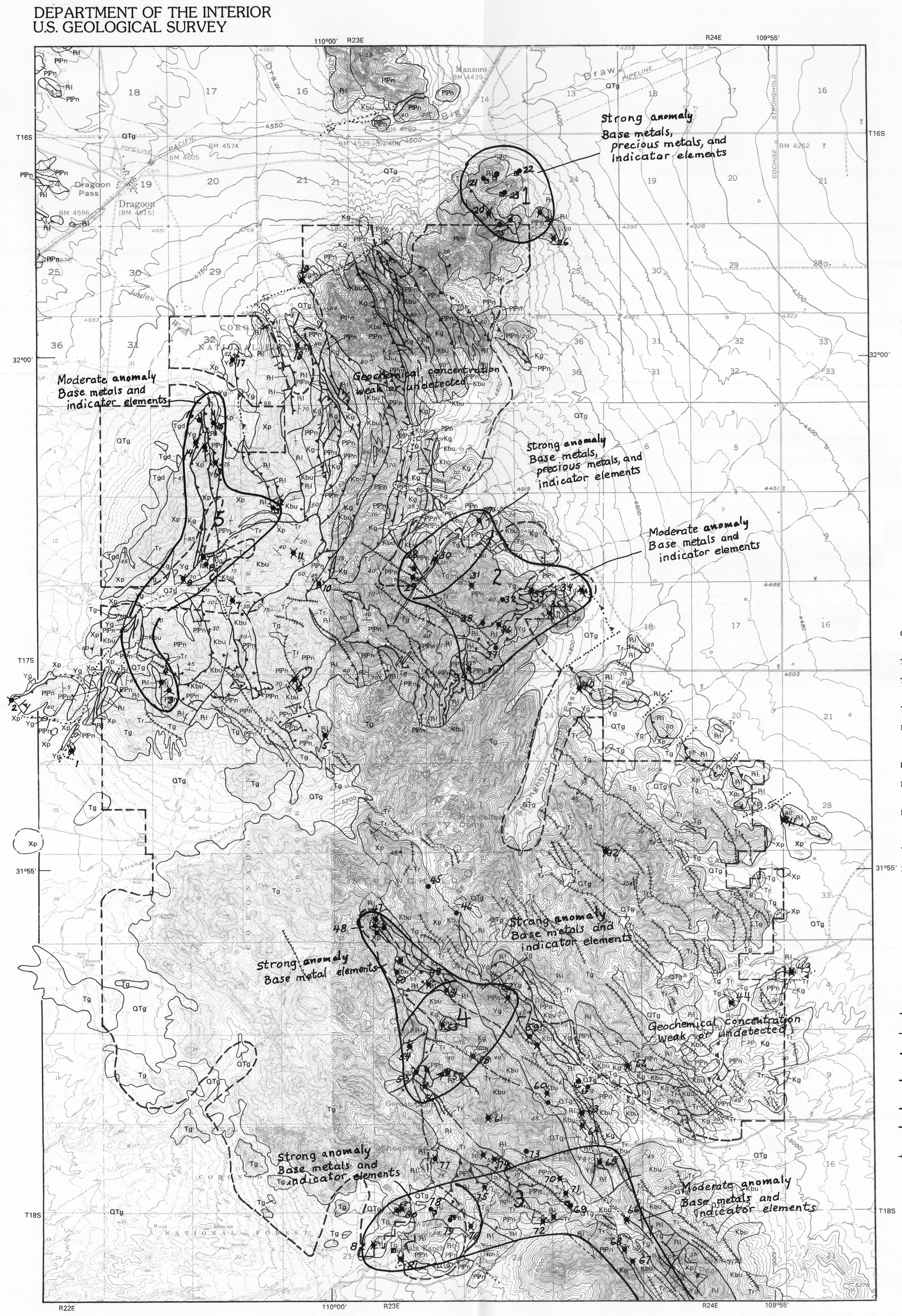
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1521-D



Base from U.S. Geological Survey Cochise, Dragoon, and Pearce, 1958, 1:62,500; Haberstock Hill and Knob Hill, 1973, 1:24,000

Geology mapped by Harald Drewes 1969 and 1980-82; assisted by Gary Sims 1980, R.M. Bruce 1981, and Grant Meyer 1982

SCALE 1:50 000

1 ½ 0 1 2 3 MILES

1 .5 0 1 2 3 KILOMETERS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

SAMPLE LOCALITIES--Numbered localities keyed to text and table 1; unnumbered localities not analyzed

37● Bedrock

Prospect

Adit

Shaft

Quarry

(1) AREA HAVING ANOMALOUS CONCENTRATION OF CERTAIN ELEMENTS

Note: The following correlation, list of map units, and explanation of symbols are for the geologic base map shown in gray.

CORRELATION OF MAP UNITS

QTg, Tr } QUATERNARY AND TERTIARY

Tg, Tgd } TERTIARY

Kbu, Kg } CRETACEOUS

PPn } PERMIAN AND PENNSYLVANIAN

Pzl } PALEOZOIC

Yg } PROTEROZOIC Y

Xp } PROTEROZOIC X

LIST OF MAP UNITS

QTg GRAVEL AND SAND (QUATERNARY AND TERTIARY)--Alluvium of terrace, pediment, and basin-fill deposits

Tr RHYOLITE (TERTIARY)--Porphyritic and nonporphyritic dikes and plugs

Tg GRANITE (TERTIARY)--Stronghold stock, alkali granite, and some aplite; fluorite-bearing

Tgd GRANITE (TERTIARY)--Stock of granite to granodiorite

Kbu SEDIMENTARY ROCK (CRETACEOUS)--Chiefly upper part of the Bisbee Group; shale and sandstone, some limestone and conglomerate

Kg SEDIMENTARY ROCK (CRETACEOUS)--Lower part of the Bisbee Group; conglomerate

PPn SEDIMENTARY ROCK (PERMIAN AND PENNSYLVANIAN)--Mainly limestone and some dolomite, shale, and sandstone

Pzl SEDIMENTARY ROCK (MISSISSIPPIAN TO CAMBRIAN)--Limestone, dolomite, shale, and quartzite. Includes the Abrigo and Martin Formations

Yg GRANODIORITE (PROTEROZOIC Y)--Includes aplite and granodiorite porphyry

Xp METAMORPHIC ROCK (PROTEROZOIC X)--Mainly Pinal Schist; includes phyllite, quartzite, arkose, sedimentary breccia and conglomerate, and intruding the Pinal, some amphibolite

APPROXIMATE BOUNDARY OF ROADLESS AREA

CONTACT

FAULT--Showing dip. Dotted where concealed

Normal fault--Bar and ball on downthrown side

Thrust fault--Teeth on upper plate

Strike-slip fault--Arrows show relative movement

Fault intruded by rhyolite dike (unit Tr)

STRIKE AND DIP OF BEDS

70 Inclined

Vertical

80 Overturned

STRIKE AND DIP OF FOLIATION

65 Inclined

Vertical

Table 1.--Semiquantitative spectrographic and atomic absorption analyses

[In ppm (parts per million) from composite chip samples taken mainly from mine and prospect dumps of the Dragoon Mountains Roadless Area, Cochise County, Arizona. Analyses by R. T. Hopkins and J. D. Sharkey.[1] Letter symbols N, not detected; L, detected but below limit of determination; G, greater than. Numbers in parentheses following elements are lower limits of determination.]

Sample no.	Field. no.	Ag (.5)	As[1] (10)	Au[1] (.05)	B (10)	Ba (20)	Be (1)	Bi (10)	Cd (20)	Cu (5)	Mn (10)	Mo (5)	Pb (10)	Sb[1] (1)	Sn (10)	Te[1] (.1)	W (50)	Zn[1] 5	Other elements shown where anomalous	Sample clusters and anomalous elements[2]
1	80S90a	N	L	N	N	20	15	N	N	50	1500	N	30	15	15	N	100	50		
2	D89	10	20	L	N	300	2	L	100	1500	700	10	G20000	20	N	1.8	N	10000		
3	67	7	L	L	N	150	5	30	G500	50	G5000	7	200	15	N	0.8	N	138000		x
4	68	15	L	L	N	50	5	150	500	700	G5000	N	1000	15	N	.8	L	69000		x
5	63	N	L	N	N	150	20	N	N	300	G5000	N	50	15	N	N	N	140		
6	65	500	30	0.15	N	70	L	N	500	7000	300	N	2000	1500	N	3.8	N	860		
7	81D79	L	L	N	N	100	L	N	N	15	2000	N	150	15	N	N	N	60		
8	74	30	L	L	N	6	100	1000	G500	1500	G5000	70	7000	15	N	35	L	16000		
9	73	30	L	N	N	200	2	30	G500	70	5000	5	7000	10	N	1.3	N	105000		Fourr Canyon-Jordan Canyon cluster; weak: Ag, Ba, Bi, Cu, Pb, Te, and Zn.
10	78	50	L	N	N	700	1.5	10	G500	300	G5000	5	G20000	25	N	1.5	N	150000		x
11	81	L	1500	L	L	300	5	N	N	30	150	50	70	40	N	.3	N	60		
12	80	50	L	L	N	200	1.5	N	500	5000	3000	10	G20000	N	N	2.3	N	4500		
13	87	N	220	L	N	100	15	N	N	1000	150	300	70	N	N	1.1	N	100	Ni70	
14	89	N	L	L	N	20	3	N	N	500	G5000	10	30	10	30	N	N	1500		x
15	92a	2	N	N	N	150	2	20	N	500	70	15	100	N	N	N	N	130		x
16	91	10	L	L	N	150	5	L	N	3000	G5000	5	50	15	15	L	N	450		x
17	92b	1	L	N	N	L	10	N	N	10000	2000	70	500	15	N	.5	N	540		
18	96	3	160	L	N	30	L	N	N	70	100	30	70	N	N	.2	N	65		
19	99	N	L	N	30	150	L	N	N	10	500	N	70	N	N	.3	N	50		
20	109	50	90	.35	N	50	1.5	30	G500	20000	700	70	G20000	60	20	40	N	13000		
21	118	3	20	1.5	20	150	1.5	15	N	7000	300	N	7000	10	N	N	N	11000		
22	117	30	40	L	30	300	2	300	N	300	100	15	15000	10	N	1.0	N	190		Golden Rule mine cluster: Ag, As, Au, Mo, Pb, Sb, and Te.
23	112	15	20	.15	10	30	L	20	100	5000	300	70	5000	15	N	2.5	L	1800		
24	108	200	460	.35	N	20	L	N	N	3000	1500	70	G20000	1000	N	37	N	5200	Sr1500,V700	
25	106	100	30	2.5	N	70	1.5	N	300	7000	1500	300	10000	20	N	28	70	17000		
26	105	70	L	.05	N	200	1	N	N	100	500	150	G20000	40	N	.3	N	60	Sr1000	
27	34	200	40	.05	N	200	2	1000	N	300	70	20	G20000	25	N	62	N	880		
28	37	15	10	.10	N	200	7	70	150	1500	200	500	10000	700	15	1.5	L	5300		
29	38	100	20	L	N	300	3	30	G500	G20000	1500	200	G20000	45	15	4.0	L	3000	La70	
30	B35	300	40	.10	N	300	2	1000	200	20000	1000	500	20000	50	N	40	N	2400	La50,Ni70	
31	32	30	10	L	N	300	1	N	N	20000	1500	L	500	10	N	.2	L	780	Cr150,La70,Ni100,Zr500	
32	D31	50	L	L	N	N	1.5	50	150	G20000	1500	10	700	15	N	.2	N	14000		Stronghold Canyon East cluster: Ag, As, Ba?Be, Cu, Mo, Pb, Sb, Sn, Te, and Zn.
33	30	20	10	.10	70	200	1.5	30	300	700	500	N	2000	20	N	1.0	N	41000		
34	40	5	60	N	70	70	100	G1000	N	700	500	300	150	25	150	10	200	1100		
35	39	N	L	N	N	30	20	N	N	100	G5000	7	30	5	30	.2	N	180		
36	29	7	10	N	N	20	10	70	N	7000	300	50	300	10	300	2.0	L	3600		
37	19	N	10	L	N	L	50	N	N	100	G5000	N	30	6	N	N	N	140		
38	26	30	L	N	N	L	10	30	N	500	G5000	N	2000	6	N	.7	N	4300		
39	20	30	20	N	N	70	70	30	200	5000	G5000	5	3000	10	100	1.8	L	13000		
40	11	.5	L	N	N	500	2	N	N	200	150	20	100	6	L	N	N	15	Nb50	
41	60	N	N	N	10	700	2	N	N	30	1000	N	20	L	N	N	N	80		
42	17	1	L	L	N	L	2	15	N	30	300	N	100	15	20	.3	N	60		
43	80D90	N	L	.05	N	200	20	N	100	1000	5000	N	70	10	150	1.8	L	16000		
44	91b	N	L	L	N	20	10	L	N	20	G5000	N	100	10	N	N	N	280		
45	B8	N	L	N	N	100	L	10	N	150	700	N	50	10	N	N	N	35		
46	D7	N	L	N	N	50	2	N	N	30	1000	N	20	10	N	.1	N	100		
47	37	N	L	N	L	20	2	N	N	30	1000	L	20	15	N	N	N	150		
48	36	50	L	N	N	N	300	150	G500	20000	G5000	200	3000	20	N	1.0	50	114000		
49	40	70	L	N	L	50	1.5	70	500	3000	2000	20	5000	15	N	2.5	N	56000		
50	33	N	L	N	N	70	7	N	N	20	5000	N	100	15	10	N	N	120		China Peak cluster: Ag, Bi, Cd, Mo, Pb, Sn?, Te, W?, and Zn.
51	41	200	10	L	N	L	L	700	100	10000	1500	1500	G20000	20	N	6.2	N	5300	V700	
52	45a	20	L	L	N	70	50	200	100	100	G5000	300	10000	15	N	2.8	N	4500		
53	25	150	40	L	N	N	10	300	G500	100	G5000	1000	G20000	15	10	6.0	50	200000	Co200,V1000	
54	28	N	L	N	N	500	10	N	N	70	1000	7	70	10	10	.1	N	160		
55	29	30	L	L	N	N	100	500	50	15000	G5000	5	1000	15	30	3.5	70	21000		
56	15	70	L	L	N	L	100	200	500	200	G5000	15	10000	15	20	1.5	N	106000	Co200	
57	13	300	L	L	15	N	50	1000	G500	70	G5000	300	G20000	10	N	1.5	N	189000		
58	24	30	L	L	N	N	10	N	N	20000	G5000	N	100	20	N	.3	N	660		
59	42	15	10	L	N	N	3	N	N	20000	5000	10	70	20	N	.1	N	250		
60	S20	50	L	.05	N	20	7	20	N	5000	300	10	300	15	N	.9	N	480		
61	D12	15	L	N	L	700	L	10	N	7000	2000	300	200	10	10	.2	N	300	V700,Y100,Zr300	
62	S46	15	L	L	N	L	150	30	N	100	5000	L	200	10	N	.2	L	10000		
63	48	30	10	L	N	30	5	150	20	5000	1000	30	2000	25	N	6.2	N	10000		x
64	D47	20	L	L	N	30	7	30	100	300	G5000	7	2000	20	N	.6	N	4900		x
65	51a	70	L	N	N	300	1	20	N	G20000	2000	30	150	25	N	.2	N	900		x
66	B130	500	10	L	N	1500	L	G1000	G500	3000	3000	10	15000	20	N	10.7	N	100000	V1000	x Middlemarch Canyon cluster: Ag, As, Ba, Cu, Sn, Pb, Te, and Zn.
67	131	100	10	L	N	L	2	50	300	15000	G5000	30	G20000	25	10	.9	N	3000		x
68	128	10	20	N	15	200	7	N	G500	G20000	3000	N	200	30	N	N	N	110000		x
69	D70	500	10	.20	N	20	L	G1000	G500	20000	2000	20	G20000	35	30	100	L	85000		x
70	53	30	60	L	N	150	3	100	150	300	G5000	N	3000	20	15	.4	N	520		
71	76	1	20	N	N	G5000	L	L	N	200	200	15	150	10	N	N	N	250	Sr5000	x
72	75	150	L	N	L	1000	1.5	1000	G500	100	5000	70	20000	10	N	12	N	160000		
73	52	20	L	N	N	150	7	50	N	20000	G5000	N	5000	10	70	.3	N	2800	Co300,Y150	
74	72	100	L	L	N	L	2	N	N	G20000	1500	7	1500	20	N	N	N	1600		
75	73	700	L	L	N	2000	N	G1000	20	100	2000	500	G20000	15	N	18	N	22000		
76	74	150	L	N	N	150	7	300	20	1500	5000	20	10000	15	N	3.9	150	5500		
77	S6	2	L	N	N	N	50	20	N	1000	5000	N	70	8	100	2.8	100	900		
78	4	10	L	L	N	L	3	50	150	20	5000	1500	10000	8	N	1.0	100	2200		Sala Ranch cluster: Ag, Be, Sn, Te, and W.
79	D3	100	L	N	N	L	10	70	500	2000	G5000	30	10000	15	N	.3	700	92000		
80	9	5	10	L	N	50	7	70	N	700	200	70	100	10	50	5.6	300	420	Zr300	
81	2	2	30	L	N	300	3	20	N	200	G5000	50	150	20	150	1.2	50	190		
82	1	N	L	L	N	206	20	150	N	150	G5000	70	300	8	100	1.9	50	300		

[1]Elements determined by atomic absorption, or by both methods, but more accurately determined by atomic absorption method.

[2]Clusters of samples from specific areas comprise all samples in bracket, except where shown as x's.

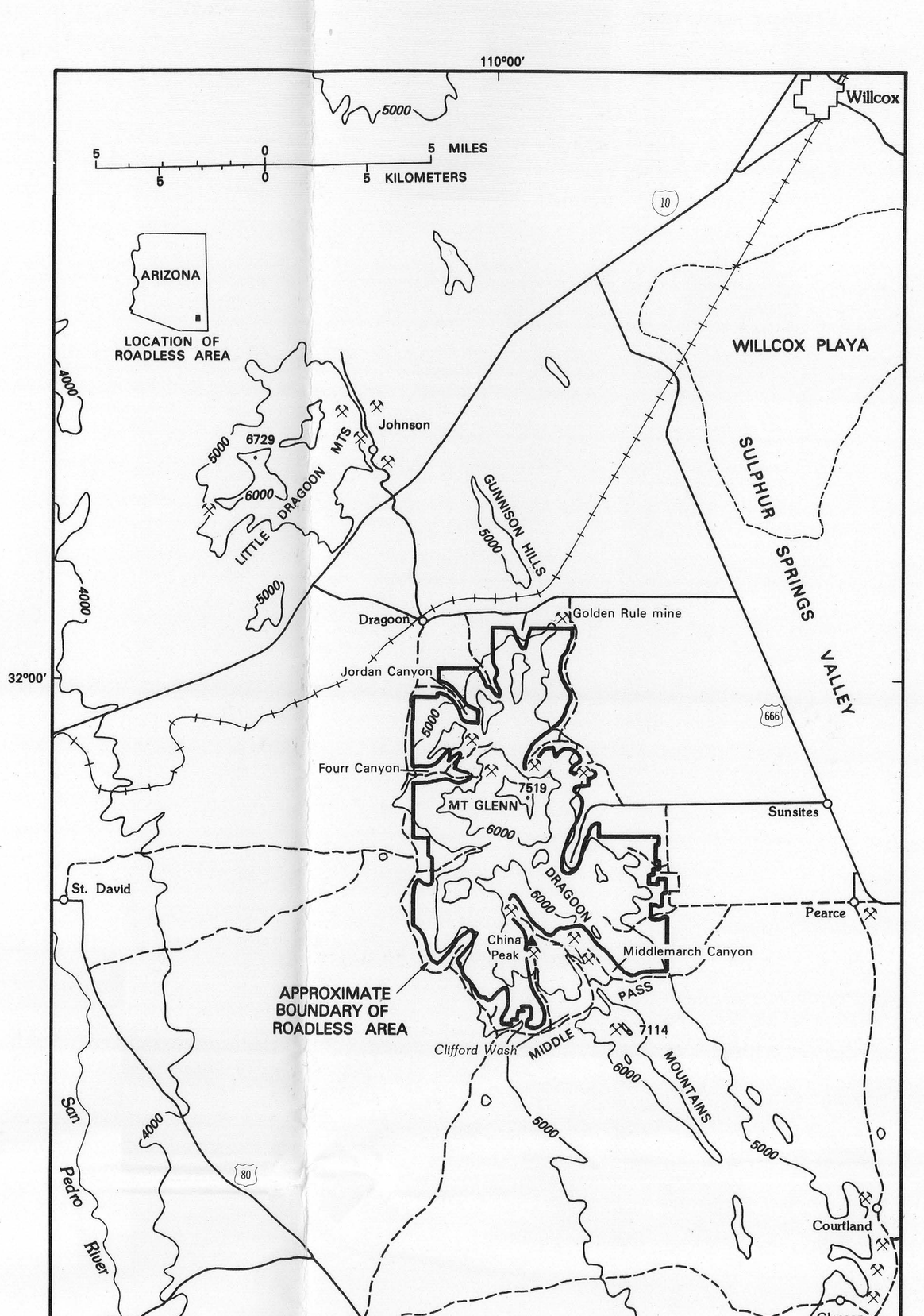


Figure 1.--Map showing location of the Dragoon Mountains Roadless Area (03201).

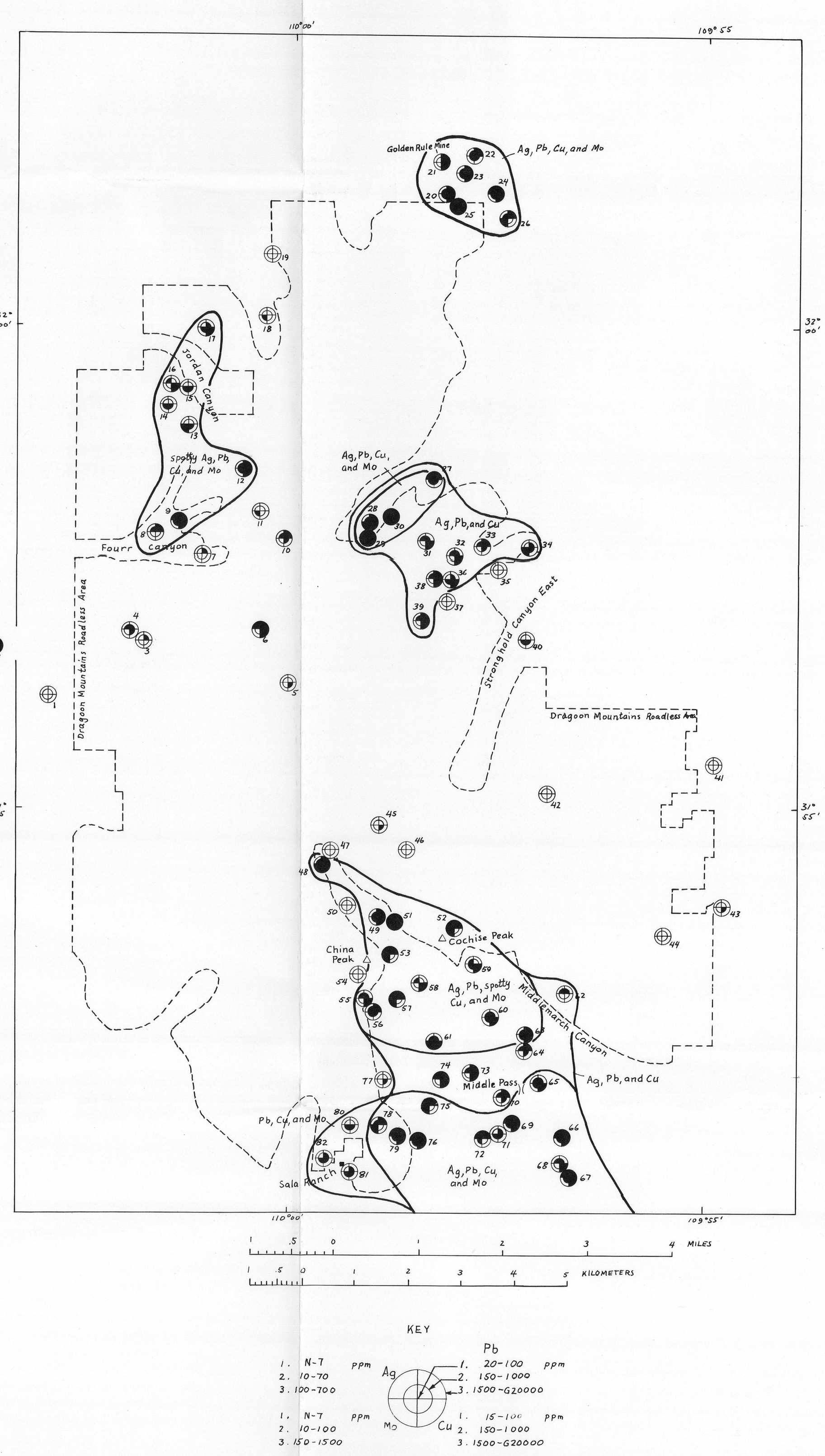


Figure 2.--Distribution of silver (Ag), lead (Pb), copper (Cu), and molybdenum (Mo) in mineralized rocks of the Dragoon Mountains Roadless Area, Cochise County, Ariz.

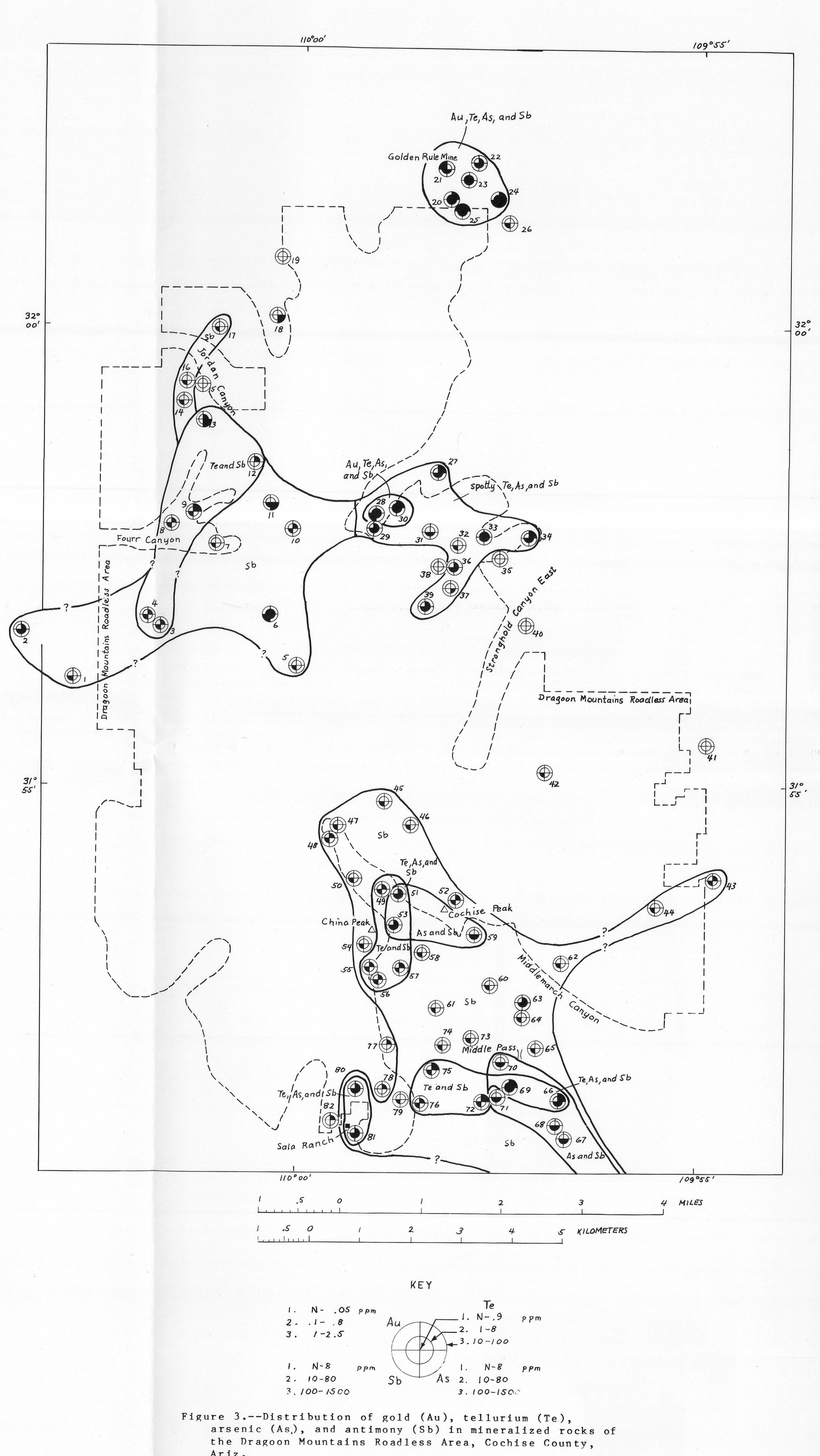


Figure 3.--Distribution of gold (Au), tellurium (Te), arsenic (As), and antimony (Sb) in mineralized rocks of the Dragoon Mountains Roadless Area, Cochise County, Ariz.

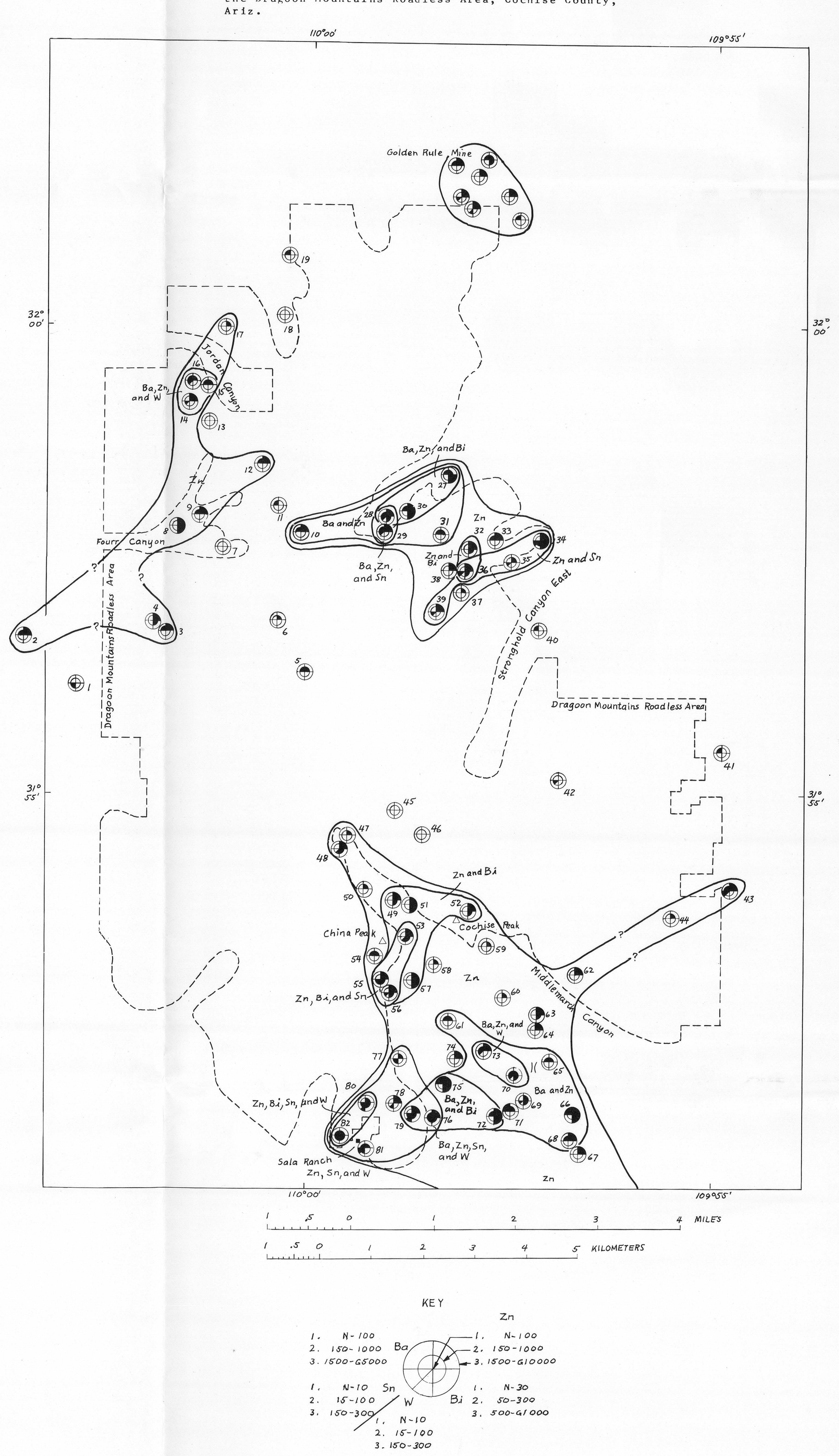


Figure 4.--Distribution of barium (Ba), zinc (Zn), bismuth (Bi), tungsten (W), and tin (Sn) in mineralized rocks of the Dragoon Mountains Roadless Area, Cochise County, Ariz.

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and 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 Dragoon Mountains Roadless Area in the Coronado National Forest, Cochise County, Ariz. The Dragoon Mountains Roadless Area (03201) was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

INTRODUCTION

The Dragoon Mountains of central Cochise County are one of a group of northwest-trending ranges in southeastern Arizona. The Dragoon Mountains have a broad, low southeastern part; a narrow, moderately high central part; and a broad, high, northwestern part. The Dragoon Mountains Roadless Area, about 55 mi^2 (140 km^2) in size, covers most of this northwestern part. The roadless area thus extends from Middle Pass in the southeast to Big Draw in the northwest, and from the edge of Sulphur Springs Valley in the northeast to the edge of the San Pedro River valley in the southwest, excluding several canyon mouths and other developed areas as shown on figure 1.

Access to the roadless area is from the towns of Willcox, 15 mi (25 km) northeast, or Tombstone, 10 mi (16 km) southwest, or from the villages of Pearce, 6 mi (10 km) southeast, or Dragoon, 2 mi (3 km) north of the mountains. There are county roads across Middle Pass and past the north end of the range in a lowland also used by the Southern Pacific Railroad. Interstate Highway 10 is 5 mi (8 km) north of the range and U.S. Highway 666 comes to within 6 mi (10 km) of the northeast side. Additional local roads provide access to ranches and recreation areas in the lower reaches of major canyons, and unmaintained roads extend well into the roadless area in several places.

Further access for study purposes is by foot. The core of the mountains is rugged and in places is steep and craggy. The foot of the range is at elevations of 4,500 to 5,000 ft (1,400 to 1,500 m); the highest peak, Mt. Glenn, reaches an elevation of 7,512 ft (2,300 m). The highest slopes are covered with fairly dense stands of scrubby mountain mahogany, but most of the slopes have more open stands of juniper, pinon, or oak. On the lower mountain flanks access is rarely hindered, and the vegetation is mostly grass, shrubs, cactus, and open stands of live oak.

OBJECTIVES AND RESULTS

A reconnaissance geochemical study of mineralized rocks in the Dragoon Mountains Roadless Area has defined the distribution of economically important elements, and groups of elements in anomalous concentrations. This study is one of three kinds of complementary geochemical studies that include studies of alluvial material in tributary drainages by Watts and others (in press) and of bulk samples from large mines by Kreidler (in press). The present study differs from the other two because it includes sample localities (1) in major drainages and tributaries, not just in tributaries, (2) in small and large mines and prospects, not just in the few large mines, and (3) in mineralized rock far from prospects, not just near them. The focus of this study was on determining what elements not readily seen in the field were enriched in the mineralized areas. Results of these geochemical studies were integrated with a geophysical study (Klein, 1983) and a geological study (Drewes and Meyer, 1983) to help assess the mineral resource potential of the Dragoon Mountains Roadless Area (Drewes and others, 1983).

Several assemblages of elements (metals mostly) are recognized, which, together with geological field relations, give some idea of their mode of emplacement. The assemblage of tin, tungsten, beryllium, and some base metals (including copper, lead, zinc, and molybdenum) is typically found in contact metasomatic deposits and replacement deposits near margins of granitic intrusive masses. The assemblage of gold, antimony, arsenic, tellurium, and base metals is characteristic of fissure vein deposits, which probably are older than most of the contact metasomatic deposits. Another assemblage, mainly of base metals and silver, occurs in replacement deposits and fissure vein deposits, and may represent the oldest episode of mineralization. Rock containing this assemblage was probably mineralized again with similar elements during a later period by a hydrothermal system farther away than the source of the older mineralization. Anomalous concentrations of elements, such as barium, antimony, arsenic, bismuth, and tellurium, characterize certain types of ore deposits, including disseminated precious-metal deposits, and may be a guide to the distribution of some deposits where the metals are not directly observed.

Other maps of the area include those of Gilluly (1956), Drewes (1981), and in the surrounding region include those of Cooper (1960), Cooper and Silver (1964), Gilluly (1956), and Drewes (1980). Geologic studies of local areas and specific mines in and near the roadless area are given by Kreidler (1983).

From this study, the following results are inferred: (1) silver probably occurs mainly as argentiferous galena (a silver-lead sulfide association), because high concentrations of silver and lead occur together; visible galena may thus be taken as an indication of significant silver values; (2) gold occurs with the indicator elements antimony, arsenic, and tellurium at several sites in the Dragoon Mountains, and other places having some elements of this assemblage are also potential sites for gold to occur; (3) molybdenum has a scattered distribution in all of the known mineralized areas, but in a few places geologic factors suggest the possible presence of stockwork or disseminated deposits; (4) tin occurs at several sites around the Stronghold granite stock and could be an important byproduct of any disseminated or stockwork ore deposit there; (5) tungsten also occurs at several sites around the Stronghold stock and in one place near the Fourr Canyon stock; its distribution indicates fault control; (6) copper, lead, and zinc are widespread, as noted from mining history and direct observation. The erratic association of base metals with indicator elements suggests that base-metal mineralization may be of various kinds and/or of various ages. The larger ore deposits of the roadless area contain base metals in replacement deposits or fissure vein deposits. Base metal mineralization is controlled more by major steep faults than by stock contacts, which reflects the geochemical mobility of these elements and perhaps also several kinds and ages of mineralization. While these factors may complicate the search for economic deposits, they could also be the cause of enrichment that is needed to make a deposit economic.

METHODS

The investigation of mineralized rocks from the Dragoon Mountains Roadless Area is based on analyses of 82 samples (table 1). Most of the samples were collected from dumps of prospects or mines, but a few were from bedrock away from prospects (see map). The mines and prospects are typically small and consequently the material in the dumps was derived from a fairly restricted mass of rock. Samples came mostly from the upper parts of dumps, which usually represent material from the deepest parts of prospects or mines, but parts of some samples came from piles of rock that miners set aside, thinking they had the greatest value. In a few cases dumps had been slightly disrupted by previous (private industry?) geochemical studies based on bulk sampling. Dump samples are generally the easiest way to review in reconnaissance some aspects of mineralization.

At each collection site, about 10 or 12 rock chips 1-2 in. (3-6 cm) across were collected and combined to form a sample. These chips represented a variety of altered and mineralized rock, and commonly included some ore material, vein material, skarn, gossan, discolored and oxidized rock that probably came from along a fracture, and any other altered or mineralized material. No attempt was made to concentrate on collecting ore chips or rock most typical of the dump or to apportion the composite sample among the various types of mineralized rocks present. This approach is commensurate more with the objective of testing for the presence of various elements than for testing their quantitative occurrence.

Where dumps apparently came from the same ore body, such as a pair of adits one above the other on a single short vein, samples from their dump material were combined and a single symbol is shown on the map. Where a vein is long and had separate workings along its length, separate samples were collected. The sampling density was controlled by the field mapping scale of 1:24,000 and the time available for the study; consequently not all workings, or perhaps ore masses, were sampled.

The rock chips of each sample were broken in two using a jaw crusher in the laboratory. One group of half chips was crushed for analyses and the other group was stored for reference. The crushed material was further split, one fraction being spectrographically analyzed by R. T. Hopkins, using the six-step direct-current arc method described by Grimes and Marranzino (1968). Most of the 31 elements tested by this method are listed in table 1. Only major rock-forming elements, such as iron; elements found nowhere in the roadless area, such as thorium; and the elements whose analyses were superseded by the more accurate atomic absorption method are omitted from the table. The second fraction of crushed half-chip material was tested for five elements by J. D. Sharkey, using the atomic-absorption method described by Ward and others (1969).

Selected elements were plotted, four or five at a time, in cluster diagrams on a simplified base map (figs. 2-4), to graphically show their distribution and their abundance in approximate orders of magnitude. Clusters of related elements are shown on the three figures. This procedure emphasizes sample location and element presence more than abundance. Elemental concentration is divided into three categories that might be read as (1) absent or sparse; (2) moderately anomalous; and (3) more strongly anomalous. Typically, these categories are reported in table 1 as 0-10 ppm (parts per million), 10-100 ppm, and 100-1,000 ppm or a comparable distribution at other ranges of abundance appropriate to the particular element.

Areas surrounded by heavy lines on figures 2-4 and the map summarize the salient information from the cluster diagrams. These lines encircle areas containing anomalous concentrations of one or several elements.

These procedures for sampling, analyzing, and presenting the geochemical data from mineralized rocks are suitable for a reconnaissance study and the results are believed to show qualitatively the salient characteristics of the mineralized rocks related to mineralogy, ore genesis, and exploration possibilities. The conclusions are summarized on the map as areas of strong (indicating mostly high concentrations from most of the included samples) or moderate (indicating mostly moderate concentrations and a more scattered occurrence) geochemical anomalies of base metals, precious metals, and indicator elements. Arsenic, bismuth, and antimony, which are at times considered base metals, particularly where they are parts of major ore-forming systems, are here viewed as indicator elements because of their lower degree of concentration and probability of migration to the extremities of ore-forming systems. Elements shown in table 1 but not plotted on the figures are of less consequence to this study, although beryllium may be an exception because of its tendency to occur in contact zones.

AREAS HAVING ANOMALOUS CONCENTRATIONS OF ELEMENTS

This study of mineralized rocks of the Dragoon Mountains Roadless Area has identified five areas having noteworthy element assemblages and concentrations (see map). At some sites the data suggests a particular mineralogy, elsewhere it gives evidence of kinds of mineralization, and at still others it indicates the possible presence of structural controls not recognized at the surface. These results augment production records and the other geological, geophysical, and geochemical studies in providing a basis for assessing the mineral potential of the roadless area (Drewes and others, 1983).

One anomalous assemblage of elements occurs in samples from near the Golden Rule mine (area no. 1 on the map). This mine was a known producer of gold and silver, so it is not surprising to find that the dump contains precious metals, but the site also contains base metals and the indicator elements antimony, arsenic, and tellurium. The gold apparently occurs as antimonides, arsenides, or tellurides, or as complex sulfosalts. This assemblage of indicator elements may be gold specific.

Mineralization at this site may be of Late Cretaceous or early Tertiary age, and is presumed to be genetically related to nearby quartz latite porphyry plugs because of their spatial association (Drewes and Meyer, 1983). The plugs may be correlative with one of the nearby stocks, one of which is early Eocene (50-53 m.y. old) and the other early Oligocene (37 m.y. old). A mineralized basalt dike from near sample locality 22 was dated as 74 m.y. old, using the potassium-argon method on a whole-rock sample (Shafiqullah and others, 1980, p. 246, no. 30); however the significance of a whole-rock age is uncertain, in light of the degree of alteration of the rocks at this site. The composite geochronological evidence permits an age of mineralization late in the Cordilleran orogeny, as is typical of many mining districts in this region.

The assemblage of anomalous concentrations of base metals, precious metals, and indicator elements with quartz veins near plugs suggests that the deposits may have been emplaced above the apex of a concealed stock in an epigenetic to mesogenetic (shallow to moderate depth of emplacement) environment. Other hidden veins may occur in comparable parts of the host rock above the postulated stock, and base-metal deposits may occur at other levels in place of the gold, antimony, arsenic, and tellurium assemblage. The petrology and age of the plugs, nature of the alteration, and configuration of the stock deserve further study.

A second anomalous area is northwest of Stronghold Canyon East, marked by an extensive area of moderate concentration of base metals and indicator elements and containing a small area of strong concentration of precious metals to the northwest (area no. 2 on the map). The middle Tertiary (22-27 m.y. old) Stronghold granite stock lies along the south side of this area and the part that has a strong anomaly is along a northeast-trending quartz-latite porphyry dike that may correlate with the plugs at the Golden Rule mine. The part of this area that has a strong anomaly that contains gold, antimony, arsenic, and tellurium, together with abundant base metals occurs near the dike. The association of the dike with this assemblage suggests a genetic link with that at area 1.

Elsewhere at this second location, tin and bismuth occur with base metals and beryllium. This assemblage may reflect the effects of a combination of contact metasomatic bodies and replacement and fissure vein deposits genetically and spatially related to the adjacent stock. In this case, it is younger mineralization than the gold-bearing episode of the area, and it may have spread northwestward and have been superposed on the mineralization near the dike. Structural controls of this area are discussed by Drewes and Meyer (1983) and Klein (1983).

Further petrographic and geochronological studies of the dike and additional geochemical and geophysical studies may be fruitful at this site. The structural levels of the favorable lower Paleozoic formations might prove to be attractive exploration targets, particularly near intersections of dikes and steep faults.

Another area of mineralization (area no. 3 on the map) lies along the southern boundary of the roadless area, extending from the Sala Ranch in the west, to near Middle Pass in the northeast, and with a bend, to the Black Diamond mine area about 0.5 km (0.3 mi) south of the area of the map. Base metals and indicator elements occur in moderate concentration over much of this area, but concentrations are higher to the west. Indicator elements tend to be scattered erratically over the area but are mostly concentrated along the northeast-trending part. For example, barium is characteristic of the middle part of this area; bismuth, tin, and tungsten are found in the southwestern and middle parts; arsenic and antimony appear largely in the northeastern part but also to the extreme southwest; and tellurium is found in most of the area.

This scatter of indicator elements may be due to several kinds and ages of mineralization. Most of the base-metal and silver mineralization appears to be of replacement and fissure-vein origin related to an early episode of hydrothermal activity, possibly related to the older mineral deposits at areas 1 and 2. Later, additional enrichment of base metals, and perhaps also tin, tungsten, and other elements took place near the Stronghold stock near the Sala Ranch. The older mineralization probably took place at a lower temperature than did the younger mineralization, although both of them probably were epigenetic, because only the rocks near the stock are metamorphosed. The strong control on both mineralization events by steeply dipping northwest-trending faults increases the overlapping effects of the two and would mix the distribution patterns of metals. The northeast trend to part of area 3 may be structurally controlled, but such structure is concealed. Intersections of the known northwest-trending structures and the predicted northeast-trending feature underlying the geochemical anomaly may make promising exploration targets.

A fourth mineralized area lies between the Abril mine to the northwest and China and Cochise Peaks to the southeast (area no. 4 on the map). Geologic mapping indicates that this area is on a keel-shaped septum of sedimentary and metasedimentary rocks between two lobes of the Stronghold stock. The area contains contact metasomatic, replacement, and fissure vein deposits. The area lies close to the stock and along an extension of the northwest-trending faults of the Black Diamond mine-Middle Pass part of area 3, and thus a two-stage history of mineralization may have occurred here, too. The northeast-trending part of this area between the peaks has more indicator elements than does the rest of the area and no surface feature to explain a northeast-trending geochemical anomaly. This situation resembles those at areas 2 and 3, and consequently this part of area 4 deserves further study.

The final area, near Fourr Canyon, has a moderate concentration of some base metals and indicator elements (area no. 5 on the map). Zinc and antimony are widespread, base metals are found in the central and northern parts of the area, and tungsten appears only to the north near the contact with the Fourr Canyon stock. North-trending faults and chemically favorable rock types along the faults are guides to this stock-related mineralization. The stock is dated as about 37 m.y. old (R. F. Marvin, written commun., 1982), thus genetically related mineralization took place between the silver and gold mineralization episodes. At this site ideas for further study are indicated more by geologic features than by geochemical features.

CONCLUSIONS

From this geochemical study of mineralized rocks, it is suggested that direct observation of galena or its oxidation products provides a practical first approximation to the distribution of silver, which is typically not seen.

Gold is likely to occur with antimony, arsenic, and tellurium in an older episode of mineralization. Other occurrences of these indicator elements may lead to additional places of gold enrichment. The relatively high thresholds of detection for gold (10 ppm) by semiquantitative spectrographic analyses, relative to their abundance in rocks, makes it desirable not to rely on direct spectrograhic means to explore for gold.

Mineralization appears to have been recurrent in the Dragoon Mountains, which adds complications to any geochemically oriented search for ore deposits. Additional field and laboratory studies are needed to document the mineralization history so that suitable geochemical techniques and geological constraints may be applied to cope with element remobilization or the masking effects of superposed mineralization.

At three areas, geochemical data indicate the presence of northeast-oriented control, along with the many mapped north- or northwest-trending faults. At one of these areas, a dike also trends northeast but there are no other known northeast-trending surface features. Intersections of northeast-trending concealed structures and northwest-trending mapped structures, especially in areas of known anomalous metal concentrations and igneous activity, deserve further geologic study and economic evaluation.

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By
Harald Drewes
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