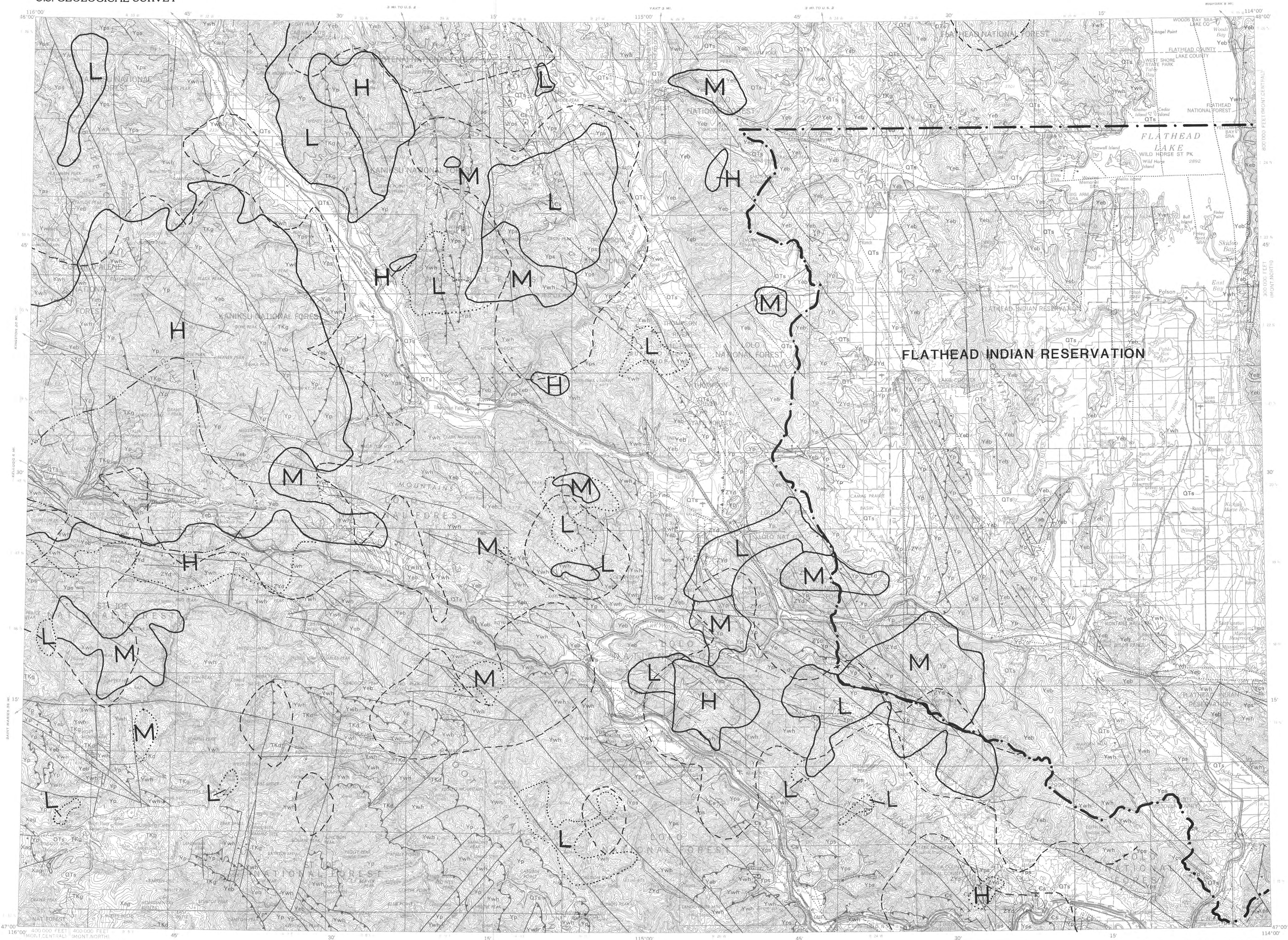
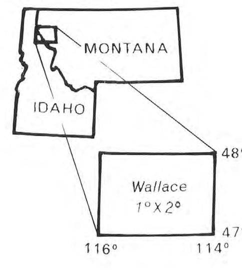


Base from U.S. Geological Survey, 1956, revised 1981

SCALE 1:250 000

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
NATIONAL GEODETIC VERTICAL DATUM OF 1929



Geology by J.E. Harrison, A.B. Griggs, and J.D. Wells, 1970–1980; assisted by H.R. Covington, 1972; Joseph Boggs, 1973; and J.P. Harrison, 1970–80.

MAP SHOWING GEOCHEMICAL FAVORABILITY FOR MESOTHERMAL BASE- AND PRECIOUS-METAL VEINS IN THE WALLACE 1°X2° QUADRANGLE, MONTANA AND IDAHO

By
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1989

CORRELATION OF MAP UNITS

QTs — QUATERNARY AND TERTIARY
Tv — TERTIARY
TKg, TKd — TERTIARY AND CRETACEOUS
Unconformity
Ꞓs — CAMBRIAN
Unconformity
ZYd — PROTEROZOIC Z AND Y
Yps (Missoula Group), Ywh, Yeb (Ravalli Group), Yp — Belt Supergroup — PROTEROZOIC Y
Unconformity
Xag — PROTEROZOIC X

DESCRIPTION OF GEOLOGIC MAP UNITS

QTs VALLEY FILL DEPOSITS (QUATERNARY AND TERTIARY)—Alluvium, glacial deposits, and semiconsolidated to consolidated conglomerate interlayered in places with shale, coal, and volcanic ash; shown only in major valleys and basins or along main stream courses.

Tv VOLCANIC ROCKS (TERTIARY)—Largely andesitic to dacitic welded tuff

TKg GRANITIC INTRUSIVE ROCKS (TERTIARY AND CRETACEOUS)

TKd DIORITIC INTRUSIVE ROCKS (TERTIARY AND CRETACEOUS)

Ꞓs SEDIMENTARY ROCKS (CAMBRIAN)—Includes Red Lion Formation, Hasmark Dolomite, Silver Hill Formation, Flathead Quartzite, and equivalent rocks

ZYd DIORITIC TO GABBROIC SILLS AND DIKES (PROTEROZOIC Z AND Y)

Yps MISSOULA GROUP (PROTEROZOIC Y)—Includes Pilcher, Libby, Garnet Range, and McNamara Formations, Bonner Quartzite, and Striped Peak, Mount Shields, Shepard, and Snowslip Formations

Ywh WALLACE AND HELENA FORMATIONS (PROTEROZOIC Y)

Yeb RAVALLI GROUP (PROTEROZOIC Y)—Includes Empire, St. Regis, Spokane, Revett, and Burke Formations

Yp PRICHARD FORMATION (PROTEROZOIC Y)

Xag ANORTHOSITE, SCHIST, AND GNEISS (PROTEROZOIC X)

CONTACT

FAULT—Dotted where concealed. Bar and ball on downthrown side; arrows show relative direction of apparent horizontal movement

THRUST FAULT—Dotted where concealed. Sawteeth on upper plate

EXPLANATION

Geochemical favorability for mesothermal base- and precious-metal veins--See table 2 for criteria used to establish favorability.

H High

M Medium

L Low

Approximate boundary of area of favorability

Favorability based on the sum of the ranks of lead plus zinc plus copper plus silver or the sum of the ranks of lead plus zinc in stream-sediment samples

Favorability based on anomalous concentrations of lead, zinc, copper, silver, antimony, and arsenic in nonmagnetic heavy-mineral-concentrate samples

Favorability based on enrichment of partially extractable antimony in stream-sediment samples

Approximate boundary of Coeur d'Alene mining district

Approximate boundary of Flathead Indian Reservation

INTRODUCTION

This map shows the geochemical favorability for mesothermal base- and precious-metal veins in the Wallace 1° x 2° quadrangle, Montana and Idaho. The information presented here is part of the Wallace CUSMAP (Conterminous United States Mineral Assessment Program) project conducted by the U.S. Geological Survey.

Mesothermal base- and precious-metal veins are one of several types of metallic mineral resources that the Wallace CUSMAP project considered in the mineral resources assessment. The geochemical favorability presented here represents one of several types of information that was used to arrive at the mineral appraisal for mesothermal base- and precious-metal veins in the Wallace quadrangle (Harrison and others, 1986).

This report summarizes the steps used to establish levels of geochemical favorability for mesothermal veins in the quadrangle. A single map presenting the details of each step would be extremely complex and essentially unreadable. Considerable judgment has been used in developing the occurrence model and in the interpretation of the reconnaissance data. Users of the Wallace folio may wish to examine the data on which the assessment is based to determine by their own criteria whether a given subarea of the quadrangle is worthy of further study. The appraisal process for mesothermal base- and precious-metal veins is complex, but the assumptions and rationale used in making the assessment can be found in this report.

Samples of stream sediment and nonmagnetic heavy-mineral concentrates were collected from 1,229 locations in the Wallace quadrangle. Our sample coverage is incomplete on the Flathead Indian Reservation where we were asked to not sample. Each sample of stream sediment was analyzed by atomic-absorption spectrometry for total and partially extractable concentration of six metals. Samples of nonmagnetic heavy-mineral concentrate and stream sediment were also analyzed by semiquantitative emission spectroscopy for 31 elements. A complete tabulation of the data, detailed discussion of the sampling and analytical methods, and statistical summaries of the data are presented by Leach and others (1982). The data are also available on computer tape from the National Technical Information Service (McDanal and others, 1982).

OCCURRENCE MODEL

The Wallace folio includes a series of mineral resource appraisal maps based upon mineral occurrence (nongenetic) models for each type of known or probable metallic mineral resource in the quadrangle. The models are derived from observed characteristics of ore deposits in the Wallace quadrangle or, if there are no known occurrences in the quadrangle, from characteristics of deposits as nearby as possible. For each of these occurrence models, we have identified a suite of elements that best characterizes the most common geochemical signature (table 1). In addition, we have developed criteria to identify a range in favorability for each geochemical signature and have assigned favorability scores to the criteria that form subdivisions within each. The scores range from 0 through positive numbers that were deliberately kept low for each geochemical signature. Thus a few broad subdivisions could be used for classifying the reconnaissance data. Finer subdivisions, though desirable, would require more detailed information than was available in the quadrangle.

The geochemical favorability scores for subareas of the quadrangle were combined with favorability scores from other kinds of diagnostic data to establish a measure of probability for the occurrence of an ore deposit. A more detailed discussion of the procedures used for resource appraisal for mesothermal veins in the Wallace quadrangle is presented by Harrison and others (1986).

The mesothermal vein category includes vein occurrences of the famed Coeur d'Alene district as well as numerous vein occurrences located over a wide area in the quadrangle. We have combined all of the vein occurrences into a single model because we could not establish any geochemical differences between the veins in the Coeur d'Alene district and those widespread throughout the quadrangle.

By local usage, the Coeur d'Alene district includes an area about 26 mi long and 9 mi wide centered more or less around the town of Osburn, Idaho. The Wallace quadrangle contains the eastern part of the district. A larger area referred to as the greater Coeur d'Alene mineral belt extends along the Lewis and Clark line from Coeur d'Alene, Idaho, on the west, to Superior, Mont., on the east. Within the Wallace quadrangle, it includes the area between Wallace, Idaho, and Superior, Mont.

Host rocks for mesothermal veins are formations of the Belt Supergroup--mostly the Prichard, Burke, Revett, and St. Regis Formations, although some veins occur in the stratigraphically higher Wallace Formation. Present production from active mines in the Coeur d'Alene district is from veins located in quartzite and siltite units in the Revett and St. Regis Formations.

Table 1.--Elements that may be present in anomalous concentrations for the mineral resource occurrence models of the Wallace 1° x 2° quadrangle, Montana and Idaho

[Underscored elements were used as signature elements for the particular resource type; leaders (--) indicate none detected]

Mineral-resource type	Total metal in stream sediments	Partially extractable metal in stream sediments	Nonmagnetic heavy-mineral concentrate
Mesothermal veins	Ag, Cu, Cd, Pb, Sb, Zn, minor Bi	Ag, Cu, Cd, Pb, Sb, Zn	Ag, As, Cu, Pb, Sb, Zn, minor Cd, Bi, Co
Stratabound copper-silver	Ag, Cu, minor Bi, Mo, Hg, Zn, Pb	Ag, Cu, minor Pb	Ag, Cu, minor Pb
Sullivan-type strata-bound lead-zinc	Pb, Zn, minor Ag, Sb, Cu	Pb, Zn	Pb, Zn
Stockwork porphyry molybdenum-tungsten	Bi, C, Cu, Pb, Zn	Bi, Cu, Pb, Zn	Bi, Mo, Sn, W
Epithermal high-grade silver	Ag, Zn, minor Cd	Zn	--
Placer gold	--	--	Au, minor Ag

The lead-zinc-silver-copper ore deposits in the Coeur d'Alene district are found as fissure-filled veins and replacement ore bodies. Principal ore minerals are galena, sphalerite, tetrahedrite, and chalcopyrite. Parts of the district appear to be zoned as indicated by the common occurrence of copper sulfides on the eastern end, through predominantly lead-zinc-silver sulfides and sulfosalts, to zinc and lead sulfides on the western end. Stibnite tends to be most abundant in veins that are in a crude outer zone around the district. Outside the district but within the greater Coeur d'Alene mineral belt, small areas of replacement or fissure-filled veins may be dominated by lead, gold, or antimony. Outside the Coeur d'Alene district and the greater Coeur d'Alene mineral belt, veins of this deposit type are mostly fissure fillings but include some replacement ore zones. They commonly occur near exposed felsic plutons or in areas of positive magnetic anomalies. Primary ore minerals are galena, sphalerite, bornite, and chalcopyrite accompanied by various amounts of gold or silver.

The mesothermal-type deposits may range in composition from simple lead-zinc or copper ores, through those that also contain gold and silver, to highly complex veins in which antimony, arsenic, nickel, cadmium, cobalt, iron, and barium may also be significant components of the ores. The wide variety of ore minerals present is responsible in part for the complex geochemical signature observed. This complex geochemical signature may also result from variable surficial exposure of mineralogically zoned vein systems--commonly significantly displaced and offset by faults. Nearly all possible combinations of anomalous concentrations of silver, bismuth, cadmium, copper, lead, antimony, and zinc are observed in samples of stream sediments and nonmagnetic heavy-mineral concentrates near known occurrences of mesothermal veins.

FAVORABILITY SCORES

One of the difficulties in evaluating the favorability for mesothermal veins at this reconnaissance scale is that some of the mineralogically simple veins may yield a simple geochemical signature that shows only anomalous concentrations of one or two elements. A simple suite of anomalous elements may also be derived from other types of mineral occurrences, such as stratabound copper-silver (may show Cu ± Ag ± Pb) or epithermal silver (may show Ag ± Zn) or stockwork porphyry molybdenum-tungsten (may show Pb ± Cu ± Zn), or Sullivan-type occurrences (may show Pb ± Zn). However, it is unusual for any of these other occurences to show consistently anomalous concentrations of more than one or two elements. Mesothermal veins are generally dominated by lead and zinc and commonly contain copper, silver, and antimony. Therefore, the complexity of the suite of anomalous elements present in a sample, with emphasis on lead, zinc, and antimony, is a measure of the favorability for mesothermal vein occurrence. Using this concept, a three-step method that integrated the data from stream sediments with the data from nonmagnetic heavy-mineral concentrates was employed to establish level of geochemical favorability. Prior to establishing favorability scores for mesothermal veins, all of the sites that had been previously assigned some level of favorability for epithermal silver, stockwork porphyry molybdenum-tungsten, or stratabound copper-silver were excluded from further consideration. These areas were excluded to simplify the procedure for establishing favorability for mesothermal veins. We are not suggesting that these areas are unfavorable for the presence of mesothermal veins, but rather that these areas have geochemical signatures more characteristic of other resource types. Sites assigned favorability scores for Sullivan-type lead-zinc occurrence were retained because it is practically impossible to distinguish this deposit type from mesothermal veins at the reconnaissance scale of the sampling.

EVALUATION

Step one--The first step considered the total concentrations of lead, zinc, copper, and silver as signature elements in samples of stream sediments. Cadmium, which is commonly present in anomalous concentrations in stream sediments near mesothermal veins, was not used. Cadmium is so clearly related to zinc, commonly in sphalerite, that use of both zinc and cadmium would in effect give double weight to a single factor. Bismuth, also common to some mesothermal veins, was not used because it has a high local variability in the quadrangle. Such erratic behavior limits the usefulness of bismuth in defining regional geochemical trends. Some other trace elements, such as arsenic, molybdenum, and gold, might have been included in the geochemical signature for mesothermal veins, but they were not because only a few stream-sediment samples contained concentrations of those elements that were detectable by the analytical methods used. Antimony was treated separately (step 3).

To quantify this suite of elements (Pb, Zn, Cu, and Ag) for each sample of stream sediment, we chose to use a simple nonparametric statistical treatment of the data to rank each sample based upon the relative concentration of all four elements. This allowed us to compare the relative elemental content of the samples of stream sediment while avoiding absolute or threshold concentrations to identify anomalous samples. In the statistical procedure, all 1,229 samples of stream sediment were assigned a rank number for their lead, zinc, copper, and silver concentration. For example, the sample with the greatest lead concentration was assigned 1,229, the sample with the second greatest concentration was assigned 1,228, and so forth. If several had the same concentration, all were ranked equally. This procedure was completed for all four elements, and then the sum of all four rank numbers was determined for each sample. The net effect of this procedure was to transform four separate elemental distributions into a single unitless distribution that represents a total metal signature for the four summed elements. The rank sums were divided into seven percentile classes that are 100-99, <99-95, <95-90, <90-85, <85-75, <75-50, and <50.

Areas with groups of sample sites that could be characterized as being in the 85th percentile or higher for lead plus zinc plus copper plus silver were identified and assigned a favorability of high, medium, or low as outlined in the criteria described in table 2. This same procedure was applied to the sum of the ranks for lead plus zinc, which identified additional areas that possibly contain lead-zinc veins that contain little or no silver or copper. The boundaries of these favorable areas (shown as solid lines on the map) have been drawn approximately along drainage divides that enclose groups of favorable samples. Isolated single sample sites were not considered favorable unless they were within the top five percent of the rankings. These procedures are described in more detail by Leach and Goldfarb (1989).

Second step--The data for nonmagnetic heavy-mineral concentrates were examined for presence of anomalous concentrations of lead, zinc, copper, silver, antimony, and arsenic (see Leach and Domenico, 1986). Groups of sample sites showing various combinations of these signature elements were classified into categories of high, medium, and low favorability as described in table 2. Higher favorability scores were assigned to sites that have multielement anomalies and that also contain anomalous antimony. Many of these sites correspond in location and level of favorability to the areas outlined in step one. Where they do not, commonly just beyond the boundaries established in the first step, the boundaries were expanded to include favorable areas indicated by the data from the nonmagnetic heavy-mineral concentrates (dotted lines on the map).

Third step--Areas in the quadrangle showing an enrichment of partially extractable antimony in stream sediments were identified (Leach and others, 1983). The enriched areas were found by computer-contouring of weighted averages at the corners of a square grid that enclosed a 10.4 mi^2 area; the weighted averages are determined by a computer program that gives decreasing weight to values based on the distance away from the counting point. Areas then were identified where the weighted values exceed the geometric mean for all data (1.2 parts per million for antimony, shown as dashed lines on the map). Relatively high values for antimony are believed to be another indication of favorable ground. Most areas of antimony enrichment correspond to areas already identified as favorable in steps one or two, or serve to expand them slightly.

Table 2.--Criteria used to establish geochemical favorability

Favorability score	Criteria
+4 High (H)	Stream-sediment samples predominantly in the 90-95th percentile for summed signature elements; at least 1/3 are in the 95+ percentile. Nonmagnetic heavy-mineral concentrates from groups of sites have anomalous amounts of three or more signature elements, and antimony is present; also a single site shows four signature elements without antimony.
+3 Medium (M)	Stream-sediment samples predominantly in the 85-95th percentile for summed signature elements; at least 1/3 are in the 90+ percentile. Nonmagnetic heavy-mineral concentrates from groups of sites either have anomalous amounts of two signature elements other than antimony or are single sites that contain antimony plus at least one other signature element.
+2 Low (L)	Stream-sediment samples predominantly in the 85-90th percentile for summed signature elements; at least 1/2 are in the 85+ percentile. Nonmagnetic heavy-mineral concentrates from groups of sites have anomalous amounts of a single signature element, or a single site has two or more signature elements.
+1	Stream sediments enriched in partially extractable antimony.
0	Stream-sediment samples predominantly below the 85th percentile for summed signature elements. Isolated single-site anomalies for one signature element in the nonmagnetic heavy-mineral concentrates. Partially-extractable antimony in the weighted concentrations is less than the geometric mean value of 1.2 part per million.

DISCUSSION

The geochemical data are reconnaissance in nature; therefore, we have identified large-scale or regional geochemical patterns that may relate to mesothermal vein resources. This is consistent with our assumption that the many mesothermal veins present in the quadrangle relate to large-scale geologic and geochemical processes and did not result from unrelated or independent processes.

The boundaries for favorable ground have been drawn approximately along drainage divides that enclose favorable sample sites. These boundaries are clearly subjective within reasonable limits that largely depend on the density of samples. Typically, the reconnaissance geochemical samples are 2 mi apart, but some are as much as 5 mi apart. The uncertainty of a boundary between two samples, therefore, typically will be 1 mi but in some cases as much as 2.5 mi. The precision of the geochemical boundaries is within the limits of the boundaries established by some of the geologic and geophysical data used in the mineral resource evaluation (Harrison and others, 1986). For most areas, the boundary between geochemically favorable and unfavorable ground can be clearly defined, although in a few areas, where such boundaries are not well defined, considerable judgment was used to locate them.

On the map we show the highest level of favorability found for an area in any step of the three-step procedure. The favorability has been deliberately made broad and the score low to be consistent with the generalized favorability established from other categories of data used to establish the mineral resource potential as well as to keep the assessment procedure simple.

There are many areas in the quadrangle identified as having some geochemical favorability for mesothermal veins. A detailed discussion of each one is beyond the purpose of this report. However, some of the more extensive areas are briefly reviewed.

A broad area of highly favorable ground surrounds the Coeur d'Alene district. This zone extends north and northeast to the Clark Fork River. Although there are numerous mines and prospects in and near the Coeur d'Alene district, the northern and northeastern half of this favorable zone contains only a few known occurrences of mesothermal veins. This suggests that there is high potential for discovery of mesothermal veins in this area. South of the Coeur d'Alene district is an area of medium favorability where only one occurrence of mesothermal veins is known.

Northeast from the town of Trout Creek and across the Clark Fork River are areas with high, medium, or low favorability scores. These areas are separated from the highly favorable zone that surrounds the Coeur d'Alene district by the flood plain of the Clark Fork River. These areas contain several known occurrences of mesothermal veins; however, the areas of geochemically favorable ground are much more extensive than the known ore occurrences.

In the southeast part of the quadrangle near Superior, Mont., several areas show geochemical favorability for mesothermal veins. Parts of these areas lie within the greater Coeur d'Alene mineral belt and contain many mines and prospects. The geochemically favorable ground extends well away from the known vein occurrences, which suggests that favorable ground in the greater Coeur d'Alene mineral belt extends to the southeast of Superior, Mont. Favorable areas in the north-central part of the quadrangle, north and northeast of Thompson Falls, contain only a few occurrences of mesothermal veins. Further prospecting in these areas seems warranted.

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