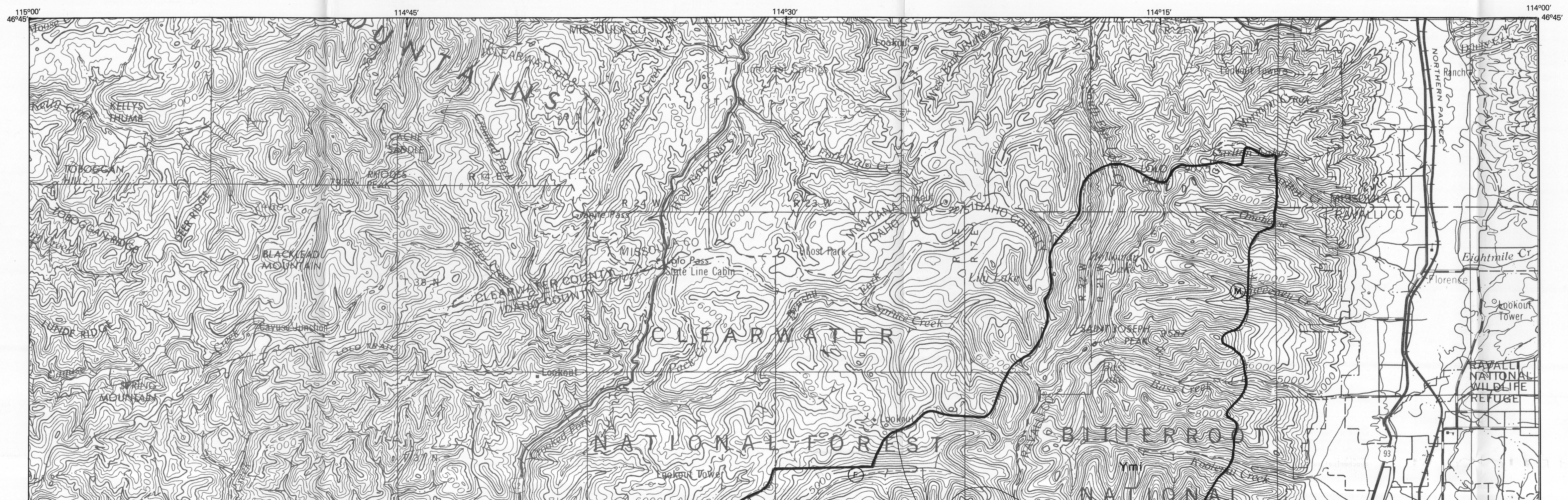
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1495-C
SHEET 1 OF 2

Figure 1.--Map showing location of the Selway-Bitterroot Wilderness and landmarks mentioned in the text.




Base from U.S. Geological Survey, 1:250,000, Hamilton, 1956, revised, 1969; Elk City, 1956, limited revision, 1963

SCALE 1:125 000

2 0 2 4 6 8 10 MILES

2 0 2 4 6 8 10 KILOMETERS

- ○ - Ag
- ⬭ - As
- ⬡ - Bi
- △ - Cd
- □ - Zn
- F — FINES FRACTION OF STREAM SEDIMENT
- N — NONMAGNETIC FRACTION OF STREAM-SEDIMENT CONCENTRATE
- M — MAGNETIC FRACTION OF STREAM-SEDIMENT CONCENTRATE--Highly anomalous concentration values indicated by subscript number. Concentrations are in parts per million (ppm)
- F_2 REPRESENTS TWO PPM SILVER IN THE FINES FRACTION

Simplified geology from Toth (1983)

MAP A.-DISTRIBUTION OF ANOMALOUS CONCENTRATIONS OF Ag, As, Cd, Bi, AND Zn IN STREAM SEDIMENTS AND STREAM-SEDIMENT CONCENTRATES

GEOCHEMICAL MAPS OF THE SELWAY-BITTERROOT WILDERNESS, IDAHO COUNTY, IDAHO, AND MISSOULA AND RAVALLI COUNTIES, MONTANA

By

Berton W. Coxe and Margo I. Toth

1983

CORRELATION OF MAP UNITS

Unit	Age	
Tg	Eocene	TERTIARY
TKp	Paleocene and(or) Upper Cretaceous	TERTIARY AND(OR) CRETACEOUS
TKg		
Kt		CRETACEOUS
Ym, Ymi		PROTEROZOIC Y(?)

DESCRIPTION OF MAP UNITS

Tg EPIZONAL HORNBLENDE-BIOTITE GRANITIC PLUTONS (EOCENE)--Medium to coarse grained, massive

TKp PARADISE PLUTON OF THE BITTERROOT LOBE OF THE IDAHO BATHOLITH (PALEOCENE AND (OR) UPPER CRETACEOUS)--Mesozonal, chemically zoned, medium-grained, foliated, hornblende-biotite tonalite to monzogranite

TKg GRANITIC PLUTONS OF THE BITTERROOT LOBE OF THE IDAHO BATHOLITH (PALEOCENE AND (OR) UPPER CRETACEOUS)--Mesozonal, medium-grained, foliated, muscovite-biotite granodiorite and monzogranite

Kt TONALITE AND QUARTZ DIORITE PLUTONS OF THE BITTERROOT LOBE OF THE IDAHO BATHOLITH (CRETACEOUS)--Mesozonal, fine- to medium-grained, foliated, hornblende-biotite tonalite and quartz diorite

Ymi MIGMATITE (MIDDLE(?) PROTEROZOIC)--Consisting of Proterozoic metasedimentary rocks (Ym) injected by granodiorite and monzogranite, and lesser tonalite and quartz diorite

Ym CALC-SILICATE GNEISS, QUARTZITE AND QUARTZOFELDSPATHIC SCHIST (MIDDLE(?) PROTEROZOIC)

CONTACT--Dashed where approximately located or inferred. Queried where uncertain

FAULT---Showing dip. U on upthrown side, D on downthrown side. Arrows indicate relative directions of accompanying strike-slip movement. Dashed where approximately located; dotted where concealed; queried where uncertain

APPROXIMATE BOUNDARY OF WILDERNESS

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 Selway-Bitterroot Wilderness in the Clearwater National Forest, Idaho County, Idaho; the Bitterroot National Forest, Ravalli County, Montana, and Idaho County, Idaho; the Lolo Forest, Missoula and Ravalli Counties, Montana; and the Nez Perce Forest, Idaho County, Idaho. The Selway-Bitterroot Wilderness was established as a primitive area by the U.S. Forest Service in 1932, received wilderness classification in 1963, and became a part of the National Wilderness Preservation System with the passage of the Wilderness Act in 1964.

INTRODUCTION

The Selway-Bitterroot Wilderness occupies almost 2,000 mi^2 in east-central Idaho and western Montana (fig. 1). The wilderness lies across the Bitterroot Mountains, which form the boundary between Idaho and Montana, and includes large portions of the drainage basins of the Selway, Lochsa, and Bitterroot Rivers. Elevations range from 1,800 ft on the Selway River near Lowell, Idaho, to 10,157 ft at Trapper Peak, Mont. Specific areas within the wilderness mentioned in this report are shown in figure 1.

The geochemical evaluation of the wilderness consisted of sampling and subsequent chemical analysis of more than 4,000 stream-sediment, stream-sediment-concentrate, and soil samples, and approximately 3,000 rock samples. Because of the large number of analytical determinations (>200,000), a computer was extensively used to analyze the data and compile the geochemical maps. The geologic base for the geochemical maps in this report is simplified from Toth (1983). Sample locality maps for samples mentioned in this report are published as part of a U.S. Geological Survey Open-File Report (Coxe and Toth, 1983).

ACKNOWLEDGMENTS

W. R. Greenwood designed the sampling program and oversaw the project for 3 years and S. D. Ludington helped a great deal with initial interpretation of the data. W. M. Rehn rendered much time to many phases of the project and his ideas and help were invaluable. C. M. McDougal oversaw the task of inputting all of the data into the computer, and G. Van Trump and W. D. Grundy offered much assistance in the computer handling of the data. During the last 5 years, a large number of people contributed to the project and nearly every one of them was somehow involved in the sampling program. Those people are: D. Ackerman, C. Allen, S. Azadian, B. Bailey, H. Barton, D. Birch, E. Bittner-Gaber, B. Bruce, B. Bye, D. Campbell, G. Campbell, D. Callahan, L. Garmezy, E. Goodstein, T. Hayden, D. Hovorka, N. Hurley, M. Koesterer, S. Lozon, K. Lund, J. McHugh, G. Meyer, B. Moffett, H. Morris, W. Motzer, M. Pawlowski, R. Reid, C. Schmidt, J. Scott, D. Seaver, C. Sims, G. Sims, M. A. Smith, R. Smith, P. Theobald, D. Thompson, and B. Wheaton.

GENERAL GEOLOGY

The Selway-Bitterroot Wilderness is underlain by large amounts of granitic rocks, which form most of the northern part of the Idaho batholith, entitled the Bitterroot lobe. These rocks intrude highly deformed metasedimentary rocks of amphibolite grade metamorphism and have widely variable compositions and ages. Cretaceous, foliated, medium-grained hornblende-biotite tonalite and quartz diorite plutons (Kt) form the southern and southwestern margins of the wilderness and are present as isolated plutons along the northern margin. These plutons are intruded by Paleocene and (or) Upper Cretaceous, mesozonal, chemically homogeneous, medium-grained muscovite-biotite plutons, which make up most of the wilderness and are referred to in this report as main phase Idaho batholith. Elongate migmatite bodies (Ymi) are commonly present between the Kt and TKg units and involve Precambrian metasedimentary rocks (Ym) intruded by the granitic material. The Paradise pluton (TKp) intrudes the main phase rocks in the center of the wilderness and consists of mesozonal, foliated, chemically zoned hornblende-biotite tonalite to monzogranite. The youngest igneous phase (Tg) consists of Eocene, highly differentiated, subalkalic, coarse-grained, hornblende-biotite syenogranite, containing fluorite-lined miarolitic cavities. This unit is divided into several different plutons: the Whistling Pig pluton in the western part of the wilderness, the Running Creek pluton in the southern part of the wilderness, and the Painted Rocks pluton in the southernmost part of the wilderness. Most of the geochemical anomalies in the wilderness are associated with these Eocene plutons.

SAMPLING

In the summer of 1976, P. K. Theobald undertook a geochemical orientation survey in the Selway-Bitterroot Wilderness to determine the optimal sampling medium and spacing for a stream sampling program. He tested 11 separate media from each chosen stream site, including various size fractions of stream sediments, various magnetic fractions of panned-concentrate samples, iron-oxide coated stream cobbles, and acid leachates of some of the above-mentioned fractions. From the results of this survey and a later experiment comparing panned concentrates against Wilfley[1] table concentrates (Greenwood and others, 1978), three separate media were chosen for analysis at each stream site: the less-than-170-mesh (0.0035 in.) stream sediment, the fraction of Wilfley table concentrate attracted to a hand magnet, and the fraction of Wilfley table concentrate not attracted to a hand magnet.

Stream Samples

While the orientation survey was in progress, a sampling program had been started and continued through the 1976 field season. At 164 stream sample sites along the eastern and southern parts of the wilderness, panned-concentrate, stream-sediment, and stream-cobble samples were taken. For the field seasons from 1978 to 1981, the sampling method was changed and many of the streams sampled in 1976 were resampled in accordance with the updated design, so that they could be statistically compared with the rest of the sampled streams. Beginning in 1978, all of the second-order streams and half of the first-order streams (chosen by a coin toss), which flowed directly into third or higher order streams, were sampled.

First-order streams are defined as the smallest unbranched tributaries depicted on U.S. Geological Survey 1:24,000-scale topographic quadrangle maps. Second-order streams are defined as streams having two or more first-order tributaries and no higher order tributaries. Third-order streams have two or more second-order tributaries and no higher order tributaries.

One stream out of every 19 streams was chosen for replication by random choice. Three samples were taken from each replication site: one sample at the mouth of the stream, another collected approximately 100 yd upstream from the first sample, and a third sample collected at the same place as either one of the first two samples (the site was decided by flip of a coin). A fourth sample was created by splitting the third sample in the lab.

Each stream sample was collected by traversing the stream in a zigzag fashion, sampling sediment all along the traverse for a distance of 10 times the stream's width. Samples were wet screened at the site to less than 10 mesh (0.039 in.). Approximately 5 lbs of sediment was collected.

Rock Samples

Two types of rock samples were collected. The first type is termed samples of opportunity--that is, samples of interest collected during geologic mapping or stream-sediment sampling, subjectively chosen at the sampler's discretion. These samples included altered rocks, veins, or representative or unusual rocks encountered in the field. The second type is termed grid samples, which consist of samples of representative unweathered rock, taken at or as near as possible to the intersections of a 3 mi by 3 mi grid.

For both samples of opportunity and grid samples, 0.5 lb of monolithologic, thumb-sized rock chips were collected at each site by sampling along the outcrops for a distance of approximately 30 ft. If a geologic structure (foliation or bedding) was present in the outcrop, the sample was collected over a distance of 30 ft perpendicular to the trend of the local structure. For veins and altered zones, chip samples were collected continuously across the vein or altered area.

One in every 19 rock samples of opportunity and every grid sample was replicated. Three samples were collected at each replicate site: one at the primary site, one at a secondary site 300 ft away from the primary site and on a direction perpendicular to any structural trend, and a third sample as an exact duplicate of either the first or the second sample, chosen by the flip of a coin. A fourth sample was created by splitting the third duplicate sample in the lab after pulverizing.

Rock samples of opportunity were submitted for analysis in blocks of 23 which included one replicate suite of samples and one blind standard sample for an analytical check. Grid samples were submitted for analysis in blocks of 21 samples, which included five replicate suites of samples and one blind standard sample.

SAMPLE PREPARATION

Rock samples were reduced to pea-size fragments in a steel-jaw crusher and then pulverized to less than 100 mesh (0.0059 in.) using a vertical pulverizer having ceramic plates.

Stream-sediment samples collected in 1976 were air dried, sieved to less than 80 mesh (0.0070 in.) using stainless-steel sieves, and then pulverized in a vertical pulverizer having ceramic plates. Panned-concentrate samples from 1976 were further separated in the lab with bromoform liquid (specific gravity, 2.86). The lighter mineral fraction separated out by the bromoform was discarded and the heavier mineral fraction was further processed by magnetic separation techniques. The ferromagnetic minerals were first extracted with a hand magnet and the remaining sample was then passed through a Franz Isodynamic Magnetic Separator[1] with settings first at 0.1 amp where part of the sample was extracted, and then at 1.0 amp. All four of these fractions, the fraction attracted to a hand magnet (HM fraction), the fraction attracted at a setting of 0.1 amp on the Franz separator (HG fraction), the fraction attracted at a setting of 1.0 amp on the Franz separator (HL fraction), and the fraction remaining after the final pass through the Franz separator at a setting of 1.0 amp (HN fraction) were then pulverized and submitted for spectrographic analysis. The iron-oxide-coated stream-cobble samples taken in 1976 were crushed and pulverized in the same manner as the rock samples.

The stream-sediment samples collected during the field seasons of 1978–81 were air dried before being sieved through 35 mesh (0.020 in.) and 170 mesh (0.0035 in.) stainless steel screens. The less-than-170-mesh fraction (fines fraction, sample number followed by SF) was analyzed without further preparation, and the greater-than-35-mesh sediment was discarded. The intermediate fraction was gravitationally concentrated on the Wilfley Table to obtain a concentrate made up largely of minerals with a specific gravity greater than 3.0. The less dense material was discarded. The ferromagnetic minerals were extracted from this concentrate with a hand magnet and pulverized with an agate mortar and pestle before analysis (magnetic fraction, sample number followed by SM). The remaining fraction (nonmagnetic fraction, sample number followed by SN) was treated likewise.

As stated earlier, replicate samples were taken at 1 of every 19 sample sites. The resample in the replicate suite was processed as a single sample except for the last stage when the three separated fractions from the sample were all split in half creating six separate samples for analysis.

For control on the analytical accuracy and precision, a blind standard sample was placed in a random position within each block of 23 rock or stream samples to be analyzed. Eleven separate standards were used. The standard samples were either USGS rock standard samples RGM-1, QLO-1, SCO-1, SDC-1, STM-1, and BHVO-1 (Flanagan, 1976); or USGS geochemical exploration reference samples GXR-1, GXR-2, GXR-3, GXR-5, or GXR-6 (Alcott and Lakin, 1975).

ANALYTICAL PROCEDURE

All of the samples were analyzed for 30 elements by the semiquantitative, six-step, D.C.-arc, optical emission spectrographic method described by Grimes and Marranzino (1968). The elements that were analyzed for were Fe, Mg, Ca, Ti, Mn, Ag, As, Au, B, Ba, Be, Bi, Cd, Co, Cr, Cu, La, Mo, Nb, Ni, Pb, Sb, Sc, Sn, Sr, V, W, Y, Zn, and Zr. Many samples were additionally analyzed for Ce and Th. A discussion of the precision of the technique can be found in Motooka and Grimes (1976).

Three hundred twenty-one samples were analyzed in a laboratory outside of the U.S. Geological Survey laboratory (Specomp Services Inc. of Hayden, Colo.). These samples were analyzed for Al, Na, Li, and Th in addition to the 30 standard elements. The rest of the samples were analyzed in U.S. Geological Survey laboratories in Golden, Colo., or in the field in a U.S. Geological Survey mobile lab. E. Mosier performed most of the analyses, but was assisted by H. Barton, D. Risoli, and R. Hopkins. The analytical data are available as a computer-readable magnetic tape through the U.S. Department of Commerce National Technical Information Service (NTIS), Springfield, Va. (Coxe and others, 1982).

One hundred ninety-six selected stream-sediment samples (less than 170 mesh) were analyzed for U and Th by the delayed neutron-activation method described by Millard (1976); the precision of this technique is discussed by Stuckless and others (1977). Delayed neutron-activation analyses were performed by H. Millard, M. Solt, N. Coughlin, and B. Vaughn and these analyses are also listed on the NTIS computer tape by Coxe and others (1982).

Major-element oxide analyses were performed on rock samples using automated X-ray fluorescence techniques and are presented in a U.S. Geological Survey Open-File Report (Koesterer and others, 1982). Analysts included H. Elsheimer, L. Espos, S. King, S. Morgan, V. Massotti, and K. Wong in Menlo Park, Calif., and J. Baker, J. Taggart, and J. Wahlberg in Lakewood, Colo.

GENERALIZATIONS ABOUT THE DIFFERENT SAMPLE MEDIA

Due to the large size of the area, the large number of samples, and the variety of sample media, it is necessary to limit the scope of this report to a discussion of the geochemical variation of only a few of the different sample media collected. From examination of distribution statistics (histograms and frequency distributions) and an analysis of replicate samples, it was determined that the two media best suited for evaluation of mineral potential were the nonmagnetic Wilfley-table concentrate samples and the fines fraction from the stream sediments. Except for a discussion of a few of the 1976 panned-concentrate samples, which are highly anomalous in several elements, any further discussion of samples taken prior to 1978 will be omitted from this report and will not be represented in any of the plates, tables, or figures.

For most elements, the nonmagnetic fraction exhibited the greatest variation between sample sites and the smallest percentage of qualified values. However, the population distributions for many of the elements were highly irregular, and within-site variation was commonly high enough to obscure between-site variation. Elements whose distribution were best represented by the nonmagnetic fraction include Bi, Mo, Nb, Ni, Sn, V, W, Zn, and Th.

The fines fraction also exhibited a high variation between sites for several elements. Moreover, the population distributions usually approximated a log normal model and within-site variation was substantially less for most elements than in the nonmagnetic fraction. Elemental distributions best represented by the fines fraction include Ag, Be, Co, and Cu.

The ferromagnetic Wilfley table concentrate fraction is discussed in more detail later. The data indicate, however, that this fraction is a good delineator of regional geochemical provinces, but is relatively insensitive to intersite geochemical variance. For this reason, it is not utilized heavily in this study. The rock data is useful in several ways, but it, too, is not a powerful reconnaissance tool for the wilderness.

The spectrographic rock data were somewhat useful in establishing background values for the relative abundance of various trace elements and in distinguishing specific rock units. Because of the very low relative abundance of most of the trace elements in the rocks and the relatively high detection limits for the emission spectrographic technique, many elements of interest were not detected in a large percentage of the samples.

SILVER, ARSENIC, BISMUTH, CADMIUM, AND ZINC IN STREAM SEDIMENTS

The emission spectrographic analytical technique is relatively insensitive to the elements Ag, As, Bi, Cd, and Zn, and the detection limits for these elements are high compared to their abundance in streams within the wilderness. For this reason and because high concentration of any one of these elements is often associated with mineralization, any detectable amounts of these elements in stream sediments were taken to be anomalous. Map A shows the areal distribution of samples having detectable amounts of these elements in the fines fraction, the nonmagnetic fraction, and the magnetic fraction. Table 1 summarizes the detection limits for each element.

Silver

Silver was detected in 23 of the 1,142 samples in the fines fraction, in 4 of 1,104 samples in the nonmagnetic fraction, and in 5 of 1,039 samples in the magnetic fraction. The silver anomalies are dispersed throughout the wilderness and are not judged to be associated with known mineralized areas or specific geologic units. A sample of note is 78EB077SM, which contained 70 parts per million (ppm) silver, yet, the sample is not anomalous in regard to any other elements.

Sample 79ME069, from a stream draining an area near Dog Point, had detectable Ag in the fines fraction and the nonmagnetic fraction contained an anomalous concentration of Bi. Sample 79ME070, from the adjacent drainage eastward also showed an anomalous concentration of Ag, and sample 79ME071, from the drainage across the valley contained an anomalous concentration of Bi. This area is underlain by migmatite and granite to granodiorite of the Idaho batholith, and evidence of mineralization was not seen during field examinations.

Sample 78RR025, from north of Copper Butte contained 5 ppm Ag in the fines fraction and an anomalous concentration of Bi in the nonmagnetic fraction.

Arsenic

Arsenic was detected in only one sediment sample. Sample 79ME081SN had 700 ppm As, 300 ppm Bi, and 100 ppm Cu. Samples 79ME082SN and 79ME083SN are from the same drainage area and contained anomalous concentrations of Bi (200 and 150 ppm, respectively). Nearby, sample 79DA007SN contained anomalous concentrations of Zn and Cu (500 and 300 ppm, respectively). The bedrock underlying this area is the highly differentiated Eocene Whistling Pig pluton.

Bismuth

Bismuth was detected in 40 of 1,104 nonmagnetic-concentrate samples and was detected in one sample in the fines fraction. One striking Bi anomaly was found in an area north of West Moose Creek where sediments from four streams draining a broad area had Bi in concentrations of 100 ppm or greater: 79RR089SN, 100 ppm; 79RR090SN, 200 ppm; 79RR079SN, 200 ppm; and 79RR084SN, 200 ppm. This area is underlain by foliated granite to granodiorite of the Idaho batholith. No related evidence of mineralization was seen in the field.

Cadmium

Cadmium was only detected in two samples. Sample 78MT162SM had 200 ppm Cd and 1 ppm Ag. Sample 78MT166SM had less than 50 ppm Cd.

Zinc

Zinc was detected in 22 of 1,104 nonmagnetic fraction samples and 9 of 1,142 fines fraction samples. Zn anomalies were found in three areas of interest. A cluster of Zn anomalies was found in the southern part of the wilderness near Archer Point in both the nonmagnetic and fines fractions (samples 78WM024, 78WM025, 78WM027, and 78WM028), containing concentrations as high as 1,000 ppm. Sediments from streams also contained anomalous concentrations of Mo, Sn, Nb, Be, and Pb and are discussed later.

Sediment samples (78WM142, 78WM143, and 78WM144) from three streams from a similar area northeast of Little Copper Butte contained anomalous concentrations of Zn. The area drained by these three streams also has anomalous concentrations of Sn, Mo, Nb, Be, Th, and Cu and is discussed later.

A third area containing an anomalous concentration of Zn was delineated by sediment samples from streams draining Sixtytwo Ridge. Samples 78KL007SN and 78KL009SN both contained anomalous concentrations of Zn, and 78KL004SN, which drains an area north of these streams, contained 500 ppm Bi. This area is underlain by the Eocene Whistling Pig pluton and no alteration or mineralization is known within the area.

MOLYBDENUM AND ASSOCIATED ELEMENTS

Molybdenum was detected in 10 percent of the fines fraction samples and 15 percent of the nonmagnetic fraction samples. Because of the low percentage of samples with detectable Mo, all reported values were considered anomalous. Map B shows the distribution of Mo in both of these fractions. The two classes of values represented from each sample medium attempt to represent "high" and "low" anomalies, but the classes have no real statistical significance.

The distribution of Mo in the nonmagnetic fraction can be related to three separately mapped plutons. The cluster furthest east corresponds to streams draining the Paradise pluton, a chemically zoned mesozonal tonalite to monzogranite pluton that intrudes the main phase of the Idaho batholith. Northwest of this cluster is a diffuse cluster of "low" anomalies corresponding to streams draining the Whistling Pig pluton. The largest and most striking cluster of samples containing anomalous concentrations is in the Running Creek pluton in the southwestern part of the wilderness. This pluton is a highly differentiated epizonal granite pluton that intrudes granite to granodiorite of the Idaho batholith.

Anomalous patterns of Mo are not as easily distinguished within the fines fraction of the stream sediments, but the greatest cluster of samples containing anomalous concentrations of Mo also lies within the Running Creek pluton. Many of the sediment samples from streams draining the Running Creek pluton contained anomalous concentrations of Mo in both the fines fraction and the nonmagnetic fraction, but this correlation does not hold true elsewhere.

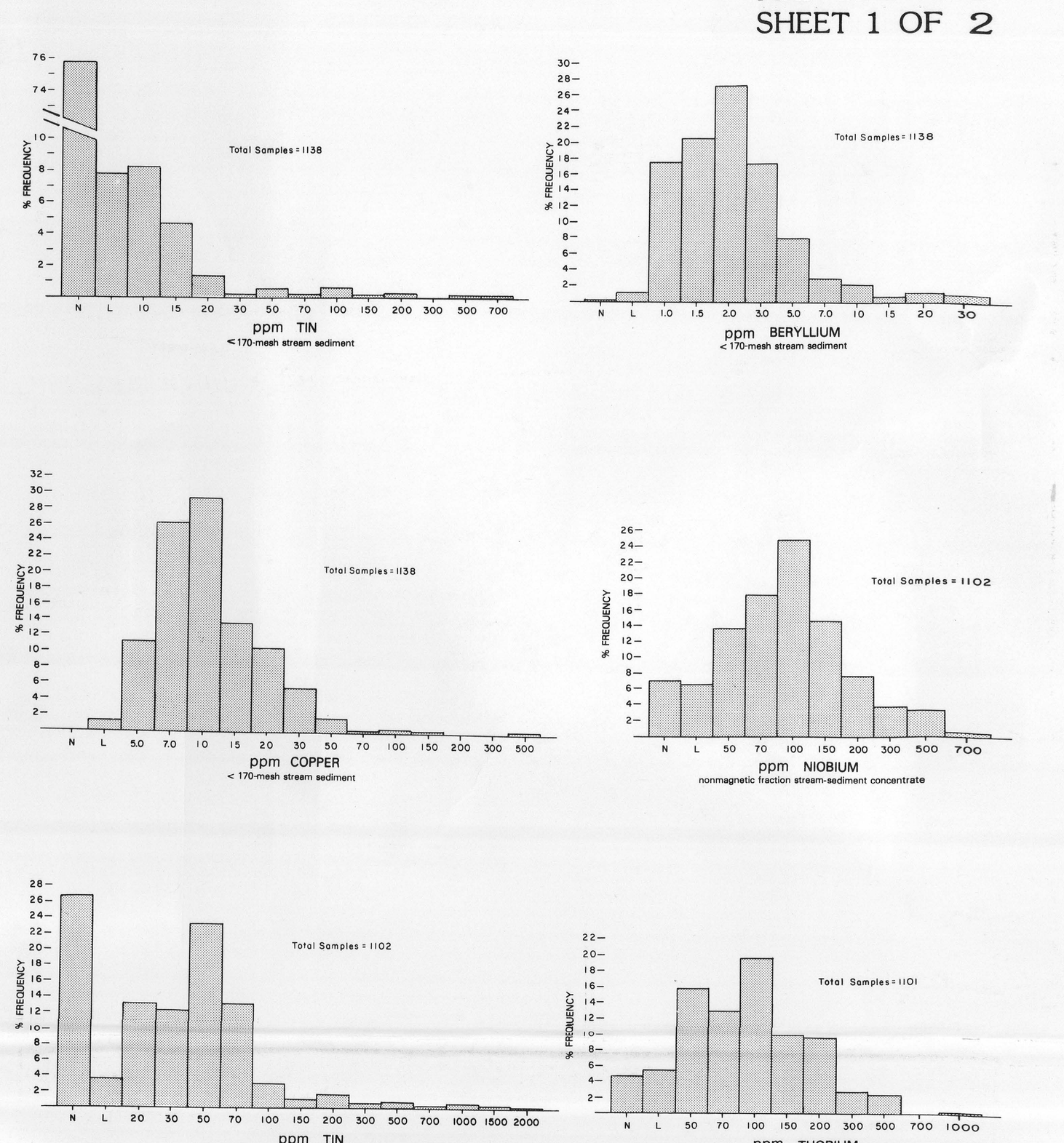
Figures 2 and 3 (sheet 1) are drainage basin anomaly maps of the area underlain by the Running Creek pluton. The maps show drainage basin outlines and elements for which sediment samples contained anomalous concentrations of two or more elements commonly associated with molybdenum mineralization and molybdenum-enriched differentiated granites. Anomalous concentrations for each element are indicated on the maps. Four broad areas containing strikingly anomalous concentrations of several elements are evident from these maps.

The first and foremost area is centered near Archer Point. The nonmagnetic fraction of sediments from six drainages and the fines fraction for sediments in two drainages contained anomalous concentrations of two or more of the elements Mo, Sn, Nb, Be, Pb, and Zn. Mo concentrations were as high as 50 ppm, Sn and Nb concentrations were as high as 5,000 ppm and Zn concentration was as high as 1,000 ppm in the nonmagnetic fraction. Samples containing anomalous concentrations of Mo and associated elements in this area were 78WM024, 78WM025, 78WM027, 78WM028, 78WM035, 78WM036, and 78WM100.

The second area of note is on and east of Little Copper Butte on the western margin of the Running Creek pluton. Sediments from four drainages exhibited anomalous concentrations of Mo and associated elements in the nonmagnetic fraction while sediments from only one of these drainages had a multi-element anomaly in the fines fraction. Sediments from each drainage outlined contained anomalous concentrations of two or more of the elements Mo, W, Sn, Nb, and Be and possibly Zn and Cu. Samples that contained anomalous concentrations include 78WM136, 78WM142, 78WM143, 78WM144, and 78WM145.

The third area lies at the head of Grouse Creek. Sediments from four drainages contained anomalous concentrations of Mo and associated elements in the fines fraction and two of these drainages had anomalous concentrations in the nonmagnetic fraction. The samples 80HM005, 80HM006, and 80HM007 contained anomalous concentrations of two or more of the elements Mo, Sn, Nb, Be and Y.

The final area is west of Wylies Peak and is defined by anomalous concentrations of elements in three nonmagnetic-fraction samples: 79BC082, 78WM190, and 78WM191. Sample 79BC082 contained anomalous concentrations of Mo and Nb and had 1,000 ppm Sn and detectable W. Sample 78WM191 contained anomalous concentrations of Sn and Nb and sample 78WM190 contained anomalous concentrations of Mo and Nb. No evidence of mineralization is known to be associated with any of these anomalies.



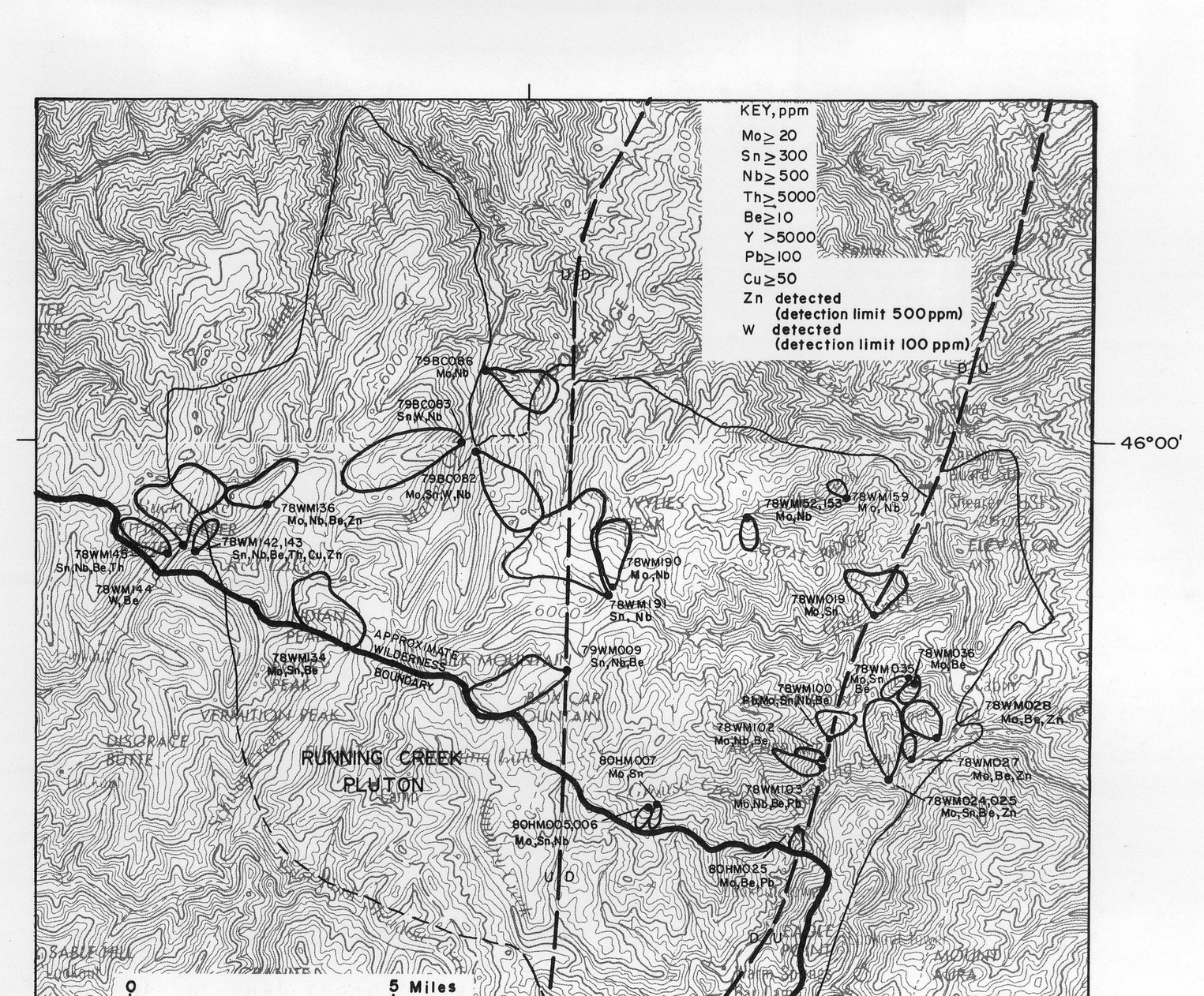


Figure 2.--Map showing drainage-basin anomalies underlain by the Running Creek pluton. From analysis of nonmagnetic fraction of stream-sediment-concentrate samples; selected multi-element anomalies shown.

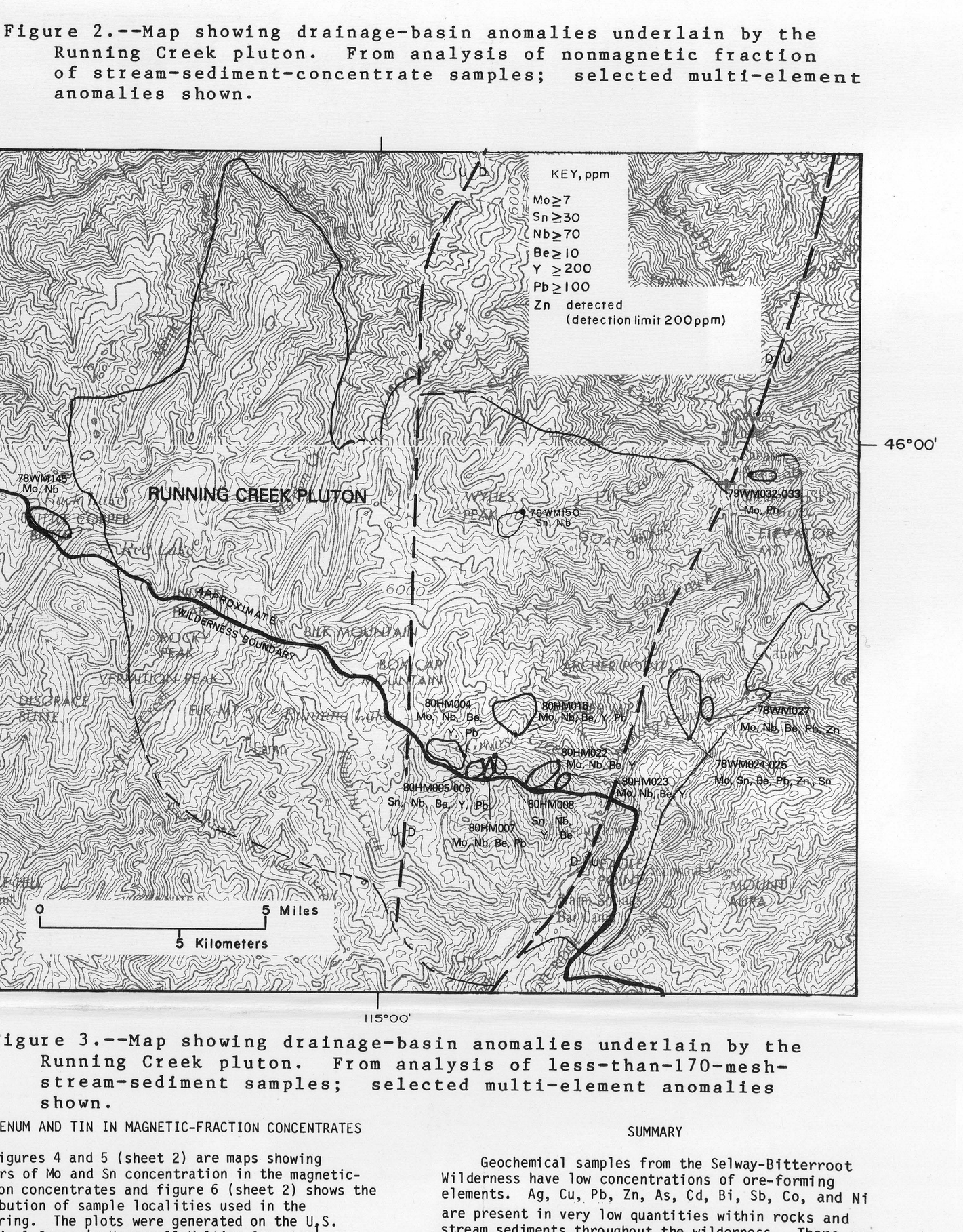


Figure 3.--Map showing drainage-basin anomalies underlain by the Running Creek pluton. From analysis of less-than-170-mesh-stream-sediment samples; selected multi-element anomalies shown.

MOLYBDENUM AND TIN IN MAGNETIC-FRACTION CONCENTRATES

Figures 4 and 5 (sheet 2) are maps showing contours of Mo and Sn concentration in the magnetic-fraction concentrates and figure 6 (sheet 2) shows the distribution of sample localities used in the contouring. The plots were generated on the U.S. Geological Survey's Honeywell Multics Computer[1] using a contouring program called Korkstp (John O. Kork, unpub. program, 1982). The program gridded the data on a 2-km spacing and used a gridding method which weighted the average of the values of the samples within each circle search according to the inverse of the square of the distance from the center of the search circle (a grid intersection). The contouring classes are spectrographic classes and are not necessarily statistically significant.

Strikingly near-identical patterns are evident on both contour maps. The extreme highs in the southwestern part of both maps correspond to the area underlain by the Running Creek pluton. The modal values for Mo and Sn in the magnetic concentrates from streams that drain this area are 70 ppm and 100 ppm, respectively. Histograms of these two elements within the magnetic fraction are also presented on the maps. Both histograms are strongly bimodal and the high population of each element corresponds closely to the samples within the Running Creek pluton. The other large anomaly shown on both maps north of the Running Creek pluton corresponds to the area underlain by the Whistling Pig pluton. The lesser tin anomaly in the southeast part of the wilderness represents only two samples, and there is no known geologic explanation for this anomaly.

The enrichment of Mo in the magnetic fraction of stream sediments draining the Running Creek and Whistling Pig plutons is unusual and possibly significant. Comparable enrichment of Mo is also reported in magnetic concentrates taken from streams draining mineralized areas near the Questa molybdenite mine in northern New Mexico (S. D. Ludington, P. Billings, and D. W. Jones, unpub data, 1982). Overstreet and others (1978) studied 680 magnetic concentrates from Alaska and within those concentrates only 3.5 percent of the samples analyzed exhibited Mo values greater than or equal to 5 ppm, and only 3 samples were found to contain values of 50 ppm; no values were higher than 50 ppm. The authors attribute anomalous Mo concentrations in these Alaskan magnetic concentrates to both ionic substitution of Mo^{+4} for Fe^{+3} (ionic radii 0.68 angstrom versus 0.67 angstrom) and inclusions of molybdenite within the magnetite itself. Microscopic examination of five anomalous magnetic concentrate samples from the Running Creek pluton revealed no observable source for the Mo in these samples.

ROCK DATA

Table 2 summarizes the spectrographic rock data. For each element the minimum, maximum, and mode are tabulated; the percentage of samples in which each element was not detected and the percentage of samples in which the element was detected but below the quantifiable limit is also presented.

A high percentage of the data for each element is qualified. Having such highly censored populations makes statistical treatment of the data extremely difficult. For this reason, anomalous concentrations within rock samples were chosen at either "eyeball" detectable breaks in the population or within the 95 percentile. Rock samples containing anomalous concentrations are listed in table 3, and there are several noteworthy samples.

Sample 78KL073B is from a limonitic and silicified shear and breccia alteration zone on the top of Trout Peak. It contains 150 ppm Mo but is relatively lacking in other elements. Two other samples from the same altered shear zone are anomalous. Sample 81ME504B has 5 ppm Mo and 81ME503A has detectable Zn (detection limit 200 ppm).

Several samples from Watchtower Pass in the southeastern part of the wilderness are anomalous. Sample G0005G, from a quartz vein with visible sulfides, has 50 ppm Ag and 5 ppm Mo. Sample 81ME506A, from another quartz vein with pyrite altered to limonite, has 2 ppm Ag, 0.05 ppm Au, 700 ppm As, and 20 ppm Cu. Sample 81ME507A is from a massive quartz vein with 0.7 ppm Ag and detectable Au (detection limit less than 0.5 ppm). Sample G0007G had detectable Mo (detection limit 0.5 ppm). Sample G0006G also had detectable Ag and G0011G had detectable Mo and 100 ppm Cu.

MAJOR-ELEMENT ROCK DATA

Table 4 summarizes the major element data for four of the main igneous bodies in the area and values for the Whistling Pig and Running Creek plutons are of particular interest. According to Mutschler and others (1981), three definitive parameters of source-host plutons for granite molybdenite deposits are SiO_2 greater than 74 weight percent, K_2O greater than 4.5 weight percent, and Na_2O less than 3.6 weight percent within fresh unaltered rock. The Running Creek pluton values fall well within these parameters and the Whistling Pig pluton values fall within or near these parameters.

SUMMARY

Geochemical samples from the Selway-Bitterroot Wilderness have low concentrations of ore-forming elements. Ag, Cu, Pb, Zn, As, Cd, Bi, Sb, Co, and Ni are present in very low quantities within rocks and stream sediments throughout the wilderness. There are several clusters of anomalies in the sediment samples indicating elemental enrichment within a few confined areas, but no known mineralized areas are associated with any of these.

Known areas of alteration and mineralization are few and small. Anomalies in rock samples are present in the altered shear and breccia zone of the Trout Peak and Trout Creek area, the gossan and mineralized zone on Watchtower Pass, and the Ag-, Pb-, and Cu-bearing breccia zones on the south side of Saint Joseph Peak (Cliff mine). However, these have no detectable chemical expressions within the stream-sediment samples.

Both the sediment and concentrate samples indicate that Running Creek pluton is enriched in Mo, Sn, Nb and Be, and the sediment data alone indicates Zn and Pb are also enriched. Furthermore, the major-element data for the Running Creek pluton indicate it is the type of pluton associated with granite molybdenite deposits. Several multi-element anomaly clusters indicate local elemental enrichment, especially in Mo, but there is no known mineralization associated with the enrichment in these sediment samples.

[1]Use of brand names in this report is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.

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