated with antimony in sulfosalt minerals. Bismuth commonly occurs as bismuthinite but may also substitute for other elements in lead or rare-earth minerals. Cadmium usually substitutes for zinc in zinc minerals. Manganese commonly occurs in various manganese oxides. High boron and cobalt concentrations, particularly in concentrate samples, may be related to tourmaline and pyrite (or pyrrhotite), respectively. These two minerals are sometimes associated with the types of mineral deposits known or suspected to be present in the study area.

The range of background and anomalous concentrations for each selected element was determined by studying percent-frequency distribution histograms for these elements, the spatial distributions of background and anomalous element concentrations relative to known rock types in the study area, and ranges developed for these same elements for mineral assessments in other areas in the Sierra Nevada. (See for example, Armstrong and others, 1983; Brem and others, 1984; Chaffee and others, 1980; Chaffee, Hill, and Sutley, 1983a,b,c; Huber and others, 1983; John, Armin, Plouff, Chaffee, Federspiel, and others, 1983; John, Chaffee, and Stebbins, 1983; Keith and others, 1983; McKee and others, 1982; Sutley, Chaffee, Brem, and others, 1983.)

For the roadless areas considered here, some of the selected elements were not found in anomalous concentrations in any of the three media sampled. Only three of the selected elements (Mo, Pb, and Zn) were found to have anomalous concentrations in the rock samples (table 1). In a similar manner, 8 elements (As, B, Bi, Cd, Cu, Mo, Sb, and Zn) were found to have anomalous concentrations in the stream-sediment samples (table 2) and 11 elements (As, B, Bi, Cd, Co, Cu, Mn, Mo, Pb, W, and Zn) in the concentrate samples (table 3).

DISCUSSION OF ELEMENT ANOMALIES

Rock samples

Anomalous concentrations of the selected elements in rock samples (table 1) are shown on the map. Only 3 of the 21 rock samples collected for this study contained any elements with anomalous concentrations. Two are granodiorite samples and the third is quartz monzonite. All three contained only weakly anomalous concentrations of lead, molybdenum, or zinc; these anomalies probably only represent abnormally high background concentrations for the respective rock types.

Stream-sediment and concentrate samples

The anomalous concentrations of the 8 selected elements found in the stream-sediment samples (table 2) and of the 11 selected elements found in the concentrate samples (table 3) are also shown on the map. Most of the anomalous element concentrations found in these two sample types are thought to be related to base- and precious-metal or tungsten mineralization in altered roof-pendant rocks or in quartz veins, or to contamination from mine dumps in skarn areas.

DISCUSSION OF SCORESUM ANOMALIES

To emphasize the relative importance of the stream-sediment and concentrate anomalies for each sample site, the anomalous concentrations for each sample were evaluated using a technique called SCORESUM (Chaffee, 1983).

The SCORESUM values, which are also shown on the map, were created in the following manner. First, the threshold value for each selected element was determined, as described above. Next, the full range of reported analyses for each element of interest was divided into four categories or scores, as shown in tables 2 and 3. Anomaly scores of 0 (background), 1 (weakly anomalous), 2 (moderately anomalous), or 3 (strongly anomalous) were substituted for all of the analytical values. As a rough guide, the concentrations assigned to the weakly anomalous category commonly included those values between the threshold value and the 95th percentile value, moderately anomalous generally fell between the 95th and 98th percentiles, and strongly anomalous concentrations were generally restricted to the upper 2 percent of the samples. The scores for the elements were summed for each sample type at each site (SCORESUM) and then plotted on the map for each drainage basin containing a sample with one or more anomalous elements. In addition, the total of the stream-sediment and concentrate SCORESUMS was also determined and plotted as a circled number in each appropriate drainage basin.

The higher the individual or total SCORESUM is for the samples from one site, the more anomalous and significant is the associated drainage basin in terms of mineral potential. If the total SCORESUM for the samples from a site was zero, then the associated drainage was not outlined on the map. Those drainage basins where samples have SCORESUMS greater than or equal to 3 for either the stream-sediment or concentrate samples were deemed to be the most significant in terms of mineral potential. These basins are marked with line patterns on the map.

The most significant geochemical anomalies occur within two areas, which are labelled on the map. Area A is along the entire east side of the Dardanelles Roadless Area. The highest SCORESUMS are present in the two drainage basins containing the Alpine mine and Alhambra prospect; however, drainages with high SCORESUMS extend from Luther Pass on the north to Carson Pass on the south. In roof-pendant rocks near their contacts with younger plutonic rocks, the suites of anomalous elements in the samples from this general area suggest a contact-metasomatic environment in which tungsten, accompanied by a number of other elements, seems to be enriched.

The northernmost basin in area A was sampled below Scotts Lake, in an area of glacial moraine. No obvious source of the anomalies is known, although minor exposures of roof-pendant rocks may crop out in the basin. The anomalous elements may actually be from sample material transported from an unknown source (perhaps from the south) by glacial action rather than from material eroded from bedrock within the outlined drainage basin.

Area B consists of two isolated basins in the northeastern part of the Freel Roadless Area. The first basin is upper Cold Creek basin in the northernmost part of the study area. The stream-sediment sample from this basin contained weakly anomalous molybdenum (20 ppm), and the concentrate sample contained weakly anomalous bismuth (200 ppm) and lead (100 ppm). This suite of anomalous elements suggests minor lead or molybdenum mineralization associated with local quartz veins. The entire basin is underlain by granodiorite, an environment compatible with minor mineralization associated with quartz veins, such as that described for the Mountain Top mine several miles to the west (John, Armin, Plouff, Chaffee, Peters, and others, 1983).

The second basin of interest in the Freel Roadless Area is upper Willow Creek basin. The stream-sediment sample from this basin contained weakly anomalous copper (50 ppm) and molybdenum (20 ppm). This basin is also underlain entirely by generally granodioritic plutonic rocks. The anomalous elements are thus thought to be related to minor mineralization associated with localized quartz veins in one or more of the plutonic units.

Other, less significant, anomalies are scattered throughout the two roadless areas. All of these anomalies are thought to represent only unusually high background concentrations of the various elements considered anomalous.

SUMMARY AND CONCLUSIONS

Several anomalies thought to indicate mineralized areas were found as a result of this geochemical study. The eastern end of the Dardanelles Roadless Area contains anomalies that are probably related to base- and precious-metal and (or) tungsten occurrences in metamorphosed roof-pendant rocks. Tungsten mineralization in this area may be more extensive than the presence of the Alpine mine and other prospects just to the east of this roadless area would indicate.

Minor anomalies of bismuth, copper, molybdenum, and (or) lead in the northern and eastern parts of the Freel Roadless Area are thought to be related to local, mineralized quartz veins in one or more of the granodiorite plutons.

[1]Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

ACKNOWLEDGMENTS

R. A. Armin, D. A. John, D. W. Lunn, and W. J. Moore helped collect the samples. D. L. Fey, A. D. McCollaum, R. H. Hill, and S. J. Sutley assisted with the sample preparation and analysis.

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Table 1.--Summary of background and anomaly concentrations for 3 selected elements in 21 samples of rock, Freel and Dardanelles Roadless Areas, California

[Concentration value or range in parts per million. N, not detected at the lower limit of determination shown in parentheses]

Element	Background samples: Value or range	Background samples: Number of samples	Anomalous samples: Value or range	Anomalous samples: Number of samples
Mo	N(10)	20	20	1
Pb	20-50	20	100	1
Zn	10-70	20	75	1

Table 2.--Summary of background concentrations and anomaly scores for 8 selected elements determined to have anomalous concentrations in 35 samples of minus-60-mesh stream-sediment, Freel and Dardanelles Roadless Areas, California

[Concentration value or range in parts per million. N, not detected at the lower limit of determination shown in parentheses; <, detected, but in a concentration below that shown. Leaders (--) indicate no data]

Element	Background samples		Anomalous samples					
	Score = 0		Score = 1 (weak)		Score = 2 (moderate)		Score = 3 (strong)	
	Value or range	Number of samples	Value or range	Number of samples	Value or range	Number of samples	Value or range	Number of samples
As	N(10)	32	10	1	20	2	--	--
B	<10-50	34	100	1	--	--	--	--
Bi	N(0.5)-1.5	33	2	2	--	--	--	--
Cd	N(0.05)-0.30	31	0.50	2	0.70	1	4.50	1
Cu	<5-30	32	50	2	70	1	--	--
Mo	N(5)-10	32	15	2	20	1	--	--
Sb	<1-2	31	3	4	--	--	--	--
Zn	15-50	31	75-80	2	100	1	700	1

Table 3.--Summary of background ranges and anomaly scores for 11 selected elements determined to have anomalous concentrations in 35 samples of minus-60-mesh stream-sediment, Freel and Dardanelles Roadless Areas, California

[Concentration value or range in parts per million. N, not detected at the lower limit of determination shown in parentheses; <, detected, but in a concentration below that shown. Leaders (--) indicate no data]

Element	Background samples		Anomalous samples					
	Score = 0		Score = 1 (weak)		Score = 2 (moderate)		Score = 3 (strong)	
	Value or range	Number of samples	Value or range	Number of samples	Value or range	Number of samples	Value or range	Number of samples
As	N(500)	34	--	--	--	--	500	1
B	N(20)-150	32	200	1	300	1	500	1
Bi	N(20)	32	--	--	--	--	70-200	3
Cd	N(50)	34	--	--	--	--	<50	1
Co	N(10)-30	34	50	1	--	--	--	--
Cu	N(10)-30	33	50	1	--	--	200	1
Mn	700-2,000	33	3,000	1	5,000	1	--	--
Mo	N(10)-50	32	70	1	--	--	300-5,000	2
Pb	N(20)-70	32	100-150	2	200	1	--	--
W	N(100)-150	30	--	--	--	--	500-5,000	5
Zn	N(500)	34	--	--	--	--	1,500	1

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