STUDIES RELATED TO WILDERNESS

SAWTOOTH NATIONAL RECREATION AREA, IDAHO

GEOLOGICAL SURVEY BULLETIN 1545

Mineral Resources of the Eastern Part of the Sawtooth National Recreation Area, Custer and Blaine Counties, Idaho

STUDIES RELATED TO WILDERNESS—PRIMITIVE AREAS

GEOLOGICAL SURVEY BULLETIN 1545

An evaluation of the mineral potential of the area
Chapters A-E

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STUDIES RELATED TO WILDERNESS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines are making mineral surveys of areas under consideration for incorporation into the National Wilderness Preservation System. The act provides that each area be studied for its suitability for incorporation into the Wilderness System, and the mineral surveys constitute one aspect of the suitability studies. This report presents the results of a mineral survey of national forest lands within the eastern two-thirds of the Sawtooth National Recreation Area, Idaho. These lands are under consideration for wilderness designation.

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STUDIES RELATED TO WILDERNESS—PRIMITIVE AREAS

MINERAL RESOURCES OF THE EASTERN PART OF THE SAWTOOTH NATIONAL RECREATION AREA, CUSTER AND BLAINE COUNTIES, IDAHO

By U S GEOLOGICAL SURVEY and U S BUREAU OF MINES

SUMMARY

The mineral resources of the eastern two-thirds of the Sawtooth National Recreation Area, hereafter referred to as the study area, were investigated in 1971 and 1972 by the U S Geological Survey and U S Bureau of Mines. A similar study of the western part of the recreation area, the former Sawtooth Primitive Area—now the Sawtooth Wilderness—has been published as U.S. Geological Survey Bulletin 1319–D. The study area consists of about 820 mi² (2,100 km²) mostly in the Sawtooth and Challis National Forests, and includes the White Cloud Peaks, northern Boulder Mountains, Sawtooth Valley, Stanley Basin, and some areas adjacent to the Sawtooth Wilderness The area studied covers parts of Blaine and Custer Counties in the central part of Idaho

The mineral resource investigation was made at the request of members of the Idaho congressional delegation. The purpose of the investigation and of concurrent studies by the U.S Forest Service, U S Park Service, and other agencies is to provide the data needed by Congress to determine the ultimate status of the recreation area that was established by Public Law 92–400 in August 1972.

The study area is a part of one of the more extensively mineralized and potentially productive mining regions in Idaho. Although mineral production from the study area has not been high, the immediately surrounding region includes four of the six most productive silver districts in the State: Clayton (silver-lead), Yankee Fork (gold-silver), Warm Springs (silver-lead-zinc), and Mineral Hill (silver-lead-gold) In

addition, the adjacent Sawtooth, Vienna, and Alta districts have yielded ores valued at about $1 million each in base and precious metals, and the nearby Stanley uranium district has produced uranium ore valued at about $300,000. The Atlanta district to the southwest has produced more than $6 million in gold and silver values. The Clayton silver mine, about 4 mi (6.4 km) north of the study area, has been in nearly continuous production since 1937 and is by far the most productive mine in the region. The total estimated value of mineral production from these nearby mining districts is nearly $85 million, of which an estimated $50 million was produced within 15 mi (24 km) of the study area.

The total value of metals produced from the study area is estimated from incomplete records to be at least $5 million, about half of which was produced prior to 1890, before records were kept. Most of the metals produced since 1890 have been from the Livingston mine The value of produced metals would have been much higher had present-day metal prices prevailed at the time of mineral production. In estimated order of decreasing value, the metals produced were silver, gold, lead, zinc, and byproduct copper.

The economic potential of the mineral resources in the study area, especially those containing gold and silver, has been significantly enhanced by the several-fold increase in world prices of precious metals in recent years. Any evaluation of possible future metals that might be produced must, of course, be tempered by consideration of concurrent increases in the cost of production.

To keep the mineral evaluation of the study area on a factual basis, all data are presented quantitatively in terms of percent, parts per million, ounces, pounds, and so on, with their metric equivalents. Values in dollars and cents are calculated in a few examples where such notation seems pertinent.

The study area contains large undeveloped mineral resources, part of which can be identified as reserves and part as marginal or submarginal resources The estimated potential value of reserves and resources of the four largest deposits is 100 to 200 times the total value of minerals already produced The principal resources that are known, in estimated order of decreasing potential value, are molybdenum, zinc, silver, gold, lead, fluorite, antimony, and cadmium. Niobium, uranium, thorium, rare earths, and titanium are potential coproducts of possible future mining of placer gold deposits Smaller amounts of copper, tin, tungsten, bismuth, mercury, selenium, and tellurium are present

Four large deposits contain the major part of the total resources. These deposits comprise about 135 million tons (122 million t (metric tons)) of marginal molybdenum resources containing about 242 million pounds (110 million kg (kilograms)) of molybdenum, 870,000 tons (789,000 t) of inferred zinc reserves, 250,000 tons (227,000 t) of inferred low-grade gold resources, and 200,000 tons (181,000 t) of inferred fluorite resources The resource potential of silver, gold, and lead also is large, although most known deposits are small. Significant resources of byproduct antimony, cadmium, tin, and tungsten were identified. The economic potential of several large placer deposits containing gold, niobium, titanium, uranium, thorium, rare earths, and locally, mercury is uncertain, but possibly is large if the deposits are dredgeable The resource potential of inaccessible productive mines, relatively unexplored mineralized areas, and areas considered favorable for exploration also could be large, but they have not been evaluated quantitatively.

Tungsten, molybdenum, and uranium deposits have been discovered or developed within or near the study area since 1952 Other deposits, particularly of zinc, tungsten, and silver, may be within reach of modern exploration and production techniques.

The mineral resources investigation of the study area included an aeromagnetic survey, reconnaissance geologic mapping, extensive sampling, studies of known mineral deposits and mining claims, and detailed geochemical and geophysical studies of five areas considered favorable for further mineral exploration.

During the study 2,875 stream-sediment samples, 255 soil samples, 14 heavy-mineral concentrates, 621 mineralized rock samples, and 826 unmineralized rock samples were obtained and analyzed by the U.S Geological Survey In addition, about 1,817 representative samples from mines and prospects and 268 heavy mineral concentrates from placers were assayed and scanned for the presence of radioactive and fluorescent minerals by the U.S. Bureau of Mines. More than 6,600 samples were analyzed.

Some areas were scanned for radioactivity using a scintillometer, and some outcrops were examined by ultraviolet light to detect fluorescent minerals such as scheelite. Several thousand miles of foot traverses were supplemented by horseback traverses and use of helicopters. A total of 83 man-months were spent in field studies.

Several targets of potential economic interest were revealed by the study, both near known deposits and in areas not previously known to contain mineral deposits. The most promising are areas in the Mill Creek–Slate Creek drainage and along Grand Prize Gulch (Horton Peak quadrangle). Geochemical samples in those areas contain anomalous quantities of zinc, silver, and lead. Electromagnetic conductors that may be mineralized zones were detected in the areas as well as near gold-silver-lead veins at the Buckskin and Valley Creek mines Previously unknown cadmium and potential tin resources also were found Cadmium adds appreciably to the value of zinc reserves of the

Hoodoo mine. The economic value of the low-grade tin resources in the silver-lead veins of the area is uncertain, but because tin-bearing deposits are rare in the United States, those of the study area are a possible future source of this domestically scarce metal

The geology of the study area is complex. Deformed and metamorphosed sedimentary rocks have been intruded by granitic rocks and overlain in part by volcanic rocks and by glacial and alluvial deposits. The study area is near the southeast margin of the composite Idaho batholith, which underlies the northwest third of the area and which has been intruded by the smaller and younger Sawtooth batholith The Idaho batholith has intruded metasedimentary rocks of probable Precambrian age in the northwest part of the area. Folded and faulted sedimentary rocks of Paleozoic age form an arcuate belt trending northerly through the center of the area and are intruded by the Idaho batholith, the White Cloud, Horton Peak, and Boulder Mountains stocks, and by several smaller stocks. The Paleozoic sedimentary rocks and older intrusive plutons are overlain by the Challis Volcanics, which together with related intrusive hypabyssal porphyry stocks and dikes are exposed in most of the eastern third of the area.

Calcareous sedimentary rocks near the granitic intrusive masses, particularly those surrounding the White Cloud stock, commonly are transformed into white, wollastonite-bearing, calc-silicate rocks, which have given the high, glaciated White Cloud Peaks their name. Locally at the contacts, green diopside and dark garnet calc-silicate rocks also have been formed

The complex geology of the Paleozoic sedimentary rocks is poorly understood because of facies changes, unconformities, thrust faults, high-angle faults of several ages, and the extensive volcanic rock cover. They were faulted and folded during three major periods of intrusion: (1) in Late Cretaceous time during the intrusion of successive phases of the Idaho batholith (94–80 m.y. (million years) ago); (2) in Eocene time (48–44 m.y. ago) during emplacement of the Sawtooth batholith and several Eocene stocks that are partly synchronous with the Challis Volcanics; and (3) in later Tertiary time when small granitic stocks and many granite porphyry dikes younger than some of the Challis Volcanics were intruded.

The Challis Volcanics were extruded in several pulses onto a faulted terrane of great relief during uplift, faulting. local erosion, and, in the Boulder Mountains, during intrusion of hypabyssal porphyries These porphyries form dikes and irregular small plutons that intruded volcanic and Paleozoic rocks as intricate complexes, and may be vents from which some of the volcanic rocks were extruded. Aeromagnetic data outline the subsurface extent of the major plutons, with the exception of the Idaho batholith.

Most of the mineral deposits are in the belt of Paleozoic sedimentary rocks Vein deposits are found in the Idaho batholith in the northern part of the study area and in the adjacent Stanley, Sawtooth, Vienna, and Atlanta districts. Many of the deposits appear to be related to dikes Mineral deposits in Boulder Basin and smaller deposits elsewhere are in Paleozoic rocks near intrusive porphyry complexes. Extensive areas of pyritized and hydrothermally altered rocks in and near these porphyry complexes suggest the possible presence of sulfide base-metal deposits at depth. Volcanic rocks within the study area, unlike those of the Yankee Fork district a few miles to the north, do not contain significant metallic deposits. Larger intrusive stocks within the study area contain few mineral deposits.

Many of the mineral deposits and mineralized areas are structurally controlled. Most common are veins along dikes, fractures, and faults, often at or near their intersections. The productive deposits in Germania Basin are in breccia along a gently dipping thrust fault, and some veins in Boulder Basin also are near thrust(?) faults. Ore bodies in the most productive mine, the Livingston mine, formed in a vein that follows a gently dipping shear zone and along a nearby parallel rhyolite porphyry dike. The newly developed Hoodoo zinc mine is a replacement deposit just below a regional unconformity. Other deposits replace calcareous rocks, or form in tactites at the margins or near the crests of intrusive rock bodies. Regionally, most tungsten and molybdenum deposits are in such tactites.

To aid systematic description of the mines and prospects, the Sawtooth National Recreation Area was arbitrarily divided into 14 districts. Ore was mined in 9 of these, and mineral production since 1902 from 7 districts is documented by U.S. Bureau of Mines records. Two districts have no record of prospecting activity and are not described Of the 14 districts, 9 are considered to have good mineral potential

The Little Boulder district contains a molybdenum deposit that consists of two possibly connecting zones estimated to contain 100 million and 35 million tons (91 million and 32 million t) of material, the weighted averages of which are 0.16 and 0.12 percent MoS_2, respectively The deposit is considered to be marginal in economic value. The district has few other prospects of economic interest and no recorded mineral production.

The Big Boulder district has yielded ore worth nearly $2,300,000 in lead, zinc, silver, copper, and gold values, mostly from the Livingston mine At the Livingston mine, about 50,000 tons (45,000 t) of material that contains about 0 005 oz gold per ton (0.0171 g/t (grams per metric ton)) and 4 oz silver per ton (137 g/t), 4 percent lead, 5 percent zinc, and 0 02 percent copper are estimated to remain in the main ore zones. An additional 30,000 tons (27,000 t) of lower grade material may be present at the Lakeview (Crater Lake) mine. The district is potentially favorable for discovery of additional mineral resources

The Slate Creek district reportedly yielded about $600,000 worth of metals before 1912 from the Silver Rule mine, which is now inaccessible Remaining mineralized bodies in the mine, if any, cannot be evaluated due to lack of data. The Hoodoo mine, the newest and only operating mine in the study area, contains 870,000 tons (790,000 t) of inferred reserves averaging 11.0 percent zinc, 0.47 percent lead, and 0 35 oz silver per ton (12 g/t) Zinc concentrates produced at the mine contain about 0 46 percent cadmium Two other properties in the district are each estimated to contain about 20,000 tons (18,000 t) of resources averaging 1.6 and 5.6 oz silver per ton (54.8 and 192 g/t), 2.7 and 3 3 percent lead, 0 8 and 1 4 percent zinc, respectively, and small amounts of antimony, copper, and cadmium The district has a good potential for the discovery of other, similar deposits.

The North Fork Wood River district produced ore worth more than $1,200,000 from Boulder Basin before 1890—mostly high grade silver-lead-gold ore from the Golden Glow mine, and the rest from the adjacent Boulder Consolidated properties Little ore has been produced since 1921 As much as 4,000 tons (3,600 t) of indicated reserves containing 0 05 oz gold per ton (1 7 g/t), 21 7 oz silver per ton (744 g/t), 8.7 percent lead, and 0 5 percent zinc are estimated to remain in accessible workings Fewer than 20,000 tons (18,000 t) of potential resources could be estimated because of the inaccessibility of major workings. Considering the rich ore formerly mined from the now-flooded part of the Golden Glow mine and current high gold and silver prices, larger minable resources could exist.

The Valley Creek district has yielded metal valued in excess of $500,000, principally from gold placers along Stanley Creek Production from lode deposits is valued at about $80,000. Most of the richer placer deposits were worked before 1914, but some of them might be reworked profitably at present higher gold prices if the fine gold that was not previously recovered could be retrieved Lode deposits in the Buckskin and Valley Creek mines may contain 295,000–410,000 tons (267,000–372,000 t) of resources with average grades of 0 06–0.25 oz gold per ton (2–8 5 g/t), 1.8–4.12 oz silver per ton (61.7–141.2 g/t), and 1.97–2 8 percent lead The Valley Creek mine contains most of the higher grade gold resources. At least seven electrical conductors that could indicate mineralized zones were detected near the Valley Creek mine, mostly in unexplored ground, and at least two of these are believed to be continuations of veins that locally contain high gold and silver values Some of the Valley Creek resources might be minable by open pit methods.

The Germania Creek district, which includes Germania and Washington Basins, yielded ore before 1890 valued at as much as $500,000, mostly from mines in Germania Basin The Idahoan and Old Bible Back mines in Germania Basin contain an estimated resource of about 38,600 tons (35,000 t) averaging 0.06 oz gold per ton (2.05 g/t) and 12 6 oz silver per ton (432 g/t), 4 27 percent lead, 1.02 percent zinc, 0.58 percent copper, and 0.45 percent antimony. Similar metal values were found at four other properties in Germania Basin.

No production is recorded from mines in the Washington Basin despite the presence of two old mills, but ore valued at between $50,000 and $175,000 may have been produced from these before 1890. Five veins in the basin contain more than 7 4 million tons (6.7 million t) of submarginal resources that average less than 0 05 oz gold per ton (1 7 g/t), and 1 0 oz silver per ton (34 28 g/t), and contain small amounts of lead, antimony, tungsten, tellurium, bismuth, and selenium Additional lead-silver-zinc resources may be discovered at several other properties in the Germania Creek district.

Three mines (Deer Trail, Confidence, and Rupert) in the Fourth of July Creek district have a recorded mineral production totaling about $7,400 in value Estimated resources at these three properties total 490,000 tons (444,000 t), with average grades of 0.17–10.65 percent lead, 0 93–3 84 percent zinc, and 0.26–4.4 oz silver per ton (8.9–150.8 g/t) A fourth property, the Meadow View, may contain about 14,500 tons (13,000 t) of resources averaging 0.22 oz silver per ton (7.54 g/t), 4 9 percent zinc, and 0 20 percent WO_3 At the Timberline prospect, resources are estimated to be at least 27,000 tons (24,000 t) averaging 9 3 oz silver per ton (318 8 g/t), 0 25 percent copper, 1 96 percent lead, 2.28 percent zinc, 0.63 percent antimony, and about 0 48 percent tin Small deposits of lead, silver, zinc, tin, copper, and antimony may be present at two other properties.

The Galena district contains 14 patented mining claims and produced unknown amounts of silver and lead, largely before 1900. Output from the deposits temporarily supported a 20-ton/day smelter at the Galena townsite. The district has been explored by hundreds of workings, most now caved and inaccessible. Four properties have estimated potential resources of 27,000 tons (24,000 t) averaging about 4 oz silver per ton (137 g/t) and 5 percent lead An additional 180,000 tons (163,000 t) of resources containing at least 4.4 percent zinc, about 0.4 oz silver per ton (13.7 g/t), and 1.0 percent lead are estimated for the Highland Chief property. About half this resource could contain 8–16 percent zinc. Several other prospects are promising Several silver-lead veins contain as much as 0 8–2.0 percent tin

Recorded mineral production from the Casino Creeks district is valued at approximately $33,000, with about 80 percent from gold placers Future gold and silver output from the district is likely to be negligible, but at least 200,000 tons (181,000 t) of fluorite resources, possibly averaging between 20 and 30 percent CaF_2, are estimated for deposits at the patented Giant Spar group of claims and for nearby prospects on unpatented claims

Principal resources of the Warm Springs Creek district are gold placer deposits at terraces along the Salmon River near Robinson Bar. These placer deposits produced gold valued at about $200,000. Gold-bearing veins are known at the Aztec mine. The mine was inaccessible and could not be evaluated, but gold ore is reported from the deepest workings and geochemical studies reveal a distinct gold anomaly about 5 mi (8 km) long that trends north through the mine area along the faulted east contact of the Idaho batholith Further exploration will be necessary to determine the gold potential of the area.

Prospects in the Vienna district contain antimony, tungsten, gold, silver, lead, and minor amounts of molybdenum, copper, and mercury The gold, silver, and lead values are much lower in these prospects than in the once productive mines in part of the district south of the study area. The district has some potential for antimony and, near the Idaho batholith, for tungsten and molybdenum.

Gold has been produced from at least 12 placers on Stanley Creek and from the Salmon River and its tributaries in the Valley Creek, Casino Creeks, and Warm Springs Creek districts Evaluation of the gold placer resources would require extensive drilling, but parts of the placers may be minable at high gold prices Gold content of 268 widely scattered samples panned from near-surface material and from shallow pits at the placer deposits ranged from 0 to 0.0228 oz/yd^3 (0.928 g/m^3). The highest average gold content from surface samples was 0 0026 oz/yd^3 (0.105 g/m^3). Surface samples are not considered representative of placer deposits, as the relatively coarse gold typically is concentrated near bedrock Therefore, higher average gold values usually are found in deeper parts of the placer deposits The gold placers on upper Valley and Stanley Creeks possibly could be profitably mined, and some older terrace deposits might be reworked by modern methods and at higher prices

Twelve thermal springs were tested as possible sources of geothermal power, but were found to have little potential for such use.

INTRODUCTION

The Sawtooth National Recreation Area in south-central Idaho consists of the Sawtooth Wilderness and a large mountainous area to the east that includes the White Cloud Peaks and the Boulder Mountains.

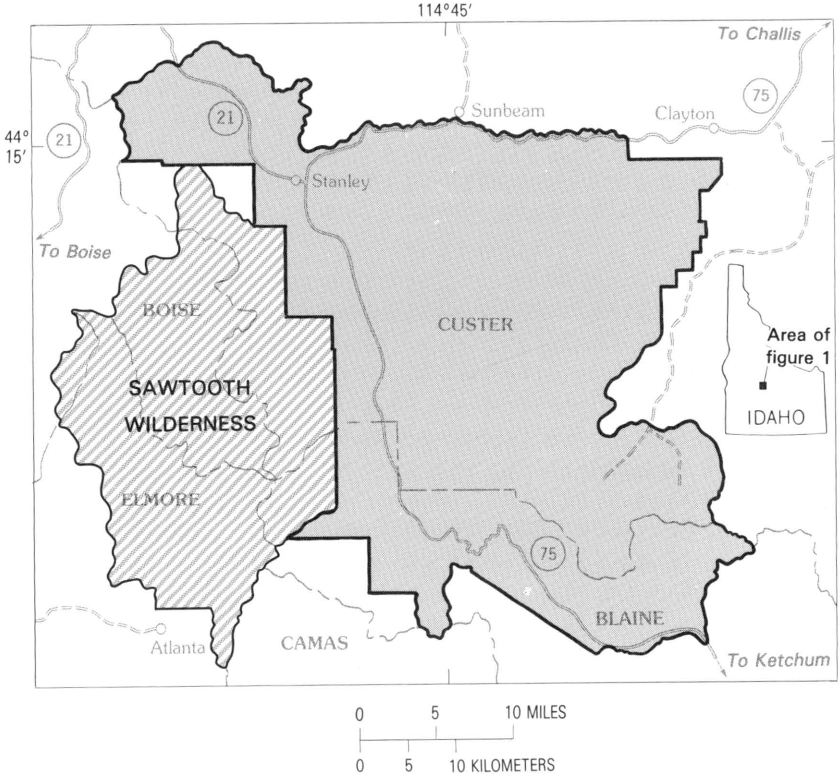

FIGURE 1.—Index map showing location of Sawtooth National Recreation Area, Idaho. Western part is the Sawtooth Wilderness. Study area shaded.

This report presents the results of a mineral survey of the eastern part of the recreation area, which covers 510,000 acres (2,060 km^2) of Blaine and Custer Counties and includes part of Challis and Sawtooth National Forests (fig. 1). A similar, earlier survey of the Sawtooth Primitive Area was published as U.S. Geological Survey Bulletin 1319-D (Kiilsgaard and others, 1970), and another study of the Boulder-Pioneer area that adjoins the southeast corner of the recreation area is also available (U.S. Geological Survey and U.S. Bureau of Mines, 1981). Much of Sawtooth Valley and scattered patented claims in various mining districts are privately owned. The part of the recreation area investigated in this report will be referred to as the "study area."

Sawtooth Valley, in part known as Stanley Basin, occupies the western part of the study area. The western boundary of the area studied conforms to the eastern boundary of the Sawtooth Wilderness (Kiilsgaard and others, 1970) and locally differs from the Sawtooth Recreation Area boundary, as defined by the U.S. Forest Service (fig 1) East from the town of Stanley, the north boundary of the study area more or less follows the ridge crest parallel to but immediately north of the Salmon River The East Fork Salmon River is the approximate east edge of the area, and the southern part of the area is drained by the upper reaches of the Big Wood River and its tributaries

The high peaks and ridges of the White Cloud Peaks and Boulder Mountains are mostly barren and rocky. Former glaciers carved steep-walled cirques and scoured U-shaped valleys along major tributaries of the Salmon River Lateral and terminal moraines were deposited in the lower reaches of these valleys.

The area is readily accessible via State Highway 75, an oil-surfaced, all-year road that follows the Salmon River along the northern border of the study area, connecting the towns of Clayton at the northeast corner and Stanley in the northwest, and thence southeastward through the Sawtooth Valley, over Galena Summit, and down the Big Wood River to Ketchum, 8 mi (13 km) south of the boundary State Highway 21 connects Stanley with Boise, 130 mi (210 km) to the west. Numerous side roads, mostly unpaved, extend for various distances into the country on either side of the main highways In the western part of the Sawtooth Valley, roads provide access to Redfish, Yellow Belly, Pettit, and Alturas Lakes, and others extend up Beaver, Smiley, and Frenchman Creeks The region east of the valley is accessible from roads along Fisher, Fourth of July, and Pole Creeks Roads from State Highway 21 in the northwest corner of the area extend up Stanley, Elk, and Valley Creeks, and trails from the ends of some of these roads provide foot or horseback access to the higher country The northern part of the area is accessible from State Highway 75 by a road up Slate Creek to the Hoodoo mine and by jeep trails from this road up Silver Rule and Livingston Creeks.

A road that extends up the East Fork Salmon River and branch roads that extend up Big Boulder Creek to the Livingston mine and up West Pass Creek (Ryan Peak quadrangle) to various prospects provide primary access to the eastern part of the area. Trails from these roads extend to more inaccessible parts of the study area.

Access to the southeast corner of the area is from roads that extend from State Highway 75 short distances up Westernhome Gulch, Gladiator, Senate, Spring, King, and Silver Creeks. Longer roads extend up Boulder Creek to the mines in Boulder Basin and up the North Fork Big Wood River These roads are supplemented by trails, especially in the North Fork drainage.

The winter climate is severe with low temperatures and heavy snowfall, especially at the higher elevations Many roads into the back country are closed until early summer due to high water, snowbanks, and fallen timber Access to the remote parts of the area is limited to the months of July, August, and September.

PREVIOUS STUDIES

The earliest published geologic study was made in 1912 by Umpleby (1915) during a 12-day reconnaissance of the Sawtooth 30-minute quadrangle, which includes the southwest part of the study area. Umpleby and Livingston (1920) reported briefly on gold-silver mines and placers of the Valley Creek drainage. Ballard (1922) described the geology and ore deposits of the Alturas quadrangle, and Ross (1927) mapped the Vienna district, part of which is just south of the area. Ross (1937) also mapped the Bayhorse quadrangle and parts of the Custer and Sawtooth quadrangles, including most of Sawtooth Valley, and briefly described many of the mineral deposits. Williams (1961) studied the glacial geology of Sawtooth Valley. Kern (1959) and Choate (1962) described the geology and ore deposits of the Stanley area. Reid (1963) described the geology of the Sawtooth Range. Kiilsgaard, Freeman, and Coffman (1970) studied the mineral resources of the Sawtooth Primitive Area. Shannon (1971) wrote on geology and geochemical exploration of the Vienna district In 1971, Kern (1972) mapped most of the Slate Creek drainage and studied the mineralogy of many mines and prospects from the Livingston mine north to Salmon River The Washington Peak quadrangle (pl 1, index) was largely mapped by Seeland before the present project was begun, but the results were not previously published.

Several mining properties in the area were investigated by the U S Bureau of Mines prior to this study During the period 1949–1955, studies of radioactive placer deposits were made by the U.S. Bureau of Mines for the U S Atomic Energy Commission Churn drilling and trenching were done on selected areas within this study area and the results were published by Eilertsen and Lamb (1956) and Storch and Holt (1963) Several unpublished War Minerals and Defense Minerals Exploration Administration reports by the U S. Bureau of Mines and the U S Geological Survey describe exploration at several properties in the study area, and many of the data are incorporated in this report

PRESENT INVESTIGATION AND ACKNOWLEDGMENTS

Present investigations were divided between the U S. Geological Survey and the U.S Bureau of Mines, and the findings are presented in this report as separate but complementary chapters. Interim results of each study were used by both organizations during the course of the work in order to better evaluate the mineral resources of the area. The U S Geological Survey was responsible for geologic mapping, geochemical and geophysical surveys, and for systematic sampling and evaluation of the study area outside the known ore deposits The geologic mapping was done largely on 1:24,000 topographic base maps, on aerial photographs, and partly on the 1:62,500 composite topographic-planimetric base map that was a working base for plate 1. Anomalous and mineralized areas identified by the work were further evaluated by detailed geochemical studies of closely spaced stream-sediment, soil, and rock samples and (or) by electromagnetic surveys. Particular care was given to study of the geologic factors involved in formation of the mineral deposits and to the evaluation of the long-range mineral potential of the area.

The U.S. Bureau of Mines was responsible for mining claim data, for sampling and evaluation of known mines, prospects, and placer deposits, for calculation of mineral reserves, compilation of mineral production data; and evaluation of potential geothermal resources Claim locations are from courthouse records at Challis, in Custer County, and at Hailey, in Blaine County Production records are from statistical files compiled from 1902 to the present and from other sources for the period prior to 1902. The data prior to 1902 commonly are highly generalized and their validity cannot be verified Records and survey plats of patented claims are from the U S. Bureau of Land Management, Boise, Idaho.

Each agency used different, complementary sampling and analytical methods appropriate to their separate tasks The U S Bureau of Mines evaluations of mines and prospects are based, as far as feasible, on representative samples and standard assays of as many as 6 selected elements for determination of average grade; most rock samples collected from mines and prospects by the U.S. Geological Survey were of the highest grade material readily available and were analyzed by semiquantitative spectrographic analyses for 30 elements and by quantitative methods for the 6 to 9 elements of greatest economic interest The primary objective was to detect and measure all potentially valuable elements and their geochemical associations. Analytical data from all parts of the report are needed to fully evaluate the economic potential of many deposits.

The appraisal of potential mineral resources by the U S Geological Survey is based on geologic studies, on Bureau of Mines property evaluations, and on analyses from 4,636 samples, collected by Geological Survey personnel. The localities of most of these samples are shown on plate 2 The few remaining sample localities that are too closely spaced to be shown on plate 2 are plotted on larger scale maps Complete analyses of rock samples that exceed minimum values established for one or more of 13 elements are tabulated (table 2) Analyses of 14 selected elements are presented on 18 computer-generated anomaly maps (figs 4–21), which are discussed later in the text.

Field work by the U S Geological Survey was done by three field parties working independently in 1971 and two parties in 1972. Mapping and sampling credits are shown on the geologic and sample locality maps (pls 1, 2) Field work was done largely on foot aided by four-wheel vehicles, trail bikes, and helicopter. Geological Survey authors were ably assisted in the field by Gilbert Aguilar, P D. Erickson, and Earl H Bennett, III, in 1971, and by Erickson, Bennett, Dennis Bird, Steven R. Munts, and Dario Barrero Lozano in 1972.

Field work by the U S Bureau of Mines during the 1971 and 1972 field seasons totaled 47 man-months. Bureau of Mines authors were assisted in the field work by Edwin West, Rodney Vaughn, Stephen Brown, Robert Codd, John Mitchell, Richard Newcomb, Paul Pierce, John Roskelly, and Steven Schmauch.

Samples collected by the U S. Geological Survey and most of those collected by the U.S. Bureau of Mines in 1971 were analyzed in a field laboratory of the U.S. Geological Survey under the supervision of R W Leinz Semiquantitative spectrographic analyses of the samples were made by David F. Siems assisted by Richard N. Babcock and Charles D Smith, using analytical methods described by Grimes and Marranzino (1968) Chemical analyses were performed by R. W. Leinz, J D Hoffman, J R Hassemer, S H Truesdell, and L. A. Vinnola using atomic absorption (Ward and others, 1969), colorimetric tests (Ward and others, 1963), and mercury vapor detection (Vaughn and McCarthy, 1964) Selected samples were analyzed for fluorine and molybdenum in the Denver laboratories of the U S Geological Survey Samples collected by the Bureau of Mines also were assayed by the Bureau's analytical laboratory at Reno, Nev.

Analytical data from Geological Survey samples were stored in the computer. Retrieval and statistical analysis of stored data were under the direction of Lamont O Wilch and S. K McDanal. Glenn H. Allcott, U S Geological Survey, supervised the preparation of computer-generated geochemical anomaly maps.

Electromagnetic traverses were made at the Valley Creek and Buckskin mines and across promising geochemical anomalies in the Mill Creek and Grand Prize Gulch areas by Frank C. Frischknecht, assisted by Charles L. Tippens and Steven R Munts. Munts later made additional electromagnetic surveys in the Mill and Sheephead Creeks and Grand Prize areas.

We thank the many property owners for their cooperation and the U S Forest Service personnel of the Challis and Sawtooth National

Forests for assistance given the project, especially Tom Kovelicky, district ranger at Stanley, Idaho. Special acknowledgment is due American Smelting and Refining Co. for permission to use unpublished mapping and other data relative to the Little Boulder molybdenum deposit We also acknowledge the help of local residents, including George Castle, Leroy Davis, Elmer Enderlin, Fletcher Fisher, Ruth Halvorsen, Cliff Larsen, O J. Neeley, Paul Reed, Martin Pollack, Stanley Schindler, E. H Swanson, and Vern Taylor III, most of whom are claim owners.

Thanks are due Richard Kern (1972), who studied part of the Slate Creek district and supplied both agencies with copies of his thesis.

ECONOMIC POTENTIAL

Parts of the study area have good economic potential, and new minable deposits could well be discovered by diligent exploration This conclusion is supported by the discovery and (or) development since 1950 of molybdenum, silver, zinc, tungsten, and uranium deposits within or near the study area. It is further supported by discovery during the present study of veins and promising geochemical anomalies enriched in the common metals of commerce. Some of these deposits also contain cadmium, bismuth, and tin, which might be recoverable as coproducts Potential mineral resources of the study area are estimated to have a worth that exceeds that of total historic production by a factor between 100 and 200 Other identifiable mineral resources, for which data are insufficient to determine monetary values, and as yet undiscovered resources may be expected to add further to the total value of the area.

Increases in the prices of gold and silver during the course of this study have enhanced the value of the reserves at the Valley Creek mine and the potential resources in the gold placer deposits on Valley and Stanley Creeks, as well as the value of the silver, gold-silver, and silver-lead deposits in other parts of the area.

The study area has been geologically mapped, sampled, and evaluated within the time and man-power limits imposed by the project Much has been learned, but much more must be done before a full understanding of its overall potential is realized. Most of the surrounding region has received far less attention and may have equal or greater potential It is reasonable to assume that more detailed geological and geochemical work and the application of more sophisticated exploration techniques that have been developed in the last few decades could outline minable reserves of base and precious metals in the study area and the surrounding terrain.

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Geology of the Eastern Part of the Sawtooth National Recreation Area, Idaho

By CHARLES M TSCHANZ, THOR H KIILSGAARD, *and* DAVID A SEELAND, U S GEOLOGICAL SURVEY

MINERAL RESOURCES OF THE EASTERN PART OF THE SAWTOOTH NATIONAL RECREATION AREA, CUSTER AND BLAINE COUNTIES, IDAHO

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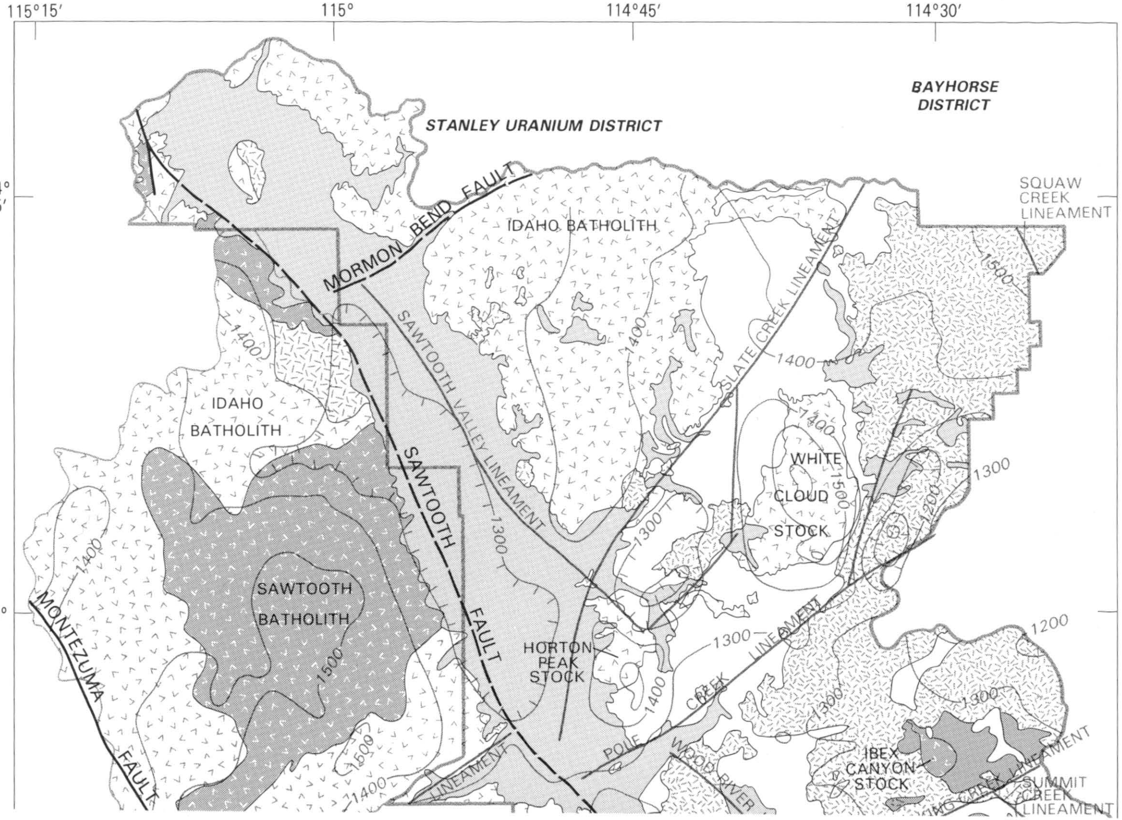
GEOLOGIC SETTING

The eastern two-thirds of the Sawtooth National Recreation Area, the study area of this report, is along the east edge of the Idaho batholith near its south end. Rocks of the batholith, which occupies about 25,000 mi^2 (64,750 km^2) in central Idaho, underlie most of the northwestern one-third of the study area. Marginal parts of the much smaller and younger Sawtooth batholith, which occupies much of the adjacent Sawtooth Wilderness Area to the west (fig 2), locally project into the area, and several small plutons of various ages occur farther east

Rocks into which these batholiths and small plutons are intruded include metamorphosed sedimentary rocks of probable Precambrian age and a complex sequence of sedimentary rocks ranging in age from Ordovician to Permian

The Paleozoic sedimentary rocks crop out as a broad north-south band through the central part of the study area and again in the southeast corner, beyond which they extend southeasterly for many miles in the Boulder and Pioneer Mountains Similar sedimentary rocks also crop out north and northeast of the study area. Most of the eastern one-third of the study area, like much of the region to the north, east, and south, is extensively blanketed by the Challis Volcanics that obscure large areas of the Paleozoic sedimentary rocks.



115°15′
115°
114°45′
114°30′
44° 15′
44°
BAYHORSE DISTRICT
STANLEY URANIUM DISTRICT
MORMON BEND FAULT
IDAHO BATHOLITH
SQUAW CREEK LINEAMENT
SLATE CREEK LINEAMENT
SAWTOOTH VALLEY LINEAMENT
IDAHO BATHOLITH
SAWTOOTH FAULT
WHITE CLOUD STOCK
SAWTOOTH BATHOLITH
MONTEZUMA FAULT
HORTON PEAK STOCK
POLE CREEK LINEAMENT
WOOD RIVER
LINEAMENT
IBEX CANYON STOCK
SUMMIT CREEK LINEAMENT
1200
1300
1400
1500

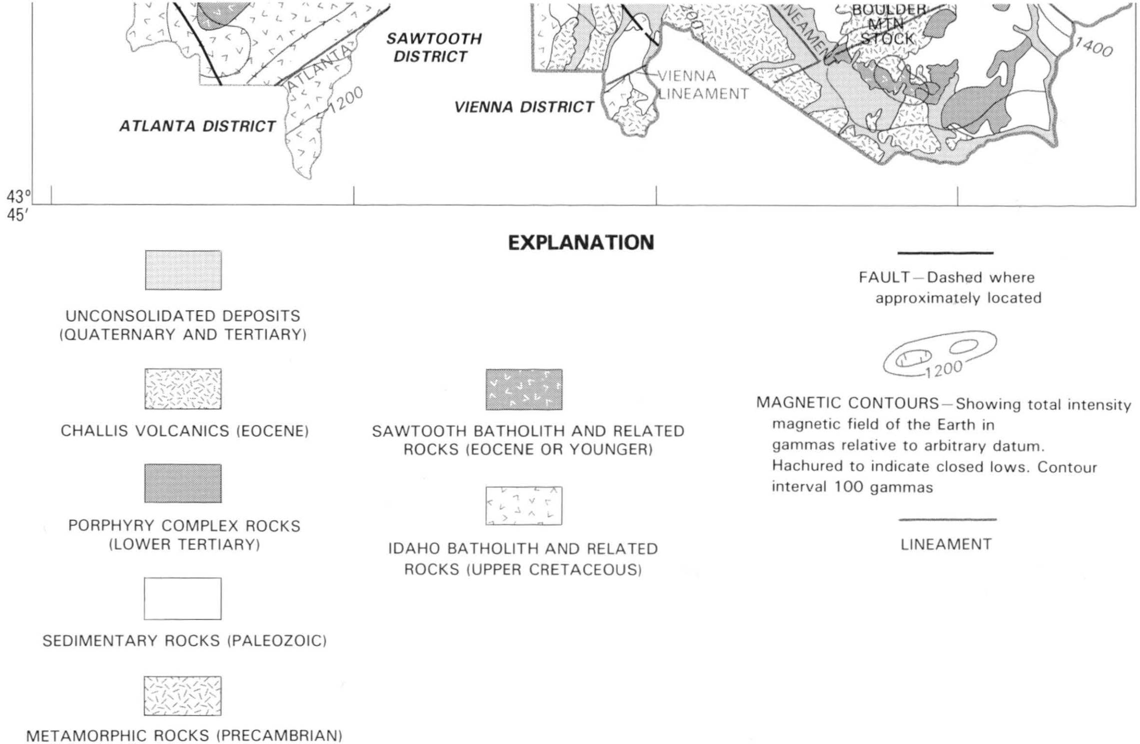


FIGURE 2.—Generalized geologic map of the Sawtooth National Recreation Area, Idaho, showing aeromagnetic contours, lineaments inferred from magnetic and geologic data, and adjacent mining districts.

The Paleozoic strata were strongly deformed by folding and thrust faulting before they were intruded by igneous rocks Subsequent steep normal faulting has displaced these earlier structures as well as the overlying Challis Volcanics A major steeply dipping fault zone along which the Sawtooth Mountains were uplifted marks the western margin of the Sawtooth Valley (fig. 2). Most of its trace along the valley is buried by unconsolidated Quaternary gravels and glacial debris

SEDIMENTARY ROCKS

PRECAMBRIAN(?) METASEDIMENTARY ROCKS

THOMPSON PEAK FORMATION OF REID (1963)

Sericite and biotite schist similar to the Thompson Peak Formation of Reid (1963) crop out on Elk Mountain northwest of Stanley Lake and on both sides of Valley Creek, near the junction of the Stanley Lake road and State Highway 21 (pl 1) Biotite and graphite schist, which strikes northeast and dips northwest at the north end of Elk Mountain, appears to overlie sericite schist. Interfoliated with the biotite schist are stringers and lenses of garnet-rich skarn and quartz that range from a fraction of an inch to several feet (1 cm to 1 m) in thickness Granitic gneiss crops out at the north end of the mountain near the intrusive contact with the Idaho batholith

The metamorphic rocks east of Valley Creek near the junction of the Stanley Lake road with State Highway 21 are chiefly crenulated, coarse-grained marble and some interbedded quartzite Flecks of graphite, diopside(?), and garnet occur in the marble This marble is identical to rocks along Fishhook Creek east of Thompson Peak, which is about 7 mi (11 2 km) southwest of Stanley in the Sawtooth Wilderness

Similar schists of possible Precambrian age are in the Pioneer Mountains to the southeast (Umpleby and others, 1930, p 11; Dover, 1969, p 8) and in the Casto quadrangle to the north (Ross, 1934, p 22) Inclusions of schist in the northern part of the White Cloud stock suggest that a regional basement of schist underlies the known Paleozoic rocks east of Sawtooth Valley Precambrian age for the Thompson Peak Formation, as proposed by Reid (1963), seems to be valid

PALEOZOIC SEDIMENTARY ROCKS

UNDIVIDED ORDOVICIAN AND SILURIAN(?) ROCKS

Rocks of Ordovician and Silurian(?) age crop out in two small isolated areas in the study area. (1) in the northeast corner and (2) in Cougar Canyon (Ryan Peak quadrangle) near the eastern boundary (pl 1)

In the northeast corner of the area, the sedimentary rocks are exposed in fault blocks and erosional windows in Challis Volcanics, part of a structurally complex north-trending belt of lower Paleozoic rocks that lies almost entirely outside the study area Clayton Mine Quartzite of Middle Ordovician or older age (Hobbs and others, 1968, p J15–J17) crops out north and east of Potaman Peak Siltstone that crops out west of this locality is probably Saturday Mountain Formation of Middle and Late Ordovician age (Ross, 1937, p 19) Impure Silurian(?) quartzite and siltstone southwest of Potaman Peak were mapped by Ross (1937) as Ramshorn Slate of Ordovician age Dark-gray carbonaceous siltstones in Cougar Canyon (pl. 1) contain very poorly preserved graptolites of probably Middle or Late Ordovician age (W. B. N. Berry, written commun , 1971)

MILLIGEN FORMATION

The Milligen Formation of this report includes rocks essentially the same as those originally described and mapped in the Wood River region (Umpleby and others, 1930, p 25–29) Rocks of the Milligen Formation are recognized in the southeast corner of the study area, south and southeast from the Ibex Canyon stock, and along the East Fork Salmon River within several miles of the Bowery Guard Station

The Milligen Formation consists mostly of dark-gray, fine-grained carbonaceous or graphitic, chlorite-bearing subphyllite that parts along the bedding, can be scratched with a fingernail, and feels greasy. The subphyllite, which commonly has a lineation formed by crinkle-cleavage, is interbedded with quartzite and silty orange-weathering dolomitic limestone. The quartzites are commonly thin bedded and fine grained, and they resemble chert, they are commonly near the top of the formation in the drainages of the North Fork Big Wood River and the East Fork Salmon River.

As originally described by Umpleby and others (1930), the basal part of the Milligen Formation in the type locality east of Ketchum, Idaho, was considered to be Devonian, but the remainder of the formation was thought to be Mississippian in age. Recent studies of the Milligen Formation in the type locality, however, have shown that the youngest rocks contain Late Devonian conodonts, identified independently by Charles A Sandberg and John W Huddle, U S Geological Survey (written commun., 1971, 1972).

Stratigraphic relations between the Milligen Formation and older and younger sedimentary rocks are uncertain in the study area. The base of the formation is not exposed, and the upper contact with the overlying Wood River Formation is believed to be unconformable. Many exposures of the formation are in thrust fault contact with other rocks North of Pole Creek, Ross (1937) included in the Milligen Formation much dark-gray calcareous sandstone and sandy limestone, which in this report are assigned to the overlying Wood River Formation Because of the questionable age of the rocks, the remaining part of Ross's Milligen Formation, north of Pole Creek, is described separately in this report as Mississippian rocks, undivided.

MISSISSIPPIAN ROCKS, UNDIVIDED

Dark-gray argillite and quartzite and some medium-gray limestone characterize a unit of Mississippian rocks, undivided that crop out in a belt from the Salmon River south to the center of the study area. These rocks are tightly folded and the internal stratigraphy is obscure

Differences in lithology are evident from place to place, but whether these differences are the result of facies or stratigraphic changes is not known Near Salmon River the Mississippian rocks contain about 200 ft (61 m) of noncalcareous light-colored quartzite that is bimodal, the pelitic rocks are increasingly phyllitic eastward To the south the unit is more argillitic, and a few lenticular beds 20–30 ft (6–9 m) thick of coarse-grained recrystallized limestone are in the upper part.

Contact-metamorphic effects in the Mississippian rocks, undivided are in most places evident only in limestone that has been recrystallized However, on the north side of Washington Basin, argillite, previously mistaken for Wood River Formation, has been bleached to a medium-gray rock for several hundred feet from the contact with hornblende quartz diorite.

The age of the unit is known only from conodonts from limestones collected by S Warren Hobbs, U.S Geological Survey, from three places along the Salmon River Oster Gulch (just west of Thompson Creek), lower Mill Creek, and near the small gulch opposite the mouth of Slate Creek The conodonts were assigned to the Late Mississippian (Meramecian) age by J W. Huddle (written commun., 1972, 1973). Some rocks in the unit may be older.

The Mississippian rocks, undivided, although generally finer grained and of somewhat different lithology, are correlated with part of the Copper Basin Formation, probably the lower Muldoon Canyon and (or) upper Scorpion Mountain Formations of Paull and others (1972) This part of the Copper Basin Formation is Meramecian(?) to early Chesterian and Kinderhookian to Osagean(?) in age, respectively, according to Betty Skipp (written commun , 1972) The Mississippian rocks, undivided lack the abundant pebble and granule conglomerates that are characteristic of much of the Copper Basin Formation and probably represent a basin facies farther from the source area.

WOOD RIVER FORMATION

The Wood River Formation was named originally by Lindgren (1900, p. 89) to include all of the argillite, sandstone, limestone, and conglomerate of the Wood River area. Subsequently the formation was restricted to Pennsylvanian and Permian rocks by Umpleby and others (1930), who separated the Wood River and Milligen Formations Later the Wood River Formation was divided into four units by Thomasson (1959) and still later into seven units by Hall and others (1974), who excluded the uppermost noncalcareous units as a part of an overlying unnamed formation. Similar uppermost noncalcareous rocks are mapped in the highest unit of the Wood River Formation in this report

All seven units recognized by Hall and others (1974) were mapped in different combinations in various places in the study area (pl 1) Unit 1, the basal conglomerate, was mapped separately where thick enough to be shown, as were the highest rocks, unit 7, except at some localities north of Pole Creek where units 2-7 were mapped as a single unit. The formation was mapped as two units in the Boulder Mountains.

The Wood River Formation comprises the most widely distributed Paleozoic rocks in the study area. Unlike rocks of the Milligen Formation, the Wood River rocks generally do not show evidence of regional or dynamic metamorphism. The formation contact with underlying rocks is probably everywhere an unconformity or a thrust fault, but only locally and southeast of the study area is there an obvious angular discordance

The Wood River Formation has been studied in detail in the Wood River district 25 mi (40 km) to the south by Hall and others (1974), where a minimum of 9,800 ft (2,990 m) of section was measured. In the study area, along Fourth of July Creek, an incomplete measured section that includes part of unit 3 through the lower part of unit 7 is about 6,970 ft (2,125 m) thick. Unit 5 was not identified, the lowest part of unit 7 may be faulted out because the cherty basal part identified south of Pole Creek is not present. In the cirque south of Six Lakes, the Hailey Conglomerate Member (unit 1) is about 3,000 ft (940 m) thick, elsewhere in the study area it is much thinner or absent. An estimate of more than 10,000 ft (3,040 m) of Wood River Formation in the study area appears to be reasonable.

Units mapped south of Pole Creek are referred to as lower, middle, and upper parts of the Wood River Formation. The lower part is of Middle Pennsylvanian (Des Moinesian) age and consists of basal conglomerate (unit 1), limestone (unit 2), and pink-weathering shaly limestone (unit 3). The thick middle part of Late Pennsylvanian (Virgilian) to Early Permian (Wolfcampian) age consists predominantly of fine-grained, brown-weathering, calcareous sandstone (units 4 and 6) and brittle vitreous quartzite (unit 5) Massive quartzite with local phyllite partings occurs in what is considered to be the uppermost part of unit 6 The upper part (unit 7) of Early Permian (Wolfcampian) age consists of dark-gray, generally thin bedded chert and sandy limestone near the base, and siliceous sandstone, laminated siltstone, and quartzite in the upper part

LOWER PART (UNITS 1, 2, AND 3)

Unit 1—The Hailey Conglomerate Member (Thomasson, 1959, p 52–54) is mostly a massive conglomerate that locally contains beds of quartzite, brown sandy limestones, or gray limestone. The conglomerate consists of predominant well-rounded to angular pebbles and cobbles of silicified siltstones or quartzites that resemble cherts, white to medium-gray quartzite, and locally of vein quartz, argillite, and limestone or sandy limestone in a sandy matrix. The number, size, and lithology of the pebbles vary from one area to another. The silicified siltstone and quartzite may have been derived from the Milligen Formation North of Pole Creek angular quartzite pebbles and platelike fragments predominate

In the study area the Hailey Conglomerate Member ranges from zero to about 3,000 ft (940 m) in thickness but rarely exceeds 300 ft (94 m) It is absent or very thin at many places where cut out or thinned by thrust faulting as in the drainage of the North Fork Big Wood River Elsewhere, nondeposition or prelithification slumping may account for its variable thickness and local absence The proposed thickness of the Hailey Conglomerate Member is only 6–20 ft (2–6 m) near the Livingston mine, Bowery Guard Station, east of Kent Peak, and elsewhere Where this thin, it was mapped with units 2 and 3

Unit 2—This unit, in its type area near Bellevue in the Wood River District to the south, is a distinctive, medium- to thick-bedded, bluish-gray limestone about 50 ft (15 m) thick that usually contains abundant fossils, including crinoid columnals, bryozoa, brachiopods, and, locally, large horn corals In the study area, unit 2 commonly is between 50 and 100 ft (15 and 30 m) thick, and the lithology is generally similar. Locally, however, it has changed so that in the area between Ryan and Kent Peaks it consists of dark-gray limestone only about 30 ft (9 m) thick that contains abundant large white crinoid stems and conodonts (*Hindeodella* sp. and *Idiognathodus* sp). Farther north, near the Bowery Guard Station, the limestone is either absent or is so silty and sandy that it is difficult to distinguish from the overlying unit 3 However, still farther north on Railroad Ridge and on Slate Creek fossiliferous sandy limestone of unit 2, 30–50 ft (9–15 m) thick, has been recognized.

Unit 3—In the Wood River drainage, unit 3 is mostly thin bedded, gray to light-brownish-gray shaly or silty limestone that characteristically weathers pink or purplish gray. It forms thin slabs that mask the outcrops in most places. The fresh rock is generally medium to dark gray. In the southern part of the study area, the unit is similar to that in the 711-ft (217-m) section measured by Hall and others (1974) north of Bellevue, except for the absence of some thick-bedded, bluish-gray limestone noted by them. In most of the rest of the study area, unit 3 is much thinner and weathers tan to light grayish brown instead of predominantly pink or purplish gray.

The lower part of the Wood River Formation (units 1, 2, and 3 combined) is about 1,200 ft (366 m) thick in the southern part of the area, and probably about as thick in the northern part, although no complete section was measured.

MIDDLE PART (UNITS 4, 5, AND 6)

The middle part of the Wood River Formation consists predominantly of fine-grained calcareous sandstone or quartzite (units 4 and 6) that are separated by a thick section of light-gray or brown, brittle, vitreous silica-cemented orthoquartzite (unit 5)

Units 4 and 6.—Fresh rocks of units 4 and 6 are medium-gray to medium-dark-gray calcareous sandstone that weather, especially on talus slopes, to a brownish porous rock from which the carbonate cement has been leached. Though somewhat similar, units 4 and 6 can be distinguished by the greater abundance of grayish-brown limestone and calcareous quartzite in unit 4 and by the greater abundance of fusulinids in unit 6 Unit 6 characteristically weathers yellowish brown to reddish brown in the Wood River drainage

Unit 5—This unit consists of orthoquartzite that weathers brown and is commonly shattered. It is easily mapped where its full thickness and the adjacent rocks are exposed; otherwise, it is difficult to distinguish from quartzites of the upper half of unit 6. In southeastern Boulder Basin, units 6 and 7 are thrust over lower units of the Wood River Formation Quartzite at that locality was mapped as unit 6, but it is similar to and could be assigned to unit 5.

The thicknesses of units 4, 5, and 6 were not measured south of Pole Creek, but could reasonably approximate the thickness of 694, 545, and 5,694 ft (203, 116, and 1,727 m), respectively, measured by Hall and others (1974) in the Wood River region farther to the south In the apparently continuous measured section of units 4 through 6 on Fourth of July Creek, unit 5 probably is present even if not recognized and is included in the total thickness of about 4,400 ft (1,342 m)

UPPER PART (UNIT 7)

Unit 7—The upper part of the Wood River Formation, unit 7, has been recognized throughout the study area, but it has not been mapped separately at all places north of Fourth of July Creek because of lithologic and structural complications In the southern part of the study area, the top of unit 7 is not exposed

In the study area, the lithology and thickness of unit 7 differ from the type section to the south, which consists of 1,730 ft (527 m) of interbedded gray sandy limestone, gray calcarenite and thin-bedded dark-gray chert in fault contact with rocks of unit 6 (Hall and others, 1974). Most lithologic differences are the result of facies changes, by which noncherty rocks thicken at the expense of cherty rocks. Thickening of the unit also probably has resulted from inclusion of several hundred feet of rocks mapped outside the study area as components of the Permian part of unit 6, and also by inclusion of conformable younger Permian rocks overlying the Wood River Formation

Rocks of the Wood River Formation, particularly those of unit 7, are difficult to correlate across Pole Creek. Differences in lithology and thickness may be the product of a buried structure along the drainage, a structure suggested by the aeromagnetic map (pl 1)

South of Pole Creek the lower part of unit 7 consists of a cherty sequence 200 feet (61 m) thick, composed of thin-bedded black chert and interbedded sandy limestone, laminated siltstone and thin-bedded calcareous quartzite. In that locality the lower contact of the cherty sequence was mapped at the color change between typical reddish-brown-weathering rocks of unit 6 and the overlying dark-gray, thinner bedded rocks of unit 7 The cherty sequence also forms the basal part of unit 7 south of Grand Prize Gulch, but north of the headwaters of the gulch the basal part is a fossiliferous conglomeratic sandy limestone 100–200 ft (30–60 m) thick, which suggests an unconformity Elsewhere, the conglomeratic section is much thinner or absent and fossiliferous conglomeratic limestone or calcarenites may occur locally several hundred feet above the basal contact

North of Pole Creek, the basal cherty sequence is overlain by a heterogeneous noncherty sequence, which, east of Horton Peak, may be 4,000 ft (1,219 m) thick Generally, rocks in the upper part of the unit are dark-gray to black sandy and silty limestone, calcareous sandstone, and siltstone Locally, the sandstone is quartzitic. On Fourth of July Creek, the upper part of unit 7 consists of about 1,700 ft (520 m) of dark- to medium-gray, thinly laminated to medium-bedded calcareous quartzite, sandy limestone, and limestone East of Horton Peak, distinctive rusty-weathering, gray, fine-grained sandstone is overlain by black conglomeratic limestone, the youngest Paleozoic rocks found in the study area.

Unit 7 is less fossiliferous than unit 6. Early Permian conodonts (T522F) identified by J. W. Huddle, and fusulinids (T580F) identified by G. A. Weber were found near the Pole Creek road and north of the headwaters of Grand Prize Gulch, respectively Fernlike feeding trails and worm burrows are common in sandy beds, and some of the conglomeratic calcarenites and limestones contain crinoidal debris and (or) fusulinids

Rocks of uncertain age tentatively assigned to unit 7 and queried on plate 1 include dark-bluish-gray massive siliceous quartzite and siltite northwest of Galena Summit. Post Wood River rocks also may be present in structurally complex areas north and west of Ryan Peak, where massive, streaky-banded, dark-colored siliceous siltstones and quartzites predominate and north of the East Fork of North Fork Big Wood River where bleached(?), light-gray, brown-weathering quartzites alternate with darker beds. The rocks in both areas are intruded by numerous porphyry dikes that make up 30–60 percent of the total volume

INTRUSIVE ROCKS

Intrusive rocks of the study area are divided into four groups, (1) the Idaho batholith, the White Cloud, the Horton Peak stocks, and granitic rocks of the Washington Basin of Late Cretaceous age, (2) dacite porphyry stocks, dikes, and sills of early Tertiary age, (3) Sawtooth batholith, Boulder Mountains and Ibex Canyon stocks, and related smaller bodies of Eocene or younger age, and (4) Tertiary dikes and sills of several types

The White Cloud, Horton Peak, and Ibex Canyon stocks, several smaller bodies, and much of the Idaho batholith consist largely of similar porphyritic biotite quartz monzonite that contains pink phenocrysts of potassic feldspar. The Sawtooth batholith and Boulder Mountains stock consist of similar pink equigranular granite, except the grain size of the batholith is coarser The Idaho batholith is more variable in composition and mineralogy, particularly near the eastern margin, than the stocks Marginal rocks of the batholith contain hornblende and, locally, pyroxene, as well as three varieties of biotite.

IDAHO BATHOLITH

The Idaho batholith underlies most of the northwest quarter of the study area and also crops out in the southwestern part It forms somewhat rounded, forested mountains on which outcrops are common, particularly along ridges.

The Idaho batholith consists mainly of several types of porphyritic quartz monzonite, but quartz diorite is present locally along the margin, particularly between The Meadows and Swimm Lake In some places the quartz diorite has a marginal zone of hornblende quartz monzonite in which are inclusions of diorite Inclusions of quartz diorite as much as 23 6 in. (60 cm) long occur in the porphyritic quartz monzonite from the margin to as much as 3 mi (4.8 km) into the interior of the batholith along the divide north of Pigtail Creek (Washington Peak quadrangle). Dark-gray quartz diorite to granodiorite in the southwestern part of the area also may be part of the marginal facies of the batholith Field evidence indicates the diorite is the oldest rock, followed by hornblende quartz monzonite, then quartz diorite, and finally porphyritic quartz monzonite

The batholith is discordant, particularly on a small scale, although on a regional scale much of the contact with the Wood River Formation is subparallel to the strike of the bedding in the Wood River Formation. This is particularly noticeable west of Warm Springs Creek

Average age of the eastern part of the Idaho batholith may be about 88 m y This is suggested by potassium-argon ages of biotite from batholith samples along Salmon River east of Stanley, but within the study area. These ages are 79, 79, 82, and 95 m.y., according to R L Armstrong (written commun , 1971). Elsewhere, Larsen and others (1958) report lead-alpha ages on various minerals from several parts of the batholith that range from 94 to 135 m.y and average 108 m y McDowell and Kulp (1969) concluded that primary igneous activity was Early Cretaceous (125 m y) or earlier, but they also found Eocene K-Ar ages within the Idaho batholith. These probably reflect younger plutons such as the Sawtooth batholith.

Ross (1937) correctly related the White Cloud and Horton Peak stocks to the Idaho batholith, but incorrectly included with them the Sawtooth batholith, which subsequently has been shown by radiometric and petrographic evidence to be of Eocene age

WHITE CLOUD STOCK

The White Cloud stock in the north-central part of the study area is about 8 mi (13 km) long and 2 5 mi (4 km) wide and was intruded into Paleozoic sedimentary rocks (pl 1). The east contact is very steep and appears to have been controlled in part by pre-intrusion faulting, as suggested by the magnetic and geologic data (pl 1). The west contact dips moderately to the west

The White Cloud stock (as mapped by Russell Smith, American Smelting and Refining Co.) is a zoned pluton with a wide core of leucocratic porphyritic biotite quartz monzonite containing pink potassic feldspar phenocrysts as much as 1 5 in (3.8 cm) long in an equigranular, medium-grained groundmass, and a peripheral zone 0 25–1 mi (0 4–1 6 km) wide of nonporphyritic equigranular pinkish-gray biotite quartz monzonite The rock, particularly in the border zone, is cut by numerous irregular dikes and veinlets of fine-grained granite, granophyre, and potassium feldspar of diverse orientation Younger northeast-trending andesitic and (or) lamprophyric dikes, related to the Eocene Challis Volcanics, are more numerous in the core area than in the border zone

A single K-Ar biotite age of 83 6±2 8 m y for the White Cloud stock was obtained by R. F Marvin (oral commun., 1974) This age is comparable to an age of 88 m.y. obtained at a small stock on Pat Hughes Creek about 4 mi (6 4 km) north of the study area, and is within the range of dates obtained for rocks of the Idaho batholith along Salmon River

HORTON PEAK STOCK

The Horton Peak stock is near the east margin of Sawtooth Valley, it consists of porphyritic biotite quartz monzonite containing pink potassic feldspar phenocrysts as much as 2 in (5 cm) long These rocks are not distinguishable in hand specimen from similar rocks in larger exposures of the Idaho batholith, the core of the White Cloud stock, and smaller bodies in the Pole Creek drainage. Magnetic contours allow equally feasible but unproven subsurface connections with either the Idaho batholith exposure to the north or the White Cloud stock

GRANITIC ROCKS IN WASHINGTON BASIN

Granitic rocks exposed in and near Washington Basin are of uncertain age and correlation and comprise predominant biotite quartz monzonite and subordinate amounts of quartz diorite The quartz diorite is found only along the eastern margin of the basin and at the Black Rock mine, and probably correlates with the older border facies of the Idaho batholith On plate 1 the biotite quartz monzonite and quartz diorite are shown as one unit, and as part of the Idaho batholith

INTRUSIVE ROCKS OF TERTIARY AGE

Tertiary plutons in the study area occur as (1) a hypabyssal dacite porphyry complex, (2) equigranular granite of the Sawtooth batholith and the Boulder Mountains stock, (3) porphyritic quartz monzonite of the Ibex Canyon stock, and (4) Tertiary dikes and stocks. The dacite porphyry complex and the Challis Volcanics are approximately contemporaneous but are older than the Boulder Mountains and Ibex Canyon stocks Potassium-argon dating of biotite from the Sawtooth batholith shows the rock to be of Eocene age The Ibex Canyon and Boulder Mountains stocks and related dikes intrude the Challis Volcanics and thus are Eocene or younger. If the Horton Peak stock, the undated quartz monzonites in the Washington Basin area, the White Cloud pluton, and the two small satellite stocks to the east are related to the Idaho batholith, as seems probable, all the Tertiary plutonic rocks are confined to the areas southeast of the Pole Creek lineament and west of the Sawtooth fault (fig 2)

DACITE PORPHYRY COMPLEX

The dacite porphyry complex consists of dikes, stocks, and sills that range in composition from andesite to latite and which crop out mainly in the Boulder Mountains They also are abundant on divides between drainages of North Fork Big Wood River, North Fork Big Lost River, and East Fork Salmon River and its tributaries An exposure of dacite porphyry west of the junction of Ibex Creek and East Fork Salmon River is difficult to identify because texture of the porphyry is similar to that of the surrounding volcanic rock In some areas, the dacitic bodies are too numerous to be shown individually on plate 1

Rocks of the dacite porphyry complex are gray to green and have varying textures Phenocrysts of plagioclase vary in size and proportion, and hornblende, biotite, and quartz are present in varying amounts Rocks of the complex in the southeastern part of the area were mapped as quartz diorite porphyry by Umpleby and others (1930) Only two exposures of quartz diorite porphyry are shown on plate 1, however, both of which are in the eastern headwaters area of West Pass Creek

The porphyries are hypabyssal rocks that represent eroded roots of a volcanic field, they probably were the source of at least part of the andesite and latite of the Challis Volcanics Many, if not all, are older than the nearby Boulder Mountains stock of granite

SAWTOOTH BATHOLITH

Pink granite of the Sawtooth batholith is exposed near the western boundary of the area (fig 2), and has been described in a report on the adjoining Sawtooth Wilderness (Kiilsgaard and others, 1970). The distinctive color of the coarsely granitoid rock is derived from the abundance of pink perthitic orthoclase, which at many exposures may form two-thirds of the rock. Other minerals in the rock include quartz, plagioclase (albite-andesine), hornblende, biotite, and muscovite. Sphene, zircon, allanite, apatite, ilmenite, and magnetite are common accessories.

The granite is markedly different in appearance from granitic rocks of the Idaho batholith and is intrusive into it. Pink granite dikes with chilled contacts intrude gray quartz monzonite of the Idaho batholith, and xenoliths of the Idaho rocks are common in the Sawtooth rocks (Kiilsgaard and others, 1970, p D12)

The Sawtooth batholith contains abnormally high amounts of beryllium, molybdenum, lead, radioactive elements, niobium, and probably rare earths, and abnormally low amounts of lime and magnesia On this basis it is a typical "tin granite" (Kiilsgaard and others, 1970, p D25–D26)

The long-suspected Tertiary age of the Sawtooth batholith and its emplacement after the onset of Challis volcanism (Reid, 1963, p. 14) have been confirmed by K-Ar radiometric dating of biotite from samples of the granitic rock, and by analysis of whole rock from seven samples of volcanic rocks (R. L Armstrong, written commun., 1972). The average age of the Sawtooth batholith is 44 4 m.y (late Eocene), well within the age range of the Challis Volcanics. Several other plutons in central Idaho have similar age dates. The Casto pluton, about 25 mi (40 km) north of the study area, has many similarities to the Sawtooth batholith, and is late Eocene (42 7 m.y; Cater and others, 1973) Quartz monzonite from the Summit Creek stock east of the study area and from other exposures in the Pioneer Mountains also have been dated as Eocene by R L Armstrong. Numerous other rocks within what has formerly been considered the Idaho batholith have yielded Eocene radiometric ages (McDowell and Kulp, 1969).

BOULDER MOUNTAINS STOCK

The Boulder Mountains stock is a northwest-trending pluton of granite along the steep southwest face of the Boulder Mountains. It is about 4.5 mi (7 km) long and as much as 1 5 mi (2 5 km) wide in outcrop and intrudes Challis Volcanics, Paleozoic rocks, and dacite porphyry

The stock consists of fine- to medium-grained, pink, equigranular granite that contains no mafic minerals except sparse biotite. The southeastern and higher parts are fine grained, nearly granophyric or aplitic, but toward the northwest, particularly at lower elevations, rock of the stock gradually becomes coarser grained and begins to resemble the still coarser grained granite of the Sawtooth batholith.

A closed magnetic anomaly associated with the Boulder Mountains stock (pl 1) is centered mostly north and east of the main outcrop in an exceedingly complex area of faulted, altered Paleozoic rocks and dacite porphyry, which make up more than half of the exposed rocks between Silver Creek and Boulder Basin. The position of the anomaly, the structural complexity of this area, and the pervasive alteration of the Paleozoic rocks suggest that the stock extends underground northeast from the outcrop area, and that it underlies the highly disturbed surface rocks.

IBEX CANYON STOCK

A stock that consists mainly of porphyritic quartz monzonite crops out at the head of Ibex Canyon Typical rock contains phenocrysts of sodic plagioclase, quartz, and biotite in a pink granophyric groundmass of quartz and potassic feldspar. The stock has surprisingly weak magnetic expression, although it lies just beyond the nose of a major northwest-trending magnetic anomaly caused by the Summit Creek stock, which crops out southeast of the study area.

The Ibex Canyon stock intrudes the Challis Volcanics; hence it is of Eocene or younger age.

GRANITE OR RHYOLITE PORPHYRY STOCKS AND DIKES

Dikes of granite porphyry, rhyolite porphyry, and granophyric granite intrude the Challis Volcanics and are the youngest granitic rocks in the area They are most abundant in the Boulder Mountains, especially near the Ibex Canyon and Boulder Mountains stocks and, like them, probably were derived from a major batholith that underlies the southeastern part of the study area and extends southeast from it

The granitic intrusives were mapped separately from other dikes and stocks because they are altered or mineralized locally, or are closely associated with mineral deposits of several types.

OTHER TERTIARY DIKES

Countless other dikes of variable Tertiary age and composition crop out in the study area. They intrude granitic rocks, Paleozoic sedimentary rocks, and the Challis Volcanics. They occur both as single dikes and as swarms of dikes, as in the areas north of Stanley Creek and along the upper reaches of Valley Creek (pl 1). The dikes range in composition from lamprophyre to latite, in width from a few inches to about 100 ft (30 m) and in length from a few feet to more than 1 mi (1.6 km) The dikes commonly dip vertically and most of them strike northeast Fresh dike rock ranges from light to dark gray, and textures vary from aphanitic without phenocrysts to porphyritic. Their weathered surfaces are darkened by oxidation to shades of brown, thus, they commonly form dark lineaments at the outcrop that are readily distinguished from light-colored granitic rock

INTRUSIVE BRECCIA

Intrusive breccia is present in a roughly circular body on upper Fourth of July Creek, and in a dike on the Salmon River between Mill and Slate Creeks The breccia consists of angular fragments of sedimentary rock that average about 5 in. (13 cm) across imbedded in a matrix of gray aphanitic andesite The circular body, possibly a pipe, is nearly surrounded by morainal deposits, but it probably was intruded into the White Cloud stock.

EXTRUSIVE ROCKS

CHALLIS VOLCANICS

The Challis Volcanics cover large areas of central Idaho They are exposed in nearly 30 percent of the study area, mainly in the eastern and southern parts, where the maximum thickness is about 5,000 ft (1,500 m). Although many members are evident, only a series of andesite and basaltic andesite flows in the Boulder Mountains were mapped separately (pl. 1).

A regional unconformity of mountainous relief separates the Challis Volcanics from the underlying sedimentary and granitic rocks. Rocks of the Challis Volcanics consist—in general order of decreasing age—of the latite-andesite member, the Germer Tuffaceous Member, and the Yankee Fork Rhyolite Member of Ross (1937), who mapped the volcanic rocks over much of the study area These units are interfingering lithologic facies that reflect eruption from several volcanic centers at different times rather than well-defined superimposed time-stratigraphic units Rocks assignable to each of these members are present in the study area, but their relationships are complex Rock names and type are inferred from hand specimens because none were studied in thin section, nor were the rock compositions determined

The oldest and most widely distributed part of the volcanic sequence is the latite-andesite member, which consists of a thick sequence of breccias, flows, and well-indurated quartz-bearing crystal or crystal-lithic ignimbrites containing abundant fragments of the Paleozoic rocks Except possibly for andesite and basaltic andesite flows that cap the Boulder Mountains, all Challis Volcanics in the southern part of the study area are of this member.

The latite-andesite member interfingers with and is partly overlain by the light-colored rhyolite tuffs of the Germer Tuffaceous Member, which includes several thin basalt flows in the northeast corner of the study area In the northeast part of the study area and north of Salmon River, the Germer Tuffaceous Member is overlain by the Yankee Fork Rhyolite Member.

The older part of the Challis Volcanics may be older than the several stocks and batholiths of pink granite or quartz monzonite that have been radiometrically dated The range of six K-Ar whole rock or feldspar ages of the volcanic rocks determined by R. L. Armstrong (written commun , 1971) is from 49 2±1.8 to 43 8±1 0 m y The radiometrically determined dates suggest that the Challis Volcanics range in age from early or middle Eocene to at least late Eocene The ages compare to average ages of about 44 m y for the Sawtooth batholith, 42 7±0 9 m y for the Casto pluton, and 46 7 m y for the Summit Creek stock Granite porphyry dikes and small irregular masses in the Glassford Peak area (Ryan Peak quadrangle) intrude the volcanic rocks and probably are Eocene and about the age of the Yankee Fork Rhyolite Member

SURFICIAL DEPOSITS

A wide variety of unconsolidated surficial deposits of Holocene, Pleistocene and possibly Tertiary age are scattered over the study area These include older, high-level gravels of enigmatic origin, glacial moraines, large alluvial fans, and stream terraces of two ages A category of other gravels or debris of various origin includes landslides, rock glaciers, talus, and alluvium These units are shown where possible on plate 1, but many exposures are too small to map Many of these deposits could be classified in different ways.

OLDER GRAVEL

Bouldery gravels form widespread disconnected deposits on ridges extending easterly from the White Cloud Peaks nearly to the East Fork Salmon River, and small remnants occur near and west of the crest of the White Cloud Peaks A few patches occupy more than 2 mi² (5 km²), as on the gently east sloping erosion surface that caps Railroad Ridge, from an altitude of about 10,300 ft (3,140 m) down to about 7,800 ft (2,400 m) Other deposits below 7,800 ft (2,400 m) appear to lie on a steeper surface below the projection of the higher gentle slopes, and they are found as low as 6,600 ft (2,000 m)—only about 500 ft (150 m) above the East Fork Salmon River The small patches high in the White Cloud Peaks are mostly at altitudes of about 10,000 ft (3,000 m), where they are mainly preserved in cirques at elevations above the most recent glaciation. Between Big Boulder Lakes and Boulder Chain Lakes, a patch of gravel lies on a ridge at 10,600 ft (3,230 m) only a few hundred feet (less than 100 m) below the highest peaks In places these gravels are overlain by upper Pleistocene glacial deposits

The gravels are unsorted and unconsolidated East of the crest of White Cloud Peaks, they are composed largely of rocks of the White Cloud stock, west of the crest they are mostly from sedimentary rocks Well-rounded cobbles and boulders 6 in to 1 ft (15–30 cm) across, of the Hailey Conglomerate Member of the Wood River Formation, are common. The gravels were very likely transported by ice or water, but because the topography has been modified considerably since they were deposited, their mode of origin is obscure.

Ross (1937, p 93) concluded that the older gravels probably are of pre-Wisconsin (Nebraskan?) glacial origin Large ice-sculptured and striated bedrock surfaces were noted on an ice-cut bench at least 400 ft (122 m) above the East Fork Salmon River near Bowery Guard Station and near the mouth of Germania Creek (Bowery Creek quadrangle) Evidently glaciers occupied the main valleys in the East Fork drainage above the mouth of Little Wickiup Creek, it therefore seems probable that similar glaciers occupied all the principal valleys in the entire East Fork drainage. The older gravels could represent remnants of glacial deposits and (or) kames formed at a time when ice flooded most of the region Similar gravels and (or) morainal debris that was left within the valleys when the ice melted subsequently have been largely eroded

MORAINE DEPOSITS

Glacial deposits of unsorted boulders, gravel, sand, and clay mantle much of Sawtooth Valley and Stanley Basin (pl. 1). Coalescent glacial moraines that rise more than 1,500 ft (457 m) above the valley floor form most of the pine-covered foothills along the western side of the valley. Williams (1961) recognized moraines of Bull Lake and Pinedale age in Sawtooth Valley. Glacial moraines and outwash gravels also are conspicuous along the east side of the valley, particularly between Fisher and Lost Creeks and near the mouth of Pole Creek. Other moraines are present in upland areas in the vicinity of The Meadows, the head of Fourth of July Creek, and Lookout Mountain.

In the Big Wood River drainage, poorly preserved glacial moraines were recognized only near the mouths of Boulder Creek and its western tributary. Well-developed moraines are small and distinctly uncommon in the Boulder Mountains, although cirques are common, especially on the northeastern slope. Many of the glacial cirques, particularly those southwest of the crest of the northern Boulder Mountains, are now choked by talus.

STREAM-TERRACE DEPOSITS, ALLUVIAL FANS, AND UNDIVIDED ALLUVIAL DEPOSITS

Major stream terraces at several elevations flank the Salmon and Big Wood Rivers and the lower parts of some major tributaries. These terraces, where best developed in Sawtooth Valley, are remnants of deep gravel fill that flooded the valley as outwash material from Pleistocene glaciers. In some places, however, the gravel caps surfaces cut in bedrock. Williams (1961), who studied these terraces and the related deposits in the Sawtooth Valley, divided them into two ages related to the (older) Bull Lake and the (younger) Pinedale Glaciations. The Bull Lake deposits are more deeply weathered and dissected and generally found at higher elevations, as at the mouth of Fisher Creek, where one remnant is 350 ft (107 m) above the stream. Except in Sawtooth Valley, the several ages of stream terraces are not separated on the map, along the East Fork Salmon River, terrace gravels that may be equivalent to this group are mapped with the undivided alluvial deposits.

East of Stanley in the narrow canyon of the Salmon River, gravels of several terraces are combined into a single unit on plate 1. The highest of these terrace gravels is 800 ft (244 m) above the river, between the mouths of Mill and Slate Creeks. At places along this stretch of the Salmon River, especially between Little Casino Creek and Robinson Bar, the terrace gravels have been worked for placer gold.

Alluvial fans built out from the mouths of the main tributaries merge with the terrace gravels along the main stream courses or overlie them. Some of these (such as the one between Lost and Champion Creeks) are anomalously large and require postulated Pleistocene drainage diversions to explain their origin. Certain unusual stream-deposited alluvial fans were developed by recurrent snow slides that are common in the Boulder Mountains. Such fans are generally smaller, consist of more angular material, and tend to be less gullied by running water. Extensive gravel deposits along the southwest flank of the Boulder Mountains probably consist of coalescent alluvial fans; they are dissected to depths of several hundred feet by principal drainages of the Boulder Mountains. These deposits may be equivalent in age to the older gravel east of the White Cloud stock.

Undivided alluvial deposits of different ages and composition occur at many places above the present stream courses and have been mapped as a separate group, even though that group may include some of the deposits described in the preceding paragraph. Included with the undivided deposits are well-developed fan and terrace deposits and alluvium along the East Fork Salmon River and its tributaries as well as extensive deposits in the northern Sawtooth Valley and in Valley Creek west of Stanley.

Landslides and (or) debris flows are common in volcanic terrains within the study area and in the surrounding region. They commonly are associated with water-saturated layers of white tuff or tuffaceous sedimentary rocks within the Challis Volcanics, particularly in the Germer Tuff Member or Yankee Fork Rhyolite Member. Unstable swelling montmorillonite in the tuffs and altered volcanic rocks also adds to their instability. Although water saturation is the main element promoting the movement of these slides, some may have been triggered by earthquakes, because the Sawtooth National Recreation Area is in an abnormal seismic area (zone 3) compared to surrounding regions. Mild earthquakes occur many times a year, according to the National Geophysical Data Center, National Oceanic and Atmospheric Administration (written commun., 1972).

The largest slides, including two between Boulder and Little Boulder Creeks, are as much as 1.5 mi (2.4 km) long and 1 mi (1.6 km) wide. Slides also occur in pre-Challis rocks. Several are in the Wood River Formation near Crater Lake (Livingston Creek quadrangle), north of Blackman Peak, and just north of Champion Lakes (Washington Peak quadrangle). A large slide in the Idaho batholith is about 1.5 mi (2.4 km) northwest of Swimm Lake.

The geologic effects of landslides include the large-scale movement of debris downslope with the formation of typical hummocky topography and, where slides flow into a valley, the damming of streams and production of lakes. Jimmy Smith Lake, barely outside the northeastern boundary of the study area, is an example of such a body of water. The effects of landslides on human endeavor are slight in areas as inaccessible as this one, with the exception of access roads, which are difficult to maintain in active slide areas

Well-developed rock glaciers are common at the headwalls of the glacial cirques on the northeast flank of the Boulder Mountains but are uncommon on the southwest flank (pl 1). On the geologic map they have been mapped to include the adjacent talus deposits, with which they merge One of the few rock glaciers in the White Cloud Peaks has an ice core that has melted locally, collapsing the overriding rock debris into deep craterlike depressions

Talus covers many of the steep slopes in the higher parts of the recreation area and many of the canyon bottoms on the southwest flank of the Boulder Mountains. Only the larger talus deposits or those of special geologic interest are shown on the map (pl. 1) In the Boulder Mountains some of the talus deposits obscure the geology and structure, contain significant mineralized float, or are the apparent immediate source of stream-sediment anomalies downstream.

ALLUVIUM

A thin cover of alluvium extends along most streams Fairly extensive alluvial deposits are at the heads of the larger lakes, as at Stanley and Alturas Lakes (pl 1) Broad alluvial-floored meadows, as along Elk Creek and parts of Smiley Creek, probably represent sediment-filled lakes that subsequently were drained by erosion. A thick cover of peaty soil characterizes such old lake basins.

The large alluvium deposit at The Meadows along Warm Springs Creek probably formed in an old lake behind the Bear Lake Creek moraine Alluvium on Boulder Creek below the Livingston mine probably formed in a temporary lake behind a large landslide

The alluvium in several areas contains gold or overlies gold-bearing gravel deposits, as in the Stanley Creek Basin.

STRUCTURE

The complex structure of the Sawtooth National Recreation Area was not fully resolved in this reconnaissance study Principal structures shown on plate 1 are (1) folds and thrust faults restricted to the Paleozoic sedimentary rocks and (2) younger high-angle faults that displace all rock units. Aeromagnetic lineaments suggest the presence of old deep-seated through-going faults that may be of regional extent (fig 2) The precipitous east front of the Sawtooth Range is indicative of very young fault movement, as is the offset of surficial deposits in the Sawtooth Valley

The style of structural deformation of the Paleozoic rocks differs north and south of the Pole Creek lineament (fig. 2). North of the lineament, especially between the White Cloud and Horton Peak stocks and the Idaho batholith, the rocks show deep-seated major folds and steep reverse faults that nearly parallel the bedding. Some of these faults must be steep thrust faults or folded, formerly flat thrusts, where at least 5,000 ft (1,560 m) of overturned strata are apparently cut out. South of the lineament, particularly east of the Boulder Mountains stock, the characteristic deformation is gently dipping imbricate thrust plates that, east of the study area, override steep overturned and thrusted folds.

The major folding and thrusting are older than the Eocene intrusive and volcanic rocks, and probably represent a process that was continuous

THRUST FAULTS

Thrust faults in the study area are rarely well exposed and are generally recognized only by missing stratigraphic units, by drag folds beneath them, and by springs, drag blocks, and shattered quartzite along them. In a few places they can be specifically identified, as in cliff faces or as breccia zones in quartzite Better knowledge of the stratigraphic sequence will be required to map many of the thrust faults that probably exist within the Devonian, Mississippian, and Permian strata.

The thrust faults shown on plate 1 generally carry younger over older rocks, but locally the Milligen or Mississippian rocks are thrust over the Wood River Formation, or rocks of the middle part of the Wood River are thrust over those of the upper part of the Wood River Formation.

FOLDS

The Paleozoic rocks in the northern part of the area are deformed, mainly by north-trending isoclinal folds (pl. 1). A major anticline extends from the Slate Creek drainage south for 6 mi (9 6 km) to the ridge north of Fourth of July Creek Numerous other fold axes probably represent subsidiary folds on the flanks of the major anticline. Rocks cropping out in Strawberry Basin (Washington Peak quadrangle) and about 2 mi (3 km) west of there seem to be fault-bounded blocks, but they may be in anticlines. The Idaho batholith truncates folded Paleozoic rocks, thus dating the folding as older than Late Cretaceous.

The visible folds in the Boulder Mountains are generally small drag structures Two belts of Milligen Formation in the southeastern part of the study area extend southeast another 7 mi (11 km) beyond the study area boundary and may be anticlines that were first overturned and later overridden by thrust faults If isoclinal folds exist beneath the thrust plates, they are no longer easily recognized

HIGH-ANGLE FAULTS

Many high-angle faults are shown on the geologic map (pl 1), and many more exist that are too small to map. In the northern part of the area, most of these faults trend northerly, whereas in the southern part, they trend generally northeast For the most part the steep faults cannot be traced for great distances and usually intersect other faults or end against intrusive rock. Some of the steep faults cut thrust planes, and others displace Challis Volcanics, indicating that some of their movement is post-thrusting and in part, at least, post-Eocene. A few of the north-trending steep faults in the north-central part of the area may actually be oversteepened segments of folded thrusts

The Sawtooth fault probably continues southeast of Alturas Lake, as shown on plate 1, but it may splay into two or more branches, one of which may extend south along the west side of Smiley Creek Physiographic expression of the Sawtooth fault and of several parallel faults along the east side of Sawtooth Valley, and faults cutting unconsolidated deposits, all indicate the young age of faulting.

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Aeromagnetic Survey and Tentative Interpretation of the Eastern Part of the Sawtooth National Recreation Area, Idaho

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U S GEOLOGICAL SURVEY

MINERAL RESOURCES OF THE EASTERN PART OF THE SAWTOOTH NATIONAL RECREATION AREA, CUSTER AND BLAINE COUNTIES, IDAHO

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MINERAL RESOURCES OF THE EASTERN PART OF THE SAWTOOTH NATIONAL RECREATION AREA, CUSTER AND BLAINE COUNTIES, IDAHO

AEROMAGNETIC SURVEY AND TENTATIVE INTERPRETATION OF THE EASTERN PART OF THE SAWTOOTH NATIONAL RECREATION AREA, IDAHO

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INTRODUCTION

Results of aeromagnetic surveys flown in 1968, 1971, and 1972 are shown on plate 1 and figure 2 as contoured values of the total intensity of the Earth's magnetic field The 1968 and 1971 surveys were flown at an elevation of 12,000 ft (3,658 m) above sea level with flightlines 1 mi (1 6 km) apart Flightlines are north-south except in the area east of 114°45′ W meridian and north of lat 44°15′ N , where they are east-west. Data from these surveys are adjusted to a common datum except as follows The 1972 survey north of lat 44°15′ N. and west of long 114°45′ W was flown at an elevation of 11,000 ft (3,353 m) above sea level and has a regional gradient removed, but it was not adjusted to a common datum, which accounts for the break in the magnetic contours along the 44°15′ latitude

The magnetic field at 12,000 ft (3,658 m) over the study area is moderately complex Most of the magnetic anomalies are produced by masses of intrusive or extrusive igneous rocks. A broad low swell in the magnetic field occurs over the extensive exposures of the Idaho batholith between Sawtooth Valley and Warm Springs Creek In contrast, prominent magnetic highs produced by the Sawtooth batholith and the White Cloud, Horton Peak, and Boulder Mountains stocks (fig. 2) suggest that they are in some way different from the Idaho batholith.

Approximately coextensive with the superficial deposits in Sawtooth Valley is a large fault-bounded magnetic low that coincides with a major gravity low. The gravity data suggest 1,000–2,000 ft (305–610 m) of valley fill in the central part of Sawtooth Valley. A north-south fault inferred from a strong lineament visible on oblique aerial photographs separates the magnetic and gravity low from the magnetic high over the Horton Peak stock. This fault (fig. 2) coincides with the south end of the Slate Creek lineament, a much older structure. Although minor Holocene movement in the unconsolidated valley fill seems likely from the photo, ground studies were not made.

ANOMALIES RELATED TO INTRUSIVE ROCKS

The broad low swell in the magnetic field observed over the Idaho batholith along the divide east of Sawtooth Valley is typical of the low to moderate and relatively uniform magnetic susceptibility of the Idaho batholith (pl. 1). The major local variations in magnetic intensity are related to topography, but some lows, such as the one in the Vienna district, may reflect zones of sheared and (or) altered rocks.

The magnetic high over the White Cloud stock is the most prominent in the area. The steep gradient east of the stock indicates that the contact dips steeply and may be fault controlled, at least on the southeast. The contours along the west side of the stock indicate that the contact between the stock and the surrounding sedimentary rocks dips gently outward. On the northeast, the stock crops out about 1 mi (1.6 km) beyond the well-defined anomaly, suggesting that this part may be a thin sheet. Northwest and southeast subsurface extensions about 1.5 mi (2.4 km) beyond the exposed contact are indicated by the magnetic anomaly and the granitic rocks exposed locally. Two small magnetic highs over the stock probably reflect topography.

The form and location of the magnetic anomaly associated with the Horton Peak stock indicate that at shallow depth the stock extends 2 mi (3.2 km) south and southeast of its surface exposure. The magnetic saddle that separates the Horton Peak and White Cloud stocks may indicate continuity at depth—as is also suggested by the outcrops of granitic rock between them (pl. 1).

The main part of the deep magnetic low north of the Horton Peak stock is probably partly a polarization effect produced by the magnetic intrusive rocks to the south, and partly produced by inversely magnetized volcanic rock. However, neither effect explains the northward extension of the low over Paleozoic sedimentary rocks near Fourth of July Creek The southeast and east limits of this low approximately coincide with faults on plate 1, which may form the subsurface limits of the adjacent intrusive rocks.

A small magnetic high about 1 mi (1.6 km) east of Galena may reflect a small, largely buried, granite porphyry stock, judging by unusually abundant float along the range front. Several small magnetic features over nearby Tertiary volcanic rock are assumed to reflect lithology or structure within the volcanic rock

A magnetic ridge extends east-southeast from near Ryan Peak for about 5 mi (8 km) east of the study area to a maximum near the western exposure of the Summit Creek stock This large anomaly and the smaller closed magnetic highs over the Boulder Mountains stock and south of the Ibex Canyon stock indicate that a large mass of intrusive rock underlies the entire southeastern part of the study area and that the stocks are cupolas rising from it. This same general area contains abundant subvolcanic dacite porphyry bodies that have little magnetic expression The magnetic high produced by the Boulder Mountains stock is centered north of the outcrop, suggesting that the stock extends north beneath the volcanic rocks near Silver Peak (Easley Hot Springs quadrangle) The absence of major magnetic expression of the Ibex Canyon stock is puzzling when compared to the other large granitic stocks, which have associated pronounced magnetic highs. Possibly the exposed part of the stock is thin and dips north or south toward moderate magnetic highs beyond the main outcrop The Ibex Canyon stock is beyond the nose of the pronounced magnetic high

ANOMALIES RELATED TO VOLCANIC ROCKS

The magnetic expression of the Challis Volcanics implies the presence of both normally and inversely polarized layers Because the data were obtained at a constant elevation above sea level, local surface relief on magnetic rock units is reflected in the magnetic contours, and therefore good correlation between magnetic anomalies and topography implies that rocks at or near the surface produce the anomaly

Two deep magnetic lows occur over the Challis Volcanics between the White Cloud stock and Wickiup Creek and east of West Pass Creek (Ryan Peak quadrangle) These rocks possess a strong reverse remanent magnetization and are probably anomalously thick in these areas. A third strong magnetic low near Champion Creek (Obsidian quadrangle), as discussed in preceding paragraphs, is difficult to explain, but may be partly produced by inversely magnetized volcanic rock

The low at the mouth of Frenchman Creek may reflect buried volcanic rock

On the ridge between the East Fork Salmon River and Germania Creek is a magnetic high with two areas of closure. The correlation between the magnetic intensity and surface topography suggests that normally magnetized volcanic rocks at the surface produce the anomaly

The magnetic data have proved useful in inferring the subsurface extent of known bodies of intrusive rock and suggest genetic relations between bodies These data also suggest lineaments that are significant in the study of regional geologic structures However, other than suggesting that the Glassford Peak–Ryan Peak area may be underlain by a large mass of intrusive rock, the magnetic data within the study area do not reveal any large hidden intrusive bodies nor were any anomalies interpreted as directly suggesting mineral exploration targets outside known areas of mineralization The indirect economic implications of some of the lineaments described in this section, however, are discussed in the next section

LINEAMENTS AND POSSIBLY RELATED STRUCTURAL FEATURES

A conjugate system of poorly understood, N 30° W.- and N. 50°E.-trending regional lineaments in the study area and the surrounding region (fig 2) is inferred from linear magnetic features, fault-controlled(?) intrusive contacts and other geologic and topographic evidence. The largest of these, the Squaw Creek and Atlanta lineaments, are well-defined magnetic features that are postulated to represent ancient major basement fault zones of considerable extent and persistence through time that have exerted control on subsequent geologic events—such as intrusions of several ages, late Tertiary and Holocene faults, and perhaps the structural location of a few mining districts The Squaw Creek and Atlanta lineaments are not related to location of mineral deposits within the study area but may have controlled the location of mining districts adjacent to it. The Clayton Silver mine and several other mines in the Bayhorse district (pl. 3) are close to the Squaw Creek lineament, which has strong magnetic expression for at least 55 mi (88 km) and is evident on the geologic maps of Ross (1937) and Umpleby and others (1930). Only a short length of the Squaw Creek lineament is shown on figure 2 The Atlanta district and several prospects (pl 3) are along the Atlanta lineament, which extends as a regional magnetic feature from the Sawtooth fault at least 30 mi (48 km) southwest of Atlanta. M D. Kleinkopf, U S Geological Survey, has tentatively identified this lineament as a fault bounding the vertical subsurface limit of the Sawtooth batholith (*in* Kiilsgaard and others, 1970, p D26–D27). Anderson (1939, p. 14) described lode deposits in the Atlanta district as striking N. 50°–75° E , thus they trend more or less parallel to the Atlanta lineament. The Vienna district is along the parallel, possibly related Vienna lineament; the Sawtooth district is between the two.

The Sawtooth and Montezuma faults trend roughly parallel to the Squaw Creek lineament, and both faults are marked by magnetic gradients (Kiilsgaard and others, 1970, pl 1). Both faults are late Tertiary in age. The Montezuma fault cuts across mineralized veins in the Atlanta district and therefore is younger than the veins. Northwest of Atlanta, a number of mineralized occurrences along the Montezuma fault suggest structural control by the fault (Kiilsgaard and others, 1970, p. D17). No mineral deposits are known along the Sawtooth fault.

Most of the other lineaments (fig. 2) are rather subtle features of local extent that usually are well defined magnetically only along linear intrusive contacts. These lineaments do not appear to control the distribution of mineral deposits in the study area.

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Geologic Appraisal of Mineral Resources of the Eastern Part of the Sawtooth National Recreation Area, Idaho

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INTRODUCTION

The study area and nearby region contain a wide variety of mineral commodities that occur in different types of deposits Many of these deposits have been productive in the past and others potentially could be productive in the future To provide background information and economic perspective of the region, historical development, mineral production, and geologic setting of the deposits are reviewed. Extensive geochemical studies were made of the area and the various techniques and interpretations are described Analytical results of the geochemical studies are presented under various commodity headings. Types of occurrence, distribution, and potential of individual commodities are discussed, as are localities considered promising for mineral exploration

Localities of nearly 4,700 analyzed samples of rocks, stream sediments, and soils collected by the U.S Geological Survey throughout the study area are shown on plate 2. Geochemical determinations are presented in a series of small-scale maps (figs 4–21) Locations of the 234 mines, prospects, and groups of prospects that were sampled by the U S Bureau of Mines, and in some instances by the U S Geological Survey, are shown on plate 3 Large-scale maps were made of certain mineralized areas, where detailed geochemical and electromagnetic studies were undertaken.

PRODUCTION AND HISTORICAL DEVELOPMENT

The value of metals produced from the study area is estimated at $5 3 million, of which two-thirds was from the Livingston ($2 3 million) and Golden Glow ($1 3 million) mines. Systematic production records, however, have been kept only since 1902 A production value of $2 8 million, prior to 1902, is based on published estimates (Choate, 1962, Ross, 1937, Umpleby and Livingston, 1920, and Umpleby, 1915) that cannot be verified, and does not include unknown early production from silver-lead veins and a smelter in the Galena district, from three gold mills in Washington Basin and at the Aztec mine, and from three gold placers Most production prior to 1902 was silver, gold, and lead from Boulder Basin ($1 million), mostly from the Golden Glow mine; the Silver Rule mine ($600,000) on Slate Creek, the mines on the ridge between Germania and Washington Basins ($400,000) (pl 3); and from gold placers on Stanley Creek ($300,000) and on Salmon River between Stanley and Robinson Bar ($260,000) (pl 3) After 1902, the production of silver and especially gold declined, whereas that of lead and zinc increased

The study area has a long history of intermittent mining dating from the discovery of gold on Stanley Creek in 1863 The first gold placers were worked in the 1860's, but the first placer claims were not recorded until almost 10 years after the first claims on lode gold deposits were staked in 1872 The mining history consists of several periods of intensive activity separated by long periods of relative inactivity Gold placers in the Stanley district and along Salmon River as far east as Robinson Bar were the earliest exploited deposits; they produced about $500,000 worth of gold (at $20/oz), mostly between 1872 and 1880, some gold also was produced between 1900 and 1910, and a little in the 1930's Gold placers on Pigtail Creek also were worked before 1900, but the value of gold produced there is unknown.

The earliest silver lode deposits were located in 1879. These were in Boulder Basin, the Galena district, and on the ridge between Germania and Washington Basins During the next 3 or 4 years, many other lode deposits were located, including the Aztec (Fisher) gold mine and silver-lead deposits at the Silver Rule and Livingston mines. Thriving mining centers were established in Boulder and Germania Basins and in the Galena district The silver boom ended around 1890; operations declined and had almost ceased by 1902, except for sporadic small-scale operations The mines in Boulder Basin operated intermittently between 1902 and 1949 (table 29) Mines in the Galena district were most active in the 1880's but produced until 1902 They also were active in 1928, and 1941–1942 The mines on Bible Back Mountain were actively worked from 1880 to 1887, and in Washington Basin from 1894 to 1902

The Livingston mine was the principal producer in the area between 1924 and 1930 It produced complex lead-silver-zinc antimony ore The mine also was active in the period 1946–1951 (table 18) and from 1953 to 1958. Except for the Livingston mine, virtually all production has been from relatively narrow high-grade veins and small rich gold placers Since 1952, no sustained mine production occurred in the study area until the Hoodoo zinc mine began producing in 1973.

Before 1926, gold, silver, and lead were the principal metals sought, and zinc was discarded Since 1950, exploration interest has shifted to lode deposits of molybdenum, zinc, tungsten, fluorite, uranium, and to placer deposits containing uranium, thorium, niobium, tantalum, and rare earths. Although significant mineral production has not yet resulted from this exploration activity, very large low-grade reserves of molybdenum and large reserves of zinc and fluorite have been partly developed. Production from a new and promising zinc deposit at the Hoodoo mine began after the field work for this report was completed

REGIONAL PRODUCTION

The study area is an integral part of the highly mineralized section of central Idaho that includes the nearby Wood River mining region and the Atlanta, Bayhorse, and Yankee Fork mining districts, each of which has produced much more than the study area. Less important adjacent districts are the Vienna and the Sawtooth districts (fig. 2), and the Stanley uranium district (pl. 3).

Thriving mining camps were established in the Vienna, Sawtooth, and Yankee Fork districts and in the Carrietown (Rosetta district) and Boyle Mountain areas during the silver boom of the 1880's

The Bayhorse lead-silver district, northeast of the study area, ranks second to the Wood River area in total value of production among the districts in central Idaho, largely because of the Clayton Silver and Redbird mines, and the mines on Bayhorse Creek near Challis The Clayton Silver and the Redbird mines, both within 5 mi (8 km) of the northern boundary of the study area, have produced a total of 5,400,000 oz of silver (167,940 kg), 86,600,000 lb of lead (37,467 t), 17,300,000 lb of zinc (7,847 t), 1 million lb of copper (454 t), and 1,600 oz of gold (50 kg) between 1901 and 1968, according to U S. Bureau of Mines records Excluding the preeminent production from the Coeur d'Alene district, the Clayton Silver mine (pl. 3) has been, for many years, the principal silver producer in Idaho. The Yankee Fork district (pl 3) north of the study area has produced gold and silver valued at about $15,400,000 (Anderson, 1949; Choate, 1962). The Stanley uranium district (pl 3), which was discovered in 1955, has produced 34,000 lb (15.4 t) of U_3O_8 worth about $300,000 (A. P Butler, oral commun , 1973). Between the Yankee Fork and Bayhorse districts, a 100-million-ton molybdenum deposit on Pat Hughes Creek (Thompson Creek quadrangle, pl 3) was explored and tested by Cyprus Mines, Inc , in the period 1971-1974 In the same general area are the Buckskin and Thompson Creek tungsten deposits (pl 3) The Thompson Creek deposit, discovered in 1953, produced 288 short-ton units (5,760 lb) (2 6 t) of WO_3 from ore averaging 0 77 percent WO_3 (Cook, 1956, p 22) A tungsten-molybdenum deposit on Peach Creek (pl 3), about 1 5 mi (2 4 km) north of the study area, is promising

Mines in the Atlanta gold-silver district are about 11 mi (18 km) southwest of the study area (fig 2) Anderson (1939, p. 21) estimated from incomplete production records that the value of metal produced from the Atlanta mines to 1936 exceeded $6 million

The Sawtooth and Vienna silver-lead districts adjoin the study area on the southwest (fig. 2, pl 3) At least 15 mines were worked in the Vienna district (Ross, 1927, p 3) Fissure veins in rocks of the Idaho batholith contained rich silver ore Metals produced from each of the districts in the 1880's were valued at about $1 million Most of the veins contained negligible amounts of base metals or gold, but some ore from the Mountain King (Webfoot?) mine, Vienna district (fig 2) contained 0 58-1 58 oz gold per ton (19 8-54 2 g/t), 4 9-26 4 oz silver per ton (168-905 g/t), and as much as 28 percent lead and 15 percent zinc (Umpleby, 1915, p 248) Shannon (1971, p. 14) noted that mineral production was small and discontinuous in the Vienna district between 1913 and 1932, and that ore valued at $63,149 was produced from 1933 to 1950 Ballard (1922, p 22-23) described nine mines in the Sawtooth district. The Silver King mine (fig 2) was the principal producer, yielding minerals valued at about $700,000, according to Umpleby (1915, p. 249)

High silver prices in the early 1970's renewed interest in the Vienna and Sawtooth districts Previously unexplored ground beneath the main workings in the Webfoot mine, the most productive in the Vienna district, was being explored in 1971 by drilling and crosscuts from an adit that extends 2,600 ft (792 m) beneath the productive higher levels A few tons of ore containing about 758 oz silver per ton (26,000 g/t) (sample T300, pl 2) were mined from a pyrargyrite-quartz vein 4-6 in (10-17 cm) thick that was being explored.

The Wood River mining region, southeast of the study area, includes several mining districts that have a combined total production value second only to the Coeur d'Alene district (U S Geological Survey, 1964, fig. 3). Among these are the Warm Springs district near Ketchum, the Mineral Hill district near Hailey, and the Camas gold district (Hailey gold belt) west of Hailey Although the Warm Springs district overlaps the study area, most productive mines, except those in Boulder Basin (pl. 3), are 7 mi (11 km) or more distant from the study area boundary, and only a few prospects are found within 3 mi (5 km) of it The productive mines nearest the study area are in the Boyle Mountain and Rosetta areas and a few are on the West Fork of Warm Springs Creek

The Warm Springs district consists of several widely separated mining areas The Boyle Mountain subdistrict around a small stock about 7 mi (11 km) south of the study area and the same distance west of Ketchum produced lead-silver ores valued at nearly $1 million in the 1880's (Umpleby, 1915, p 240) This area adjoins the Rosetta subdistrict, which also produced about $1 million from nine mines near Carrietown and Dollarhide Mountain (Umpleby, 1915, p 233–240). Since about 1917, most of the production from the Warm Springs district has come from the complex, fine-grained, base-metal ores in the Independence and Triumph mines east of Ketchum.

CENTRAL IDAHO MINERAL BELT

The study area is within a broad N 30°W.-trending belt of mineral deposits, here referred to as the Central Idaho Mineral Belt. This belt extends from the vicinity of Mackay to northwest of Yellow Pine, Idaho, and contains many deposits of tungsten, molybdenum, antimony, mercury, silver, lead, zinc, and gold. The mineralized trend was first recognized by Cook (1956, figs 1 and 2) in his study of tungsten deposits of south-central Idaho, wherein he outlined the "south-central Idaho Tungsten Belt" Tungsten (scheelite) deposits in the center (inner) part of this tungsten belt delineate the N. 30°W trend better than deposits of the tungsten minerals wolframite, huebernite, or ferberite on the margins Most of the scheelite deposits occur in tactite near the contacts of the Cretaceous Idaho batholith and Upper Cretaceous and Eocene stocks Farther north, the Yellow Pine district, the most productive scheelite district in Idaho, lies along this trend

Molybdenum occurrences, although not restricted to the belt, show a preferred distribution along it The discovery and recent exploration of three potentially economic molybdenum deposits along the belt add credibility to it as a locale for important deposits One of these, the Little Boulder Creek deposit, contains 135 million tons (122.4 million t) of molybdenum resources and is within the study area. The others are less than 4 mi (6 km) north, and less than 6 mi (10 km) southeast from the study area boundary. Interestingly, very little scheelite is associated with these deposits It is significant that the scheelite and molybdenum deposits that best define the belt are high-temperature deposits near to Upper Cretaceous and Eocene granitic plutons within the belt

Major antimony and mercury deposits occur in the northern part of the belt, in and near the Yellow Pine district and far from the study area, but other occurrences are scattered in or near the belt. Within the study area are several minor veins that contain the antimony mineral stibnite and one that contains the mercury mineral cinnabar Ore mined from the Livingston mine was rich in the antimony mineral jamesonite, but there is no record of any antimony ever being recovered from the ore

Silver, lead, and zinc deposits show some preference for the mineral belt, especially in its southern part, but are by no means restricted to it Gold shows a poor relation to the belt.

STRUCTURAL CONTROL OF MINERAL DEPOSITS

The Central Idaho Mineral Belt is considered to be related to regional tectonic development of central Idaho either as a reflection of some ancient, through-going basement fracture system or as a zone developed in near-surface rocks in response to regional fracture patterns Whatever its origin, the belt appears to be responsible for a regional pattern of ore deposition. Some of the geologic structures and inferred magnetic lineaments within or near the study area trend northwest—particularly the Sawtooth Valley and Squaw Creek lineaments (fig 2)—roughly parallel the trend of the belt, and appear to have exerted regional control on the positioning of the mineralized districts On the other hand, gold-silver deposits such as those in the Atlanta and Vienna districts appear to have developed along less prominent lineaments that trend N. 50°E.

Both the northwest and northeast regional trends are evident in the study area, but mineral deposits in the area are not notably concentrated along any of the major lineaments, and most individual deposits are more directly controlled by structures too small to show on plate 1. Examples of the smaller structures include dikes, gently to steeply dipping faults and fractures, and structural intersections Many of these structures are clearly evident on mine maps Pre-mineral fractured and altered dikes are common controls for gold veins in the northern part of the study area. The veins in the Iron Crown mine area are confined to a rhyolite dike (Choate, 1962). Elsewhere, fluorite veins follow along rhyolite porphyry dikes. Veinlets of galena, sphalerite, and tetrahedrite occur in the Grand Prize rhyolite porphyry dike. The Livingston mine (pl 3) is a replacement deposit along the contact between an east-west, gently dipping fault and a nearby, steeply dipping, sericitized rhyolite porphyry dike. The ore bodies are bounded on the east and west by north-trending pre-mineral faults (Kiilsgaard, 1949). Ore deposition at the Hoodoo zinc mine may be partly controlled by an unconformity or by faulting along it. Small deposits in Mississippian argillite east of the Hoodoo mine are discontinuous quartz veins along gently dipping shear zones that appear to be reverse faults.

Some mineral deposits within the study area are controlled by features large enough to be shown on plate 1. On the southeast side of the White Cloud stock, quartz veins and silicified diopside tactite are associated with a N 20° E.-trending fault system that also has controlled the intrusive contact West of the stock, location of the Aztec gold veins (pl. 3, 106) may be controlled by faults that parallel the Slate Creek lineament (fig. 2), although the veins may also occupy subsidiary fractures of divergent trends.

South of Washington Basin, several gold-bearing silver-lead deposits, including the productive Idahoan mine (pl 3, 144), are in brecciated quartzite along a thrust fault on Bible Back Mountain (pl 1).

HYDROTHERMAL ALTERATION AND ITS RELATION TO MINERAL DEPOSITS

Various rock types in the study area have been altered locally by hydrothermal solutions that were, in some cases, the ore-forming fluids The effects of hydrothermal alteration depend on the nature of the solutions, the composition of the rocks, and the intensity of reaction, and consequently the altered rock differs from place to place. Many altered zones were analyzed for trace metals to determine any relation to nearby mineral deposits, or to detect indications of undiscovered mineral deposits. Most of the hydrothermally altered areas are shown on plate 3 in one of three categories: chloritized rocks, barren pyritized rocks, and a general group of other types that includes silicified rocks. Several of the altered zones are closely related to individual mineral deposits; others are broadly associated with well-mineralized areas, but known deposits are not associated with most areas of pervasive pyritic alteration.

Rocks of the Milligen Formation on the ridges south of productive mines in Boulder Basin have been altered, probably by hydrothermal solutions associated with dike intrusion Where altered, the rocks are highly chloritized and locally mineralized. The normally dark gray subphyllite is bleached, recrystallized, and weathers brown to olive green.

The altered rock contains parallel streaks of recrystallized, coarse, green chlorite and innumerable parallel gash veinlets of carbonate up to 0 25 in (6 mm) in thickness. These veinlets commonly cross the streaks of chlorite and the crinkle cleavage at nearly right angles Locally, the altered subphyllite contains visible secondary copper minerals and anomalous amounts of silver, and other metals. Many thin quartz or quartz-carbonate veins in the altered rocks contain uneconomic pockets of gold, silver, and copper sulfide minerals. Limestone in the vicinity commonly is bleached or metamorphosed to marble.

Large areas of rusty- or red-weathering barren pyritized rocks are present in and near the subvolcanic porphyry complexes north of the Boulder Basin (pl 3) These red-weathering hydrothermally altered rocks were easily recognized in the field, but could be mapped only sketchily on black and white aerial photographs The pervasive pyritic alteration made it impossible to distinguish accurately between the red pyritized dacite porphyries, volcanic rocks, and engulfed blocks of Paleozoic rocks in and near the porphyry complexes southeast of the Ibex Canyon stock

Some red-weathering pyritized porphyry or volcanic rock contains slightly anomalous amounts of silver, lead, and zinc, tin, mercury, and (or) antimony, or only molybdenum, but significant mineral deposits were not found The barren, hydrothermally altered zones might be considered analogous to those postulated by Sillitoe (1972) to overlie porphyry copper deposits However, the general scarcity of copper sulfides in the region, especially in the exposed stocks, indicates that porphyry deposits are not to be expected beneath these altered rocks. More likely deposits would be molybdenite in the plutonic rocks, scheelite in the tactites, and complex silver-base metal ores in the Paleozoic rocks

Rocks in the north zone of the Little Boulder Creek molybdenum deposit (pl 3, 94) have been altered by pervasive silicification Silica and molybdenite were introduced together into diopside tactite adjacent to a small quartz monzonite stock to form the significant deposit. Elsewhere, narrow selvages of silicified rocks are common in the walls of veins, but no other extensive areas of silicified rocks were found in the study area. Varicolored tan to brown, well-rounded jasperoid cobbles are abundant in gold placers on the divide at the head of Kelly Creek (Basin Butte quadrangle) Rusty-weathering jasperoid cobbles contain pyrite and as much as 3,000 ppm zinc and arsenic, 1,500 ppm lead, 526 ppm silver, 200 ppm antimony, and 1 1 ppm gold, but the paler colored cobbles do not contain anomalous quantities of metals

In the Galena district pervasive hydrothermal alteration and subsequent weathering probably account for the yellowish- to rusty-brown colors of the Permian quartzite in which are about half the known veins (pl 3) The quartzite is overlain by unaltered Challis Volcanics Gases, liquids, and heat rising from intrusive rocks and trapped beneath a volcanic roof may account for the alteration and the introduction of very fine grained disseminated pyrite or other sulfides, which are common in and near some veins

A yellow to greenish-yellow stain that is confined largely to light-gray to white noncalcareous quartzite is a possible exploration guide in the Galena district Near Spring Creek (Easley Hot Springs quadrangle) the yellow stain is developed in a zone of mineralized quartzite as much as 60 ft (19 m) wide in which massive galena float containing high silver and tin values (pl 2, T564-567) was found North of the Galena district, two large composite samples (pl 2, A602, 605, table 2), collected over several hundred feet of yellow to yellow-green stained quartzite, contained more silver, arsenic, antimony, and lead than is normal for quartzite

Alteration along pre-mineral dikes is common near some of the study area mineral deposits A northeast-trending belt of altered quartz monzonite encloses the dikes and gold-silver veins of the Buckskin and Valley Creek mines Irregular pods and veinlets of quartz and disseminated pyrite are common near the veins The enclosing quartz monzonite is sheared, irregularly bleached, and iron stained, and the feldspars are altered to clay minerals Mineralized, pre-mineral granite porphyry dikes near productive veins, as in the Livingston mine, commonly are sericitized. Many dikes in the Boulder Mountains are pyritized and weather rusty brown.

CONTACT METAMORPHISM AND RELATED ORE DEPOSITS

Two varieties of contact metamorphic rocks were mapped from colored aerial photographs taken over the triangular area between Pole Creek and the Salmon River The two varieties are widely distributed, conspicuous, white, wollastonite-bearing calc-silicate rock, and green, rusty-weathering, diopside-bearing calc-silicate rock (pl 3). Other types of contact metamorphic rocks, such as hornfels and metamorphosed transitional rocks, occur near the contact zones but could not be distinguished on the colored photographs; thus the overall contact aureoles are more extensive than shown on plate 3

The two varieties of calc silicate rocks developed from calcareous sandstones and siltstones, which were affected by contact metamorphism generated by intrusive plutons Neither variety received much additive metasomatism and both are loosely termed tactites in this report

Green diopside tactite is the host rock for the molybdenite and scheelite deposits (pl 1) The green tactite, which locally contains garnet or hornblende and disseminated molybdenite or sparse scheelite, is confined largely to a narrow zone along the steeply dipping, faulted eastern contact zone of the White Cloud and Little Boulder stocks (pl 1) Adjacent to the Little Boulder Creek stock, the molybdenum content is greatest in the darkest green and more silicified tactite. Molybdenum content of the rock decreases eastward from the stock, as the green color fades and the silicification decreases. At other sites, scheelite or molybdenite occurs in somewhat similar but coarser grained diopside tactite, but these lack the silification characteristic of the major molybdenite deposit.

The white wollastonite tactite may extend several miles from gently dipping intrusive contacts and is developed largely from calcareous sandstones of the Wood River Formation (pl 3) The width of the contact aureole corresponds roughly to the width of the nonporphyritic border facies of the White Cloud stock Elsewhere, white wollastonite tactite suggests proximity to buried intrusive bodies, as inferred from the magnetic data (pl 1)

THE ZONAL DISTRIBUTION OF MINERAL DEPOSITS

The fact that ore minerals are, in many places, arranged in a regular sequential order outward from a presumed source area has long been recognized In most cases where the source areas can be identified as centers of igneous activity, the minerals stemming from them are distributed outward from the centers in various patterns—horizontally, vertically, concentrically, or in various combinations of these patterns. In general, the ores or minerals formed at high temperatures lie closest to the magmatic source, and the lower temperature minerals lie in more distant zones The ideal zoning sequence as proposed by W. H Emmons (*in* Bateman, 1950, p 314) is (1) barren zone with quartz, (2) tin (as cassiterite), (3) tungsten, (4) bismuth and molybdenum, (5) gold, (6) copper, (7) zinc (and some lead), (8) lead (and some zinc, silver, copper, and manganese), (9) silver, (10) barren zone, (11) gold and silver, (12) antimony, (13) mercury, and (14) upper barren zone This complete sequence is rarely, if ever, present in any one mineral district Usually some zones are missing, in most places only small parts of the sequence may be recognized

In recent years the zoning sequence has been refined for specific types of deposits by the use of trace-element content, metal ratios, and recognition that the position of many metals in the sequence is governed by the dominant minerals containing them For example, in the study area, tin, which usually occurs as cassiterite close to the intrusive source, is concentrated only in low-temperature, silver-lead ores, chiefly in combination with silver, copper, and zinc in sulfides and tellurium-bearing sulfides Bismuth occurs in scheelite-bearing gold-silver veins, chiefly as native bismuth or as bismuth telluride, instead of bismuth sulfide that is typical of the high-temperature scheelite or molybdenite deposits. The position of copper varies greatly depending on its principal mineral form

Several minerals in or near the study area conform rather well to the general zoning pattern Most tungsten and molybdenum deposits are confined to tactite near the contacts of the parent pluton, although the molybdenite in two nearby deposits is in quartz-vein stockwork within small quartz monzonite stocks Complex radioactive oxides of niobium, tantalum, uranium and thorium, ilmenite, and perhaps cassiterite occur as accessory minerals in pegmatites, aplite, and quartz veins in granitic rocks. Beryllium occurs as late-stage blue-green beryl in the Sawtooth batholith, and rare earths are major components of monazite, which is a common accessory mineral in parts of the Idaho batholith Silver-lead, lead, and zinc deposits are confined largely to the north-trending belt of Paleozoic rocks in the central part of the area and are generally somewhat removed and less obviously related to the intrusive rocks Within this group, however, zinc-rich deposits (Livingston mine, pl 3, 90) tend to be more numerous closer to plutons or their contact aureoles

ZONED PRIMARY GEOCHEMICAL HALOS

Many workers have shown that most, if not all, metalliferous sulfide deposits are surrounded by a very dispersed concentric halo of trace elements that are related to the deposit Such primary halos often extend vertically from below to above, and laterally beyond, most types of mineral deposits, and they are zoned systematically, depending upon the different mobilities of the various elements. Ovchinnikov and Grigoryan (1971) summarized geochemical studies of this phenomenon since about 1962 and reported on their own extensive research in the Soviet Union, where studies of primary geochemical halos have been used successfully in the discovery and evaluation of concealed or marginally outcropping mineral deposits The almost universal zoning of the primary geochemical halos is independent of the geologic environment but is similar to and more widespread than the well-known zoning of the ore bodies themselves. More importantly, the relative position of most metals within the vertical zoning sequence is almost constant in 10 common types of metalliferous deposits despite great differences in the amount and proportion of the valuable metals in each However, the position of copper, antimony, and tin depends somewhat on the predominant mineral species, if their temperatures of formation are notably different The composite vertical zoning sequence summarized by Tauson and others (1971) is from top to bottom mercury, antimony, arsenic, barium, silver, lead, zinc, copper, bismuth, tungsten, molybdenum, tin, cobalt, nickel, and beryllium. The first four are the common useful "supraore" indicators and form wide, relatively intense halos above mineral deposits of metals lower in the sequence Conversely, the elements near the bottom of the sequence (or well below the principal valuable metals) are possible "subore" indicators that generally form narrow halos in the root zone.

The detection of zoned primary halos on the surface or in drill holes is of value in the exploration for buried ore deposits The Russians reported discoveries of ore bodies in 24 of 26 geochemically anomalous localities in one Asian district by use of this method (Ovchinnikov and Grigoryan, 1971) Some of the ore bodies were as deep as 1,640 ft (500 m) Primary halos in bedrock as well as secondary dispersion halos in soil and stream sediments derived from outcropping mineral deposits or from sufficiently intense primary halos can be detected by relatively widely spaced sampling, which can serve as an exploratory technique in testing large terrains and in narrowing target areas for more detailed exploration

The almost universal zoning of primary halos offers a guide for judging whether a geochemical anomaly overlies a mineral deposit or whether a mineral deposit is bottoming out, and for predicting probable changes in grade or composition with greater depth. In some cases even the character of concealed or partly outcropping mineral deposits can be determined by studying the amount and relative proportion of the principal and associated minor metals in the primary or secondary halos

A detailed interpretation of the chemical and mineralogical data in this report could not be made in the available time, but there is no doubt that Russian work on geochemical halos is a powerful, but little-known, tool for exploration and evaluation of mineral deposits The technique could be used in the study area and in most other mineralized districts

APPRAISAL OF POTENTIAL MINERAL RESOURCES

Appraisal of mineral resources by the U S Geological Survey is a qualitative appraisal of potential resources; an economic appraisal by the U.S. Bureau of Mines concerns mineral resources in mines, prospects, and potential placers, and the geothermal capacity of hot springs.

The U S. Geological Survey appraisal of identified or inferred but unexplored mineral resources, and the determination of geologically favorable environments in which mineral resources might be found, are based primarily on geologic studies, on the collection and analyses of 4,636 rock, stream-sediment, panned-concentrate, and soil samples, and on geophysical studies. The mineral deposits, geochemical determinations, and interpretations from the analyses are described in separate sections under commodity headings. These commodity descriptions present an overall view on the location, geologic environment, distribution, and geochemical relationship of the various deposits and associated areas. Analytical determinations are presented on geochemical maps and in various tables or graphs Following the commodity descriptions, three of the five favorable exploration targets revealed by the studies are described. Information on the other two targets is combined with the corresponding mine descriptions in the Bureau of Mines chapter of this report

DEFINITION OF MINERAL RESOURCES

Categories of mineral resources used throughout this study generally follow those outlined by the U S. Geological Survey and Bureau of Mines in 1943 and by the President's Materials Policy Commission, 1952 Resources consist of *mineral reserves*, *potential resources*, and *potential future sources* *Mineral reserves* refers to mineralized material (ore) that can be profitably mined and marketed at prevailing economic conditions Terms *marginal* and *submarginal* refer to decreasing probability of profitable recovery *Potential resources* are materials that require more favorable prices to be economically minable *Potential future sources* are mineralized materials that must await advances of mining and extractive technologies. The terms *measured*, *indicated*, and *inferred* refer to reliability of estimations. *Measured* reserves (ore) are calculated using data from closely spaced drill holes, trenches, and other exposures, and for which the grade is determined from analyses of detailed sampling *Indicated* is used where tonnage and grade are calculated using some subsurface control and reasonable projections based upon geologic evidence *Inferred* refers to estimates based on the general geologic character of the deposit and the assumed continuity between and beyond sporadic outcrops and sample sites.

Revised and extended definitions of mineral resources adopted in 1974 by the U S Bureau of Mines and U S Geological Survey were not used because they postdate report preparation

GEOCHEMICAL SAMPLING

A total of 4,636 geochemical samples were collected by the U S. Geological Survey from within or near the study area. Sample sites, type of sample, and sample numbers are shown on plate 2 Comprising the total are 885 samples of unmineralized and unaltered rocks that were collected to determine background metal content, 621 samples of mineralized or altered rocks, 2,875 stream-sediment samples, and 255 soil samples Emphasis was placed on stream-sediment sampling because this technique permits large areas to be tested quickly Principal streams and drainage patterns of the study area are shown on figure 3

Sample numbers shown on plate 2 have a prefix letter determined from the sample collector's name. By contrast, analytical tables show the laboratory sample number, which consists of the letters "WC" (White Clouds), the prefix letter from the sampler's name, a zero, the field sample number and often the suffix "R," which indicates it was a rock sample, or the suffix "M," which indicates it was a mineralized sample Thus, a mineralized sample collected by Tschanz and shown on plate 2 as T570 is listed as WCT0570M in table 2 (see pages 163–208)

There are two exceptions to the numbering procedure Samples collected by Earl H. Bennett are shown on plate 2 as numbers only, without the prefix "B." In analytical tables, however, Bennett's sample numbers have the prefix "B " This variance should be considered in any attempt to relate analytical data to plate 2, or vice versa. Also, some laboratory numbers have the prefix "R " These samples were collected by Robert K Evans, U S Bureau of Mines The sample numbers are not shown on plate 2 but are shown on various illustrations in the Bureau of Mines chapter of this report

Laboratory sample numbers, the latitude and longitude of the sampled site, and analytical determinations of all samples collected by the U S Geological Survey are stored on magnetic tape. The taped data are available from the National Technical Information Service (Tschanz and others, 1973)

ANALYTICAL METHODS

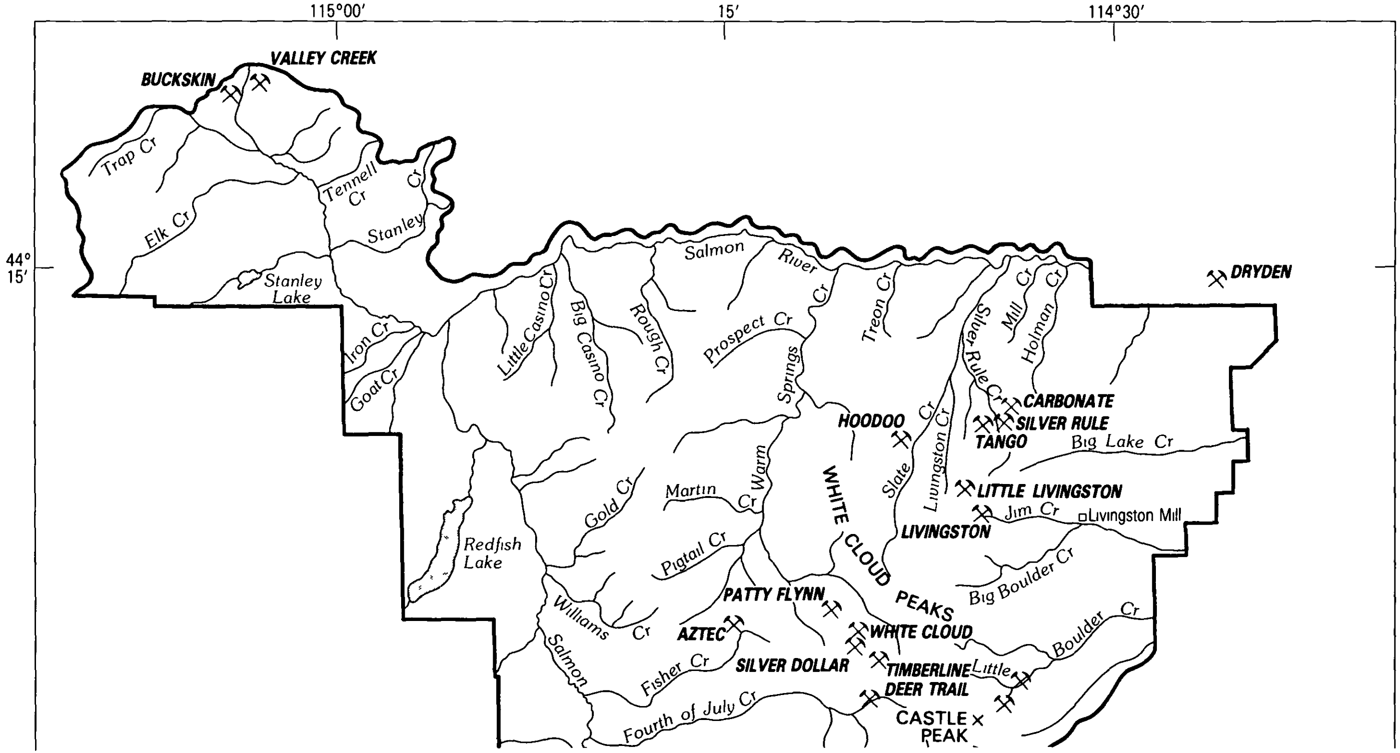
Samples collected by U S Geological Survey members of the field team were analyzed chiefly by the six-step semiquantitative spectrographic method, although many were analyzed by atomic absorption, colorimetric, and instrumental techniques. Many of the determinations were made in a field laboratory and the remaining ones in the U S Geological Survey laboratory in Denver, Colo. Analytical results are reported in ppm (parts per million), except for iron, magnesium, calcium, and titanium, which are reported in percentages. Routine field quantitative methods are designed to measure trace amounts of the element being tested but not assay values of ore, because of decreasing accuracy in concentrated solutions. For mineral exploration purposes, these analytical methods are helpful in that they identify subsidiary metals that are not determined in normal assay methods. Maximum values reported routinely from field analyses are given in table 1; where obtained values exceeded those limits, the sample usually was reanalyzed, using either a greater dilution of sample solution or another analytical method. Repeat analyses routinely were made on samples that contained abnormal quantitites of mercury, cadmium, and tin Routine analyses showing 40,000 to 100,000 ppm of lead and zinc probably are low, but all determinations showing more than 100,000 ppm lead and zinc are repeat analyses and are considered to be accurate

PRESENTATION OF ANALYTICAL DATA

Analytical data from samples from the study area are shown on 18 small-scale computer-generated geochemical maps (figs 4–21) The small size of the maps permits only a computer-generated range in analytical determinations to be shown. The map size also prevents showing all analytical findings at sites where many samples were taken in close proximity to each other Because the maps are computer generated, sample-site locations are not plotted exactly on the course of the stream, whereas other samples are along streams too small to show on the maps. Explanations on the maps show the number of samples within the various analytical class limits Not located on the maps but included in the map captions are the number and percent of samples where the quantity of element in the sample was too small to detect by analysis or too small to measure.

Complete analyses of mineralized or anomalous rocks of the area are presented in table 2.

The array of analytical data on the maps permits a quick scan of geochemical findings Clusters of symbols denoting higher metal values generally mark areas of anomalous metal content. On rock sample maps, the clusters may be centered at the site of a known mine or they may fix the site of an unexplored mineral deposit. Similarly, on stream-sediment sample maps, such clusters may be downstream from a known deposit that is being eroded or they may reflect erosion of an unknown deposit Maps showing rock and stream-sediment sample data of the same metal or associated metals therefore should be com-


115°00'
15'
114°30'
44°
15'
VALLEY CREEK
BUCKSKIN
Trap Cr
Elk Cr
Tennell Cr
Cr
Stanley
Stanley Lake
Iron Cr
Goat Cr
Little Casino Cr
Big Casino Cr
Rough Cr
Salmon
River
Prospect Cr
Cr
Springs
Treon Cr
Silver Rule Cr
Mill Cr
Holman Cr
DRYDEN
CARBONATE
SILVER RULE
TANGO
HOODOO
Cr
Livingston Cr
Slate
Big Lake Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
WHITE CLOUD PEAKS
Gold Cr
Martin
Warm
Cr
Redfish Lake
Pigtail Cr
Big Boulder Cr
PATTY FLYNN
WHITE CLOUD
Williams
Cr
AZTEC
Boulder
Cr
Salmon
Fisher Cr
SILVER DOLLAR
TIMBERLINE
Little
DEER TRAIL
Fourth of July Cr
CASTLE PEAK

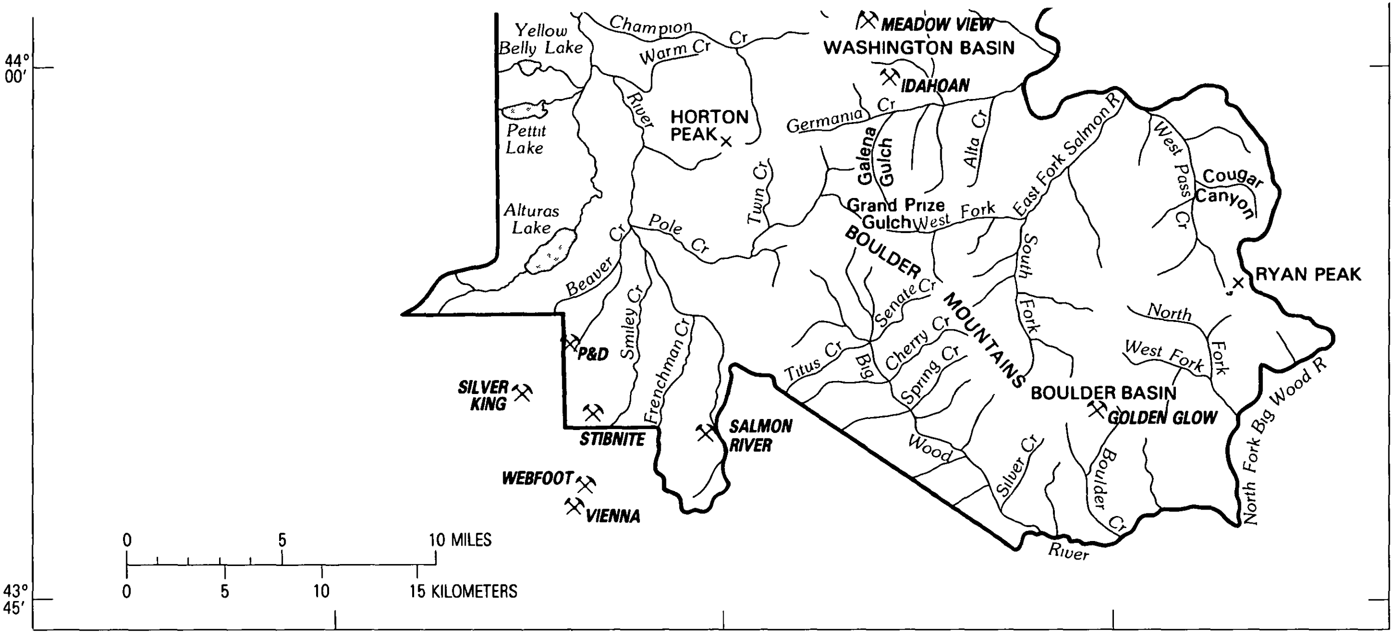


FIGURE 3.—Principal streams, mines and prospects, and physiographic features of the eastern part of the Sawtooth National Recreation Area, Idaho. Base from AMS 1:250,000 Challis (1954), Hailey (1955).

TABLE 1 —*Maximum values reported from routine analyses of rock samples*

[Fe, Ca, and Ti reported in percent, all other metals reported in parts per million S, analysis by the semiquantitative method AA atomic absorption analysis, CM color spectrophotometer or colorimetric analyses I, instrumental vapor detection analysis P partial digestion]

Antimony (Sb)	5,000 (CM)	Lanthanum (La)-	1,000 (S)
	10,000 (S)	Lead (Pb)------	20,000 (S)
Arsenic (As)-	10,000 (S)	Manganese (Mn)-	5,000 (S)
Barium (Ba)--	5,000 (S)	Mercury (Hg)---	10 (I)
Boron (B)----	2,000 (S)	Molybdenum (Mo)	2,000 (S)
Cadmium (Cd)-	500 (S)	Silver (Ag)----	5,000 (S)
Calcium (Ca)-	20 (S)	Tin (Sn)-------	1,000 (S)
HM[1]----------	100 (CM)	Titanium (Ti)--	1 (S)
Iron (Fe)----	20 (S)	Zinc (Zn)------	10,000 (S)
			100,000 (AA-P)

[1]Combined heavy metals.

pared The geochemical maps should be compared to plate 2, from which sample numbers in areas of interest may be obtained They also should be compared to plate 3, where the sites of known mines and prospects are located Comparison to plate 1 will yield information on the geologic environment and terrane of the areas of interest These comparisons are particularly useful in studying the geochemical rock sample maps, as these maps show only the highest metal value within a map area of 800 ft^2 (74 mi^2) At mineralized outcrops, however, many closely spaced samples commonly were taken as a means of determining the extent of the deposit Presentation of additional analytical data from such closely spaced sample sites congests the data on the small-scale maps to a point where they become illegible The number of samples referenced to a given analytical class limit therefore may indicate more sample locations than are shown on the map

Background data used in preparing the geochemical maps are condensed in table 3 Threshold values for anomalous metal content are not shown in the table, nor on the geochemical maps. Approximate threshold values may, however, be determined from table 3 For example, under stream sediments the approximate threshold value for a particular element may be determined by multiplying the geometric mean by a factor of two In such an instance, consideration should be given to the type of analysis for the particular element For the elements gold, silver, tungsten, and others (table 3), where the geometric mean is based on only a few analytical findings, such a calculated threshold value would not be valid as it would be based on insufficient sample data. Similar but less accurate threshold values may be determined by multiplying the arithmetic means of elements analyzed in barren igneous and sedimentary rocks by two, but in these columns also the arithmetic means of elements determined from a large population of analyzed samples are more valid. The geometric means of elements in the 621 anomalous and mineralized rock samples is higher generally, as would be expected, than the geometric means of elements in the 1,461 overall rock samples, as the latter reflect dilution of analytical data from the barren rock samples.

INTERPRETATION OF GEOCHEMICAL ANOMALIES IN STREAM SEDIMENTS

Many stream sediments in the study area are anomalous; they contain higher proportions of a metal or metals than is normal. Stream sediments represent the weathered products of rocks undergoing erosion. Metal content of a sediment sample therefore reflects the metals of the various rocks or mineral deposits that are being eroded in the area drained by the stream. Some eroded elements occur as residual mineral particles in the stream sediments, whereas others are absorbed on particles of clay or precipitated in compounds for which they have an affinity.

Eroded elements in stream sediments are transported a considerable distance from their source, but anomalous quantities of metallic elements commonly are within a mile (1.6 km) or so of the source. The magnitude of the anomaly and the distance that transported elements can be detected generally increase directly with the size and metal content of the exposed source and decrease with increased volume of diluting barren sediments and distance from the source. Anomalous samples are most common downstream from known mineral deposits, mines, or old mills, but many were obtained in drainage areas in which no mineral deposits are known.

Identification of the contributing source is relatively simple where anomalous stream sediments are derived directly from nearby mineral deposits or near the headwaters of the stream, but it becomes increasingly difficult downstream. Identification of the source also is difficult in areas that contain large amounts of glacial gravels or older terrace deposits, whose ultimate source and distance of transport is unknown and which may themselves be contributing to the anomaly. The older gravel deposits that are perched above present stream bottoms east of the White Cloud Peaks and on the margins of Sawtooth Valley and its extension up Valley Creek are examples of possible source gravels whose place of origin is in question. The magnitude of the anomaly may not, however, reflect the size, metal content, and distance from the source, where adsorption or precipitation is controlled by local chemical factors, as in the case of uranium in organic-rich highly reduc-

TABLE 3 —*Geometric and arithmetic means of analytical data of selected elements*

[Analyses in parts per million Analytical methods S, six-step semiquantitative spectrographic, AA, instrumental vapor detector; CM-HM colorimetric-citrate soluble heavy metals The number of samples in which measurable quantities of the particular metal were detected Geometric means are

Element (Analytical method)		Minimum measured value	Geometric mean and number of measured values in				Estimated regional background values[1]	670 barren intrusive rock samples	
			2,875 stream-sediment samples		255 soil samples				
Au	(AA)	[3]0 02	0 13±	(98)	0 57±	(8)	<0 005	0 04±	(3)
	(S)	10	--		--		--	--	
Ag	(AA)	[3] 2	77±	(1,049)	99±	(173)	<0 2	46±	(39)
	(S)	5	91±	(702)	1	(161)	--	75±	(25)
As	(CM)	10	21	(63)	14	(14)	<5	12	(5)
	(S)	200	--	(2)	--		--	--	
Sb	(CM)	[3] 5	1 8	(1,959)	2 7	(205)	0 5±0 2	1 7	(192)
	(S)	100	--	(2)	--		--	--	
Hg	(Inst)	01	25	(22)	--		0 07±0 03	11±	(411)
Cu	(AA)	5	14	(2,710)	22	(255)	10±3	13	(197)
	(S)	5	17	(2,836)	24	(255)	--	20	(544)
Pb	(AA)	5	26	(2,856)	55	(255)	15±4	12	(446)
	(S)	10	31	(2,817)	69	(255)	--	32	(601)
Zn	(AA)	5	87	(2,860)	261	(255)	31±6	37	(597)
	(S)	200	304	(382)	539	(112)	--	--	
Cd	(S)	20	22	(118)	--		0 4±0 2	20	(1)
HM	(CM-HM)	5	4	(1,115)	--		2 ±1	3 7	(16)
Bi	(S)	10	24	(22)	--	(2)	<0 5	--	
Sn	(S)	10	13	(235)	12	(237)	<1	11	(39)
Nb	(S)	10	16	(2,161)	13	(202)	10±3	14	(503)
Mo	(S)	5	7	(476)	7	(35)	<1	5	(12)
W	(CM)	20	23	(91)	--		<1	20	(7)
	(S)	50	65	(108)	--		--	--	

[1]Based on unmineralized rock and stream-sediment sample data <, less than

[3]Value applies to analyses of 1,400 stream-sediment samples

ing mud and bog sites within the Sawtooth Wilderness (Kilsgaard and others, 1970, p. D35)

The metal content in natural stream-sediment anomalies generally increases upstream toward the source and thus serves as a guide to such sources whether they be outcropping mineral deposits or primary geochemical halos above unexposed deposits. The actual source can only be precisely located by detailed examination and sampling of bedrock at the head of the stream-sediment anomalies During this study, detailed examination and sampling in possible source areas generally was insufficient to precisely locate the contributing source except for those exposed in mines, prospects, or mineralized outcrops

Concentrations of indicator elements are helpful in evaluating stream-sediment anomalies Many precious- and base-metal deposits *in samples from the eastern part of the Sawtooth National Recreation Area, Idaho*

atomic absorption, CM, color spectrophotometer (Sb), color spot-Gutzeit (As), colorimetric (W), Inst, samples analyzed is shown in column headings numbers in parentheses represent the numbers of median antilogs calculated from logarithmic classes, leaders (-), no data]

Arithmetic mean and number of measured values in				Geometric mean of measured values in	
215 barren sedimentary rock samples	117 anomalous and mineralized intrusive rock samples	262 anomalous and mineralized sedimentary rock samples	621 anomalous and mineralized rock samples[2]	621 anomalous and mineralized rock samples	1,506 rock and mineralized samples
--	8 1± (43)	0 31± (44)	3 4± (179)	0.27	0 24
--	24 2± (6)	--	23 7± (12)	19	19 5
0 48± (66)	192 (68)	34 (201)	229 (459)	5.5	3 5
87± (84)	70 (56)	26 (203)	125 (423)	5.5	3 6
17 (8)	1,021 (10)	69 (41)	1,356 (113)	92	76
--	2,569 (13)	1,036 (36)	2,450 (116)	1,052	1,033
2 4 (95)	27 (84)	356 (213)	569 (504)	13	5 5
--	890 (10)	1,703 (45)	2,668 (112)	949	949
15± (62)	5± (83)	2 6 (158)	1 7± (424)	.21	.11
13 (175)	154 (83)	223 (245)	370 (546)	40	23
18 (187)	116 (113)	186 (246)	234 (588)	42	25
19 (203)	4,183 (100)	3,575 (251)	10,700 (598)	141	38
20 (178)	1,680 (113)	1,191 (225)	2,258 (563)	137	51
26 (192)	307 (117)	7,160 (255)	4,102 (608)	147	57
--	1,122 (23)	1,126 (101)	2,142 (264)	891	867
--	42 (8)	142 (32)	157 (91)	78	77
8 (15)	1 5± (3)	13 5 (12)	27 5± (31)	7 8	5
--	74 (9)	65 (18)	90 (52)	34	34
10 (6)	27 (19)	24 (42)	157 (126)	65	40
11 (93)	21 (92)	17 (62)	32 (246)	17	14
5.6 (17)	74 (33)	106 (108)	98 (235)	27	23
--	53 (6)	229 (20)	101 (63)	36	36
--	145 (6)	254 (18)	160 (41)	85	85

[2] Includes all anomalous and mineralized samples of which those listed in prior columns as intrusive and sedimentary samples comprise only a part

contain associated but uneconomic quantities of such elements as arsenic, antimony, and mercury, and anomalous concentrations of these in stream sediments may indicate the proximity of a deposit. Ratios between metals of economic value and indicator elements also aid in evaluating anomalies Additive ratios of closely associated indicator elements and economic metals frequently aid more than ratios of selected pairs of elements.

Indicator elements in stream sediments are silver-antimony ± arsenic, and commonly a little gold or base metals, all of which may be derived from veins containing ruby silver minerals Anomalous concentrations of silver-gold-arsenic and lead are downstream from gold-silver veins at the Valley Creek mine Strong silver-lead anomalies also may be marked by zinc, tin, antimony, and occasionally gold, and are derived from lead-silver veins in rocks of Paleozoic age. Strong silver-lead anomalies, containing relatively high gold and antimony and low zinc values, are derived from rich gold-bearing argentiferous galena veins at the Golden Glow mine. Silver-lead-antimony-tin-zinc anomalies with very high zinc-cadmium ratios are derived from tin-bearing silver-lead sulfantimonide veins such as the Timberline prospect.

Strong antimony anomalies with low values of other metals are derived from stibnite deposits in the Idaho batholith. Strong zinc-cadmium anomalies with low lead, silver, and antimony contents are derived from sphalerite deposits of the Hoodoo mine type. Zinc-lead-tungsten anomalies are derived from scheelite-bearing sphalerite deposits in tactite (Meadow View mine). Molybdenum ± tungsten anomalies with low content of other metals are derived from molybdenite deposits, but molybdenum anomalies with high content of other metals do not necessarily indicate economically significant molybdenite concentrations.

Most natural anomalies containing gold and silver with low amounts of other metals that were detected in this study are far downstream from the sources and represent only finely divided material in the sieve fraction that was analyzed. This material probably was too fine to have been recovered during past placer operations. Gold anomalies containing relatively high amounts of other metals generally lie below old mills.

The study area contains little copper (table 2) except as a minor constituent of many types of ore. Copper, therefore, was among the least useful and least common metals in the stream-sediment anomalies.

Mercury is concentrated in many low- to moderate-temperature sulfide deposits in the study area and is likely to be found in anomalous amounts in the stream sediments downstream from them, but few stream-sediment mercury analyses were made (table 2). Anomalous mercury in stream sediments, without significant amounts of other metals, could be derived from cinnabar deposits. Weak mercury anomalies in rocks are ambiguous and could represent the roots of an eroded deposit or part of an alteration halo.

In the study area, silver and mercury are perhaps most useful in geochemical prospecting because they can be detected at very low concentrations and are present in most of the precious- and base-metal deposits. Zinc and gold, though more localized, are the next most useful metals, followed by lead, antimony, molybdenum, tin, arsenic, cadmium, bismuth, copper, and tungsten, in that order. The last seven are very useful for a few specific deposits but are not widely distributed in detectable amounts in other deposits. Silver, lead, molybdenum, tin, bismuth, copper, and tungsten can be analyzed at relatively low cost by semiquantitative spectrographic methods, mercury, gold, zinc, arsenic, and antimony require more elaborate analytical techniques.

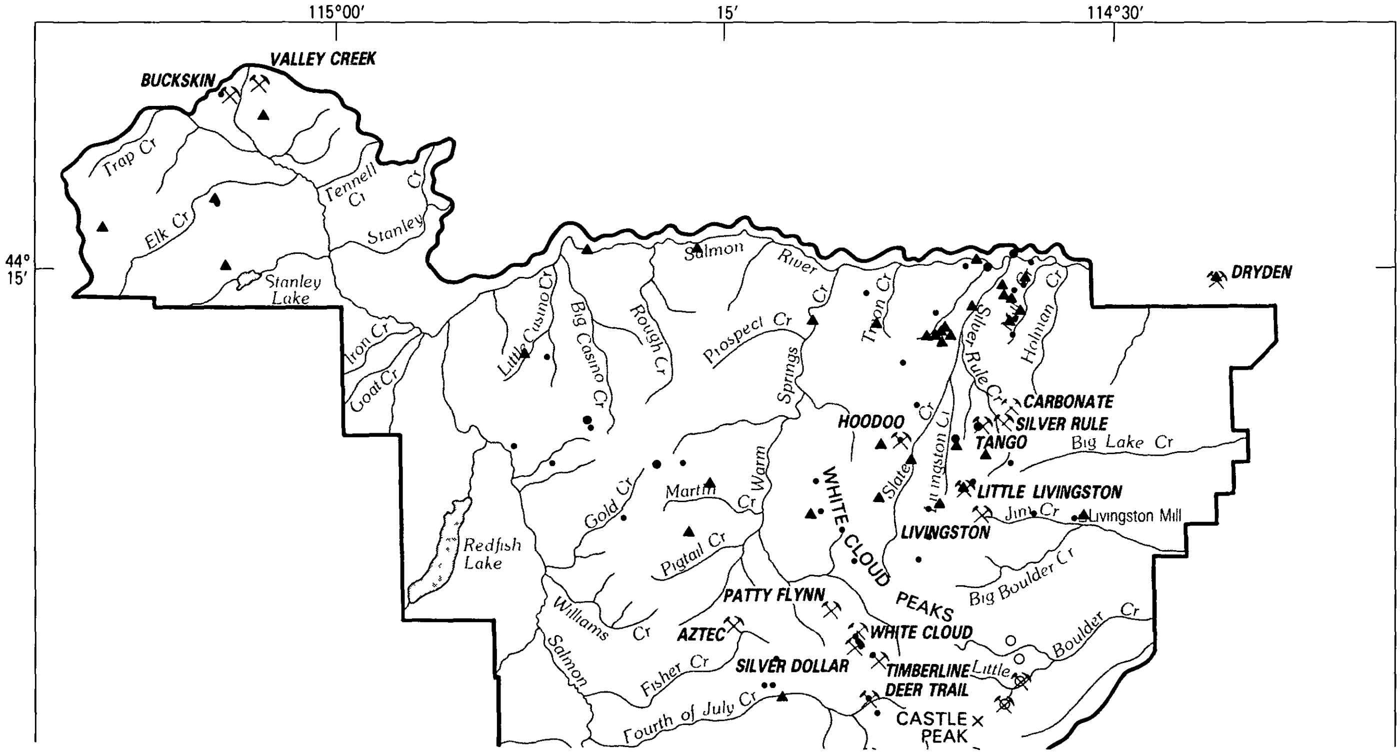
Geochemical anomalies below old mines or mills for the most part reflect the composition of extracted and processed ore. Such contaminated anomalies often provide valuable information on the composition of ore in now inaccessible mines. These mines originally were worked only for such metals as gold, silver, and lead, but may contain other commodities that were unrecognized or were then of no economic interest and were discarded in waste dumps. Contaminated anomalies below old mills commonly reflect the tailings more than the ore, and in some cases they indicate very poor mill recovery (Valley Creek mine). They also may indicate unsuspected valuable minerals or metals that can be used to reevaluate the economic potential of the remaining tailings or mine resources and to devise suitable recovery methods. A notable example of the latter case is a soil-like mill product(?) in Washington Basin that contains an order of magnitude more gold (110 ppm) than any samples form the known nearby veins, and very high selenium content It might be postulated that the deposit contains gold selenide, which was discarded because it was not recognized Contaminated dispersion trains, especially those below productive ore zones that were extensively developed, also provide models for the interpretation of natural dispersion trains below undiscovered deposits

Weak anomalies of a single element in stream sediments or soils, particularly of mercury and silver, which have very low detection limits, are suspect because anomalous amounts have been found in apparently unmineralized fresh rock. Stronger, multi-element anomalies are much more significant and informative

MOLYBDENUM

Molybdenum is the most important mineral commodity in the study area, even though none has been produced This ranking is based on the Little Boulder Creek deposit (pl. 3; fig. 4), where exploration has outlined an estimated 135 million tons of molybdenum-bearing material. A second major deposit, discovered in recent years—reportedly by stream-sediment sampling—is on Pat Hughes Creek, about 4 mi (6 km) north of the study area (pl 3). The deposit was being intensively explored by Cyprus Mines, Inc., in 1971 and 1972 A third molybdenum deposit, the Walton prospect, is on Little Fall Creek about 6 mi (10 km) southeast of the study area. The Walton prospect was tested by diamond drilling in recent years, but its potential is unknown

The Little Boulder Creek (Baker Lake) deposit was sampled originally by the U S. Bureau of Mines (L. E Shaffer and Frank Gunnell, written commun., 1943) and later during World II by the U S. Geological Survey (Kirkemo and others, 1965).


115°00′
15′
114°30′
44°
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VALLEY CREEK
BUCKSKIN
Trap Cr
Elk Cr
Tennell Cr
Cr
Stanley
Stanley Lake
Iron Cr
Goat Cr
Redfish Lake
Salmon River
Little Casino Cr
Big Casino Cr
Rough Cr
Prospect Cr
Springs Cr
Tryon Cr
Silver Rule Cr
Holman Cr
DRYDEN
CARBONATE
SILVER RULE
HOODOO
TANGO
Big Lake Cr
Slate Cr
Li ingston Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
Gold Cr
Martin Cr
Warm
WHITE CLOUD PEAKS
Pigtail Cr
Big Boulder Cr
PATTY FLYNN
WHITE CLOUD
AZTEC
Williams Cr
Salmon
Fisher Cr
SILVER DOLLAR
TIMBERLINE
Little
Boulder Cr
DEER TRAIL
Fourth of July Cr
CASTLE PEAK

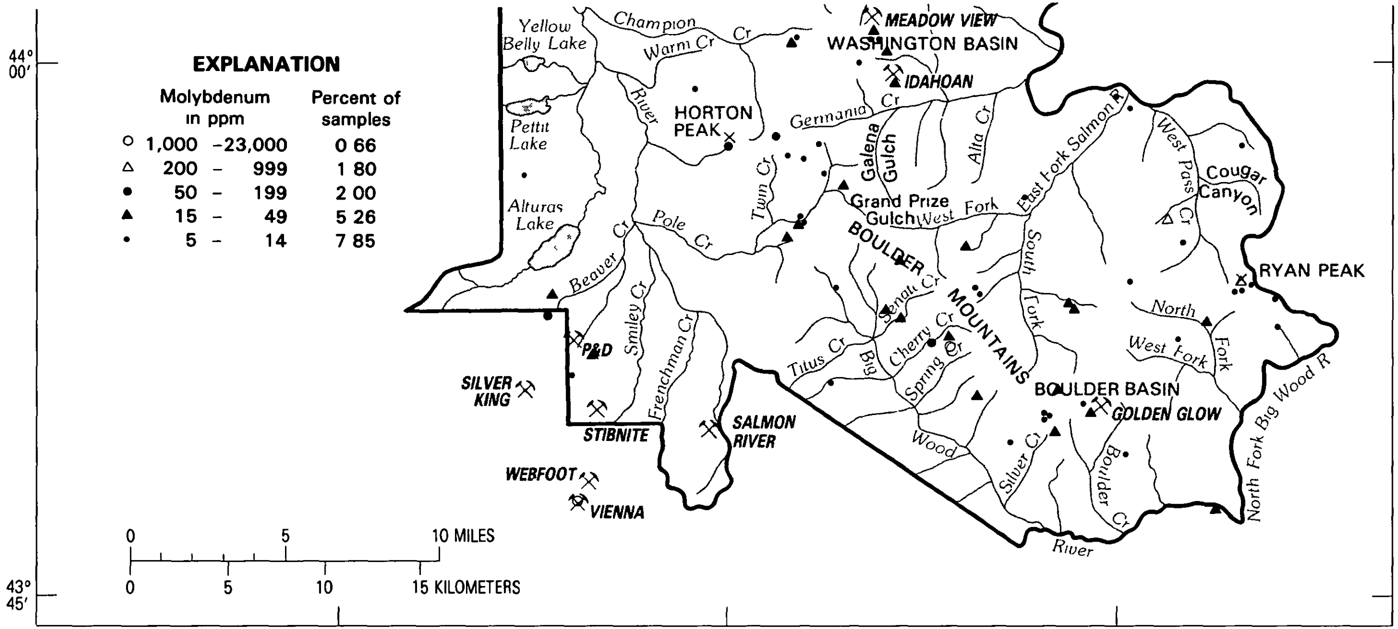


FIGURE 4 —Molybdenum distribution in rock samples, eastern part of the Sawtooth National Recreation Area. Molybdenum content of 1,241 samples or 82 43 percent of the total sample population either was nondetectable or present in amounts too small to measure Determinations by semiquantitative analysis

Most major productive molybdenite deposits are stockworks of molybdenite-bearing quartz veinlets or the so-called porphyry type in which molybdenum is disseminated in intrusive rocks In contrast, the Little Boulder Creek deposit consists of very fine grained, uniformly disseminated molybdenite within the silicified contact metamorphic aureole of a small detached pluton (Little Boulder Creek stock) that is probably related to the nearby White Cloud stock (pl 1). The host rock is fine-grained, green, diopside tactite of quartzitic appearance, which probably developed from a calcareous or dolomitic quartzite. The molybdenite is most abundantly disseminated in silicified diopside tactite that contains innumerable small, randomly oriented, discontinuous quartz veinlets that may have served as conduits for deposition of the molybdenite The quartz veinlets themselves, however, are nearly barren of molybdenite except adjacent to and within the bordering pluton

The Little Boulder Creek deposit grades eastward into sparsely mineralized light-green tactite and then into barren light-gray to tan tactite The darker green tactite generally has a higher content of molybdenite The adjacent part of the Little Boulder Creek stock also contains appreciable amounts of molybdenite The molybdenite mineralization obviously is younger than the tactite host rock and may be related genetically to intrusive activity that formed the adjacent small pluton

Spotty, irregular disseminations of molybdenite also were found in an aplite dike at the Little Boulder Creek deposit, and in coarser grained, garnet-bearing, dark-green tactite at several other localities along the east side of the White Cloud stock for about 3.5 mi (5.6 km) north of the deposit Molybdenite also was seen at several widely separated localities within the White Cloud stock and in several small isolated quartz monzonite outcrops, but none appear to be economically significant A molybdenite deposit of unknown economic potential was reported by A L Freeze (written commun , 1972) after field work was completed This deposit is west of Smiley Creek Lodge near the head of Little Beaver Creek.

Molybdenite and scheelite seldom occur together in more than trace amounts within the study area, and only two deposits of this mineral assemblage are known However, about a mile north of the study area, on Peach Creek (Sunbeam quadrangle), a quartz vein contains as much as 3 56 percent WO_3 and 3 0 percent Mo. This vein is near a molybdenite-bearing scheelite deposit in tactite along the east contact of the Idaho batholith (Choate, 1962, p 99–100).

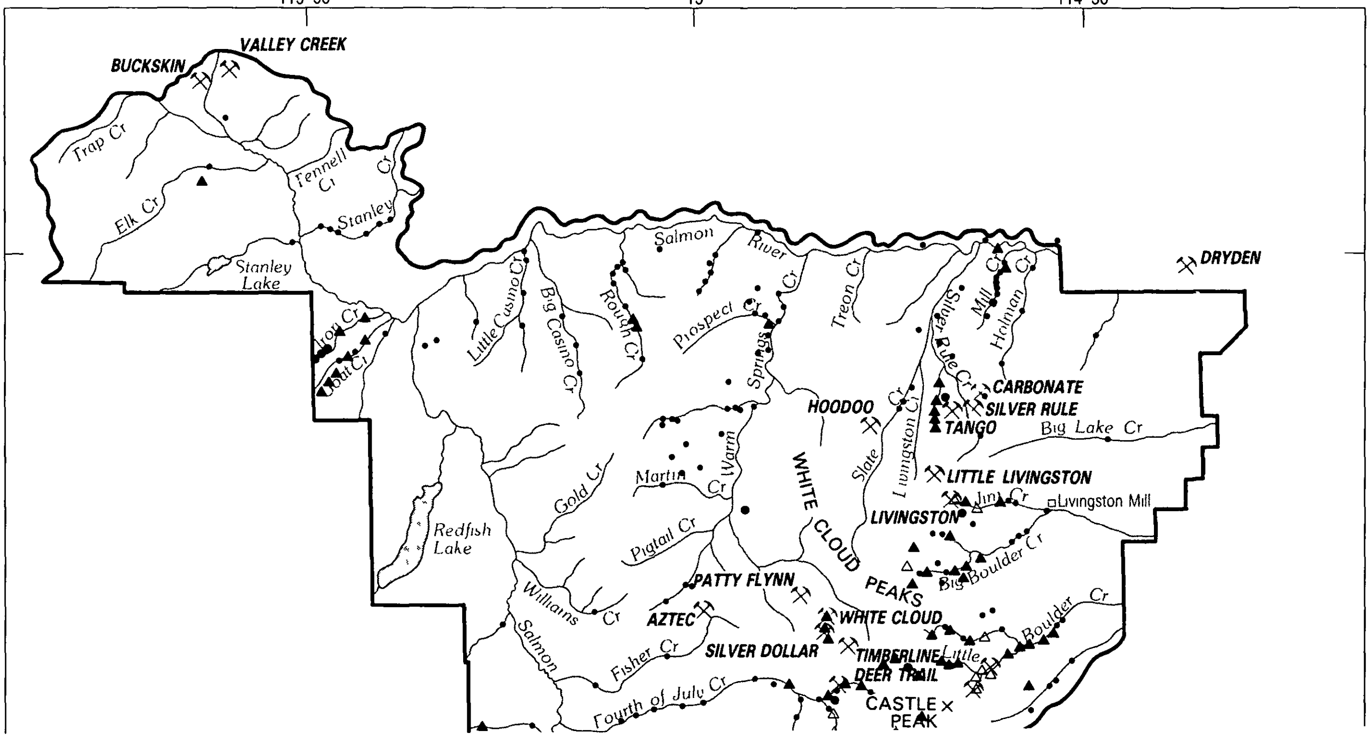
In the Vienna district just south of the study area, molybdenite was seen in the selvage of the principal vein of the Webfoot mine and on the dump of a prospect in the headwaters of Smiley Creek

Molybdenite occurs in several quartz-sulfide veins in the Sawtooth Wilderness, the western part of the Sawtooth National Recreation Area. In that area anomalous molybdenum also is widespread in rocks of the Sawtooth batholith and in stream sediments derived from them (Kilsgaard and others, 1970)

Anomalous molybdenum values occur in many stream sediments eroded from the White Cloud stock (fig 5). Noteworthy are those along Big and Little Boulder Creeks and their tributaries, which obviously were derived from known molybdenite deposits in the contact aureole along the east side of the stock. The stream-sediment anomaly below the Little Boulder Creek molybdenite deposit decays very rapidly downstream, dropping from over 100 ppm molybdenum at the deposit to about 30 ppm immediately below it and to less than 15 ppm about 1,000 ft (305 m) downstream The detection limit of molybdenum (5 ppm) was reached in samples taken 3 mi (4.8 km) downstream. The north-trending belt of anomalous values north of Germania Creek, near the southwest corner of the White Cloud stock, is derived from molybdenite-bearing scheelite deposits at the Red Robin prospects (pl 3, 114 and 115) and from scheelite-bearing tactite and bismuth-bearing gold-silver veins in Washington Basin. Deposits of molybdenite are not known at that locality.

Anomalous molybdenum in stream sediments in the northern part of the study area probably was derived from vein outcrops Sediment samples along Mill and Slate Creeks that are anomalous in molybdenum also are anomalous in silver, zinc, and lead, metals believed to have originated in known deposits upstream. The anomalous dispersion train along the west fork of Silver Rule Creek is as impressive as the one below the Little Boulder Creek deposit, but it is believed to have been derived from veins that crop out near the head of the canyon (pl 3, 72, 76, 77, and 78, table 11) No molybdenite deposits of significance are known in the drainage basins above the sample sites and the geological environment in the area is considered unfavorable for molybdenite deposits

Stream sediments anomalous in molybdenum were found along Iron, Goat, and Yellow Belly Creeks on the west side of Sawtooth Valley The samples are mainly from sites in glacial moraines that were eroded from rocks in the Sawtooth Wilderness The anomalous molybdenum could be from the morainal debris, in which case the original source would be unknown, but more likely it is in sediments eroded from mineralized parts of the Sawtooth batholith (Kilsgaard and others, 1970). The extent and values of anomalous sediments along streams draining the Sawtooth batholith are impressive Rocks of the batholith contain more molybdenum than is normal, and it is quite possible that they contain undiscovered molybdenite deposits of commercial significance



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Trap Cr
Elk Cr
Tennell Cr
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Stanley
Stanley Lake
Iron Cr
Goat Cr
Little Casino Cr
Big Casino Cr
Rough Cr
Salmon
River
Prospect Cr
Cr
Springs
Treon Cr
Silver Rule Cr
Mill Cr
Cr
Holman
DRYDEN
CARBONATE
SILVER RULE
TANGO
HOODOO
Cr
Livingston Cr
Big Lake Cr
Slate
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
WHITE CLOUD PEAKS
Warm
Martin
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Gold Cr
Redfish Lake
Pigtail Cr
Big Boulder Cr
PATTY FLYNN
Williams
Cr
AZTEC
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Fisher Cr
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TIMBERLINE
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Boulder
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DEER TRAIL
Fourth of July Cr
CASTLE PEAK

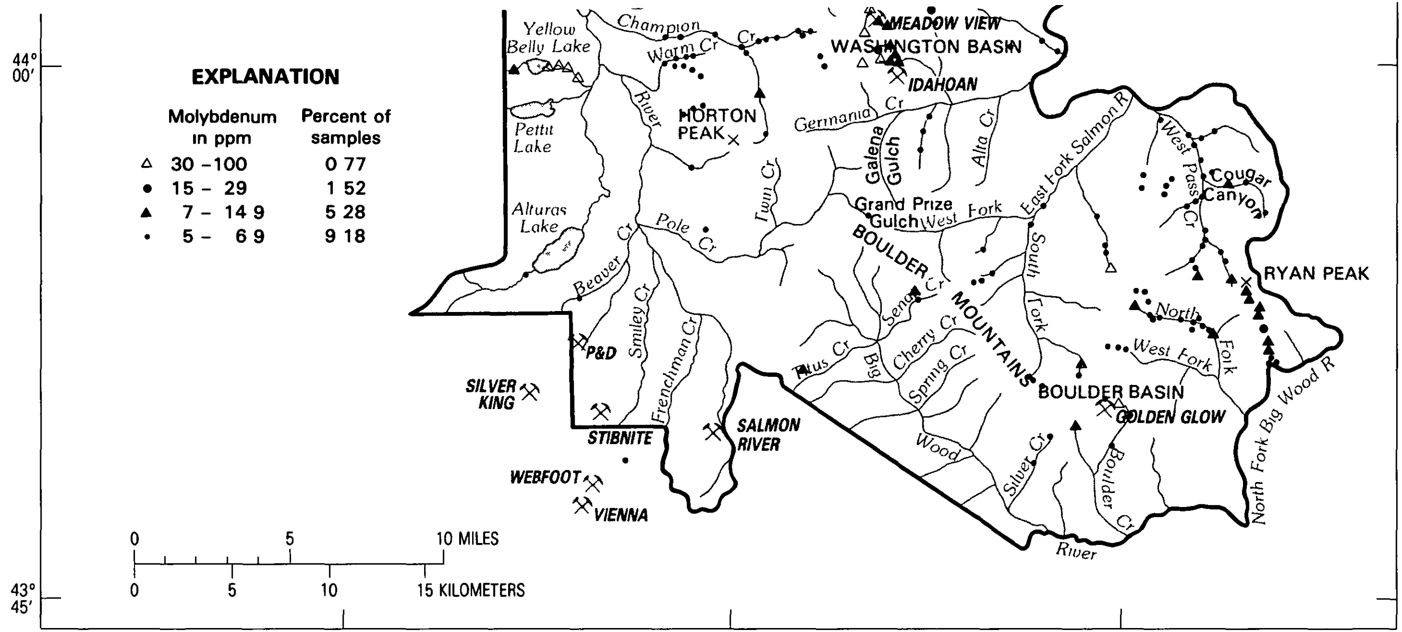


FIGURE 5 —Molybdenum distribution in stream-sediment samples, eastern part of the Sawtooth National Recreation Area. Molybdenum content of 2,393 samples or 83 25 percent of the sample population either was nondetectable or present in amounts too small to measure Determinations by semiquantitative analysis

Anomalous stream sediments along Ibex Canyon, West Pass Creek and the upper reaches of the North Fork Big Wood River probably were eroded from the Ibex Canyon stock and the altered and pyritized younger porphyritic intrusive rocks near the headwaters of West Pass Creek. These rocks, like other granitic intrusives of Tertiary age in the area, are a geologically favorable environment for molybdenite deposits. The altered zones are near the tops of these intrusive porphyries and may represent the upper parts of mineralized zones

Findings from this investigation indicate that within and near the study area the most favorable environment for molybdenite deposits is near the margins of granitic stocks of Late Cretaceous or Eocene age The composition of these intrusives approaches that of quartz monzonite Biotite is the only mafic silicate and the potassium feldspar is pink perthitic orthoclase rather than microcline The texture usually is porphyritic Molybdenum, beryllium, niobium, and uranium tend to be relatively concentrated in these rocks, particularly in those of low CaO and MgO content and especially in associated late granitic, pegmatitic, and aplitic dikes Large quantities of silica were introduced with the molybdenite in the major deposits

All of the granitic stocks reflect large positive magnetic anomalies with steep marginal gradients (pl 1; fig 2) Some of the anomalies within the study area are produced by apparently barren rocks. Two magnetic anomalies outside the area and not shown on the map warrant investigation· one is at Sheep Mountain, about 4 mi (6 4 km) east of the East Fork Salmon River, and the other is about 5 mi (8 km) west of the Cyprus Mines molybdenite deposit north of the study area. Neither magnetic area is known to be mineralized Other types of geographical investigations would be worthwhile in the study area. For example, the induced potential method successfully outlined the Little Boulder Creek deposit and might be used to evaluate other deposits of disseminated molybdenite

GOLD

The economic potential of gold resources in the study area is intrinsically difficult to evaluate, especially in recent years when the price has fluctuated Since this study began, the price of gold has increased from $35/oz to successive record prices. This increase has radically changed the economic evaluation of gold resources in the U S. Bureau of Mines chapter of this report Increases in the price of silver and fluctuations in prices of other metals have similarly changed the economic potential of lode gold deposits, which contain at least 2 to 10 times as much silver as gold, and of the silver and argentiferous base-metal deposits, which commonly have silver/gold ratios of several hundred. Although higher prices of precious metals have enhanced the economic potential of the deposits, the costs of labor and supplies likewise have increased so that the increase in real values is much less than suggested by the higher prices. In such time of rapid change, the real, current, or future value of gold resources is indeterminate in a report of this kind, but the assembled data indicate identifiable resources that are of potential economic value.

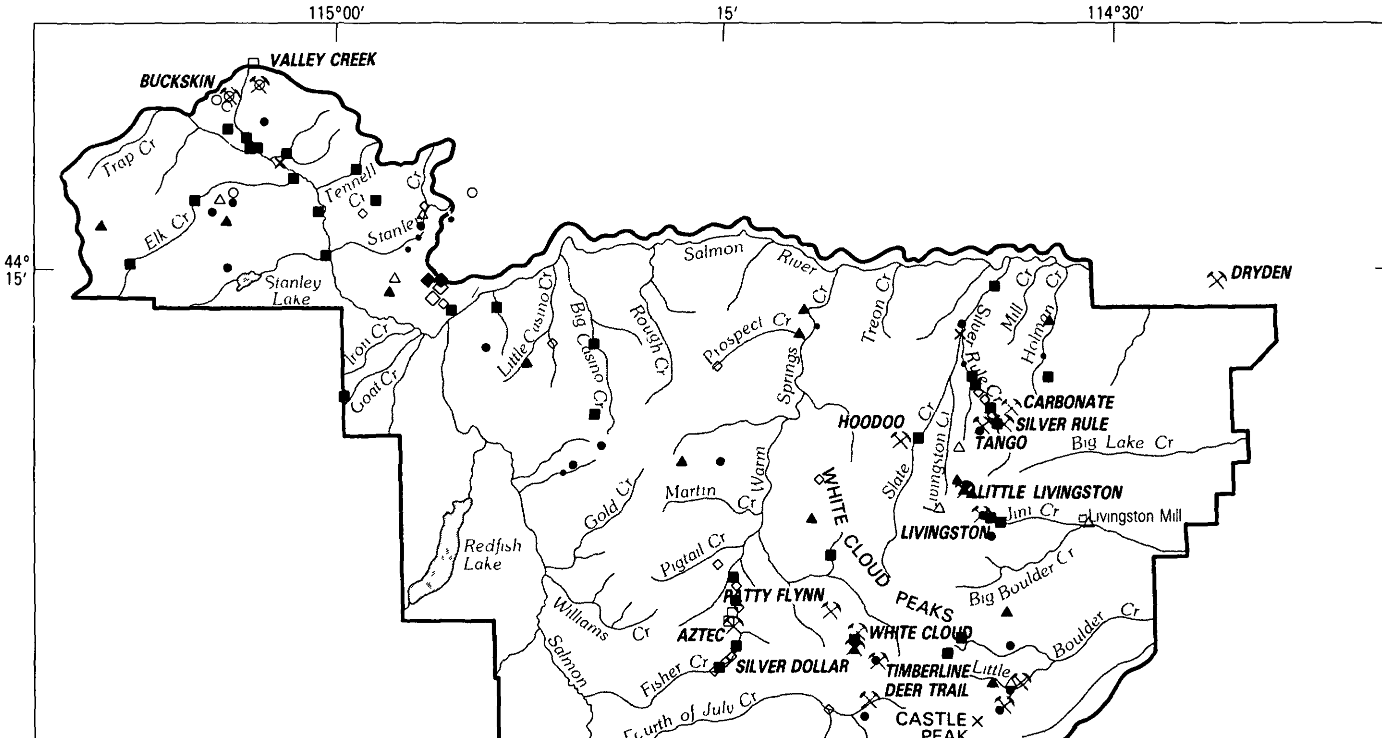
PRODUCTION

In the study area, gold occurs in both veins and placers (pl. 3), many of which were described by Umpleby (1915), Umpleby and Livingston (1920), and Choate (1962). About 40,000 oz (1,244 kg) of gold have been produced, including 33,000 oz (1,026 kg) from placers, according to the U S Bureau of Mines. Gold placer deposits worked between 1870 and 1900 in the northern part of the study area (pl. 3) account for perhaps 25,000 oz (777 kg) The Golden Glow mine in Boulder Basin was the major source of lode gold before 1902. Gold also has been produced from veins at the Valley Creek and Buckskin mines (1,583 oz–54.3 kg) and as a byproduct of complex lead-zinc-antimony ore at the Livingston mine (585 oz–18.2 kg). In addition, an unknown amount of gold was produced from an old five-stamp mill at the Aztec mine, two old mills in Washington Basin, and from placers on Pigtail Creek and along the Salmon River Some gold has been produced from all districts that have produced metals. Since official records were kept beginning in 1902, gold from both lode and placer deposits accounted for only 3 percent of the $2,500,000 production value of all metals.

GEOCHEMICAL ANOMALIES

Rock, stream-sediment, and soil samples that contain anomalous amounts of gold are shown in figure 6 The complete analyses of the rock samples containing at least 0.05 ppm gold are given in table 2. All measurable gold values are considered anomalous. The minimum measurable value in about half the samples was 0.02 ppm (those collected in 1971) and 0.05 ppm for the remainder (those collected in 1972) Gold was not detected in 96 percent of 225 soil samples, 51 percent of 2,875 stream-sediment samples, and 45 percent of 621 anomalous rock samples. None of 1,524 unmineralized rock samples contained as much as 0 05 ppm gold.

Assay measures in gold normally are given in troy ounces per short ton. Analytically, gold also is measured in ppm (parts per million) and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VALLEY CREEK
BUCKSKIN
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Tennell Cr
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Stanley
Stanley Lake
Iron Cr
Goat Cr
Little Casino Cr
Big Casino Cr
Rough Cr
Salmon River
Prospect Cr
Springs Cr
Treon Cr
Mill Cr
Holman Cr
Silver Rule Cr
DRYDEN
CARBONATE
SILVER RULE
HOODOO
TANGO
Big Lake Cr
Slate Cr
Livingston Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
Redfish Lake
Gold Cr
Martin Cr
Warm
WHITE CLOUD PEAKS
Pigtail Cr
Big Boulder Cr
Boulder Cr
PATTY FLYNN
Williams Cr
AZTEC
WHITE CLOUD
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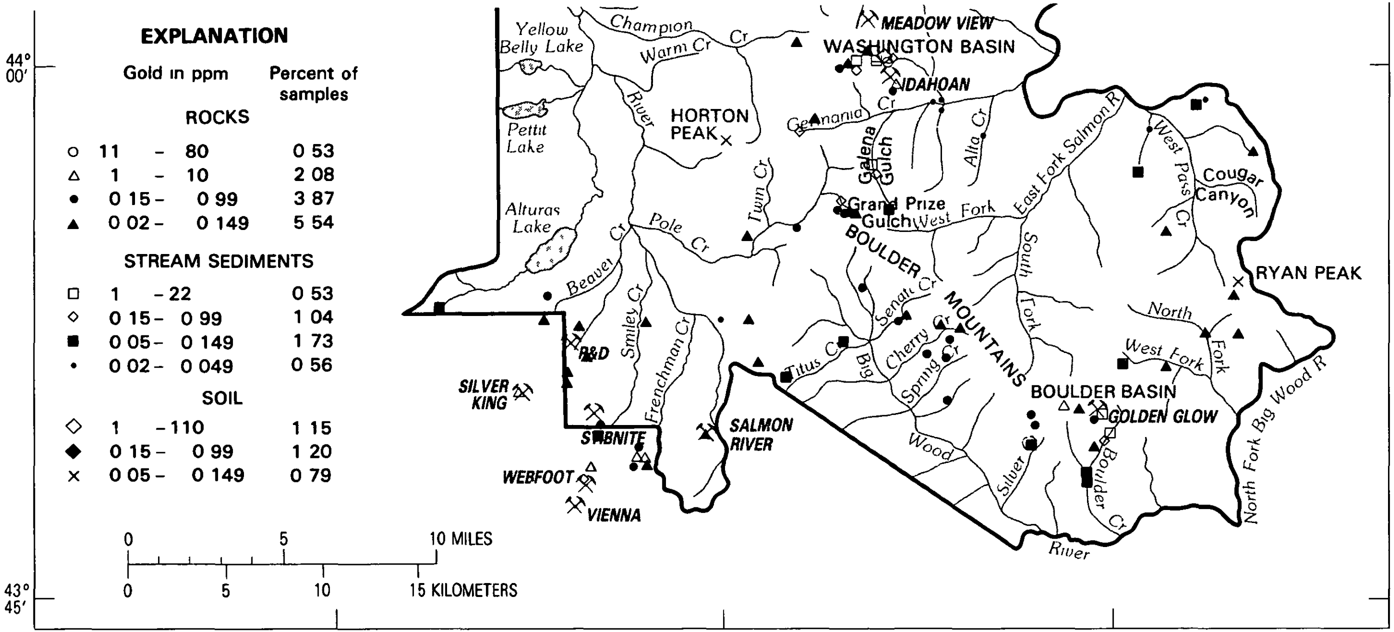


FIGURE 6 —Gold in rock, stream-sediment, and soil samples, eastern part of the Sawtooth National Recreation Area. Gold content in 1,324 rock samples or 87 98 percent of the rock sample population, in 2,773 stream-sediment samples or 96 46 percent of the stream-sediment sample population, and in 247 soil samples or 96 86 percent of the soil sample population either was nondetectable or present in quantities too small to measure Determinations by atomic absorption

conversions of these units to ounces per ton and grams per metric ton are given in table 4.

Only the minus-80 mesh (0.15-mm) screen fraction of stream sediments and soils was analyzed, consequently coarser gold was not detected. This sampling procedure accounts for the absence of anomalous gold values in soil and stream-sediment samples collected over many formerly productive gold placer deposits. Only gold too fine to have been recovered normally in former placer mining and milling operations would have been detected in the stream-sediment samples. This explains the strong stream-sediment anomalies below old mills, for example those in Washington and Boulder Basins (fig. 6).

For panned concentrates, gold coarser than 0.15 mm was analyzed. Panned concentrate samples enriched in gold were collected from the head of Kelly Creek (Basin Butte quadrangle) north of the study area (pl. 2, K96, 70 ppm), on Elk Creek below a lode gold mine (K202, 17 ppm), on Stanley Creek from old placer workings (K85, 3 ppm), and at the old dredge pond (K101, 5 ppm).

Anomalous gold values are widely distributed in stream sediments derived from most major rock units, except the glacial deposits. Stream sediments from the Challis Volcanics were found to contain anomalous gold values only in the drainages of Holman Creek and West Pass Creek (fig. 6). Values of more than 1 ppm gold were found only in stream sediments in the Nip and Tuck Creek, Aztec mine, Washington and Boulder Basins, and Galena Gulch area. Gold was known previously in all but the last named area. Two soil samples near old placer workings on Nip and Tuck Creek contain more than 1 ppm gold.

Samples anomalous in gold generally contain anomalous amounts of silver, lead, arsenic, mercury, antimony, and less commonly zinc, molybdenum, and tin. This is particularly true of stream sediments in contaminated dispersion trains below the Golden Glow, Silver Rule, and Valley Creek mines and in Washington Basin (fig. 6), and may be true generally of natural anomalies that are relatively near their sources.

Arsenic, antimony, mercury, and silver are particularly useful indicator elements in the study area and commonly are found in mineral assemblages in gold veins and in altered rocks near the veins. Of these, arsenic appears to have a particular affinity, as shown by the decreasing correlation coefficient of arsenic, from 0.79 in 179 rock samples with a minimum content of 0.05 ppm gold, to 0.66 in 145 rock samples with a minimum content of 0.15 ppm gold, and to only 0.33 in 8 rock samples with a minimum content of 10 ppm gold. Veins in the Valley Creek–Buckskin belt are particularly enriched in arsenic.

Most anomalous gold samples from the study area are downstream

TABLE 4 —*Conversion of parts per million to percent and to ounces per ton and vice versa*[1]

[Conversion factors 1 lb avoirdupois=14 583 oz troy, 1 ppm=0 0001 percent=0 0291667 oz troy per short ton=1 gram per metric ton, 1 oz/t (Au or Ag)=34 286 ppm=0 0034286 percent]

Parts per million to percent to ounces per ton			Ounces per ton to percent to parts per million		
ppm	percent	oz/ton	oz/ton	percent	ppm
0.01	0.000001	0.0003	0.01	0.00003	0.3
.02	.000002	.0006	.02	.00007	.7
.05	.000005	.0015	.05	.00017	1.7
.10	.00001	.003	.10	.00034	3.4
.20	.00002	.006	.20	.00069	6.9
.30	.00003	.009	.30	.00103	10.3
.40	.00004	.012	.40	.00137	13.7
.50	.00005	.015	.50	.00171	17.1
.60	.00006	.017	.60	.00206	20.6
.70	.00007	.020	.70	.00240	24.0
.80	.00008	.023	.80	.00274	27.4
.90	.00009	.026	.90	.00309	30.9
1.0	.0001	.029	1.0	.00343	34.3
10.0	.001	.292	10.0	.03429	342.9
20.0	.002	.583	20.0	.06857	685.7
50.0	.005	1.458	50.0	.17143	1,714.0
100.0	.01	2.917	100.0	.34286	3,429.0
500.0	.05	14.583	500.0	1.71	17,143.0
1,000.0	.10	29.167	1,000.0	3.43	34,286.0
10,000.0	1.00	291.667	10,000.0	34.29	342,857.0

[1]From Kiilsgaard and others (1970, table 2).

from known gold-bearing deposits or along streams below the known mines and (or) mills, but anomalous gold values also were found along streams draining areas where no gold-bearing deposits are known. Among the most promising of the latter is the Valley Creek drainage north of the Valley Creek mine where a sample of surface gravel contained 60 mg of gold per yd^3 (78 mg/m^3) (pl 3), much more than all but one of the gravel samples below the known veins. This suggests undiscovered lode gold in a northern continuation of the Valley Creek–Buckskin gold belt Sediment samples anomalous in gold content also were collected along Elk, Hanna, McGowan, Tennell, and Stanley Creeks (Elk Meadow quadrangle) (pl 3, fig 6) but neither prospects nor gold veins are known above the sample sites All of these anomalous sample sites are underlain by granitic rocks of the Idaho batholith

Undiscovered gold-bearing veins may occur in the Idaho batholith southeast of Stanley (pls 1, 3) Anomalous gold values in rocks or stream sediments were found along several creeks in that area. The gold anomalies in rocks overlap those of silver, copper, tin, and molybdenum, as seen by comparing the geochemical maps of those metals

Another promising area in the Idaho batholith is a north-trending belt that extends north from Fisher Creek through the Aztec gold mine area at least to Pigtail Creek and possibly past Martin Creek. Only near the Aztec mine is there evidence of prospecting, but gold veins may be present in the Pigtail drainage where gold placers were mined in the early days (unpublished DMEA report, 1959). Eleven stream-sediment and three rock samples taken near and north of the Aztec mine were anomalous in gold, silver, bismuth, and lead. The highest gold values were from a drainage below an adit about 0.2 mi (0.3 km) northwest of the mine (pl 2, 1 6 ppm, E635; 2 ppm, E636). At the Aztec mine, the silver/gold ratio is low (2–3), and the best gold and copper values are in the deepest workings, according to old reports.

A promising area is in Galena Gulch (fig 6) near the contact of the Paleozoic rocks with the Challis Volcanics, where 2.5 ppm gold and slightly anomalous amounts of lead and zinc were found in a stream-sediment sample (pl 2, L212) that was collected to confirm a 0 5-ppm gold value in a nearby stream-sediment sample (778) The most probable source of this anomaly is a vein along an east-trending fault that extends into Grand Prize Canyon just west of the anomaly

A highly anomalous dispersion train of gold, silver, and lead downstream from the inaccessible Silver Rule mine, the apparent source of the metals (figs 6, 8, and 10), suggests that gold content of ore mined before 1902 was higher than that indicated by recorded production after 1914

Anomalous gold in 10 stream-sediment and soil samples along a 2-mi (3 2-km) segment of Washington Basin obviously was derived from the five low-grade veins described in Chapter E Four samples contain more than 1 ppm gold A sample (E929) of soil-like tailings(?) below an old mill on the hillside north of Washington Creek contained 110 ppm gold, 480 ppm selenium, 11 ppm silver, 1,000 ppm copper, 100 ppm bismuth, and anomalous arsenic and antimony The minus-80-mesh material that was analyzed contained very fine grained gold The material may have been concentrated at the mill, where the gold was not recovered, possibly because the gold mineral was not recognized No native gold was seen in a part of the sample that was studied under the microscope, but sulfides and an unidentified substance that reacted with methylene iodide to precipitate native sulfur were present This sample has the second highest gold and selenium content found in the study area and may contain a gold-selenide mineral Ore from the Reconstruction vein contained 1 oz/ton (34 28 g/t) of very fine, pannable gold over a 20-ft (6-m) width, according to amalgamation

TABLE 5 —*Conversion of troy ounces per short ton to grams per metric ton and of troy ounces per cubic yard to milligrams per cubic yard and to grams per cubic meter*

[Conversion factors 1 troy oz (Au or Ag)=1 09714 oz avoirdupois=31 103 g=0 311 kg, 1 troy oz per short ton=34 2857 g/t, 1 troy oz/yd³=40 679 g/m³=31,103 mg/yd³, 1 yd³=0 7646 m³, 1 short ton=2,000 lb=0 90718 t]

Troy ounces per short ton to grams per metric ton		Ounces per cubic yard to milligrams per cubic yard to grams per cubic meter		
oz/ton	g/t	oz/yd^3	mg/yd^3	g/m^3
0.01	0.34	0.0001	3	0.0041
.05	1.71	.0005	16	.0203
.1	3.4	.001	31	.041
.2	6.9	.002	62	.081
.3	10.3	.003	93	.122
.4	13.7	.004	124	.163
.5	17.1	.005	156	.203
.6	20.6	.006	187	.244
.7	24.0	.007	218	.285
.8	27.4	.008	249	.325
.9	30.9	.009	280	.366
1.0	34.	.01	311	.41
2.0	68.	.02	622	.81
5.0	171.	.05	1,555	2.03
7.0	240	.07	2,177	2.85
10.0	343.	.1	3,110	4.1
100.0	3,429.	.2	6,221	8.1
1,000.0	34,286.	.5	15,552	20.3
10,000.0	342,857.	1.0	31,103	40.7

tests (Umpleby, 1915, p 246) Umpleby (unpub data, 1912) also reported that 30-ft (9-m) widths of quartz in the Empire vein averaged 0 6 oz/ton (20 5 g/t) at a shaft on the crest of the hill, some rock assayed 2.5 oz/ton (85.7 g/t) and a 60-ft (18-m)-wide cut was reported to contain 0 3 oz/ton (10.3 g/t) These values are much higher than the assays from samples of these veins collected during the present investigation Conversion of troy ounces per short ton to metric equivalents is shown in table 5

Cobbles in gold placers in the Stanley Creek drainage, particularly those at the headwaters of Kelly Creek (Basin Butte quadrangle), consist largely of jasperoid and granitic rocks of the Idaho batholith A possible genetic relation between placer gold and jasperoid is indicated by the presence of gold, silver, and associated elements in the pyritic jasperoid. A sample of rusty pyritic jasperoid contained 526 ppm silver, 1 1 ppm gold, 3,000 ppm arsenic and zinc, 1,500 ppm lead, 200 ppm antimony, 150 ppm barium, and 20 ppm copper, but the more abundant paler colored nonpyritic jasperoid cobbles are essentially barren. The very high gold/silver ratio and the arsenic, antimony, and barium content suggest that the pyritic jasperoid is a mineralized alteration product. The source of the jasperoid is unknown, but similar jasperoid commonly is present in or near many epithermal gold-silver deposits

LODE DEPOSITS

The U.S. Bureau of Mines has estimated that veins in the Valley Creek district contain 295,000-410,000 tons (268,000-372,000 t) of resources that average 0 06-0.25 oz gold per ton (2 1-8.6 g/t), 1 8-4 12 oz silver per ton (61-141 g/t), and 1.9-2 8 percent lead. Most of these resources, including those with the highest average gold content, are in the Valley Creek mine, which may contain 250,000 tons (227,000 t) of minable reserves, at 1974 prices Geochemical and geophysical evidence suggests that additional gold resources might be developed at depth in the Valley Creek and Buckskin mines and in unexplored parts of the northeast-trending mineral belt in which they occur. The high gold content of a panned sample from the drainage above the Valley Creek mine (pl. 3) indicates that other gold-bearing veins exist in the area. Placer gold of economic interest probably exists at places on bedrock along upper Valley Creek despite generally low gold values found in near-surface placer samples.

The U S. Bureau of Mines infers 7,400,000 tons (6,717,000 t) of submarginal gold-silver resources in the veins in Washington Basin that contain weighted averages of up to 0.05 oz gold per ton (1.7 g/t), 1.3 oz silver per ton (44 5 g/t), and 1 27 percent lead, besides significant amounts of bismuth, tungsten, antimony, and arsenic. The economic value of these submarginal resources is nil, but local minable widths of higher grade material are shown in the table accompanying figure 52.

Geochemical evidence suggests the possibility of additional and possibly higher grade gold- and silver-bearing bodies at depth in at least some of the veins in Washington Basin. The silver/gold ratios consistently decrease with increasing gold content, from 260 in the lowest grade material to 0 83 in the highest grade. The high ratios and high arsenic and antimony content of some samples suggest a zoned mineral assemblage, in which gold and silver content might increase with depth.

Although silver-base-metal deposits in many mines and prospects in the Paleozoic rocks locally contain as much as a few tenths of an ounce of gold per ton, by far the richest lead-silver-gold ore from the study area was the rich Cache ore shoot of massive galena in the Golden Glow mine (pl. 3; fig 6), which contained 3 oz gold per ton (102.8 g/t), 360 oz silver per ton (12 3 kg/t), and 55 percent lead (Umpleby, 1915). The mined area was flooded at the time of the present investigation, but these reported high values are supported by analyses (15–235 ppm gold and 1,040–4,300 ppm silver) and by microscopic study of selected samples from several dumps and from the old mill site Samples T580–581 (pl 2) of galena contained up to 4 3 percent antimony, 7 4 percent zinc, and 2.5 percent copper, in addition to high lead and silver values. In five polished sections, gold grains range in size from 1 to 15 μm wide and 75 μm long and are more closely associated with argentian tetrahedrite, several other silver minerals, and pyrite than with galena Gold and silver minerals are more abundant in some sulfide-poor quartzite wall rock than in the massive galena ore, suggesting that minable amounts may occur adjacent to the massive sulfide ore Other mineral deposits in Boulder Basin contain from 0.1 to 0 66 oz gold per ton (3 4–22.6 g/t).

A single sample from the dump of the upper shaft on the Champion vein contained 235 ppm gold, 1,040 ppm silver, 1,090 ppm selenium, and 35.2 percent lead, but no zinc The sample contained the highest gold and selenium values found in the study area.

GOLD PLACERS

The economic potential of unmined gold placers in the study area (pl 3) cannot be quantitatively evaluated using the existing data, summarized in table 37 Only near-surface samples were collected and analyzed during this study, and values of subsurface gold are not generally available from several earlier exploration projects Average near-surface gold values (table 37) are low, but higher average gold content may be inferred for favorable pay streaks at depth or on bedrock, a conclusion supported by the distribution of the lode gold deposits and by the grade and vertical distribution of gold in old placer workings (Umpleby and Livingston, 1920, Choate, 1962)

Gold resources of potential economic value are inferred, particularly along Stanley Creek and upper parts of Valley Creek, by: (1) lode gold deposits in the source areas, some of which have significant reserves (Buckskin and Valley Creek mines) (pl 3), (2) low values of near-surface samples from many placer deposits that were productive at or near bedrock, (3) coarse average grain size of gold in nearly all placer deposits and its tendency to concentrate near bedrock, (4) the high grade of the formerly productive gold placers and the probability that much fine gold was not recovered, (5) the presence of other valuable byproduct heavy minerals including cinnabar, brannerite, euxenite, zircon, monazite, and ilmenite in some gold placers; (6) large volumes of gravels that may contain potentially dredgeable pay streaks; and (7) the potential for better recovery by modern methods and equipment.

The low gold values from surface samples and the rich pay streaks on bedrock are both consequences of the coarse gold size reported by Umpleby and Livingston (1920, p. 13-17). Choate (1962, p. 102) reported that nearly all placer gold production was coarse gold from rich pay streaks in the lower 18 in to 5 ft (0.5-1.5 m) of terrace deposits. The gold content of the gravel mined from the old placer deposits ranges from 0.015 to 0.17 oz/yd^3 (0.61-6.9 g/m^3) according to data reported by Choate (1962) and Umpleby and Livingston (1920). Dilution would cause progressively lower gold values in potentially dredgeable ground downstream from productive terrace deposits and from lode deposits on upper Valley and Stanley Creeks. An example of the expected dilution is given by the comparison of the gold values in the Buckley bar terrace placer (pl. 3) and downstream dredgeable ground on Stanley Creek, the only large placer whose average gold content has been tested. The original average gold content of the Buckley bar placer was 0.17 oz/yd^3 (6.9 g/m^3) (Choate, 1962, p. 113) compared to a range of 0.015-0.05 oz/yd^3 (0.61-2.03 g/m^3) in the dredged ground 1-2 mi (1.6-3.2 km) farther downstream (Umpleby and Livingston, 1920, p. 16) and a range of 0.025-1.02 oz/yd^3 (1-41.4 g/m^3) in the ground worked during the last dredge operation (Choate, 1962, p. 115).

Most placer gold produced from the study area averaged the size of flax, rice, or wheat grains (Umpleby and Livingston, 1920, p. 13-17), much coarser than the minus 0.15-mm size that was analyzed in the sieved fraction of the stream sediments and soils. Gold particles in the Grubstake placer on Rough Creek ranged in size from 0.4 to 30 mm. These coarse particles are rarely found in hand-panned samples from the surface. Even in very shallow gravel deposits such as in Willow Creek (pl. 3), the surface gold content is only 20-40 percent of that on bedrock 3 ft (0.8 m) below, and the material overlying some placers (Weidman and Grubstake, pl. 3) is essentially barren (Choate, 1962, p. 109-110, 118).

Considering the inefficient mining methods formerly used, and the availability of good roads and relatively cheap electric power today, it is possible that some of the richer terrace placers can be reworked profitably at recent gold prices. The potentially larger placers of unknown but undoubtedly lower grade along the present stream levels probably could be exploited only by large dredges that could recover other heavy minerals in addition to gold and thus enhance the total value of the product.

RESOURCES

The largest resources of lode gold are at the Valley Creek and Buckskin mines near the northwestern tip of the study area, and in large submarginal veins in Washington Basin. The principal placer gold resources are along Valley and Stanley Creeks and along the Salmon River and its north-flowing tributaries east of Stanley. Placer gold resources on Pigtail Creek near the Aztec mine, though formerly worked, apparently are small.

SILVER

Silver-bearing minerals are widely distributed in the study area, especially in the Paleozoic rocks, which contain most of the argentiferous base-metal deposits. Silver usually is abundant in lead sulfantimonide–sphalerite veins that are relatively rich in tin compared to the tin-poor but much larger jamesonite–sphalerite deposits (Livingston mine) and lead-poor sphalerite deposits (Hoodoo deposits). For example, silver content of 10–46 oz/ton (343–1,577 g/t) is common in many narrow silver-rich base-metal veins compared to values of 3 oz/ton (103 g/t) or less in the productive ore bodies of the Livingston and Hoodoo mines.

In addition to silver, the base-metal deposits with a higher tin content generally contain increased quantities of lead, antimony, and gold (Silver Dollar and Timberline prospects; table 7). The richest galena ore mined in the study area (Cache shoot, Golden Glow mine) averaged 360 oz silver per ton (12,000 ppm or 12.3 kg/t).

The richest silver content and highest silver/gold ratios found in the region are in epithermal veins that contain ruby silver minerals in the Vienna and Sawtooth districts south of the study area (26,000 ppm, Webfoot mine, 18,000 ppm, Silver King mine). These ruby silver veins are in granitic rocks of the Idaho batholith. In the Stanley district, gold-silver-lead veins in the Idaho batholith rarely contain more than 600–900 ppm silver, and the silver content of stibnite, uraninite, or fluorite veins is very low.

Little is known of the mineralogy of the silver deposits. Five polished sections from a galena-rich sample (pl. 2, T283) collected at an ore pile in Grand Prize Gulch were studied and the following silver minerals identified: pyrargyrite, miargyrite, diaphorite(?), acanthite, tellurian canfieldite, and a silver-gold alloy (B. F. Leonard, USGS, written commun., 1973). Of these, tellurian canfieldite, a tin-silver sulfide that contains 10–15 percent tellurium, is the principal silver mineral. Leonard also identified 18 other metallic minerals in sample

T283, the analysis of which revealed 2.25 percent tin, 73 oz silver per ton (2 50 kg/t), and 34 percent lead. Other silver minerals reported from the study area include argentiferous tetrahedrite, argentopyrite, proustite, stephanite, argentite, hessite, and argentiferous galena. Much of the silver in exceptionally rich deposits probably occurs as minute inclusions of silver minerals in sulfides, especially in galena

GEOCHEMICAL EVALUATION

The highest silver content of rock samples within any given 800-ft-square (244-m-square) grid area is shown on figure 7. Only about half of the samples in some intermediate ranges could be plotted

Correlation analyses utilizing differences in minimum contents of the composite highly mineralized and the less mineralized or anomalous rock population from table 2 suggest that mercury, antimony, and arsenic are the best pathfinders for buried zones of optimal silver mineralization On the other hand, lead, antimony, and copper are the best indicator elements for detecting outcropping argentiferous deposits, as supported by the common association of galena with argentiferous tetrahedrite and silver sulfantimonides or other silver minerals Silver in mineral deposits and in primary geochemical halos is associated with the other metals in proportions and concentrations that reflect the composition and mineralogy The above elements accompany silver in stream-sediment and soil anomalies in proportions that at least indirectly reflect the composition of their sources as shown on the appropriate sample distribution maps

The distribution of silver in stream sediments is shown in figure 8, which should be compared with figure 7. A belt of anomalous silver values within the exposed Paleozoic rocks extends northward across the central part of the study area. The higher values generally are clustered near or below the known silver-rich deposits and partly reflect contamination Similar distribution patterns are shown on the anomaly maps for the associated metals. Slight silver values are widely distributed in the Challis Volcanics and the related sub-volcanic porphyries near the eastern border of the study area. Both silver and molybdenum are slightly anomalous in sediments along West Pass Creek and the headwaters of the North Fork Big Wood River These sediments probably are derived from altered and pyritized zones near the top of the intrusive porphyry

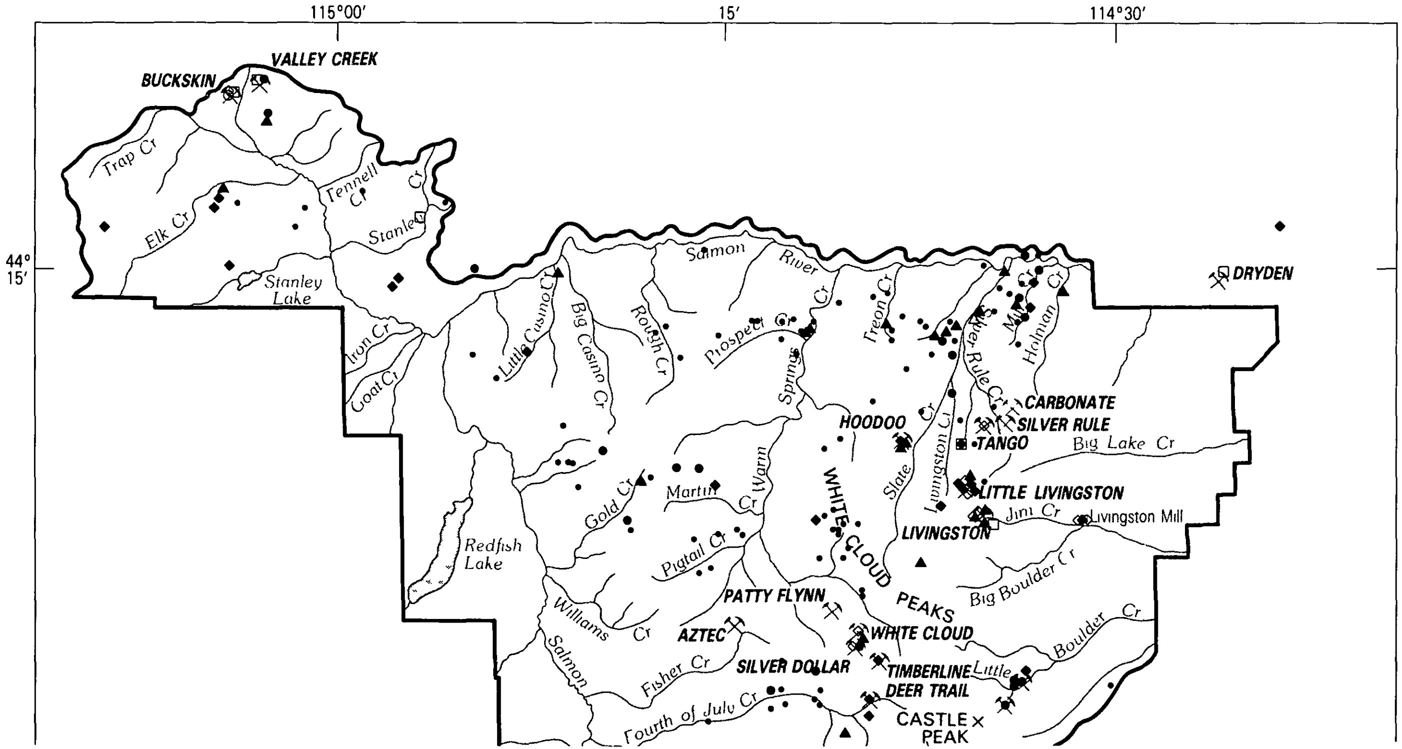
The highest silver values found in stream sediments were just below the Golden Glow mine and mill in Boulder Basin, although silver values continue in decreasing amounts almost to the mouth of Boulder Creek (fig 8) Other stream sediments that contain at least 10 ppm silver are along Gladiator Creek, Grand Prize Gulch, and in tributary streams just below the Livingston and Silver Rule mines, all in Paleozoic rocks Stream-sediment samples anomalous in silver also were found below the Aztec and Valley Creek mines, which are in the Idaho batholith. These high silver values reflect contamination from mining activity, except possibly for those along Grand Prize Gulch, to be discussed later Stream-sediment samples taken below known mines or prospects along Beaver, Valley, Stanley, and West Pass Creeks and the creeks draining Germania and Washington Basins also contained 10 ppm or more silver

Sediments anomalous in silver and other associated metals, along streams that do not contain known silver-bearing deposits or prospects, may indicate undiscovered or blind argentiferous mineral deposits A good example is the area southeast of the Horton Peak stock, between Twin Creek, the South Fork of Champion Creek, and the headwaters of Pole Creek (fig 8), where stream sediments are anomalous in silver and zinc Rocks containing slightly anomalous silver values also are common in this area (fig 7) Another unprospected area with anomalous silver values in stream sediments is at the head of Titus Creek (fig 8), where Paleozoic rocks and a small diorite body are exposed (pl 1)

Five stream-sediment samples from Bear Lake Creek (fig 8) contained low silver values that apparently relate to mineralized, hornblende-bearing granitic talus at the head of the stream A sample from this talus (pl 2, D150) contained 0.15 ppm gold, 22 ppm silver, 500 ppm bismuth, about 150 ppm arsenic and lead; and anomalous values of tungsten, copper, tin, and molybdenum These values reflect the possible presence of bismuth-silver veins similar to those west of Washington Basin. Low silver and gold values (fig 6) and anomalous cadmium (fig 13) near the head of Prospect Creek suggest an area of mineralization in the Idaho batholith.

Of 255 soil samples, 172 contained 0.5 ppm or more silver, 93 contained 1 ppm or more, 37 contained 1.5 ppm or more, 14 contained more than 2 ppm, and 3 contained more than 10 ppm Most of these are shown on the detailed maps of the Slate Creek–Mill Creek, and Grand Prize Gulch areas (figs. 23, 28, and 29)

The two highest values of silver in soil samples, 60 ppm (T488) and 14 ppm (T485), are from black organic peat, a natural collector of metals, from spring bogs at the head of perennial streams just south of Senate Creek and on North Cherry Creek These are the only "soil" analyses shown on figure 8 The springs probably rise along a mineralized(?) fault in the Wood River Formation that may control the north-south segment of Senate Creek. Two soil samples (pl 2, A232 and A237) from that locality contained 3–4 ppm silver Another peat



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Tennell Cr
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Elk Cr
Stanley
Stanley Lake
Iron Cr
Goat Cr
Salmon
River
Little Casino Cr
Big Casino Cr
Rough Cr
Prospect Cr
Springs
Cr
Treon Cr
Silver Rule Cr
Mill Cr
Holman
DRYDEN
CARBONATE
SILVER RULE
HOODOO
Cr
TANGO
Big Lake Cr
Livingston Cr
Slate
LITTLE LIVINGSTON
WHITE CLOUD PEAKS
Jim Cr
Livingston Mill
LIVINGSTON
Gold Cr
Martin
Warm
Cr
Redfish Lake
Pigtail Cr
Big Boulder Cr
PATTY FLYNN
Williams
Cr
AZTEC
WHITE CLOUD
Boulder
Cr
Salmon
Fisher Cr
SILVER DOLLAR
TIMBERLINE
Little
DEER TRAIL
Fourth of July Cr
CASTLE PEAK

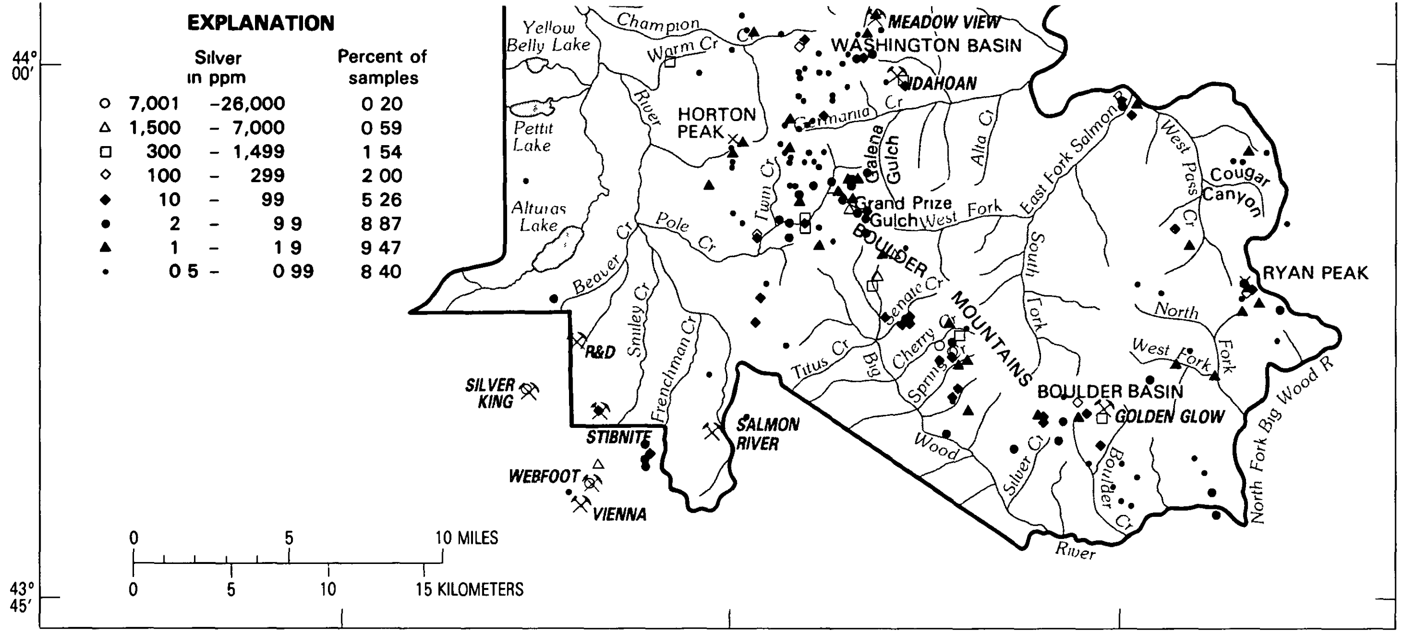
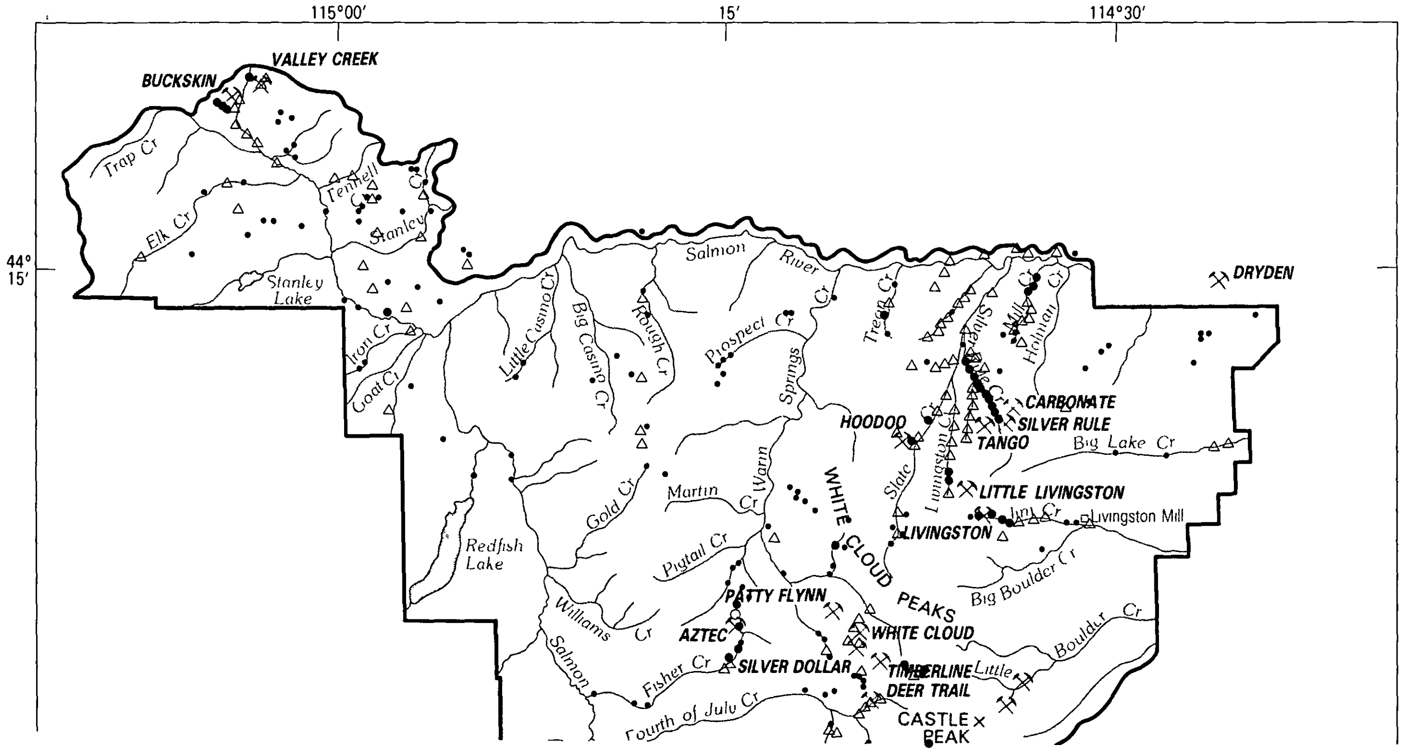


FIGURE 7 —Silver distribution in rock samples, eastern part of the Sawtooth National Recreation Area. Silver content in 958 samples or 63 67 percent of the sample population was either nondetectable or present in quantities too small to measure Determinations by atomic absorption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Salmon River
Prospect Cr
Springs Cr
Trean Cr
Mill Cr
Holman Cr
Slate Cr
Livingston Cr
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Little Boulder Cr
Fourth of July Cr
CASTLE PEAK

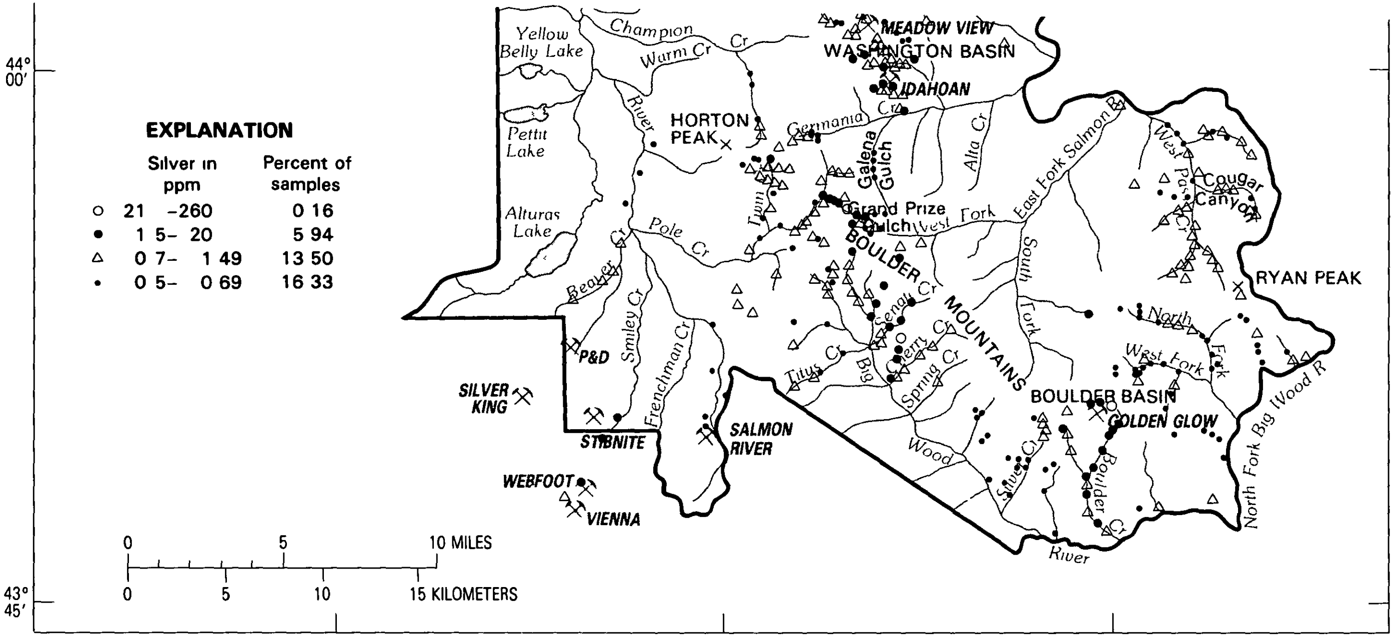


FIGURE 8 —Silver distribution in stream-sediment samples, eastern part of the Sawtooth National Recreation Area. Silver content of 1,842 samples or 64 07 percent of the sample population was either nondetectable or present in quantities too small to measure Determinations by atomic absorption

sample, taken at a spring near Cherry Creek, about a half mile (0 8 km) below an old adit, contained 2 ppm silver

SILVER-LEAD-ZINC DISCOVERIES

During this study, mineralized float and outcrops were discovered at sites where no prospects or mining claims are known. Argentiferous galena float was discovered on the ridge west of and near the head of Spring Creek, in the southern part of the study area (pl 2, sample site T564-68) Two pieces of similar galena float were found about 70 ft (21 3 m) apart. A sample of the float (WCTO565M, table 2) contained 7,000 ppm silver (204 oz silver) per ton (6 9 kg/t) and 60 percent lead Yellow-stained massive quartzite crops out above the float to the crest of the ridge. In an area of the quartzite about 200 ft (60 m) long and 70 ft (21 m) wide directly above the discovery site is a stockwork of quartz stringers and eight or more quartz veins 6 in (15 cm) to 2 ft (0.6 m) thick that strike parallel to the steeply dipping quartzite beds Presumably, the galena float came from a mineralized zone along one of the quartz veins, although an outcrop of galena was not found A narrow oxidized outcrop was found about 20 ft (6 1 m) below the ridge crest, and a sample from it (pl. 2, T567) contained 660 ppm silver and 7 3 percent lead

The yellow-stained quartzite country rock at the discovery site of the galena float contains disseminated lead and silver A composite float sample of the yellow-stained quartzite (T568), taken within a 50-ft (15-m) radius at the discovery site, contained 90 ppm silver and 5,000 ppm lead

Prospects nearest to the discovery site of the galena float are about 700 ft (213 m) farther up Spring Creek and lower on the slope, and about 500 ft (152 m) across the ridge in the Cherry Creek drainage. Neither of these could be the source of the galena float

Narrow seams that contain lead and silver minerals were discovered south of the hot spring at the mouth of Bowery Creek, along the East Fork Salmon River. The discovery site is several hundred feet south of the Warm Springs group of claims (pl 3, 225), at a hot spring that issues from an adit The seams are in rocks of the Milligen Formation, near a thrust fault(?) that separates the rocks from the lower part of the Wood River Formation (pl. 1), and on strike of veins of the Warm Springs group The seam therefore may be an extension of the Warm Springs zone or a parallel mineralized structure. A sample from the discovery site (pl 2, T269) contained 30 ppm silver, 2 percent lead, and traces of gold, antimony, copper, and zinc Many hot springs in the Bowery area issue from faults parallel to known mineralized structures, and the mineral discovery in one of them suggests that some phase of the mineralization may be related genetically to the hot springs, or that minerals in older deposits are being remobilized by the hot water. The abnormally high mercury content of the mineralized rocks supports this interpretation

An outcrop of sulfide-bearing impure limestone was discovered near the headwaters of the North Fork Big Wood River. A sample (pl. 2, T573) of the limestone contained 3.1 percent lead, 2.2 percent zinc, and traces of silver, copper, cadmium, and mercury

Another discovery was a yellow-stained quartz vein in the Horton Peak stock, along the upper reaches of Warm Creek (fig 7). A sample from the vein (pl 2, E733) contained 9 oz silver per ton (308.5 g/t), 0.5 percent lead, and trace amounts of copper, zinc, and germanium No sulfide minerals were seen in the vein

LEAD

In the study area, lead probably ranks third among the metals in total value of past production and perhaps fourth in potential value of resources. U S Bureau of Mines reports recorded lead produced at 18,300,000 lb (8,301,000 kg), which accounts for about 60 percent of the total value of metal production since 1902. About 17 million lb (7,711,000 kg) came from the Livingston mine; and 1,100,000 lb (499,000 kg) from mines in Boulder Basin. Unrecorded lead produced before 1902 probably came chiefly from the Golden Glow and Silver Rule mines, with smaller amounts from silver mines in Germania Basin and in the Galena district According to Umpleby (1915, p 242–246), the silver-lead-gold ore produced from the Golden Glow mine before 1890 contained between 32 and 60 percent lead Most silver ore mined from the Galena district and Germania Basin contained much less lead, judging by analyses of remaining material Lead was produced chiefly from veins in the Wood River Formation, largely as a byproduct of mining for gold and silver until 1926, when production from the Livingston mine began

The most promising geologic environment for undiscovered lead and zinc in the study area is replacement deposits in favorable calcareous rock of Paleozoic age Most of the known replacement deposits of zinc are in Mississippian argillite or tactite, but the best possibilities for stratigraphically controlled deposits of lead are in calcareous rocks of the Wood River Formation Limestone (unit 2) that overlies the Hailey Conglomerate Member is considered a particularly favorable host rock; many small mineralized quartz veins are found at this horizon east of the study area.

Most of the known replacement deposits contain more zinc than lead The Hoodoo mine, for example, is a replacement deposit, chiefly zinc (sphalerite), but the content of lead and silver appears to increase in upper parts of the deposit Some stratiform replacement deposits appear to be confined to favorable beds (Deer Trail mine; pl 3, 109) or else related to unconformities (Hoodoo mine)

Galena, jamesonite or boulangerite, and sphalerite occupy successively higher temperature zones in zoned sulfide deposits of the area.

Silver is by far the most useful pathfinder element in the geochemical search for concentrations of lead in rocks, as shown by the following correlation coefficients for rock samples containing at least 200 ppm lead silver (0.77), antimony (0.68), tin (0 62), copper (0.48), zinc (0 44), arsenic and cadmium (0.41) Barium, which appears to be anomalous along the fringe of the primary halos surrounding lead-zinc deposits, may be a useful pathfinder, although the base-metal deposits generally have very low barium content.

The distribution of rock samples that contain 50 ppm or more lead is shown in figure 9 Anomalous lead values greater than 300 ppm generally are in known mineralized areas in the Paleozoic rocks, and only a few scattered values as high as 100 ppm were found in igneous rocks, away from known deposits

The localities of stream-sediment samples that contain 50 ppm or more lead are shown in figure 10 Most of the high lead values downstream from productive lead-bearing deposits (fig. 10) reflect contamination from mining and especially from milling operations. Examples of such contamination are anomalous concentrations of lead below the gold-silver mines on upper Valley Creek, below the silver-lead-gold veins in Boulder Basin, and below the Silver Rule and Livingston mines The Valley Creek concentration coincides with anomalous gold, silver, and arsenic, and probably is derived from the same sources

Stream-sediment samples with lesser lead values (fig. 10), not downstream from known deposits (fig 9), may indicate favorable areas for prospecting, if anomalous amounts of closely associated metals also are present Samples anomalous in lead near the headwaters of West Pass Creek and the North Fork Big Wood River also are anomalous in silver and molybdenum

ZINC

Zinc probably ranks fourth in total production value and second in recorded production value of all metals produced in the study area since 1901 The Livingston mine has produced 95 percent of the

4,200,000 lb (1,905,120 kg) of zinc mined since 1902. Kiilsgaard (1949, p. 10) cited a company report that stated that 86.3 percent of the zinc mined before 1930 went into the mill tailings, but some of this was recovered in 1950-1951, when 60,000 tons (54,000 t) of tailings were reworked.

The U.S. Bureau of Mines estimated potential zinc resources in the study area to be about 1,700,000 tons (1,540,000 t) containing a weighted average of 7.2 percent zinc, based on grades ranging from 1 to 11 percent zinc. This does not include possible potential resources indicated by geochemical sampling during this study. Several zinc anomalies were found in the Mill and Slate Creek drainages and are described later (pl. 4).

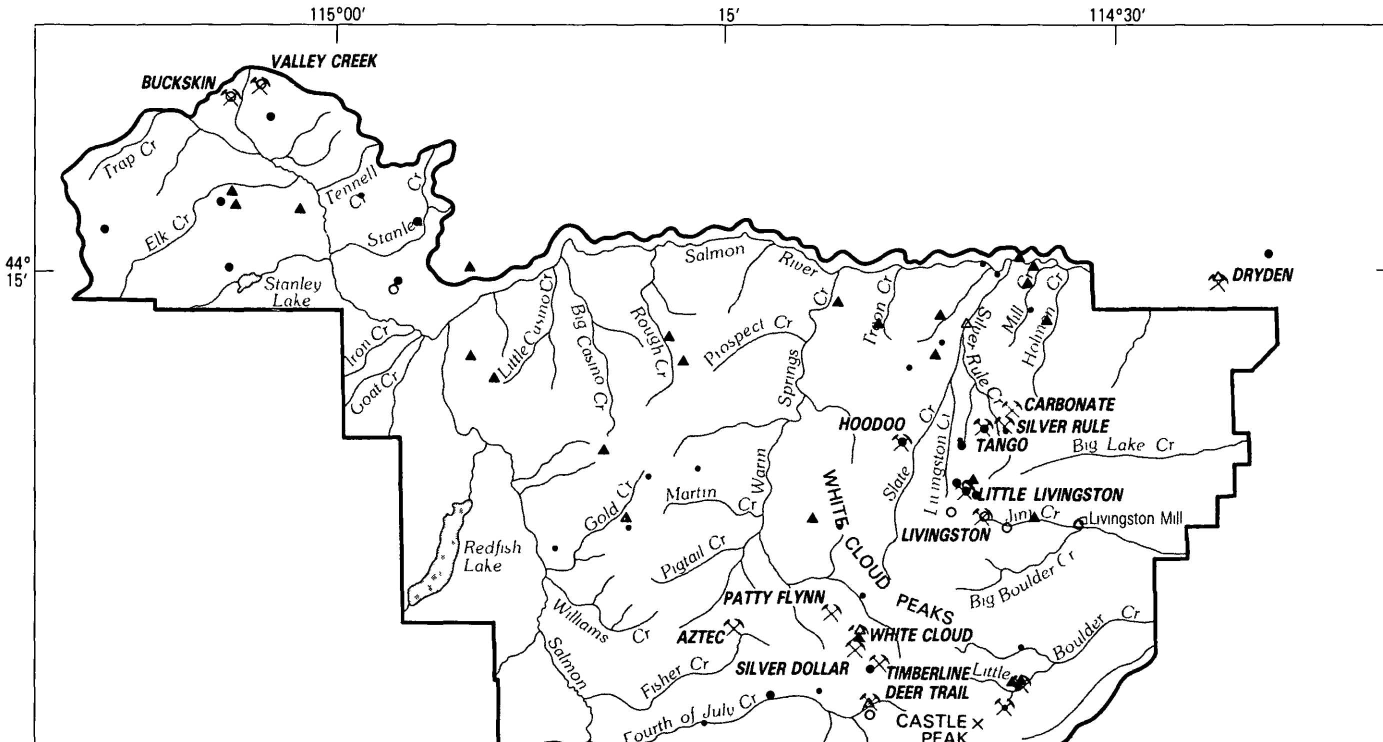
The Hoodoo mine (pl. 3), the newest and only operating mine in the study area at the time of this investigation, contains an estimated 870,000 tons (789,000 t) of inferred reserves averaging 11 percent zinc, 0.47 percent lead, and 0.35 oz silver per ton (12 g/t), according to the 1971 evaluation by the U.S. Bureau of Mines. Mine development since that time has outlined indicated reserves of 100,000 tons (91,000 t) averaging 26 percent zinc, according to LeRoy Davis, Mine Superintendent (written commun., February 4, 1974). Davis reported that the grade of the indicated reserves ranges from 5.6 to 30 percent zinc, from 2.3 to 6.7 percent lead, and from 0.8 to 4.6 oz silver per ton (27.4–157.7 g/t), and that the higher grades are on the upper levels. The limits of the ore shoots are not fully outlined and total reserves are unknown. Additional zinc reserves are possible because about two-thirds of the inferred strike length has not been sampled or explored (fig. 42).

The Deer Trail mine contains 470,000 tons (426,000 t) of submarginal zinc resources averaging about 3.7 percent zinc, according to U.S. Bureau of Mines estimates. Three other properties in the Fourth of July drainage (Confidence, Rupert, and Meadow View mines; pl. 3) together contain about 35,000 tons (32,000 t) of submarginal zinc resources. The Meadow View mine is unique in that the tactite host rock contains 0.12–0.28 percent WO_3 (scheelite) and 0.7–11.8 percent zinc.

About 50,000 tons (45,000 t) of unmined material, estimated to average 5 percent zinc, 4 percent lead, and 4 oz silver per ton (137 g/t) remain in the Livingston mine (pl. 3).

Figure 11 shows the distribution of rock samples that contain 70 ppm or more zinc. All plotted values of 10,000 ppm zinc or more and many over 1,000 ppm are from mines and prospects. Other deposits that contain zinc are described in the Bureau of Mines chapter herein but are not plotted on figure 11.

The distribution of stream-sediment samples that contain 100 ppm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River
Prospect Cr
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Springs
Tryon Cr
Silver Rule Cr
Mill Cr
Holman Cr
DRYDEN
CARBONATE
SILVER RULE
HOODOO
TANGO
Big Lake Cr
Slate Cr
Livingston Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
WHITE CLOUD PEAKS
Redfish Lake
Gold Cr
Martin
Warm
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Pigtail Cr
Big Boulder Cr
PATTY FLYNN
Williams
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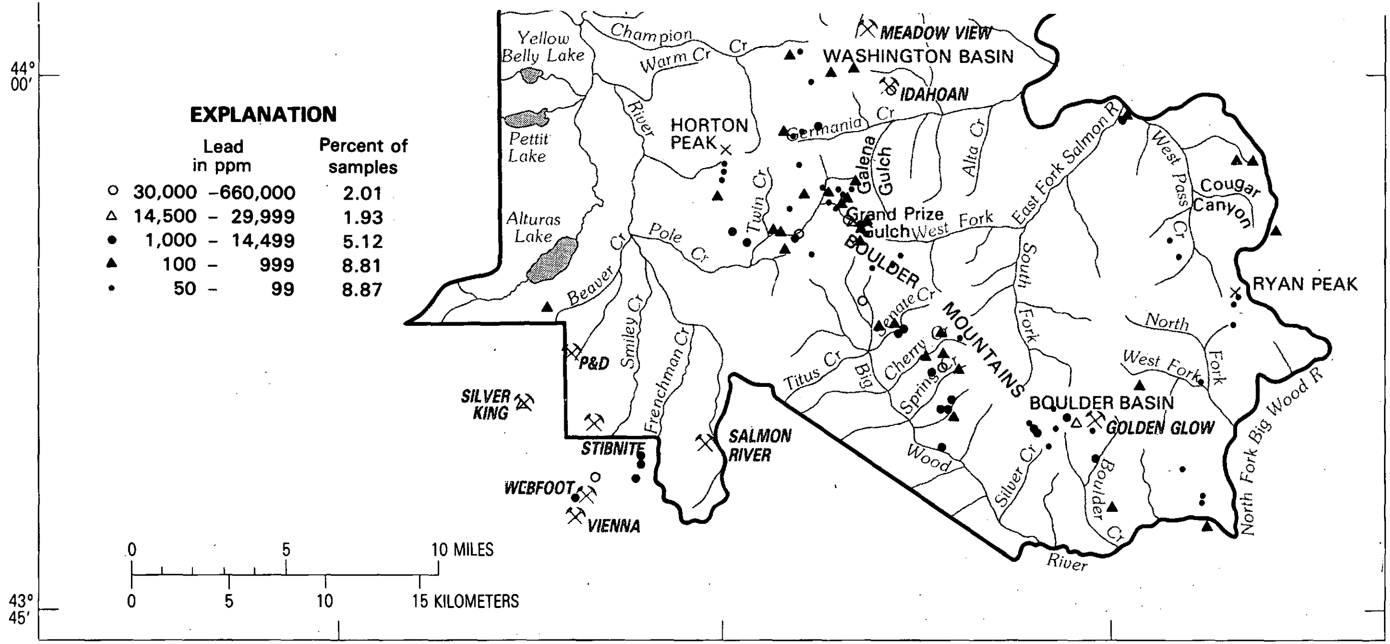
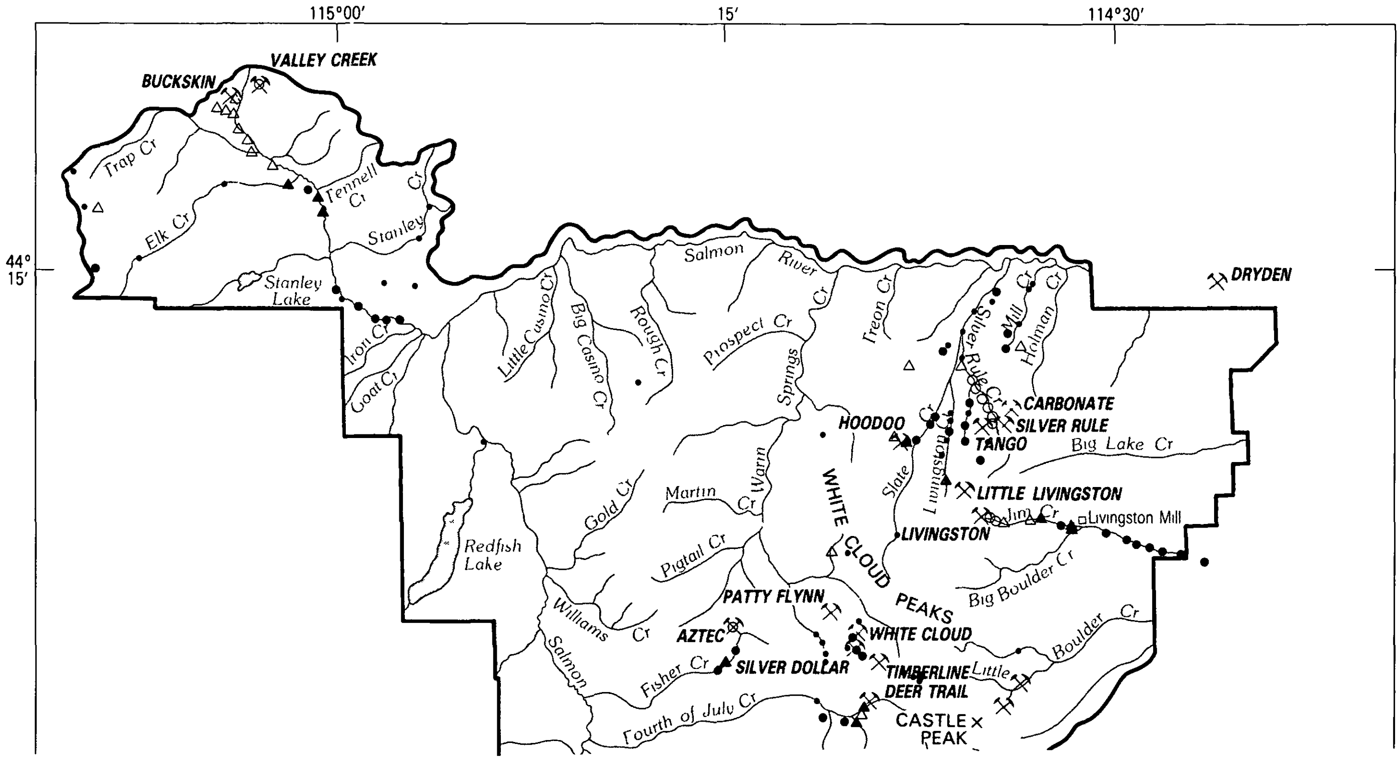


FIGURE 9.—Lead distribution in rock samples, eastern part of the Sawtooth National Recreation Area. A total of 898 samples, 59.62 percent of the sample population, contained from 5 to 49 ppm lead and are not shown. Lead content in 205 samples, 13.64 percent of the sample population, was too small to measure. Determinations by atomic absorption.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Big Casino Cr
Rough Cr
Prospect Cr
Springs Cr
Treon Cr
Mill Cr
Holman Cr
Silver Rule Cr
DRYDEN
CARBONATE
SILVER RULE
TANGO
HOODOO
Big Lake Cr
Slate
Livingston
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
WHITE CLOUD PEAKS
Gold Cr
Martin Cr
Warm
Pigtail Cr
Redfish Lake
Williams Cr
Salmon
Big Boulder Cr
Boulder Cr
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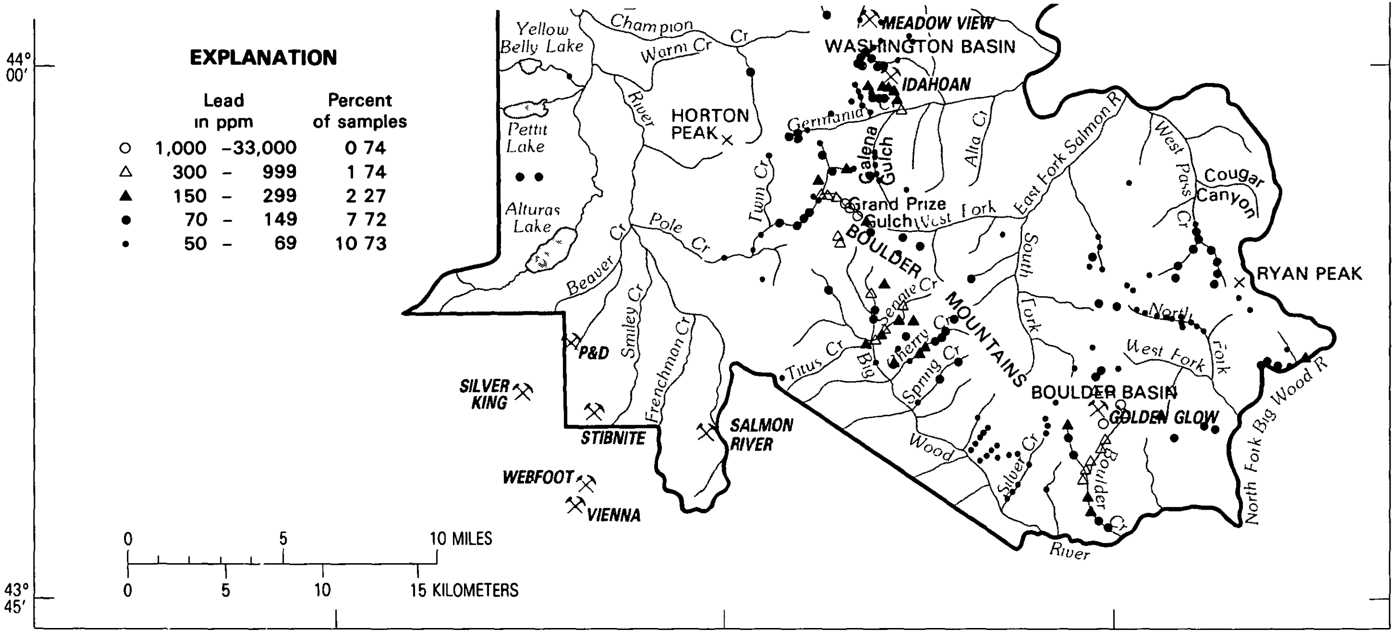
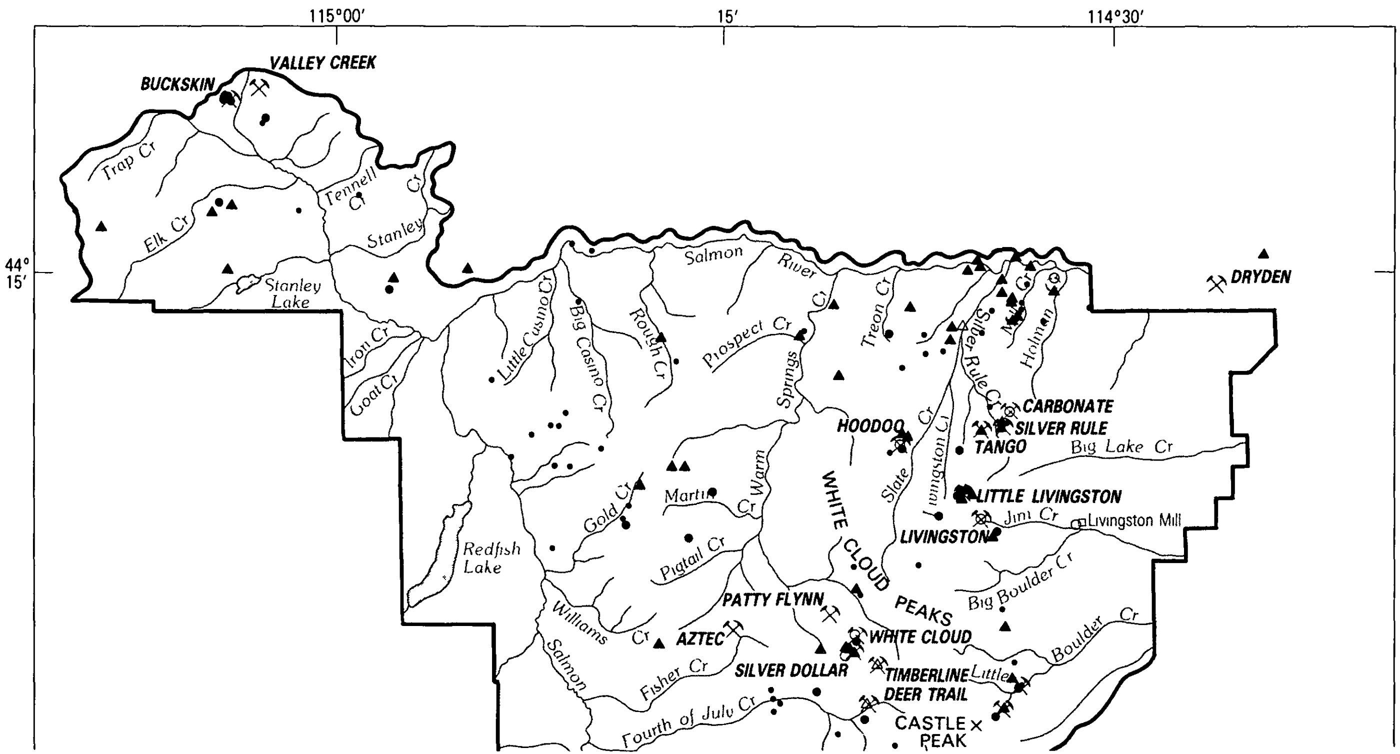


FIGURE 10 —Lead distribution in stream-sediment samples, eastern part of the Sawtooth National Recreation Area. A total of 2,208 samples, 76 80 percent of the sample population, contained from 10 to 49 ppm lead and are not shown Determinations are by atomic absorption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Goat Cr
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Rough Cr
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Springs Cr
Treon Cr
Silver Rule Cr
Mill Cr
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DRYDEN
CARBONATE
SILVER RULE
HOODOO
TANGO
Big Lake Cr
Slate Cr
Livingston Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
Gold Cr
Martin Cr
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Redfish Lake
Pigtail Cr
Big Boulder Cr
PATTY FLYNN
WHITE CLOUD
Williams Cr
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Fisher Cr
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TIMBERLINE
Little
Boulder Cr
DEER TRAIL
Fourth of July Cr
CASTLE PEAK

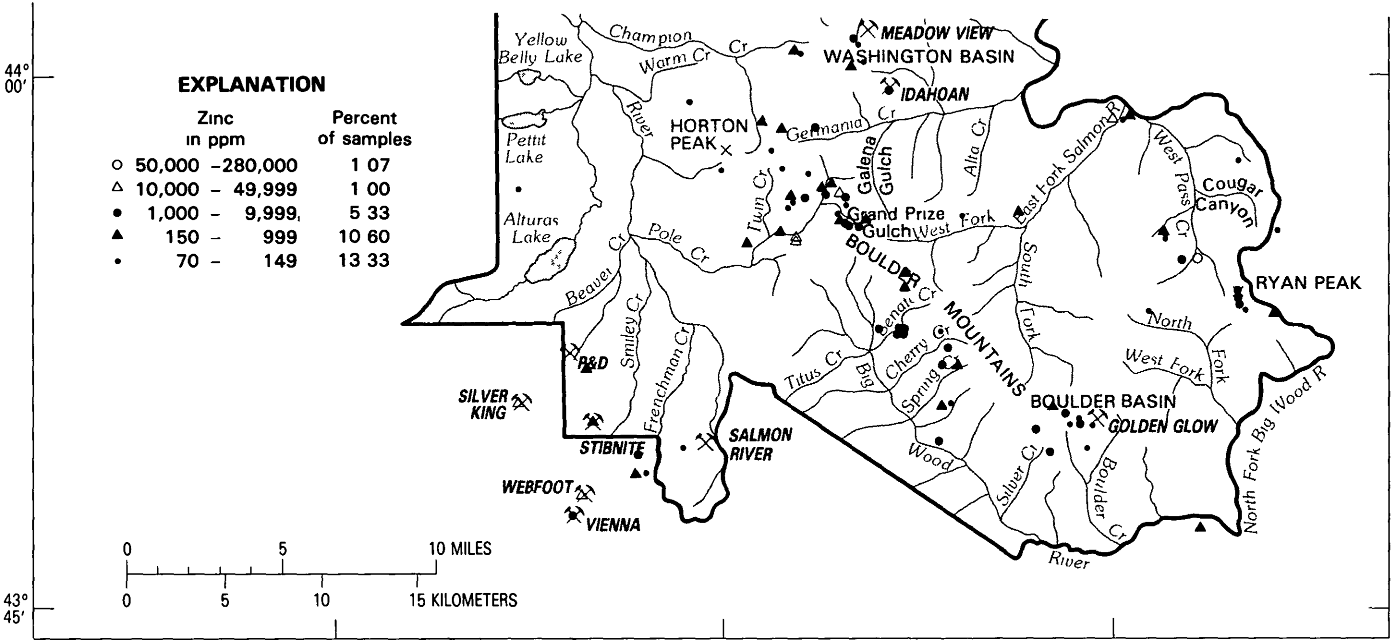


FIGURE 11 —Zinc distribution in rock samples, eastern part of the Sawtooth National Recreation Area. A total of 994 samples, 66 percent of the sample population, contained from 5 to 69 ppm zinc and are not shown Zinc content of 40 samples, 2 67 percent of the sample population, was too small to measure Determinations by atomic absorption

zinc or more is shown in figure 12. Stream sediments anomalous in zinc are concentrated in a belt of Paleozoic rocks that extends from Pole Creek north to the Salmon River. Some anomalous samples reflect contamination from mining and milling activities Typical is the 40,000-ppm zinc value obtained from a contaminated sediment sample taken just below the Hoodoo mine Zinc dispersion trains that reflect some degree of contamination are immediately downstream from Boulder, Washington, Germania, and Strawberry Basins and in the Galena district drainage On the other hand, some large anomalies along Grand Prize Gulch and Mill Creek and in the Slate Creek drainage are not contaminated from mining or milling activities. These natural anomalies contain as much as 7,000 ppm zinc, and some are stronger than the contaminated anomaly below the Livingston mine, the most productive zinc mine in the area. Anomalous values below the Livingston mine are surprisingly weak, considering the amount of sphalerite in the ore body

Study of the stream-sediment and rock sample data suggests that rocks having the greatest potential for discovery of new zinc deposits are Mississippian argillites north and west of the White Cloud stock, particularly in the Slate and Mill Creek drainages

Undiscovered zinc resources also might be inferred from dispersion trains along two south-flowing tributaries of Pole Creek and in the headwaters of Warm Springs Creek (fig 12) Anomalous silver values also are found in rock and stream-sediment samples from these areas (figs 7 and 8)

A zinc anomaly near the terminal moraine below Yellow Belly Lake coincides with molybdenum and tin anomalies and probably represents material transported from an unknown site in the glaciated Sawtooth Wilderness This is the most prominent metallic anomaly found in glacial moraines of the study area.

Sediment samples that contain as much as 150 ppm zinc are rare along streams that drain the Idaho batholith The only notable anomaly is on Treon Creek and probably is derived from the contact-metamorphosed Paleozoic rocks rather than from the batholith (pl. 1) Zinc anomalies derived from volcanic rocks also are rare. The dispersion train on West Pass Creek is likely derived from pyritized porphyry or from small outcrops of Paleozoic rocks rather than from the unaltered volcanic rocks Significant deposits of zinc are not likely to be found in the batholithic or the volcanic rocks

CADMIUM

Cadmium is associated with zinc and usually occurs in solid solution in zinc sulfides It is recovered as a smelter byproduct from zinc concentrates Although not reported previously from the study area, cadmium was found in many samples, particularly in samples of sphalerite and in sediments from streams that drain Paleozoic rocks, the host rocks for most of the zinc deposits.

According to La Heist (1964, p. 198), the regional average cadmium content of western zinc ores (probably zinc concentrates) is about 0.25 percent, which compares to the world average of 0 24 percent in concentrates containing 55 percent zinc (Wedow, 1973). Based on this world average cadmium content, the world zinc/cadmium ratio is 230. In the study area, zinc/cadmium ratios in samples containing 10 to 44 percent zinc range from 108 to 250, but most are below the world average. This indicates a comparative regional enrichment in cadmium, and suggests low temperatures of deposition for the low-ratio zinc deposits

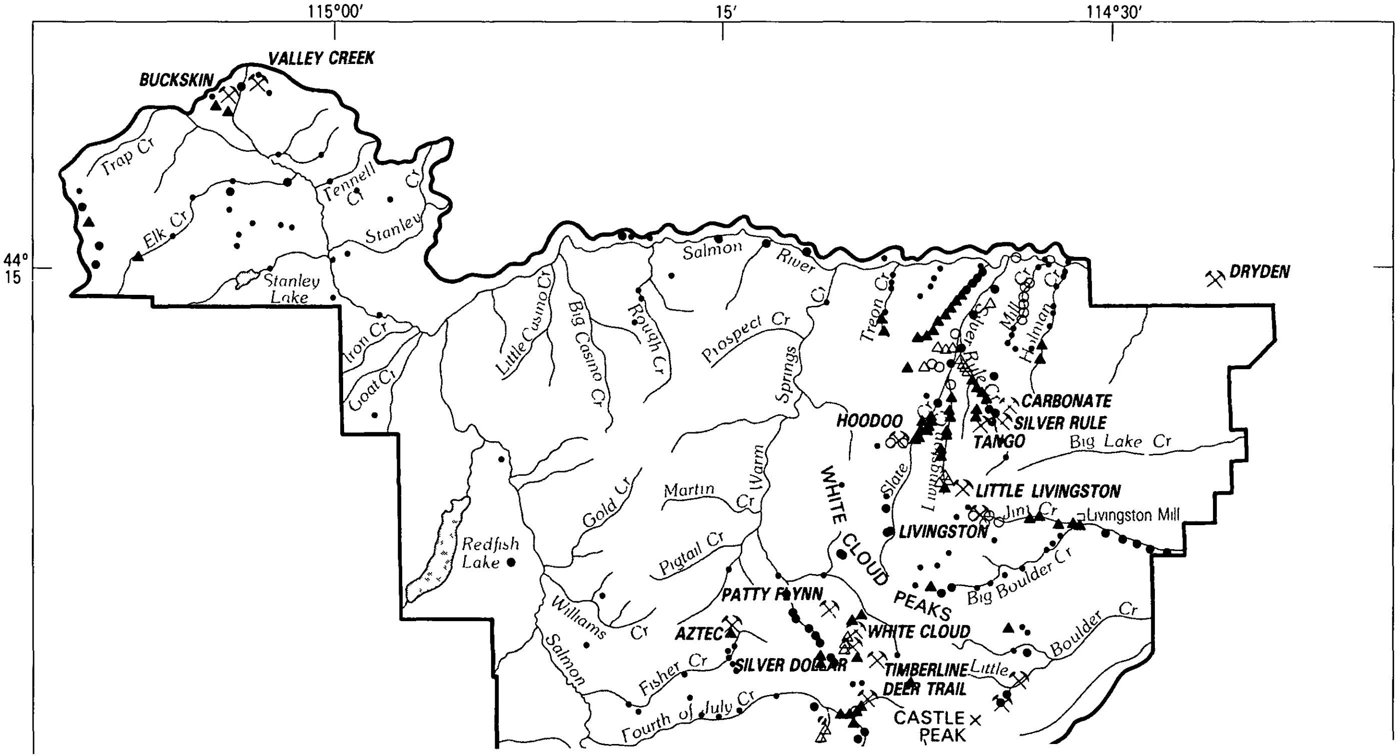
Inferred zinc resources of the study area are estimated to contain about 2 million lb (907,000 kg) cadmium. This estimate is based, in part, on analyses shown in table 6. About 1.4 million lb (680,000 kg) are probably present in the inferred zinc resources at the Hoodoo mine, based on an average zinc content of 11 percent and a zinc/cadmium ratio of 130 Zinc concentrate produced from the Hoodoo mill contained 59 percent zinc and 0.45 percent cadmium

Cadmium content of inferred zinc resources at the Deer Trail mine and the nearby Confidence, Rupert, and Meadow Valley properties (pl 3) is estimated to exceed 110,000 lb (49,000 kg), of which 90 percent is in submarginal resources of two tactite zones in the Deer Trail mine, where the zinc/cadmium ratio averages 336, the highest in the study area.

Ore produced from the Livingston mine is estimated to have contained about 36,000 lb (16,000 kg) of cadmium, although there is no record of production or of payment for the cadmium. At least that much cadmium is estimated to remain in inferred resources at the mine

The distribution of rock and stream-sediment samples that contain 20 ppm or more cadmium is shown in figure 13 Mineralized samples collected by the U S Bureau of Mines are not shown on the map. The distribution pattern of cadmium is seen to closely parallel those of zinc, lead, and silver. High values were obtained from rock samples at some mines and from contaminated sediments downstream from them, but some anomalous stream sediments were found downstream from areas in which no mineralized deposits are known

Many stream-sediment samples from the Big Wood River drainage contain from 20 to 49 ppm cadmium (fig 13) In samples taken near the headwaters of the stream, the cadmium probably was derived from base-metal deposits in the Galena district Anomalous samples along Silver Creek, north of the river, probably reflect known base-metal deposits upstream, but no deposits are known upstream from the anomalous samples taken south of the river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Rough Cr
Prospect Cr
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Treon Cr
Silver Rule Cr
Mill Cr
Holman Cr
CARBONATE
SILVER RULE
TANGO
HOODOO
Big Lake Cr
LITTLE LIVINGSTON
Livingston Mill
Jim Cr
LIVINGSTON
Slate Cr
WHITE CLOUD PEAKS
Martin Cr
Warm
Gold Cr
Pigtail Cr
Redfish Lake
Big Boulder Cr
Boulder Cr
Little
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Fisher Cr
Fourth of July Cr

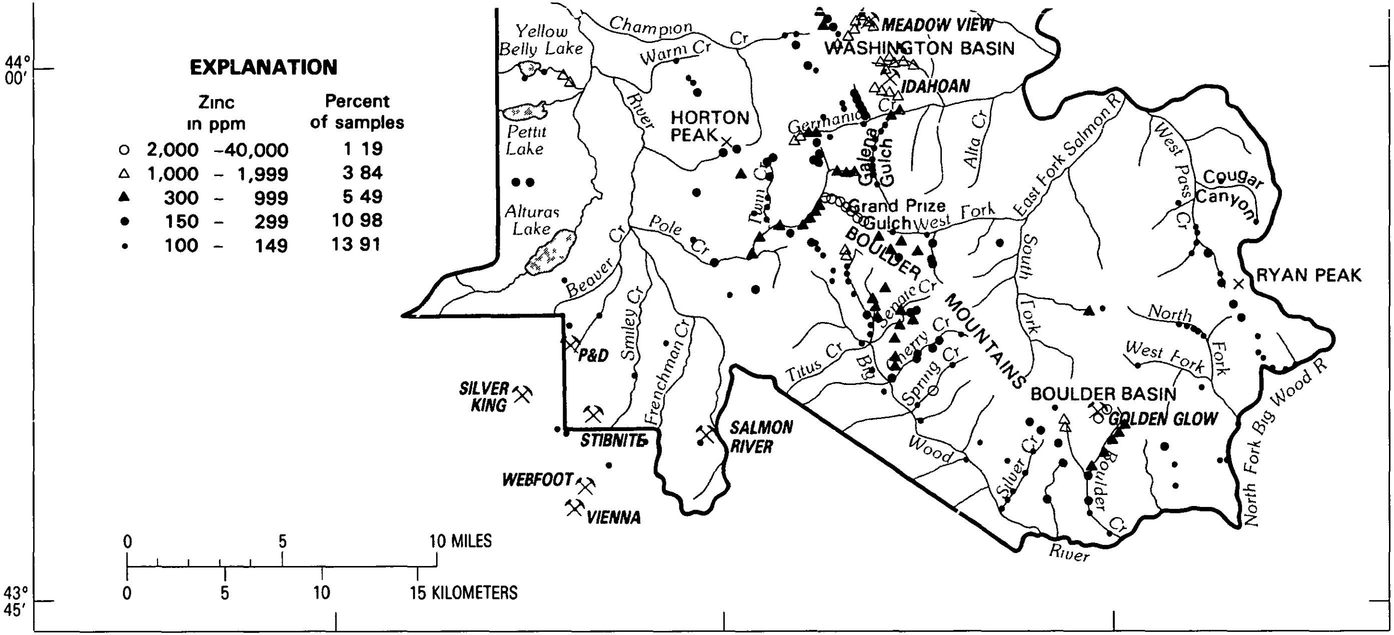


FIGURE 12 —Zinc distribution in stream-sediment samples, eastern part of the Sawtooth National Recreation Area. A total of 1,856 samples, 64 59 percent of the sample population, contained less than 100 ppm zinc and are not shown Determinations by atomic absorption

TABLE 6.—*Mineralized rocks containing high values of cadmium, Sawtooth National Recreation Area, Idaho*

[B, not analyzed, N, not detected, L, detected, but below the limit of determination, Tr trace, G detected in quantities greater than value shown, H, interference, S, spectrographic analysis, AA atomic absorption CM, colorimetric test]

Samples collected and assayed by the U.S. Bureau of Mines

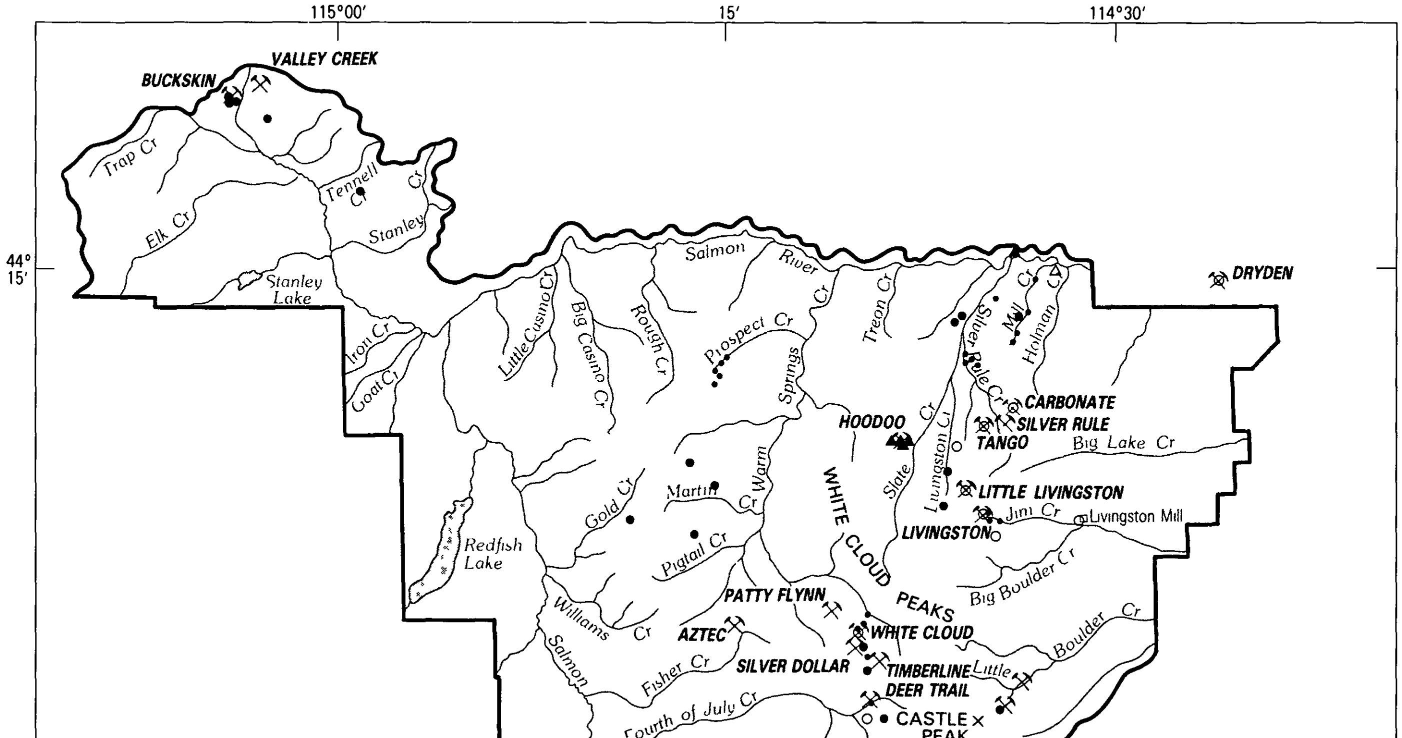
Sample No.	Cd (percent)	Zn (percent)	Pb (percent)	Ag (oz/ton)	Sb (percent)	Au (oz/ton)	As (percent)	Cu (percent)	Property
V66	0.13	14.0	0.08	0.12	B	N	B	B	Hoodoo mine.
V68	.10	16.0	.13	.12	B	N	B	B	Do.
V67	.09	12.0	.42	.32	B	N	B	B	Do.
V70	.04	10.0	.08	.10	B	N	B	B	Do.
R011	.075	.24	19.40	13.7	2.76	N	B	0.02	Little Livingston mine.
R282 to R285[1]	.52	14.34	.16	.1	.02	.02	B	.13	Livingston mine, 1800 level.
R285	.52	52.00	.15	.4	.02	.08	.02	.18	Livingston mine, dike-argillite contact.
R202	.1890	20.00	.120	.910	.0600	.008	B	.042	Livingston mine, drill core.
R205	.1660	17.00	.920	1.290	.5G	Tr	B	.016	Do.
R200	.1160	16.00	1.500	2.880	.5G	Tr	B	.240	Do.
R197	.0700	7.00	.080	.410	.0800	.005	B	.011	Do.
R199	.0680	6.60	1.900	1.670	.5G	.007	B	.016	Do.
R198	.0560	7.40	.290	1.390	.0800	.02	B	.004	Do.
F177	.03	6.70	.02	.10	B	Tr	B	B	Deer Trail mine.
F196	.04	12.80	2.96	1.40	B	Tr	B	B	Do.
F118	.12	8.80	B	N	B	B	B	B	Meadow View mine.

			Analyses by U.S. Geological Survey								
Sample No.	S-Cd[2] (ppm)	Cd[3] assay (percent)	AA-Zn	AA-Pb	AA-Ag	CM-Sb (ppm)	AA-Au	AA-Te	AA-Cu	S-Sn[2]	Property
T072M	5,000	B	100,000G	16,000	560	500	0.02L	N	2,000	N	Dryden mine.
F043	1,500	B	55	15	.2	.5	N	B	10	N	Do.
V052	2,000	B	400,000	900	160	30	.15	.5	5,500	5,500	Cal-Ida mine (Carbonate group).
V057	2,000	B	140,000	8,500	200	600	.45	3	1,500	500	Do.
V066	1,500	B	140,000	800	4.0	15	N	B	30	N	Hoodoo mine.
T571	5,000	0.22	440,000	2,600	20L	100	.05L	B	50	N	Do.
Tr-1	2,000	.450	590,000	4,400	36	100	0.15	B	700	N	Hoodoo zinc concentrate.
Tr-2	150	.018	24,000	400,000	1,700	500	2.6	B	300	70	Hoodoo lead concentrate.
S024	500	B	280,000	600	2.0	10	.02L	B	40	N	West of Hoodoo mine.
S027	300	B	50,000	2,200	18	150	.02L	B	30	N	West of Hoodoo mine, oxidized vein.
R202	3,000	.189	200,000	1,200	38	600	.36	1	420	30	Livingston mine, drill core.
R200	2,000	.116	110,000	15,000	120	4,500	.06H	4	2,400	700	Do.
R205	2,000	.166	170,000	9,200	54	5,000G	.06H	B	160	70	Do.
R199	1,000	.068	46,000	19,000	70	5,000G	.3	B	160	700	Do.
R197	1,000	.070	58,000	800	17	800	.22	B	100	N	Do.
R044	5,000	B	270,000	10,000	42	2,000	.021	B	550	500	Livingston mill.
S272	5,000	B	250,000	20,000	150	32,000	N	B	350	100	Prospect northeast of White Cloud group.
T274M	1,000	B	90,000	20,000	120	19,000	.2	40	2,600	4,000	Peace of Mine prospect.
T575M	2,200	B	147,000	186,000	800	66,000	1.9	B	B	B	White Cloud prospect.

[1]Numerical average of analyses of four samples.

[2]Average of several semiquantitative spectrographic analyses by David F. Siems of samples that exceeded 1,000 ppm tin and 500 ppm cadmium by routine analysis.

[3]Analyzed by U.S. Bureau of Mines except Tr-1, Tr-2, and T571, which are averages of many atomic absorption analyses.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Treon Cr
Silver Rule Cr
Mill Cr
Holman Cr
DRYDEN
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Martin Cr
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Gold Cr
Pigtail Cr
Redfish Lake
Big Boulder Cr
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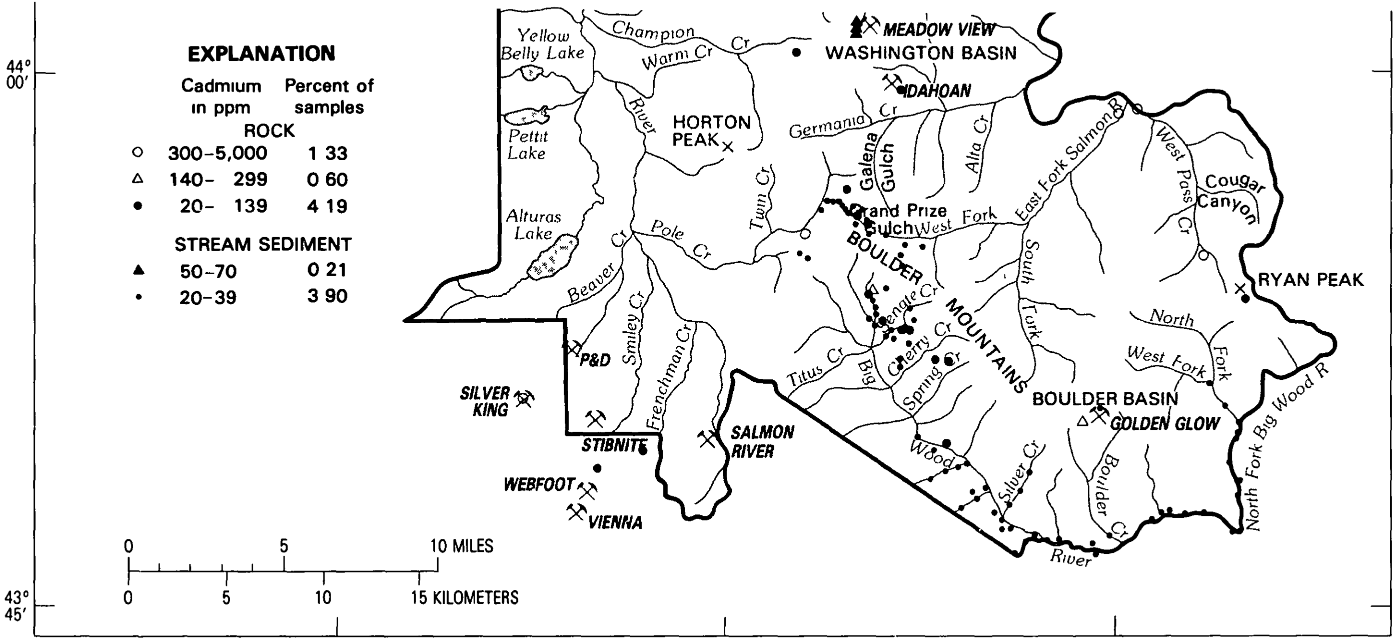


FIGURE 13.—Cadmium distribution in rock and stream-sediment samples, eastern part of the Sawtooth National Recreation Area. Cadmium content in 1,413 rock samples, 93 88 percent of the rock sample population, and in 2,756 stream-sediment samples, 95 89 percent of the stream-sediment sample population, was nondetectable Determinations are by semiquantitative spectrographic analysis

Sediment samples anomalous in cadmium in the northern part of the study area, near the headwaters of Prospect Creek also are anomalous in gold, whereas those on Mill Creek to the east also are anomalous in zinc Mineralized deposits are not known above either of these localities

High cadmium and moderate zinc content in stream sediments above the Meadow View mine suggest a possible upstream cadmium-bearing zinc deposit Mississippian argillite overlain by the Hailey Conglomerate Member of the Wood River Formation in the upstream area provides a favorable geologic environment for such a deposit. The cadmium content of the anomaly is comparable to that of the contaminated anomaly downstream from the Hoodoo mill No contributing mineral deposit is known in the possible source area above the Meadow View mine, and the low magnitude of the associated zinc anomaly does not support the possibility of a large zinc deposit outcrop It is possible that the cadmium is derived from a primary geochemical halo that overlies a concealed deposit of sphalerite Cadmium in wall rock, adjacent to a vein containing sphalerite in the Coeur d'Alene district of Idaho, is documented (Gott and Botbol, 1972)

FLUORITE

Fluorite deposits have been known in the study area for many years, but only a few tons of fluorite have been mined there A more active locality is Meyers Cove in central Idaho where about 12,800 tons (11,500 t) of fluorite were mined between 1951 and 1953, from deposits in the Challis Volcanics (Anderson and Van Alstine, 1964) Fluorite also has been mined in the Bayhorse district, about 15 miles (24 km) northeast of the study area.

Major fluorite resources in the study area are at the Giant Spar claims and four nearby properties (Hideout, Bright Star, Gold Chance, and Homestake, pl 3) close to the confluence of Big Casino Creek and the Salmon River The deposits are in veins in the Idaho batholith One composite sample of a vein zone, collected by the U S Bureau of Mines, averaged 76 26 percent fluorite (CaF_2), and extensions of the zone are estimated to contain at least 200,000 tons (180,000 t) of potential resources averaging 20–30 percent CaF_2 The Giant Spar and nearby area is considered favorable for the discovery of other fluorite deposits Some fluorite-bearing veins in the area contain gold and silver (Choate, 1962, p 83–84)

Fluorite float was found in the eastern part of the study area, near rhyolite or granite porphyry dikes in the Challis Volcanics, at four widely separated localities· (1) Crooked Canyon, a tributary of West Pass Creek (pl 2, 226), (2) the west tributary of Silver Creek (sample T559); (3) near a small lake at the head of a tributary east of the Upper East Fork Salmon River (629), and (4) several places along the upper valley of the East Fork of the North Fork Big Wood River

At the Crooked Canyon site, coatings of euhedral, colorless to pale-green fluorite occur on surfaces of altered andesite and silicified rhyolite porphyry float blocks that are as much as 10 ft (3 m) across The float blocks, scattered for 1,000 ft (305 m) along the canyon, probably were derived from the ridge to the southwest The source of the float was not located, but altered and silicified rhyolite porphyry dikes were observed on the southwest ridge, and rock of the dikes is similar to that of the fluorite-bearing float

The apparent source of the pale-green to colorless fluorite at Silver Creek is one of several large rhyolite porphyry dikes at the headwall of a cirque above a rock glacier in which a single 1-ft (0.3-m) block of fluorite-bearing float was found Sample T559 was broken from this block of float, the sample contained 20.2 percent CaF_2, equivalent to about 41 percent fluorite

The East Fork occurrence consists of dike float of rhyolite porphyry containing sparsely disseminated euhedral crystals of green fluorite in vug fillings and veinlets Fluorite also was seen in float from narrow, banded chalcedonic to drusy quartz veins on the slope several hundred feet above the stream

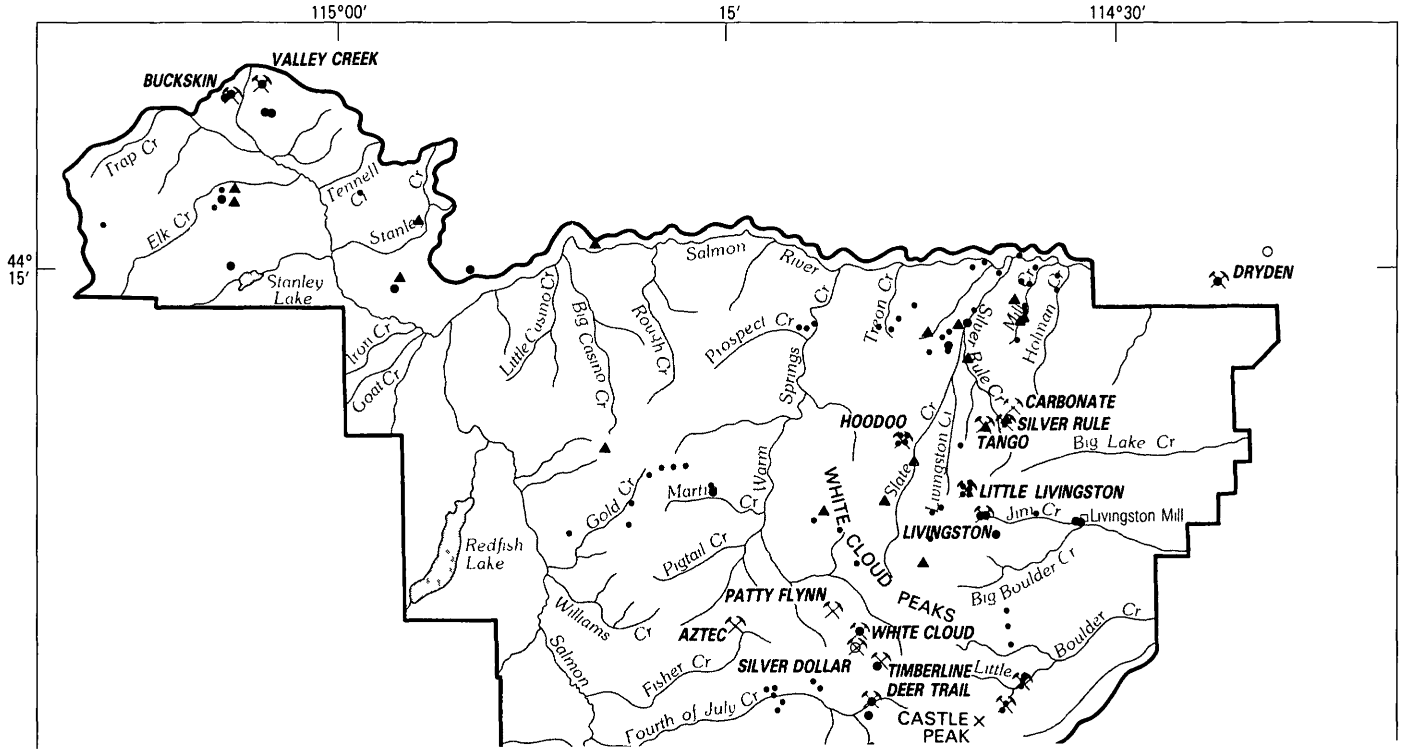
Fluorite float found along the upper valley of the East Fork of the North Fork Big Wood River probably came from rhyolite porphyry dikes that are numerous in the area.

The economic potential of fluorite in the four localities is small

COPPER

Only sparse amounts of copper are known in the Sawtooth National Recreation Area (fig 14) According to the records, 94,000 lb (42,600 kg) of copper have been produced since 1902, mainly as a minor byproduct from the Livingston mine (47,300 lb, 21,500 kg), as a byproduct from the mines in Boulder Basin (42,000 lb, 19,000 kg), and in much smaller amounts from the Buckskin Valley Creek mines Production of copper before 1902 is unknown

The copper sulfide minerals, chalcopyrite, digenite, and covellite, the oxide cuprite(?), several tin-copper sulfides of the stannite family, and native copper were identified in a complex silver-lead-tin-gold sample that contains 3,400 ppm copper (table 7, T283M). Most of the copper from the area, however, probably came from complex sulfosalts such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Silver Rule Cr
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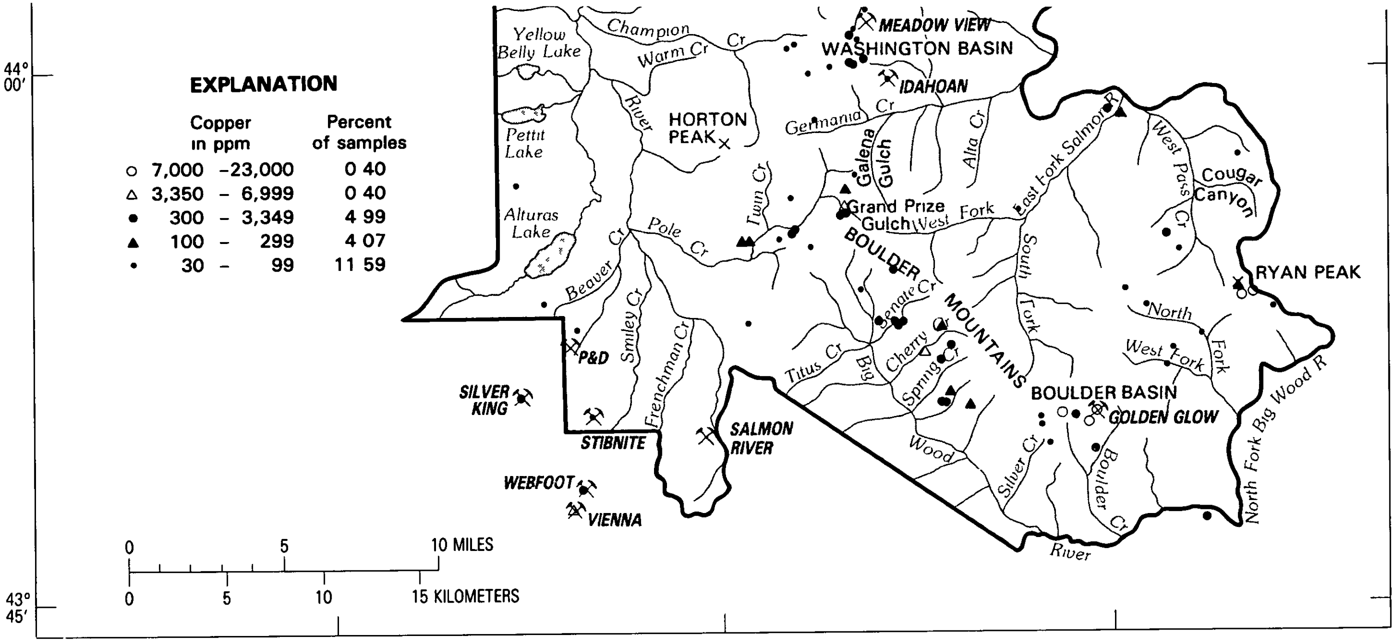


FIGURE 14 —Copper dıstrıbutıon ın rock samples, eastern part of the Sawtooth Natıonal Recreatıon Area. A total of 640 samples, 42 61 percent of the sample populatıon, contaıned from 5 to 29 ppm copper and are not shown Copper content ın 541 samples, 35 94 percent of the sample populatıon, was nondetectable or too low ın quantıty to measure Determınatıons by atomıc absorptıon

TABLE 7 —*Mineralized rocks containing high values of tin, Sawtooth National Recreation Area, Idaho*

[Samples are arranged in order from north to south, B, not analyzed, N, not detected, L, detected but below the limit of determination Tr trace amounts detected, G, detected in quantities greater than value shown, H, interference S semiquantitative spectrographic analysis, AA, atomic absorption, CM, colorimetric test Samples collected by the U S Bureau of Mines all values in percent except Au and Ag, oz/ton 1 oz/ton=34 285 g/t <, less than amount shown U S Geological Survey analyses in ppm, leaders (-), none reported]

Sample No	Sn[1]	Ag	Pb	Sb	Zn	Cd	Au	As	Cu	Property
		Samples collected and assayed by the U S Bureau of Mines								
V89	0.19	3 1	16 0	0 03	16 4	B	Tr	B	B	Lower Carbonate
J098	[2]1 01	153 4	16 0	5 50	1 80	B	0 60	B	B	Silver Dollar [3]
J020	[2] 76	46 5	5 20	2 68	5 00	B	12	B	B	Do
J096	[2] 27	15 4	1 75	62	B	B	11	B	B	Do
F299	[2] 60	29 6	6 00	1 37	1 80	B	03	B	B	Timberline [3]
F077	[2] 53	13 4	4 00	1 78	2 80	B	01	B	B	Do
F089	[2] 31	14 9	2 45	87	3 80	B	N	B	B	Do
F217	35	18 6	9 00	B	B	B	13	B	B	Rock Slide No 1
J117	33	18 0	8 80	63	B	B	16	B	B	Idahoan mine, west adit
J116	33	17 4	4 40	55	13	B	09	B	B	Do
J125	18	32 4	8 3	B	B	B	14	B	B	Do
J124	11	25 3	4 6	B	B	B	04	B	B	Do
J109	25	25 2	4 72	B	B	B	09	B	B	Idahoan mine
J108	23	22 2	3 52	68	B	B	10	B	B	Do
J214	25	41 0	9 1	B	22	B	24	B	B	Do
R339	10	5 5	6 8	B	1 8	B	Tr	B	B	Peace of Mine
R317	14	8 3	10 0	B	2 4	B	Tr	B	B	Jim Nash No 6
R318	22	13 0	19 0	B	3 2	B	Tr	B	B	Do
Z164	31	9 6	Tr	B	Tr	B	01	B	B	Stoneboat group
W201	40	4 1	B	B	B	B	02	B	B	Lucky Anti
Z172	[2] 91	9 6	17 6	B	5 00	B	07	B	B	Lone Trail group.
Z171	60	26 0	18 9	B	N	B	04	B	B	Do
7170	[2] 88	19 6	12 7	B	1 00	B	03	B	B	Do
Z175	64	4 3	02	B	20	B	01	B	B	Do
Z166	18	02	6 4	B	B	B	Tr	B	B	Do
Z174	05	8 2	9 9	B	N	B	03	B	B	Do
W289	21	9 9	15 0	B	46	B	Tr	B	B	Lucky group
W285	24	8 4	10 0	B	14 0	B	Tr	B	B	Do
W254	18	6 9	6 1	B	B	B	01	B	B	Do
W250	11	4 3	5 0	B	10	B	Tr	B	B	Do
W281	15	11 5	1 5	B	Tr	B	01	B	B	Big Five claims
W277	15	3 5	2 6	B	B	B	Tr	B	B	Do
W278	15	3 4	3 3	B	B	B	Tr	B	B	Do
W275	04	5 3	1 1	B	B	B	Tr	B	B	Do
W279	10	1 7	2 5	B	B	B	Tr	B	B	Do
W224	31	11 3	B	B	B	B	Tr	B	B	Lucky group
W219	13	18 8	1 8	B	B	B	02	B	B	Summit View
W191	09	2 1	B	B	B	B	Tr	B	B	Conway Castle
W203	11	2 6	5 0	B	N	B	Tr	B	B	Senate Lode
W222	< 01	2	B	B	B	B	N	B	B	Occident
W186	24	12 1	15 0	B	N	B	N	B	B	Chief Claim
W196	78	6 4	18 7	B	Tr	B	03	B	B	Do
W236	1	6 4	3 9	B	B	B	Tr	B	B	Hidden Treasure
W144	29	12 7	0017	B	--	B	Tr	B	B	Strawberry Hill
W145	30	26 3	0032	B	--	B	N	B	B	Do
W168	23	6 2	9 5	B	B	B	Tr	B	B	Ford
W147	25	11 5	B	B	B	B	01	B	B	Galena Belle
W152	20	15 8	B	B	B	B	N	B	B	Maggie
W149	73	22 7	B	B	B	B	11	B	B	Do
W153	22	39 8	10 1	B	8 0	B	N	B	B	Black Carbonate
W179	12	9	35	B	--	B	04	B	B	Combination
W180	14	9 4	9 8	B	--	B	N	B	B	Do
R388	48	26 4	B	B	B	B	02	B	B	Prospect, Galena district
Z110	56	26 7	005	B	B	B	Tr	B	B	Lone star
Z109	11	9 0	8 5	B	B	B	N	B	B	Do
L068	2	12 8	009	B	01	B	66	B	B	Boulder mines
L072	1	1	05	B	7 40	B	Tr	B	B	Do
Z135	10	16 4	4 0	B	B	B	17	B	B	Do
Z124	1	9 0	B	B	B	B	Tr	B	B	Do

[1]Tin contents of two decimal places are quantitative X-ray fluorescence analyses Tin contents to one decimal place are semiquantitative spectrographic analyses

[2]Average of chemical, X-ray fluorescence, and atomic absorption tin analyses

[3]See higher tin values for selected samples analyzed by U S Geological Survey in second part of table

TABLE 7 —*Mineralized rocks containing high values of tin*—Continued

Sample No	S-Sn[4]	AA-Ag	AA-Pb[5]	CM-SB	AA-Zn	S-Cd[4]	AA-Au	CM-As	AA-Cu	Property
Samples analyzed by U S Geological Survey										
[6]T266M	700	90	9,500	0 5	200	N	0 02L	B	40,000	Old Clayton smelter, slag
[6]T268	500	70	1,500	20,000	<15,000	N	28	70,000	15,000	Old Clayton smelter, metal-sulfide phase
T617M	3,100	100	38,000	1,000	3,800	N	--	N	1,000	Old Galena smelter, slag
V052	5,000	160	900	30	400,000	2,000	15	B	5,500	Cal-Ida mine (Carbonate group)
V057	500	200	8,500	600	140,000	2,000	45	B	1,500	Do
V017	1,750	200	75,000	5,000G	1,600	150	2 4	B	1,400	Tango mine (Star group)
V035	5,000	500	3,000	100	100	N	1 2	B	800	Prospect south of Tango mine
R200	700	120	15,000	5,000G	110,000	2,000	06H	B	2,400	Livingston mine, drill core
R199	700	70	19,000	5,000G	46,000	1,000	3	B	160	Do
R044	500	42	10,000	2,000	270 000	5 000	0 2L	B	550	Livingston mill
T316M	1,500	130	300,000	5,000G	5 0L	N	06	B	30	Patty Flynn prospect
T576M	[9]3,600	840	430,000	64,000	--	N	5 7	10,000	70	Do
S272R	100	150	20,000	32,000	250,000	5,000	N	B	350	Prospect northeast of White Cloud group
T312M	2,000	500	60,000	3,000	2,000	50	8	B	2,500	Prospect southeast of Alice Lode
T283M	22,500	2,500	340,000	13,000	29,700	200	1 0	B	3,400	Grand Prize Gulch, ore pile[7]
T274M	4,000	120	30,000	19,000	90,000	1,000	2	B	2,600	Peace of Mine prospect
K312	1,500	450	40,000	900	15,000	150	08	B	800	Do
K313	1,000	180	20,000	1,500	20,000	200	06	B	750	Do
T272M	1,750	600	12,000	250	11,000	70	15	B	1,500	Do
T557M	7,000	700	160,000	1,000	600	N	75	2,400	800	Prospects northeast of Stoneboat group
T556M	2,000	1,000	220,000	700	600	N	4	300	1,200	Do
T558M	2,000	3,000	400,000	2,000	2,400	20L	85	30	1,800	Do
T503M	1,000	3,000	600,000	30,000	700	300	25	8,000	450	Prospect southwest of Lone Trail group
T563M	700	800	190,000	70	1,400	N	4	120	600	Prospect S -SE of Highland Chief prospect
B926R	1,750	150	90,000	1 000	1,100	N	40	300	2,900	Maggie prospect
B927R	1,750	1,400	100,000	5,500	50	100	2	40	4,800	Do
B927M	1,000	2,600	420,000	8,000	N	100	05	200	3,600	Do
T566M	5,000	4,400	660,000	2,200	1,000	100	05L	100	2,400	New vein east of Black Carbonate prospect
[8]T564M	2,000	50	32,000	15	260	N	15	200	290	Do
T565M	2,000	7,000	600,000	3,000	600	150	N	100	2,200	Do
T567M	2,000	600	73,000	280	1,100	N	4	1,200	900	Do
B1401	500	70	17,000	2,000	6 000	200	15	50	700	Prospect, Boulder basin
T572M	[9]60,000	340	100,000	40,000	2,500	N	7	1,000	2,100	Timberline
[10]T619M	[9]11,000	1,500	116,000	29,000	8,900	1,500	39	3 000	5 000	Timberline prospect
[10]T620M	[9]9,100	700	86,000	35,000	2,000	300	1 1	1,500	2,000	Do
[10]T621M	[9]5,900	500	78,000	29,000	10,330	700	1 6	3,000	3,000	Do
T611M	[9]4,700	1,150	330,000	10,000	3,000	30	51	1,000	1,000	Wednesday prospect
T574M	[9]30,000	820	79,000	39,000	120,000	N	1 5	1,200	20,000	Silver Dollar
T622M	[9]1,700	1,200	350,000	29,000	1,500	300	--	20,000	300	Lone Trail No 1 prospect
T575	300	800	186,000	66,000	147,000	2,200	1 9	3,000	200	White Cloud prospect

[4]Average of several semiquantitative spectrographic analyses by David F Siems of samples that exceeded 1,000 ppm and 500 ppm cadmium by routine analysis

[5]AA-Pb values higher than 100,000 ppm were determined by repeat analysis using more suitable dilutions

[6]Contains 700 ppm molybdenum

[7]This sample was probably from one of the veins in the Galena district

[8]Contains 1,500 ppm molybdenum

[9]Quantitative X-ray-fluorescence analyses of selected high-grade samples

[10]Semiquantitative spectrographic analyses for silver, arsenic, cadmium, and copper

as tetrahedrite, stannite, or copper carbonates derived from sulfosalts. Minor chalcopyrite occurs with galena and sphalerite in some gold-bearing veins, and smaller amounts are present in sphalerite, chiefly as microscopic exsolution blebs

The economic potential of copper in the study area is slight Small occurrences of copper-bearing minerals crop out in the Boulder Basin and Ryan Peak areas of the Boulder Mountains Copper content greater than 3,000 ppm is confined to small occurrences in the Paleozoic sedimentary rocks (fig 14)

The most favorable area for prospecting extends southeast along the Boulder Mountain crest from Ryan Peak, on the southeast boundary of the study area, to the head of Murdock Creek (Amber Lakes quadrangle) Outcrops of copper-silver minerals were found at several places in that area, but none are large enough to be economically significant Larger deposits possibly could be discovered by more detailed exploration South of Ryan Peak, a mineralized outcrop of streaky, laminated, massive argillite, with azurite and malachite along fractures, contained 150 ppm silver (4.4 oz/ton, 151 g/t), 0.7 percent copper, 0 35 percent zinc, and 0.15 percent antimony (pl. 2, T406, table 2). Brecciated, malachite-stained quartzite from a klippe on the ridge crest about 600 ft (182 m) higher and 1,500 ft (475 m) east contained 1 0 percent copper, 19 ppm silver, and trace amounts of chromium, zinc, and antimony (pl 2, T417) Similar mineralized outcrops may occur farther east, near the eastern tip of the area, where anomalous copper values have been reported in sediments of south-flowing streams Insignificant traces of copper stain were found on the ridge just east of the study area (pl 2, T608), and blebs of copper-stained argentian tetrahedrite crop out in fractured quartzite on a peak at the head of Murdock Creek (T607) A sample of the highest grade material contained 3 1 percent copper, 2 2 percent antimony, and 1,750 ppm silver Mineralized rock of this grade appeared to be highly localized

Another area to be considered is on the ridge south of Boulder Basin, where a sample (pl 2, T531) of copper-stained altered rhyolite float contained 2 3 percent copper and 40 ppm silver, and a sample (T539) from a sulfide pocket in a quartz-carbonate vein contained 0 83 percent copper as chalcopyrite, 0 58 percent lead, 6 5 ppm gold, and 190 ppm silver The sampled vein is too small to be mined, but other quartz-carbonate veins that do not contain visible sulfides follow a large altered zone that probably extends as far west as Silver Creek

All stream-sediment samples that contained at least 100 ppm copper also contained anomalous amounts of other metals Most of these samples were taken below mines and prospects in Boulder and Washington Basins and below the Aztec and Livingston mine areas. The samples reflect contamination The only anomalous copper in stream-sediment samples that appear to be unrelated to known prospects were E854 (10 ppm), from a stream that drains into Fourth of July Creek and which is one-half mile west of Phyllis Lake (Washington Peak quadrangle), E600 (320 ppm), north of Ants Basin, and E31 (120 ppm), from upper Treon Creek Only three soil samples (pl. 2, A308, 1484, E741) contained 100 ppm copper or more, and the only anomalous soil sample where no prospect was found above it was from a short tributary on the south side of Sheephead Creek (E741, 200 ppm) (Livingston Creek quadrangle)

ANTIMONY

Antimony is abundant and widely distributed in the study area. It occurs chiefly in the mineral jamesonite, less commonly in stibnite, and also in various sulfosalt minerals associated with silver-lead sulfides in veins Kiilsgaard (1949, p 18) stated, "The lead and iron antimony sulphide (jamesonite) ($Pb_4FeSb_6S_{14}$) is the dominant ore mineral at the Livingston mine, and has accounted for the bulk of the lead production It occurs throughout the mine, from the outcrop to the lowest working places, without any noticeable change in physical characteristics or in quantity " If 75 percent of the 17 million lb (7,760,000 kg) of lead produced from the mine came from jamesonite, a 0.8 antimony/lead ratio of jamesonite indicates that 10 2 million lb (4,630,000 kg) of antimony were present as a coproduct in the lead concentrates, but no record of antimony recovery appears in the smelter returns.

Stibnite is the dominant metallic mineral in the Silver Dollar prospect (Head of Stanley Creek) and in the P & D and the Stibnite prospects (Vienna district), and it occurs in minor amounts in some gold-silver veins in the Stanley district and Washington Basin. Stibnite also has been reported from upper levels of the Livingston mine (pl 3)

High antimony contents are reported in the U S. Bureau of Mines chapter of this report from the following mines and prospects (pl. 3): Silver Dollar stibnite vein (14 6 percent), 85 NW claim (6 10 percent), Silver Dollar jamesonite vein (2 7–5 5 percent), Yacomella veins (5.4 percent), Patty Flynn prospect (4 68 percent), P & D stibnite prospect (4 percent), Lakeview and Alice (3 percent), Livingston and Little Livingston mines (2.6–2.8 percent), White Cloud prospect (1 99–10.0 percent), Timberline group (1.78 percent), and Washington vein (1 12 percent). Antimony in sulfosalt minerals was detected in selected mineralized samples from the Golden Glow mine (4 3 percent), and the White Cloud and White Cloud No 2 (6 5 and 3 2 percent), Patty Flynn (6 4 percent), Silver Dollar (3 9 percent), Timberline (4.0 percent), Lone Trail Nos 1 and 4 (2.9 and 1.2 percent), and Peace of Mine (1 9 percent) prospects (pl 3, tables 2, 6, 7). Sample T581 from the Golden Glow mine is a gold-rich galena-sphalerite-chalcopyrite ore, those from the White Cloud and Silver Dollar prospects are sphalerite (S272) or sphalerite-jamesonite (T574–T575) ores, and that (T576) from the Patty Flynn consists almost entirely of a lead sulfantinomide. The samples from the last four prospects listed above contain significant amounts of tin in addition to lead, silver, and usually zinc (table 7).

In contrast to the antimony-rich deposits listed above, the molybdenite or scheelite deposits in tactite and the higher grade arsenic-rich gold-silver deposits of the Valley Creek type generally contain less than 150 ppm antimony. Antimony and arsenic have an antithetical relation in most deposits relatively rich in gold or silver. In samples from gold-rich veins that may contain appreciable amounts of silver and lead, the antimony content tends to decrease as the arsenic content increases. On the other hand, antimony predominates in the silver-rich base-metal deposits, whereas the arsenic content is lower.

In the study area, stibnite and lead sulfosalts form in different geological environments and at different temperatures. Stibnite forms in low-temperature (epithermal) veins that seldom contain significant amounts of other valuable metals and are most common in the Idaho batholith, in or near gold-silver districts. In contrast, the lead sulfosalts invariably occur in higher temperature base-metal deposits that contain lead and silver, and less commonly zinc and tin, and are usually in Paleozoic sedimentary rocks relatively close to contacts of intrusive rocks. From exsolution textures of chalcopyrite in sphalerite, Kern (1972) estimated the temperature of formation of the largest jamesonite deposit (Livingston mine) to be 350°–400°C.

The distribution of rock samples containing 3 ppm or more antimony is shown in figure 15.

Antimony anomalies that have been produced by contamination were detected in stream sediments downstream from several productive mines (fig. 16), but natural antimony anomalies also were detected downstream from areas not known to contain antimony deposits. The pattern of stream-sediment antimony anomalies generally closely resembles those of silver, lead, zinc, and, to a lesser degree, tin and cadmium.

Stream sediments that contain anomalous antimony near the south edge of the study area, in and near the Vienna district (fig. 16), lack significantly anomalous amounts of other metals, which suggests the possible presence of undiscovered stibnite veins. The potentially mineralized areas are as far as 2 mi (3 km) from the nearest known stibnite veins. Similar undiscovered stibnite near the head of the West Fork of Warm Springs Creek (fig. 16) may be the source of an anomalous stream-sediment sample (pl. 2, E206) that contained 180 ppm antimony but no anomalous amounts of other metals.

Stream sediments that contain weakly anomalous antimony (3–20 ppm) are distributed in areas underlain by the Idaho batholith and by volcanic rocks and porphyries in the eastern part of the study area. These anomalous samples probably do not indicate economically significant mineral deposits, although together with the associated anomalous metals, they may reflect primary geochemical halos that could be related to undiscovered mineral deposits.

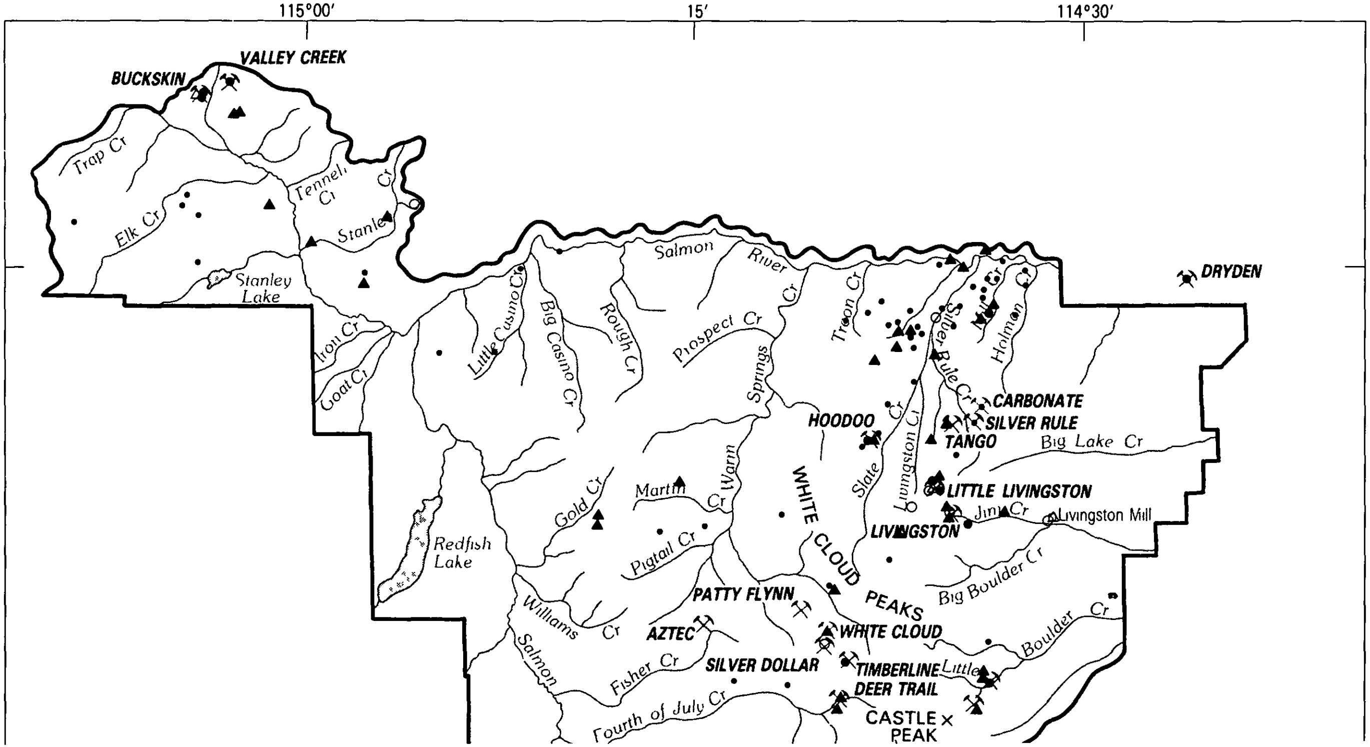
Slightly anomalous antimony, silver, lead, molybdenum, and zinc values were detected in rocks and stream-sediment samples in and downstream from pyritized volcanic rocks and porphyries near the southeastern tip of the study area. The sample data suggest a primary geochemical halo that may be related to the pyritization and to possible mineral deposits in the prevolcanic rocks.

ARSENIC

Arsenic is associated with many mineral deposits in the study area and also is dispersed in rocks, soils, and stream sediments, where relative amounts of it may be used as a guide in the location of more valuable metals. Arsenic may be produced as a byproduct from the smelting of precious- and base-metal ores, but it usually is a troublesome impurity that is not recovered. Arsenic therefore is more likely to detract from rather than add to the net value of ores or concentrates.

Arsenic occurs in various minerals either as a major constituent or in combination with other metallic elements. It is closely associated with gold and may occur in primary halos in and above zones of gold-silver mineralization Arsenopyrite is the principal arsenic-bearing mineral in the study area, but others that have been identified include geochronite, guitermanite, enargite, tennantite, proustite, and miargyrite The oxide realgar also was noted. The most enriched sample that was collected came from a silver-bismuth vein (8.4 percent arsenic) at the Empyreum claim (pl 3, 145) Samples from gold-silver veins at the Valley Creek mine ranged from 1 to 5 percent arsenic, whereas those from some base-metal deposits that contain silver and gold ranged from 0 5 to 1 0 percent arsenic

Although arsenic is a useful pathfinder element, particularly in the detection of gold-silver deposits, its usefulness in spectrographic analysis of rock and stream-sediment samples is limited by a detection limit of 200 ppm. A colorimetric analytical method (Spot-Gutzeit) is more sensitive (detection limit of 10 ppm arsenic), but only 41 percent of the rock samples, 27 percent of the soil samples, and 7 percent of the stream-sediment samples were analyzed by this method Only about 10 percent of the stream-sediment samples and 2 percent of the soil samples contained quantities of arsenic that could be measured by the colorimetric method All samples were analyzed spectrographically


115°00′
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VALLEY CREEK
BUCKSKIN
Trap Cr
Elk Cr
Tennell Cr
Cr
Stanley
Stanley Lake
Iron Cr
Goat Cr
Little Casino Cr
Big Casino Cr
Rough Cr
Salmon
River
Prospect Cr
Cr
Springs
Troon Cr
Silver Rule Cr
Holman
DRYDEN
CARBONATE
SILVER RULE
HOODOO
TANGO
Big Lake Cr
Slate
Livingston Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
WHITE CLOUD PEAKS
Martin
Warm
Cr
Gold Cr
Pigtail Cr
Redfish Lake
Big Boulder Cr
Boulder
Cr
PATTY FLYNN
Williams
Cr
AZTEC
WHITE CLOUD
Salmon
Fisher Cr
SILVER DOLLAR
TIMBERLINE
Little
DEER TRAIL
Fourth of July Cr
CASTLE PEAK

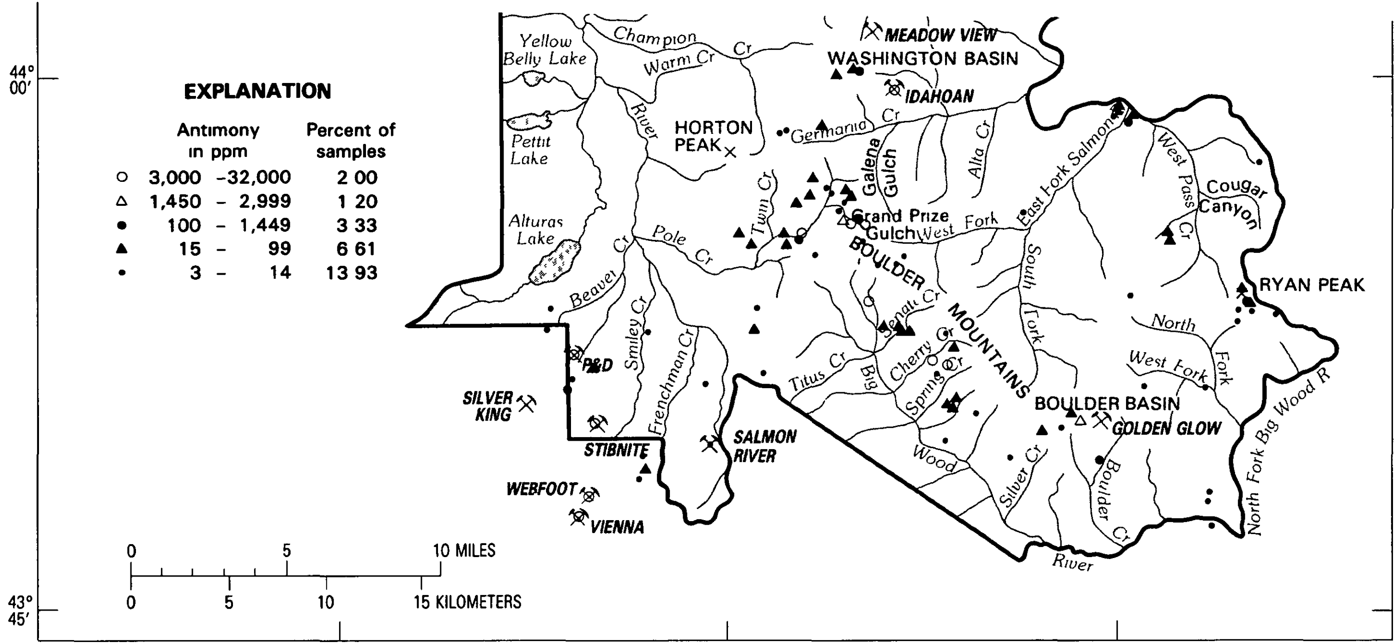
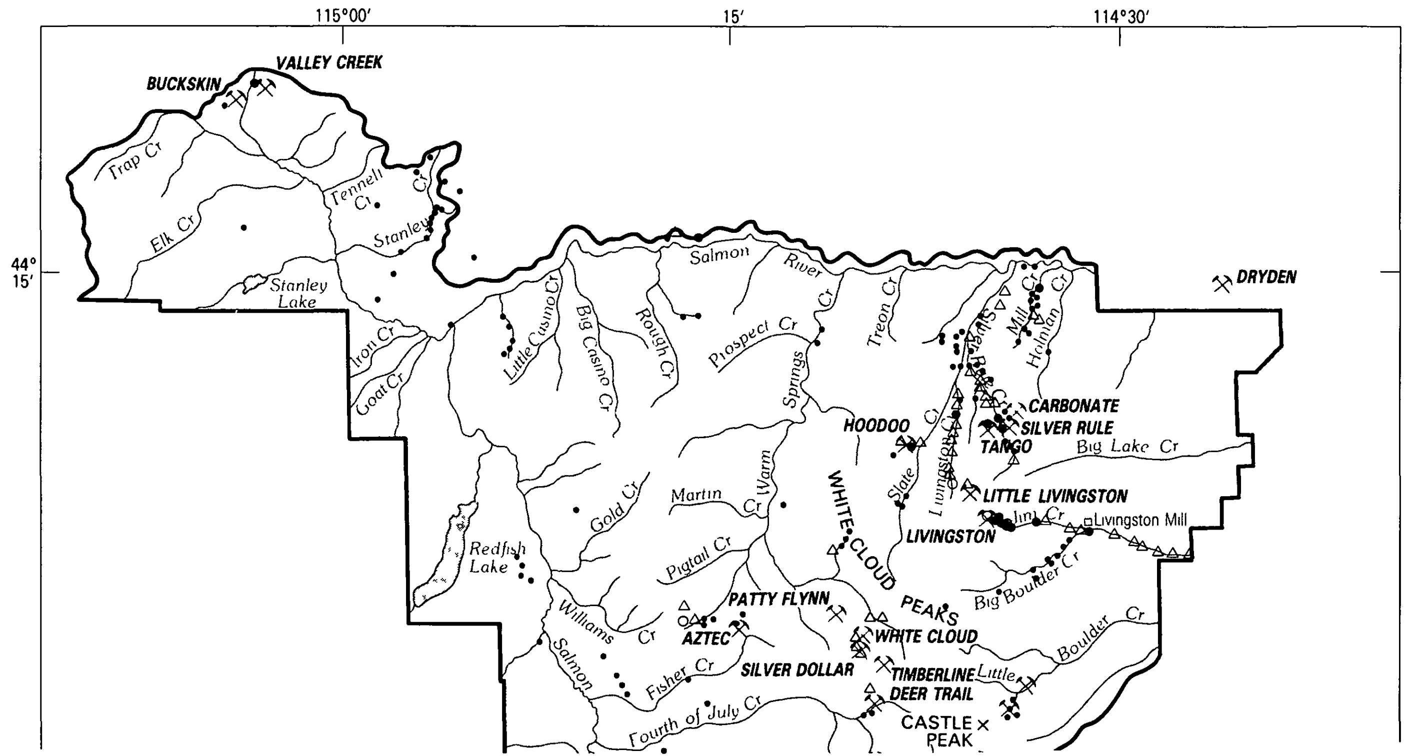


FIGURE 15 —Antimony distribution in rock samples, eastern part of the Sawtooth National Recreation Area. A total of 424 samples, 28 20 percent of the sample population, contained from 0 3 to 2 9 ppm antimony and the locality of these samples is not shown Antimony content in 673 samples, 44 73 percent of the sample population, was either too low to measure or nondetectable Determinations by color spectrophotometer analysis


115°00′
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VALLEY CREEK
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Big Casino Cr
Rough Cr
Prospect Cr
Springs Cr
Treon Cr
Silver Rule Cr
Mill Cr
Holman Cr
DRYDEN
CARBONATE
SILVER RULE
TANGO
HOODOO
Big Lake Cr
Livingston Cr
Slate Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
Gold Cr
Martin Cr
Warm Cr
WHITE CLOUD PEAKS
Redfish Lake
Pigtail Cr
Big Boulder Cr
PATTY FLYNN
Williams Cr
AZTEC
WHITE CLOUD
Boulder Cr
Salmon
Fisher Cr
SILVER DOLLAR
TIMBERLINE
Little
DEER TRAIL
Fourth of July Cr
CASTLE PEAK

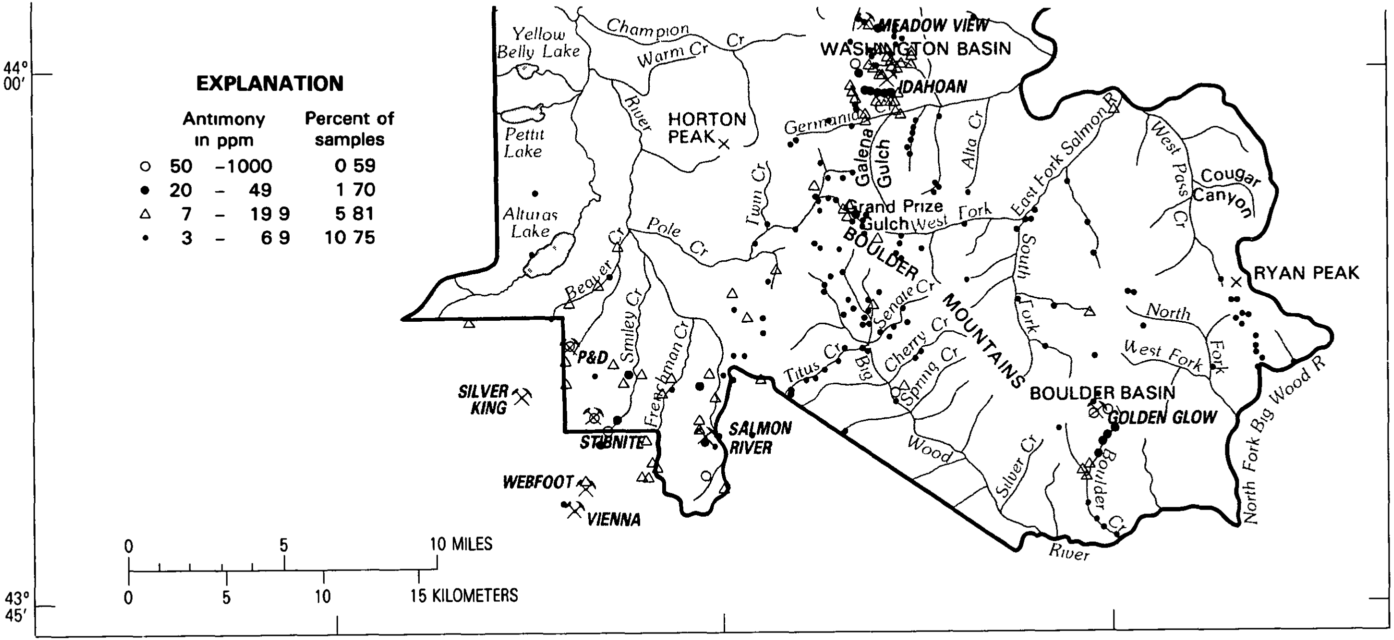


FIGURE 16 —Antimony distribution in stream-sediment samples, eastern part of the Sawtooth National Recreation Area. Antimony content in 53 42 percent of the samples ranged from 0 5 to 2 9 ppm and the locality of these samples is not shown Antimony content in 27 73 percent of the samples was either too low to measure or nondetectable Determinations by color spectrophotometer analysis

The distribution of arsenic values is shown in figure 17. Rock samples with the highest arsenic content are from the Valley Creek, Buckskin, and Stanley Ace mines in the Stanley gold district, the Peace of Mine prospect, and a base-metal vein in the Little Boulder Creek molybdenite deposit.

Stream sediments and soils anomalous in arsenic characteristically are associated with those anomalous in gold and silver, often in proportions that reflect the arsenic content and silver/gold ratios at the source The most anomalous sediment samples are below mining areas and as such reflect contamination Illustrative of this are sediments downstream from the Valley Creek-Buckskin gold veins. A sediment sample below the tailing pond of the Valley Creek mine contained 3,000 ppm arsenic and others taken over a distance of several miles downstream from the tailing pond contained 30-120 ppm arsenic. Stream sediments downstream from the gold veins and two old mills in Washington Basin are anomalous in arsenic. One sediment sample from that locality contained 200 ppm arsenic, 9 ppm gold, and 7.5 ppm silver (pl 2, E893); and another, a soil-like possible mill concentrate, contained 100 ppm arsenic and bismuth, 480 ppm selenium, 1,000 ppm copper, and 11 ppm silver (pl. 2, E929) Deposits in Washington Basin contain abnormal amounts of arsenic, gold, selenium, bismuth, and molybdenum, elements that are reflected in sediment samples from the basin Likewise, deposits in the Buckskin-Valley Creek mine area are high in arsenic, gold, and lead, but low in selenium and bismuth; this relationship is reflected in the stream sediments. The relatively low silver/gold ratios of ore minerals from both areas are reflected in the stream sediments Conversely, the high silver/gold ratios and lesser arsenic content (10-30 ppm) in stream sediments in Boulder Basin below the Golden Glow mine (pl 2, 1405) and along Grand Prize Gulch (fig 17) reflect the differing composition of mineral deposits in those areas.

An area suggested by sediment samples anomalous in arsenic as favorable for gold-silver occurrences is at the headwaters of Titus Creek (fig 17) Stream sediments strongly anomalous in zinc along Mill Creek (pl. 4) also are anomalous in arsenic.

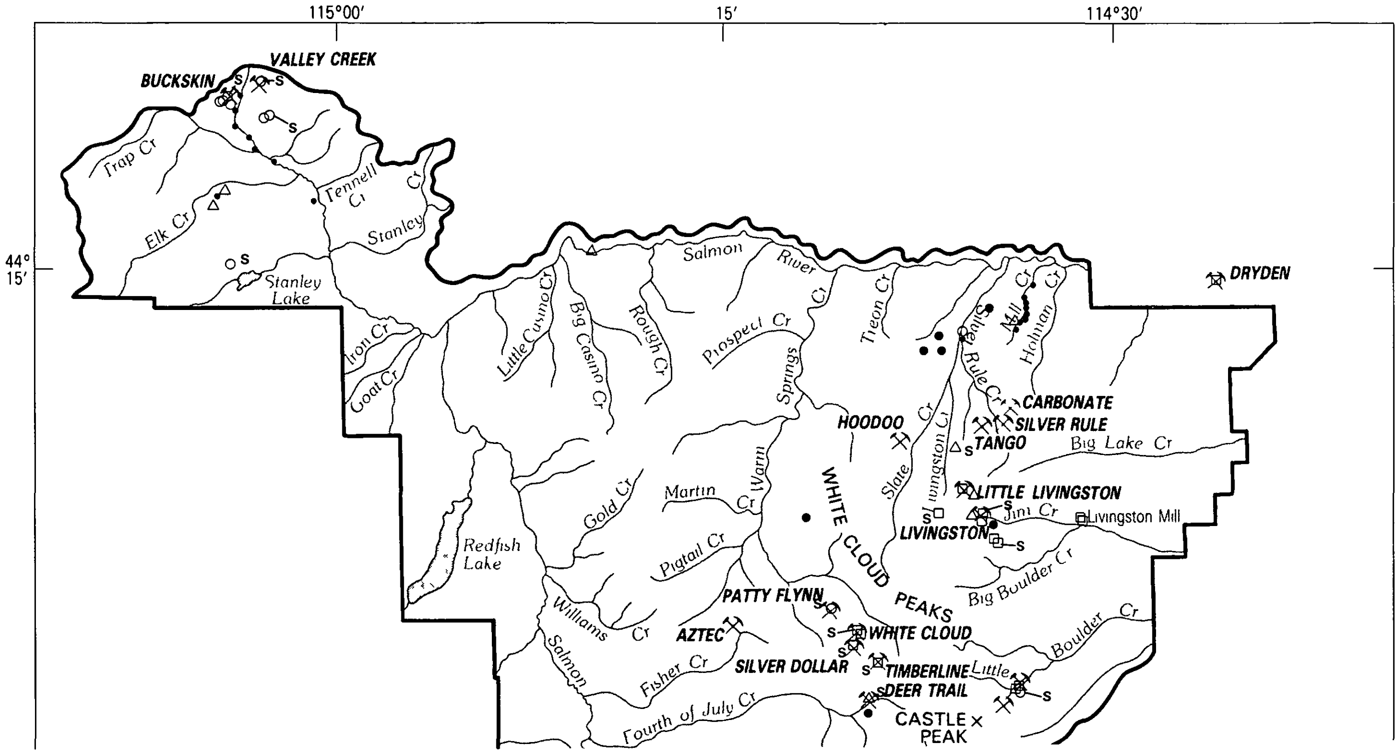
BISMUTH, TELLURIUM, AND SELENIUM

Bismuth, tellurium, and selenium are produced chiefly as byproducts from the smelting of ores and concentrates. No production of these three metals is recorded from the study area, and their economic potential is small It is conceivable that bismuth could be recovered from gold-silver veins in the Washington Basin. The volume of inferred submarginal gold-silver vein material at the Empire and Washington veins may be estimated at about 5,000,000 tons (4,500,000 t) and semiquantitative analyses and a few assays of the material vary from 0 05 to 0.07 percent bismuth. An additional 1,600,000 tons (1,450,000 t) of submarginal material from the nearby Last Resort vein may average 0 30 percent bismuth. Also, samples from small shoots in the Last Resort and Yacomella veins and in three smaller veins in the vicinity contained from 0 06 to 1 0 percent bismuth

Most bismuth determinations are semiquantitative spectrographic analyses by two different laboratories whose results may not be closely comparable. The spectrographic analyses of samples collected by the U S Geological Survey and the U.S. Bureau of Mines are expressed as one significant digit to distinguish them from the relatively few but more reliable two-digit chemical analyses.

Bismuth occurs in several different veins and in the adjacent rocks in Washington Basin and the surrounding region. It is the principal metal in samples from the Contact and Red Warrior veins (pl 3, 126, 125), which contain 0 36 and 0 34 percent bismuth, respectively. Other bismuth-bearing veins also contain silver, or gold and silver, or silver, lead, and antimony A sample of Mountain View vein material (pl. 3, 118) contained 0 43 percent bismuth, 2 6–17 8 oz silver per ton (89–610 g/t) and traces of other metals A sample from a stockpile of ore on the Germania group of claims (pl 3, 150) contained 0 14 percent bismuth, 13.7 oz silver per ton (470 g/t), and only 0 09 oz gold per ton (3 g/t) A 35-ft (10 6-m) sample across the Reconstruction pyrite vein (pl 3, 136, fig 55, J282) and adjacent wall rocks contained 0.1 percent bismuth, 1 0 oz silver per ton (34.2 g/t), and 0 09 oz gold per ton (3 g/t) Another sample across the Reconstruction vein, which has a maximum exposed width of 15 ft (4 5 m), contained 0.18 percent bismuth and 0.09 percent WO_3 A 10-ft (3-m) sample across a tactite zone along the Last Resort vein contained 0 14 percent bismuth, 0 1 oz silver per ton (3.4 g/t), and 0 01 oz gold per ton (0 3 g/t) The corresponding values for a 3-ft (0.9-m) width across the richest part of the Last Resort vein are about 1 percent bismuth, 0 8–1.7 oz silver per ton (27 4–58 3 g/t), and 0 16–0.22 oz gold per ton (5.5–7.5 g/t). Widths of 4.5–5 ft (1 3–1.5 m) contain 0 3 percent bismuth A sample of silver-jamesonite ore (J266) from a stockpile from the Yacomella vein (fig 57) contained about 1 percent bismuth, 49 3 oz silver per ton (1,690 g/t), lead, and antimony, but little gold

The preceding analyses indicate that most of the higher bismuth values occur in veins that also contain high values of silver, silver and gold, or silver-lead antimony Bismuth and the associated metals are not confined to the veins, they also are found in adjacent tactite zones and sheared mineralized rocks


115°00′
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VALLEY CREEK
BUCKSKIN
DRYDEN
Trap Cr
Tennell Cr
Cr
Elk Cr
Stanley
Stanley Lake
Salmon
River
Iron Cr
Goat Cr
Little Casino Cr
Big Casino Cr
Rough Cr
Prospect Cr
Springs
Cr
Treon Cr
Silver Rule Cr
Mill Cr
Holman Cr
CARBONATE
SILVER RULE
HOODOO
TANGO
Big Lake Cr
Slate Cr
Livingston Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
WHITE CLOUD PEAKS
Gold Cr
Martin
Cr
Warm
Redfish Lake
Pigtail Cr
Big Boulder Cr
PATTY FLYNN
AZTEC
WHITE CLOUD
Williams
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Salmon
Fisher Cr
SILVER DOLLAR
TIMBERLINE
Little
Boulder
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DEER TRAIL
Fourth of July Cr
CASTLE PEAK

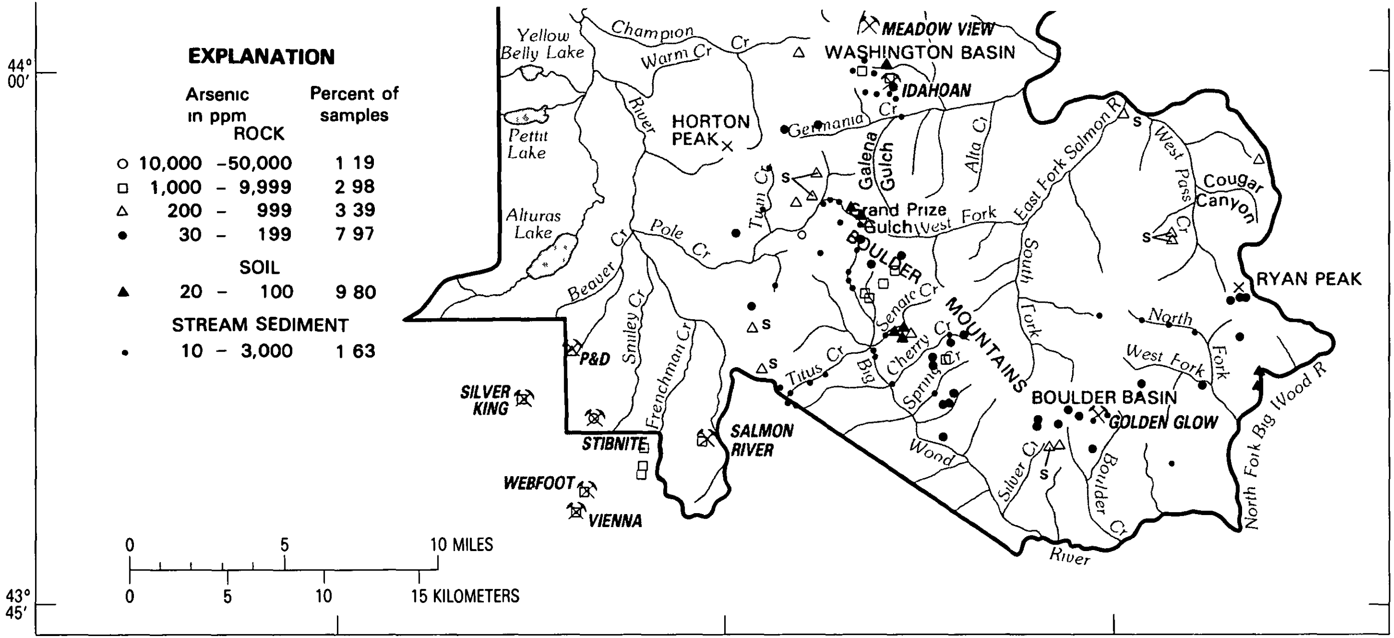


FIGURE 17 —Arsenic distribution in rock, stream-sediment, and soil samples, eastern part of the Sawtooth National Recreation Area. Arsenic content in 7 17 percent of the rock samples ranged from 10 to 29 ppm and the locality of these samples is not shown Arsenic content in 77 30 percent of the rock samples was either too low to measure or nondetectable Determinations by color analysis (Spot-Gutzeit) for values shown as less than 200 ppm arsenic, or by semiquantitative spectrographic analysis (s) for values of 200 ppm or more arsenic

Identified bismuth minerals from veins in Washington Basin include bismuthinite, native bismuth (Empire vein (La Heist, 1964, p. 197)), and the bismuth tellurides, tetradymite, and joseite (Empire and Washington veins (La Heist, 1964, p. 199, Ross, 1937, p. 156)).

Bismuth appears to be concentrated in only a few mineral deposits in the study area; only 8.4 percent of the mineralized and anomalous rock samples and only 2.4 percent of all rock samples contain 10 ppm or more bismuth, the minimum measurable value. All measurable values were found in mineralized rocks (table 2). Less than 1 percent of the soil and stream-sediment samples contained 10 ppm or more bismuth.

The distribution of bismuth is shown in figure 18. Excluded from figure 18 are 120 rock samples containing at least 100 ppm bismuth that were analyzed spectrographically by the Bureau of Mines. Thirty-seven of the USBM samples that contained 0.1–1 percent bismuth are from localities shown on figure 18. Of these, three contained 0.6 percent and three contained 1 percent bismuth.

Samples containing more than 0.1 percent bismuth were collected chiefly from veins and adjacent tactites of the Washington Basin area, from gold veins and adjacent graphitic schists in the Gem State (Elk Mountain) area, and from some tin-bearing veins in the Galena district. Of these samples, those with values greater than 0.6 percent bismuth were found only in the Washington Basin area.

Stream-sediment samples that contain detectable quantities of bismuth were found on Fisher Creek at the south end of the Aztec gold belt, and in and near Washington Basin (fig. 18). Anomalous values in soils were found only in Washington Basin.

The distribution of tellurium and selenium in the study area is known only from 50 tellurium and 28 selenium analyses of widely scattered mineralized rock samples selected for their high gold, silver, tin, or zinc content. On the basis of these, selenium appears to be more abundant than tellurium, as shown by average contents of 115 and 21 ppm, respectively.

Sample T283M from a stockpile at Grand Prize Gulch contained 4,300 ppm tellurium and 450 ppm selenium, and very high silver, lead, and tin (table 2). This sample contained tellurian canfieldite and hessite and is the only known occurrence of tellurium minerals outside Washington Basin where the tellurium is in bismuth tellurides. The second richest sample (table 2, S257R) contained 140 ppm tellurium, 1.2 ppm selenium, 260 ppm silver, 300 ppm bismuth, and minor lead and zinc. The third highest tellurium content (40 ppm) is a complex zinc-lead-antimony-tin-copper-silver sample (T574) from the Silver Dollar prospect (pl. 3, 101), which contained 3.07 percent tin and 180 ppm selenium. Sample S272 from the nearby White Cloud No. 2 sphalerite-jamesonite prospect (pl. 3, 102) contained 25 ppm tellurium and 445 ppm selenium. Selected samples (tables 2 and 7, T565–566, B927) of silver-rich, tin-bearing galena from the Galena district contained from 3 to 19 ppm tellurium and from 90 to 160 ppm selenium.

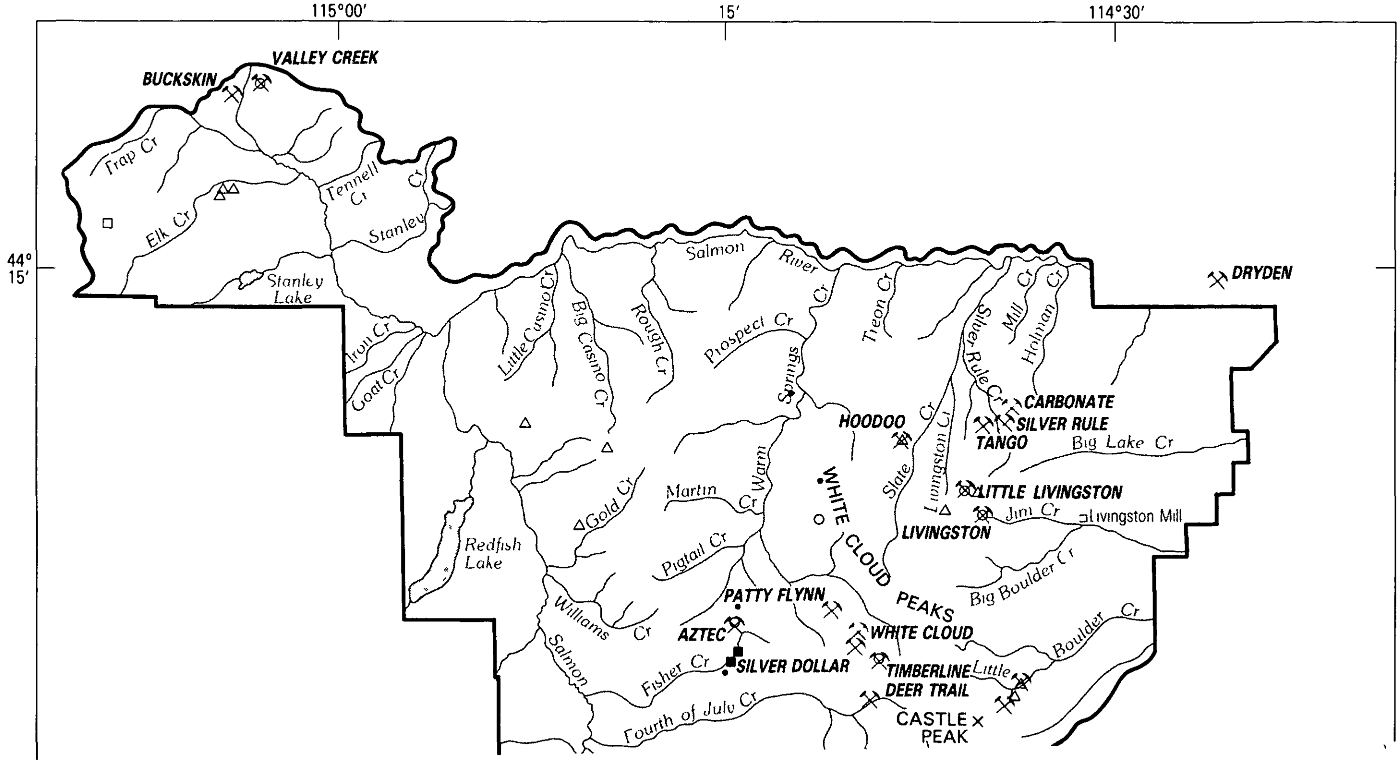
Samples containing 0.5 ppm or less tellurium were taken from gold veins of the Valley Creek, Buckskin, and Golden Glow mines (pl. 3, nos. 3, 5, 229), a tin-rich sample (T572) from the Timberline prospect (pl. 3, 99), and a ruby silver vein (pl. 2, T455) at the Silver King mine, Sawtooth district (pl. 3). The ruby silver and arsenic-rich gold veins also have exceptionally low selenium contents ranging from zero to 0.52 ppm, except for 6 ppm in the sample containing the highest gold value. Selenium minerals have not been identified.

Selected galena from the dump of the highest shaft on the Champion vein above the Golden Glow mine contained (in ppm): 1,090 selenium, 1,000 gold, and 2,000 silver, compared to 480 selenium, 110 gold, 11 silver, and 6 tellurium in a soil-like mill concentrate from the Washington Basin. These very different arsenic-poor samples clearly illustrate the association of selenium with gold.

The association of bismuth, tellurium, and selenium with gold and silver make these elements useful geochemical indicators for precious-metal deposits. In Washington Basin, bismuth and tellurium occur as bismuth tellurides and tend to increase proportionately to increased amounts of silver; on the other hand, selenium, as elsewhere, increases proportionately to increases in gold. In the Valley Creek mine, bismuth is concentrated 10 to 50 fold in the two samples highest in gold but is not detectable in lower grade ores. Bismuth is also concentrated in the gold deposits in the Aztec and Elk Mountain areas. Selenium is most abundant in the two samples from Washington and Boulder Basins that have the highest gold contents found in the study area.

TUNGSTEN

Several tungsten deposits occur in the study area, although no tungsten has been mined from them. Tungsten has been mined from nearby deposits, notably from Wildhorse Creek 15 mi (24 km) southeast of the study area and from Thompson Creek 5 mi (8 km) to the north. Scheelite in tactite is the most common type of tungsten deposit in the region, which is defined by Cook (1956) as part of the Central Idaho Tungsten Belt. The scheelite-bearing tactite occurs in the inner parts of metamorphic aureoles at the contacts of plutonic rocks and intruded calcareous sedimentary rocks. As noted by Cook (1956, p. 6), scheelite preferentially is concentrated in tactite containing garnet, epidote, and vesuvianite. Rocks of this type crop out along the east contact of the White Cloud stock, north of the Little Boulder Creek molybdenum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Rough Cr
Prospect Cr
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Treon Cr
Springs
Silver Rule Cr
Mill Cr
Holman Cr
DRYDEN
CARBONATE
SILVER RULE
TANGO
HOODOO
Big Lake Cr
Slate Cr
Livingston Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
WHITE CLOUD PEAKS
Martin Cr
Warm
Gold Cr
Redfish Lake
Pigtail Cr
Big Boulder Cr
PATTY FLYNN
WHITE CLOUD
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TIMBERLINE
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Salmon
Fisher Cr
Fourth of July Cr
CASTLE PEAK

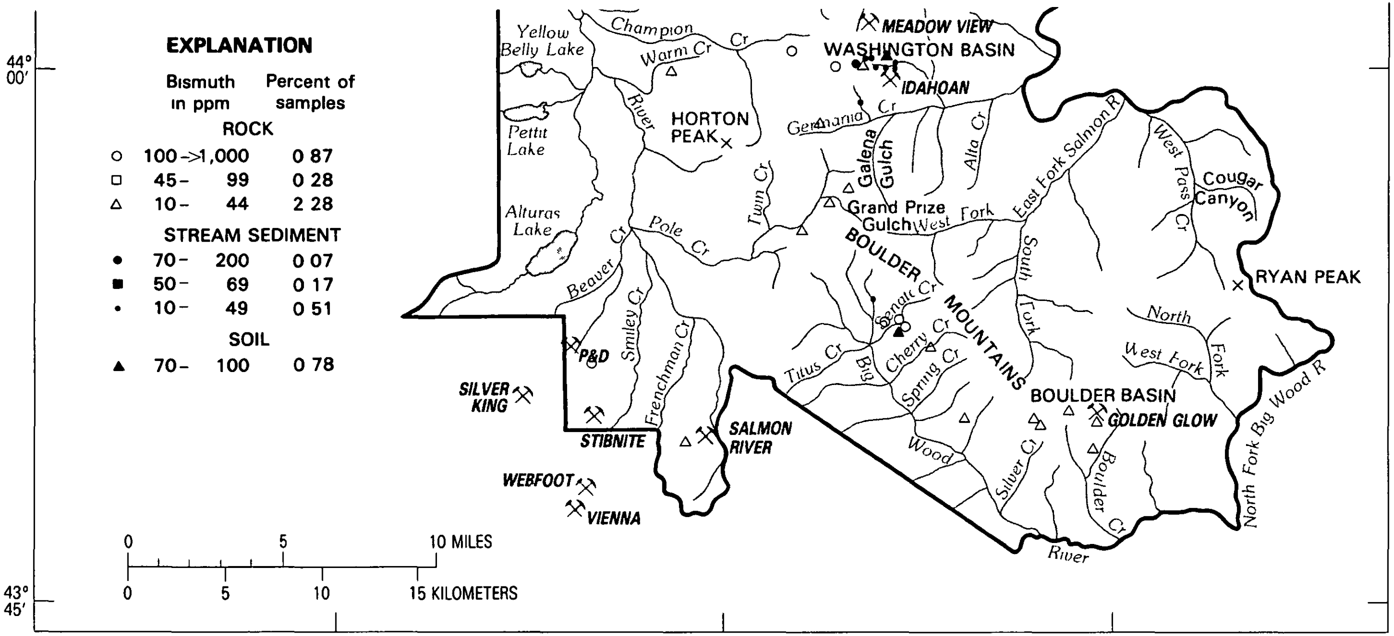


FIGURE 18 —Bismuth distribution in rock, stream-sediment, and soil samples, eastern part of the Sawtooth National Recreation Area. Bismuth content in 96 57 percent of the rock samples, in 99 25 percent of the stream-sediment samples, and in 99 22 percent of the soil samples was nondetectable Determinations by semiquantitative spectrographic analysis

deposit, and are known to contain traces of scheelite locally Samples from the Little Boulder Creek molybdenite deposit contained as much as 0 02 percent WO_3.

Mineral deposits in the study area that contain scheelite include the Meadow View mine, Red Robin prospects, veins and tactite zones in Washington Basin, and the Ura deposit The largest potential tungsten resources are at the Meadow View mine (pl. 3, 117), where scheelite is a minor constituent of sphalerite deposits formed in a roof pendant of argillite and tactite in quartz monzonite. Marginal reserves at the mine are estimated to contain 67,000 lb (30,000 kg) of WO_3, of which about 82 percent is present in material averaging 6 5 percent zinc and 0 28 percent WO_3; the remainder is in submarginal reserves averaging 3 3 percent zinc and 0.12 percent WO_3 At the Red Robin prospects (pl 3, 114, 115), scheelite and minor molybdenite occur together in tactite, molybdenite is present locally, in quartz veins less than 1 ft (0.3 m) thick

In Washington Basin, traces of scheelite occur in the Empire vein (less than 0.01 percent WO_3) and in the Reconstruction veins (0 9 percent WO_3) Scheelite is more abundant in some massive pyrrhotite replacement bodies along the Empire vein and along some tactite zones, but previously reported contents of up to 0 52 percent WO_3 were not confirmed. The Ura deposit in the Vienna district (pl 3, 171) is in tactite at the contact of the Idaho batholith Samples over a 3.5-ft (1-m) width contained as much as 1.16 percent WO_3, and over a 6-ft (1.8-m) width as much as 0 40 percent WO_3. Other rock samples from the Ura deposit contained as much as 1,000 ppm tungsten (fig. 19). The scheelite occurrence south of Boulder Basin (pl. 3) mentioned by Cook (1956, p 29) apparently consists of scheelite float that probably was derived from the contact of a dacite porphyry or granite porphyry dike with calcareous Paleozoic rocks.

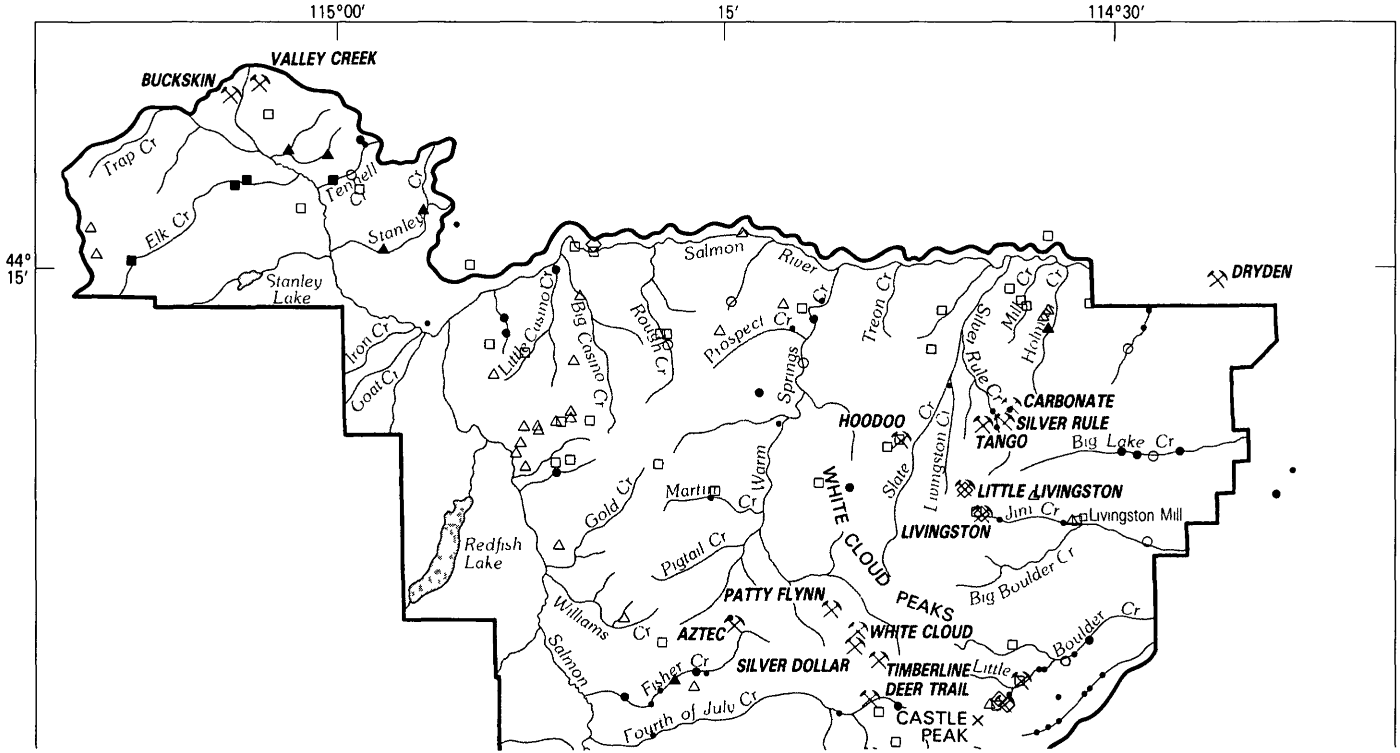
Tungsten was detected spectrographically in only about 3 percent of the rock and stream-sediment samples and is widely scattered (fig. 19) The sediment samples do not reveal previously unknown areas considered favorable for tungsten deposits. The tungsten values in stream sediments are about the same below known scheelite-bearing deposits as elsewhere, perhaps because the principal tungsten minerals are heavy insoluble oxides that are resistant to abrasion and therefore, like gold, tend to work down to bedrock. Most of the detectable tungsten in rock and stream-sediment samples are in igneous and contact metamorphic rocks. No association of tungsten with the sulfide-forming metals is discernible. Five rock samples that contain more than 150 ppm tungsten are all from mines and prospects.

TIN

Tin production from mineral deposits in the United States is negligible, with only small quantities produced as a byproduct from molybdenum mining in Colorado. For this reason the discovery of tin minerals in silver-base-metal veins in the study area is interesting mineralogically and also possibly significant from the standpoint of potential tin resources. Certainly, the recovery of tin from ore that might be mined from these deposits in the future would increase the value of the ore More exploration would be needed to determine the amount of tin that exists in potential resources of the area.

Tin minerals are widespread in the silver-base-metal deposits that form an arcuate belt extending from the Boulder Mountains in the southern part of the area to the Salmon River region in the north (figs 7, 11, and 20). Veins richest in tin content, however, are clustered in two areas about 12 mi (19 km) apart. The northern of these areas is in the Fourth of July Creek district, west of the White Cloud stock, whereas the southern area is in the Galena district, in the Boulder Mountains (fig. 20; pl. 3). Selected samples from veins in these areas contained from 2 to 6 percent tin (table 7). Samples from veins outside the two areas contained 0.1-0.5 percent tin.

The greatest concentration of tin-bearing veins is in the Galena district (fig. 20), where the mineralogy of tin-rich samples is complex. A variety of tin and silver minerals is present as indicated by a detailed study of a rich sample that contained 2 25 percent tin (T283M, table 7) The sample is from a small ore pile of uncertain source. Five polished sections of this sample were studied by B. F. Leonard (written commun., 1973), using supplemental X-ray diffraction photographs by R. B. Tripp and electron microprobe analyses by G. A. Desborough (all three of the U.S Geological Survey). Leonard identified 6 tin minerals in a suite of about 25 metallic minerals. The principal tin minerals are cassiterite (SnO_2), tellurian canfieldite ($Ag_8Sn(Se, Te)_6$), and several members of the stannite family (Cu_2FeSnS_4, 29 5 percent tin) The stannite minerals include a stannite-like mineral containing 7 percent zinc, kesterite(?), the zinc-rich analog of stannite, and suspected isostannite and "brown stannite." In addition a mixture of secondary stannic oxides and hydrates, collectively known as varlamoffite, are in the oxidized matrix, which consists largely of anglesite ($PbSO_4$) and cerussite ($PbCO_3$). Several unidentified sulfidic tin minerals are present as minute inclusions in galena and pyrite. Lead in the sample occurs principally as galena, although lead sulfosalt minerals also may be present.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Big Casino Cr
Rough Cr
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Prospect Cr
Springs
Treon Cr
Silver Rule Cr
Mill Cr
Holman Cr
DRYDEN
CARBONATE
SILVER RULE
TANGO
HOODOO
Slate Cr
Livingston Cr
Big Lake Cr
LITTLE LIVINGSTON
Jim Cr
Livingston Mill
LIVINGSTON
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Big Boulder Cr
Boulder Cr
Little
Redfish Lake
Gold Cr
Martin Cr
Warm
Pigtail Cr
Williams Cr
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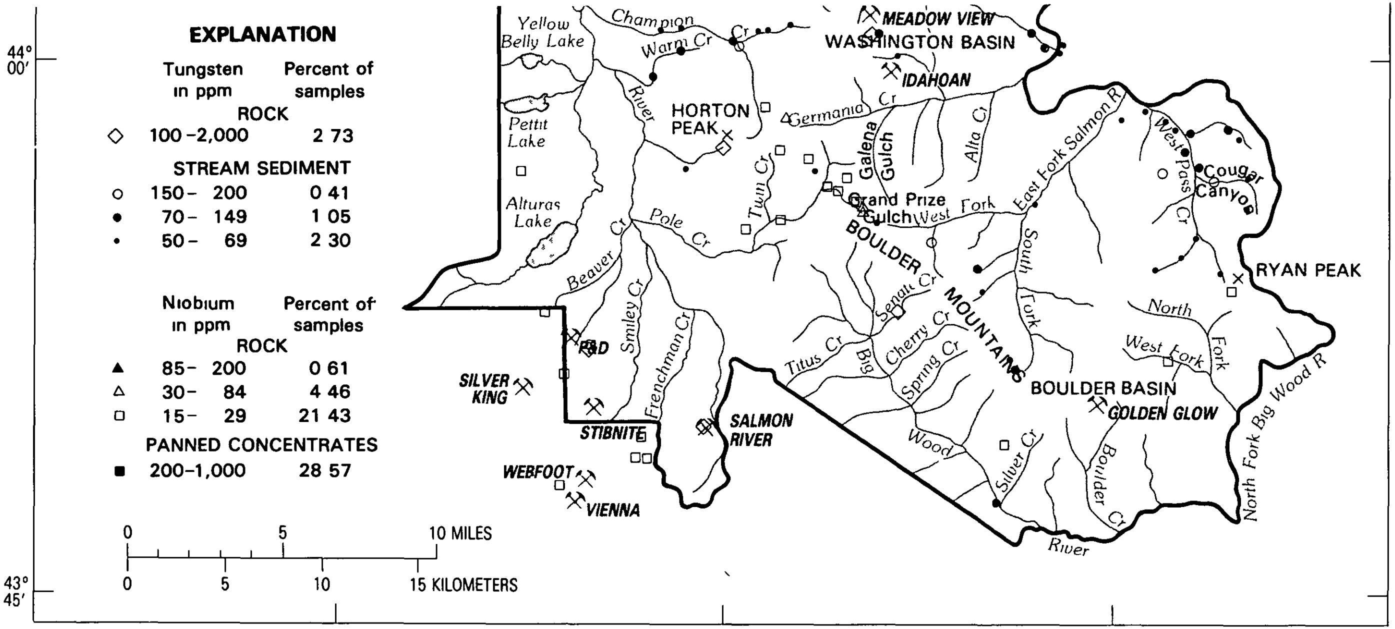
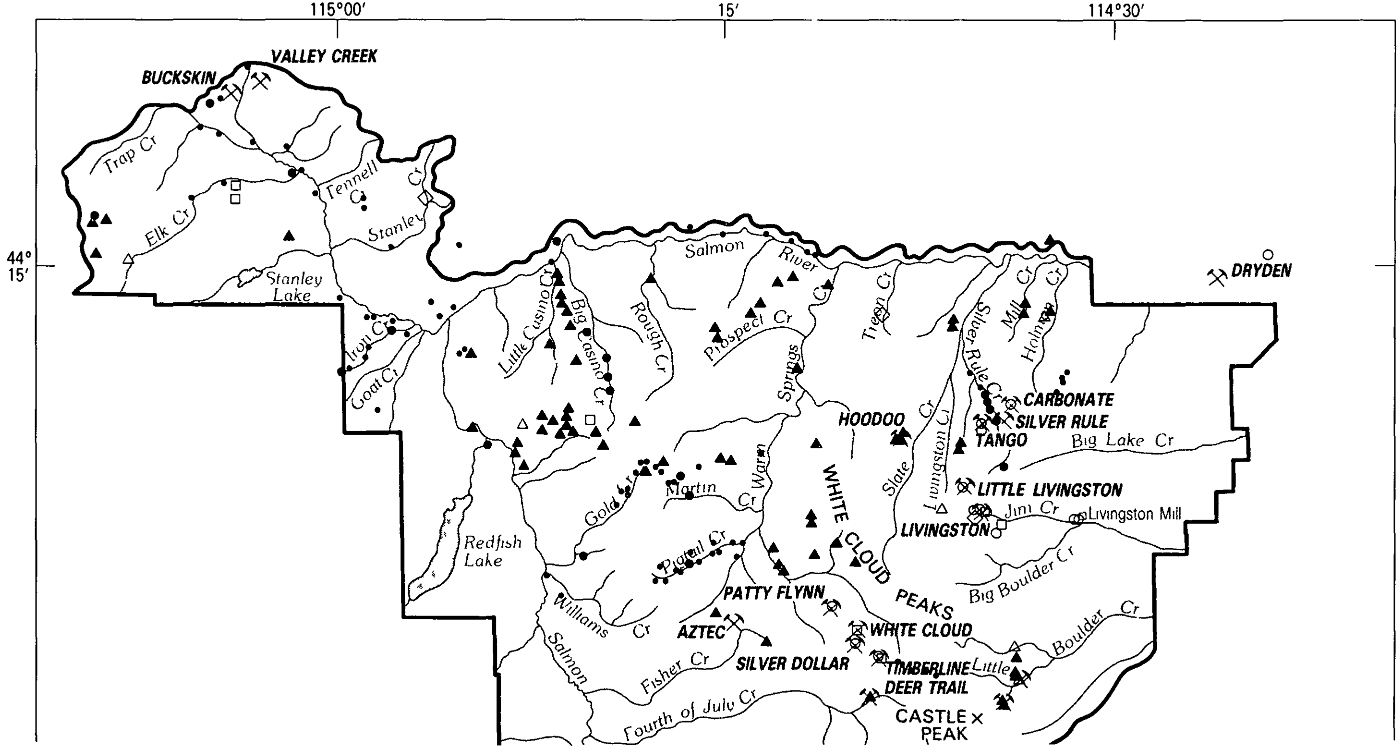


FIGURE 19 —Tungsten and niobium distribution in rock, stream-sediment, and panned-concentrate samples, eastern part of the Sawtooth National Recreation Area. Tungsten content in 97 27 percent of the rock samples and in 96 24 percent of the stream-sediment samples was too low to measure or else nondetectable Niobium content in 33 09 percent of the rock samples ranged from 10 to 14 ppm and the locality of these samples is not shown Niobium content in 40 41 percent of the rock samples was too low to measure or else nondetectable Determinations by semiquantitative spectrographic analysis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Big Casino Cr
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Salmon River
Prospect Cr
Springs
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Toban Cr
Silver Rule Cr
Mill Cr
Holman Cr
DRYDEN
CARBONATE
SILVER RULE
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Livingston Cr
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Redfish Lake
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Martin Cr
Warm
Pigtail Cr
Big Boulder Cr
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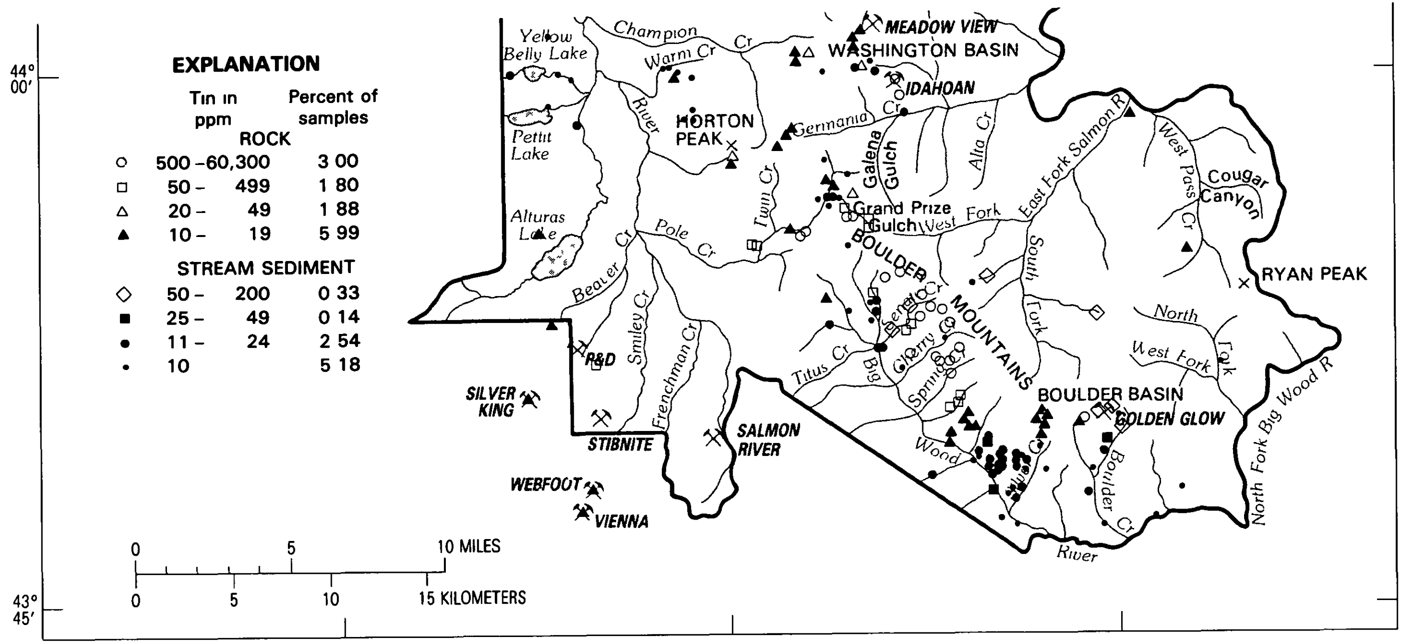


FIGURE 20.—Tin distribution in rock and stream-sediment samples, eastern part of the Sawtooth National Recreation Area. Tin content in 87.33 percent of the rock samples and in 91.81 percent of the stream-sediment samples was either too low to measure or nondetectable. Determination by semiquantitative spectrographic analysis, except samples that contained 5,000 ppm tin, which are by X-ray fluorescent analysis.

The relative abundance of primary tin minerals, in volume percent in one polished section of sample T283M (table 7), was cassiterite (0 6±0 4), tellurian canfieldite (0.5), and minerals of the stannite group (less than 0 5) A substantial part of the lead, tin, and zinc is in the oxidized matrix, which makes up at least 75 percent of the polished sections, whereas the silver is in tellurian canfieldite and six rare silver minerals Rare native copper contains 5 percent tin in solid solution. The reported gold content (1 ppm) may be lower than exists, judging from identification of several particles of gold and one of electrum in the polished sections

Tin-rich veins in the cluster west of the White Cloud stock (fig 20) contain both cassiterite and sulfidic tin minerals of the stannite family and are characterized by lead sulfosalts of the jamesonite-boulangerite group, instead of galena and abundant sphalerite Veins in the Timberline and Silver Dollar prospects are the richest in tin, but some other veins that contain lead sulfosalt and (or) sphalerite (Patty Flynn, White Cloud, and White Cloud No 2 prospects) have low tin content. The tin content of the sulfide ore from Silver Dollar prospect increases with increases in silver, lead, antimony, and gold content This is true to a lesser degree in the Timberline prospect, where the available material is largely oxidized

Relatively high tin content also occurs in several veins that contain lesser amounts of antimony. Examples are a vein containing massive argentiferous galena, east of the Black Carbonate prospect (table 7, T566M), a vein at the Cal-Ida mine that contains sphalerite and minor exsolved stannite(?) (table 7, V52), and a vein at a prospect south of the Tango mine in which cassiterite is the most abundant mineral (table 7, V35)

The principal silver–base-metal–tin deposits in the study area resemble productive silver-tin deposits in Bolivia (Ahlfeld and Schneider-Scherbina, 1964) that contain silver minerals and silver-bearing tin sulfides and sulfosalt minerals. In the Bolivian silver-tin deposits, needle-like cassiterite is largely a secondary mineral in the oxidized zone or is formed by exsolution of tealite ($PbSnS_2$) Sparse primary cassiterite usually is formed earlier and at higher temperatures than the sulfidic tin minerals, and it is notable that some Bolivian silver-tin deposits grade downward into deposits that contain more tin as primary cassiterite and less silver and lead. In both Bolivia and the study area, the silver-tin deposits are related to small stocks or dikes

The Timberline prospect, west of the White Cloud stock, appears to have the largest tin potential in the study area. Three samples of vein material from that prospect collected by the U S Bureau of Mines averaged 0.48 percent tin (table 7), a grade estimated for a volume of vein material of 27,000 tons (25,000 t). Selected samples from the prospect collected by the U.S. Geological Survey contained as much as 6 percent tin, which indicates that the vein locally contains above-average enrichment in tin. Another potential tin producer is the Idahoan mine, south of the White Cloud stock, where seven samples of vein material averaged 0.24 percent tin (table 7). Potential resources of vein material at the Idahoan mine are estimated by the U.S. Bureau of Mines at about 39,000 tons (35,000 t), which, if it averages 0.24 percent tin, could contain 185,200 pounds (84,000 kg) of tin.

Although known tin-bearing veins in the study area are in Paleozoic sedimentary rocks, anomalous tin contents of 10–20 ppm or more are widely distributed in rocks from the Idaho batholith. Only one rock sample from the Challis Volcanics contains anomalous tin, but several samples from older volcanic rocks in the southern part of the area are anomalous.

Stream sediments tend to decrease in anomalous tin downstream and with increased distance from known tin-bearing veins. Sediments anomalous in tin also tend to be anomalous in other metals eroded from the tin-bearing veins. Some anomalous sediments are not related to known tin deposits. Sediment samples from Silver Rule Creek, in the northern part of the area, and from streams draining the Galena district, in the southern part of the area, are anomalous in tin and also are anomalous in silver, gold, lead, zinc, and antimony, all derived from known veins. Stream sediments that are anomalous in tin and are not related to known deposits are derived chiefly from intrusive rocks, which are themselves anomalous in tin. Typical is the Sawtooth batholith and the similar Boulder Mountains stock, both of which are enriched in tin minerals and may be classed as "tin granites." Stream sediments from the Sawtooth batholith commonly are anomalous in tin, and the Boulder Mountains stock is the probable source of anomalous sediments along streams draining the south side of the stock. Concentrations of accessory tin minerals in the Idaho batholith and in late magmatic dikes that cut the batholith probably are the source for anomalous sediment samples derived from the batholith. Typical are the anomalous sediment samples clustered along the drainage of Big Casino Creek, small western tributaries of Warm Springs Creek, Pigtail Creek, Valley Creek, and along the Salmon River downstream from Stanley.

A few scattered stream sediments that are anomalous in tin, north of the Boulder Mountain crest, apparently were derived from isolated mineralized outcrops in Paleozoic rocks, rather than from igneous rocks. Alternatively, they could be derived from younger granite porphyry dikes.

Intrusive rock areas that warrant prospecting for concentrations of tin are at the head of Treon Creek, on Elk Mountain near the contact with Precambrian rocks, and on the divides between Gold and Martin Creeks and between Williams and Pigtail Creeks (fig 20)

The potential for economically viable tin resources in the relatively small silver–base-metal deposits of the study area is slight. Nevertheless, available analyses (table 7; fig 20) reveal that tin occurs over a wide area that has not been studied or prospected for tin The study area is one of the most promising potential sources of tin in the United States and deserves further investigation.

NIOBIUM (COLUMBIUM) AND TANTALUM

Niobium and tantalum occur in several radioactive black accessory minerals (euxenite, samarskite, fergusonite (table 8), and columbite-tantalite) concentrated in black-sand placer deposits derived principally from the Idaho batholith and possibly younger granite Information on black-sand placer deposits in the study area is presented in the placer section, Chapter E of this report

Placer deposits derived from the Idaho batholith and outside the study area have been the principal domestic sourse for niobium and tantalum The most productive locality has been placer deposits in Bear Valley, about 16 mi (26 km) west of the study area, where about 1,050,000 lb (476,000 kg) of concentrates that contained 90 percent niobium-tantalum pentoxide were produced (Parker, 1964) Resources of niobium and tantalum in placer deposits derived from the Idaho batholith were estimated at 20,000 tons (18,140 t) of combined pentoxide by the National Academy of Sciences–National Research Council in 1959 (Parker, 1964).

Many placer deposits in the Idaho batholith have been investigated as potential sources of niobium, tantalum, and closely associated metals such as titanium, iron, uranium, thorium, zirconium, and rare earths, including several in the study area (Savage, 1961, Storch and Holt, 1963, Choate, 1962) According to Storch and Holt (1963), the most important black-sand placer deposit in the study area is between the mouths of Gold and William Creeks (pl. 3, 25), which has a volume of about 12 5 million yd^3 (9 5 million m^3) containing 33 lb of black sand concentrate per yd^3 (20 kg/m^3) A reserve of 5,575 tons (5,060 t) of monazite (rare-earth phosphate) and 2,150 tons (1,950 t) of $(Nb, Ta)_2O_5$ (niobium-tantalum pentoxides) is indicated The average content of the black-sand concentrates in lb/yd^3 (kg/m^3) was 25 (14.8) magnetite, 3.5 (2 1) ilmenite, 0 89 (0 53) monazite, 0 34 (0 20) combined columbium (niobium) and tantalum pentoxides, and 0 20 (0 02) zircon In contrast, richer black sand concentrates from the productive Bear Valley placer

TABLE 8.—*Normal amounts, in percent, of oxides of uranium, thorium, niobium, tantalum, titanium, rare earths, and tin in radioactive heavy minerals found in Idaho placers*

[Data from Parker (1964, p. 139), Palache and others (1951, p. 694, 1952, p. 759–797). <, less than; leaders (--), element absent or negligible]

Mineral	Oxides						
	U	Th	Nb	Ta	Ti	Rare earths	Sn
Monazite---	--	6-12	--	--	--	51-82	--
Euxenite---	10-13	2.5-5	23-29	1.5-3	22-26	24-28	--
Brannerite-	44	4	--	--	39	4	--
Samarskite-	4-17	1-4	28-46	2-27	<1.5	9-27	<1
Fergusonite	1-7	1-5	35-47	5-17	<2	29-44	--

contain, in lb/yd^3 (kg/m^3), 7 (4.2) magnetite, 28 (16.9) ilmenite, 0.5 (0.30) monazite, 1.2 (0.72) combined euxenite and columbite-tantalite, 0.44 (0.26) $(Nb, Ta)_2O_5$, as calculated from the mineral analyses and abundances given by Parker (1964), and 0.05 (0.03) zircon.

Euxenite (24.5–31 percent $(Nb, Ta)_2O_5$), brannerite, monazite, cinnabar, and native mercury have been identified in the placers on Kelly and Stanley Creeks, but the quantity of these minerals or of associated gold and silver is not known to the author. Data on deposits along Kelly Creek show that combined brannerite and euxenite content could not exceed 1.8 lb/yd^3 (1.09 kg/m^3), from concentrate containing 8.16 lb of black sand per yd^3 (4.94 kg/m^3) (Choate, 1962, p. 112). Traces of euxenite and urano-thorite have been reported from Martin and Pigtail Creeks (Savage, 1961, p. 100), but the niobium content is unknown.

Rocks and panned-concentrate samples that contained 15 ppm or more niobium are shown on figure 19. All but one of the samples that contained 85 ppm or more niobium are panned concentrates from sediments derived from the Idaho batholith in the Stanley gold-silver district. Panned samples that contained higher values in niobium minerals indicate placer deposits in which niobium may be concentrated (fig. 19). An example is sample K202 (pl. 2), which contained 1,000 ppm niobium. Although rocks of the Idaho batholith are the source of niobium-bearing placer deposits, little or no possibility exists for discovery of signficant lode deposits of niobium in the area. The cluster of rock samples anomalous in niobium is within or near rhyolitic and porphyritic volcanic rocks north of Boundary Creek (fig. 19). Although these rocks were mapped as Challis Volcanics (pl. 1), they may instead be a remnant of the volcanic roof of the Idaho batholith, an observation based on their different trace-element content as shown on the anomaly maps for niobium, mercury, and several other metals.

URANIUM, THORIUM, AND RARE EARTHS

Minable deposits of uranium, thorium, and rare earths are not known in the study area, but these metals are potential byproducts that might be recovered should the gold or niobium-bearing black-sand deposits be worked in the future. Uranium has been and probably will be mined in the adjacent Stanley uranium district (pl. 3). Trace amounts of uranium are present locally in some gold-silver-fluorite veins near the north edge of the study area, and a vein that contains brannerite has been reported on Stanley Creek (Choate, 1962, p. 113). A sample from the P & B prospect (pl. 3, 45), in the northern part of the study area, contained 0.32 percent U_3O_8.

Veins that contain uraninite and bedded uranium deposits of the Stanley uranium district were not studied by the writers, but they are described by Kern (1959) and in more detail by Choate (1962).

Uranium, thorium, and rare earths occur in radioactive heavy minerals in placers and as accessory minerals in intrusive rocks, both within and outside the study area. The principal minerals are monazite, euxenite, and brannerite. Less important accessory radioactive minerals are samarskite, fergusonite, and uranofluorite. The compositions of the first five minerals are given in table 8.

Quantitative data are not available on the content of brannerite and euxenite in placers in or near the study area, but the amount of monazite in lb/yd^3 (kg/m^3) in the following placers is: Gold and Williams Creeks, 0.89 (0.53), Stanley Creek, 0.15 (0.09), Kelly Creek, 0.13 (0.08) (Storch and Holt, 1963, p. 52–53), Club Canyon, 4.3 (2.6), Boundary Creek, 1.0 (0.60), and Cleveland Creek, 0.6 (0.36) (Savage, 1961, p. 101). Savage (1961) also gave an average monazite content of 1.8 lb/yd^3 (1.09 kg/m^3) for placers in the Stanley Basin area and suggested that samarskite may occur in placer deposits along Kelly Creek.

In igneous rocks the contents of uranium, thorium, and associated lithophile elements generally increase with the degree of differentiation, and these elements are most highly concentrated in the last differentiates—aplite, pegmatite, and potassic granite that have low CaO, MgO, and FeO contents. Such late differentiates are common in the study area, but none are likely sources of significant amounts of uranium.

The Sawtooth batholith has a high uranium content compared to most granites (Kulsgaard and others, 1970, p. D32), and the similar highly differentiated granite in the Boulder Mountains stock may be enriched comparably in uranium and associated elements. A small contact metamorphic deposit on the border of the Summit Creek stock, southeast of the study area, yielded 840 lb (381 kg) of scheelite concentrate that contained significant amounts of a black uranium-bearing mineral (brannerite(?)) for which $1,140 was paid Quartz monzonite at the scheelite deposit is about 3-5 times as radioactive as quartz monzonite away from the deposit Comparable responses in radioactivity were detected at the Walton molybdenite prospect on Little Fall Creek southeast of the study area.

TITANIUM

The titanium mineral ilmenite is abundant in placer deposits of the study area, but is not minable except as a potential byproduct from mining of other placer minerals The black sand in a placer deposit consists chiefly of magnetite ($FeFe_2O_4$) and ilmenite ($FeTiO_3$)

Ilmenite concentrates were produced at Bear Valley, about 12 mi (19 km) west of the study area, during placer operations from 1956-1959 In placer deposits within or adjacent to the study area, the ilmenite contents in lb/yd^3 (kg/m^3) has been determined as follows Gold and Williams Creeks, 3 5 (2 1), Kelly Creek, 4 9 (2.9); Stanley Creek, 2 9 (1 7); Valley Creek 2 4 (1 4), Meadow Creek, 1.3 (0.8) (Storch and Holt, 1963, p 52-53); Cleveland Creek, 14.6 (8 8), Martin Creek, 11 2 (6.8), Boundary Creek, 10.2 (6.2); and Club Canyon, 5 6 (3 4) (Savage, 1961, p 101, pl 3) Savage (1961) gave an overall ilmenite content of 7 4 lb/yd^3 (4 4 kg/m^3) for seven placers in the Stanley Basin area. The sediments with the highest ilmenite content are from streams that drain parts of the Idaho batholith

MERCURY

No record exists of mercury production from the study area, and potential resources of the metal are insignificant. It is possible, however, that byproduct mercury could be produced from a few of the placer deposits Placers that contain mercury, as the mineral cinnabar, are on Kelly Creek, just north of the study area. Placer deposits that contain cinnabar and are within the study area are on Stanley Creek—across the divide from Kelly Creek, Big Casino, and Elk Creeks (pl. 3; Umpleby and Livingston, 1920, p 16, Choate, 1962, p. 99, 113). Cinnabar is reported at the Bell Cross prospect (pl 3, 13), outside the study area, and a sample from that prospect contained 0.20 percent HgO (Choate, 1962, p. 58) Choate also noted that a single specimen of cinnabar about 4 in (10 cm) long was found on Stanley Creek, and he reasoned that cinnabar in placer deposits of Stanley Creek and Kelly Creek may have come from the southwest slope of Potato Mountain, the locality of the Bell Cross prospect Cinnabar also may occur elsewhere in the Idaho batholith, particularly above cinnabar-bearing placer deposits on Big Casino Creek, where stream sediments are anomalous in mercury (fig. 21) but lack significant amounts of other metals

Mercury is a useful indicator element in the search for sulfide deposits formed at intermediate and low temperatures It tends to be concentrated in the fringe areas of these deposits In the study area it would be a particularly useful guide in prospecting for antimony and gold-silver deposits. Because of its usefulness as an indicator element, most of the rock samples were analyzed for mercury.

Analyses show that mercury was present in measurable amounts (0 01 ppm mercury or more) in 91 percent of the rock samples, which were analyzed by an instrumental vapor detector. Although all analyses of 0 05 ppm mercury or more are shown on figure 21, only values greater than 0.10 ppm are considered anomalous. Average mercury content of various types of rocks is shown in table 3.

The distribution of mercury in the study area is consistent with its position in the upper part of the vertical zoning sequence that is characteristic of many metallic deposits It is concentrated in epithermal veins and is depleted in higher temperature deposits that formed at greater depth The veins that contain the highest mercury values typically contain high values of silver and antimony or arsenic and have high silver/gold ratios, as at the Buckskin mine (fig. 21) Mercury is abundant in a few zinc deposits near hot springs but is depleted in higher temperature zinc deposits in contact metamorphic rocks

Between 20 and 45 ppm mercury was detected in the Buckskin mine and in zinc deposits near Holman Creek and at the Blue Buoy prospect (fig 21) The highest mercury content (300 ppm) in U S Geological Survey samples is from a sphalerite-galena deposit (Dryden mine, fig. 21), which is exceptionally rich in silver and arsenic The U.S Bureau of Mines, however, reported 700 ppm mercury at the Stibnite prospect on Smiley Creek (pl. 3, 127). The Dryden and Blue Buoy zinc veins are near hot springs (pl. 3)

Other metalliferous deposits from which samples relatively enriched in mercury (5 5–16.5 ppm) were taken include the P & D stibnite prospect, Silver King mine (ruby-silver minerals), Golden Glow prospect (argentiferous galena-gold-antimony), and the Peace of Mine and Tango prospects (galena-sphalerite-cassiterite (fig 21))

High-temperature contact metamorphic deposits (scheelite- and molybdenite-bearing tactites) were found to be low in mercury content (0.01–0.12 ppm), whereas poorly mineralized quartz veins in molybdenite-bearing tactite at the Little Boulder Creek molybdenum deposit contained increased amounts of mercury (3.5–4.0 ppm).

Only 22 stream-sediment samples were analyzed for mercury, and nearly all of these were from the zone anomalous in zinc and other metals along Mill Creek. The 22 samples averaged 0.17 ppm mercury, but because of the limited sample population, this average probably is meaningless It does, however, check reasonably well with the mean of 0.11 ppm mercury for 1,461 samples of rocks taken from the study area (table 3).

Mercury content in rocks and mineralized prospects suggests several areas that are favorable for prospecting for precious- and base-metal deposits Poorly mineralized veins near Pole Creek and Grand Prize Gulch (fig 21) contain anomalous mercury at the outcrop, which suggests the possible presence of base-metal ore shoots at depth. Mercury also appears to be concentrated in poorly mineralized prospects on the high ridges north and south of the Livingston mine (1 0–4 5 ppm mercury) in contrast to mineralized drill core from the 2500 level of the mine, which contains only 0.04–0.26 ppm mercury The presence of mercury enrichment in the fringe areas of the Livingston mine supports a zoned pattern for the mineralization and suggests the possibility of concealed deposits in the area. A similar situation exists at the Hoodoo mine, where an outcrop of smithsonite well above the sphalerite ore bodies contained 10 ppm mercury.

Mercury content in rock samples from the Idaho batholith south and east of the Salmon River (fig 21) indicates that area to be favorable for the occurrence of gold-silver deposits Scattered anomalous values in gold and silver from that area (figs. 6, 7) support that conclusion as do placer deposits on Gold, Williams, and Casino Creeks. Another area indicated by rock samples anomalous in mercury as favorable for gold and silver deposits is on Elk Mountain, in the vicinity of the Shorty, Gold Coin, and Stanley Ace prospects (pl. 3, nos. 7, 8, and 9).

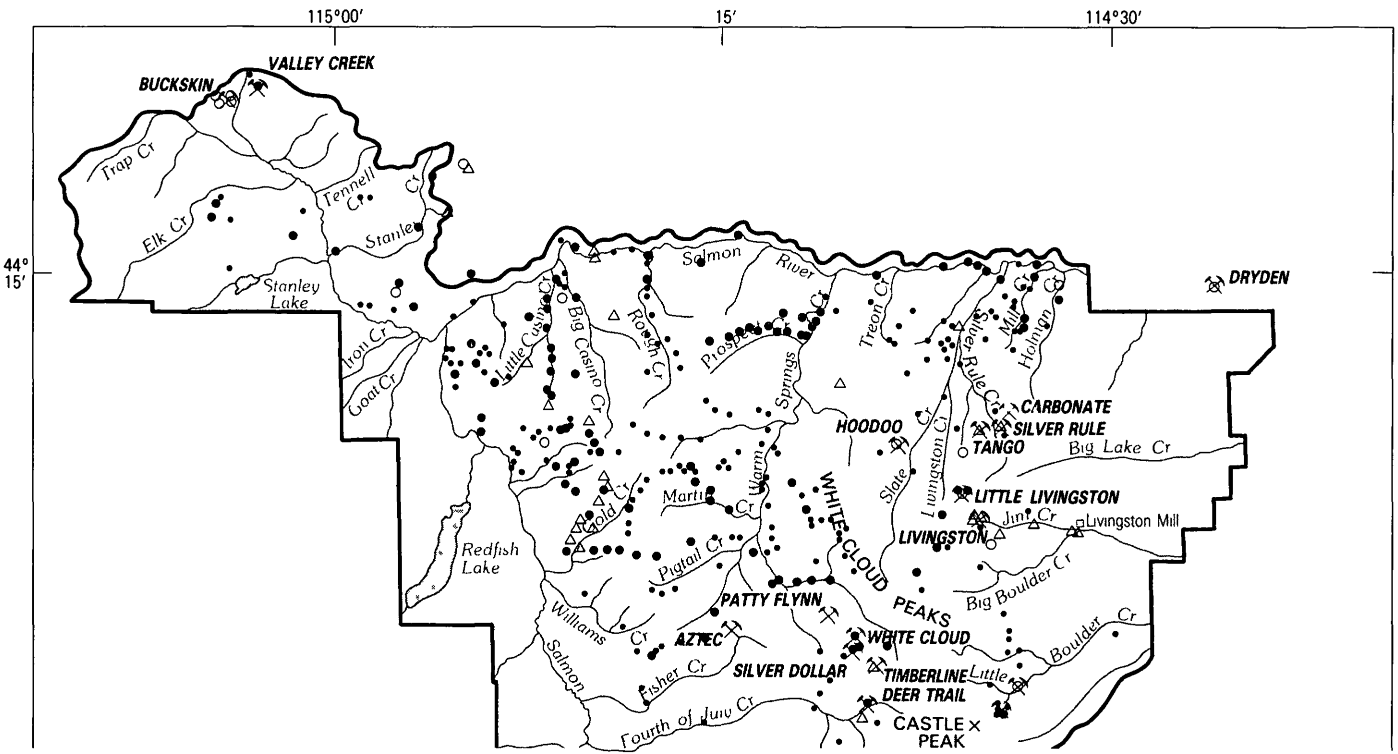
GRAPHITE

Graphitic schist of Precambrian(?) age crops out on Elk Mountain (pl 1). The graphite content of the schist is low (2.5 percent, U.S. Bureau of Mines analyses), and the size of the graphite flakes is small, ranging from less than 0 074 to 0.35 mm. It is unlikely that graphite from the area would be competitive with other sources of graphite. The graphite resources of the area are considered insignificant.

BUILDING STONE, LIMESTONE, AND SAND AND GRAVEL

Granite suitable for building stone is widespread in the study area, but the sedimentary rocks are too closely jointed for such use.

Limestone crops out in many parts of the study area, and some in


115°00′
15′
114°30′
44°
15′
VALLEY CREEK
BUCKSKIN
Trap Cr
Elk Cr
Tennell Cr
Stanley
Stanley Lake
Iron Cr
Goat Cr
Redfish Lake
Salmon River
Little Casino Cr
Big Casino Cr
Rough Cr
Prospect Cr
Springs
Warm
Martin Cr
Gold Cr
Pigtail Cr
Williams Cr
Salmon
Fisher Cr
Fourth of July Cr
Treon Cr
Silver Rule Cr
Mill Cr
Holman Cr
Slate Cr
Livingston Cr
Big Lake Cr
Jim Cr
Big Boulder Cr
Boulder Cr
Little
DRYDEN
CARBONATE
SILVER RULE
HOODOO
TANGO
LITTLE LIVINGSTON
Livingston Mill
LIVINGSTON
WHITE CLOUD PEAKS
PATTY FLYNN
AZTEC
WHITE CLOUD
SILVER DOLLAR
TIMBERLINE
DEER TRAIL
CASTLE PEAK

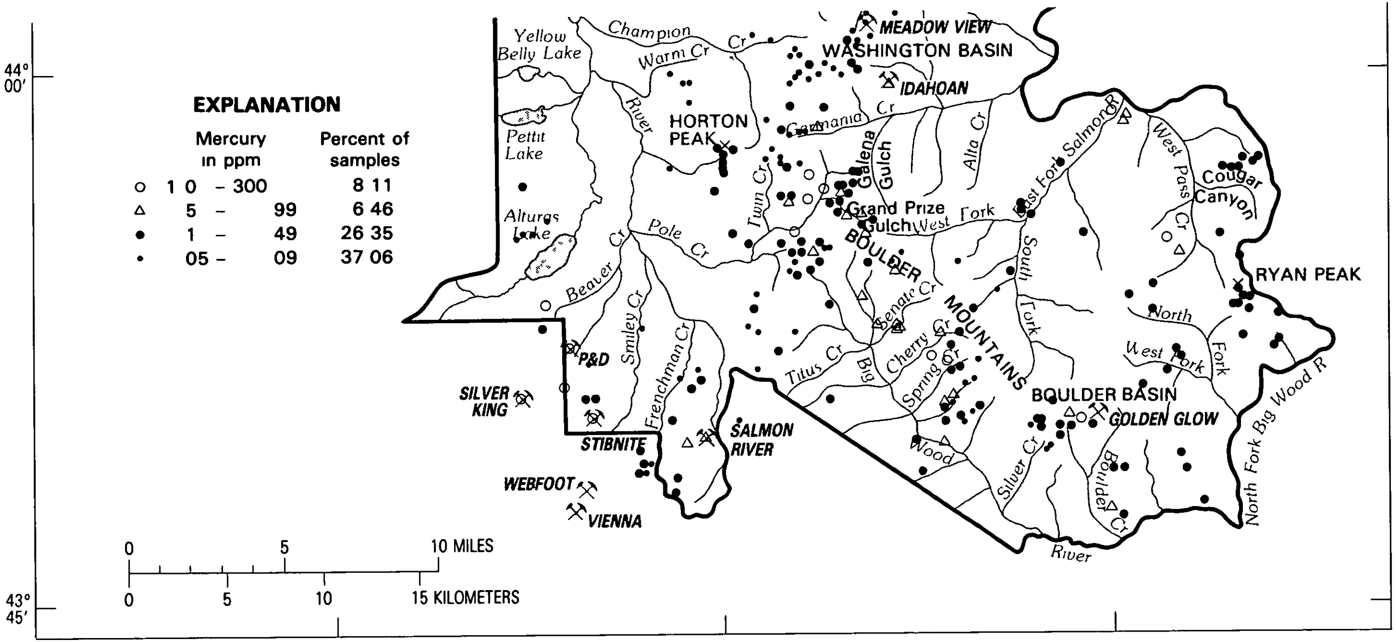


FIGURE 21 —Mercury distribution in rock samples, eastern part of the Sawtooth National Recreation Area. In 13 12 percent of the samples, mercury content ranged from 0 01 to 0 05 ppm, and the locality of these samples is not shown Mercury content in 9 00 percent of the samples was either too low to measure or nondetectable Determination by instrumental vapor-detector analysis

the Wood River Formation, just above the basal Hailey Conglomerate Member, is relatively pure

Large volumes of sand and gravel occur along the Salmon River and its tributaries, they may contain deleterious materials such as clays that could limit the use of the sand and gravel as a concrete aggregate unless removed by washing or by some other means

The remote location of the study area and the low unit value of these commodities indicate that exploitation of building stone, limestone, and sand and gravel deposits is not likely except for minor local use

SEMIPRECIOUS STONES

Volcanic rocks of the area locally contain agate, jasper, common opal, chalcedony, and rarely geodes lined with amethystine quartz crystals Some of these materials have attractive colors and textures of ornamental value when polished Petrified wood is found in some tuffaceous layers, especially in the northeastern part of the study area. The value of these materials, in terms of total mineral resource value of the study area, is not significant

FOSSIL FUELS

The probability of finding petroleum and natural gas in the area is low Sedimentary rocks that could be possible reservoir rocks have been intensely folded and faulted and slightly to strongly metamorphosed by intruded igneous rocks ranging in form from dikes to stocks to batholithic bodies

Although the undivided Mississippian argillites contain carbonaceous beds and a few discontinuous beds less than 5 in. (12 7 cm) thick that are coal-like in appearance, no minable coal occurs in the area.

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TABLE 2.—*Complete analyses of mineralized or anomalous rocks, Sawtooth National Recreation Area, Idaho*

[This table includes all analyses for all rock samples that exceed at least one of the following minimum values 0 05 ppm gold 0 75 ppm silver, 51 ppm arsenic or antimony, 100 ppm copper, lead, or zinc 31 ppm cadmium, tin, niobium, or bismuth, 10 ppm molybdenum, or 50 ppm tungsten Column head letter symbols indicate analytical methods, as follows S six step semiquantitative spectrographic, A, atomic absorption CM, colorimetric I instrumental N, looked for but not detected, L, detected but below the limit of value shown, G, detected in quantities greater than value shown B not analyzed H reported value suspect because of interference Analytical values in ppm except iron (Fe) calcium (Ca), magnesium (Mg) and titanium (Ti), in percent]

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCA0045R	0.10	10 N	0.5	1.0	80	200 N	1	100 N	0.06	15	20	60	50
WCA0047R	0.10	10 N	2.0	2.0	60	200 N	3	100 N	0.55	130	70	170	70
WCA0052R	0.10	10 N	0.5 L	0.5 L	10 L	200 N	1 L	100 N	0.12	35	100	25	50
WCA0054M	0.05 N	10 N	1.5	0.5 N	10 L	200 N	1	100 N	0.10	5	5 L	40	10 N
WCA0078R	0.10	10 N	0.5 L	0.5	20	200 N	2	100 N	0.12	30	70	30	70
WCA0084R	0.10	10 N	0.5 L	0.5 L	10	200 N	1 L	100 N	0.10	10	7	10	10
WCA0095R	0.05	10 N	0.5 L	1.5	10 N	200 N	1	100 N	0.08	40	20	15	20
WCA0106R	0.05 N	10 N	1.5	1.5	10 L	200 N	1	100 N	0.14	5	5 L	10	10
WCA0109M	0.05 N	10 N	0.5	0.5	60	200 N	4	100 N	0.12	25	70	85	70
WCA0148R	0.05 N	10 N	0.5 L	0.5 N	10 L	200 N	1 L	100 N	0.06	10	30	5 L	10
WCA0162M	0.05 N	10 N	2.0	3.0	30	200 N	3	100 N	0.40	10	50	280	200
WCA0163M	0.05 N	10 N	2.0	2.0	20	200 N	5	100 N	2.50	5	20	400	500
WCA0163M	0.05 N	10 N	6.0	7.0	10	200 N	4	100 N	1.00	10	10	1600	1000
WCA0168M	0.05 N	10 N	1.0	1.0	20	200 N	10	100 N	0.35	5 L	7	60	70
WCA0182R	0.05 N	10 N	1.0	0.7	10 L	200 N	1	100 N	0.12	5 L	30	30	50
WCA0186M	0.05 N	10 N	2.0	1.0	10 L	200 N	1 L	100 N	0.16	5	5 L	50	10
WCA0188R	0.05 N	10 N	1.5	0.5 N	10 L	200 N	1 L	100 N	0.16	5	5	30	15
WCA0192M	0.05 N	10 N	1.0	1.0	10 L	200 N	2	100 N	0.30	5 L	20	200	70
WCA0200[illegible]	0.05 N	10 N	3.0	10.0	100	200 N	3	100 N	0.18	10	10	75	200
WCA0201R	0.05 N	10 N	1.5	2.0	10 L	200 N	3	100 N	0.12	5	15	230	500
WCA0205M	0.05 N	10 N	1.5	1.5	10 L	200 N	2	100 N	0.10	5 L	50	90	100
WCA0234M	0.05 N	10 N	0.5	0.5 N	40	200 L	2	100 N	0.20	30	20	600	200
WCA0235M	0.05 N	10 N	0.5	0.5 N	10 N	200 N	2	100 N	0.12	10	15	100	30
WCA0236M	0.05 N	10 N	9.0	10.0	160	200 L	25	100 N	1.00	500	300	120	150
WCA0258S	0.20 N	10 N	0.5	0.7	0 B	200 N	3	100 N	0.0 B	110	10	450	300
WCA0259S	0.10 N	10 N	0.5	0.7	0 B	200 N	2	100 N	0.0 B	25	30	160	200
WCA0260S	0.20	10 N	0.5 L	0.5	0 B	200 N	1	100 N	0.0 B	25	70	170	200
WCA0272R	80.00	30	650.0	200.0	10000	10000	60	150	0.80	450	500	15000	20000
WCA0273R	0.15	10 N	2.0	5.0	2000	1000	5	100 N	0.16	45	50	7500	20000
WCA0274R	0.05 N	10 N	0.5	0.5	10	200	2	100 N	0.10	5 L	20	70	100
WCA0275R	70.00	50	110.0	150.0	50000	10000 G	80	150	2.00	1000	1500	100000	20000 G
WCA0276R	60.00	20	400.0	300.0	30000	10000 G	90	200	0.50	1200	3000	55000	20000 G
WCA0277R	0.05 L	10 N	3.0	5.0	40	200	2	100 N	0.16	500	300	1100	2000
WCA0278R	45.00	20	260.0	150.0	10000	10000 G	30	100 L	3.00	450	300	18000	10000
WCA0279M	55.00	50	130.0	200.0	12000	10000 G	100	150	2.00	75	200	13000	20000
WCA0337M	0.05 N	10 N	1.5	7.0	10	200 N	1 L	100 N	0.08	5	5	400	200
WCA0338M	12.00	10	900.0	1000.0	12000	10000 G	150	150	10.50	400	700	20000	20000
WCA0340M	0.05 N	10 N	6.0	10.0	30	200 N	4	100 N	0.75	40	50	650	1500
WCA0341M	0.05 N	10 N	12.0	20.0	600	1500	15	100 N	0.75	100	150	2600	7000
WCA0343M	0.05 N	10 N	0.5 L	1.0	10 L	200 N	1 L	100 N	0.10	5	5 L	500	700
WCA0344M	0.05	10 N	2.0	3.0	60	200 N	4	100 N	0.28	65	30	1600	1500
WCA0345M	0.10	10 N	10.0	20.0	400	500	10	100 N	0.40	55	50	4000	7000

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCA0045R	60	200 L	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	200	1.00
WCA0047R	140	300	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	70	0.30
WCA0052R	30	200 N	20 N	0.0 B	10 N	10 N	15	2	5 N	0 B	50 N	150	3.00
WCA0054M	10	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	50	0.30
WCA0078R	50	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	200	5.00
WCA0084P	5 L	200 N	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	100	0.70
WCA0095R	65	200 N	20 N	0.0 B	10 N	10 N	10	1	15	0 B	50 N	150	5.00
WCA0106R	10	200 N	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	150	0.30
WCA0109M	20	200 N	20 N	0.0 B	10 N	10 N	10	1	20	0 B	50 N	200	2.00
WCA0148P	15	200 N	20 N	0.0 B	10 N	10 N	10	1	10	0 B	50 N	100	0.50
WCA0162M	750	700	20 N	0.0 B	10 N	15	10	1 N	5 N	0 B	50 N	500	0.30
WCA0163M	4000	5000	50	0.0 B	10 N	15	10	1 N	5 N	0 B	50 N	150	0.30
WCA0163[illegible]	4100	2000	30	0.0 B	10 N	15	10 N	1 L	5 N	0 B	50 N	150	0.50
WCA0158M	110	200 N	20 N	0.0 B	10 N	15	20	2	5 N	0 B	50 N	70	1.00
WCA0182R	100	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	300	0.70
WCA0186M	25	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	10	0.05 N
WCA0188R	15	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	10	0.20
WCA0192M	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	0.05
WCA0200M	15	200 N	20 N	0.0 B	10 N	100	20	2	5 N	0 B	50 N	70	3.00
WCA0201P	75	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	200	1.00
WCA0205M	20	200 N	20 N	0.0 B	10	10 L	20	1	5 N	0 B	50 N	50	0.30
WCA0234M	25	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	30	0.20
WCA0235M	30	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	10 N	0.10
WCA0236M	2800	5000	20 N	0.0 B	150	10 N	10 N	1 N	5 N	0 B	50 N	300	10.00
WCA0253S	900	1000	20 N	0.0 B	10 N	200	500	1 L	5 N	0 B	50 N	1000 G	15.00
WCA0259S	750	1000	20 N	0.0 B	10 N	70	100	2	5 N	0 B	50 N	700	5.00
WCA0260S	150	200 N	20 N	0.0 B	10 N	15	100	2	5 N	0 B	50 N	300	5.00
WCA0272R	15	200 N	20 N	0.0 B	500	10 N	10	1 L	5	0 B	50 N	70	20.00
WCA0273R	5	200 N	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	200	5.00
WCA0274R	90	200 N	20 N	0.0 B	10 N	10 N	15	2	5 N	0 B	50 N	150	7.00
WCA0275R	130	500	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	30	20.00
WCA0276R	55	200 N	20 N	0.0 B	10 N	10 N	10	1	5	0 B	50 N	50	20.00
WCA0277R	6000	2000	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	150	3.00
WCA0278R	1000	1000	50	0.0 B	10 N	10 N	10	2	15	0 B	50 N	70	10.00
WCA0279M	700	2000	100	0.0 B	10 N	10 N	10 N	1	20	0 B	50 N	70	10.00
WCA0337M	400	300	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	50	3.00
WCA0338M	600	2000	50	0.0 B	10 N	10 N	10 N	2	5 N	0 B	50 N	30	7.00
WCA0340M	190	300	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	70	3.00
WCA0341M	900	2000	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	100	10.00
WCA0343M	500	500	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	100	1.50
WCA0344M	230	500	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	100	3.00
WCA0345M	300	300	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	100	2.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI %	S-V	S-LA	S-Y
WCA0045R	0.10	0.05	50	30	20	5 N	5	30	100 N	5	0.150	50	30	15
WCA0047R	0.05	0.20	20	150	30	5 N	5	10	100 N	5 L	0.030	10	20	10 N
WCA0052R	1.50	0.70	1000	700	20	7	20	70	200	7	0.200	70	50	20
WCA0054M	0.50	20.00	20	300	10 N	5 N	5 L	20	700	5 L	0.050	10	20 N	20
WCA0078R	2.00	0.70	2000	700	10	20	100	300	500	15	0.500	100	50	20
WCA0084R	0.70	0.07	700	10	100	5 N	20	70	100 N	10	0.200	200	30	30
WCA0095R	5.00	5.00	1500	500	20	10	50	200	150	20	0.500	200	50	30
WCA0106R	1.00	0.05 L	1000	50	100	5 N	5	70	100 N	10	0.300	500	20 N	10
WCA0109M	0.50	0.70	500	30	70	5 N	15	70	100 L	7	0.150	500	20	20
WCA0148R	0.10	0.05 L	50	50	15	5 N	15	50	100 N	5	0.100	30	20	15
WCA0162M	0.15	1.00	200	150	70	5 N	5	20	100 N	5 L	0.100	20	20	10
WCA0163M	0.20	3.00	100	700	50	5 N	15	20	100 L	5	0.070	20	20 N	10 L
WCA0163M	0.50	20.00	30	1500	15	5 N	5 N	20	150	7	0.050	10	20 N	20
WCA0168M	0.50	0.07	100	100	70	5 N	5 L	10 L	100 N	5	0.050	10	50	20
WCA0182R	3.00	5.00	150	500	15	5 N	5	50	100 N	5 L	0.070	20	20	10
WCA0186M	0.30	20.00 G	20 L	700	10 N	5 N	5 N	10 L	500	5 N	0.020	10 L	20	20
WCA0188R	1.00	20.00 G	20 N	2000	10 N	5 N	5	30	300	5 N	0.020	20	20	15
WCA0192M	0.02	0.05	30	20	20	5 N	5 L	10	100 N	5	0.030	15	20	10 L
WCA0200M	0.50	0.05 L	300	30	200	5 N	5 L	10 L	100 L	5	0.100	20	20 N	10 L
WCA0201R	1.50	7.00	200	700	10	5 N	5	50	100	5	0.150	20	20	10
WCA0205M	0.50	0.20	150	150	20	5 N	5 L	10 L	100 N	5	0.070	15	20	15
WCA0234M	0.30	2.00	100	70	10 N	5 N	5 L	10	100 N	5 N	0.050	15	20 N	10 N
WCA0235M	0.05	0.07	20	70	10 N	5 N	5 L	10 L	100 N	5 N	0.003	10	20 N	10 N
WCA0236M	0.07	0.05	200	10 L	15	15	5 L	30	100 N	5 L	0.100	20	20 N	10
WCA0258S	2.00	3.00	300	5000	10	7	10	500	500	15	1.000 G	200	1000 G	500
WCA0259S	2.00	3.00	700	2000	10	7	15	70	700	15	1.000	150	700	100
WCA0260S	3.00	5.00	700	2000	15	5	15	70	700	15	1.000	200	500	100
WCA0272R	0.03	0.07	70	20	10	5	5	10	100 L	5	0.050	20	20 N	10 N
WCA0273R	0.50	0.05 L	500	30	30	5 N	5 L	10 L	100 L	5	0.200	30	300	15
WCA0274R	2.00	2.00	300	1000	10	10	7	20	500	20	0.700	150	30	20
WCA0275R	0.02	0.07	50	20	10 L	5 N	5 L	10	100 N	5	0.030	70	20 N	10
WCA0276R	0.05	0.07	70	20	10 L	5 N	5 L	15	100 N	5	0.030	10	20 N	15
WCA0277R	0.50	0.10	700	700	50	5 L	5	10 L	100	5	0.150	50	70	10
WCA0278R	0.02	0.05	100	70	10	5 N	5	10	100 L	5	0.030	20	20 N	10
WCA0279M	0.03	0.15	150	200	15	5 N	5 N	10	200	5 L	0.070	50	20 N	10 L
WCA0337M	0.15	0.05 L	300	200	10 N	5 L	5 N	10 N	100	5 N	0.070	10	20 N	10 N
WCA0338M	0.05	0.05 N	150	20	20	5 N	5 N	10 L	100 N	5 N	0.030	15	20 L	10 L
WCA0340M	0.20	0.05 N	300	50	70	5 N	5 N	10 N	100 N	5 N	0.070	15	20 N	10 N
WCA0341M	0.20	0.05 N	150	150	70	5 N	5 N	10 L	100 N	5 L	0.070	20	20 N	10 L
WCA0343M	0.20	0.50	500	150	10 N	5 N	5 N	10 N	700	5 L	0.070	20	20 L	15
WCA0344M	0.30	0.05 N	200	50	50	5 N	5 N	10 N	100 N	5 L	0.150	30	20 N	10 N
WCA0345M	0.30	0.05 N	150	200	70	5 N	5 N	15	100 N	5 L	0.070	50	20 L	10

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCA0346M	0.05 N	10 N	1.5	7.0	600	700	3	100 N	0.75	30	50	450	2000
WCA0348M	0.05 L	10 N	5.5	7.0	200	300	3	100 N	0.35	5	7	65	50
WCA0375R	0.05 N	10 N	0.5	0.5 N	10 N	200 N	1	100 N	0.08	5 L	10	20	50
WCA0383R	0.05 N	10 N	1.0	0.5 N	10 N	200 N	1	100 N	0.14	10	15	15	30
WCA0386R	0.10	10 N	0.5 L	0.5 N	10 N	200 N	1 L	100 N	0.12	5 L	30	10	30
WCA0391R	0.05 N	10 N	1.5	2.0	40	200 N	2	100 N	0.16	5 L	10	220	150
WCA0394R	0.05 N	10 N	4.0 H	0.7	10 L	200 N	1	100 N	0.60	10	5 L	150	150
WCA0397R	0.05 N	10 N	3.5 H	1.5	10	200 N	3	100 N	0.10	10	5	140	200
WCA0399R	0.05 N	10 N	4.0 H	1.5	20	200 N	1	100 N	0.30	10	5	2000	300
WCA0403R	0.05 N	10 N	3.0 H	0.5	10 L	200 N	1	100 N	0.50	10	5	110	150
WCA0404R	0.05 N	10 N	0.5 L	1.5	10 N	200 N	1	100 N	0.08	5 L	30	140	150
WCA0405R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.08	5 L	30	90	70
WCA0406R	0.05 N	10 N	0.5 N	0.5 N	10	200 N	3	100 N	0.18	5 L	70	85	100
WCA0410R	0.05 N	10 N	0.5 N	0.5	10	200 N	2	100 N	0.40	5	30	130	100
WCA0413R	0.05 N	10 N	5.0 L	0.7	10	200 N	4	100 N	0.14	5 L	10	90	50
WCA0417R	0.05 N	10 N	2.5	2.0	10	200 N	8	100 N	0.30	5 L	50	160	70
WCA0419R	0.05 N	10 N	1.0	0.5 N	10 N	200 N	8	100 N	0.34	60	70	35	30
WCA0460R	0.05 N	10 N	0.5 L	0.5 N	0 B	200 N	1 L	100 N	0.80	5	5	250	150
WCA0508M	0.05 L	10 N	14.0	15.0	200	1000	1 L	100 N	0.06	2000	2000	760	300
WCA0602R	0.05 N	10 N	1.0	1.5	40	200 N	3	100 N	0.02	5 L	15	70	50
WCA0603R	0.05 N	10 N	1.0	1.0	60	200 N	3	100 N	0.04	5	20	70	50
WCA0604R	0.05 N	10 N	1.5	1.5	20	200 N	3	100 N	0.02 L	5	50	55	30
WCA0605R	0.05 N	10 N	3.5	2.0	120	200 N	5	100 N	0.02 L	5 L	10	260	100
WCB0226M	0.02 L	10 N	1.5	0.5 N	0 B	200 N	1	100 N	0.45	5	10	120	70
WCB0369R	0.02 L	10 N	1.0	0.7	0 B	200 N	2	100 N	0.30	20	15	105	100
WCB0428R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.26	5 L	10	5	20
WCB0470R	0.10	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.01	5 L	15	5 L	10
WCB0480R	0.02	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	10	10	5 L	10 N
WCB0481R	0.02 L	10 N	3.5	2.0	0 B	200	10	100 N	0.06	25	15	150	70
WCB0549R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.05	40	20	10	20
WCB0596R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	20	100 N	0.06	30	15	40	10
WCB0628R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.03	5	5	35	30
WCB0631R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.06	15	15	20	30
WCB0670R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	4	100 N	0.75	5 L	7	15	50
WCB0671A	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.14	5 L	10	10	20
WCB0726R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.02	15	5	5 L	15
WCB0727R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.04	15	30	5 L	10
WCB0728R	0.02 L	10 N	3.0	1.5	0 B	200 N	6	100 N	20 00	460	300	30	20
WCB0730R	0.02 L	10 N	2.5	2.0	0 B	200 N	40	100 N	0.30	15	15	20	10
WCB0731R	0.02 L	10 N	2.0	1.0	0 B	700	25	100 N	0.60	25	20	25	10
WCB0807R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.06	5 N	10	5	30
WCB0837R	0.0 B	10 N	0.5 L	0.5 L	0 B	200 N	1 L	100 N	0.10	15	5	120	100

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCA0346M	500	700	20 N	0.0 B	10 N	10 N	30	2	5 N	0 B	50 N	150	5.00
WCA0348M	50	200 N	20 N	0.0 B	10 N	10 N	10 L	2	5 N	0 B	50 N	50	2.00
WCA0375R	60	200 N	20 N	0.0 B	10 N	10	50	20	5 N	0 B	50 N	150	5.00
WCA0383R	25	200 N	20 N	0.0 B	10 N	10 N	10	1 N	5 N	0 B	50 N	70	7.00
WCA0386R	35	200 N	20 N	0.0 B	10 N	10 N	30	2	5 N	0 B	50 N	100	3.00
WCA0391R	600	500	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	200	0.50
WCA0394R	100	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	50	1.00
WCA0397R	80	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	70	1.50
WCA0399R	80	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	30	0.70
WCA0403R	110	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	100	0.70
WCA0404R	140	200	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	300	0.70
WCA0405R	130	300	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	200	0.70
WCA0406R	300	700	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	500	1.00
WCA0410R	170	300	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	300	1.00
WCA0413R	120	200 L	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	500	0.70
WCA0417R	5	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	150	0.07
WCA0419R	110	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	150	7.00
WCA0460R	90	200 N	20 N	0.0 B	10 N	10 N	50	1	5 N	0 B	50 N	200	2.00
WCA0508M	4500	5000	20 L	0.0 B	50	300	10 N	1 N	5 N	0 B	100	70	15.00
WCA0602R	35	200 N	20 N	0.0 B	10 N	10 N	20 N	1 L	5 N	0 B	50 N	200	1.50
WCA0603R	25	200 N	20 N	0.0 B	10 N	10 N	20 N	1 L	5 N	0 B	50 N	300	1.00
WCA0604R	50	200 N	20 N	0.0 B	10 N	10 N	20 N	1 L	5 N	0 B	50 N	200	0.50
WCA0605R	5 L	200 N	20 N	0.0 B	10 N	10 N	20 N	1 L	5 N	0 B	50 N	200	0.70
WCB0226M	105	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	20 N	50 N	10	0.70
WCB0369R	145	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 N	50 N	100	5.00
WCB0428R	10	200 N	20 N	0.0 B	10 N	10 N	50	1	5 N	20 N	50 N	100	1.00
WCB0470R	30	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 L	50 N	100	1.50
WCB0480R	45	200 N	20 N	0.0 B	10 N	10 N	10	2	200	20 H	50 N	100	7.00
WCB0491R	350	200	20 N	0.0 B	10 N	10 N	10 N	2	7	20 N	50 N	20	0.20
WCB0549R	10	200 N	20 N	0.0 B	10 N	10 N	20	2	5 N	160	100	50	1.00
WCB0596R	20	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	15	20 L	50 N	50	2.00
WCB0628R	10	200 N	20 N	0.0 B	10 N	10 N	10	1	15	20 L	50 N	70	0.70
WCB0631R	40	200 N	20 N	0.0 B	10 N	10 N	10 N	1	30	20 L	50 L	70	5.00
WCB0670R	50	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	80	100	150	5.00
WCB0671A	130	200 N	20 N	0.0 B	10 N	10 N	20	1	5 N	20 L	50 N	150	5.00
WCB0726R	20	200 N	20 N	0.0 B	10 N	10 N	10 N	2	200	20 L	50 N	100	2.00
WCB0727R	20	200 N	20 N	0.0 B	10 N	10 N	10 N	1	10	20 L	50 N	70	2.00
WCB0728R	37000	10000 G	500	0.0 B	10 N	10 N	10 N	1 N	5 N	20 L	50 N	10 N	1.00
WCB0730R	120	200	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 L	50 N	100	15.00
WCB0731R	90	200 N	20 N	0.0 B	10 N	10 N	10 N	1	10	20 L	50 N	150	3.00
WCB0807R	10	200 N	20 N	0.0 B	10 N	10 N	50	1	5 N	0 B	50 N	70	0.70
WCB0837R	45	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	1.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI %	S-V	S-LA	S-Y
WCA0346M	0.70	0.07	300	2000	70	5	5 N	10	100 N	7	0.200	70	50	15
WCA0348M	0.05	0.05 L	70	300	20	5 L	5 N	10	100 N	5 L	0.030	15	70	20
WCA0375R	1.50	1.00	500	700	20	10	7	30	700	15	0.500	70	50	20
WCA0383R	3.00	5.00	200	1000	15	50	10	30	1000	20	0.700	150	30	20
WCA0386R	1.00	1.50	300	700	10 N	5 L	5 L	10	700	5	0.200	70	20	15
WCA0391R	1.50	3.00	150	500	15	5 N	5 N	20	100 N	5 L	0.100	15	20 N	10 L
WCA0394R	1.00	20.00 G	70	1500	10 N	5 N	5 L	150	1000	5 N	0.070	30	20 L	20
WCA0397R	1.50	20.00 G	20	1500	10 N	5 N	5 L	100	500	5 L	0.070	30	20	30
WCA0399R	1.00	20.00 G	20 L	1000	10 N	5 N	5 L	70	300	5 L	0.070	20	20 N	15
WCA0403R	1.00	20.00 G	30	1500	10 N	5 N	5 L	100	500	5 L	0.070	20	20 N	20
WCA0404R	0.15	0.20	300	500	30	5 N	5	50	100 N	5 L	0.100	20	20 N	10 L
WCA0405R	0.07	0.07	150	500	20	5 N	5 L	20	100 N	5 L	0.100	20	20 N	10 L
WCA0406R	0.20	0.10	200	700	30	5 N	5 L	50	100 N	5 L	0.150	30	20 N	10 L
WCA0410R	0.30	0.10	100	700	20	5 N	5	50	100 N	5	0.100	30	20 N	10 L
WCA0413R	0.15	0.07	150	700	30	5 N	5	50	100 N	5 L	0.150	20	20 N	10 L
WCA0417R	0.05	0.05 N	20	20	10 L	5 N	5 N	15	100 N	5 L	0.070	20	20 N	10
WCA0419R	1.50	7.00	300	700	10 N	5 N	30	700	100 N	30	0.700	300	70	50
WCA0460R	0.07	0.10	30	500	10 N	5 N	5 N	10 N	100 N	5	0.100	10	70	20
WCA0508M	0.10	0.07	100	10 L	10 L	20	70	50	100 N	5 L	0.070	10	20 N	10 L
WCA0602R	0.20	0.05 L	150	70	20	5 N	5 L	30	100 N	5	0.150	30	30	15
WCA0603R	0.07	0.05 L	150	30	15	5 N	5 L	15	100 N	5	0.150	20	30	15
WCA0604R	0.07	0.05 L	150	70	15	5 N	5 L	15	100 N	5	0.100	15	20	10
WCA0605R	0.05	0.05 L	70	20	10	5 N	5 L	10	100 N	5	0.070	15	50	10
WCB0226M	0.20	10.00	200	100	10 N	5 L	5 L	10 N	100	5 L	0.030	10	20 N	10
WCB0369R	1.50	1.00	1500	500	10 L	10	20	100	300	7	0.100	50	20	10
WCB0428R	0.20	0.30	300	100	10 L	5 N	5 L	10 N	150	5 L	0.050	10 L	20	20
WCB0470R	0.50	0.50	1000	150	10 N	5 N	5 L	10 N	500	5 L	0.100	20	30	10 L
WCB0480R	1.50	3.00	200	1500	10 N	10	5	10 N	100	5	0.100	50	20 N	10
WCB0481R	0.05	0.05 L	100	20	15	5 N	5 L	10 N	100 L	5 N	0.030	20	20 N	10 N
WCB0549R	0.02	0.07	100	50	10 N	5 N	5 L	10 N	100 L	5 L	0.030	10 L	20 N	15
WCB0596R	1.00	5.00	300	150	10 N	5	30	30	100 L	5	0.070	100	20	15
WCB0628R	0.10	0.05	500	150	10 N	5 N	5 L	10 N	100	5 N	0.050	10 L	20	10 L
WCB0631R	1.50	0.50	500	300	10 N	15	30	100	200	7	0.100	50	20	10
WCB0670R	1.00	1.00	1000	500	10 N	7	5 L	10 N	500	5	0.150	50	30	10
WCB0671A	1.00	1.00	1000	300	10 N	7	5 L	10 N	500	5	0.150	50	50	10
WCB0726R	0.50	0.50	700	200	10 N	5 N	5 L	10 N	300	5 L	0.070	20	20	10 N
WCB0727R	0.30	0.30	500	150	10 N	5 N	5 L	10 N	200	5 N	0.070	15	20	10 N
WCB0728R	0.30	7.00	50	1500	10 N	5 N	5	10 N	500	5	0.010	10	30	30
WCB0730R	1.00	0.70	70	300	10 N	20	70	70	100	15	0.100	70	20	10
WCB0731R	0.15	0.05	1000	15	30	15	50	10	100 N	5 L	0.070	100	20	10
WCB0807R	0.10	0.15	150	200	10	5 N	5 L	10 L	200	5 L	0.100	10	20 L	15
WCB0837R	2.00	20.00	50	200	10 N	5 N	10	50	300	5 L	0.070	20	20	20

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCB0852R	0.05 N	10 N	10.0	7.0	80	200 N	10	100 L	0.16	15	20	5	10 N
WCB0861R	0.05 N	10 N	1.0	0.7	0 B	200 N	2	100 N	0.22	95	100	25	50
WCB0862R	0.05 N	10 N	0.5 L	0.5 N	0 B	200 N	1	100 N	0.04	45	70	20	30
WCB0888R	0.05 N	10 N	1.5 H	0.7	0 B	200 N	1 L	100 N	0.45	5	15	100	50
WCB0897R	0.05 L	10 N	1.5	2.0	10 L	200 N	1 L	100 N	0.06	25	20	40	70
WCB0914R	0.05 N	10 N	0.5 L	0.5 N	0 B	200 N	3	100 N	0.06	200	100	30	10
WCB0925R	0.05 N	10 N	40.0	30.0	60	200 N	5	100 N	0.12	70	100	1700	1000
WCB0926R	0.40	10 N	15.0	150.0	30	200 L	1000	1000	3.00	29	5000	9000	20000 G
WCB0927M	0.05	10 N	2600.0	2000.0	200	200 N	8000	7000	0.50	3600	5000	420000	20000 G
WCB0927R	0.20	10 N	1400.0	1000.0	40	200 N	5500	5000	1.50	4800	3000	100000	20000 G
WCB0928R	0.05 N	10 N	3.0	5.0	10 L	200 N	15	100 N	0.14	30	50	560	1000
WCB0936R	0.05 N	10 N	4.0	2.0	10 L	200 N	4	100 N	0.14	10	5	180	500
WCB0938R	0.05 N	10 N	1.0	0.7	10 L	200 N	2	100 N	0.08	5	5 L	80	70
WCB0942R	0.05 N	10 N	1.0	0.5	10 L	200 N	1 L	100 N	0.14	10	10	40	70
WCB0980R	0.05 N	10 N	1.0	1.0	10 N	200 N	2	100 N	0.70	20	20	170	200
WCB0999R	0.05 N	10 N	1.0	0.7	20	200 N	10	100 N	2.50	15	10	900	700
WCB1002R	0.05 N	10 N	2.0	0.5	10 L	200 N	1 L	100 N	0.18	5	5	55	15
WCB1011R	0.10	10 N	40.0	20.0	1000	700	80	100	0.18	550	150	5600	2000
WCB1013R	0.35	10 N	21.0	10.0	400	200	40 H	100	1.10	130	100	5800	1500
WCB1017R	0.05 L	10 N	40.0	10.0	160	200 N	45	100 L	0.70	1200	5	950	300
WCB1393R	0.05 N	10 N	3.0	1.5	10 N	200 N	3	100 N	0.06	5 L	20	20	70
WCB1401M	0.15	10 N	70.0	20.0	50	200 N	2000	3000	0.80	700	700	17000	10000
WCB1402M	0.05 N	10 N	1.0	0.7	10 L	200 N	4	100 N	0.06	5	50	130	100
WCB1421R	0.05 N	10 N	0.5	0.5 N	10 N	200 N	1 L	100 N	0.02	15	20	100	30
WCB1424R	0.05 N	10 N	0.5 L	0.5 L	10 N	200 N	2	100 N	0.06	15	10	5	20
WCB1425R	0.05 N	10 N	1.0	0.5 N	10 N	200 N	1 L	100 N	0.04	5 L	10	10	30
WCB1461R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.06	5	5	10	30
WCB1516M	0.05 N	10 N	4.0	7.0	10	200 N	5	100 N	0.04	1000	1000	520	200
WCB1544R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.60	250	150	5 L	30
WCB1596M	0.05 N	10 N	8.0	7.0	10	200 N	3	100 N	0.04	2200	3000	140	150
WCB1597M	0.15	10 N	50.0	50.0	100	200 N	1000	1000	0.02	100	70	14000	15000
WCB1626R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.04	5 L	30	5	30
WCB1679R	0.15	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.14	5 N	15	5	30
WCB1682R	0.10	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.06	5 N	30	5	30
WCD0022R	0.05 N	10 N	0.5	0.5 N	0 B	200 N	1 L	100 N	0.06	30	50	20	30
WCD0082R	0.05 N	10 N	2.0	5.0	20	200 N	10	100 N	0.35	20	50	120	300
WCD0121R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 N	100 N	0.02 L	5	70	10	10
WCD0150R	0.15	10 N	22.0	20.0	160	200 N	4	100 N	0.08	45	70	140	100
WCD0179A	0.55	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.08	5 L	50	5	15
WCD0212R	0.05 N	10 N	0.5	0.5	10 L	200 N	1	100 N	0.06	75	50	25	10
WCD0263R	1.00	10 N	3.0	2.0	10 L	200 N	1 L	100 N	0.04	200	100	100	100
WCD0270R	0.05 N	10 N	0.5	0.5 N	10 L	200 N	1	100 N	0.04	10	20	15	30

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCB0852R	5	200 N	20 N	0.0 B	10 N	10 N	10 L	2	5 N	0 B	50 N	30	0.15
WCB0861R	35	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	150	7.00
WCB0862R	20	200 N	20 N	0.0 B	10 N	10 N	15	1	10	0 B	50 N	200	7.00
WCB0888R	380	500	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	70	0.10
WCB0897R	10	200 N	20 N	0.0 B	10	10	10	2	5 N	0 B	50 N	150	2.00
WCB0914R	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1	30	0 B	50	10	5.00
WCB0925R	65	200	20 N	0.0 B	10 N	50	10	1 L	5 N	0 B	50 N	300	0.50
WCB0926R	1100	1000	20 N	0.0 B	10 N	1750	10 L	1 L	50	B	50 N	100	10.00
WCB0927M	5 N	200 N	100	0.0 B	10 L	1000	10 N	1 L	70	0 B	50 N	70	1.00
WCB0927R	50	200 N	100	0.0 B	10	1750	10 N	1 N	30	0 B	50 N	50	0.30
WCB0928R	25	200 N	20 N	0.0 B	10 N	10	10 L	1	5 N	0 B	50 N	150	5.00
WCB0936R	55	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	100	0.70
WCB0938R	10	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	20	0.20
WCB0942R	30	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	0.50
WCB0980R	25	200 N	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	100	3.00
WCB0999R	720	700	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	200	3.00
WCB1002R	5 L	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	50	0.30
WCB1011R	2900	2000	20 N	0.0 B	10 N	30	10 L	1 L	30	0 B	50 L	200	10.00
WCB1013R	3200	1000	20	0.0 B	10 N	150	10 L	1 N	5 N	0 B	50 N	70	5.00
WCB1017R	4000	2000	20	0.0 B	200	10 N	10 L	1 N	5 N	0 B	50 N	50	5.00
WCB1393R	20	200 N	20 N	0.0 B	10 N	10	20	2	10	0 B	50 N	200	2.00
WCB1401M	6000	10000 G	200	0.0 B	10 N	500	20 L	1 N	5 N	0 B	50 N	10	0.30
WCB1402M	120	200	20 N	0.0 B	10 N	20	20 L	1 L	7	0 B	50 N	100	5.00
WCB1421R	90	200 N	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	100	3.00
WCB1424R	170	200 N	20 N	0.0 B	10 N	10 N	20	2	5 N	0 B	50 N	150	3.00
WCB1425R	30	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	150	3.00
WCB1461R	50	200 N	20 N	0.0 B	10 N	10 N	50	2	5 N	0 B	50 N	200	5.00
WCB1516M	300	1000	20 N	0.0 B	10 N	10 N	10 N	1 N	30	0 B	50 N	150	5.00
WCB1544R	25	200 N	20 N	0.0 B	15	10 N	10 L	1 L	5 N	0 B	50 N	150	2.00
WCB1596M	90	200 N	20 N	0.0 B	10	10 N	10 L	1 L	5 N	0 B	50 N	150	5.00
WCB1597M	100	200 N	20 N	0.0 B	10 L	15	10 L	1 L	5 N	0 B	50 N	150	15.00
WCB1626R	160	200	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	100	2.00
WCB1679R	40	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	300	3.00
WCB1682R	40	200 N	20 N	0.0 B	10 N	10 N	10 L	1	5 N	0 B	50 N	150	3.00
WCD0022R	70	200 N	50	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	200	15.00
WCD0082R	420	500	20 N	0.0 B	10 N	20	70	5	5 N	0 B	50 N	100	1.50
WCD0121R	200	300	20 N	0.0 B	10 N	10 N	10	1 N	5 N	0 B	50 N	150	1.50
WCD0150R	60	200 N	20 N	0.0 B	500	20	10	2	15	0 B	50	70	5.00
WCD0179A	5	200 N	20 N	0.0 B	10 N	10 L	10	2	5 N	0 B	50 N	100	3.00
WCD0212R	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	10	0 B	50 N	200	7.00
WCD0263R	20	200 N	20 N	0.0 B	20	10 N	10	2	5 N	0 B	50 N	100	3.00
WCD0270R	100	200 N	20 N	0.0 B	10 N	10 N	20	1	5 N	0 B	50 N	300	5.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI%	S-V	S-LA	S-Y
WCB0852R	0.02	0.05	100	150	10	5 N	5	10	100 L	5 L	0.020	20	20 N	10 N
WCB0861R	3.00	0.20	700	3000	10 L	15	100	300	200	15	0.500	150	50	20
WCB0862R	3.00	2.00	1000	1000	10	15	100	500	700	20	0.500	100	50	20
WCB0888R	0.05	7.00	100	700	10	5 N	7	10	100 L	5	0.030	10	20	10
WCB0897R	0.07	0.07	50	100	10	5 N	5 L	10 L	100 N	5 L	0.100	10	50	15
WCB0914R	0.10	0.50	30	200	10	5 L	20	20	100 L	5 L	0.015	70	50	15
WCB0925R	0.10	0.05 L	50	100	50	5 N	5 L	20	100 N	5	0.150	20	20	10
WCB0926R	0.02	0.05 L	20	20	10 L	5 N	5 L	10	100 N	5	0.050	20	20 N	10 L
WCB0927M	0.03	0.05 N	70	10 N	10 N	5 N	5 N	10 L	100 N	5 N	0.050	10 L	20 N	10 N
WCB0927R	0.02 L	0.05 L	20	10 N	10 L	5 N	5 L	10 L	100 N	5	0.015	10	20 L	10 N
WCB0928R	1.50	2.00	700	500	10	10	70	100	500	15	0.300	100	30	15
WCB0936R	0.50	20.00	30	200	10	5 N	10	70	300	5 L	0.070	20	20	15
WCB0938R	0.20	20.00	20 L	200	10 L	5 N	5	20	200	5 L	0.020	20	20 L	10
WCB0942P	2.00	5.00	50	100	20	5 N	5	30	100	5 L	0.070	20	20 L	10 L
WCB0980R	1.50	0.50	700	500	10 L	5 L	50	70	300	7	0.200	70	30	10
WCB0999R	1.00	0.05 L	70	2000	50	5 N	30	70	100 N	10	0.200	50	50	70
WCB1002R	1.00	20.00	20	200	10 L	5 N	7	50	200	5 L	0.050	10	20	15
WCB1011R	0.05	0.10	20	20	10	5 N	10	30	100 N	5	0.100	15	20 N	10 L
WCB1013R	0.03	0.05 L	20 L	10 L	10	5 N	5 L	20	100 N	5	0.050	30	20 N	10 N
WCB1017R	0.15	0.07	50	50	10 L	5	15	10	100 N	5	0.050	10	20 N	10 N
WCB1393R	0.15	0.15	100	300	10	5 N	5	10 L	100 L	5	0.100	10	50	20
WCB1401M	0.20	1.50	70	150	10	5 N	10	10 L	100	5 L	0.015	10	20	10 L
WCB1402M	2.00	7.00	1000	1500	10	10	50	100	500	10	0.300	300	30	20
WCB1421R	1.50	1.00	700	700	10	5	5	20	1000	7	0.300	50	30	10 L
WCB1424R	1.50	1.00	500	700	10	5	5	20	700	7	0.500	70	70	20
WCB1425R	1.00	1.50	1000	700	10	5	5	10	1000	7	0.300	50	100	15
WCB1461R	1.50	1.50	500	700	10	7	5 L	15	700	7	0.700	70	150	20
WCB1516M	2.00	10.00	150	700	50	30	70	70	200	5	0.150	100	30	20
WCB1544R	0.50	1.00	500	300	10	5 L	5 L	10 N	700	5	0.150	50	70	10
WCB1596M	3.00	7.00	1500	700	70	20	100	150	500	15	0.300	300	50	30
WCB1597M	3.00	1.50	150	300	2000 G	30	100	150	150	15	0.500	300	100	30
WCB1626R	1.00	1.50	300	500	10	5 L	5 N	15	700	5 L	0.200	50	30	10
WCB1679R	1.50	2.00	500	700	10 L	7	5 N	30	700	7	0.500	70	100	15
WCB1682R	1.50	2.00	700	500	10 L	5	5 N	10	700	7	0.300	70	70	10
WCD0022R	3.00	3.00	1000	2000	10 L	20	5 L	10	1000	30	1.000 G	200	100	70
WCD0082R	0.50	0.50	150	50	70	5 N	5 L	10 L	100	7	0.100	15	20 N	20
WCD0121R	0.50	0.50	200	150	50	5 N	15	50	100 L	5	0.100	50	20	10
WCD0150R	0.30	0.10	150	200	30	5	5	50	100 N	10	0.200	150	20	10
WCD0179A	0.50	0.07	300	2000	30	5 L	5	15	100 L	5	0.300	50	50	10 L
WCD0212R	3.00	7.00	100	2000	10	15	15	150	100	50	0.200	500	30	50
WCD0263R	0.50	0.05	200	700	20	5	5	10 L	100 N	5	0.150	50	50	10
WCD0270R	0.70	1.00	1000	1000	10 L	15	5 L	10 L	300	10	0.300	100	50	30

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCD0272A	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1	100 N	0.04	5 L	20	10	30
WCD0272R	0.05 N	10 N	0.5 L	0.5 L	10 N	200 N	1 L	100 N	0.02	5 L	15	15	50
WCD0273R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1	100 N	0.02	5 L	5	15	50
WCD0274R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.04	5 L	5 L	10	50
WCD0275R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.02	5 L	5 L	10	10
WCD0285R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.04	5 L	10	15	50
WCD0296R	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.02 L	5 N	15	15	50
WCD0301R	0.05 N	10 N	60.0	5.0	10 L	200 N	10	100 N	0.08	40	70	110	20
WCD0308R	0.05 N	10 N	17.0	0.5 N	10 L	200 N	1 L	100 N	0.04	5	5 L	40	15
WCD0309R	0.05 N	10 N	16.0	15.0	140	200 N	30	100 N	0.40	90	100	60	50
WCD0310R	0.05 N	10 N	3.5	2.0	20	200 N	10	100 N	0.10	30	15	100	30
WCD0323R	0.05 N	10 N	1.0	0.5 N	10 N	200 N	1 L	100 N	0.06	50	50	10	15
WCD0339R	0.05 N	10 N	0.5	0.5 N	10	200 N	2	100 N	0.04	5	5 L	20	10
WCD0364R	0.05 N	10 N	0.5 L	0.5 L	60	200 N	4	100 N	0.02 L	310	500	40	30
WCD0366R	0.05 N	10 N	1.0	1.5	10 L	200 N	8	100 N	0.02 L	35	20	30	30
WCD0521R	0.15	10 N	0.5 N	0.5 N	10 N	200 N	1 L	100 N	0.02 N	5 L	5 L	10	30
WCE0024R	0.05 N	10 N	2.0	3.0	0 B	200 N	70	100	0.04	250	200	35	30
WCE0030R	0.05 N	10 N	2.0	5.0	0 B	200 N	6	100 N	0.10	60	70	160	500
WCE0052R	0.05 N	10 N	2.0	2.0	0 B	200 N	3	100 N	0.04	30	50	20	30
WCE0053R	0.05 N	10 N	1.5	1.0	0 B	200 N	1	100 N	0.04	5	10	40	50
WCE0067R	0.05 N	10 N	1.5	0.5 N	0 B	200 N	1 L	100 N	0.02 L	5	5	20	10
WCE0069R	0.10	10 N	0.5	0.5 N	0 B	200 N	2	100 N	0.04	70	70	15	30
WCE0167R	0.05	10 N	11.0	15.0	0 B	200 N	6	100 N	0.55	5	10	25	50
WCE0182R	0.45	10 N	0.5 L	0.5 N	0 B	200 N	1	100 N	0.02 L	5	15	25	30
WCE0263R	0.05 N	10 N	1.0	0.5	0 B	200 N	5	100 N	0.04	25	15	15	10
WCE0267R	0.05 N	10 N	6.0	5.0	0 B	200 N	30	100 N	0.02	100	500	80	50
WCE0268R	0.05 N	10 N	2.0	1.5	0 B	200 N	1	100 N	0.04	120	200	10	10
WCE0269R	0.05 N	10 N	0.5	0.5	0 B	200 N	2	100 N	0.04	15	70	5	10
WCE0279R	0.05 N	10 N	0.5 L	0.5	0 B	200 N	1 L	100 N	0.02	15	20	10	70
WCE0281R	0.05 N	10 N	0.5 N	1.0	0 B	200 N	1	100 N	0.02	5 L	10	20	50
WCE0284R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.02 N	5 L	10	20	50
WCE0298R	0.60	10 N	0.5	0.5 N	0 B	200 N	1 L	100 N	0.04	10	50	10	50
WCE0313A	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	2	100 N	0.02 N	5 L	15	5	10
WCE0313R	0.05 N	10 N	2.0	1.0	0 B	200 N	2	100 N	0.02 N	30	50	10	10
WCE0395	0.05 N	10 N	30.0	15.0	400	200 N	100	200	1.50	700	300	7500	5000
WCE0410	0.05 N	10 N	1.5	0.5	10 L	200 N	1	100 N	0.14	5	5 L	35	10
WCE0430	0.05 N	10 N	1.0	0.5 N	10 N	200 N	1 L	100 N	0.12	10	5	350	30
WCE0435	0.05 N	10 N	0.5	0.5 N	10 N	200 N	1	100 N	0.04	5	5	280	50
WCE0441	0.05 N	10 N	8.0	10.0	10 L	200 N	3	100 N	12 50	5 L	10	130	100
WCF0442	0.05 N	10 N	1.5 H	0.5 L	10 L	200 N	4	100 N	0.45	10	5	60	50
WCE0443	0.05 N	10 N	1.0	0.5 N	10 N	200 N	1	100 N	0.20	5	5	30	20
WCE0445	0.05 N	10 N	1.0	1.0	10	200 N	35	100 N	0.45	15	10	370	300

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCD0272A	60	200 N	20 N	0.0 B	10 N	10	50	3	5 N	0 B	50 N	300	2.00
WCD0272R	65	200 N	20 N	0.0 B	10 N	10	50	2	5 N	0 B	50 N	300	2.00
WCD0273R	60	200 N	20 N	0.0 B	10 N	10 L	50	3	5 N	0 B	50 N	300	2.00
WCD0274R	30	200 N	20 N	0.0 B	10 N	10	50	3	5 N	0 B	50 N	300	2.00
WCD0275R	10	200 N	20 N	0.0 B	10	50	10	2	5 N	0 B	50 N	150	3.00
WCD0285R	70	200 N	20 N	0.0 B	10 N	10 N	50	2	5 L	0 B	50 N	300	3.00
WCD0296R	65	200 N	20 N	0.0 B	10 N	10 N	50	2	5 N	0 B	50 N	300	2.00
WCD0301R	110	200 N	20 N	0.0 B	10 N	10 N	10 N	30	5	0 B	50 N	100	3.00
WCD0308R	30	200 N	20 N	0.0 B	10 N	10 N	10	2	5 N	0 B	50 N	70	0.10
WCD0309R	100	200 N	20 N	0.0 B	10 N	20	15	2	15	0 B	50 N	100	5.00
WCD0310R	70	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	50	0.05
WCD0323R	30	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50	150	7.00
WCD0339R	140	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	10	0.15
WCD0364R	300	300	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	150	2.00
WCD0366R	400	700	20 N	0.0 B	10 N	10 N	10 L	1 N	50	0 B	50 N	200	5.00
WCD0521R	10	200 N	20 N	0.0 B	10 N	10 N	20	2	30	0 B	50 N	300	1.50
WCE0024R	85	200	20 N	0.0 B	10 N	10 N	10	1	20	0 B	50 N	200	5.00
WCE0030R	1700	500	20 N	0.0 B	10 N	10 N	10	2	10	0 B	50 N	150	5.00
WCE0052R	5	200 N	20 N	0.0 B	10 N	10 N	15	1 N	30	0 B	50 N	300	3.00
WCE0053R	120	300	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	2.00
WCE0067R	5	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	0.70
WCE0069R	50	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 L	150	7.00
WCE0167R	25	200 N	20 N	0.0 B	10 N	10 N	15	2	20	0 B	50 N	100	2.00
WCE0182R	25	200 N	20 N	0.0 B	10 N	10 N	20	2	5 N	0 B	50 N	150	2.00
WCE0263R	50	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	15	0 B	50 N	150	0.70
WCE0267R	130	200 N	20 N	0.0 B	10 N	10 N	10 L	10	20	0 B	50 N	50	0.50
WCE0268R	900	300	30	0.0 B	10 N	10 N	10	1 L	20	0 B	50 N	150	2.00
WCE0269R	15	200 N	20 N	0.0 B	10 N	20	10	1	30	0 B	50 N	300	5.00
WCE0279R	95	200 N	20 N	0.0 B	10 N	10 L	15	1	15	0 B	50 N	300	7.00
WCE0281R	70	200 N	20 N	0.0 B	10 N	10	50	5	7	0 B	50 N	500	3.00
WCE0284R	50	200 N	20 N	0.0 B	10 N	10	50	3	5 N	0 B	50 N	300	3.00
WCE0298R	35	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	300	10.00
WCE0313A	160	200	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	10 N	0.10
WCE0313R	50	500	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	10.00
WCE0395	5300	500	70	0.0 B	10 N	500	10	1 L	7	0 B	50 L	70	7.00
WCE0410	5	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	300	0.30
WCE0430	35	200 N	20 N	0.0 B	10 N	10 N	50	2	5 N	0 B	50 N	50	0.30
WCE0435	40	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	70	1.00
WCE0441	20	200 N	20 N	0.0 B	10 N	10 N	10	1	7	0 B	50 N	200	2.00
WCE0442	1100	1000	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	70	3.00
WCE0443	350	300	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	150	0.50
WCE0445	12000	10000 G	50	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	0.70

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI%	S-V	S-LA	S-Y
WCD0272A	0.03	0.15	20 N	150	10	5 N	5 L	10 L	100 N	5 L	0.070	10 L	50	30
WCD0272R	0.02	0.05	20 N	150	10	5 N	5 L	10 L	100 N	5 L	0.070	10 L	20	20
WCD0273R	0.02	0.05	30	200	10	5 N	5 L	10 L	100 N	5 L	0.050	10 L	20	20
WCD0274R	0.02	0.05	30	300	10	5 N	5 L	10 L	100 N	5 L	0.050	10 L	20	20
WCD0275R	1.50	0.07	500	1000	10	5 N	5 L	10 L	100 N	7	0.300	70	30	10
WCD0285R	0.05	0.10	30	300	10 L	5 L	5 N	10 N	100 N	5 L	0.100	10 L	30	20
WCD0296R	0.10	0.10	70	150	10 N	5 N	5 N	10 N	100 N	5 L	0.100	10	30	20
WCD0301R	0.50	0.20	200	100	30	5 N	20	100	100 L	5	0.150	1500	20	20
WCD0308R	0.20	0.50	700	200	20	5 N	5 L	10 N	100	5 L	0.150	20	20 N	10 L
WCD0309R	1.00	0.70	700	500	1500	5 L	10	30	100 L	7	0.150	100	20	20
WCD0310R	0.10	0.50	500	20	50	5 N	7	30	100 L	5	0.100	150	20	15
WCD0323R	5.00	3.00	1000	1500	20	30	200	1500	700	20	0.300	150	50	20
WCD0339R	0.05	0.05	50	150	10 L	5 N	15	10 L	100 N	5	0.020	20	20	10 N
WCD0364R	5.00	5.00	300	3000	70	150	300	70	100 N	7	0.150	150	20	20
WCD0366R	2.00	1.00	300	200	150	5 L	100	100	100 N	10	0.200	700	30	20
WCD0521R	1.50	1.00	700	70	15	5 N	5 N	20	1000	7	0.500	70	70	15
WCE0024R	0.20	0.05	200	150	20	30	20	30	100 L	5	0.100	100	20	15
WCE0030R	3.00	5.00	300	300	700	15	100	700	500	20	0.500	300	50	30
WCE0052R	3.00	3.00	1000	150	30	5 L	70	700	500	30	0.700	200	300	50
WCE0053R	7.00	15.00	20 L	100	10 L	5 N	5	30	100	5 L	0.050	30	20 N	15
WCE0067R	1.00	15.00	150	200	10	5 N	10	50	200	5 L	0.100	20	20	15
WCE0069R	2.00	5.00	1000	1000	10	30	50	300	700	20	0.500	200	20	20
WCE0167R	0.30	2.00	500	100	20	5 L	5	10 L	150	5	0.100	30	30	10
WCE0182R	0.10	0.07	200	100	10	5	5	10 L	100 L	5 L	0.100	10	50	20
WCE0263R	0.20	0.05	200	10	20	5 N	10	15	100	5	0.050	150	20	10
WCE0267R	0.30	1.00	700	20	20	5 N	30	50	100	5	0.050	3000	100	500
WCE0268R	1.50	7.00	1000	100	15	5 N	50	150	150	10	0.200	1000	50	50
WCE0269R	3.00	3.00	700	150	15	5 L	5	20	2000	10	1.000	200	50	10
WCE0279R	2.00	0.70	3000	500	20	7	30	50	300	10	0.300	150	70	30
WCE0281R	0.05	0.07	30	700	10	5 N	5 L	10 L	100 L	5 L	0.100	10 L	100	50
WCE0284R	0.05	0.07	20	500	10	5 N	5 L	10 L	100 N	5 L	0.050	10 L	20	20
WCE0298R	1.50	2.00	1500	1500	10	10	5 L	10	500	15	0.700	100	70	50
WCE0313A	0.07	1.00	30	100	10	5 N	5	10	100 L	5 L	0.030	30	100	70
WCE0313R	2.00	5.00	30	5000	10	10	15	100	100	5	0.150	50	20	10
WCE0395	1.00	7.00	20	500	10	5 N	10	50	100	5	0.100	30	200	20
WCE0410	1.00	15.00	150	150	20	5 N	5	50	100	5 L	0.100	20	20	15
WCE0430	0.02	0.15	20	700	10	5 N	5 L	10 L	100 N	5	0.020	10 L	20 L	50
WCE0435	0.10	0.10	500	150	10	5 N	5 L	10 L	200	5 L	0.070	10	20	20
WCE0441	0.15	0.05	150	20	70	5 N	5 L	200	100 N	10	0.300	200	30	50
WCE0442	3.00	20.00	20 L	2000	30	5 L	20	200	500	7	0.150	50	20	15
WCE0443	1.00	7.00	200	300	10 L	5 N	15	50	100	5	0.150	30	20 N	10
WCE0445	1.50	1.50	200	500	10 L	5 L	10	10	100 N	5	0.070	20	20 N	10 L

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCE0446	0.05 N	10 N	1.5	0.7	10	200 N	4	100 N	0.14	10	10	65	50
WCE0447	0.05 N	10 N	3.0	2.0	20	200 N	8	100 N	0.55	10	15	530	300
WCE0448	0.05 N	10 N	4.0	7.0	80	200 N	30	100 N	1.20	100	100	420	300
WCE0449	0.05 N	10 N	3.0	5.0	200	200 N	10	100 N	0.14	10	20	160	200
WCE0450	0.05 N	10 N	3.5	2.0	20	200 N	5	100 N	0.14	10	5	110	100
WCE0451	0.05 N	10 N	2.0	1.0	10 L	200 N	2	100 N	0.12	10	7	50	200
WCE0452	0.05 N	10 N	2.5	0.7	10 L	200 N	2	100 N	0.08	15	5 L	140	15
WCE0499	0.05 N	10 N	0.5 N	0.5 N	10 N	200 N	1	100 N	0.04	10	15	30	50
WCE0501R	0.05 N	10 N	1.0	1.5	0 B	200 N	1 L	100 N	0.08	300	200	5	20
WCE0528	0.05 N	10 N	0.5 L	0.5 N	400	200 N	2	100 N	1.30	100	150	10	15
WCE0555	0.05 N	10 N	3.5	2.0	10 L	200 N	2	100 N	0.10	600	150	550	500
WCE0572	0.05 N	10 N	1.0	0.5	10 L	200 N	1 L	100 N	0.08	5	5	50	50
WCE0573	0.05 N	10 N	1.0	0.5	10 L	200 N	2	100 N	0.10	15	10	35	10
WCE0574	0.05 N	10 N	1.0	0.7	10 L	200 N	1 L	100 N	0.28	10	5	50	10 L
WCE0575	0.05 N	10 N	1.5	0.7	10 L	200 N	1 L	100 N	0.45	10	10	70	50
WCE0579	0.05 N	10 N	2.0	1.0	10 L	200 N	1 N	100 N	0.30	10	10	40	10 L
WCE0627	0.05 N	10 N	1.0	0.7	10 L	200 N	1 L	100 N	0.28	5	5 L	20	10 N
WCE0727	0.05 N	10 N	0.5	0.5 N	0 B	200 N	2	100 N	0.10	5	15	35	50
WCE0732	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.07	5 L	50	15	30
WCE0733	0.20 N	10 N	0.5 N	0.5 N	0 B	200 N	1 N	100 N	0.08	5 L	100	25	30
WCE0735	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.12	5 L	70	5	30
WCE0813	0.05 N	10 N	0.5 L	0.5 N	0 B	200 N	1 N	100 N	0.18	5	50	5 L	20
WCE0890	0.05 N	10 N	2.0	10.0	10 N	200 N	20	100 N	0.26	370	500	45	50
WCE0891	0.05	10 N	20.0	30.0	160	2000	500	700	0.18	15	20	800	700
WCE0892	0.05	10 N	3.0	2.0	120	200 N	30	100 N	0.08	650	700	40	30
WCE0952	0.20	10 N	80.0	100.0	40	200 N	60	100 N	1.10	550	700	82000	2000 G
WCE0969R	0.05 N	10 N	1.0	2.0	10 N	200 N	3	100 N	0.02	140	150	25	15
WCE0971R	0.05 N	10 N	2.0	0.5 N	10 N	200 N	1 L	100 N	0.04	5 L	5 N	60	10 N
WCE0972R	0.05 N	10 N	0.5 L	0.5 N	10 N	200 N	2	100 N	0.02	5 L	10	110	100
WCK0008	5.00	10 N	9000.0	2000.0	0 B	1000	400	300	10.00	85	50	1300	700
WCK0009	2.00	10 N	30.0	20.0	0 B	10000 G	30	100 N	2.40	100	70	9500	7000
WCK0010	1.80	10 N	28.0	30.0	0 B	10000 G	300	200	4.50	70	70	80000	20000
WCK0012	1.30	10 N	130.0	50.0	0 B	1500	60	100 L	6.00	200	150	7000	7000
WCK0013	9.50	15	1000.0	300.0	0 B	10000 G	400	500	22 00	280	200	10000	10000
WCK0014	0.06	10 N	4.0	3.0	0 B	1000	2	100 N	0.70	55	20	1400	1000
WCK0015	20.00	10	220.0	200.0	0 B	10000 G	200	200	30 00	600	700	13000	15000
WCK0022	1.40	10 N	8.0	5.0	0 B	10000	5	100 N	0.26	50	70	9800	10000
WCK0023	38.00	10 L	200.0	100.0	0 B	10000 G	150	100	0.05	1700	1000	40000	15000
WCK0029	0.60	10 N	1.5	0.5 N	0 B	200 N	1	100 N	0.07	25	15	1700	1000
WCK0061	0.06	10 N	90.0	50.0	0 B	200 N	25	100 N	4.00	900	700	55000	20000
WCK0062	5.00	10 N	28.0	10.0	0 B	200 N	5	100 N	0.16	180	200	3400	1000
WCK0102	0.32	10 N	400.0	150.0	0 B	200 N	50	100 N	0.12	140	200	5000	5000

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCE0446	400	300	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	150	2.00
WCE0447	900	1500	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	500	3.00
WCE0448	3300	1500	20 N	0.0 B	10 N	10 N	10 L	1 N	20	0 B	50 N	50	20.00
WCE0449	85	200	20 N	0.0 B	15	50	20	2	5 N	0 B	50 N	70	1.00
WCE0450	600	300	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	100	1.50
WCE0451	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	200	2.00
WCE0452	40	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	1.00
WCE0499	10	200 N	20 N	0.0 B	30	10	10	5	5 N	0 B	50	200	3.00
WCE0501R	15	500	20 N	0.0 B	10 N	10 N	10	1	10	0 B	50 N	150	20.00 G
WCE0528	20	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5	0 B	50 N	70	7.00
WCE0555	750	700	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	200	7.00
WCE0572	45	200	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	300	0.70
WCE0573	20	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	200	0.50
WCE0574	5	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	100	0.70
WCE0575	5 L	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	1.50
WCE0579	5 L	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	70	1.50
WCE0627	15	200 N	20 N	0.0 B	10 N	30	10	1 L	150	0 B	500	300	10.00
WCE0727	120	200 N	20 N	0.0 B	10 N	10 N	20	1 L	5 N	0 B	50 N	300	7.00
WCE0732	45	200 N	20 N	0.0 B	10 N	10	70	3	5 N	0 B	50 N	200	2.00
WCE0733	75	200 N	20 N	0.0 B	10 N	10 L	50	3	5 N	0 B	50 N	500	2.00
WCE0735	35	200 N	20 N	0.0 B	10 N	10 L	50	2	5 N	0 B	50 N	200	3.00
WCE0813	55	200 N	20 N	0.0 B	10 N	10 L	50	2	5 N	0 B	50 N	300	7.00
WCE0890	300	700	20 L	0.0 B	15	50	10 N	2	5 N	0 B	50 N	200	10.00
WCE0891	400	1000	20 N	0.0 B	10 N	30	10 N	1	5 N	0 B	50 N	70	20.00
WCE0892	110	300	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	100	20.00
WCE0952	100000	10000 G	500	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	200	7.00
WCE0969R	20	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	30	20.00
WCE0971R	5 L	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	10 N	0.20
WCE0972R	40	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	150	0.20
WCK0008	310	300	20	0.0 B	10 N	10 N	10 N	2	5 N	20 L	50 N	50	5.00
WCK0009	2500	1500	50	0.0 B	10 N	10 N	10 N	3	5 N	20 N	50 N	20	7.00
WCK0010	1200	1500	20 N	0.0 B	10 N	10 N	10	2	5 N	20 H	50 N	50	10.00
WCK0012	700	700	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 N	50 N	50	7.00
WCK0013	220	200	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	20 H	50 N	30	10.00
WCK0014	760	500	20 N	0.0 B	10 N	10 N	10	3	5 N	20 N	50 N	150	3.00
WCK0015	2000	3000	70	0.0 B	10 N	10 N	10 N	1 L	10	20 H	50 N	10 N	20.00
WCK0022	10	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 H	50 N	100	5.00
WCK0023	150	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 H	50 N	150	10.00
WCK0029	20	200 N	20 N	0.0 B	10 N	10 N	10 N	2	5 N	20 N	50 N	70	5.00
WCK0061	9000	5000	20 N	0.0 B	10 N	10 N	10 N	2	5 N	20 L	50 N	50	5.00
WCK0062	260	200 N	20 N	0.0 B	10 N	10 N	10 N	2	5 N	20 N	50 N	100	2.00
WCK0102	40	200 N	20 N	0.0 B	10 N	10 N	10 N	2	5 N	20 N	50 N	100	1.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI%	S-V	S-LA	S-Y
WCE0446	2.00	15.00	100	1000	200	5 L	20	100	150	7	0.150	50	30	20
WCE0447	0.10	0.05	150	50	10	5 N	5	10	100 N	5	0.070	20	20	10 L
WCE0448	0.02 L	0.05 L	100	10	10 N	5 N	5 L	500	100 L	5 L	0.050	500	20 N	10 N
WCE0449	0.30	0.05	100	50	70	5 N	5 L	10 L	100 N	5	0.070	10	20 L	15
WCE0450	0.30	20.00	50	1000	10 L	5 N	15	100	300	5	0.100	50	30	20
WCE0451	2.00	20.00	1000	1000	10 L	5	20	100	300	5	0.150	30	20	20
WCE0452	2.00	20.00 G	150	300	10 N	5 N	15	70	500	5	0.150	30	20	20
WCE0499	1.00	0.07	500	1000	10	5 L	5 L	15	100 L	5	0.300	70	20	10 L
WCE0501R	3.00	15.00	30	5000 G	20	15	10	200	100	7	0.200	100	20	30
WCE0528	3.00	5.00	150	1000	10 L	20	50	300	300	50	0.300	200	20 N	20
WCE0555	2.00	3.00	700	2000	10 N	50	70	100	700	20	1.000	150	30	30
WCE0572	1.50	5.00	150	150	10 L	5 L	10	30	100	5 L	0.100	20	20 L	10 L
WCE0573	0.70	5.00	100	100	10 L	5 N	10	30	100	5	0.070	30	20	10
WCE0574	1.50	10.00	20 L	200	10 L	5 N	10	50	150	5 L	0.070	20	20	15
WCE0575	2.00	10.00	100	200	10	5 N	15	70	150	5	0.150	30	20	20
WCE0579	2.00	10.00	70	200	10	5 L	20	150	100	7	0.150	50	30	20
WCE0627	0.70	15.00	20 L	5000	10 N	5	5	30	100 N	5	0.070	70	20 L	15
WCE0727	1.50	1.50	1000	1000	10 N	15	5 N	10 L	500	15	0.500	50	100	30
WCE0732	0.07	0.07	20 L	300	10 L	5 N	5 N	10 L	100 N	5 N	0.100	10	70	20
WCE0733	0.07	0.05	20	300	10 L	5 N	5 N	10 L	100 N	5 N	0.100	15	100	30
WCE0735	0.30	0.20	300	150	10	5 N	5 N	10	100 N	5	0.200	15	100	30
WCE0813	2.00	3.00	300	1000	10 N	20	5 N	30	700	10	0.700	100	100	20
WCE0890	1.50	0.20	150	50	2000 G	5 N	30	70	150	10	0.200	100	20 N	10
WCE0891	0.15	0.05 N	100	10 L	30	50	50	30	100 N	5 L	0.070	15	20 N	10
WCE0892	0.15	0.10	20 N	50	30	50	7	70	100 N	5 L	0.150	100	20 N	10 N
WCE0952	1.50	3.00	50	5000	10 N	10	50	70	100 N	7	0.150	70	20 N	20
WCE0969R	0.10	0.30	20 L	200	10 L	5 N	5 N	30	100 N	5 L	0.070	50	50	10 N
WCE0971R	0.03	20.00	20 N	500	10 N	5 N	5 N	10 N	100	5 N	0.010	15	20 N	20
WCE0972R	0.07	10.00	150	150	10 L	5 N	5 N	20	100 N	5 L	0.070	20	20 N	10 N
WCK0008	0.05	0.05 L	100	20	10	5 N	5 L	10 N	100 N	5 N	0.030	10 L	20 N	10 N
WCK0009	0.07	0.05	100	1000	10 L	5 N	5 L	10 N	100 N	5 L	0.030	10	20 N	15
WCK0010	0.05	0.05 L	100	100	10 L	5 N	5 L	10 N	100 N	7	0.070	30	20 N	20
WCK0012	0.07	0.05 L	100	50	10	5 N	5 L	10 N	100 N	5 L	0.050	10 L	20 N	10 N
WCK0013	0.03	0.05 L	100	100	10	5 N	5 L	10 N	100 N	5 L	0.030	10 L	20 N	10 L
WCK0014	0.20	0.07	200	1000	20	5 N	5 L	10 N	100 N	5 L	0.070	30	20	10
WCK0015	0.02	0.05 L	30	100	10 L	5 N	5 N	10 N	100 N	5 N	0.015	10	20 N	10 N
WCK0022	0.15	0.05 L	200	20	10	5 N	5 L	10 N	100 N	5 L	0.070	20	20	10 N
WCK0023	0.10	0.05	150	70	10 L	15	5 L	10 N	100 N	5 N	0.070	10	20 N	10 N
WCK0029	0.15	0.05 L	200	150	10 L	5 N	5 L	10 N	100 N	5 N	0.050	30	20 N	10 N
WCK0061	0.30	0.05	500	500	10 N	5	5 L	10 N	100 L	5 N	0.050	10	30	10 L
WCK0062	0.15	0.05	150	300	10 N	5 N	5 L	10 N	100 L	5 N	0.050	20	20 N	10 L
WCK0102	0.15	0.05	200	70	15	5 N	5 L	10 N	100 N	5 N	0.070	10	20	10 L

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCK0113	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.01 L	5 L	15	10	10
WCK0133	1.00	10 N	30.0	30.0	0 B	10000 G	8	100 N	0.08	2600	1000	3600	1000
WCK0135	0.02 L	10 N	1.0	1.0	0 B	200 N	10000 G	7000	0.75	10	15	20	20
WCK0136	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	20	100 N	0.35	5 L	10	20	20
WCK0138	0.02 L	10 N	50.0	30.0	0 B	200 N	4	100 N	0.45	3000	700	1500	700
WCK0139	0.80	10 N	15.0	0.7	0 B	200	3	100 N	0.12	35	50	40	10
WCK0140	3.00	10 N	2.0	7.0	0 B	300	2	100 N	0.04	70	15	25	100
WCK0151	0.10	10 N	0.2 L	1.5	0 B	200 N	5	100 N	0.02	20	15	25	100
WCK0174	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	5 L	15	15	70
WCK0177	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.02	5 L	15	10	70
WCK0186	0.15	10 N	15.0	10.0	0 B	200 N	3	100 N	0.02	50	50	1400	3000
WCK0196	1.00	10 N	100.0	50.0	0 B	10000	200	200	8.50	900	150	11000	15000
WCK0197	11.00	10 N	660.0	150.0	0 B	1000	400	500	32.00	300	100	1800	1000
WCK0309A	0.04	10 N	10.0	10.0	0 B	200 N	50	100 N	0.30	110	100	1500	2000
WCK0312A	0.08	10 N	450.0	500.0	0 B	1000	900	1000	4.00	800	1000	40000	20000 G
WCK0313A	0.06	10 N	180.0	150.0	0 B	1500	1500	2000	6.00	750	1000	20000	15000
WCK0314A	0.02	10 N	60.0	70.0	0 B	500	200	500	1.80	600	500	15000	10000
WCK0315A	0.02 L	10 N	2.0	3.0	0 B	200 N	35	100 N	2.60	15	30	250	500
WCK0321	0.02 L	10 N	6.0	5.0	0 B	200 N	70	100 N	0.24	30	50	500	500
WCK0323	0.06	10 N	80.0	100.0	0 B	200	25	100 N	0.06	10	10	20	10
WCK0344	0.02 L	10 N	0.4 H	0.5 N	0 B	200 N	1	100 N	0.80	20	50	15	10
WCK0358	0.04	10 N	0.4	0.5	0 B	500	6	100 N	1.00	5	50	10	10
WCK0361	0.02 L	10 N	1.0	0.5	0 B	200 N	6	100 N	0.30	25	70	30	50
WCK0370	1.50	10 N	13.0	20.0	0 B	3000	25	100 N	0.26	5 L	20	10000	7000
WCK0371	1.70	10 N	4.0	5.0	0 B	1000	8	100 N	0.26	15	30	300	200
WCK0372	0.10	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.08	5 L	50	20	50
WCK0373	0.16	10 N	5.0	5.0	0 B	2000	8	100 N	0.10	10	70	1500	2000
WCK0380	0.08	10 N	0.2	0.5 N	0 B	200 N	1	100 N	0.06	5 L	10	65	200
WCK0383	0.06	10 N	0.4	0.5 L	0 B	200 N	3	100 N	0.35	5 L	20	40	20
WCK0384	0.54	10 N	6.5	7.0	0 B	2000	6	100 N	0.14	10	30	4000	5000
WCK0391	0.08	10 N	0.2 L	0.5 N	0 B	500	5000 G	10000 G	5.50	30	30	10	10
WCK0396	0.06	10 N	0.2 L	0.5 N	0 B	200 N	10	100 N	0.06	5 L	10	10	15
WCK0397	0.08	10 N	0.8 H	0.5 N	0 B	200 N	35	100 N	0.06	5 L	20	15	10 N
WCK0398	0.08	10 N	0.4	0.5 N	0 B	200 N	8	100 N	0.06	20	30	5 L	10 N
WCK0407	0.06	10 N	0.2 L	0.5	0 B	200 N	6	100 N	0.08	5	20	5	20
WCK0429	0.18	10 N	7.0	10.0	0 B	10000	5000 G	3000	8.00	40	50	20	10
WCK0430	0.08	10 N	14.0	200.0	0 B	3000	250	500	4.50	35	50	10	15
WCK0433	0.10	10 N	1.0	3.0	0 B	5000	50	10000 G	9.50	30	50	10	10
WCK0440	0.06	10 N	0.2	0.5 N	0 B	500	150	100	8.50	5 L	50	10	20
WCK0454	0.08	10 N	0.2 L	0.5 N	0 B	200	10	100 N	0.08	5	10	5 L	10 N
WCK0460	0.04	10 N	0.2 L	0.5 N	0 B	200 N	8	100 N	0.12	10	50	10	20
WCK0461	0.28	10 N	6.0	10.0	0 B	200 N	10	100 N	4.50	30	30	70	100

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCK0113	30	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 N	70	150	2.00
WCK0133	350	300	20 N	0.0 B	10 N	10 N	10 N	1 L	20	20 N	50 L	50	2.00
WCK0135	15	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	20 N	50 N	70	0.70
WCK0136	20	200 N	20 N	0.0 B	10 N	10 N	70	2	5 N	20 N	50 N	150	1.00
WCK0138	1200	1000	20 N	0.0 B	20	10 N	10 N	1 L	15	20 H	50 N	10	1.50
WCK0139	400	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5	20 N	50 L	10 L	5.00
WCK0140	15	200	20 N	0.0 B	10	10 N	10 N	1	5 L	20 L	50 N	50	2.00
WCK151	10	200 N	20 N	0.0 B	10 N	10 N	10	1	5 L	20 L	50 N	200	1.50
WCK174	35	200 N	20 N	0.0 B	10 N	15	70	2	5 N	20 L	50 N	150	1.00
WCK177	35	200 N	20 N	0.0 B	10 N	10	70	2	5 N	20 L	50 N	70	1.00
WCK186	300	500	20 N	0.0 B	50	20	10	3	15	20 L	50 N	70	10.00
WCK196	560	700	70	0.0 B	10 N	10 N	10 N	2	5 N	20 H	50 N	100	3.00
WCK197	220	200	20 N	0.0 B	10 N	10 N	10 N	2	5 N	20 L	50 N	30	2.00
WCK0309	800	1000	20 N	0.0 B	10 N	70	15	2	5 N	20 L	50 N	500	5.00
WCK0312	15000	10000 G	150	0.0 B	10 N	1500	10 N	1	5 N	20 L	50 N	150	10.00
WCK0313	20000	10000 G	200	0.0 B	10 N	1000	10 L	1	5 N	20 L	50 N	150	10.00
WCK0314	1500	2000	20 N	0.0 B	10 N	300	10 L	2	5 N	20 L	50 N	200	7.00
WCK0315	100	200 N	20 N	0.0 B	10 N	10 L	10 L	1	5 N	20 L	50 N	200	5.00
WCK0321	65	200 N	20 N	0.0 B	10 N	10 N	10 L	2	15	20 L	50 N	70	2.00
WCK0323	20	200 N	20 N	0.0 B	10 N	10 N	10 L	2	5 N	20 L	50 N	70	1.00
WCK0344	100	200 N	20 N	0.0 B	20	10 N	10	5	5 N	20 L	50 N	500	10.00
WCK0358	10	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	20 L	200	700	5.00
WCK0361	50	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	20 L	50 N	100	10.00
WCK0370	95	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	20	50 N	150	10.00
WCK0371	30	200 N	20 N	0.0 B	10 N	10 N	10	2	5 N	20 L	50 N	100	10.00
WCK0372	60	200 N	20 N	0.0 B	10 N	10 N	20	2	5 N	20 L	50 N	200	7.00
WCK0373	300	500	20 N	0.0 B	10 N	10 N	15	3	5 N	20	50 N	100	10.00
WCK0380	55	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	20 L	50 N	150	5.00
WCK0383	50	200 N	20 N	0.0 B	10 N	10 N	15	2	5 N	20 L	50 N	150	7.00
WCK0384	3000	5000	20	0.0 B	10 N	10 N	10	2	5 N	20	50 N	100	10.00
WCK0391	25	200 N	20 N	0.0 B	10 N	10 N	10	2	5 N	20 L	50 N	100	1.50
WCK0396	55	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	20 L	50 N	150	5.00
WCK0397	650	500	20 N	0.0 B	100	70	10	30	5	300	1000	100	10.00
WCK0398	750	700	20 N	0.0 B	10 N	10 N	15	70	20	600	2000	50	20.00
WCK0407	25	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	20 L	50 N	100	7.00
WCK0429	750	1000	100	0.0 B	10 N	10 N	10 L	1	5 N	20	50 N	100	7.00
WCK0430	900	1000	20 N	0.0 B	10 N	10 N	10	1	5 N	20 L	50 N	100	10.00
WCK0433	150	200	20 N	0.0 B	10 N	10 N	10 L	1	5 N	20	50 N	150	5.00
WCK0440	45	200 N	20 N	0.0 B	10 N	10 N	20	1	10	20 L	50 N	200	10.00
WCK0454	5	200 N	20 N	0.0 B	10 N	10 N	10 L	1	5 N	20 L	50 N	1000 G	0.50
WCK0460	20	200 N	20 N	0.0 B	10 N	10	15	3	100	20 H	50 N	200	7.00
WCK0461	50	200 N	20 N	0.0 B	10 N	10 N	10	2	30	20 L	50 N	100	7.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI%	S-V	S-LA	S-Y
WCK0113	0.30	0.30	1500	200	10 L	5 N	5 L	10 N	500	5 L	0.100	10	50	10
WCK0133	0.15	0.05	300	50	10 L	5 N	5 L	10 N	100 L	5 L	0.070	30	20 N	10 L
WCK0135	0.15	0.10	300	70	100	5 N	5 L	10 N	100	5 N	0.070	10 L	50	20
WCK0136	0.03	0.05	100	70	10 L	5 N	5 L	10 N	100 L	5 N	0.050	10 L	20	30
WCK0138	0.50	0.10	300	50	10 L	5 N	5	10 N	100 N	5 N	0.050	150	20 N	10 N
WCK0139	0.07	0.05	150	100	10 N	7	20	10 N	100 L	5 L	0.050	70	20 N	10 L
WCK0140	0.30	0.15	200	70	10 L	5 N	15	10 N	100 L	5 L	0.070	150	20 N	10
WCK151	1.00	0.05 L	5000	70	10	10	15	200	100 L	10	0.200	70	50	15
WCK174	0.02 L	0.05 L	20 N	150	10 N	5 N	5 L	10 N	100 N	5 N	0.200	10 L	20	50
WCK177	0.02	0.10	20 N	100	10 N	5 N	5 L	10 N	100 N	5 N	0.200	10 L	20	30
WCK186	0.30	0.30	1000	200	10 N	5 N	5 L	10 N	200	5 L	0.050	30	70	10 L
WCK196	0.10	0.05 L	200	30	20	5 N	5 L	10 N	100 N	5 N	0.050	10	20	10 L
WCK197	0.05	0.05 L	70	100	10	5 N	5 L	10 N	100 N	5 N	0.300	10	20 N	10 N
WCK0309	1.00	0.50	200	500	50	5	15	100	100 L	10	0.500	100	70	50
WCK0312	0.30	1.00	70	150	15	5 N	5	70	100 N	5	0.200	70	100	10
WCK0313	0.50	1.50	70	200	20	5 N	10	100	100 N	7	0.200	70	100	15
WCK0314	0.70	0.50	70	1000	30	5	15	100	100 N	7	0.200	70	70	30
WCK0315	0.50	10.00	200	700	10	5	30	100	100 L	7	0.200	70	50	50
WCK0321	0.15	7.00	150	500	10 L	5 N	5	20	100 L	5	0.050	30	20	20
WCK0323	0.15	0.07	300	70	15	5 N	7	30	100 L	5	0.070	20	20 N	10
WCK0344	2.00	7.00	300	3000	10	7	20	50	300	7	0.300	70	30	20
WCK0358	0.50	0.20	200	50	50	5 N	15	100	100 N	10	0.500	70	50	20
WCK0361	3.00	0.50	1500	1000	10	30	150	500	100	15	0.500	100	50	20
WCK0370	0.20	0.10	200	70	15	5 N	5 L	10 L	200	5 L	0.150	30	70	10 L
WCK0371	0.50	0.07	200	2000	10	5	5	10 L	100 L	5	0.100	50	70	20
WCK0372	2.00	2.00	1500	500	10	7	5	10	2000	10	0.500	100	100	20
WCK0373	0.50	0.05	300	500	20	5 N	5	10 L	100 L	7	0.200	50	50	10
WCK0380	1.00	1.00	1000	300	10	5	5	10 L	500	5	0.200	50	50	10
WCK0383	1.00	1.00	700	700	30	5	5	10 L	300	7	0.300	70	100	15
WCK0384	0.70	1.00	100	5000	10	10	5	10 L	100	5	0.100	20	50	10
WCK0391	0.15	0.20	70	300	50	7	20	100	100	5	0.200	70	50	20
WCK0396	0.70	1.00	1000	300	10 L	5 N	5	10 L	500	5	0.200	20	50	10
WCK0397	3.00	10.00	30	5000 G	10 L	7	30	150	100	5	0.200	100	20 N	30
WCK0398	2.00	15.00	20	5000 G	10 N	15	20	150	100	5 L	0.100	70	30	15
WCK0407	1.00	1.50	1000	500	10	15	20	50	300	10	0.300	70	50	15
WCK0429	0.70	0.30	200	100	10	5 N	10	100	100	10	0.150	70	70	20
WCK0430	5.00	0.10	300	30	15	5 N	10	30	100 L	5	0.070	30	30	15
WCK0433	0.15	0.50	200	200	10	5 N	7	70	100	7	0.100	30	100	20
WCK0440	0.10	0.07	300	100	20	5 N	5 L	10 L	100	5	0.300	500	70	20
WCK0454	0.20	0.10	300	70	15	5 N	5 L	20	100	5	0.150	20	30	20
WCK0460	0.50	0.50	1000	300	15	5 N	5	10 L	300	5	0.150	20	50	10
WCK0461	2.00	3.00	1000	3000	20	10	30	100	100	10	0.200	100	30	20

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCK198	4.00	10 N	680.0	300.0	0 B	10000	2000	1500	45.00	2600	1000	19000	10000
WCK199	0.20	10 N	4.0	10.0	0 B	200 N	20	100 N	4.50	60	20	10000	7000
WCK200	0.40	10 N	4.0	20.0	0 B	2000	80	100 N	4.50	600	100	14000	10000
WCK201	1.00	10 N	170.0	50.0	0 B	1000	80	100 L	2.80	25	30	480	500
WCK205	0.02 L	10 N	0.6	1.5	0 B	200 N	20	100 N	0.08	5	15	25	70
WCK250	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	3	100 N	0.02	10	10	40	100
WCK280	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.04	20	30	40	100
WCK299	0.02 L	10 N	2.0	2.0	0 B	200 N	1	100 N	0.02	15	15	30	70
WCK305	0.02 L	10 N	4.0	3.0	0 B	200 N	25	100 N	0.22	20	30	160	200
WCK309	0.02 L	10 N	130.0	15.0	0 B	200 N	50	100 N	0.28	130	100	2600	1500
WCK312	0.04	10 N	340.0	150.0	0 B	500	400	500	2.00	800	500	61000	15000
WCK313	0.06	10 N	130.0	100.0	0 B	1000	1600	1500	5.00	770	700	24000	7000
WCK314	0.04	10 N	74.0	100.0	0 B	500	500	500	1.80	520	500	17000	10000
WCK315	0.02	10 N	2.5	2.0	0 B	200 N	40	100 N	1.20	10	20	100	150
WCK471	0.02 L	10 N	0.2 N	1.5	0 B	200 N	2	100 N	0.09	15	30	10	100
WCR0005	0.20	10 N	1.5	3.0	0 B	200 N	80	100	0.26	60	30	470	200
WCR0006	0.02 L	10 N	3.5	3.0	0 B	200 N	8	100 N	0.06	20	20	140	100
WCR0007	0.02 L	10 N	2.0	2.0	0 B	200 N	100	100	0.08	30	20	70	50
WCR0008	0.08	10 N	170.0	50.0	0 B	200	2000	2000	0.55	70	100	2500	1000
WCR0009	0.08	10 N	19.0	20.0	0 B	200 N	2000	1500	0.70	35	20	3700	1000
WCR0010	0.02 L	10 N	2.0	5.0	0 B	200 N	50	100 N	0.02	15	7	300	1000
WCR0011	0.35	10 N	45.0	150.0	0 B	2000	5000 G	10000 G	3.50	160	150	33000	20000
WCR0012	0.10	10 N	40.0	20.0	0 B	200 N	2000	2000	0.45	80	70	6800	700
WCR0013	0.04	10 N	6.5	5.0	0 B	200 N	5000	5000	0.02	45	30	7500	1500
WCR0014	0.02 L	10 N	4.5	3.0	0 B	200 N	60	100 N	0.04	25	15	270	150
WCR0015	0.20	10 N	48.0	50.0	0 B	200 N	2000	1500	0.03	55	70	3700	700
WCR0016	1.70	10 N	110.0	70.0	0 B	1500	5000 G	10000 G	0.03	200	100	50000	10000
WCR0018	0.25	10 N	60.0	30.0	0 B	200 N	4000	5000	0.02	15	15	6500	2000
WCR0019	0.02	10 N	26.0	20.0	0 B	500	200	300	1.00	30	20	2500	1000
WCR0020	0.65	10 N	32.0	20.0	0 B	200	2000	1500	4.50	95	30	26000	7000
WCR0021	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	60	100 N	0.60	30	20	85	100
WCR0022	0.15	10 N	64.0	50.0	0 B	300	5000 G	10000 G	9.00	200	100	30000	10000
WCR0023	0.02 L	10 N	34.0	20.0	0 B	200 N	1000	700	0.14	150	70	2000	500
WCR0024	0.02	10 N	28.0	15.0	0 B	200 N	30	200	0.18	230	70	2800	500
WCR0025	0.06	10 N	60.0	20.0	0 B	1000	800	1000	0.55	650	200	4600	1000
WCR0027	0.02 L	10 N	40.0	20.0	0 B	200 N	80	100 L	0.05	20	10	2500	200
WCR0028	0.02 L	10 N	60.0	20.0	0 B	200	10	100 L	0.28	10	15	1200	500
WCR0029	0.02	10 N	7.5	15.0	0 B	200 N	700	500	0.03	30	15	1400	500
WCR0030	1.40	10 N	180.0	70.0	0 B	200 N	400	500	0.30	40	30	26000	7000
WCR0031	0.02 L	10 N	1.0	2.0	0 B	200 N	5	100 N	0.02	20	15	55	50
WCR0032	0.02 L	10 N	2.0	2.0	0 B	200 N	25	100 N	0.10	30	20	130	70
WCR0033	0.02 L	10 N	1.5	2.0	0 B	200 N	25	100 N	0.03	10	10	85	70

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCK198	1300	1000	20	0.0 B	10 N	10 N	10 N	3	5 N	20 H	50 N	30	10.00
WCK199	340	500	20 N	0.0 B	10 N	10 N	10	2	5 N	20 L	50 N	100	2.00
WCK200	660	500	20 N	0.0 B	10 N	10 N	10	2	5 N	20 H	50 N	70	3.00
WCK201	240	300	20 N	0.0 B	10 N	10 N	10 N	2	5 N	20 L	50 N	70	3.00
WCK205	130	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	20 L	50 N	150	3.00
WCK250	20	200 N	20 N	0.0 B	10 N	10 N	100	1 N	10	80	50	1000 G	20.00 G
WCK280	35	200 N	20 N	0.0 B	10 N	10 N	10	2	5	20	50	150	7.00
WCK299	20	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 L	50 N	150	2.00
WCK305	500	500	20 N	0.0 B	10 N	10	30	1	5	20 L	50 N	500	10.00
WCK309	600	700	20 N	0.0 B	10 N	70	10 N	2	5 N	20	50 L	200	3.00
WCK312	6200	5000	30	0.0 B	10 N	1500	10 N	1 L	5 N	20	50 L	100	7.00
WCK313	14000	10000	100	0.0 B	10 N	1000	10 N	1 L	5	20	50 L	100	10.00
WCK314	1800	3000	20 N	0.0 B	10 N	500	10 N	2	5 N	80	50 L	150	7.00
WCK315	70	200 N	20 N	0.0 B	10 N	10 N	10 N	2	5 N	20	50 N	200	2.00
WCK471	15	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	20	50	200	10.00
WCR0005	500	500	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 N	50 L	200	3.00
WCR0006	45	200 N	20 N	0.0 B	10 N	10 N	10 N	1	7	20 N	50 N	100	1.00
WCR0007	150	200	20 N	0.0 B	10 N	10 N	10 N	1	5 L	20 N	50 N	70	2.00
WCR0008	1000	1500	20	0.0 B	150	10 N	10 N	1 L	5 N	40	100	100	10.00
WCR0009	860	1000	50	0.0 B	10 N	50	10 N	1 N	5 N	20 N	50 N	70	1.00
WCR0010	400	300	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	20 N	50 N	50	0.30
WCR0011	2000	2000	500	0.0 B	10 N	500	10 N	1 L	5 N	20 N	70	70	5.00
WCR0012	400	200	20 N	0.0 B	30	10 N	10 N	1 N	5 N	20 N	50 N	200	3.00
WCR0013	50	200 N	20 N	0.0 B	20	10 L	10 N	1 N	5 N	20 N	50 N	500	1.50
WCR0014	55	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	20	20	50 N	70	2.00
WCR0015	3000	2000	30	0.0 B	10 L	10 N	10 N	1 N	5 N	20 N	50 N	200	2.00
WCR0016	300	200 N	20 N	0.0 B	10	50	10 N	1 L	5 N	20 N	50 N	100	3.00
WCR0018	35	200 L	20 N	0.0 B	20	10 N	10 N	1 N	5 N	20 N	50 N	10 N	0.20
WCR0019	1300	700	20	0.0 B	15	10 N	10 N	1 L	5 N	20 N	50 N	100	1.50
WCR0020	2000	1500	30	0.0 B	10 N	20	10 N	1 N	5 N	20 L	50 N	10 N	3.00
WCR0021	35	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	10	20 L	50 N	100	5.00
WCR0022	7000	5000	500	0.0 B	300	30	10 N	1 N	15	20 H	50 N	10 N	7.00
WCR0023	800	500	20 N	0.0 B	10 L	20	10 N	1 N	5 N	20 N	50 N	10 N	1.00
WCR0024	1400	1000	20 N	0.0 B	10 N	30	10 N	1 N	10	20 L	50 N	10	2.00
WCR0025	4500	3000	100	0.0 B	10	10	10 N	1 N	5	20 N	50 N	10	5.00
WCR0027	45	200 N	20 N	0.0 B	20	10 N	10 N	1 N	5 N	20 N	50 N	10 N	0.50
WCR0028	55	200 N	20 N	0.0 B	20	10 N	10 N	1 N	5 N	20 N	50 N	10 N	5.00
WCR0029	1000	700	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	20 N	50 N	10 N	2.00
WCR0030	70	200 N	20 N	0.0 B	200	200	10 N	1 N	5 N	20 N	50 N	10 N	0.50
WCR0031	1700	1000	50	0.0 B	10 N	10 N	10 N	1	5 N	20 N	50 N	150	3.00
WCR0032	2500	1000	100	0.0 B	10 N	10 N	10 N	2	5 N	20 N	50 N	200	2.00
WCR0033	140	200 L	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	20 N	50 N	200	1.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI%	S-V	S-LA	S-Y
WCK198	0.05	0.05 L	50	70	10	5 N	5 L	10 N	100 N	5 N	0.020	10	20 N	10
WCK199	0.15	0.05 L	150	1000	20	5 L	5 L	10 N	100 N	5 L	0.070	20	50	10
WCK200	0.10	0.05 L	150	500	20	5 N	5 L	10 N	100 N	5 L	0.070	15	50	10
WCK201	0.05	0.05 L	150	200	10	5 N	5 L	10 N	100 L	5 N	0.030	10 L	20 N	10 L
WCK205	0.50	0.10	300	300	10 N	5	5 L	10 N	150	7	0.100	20	100	15
WCK250	0.70	1.50	50	1000	10 N	20	20	700	100	15	1.000 G	500	500	150
WCK280	0.50	0.30	1000	200	10 L	10	5	10 N	200	5	0.100	50	30	10 L
WCK299	2.00	7.00	700	150	10 L	5	30	200	200	10	0.150	70	20	20
WCK305	1.00	1.00	1000	300	20	15	50	150	150	10	0.200	70	70	20
WCK309	0.70	0.20	150	300	10	5	15	100	100 L	10	0.150	70	50	30
WCK312	0.20	0.70	50	100	10 L	5 N	5 L	50	100 L	5	0.100	30	70	10 L
WCK313	0.30	0.70	100	200	10 L	5 N	10	70	100 N	5	0.100	50	70	15
WCK314	0.50	0.20	70	1000	15	5	15	100	100 L	10	0.100	50	50	30
WCK315	0.20	5.00	150	500	10 L	5	15	70	100 N	7	0.100	30	20	20
WCK471	2.00	2.00	1000	1000	10	20	50	100	500	20	0.300	200	70	20
WCR0005	0.20	0.05	300	500	300	10	50	10	100 N	5 L	0.100	50	20 N	20
WCR0006	0.30	0.07	700	10 N	50	5 N	5	30	100 N	5	0.100	200	20 N	10
WCR0007	0.30	0.10	700	20	30	5 N	30	30	100 N	5	0.100	200	20	10
WCR0008	0.07	0.05	150	70	10 N	5 N	5 L	10 N	100 N	5 N	0.030	70	20 N	30
WCR0009	0.05	0.05 L	150	30	15	5 N	5 L	10 N	100 N	5 N	0.030	100	20	10
WCR0010	0.07	0.05 L	200	50	10 L	5 N	5 L	10 N	100 N	5 N	0.030	10	20 N	10 N
WCR0011	0.07	0.30	20	150	200	5 N	5 L	10 N	100 N	5 N	0.030	100	70	20
WCR0012	0.15	0.05	20	50	100	5 N	5	10 N	100 N	5 N	0.020	10 L	20 N	10 L
WCR0013	0.70	0.50	20	150	50	5 N	5 L	10 N	100 N	5 N	0.050	15	20 N	10
WCR0014	0.20	0.30	1000	70	10	5 N	5 L	50	100 L	5	0.100	200	20 N	20
WCR0015	1.00	0.50	500	100	150	5 N	5 L	20	100 L	5 L	0.100	50	20	20
WCR0016	1.00	1.00	50	150	10	7	5	10 N	100 N	5 L	0.050	30	100	20
WCR0018	0.70	5.00	20 N	300	700	5 N	5 L	10	100 L	5 L	0.020	100	20 N	20
WCR0019	0.50	0.20	200	150	15	5 N	5	10 N	100 N	5 L	0.070	30	20 N	10
WCR0020	0.07	0.05	20 L	70	10 N	5 N	5 L	10 N	100 N	5 N	0.003	10 L	20 N	50
WCR0021	1.50	0.70	1000	500	10 N	10	30	200	200	10	0.150	70	20 N	10 N
WCR0022	0.05	0.10	50	30	200	5 N	10	10 N	100 N	5 N	0.010	50	20	10 N
WCR0023	0.02	0.05 L	70	30	15	5 N	5 L	10 N	100 N	5 N	0.002	10	20	10
WCR0024	0.10	0.05 L	150	100	100	5 N	5	10 N	100 N	5 N	0.030	50	20 N	10
WCR0025	0.10	0.05	20	30	500	5 N	10	10 N	100 N	5 N	0.020	70	20 N	10 N
WCR0027	0.02	0.05 L	200	10 N	10 L	5 N	5 L	10 N	100 N	5 N	0.015	50	20 N	10 N
WCR0028	0.02 L	0.05 L	20	20	10	5 N	10	20	100 N	5 N	0.005	10	20 N	10
WCR0029	0.02	0.05 L	20	50	10 L	5 N	5 L	10 N	100 N	5 N	0.015	50	20 N	10 N
WCR0030	0.02 L	0.70	100	70	10 N	5 N	5 L	70	100 N	5 N	0.005	30	20 N	10 N
WCR0031	0.20	0.30	200	300	50	5 N	50	10	100 N	5	0.100	50	20 N	20
WCR0032	0.30	0.50	500	500	50	5 N	50	20	100 N	7	0.100	70	30	50
WCR0033	0.30	3.00	200	100	50	5 N	20	10 N	100 N	5	0.100	50	20	20

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCR0034	0.02 L	10 N	1.5	1.5	0 B	200 N	15	100 N	0.05	15	15	100	70
WCR0035	0.04	10 N	20.0	20.0	0 B	1000	160	200	0.20	240	100	2300	1000
WCR0036	0.02	10 N	14.0	15.0	0 B	200	1000	500	1.00	40	20	820	500
WCR0037	0.04	10 N	2.0	1.5	0 B	200 N	20	100 N	0.02	30	15	130	100
WCR0038	0.02 L	10 N	2.0	3.0	0 B	200 N	100	100	0.04	150	70	280	150
WCR0039	0.02 L	10 N	3.5	3.0	0 B	200 N	10	100 L	0.04	55	20	300	150
WCR0040	0.08	10 N	30.0	20.0	0 B	1500	200	300	0.07	800	500	2700	1000
WCR0041	0.65	10 N	86.0	50.0	0 B	300	2000	1000	0.04	680	500	3600	700
WCR0042	0.02 L	10 N	1.0	1.0	0 B	200 N	6	100 N	0.04	70	70	170	100
WCR0043	1.30	10 N	270.0	300.0	0 B	1000	5000 G	10000	0.08	900	500	27000	15000
WCR0044	0.02 L	10 N	42.0	30.0	0 B	200 N	2000	1000	1.10	550	300	10000	5000
WCR0045	0.02	10 N	30.0	30.0	0 B	1000	2000	1500	0.09	20	20	12000	10000
WCR0046	0.15	10 N	100.0	100.0	0 B	1500	5000 G	7000	0.18	600	200	7400	20000
WCR0047	0.02 L	10 N	2.5	2.0	0 B	200 N	20	100 N	0.18	190	100	170	150
WCR0048	0.15	10 N	250.0	100.0	0 B	1500	2000	2000	1.60	550	300	50000	20000 G
WCR0049	0.02 L	10 N	2.5	3.0	0 B	200 N	8	100 N	2.80	10	15	270	150
WCR0050	0.02 L	10 N	1.0	1.5	0 B	200 N	10	100 N	0.30	15	15	95	100
WCR0051	0.02 L	10 N	1.0	1.0	0 B	200 N	10	100 N	0.35	10	15	75	50
WCR0052	0.02 L	10 N	90.0	50.0	0 B	200 N	2500	1500	31 00	2000	700	6700	1500
WCR0053	0.02 L	10 N	2.0	2.0	0 B	200 N	6	100 N	1.60	15	15	690	200
WCR0054	0.02 L	10 N	2.5	2.0	0 B	200 N	15	100 N	4.50	20	15	200	100
WCR0055	0.02 L	10 N	0.2 L	1.0	0 B	200 N	2	100 N	0.10	160	100	5	10 N
WCR0056	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.08	110	100	5	10
WCR0057	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	20	20	5 L	10 N
WCR0058	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	15	20	5 L	10 N
WCR0059	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	5	100 N	0.18	10	30	5 L	10 N
WCR0060	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.26	5	10	5	10 N
WCR0061	0.18	10 N	0.2 L	0.5 N	0 B	200 N	5	100 N	0.08	10	15	5	10 N
WCR0062	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	3	100 N	0.04	60	50	5	10 N
WCR0063	0.02 L	10 N	4.0	3.0	0 B	200 N	3	100 N	0.11	200	150	360	200
WCR0064	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.06	140	70	5	10 N
WCR0065	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	3	100 N	0.30	5	10	60	20
WCR0066	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	4	100 N	0.04	65	30	15	10 N
WCR0067	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	60	100 N	0.35	55	30	20	10
WCR0068	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	6	100 N	0.12	150	100	5	10 N
WCR0069	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.04	75	50	5 L	10 N
WCR0070	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.04	75	50	5 L	10 N
WCR0072	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.01 L	20	20	5 L	10 N
WCR0073	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.02	15	10	5	10 N
WCR0074	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	5	5	10	10 N
WCR0075	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	5	15	5	10 L
WCR0076	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	5	5	5	10 N

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCR0034	30	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	40	50 N	100	1.50
WCR0035	6200	5000	100	0.0 B	10 N	20	10 N	2	70	20 H	50 N	70	15.00
WCR0036	1000	1000	20	0.0 B	10 N	20	10 N	1 L	20	20 N	50 N	20	2.00
WCR0037	140	200 N	20 N	0.0 B	10 N	10 N	10 N	1	15	20 N	50 N	100	5.00
WCR0038	65	200 N	20 N	0.0 B	10 N	10 N	70	2	10	20 L	50 N	150	15.00
WCR0039	2500	1500	30	0.0 B	10 N	15	50	2	5 N	20 L	50 N	20	1.00
WCR0040	60	200 N	20 N	0.0 B	10 N	70	10 N	1	20	20 L	50 N	50	3.00
WCR0041	130	200 N	20 N	0.0 B	10 N	10 N	50	1	10	20 L	50 N	100	20.00
WCR0042	400	200	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	20 N	50 N	150	2.00
WCR0043	70000	10000 G	500	0.0 B	10 N	150	50	1	15	20 H	50 L	100	20.00
WCR0044	270000	10000 G	5000	0.0 B	10 N	500	10 N	1 L	5 N	20 L	50 N	100	10.00
WCR0045	400	200	20 N	0.0 B	10 N	10	20	1	5	20 N	50 N	100	20.00
WCR0046	65	200 N	20 N	0.0 B	10 N	70	10 N	1 L	5	20 N	50 N	10	20.00
WCR0047	170	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	50	20 N	50 N	100	3.00
WCR0048	1000	500	100	0.0 B	10 N	500	30	2	20	20 N	50 N	20	3.00
WCR0049	680	500	20	0.0 B	10 N	10 N	10 N	1 L	5 N	20 N	50 N	100	2.00
WCR0050	80	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 N	50 N	100	0.70
WCR0051	400	300	20 N	0.0 B	10 N	10 N	10 N	1 L	5 L	20 N	50 N	70	1.00
WCR0052	55000	10000 G	500	0.0 B	10 N	10 N	10 N	1 L	5 L	20 L	50 N	100	1.50
WCR0053	200	200 L	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	20 L	50 N	100	1.00
WCR0054	3500	1000	20	0.0 B	10 N	10 N	10 N	1 N	5	20	50 N	50	1.50
WCR0055	150	300	20 N	0.0 B	10 N	10 L	10	5	700	20 L	50 L	200	5.00
WCR0056	780	700	20 N	0.0 B	10 N	10 N	10	5	500	20 L	50 N	100	5.00
WCR0057	30	200 N	20 N	0.0 B	10 N	10 N	10 N	1	50	20 L	50 N	100	3.00
WCR0058	40	200 N	20 N	0.0 B	10 N	10 N	10 N	2	100	20	50 N	50	5.00
WCR0059	2500	2000	20	0.0 B	10 N	10 N	10 N	2	50	20 L	50 L	200	5.00
WCR0060	30	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	10	20 L	50	150	0.20
WCR0061	1500	1000	20 N	0.0 B	10 N	10 N	10 N	2	20	20 L	50 N	150	5.00
WCR0062	830	700	20 N	0.0 B	10 N	10 N	10 N	1	70	20	50 N	150	5.00
WCR0063	4000	3000	20	0.0 B	10 N	10 N	10 N	5	15	20 L	50 N	100	5.00
WCR0064	1500	1000	20 N	0.0 B	10 N	10 N	10 N	2	30	20 L	100	200	2.00
WCR0065	10	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	50	80	100	150	0.15
WCR0066	650	500	20 N	0.0 B	10 N	10 N	10 N	1	100	80	50 N	150	2.00
WCR0067	390	300	20 N	0.0 B	10 N	15	10 N	1 N	1000	20 L	50 L	100	10.00
WCR0068	35	200 N	20 N	0.0 B	10 N	10 N	10 N	2	500	20 L	50 N	150	7.00
WCR0069	35	200 N	20 N	0.0 B	10 N	10 N	10 N	1	300	20 L	50 N	70	5.00
WCR0070	60	200 N	20 N	0.0 B	10 N	10 N	10	2	300	20 L	50 N	200	7.00
WCR0072	30	200 L	20 N	0.0 B	10 N	10 N	10 N	2	50	20 L	50	70	7.00
WCR0073	20	200 N	20 N	0.0 B	10 N	10 N	10 N	2	30	20 L	50 N	100	5.00
WCR0074	20	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	20	50	150	2.00
WCR0075	20	200 N	20 N	0.0 B	10 N	10 N	20	1	10	20 L	50 N	100	0.70
WCR0076	10	200 N	20 N	0.0 B	10 N	10 N	70	2	10	20 L	50 N	70	0.70

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI%	S-V	S-LA	S-Y
WCR0034	0.30	0.05	1000	10	50	5 N	10	50	100 L	7	0.100	150	20	20
WCR0035	2.00	0.10	1000	200	20	20	100	20	100 L	10	0.100	100	20 N	30
WCR0036	2.00	0.07	200	200	15	7	50	30	100 N	5	0.050	30	20 N	10
WCR0037	1.50	0.15	700	100	15	10	50	50	100 N	5	0.070	70	20 N	10
WCR0038	1.50	0.10	100	100	2000	5 N	50	10 N	100 N	10	0.100	200	20 N	10
WCR0039	0.20	0.05	150	10	50	5 N	5 L	100	100 N	5 N	0.030	10 L	20 N	10
WCR0040	1.00	1.00	500	300	10 N	20	70	10	100 L	7	0.070	150	20 N	15
WCR0041	0.50	0.20	20 N	70	2000	50	50	10	100 L	7	0.100	150	20 N	10
WCR0042	2.00	3.00	500	500	15	5	10	100	100 L	5	0.070	50	20 N	10
WCR0043	0.70	0.20	20 N	200	2000	7	30	20	100 L	7	0.150	150	30	10
WCR0044	0.10	0.05	100	500	20	5 N	5	500	100 N	5	0.050	70	20 N	10 N
WCR0045	1.00	0.07	20 N	20	2000	10	50	50	100 L	5	0.070	100	20 N	10 N
WCR0046	0.05	0.30	500	20	15	15	30	50	100 L	5 L	0.050	50	20 N	70
WCR0047	3.00	7.00	100	1000	10 N	10	50	10 N	100	5	0.100	300	20 N	30
WCR0048	0.20	0.05 L	150	10	50	5 N	5 N	10 N	100 N	5 L	0.020	10 L	20	10 N
WCR0049	1.50	2.00	300	1000	20	7	15	10 N	100 L	5	0.100	50	20 N	10
WCR0050	1.00	2.00	200	500	15	5 N	10	10 N	150	5 L	0.070	50	20 N	10
WCR0051	1.50	2.00	100	1000	15	5	15	10 N	100	5	0.070	50	20	10
WCR0052	1.50	2.00	100	700	10	5 N	10	10 N	150	5 L	0.070	30	20 N	10
WCR0053	0.70	1.00	100	500	15	5 N	10	10 N	100 N	5	0.100	50	20 N	10
WCR0054	1.00	1.50	3000	1000	15	5 N	15	10 N	100 N	5 L	0.070	70	20 N	10
WCR0055	1.50	2.00	30	2000	10 N	7	5 L	20	150	5 L	0.100	30	20 N	15
WCR0056	1.50	2.00	150	1500	10 N	5	10	50	100	5 L	0.070	50	30	10
WCR0057	1.00	2.00	150	1000	10 N	5	15	50	100	5 L	0.070	30	20 N	10 L
WCR0058	1.00	3.00	50	1500	10 N	5	10	30	100 L	5 L	0.070	30	20 N	10
WCR0059	1.00	0.20	500	2000	10 N	10	15	10 N	100 L	5	0.070	10	20	20
WCR0060	0.02	0.07	300	70	10 N	5 N	5 L	10 N	100 L	5 L	0.070	15	20 N	10 N
WCR0061	1.00	1.00	200	1000	10 N	5	15	10 N	100 L	5 L	0.070	20	30	15
WCR0062	2.00	1.50	200	1500	10 N	5	10	10 N	100 L	5 L	0.070	30	20 N	10
WCR0063	1.00	3.00	150	2000	10 N	10	15	10 N	100 L	5 L	0.050	15	20	20
WCR0064	0.10	0.20	500	1500	10 N	5	10	10 N	100 L	5 L	0.070	10	20	10
WCR0065	0.02	0.07	200	20	10 N	5 N	5 L	10 N	100 L	5 N	0.070	10	20 N	10 N
WCR0066	1.00	1.00	700	1500	10 N	5 N	10	10 N	100 L	5 N	0.070	15	20	10
WCR0067	0.03	0.07	150	20	10 N	5 N	10	10	100 L	5 N	0.070	100	20 N	10 N
WCR0068	0.70	2.00	100	1500	10 N	5	5	10 N	100 L	5 L	0.070	50	20	10
WCR0069	0.50	1.00	150	500	10 N	7	10	20	100 L	5 L	0.050	30	20 N	10
WCR0070	0.50	0.70	100	500	10 N	10	5 L	10 N	100	5 L	0.050	20	20 N	10
WCR0072	0.50	3.00	20	2000	10 N	5	5	10 N	100 L	5 N	0.030	30	20 N	10
WCR0073	0.50	2.00	50	1000	10 N	5	5	10 N	100 L	5 L	0.070	30	20 N	10 L
WCR0074	0.50	3.00	300	1000	10 N	5 N	5	10 N	100 L	5 N	0.050	10 L	20 N	10 L
WCR0075	0.10	0.20	300	150	10 L	5 N	5 L	10 N	150	5 N	0.070	10	20	10 L
WCR0076	0.10	0.05	150	10	10 L	5 N	5 L	10 N	100	5 N	0.030	10 L	20 N	10

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCR0077	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.01 L	15	15	5	10
WCR0078	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.01 L	5 L	10	5	10 N
WCR0079	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	5	10	10	10 N
WCR0080	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.01 L	40	15	5	10 N
WCR0081	0.60	10 N	2.0	5.0	0 B	10000	400	200	0.08	25	15	2500	1000
WCR0082	0.02 L	10 N	0.8	0.5	0 B	300	10	100 N	0.55	15	15	100	70
WCR0083	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	8	100 N	0.80	50	20	15	10 N
WCR0084	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	8	100 N	1.50	10	10	5	10 N
WCR0085	0.06	10 N	1.5	1.0	0 B	200 N	8	100 N	0.80	10	10	250	150
WCR0086	0.02 L	10 N	2.5	2.0	0 B	200 N	8	100 N	4.00	10	10	35	15
WCR0087	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	8	100 N	3.50	10	20	15	10 N
WCR0088	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.90	5	10	15	10
WCR0089	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.35	10	15	5	10 N
WCR0090	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.40	10	15	5 L	10 N
WCR0091	0.02 L	10 N	10.0	15.0	0 B	300	15	100 N	0.14	55	20	320	200
WCR0092	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.40	5	10	5	10 N
WCR0093	5.00	10 N	900.0	700.0	0 B	700	5000 G	10000	16 50	2500	1500	100000	20000 G
WCR0196	0.02 L	10 N	2.0	1.5	0 B	200 N	4	100 N	0.0 B	10	10	25	70
WCR0197	0.22	10 N	17.0	20.0	0 B	200 N	800	1000	0.0 B	110	100	800	700
WCR0198	0.78	10 N	58.0	30.0	0 B	200 N	800	1000	0.0 B	40	30	2900	2000
WCR0199	0.30	10 N	70.0	100.0	0 B	2000	5000 G	7000	0.0 B	160	200	19000	20000
WCR0200	0.06 H	10 N	120.0	70.0	0 B	1500	4500	3000	0.0 B	2400	1000	15000	7000
WCR0201	0.02 L	10 N	7.0	5.0	0 B	200 N	60	100	0.0 B	400	500	40	50
WCR0202	0.36	10 N	38.0	30.0	0 B	200 N	600	500	0.0 B	420	200	1200	500
WCR0203	0.04	10 N	6.0	5.0	0 B	200 N	10	100 N	0.0 B	200	300	90	70
WCR0204	0.02 L	10 N	4.0	3.0	0 B	200 N	20	100 N	0.0 B	90	200	100	100
WCR0205	0.06 H	10 N	54.0	30.0	0 B	300	5000 G	5000	0.0 B	160	200	9200	5000
WCR0206	0.02 L	10 N	2.0	1.0	0 B	200 N	1	100 N	0.0 B	25	20	35	30
WCS0014R	0.05 N	10 N	2.5	0.5 L	0 B	200 N	3	100 N	0.04	20	15	30	15
WCS0019	0.02 L	10 N	1.2	1.0	0 B	200 N	25	100 N	0.35	70	70	10	10
WCS0020	0.02 L	10 N	1.0	0.5	0 B	200 N	35	100 N	0.12	50	50	70	30
WCS0021	0.02 L	10 N	0.4	0.5 N	0 B	200 N	4	100 N	35 00	60	50	20	10
WCS0023A	0.05 N	10 N	1.0	0.7	0 B	200 N	5	100 N	0.08	10	10	20	20
WCS0023B	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1	100 N	0.02 L	15	5	5	10 N
WCS0024	0.02 L	10 N	2.0	2.0	0 B	200 N	10	100 N	10.00	40	50	600	500
WCS0025	0.02 L	10 N	1.4	2.0	0 B	200 N	40	100 N	0.28	40	50	40	15
WCS0026	0 02 L	10 N	0.8	1.0	0 B	200 N	10	100 N	0.16	30	30	20	15
WCS0027	0.02 L	10 N	18.0	10.0	0 B	200 N	150	200	0.02 L	30	70	2200	1000
WCS0031	0.02 L	10 N	0.4	0.5 L	0 B	200 N	1	100 N	0.70	20	20	20	30
WCS0032	0.02 L	10 N	0.8	0.7	0 B	200 N	1	100 N	0.16	30	50	30	30
WCS0035	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	15	70	10	10
WCS0039	0.02 L	10 N	0.2	0.5 N	0 B	200 N	1	100 N	0.02	30	50	20	15

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCR0077	20	200	20 N	0.0 B	10 N	10 N	10 N	2	70	20 L	50 N	100	7.00
WCR0078	25	200	20 N	0.0 B	10 N	10 N	10 N	2	7	80	150	100	5.00
WCR0079	25	200 L	20 N	0.0 B	10 N	10 N	10 N	1	15	20 L	50 N	100	3.00
WCR0080	90	200 L	20 N	0.0 B	10 N	10 N	10 N	3	200	20 L	50 N	150	7.00
WCR0081	1900	1000	20 N	0.0 B	10 N	10 N	10 N	1	50	20 L	50 N	50	10.00
WCR0082	1800	1000	20 N	0.0 B	10 N	10 N	10 N	2	200	20	50	100	5.00
WCR0083	260	200	20 N	0.0 B	10 N	10 N	10 N	2	150	20	50	70	3.00
WCR0084	5	200 N	20 N	0.0 B	10 N	10	10 N	1 L	500	20	50	100	2.00
WCR0085	250	200 L	20 N	0.0 B	10 N	50	20	1 L	2000	20 L	50 L	50	5.00
WCR0086	25	200 N	20 N	0.0 B	10	10 N	10 N	1	200	20 L	50 L	100	1.50
WCR0087	35	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	300	20 L	50 L	200	1.50
WCR0088	40	200 N	20 N	0.0 B	10 N	10 N	10 N	1	20	20 L	50 N	150	1.00
WCR0089	160	200 L	20 N	0.0 B	10 N	10 N	10 N	3	300	20	50	70	2.00
WCR0090	55	200 N	20 N	0.0 B	10 N	10 N	10 N	3	500	20 L	50 N	100	5.00
WCR0091	50	200 N	20 N	0.0 B	30	10 N	10 N	2	70	20 L	50 N	150	2.00
WCR0092	35	200 N	20 N	0.0 B	10 N	10 N	10 N	2	500	20 L	50 N	150	3.00
WCR0093	2500	1500	70	0.0 B	30	500	10 N	2	30	150	300	10 N	1.00
WCR0196	65	200 N	20 N	0.0 B	10 N	10	10 N	1 N	5 N	0 B	50 N	100	2.00
WCR0197	58000	10000 G	1000	0.0 B	150	10 N	10	2	10	0 B	50 L	100	7.00
WCR0198	44000	10000 G	500	0.0 B	20	10 N	30	2	20	160	150	150	5.00
WCR0199	46000	10000 G	1000	0.0 B	10 N	700	10	2	20	20 L	50 L	100	10.00
WCR0200	110000	10000 G	2000	0.0 B	10 N	700	10 N	1	15	20 L	50 L	70	10.00
WCR0201	280	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	30	0 B	50 N	70	20.00
WCR0202	200000	10000 G	3000	0.0 B	20	30	10 N	1	20	0 B	50 N	100	7.00
WCR0203	380	200 N	20 N	0.0 B	10 N	10 N	10 N	1	50	0 B	50 N	70	20.00 G
WCR0204	680	1000	20 N	0.0 B	10 N	10 N	10 N	1	30	20 L	150	100	15.00
WCR0205	170000	10000 G	2000	0.0 B	30	70	10 N	1	10	0 B	50 N	70	10.00
WCR0206	100	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	10	0 B	50 N	50	2.00
WCS0014R	20	200 N	20 N	0.0 B	10 N	10 N	20 N	1 L	5 N	0 B	50 N	70	1.50
WCS0019	560	500	20 N	1.0	10 N	10 N	10 N	1	70	20 L	50 N	50	7.00
WCS0020	150	200 N	20 N	1.0	10 N	10 N	10 N	1	20	20 L	50 N	20	10.00
WCS0021	61000	10000 G	200	100.0 G	10 N	10 N	10 L	1 N	5 N	20 N	50 N	20	0.50
WCS0023A	10	200 N	20 N	0.0 B	10 N	10 N	10	1	7	0 B	50 N	150	0.70
WCS0023R	400	500	20 N	0.0 B	10 N	10 N	20 L	1 N	5	0 B	50 N	150	0.70
WCS0024	280000	10000 G	500	100.0 G	10 N	10 N	10 L	1 L	10	20 N	50 N	100	2.00
WCS0025	2500	5000	20	100.0 G	10 N	10 N	10 L	1 N	5 N	20 N	50 N	150	2.00
WCS0026	680	1000	20 N	100.0 G	10 N	15	20	1	5 N	20 N	50 N	150	7.00
WCS0027	50000	10000 G	300	100.0 G	15	10 N	10 L	1 N	5 N	20 N	50 N	20	7.00
WCS0031	170	500	20 N	50.0	10 N	10 N	10 L	1	5 N	20 N	50 N	200	5.00
WCS0032	140	200 L	20 N	30.0	10 N	10 N	10	1	7	20 N	50 N	200	5.00
WCS0035	160	10000	20 N	19.0	10 N	10 N	10 L	1	5	40	50 N	50	20.00
WCS0039	190	200	20 N	8.0	10 N	10 N	10	1	5 N	20 N	50 N	70	0.70

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI%	S-V	S-LA	S-Y
WCR0077	1.00	2.00	20 L	2000	10 N	7	5	20	100 L	5 L	0.070	70	20 N	10
WCR0078	1.00	3.00	20 L	2000	10 N	5 N	5	10	100	5 L	0.070	10	20 N	10
WCR0079	1.00	3.00	100	1000	10 N	5 N	10	30	100	5 L	0.100	20	30	10
WCR0080	1.00	3.00	50	1500	10 N	7	5 L	10 N	100	5 L	0.070	50	20 N	10
WCR0081	0.15	0.15	20 L	200	10 N	5 N	5	10 N	100 N	5 L	0.050	20	20 N	10 N
WCR0082	0.30	1.50	150	1500	10 N	5	5	20	100 L	5 L	0.070	50	20	10
WCR0083	0.30	1.00	70	1000	10 N	5	10	10 N	100 L	5 N	0.030	30	20 N	10 L
WCR0084	0.30	0.30	100	200	10 N	5 N	5 L	10 N	100 L	5 N	0.070	50	20 N	10 N
WCR0085	0.30	1.00	200	300	10 N	7	20	200	100	5 N	0.100	150	1000 G	50
WCR0086	0.03	0.05	150	15	10 N	5 N	5 L	10 N	100 L	5 N	0.070	20	20 N	10 N
WCR0087	0.10	0.07	150	20	10 N	5 N	5 L	10 N	100 L	5 L	0.070	30	20 N	10 N
WCR0088	0.20	0.30	1000	100	10 N	5 N	5 L	10 N	500	5 N	0.100	15	20 N	10 L
WCR0089	0.20	0.50	100	500	10 N	5	5	10 N	100	5 N	0.050	30	20 N	10 L
WCR0090	0.70	1.50	150	1000	10 N	7	5	10 N	100	5 N	0.070	50	20 N	10 L
WCR0091	0.30	0.50	1000	300	10 L	5 N	5 L	10 N	300	5 N	0.100	20	20	10 N
WCR0092	0.50	1.00	500	1000	10 N	5 N	5 L	10 N	200	5 N	0.070	20	20	10 N
WCR0093	0.02 L	0.30	150	20	10 N	5 N	30	10 N	100	5 N	0.002 L	1500	50	20
WCR0196	5.00	10.00	500	700	10 N	5 N	15	10 N	200	5 N	0.050	50	20 N	15
WCR0197	0.70	0.50	700	200	1000	10	30	50	100 L	7	0.150	200	20 N	15
WCR0198	1.00	0.70	300	300	1000	7	50	100	100	5	0.150	500	20 N	20
WCR0199	0.30	0.50	500	300	100	7	70	150	100 N	10	0.100	500	20 N	30
WCR0200	0.20	0.50	150	500	500	10	100	20	100 L	5 L	0.070	200	30	20
WCR0201	0.30	0.15	200	100	300	15	100	70	100 L	5	0.070	200	100	30
WCR0202	0.50	0.30	700	500	1000	10	70	50	100 L	5	0.100	500	50	20
WCR0203	0.30	0.50	100	200	50	15	200	70	100 L	5	0.070	500	20 N	30
WCR0204	0.30	1.50	150	150	200	5	100	100	100 N	5 L	0.070	500	50	70
WCR0205	0.30	0.30	200	300	700	10	50	30	100 N	5	0.100	200	20 N	10 L
WCR0206	5.00	5.00	700	500	10 N	5 N	50	30	100	5	0.070	100	20 N	15
WCS0014R	3.00	20.00	3000	300	100	5	15	70	700	10	0.100	70	20	20
WCS0019	0.20	0.10	300	50	15	5 N	50	20	100 N	7	0.050	200	20 N	10
WCS0020	0.02	0.10	200	70	10 N	5 N	10	20	100 N	5	0.050	500	20 N	10 N
WCS0021	0.50	0.70	1000	100	10	10	10	10 L	100 N	5	0.020	15	20	10 N
WCS0023A	1.00	0.07	1000	30	100	5 N	5	70	100 L	10	0.200	500	20	10
WCS0023R	5.00	5.00	300	1000	10	7	30	10	100 L	5	0.030	50	20	10
WCS0024	1.00	2.00	500	1000	15	5	50	20	100	7	0.100	70	30	15
WCS0025	0.30	5.00	1500	200	10	5 N	50	30	100	5	0.100	20	50	10
WCS0026	5.00	0.20	1500	300	500	5 N	30	1500	100 L	50	0.700	200	70	20
WCS0027	1.00	1.00	30	2000	200	15	10	50	100 N	5	0.020	30	70	10
WCS0031	5.00	15.00	500	300	10	10	70	200	300	15	0.500	100	50	20
WCS0032	3.00	5.00	300	100	50	5	20	200	100	10	0.300	200	30	10
WCS0035	2.00	20.00	70	5000	10 N	15	70	100	100	10	0.150	200	30	30
WCS0039	0.20	0.15	100	70	30	5 N	20	100	100 N	10	0.150	3000	20	15

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCS0039A	0.05 N	10 N	1.0	1.5	0 B	200 N	4	100 N	0.02	30	50	30	20
WCS0040	0.02 L	10 N	1.2	3.0	0 B	200 N	70	100	0.14	80	70	260	150
WCS0042R	0.05 N	10 N	0.5 L	7.0	0 B	200 N	8	100 N	0.06	20	10	10	20
WCS0043R	0.40	10 N	100.0	50.0	0 B	200 N	100	100	1.50	140	200	9000	5000
WCS0057	0.02 L	10 N	0.8	0.5 L	0 B	200 N	1 L	100 N	0.02 N	5 L	20	220	100
WCS0067	0.02 L	10 N	0.6	0.7	0 B	200 N	15	100 N	0.06	290	500	30	20
WCS0071	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.02	20	50	10	70
WCS0072	0.24	10 N	1500.0	700.0	0 B	200 N	4000	3000	1.00	3000	2000	20000	15000
WCS0084	0.02 L	10 N	2.6	3.0	0 B	200 N	8	100 N	0.18	70	100	120	100
WCS0085	0.02 L	10 N	1.8	2.0	0 B	200 N	3	100 N	0.10	60	50	45	30
WCS0091	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02 L	5 L	10	25	10
WCS0093	0.04	10 N	0.2	0.5	0 B	200 N	4	100 N	0.02	5 L	70	380	500
WCS0098R	0.05 N	10 N	0.5	0.7	0 B	200 N	30	100 N	0.02	20	30	60	70
WCS0099A	0.02 L	10 N	0.2	0.5	0 B	200 N	10	100 N	0.02	5	10	510	200
WCS0105R	0.05 N	10 N	1.0	0.7	0 B	200 N	2	100 N	0.02 L	20	20	15	20
WCS0108R	0.05 N	10 N	1.0	0.5 N	0 B	200 N	1 L	100 N	0.02 N	15	10	15	15
WCS0121	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02 N	5	20	10	20
WCS0132	0.02 L	10 N	0.4	0.5 N	0 B	200 N	2	100 N	0.08	120	150	20	10 L
WCS0133	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.06	120	70	5	10
WCS0142	0.02 L	10 N	0.2	0.5 N	0 B	200 N	4	100 N	0.04	30	30	10	10
WCS0144	0.02 L	10 N	1.0	0.7	0 B	200 N	3	100 N	0.06	80	70	10	10
WCS0151R	0.05 N	10 N	0.5 L	1.0	0 B	200 N	1 L	100 N	0.04	40	50	5	10
WCS0153R	0.05 N	10 N	2.5	0.5	0 B	200 N	3	100 N	0.70	5	5 L	30	10
WCS0154R	0.05 N	10 N	2.0	0.5	0 B	200 N	8	100 N	0.22	5	10	30	20
WCS0160R	0.05 N	10 N	1.5	0.5	0 B	200 N	1	100 N	0.02	5	7	20	15
WCS0162R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.02	5	10	10	50
WCS0166R	0.05 N	10 N	2.0	0.5	0 B	200 N	2	100 N	0.02	5	7	30	10
WCS0198R	0.05 N	10 N	1.0	0.5 N	0 B	200 N	1 L	100 N	0.02	5	5	25	15
WCS0201R	0.05 N	10 N	1.0	0.5 N	0 B	200 N	1 L	100 N	0.02	5	5 L	50	20
WCS0202R	0.05 N	10 N	4.0	3.0	0 B	200 N	6	100 N	0.06	30	70	2000	1000
WCS0208R	0.05 N	10 N	1.5	3.0	0 B	200 N	1	100 N	0.10	20	50	35	50
WCS0209R	0.05 N	10 N	1.0	0.7	0 B	200 N	1	100 N	0.04	25	20	30	30
WCS0218R	0.05 N	10 N	0.5 L	0.5 N	0 B	200 N	1 L	100 N	0.02	5	15	5	30
WCS0220R	0.05 N	10 N	1.0	0.5	0 B	200 N	1 L	100 N	0.02	10	5	15	15
WCS0221R	0.05 N	10 N	1.0	1.5	0 B	200 N	1 L	100 N	0.04	20	50	10	10
WCS0225R	0.05 N	10 N	1.5	0.5 N	0 B	200 N	1 L	100 N	0.02 L	10	5 L	40	10
WCS0228R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.04	30	20	15	20
WCS0229R	0.05 N	10 N	1.0	0.5	0 B	200 N	1	100 N	0.04	30	20	40	15
WCS0231R	0.05 N	10 N	1.0	0.7	0 B	200 N	1	100 N	0.04	5	10	25	20
WCS0233R	0.05 N	10 N	1.0	0.5	0 B	200 N	2	100 N	0.04	10	15	30	30
WCS0239R	0.05 N	10 N	1.0	1.0	0 B	200 N	2	100 N	0.04	30	50	80	100
WCS0240R	0.05 N	10 N	1.0	2.0	0 B	200 N	1 L	100 N	0.02	15	15	30	10

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCS0039A	50	200 N	20 N	0.0 B	10 N	10 N	20 L	1 N	5 N	0 B	50 N	100	1.00
WCS0040	370	500	20 N	5.0	10 N	10 N	10 L	1	20	20 N	50 N	50	3.00
WCS0042R	10	200 N	20 N	0.0 B	10 N	10 N	10	1	50	0 B	50 N	150	1.00
WCS0043R	800	1000	20	0.0 B	10 N	30	10	1	100	0 B	50 N	70	2.00
WCS0057	390	300	20 N	14.0	10 N	10 N	10 L	2	5 N	20 N	50 N	100	1.50
WCS0067	700	1500	20 N	4.0	10 N	10 N	10	2	20	20 N	50 N	150	10.00
WCS0071	110	200 N	20 N	1.0	10 N	10 N	10 L	2	5 N	20 N	50 N	50	7.00
WCS0072	16000	10000 G	150	100.0	10 N	10 N	10 L	1 N	5 N	20 L	50 N	10 N	20.00
WCS0084	220	200	20 N	2.0	10 N	10 N	10	2	10	20 N	50 N	300	5.00
WCS0085	600	1000	20 N	4.0	10 N	10 N	10	2	5 N	20 H	50 N	70	3.00
WCS0091	60	200 N	20 N	10.0	10 N	20	100	1 L	5 N	20 N	50 N	700	0.07
WCS0093	20	200 N	20 N	2.0	10 N	30	70	2	5 N	20 N	50 N	150	5.00
WCS0098R	75	200 N	20 N	0.0 B	10 N	10 N	10	1	10	0 B	50 N	200	3.00
WCS0099A	30	200 N	20 N	2.0	10 N	10 N	15	2	5 N	20 N	50 N	200	1.00
WCS0105R	25	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	300	2.00
WCS0108R	5	200 N	20 N	0.0 B	10 N	10 N	20 L	1 L	5 N	0 B	50 N	100	0.50
WCS0121	40	200 N	20 N	0.5	10 N	10 N	20	1	10	20 N	50 N	150	7.00
WCS0132	40	300	20 N	0.5	10 N	10 N	10 N	1	50	20 N	50 N	100	10.00
WCS0133	1000	1000	20 N	17.0	10 N	10 N	10	2	20	20 N	50 N	70	2.00
WCS0142	130	200	20 N	3.0	10 N	10 N	10 L	1	5 N	20 N	50 N	150	5.00
WCS0144	350	200	20 N	9.0	10 N	10 N	15	1	15	20 N	50 N	100	1.00
WCS0151R	20	200 N	20 N	0.0 B	10 N	10 N	20 L	1 L	10	0 B	50 N	150	3.00
WCS0153R	20	200 N	20 N	0.0 B	10 N	10 N	20 L	1 N	5 N	0 B	50 N	70	0.30
WCS0154R	25	200 N	20 N	0.0 B	10 N	10 N	20 L	1 N	5 N	0 B	50 N	50	0.30
WCS0160R	20	200 N	20 N	0.0 B	10 N	10 N	20 L	1 N	5 N	0 B	50 N	200	0.50
WCS0162R	20	200 N	20 N	0.0 B	10 N	10 N	50	3	5 N	0 B	50 N	200	2.00
WCS0166R	15	200 N	20 N	0.0 B	10 N	10 N	20 N	1 N	5 N	0 B	50 N	150	0.50
WCS0198R	35	200 N	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	200	3.00
WCS0201R	20	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	300	1.00
WCS0202R	130	200 N	20 N	0.0 B	10 N	10 N	10 L	1	5	0 B	50 N	150	7.00
WCS0208R	30	200 N	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	200	1.00
WCS0209R	30	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	2.00
WCS0218R	10	200 N	20 N	0.0 B	10 N	10 L	10	1	10	0 B	50 N	150	3.00
WCS0220R	110	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	200	1.00
WCS0221R	45	200 N	20 N	0.0 B	10 N	10 N	10	1 L	20	0 B	50 N	500	2.00
WCS0225R	110	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	30	0.30
WCS0228R	100	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	150	5.00
WCS0229R	40	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	100	3.00
WCS0231R	35	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	0.50
WCS0233R	1100	200	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	200	3.00
WCS0239R	65	200 N	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	300	2.00
WCS0240R	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	0.70

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI %	S-V	S-LA	S-Y
WCS0039A	0.05	0.70	150	200	10	5	20	30	100 L	5 L	0.070	100	30	10
WCS0040	0.15	1.50	300	200	10	5 N	50	70	100	7	0.100	2000	50	100
WCS0042R	0.50	0.05 L	1000	30	100	5 N	10	70	100 N	10	0.300	500	20	100
WCS0043R	0.20	0.20	500	200	30	5 L	50	70	100 L	7	0.100	300	30	20
WCS0057	0.50	10.00	100	1000	15	5 N	5	10 L	100	5	0.070	20	20	10
WCS0067	0.50	0.15	1000	100	150	10	150	70	100	10	0.200	200	20	15
WCS0071	1.00	0.50	300	200	10 L	15	50	100	100	7	0.100	50	20	10
WCS0072	2.00	3.00	30	5000 G	10 N	5 N	15	10	150	5	0.010	300	20 N	20
WCS0084	1.00	0.30	1500	100	100	5	100	100	100 L	15	0.300	700	50	30
WCS0085	0.70	0.30	300	200	70	10	70	30	100 L	10	0.150	200	20	20
WCS0091	0.15	0.70	70	100	500	5 N	5 L	10 L	100 N	10	1.000	50	50	200
WCS0093	0.50	0.10	1000	50	1000	5 N	5 L	10 L	100 L	5	0.200	50	100	10 L
WCS0098R	7.00	7.00	200	1000	70	5	30	150	100	15	0.300	150	50	50
WCS0099A	0.50	0.05	500	50	50	5 N	5 L	10 L	100 L	5	0.150	30	30	10
WCS0105R	3.00	3.00	700	700	70	5	30	70	100	10	0.200	100	30	20
WCS0108R	0.15	5.00	150	300	15	5 L	15	50	100	5	0.070	200	30	20
WCS0121	2.00	2.00	700	700	10	15	10	70	500	15	0.300	70	150	15
WCS0132	5.00	10.00	150	700	10 N	15	150	1000	300	10	0.200	500	20 N	20
WCS0133	0.70	1.00	1500	70	10	7	150	50	100	5	0.150	500	20	20
WCS0142	5.00	10.00	700	2000	10	10	30	20	100	5	0.100	70	20 N	15
WCS0144	1.00	0.50	2000	70	10	5 N	100	100	100 L	7	0.150	700	30	20
WCS0151R	3.00	5.00	200	500	10	5	30	70	100	7	0.200	100	20	20
WCS0153R	0.50	20.00	70	150	10 L	5 N	5	70	300	5	0.050	30	30	20
WCS0154R	0.10	15.00	150	100	10 L	5 N	5	50	100	5	0.030	30	20	15
WCS0160R	0.70	10.00	200	200	10	5 N	10	50	100	5	0.050	30	20	15
WCS0162R	0.07	0.10	70	500	10	5 N	5 L	10 L	100 N	5 L	0.070	20	70	30
WCS0166R	0.30	10.00	100	500	10 L	5 N	5	50	150	5 L	0.070	20	20	20
WCS0198R	5.00	5.00	500	700	20	5 L	20	50	300	7	0.100	70	20	15
WCS0201R	2.00	20.00	100	500	10 L	5 N	5	70	200	5	0.100	20	20	20
WCS0202R	1.50	1.00	50	200	500	7	30	70	100 N	7	0.100	100	20 N	10
WCS0208R	2.00	3.00	200	150	100	5	20	200	100 L	10	0.300	100	50	20
WCS0209R	3.00	20.00	500	1000	100	5	20	150	700	10	0.300	150	30	30
WCS0218R	3.00	5.00	300	300	100	5 L	15	100	300	15	0.500	100	30	30
WCS0220R	3.00	20.00	150	700	20	5 N	15	100	200	5	0.200	50	30	20
WCS0221R	2.00	1.00	200	200	200	5 N	30	300	100	10	0.500	200	50	50
WCS0225R	1.00	20.00	70	200	10 L	5 N	10	50	700	5 L	0.050	20	20	15
WCS0228R	3.00	2.00	5000	700	100	7	50	150	200	20	0.300	200	50	30
WCS0229R	2.00	15.00	200	3000	20	5	20	100	700	7	0.200	100	30	30
WCS0231R	2.00	15.00	150	500	50	5 N	15	50	150	5	0.100	30	20	15
WCS0233R	2.00	10.00	150	2000	20	5 N	15	50	100	5	0.150	20	20	15
WCS0239R	2.00	5.00	300	200	50	5	70	100	100	10	0.200	70	30	20
WCS0240R	2.00	20.00	150	150	10	5 N	20	100	300	5	0.100	30	30	20

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCS0241R	0.05 N	10 N	1.0	1.5	0 B	200 N	1 L	100 N	0.02	15	20	20	10
WCS0242R	0.05 N	10 N	1.0	0.5 L	0 B	200 N	1	100 N	0.02 N	10	10	35	20
WCS0245R	0.20	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.02 N	5 L	5	10	15
WCS0246R	0.05 N	10 N	1.0	1.0	0 B	200 N	50	100 N	0.04	15	15	300	100
WCS0251R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.02	10	10	10	20
WCS0252R	0.05	10 N	13.0	5.0	0 B	200	1 L	100 N	0.06	70	70	700	300
WCS0255R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1	100 N	0.02	20	30	15	50
WCS0256R	0.05 N	10 N	1.0	2.0	0 B	200 N	1	100 N	0.04	30	20	30	50
WCS0257R	0.05 N	10 N	260.0	100.0	0 B	200 N	1	100 N	0.08	65	100	1000	500
WCS0258R	0.05 N	10 N	18.0	15.0	0 B	200	15	100 N	0.14	750	500	20000	10000
WCS0259R	0.05 N	10 N	2.0	0.5	0 B	200 N	1 L	100 N	0.02	15	5	85	150
WCS0262R	0.05 N	10 N	0.5	0.5	0 B	200 N	1	100 N	0.06	75	50	10	15
WCS0263R	0.05 N	10 N	1.5	1.0	0 B	200 N	1 L	100 N	0.02	35	20	10	15
WCS0264R	0.05 N	10 N	1.0	0.5 N	0 B	200 N	1 L	100 N	0.02	20	5	20	10
WCS0270R	0.05 N	10 N	1.0	0.7	0 B	200 N	1	100 N	0.04	30	15	20	10
WCS0271R	0.05 N	10 N	4.0	3.0	0 B	200 N	5	100 N	0.12	100	50	25	20
WCS0272R	0.05 N	10 N	150.0	70.0	0 B	200 N	32000	10000 G	0.24	350	150	20000	10000
WCS0273R	0.05 N	10 N	2.0	0.5	0 B	200 N	70	100 N	0.10	10	5 L	140	200
WCS0274R	0.05 N	10 N	1.0	1.5	0 B	200 N	30	100 N	0.02	20	15	70	70
WCS0275R	0.05 N	10 N	0.5	1.0	0 B	200 N	3	100 N	0.02	10	15	15	15
WCS0280R	1.00	10 N	10.0	20.0	0 B	200 N	300	2000	2.00	1500	700	2200	700
WCS0281R	0.05 N	10 N	1.0	0.7	0 B	200 N	10	100 N	0.04	15	10	15	20
WCS0282R	0.05 N	10 N	1.0	1.0	0 B	200 N	10	100 N	0.06	250	150	10	10
WCS0283R	0.05 N	10 N	0.5 L	1.0	0 B	200 N	5	100 N	0.06	50	20	15	10
WCS0286R	0.05 N	10 N	0.5 L	0.5	0 B	200 N	1	100 N	0.08	70	70	5	10 L
WCS0288R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.02	5	10	5 L	30
WCS0289R	0.05 N	10 N	2.0	0.7	0 B	200 N	2	100 N	0.04	20	70	5 L	10
WCS0291R	0.05 N	10 N	0.5 L	1.5	0 B	200 N	2	100 N	0.10	500	200	10	20
WCS0294R	0.05 N	10 N	13.0	15.0	0 B	200 N	30	100 N	0.40	400	500	40	70
WCS0296R	0.05 N	10 N	2.5	0.5 L	0 B	200 N	1 L	100 N	0.04	20	7	60	15
WCS0297R	0.05 N	10 N	0.5 L	0.5 L	0 B	200 N	1 L	100 N	0.02 L	45	20	5	10
WCS0299R	0.05 N	10 N	2.5	1.0	0 B	200 N	1 L	100 N	0.02	40	20	30	20
WCS0300R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.02	30	30	10	30
WCS0302R	0.05 N	10 N	1.0	1.5	0 B	200 N	1	100 N	0.06	65	50	80	70
WCS0303R	0.05 N	10 N	1.5	10.0	0 B	200 N	1	100 N	0.02	5	10	20	20
WCS0306R	0.50	10 N	40.0	20.0	0 B	200	6000	10000	0.18	10	10	45000	10000
WCS0307R	0.05 N	10 N	2.5	2.0	0 B	200 N	70	100 N	0.06	45	30	160	300
WCS0308R	0.05 N	10 N	1.0	0.7	0 B	200 N	30	100 N	0.04	5	20	70	100
WCS0310R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	8	100 N	0.14	120	100	20	50
WCS0314R	0.05 N	10 N	1.0	0.5	0 B	200 N	10	100 N	0.28	25	20	20	10
WCS0315R	0.05 N	10 N	1.0	0.5 N	0 B	200 N	1 L	100 N	0.02	5	5 L	15	10
WCS0316R	0.05 N	10 N	1.0	1.0	0 B	200 N	3	100 N	0.04	10	20	20	20

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCS0241R	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	1.50
WCS0242R	20	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	200	1.50
WCS0245R	50	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	300	5.00
WCS0246R	35	200 N	20 N	0.0 B	1000 G	10 N	10 L	1	5 N	0 B	50 N	20	0.50
WCS0251R	5 L	200 N	20 N	0.0 B	10 N	50	10	1	5 N	0 B	50 L	100	3.00
WCS0252R	70	200 N	20 N	0.0 B	15	10 N	10 L	2	5 N	0 B	50 L	10 N	3.00
WCS0255R	600	700	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 L	100	3.00
WCS0256R	800	700	30	0.0 B	10 N	15	10	2	7	0 B	50 L	150	3.00
WCS0257R	800	1500	20 N	0.0 B	300	10 N	10 L	1 N	30	0 B	50 N	10 N	5.00
WCS0258R	30000	10000 G	200	0.0 B	10 N	10 N	10 L	1 N	5	0 B	50	20	20.00
WCS0259R	130	500	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	50	1.00
WCS0262R	110	200 L	20 N	0.0 B	10 N	10 N	10	1	10	0 B	50 N	150	3.00
WCS0263R	120	200 L	20 N	0.0 B	10 N	10 N	10	1 L	10	0 B	50 N	100	0.50
WCS0264R	30	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50	50	2.00
WCS0270R	15	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	70	2.00
WCS0271R	150	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	7	0 B	50 N	50	10.00
WCS0272R	250000	10000 G	5000	0.0 B	50	100	10	1 N	5 N	0 B	50 N	100	10.00
WCS0273R	5500	1000	30	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	70	0.50
WCS0274R	220	200	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	100	0.20
WCS0275R	130	200	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	150	0.30
WCS0280R	15000	10000 G	150	0.0 B	150	100	10 L	1 L	10	0 B	50	10	20.00
WCS0281R	50	200 N	20 N	0.0 B	10 N	10 N	10	1	7	0 B	50 N	150	0.30
WCS0282R	700	1000	20 N	0.0 B	10 N	10 N	10	2	5	0 B	50 N	70	2.00
WCS0283R	140	200	20 N	0.0 B	10 N	10 N	10	1 L	5	0 B	50 N	70	1.00
WCS0286R	1600	1000	20	0.0 B	10 N	10 N	10 L	1 L	20	0 B	50 N	70	1.00
WCS0288R	110	200 N	20 N	0.0 B	10 N	10 N	15	2	5 N	0 B	50 N	150	3.00
WCS0289R	50	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	0.30
WCS0291R	40	200 N	20 N	0.0 B	10 N	15	10	1 N	5	0 B	50 N	100	7.00
WCS0294R	3000	2000	20	0.0 B	10 N	10 N	10 L	1	15	0 B	50 N	70	3.00
WCS0296R	40	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	70	1.00
WCS0297R	150	200	30	0.0 B	10 N	10 N	10	1	10	0 B	50 N	150	1.50
WCS0299R	150	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	50	2.00
WCS0300R	50	200 N	20 N	0.0 B	10 N	10 L	15	2	200	0 B	50 N	150	3.00
WCS0302R	140	200 L	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	150	2.00
WCS0303R	180	200	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	200	0.15
WCS0306R	100	200 N	20 N	0.0 B	10 N	70	10 L	1 L	5 N	0 B	50 N	200	2.00
WCS0307R	2500	700	20	0.0 B	10 N	10 N	10 L	1 L	7	0 B	50 N	150	1.00
WCS0308R	5	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	200	1.00
WCS0310R	45	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	7.00
WCS0314R	1600	300	50	0.0 B	10 N	10 N	10 L	1	15	0 B	50 N	100	10.00
WCS0315R	5	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	700	0.30
WCS0316R	5	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	100	2.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI %	S-V	S-LA	S-Y
WCS0241R	3.00	10.00	150	200	20	5	30	100	200	7	0.150	70	20	20
WCS0242R	1.00	20.00	5000 G	300	10 L	5 N	5	50	300	5	0.100	30	20	20
WCS0245R	2.00	3.00	700	1000	10	5	15	100	1000	10	0.500	100	50	15
WCS0246R	0.02	0.07	30	30	10 L	5 N	10	10 L	100 N	5	0.010	10	20	10 L
WCS0251R	2.00	1.50	1000	200	700	5 N	5 L	70	700	10	0.500	100	70	15
WCS0252R	0.02	0.05 L	20	30	10 N	20	20	10	100 N	5 L	0.005	10	20	10 N
WCS0255R	2.00	2.00	1000	500	10 L	15	70	200	500	10	0.300	70	50	15
WCS0256R	0.30	0.07	200	5000	20	5 N	20	20	100 L	5	0.200	50	30	10
WCS0257R	0.02	0.05 L	20 L	2000	10	5 N	5	10 L	100 N	5	0.002	20	20 N	10
WCS0258R	1.50	5.00	20 L	5000 G	10 N	5	20	30	100 L	5	0.050	100	20 N	15
WCS0259R	2.00	20.00 G	1500	300	70	5 L	15	70	1000	5	0.100	50	20	10
WCS0262R	3.00	5.00	300	500	15	7	50	70	150	10	0.200	100	20	20
WCS0263R	1.00	0.70	700	70	50	5 N	50	70	100	10	0.200	200	20	30
WCS0264R	2.00	20.00	700	500	10 L	5	30	70	200	7	0.100	70	20	10
WCS0270R	3.00	10.00	150	150	10	5	50	150	300	7	0.200	70	20	15
WCS0271R	5.00	5.00	20 N	700	10 L	5 N	5	70	100 N	7	0.070	200	20 N	10
WCS0272R	0.30	0.10	20 L	500	1500	7	50	30	100 N	7	0.150	100	30	30
WCS0273R	1.50	20.00	30	200	20	5 N	10	50	500	5 L	0.050	20	20	20
WCS0274R	0.20	10.00	500	300	20	5 N	15	50	300	5	0.070	150	20	15
WCS0275R	2.00	1.00	500	200	100	5 N	30	100	150	7	0.200	500	20	20
WCS0280R	0.02	0.05	20 N	20	10 N	5 N	10	20	100 N	5 L	0.005	30	20 N	20
WCS0281R	0.50	0.07	700	20	200	5 N	5	50	100 L	7	0.200	500	30	10
WCS0282R	0.30	0.20	300	50	200	5	70	30	300	7	0.070	300	30	20
WCS0283R	0.70	0.20	100	50	20	5 N	30	50	100	7	0.070	300	50	15
WCS0286R	1.00	2.00	500	50	10 L	5	50	70	100	7	0.100	500	30	20
WCS0288R	0.70	1.00	700	700	10 L	5 N	5	10	700	7	0.200	50	30	10
WCS0289R	0.20	3.00	700	150	30	5 N	15	50	100	5	0.150	200	20	15
WCS0291R	3.00	5.00	500	300	10	20	15	200	500	30	0.500	300	20	20
WCS0294R	10.00	15.00	100	700	10	10	50	100	100 N	7	0.100	500	20	15
WCS0296R	2.00	20.00 G	700	700	70	5 N	70	100	1000	10	0.200	100	30	20
WCS0297R	3.00	5.00	1000	200	10	5	150	200	200	10	0.200	1500	70	30
WCS0299R	2.00	20.00 G	100	500	70	5	20	70	1000	7	0.100	50	20	15
WCS0300R	1.00	1.00	700	500	10	5 L	5 L	10	1000	5	0.200	30	50	10
WCS0302R	2.00	3.00	2000	1000	10	5	30	200	200	10	0.300	200	30	20
WCS0303R	0.70	15.00	150	700	150	5 N	5	20	100	5	0.070	20	20	15
WCS0306R	0.07	0.07	20 L	10	500	5	10	20	100 L	5	0.070	10	20	10 L
WCS0307R	0.30	10.00	20	300	20	5	50	70	100	5	0.100	200	20	10
WCS0308R	1.50	10.00	300	200	10	5 N	7	50	100	5	0.150	20	20	15
WCS0310R	5.00	3.00	1000	1000	10 L	30	100	700	500	20	0.300	150	30	20
WCS0314R	0.50	1.00	100	100	20	5 L	50	70	100	5	0.050	300	20	20
WCS0315R	0.70	7.00	200	150	10 L	5 N	5	50	150	5	0.150	20	20	15
WCS0316R	2.00	7.00	100	150	50	5	30	150	150	7	0.200	50	30	15

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCS0318R	0.05	10 N	12.0	10.0	0 B	200	40	100 N	0.24	35	50	10000	5000
WCS0319R	0.05 N	10 N	0.5 N	0.5	0 B	200 N	1	100 N	0.02	15	10	30	70
WCS0354R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.02 N	5	70	10	30
WCS0375R	0.05 N	10 N	0.5 N	0.5 N	0 B	200 N	1 L	100 N	0.02	10	15	5	10
WCS0387R	0.05 N	10 N	1.5	1.5	0 B	200 N	4	100 N	0.02 L	5 L	5	10	10
WCS0393R	0.05 N	10 N	1.0	0.5	0 B	200 N	2	100 N	0.02 L	5	5 L	30	50
WCS0395R	0.05 N	10 N	1.0	0.5	0 B	200 N	1 L	100 N	0.02 N	5	5 L	50	10 L
WCS0398R	0.05 N	10 N	1.0	0.7	0 B	200 N	1 L	100 N	0.02 N	5	5 L	25	10
WCS0400R	0.05 N	10 N	0.5	1.0	0 B	200 N	2	100 N	0.02 N	20	20	10	20
WCS0403R	0.05 N	10 N	0.5 L	1.0	0 B	200 N	1 L	100 N	0.02 N	5 L	5 L	5	15
WCS0405R	0.05 N	10 N	1.5	1.0	0 B	200 N	1 L	100 N	0.02	5	5 L	30	10
WCS0406R	0.05 N	10 N	1.0	1.5	0 B	200 N	1 L	100 N	0.02 N	25	20	10	20
WCS0407R	0.05 N	10 N	1.0	1.0	0 B	200 N	1 L	100 N	0.02	10	15	25	15
WCS0408R	0.05 N	10 N	1.0	1.0	0 B	200 N	1	100 N	0.04	10	10	10	15
WCS0411R	0.05 N	10 N	0.5	1.0	0 B	200 N	5	100 N	0.02	55	100	10	30
WCS0414R	0.05 N	10 N	4.0	5.0	0 B	200 N	6	100 N	0.08	40	50	10	20
WCS0415R	0.05 N	10 N	1.5	2.0	0 B	200 N	4	100 N	0.04	130	100	10	10
WCS0417R	0.05 N	10 N	2.5	3.0	0 B	500	300	500	0.24	130	500	10	30
WCS0418R	0.05 N	10 N	0.5	0.5	0 B	200 N	10	100 N	0.02	55	50	10	15
WCS0419R	0.05 N	10 N	0.5 L	0.7	0 B	200 N	30	100 N	0.08	15	20	10	15
WCS0422R	0.05 N	10 N	1.0	1.0	0 B	200 N	2	100 N	0.02	10	5	90	100
WCS0423R	0.05 N	10 N	1.0	0.5	0 B	200 N	1	100 N	0.02	5	5	25	30
WCS0424R	0.05 N	10 N	0.5	0.5 N	0 B	1000	100	200	10.00 G	15	30	20	50
WCS0427R	0.05 N	10 N	6.5	5.0	0 B	500	80	100 L	3.50	10	10	360	150
WCS0455	0.10	10 N	79.0	20.0	140	200 N	50	100 N	0.75	80	50	2400	500
WCS0477	0.05 N	10 N	1.5	1.5	60	200 N	15	100 N	0.04	30	30	35	15
WCS0482	0.05 L	10 N	1.0	0.5	80	200 N	40	100 N	0.04	30	15	350	100
WCS0483	0.05 N	10 N	4.0	1.5	10 L	200 N	8	100 N	0.08	40	20	35	10
WCS0485	0.05 N	10 N	0.5 L	0.5 N	10 L	200 N	6	100 N	0.50	120	70	45	20
WCS0487	0.05 N	10 N	1.0	1.0	10 L	200 N	4	100 N	0.06	85	70	65	30
WCS0500	0.05 N	10 N	1.0	0.7	60	200 N	15	100 N	0.45	15	500	20	10
WCS0510	0.05 N	10 N	1.5	1.5	10 L	200 N	5	100 N	0.02 L	80	70	35	15
WCS0520	0.05 N	10 N	0.5 N	0.5	10 L	200 N	1 L	100 N	0.02 N	25	20	15	20
WCT0072M	0.02 L	10 N	560.0	500.0	0 B	7000	500	500	300.00	2000	1000	16000	20000 G
WCT0074R	0.02 L	10 N	1.5	2.0	0 B	200 N	1	100 N	0.70	10	15	90	150
WCT0079R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.04	35	15	35	20
WCT0084R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.06	35	30	15	15
WCT0091	0.02 L	10 N	2.0	0.5 N	0 B	200 N	1	100 N	0.04	5 L	5 N	40	10 N
WCT0092	0.02 L	10 N	1.0	0.5 N	0 B	200 N	15	100 N	0.50	20	7	135	20
WCT0094	0.02 L	10 N	1.0	1.0	0 B	200 N	1	100 N	0.06	30	20	55	50
WCT0110M	0.02 L	10 N	1.0	0.5 N	0 B	200 N	1	100 N	0.01 L	5 L	7	20	10
WCT0117R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.01	5	10	5	10 N

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCS0318R	9000	10000	50	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	200	10.00
WCS0319R	50	200 N	50	0.0 B	10 N	10 N	15	2	7	0 B	50 N	150	3.00
WCS0354R	40	200 N	20 N	0.0 B	10 N	10 N	15	1	10	0 B	50 N	200	7.00
WCS0375R	5 L	200 N	20 N	0.0 B	10 N	70	15	5	100	0 B	50	300	7.00
WCS0387R	25	200 N	20 N	0.0 B	10 N	10	10	5	5 N	0 B	50 N	100	2.00
WCS0393R	10	200 N	20 N	0.0 B	10 N	10 N	10	1 N	5 N	0 B	50 N	70	1.50
WCS0395R	15	200 N	20 N	0.0 B	10 N	10 N	20 L	1 N	5 N	0 B	50 N	20	0.50
WCS0398R	20	200 N	20 N	0.0 B	10 N	10 N	20 L	1 N	5 N	0 B	50 N	50	0.70
WCS0400R	20	200 N	20 N	0.0 B	10 N	10 L	10	1	100	0 B	50 N	200	2.00
WCS0403R	120	500	20 N	0.0 B	10 N	10 N	10	1 N	5 N	0 B	50 N	500	2.00
WCS0405R	10	200 N	20 N	0.0 B	10 N	10 N	10	1 N	5 N	0 B	50 N	200	0.50
WCS0406R	10	200 N	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50 N	700	2.00
WCS0407R	80	200 N	20 N	0.0 B	10 N	10 N	20 L	1 N	5 N	0 B	50 N	100	1.50
WCS0408R	5	200 N	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	500	1.50
WCS0411R	10	200 N	20 N	0.0 B	10 N	10 L	10	1 N	20	0 B	50 N	200	2.00
WCS0414R	130	200	20 N	0.0 B	10 N	10 N	15	1	20	0 B	50 N	100	0.70
WCS0415R	700	2000	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	70	0.70
WCS0417R	850	5000	50	0.0 B	10 N	10 N	10	2	500	0 B	50	100	15.00
WCS0418R	170	500	20 N	0.0 B	10 N	10 N	10	1	5	0 B	50 N	100	5.00
WCS0419R	10	500	20 N	0.0 B	10 N	10 N	10	1	20	0 B	50 N	500	2.00
WCS0422R	60	500	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	200	2.00
WCS0423R	80	500	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	150	2.00
WCS0424R	30	500	20 N	0.0 B	10 N	10 N	15	1	5 N	0 B	50	100	20.00
WCS0427R	4500	10000	20 N	0.0 B	10 N	10 N	10	1 N	5 N	0 B	50 N	10	5.00
WCS0455	2400	1500	20 N	0.0 B	20	10 N	20 N	1 N	5 N	0 B	50 N	100	2.00
WCS0477	20	200 N	20 N	0.0 B	10 N	10 N	20 L	1	50	0 B	50 N	70	3.00
WCS0482	15	200 N	20 N	0.0 B	10 N	10 N	20	1 L	5 N	0 B	50 N	70	1.50
WCS0483	120	200 N	20 N	0.0 B	10 N	10 N	20 L	2	5 N	0 B	50 N	50	0.50
WCS0485	360	300	20 N	0.0 B	10 N	10 N	20 L	2	5 N	0 B	50 N	100	5.00
WCS0487	190	200	20 N	0.0 B	10 N	10 N	20 L	1	5 N	0 B	50 N	70	5.00
WCS0500	65	200 N	20 N	0.0 B	10 N	10 N	20 L	1	5 N	0 B	50 N	300	1.50
WCS0510	30	200 N	20 N	0.0 B	10 N	10 N	20 L	1	50	0 B	50 N	70	1.00
WCS0520	160	200 N	20 N	0.0 B	10 N	10 N	20	1	5 N	0 B	50 N	500	3.00
WCT0072M	100000 G	10000 G	5000	0.0 B	10 N	10 N	10 N	1 N	30	20 H	50 N	10 N	7.00
WCT0074R	110	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5	20 N	50 N	100	5.00
WCT0079R	45	200 N	20 N	0.0 B	10 N	10 N	10 N	2	10	20 L	50 N	100	7.00
WCT0084R	680	500	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 N	50 N	100	5.00
WCT0091	15	200 N	20 N	0.0 B	10 N	10 N	10 N	2	5 N	20 N	50 N	10 N	0.05
WCT0092	290	200 L	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	20 N	50 N	50	1.50
WCT0094	1800	1000	20 N	0.0 B	10 N	20	10 N	1	5 N	20 N	50 N	100	3.00
WCT0110M	10	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	20 N	50 N	150	2.00
WCT0117R	40	200	20 N	0.0 B	10 N	15	10 N	3	1000	20 H	50 N	100	7.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI %	S-V	S-LA	S-Y
WCS0318R	0.70	0.70	50	2000	15	5 N	20	70	100 L	5	0.150	50	30	20
WCS0319R	0.70	0.70	700	300	10 L	5 N	5	10	700	5	0.200	30	50	10
WCS0354R	3.00	3.00	700	1000	20	15	30	150	700	15	0.500	150	50	30
WCS0375R	1.50	0.05	500	1500	20	5 L	5 L	10	100 L	15	0.700	150	300	20
WCS0387R	0.20	2.00	500	100	10	5 N	5	10	150	7	0.150	30	30	10
WCS0393R	3.00	20.00	150	700	30	5 N	20	100	500	7	0.150	50	20	15
WCS0395R	1.00	20.00 G	20 L	700	10 N	5 N	5	30	300	5 N	0.020	20	30	20
WCS0398R	1.50	20.00	50	200	20	5 N	15	70	150	7	0.070	30	20	30
WCS0400R	1.50	1.00	500	500	150	5 N	10	70	100	15	0.300	150	30	30
WCS0403R	3.00	10.00	100	1000	10	5 L	15	50	100 L	5	0.100	30	30	20
WCS0405R	0.70	20.00	50	150	15	5 N	7	100	300	5	0.100	50	30	20
WCS0406R	3.00	3.00	500	200	150	5 N	15	300	100	20	0.700	200	70	50
WCS0407R	0.70	20.00 G	70	500	10 L	5 N	15	70	500	5	0.100	50	30	30
WCS0408R	3.00	7.00	200	200	50	5 N	20	70	100	7	0.200	50	30	20
WCS0411R	0.50	0.05 L	500	20	500	5 N	5	200	100 L	15	0.700	300	50	30
WCS0414R	1.00	0.15	2000	70	70	5 N	70	70	100	10	0.200	1000	30	20
WCS0415R	0.20	0.15	200	200	20	5 N	70	50	100 L	7	0.050	500	30	20
WCS0417R	0.50	0.10	1500	150	150	5 L	150	70	100 L	10	0.200	700	20 N	30
WCS0418R	0.30	0.05	1000	50	50	5 N	30	30	100 N	10	0.200	300	30	20
WCS0419R	0.50	0.05	2000	20	200	5 N	5	70	100 L	10	0.200	500	30	20
WCS0422R	2.00	20.00	200	1000	30	5 L	20	100	700	10	0.200	70	50	30
WCS0423R	1.50	20.00	500	2000	10	5	20	70	700	10	0.200	50	30	20
WCS0424R	0.50	0.20	300	50	10	5 N	15	50	100 L	10	0.200	200	50	15
WCS0427R	0.05	1.00	20	200	10	5 N	10	10	100 N	5	0.015	30	30	20
WCS0455	0.20	0.15	50	10	500	5 N	5 L	10	100 L	5 L	0.070	10	20	10
WCS0477	0.30	0.07	300	10	100	5 N	7	70	100	7	0.100	500	30	15
WCS0482	0.20	0.05 L	200	20	50	5 N	5 L	15	100 L	5	0.070	100	30	10
WCS0483	0.07	0.20	200	20	15	5 N	5	30	700	7	0.070	200	20	70
WCS0485	0.30	0.15	300	150	30	5	100	50	100 L	10	0.150	200	30	15
WCS0487	0.30	0.10	300	300	50	10	50	50	100 N	7	0.100	200	30	15
WCS0500	0.20	0.07	100	70	50	5 N	7	20	100 N	7	0.150	50	30	15
WCS0510	0.30	0.05 L	500	20	100	5	30	150	100 N	10	0.200	1000	20	10
WCS0520	3.00	1.50	300	200	100	5 N	30	200	100	10	0.500	150	30	30
WCT0072M	0.02 L	0.05 L	5000 G	100	10 N	5 N	15	10 N	200	5 N	0.002 L	10 L	20 N	10 N
WCT0074R	2.00	5.00	1000	1000	10 N	10	30	100	200	10	0.100	70	20	10
WCT0079R	1.50	0.07	100	300	10 L	15	50	200	100 N	10	0.100	50	30	10
WCT0084R	1.00	0.50	1000	100	10 L	15	50	200	300	10	0.100	50	20	10
WCT0091	0.70	15.00	500	700	10 N	5 N	5 N	10 N	1500	5 N	0.005	10 L	20 N	10
WCT0092	1.00	1.50	100	500	10	5 N	10	10 N	100 N	5 L	0.050	30	20 N	10 L
WCT0094	1.50	1.50	1000	1000	10 N	10	20	100	300	7	0.150	50	30	10
WCT0110M	2.00	10.00	50	300	10 N	7	20	70	200	5	0.100	30	20 N	10
WCT0117R	1.50	5.00	20 N	2000	10 N	10	20	20	100 L	5 L	0.050	70	20 N	15

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCT0120R	3.50	10 N	9.0	5.0	0 B	2000	30	100 L	0.18	150	100	1000	200
WCT0121R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.01 L	5	7	10	10 N
WCT0122R	0.04	10 N	1.5	1.0	0 B	1500	10	100 N	0.02	10	10	500	100
WCT0123R	0.02	10 N	1.0	2.0	0 B	200 N	60	100 L	0.01	10	15	700	200
WCT0124R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.01	10	15	5	10 N
WCT0125R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.02	35	20	5 L	10 N
WCT0126R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.01 L	5 L	15	5 L	10 N
WCT0171M	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1	100 N	0.04	20	70	25	70
WCT0183R	0.02 L	10 N	2.0	1.5	0 B	200 N	7	100 N	0.10	150	300	25	50
WCT0213M	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.04	5	30	15	10 N
WCT0229M	0.04	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.05	55	70	5	10 N
WCT0233M	0.02 L	10 N	0.4	0.5	0 B	200 N	1	100 N	0.04	200	300	10	10 N
WCT0250M	0.30	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.04	75	30	20	10
WCT0251M	0.06	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.08	10	30	5	10 N
WCT0252R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.01 L	10	20	10	20
WCT0253M	0.10	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.01 L	10	30	5	10 N
WCT0257R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	5	100 N	0.06	15	50	50	10 N
WCT0261M	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.05	25	30	15	10 N
WCT0265R	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	1 L	100 N	0.01 L	5	10	5 L	10
WCT0266M	0.02 L	10 N	90.0	30.0	0 B	200 N	1	10000 G	0.01 L	40000	2000	9500	2000
WCT0269M	0.04	10 N	25.0	30.0	0 B	200 N	250	500	2.80	200	500	2500	20000
WCT0270R	0.02 L	10 N	2.5	2.0	0 B	200 N	20	100 N	0.04	30	70	450	200
WCT0271M	0.02 L	10 N	0.2 L	0.5 N	0 B	200 N	2	100 N	0.03	35	30	10	70
WCT0272M	0.15	10 N	600.0	700.0	0 B	500	250	300	1.60	1500	1000	12000	20000 G
WCT0274M	0.20	10 N	120.0	1000.0	0 B	10000 G	19000	10000 G	3.00	2600	2000	30000	20000 G
WCT0279M	0.02 L	10 N	120.0	100.0	0 B	200 N	180	200	7.00	15	15	20000	15000
WCT0280M	0.02 L	10 N	7.5	3.0	0 B	200 N	10	100 N	0.40	15	15	600	200
WCT0281M	0.02 L	10 N	2.0	2.0	0 B	200 N	7	100 N	0.35	5	10	350	300
WCT0283M	1.00	10	2500.0	3000.0	0 B	1000	11000 G	10000	7.50	3400	3000	70000	20000 G
WCT0286M	0.10	10 N	11.0	15.0	0 B	500	5000 G	3000	0.08	25	70	2500	3000
WCT0299M	0.02 L	10 N	1.0	1.5	0 B	200 N	7	100 N	0.01 L	5 L	70	20	100
WCT0300M	21.00	10 N	26000.0	5000.0	0 B	1500	5000 G	10000 G	7.50	4100	2000	6000	2000
WCT0301M	4.00	10 N	4500.0	2000.0	0 B	1000	4800	2000	3.00	2300	1000	20000	7000
WCT0302M	0.02 L	10 N	850.0	1000.0	0 B	200	1800	1500	0.14	110	30	600000	20000 G
WCT0303M	0.02 L	10 N	2.5	3.0	0 B	200 N	9	100 N	0.10	5 L	30	700	500
WCT0304M	0.10	10 N	4.0	3.0	0 B	200 N	1 L	100 N	0.26	700	700	85	70
WCT0305R	0.02 L	10 N	1.0	2.0	0 B	200 N	1	100 N	0.12	15	300	35	150
WCT0308R	0.02 N	10 N	0.2 N	0.5 N	0 B	200 N	1	100 N	0.0 B	5	20	60	50
WCT0309R	0.02 N	10 N	0.2 N	0.5	0 B	200 N	1 L	100 N	0.0 B	5	20	60	200
WCT0311M	2.80	10 N	75.0	100.0	0 B	3000	600	1000	1.00	5	30	6000	7000
WCT0312M	0.80	10 N	500.0	200.0	0 B	3000	3000	5000	0.20	2500	1000	60000	15000
WCT0316M	0.06	10 N	130.0	150.0	0 B	2000	5000 G	10000 G	0.02	30	70	300000	20000 G

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCT0120R	350	200	20 N	0.0 B	10 N	10 N	10 N	2	5 L	20 L	50 N	10 N	1.00
WCT0121R	25	200 N	20 N	0.0 B	10 N	10 N	10 N	3	150	20	50 N	100	3.00
WCT0122R	750	700	20 N	0.0 B	10 N	10 N	10 N	1 N	500	20 H	50 N	10 N	0.20
WCT0123R	25	200 N	20 N	0.0 B	10 N	50	10	2	2000 G	20 H	50 N	20	0.50
WCT0124R	20	200 N	20 N	0.0 B	10 N	10 N	10 N	2	300	80	50	100	3.00
WCT0125R	100	200	20 N	0.0 B	10 N	10 N	10 N	1 L	200	40	50 N	150	7.00
WCT0126R	20	200 N	20 N	0.0 B	10 N	10 N	10 N	2	10	20 L	50 N	100	1.00
WCT0171M	15	200 N	20 N	0.0 B	10 N	10 N	10	1	15	20 L	50 N	200	3.00
WCT0183R	80	200 N	20 N	0.0 B	10 N	10 N	10	1	5	20 L	50 N	150	5.00
WCT0213M	100	200 N	20 N	0.0 B	10 N	10 N	10	1 L	5 N	20 L	50 N	70	0.30
WCT0229M	15	200 N	20 N	0.0 B	10 N	10 N	10 L	1	20	20 L	50 N	100	7.00
WCT0233M	500	1000	20 N	0.0 B	10 N	10 N	10	1	5 N	20 L	50 N	10 N	10.00
WCT0250M	50	500	20 N	0.0 B	10 N	50	10	10	2000 G	20 L	50 N	20	10.00
WCT0251M	45	500	20 N	0.0 B	10 N	10 N	10	5	500	20 L	50 N	30	15.00
WCT0252R	35	200 N	20 N	0.0 B	10 N	10 N	10	1	15	20 L	50 N	70	7.00
WCT0253M	90	500	20 N	0.0 B	10 N	50	15	10	2000 G	200	50 N	150	7.00
WCT0257P	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1	10	20 L	50 N	100	3.00
WCT0261M	40	200	20 N	0.0 B	10 N	10 N	10	10	1500	20 L	50 N	15	15.00
WCT0265R	10	200 N	20 N	0.0 B	10 N	10 N	10 L	2	30	20 L	50 N	70	0.70
WCT0266M	200	200 N	20 N	0.0 B	10 N	700	10 L	1 N	700	20 L	50 N	10 N	20.00 G
WCT0269M	110	200 N	20 N	0.0 B	10 N	10	10	1 L	5	20 L	50 N	500	7.00
WCT0270R	180	200	20 N	0.0 B	10 N	10 N	10	1	100	20 L	50 N	150	2.00
WCT0271M	65	200 N	20 N	0.0 B	10 N	20	15	3	500	20 L	50 N	200	7.00
WCT0272M	11000	10000	70	0.0 B	10 N	1750	10 N	1 N	5 L	20	50 N	150	15.00
WCT0274M	90000	10000 G	1000	0.0 B	30	4000	10 L	1 L	15	20 L	50 N	50	10.00
WCT0279M	9000	10000	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	20 L	50 N	50	0.70
WCT0280M	7000	5000	20	0.0 B	10 N	10 N	10 N	1 N	5 N	20 L	50 N	200	20.00
WCT0281M	400	500	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	20 L	50 N	300	3.00
WCT0283M	25000	10000 G	200	0.0 B	10 N	22,500	10 N	1 L	5 L	20 L	50 N	150	3.00
WCT0286M	4500	5000	30	0.0 B	10 N	200	70	2	5 N	20 L	50 N	30	2.00
WCT0299M	20	200 N	20 N	0.0 B	10 N	20	20	2	1000	20 L	50 N	150	3.00
WCT0300M	1500	2000	20	0.0 B	10 N	20	10	3	5 N	20	50 N	70	1.50
WCT0301M	30000	10000 G	70	0.0 B	10 N	10 N	10	2	5 N	20 L	50 N	70	3.00
WCT0302M	500	200	50	0.0 B	10 N	10 N	10 N	1 N	5 N	20 L	50 N	10 N	5.00
WCT0303M	20	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	20 L	50 N	70	0.20
WCT0304M	85	200 N	20 N	0.0 B	10 N	10 N	10 N	50	5 N	200	150	30	20.00
WCT0305R	75	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	20 L	50 N	50	10.00
WCT0308R	600	300	20 N	0.0 B	10 N	20	10 L	1	5 N	20 L	50 N	50	10.00
WCT0309R	600	500	20 N	0.0 B	10 N	10 N	10	1	5 N	20 L	50 N	70	10.00
WCT0311M	450	700	20 N	0.0 B	10 N	150	10 N	1	20	20 L	50 N	150	15.00
WCT0312M	2000	1500	50	0.0 B	10 N	2000	10	1	5 N	20 L	50 N	200	10.00
WCT0316M	5 L	200 N	20 N	0.0 B	10 N	1500	10 L	1 L	5 N	20 L	50 N	10 N	0.30

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI %	S-V	S-LA	S-Y
WCT0120R	0.05	0.05 L	100	20	10 L	5 N	5 L	10 N	100 N	5 N	0.005	10	20 N	10 N
WCT0121R	0.70	2.00	200	1000	10 N	5	5	10 N	100	5	0.070	50	20 N	10
WCT0122R	0.02	0.05 L	30	15	10 N	5 N	5 L	10 N	100 N	5 N	0.007	10	20 N	10 N
WCT0123R	0.10	0.05 L	100	20	10 L	5 N	5 L	10 N	100 N	5 L	0.050	10	20 N	10 L
WCT0124R	0.70	1.50	150	1000	10 N	7	5	20	100	5	0.070	30	20 N	10
WCT0125R	1.50	2.00	200	1500	10 N	10	10	30	100	5	0.070	30	20 N	10
WCT0126R	0.20	0.50	700	200	10 N	5 N	5 L	10 N	500	5 L	0.070	20	50	10
WCT0171M	0.70	0.50	1000	150	10	10	20	50	100	10	0.200	30	30	15
WCT0183R	2.00	3.00	500	300	10	10	50	50	100	7	0.150	200	70	20
WCT0213M	0.20	10.00	70	200	30	5 N	15	30	100	5	0.100	20	50	15
WCT0229M	3.00	7.00	70	300	10	5	20	50	100 L	7	0.150	300	20 N	15
WCT0233M	0.05	0.05 L	20	70	10	7	50	10 L	100 N	5	0.002	10	20 N	10 N
WCT0250M	1.00	5.00	20 L	5000	10 L	10	70	70	300	10	0.150	150	20 N	30
WCT0251M	1.50	15.00	20	5000 G	10 L	20	50	30	100	7	0.100	70	70	20
WCT0252R	1.50	1.50	1500	500	10 L	20	50	100	700	10	0.200	70	30	10
WCT0253M	2.00	7.00	20 N	3000	10 L	15	50	70	100 L	15	0.300	50	20	20
WCT0257R	0.30	7.00	200	300	10 L	5 N	10	10	100 L	5	0.070	10	20 N	10
WCT0261M	2.00	10.00	20	5000	10 N	10	15	20	100	5	0.070	100	20	10
WCT0265R	0.20	0.50	500	70	10 L	5 N	5	10 L	500	5 L	0.070	10	20	10 N
WCT0266M	3.00	0.05 N	50	70	10 N	200	2000	10 L	100 N	5 L	0.002	10 L	20 N	10
WCT0269M	0.20	0.05 L	200	20	50	5 N	5	50	100	7	0.200	50	70	10
WCT0270R	2.00	0.15	700	50	50	5 N	30	50	100 N	10	0.150	2000	30	20
WCT0271M	0.50	0.10	700	300	50	10	5	10 L	100	7	0.150	30	30	10
WCT0272M	0.05	2.00	20	20	10 N	15	50	20	100	5	0.070	30	20	10
WCT0274M	0.15	0.30	70	300	10 N	5 N	15	20	100 L	5	0.050	20	50	10
WCT0279M	0.05	0.05 L	50	20	10	5 N	5	10 L	100 N	5 N	0.050	15	20 N	10 N
WCT0280M	0.07	0.05 L	70	70	10 L	5 N	15	30	100 N	5	0.070	20	20 N	10
WCT0281M	0.10	2.00	100	100	15	5 N	100	15	100 N	5 N	0.070	15	20 N	10 L
WCT0283M	0.15	0.05	50	100	500	5 N	5	10	100 L	5 L	0.050	15	70	10 L
WCT0286M	0.20	0.07	200	50	100	5 N	5	10 L	100 N	5	0.070	20	20	20
WCT0299M	0.50	1.00	1000	500	150	5 N	5	10 L	300	5	0.200	50	70	15
WCT0300M	0.10	0.50	150	300	15	5 N	5	10 L	100 L	5	0.050	10	30	10 N
WCT0301M	0.10	0.20	200	100	20	5 N	7	10 L	200	5	0.050	20	20 N	10 N
WCT0302M	0.02 N	0.05 L	20 N	300	10	10	5 L	10 N	100	5	0.002	10	20 N	10 L
WCT0303M	0.30	10.00	20	150	10 L	5 N	5	10 L	100	5 L	0.010	10	20	15
WCT0304M	0.70	0.70	30	100	10 N	100	50	20	100	5	0.100	70	20 N	15
WCT0305R	5.00	2.00	300	1500	10 N	50	30	100	700	20	0.500	200	50	20
WCT0308R	3.00	15.00	20 L	3000	10	5	20	150	100	5	0.150	100	50	20
WCT0309R	5.00	7.00	700	1000	10 N	20	20	300	1000	20	0.700	200	70	30
WCT0311M	0.20	0.10	1500	10	1000	5 N	5	70	100 N	10	0.150	150	20 N	10 L
WCT0312M	0.50	0.07	300	15	100	5 N	7	70	100 N	7	0.200	70	20	10
WCT0316M	0.07	0.05 L	20 N	20	200	5 N	5	10 L	100 N	5	0.010	10	70	10 N

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCT0317M	0.0 B	10 N	0.0 B	0.5 N	0 B	200 N	0 B	100 N	0.0 B	0 B	20	0 B	100
WCT0318M	0.02 N	10 N	0.2 N	0.5 N	0 B	200 N	150	200	0.02	90	100	360	200
WCT0328M	0.05 L	10 N	50.0	20.0	400	500	35	100 L	2.00	1000	700	700	500
WCT0332M	0.05 L	10 N	2.0	2.0	10	200 N	2	100 N	0.08	20	30	110	70
WCT0333M	1.00	10 N	60.0	15.0	160	200 N	70	100	0.12	60	50	3800	500
WCT0338R	0.05 N	10 N	1.5	0.5 L	0 B	200 N	1 L	100 N	0.0 B	10	5 L	45	20
WCT0339M	0.20	10 N	11.0	10.0	10 N	200 N	1 L	100 N	0.12	5 L	5	2600	2000
WCT0340M	0.05 N	10 N	2.0	0.5 N	30	200 N	2	100 N	0.18	30	30	80	70
WCT0341M	0.05 N	10 N	1.5	0.5 N	20	200 N	1 L	100 N	0.14	5	30	100	70
WCT0376M	0.05 L	10 N	6.0	7.0	10 L	200 N	2	100 N	0.08	15	30	60	50
WCT0377M	0.05	10 N	3.0	7.0	10 L	200 N	1	100 N	0.06	45	20	50	10
WCT0385M	0.05 N	10 N	60.0	20.0	200	300	80	150	0.90	500	500	10000	3000
WCT0386M	0.40	10 N	20.0	20.0	40	200 N	15	100 N	0.28	650	700	2800	1500
WCT0387M	0.05 N	10 N	70.0	50.0	200	200	25	100 N	1.10	200	100	3500	1500
WCT0400R	0.05 N	10 N	0.5 N	1.0	0 B	200 N	1 L	100 N	0.10	5	70	30	20
WCT0402M	0.05 N	10 N	3.0	1.0	300	200	70	100 N	0.55	55	50	30	10 L
WCT0403R	0.05 N	10 N	1.5	2.0	0 B	200 N	1 L	100 N	0.04	10	30	70	70
WCT0404R	0.05 N	10 N	4.0	5.0	0 B	200 N	30	100 N	0.35	80	200	70	70
WCT0405R	0.05 N	10 N	1.5	0.7	0 B	200 N	4	100 N	0.06	25	20	30	10 N
WCT0406M	0.05 N	10 N	150.0	150.0	20	200 N	1500	1500	0.45	7000	5000	45	30
WCT0407M	0.05 N	10 N	1.5	0.7	10	200 N	4	100 N	0.30	35	100	30	10
WCT0408R	0.05 N	10 N	1.5	1.0	0 B	200 N	4	100 N	0.04	15	10	65	50
WCT0409R	0.05 N	10 N	1.0	1.0	0 B	200 N	3	100 N	0.10	20	10	15	10 N
WCT0410R	0.05 N	10 N	0.5 N	0.7	0 B	200 N	1	100 N	0.06	5 L	15	35	50
WCT0414R	0.05 N	10 N	2.0	0.5	0 B	200 N	5	100 N	0.06	20	5	50	10 N
WCT0416R	0.05 N	10 N	0.5 L	0.5 N	0 B	200 N	1 L	100 N	0.12	10	50	45	70
WCT0417M	0.05 N	10 N	19.0	10.0	10	200 N	90	100 L	0.10	10000	5000	15	10 L
WCT0421R	0.05 N	10 N	1.5	0.5 N	10 N	200 N	2	100 N	0.14	20	30	40	30
WCT0428R	0.05 N	10 N	3.0	5.0	0 B	200 N	4	100 N	0.35	40	30	25	10
WCT0446M	0.05 N	10 N	1.0	0.5	10 N	200 N	3	100 N	0.08	70	50	30	20
WCT0451R	0.05 N	10 N	1.0	0.5 N	10 N	200 N	1	100 N	0.16	35	50	30	30
WCT0455M	4.00	10 N	18000.0	5000.0 G	1200 H	1000	20000	10000 G	8 50	1100	1000	16000	15000
WCT0464R	0.05 N	10 N	1.0	0.5 N	10 N	200 N	1 L	100 N	0.55	5	7	50	20
WCT0475R	0.05 N	10 N	10.0	15.0	40	200 N	10	100 N	0.24	5	7	500	500
WCT0476R	0.05 N	10 N	8.0	15.0	10	200 N	10	100 N	0.14	5	10	450	700
WCT0490M	0.05 N	10 N	2.0 H	0.5 N	10 L	200 N	1 N	100 N	0.05	40	50	120	50
WCT0502M	0.20	10 N	400.0	500.0	2000	3000	15000	10000	0.80	75	100	40000	20000 G
WCT0503M	0.25	10 N	3000.0	3000.0	8000	7000	30000	10000 G	6.00	450	500	600000	20000 G
WCT0504M	0.05	10 N	1000.0	1000.0	60	200 L	800	700	0.65	45	70	68000	20000 G
WCT0505R	0.05 N	10 N	3.0	5.0	10 N	200 N	1 N	100 N	0.26	10	7	10	20
WCT0506R	0.05 N	10 N	3.0	2.0	10 N	200 N	4	100 N	0.10	25	30	40	20
WCT0514M	0.05 N	10 N	5.0	5.0	20	200 N	30	100 N	1.40	25	30	400	100

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCT0317M	0 B	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	20	0 B	50 N	10 N	1.00
WCT0318M	5 N	200 N	20 N	0.0 B	10 N	150	10	1	2000 G	20 L	50 N	150	0.20
WCT0328M	5000	7000	30	0.0 B	200	15	10 L	1 L	15	0 B	50 N	200	15.00
WCT0332M	350	500	20 N	0.0 B	10 N	10 N	10 L	1 L	5	0 B	50 N	100	3.00
WCT0333M	200	200 L	20 N	0.0 B	10	10 N	10 L	1 L	10	0 B	50 N	50	5.00
WCT0338R	55	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	70	1.50
WCT0339M	1100	1500	20 N	0.0 B	15	15	10 L	1 L	10	0 B	50	30	10.00
WCT0340M	430	500	20 N	0.0 B	10 N	20	10 L	3	10	0 B	50 L	50	10.00
WCT0341M	350	200	20 N	0.0 B	10 N	20	10 L	2	10	0 B	50 N	50	10.00
WCT0376M	70	200 N	20 N	0.0 B	10 L	10	10	1	5 N	0 B	50 N	150	5.00
WCT0377M	60	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	10 N	20.00 G
WCT0385M	320	500	20 N	0.0 B	10 N	300	10 L	1 L	5	0 B	50 N	300	2.00
WCT0386M	580	700	20 N	0.0 B	10 N	100	10 L	1 L	5 N	0 B	50 N	300	2.00
WCT0387M	140	200	20 N	0.0 B	10 N	100	10 L	1 L	5	0 B	50 N	150	1.50
WCT0400P	600	500	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	200	0.30
WCT0402M	70	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	200	10.00
WCT0403P	90	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	300	0.50
WCT0404R	1700	1500	20 N	0.0 B	10 N	10 N	10 L	1 L	500	0 B	50 N	70	5.00
WCT0405R	20	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	1.00
WCT0406M	3500	500	20	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	200	0.70
WCT0407M	90	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	15	0 B	50 N	50	1.50
WCT0408R	200	200 L	20 N	0.0 B	10 N	10 N	10 L	1 N	10	0 B	50 N	70	3.00
WCT0409R	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1	5 N	0 B	50 N	100	1.00
WCT0410R	10	200 N	20 N	0.0 B	10 N	10 N	15	1	10	0 B	50 N	70	1.00
WCT0414I	10	200 N	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	150	0.30
WCT0416R	35	200 N	20 N	0.0 B	10 N	10 N	10	1	10	0 B	50 N	150	3.00
WCT0417M	200	200	20 N	0.0 B	10 N	10 N	10 L	1 N	5 N	0 B	50 N	100	1.00
WCT0421P	80	200 N	20 N	0.0 B	10 N	10 N	10	1	5 N	0 B	50 N	300	5.00
WCT0428R	200	200	20 N	0.0 B	10 N	10 N	10 L	1	10	0 B	50 N	150	2.00
WCT0446M	30	200 N	20 N	0.0 B	10 N	10 N	10 L	1 L	5 N	0 B	50 N	150	5.00
WCT0451R	70	200 N	20 N	0.0 B	10 N	10 N	10	1 L	5 N	0 B	50 N	200	7.00
WCT0455M	13000	10000 G	500	0.0 B	10 N	10	20 L	1	5 N	0 B	50 N	20	0.20
WCT0464R	90	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	50	0.05
WCT0475R	20	200 N	20 N	0.0 B	10 N	50	30	2	5 N	0 B	50 N	70	1.00
WCT0476R	25	200 N	20 N	0.0 B	10 N	150	50	2	5 N	0 B	50 N	100	1.00
WCT0490M	30	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	0 B	50 N	70	0.70
WCT0502M	400	500	20	0.0 B	10 N	150	10 N	1 L	5 N	0 B	50 N	100	1.50
WCT0503M	700	700	300	0.0 B	10 N	1000	10 N	1 L	5 N	0 B	50 N	70	1.50
WCT0504M	3800	5000	20 N	0.0 B	10 N	100	10 N	1 L	5 N	0 B	50 N	100	0.20
WCT0505R	250	500	20 N	0.0 B	10 N	10 N	10 N	1	5 N	0 B	50 N	100	1.50
WCT0506R	160	200	20 N	0.0 B	10 N	10 N	10 L	1 L	20	0 B	50 N	100	1.00
WCT0514M	350	500	20 N	0.0 B	10 N	10 N	10 N	1	5 L	0 B	50 N	70	1.50

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI%	S-V	S-LA	S-Y
WCT0317M	0.05	0.05	200	30	10	5 N	5	70	100 L	5	0.020	500	20 N	10 N
WCT0318M	0.05	0.05 L	50	10	10 L	5 N	5 L	10 N	100 N	5	0.100	10	20 N	100
WCT0328M	0.10	0.10	70	100	10	10	10	30	100 N	5	0.100	50	50	10
WCT0332M	0.70	0.20	300	100	10 L	5 L	20	30	150	5	0.100	70	20	10
WCT0333M	0.15	0.05	20 L	15	10 N	5 N	10	10 L	100 N	5	0.050	50	20 N	10 L
WCT0338R	2.00	20.00 G	1000	500	30	5 L	20	70	700	7	0.100	150	20 L	20
WCT0339M	2.00	20.00	20 N	5000	10 N	10	20	50	100 N	5	0.070	70	20 N	10
WCT0340M	2.00	20.00	20 L	5000	10 N	30	70	70	500	7	0.100	300	20	20
WCT0341M	1.00	20.00 G	20	2000	10 N	20	70	30	150	5	0.070	500	20 N	20
WCT0376M	0.20	3.00	700	700	1000	7	70	150	300	20	0.300	200	30	15
WCT0377M	0.02 L	0.05 L	20 L	70	10 L	20	100	10 L	100 N	5 L	0.002	10	20 N	10 N
WCT0385M	0.05	0.05 L	30	10	20	5 N	5	15	100 N	5	0.050	20	20	10
WCT0386M	0.20	0.05 L	50	30	20	5	5	50	100 N	5	0.150	30	20	15
WCT0387M	0.05	0.05 L	20	15	20	5	5 L	10	100 N	5	0.070	20	20	10
WCT0400R	2.00	3.00	200	700	20	5 N	5	20	100 L	5	0.100	20	20	10
WCT0402M	0.05	0.07	20	50	10	5 N	30	50	100 N	5	0.070	70	20	20
WCT0403R	1.50	3.00	300	200	10	5 N	7	50	100 L	5	0.100	20	20	10
WCT0404R	0.20	0.10	150	200	50	5	50	30	100 L	7	0.100	200	30	10
WCT0405R	1.00	15.00	150	200	15	7	50	70	300	5	0.100	70	30	30
WCT0406M	1.50	20.00	70	1000	10	5 N	10	50	500	5	0.070	20	20	20
WCT0407M	0.10	0.05	150	100	50	5	15	20	100 N	5	0.070	100	20	10 L
WCT0408R	5.00	10.00	700	1000	10	10	50	20	300	5	0.070	70	20 N	15
WCT0409R	0.50	0.15	500	20	70	5 N	15	70	100 L	7	0.150	200	20	10
WCT0410R	0.10	0.05 L	1000	100	10	5 N	5	10	100 L	5 L	0.070	10	30	10
WCT0414R	2.00	20.00	150	150	10	5 N	5	50	300	5 L	0.070	10	20	15
WCT0416R	1.50	1.00	1000	500	10	5	15	70	200	7	0.200	70	50	15
WCT0417M	0.20	0.05	20	150	10	5 N	10	500	100 N	5	0.050	10	20 N	20
WCT0421R	3.00	3.00	1500	1000	10	50	20	150	500	30	0.500	200	50	30
WCT0428R	1.00	7.00	500	200	70	5	100	300	200	10	0.200	100	50	70
WCT0446M	2.00	0.70	1000	500	20	15	70	300	700	15	0.200	100	50	15
WCT0451R	5.00	3.00	1000	700	10	50	150	500	1000	20	0.500	150	70	30
WCT0455M	0.03	0.70	30	300	20	5 N	5	10	100 N	20	0.015	10	30	10 N
WCT0464R	0.03	0.05 L	20	50	10 L	5 N	5 L	10 L	100 N	5 N	0.015	10	20 N	10 N
WCT0475R	0.30	0.05 N	200	15	70	5 N	5 N	10 N	100 N	5 L	0.070	10	20 N	20
WCT0476R	0.50	0.05 L	200	50	100	5 N	5 N	10 N	100 N	5	0.070	10	20	20
WCT0490M	0.70	15.00	70	300	10	5 N	20	70	500	5	0.100	50	20 L	20
WCT0502M	0.15	0.15	20	10 L	700	5 N	5 L	20	100 N	5 L	0.100	30	100	20
WCT0503M	0.02 L	0.30	20	10 L	50	5 N	5 N	10	100 N	5 L	0.015	50	150	10
WCT0504M	0.07	0.15	50	100	10 N	5 N	5 N	10 L	100 N	5 L	0.010	15	20 N	10 N
WCT0505R	10.00	5.00	100	1000	15	5 N	30	70	100 N	10	0.100	300	20 N	20
WCT0506R	2.00	1.50	500	150	70	5 N	30	100	100 N	10	0.150	1000	20 N	30
WCT0514M	0.07	0.05	100	50	10 N	5 N	5 N	10	100 N	5 L	0.050	150	20 N	10 N

SAMPLE	A-AU	S-AU	A-AG	S-AG	CM-AS	S-AS	CM-SB	S-SB	I-HG	A-CU	S-CU	A-PB	S-PB
WCT0520M	0.25	10 N	150.0	150.0	800	2000	40	100 L	1.50	400	200	50000	20000
WCT0524M	0.05 N	10 N	3.0	2.0	30	200 L	8	100 N	0.20	20	30	110	100
WCT0526M	0.10	10 N	1.0	3.0	300	200 L	10	100 N	0.40	5	50	130	500
WCT0528M	0.05 N	10 N	2.5	2.0	160	200 N	10	100 N	0.35	15	50	75	70
WCT0529M	0.10	10 N	3.0	3.0	200	500	30	100 N	5.00	45	70	190	150
WCT0530M	0.05 N	10 N	16.0	10.0	300	300	30	100 N	0.30	600	500	450	200
WCT0531M	0.25	10 N	400.0	500.0	10 N	200 N	1 N	100 N	0.28	23000	20000	50	100
WCT0532R	0.05 N	10 N	1.0 H	0.5 N	10 N	200 N	1 N	100 N	0.10	15	30	20	20
WCT0537M	0.05 N	10 N	1.0	0.7	10 N	200 N	2	100 N	0.08	45	70	50	70
WCT0539M	6.50	10 N	190.0	200.0	10	200 N	100	100	0.70	8300	5000	5800	700
WCT0540R	0.05 N	10 N	2.0 H	1.0	10 L	200 N	1 N	100 N	0.14	15	20	25	15
WCT0544M	0.05 N	10 N	3.0	0.7	120	200 N	8	100 N	0.16	20	10	50	15
WCT0549M	0.05 N	10 N	3.0	5.0	40	200 L	4	100 N	0.45	10	20	480	150
WCT0552M	0.05 N	10 N	3.0	5.0	400	500	1	100 N	0.04	150	200	65	70
WCT0556M	0.40	10 N	1000.0	1000.0	300	300	700	700	0.06	1200	1500	220000	20000 G
WCT0557M	0.75	10 N	700.0	1000.0	2400	300	1000	1000	0.04	800	1500	160000	20000 G
WCT0558M	0.85	10 N	3000.0	3000.0	30	500	2000	3000	1.30	1800	3000	400000	20000 G
WCT0563M	0.40	10 N	800.0	700.0	120	200 L	70	100	0.40	600	500	190000	20000 G
WCT0564M	0.15	10 N	50.0	70.0	200	500	15	100 N	0.20	290	500	32000	20000 G
WCT0565M	0.05 N	10 N	7000.0	5000.0 G	100	200 N	3000	5000	7.00	2200	2000	600000	20000 G
WCT0566M	0.05 L	10 N	4400.0	3000.0	100	200 N	2200	2000	0.60	2400	2000	660000	20000 G
WCT0567M	0.40	10 N	600.0	200.0	1200	1000	280	300	0.26	900	1000	73000	20000 G
WCT0568M	0.05 L	10 N	40.0	30.0	200	200	10	100 L	0.04	80	70	50000	20000 G
WCT0569M	0.05 N	10 N	1.5	5.0	10 L	200 N	1	100 N	0.02	15	50	160	500
WCT0570M	0.05 N	10 N	0.5 L	0.7	40	200 N	1	100 N	0.14	5	7	280	150

SAMPLE	A-ZN	S-ZN	S-CD	CM-HM	S-BI	S-SN	S-NB	S-BE	S-MO	CM-W	S-W	S-ZR	S-FE %
WCT0520M	90	200 N	20 N	0.0 B	10 N	150	10 N	1	300	0 B	50 N	200	3.00
WCT0524M	20	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 L	0 B	50 N	300	5.00
WCT0526M	20	200 N	20 N	0.0 B	10 N	10 N	10 L	2	5 N	0 B	50 N	100	5.00
WCT0528M	60	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5	0 B	50 N	100	3.00
WCT0529M	100	200 N	20 N	0.0 B	10 N	10 N	10 N	1	5 N	0 B	50 N	300	10.00
WCT0530M	210	200	20 N	0.0 B	10 N	10 N	10 N	2	300	0 B	50 N	300	7.00
WCT0531M	120	200 L	20 N	0.0 B	10	10 N	10 N	1	30	0 B	50 N	100	3.00
WCT0532R	130	200	20 N	0.0 B	10 N	10 N	10 L	1	5 N	0 B	50 N	150	5.00
WCT0537M	40	200 N	20 N	0.0 B	10 N	10 N	10	1 L	20	0 B	50 N	150	3.00
WCT0539M	210	200 N	20 N	0.0 B	15	10 N	10 N	1 L	5 N	0 B	50 N	10 N	0.70
WCT0540R	100	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	100	1.50
WCT0544M	40	200 N	20 N	0.0 B	10 N	10 N	10 N	1 L	5 N	0 B	50 N	70	1.00
WCT0549M	1200	2000	20 N	0.0 B	10 N	10	10 L	1 L	5 N	0 B	50 N	150	3.00
WCT0552M	1300	2000	20 N	0.0 B	10 N	10 L	10 N	1	30	0 B	50 N	10 N	10.00
WCT0556M	600	300	20 N	0.0 B	10 N	2000	10 L	2	30	0 B	50	300	7.00
WCT0557M	600	500	20 N	0.0 B	10 N	7000	10 L	1 N	5 L	0 B	70	200	7.00
WCT0558M	2400	5000	20 L	0.0 B	10 N	2000	10 L	1	30	0 B	50 L	300	7.00
WCT0563M	1400	1000	20 N	0.0 B	10 N	700	10 L	1 L	50	0 B	50 N	300	3.00
WCT0564M	260	700	20 N	0.0 B	10 N	2000	10 N	1 L	1500	0 B	50 L	300	1.50
WCT0565M	600	500	150	0.0 B	10 N	2000	10 N	1 N	7	0 B	50 N	10 L	0.05
WCT0566M	1000	300	100	0.0 B	10 N	5000	10 N	1 L	7	0 B	50 N	150	1.00
WCT0567M	1100	1500	20 N	0.0 B	10 N	2000	10 L	1 L	200	0 B	50 L	300	7.00
WCT0568M	220	300	20 N	0.0 B	10 N	300	10 L	1 L	20	0 B	50 N	300	2.00
WCT0569M	40	200 N	20 N	0.0 B	10 N	10	10 L	1 L	5 N	0 B	50 N	500	2.00
WCT0570M	60	200 N	20 N	0.0 B	10 N	10 N	10 N	1 N	5 N	0 B	50 N	300	2.00

SAMPLE	S-MG %	S-CA %	S-BA	S-MN	S-B	S-CO	S-NI	S-CR	S-SR	S-SC	S-TI %	S-V	S-LA	S-Y
WCT0520M	0.30	0.07	150	30	100	5 N	5 N	20	100 N	5	0.100	150	20 N	10
WCT0524M	0.10	0.10	50	50	10 N	5 N	50	30	100 N	5	0.150	50	30	20
WCT0526M	0.70	0.10	500	200	10 N	5 N	5 L	20	100	5 L	0.100	50	70	15
WCT0528M	0.20	0.10	200	100	70	5 N	5 L	70	100 L	7	0.200	500	20 N	10 N
WCT0529M	0.20	0.10	150	100	70	5 N	30	100	100 N	7	0.300	100	20 N	15
WCT0530M	0.20	0.10	150	200	50	5	100	100	100 N	10	0.300	100	20 L	20
WCT0531M	3.00	5.00	5000	500	20	15	100	100	2000	10	0.300	500	20	30
WCT0532R	3.00	5.00	1500	700	200	20	100	150	500	15	0.300	300	30	20
WCT0537M	2.00	0.20	1000	500	10	5 L	20	150	300	10	0.300	70	50	10
WCT0539M	0.05	5.00	500	150	10 N	5 N	5 N	10 L	150	5 N	0.007	10	20 N	10 L
WCT0540R	0.50	20.00	300	200	30	10	20	70	300	7	0.150	200	20	20
WCT0544M	0.10	0.07	100	50	30	5 N	5 N	20	100 N	5 L	0.100	300	20 N	10 N
WCT0549M	0.30	0.50	150	500	70	5 L	15	100	100 N	5 L	0.150	70	30	10 L
WCT0552M	0.15	0.15	20 L	100	10 N	15	70	15	100 N	5 L	0.030	150	20 N	10 L
WCT0556M	0.20	0.05	100	50	100	5 N	5 N	150	100 N	7	0.150	100	150	15
WCT0557M	0.20	0.05 L	50	70	100	5 N	5 N	100	100 N	7	0.150	70	70	10
WCT0558M	0.30	0.07	150	200	150	5 N	5 N	70	100	7	0.150	50	200	20
WCT0563M	0.30	0.05	100	50	70	5 N	5 N	50	150	7	0.150	70	50	15
WCT0564M	0.15	0.10	70	70	30	5 L	5 N	70	100 N	5	0.100	300	30	10
WCT0565M	0.02 L	0.05 N	20	30	10 N	5 N	5 N	10 N	100 N	5 L	0.002	15	20 N	10 N
WCT0566M	0.07	0.05 N	70	20	20	5 N	5 N	30	100 N	5	0.070	150	20 N	10
WCT0567M	0.15	0.10	100	30	30	5 N	50	150	100 N	15	0.150	300	200	30
WCT0568M	0.20	0.15	100	100	30	5 N	5 N	100	100 N	7	0.150	200	20	15
WCT0569M	3.00	5.00	500	300	10 L	7	30	150	150	10	0.300	100	30	20
WCT0570M	0.15	0.05 L	200	10 N	30	5 N	5 N	30	100 N	5 L	0.150	30	20	10

Geochemical and Geophysical Studies of Selected Areas of the Eastern Part of the Sawtooth National Recreation Area, Idaho

By CHARLES M TSCHANZ *and* F C FRISCHKNECHT,
U S GEOLOGICAL SURVEY

MINERAL RESOURCES OF THE EASTERN PART OF THE SAWTOOTH NATIONAL RECREATION AREA, CUSTER AND BLAINE COUNTIES, IDAHO

GEOLOGICAL SURVEY BULLETIN 1545-D

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INTRODUCTION

Five areas within the eastern part of the Sawtooth National Recreation Area were identified by field investigations as being particularly favorable for the discovery of new mineral deposits. These areas are: Slate Creek-Mill Creek, Sheephead Creek, Grand Prize Gulch (pl 1), and the Valley Creek and the Buckskin mines (pl 3) Because of their favorability, these areas were studied in more detail by more extensive sampling of stream sediments and by geophysical methods Results of the studies and an evaluation of the resource potential of three of the areas, Slate Creek-Mill Creek, Sheephead Creek, and Grand Prize Gulch are presented in this chapter of the report Findings of studies on the Valley Creek and the Buckskin mine areas, along with descriptions of the mines, are given in Chapter E

SLATE CREEK-MILL CREEK AREA

The Slate Creek-Mill Creek area is underlain chiefly by sedimentary rocks of Mississippian age that have a high potential for undiscovered resources of zinc (pl. 4). Many stream sediments derived from these rocks are anomalous in zinc The newest and only operating mine (Hoodoo mine) in the study area during the time of field investigation is in the Slate Creek–Mill Creek locality. Although the area has been prospected for many metals, little attention has been given to zinc, which until a few years ago was not economically viable to mine in the central Idaho region Anomalous stream sediments below the Hoodoo and Silver Rule mines obviously were derived from those deposits, but many anomalies cannot be explained by known mineralized outcrops and could lead to heretofore unknown zinc deposits.

Zinc is the predominant metal in stream sediments of the Slate Creek–Mill Creek area. Many of the sediments anomalous in zinc also are anomalous in cadmium, lead, silver, barium, strontium, copper, arsenic, antimony, and molybdenum. Stream sediments below the Silver Rule mine contain more gold, tin, and antimony than do sediments elsewhere in the area.

The strongest zinc anomalies are along streams underlain by Mississippian rocks, but weaker zinc anomalies are found along north-flowing streams between Warm Springs and Slate Creeks that cross the Idaho batholith (fig 12; pl. 4) The weak zinc anomaly on Cold Creek apparently is derived from the batholith, but the somewhat stronger anomalies on Beaver and Treon Creeks apparently are derived from contact metamorphosed Mississippian and Pennsylvanian rocks in the headwaters of those streams. Zinc anomalies along the three streams are slightly anomalous in silver (fig. 8), and Treon Creek also is anomalous in tin (fig 20) Few other zinc anomalies in the area are near surface contact of intrusive rocks except a strong anomaly near a dike on Mill Creek Significant anomalies are not found in morainal material or in the volcanic rocks

Generalized geology of the Slate Creek–Mill Creek area is shown on plate 1 and more detailed geology on plate 4. Maps of individual mines and prospects and additional analytical data are given in Chapter E under mine descriptions of the Slate Creek district

ZINC ANOMALIES

Areas anomalous in zinc are shown on plate 4. Stream-sediment samples from all of these areas contained as much as 1,000 ppm zinc, samples from five of them contained as much as 2,000 ppm zinc, and samples from the area along Mill Creek contained more than 3,000 ppm zinc Stream-sediment samples taken downstream from the Hoodoo mine, from the small stream that drains Hoodoo Lake (Robinson Bar quadrangle) and which erodes the Hoodoo deposit outcrop and passes near and below the Hoodoo mine dumps, understandably are enriched in zinc These samples contained more than 3,000 ppm zinc and the stream bed is considered anomalous to its junction with Slate

Creek Above the Hoodoo mine, zinc content in stream sediments decreases to less than 500 ppm, even though outcrops upstream contain 5-28 percent zinc in secondary smithsonite that may be derived from an unknown upstream deposit of sphalerite. Apparently, calcareous rocks such as those that crop out above the Hoodoo mine can precipitate zinc from acidic stream water, thereby detracting from formation of zinc anomalies in downstream sediments

Although the anomaly downstream from the Hoodoo mine undoubtedly is enhanced by mining activity, it provides a model for interpreting the comparable anomaly on Mill Creek and other strong zinc anomalies that are not near known deposits. Sediment samples from the central parts of the anomalies on Mill Creek and Sheephead Creek (a west branch of Slate Creek) and along several nearby creeks contain many times more zinc than any nearby rock samples or mineralized structures. Conversely, some weak zinc anomalies are below prospects that contain much higher zinc contents. Apparently the known exposed deposits are not the source of the stronger natural zinc anomalies. More likely sources are concealed sphalerite deposits or richer undetected veins near the stream bottoms

The zinc anomalies along the west branch of Silver Rule Creek and Livingston Creek are apparently derived from veins that contain jamesonite but little sphalerite (Lucky Strike and Copper prospects, pl. 4), according to Kern (1972). Analyses in Chapter E indicate that lead is more abundant than zinc in these and other veins that crop out between Slate and Carbonate Creeks.

MILL CREEK ANOMALY

The largest and strongest zinc anomaly in the study area was discovered on Mill Creek by routine stream-sediment sampling in 1971 and was further investigated in 1972 by detailed sampling and by five electromagnetic traverses The stream sediments contain as much as 4,000 ppm zinc, much more than nearby analyzed rocks, including samples from mineralized breccia zones at three prospects on the ridge west of Mill Creek (pl 4, table 2) The source of the stream-sediment anomaly is interpreted to be a concealed deposit of sphalerite in the Mississippian argillite, located upstream from the anomaly. The approximate position of this concealed deposit may be indicated by geochemical evidence and by a corresponding electromagnetic anomaly.

A pyritized biotite quartz monzonite dike that crosses Mill Creek (pl. 4) could have contributed zinc to the stream-sediment anomaly, but it is an unlikely source. Along the dike and extending a few feet from it are lime silicate minerals formed during dike intrusion Rock samples

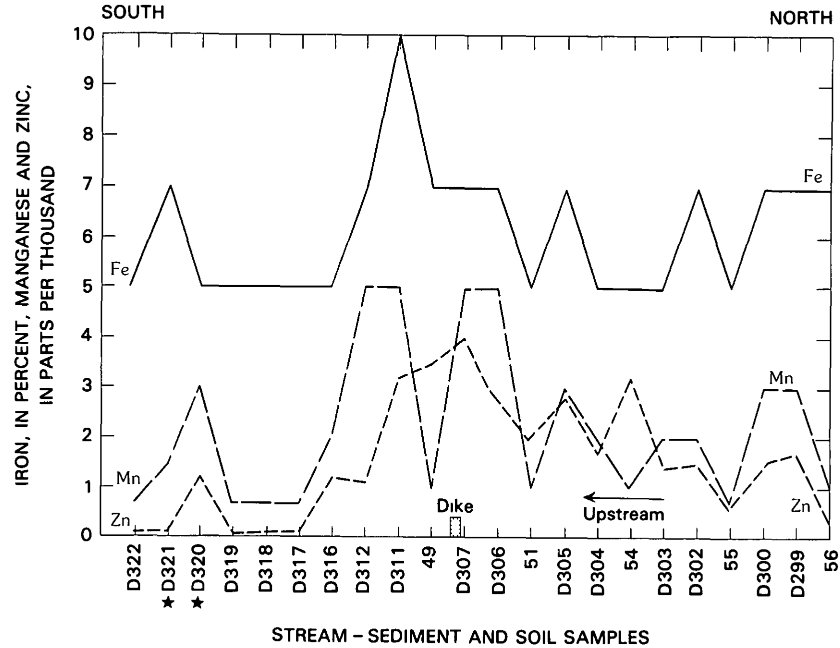


FIGURE 22 —Graph showing distribution of iron and manganese (semiquantitative spectrographic analyses) and of zinc (atomic absorption analyses) in stream-sediment and soil samples along Mill Creek Soil samples starred (See pl 4 for sample localities)

(pl 4, D308, D309, table 2) taken close to the dike contain anomalous amounts of silver and lead, but are not anomalous in zinc Lead and silver in the rock may be related to dike intrusion, but analyses indicate insufficient zinc to have formed the stream-sediment anomaly The fact that the richer part of the stream-sediment anomaly continues about 1,100 ft (361 m) upstream from the dike is another reason for discounting the dike as a source of the zinc.

A mineralized breccia at sample site S417 (pl. 4) could be the source of zinc in the stream-sediment anomaly. The breccia appears to be part of a broad structural zone that underlies an electromagnetic anomaly that crosses Mill Creek near the junction of traverses T4 and T5 (pl 4) A buried sphalerite deposit could be present in this mineralized structural zone Geochemical evidence in sample S417 supports this deduction The sample contains more zinc than do other upstream rock samples from the area. The higher antimony and barium content of the sample suggests that it may have been taken from the upper fringe of a buried sphalerite deposit.

A contrast in metal content of the dike zone from that of the breccia zone is suggested by differing zinc/silver and zinc/lead ratios. Samples

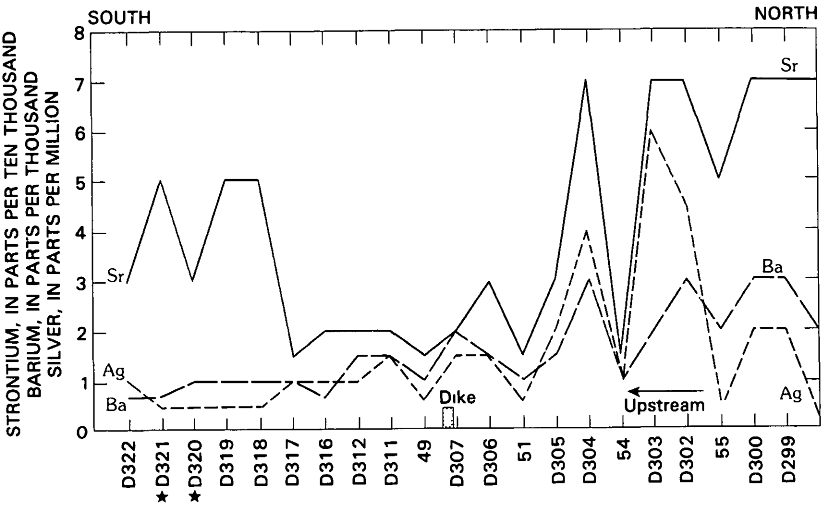


FIGURE 23 —Graph showing distribution of strontium and barium (semiquantitative spectrographic analyses) and of silver (atomic absorption analyses) in stream-sediment and soil samples along Mill Creek Soil samples starred (See pl 4 for sample localities)

D308 and D309 from the dike zone have zinc/silver ratios of 1 76 and 6 25, whereas sample S417 from the breccia zone has a zinc/silver ratio of 140. The zinc/lead ratios of samples D308 and D309 are 0 75 and 1 66, respectively, whereas the zinc/lead ratio of sample S417 is 35 This suggests that silver-lead mineralization in the dike areas may not be related to zinc mineralization in the breccia or to the possible buried sphalerite deposit

The stream-sediment anomaly is asymmetric with respect to the associated elements Zinc, iron, and manganese reach maximums in a central zone near the dike (fig 22), whereas silver, barium, and strontium vary inversely with zinc and are concentrated in the downstream part of the anomaly The increase in silver content downstream from the dike (pl 4, fig 23) suggests the dike as a source, whereas the zinc, which is concentrated largely near and upstream from the dike, probably came from the mineralized zone at and near sample site S417, a zone also marked by a geophysical anomaly.

ELECTROMAGNETIC INVESTIGATIONS OF THE MILL CREEK ANOMALY

The Mill Creek zinc anomaly was investigated by four slingram traverses (pl. 4, T1–T4) and by one AFMAG traverse (T5) Although highly conductive rocks were detected in the zone that is geochemically anomalous in zinc, the electromagnetic data do not unequivocably indicate sulfide bodies for the following reasons: (1) sphalerite, unlike other sulfides, is not a conductor and thus cannot be detected electromagnetically, (2) the iron sulfide content within the brecciated zone of primary zinc mineralization is probably no more than 3 percent above background amounts, judging from semiquantitative spectrographic iron analyses of the samples containing the most zinc, (3) the carbonaceous and pyritic argillite host rocks are highly conductive and would tend to mask moderately conductive sulfide bodies; (4) the lithologic sequence and attitude of the country rock were not determined because of poor exposures, and (5) the position and form of the inferred sphalerite body are unknown, a pyrite-poor bedded replacement deposit along certain beds could not be distinguished from barren conductive strata.

Anomalous readings were observed along nearly the full length of the four slingram traverses (pl. 4, T1–T4). Most of these anomalies are characteristic of highly anisotropic conductors where the conductive minerals are controlled by bedding, cleavage, or schistosity; but the large horizontal coplanar (HCP) anomalies between stations 2 and 3, and at 9 on traverse 1 (fig. 24*A*), and below sample S417 between stations 0 and 5 on traverse 4 (fig 24*B*) exhibit most of the characteristics of fairly homogeneous bodies of highly conductive materials The latter two anomalies, however, have negative vertical coplanar (VCP) quadrature components, which are opposite to the characteristic sign for a homogeneous conductor but are usually observed where the traverse crosses at right angles to the strike of a steeply dipping, anisotropic conductor The anomalies on traverse 3 could be fitted to theoretical curves for a model consisting of horizontal or gently inclined homogeneous layers The other slingram results are typical for traverses made at an acute angle to the strike of the "electrical grain" of a highly anisotropic rock such as a black slate. It is not certain whether the "electrical grain" coincides with bedding, as seems likely, or with some other planar feature, but the slingram results indicate a significant change in the direction of the "electrical grain" of the rock near stations 5 and 6 on traverse 4, possibly reflecting a change in the strike of the beds at that point

The AFMAG traverse on Mill Creek (Fig. 25; pl. 4, T5) shows results similar to the four slingram traverses Offset of the curve above the zero line (fig 25) is probably caused by the traverse crossing the "electrical grain" of a highly anisotropic rock at an acute angle. The pronounced crossover at station 12 falls within the highly conductive zone on the southern third of slingram traverse 4 and is near the mineralized breccia (pl. 4, sample S417). This large anomaly probably indicates a change in attitude of the conductive, anisotropic bedrock, but the possibility exists that it represents significant sphalerite mineralization, especially a bedded replacement deposit in which certain favorable beds are replaced by sulfides. In most of this area, it would be impossible to detect anything but a massive, near-surface, highly conductive sulfide body by electromagnetic methods.

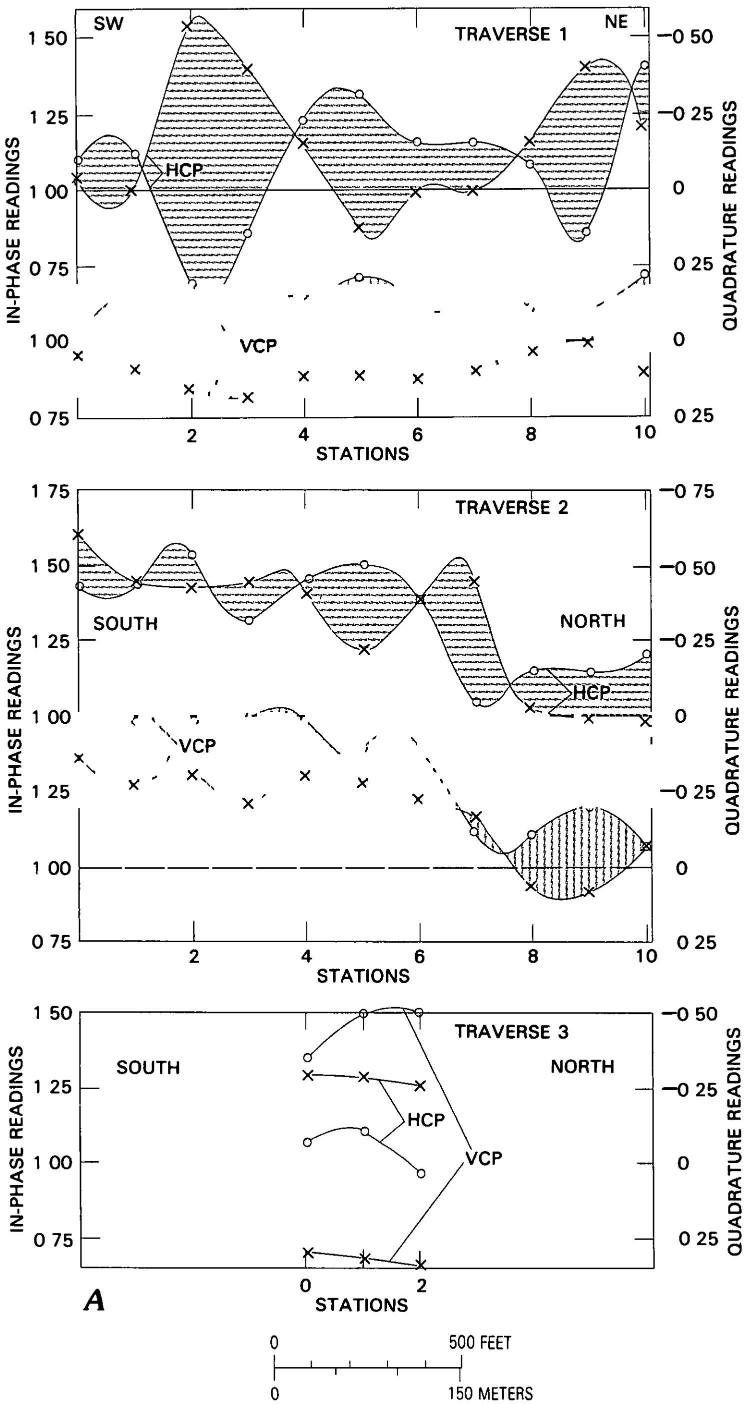
SHEEPHEAD CREEK ANOMALY

A geochemical anomaly marked by as much as 2,500 ppm zinc and 1.5 ppm silver was detected in stream sediments along Sheephead Creek (pl. 4, fig. 26). The most anomalous sample (E737) was taken from an electromagnetic anomaly (fig. 27). The high zinc and low silver, lead, and antimony contents (fig. 28) suggest a buried sphalerite deposit near the creek similar in type to that of the lower part of the Hoodoo mine. The two prospects in the Sheephead drainage contain far too little zinc to be the sources of the anomaly, according to samples analyzed by the U.S. Bureau of Mines (table 11, Nos. 64, 65).

The zinc anomaly was investigated by an 800-ft (244-m) AFMAG electromagnetic traverse (figs. 26, 27), which gave inconclusive results. A well-defined "reverse" crossover occurs at station 3 (fig. 27), which could represent a conductor associated with the zinc anomaly. The traverse was too short to assess the background conductivity of the rocks in the area.

GRAND PRIZE GULCH AREA

Discovery in 1971 of anomalous silver, lead, and zinc in stream sediments along Grand Prize Gulch prompted detailed geochemical and reconnaissance electromagnetic studies in 1972 to determine the source of the anomalous metals (pl. 5). Discovery of jamesonite-sphalerite veinlets in the Grand Prize sericitized rhyolite porphyry dike made the area more attractive. Stream sediments collected in 1971, near and downstream from the Grand Prize dike, contained as much as 36 ppm silver, 2,000 ppm lead, and 2,000 ppm zinc (pl. 5, 769, 773). Subsequently, as much as 4,000 ppm zinc was detected in this area (pl. 5, 1004) and 6,000 ppm zinc from a soil sample (T460) near the head of the gulch. High zinc values also were obtained from two areas (pl. 5, T465, T467–468) across the divide in the West Fork drainage. All of the anomalous samples are underlain by Paleozoic rocks that are part of a belt of rocks that trends southeastward more than 3 mi (4.8 km) parallel to the dike, the gulch, and the Boulder Mountain crest. Rocks of the belt contain significantly higher values of zinc and


SW
NE
TRAVERSE 1
1 50
1 25
1 00
0 75
1 00
0 75
−0 50
−0 25
0
0 25
0
0 25
IN-PHASE READINGS
QUADRATURE READINGS
HCP
VCP
2
4
6
8
10
STATIONS
1 75
1 50
1 25
1 00
1 25
1 00
0 75
−0 75
−0 50
−0 25
0
−0 25
0
0 25
TRAVERSE 2
SOUTH
NORTH
HCP
VCP
IN-PHASE READINGS
QUADRATURE READINGS
2
4
6
8
10
STATIONS
1 50
1 25
1 00
0 75
−0 50
−0 25
0
0 25
TRAVERSE 3
SOUTH
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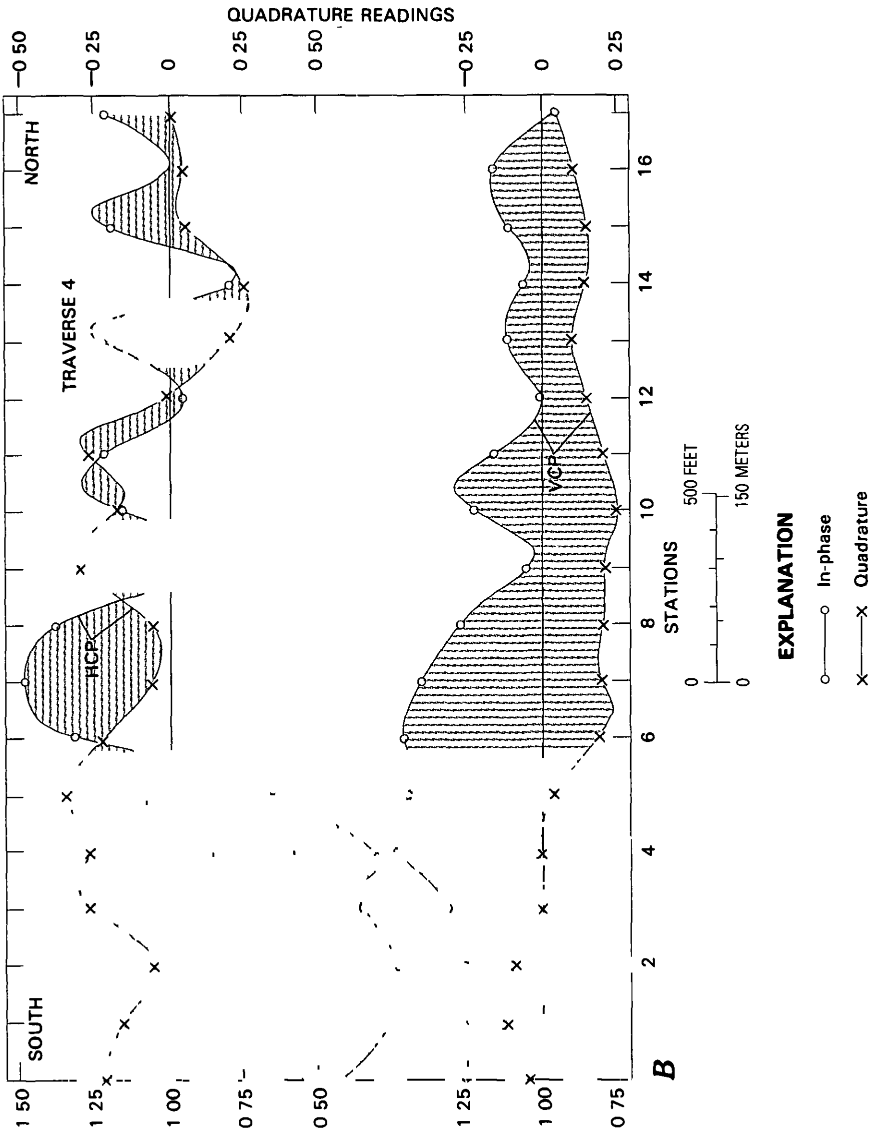


FIGURE 24.—Electromagnetic (slingram) profiles showing horizontal coplanar (HCP) and vertical coplanar (VCP) quadrature components, Mill Creek zinc anomaly, *A*, along traverses T1, T2, T2, *B*, along traverse T4. (See pl. 4 for traverse locations.)

commonly of silver and lead than do Paleozoic rocks outside the belt and much higher values than the overlying Challis Volcanics (pl. 1).

The presented geological, geochemical, and geophysical evidence suggests that deposits of zinc, lead, and silver might be discovered by

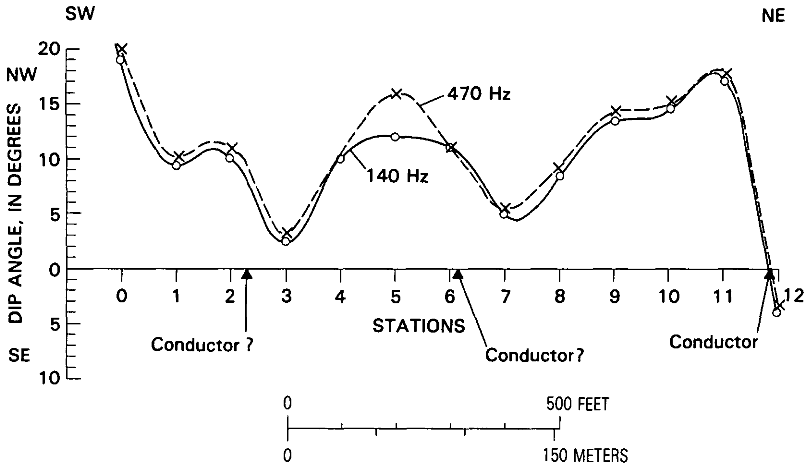


FIGURE 25.—Graph of dip angles at two frequencies along electromagnetic (AFMAG) traverse over zinc anomaly on Mill Creek (See pl 4 for the T5 traverse location)

detailed exploration within the belt although nearby prospects are not mineralized significantly. A small pile of gold-bearing lead ore rich in silver, tin, antimony, and zinc was found on the Darlin group (pl. 5; table 7, T283); but it probably was transported from a prospect in the Galena district because the adjacent prospects contain very small amounts of the elements contained in the pile. Mineralized outcrops observed in prospects might in part account for some anomalous samples along Grand Prize Gulch west of the dike, but anomalous samples farther to the southeast are not explained by known deposits. The possibility of jamesonite-sphalerite deposits adjacent to the Grand Prize dike is suggested by veinlets in the altered dike near the trail crossing (pl. 5, AMT 1-4), and by the similarity of the dike to the Scotch dike, which is associated to the jamesonite-sphalerite deposit at the Livingston mine. In addition, exploration targets may be present at depth in the Darlin group of claims, and near the head of Grand Prize Gulch and across the divide in the West Fork of the East Fork Salmon River drainage, where anomalous zinc values were obtained.

Some of the geochemical samples contain high amounts of silver, lead, and zinc as compared to the nearby prospects described in Chapter E. This suggests that higher grade undiscovered deposits may exist at the source of the geochemical anomalies A possible source area is an inferred silver anomaly that is delineated on plate 5. Twelve soil samples taken on a 100-ft (30-m) grid pattern on the Darlin group (fig. 29) show an increase in silver northwest toward the inferred anomaly. Stream-sediment sample 773, taken just below the inferred anomaly, contained 36 ppm silver, although this value could be in-

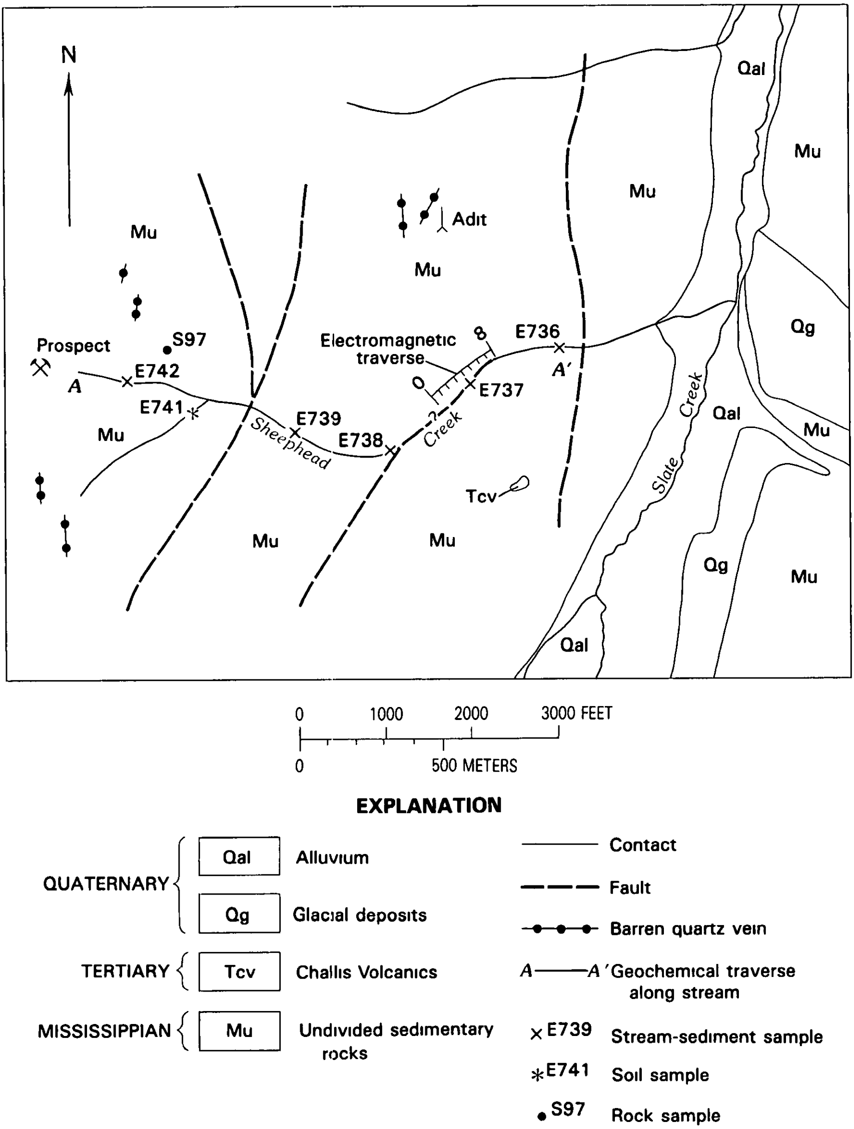


FIGURE 26.—Map showing geology and location of electromagnetic (AFMAG) and geochemical traverses along Sheephead Creek. Geology modified from Kern (1972).

fluenced by erosion from a prospect directly upslope. A sample (T279M) from the prospect contained 120 ppm silver (table 2). The anomaly also is marked by high lead and zinc content, and may have as a source a vein related to a structural intersection. Ross (1937) mapped a major fault along Grand Prize Gulch that is roughly coincident with northwest-trending faults shown on plate 1. Concealed mineralized

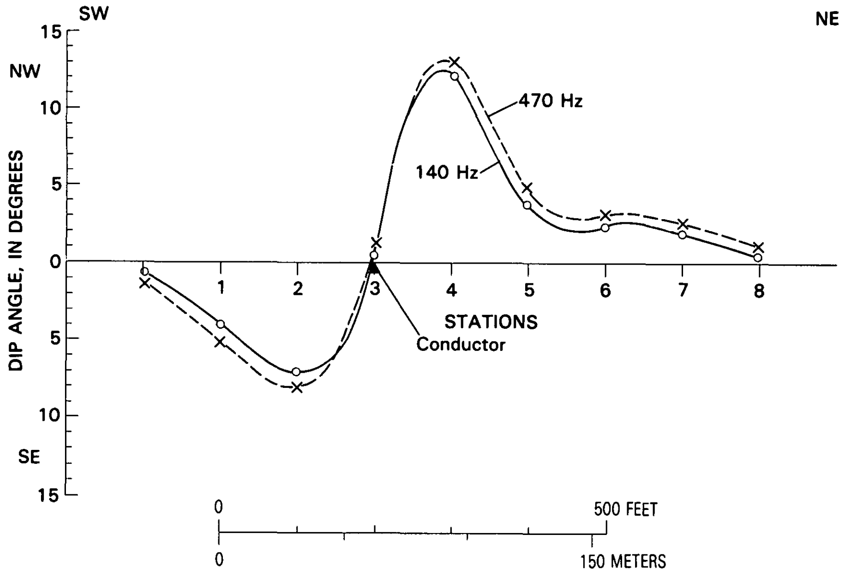


FIGURE 27 —Graph of dip angles at two frequencies along electromagnetic (AFMAG) traverse on Sheephead Creek

faults or veins might intersect the northwest faults near the inferred silver anomaly, although no mineralized outcrops were seen immediately nearby Small apparently barren quartz and quartz-carbonate veins are common along Grand Prize Gulch, and anomalous amounts of silver, lead, and zinc were found in a float sample from one such vein (T549M)

A zinc anomaly on the broad divide at the head of Grand Prize Gulch, along the projected intersection of Grand Prize dike, is suggested by two soil samples (pl 5, T460 and T461) that contained 6,000 and 3,000 ppm zinc and 160 and 300 ppm lead, respectively The samples are from small seasonal ponds. To investigate these findings, a slingram traverse (pl 5, SRT 1) was made across the divide, and rock, soil, and stream-sediment samples were taken at or near the traverse stations Sample numbers are not shown at the traverse stations on plate 5, but a graph of zinc values of the traverse samples is presented in figure 30 The highest zinc content was obtained from sample A409 (fig 30), which was collected directly upslope from station 10, which in turn is upslope from localities of soil samples T460 and T461 The locations of these anomalous samples suggest that contained zinc may have been derived from an apparently barren northeast-trending jasperoid vein that crops out on the hillside to the north, or possibly from a nearby but buried source. Such a source could be along the projected southeast extension of the Grand Prize dike Other possibly

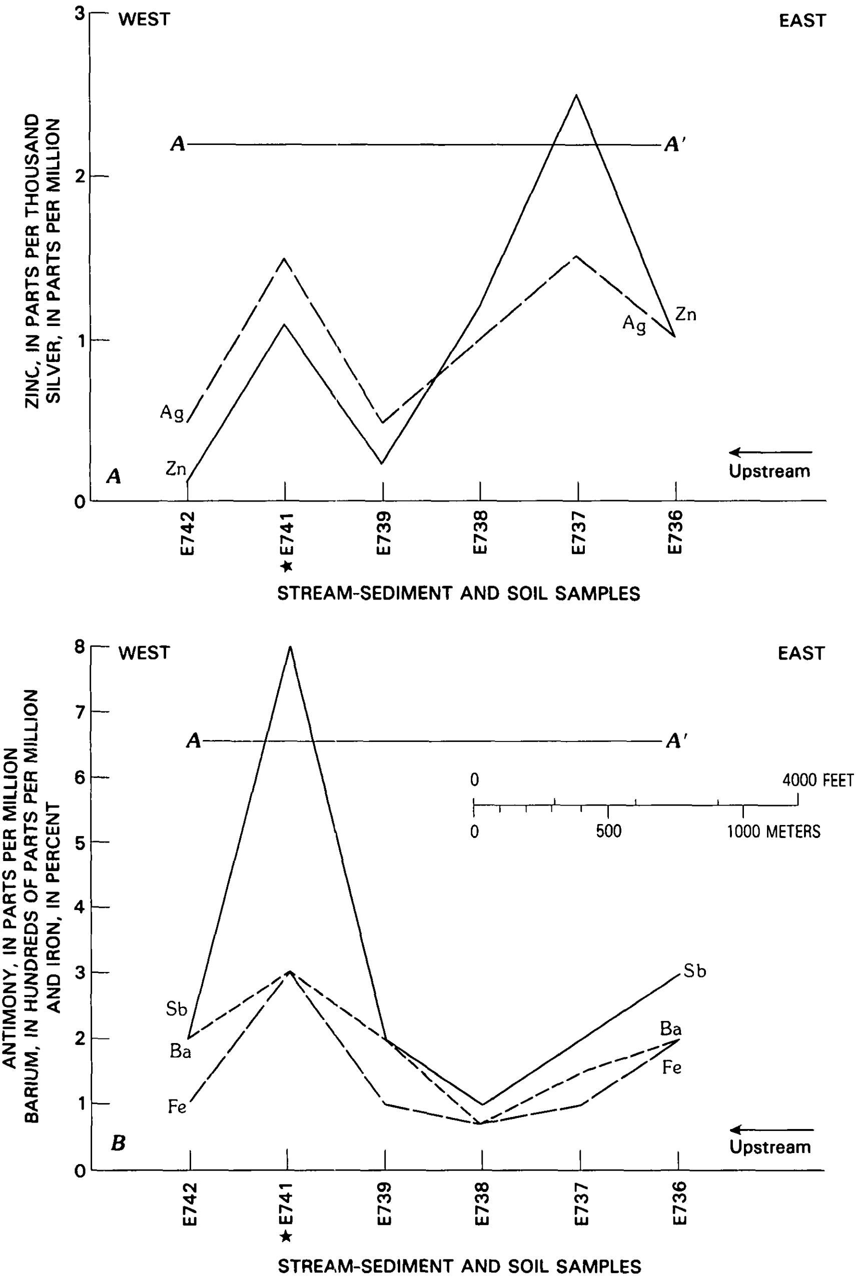
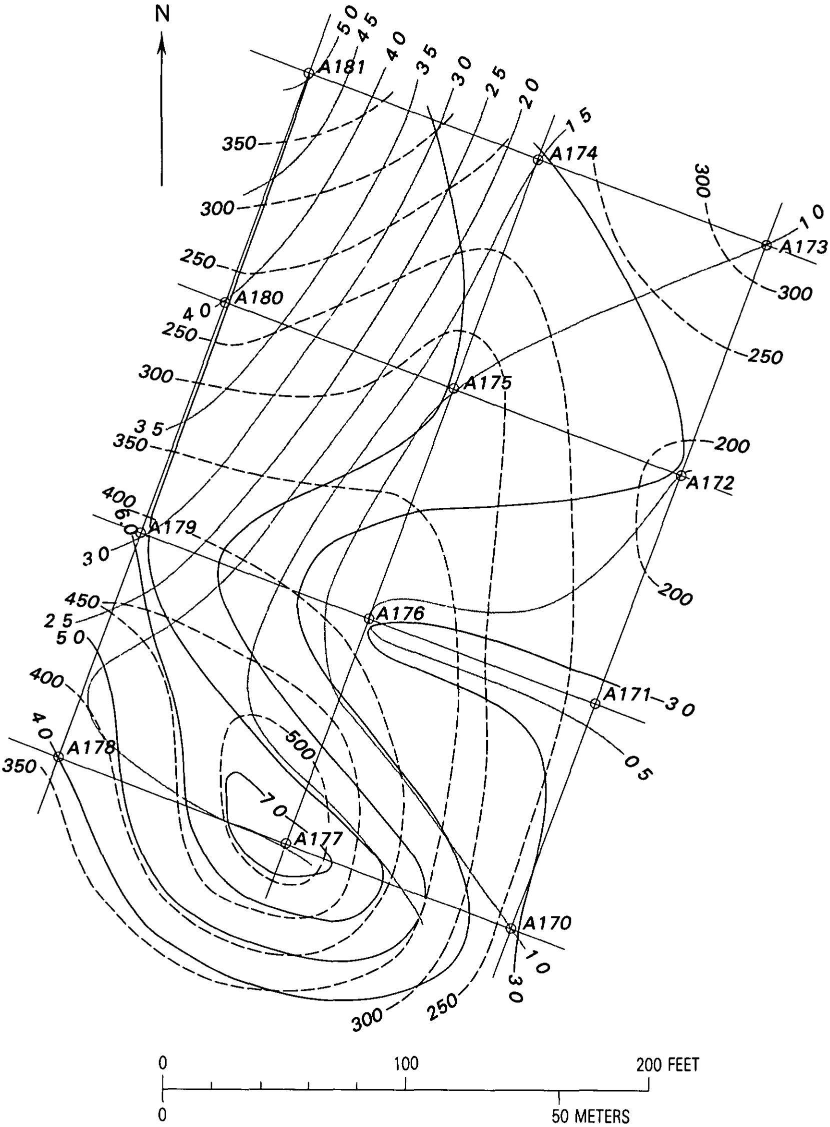


FIGURE 28.—Distribution of selected elements along geochemical traverse *A-A'* on Sheephead Creek. Soil sample starred. *A*, Zinc and silver (atomic absorption analyses). *B*, Antimony (colorimetric analyses) and barium and iron (semiquantitative spectrographic analyses).



EXPLANATION

———— Silver (Ag)—Contour interval 0 5 parts per million

———— Antimony (Sb)—Contour interval 1 0 parts per million

– – – – Lead (Pb)—Contour interval 50 parts per million

o *A172* Soil sample

FIGURE 29 —Map showing distribution of silver, antimony, and lead in soil samples collected on a 100-ft (30-m) grid in a mineralized zone on the Darlin group Silver and lead by atomic absorption analysis, antimony by colorimetric analysis Grid location shown on plate 5

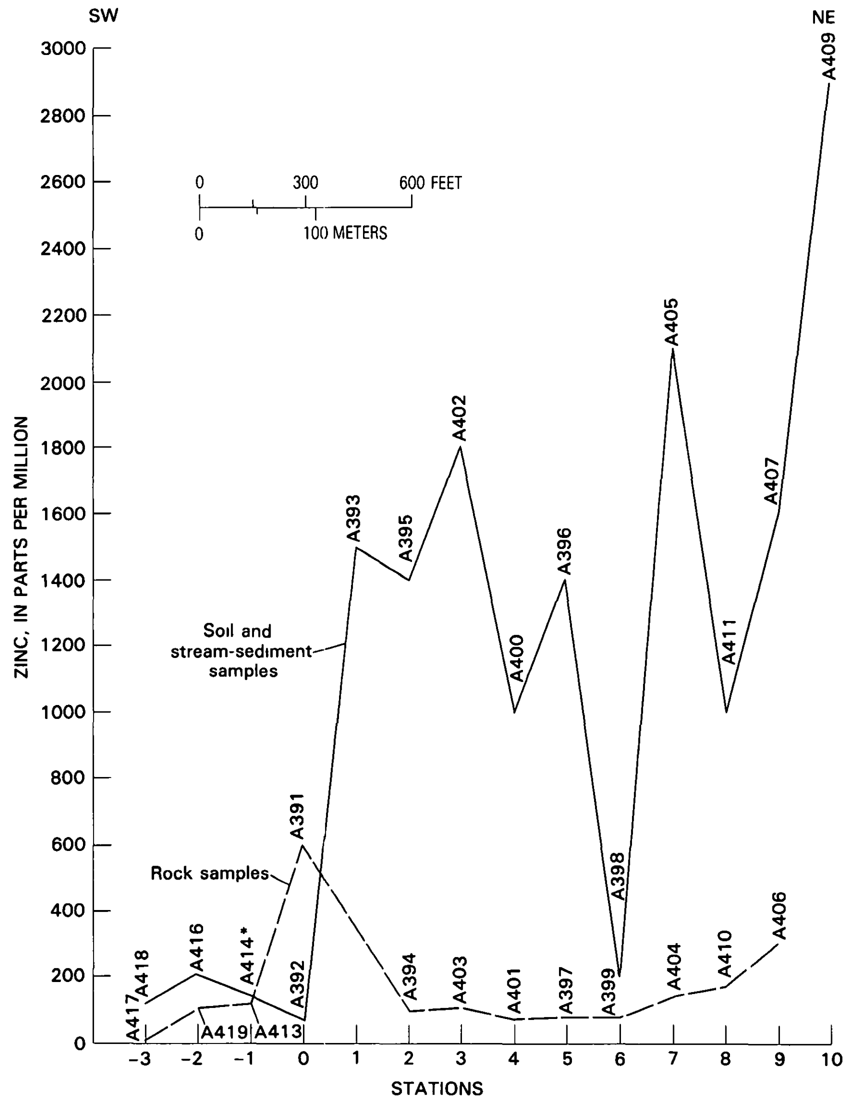


FIGURE 30 —Graph showing distribution of zinc in rock, soil, and stream-sediment samples along west part of electromagnetic (slingram) traverse SRT 1 across head of Grand Prize Gulch Starred sample, soil

mineralized structures are crossed by the slingram traverse, which is described in the following section.

Zinc is the predominant metal in anomalous stream-sediment or soil samples taken along the northwest-trending Grand Prize belt. Zinc is particularly abundant relative to lead and silver in the southeastern part of the belt, where anomalous zinc values of 800–1,800 ppm were found in the stream-sediment samples along the West Fork drainage

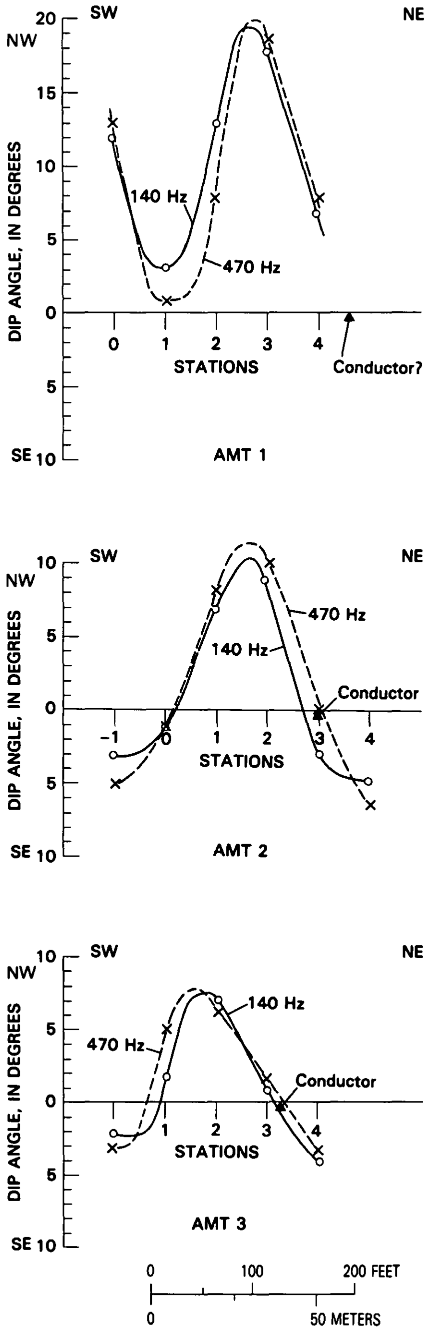


FIGURE 31 —Graphs of dip angles at two frequencies along electromagnetic (AFMAG) traverses AMT 1, AMT 2, and AMT 3 across Grand Prize rhyolite porphyry dike Traverse lines are shown on plate 5

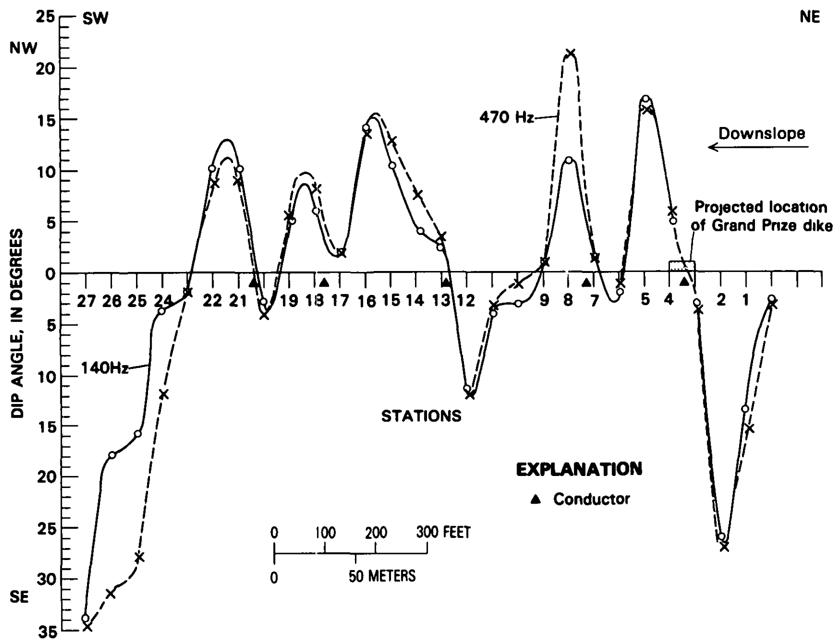


FIGURE 32 —Graph of dip angles at two frequencies along electromagnetic (AFMAG) traverse AMT 4 across mineralized zone near Grand Prize rhyolite porphyry dike Traverse line is shown on plate 5

as far as a mile (1 6 km) southeast of the strong zinc anomaly on the divide at the head of Grand Prize Gulch. At the southeast end of the Grand Prize belt, the anomalous zinc in the stream-sediment samples T467, T468, and T471 (pl. 5) seems to be derived from rocks in the floor of a cirque, above which is yellow-stained quartzite that contains anomalous arsenic but only background values of zinc. The yellow color is probably due to arsenic, according to the analyses of two large composite samples of yellow-stained quartzite talus (pl. 5, A602, A603). The content of gold, silver, lead and antimony was low in the talus samples, but yellow arsenic or arsenic-antimony bloom elsewhere in the study area occurs with gold and silver minerals The arsenic-stained quartzite could be interpreted as the upper part of a primary geochemical halo beneath which could be concentrations of silver, lead, and zinc minerals.

One long and three short AFMAG electromagnetic traverses made approximately at right angles to the Grand Prize dike (pl. 5, AMT 1–4), show crossovers (figs. 31, 32) that might indicate jamesonite-sphalerite-pyrite mineralization like that found in the dike farther east (pl 5, table 2, T286M) The electromagnetic curves on all four traverses indicate good electrical conductors along the dike rather than local induction in discrete massive sulfide bodies along the contacts The very small differences between the results of the two frequencies indicate that the cause of the anomalies is current channeling in a single long conductor Traverses AMT 1, 2, and 3 (fig. 31) were too short to detect the actual crossovers, which were extrapolated from the shapes of the curves, compared to the ideal crossover on traverse AMT 4 (fig. 32). For traverse AMT 1, the curve (fig. 31) appears to be shifted above the zero line by a feature that did not affect the other traverses Possible mineralization along the dike is not likely to be the source of the downstream inferred silver anomaly; however, the zinc anomaly southeast at the divide could be related to a subsurface continuation of the dike.

Traverse AMT 4 was intended to test the dike and to detect conductors in the wall rocks that might account for the inferred silver anomaly downstream. Several conductors were located along the traverse southwest of the dike, as shown in figure 32. Some of these may correlate with poorly mineralized veins in prospects near the traverse The conductors most worthy of further investigations are the dike and a conductor that may exist beyond the southwest end of the traverse This crossover is near the intersection of three possible structures and near the projected continuation of a fault along which is a stream-sediment sample (pl 5, 769) that contains high silver and lead values Another stream-sediment sample (pl 5, 773) rich in lead and silver was taken along a northwest projection of this fault No known deposits can be related to this possible conductor. The only evidence of mineralization seen outside the prospects near this traverse was pyritized and nonstained rock (T280 and T281), which contains anomalous silver, lead, and zinc, and which suggests the possibility of replacement deposits in intersected favorable calcareous sandstone beds

A slingram traverse (pl. 5, SRT 2) was run along the jeep trail starting near the discovery post of the Darlin No 3 claim. The quadrature curves (fig 33) may have detected the N 70E.-trending, low-grade quartz-galena vein in the old adit near station 4, near sample site T279M (pl 5), as a resistivity high; and two small peaks suggest possible mineralized zones on either side of it, near stations 2 and 5. The in-phase readings were omitted because of erroneous coil spacing. These conductors might be related to the source of the nearby inferred silver anomaly downstream

Four conductors lie along SRT 1 (pl. 5; fig 33), two near high zinc values (pl 5, T279M, T283) The small electromagnetic anomaly at station -3 and the larger one at station 1 are discernible only on the HCP curve and probably represent narrow, steeply dipping conductors (fig 33) The first conductor coincides with anomalous silver, lead, and antimony values found in soil and rock samples at that site, although the samples were not anomalous in zinc The second conductor (fig 33, station 1) coincides with the edge of a broad zinc anomaly, indicated by

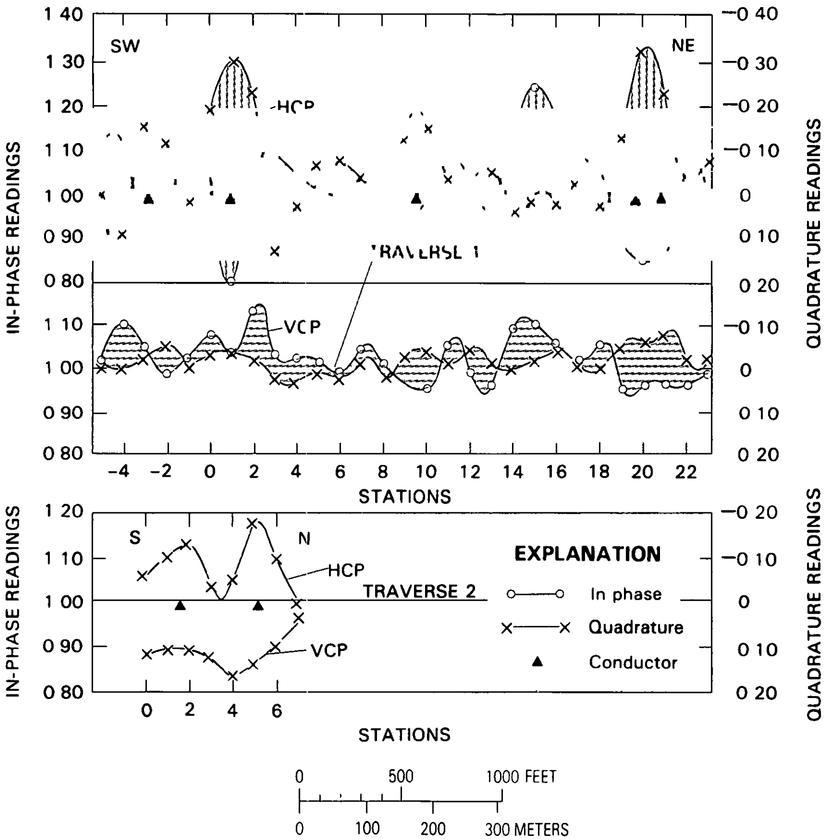


FIGURE 33.—Electromagnetic (slingram) profiles showing horizontal coplanar (HCP) and vertical coplanar (VCP) quadrature components and possible conductors along traverses SRT 1 and 2, Grand Prize Gulch Traverse lines are shown on plate 5

soil sample analyses (fig 30), and approximately with the contact between quartzite and sandy limestone Considerable quartz and calcite float was noticed across the area anomalous in zinc. Small electromagnetic anomalies for both loop configurations were observed between stations 9 and 10 near the highest zinc values found in the soil samples. The most probable cause of this anomaly is a zone of poorly conducting material at least several tens of feet wide that most likely represents altered, mineralized, or brecciated bedrock and which constitutes a prospecting target. The conductor near station 9 (fig. 33) could represent the southeast extension of the Grand Prize dike. It should be noted that sphalerite deposits containing few other sulfides are not good conductors

The broad in-phase anomaly between stations 14 and 17 (fig. 33, traverse 1) is a result of improper coil separation

The impressive anomaly between stations 19 and 21 (fig 33) in an area where no samples were collected is too broad to be caused by a single, steeply dipping sheet, judging from the relatively small VCP anomaly, it may be caused by two or more narrow, steeply dipping, conductive veins A quartz-calcite vein containing cubic casts of pyrite and striking almost normal to the traverse crops out about 50 ft (15 m) east of station 19 and is one indication that the anomaly may be caused by sulfide mineralization

The zinc anomalies and the electromagnetic conductors indicate that the divide at the head of Grand Prize Gulch is a favorable area for the discovery of zinc deposits, but the economic potential cannot be evaluated without detailed geologic mapping, further geochemical and geophysical studies, and if warranted, drilling.

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Economic Appraisal of the Eastern Part of the Sawtooth National Recreation Area, Idaho

By RONALD M VAN NOY, JAMES RIDENOUR, NICHOLAS T ZILKA, FRANK E FEDERSPIEL, ROBERT K EVANS, ERNEST T TUCHEK, *and* AREL B McMAHAN, U S. BUREAU OF MINES

MINERAL RESOURCES OF THE EASTERN PART OF THE SAWTOOTH NATIONAL RECREATION AREA, CUSTER AND BLAINE COUNTIES, IDAHO

GEOLOGICAL SURVEY BULLETIN 1545-E

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ECONOMIC APPRAISAL OF THE EASTERN PART OF THE SAWTOOTH NATIONAL RECREATION AREA, IDAHO

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INTRODUCTION

Mineral production from the Sawtooth National Recreation Area, excluding the Sawtooth Wilderness, was estimated at $5.3 million in 1972 About $600,000 was estimated for placer operations. Since 1902, a total production of $2.5 million has been realized (the total would be much greater at present prices) Of this total, 59 percent was from lead, 3 percent from gold, 16 percent from silver, and 21 percent from zinc. Less than 1 percent of the production value came from copper. It is estimated from various reports (Choate, 1962, Umpleby, 1915, Ross, 1937) that, prior to 1900, at least $2.6 million worth of gold, silver, and lead was produced.

The study area was divided into 14 arbitrary study districts (fig. 34), and the principal mines, prospects, or groups of prospects are numbered on plate 3 for ease of description. These study districts do not coincide with the mining districts referred to in the preceding chapters of this report, or in previous reports. Two study districts have no reported prospecting or known mineral deposits and are not named in figure 34. Nine districts have some recorded production. The mines within the study area that have recorded production exceeding $125,000 each are, in order of decreasing importance: the Livingston mine (pl 3, 90), Big Boulder Creek district; the mines in Boulder Basin, principally the Golden Glow mine (pl. 3, 229) in the North Fork Wood

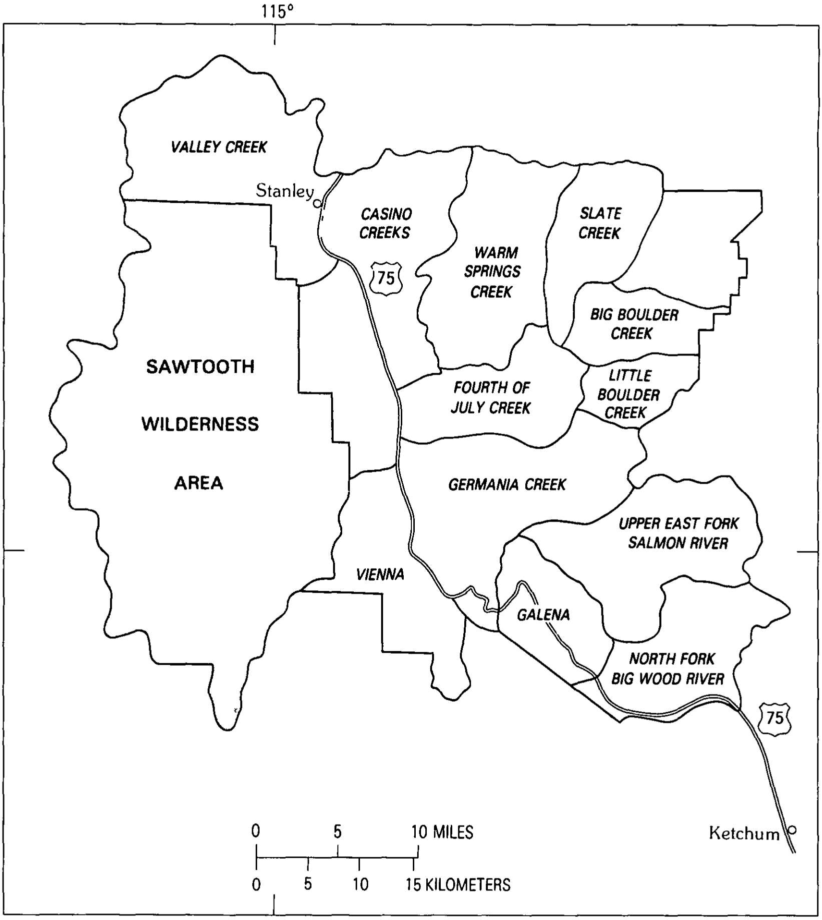


FIGURE 34 —Index to U S Bureau of Mines study districts, Sawtooth National Recreation Area. Two are unnamed

River district; Silver Rule mine (pl. 3, 80), Slate Creek district, the Idahoan mine, and the nearby Old Bible Back mine (pl. 3, 144), Germania Creek district. Less productive mines include the Buckskin and Valley Creek mines (pl. 3, Nos. 5, 3), Valley Creek district; Red Cloud and Black Carbonate mines (pl. 3, 205, 217), Galena district; Deer Trail and Rupert mines (pl 3, 109, 113), Fourth of July Creek district, the Homestake and Gold Chance mines (pl. 3, 40, 42), Casino Creeks district, and the Aztec mine (pl 3, 106), Warm Springs Creek district

The most productive gold placers in the study area are along Stanley Creek (pl. 3, Nos. 5, 6), along Salmon River below Stanley (pl. 3, 14–16), and along Casino and Rough Creeks (pl. 3, 11–13) Other gold placer deposits have been worked on Nip and Tuck Creek (pl 3, 8), at Mormon Bend (pl 3, 10), and on Pigtail Creek (pl. 3, 24).

MINING CLAIMS

The Blaine and Custer County records indicate that more than 3,800 claims including 930 placer claims have been recorded within the study area This total includes neither claims located along the north edge of the Salmon River downstream from the mouth of Joes Gulch Creek, nor numerous claims filed after June 1971. The earliest prospecting activity known was in the early 1860's, but the first claims were not filed until the late 1870's Many have been relocated, some several times.

Most lode claims are concentrated in two separate areas. The largest is within a mineralized belt that extends from the southeast corner to the northeastern part of the study area through the North Fork Wood River, Galena, Germania Creek, Fourth of July Creek, Little Boulder Creek, Big Boulder Creek, and Slate Creek districts (fig. 34). The other is in the northern part of the Casino Creeks and Valley Creek districts, in the northwestern part of the study area.

Placer claims have been located along Elk, Valley, and Stanley Creeks in the Valley Creek district; along Salmon River downstream from Stanley virtually the length of river to the northeast boundary of the study area and on various tributaries at the headwaters of Warm Springs Creek, along the upper Salmon River, and on Big Wood River along the south edge of the study area.

A total of 64 claims have been patented, including two placer claims along the Salmon River. The largest groups of patented claims are in the North Fork Wood River, Galena, Germania Creek, Big Boulder Creek, and Valley Creek districts

METHODS OF EVALUATION

Courthouse records and reports of mineral deposits were used to determine the number and location of claims, and the past relative importance of the mineralized districts. Owners or previous owners of mineral properties were contacted for data concerning the history of the property, production records, and unpublished geologic accounts.

In the field, all mines, prospects, and claims were sought. All lode properties found were studied and, if warranted, were mapped. Samples were taken from all workings whether mineralized material was apparent or not Placer deposits were examined but not studied in detail because time was not available Most placer deposits, however, were given a cursory check by panning near-surface material, channel sampling, or by sampling hand-dug pits or trenches. In some localities data from previous reports were used

SAMPLING AND ANALYTICAL METHODS

A total of 1,817 lode samples and 268 placer samples were analyzed. Most lode samples ranged from 5 to 10 lb (2 3–4.5 kg) All samples were checked for the presence of radioactive and fluorescent minerals. The samples were crushed with a jaw crusher to minus one-half inch, then cone crushed to minus one-eighth inch. Each sample then was split, pulverized to −100 mesh and mixed by rolling. Most samples were fire assayed to determine the gold and silver content. Metallic values were determined by atomic absorption, colorimetric, or X-ray fluorescent methods. At least one sample from each type of mineralized structure or zone at a property was analyzed by semiquantitative spectrographic methods. If anomalous amounts of elements with economic significance were indicated, the element was further analyzed by more accurate methods

Placer samples or channel samples were taken where placer claims had been located At some placers, 1-foot-square (0.1 m^2) channels were cut from cleaned bar edges, hand-dug pits, or trenches. The samples consist of 1–3 ft^3 (0 0028–0 085 m^3) each of material. Channel samples were concentrated at the site by a motor-driven vibrating sluice box Concentrates were further processed on a laboratory-size Wilfley table. Final concentrates were treated with sodium hydroxide to clean gold particles, and then amalgamated to determine amount of recoverable gold The remainder of the concentrate was fire assayed Combined total gold values are used in this report Samples were also checked for other heavy minerals of economic interest

In the following descriptions of mines and prospects, tabulated assay data on gold and silver are shown in ounces per ton For conversion of such data to grams per metric ton, see Chapter C, table 5, of this report Lengths in these tabulations are shown in feet and inches, conversion factors to the metric system are given.

LITTLE BOULDER CREEK DISTRICT

The widely publicized molybdenite deposits owned by the American Smelting and Refining Co (ASARCO) and other interests are in the Little Boulder Creek district in the east-central part of the study area (pl 3, fig 34)

In the east half of the district, the foothills of the White Cloud Peaks consist of Tertiary volcanic rocks and Quaternary glacial debris The west half of the district contains cirques and knife-edged ridges underlain principally by granitic rocks and contact-metamorphic rocks of Paleozoic age

The known mineral deposits are near the east side of the White Cloud stock The first mining claims were recorded in 1889 as lode claims on silver-, lead-, zinc-, and copper-bearing outcrops None of these prospecting ventures were successful. A total of 261 claims (table 9) has been recorded, but the district has no history of mineral production. Exploration, development work, and interest in the district were minimal until the possible economic value of the molybdenum deposit became widely known through wartime studies by the U S Bureau of Mines and U S Geological Survey. In 1967, ASARCO obtained an option on the Baker Lake molybdenum occurrence Other interests quickly located claims and by the end of 1969, a block of claims about 1 5 mi (2 4 km) wide and 5 mi (8 km) long had been located along the intrusive contact

BAKER LAKE (LITTLE BOULDER CREEK) PROSPECT

The Baker Lake prospect is at an altitude of 8,500 ft (2,590 m) near the base of Castle Peak (pl 3, 94, 95). It is accessible by trail from the north, south, and east The best access is by trail from the east, which follows Little Boulder Creek for about 7 mi (11 km), from the graded dirt road along the East Fork Salmon River Construction of an access road along Little Boulder Creek would be relatively inexpensive. The valley has a good gradient for road building except for about 2 mi (3.2 km) near the east end.

In 1922, Jess Baker located mining claims on this mineral deposit. He performed assessment work, drove several short adits, and dug several trenches In 1939, the Molybdenum Syndicate spent several months collecting a large number of samples, which averaged approximately 0.12 percent molybdenum The Bureau of Mines examined and sampled the northern part of the deposit in 1942. Metallurgical tests were made, and a report submitted to the Secretary of the Interior confirmed the existence of a large body of marginal-resource molybdenite-bearing material (L E. Shaffer and Frank Gunnell, unpublished U.S Bureau of Mines War Minerals Report, 1943).

A report by the U S. Geological Survey indicated that the deposit contains an appreciable reserve averaging about 0.15 percent MoS_2 (Kirkemo and others, 1965)

The American Smelting and Refining Co. obtained the Baker claims

TABLE 9.—*Summary of mining claims recorded, including relocations, 1880-1971, Little Boulder Creek district*

Decade	Number of lode claims
1880 - 1889	7
1890 - 1899	--[1]
1900 - 1909	--
1910 - 1919	3
1920 - 1929	19
1930 - 1939	1
1940 - 1949	--
1950 - 1959	7
1960 - 1969	163
1970 - 1971	61
Total----	261

[1]Leaders (--), none recorded.

and located about 50 additional claims in 1967. In 1968, they began exploration and development, including diamond drilling This work was serviced completely by helicopter Preliminary drilling indicated that a major drilling program was warranted; therefore, the company applied to the U S Forest Service for a permit to build an access road (Kesten, 1970) When the American Smelting and Refining Co plans became publicly known, the company came under intense criticism from environmental protective groups, subsequently the road was not constructed nor has there been further development of the prospect.

Molybdenite occurs in contact-metamorphosed quartzite In general, bedding of the quartzite in the area strikes northerly nearly parallel to the east contact of the White Cloud stock (fig. 35) and dips eastward, but locally it dips westward Two mineralized zones exist: the main or North zone (pl 3, 94) is separated from the South zone (pl. 3, 95) by about 3,000 ft (914 m) of forested ground with a few outcrops (fig. 36). The area between the two zones is covered by sparse outcrops of rocks and colluvium The North zone is partially obscured by talus, but mineralized quartzite crops out farther north in the Boulder Chain Lakes area. The south end of the South zone is obscured by talus, no mineralized quartzite was observed in the cirque walls beyond

Contact-metamorphosed quartzite in both zones has a green color because of the formation of diopside, epidote, and chlorite. In general, dark-green quartzite contains a higher percentage of molybdenite The amount of molybdenite in the border zone of the north ore body also correlates with the amount of quartz stockwork The molybdenum mineral is almost entirely fine, homogeneously disseminated flakes of

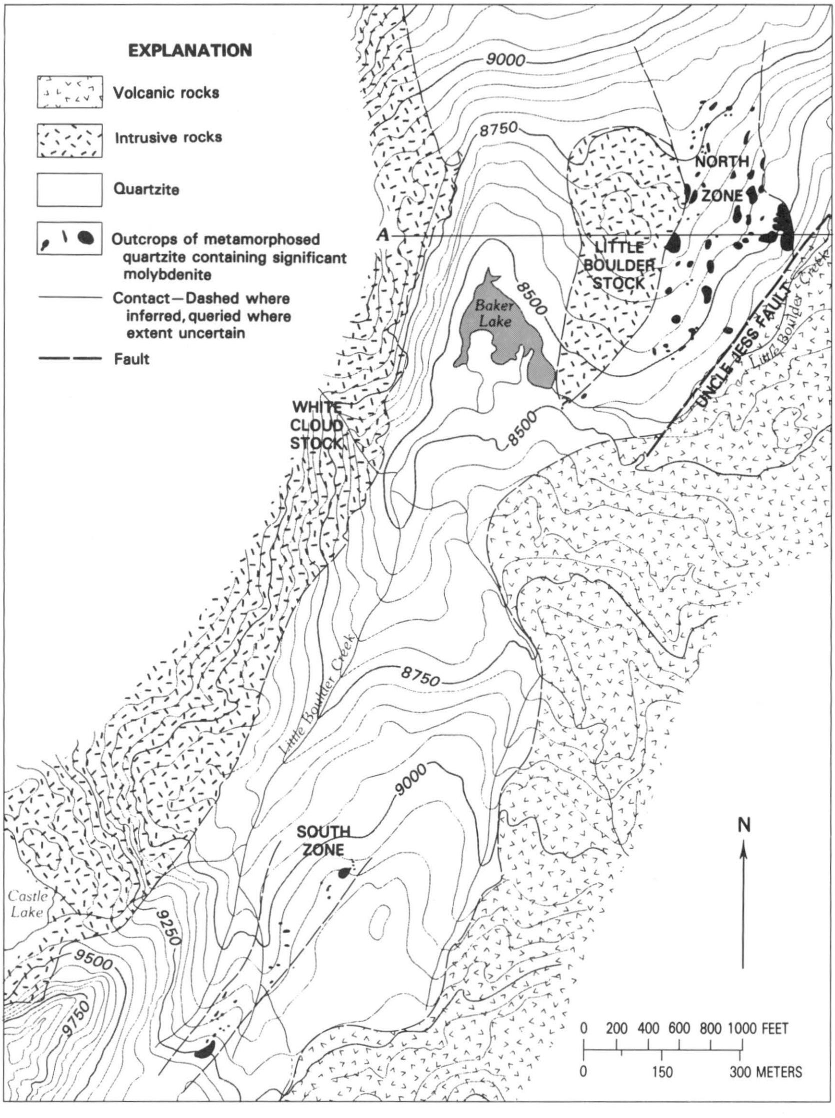


FIGURE 35.—Map of Baker Lake prospects. Section *A-A′* shown in figure 38. Contour interval 50 ft.

molybdenite (MoS_2) that range from about 0.006 to 0.03 in. (0.015 to 0.076 cm) in diameter. Occasionally a stringer or bleb of molybdenite occurs along the quartz veins in the stockwork.

Scheelite occurs in minor amounts, and some might be recoverable. Thirteen samples from the North zone and six samples from the South

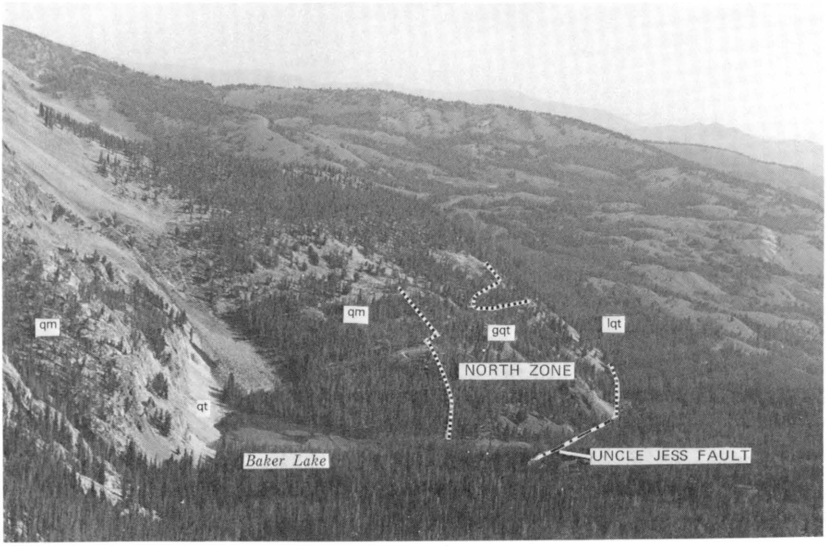


FIGURE 36.—North zone, Baker Lake prospect, looking north; qm, quartz monzonite; qt, quartzite; gqt, dark-green quartzite; lqt, light-green quartzite. Dotted line, indefinite contact.

zone were analyzed for tungsten trioxide (WO_3). Some samples contained as much as 0.02 percent WO_3, but most contained less than 0.002 percent WO_3.

Minor amounts of galena, sphalerite, chalcopyrite, and malachite occur in both zones. Eleven samples from the North zone and 17 samples from the South zone contained a weighted average of 0.004 percent copper, 0.002 percent lead, 0.02 percent zinc, and a trace of gold and silver. One representative bulk sample contained 0.0015 percent rhenium, an element commonly associated with molybdenite.

The North zone (pl. 3, 94) is along the east edge of the Little Boulder stock, bordered on the east by quartzite (fig. 37). The area between the Little Boulder and White Cloud stocks (fig. 35) is mantled with soil and talus, except for a narrow band of virtually unmineralized white, easterly dipping quartzite immediately adjacent to the White Cloud stock of quartz monzonite. Scattered outcrops of dark-green diopside-bearing quartzite mark the North zone and occur in an area about 2,300 ft (701 m) long and averaging 570 ft (174 m) wide. The quartz monzonite content is distinct near the north end, but is irregular farther south. Bedding of the quartzite strikes from N. 10° W. to N. 50° E., roughly parallel to the contact of the intrusion. Numerous quartz veinlets form in a stockwork in green quartzite near the quartz monzonite contact (fig. 38*A*, *B*). Minor amounts of galena, sphalerite, chalcopyrite, and malachite are found in the quartz veinlets and were the target of earlier exploration work Within 300–800 ft (91–244 m) eastward from the contact, the stockwork terminates, the dark-green quartzite grades into a light-green quartzite, and the molybdenite content diminishes

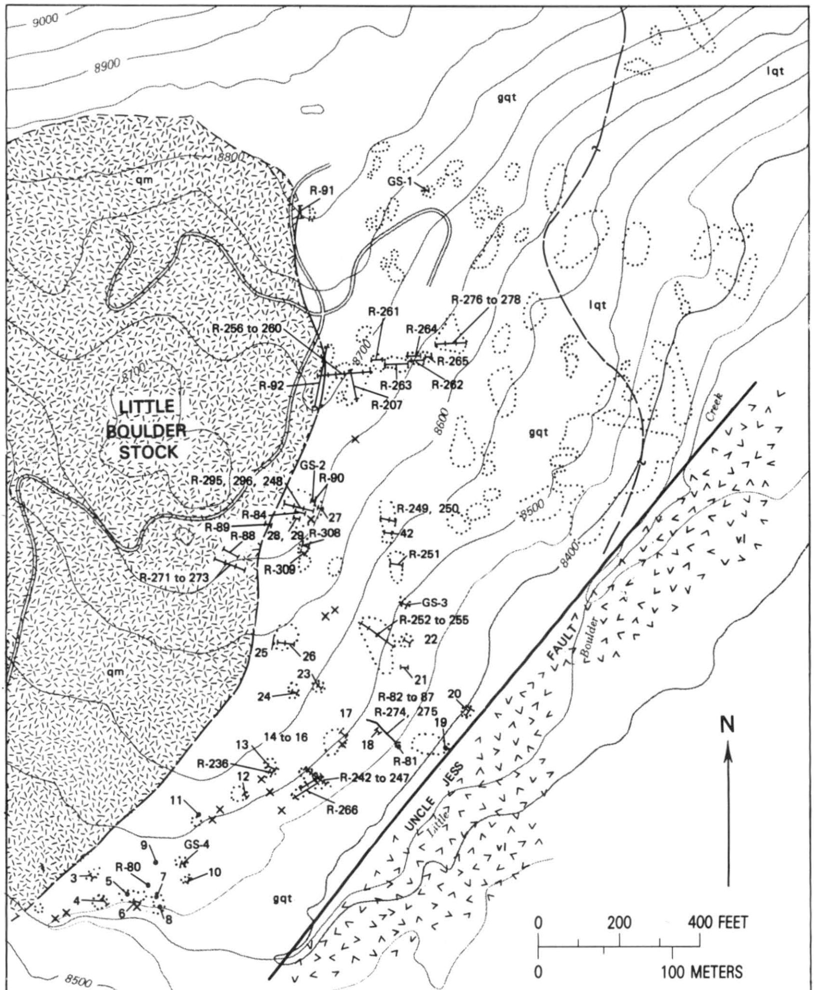
A total of 1,774 ft (501 m) of chip samples was taken from the North zone, of which 76 percent was from outcrops and the remainder from trenches and underground workings (fig 37). The MoS_2 content of samples ranged from 0.01 to 0 33 percent Samples from the adit contained a weighted average of 0 16 percent MoS_2. Subsurface samples, weighted by length, contained an average of 0.15 percent MoS_2; but outcrop samples contained a weighted average of only 0.10 percent MoS_2 The difference probably resulted from weathering

Eighty-nine percent of the sampled footage exceeded the economic cutoff grade of 0 08 percent MoS_2, a grade whose value approximates the estimated 1973 total milling cost. This material contained a weighted average of 0 16 percent MoS_2 and could be selectively mined. The higher grade material, exceeding 0.08 percent MoS_2, is in a zone estimated to average 450 ft (137 m) thick, is at least 2,300 ft (701 m) long, and is exposed through a 450-ft (137-m) difference in elevation along the strike According to American Smelting and Refining Co., the zone extends north under the talus and south beyond Little Boulder Creek According to the company, diamond drill holes to a depth of 780 ft (238 m) were in molybdenite-bearing quartzite. It is reasonable to assume that the depth extends to at least one-half the known strike length, therefore, resources in the North zone are estimated to be on the order of 100 million tons (90 million t)

The North zone would be suitable for open-pit mining. The mineralized rock–to–waste ratio, including necessary pit slopes, would be on the order of one to one to a depth of 1,200 ft (365 m) On the basis of surface sampling, operations would be economically marginal at 1974 costs of mining and milling and value of molybdenite ($2.30/lb of contained molybdenum)

The South zone (figs. 39, 40) is poorly exposed and has not been as well prospected as the North zone. Dark-green quartzite crops out about 3,000 ft (914 m) south of the North zone, and scattered outcrops occur for another 1,600 ft (488 m) to the south parallel to the contact with the White Cloud stock (fig 35) The mineralized outcrops occur in an area averaging 325 ft (99 m) in width between the volcanic rocks and barren white quartzite near the White Cloud stock. Bedding of the quartzite strikes N 40°–60° E. and dips 60°–70° SE.

A total of 356 ft (108.5 m) of chip samples were taken from the South zone, of which 82 percent was from outcrops or trenches and the remainder from underground workings. The samples, weighted by



EXPLANATION

Symbol	Explanation
vl	Volcanic rocks
qm	Quartz monzonite
gqt / lqt	Quartzite—gqt, Dark-green quartzite containing significant molybdenite; lqt, light-green or white quartzite containing minor molybdenite
(dotted outline)	Outcrop of quartzite
———	Contact—Dashed where approximate
—?—	Gradational contact
≻—	Adit
×	Prospect pit
R-242 ⊢⊣•	Sample locality

FIGURE 37.—Map of the North zone, Baker Lake prospect. Sample localities prefixed by R taken by U.S. Bureau of Mines; those prefixed by GS taken by U.S. Geological Survey; those without prefix were taken during wartime study (L. E. Shaffer and Frank Gunnell, unpublished U.S. Bureau of Mines War Minerals Report, 1943). Contour interval 50 ft.

Data for samples shown in figure 37

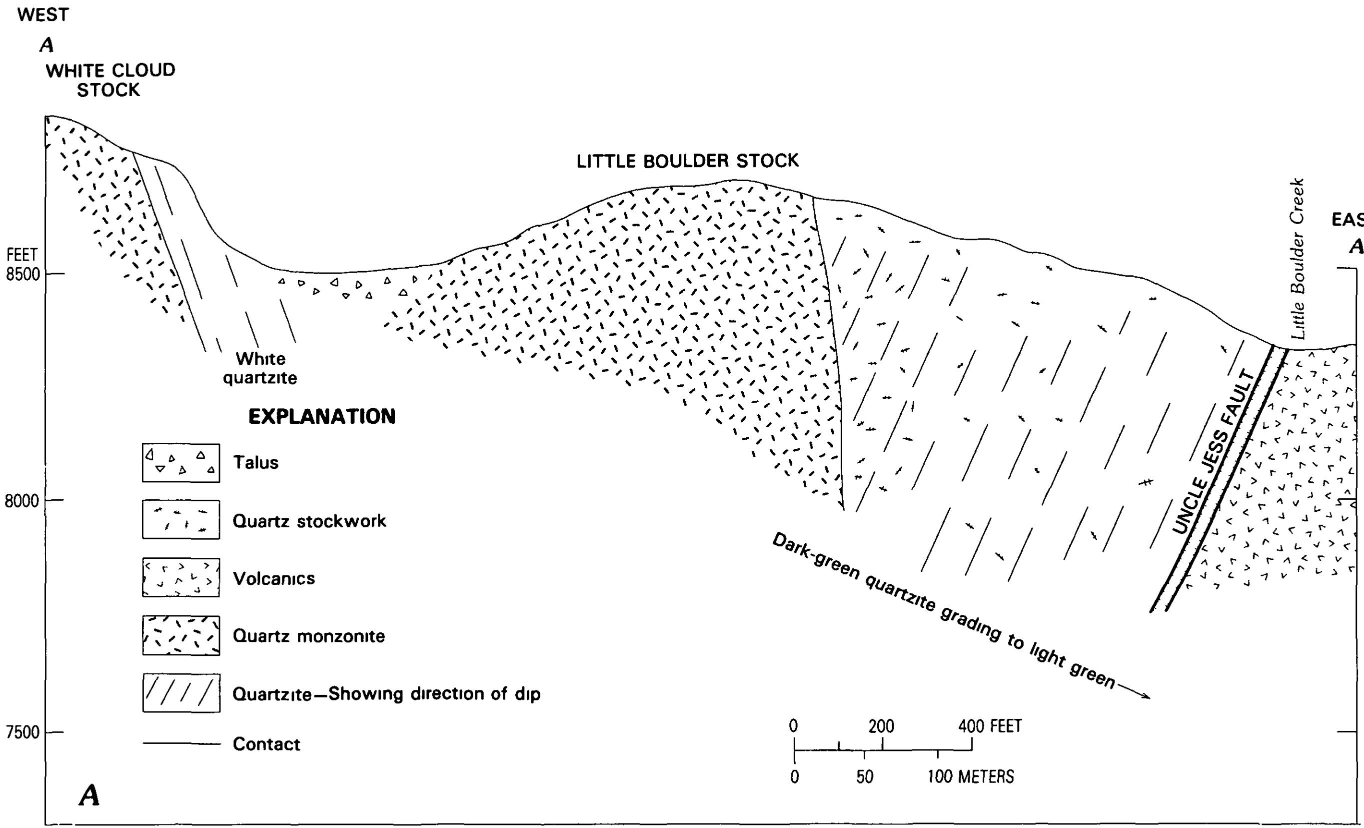
[All samples chip except R-80, R-81, select. 1 ft=0 3048 m]

Sample No	Length (ft)	Description	MoS_2 (percent)	Sample No	Length (ft)	Description	MoS_2 (percent)
3	9 0	Green quartzite, trench	0 21	R-90	50	Green quartzite	0 28
4	21 0	---do--------	14	R-91	25	Quartz monzonite, quartzite	05
5	5 2	---do--------	11	R-92	150	---do---------	11
6	10 0	---do--------	18	R-207	75	Green quartzite	10
7	7 0	---do--------	09	R-236	79	Quartz--------	14
8	6 0	---do--------	05	R-242	10	Green quartzite	.05
9	6 0	---do--------	12	R-243	10	---do---------	01
10	4 0	---do--------	27	R-244	10	---do---------	07
11	4 0	Green quartzite	09	R-245	10	---do---------	12
12	13 0	Green quartzite, trench	17	R-246	10	---do---------	.10
13	21 0	---do--------	14	R-247	10	---do---------	08
14	20 0	---do--------	22	R-248	25	---do---------	.11
15	20 0	---do--------	11	R-249	25	---do---------	13
16	20 0	---do--------	23	R-250	16	---do---------	10
17	20 0	---do--------	14	R-251	35	---do---------	10
18	10 0	---do--------	09	R-252	25	---do---------	13
19	3 0	---do--------	13	R-253	25	---do---------	10
20	12 0	---do--------	05	R-254	25	---do---------	06
21	20 0	Green quartzite	05	R-255	25	---do---------	.06
22	20 0	---do--------	18	R-256	25	---do---------	09
23	8 0	Green quartzite (trench)	14	R-257	15	---do---------	.09
24	20 0	Green quartzite	14	R-258	28	---do---------	06
25	20 0	Green quartzite (trench)	11	R-259	43	---do---------	10
26	20 0	---do--------	06	R-260	20	Green quartzite	10
27	12 0	---do--------	18	R-261	25	---do---------	08
28	15 0	---do--------	18	R-262	35	---do---------	.07
29	2 7	---do--------	16	R-263	60	---do---------	05
42	23 0	Green quartzite	10	R-264	30	---do---------	06
GS-1	7 0	---do--------	28	R-265	17	---do---------	09
GS-2	10 0	---do--------	11	R-266	65	---do---------	05
GS-3	12 0	---do--------	11	R-271	25	Quartz monzonite and quartzite	.13
GS-4	8 5	---do--------	05	R-272	25	---do---------	10
R-80	([1])	---do--------	11	R-273	25	---do---------	.15
R-81		Green quartzite specimens	08	R-274	35	Along wall (adit)	16
R-82	4	Across face (adit)	16	R-275	45	Along wall (adit)	13
R-83	3	Fragmented quartz (adit)	12	R-276	25	Green quartzite	06
R-84	20	Along wall (adit)	33	R-277	25	---do---------	07
R-85	15	Fragmented quartz (adit)	11	R-278	25	---do---------	06
R-86	5	---do--------	06	R-295	25	---do---------	13
R-87	10	Along wall (adit)	09	R-296	25	---do---------	12
R-88	40	Quartz monzonite	003	R-303	15	---do---------	11
R-89	25	Quartz monzonite and quartzite.	08	R-309	15	---do---------	15

[1] Blank, not measured

length, contained an average of 0.12 percent MoS_2. The weighted average of underground samples was the same as the overall average.

Assuming that the depth of the South zone extends to at least half the known strike length, resources are estimated to be on the order of



WEST
A
WHITE CLOUD STOCK
LITTLE BOULDER STOCK
Little Boulder Creek
EAST
A'
FEET
8500
8000
7500
White quartzite
UNCLE JESS FAULT
Dark-green quartzite grading to light green
EXPLANATION
Talus
Quartz stockwork
Volcanics
Quartz monzonite
Quartzite—Showing direction of dip
Contact
0 200 400 FEET
0 50 100 METERS
A

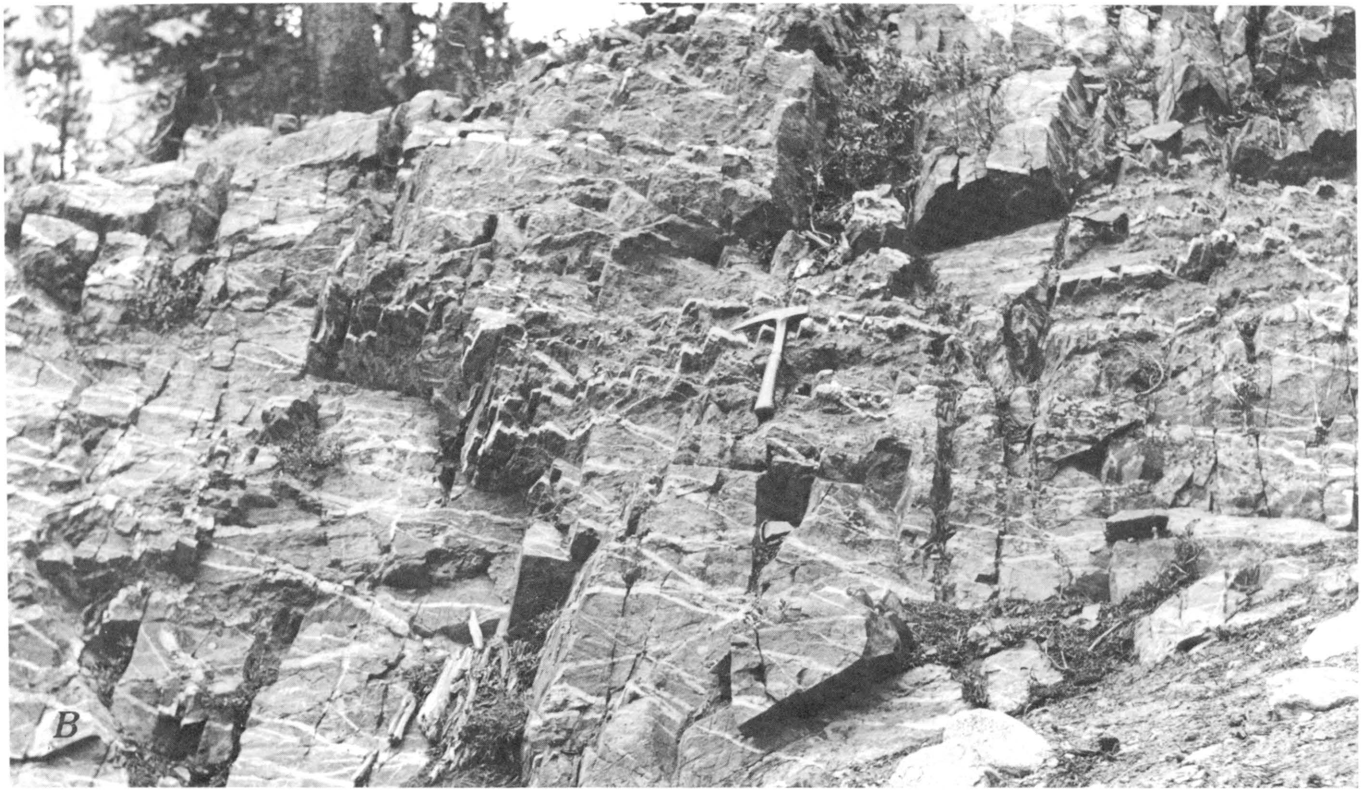


FIGURE 38.—North zone, Baker Lake prospect. *A*, Section *A-A′*, from figure 35. Elevation in feet; 1 ft=0.3048 m. *B*, Photograph of quartz veinlet stockwork in dark-green quartzite. Hammer for scale.

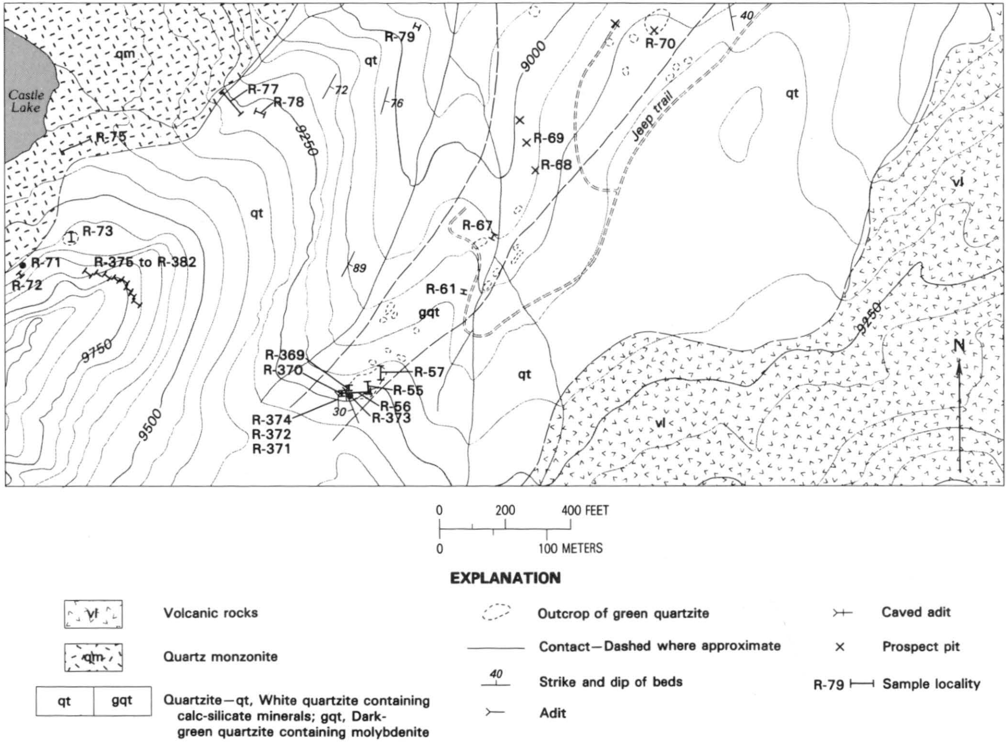


FIGURE 39.—Map of the South zone, Baker Lake prospect. Contour interval 50 ft.

Data for samples shown on figure 39

[All samples chip, 1 ft=0 3048 m]

Sample No	Length (ft)	Description	MoS_2 (percent)
R-55	30	Green quartzite--------------	0 02
R-56	80	---do------------------------	19
R-57	45	---do------------------------	18
R-61	11	Iron-oxide-stained quartzite (roadcut)	003
R-67	10	Iron-oxide-stained breccia----	27
R-68	10	Green quartzite--------------	12
R-69	10	---do------------------------	07
R-70	10	---do------------------------	12
R-71	5	Aplite dike------------------	1 06
R-72	10	Green quartzite--------------	34
R-73	30	---do------------------------	15
R-75	100	Quartz monzonite-------------	003
R-77	100	Quartzite and quartz monzonite	03
R-78	30	White quartzite--------------	004
R-79	10	Banded quartzite-------------	002
R-369	20	At portal--------------------	15
R-370	25	---do------------------------	134
R-371	28	Along east wall of adit-------	083
R-372	4	Across fault (adit)----------	117
R-373	7	Above portal-----------------	05
R-374	32	Along west wall of adit-------	15
R-375	25	White quartzite--------------	002
R-376	25	---do------------------------	007
R-377	25	---do------------------------	002
R-378	25	---do------------------------	002
R-379	25	---do------------------------	002
R-380	25	---do------------------------	001
R-381	25	---do------------------------	001
R-382	25	---do------------------------	001

FIGURE 40.—South zone, Baker Lake prospect, viewed to the south; qm, quartz monzonite, in the foreground; qt, quartzite; vl, volcanic rocks. Dotted line, general zone boundary.

35 million tons (31 million t). Economically, however, the deposit is considered to be submarginal at 1974 costs and metal prices.

West of the South zone, a few small dark-green quartzite lenses crop out along the contact of the White Cloud stock. Samples R–72 and R–73 (fig. 39), taken from two lenses, contained 0.34 and 0.15 percent molybdenite, respectively. A small aplite dike occurs near the lenses, and a sample (R–71) across its width contained 1.06 percent MoS_2. Samples of the white quartzite and quartz monzonite in the same general area, however, contained relatively small amounts of MoS_2.

BOULDER CHAIN LAKES PROSPECTS

The eastern contact of the White Cloud stock extends northerly from the Baker Lake deposit through the Boulder Chain Lakes (pl. 3, 92, 93). Sparse outcrops of molybdenite-bearing quartzite extend northward, parallel to the contact (fig. 41). The area from lake No. 2 north to lake No 1 (the easternmost lake) is covered by glacial debris, except for a few barren white quartzite outcrops. Along the contact north of lake No 1, the predominant rock type is iron-oxide-stained argillite containing some mineralized quartz lenses Claims were located in this area in 1964 by Eddie Baker. Taylor and Associates leased the claims in 1968 and located numerous additional claims covering a large area that extends into the Big Boulder Creek drainage; they conducted diamond drilling exploration near lake No. 1 in 1969.

Lenses of contact-metamorphosed quartzite in an area extending about 600 ft (183 m) southward from lake No 2 and about 1,300 ft (400 m) eastward from the stock contact locally contain disseminated flakes of molybdenite The largest exposure observed was 160 ft (49 m) long Samples taken at this locality contained 0.02 percent or less MoS_2, except for a selected sample that contained 0 12 percent MoS_2 (fig 41) Assays showed a trace or less gold and silver.

Argillite extending northward along the contact from lake No. 1 is profusely stained with iron oxides Sparse lenses of hornfelsed quartzite and tactite were observed in argillite to a point 1,500 ft (457 m) northward from lake No 1, but probably occur farther northward along the contact The lenses are dark green and contain disseminated flakes and local concentrations of molybdenite. They are generally less than 2 ft (0 6 m) thick Chip samples indicated the MoS_2 content is less than 0 01 percent except in a lens near the west edge of lake No. 1, in which MoS_2 content is as much as 0 35 percent Assays of the samples showed a trace or less gold and silver Selected high-grade samples from prospects in similar lenses above the lake contained 1 2–2.3 percent MoS_2 (T250–T253, table 2, pl 2)

The lens near lake No 1 occurs at the contact of the White Cloud stock and the argillite. Bedding in the lens strikes northward and dips steeply eastward, away from the stock. Molybdenite occurs as disseminated flakes as much as one-sixteenth inch (1–2 mm) in diameter and in seams of about the same thickness The lens is exposed intermittently for 150 ft (46 m) along the contact and to a depth of 5 ft (1.5 m) in a few trenches and a pit

Approximately 350 ft (106 m) west of the north end of the lake, an outcrop of argillite and quartzite was sampled (R–222 to R–233) Molybdenite occurs in the outcrop similar to that in the quartzite lenses and extends for 208 ft (63 m) along the strike of the bedding. A caved adit is near the center of the outcrop.

The molybdenite-bearing lenses exposed in the area are relatively small and sparse, contain low values, and are not minable under present economic conditions

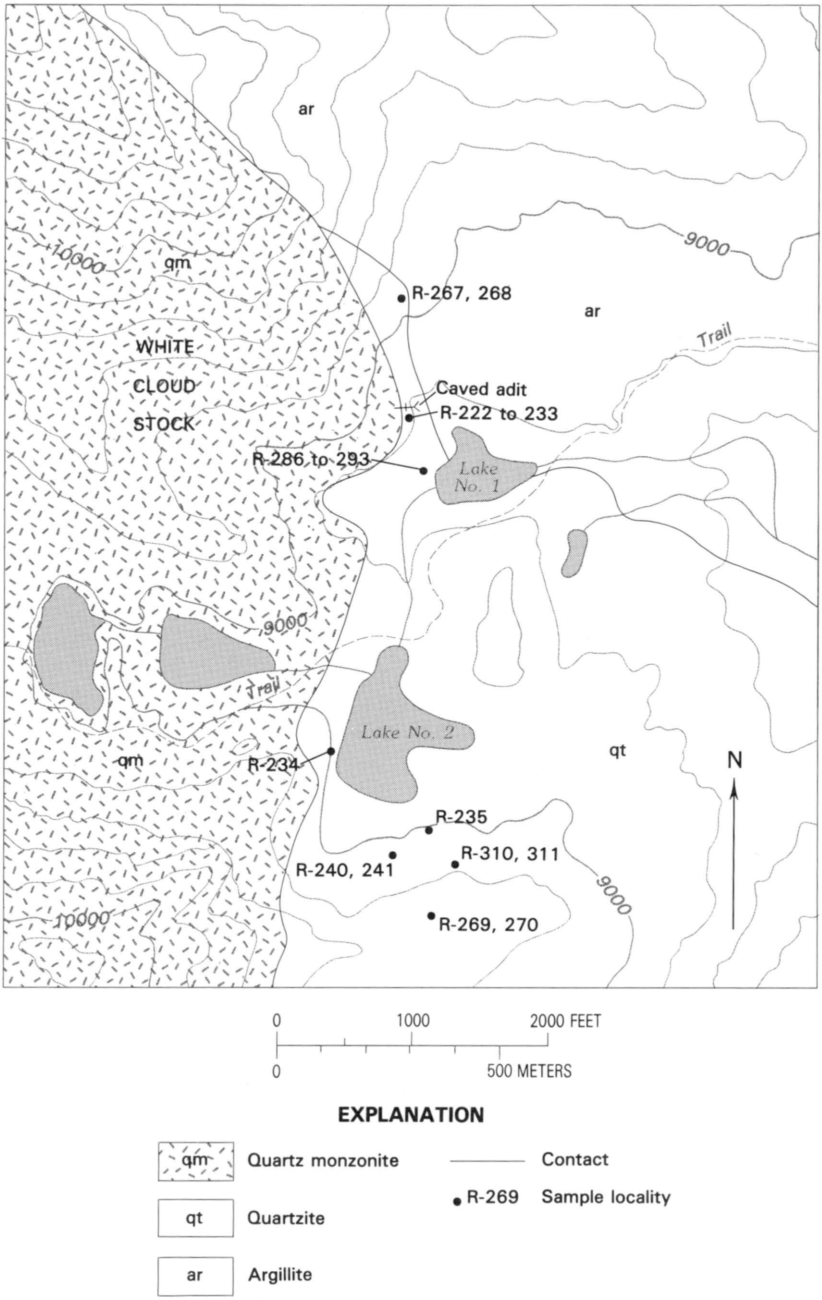


FIGURE 41.—Boulder Chain Lakes area. Contours in feet; contour interval 200 ft.

Data for samples shown on figure 41

[<, less than shown all samples chip except R-234 R-235, R-240, R-241, select, 1 ft=0 3048 m]

Sample No.	Length (ft)	Description	MoS_2 (percent)
R-222	20	Green quartzite and argillite-	<0.02
R-223	20	---do------------------------	.02
R-224	19	---do------------------------	.02
R-225	19	---do------------------------	.02
R-226	30	---do------------------------	.05
R-227	8	---do------------------------	.03
R-228	15	---do------------------------	.02
R-229	10	---do------------------------	.02
R-230	16	---do------------------------	.02
R-231	25	---do------------------------	.03
R-232	17	---do------------------------	.03
R-233	10	---do------------------------	<.02
R-234	([1])	---do------------------------	<.02
R-235		---do------------------------	.05
R-240		---do------------------------	.02
R-241		---do------------------------	.12
R-267	2.5	Across aplite dike------------	.02
R-268	20	Quartzite and argillite-------	.12
R-269	10	Tactite----------------------	.02
R-270	10	Green quartzite and quartz monzonite.	.01
R-286	15	Quartzite and quartz monzonite	.04
R-287	26	---do------------------------	.05
R-288	4	Green quartzite (pit)---------	.35
R-289	2	Across fault (pit)------------	.20
R-290	5	Green quartzite (pit)---------	.11
R-291	5	---do------------------------	.25
R-292	15	Green quartzite---------------	.08
R-293	8	---do------------------------	.01
R-310	160	---do------------------------	.07
R-311	100	---do------------------------	.005

[1]Blank, not measured.

SLATE CREEK DISTRICT

The Slate Creek district is in the northeastern part of the study area (pl 3, fig. 34). The first mineral claims in the district were located in 1881 Since then, more than 260 claims have been recorded (table 10); two are patented. Claims have been located along the length of the district from the Hermit group (pl 3, 87) northward to the Salmon River. Most mining activity, except at the Hoodoo property, has been centered in the Silver Rule-Carbonate Creeks area, near the southeast end of the district Numerous other prospects were not developed beyond the prospecting stage.

TABLE 10.—*Summary of recorded mining claims, including relocations, 1880-1969, Slate Creek district*

Decade		Number of lode claims
1880 - 1889		65
1890 - 1899		5
1900 - 1909		7
1910 - 1919		32
1920 - 1929		[1]29
1930 - 1939		21
1940 - 1949		13
1950 - 1959		53
1960 - 1969		38
	Total----	263

[1]Two were patented in 1928.

Two mills exist in the district, a third was being constructed at the time of the study. Ruins of the old Cal-Ida mill can be seen along Slate Creek, about 2 mi (3 km) south of Salmon River. It is not known whether any ore was processed at the mill. The other mills are at the Hoodoo and the Carbonate mines The Hoodoo mill was designed as a 200 ton/day flotation concentrator, but had not achieved more than half that rate in early 1974 The Carbonate mill, also designed as a flotation plant, is not completed

The Silver Rule mine is the only property in the district with a record of production According to Ross (1937, p. 148), the mine produced $600,000 worth of ore.

At the time of investigation, the only property in the development stage in the entire study area was the Hoodoo mine. Other activity in the district consisted essentially of annual assessment work on claims.

The district is underlain by Paleozoic sedimentary and metasedimentary rocks, rocks of the Idaho batholith, and Challis Volcanics (pl. 1) Mineral deposits occur in shear zones in highly contorted and fractured argillite, as contact-replacements in limestone and argillite, and as narrow fissure veins in argillite near the contact with the batholith.

Mineralized shear zones exposed at the developed properties are gently dipping deposits, with values mainly in silver and lead and with lesser gold, copper, and zinc, and sporadic amounts of antimony, cadmium, and mercury The replacement lode at the Hoodoo mine is essentially a zinc deposit with subordinate lead, silver, and cadmium. Mineralized zones near or at the contact of the Idaho batholith are small deposits that contain varying amounts of gold, silver, copper, lead, and zinc.

Most prospect pits and other workings are sloughed, and bedrock is poorly exposed Total estimated resources for the Slate Creek district are 910,000 tons (820,000 t). The Hoodoo deposit has inferred reserves of 870,000 tons (783,000 t), averaging 11.0 percent zinc, 0.47 percent lead, and 0 35 oz silver per ton (12 g/t). Of this total, an estimated 100,000 tons (90,000 t) averaging 26 percent zinc and containing 2 3–6.7 percent lead and 0.8–4.6 oz silver per ton (27.4–158 g/t) had been blocked out in new workings since the study was completed (Leroy Davis, written commun , Feb. 1974). The Carbonate and Tango mines each have an estimated 20,000 tons (18,000 t) of potential resources containing average grades of 1.6–5 6 oz silver per ton (55–192 g/t), 2 7–3 3 pecent lead, 0.8–1.4 percent zinc, and minor copper

The district has a good potential for the discovery of other minable deposits

HOODOO MINE

The Hoodoo mine is at the end of the Slate Creek road, 7 mi (11 km) south of Salmon River (pl 3, 67). The mine workings are along Hoodoo Creek and range in elevation from 7,265 to 7,910 ft (2,214 to 2,411 m) The lower part of the property can be worked year around, but the upper elevations are subject to snowslides that make access routes difficult to maintain.

The original Hoodoo group, located in 1930, included at least six claims and a millsite. An additional 22 claims were added to the group from 1951 to 1963. A DMEA (Defense Minerals Exploration Administration) contract was let in 1952 to explore the deposit by diamond drilling. At that time, the only working on the property was a 60-ft (18 3 m)-long caved adit (fig. 42, Middle adit). Reportedly the adit was driven to intersect a mineralized zone exposed at the surface. Based on the drilling results, another adit (Upper adit) was driven to crosscut and drift along the mineralized zone, and later, a 3,045-ft (928-m)-long adit (Lower adit) was driven under the Upper adit. A 645-ft (197-m) vertical raise joins the Lower and Upper adits, and three levels are being developed from it. About 4,900 ft (1,491 m) of underground workings existed at the property in early 1974, of which 700 ft (213 m) are not shown on the maps.

A 200 ton/day flotation mill began operation in 1973, and in early 1974, it was concentrating 98 tons (88 t) of ore in two shifts, or about 40 percent of the mine production capacity. Both lead and zinc concentrates were produced The zinc concentrate contained 59 percent zinc and 0 45 percent cadmium and lead. The lead concentrate contained 40

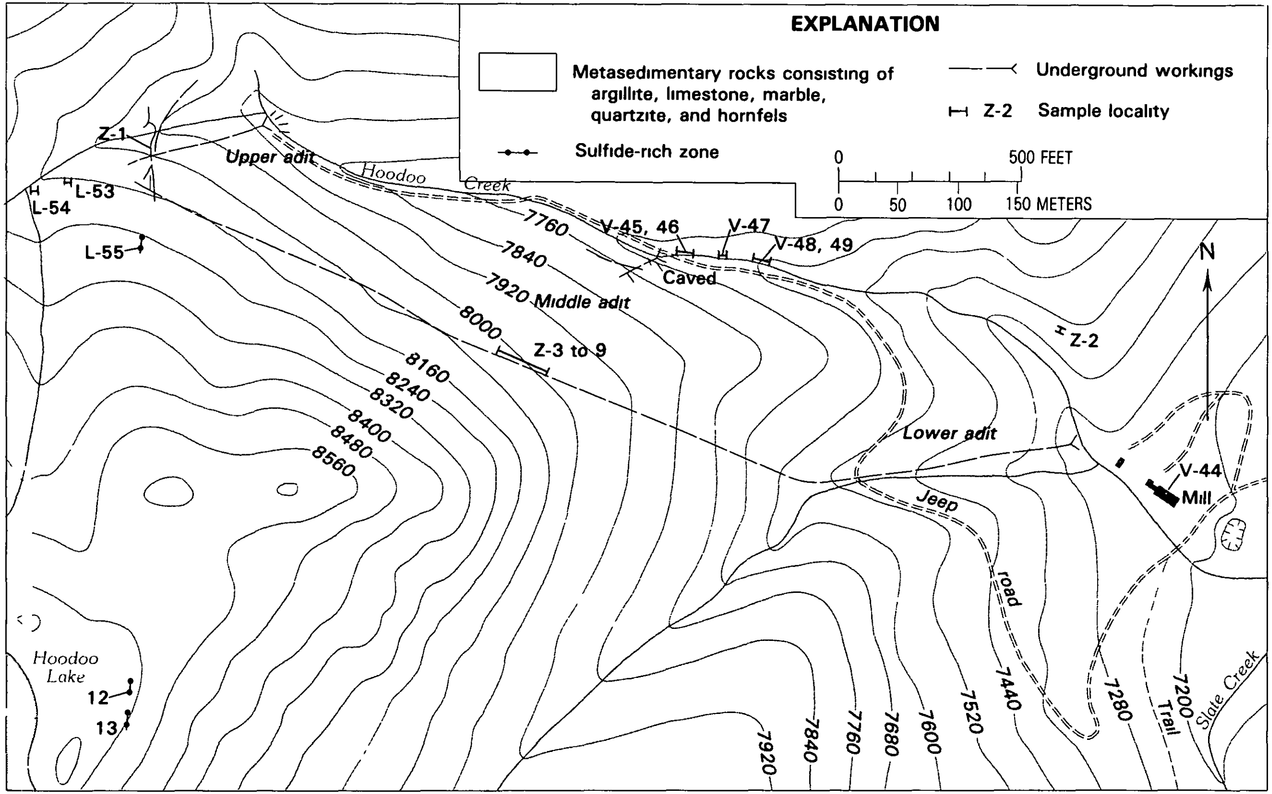


FIGURE 42 —Hoodoo mine area. Contour interval 80 ft

Data for samples shown on figure 42

[Tr trace, N, none detected, leaders (--), not analyzed, <, less than shown 1 ft=0 3048 m 1 troy oz/ton=34 285 g/t]

Sample No	Sample Type	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)
V-44	Grab--	([1])	Zinc concentrate from mill----	N	0 5	0 09	49 6
V-45	Chip--	25 0	Sheared quartzite with iron oxide stain	N	N	< 01	04
V-46	--do--	34 0	---do------------------------	N	Tr	< 01	021
V-47	Chip--	25 0	Across fault zone------------	N	Tr	12	06
V-48	Chip--	40 0	Marble with sulfide minerals--	0 01	03	< 02	02
V-49	--do--	15 0	Calcium-silicate-rich rock----	N	N	013	02
L-53	Chip--	20 0	Argillite with few sulfide minerals	Tr	10	06	42
L-54	Random chip		Limestone with few sulfide minerals	Tr	3	68	86
L-55	Chip--	10 0	Iron-oxide-stained argillite-limestone	Tr	9	74	7 6
12	--do--	7 0	Outcrop of sulfide-rich zone--	--	--	--	13 4
13	--do--	6 0	---do------------------------	--	--	--	7 6
Z-1	--do--	6.5	Sulfide zone (386-foot level in raise)	Tr	1	< 02	3 5
Z-2	Random chip		Quartz pod-------------------	Tr	N	< 02	--
Z-3	Chip--	18 0	Sheared argillite------------	Tr	2	< 02	007
Z-4	--do--	18.0	---do------------------------	Tr	1	< 02	005
Z-5	--do--	18 0	---do------------------------	N	1	< 02	003
Z-6	--do--	8 0	---do------------------------	N	N	< 02	002
Z-7	--do--	23 0	---do------------------------	Tr	Tr	< 02	005
Z-8	--do--	15.0	---do------------------------	Tr	2	< 02	02
Z-9	--do--	60 0	---do------------------------	N	N	< 02	01

[1] Blank, not measured

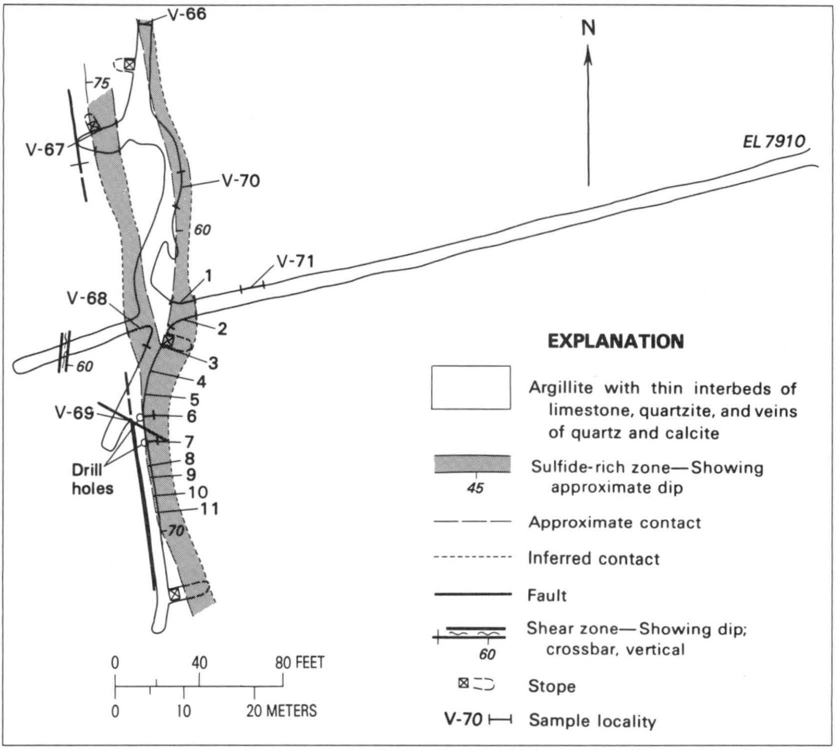


FIGURE 43.—Upper adit, Hoodoo mine. Elevation in feet; 1 ft=0.3048 m.

percent lead, 2.4 percent zinc, 49.6 oz silver per ton (1,700 g/t) and 0.7 oz gold per ton (24 g/t).

The mine area is underlain by north- to northeast-trending Paleozoic sedimentary and metasedimentary rocks that consist mainly of gray to black argillite, with some limestone, marble, quartzite, and hornfels. Much of the argillite at the surface is iron stained. The limestone and marble also contain iron sulfide minerals. Some hornfels contains calcium-silicate minerals.

The mineralized zone consists of replacement concentrations of ore minerals formed along a zone of weakness near the contact between Mississippian argillite and the Hailey Conglomerate Member of the Wood River Formation. Subsurface data from diamond drilling and from the raise between the Upper and Lower adits suggest that the several approximately parallel ore zones that have been identified may be one of two zones that have been repeated by isoclinal folding or by faulting. The most significant ore zone apparently is continuous and is exposed in the Upper adit, in the upper part of the raise, and in two surface exposures. The walls of the mineralized fracture zones are gen-

Data for samples shown on figure 43

[Samples 1-11 sample data from company maps and work done under DMEA contract. Tr, trace, N, none detected, leaders (-), not analyzed, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc	Cadmium
No	Type	Length (ft)	Description	(oz/ton)		(percent)		
V-66	Chip--	8 0	Black argillite with sulfides	N	0 12	0 08	14 0	0 13
V-67	--do--	[1]20 0	---do------------------	N	.32	42	12.0	09
V-68	--do--	25 0	Black silicified argillite with sulfides	N	12	13	16.0	10
V-69	--do--	3 0	Across shear zone in black argillite	N	.03	.013	2.6	--
V-70	--do--	10 0	Sulfide-rich rock-------	N	10	08	10 0	04
V-71	--do--	10 0	Argillite with iron sulfides	N	N	006	031	--
1	--do--	12 0	Across sulfide rich zone	--	20	20	10 3	--
2	--do--	10 0	---do------------------	--	.20	20	13 6	--
3	Grab--	([2])	Argillite, limestone, quartz, sulfides	--	20	25	8 5	--
4	--do--		---do------------------	--	16	22	5 6	--
5	--do--		---do------------------	--	07	15	7 8	--
6	Drill hole	6 0	---do------------------	--	18	2 10	4 9	--
7	--do--	6 0	---do------------------	--	Tr	80	2 0	--
8	Grab--		---do------------------	--	26	1 9	5.4	--
9	--do--		---do------------------	--	18	60	4 8	--
10	Grab--		Argillite, limestone, quartz, sulfides	--	.40	1 0	6.9	--
11	--do--		---do------------------	--	16	6	2 6	--

[1]Represents a thickness of 15 feet across the mineralized zone

[2]Blank, not measured

erally irregular and not well defined. Sphalerite and minor galena form massive lenses, between 1 and 38+ ft (0.3 and 12 m) thick, and disseminations and veinlets in brecciated argillite, limestone, and quartzite cemented by quartz and calcite Figure 43 shows the approximate contacts of the sphalerite-rich zone in the upper adit The most abundant secondary ore mineral is smithsonite ($ZnCO_3$), which occurs as fine acicular crystals in reaction rims around massive pods of sphalerite and along small fractures.

The main ore zone averages 7 7 ft (2.3 m) in thickness at the surface, but it splits into two separate zones in the northern drift of the Upper adit (fig 43) The zones trend north and dip 60° to 80° E ; where exposed in the Upper adit, they are from 12 to 15 ft (3 7 to 4.6 m) thick. Rock between the two sulfide-rich zones contains sparse ore minerals The lowest exposure of the main sulfide zone is intersected by the raise 510 ft (155 m) above the Lower adit (elevation 7,775 ft (2,370 m)). This zone was intersected after our field work was completed and was not examined by us The mine operator (Leroy Davis, written commun , October 1972) reported that the zone continued to the working face at the 548-ft (167-m) level (7,813 ft) (2,381 m) elevation) He also reported that the zone was dipping about 80° (E.?) and contained approximately "18 percent zinc, 6 percent lead, and 4.6 ounces [158 g/t] silver per ton" We do not know how much of this zone was intersected by the raise Other sulfide zones were intersected below this main zone in the raise but were of lesser grade and apparent thickness. The lowest sulfide body in the raise was intersected at the 386-ft (118-m) level. A sample (fig 42, Z–1) taken across the apparent thickness of 6 5 ft (2 m) of this zone contained 0 1 oz silver per ton (3 4 g/t), less than 0.02 percent lead, and 3.5 percent zinc.

The Hoodoo property contains significant reserves of zinc with recoverable values in lead, silver, and cadmium Reserves and resources based on diamond drilling and surface sampling during the 1952 DMEA project are estimated to be about 42,000 tons (38,100 t) of indicated reserves containing 8 9 percent zinc, 52,000 tons (47,200 t) of inferred reserves averaging 10 5 percent zinc, and 44,000 tons (39,900 t) of submarginal resources averaging 1 5 percent zinc.

During the present study, 870,000 tons (789,800 t) of inferred reserves were estimated, which includes the block of ground explored during the DMEA project The estimation assumes that the main sulfide zone is a tabular body that is continuous between the level of the exposures underground and the outcrops and has an average thickness of 10 5 ft (3.2 m) The strike length is assumed to be at least 1,725 ft (526 m), the distance between the southernmost outcrop and the northern exposure of the zone in the upper adit, although no data exist for about 1,200 ft (366 m) between these points (fig. 42). The minimum depth is 885 ft (270 m) and is measured from the uppermost outcrop at the 8,660-ft (2,640-m) elevation to the lowest exposure in the raise at the 7,775-ft (2,370-m) elevation. The main mineralized zone may logically extend beyond these control points, but this assumption, the much greater thickness and better grade in the raise reported by the operator, and the potential of other lesser mineralized but potentially productive zones are not reflected in the reserve calculation.

Samples taken across the main zone had a weighted average metal content of 11 0 percent zinc, 0.47 percent lead, and 0 35 oz silver per ton (12 g/t), and three representative samples from the upper adit had an average cadmium to zinc ratio of about 1 to 133. Zinc flotation concentrate obtained from a mill test had a cadmium to zinc ratio of 1 to 108

TANGO MINE

The Tango mine is on the west fork of Silver Rule Creek about 3 mi (4 8 km) east of the Hoodoo mine and is accessible by a jeep road (pl. 3, 79)

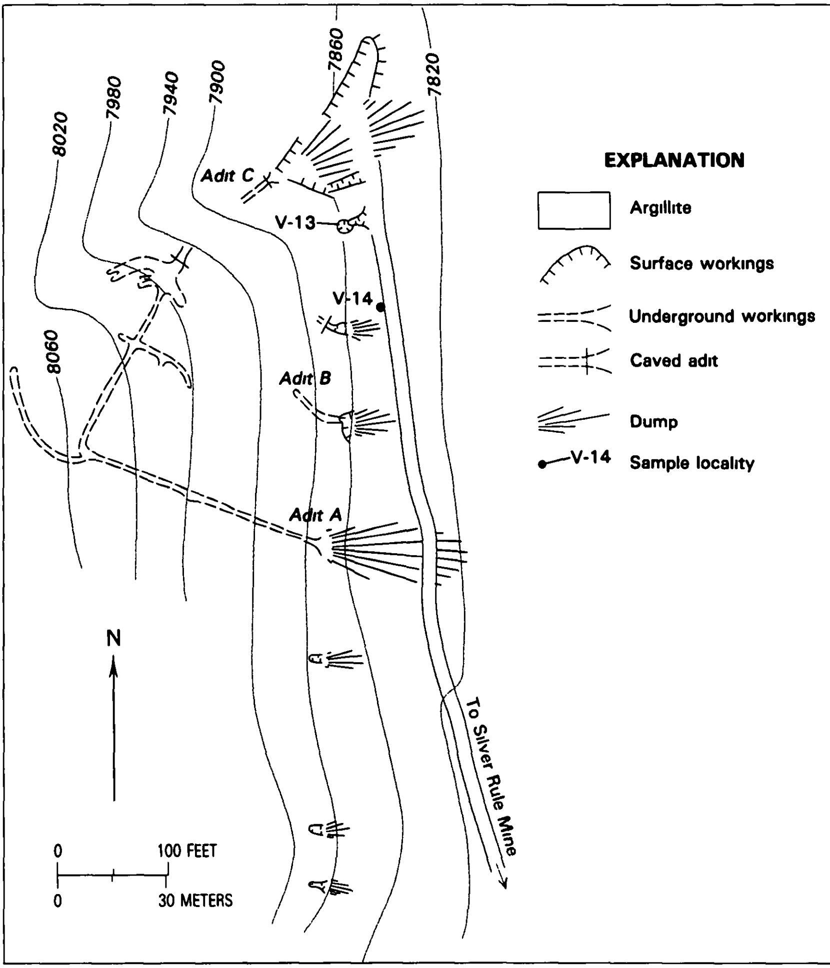


FIGURE 44 —Tango mine Contour interval 40 ft

Data for samples shown on figure 44

[Samples chip, N, none detected, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample No	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Copper (percent)
V-13	4 5	Iron-oxide-stained argillite--	N	0 3	0 65	0 006	0 002
V-14	10 0	---do------------------------	0 004	1 45	60	065	008

The Tango claims were recorded first in 1927; however, they were probably relocations of claims located as early as 1885 They have been explored by several adits and exploration cuts (fig 44) Only two adits

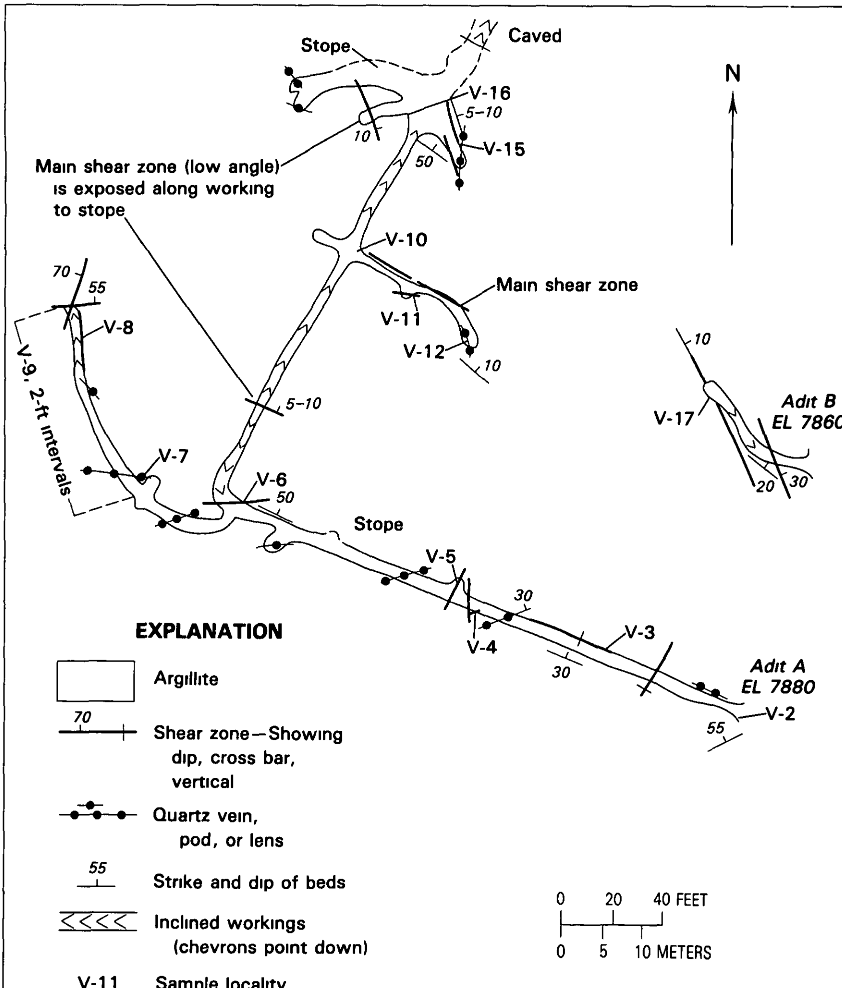


FIGURE 45 —Adits A and B, Tango mine Elevations in feet, 1 ft=0 3048 m

(A and B) are accessible. Metal production from the mine has not been recorded.

Adit A consists of 780 ft (238 m) of workings including a narrow inclined drift that connects the adit with a stope (fig 45) The stope is about 25 ft (7.6 m) lower than the portal of adit A and is probably near the level of the main adit (adit C), which is now caved. The workings beyond the stoped area were inaccessible.

The main mineralized zone is a low-angle shear zone containing sporadic quartz veins, lenses, and pods, iron-oxide-stained fault gouge,

Data for samples shown on figure 45

[All samples chip Tr, trace, N, none detected, 1 troy oz/ton=34 285 g/t]

Sample No	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Copper (percent)
V-2	5 0	Iron-oxide-stained argillite--	N	0 29	0 018	0 014	0 003
V-3	20 0	Along iron-oxide-stained shear zone	0 008	1 80	2 0	065	03
V-4	1 0	---do------------------------	N	29	006	15	027
V-5	5 0	---do------------------------	N	10	007	05	008
V-6	2 0	---do------------------------	N	20	07	08	02
V-7	2 0	Across quartz vein------------	Tr	80	33	06	02
V-8	26 0	Along iron-oxide-stained shear zone	N	1 30	28	10	03
V-9	[1]90 0	Along argillite with quartz veinlets	N	N	007	035	006
V-10	1 5	Shear zone--------------------	01	6 30	1 7	2 5	15
V-11	1 5	---do------------------------	01	3 2	2 8	1 5	10
V-12	1 5	Shear zone containing quartz veins and pods	03	1 5	1 7	06	02
V-15	1 5	---do------------------------	02	1 0	37	016	02
V-16	1 5	---do------------------------	14	16 0	10 0	09	23
V-17	1 0	---do------------------------	02	11 6	7 5	16	14

[1]At 2-ft intervals

and brecciated argillite. The main shear zone trends northwest, dips 5°-20° NE., and is 0.5-2.0 ft (0.15-0.6 m) thick.

The main shear zone, 1-2 ft (0 3-0.6 m) thick, was followed downdip by the inclined drift. Samples from the zone, weighted by length, averaged 0.04 oz gold per ton (1.37 g/t), 5.6 oz silver per ton (192 g/t), 3.3 percent lead, 0.8 percent zinc, and 0 1 percent copper. One sample contained 0.96 percent antimony, but others contained much less. Molybdenum was detected in amounts up to 0.02 percent, and two samples contained 0.009 and 0.01 lb of mercury per ton (3.7 and 4 1 g/t) Samples taken from other shear zones and quartz veins, that have no apparent relationship to the main shear zone, contained considerably less gold, silver, lead, zinc, and copper.

Adit B is 55 ft (17 m) long and exposes a shear zone as much as 1 ft (0.3 m) thick, which dips 10° NE. and is exposed nearly the length of the adit. This zone is probably an eastern extension of the main shear zone exposed in adit A A 1-ft (0 3-m)-long sample taken across the shear zone contained 0.02 oz gold per ton (0.69 g/t), 11.6 oz silver per ton (398 g/t), 7 5 percent lead, 0.16 percent zinc, and 0.03 percent copper.

If the main mineralized shear zone is continuous through the caved workings north and south of adit A, and maintains an average thickness of 1 5 ft (0.46 m), then an inferred resource of 20,000 tons (18,100 t) may be estimated. Because the shear zone dips gently, mining would require considerable artificial ground support and recovery costs would be high. The estimated amount of mineralized material is too small to be mined at a profit The property, however, has good potential for discovery of additional silver-lead resources

SILVER RULE MINE

The Silver Rule mine is on Silver Rule Creek about 2.5 mi (4 km) above its confluence with Slate Creek (pl 3, 80) It is accessible by road, requiring a four-wheel-drive vehicle The property was located in 1882 and is one of the earliest mining claims in the district. During the middle 1920's, the Ford Motor Co. acquired the property along with some other properties in the Clayton (Bayhorse) mining district, northeast of the study area.

U S. Bureau of Mines records show that the Silver Rule mine produced minor amounts of ore in 1914, 1948, and 1949 A total of 32 tons (28 8 t) of ore was shipped to the Tooele and Midvale smelters in Utah Recovered metals include 1,800 oz (56 kg) of silver and 1.36 oz (46 6 g) of gold According to Ross (1937, p 1048), "The Mackay Miner" (in a 1926 edition) stated that the Silver Rule mine had production amounting to $600,000, mostly before 1901, but part may have come from other mines

The Silver Rule claim and the adjacent New Silver Rule claim were patented in 1928 and were explored by seven adits, all now inaccessible The size of the dumps indicates that there were two main adits with extensive underground workings.

The country rock is argillite, some of which is silicified and contains minor amounts of sulfide minerals The dump contains brecciated quartz vein material, some with iron and manganese stains A report written in 1922 for the Anaconda Co asserted that the deposit was cut off by a strike-slip fault No additional description of the ore body is available

Two samples of vein quartz from dumps of the caved adits contained up to 0 01 oz gold per ton (0.34 g/t), 4 6 oz silver per ton (158 g/t), 1 2 percent lead, 0 12 percent zinc, and minor copper

Selected dump samples from two other caved adits, one on the New Silver Rule claim and another about 500 ft (152 m) to the north, contained as much as 0 03 oz gold per ton (1 03 g/t), 1 1 oz silver per ton (38 g/t), 0.4 percent lead, 0 27 percent zinc, and minor copper A sample selected from a small stockpile on the northernmost dump contained 0 03 oz gold per ton (1.03 g/t), 4.6 oz silver per ton (158 g/t), 40.0 percent zinc, 0 09 percent lead, and 0.55 percent copper.

Because the underground workings are caved, the nature of the mineral deposit was not determined. It is not known whether significant reserves remain. Past production, however, justifies further exploration and development work

CARBONATE MINE (CAL-IDA)

The Carbonate mine is on Carbonate Creek 3,300 ft (1,000 m) northeast of the Silver Rule mine (pl 3, 82)

The Carbonate property was first located in 1886 and has been developed by seven adits, but only three are accessible (fig 46) In the last few years there has been some maintenance activity at the mine, and a small flotation mill, designed to treat at least 100 tons (90 t) of ore per day, was being constructed about one-fourth mile (0 4 km) north of the mine Some ore was produced (Fletcher Fisher, oral commun , 1971), however, the tonnage has not been recorded.

The area is underlain by gray to black carbonaceous argillite with limonite stains along fracture surfaces The rock is somewhat contorted and highly fractured, and it spalls readily after exposure Rock attitude is highly variable, ranging from N 10°–70° W on strike, and 15°–70° NE. on dip. Low-angle shear zones, composed of brecciated argillite, fault gouge, and quartz veins and lenses, contain galena, sphalerite, and some jamesonite and pyrite. The shear zones are nearly parallel to the strike of the country rock but dip at angles of 15°–30° NE , generally lower than the bedding.

The upper adit is at an altitude of 7,485 ft (2,281 m) (fig 47) Raises, stopes, winzes, and an inclined drift are connected to the adit. Workings leading west are mostly caved; they probably were connected to other portals now also caved Total length of accessible workings is about 1,440 ft (440 m) The workings followed a shear zone that strikes northeasterly and dips 15°–25° SE The shear zone is 1–4 3 ft (0.3–1 3 m) thick and is composed of fault gouge, brecciated argillite, and sporadic quartz veins and lenses, which are generally limonite stained and contain a few metallic minerals. It is apparently the westward extension of the shear zone exposed in the lower adit.

The lower adit (fig. 48), 40 ft (12 m) below the upper adit, is connected with an entry shed The adit is 235 ft (72 m) long, from which extent were opened several small stopes and a 19-ft (5.8-m)-high raise near its face The best mineralized exposure is at the face, where a 1 5- to 2 5-ft (0 46–0.76-m)-thick shear zone contains a 0.5- to 2-in. (1 3–5 cm)-thick sulfide vein The vein consists of fine-grained galena, sphalerite, jamesonite, arsenopyrite, chalcopyrite, tetrahedrite, covellite, and pyrrhotite, according to Kern (1972, p. 65). The shear zone also contains quartz pods, brecciated argillite, and fault gouge

The only outcrop of the shear zone is at sample site V–61 (fig. 46). An open adit, southwest of this sample site, was driven 65 ft (20 m) southwest into argillite but did not intersect the main shear zone.

Fourteen chip samples across the mineralized shear zone underground and one at the surface had a weighted average grade of 1.6 oz

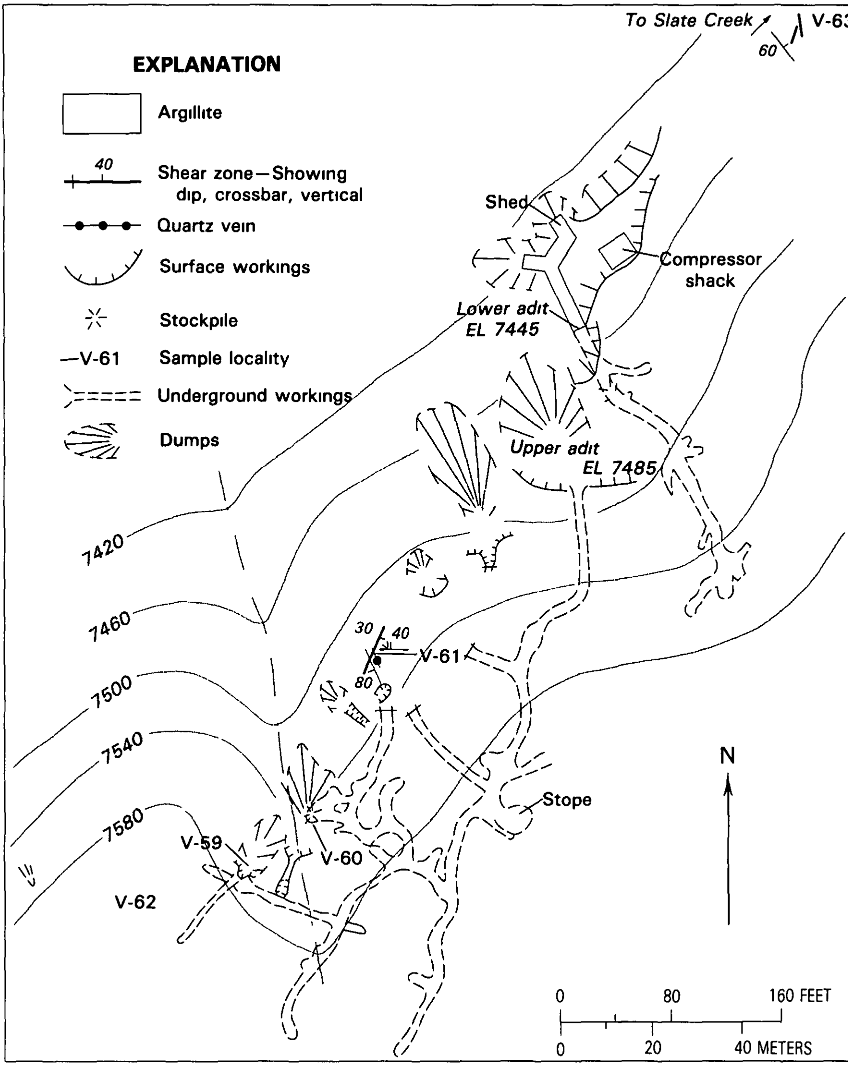


FIGURE 46 —Carbonate mine Contour interval 40 ft, elevations in feet, 1-ft=0 3048 m

silver per ton (55 g/t), 2.7 percent lead, and 1.4 percent zinc. Antimony was detected in a few samples. The highest gold value was 0.03 oz/ton (1 03 g/t) Copper was not found in amounts greater than 0.15 percent

Assuming an average thickness of 2.0 ft (0.6 m), a strike length of 480 ft (146 m), and a downdip length of 250 ft (76 m), 20,000 tons (18,100 t) of indicated resources is estimated.

The main shear zone at the Carbonate property is one of several min-

Data for samples shown on figure 46

[N, none detected, 1 troy oz/ton=34 285 g/t]

No	Sample Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Copper (percent)	Antimony (percent)
V-59	Grab--	([1])	Quartz veins in argillite	N	0 06	0 008	0 009	0 003	0 015
V-60	--do--		Iron-oxide-stained quartz with pyrite	N	03	004	55	007	0001
V-61	Chip--	3 0	Shear zone with quartz	N	N	09	10	008	002
V-62	--do--	1 2	Shear zone with argillite	N	N	004	027	005	0008
V-63	--do--	5 0	Iron-oxide-stained argillite	N	N	012	022	005	002

[1]Blank, not measured

eralized zones explored in properties to the west. The unexplored area between the properties may contain additional lead-silver-zinc resources

DISGUST GROUP

The Disgust mine is about 900 ft (274 m) south of the Tango adits and about 2,500 ft (762 m) southwest of the Silver Rule mine (pl. 3, 83)

The property was first located in 1900 and is developed by three adits, all now caved Judging from the size of dumps, total length of the underground workings probably exceeded 500 ft (152 m). Numerous exploration pits have been dug south of and upslope from the adits

Fletcher Fisher (oral commun, 1971) reported that high-grade ore was mined periodically, but there is no documented record.

The poorly exposed country rock is mostly gray- to buff-colored argillite with minor iron-oxide stains. The only mineralized material seen was in three small stockpiles that came apparently from quartz-filled shear zones containing oxides of iron and lead, and fine-grained sulfide minerals Vein quartz in the stockpiles is as much as 3 in. (7 6 cm) thick and contains voids lined with quartz crystals.

Samples from the stockpiles contained 0.04-0 08 oz gold per ton (1 37-2 74 g/t), 12 6-19 7 oz silver per ton (432-675 g/t), 10-20 percent lead, 0 01-0.50 percent antimony, 0.08-0 15 percent copper, and 0 07-0 14 percent zinc. Minor amounts of molybdenum were detected

The high silver-lead assays indicate possible resources that cannot be defined until the underground workings are reopened and examined.

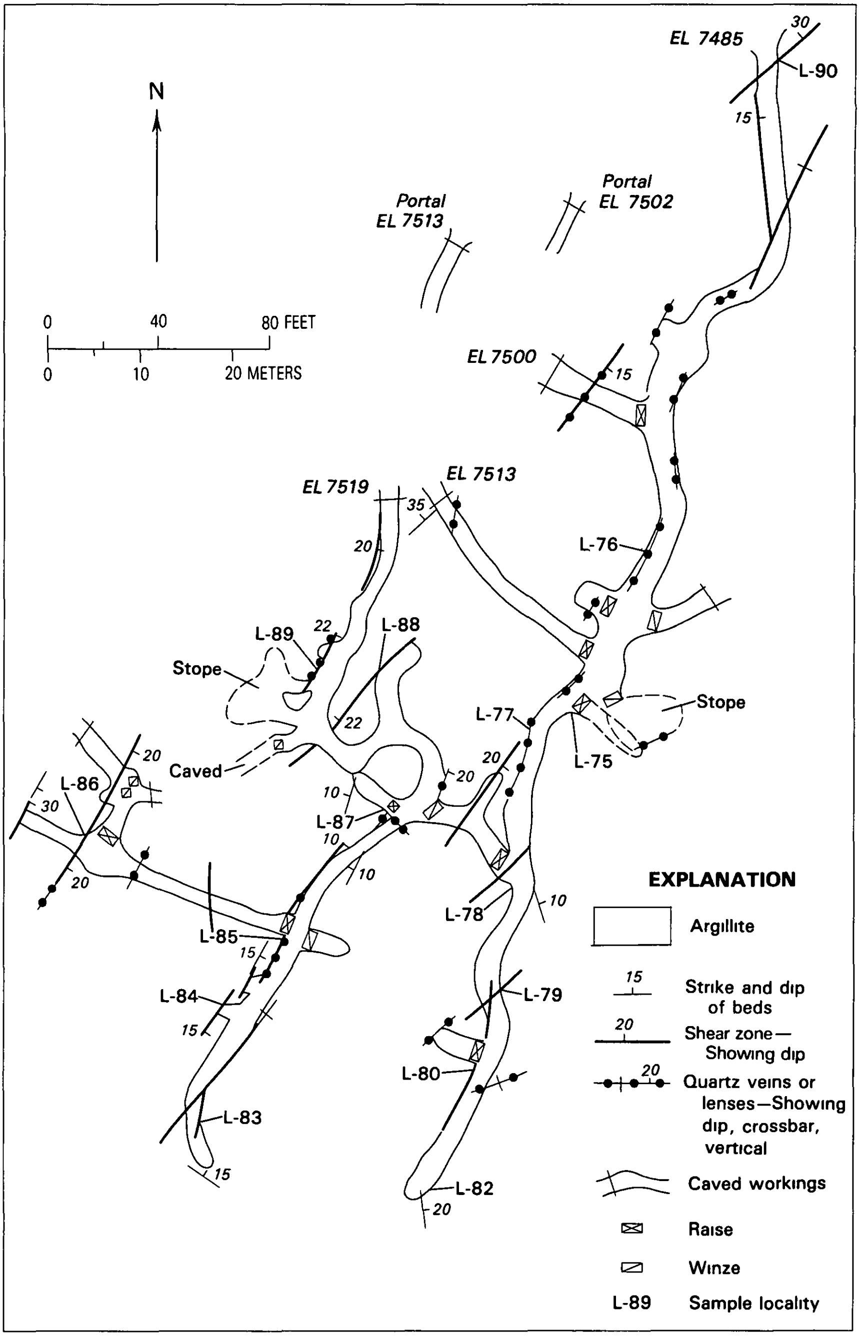


FIGURE 47 —Upper adit, Carbonate mine Elevations in feet, 1 ft=0 3048 m

Data for samples shown on figure 47

[All samples chip Tr, trace, N, none detected, leaders (--), not analyzed, 1 troy oz/ton=34 285 g/t, <, less than shown]

Sample No	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Copper (percent)	Antimony (percent)
L-75	3 3	Iron-oxide-stained, silicified argillite	N	0 1	0 02	0 06	--	<0 01
L-76	3 0	Quartz vein in iron-oxide-stained argillite	Tr	3	20	14	--	<.01
L-77	4.3	---do---	N	1	01	11	--	< 01
L-78	5 5	Iron-oxide-stained argillite with calcite veins	N	2	06	06	--	<.01
L-79	1.0	Shear zone---	N	4	27	67	--	< 01
L-80	2 0	---do---	Tr	5	.35	.09	--	< 01
L-82	5 0	Iron-oxide-stained argillite	N	N	009	01	--	< 01
L-83	4 3	Iron-oxide-stained shear zone	Tr	1 1	76	12	--	< 01
L-84	1 2	Iron-oxide-stained shear zone containing sulfide minerals	N	1 7	1 74	6 52	--	< 01
L-85	1 2	Iron-oxide-stained shear zone containing quartz veins	N	6	45	64	--	< 01
L-86	2 4	Iron-oxide-stained shear zone containing brecciated quartz	0 02	1 0	05	7 40	--	< 01
L-87	2 4	---do---	N	.2	02	42	--	01
L-88	2 0	Gouge and iron-oxide-stained argillite	N	3	11	44	--	01
L-89	3 3	Gouge and iron-oxide-stained argillite with quartz veins	03	6 7	4 01	54	0 03	03
L-90	3 0	Iron-oxide-stained shear zone in argillite	Tr	3 4	2 57	2 75	01	01

MISCELLANEOUS PROPERTIES

Numerous properties in the Slate Creek district that have little or no economic potential or are not accessible are listed in table 11

GERMANIA CREEK DISTRICT

The Germania Creek district is in the southern part of the study area (pl 3; fig 34). Approximately 329 mineral claims have been located in the district since 1870 (table 12), of which 10 lode claims have been patented. Some properties in Washington and Germania Basins were operated actively until 1910 (Ross, 1963, p 40), and intermittent surface exploration continues. Most recent exploration activity has been in Washington Basin and near Pole Creek

Most deposits are sulfide-bearing quartz veins in siliceous granitic rocks or in the Wood River Formation. Production from veins in the granitic rocks has been small. Most of the ore apparently came from replacement and fissure-filling deposits along shear zones in the Wood

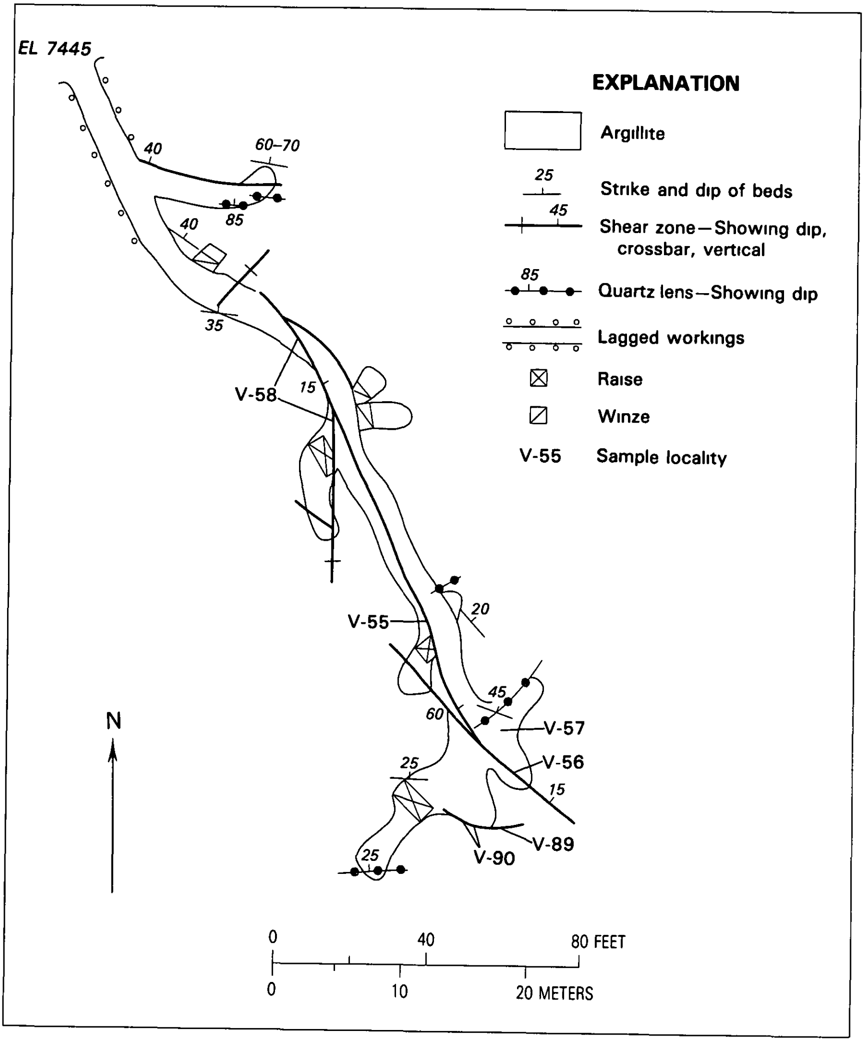


FIGURE 48 —Lower adit, Carbonate mine Elevation in feet, 1 ft=0 3048 m

River Formation The deposits were worked principally for lead, silver, or gold, but some contain bismuth, tellurium, and tungsten. Production estimates range from $375,000 (Umpleby, 1915) to $500,000 (Ross, 1937)

Four principal areas that comprise part of the East Fork mining district of Ross (1941, p 42) are described separately These areas are Bible Back Mountain, Washington Basin, Three Cabins Creek, and Pole Creek Only the Bible Back Mountain deposits, which contain silver and lead and possibly zinc, gold, and copper, approach economic

Data for samples shown on figure 48

[Tr, trace N, none detected, leaders (-), not analyzed, <, less than shown, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc	Copper	Antimony
No	Type	Length (ft)	Description	(oz/ton)		(percent)			
V-55	Chip--	0 8	Shear zone containing sulfide minerals	Tr	0 1	0 02	0.12	0 008	0 002
V-56	--do--	10 0	Sulfide-rich vein 1/2 to 1 inch thick in argillite.	Tr	1 4	70	90	.03	.015
V-57	Grab--	([1])	Sulfide-rich vein material from ore bucket	0 03	16 4	85	14 0	.15	06
V-58	Chip--	30 0	Shear zone 2 to 10 inches thick containing sulfide minerals	Tr	7 0	6 7	3 9	10	015
V-89	Select		Sulfide-rich vein 2 to 2 1/2 inches thick	Tr	3 1	16 0	16.4	--	03
V-90	Chip--	2 5	Across shear containing sulfide-rich vein	N	7	43	84	--	< 01

[1]Blank, not measured

minability. Several million tons of submarginal quartz-vein material in Washington Basin contain potential resources of gold, silver, lead, zinc, antimony, tungsten, bismuth, tellurium, and selenium. None of the areas contain economically minable reserves at present, but some are potentially favorable for discovery of minable ore shoots. Three Cabins Creek area and Pole Creek area both indicate a potential for the discovery of lead-zinc-silver ores.

Submarginal resources of the district are estimated at 25,000–100,000 tons (22,700–90,700 t) that contain 0.02–0.11 oz gold per ton (0.69–3 8 g/t), 5.8–12.6 oz silver per ton (199–432 g/t) and 3.38–4.27 percent lead. Several million tons of additional submarginal material contain 0.005–0.05 oz gold per ton (0.17–1.7 g/t), 0.59–1.3 oz silver per ton (20.2–44.6 g/t) and 0.28–1.27 percent lead.

BIBLE BACK MOUNTAIN

Bible Back Mountain forms the eastern extremity of the ridge dividing Washington Basin from Germania Creek. The mountain is bounded on the south, east, and north by a road extending from State Highway 75 to Washington Basin. The top of the mountain is accessible by two trails.

The peak is composed of three rock units (fig. 49). A dark-gray, silicified limestone is overlain by a reddish quartzite that contains iron-oxide-filled voids resulting from leaching of pyrite A wedge of white quartzite on the west end of the mountain has been intruded by porphyritic granite and a basalt dike. Sulfide minerals and metallic oxides

TABLE 11.—*Miscellaneous properties, Slate Creek district*

[1 ft=0.3048 m; 1 in.=2.54 cm; 1 oz (troy)/ton=34.285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
49	Flintstone 1 & 2	A roof pendant of highly fractured quartzite with a basalt dike in quartz monzonite. Fractures are iron oxide stained and some contain secondary quartz and minor pyrite. Scheelite was reported, but only a few specks were found.	One spiral shaped adit, two pits and dozer cuts.	Six chip samples, as much as 0.02 oz gold per ton, 0.2 oz silver per ton, 0.01 percent lead, 0.1 percent zinc, and 0.03 percent copper.
50	Prospect	Massive iron-oxide-stained quartz body.	One pit------------------	One chip sample, no gold or silver detected.
51	Prospect	Narrow quartz veins along a shear zone in quartz monzonite of the Idaho batholith.	---do--------------------	One chip sample, 0.1 oz silver per ton.
52	Sure Shot	A shear zone containing quartz veins and pods. Country rock is quartz monzonite.	Two caved adits and four pits.	Two chip samples, up to a trace gold, 0.3 oz silver per ton, and minor zinc, lead, and copper.
53	Prospect	A 3-ft-thick vertical shear zone containing iron-oxide-stained quartz. Country rock is argillite.	One pit------------------	One chip sample from shear zone, no gold or silver detected.
54	Prospect	Northeast-trending quartz veins along a quartz monzonite-argillite contact. Argillite is iron oxide stained, no metallic minerals found.	---do--------------------	One chip sample across quartz veins, 0.2 oz silver per ton.
55	Prospect	Hydrothermally altered granitic rock, some iron-oxide staining.	One 10-ft adit-----------	One chip sample, trace of gold.
56	Prospect	A northeast-trending granitic dike with quartz. Dike is iron oxide stained at surface, but not in adit.	---do--------------------	Two chip samples across dike, trace gold, up to 0.1 oz silver per ton.

57	Silver Bell group.	Iron-oxide-stained granitic rock-------	Two sloughed pits--------	Two chip samples, no gold or silver detected.
58	Old Dutchman	Iron-oxide-stained granitic rock containing pyrite.	Two pits-----------------	One select sample from stockpile, no gold or silver detected.
59	Prospect	Quartz vein in a narrow iron-oxide-stained shear zone. Country rock is quartz monzonite of the Idaho batholith.	One pit------------------	One grab sample from stockpile; 0.12 oz silver per ton, minor copper, lead, and zinc.
60	Silver Bell group.	Shear zones in massive- to thin-bedded, black argillite, near contact with batholith. Zones range up to 2 ft thick and contain calcite-siderite. Galena and pyrite occur in a one-half-inch-thick vein near portal.	A 60-ft adit and three pits.	Three chip samples across shear zones in adit, 0.02 to 2.4 percent lead, 0.26 to 2.2 percent zinc, and 0.007 to 0.017 percent copper, up to a trace gold and 7.0 oz silver per ton in a one-half inch sulfide vein. Three chip samples across oxidized argillite, up to 0.02 oz gold per ton, up to 0.07 oz silver per ton, 0.002 to 0.004 percent lead, 0.09 to 0.11 percent zinc, and 0.006 to 0.01 percent copper.
61	Rich vein	Iron-oxide-stained argillite at contact with granitic rock of the batholith. Sulfide minerals in small stockpile of granitic rock.	One pit and a dozer cut--	One chip sample across contact zone, 0.6 percent zinc. One grab sample from stockpile, 0.02 oz gold per ton, 5.4 oz silver per ton, 1.2 percent lead, and 1.0 percent zinc.
62	Orphan Boy	Limy argillite exposed at portal, no metallic minerals seen.	One caved adit-----------	One chip sample, no gold or lead detected, trace of silver and zinc.

TABLE 11.—*Miscellaneous properties, Slate Creek district*—Continued

Map No. (pl. 3)	Property Name	Summary	Number and type of workings	Sample data
63	Mayflower	Country rock is black argillite, no mineralized material found at portal.	---do--------------------	No samples taken.
64	Sheephead	A 6-in.-thick shear zone strikes N. 25° E. and dips 50° NE. in argillite.	One 45-ft adit-----------	Two chip samples across shear zone, no gold or silver, trace of zinc. One grab sample from stockpile, 0.7 oz silver per ton, trace lead and zinc.
65	Prospect	Two quartz bodies in quartz monzonite. One is a milky-white quartz lens exposed for 18 ft, about 5 ft thick. The other consists of quartz veinlets, stringers, and pods through an area 45 ft wide. Both quartz bodies are iron oxide stained.	None---------------------	Two chip samples, no gold or silver detected, 0.001 percent copper and 0.002 percent lead.
66	Last Chance No. 5	A northeast-trending, southeast-dipping narrow shear zone in black argillite. A small stockpile contains argillite and quartz with some sulfide minerals.	One 80-ft adit-----------	Two chip samples across shear zone, up to 0.1 oz silver per ton and 0.16 percent zinc. A select grab sample from the stockpile, 4.0 percent zinc, minor gold, silver, and lead.

TABLE 12.—*Summary of mining claims recorded, including relocations, 1870–1971, Germania Creek district*

Decade	Number of lode claims	Number of placer claims
1870-1879	6	--[1]
1880-1889	82	--
1890-1899	40	--
1900-1909	39	1
1910-1919	18	--
1920-1929	20	--
1930-1939	15	1
1940-1949	6	--
1950-1959	26	1
1960-1969	41	1
1970-1971	32	--
Total--	325	4

[1]Leaders (--), none recorded.

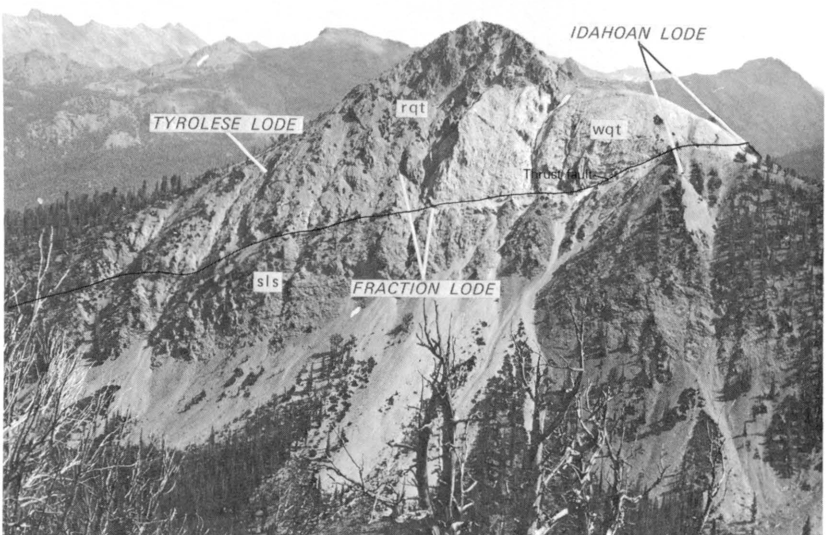


FIGURE 49.—Bible Back Mountain, looking southeast; sls, silicified limestone; rqt, red quartzite; wqt, white quartzite.

occur in a thrust fault that separates white quartzite from limestone and that dips about 18° SE, slightly less than the bedding. On the north and east flanks of the mountain, base metals occur in several extensive, steeply dipping faults and fault zones. These structures trend northerly and contain metallic oxides in quartz and calcite

Three patented claims are on Bible Back Mountain, and several unpatented ones are on the eastern flank The first activity was in 1879, and most reported production for the district probably came from the Idahoan and Old Bible Back mines (pl 3, 144) on the west end of the mountain. Several properties on the eastern flank of the mountain have a potential for the discovery of resources of silver and lead.

IDAHOAN AND OLD BIBLE BACK MINES

The Idahoan and Old Bible Back mines were actively worked during the period 1880–1887 They probably produced most of the $250,000 in lead-silver ore reported by Umpleby (1915, p. 245). The Old Bible Back mine also produced 2 tons (1 8 t) of ore in 1935, which contained 0.20 oz (6 2 g) gold, 53 oz (1,648 g) silver, 652 lb (296 kg) copper, and 625 lb (284 kg) lead The mines apparently have been inactive since that time

These mines were developed along the relatively flat lying thrust fault breccia zone in white quartzite that has numerous shears and faults, most trending a few degrees west of north and dipping steeply northeast. The flat-lying fault zone trends northeastward and ranges in thickness from 2 to 4 ft (0.6 to 1.2 m), averaging 3 ft (0.9 m).

Ore shoots in the fault zone are small and irregular replacement-type masses composed predominantly of quartz and calcite. Most of the ore was oxidized, however, visible sulfides including pyrite, galena, and jamesonite were observed at two localities. Much of the fault zone contains disseminated lead and silver minerals and small amounts of gold, zinc, and tin

The Idahoan and Old Bible Back mines have a total of eight adits, of which only three were open These three adits are on the Idahoan claim and provide access to more than 2,100 ft (640 m) of open workings (figs 50 and 51) The most extensive accessible exposures of the fault zone are in the northeast adit and the west adit Exposures indicate that the mineralized part of the flat-lying fault zone extends through an area of 41,500 ft^2 (3,855 m^2) but that thrust breccia, of which the mined zone is a part, extends through the entire mountain Development probably began at the north portal (elevation 9,510 ft (2,899 m)) on a granite porphyry outcrop. The adit apparently was driven southeast for approximately 400 ft (122 m) to intersect the fault zone at about 9,535 ft (2,906 m) elevation The ore zone was then mined updip from a series of irregular stopes to an elevation of 9,560 ft (2,914 m). Stoped areas were backfilled with wall rock and quartz At the 9,560-ft (2,914-m) level, a heading (west adit) was driven to the surface. Most of the workings stand open except those that explore the porphyritic granite Apparently the hand-sorted ore was carried off the mountain on pack animals.

Samples taken across the mineralized zone, weighted by length, averaged 0.06 oz gold per ton (2.1 g/t), 12.64 oz silver per ton (433 g/t), 4 27 percent lead, 1 02 percent zinc, 0.58 percent copper, and 0.45 percent antimony (figs. 52, 53). One sample assayed 0.45 percent arsenic, which is detrimental in beneficiation and smelting. The Idahoan and Old Bible Back mines are estimated to contain approximately 8,600 tons (7,800 t) of paramarginal reserves near the west adit and northeast adit workings

The mineralized zone appears to extend eastward into the mountain from the workings accessible from the west adit, but it could not be traced east of the large fault that separates the white and reddish quartzites near the main portal of the Old Bible Back mine (fig. 50). If the zone continues east to the fault, an additional 30,000 tons (27,200 t) of material similar to the grade given above may exist. An unknown amount of mineralized material has been mined from the Old Bible Back mine

FRACTION CLAIM

The Fraction lode (pl 3, 140), on the north face of Bible Back Mountain, can be reached from the Idahoan mine. The claim was located in 1883 and patented in 1897. No record of production is available.

Workings consist of three adits and an inclined shaft. The shaft and middle and lower adits expose a mineralized shear zone for 192 ft (58 5 m) in fractured, iron-stained quartzite (fig 52) The zone trends northwest and can be traced southeast through the Rock Slide No 1 claim It dips 57°–65° SW in the lower and middle adits and ranges from less than 2 to 3 ft (0 6–0 9 m) in thickness. The zone is brecciated, silicified, profusely iron stained, and contains some calcite. No sulfide minerals were observed

The inaccessible shaft, the highest working, is inclined 46°, S 10° E., and is about 50 ft (15 m) deep. The shear zone is 2 ft (0.6 m) thick at the collar.

A small, 20-ft (6-m)–long adit about 40 ft (12 m) northeast of the shaft follows a subsidiary shear zone trending N. 54° W The zone, consisting of limonite-stained quartz and calcite, pinches out at the face. No sulfide minerals were observed One sample, taken 1 ft (0.3 m)

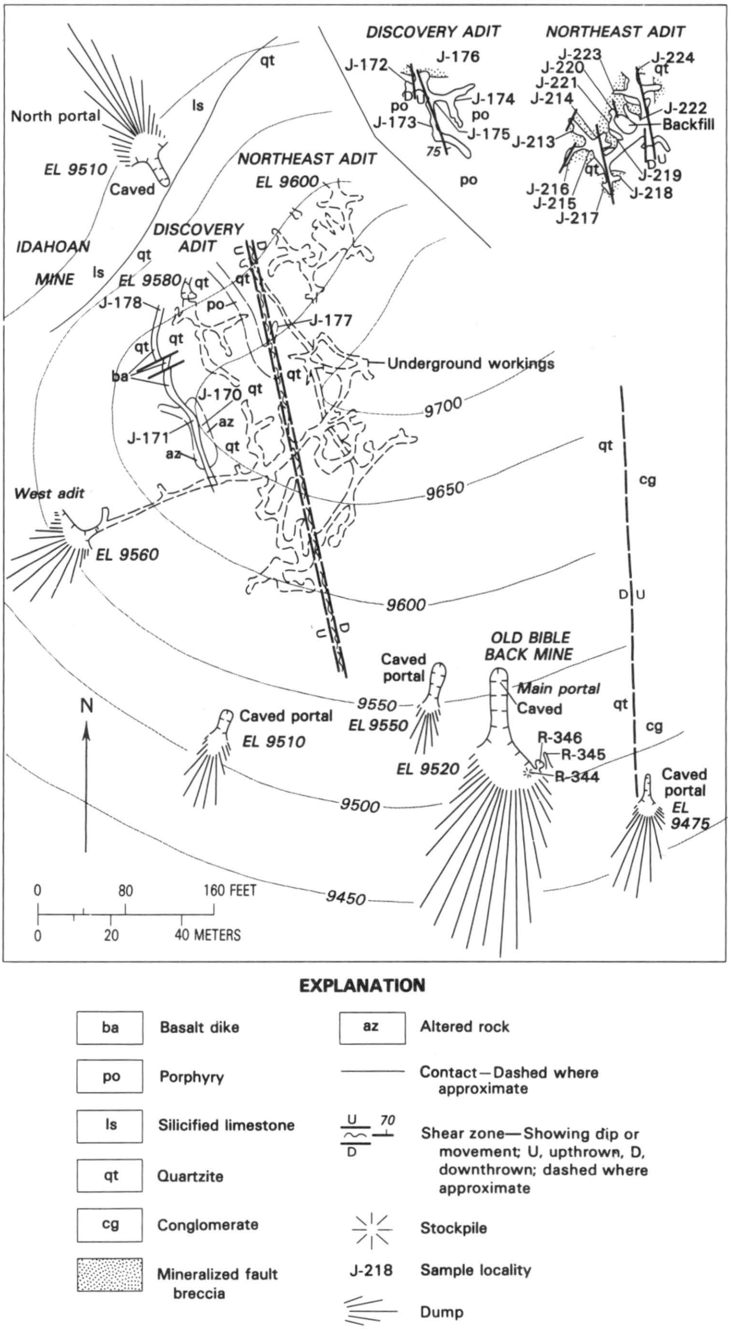


FIGURE 50.—Idahoan and Old Bible Back mines. Contour interval 50 ft; elevations in feet; 1 ft=0.3048 m.

Data for samples shown on figure 50

[All samples chip except J-174, 175, random chip R-344, grab Tr, trace, N, none detected, leaders (-) not analyzed, <, less than shown, 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver	Copper	Lead	Zinc	Antimony
No.	Length (ft)	Description	(oz/ton)		(percent)			
J-170	6 0	Across altered rock----	N	0.1	--	--	--	--
J-171	4.0	Across dike------------	Tr	.1	--	--	--	--
J-172	3 0	Across shear zone------	Tr	.6	--	0 80	--	0 01
J-173	5.0	---do------------------	N	4	--	11	--	--
J-174	([1])	Porphyry---------------	Tr	1 2	--	--	--	--
J-175		---do------------------	0 01	1.6	--	1.35	--	--
J-176	4 0	Across mineralized zone	04	16 3	--	--	--	--
J-177	6 0	Across altered rock----	N	N	<0 02	--	--	--
J-178	6 0	Across dike------------	N	Tr	--	--	--	--
J-213	2.0	Across mineralized zone	20	5.0	--	--	0 99	--
J-214	4.0	---do------------------	.24	41 0	--	9.1	22	--
J-215	2 5	---do------------------	32	17 7	--	--	--	--
J-216	3 5	---do------------------	09	13 6	--	--	--	--
J-217	2 5	---do------------------	.10	8 1	--	--	--	--
J-218	1 5	---do------------------	.03	8 8	--	--	--	--
J-219	2.5	---do------------------	11	38 7	--	6 2	86	--
J-220	2 0	---do------------------	01	2 1	--	--	--	--
J-221	1 5	---do------------------	23	16 8	--	--	--	--
J-222	5 5	---do------------------	Tr	2 9	--	97	55	--
J-223	2 0	---do------------------	.02	9.0	--	--	--	--
J-224	3 0	---do------------------	.01	5 6	--	--	--	--
R-344			04	11.6	--	--	--	--
R-345	2.5	Across mineralized zone	Tr	4 4	--	--	--	--
R-346	2.5	---do------------------	N	.1	--	--	--	--

[1] Blank, not measured.

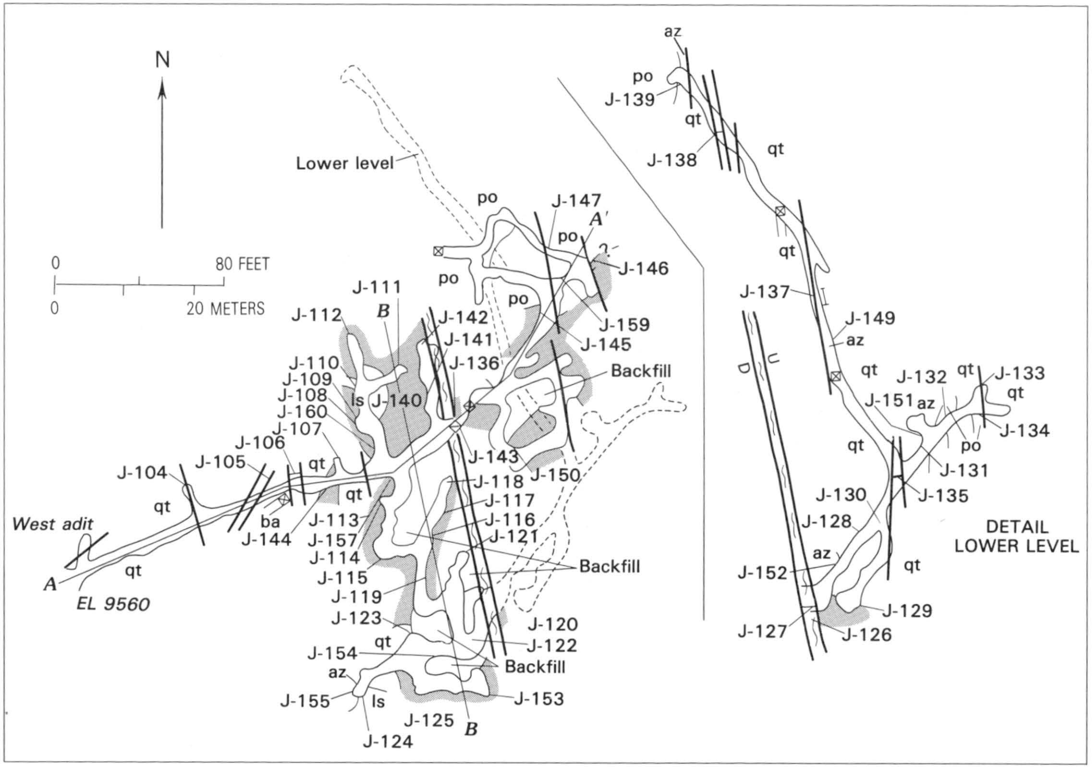
[2] Not described

across a small shear in the upper adit, assayed 14.6 oz silver per ton (501 g/t) and 0.01 oz gold per ton (0 34 g/t).

Samples taken across the shear zone in the shaft and adit averaged, weighted by length, 0 02 oz gold per ton (0.69 g/t), 5.8 oz silver per ton (199 g/t), 3.38 percent lead, 0.08 percent copper, and 1.63 percent zinc. A potential resource of 2,000 tons (1,814 t) of this grade are estimated to occur near the workings. Assuming that the zone extends through the Rock Slide No. 1 claim, additional potential resources would be about 30,000 tons (27,200 t).

ROCK SLIDE NO 1 (EMERALD)

Rock Slide No 1 claim, on the northeast side of Bible Back Mountain (pl. 3, 141), was first located as the Emerald in 1882 and relocated as the Rock Slide No. 1 in 1972. The property may have contributed to the $500,000 of lead and silver reportedly produced from the Germania Creek district.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J-159
J-160

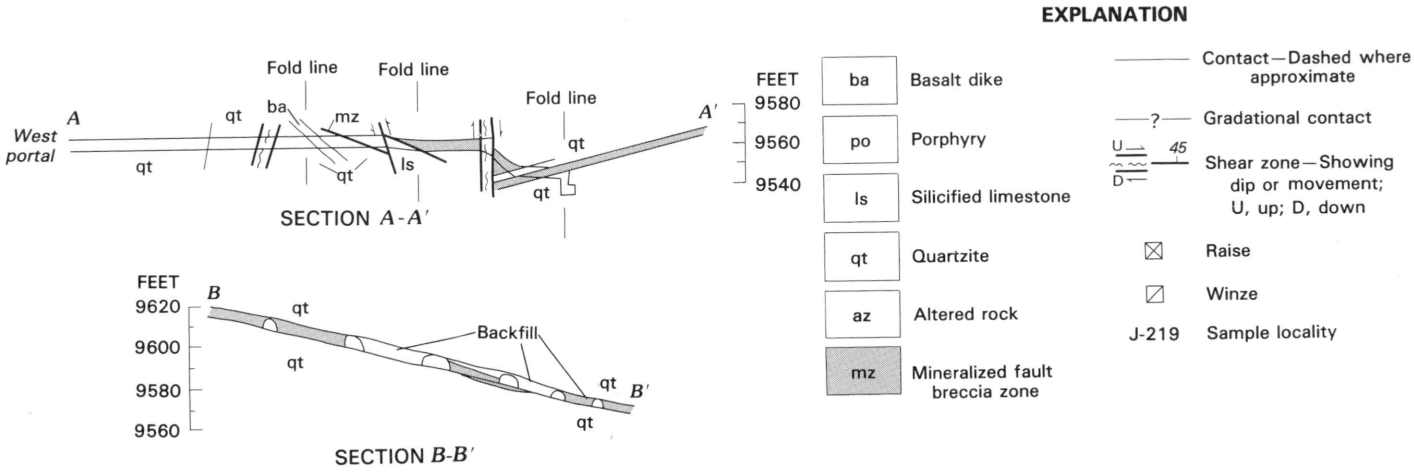

FIGURE 51.—West adit, Idahoan mine. Elevations in feet; 1 ft=0.3048 m.

Data for samples shown on figure 51

[All samples chip except J-154, J-156, J-159, grab Tr, trace, N, none detected, leaders (-), not analyzed, <, less than shown , 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver	Copper	Lead	Zinc	Antimony
No	Length (ft)	Description	(oz/ton)		(percent)			
J-104	3 5	Across shear zone--------	Tr	0 02	<0 02	<0 02	--	--
J-105	7.0	---do--------------------	Tr	.02	< 02	< 02	--	--
J-106	4 0	Across dike--------------	N	N	< 02	< 02	0 16	--
J-107	2 0	Across mineralized zone--	0 20	9.2	--	2 28	--	--
J-108	1.5	---do--------------------	10	22 2	--	3 52	--	0 68
J-109	1 0	---do--------------------	.09	25 2	--	4 72	--	--
J-110	3 5	---do--------------------	02	8 1	--	2 50	54	--
J-111	2 0	---do--------------------	04	4.3	--	1.50	--	--
J-112	1 3	---do--------------------	.07	10.1	--	1 88	84	--
J-113	.9	---do--------------------	11	7 8	--	3 76	--	--
J-114	2 5	---do--------------------	01	10 6	--	1 60	--	--
J-115	1 5	---do--------------------	09	9 2	--	7.80	--	--
J-116	1 5	---do--------------------	.09	17 4	--	4 40	13	55
J-117	1 5	---do--------------------	.16	18.0	--	8 80	--	63
J-118	1 5	---do--------------------	03	9.5	--	4.70	--	--
J-119	3.9	---do--------------------	01	6.3	--	1.80	--	--
J-120	2 5	---do--------------------	01	12 8	--	2 80	--	--
J-121	1 5	---do--------------------	Tr	1 3	--	19	--	--
J-122	10 0	Along mineralized zone---	.01	3 8	--	2 50	40	--
J-123	4.0	Across mineralized zone--	06	22.1	--	5.7	--	--
J-124	2 0	---do--------------------	04	25 3	--	4 6	--	--
J-125	1 5	---do--------------------	14	32 4	--	8.3	--	--
J-126	9 0	Across shear zone--------	Tr	0 2	--	017	--	--
J-127	6 0	---do--------------------	Tr	1 5	--	.55	.64	--
J-128	1 2	Across mineralized zone--	09	20 7	--	8 5	--	45
J-129	1 3	---do--------------------	.12	29 1	--	7 6	--	--
J-130	10 0	Along mineralized zone---	06	15 5	--	4 2	--	--
J-131	1.0	Across mineralized zone--	.01	5 9	--	1 1	--	--
J-132	5 0	Across porphyry----------	01	.9	--	20	--	--
J-133	1 0	Across shear zone--------	Tr	5	--	.16	--	--
J-134	1 0	Across porphyry----------	Tr	1 3	--	1 40	48	--
J-135	6.0	Across shear zone--------	Tr	1 3	--	38	--	--
J-136	3 5	Across mineralized zone--	Tr	8 2	--	4.7	--	--
J-137	1 4	Across shear zone--------	Tr	2	--	.063	--	--
J-138	5 0	---do--------------------	N	Tr	--	< 02	--	--
J-139	3 9	Across altered rock------	Tr	Tr	--	02	--	--
J-140	1 3	Across mineralized zone--	06	12 3	--	4 5	--	28
J-141	1.7	---do--------------------	Tr	3 2	--	96	--	--
J-142	4 0	Across shear zone--------	Tr	1 0	--	.15	--	--
J-143	4 0	---do--------------------	N	N	--	<.02	--	--
J-144	1 5	Across mineralized zone--	.01	5 5	--	1 5	--	--
J-145	2 5	---do--------------------	03	3 2	--	1 7	1 2	--
J-146	2 0	---do--------------------	.02	7 2	0 041	6 9	3 3	--
J-147	2.0	Porphyry-----------------	04	4.1	--	2 56	68	--
J-149	5.0	Across altered rock------	Tr	1	--	--	--	--
J-150	1.9	Across mineralized zone--	10	30 9	--	--	--	61
J-151	2 5	Across altered rock------	N	.2	017	032	2 7	--
J152	8.0	---do--------------------	Tr	.2	--	--	--	--
J153	3 0	Across mineralized zone--	04	5 3	3 6	--	--	17
J-154	([1])	Backfill-----------------	01	4 0	--	--	--	--
J-155	4 0	Across altered rock------	Tr	1 1	--	--	--	--
J-156		Backfill-----------------	.01	2.4	--	--	--	--
J-157	3 0	Across silicified lime-stone	N	.1	--	--	--	--
J-159		Backfill-----------------	Tr	3	--	--	--	--

[1] Blank, not measured

The country rock is iron-stained quartzite, which is profusely fractured and contains prominent shear zones that trend north and dip steeply The shear zones are part of a broad belt of shearing that extends from the Fraction claim south through the Rock Slide No 1 claim Finely disseminated, mostly oxidized sulfide minerals and large amounts of gouge are contained in the shear zones. A yellowish alteration product, possibly valentinite, occurs on scattered pieces of talus

Mine development consists of three open adits, two caved adits, and five prospect pits (fig. 53). Adit A opens three small sublevels. The main level explores shear zones that trend northeast generally and average about 2 ft (0.6 m) thick. The second level, 10 ft (3 m) lower, also explores northeast-trending shear zones that average 4 ft (1.2 m) thick, but a 30-ft (9-m) drift follows a 3-ft (0.9-m)–thick shear zone that strikes N. 20° W. and dips 70° NE. Intensely oxidized sulfide minerals occur in these zones An intermediate part of the second level, 6 ft (1 8 m) below the main level and entered through a narrow winze near the face of the adit, explores a 25-ft (7 6-m)–thick, northwest-trending shear zone composed predominantly of gouge. From the third level, reached by a 40-ft (12-m) winze from the second level, a 2-ft (0.6-m)–thick shear zone, striking N. 45° E. and dipping 70° NW., was stoped.

A 2-ft (0 6-m)–thick shear zone that strikes N 30° W. and dips 65° NE was crosscut in a caved adit and a prospect pit north and south, respectively, of adit A. Four chip samples across structures in adit A, weighted by length, averaged 0.02 oz gold per ton (0.69 g/t), 4.3 oz silver per ton (147 g/t), and 1.41 percent lead.

A caved adit with a dump indicating several hundred feet of underground workings is about 140 ft (43 m) northeast from adit A (fig 53) A 3-ft (0 9-m)–thick shear zone that trends northwest is exposed in the trench leading to the caved portal A sample from a stockpile near the portal assayed 0 13 oz gold per ton (4.4 g/t), 18 6 oz silver per ton (638 g/t), and 9 0 percent lead

A 2-ft (0 6-m)–thick shear zone that strikes N 75° W and dips 55° SW was followed in adit B and in a 24-ft (7 3-m)–deep winze (fig 53). The shear zone contains about 50 percent gouge and finely disseminated, intensely oxidized sulfide minerals in brecciated quartz A sample taken across the zone assayed 0 08 oz gold per ton (2 7 g/t), 13 7 oz silver per ton (470 g/t), 21 0 percent lead, and 0 4 percent antimony.

Adit C is in limonite-stained, fractured quartzite and exposes a 2-ft (0 6-m)–thick shear zone that strikes N 10° W and dips 70° SW , and assayed only a trace gold and 0 2 oz silver per ton (6.8 g/t)

Remaining workings include four prospect pits south of adit B (fig 53). Three of these expose north-trending, steeply dipping shear zones

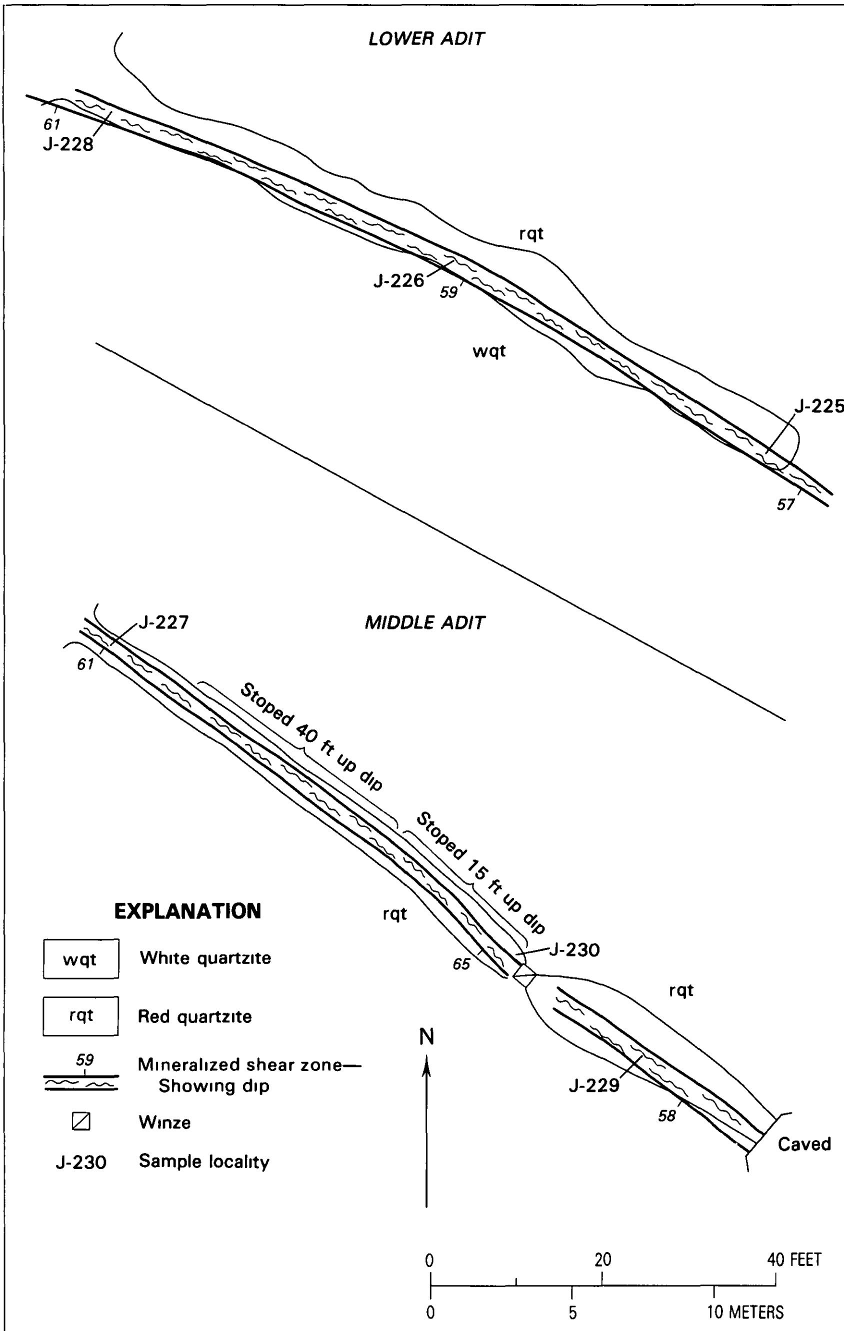

FIGURE 52.—Lower and middle adits, Fraction claim

Data for samples shown on figure 52

[All samples chip Tr, trace, leaders (-), not analyzed, <, less than shown, 1 troy oz/ton=34 285 g/t]

Sample No.	Sample Length (ft)	Gold (oz/ton)	Silver (oz/ton)	Copper (percent)	Lead (percent)	Zinc (percent)
J-225	1.0	Tr	0.5	--	0.45	1.25
J-226	2.0	0.01	8.2	0.04	1.75	--
J-227	.5	.01	4.4	--	1.90	1.28
J-228	1.3	.08	14.1	.20	14.0	--
J-229	1 5	.02	5.1	--	1.85	2.00
J-230	1.5	.01	.1	.01	.31	--

that average 2.5 ft (0 76 m) in thickness and contain finely disseminated, intensely oxidized sulfide minerals. Two samples across the structures averaged 0 5 oz silver per ton (17.1 g/t), 0.23 percent lead, and up to 0.01 oz gold per ton (0.34 g/t).

The Rock Slide No. 1 claim is representative of the entire northeast side of Bible Back Mountain, which can be considered a broad, brecciated belt several hundred feet thick comprised of many shear zones ranging in thickness from 2 to 15 ft (0.6 to 4.6 m) Samples of the shears averaged 0.03 oz gold per ton (1 g/t), 5.1 oz silver per ton (175 g/t), and 4 5 percent lead A large potential resource may lie in the brecciated quartzite, but more data are needed to make meaningful estimations of tonnage and grade

WASHINGTON BASIN AREA

Washington Basin is in the north-central part of the Germania Creek district and includes a small drainage northeast from Washington Basin proper

The host rock is mostly calcareous quartzite that contains some interlayered argillite, conglomerate, and limestone (fig. 54). The beds appear to dip to the southwest at moderate angles. A coarse-grained quartz porphyritic monzonite intrudes the quartzite in the Red Hill area. The quartz monzonite then was intruded by a fine-grained quartz diorite dike that trends northwest. A large northeast-trending reverse fault crosses the basin and the northeast end of the Red Hill area, extending at least 2 mi (3.2 km) Mineralized zones along fractures related to the fault, on the Iope claim group and Empyreum claim, indicate a potential for discovery of additional resources along the fault.

The first claims in Washington Basin were located in 1882 but were not actively explored until 1894 The remains of two ore mills and a

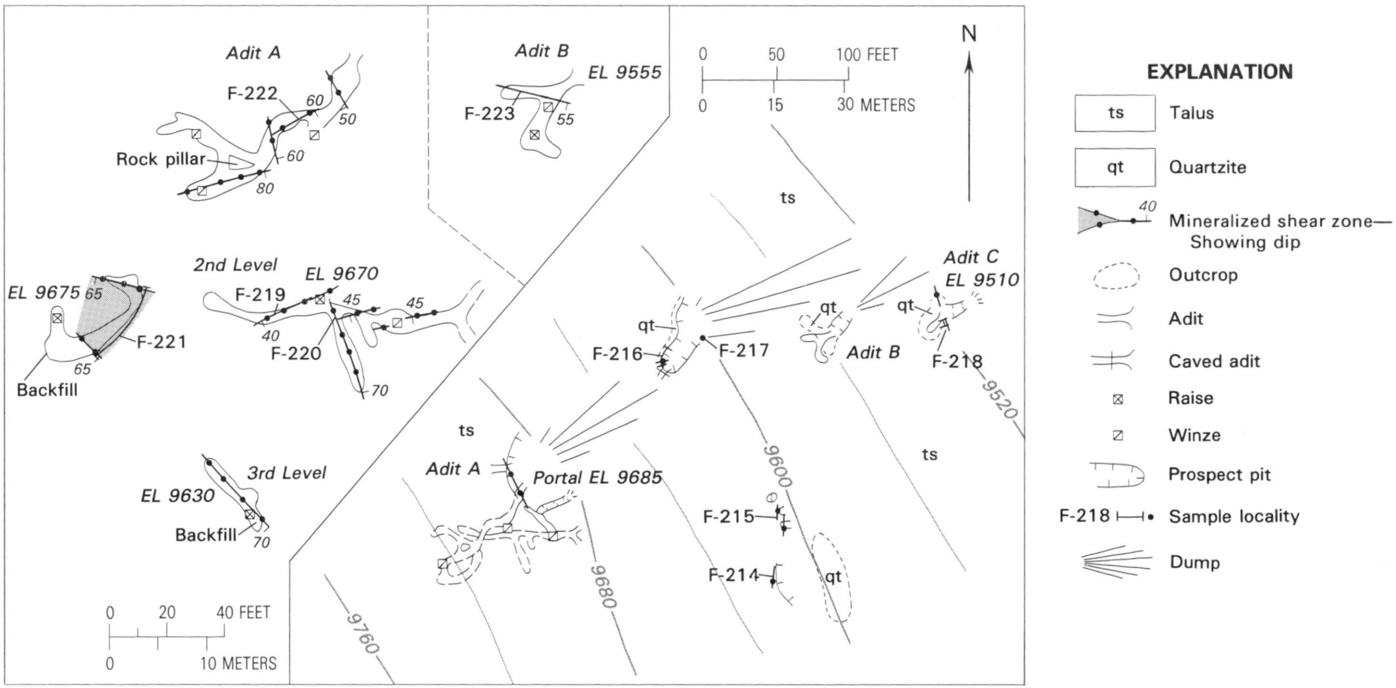

FIGURE 53.—Rock Slide No. 1 (Emerald) claim. Contour interval 40 ft; elevations in feet; 1 ft=0.3048 m.

Data for samples shown on figure 53

[All samples chip except F-217, grab Tr, trace, leaders (--), not analyzed, 1 troy oz/ton=34 285 g/t]

Sample No.	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)
F-214	4.5	Iron-oxide-stained quartzite and brecciated quartz.	Tr	0.2	0.059
F-215	4.0	---do---	0.01	.8	.40
F-216	15.0	---do---	Tr	.2	--
F-217	([1])	Iron- and manganese-oxide-stained quartzite from stockpile.	.13	18.6	9.0
F-218	2.0	Iron-oxide-stained quartzite and brecciated quartz.	Tr	2	--
F-219	4.0	---do---	.01	5.0	1.70
F-220	3.0	---do---	.03	6.8	1.90
F-221	25.0	---do---	.01	.5	.25
F-222	3.0	---do---	.01	5.0	1.80
F-223	2.0	---do---	.08	13 7	21.0

[1] Blank, not measured

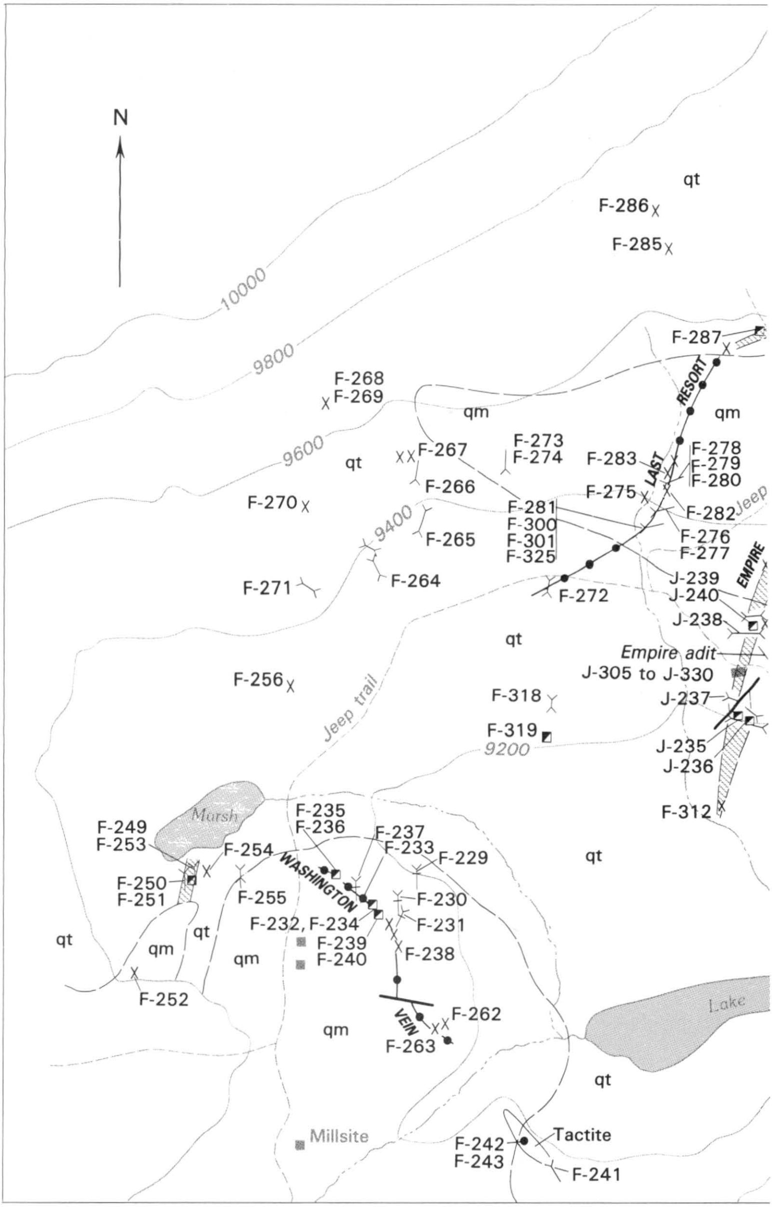

FIGURE 54.—Washington Basin workings (modified from DMEA unpub. data, 1957). Contour interval 200 ft; elevation in feet; 1 ft=0.3048 m.

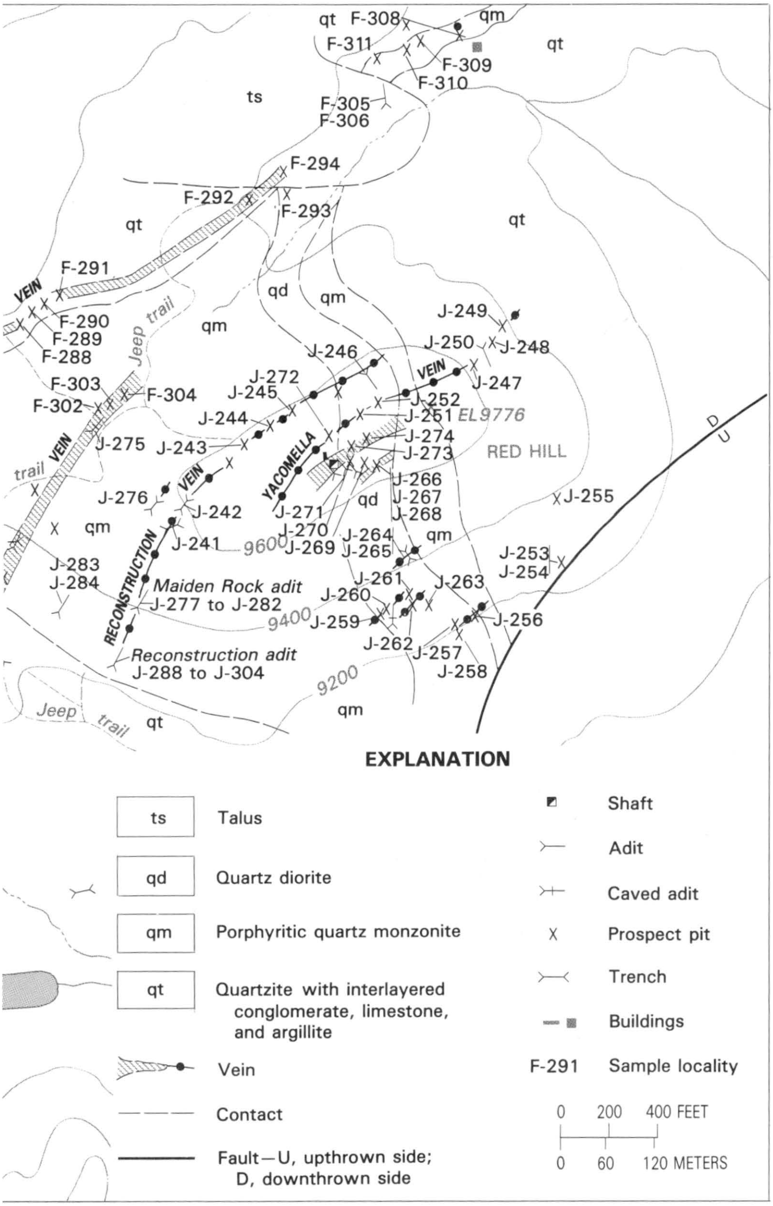

FIGURE 54.—Washington Basin workings—Continued

Data for samples shown on figure 54

[Tr, trace, N, none detected, leaders (--), not analyzed, <, less than shown, 1 troy oz/ton=34 285 g/t]

No	Sample			Gold	Silver	Lead	Antimony
	Type	Length (ft)	Description	(oz/ton)		(percent)	
			Empire vein				
J-235	Chip--	58.0	Across vein----------------	0 01	0.3	--	--
J-236	--do--	8 0	---do----------------------	Tr	3	0 84	--
J-237	--do--	45 0	---do----------------------	01	4	--	--
J-238	--do--	45 0	---do----------------------	Tr	2	02	--
J-239	--do--	25.0	---do----------------------	01	2 9	61	--
J-240	Grab--	([1])	Stockpile------------------	.10	2 9	.22	--
J-275	--do--		---do----------------------	Tr	N	.02	<0 05
J-305	Random chip.		Altered quartzite----------	.01	5 1	--	--
J-306	--do--		---do----------------------	N	1	--	--
J-307	--do--		Vein-----------------------	N	1	--	--
J-308	--do--		---do----------------------	N	5	--	--
J-309	--do--		Altered quartzite----------	N	2	--	--
J-310	--do--		Vein-----------------------	N	Tr	--	--
J-311	Random chip		---do----------------------	N	1.6	--	--
J-312	--do--		---do----------------------	N	2	--	--
J-313	--do--		---do----------------------	N	.1	--	--
J-314	--do--		---do----------------------	N	N	--	--
J-315	--do--		---do----------------------	N	1	--	--
J-316	--do--		Shear zone-----------------	N	1	--	--
J-317	--do--		Altered quartzite----------	N	2	--	--
J-318	--do--		Porphyry-------------------	N	.1	--	--
J-319	Chip--	1 2	Across shear zone----------	N	.1	--	--
J-320	Random chip		Porphyry-------------------	06	Tr	--	--
J-321	--do--		---do----------------------	N	1	--	--
J-322	--do--		---do----------------------	N	N	--	--
J-323	--do--		Altered quartzite----------	N	2	--	--
J-324	--do--		Porphyry-------------------	N	N	--	--
J-325	--do--		Altered quartzite----------	N	.2	--	--
J-326	--do--		Porphyry-------------------	N	1	--	--
J-327	--do--		---do----------------------	N	Tr	--	--
J-328	--do--		---do----------------------	N	1	--	--
J-329	Chip--	0 8	Across fault zone----------	N	3	--	--
J-330	Random chip		Altered quartzite----------	N	1	--	--
F-302	Grab--		Dump-----------------------	04	2	--	--
F-303	Chip--	3 0	Vein-----------------------	Tr	1	--	--
F-304	--do--	6 0	---do----------------------	01	2	--	--
			Washington vein area				
F-229	Grab--		Dump-----------------------	01	N	--	--
F-230	--do--		---do----------------------	Tr	8	--	--
F-231	Chip--	7 0	Across vein----------------	Tr	2	--	--
F-232	--do--	6 0	---do----------------------	N	1 5	--	--
F-233	--do--	25 0	---do----------------------	N	N	--	--
F-234	--do--	15 0	---do----------------------	01	4 8	1 90	1 12
F-235	--do--	12 0	---do----------------------	01	4 5	1 55	96

Data for samples shown on Figure 54—Continued

No.	Sample Type	Sample Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Antimony (percent)
F-236	--do--	15 0	---do---------------------	Tr	3	--	--
F-237	Grab--		Stockpile-----------------	0 01	0 1	--	--
F-238	Chip--	4 0	Across vein---------------	01	2	--	--
F-239	--do--	2 5	Vein----------------------	02	3 2	0 36	0 04
F-240	--do--	4 0	Shear zone----------------	Tr	1 1	--	--
F-241	--do--	1.5	---do---------------------	Tr	4 8	6 20	--
F-242	--do--	30.0	Tactite-------------------	N	.3	06	< 01
F-243	--do--	24.0	---do---------------------	Tr	1.5	47	13
F-249	--do--	14.0	Across vein---------------	.05	5	--	--
F-250	--do--	24.0	---do---------------------	36	3	--	--
F-251	--do--	10 0	---do---------------------	Tr	1	--	--
F-252	--do--	6 0	Iron-oxide-stained granite	Tr	.1	--	--
F-253	Grab--		Stockpile (vein)----------	47	3	008	--
F-254	Chip--	12 0	Iron-oxide-stained granite	Tr	Tr	--	--
F-255	Grab--		Limestone-----------------	Tr	Tr	--	--
F-262	Chip--	8 0	Vein----------------------	Tr	2	--	--
F-263	--do--	7 0	---do---------------------	Tr	1.4	--	--
			Yacomella veins				
J-247	Chip--	26 0	Across vein---------------	Tr	0 4	--	--
J-248	--do--	20 0	---do---------------------	Tr	3	--	--
J-249	--do--	6 0	---do---------------------	Tr	.1	--	--
J-250	Grab--		Stockpile-----------------	.01	N	--	--
J-251	Chip--	4.0	Across vein---------------	Tr	2	--	--
J-252	Grab--		Stockpile-----------------	02	1 4	79	24
J-253	Chip--	1 3	Across vein---------------	.02	2 1	1.48	.37
J-254	Grab--		Stockpile-----------------	.05	4 5	2.40	.58
J-255	Chip--	1 3	Across vein---------------	Tr	3	--	--
J-256	Random chip		Vein----------------------	Tr	N	.07	< 05
J-257	Chip--	2 5	Across vein---------------	04	1 9	1 96	89
J-258	--do--	2 5	Along vein----------------	04	2.9	--	<.05
J-259	--do--	7 0	Across vein---------------	Tr	N	.05	--
J-260	--do--	1 0	Across shear zone---------	Tr	N	--	--
J-261	Grab--		Stockpile-----------------	05	6 8	27 0	5 4
J-262	Chip--	1 5	Across vein---------------	04	3 7	2 93	1 2
J-263	Grab--		Stockpile-----------------	.03	9 0	2.45	1 6
J-264	Chip--	1.5	Across vein---------------	Tr	N	--	--
J-265	--do--	13 0	Across shear zone---------	.01	1	--	--
J-266	Grab--		Stockpile-----------------	05	49 3	8 00	4 2
J-267	--do--		---do---------------------	.03	5.8	2.70	1 5
J-268	Random chip.		Vein----------------------	Tr	1.1	--	--
J-269	Chip--	1 5	Across vein---------------	Tr	1 3	--	--
J-270	--do--	1 0	---do---------------------	02	5	--	--
J-271	--do--	1 5	---do---------------------	02	1 1	05	<.05
J-272	Grab--		Stockpile-----------------	N	2	02	< 05
J-273	--do--		---do---------------------	05	16 5	1 88	1 0
J-274	Chip--	1 0	Across vein---------------	.01	9	24	09

Data for samples shown on Figure 54—Continued

No	Sample Type	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Antimony (percent)
			Reconstruction vein				
J-291	Random chip.		Porphyry	N	N	--	--
J-292	Chip--	1 1	Across shear zone	N	Tr	--	--
J-293	Random chip		Porphyry	N	N	--	--
J-294	--do--		---do	N	N	--	--
J-295	--do--		---do	N	Tr	--	--
J-296	--do--		---do	N	2 6	--	--
J-297	--do--		---do	N	Tr	--	--
J-298	Chip--	1 8	Across shear zone	N	N	--	--
J-299	Random chip		Porphyry	N	N	--	--
J-300	--do--		---do	N	N	--	--
J-301	Chip--	3 0	Across shear zone	N	Tr	--	--
J-302	Random chip		Porphyry	N	N	--	--
J-303	--do--		---do	Tr	N	--	--
J-304	Chip--	1.5	Across shear zone	Tr	1.5	--	--
J-241	Grab--		Stockpile	Tr	1	--	--
J-242	--do--		---do	N	2	--	--
J-243	--do--		---do	Tr	1	--	--
J-244	Chip--	3.0	Vein	Tr	.2	--	--
J-245	--do--	6 0	---do	Tr	1	--	--
J-246	--do--	4 0	Across vein	Tr	3	--	--
J-277	--do--	6 0	Vein	0 01	Tr	--	--
J-278	--do--	4 0	---do	Tr	2	--	--
J-279	--do--	6 0	---do	Tr	N	--	--
J-280	--do--	25 0	Across vein	06	2	--	--
J-281	--do--	11.0	---do	12	1	--	--
J-282	--do--	35 0	---do	09	1	--	--
J-288	Random Chip		Porphyry	N	N	--	--
J-289	--do--		---do	N	N	--	--
J-290	--do--		---do	N	N	--	--
			Last Resort vein				
F-272	Chip--	4 0	Across silicified shear zone	Tr	7 4	--	--
F-276	--do--	3 5	Across vein	Tr	4	--	--
F-277	--do--	3.5	---do	0 08	2	--	--
F-278	--do--	5 0	Across quartz vein	18	4	--	--
F-279	--do--	3 0	---do	22	8	--	--
F-280	--do--	3 0	---do	Tr	3 4	--	--
F-281	--do--	3 0	---do	04	.1	--	--
F-282	--do--	8.0	---do	02	3	--	--
F-283	--do--	4.5	---do	02	1 4	--	--
F-284	--do--	2 5	Across shear zone	.01	.3	--	--
F-287	--do--	6 5	Across vein	16	1.7	--	--
F-288	--do--	3.5	---do	01	1	--	--

Data for samples shown on Figure 54—Continued

No.	Sample Type	Sample Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Anti-mony (percent)
F-289	--do--	4 0	Across contact------------	Tr	.3	--	--
F-290	--do--	5 0	Across vein---------------	Tr	.1	--	--
F-291	Grab--		Stockpile-----------------	Tr	3	--	--
F-292	Chip--	10 0	Across vein---------------	Tr	2	--	--
F-293	Grab--		Sulfide-bearing diorite---	Tr	.6	--	--
F-294	Chip	3 5	Vuggy vein quartz---------	.02	.4	--	--
F-300	--do--	6 0	Across shear zone---------	.03	2	--	--
F-301	Chip--	4.5	Across silicified shear zone.	0 23	0 3	--	--
F-305	--do--	8 0	Quartzite-----------------	Tr	3	--	--
F-306	--do--	12 0	---do---------------------	Tr	.2	--	--
F-308	--do--	70.0	Iron-oxide-stained granite	Tr	.1	--	--
F-309	--do--	5 0	Argillite-granite contact-	Tr	1	--	--
F-310	--do--	6.0	Tactite-------------------	.01	1	--	--
F-311	--do--	10 0	---do---------------------	.01	.1	--	--
			Other samples				
J-276	--do--	3.0	Across vein---------------	Tr	Tr	--	--
J-283	--do--	5.0	Altered quartzite---------	N	1	--	--
J-284	Random chip.		Porphyry------------------	N	.1	0 01	--
F-264	Grab--		Altered quartzite---------	Tr	2	--	--
F-265	Chip--	5 0	---do---------------------	Tr	.3	--	--
F-266	--do--	2 5	Across shear zone---------	Tr	3	--	--
F-267	--do--	5.0	Iron-oxide-stained quartzite	Tr	.2	--	--
F-268	--do--	3 0	Across shear zone---------	Tr	5	--	--
F-269	Chip--	6 0	Altered quartzite---------	Tr	0.4	--	--
F-270	--do--	6 0	---do---------------------	Tr	.3	--	--
F-271	--do--	6.0	---do---------------------	Tr	.3	--	--
F-273	--do--	3.0	Across shear zone---------	Tr	.3	--	--
F-274	Grab--		Stockpile-----------------	0 01	3	--	--
F-275	Chip--	5 0	Iron-oxide-stained granitic rock.	01	2	--	--

[1]Blank, not measured

dismantled sawmill attest to former activity. No production records are available, but two or three veins in the south wall near the head of Washington Basin reportedly produced about $50,000 in lead-silver ores (Umpleby, 1915, p. 245). The production was probably from the Washington vein. The "Parnell claim," probably located on the Washington vein, produced about $125,000. Present claim groups in the area are the Black Rock (28 claims), the Blackjack (16 claims), the Red Hill (2 claims), and the Maiden Rock claim. Additional claims extend northward outside the basin. Patents were granted to the Black Rock Nos. 4 and 9 claims in 1966. The claims were originally located for gold, but most production has been lead-silver ores and some interest has been shown in the scheelite and telluride occurrences.

Four northeast-trending veins and one northwest-trending vein have been found in the basin. The veins are mostly quartz containing disseminated sulfides and very small amounts of scheelite and tellurides. The outcrops are marked by prominent gossans composed of abundant hematite, limonite, jarosite, and some goethite. Pyrite, pyrrhotite, arsenopyrite, sphalerite, galena, stibnite, jamesonite, bismuthinite, native bismuth, and bismuth-bearing tellurides are among the reported metallic minerals. All five major veins have yielded low but relatively consistent assays for gold, silver, and lead, and some have a potential for discovery of additional ore shoots.

EMPIRE VEIN

The Empire vein (pl 3, 134) is in the center of Washington Basin on the Black Rock Nos. 3 and 6 claims The vein has an average outcrop width of about 30 ft (9 m), a maximum exposed width of 72 ft (22 m), and a traceable length of about 2,000 ft (610 m) The south end has been explored more thoroughly and may be traced almost continuously for 900 ft (274 m) The vein is mainly a dense mixture of quartz and pyrrhotite in which are spotty pods of arsenopyrite, sphalerite, and galena. Minor amounts of scheelite and tellurides have been identified.

The Empire adit (fig 54), several pits and trenches, and three shallow shafts were dug along the vein. The adit trends N. 45° W. and crosscuts the vein about 125 ft (38 m) from the portal. Quartzites and porphyritic quartz monzonite wall rock in the adit have been hydrothermally altered and contain small amounts of pyrite

Scheelite occurs locally in small amounts along the vein but is more abundant in irregular bodies of tactite in and along the southern part of the vein One tactite body, sampled 41 ft (12.5 m) along the Empire adit under a DMEA contract, assayed 0.52 percent WO_3. A 53-ft (16-m)-long sample from a trench 200 ft (61 m) southwestward from the portal reportedly assayed 0.52 percent WO_3. These high values, however, were not confirmed during this study, despite efforts to sample the same places

Of the 35 samples taken on or near the Empire vein, 26 were cut in the Empire adit (fig 54) Samples taken across the vein outcrop, weighted by length, averaged less than 0.01 oz gold per ton (0 34 g/t), 0 59 oz silver per ton (20.2 g/t), 0 28 percent lead, 0.40 percent arsenic, and less than 0 01 percent WO_3 Eight random chip samples of the vein taken underground averaged 0 33 oz silver per ton (11 3 g/t) and no gold One sample assayed 0 74 percent arsenic Eight random chip samples of altered quartzite averaged 0.78 oz silver per ton (27 g/t)

Approximately 1 million tons (0 9 million t) of vein material is estimated to occur to a depth of 450 ft (137 m) in the well-defined south part of the Empire vein An additional 1.5 million tons (1 36 million t) can be inferred in the north part of the vein If the vein persists to a depth of half the inferred strike length, an additional 2 5 million tons (2.27 million t) may be present The assays indicate that very little, if any, of this tonnage is commercial at 1974 prices.

WASHINGTON (BLACK ROCK) VEIN

The Washington or Black Rock vein (pl. 3, 131; fig 54) is in the southwest part of the basin, mostly within the Black Rock No 7 claim The vein strikes N 40° W, dips generally 45°-50° SW., and can be traced along the surface by gossan and in shallow excavations for more than 1,000 ft (305 m) The vein is in quartz monzonite, and outcrops indicate an average width of 15-20 ft (4 6-6 1 m) Iron oxides are common in the shallow part of the vein; pyrrhotite, arsenopyrite, and pyrite are common in the unoxidized part.

The vein is exposed in two shallow, inclined shafts, five adits, four of which are caved, and six pits The Washington adit, now caved, probably contains 500 ft (150 m) of workings Material on the dump indicates the main vein was crosscut near the face of the adit A 24-ft (7 3-m)-deep inclined shaft bottoms at an 81-ft (24.7-m)-long drift that exposes sulfide minerals in pods as much as 1 ft (0.3 m) in diameter and 2 ft (0 6 m) long

Samples of vein material averaged 0.005 oz gold per ton (0.17 g/t), 1 3 oz silver per ton (44.6 g/t), 1 27 percent lead, and 0.32 percent antimony Two samples indicated as much as 0.25 percent arsenic. Assuming the Washington vein extends to a depth equal to half the length, about 800,000 tons (726,000 t) of vein material are estimated. The occurrence of sulfides in local large pods possibly indicates some potential for profitable grade material

A tactite zone crops out southwest of the main workings on the projected strike of the Washington vein The zone extends 300 ft (90 m) northwestward from a 15-ft (4 6-m)-long adit and is as much as 54 ft (16 5 m) thick Two samples, extending continuously across the tactite, contained a weighted average of a trace gold, 0.8 oz silver per ton (27.4 g/t), 0.24 percent lead, and 0.06 percent antimony. A sample of the 1.5-ft (0 46-m)-thick mineralized shear zone opened along the entire length of the short adit contained 4.8 oz silver per ton (164.6 g/t) and 6 20 percent lead

Near a marsh west of the Washington vein, another vein that contains 0 36 oz of gold per ton (12.3 g/t) across a 24-ft (7 3-m) thickness (fig 54, F-250) is exposed in a sloughed shaft, two caved adits, many small pits, and a bulldozer cut. It trends northeast and dips steeply. Massive pyrite, pyrrhotite, and sphalerite are the main metallic minerals. The vein can be traced about 150 ft (46 m) and is as much as 50 ft (15 m) thick.

YACOMELLA VEINS

The Yacomella veins (pl. 3, 137; fig. 54) crop out on Red Hill. The main vein is exposed along a strike length of approximately 1,360 ft (415 m) by cuts, pits, and two adits. The difference in elevation of the exposures is more than 250 ft (76 m). The vein is 4–25 ft (1.2–7.6 m) thick, trends northeast, and generally dips steeply southeast except at the north end where it dips northwest. Quartz and pyrrhotite are main components of the vein, which is obscured under a thick talus cover farther to the northeast. On the east slope of Red Hill, several cuts and pits expose a series of discontinuous veins as much as 2 ft (0.6 m) thick but averaging less than 1 ft (0.3 m) thick. This system also contains quartz stringers and veinlets in which are lenses of jamesonite and pyrite as much as 2 in. (5 cm) thick.

Eight samples were taken from workings along the longest of these veins and 20 samples were cut on workings associated with the southeast part of the vein system (fig. 54). Samples across the longest vein, weighted by length, averaged less than 0.01 oz gold per ton (0.34 g/t) and 0.31 oz silver per ton (10.6 g/t). Samples taken from the narrower veins, and workings south from the main vein, contained higher values and indicate a potential for discovery of modest amounts of metallic resources.

LAST RESORT VEIN

The Last Resort or Margie Bell vein (pl. 3, 133, fig. 54) is in the northern part of the basin, mostly in the Black Rock Nos. 1, 2, and 4 claims. The vein trends N. 20°–75° E., dips 40°–60° SE., and can be traced on the surface for about 2,800 ft (850 m). Average thickness of the vein is difficult to determine; where seen underground it is 3.5 ft (1 m) thick, but locally it is as much as 12 ft (3.7 m) thick. The vein is composed of quartz lenses and silicified rock in which is partially oxidized pyrite. Argentiferous galena was the principal mineral of value seen on the dumps. Samples of the vein averaged 0.05 oz gold per ton (1.71 g/t) and 1.0 oz silver per ton (34 g/t).

The vein is developed by three adits that total 263 ft (80.2 m) long, a 41-ft (12.5-m) inclined shaft, 6 bulldozer cuts, and 22 prospect pits (fig.

54) The three adits are west of the road leading to the Red Hill area, and the inclined shaft, which is surrounded by many prospect pits, is on a bench above the adits.

A tactite zone that extends 880 ft (268 m) northeast along the projected trend of the Last Resort vein is intersected in a 54-ft (16.5-m) adit The tactite contains isolated lenses of sulfide minerals Samples of the tactite averaged 0 01 oz gold per ton (0.34 g/t) and 0 1 oz silver per ton (3 42 g/t)

Assuming a depth of 1,200 ft (370 m) (less than half the vein length) and an average thickness of 5 ft (1.5 m), the volume of vein material is estimated at about 1,600,000 tons (1,450,000 t).

RECONSTRUCTION VEIN

The Reconstructon vein (pl. 3, 136; fig. 54), which is between the Empire and Yacomella veins, may be traced through a series of adits and pits for 1,750 ft (533 m) It strikes N. 30°–50° E. and dips about 45° SE. The maximum exposed width is 15 ft (4.6 m). Its composition, similar to that of the Last Resort vein, is predominantly pyrite-bearing quartz lenses

The vein is exposed in three adits that total about 575 ft (175 m) in length The largest of these, the Reconstruction adit (fig. 54), is on the south end of the vein and was driven along the strike of the vein in porphyritic quartz monzonite. An east drift follows a shear zone for a distance of 192 ft (59 m) No sulfide minerals were observed in shear zone gouge, but the wall rock contains small amounts of disseminated pyrite The Maiden Rock adit crosscuts the vein near the portal and drifts along the foot wall for 85 ft (26 m) The wall rock is mostly altered quartz monzonite containing finely disseminated pyrite No other sulfides were seen. The portal of an adit near the north end of the vein, where it is 4 ft (1 2 m) thick (fig. 54), is in quartz diorite. Finely disseminated sulfide minerals are present in the vein.

Samples from the vein averaged 0 03 oz gold per ton (1 03 g/t) and 0 13 oz silver per ton (4.46 g/t). A single sample of the vein yielded 0.09 percent WO_3 and 0 18 percent bismuth.

IOPE GROUP

The Iope property (pl. 3, 138), on the ridge north of Washington Basin, is composed of three unpatented lode claims located in 1904, presumably for gold.

The property is underlain by fractured and contorted quartzites with interbedded silicified argillites and limestones; it lies near the northernmost exposure of a regional reverse fault that can be traced from Three Cabins Creek across Washington Basin. Some of the shear zones are filled with quartz, and these quartz veins have a maximum thickness of 2 ft (0.6 m); they trend northeast but cannot be traced for more than a few tens of feet. No sulfides other than finely disseminated pyrite were seen in the iron-stained and partly leached vein material.

The property is developed by two inclined shafts and an adit, all inaccessible. Four chip samples were taken across shear zones, and one grab sample was taken from a stockpile. The chip samples, weighted by length, averaged 0.02 oz gold per ton (0.69 g/t), 0.75 oz silver per ton (25.7 g/t), 0.44 percent lead, 3.23 percent zinc, and 0.12 percent antimony. The stockpile sample assayed no gold, 3.4 oz silver per ton (117 g/t), 1.7 percent lead, 7.0 percent zinc, 0.4 percent antimony, and 0.2 percent copper.

The Iope group is on a set of fractures parallel and related to the regional fault that extends across Washington Basin, and therefore has a potential for discovery of mineralized material.

THREE CABINS CREEK AREA

Three Cabins Creek is the next drainage south from Washington Basin and drains into Germania Creek (fig. 55).

Paleozoic quartzites, with interbedded argillites and siliceous limestones and intruded by porphyritic granite, are the main host rocks for mineral deposits in the area. The sedimentary rocks trend northeast

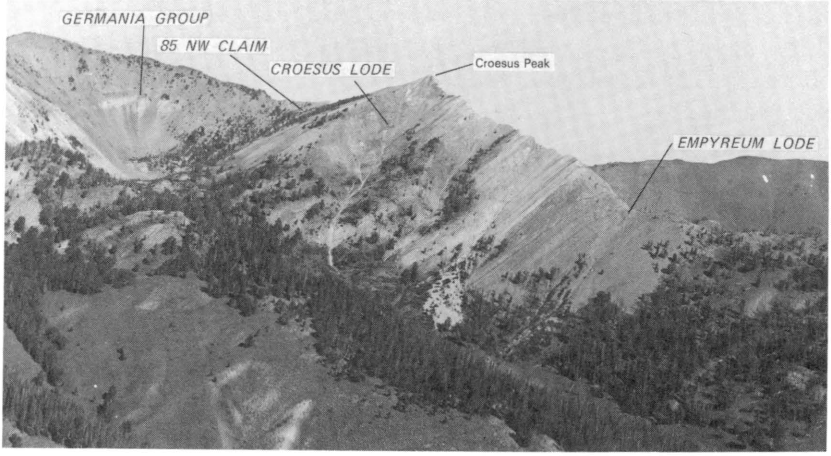

FIGURE 55.—Three Cabins Creek area, viewed from the southeast.

and dip less than 40° SE except on the eastern flank of Croesus Peak, where the bedding dips steeply to the northwest. The rocks are displaced by a large reverse fault that trends north for at least 2 mi (3 2 km) from near Three Cabins Creek across Washington Basin.

Three patented claims are in the area, on which workings were dug to explore highly oxidized and leached quartz veins along shears in the quartzites.

GERMANIA AND ARCTIC GROUPS

The Germania and Arctic groups (pl 3, 150; fig 56), at the headwall of Three Cabins Creek cirque, are on two claims patented in 1894 No record of production exists, but some lead-silver ore was probably produced Mineral Survey Nos 1105 and 1107 indicate total underground extent of 340 ft (104 m) in two adits on the Arctic lode and 670 ft (204 m) in three adits and an inclined shaft on the Germania lode. All workings were caved and inaccessible, but the distance between the northern and southernmost workings is about 1,000 ft (305 m) The workings apparently explored a quartz vein near the contact between quartzite and porphyritic granite (fig. 56) Stockpiled material from the vein is predominantly quartz but contains as much as 15 percent sulfide minerals, including pyrite, galena, sphalerite, pyrrhotite, and arsenopyrite in approximate order of abundance. The quartz is profusely limonite stained and vuggy

Samples of vein quartz from stockpiles and dumps contained an average of 0 06 oz gold per ton (2.06 g/t), 8.2 oz silver per ton (281 g/t), and 6.14 percent lead. If the quartz vein is continuous between the workings at each end, resources of silver and lead may exist on the two claims.

CROESUS LODE

The Croesus lode (pl 3, 147; fig. 55), on the south flank of Croesus Peak, was located in 1879 and patented in 1894 No records of production are available. The property apparently has been idle many years.

A northeast-trending series of cuts have been excavated along a quartz vein in a shear zone that dips 68° NW, parallel to the bedding of quartzite. Southeast of the shear zone the quartzite has been intruded by limonite-stained porphyritic granite Talus mantles the area. An adit, now caved, trends northwest towards the mineralized shear zone

The vein material is highly leached, vuggy, iron-stained quartz con-

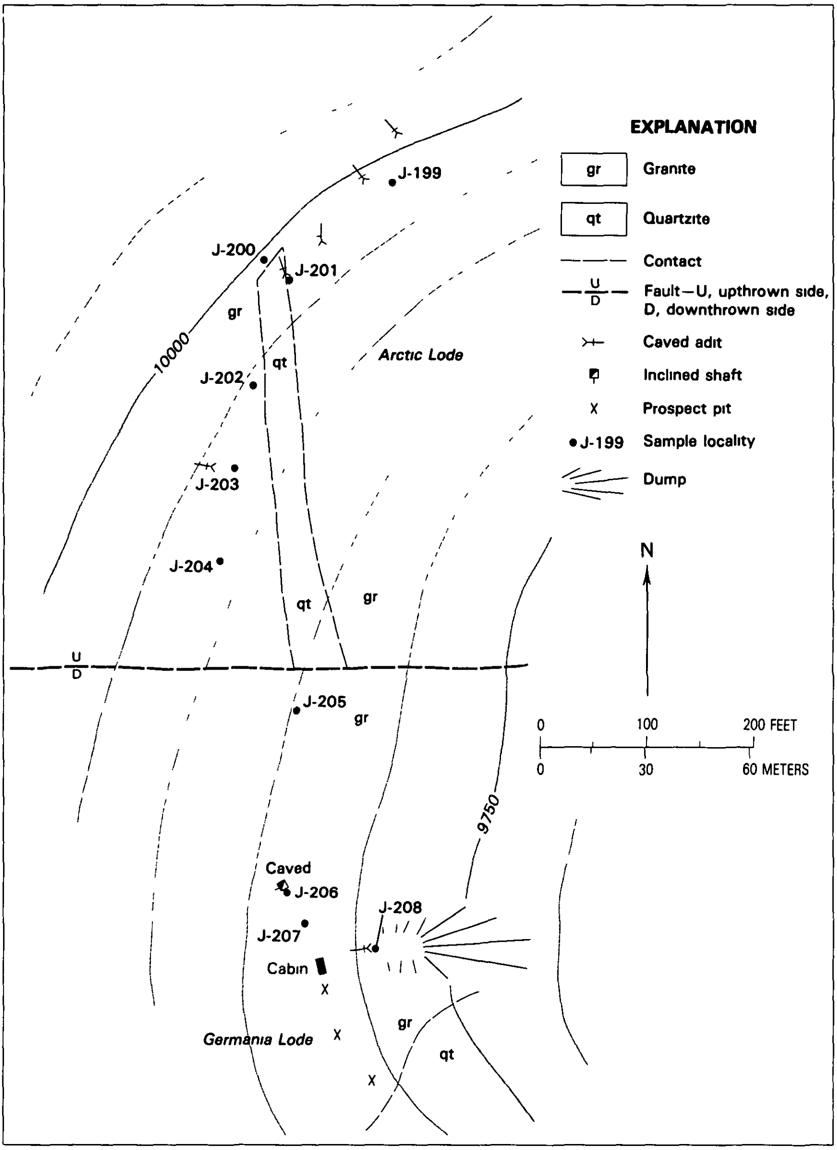

FIGURE 56 —Germania and Arctic groups Contour interval 50 ft

taining minute crystals of pyrite. The vein can be traced more than 300 ft (90 m) and is 10–15 ft (3–4.6 m) thick. Alteration indicates that the vein may extend as much as 150 ft (46 m) northeast of the discovery shaft and 100 ft (30 m) southwest of the pit. The vein material is mostly oxidized, but some galena and pyrite were observed

Data for samples shown on figure 56

[Tr, trace, N, none detected leaders (-), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

No	Sample Type	Sample Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Copper (percent)	Lead (percent)
J-199	Grab--	([1])	Stockpile---------------------	0 05	8 7	--	--
J-200	Chip--	12.0	Iron-oxide-stained granite porphyry	Tr	N	--	-
J-201	Select		Sulfide-bearing quartz (dump)	06	3.2	--	0 58
J-202	Chip--	3.0	Iron-oxide-stained granite porphyry	01	5	--	28
J-203	Select		Sulfide-bearing quartz (dump)	03	3 1	--	83
J-204	Chip--	4.0	Iron-oxide-stained granite porphyry	N	Tr	--	--
J-205	--do--	6 0	---do-----------------------	N	2	--	01
J-206	Select		Iron-oxide-stained vuggy quartz (dump)	.08	12 2	0.22	17 0
J-207	Chip--	5.0	Iron-oxide-stained granite porphyry.	Tr	1	01	.02
J-208	Select		Stockpile-------------------	.09	13 7	--	--

[1]Blank, not measured

on the adit dump The best values are in a 2.5–4-ft (0.76–1.2 m)-thick zone along the hanging wall of the vein (fig. 57).

Assuming the hanging-wall part of the vein has consistent values to a depth of 150 ft (46 m), potential resources are estimated to be 14,000–30,000 tons (12,700–27,000 t) that average 0.11 oz gold per ton (3.8 g/t), 10.9 oz silver per ton (374 g/t), and 3 7 percent lead Spectrographic analyses of some samples indicate antimony and arsenic also are present

EMPYREUM CLAIM

The Empyreum claim (pl. 3, 145) on the east flank of Croesus Peak, was discovered in 1894 and was presumably located for gold. No record of mineral production from the mine on the claim was found. The mine had been idle for many years and most underground workings are unsafe.

Mine workings apparently follow a shear zone at the south end of the large regional reverse fault that trends northeast through Washington Basin The fault zone is about 40–50 ft (12–15 m) wide and can be traced along the line of workings for more than 500 ft (150 m) (fig. 58). It dips steeply west and contains many parallel shears. Light-gray quartzite and interbedded dark-gray siliceous limestone on the hanging wall of the fault strike northeast and dip more than 60° NW. Iron-stained, pyritized white to pink quartzite on the foot wall also strikes northeast but dips less than 40° SE. The fault zone has been silicified, and the quartz contains pyrite, galena, and sphalerite over widths of as

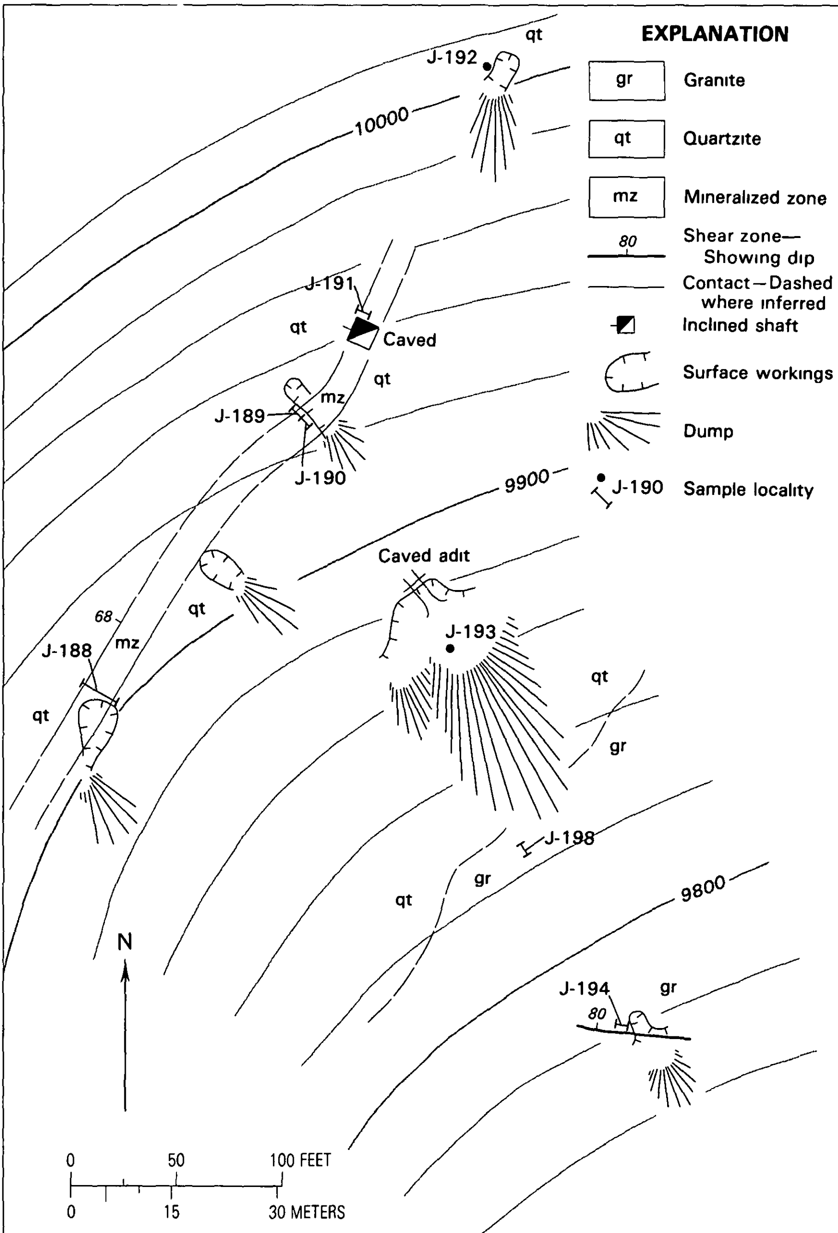

FIGURE 57 —Croesus lode Contour interval 20 ft

Data for samples shown on figure 57

[Tr, trace, leaders (--), not analyzed, <, less than shown 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)
J-188	Chip--	16.0	Vein----------------------	Tr	1.8	0.02
J-189	--do--	3.0	---do---------------------	0.13	13.7	9.00
J-190	--do--	4.0	---do---------------------	.05	2.4	.28
J-191	--do--	2.5	---do---------------------	.18	10.8	2.80
J-192	Random chip.	([1])	Iron-oxide-stained quartzite.	Tr	.5	.23
J-193	Grab--		Iron-oxide-stained quartz	.01	.9	.30
J-194	Random chip.		Porphyritic granite------	Tr	Tr	<.02
J-198	Chip--	4.0	---do---------------------	Tr	.1	--

[1]Blank, not measured

much as 4 ft (1 2 m) Much of the material is intensely oxidized and shows only traces of sulfide minerals.

Selected dump samples indicate that parts of the zone contain relatively high values Weighted samples across shear zones, however, averaged 0 01 oz gold per ton (0.34 g/t), 2.8 oz silver per ton (96 g/t), and 0 33 percent lead. One sample contained 8 40 percent arsenic. Bismuth (0.1 percent) and antimony (0.5 percent) were detected in some samples.

The mineralized shear zone is related to the extensive fault that continues through Washington Basin and is a potential site for undiscovered mineral resources

85 NW CLAIM

The 85 NW claim is between the Arctic and Croesus lodes on the southwest flank of Croesus Peak (pl. 3, 149).

Dumps of adits driven in porphyritic granite indicate at least 250 ft (76 m) of underground workings. Quartz on the dumps indicates the workings extend along a vein in altered wall rock

Two selected stockpile grab samples of iron-stained, vuggy quartz that contained minute crystals of galena and pyrite were taken from the lowermost dump The samples contained 0.02 and 0 03 oz gold per ton (0 69 and 1 02 g/t), 2.4 and 12.6 oz silver per ton (82.3 and 432 g/t), and 1 0 and 23 0 percent lead. One sample also contained 6 10 percent antimony.

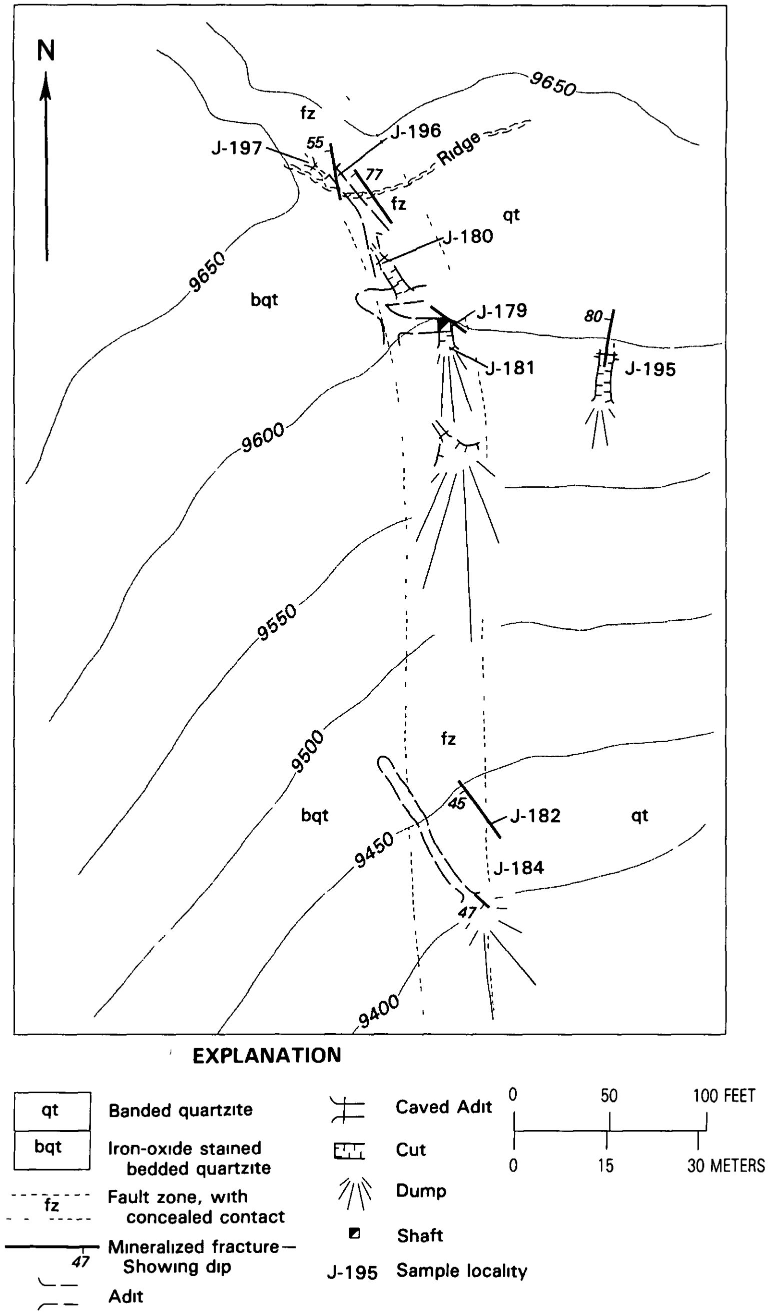

FIGURE 58 —Empyreum claim Contour interval 50 ft

Data for samples shown on figure 58

[All samples chip except J-180, J-181, grab Tr, trace, leaders (-), not analyzed 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample No.	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)
J-179	2.0	Across shear----------	Tr	2.2	0.5
J-180	([1])	Dump------------------	0.08	10.9	2.0
J-181		---do-----------------	.04	15.9	1.4
J-182	3.0	Across shear----------	.05	6.4	.31
J-183	0.7	---do-----------------	Tr	2.0	.04
J-184	1.0	---do-----------------	Tr	.3	.90
J-195	2.0	---do-----------------	Tr	1.6	.47
J-196	4.0	---do-----------------	.01	1.7	.23
J-197	1.5	---do-----------------	.02	2.6	--

[1] Blank, not measured.

Talus makes it impossible to determine the length of the mineralized structure

POLE CREEK AREA

Pole Creek area covers the Pole Creek drainage, which includes Grand Prize and Galena Gulches.

Host rocks are mainly fractured limy quartzites and argillites. Most exploration, beginning in the early 1880's, has been in gossans The underlying primary sulfide-bearing deposits appear to be replacement and fissure-filling deposits

The area has a good potential for the discovery of ore-bearing primary veins in the sedimentary strata.

PEACE OF MINE GROUP

The Peace of Mine prospect (pl 3, 160) consists of 10 unpatented lode claims

Prospect workings in contorted argillite and quartzite expose two veins that intersect at a 14-ft (4.3-m) inclined shaft, which was filled with water. One vein strikes N. 25° E, dips 80° NW., ranges in thickness from 1 in to 1 ft (2.5 to 31 cm), and is traceable for 190 ft (58 m) southwest of the shaft. The second vein strikes N 25° W, dips 75° NE, is as much as 3 ft (1 m) thick, and is exposed in a bulldozer trench that extends 90 ft (27 m) northwest from the shaft. The vein is between two parallel, narrow andesite dikes. The foot-wall dike is in contact with the vein, but the hanging-wall dike is separated from the vein by a 3-ft (1-m)-thick section of black argillite The vein is fractured and oxidized and contains iron-oxide-encrusted rock fragments and yellow oxidized lead and zinc minerals One fragment of calcite was coated with green smithsonite Sphalerite, galena, and chalcopyrite were observed on the shaft dump.

Nine samples were taken from the property. Seven chip samples of vein material yielded weighted averages of 0.04 oz gold per ton (1 4 g/t), 3 18 oz silver per ton (109 g/t), 0.07 percent copper, 4.38 percent lead, 1 00 percent zinc, and 0 07 percent antimony. Two grab samples assayed a trace gold, and as much as 8 3 oz silver per ton (285 g/t), 0.09 percent copper, 10 0 percent lead, and 3.20 percent zinc. These relatively high values indicate a potential for the discovery of minable ore shoots

POLE 16 (OLD GRAND PRIZE) CLAIM

The Old Grand Prize claim (pl 3, 158) was located in 1882 as a silver prospect and was recently relocated as the Pole 16 claim, part of a group of claims

Numerous adits explore fractured calcareous sandstone and argillite. The longest adit is 300 ft (90 m) long and has a 40-ft (12-m) winze The sedimentary rocks have been intruded by a granitic dike that trends northwest. Intermittently along and near this dike, quartz and quartz-calcite veins and stringers, which locally contain minor amounts of sphalerite and galena, transect the dike and sedimentary rocks

Six samples cut from the quartz- and quartz-calcite-filled structures contained weighted averages of 0.01 oz gold per ton (0 34 g/t), 2 17 oz silver per ton (74 4 g/t), and 0 86 percent lead Five of the six samples contained weighted averages of 0 005 percent copper and 0 46 percent zinc Selected samples contained as much as 0 01 oz gold per ton (0 34 g/t), 5 1 oz silver per ton (175 g/t), 0 02 percent copper, 2 20 percent lead, and 0.20 percent zinc.

DARLIN GROUP

The Darlin, Little Jim, and Roebuck claims are along the northeast side of the creek in Grand Prize Gulch (pl 3, 159) Quartz and quartz-calcite veins as much as 4 ft (1.2 m) thick are exposed in three adits, numerous small pits, a few bulldozed cuts, and a shallow caved shaft

The three adits total 45 ft (13 7 m) in length. The veins, apparently related to those at the Old Grand Prize mine, contain small amounts of galena and sphalerite

Seven chip samples taken across the veins averaged a trace gold, 0.20 oz silver per ton (6.4 g/t), 0.06 percent lead, and 0.10 percent zinc. Selected samples contained as much as 4.6 oz silver per ton (158 g/t), 1 5 percent lead, 0 84 percent zinc, and a trace gold.

POLE PROSPECT

The Pole prospect (pl. 3, 157), east of Pole Creek between Grand Prize Canyon and Grand Prize Gulch, is part of a large group of claims located in recent years Prospect workings consist of 13 bulldozed cuts and two diamond drill holes

The country rocks are limestone, silicified limestone, quartzite, and calcareous quartzite. A diorite dike intrudes these rocks, and pods of massive sulfides occur along the contact. The largest pod observed was 20 ft (6 m) across. Iron is the major constituent of the pods, with lesser amounts of copper, lead, and zinc Three samples contained as much as a trace gold, 0 5 oz silver per ton (17 1 g/t), 0 04 percent copper, 0 23 percent lead, and 3 1 percent zinc.

MISCELLANEOUS PROPERTIES

Several properties in the district that have little or no economic potential or were not exposed sufficiently to permit evaluation are listed in table 13.

FOURTH OF JULY CREEK DISTRICT

The Fourth of July Creek district is in the central part of the study area (pl 3, fig 34)

Host rocks include siliceous and carbonaceous argillite, quartzite, limestone, and dolomite The mineralized sedimentary rocks occur primarily as roof pendants in quartz monzonite in a 1-mi (1.6-km–wide zone of intense faulting and folding, generally west of Blackman Peak near the headwaters of Fourth of July Creek.

Mineralized structures vary greatly in thickness and are generally exposed for lengths of more than 100 ft (30 m) Ore minerals include sphalerite, galena, jamesonite, molybdenite, chalcopyrite, and

TABLE 13 —*Miscellaneous properties, Germania Creek district*

[1 ft=0.3048 m, 1 oz/ton=34.285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
118	Mountain View	Quartz vein in granite porphyry-----	One sloughed pit---------	Three samples contained from 2.6 to 17.8 oz silver per ton, no gold. One sample contained 0.43 percent bismuth.
119	Champion	Quartz vein in granite porphyry near contact with quartzite.	One short adit and a caved shaft.	Two samples, as much as 0.01 oz gold per ton, 2.1 oz silver per ton, 1.32 percent zinc.
120	First National	Claim located on mafic intrusion in propylitized quartzite.	None--------------------	Three chip samples, trace gold, no silver.
121	Prospect		Sloughed cut (possibly a caved adit).	One grab sample, trace gold, 0.03 oz silver per ton.
122	Phoenix	Claim located on sheared granite porphyry.	One caved adit.----------	One sample, trace gold, no silver.
123	Omaha	Quartz vein, 1 to 2 ft thick, in porphyritic granite. Traceable for 150 ft.	Three small sloughed pits and one cut.	Two samples, a trace and 0.1 oz silver per ton, no gold.
124	Prospect	Iron-oxide-stained, brecciated quartzite.	Prospect pit-------------	One grab, trace gold, 0.03 oz silver per ton.
125	Red Warrior	Quartz vein, 4 to 8 ft thick, in granite porphyry. Traceable for 160 ft.	Three caved adits--------	Three grab samples, as much as 0.2 oz silver per ton, no gold. One sample, 0.03 percent lead, 0.36 percent bismuth.
126	Contact	Working exposes limestone-quartzite contact trending northeast. Both rock types are highly iron oxide stained and contain disseminated sulfides.	One pit------------------	One sample across contact, trace gold, 0.2 oz silver per ton.

127	Cirque Wall	Silicified shear zones in iron-oxide stained granitic rock. No metallic minerals seen.	Thirty-eight-ft adit-----	Two samples across shear zone, as much as trace gold, 0.2 oz silver per ton.
128	Floor	A 2- to 20-ft-thick tactite zone trending north, is exposed for 200 ft. Disseminated sulfides, mostly pyrite, were observed.	One pit------------------	One sample across tactite, no gold, and trace silver.
129	Phantom	Two northeast-trending shear zones in highly iron oxide stained granitic rock. No sulfides observed.	---do--------------------	One sample across the shear zone and wall rock, no gold, 0.5 oz silver per ton.
130	Road	Workings exposed a 2-ft-thick northwest-trending shear zone in iron-oxide-stained granitic rock. Vuggy quartz with pyrite fills shear zone.	---do--------------------	One sample across shear zone, trace gold and no silver.
132	Black Rock Nos. 11 & 15	Workings expose iron-oxide-stained quartz lenses and shear zones in quartzite, and silicified fracture zones in granitic rock. No metallic minerals observed.	Two adits, 8 dozer cuts, and 14 pits.	Two stockpile grab and nine chip samples, as much as 0.01 oz gold per ton and 0.5 oz silver per ton.
135	Phantom vein	Iron-oxide-stained quartz vein striking N. 45° E. and dipping SE. is exposed in one trench. Vein is in a porphyritic quartz monzonite. No sulfides observed. Vein is exposed for 50 ft.	One trench and adit------	Three samples, as much as trace gold, 0.1 oz silver per ton.
139	Tyrolese	Brecciated quartz-filled shear zones in quartzite. Some finely disseminated, highly oxidized sulfides, probably galena and pyrite.	Three adits and one inclined shaft.	Five samples, as much as 0.01 oz gold and 3.0 oz silver per ton. Two of the samples contained as much as 0.80 percent lead, and 0.82 percent zinc.

TABLE 13 —*Miscellaneous properties, Germania Creek district*—Continued

Map No. (pl. 3)	Property Name	Summary	Number and type of workings	Sample data
142	South Bible Back	Contact between reddish quartzite and small hornblende-biotite andesite dike.	One cut------------------	Two select samples, as much as trace gold, 2.2 oz silver per ton, 0.6 percent lead.
143	Alice	Brecciated quartz vein in quartzite--	One 380-ft adit, one caved adit, and two cuts.	Eight samples, as much as 0.20 oz gold per ton, and 14.6 oz silver per ton. Five of the samples contained as much as 6.00 percent lead. Two contained as much as 0.25 percent copper. One sample assayed 3.0 percent antimony.
146	Wild cat	Quartz vein in quartzite. No apparent sulfides.	One short adit-----------	One sample, trace gold and silver.
148	West Croesus	Alteration zone between porphyritic granite and quartzite.	One 35-ft adit-----------	One sample contained a trace gold and 0.3 oz silver per ton.
151	Knob	Workings expose shear zones in altered quartzite. Finely disseminated sulfides sporadically occur in some shear zones.	Two adits and two pits---	Two samples across shear zones, as much as trace gold and 1.4 oz silver per ton. One select grab of small stockpile, 0.02 oz gold per ton and 3.7 oz silver per ton.
152	Carie Ly	Iron-oxide-stained shear zones as much as 2 1/2 ft wide containing fragmented quartz vein in argillite.	Pits---------------------	Two samples, trace gold, 0.2 oz silver per ton, as much as 0.023 percent lead and 0.083 percent zinc.

153	Black Bear	Iron-oxide-stained quartz lens, 4 in. thick, in shear zone along contact between limestone and quartzite.	Trenches	Two samples, trace gold, as much as 0.4 oz silver per ton, 0.61 percent lead, and 1.1 percent zinc.
154	Hi Bobby	Sulfide-bearing quartz-calcite veins in calcareous, argillaceous quartzite.	Pit	A 2-ft chip sample, trace gold, 0.1 oz silver per ton, 0.1 percent zinc, 0.002 percent copper, 0.006 percent lead.
155	Happy Go Lucky	Quartz-calcite vein, 4 in. thick, in argillite.	Caved adit	One sample, trace gold, 0.1 oz silver per ton, 0.17 percent lead, 1.2 percent zinc.
156	Washington	No bedrock exposed	do	A select grab sample, trace gold, 3.1 oz silver per ton, 0.85 percent lead, 0.20 percent zinc.
161	Rainbow group	Quartzite and calcareous argillite intruded by quartz monzonite with quartz and quartz-calcite veins along contact. Minor amounts of galena, sphalerite, and malachite in vein.	Several pits and trenches	Five samples, as much as a trace gold, 0.37 oz silver per ton, 0.38 percent lead, 0.24 percent zinc, 0.05 percent copper.
162	Silver Cloud-Nelson	Quartz-calcite outcrop, no sulfide minerals found.	Pits and trenches	Two samples, trace gold and 0.1 oz silver per ton.
163	Valley View	Quartz-calcite outcrop, no sulfide minerals observed.	do	Two samples, trace gold and silver, as much as 0.15 percent lead, 0.08 percent zinc, 0.01 percent copper.
164	Stibnite	Calcite veins in brown and gray argillite.	One cut	One sample, no gold and 0.10 oz silver per ton.

scheelite Most ore minerals occur as masses in lens-shaped pods, except molybdenite and scheelite, which occur as small blebs at the Red Robin prospects

County records reveal that 171 lode and 3 placer claims, including relocations, have been recorded since 1883 (table 14) The earliest exploration activity was at the Deer Trail and Confidence (Lucky Strike) properties, followed by development at the Silver Dollar and Rupert (F D R) properties The latest development work was at the Deer Trail and Meadow View claims between 1952 and 1956 Present activity is limited to assessment work Most claims in the district are held by Mr. Elmer Enderlin Reported metal production is listed in table 15.

TABLE 14 —*Summary of mining claims recorded, including relocations, 1883-1970, Fourth of July Creek district*

Decade	Number of lode claims	Number of placer claims
1883-1890	19	--[1]
1891-1900	3	--
1901-1910	27	--
1911-1920	5	--
1921-1930	35	--
1931-1940	14	3
1941-1950	16	--
1951-1960	29	--
1961-1970	23	--
Total-------	171	3

[1]Leaders (--), none recorded.

TABLE 15 —*Recorded metal production, 1937-1957, Fourth of July Creek district*

[Data from U S Bureau of Mines production records Leaders (--) none recorded 1 oz (troy)=31 1 g· 1 lb=0 45 kg]

Year	Mine	Ore (tons)	Gold (oz)	Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1937	Confidence-----	3	1	353	33	1,322	--
1941	Rupert (F.D.R.)	6	--	80	--	3,425	--
1948	---do----------	7	--	141	--	4,856	--
1954	---do----------	3	--	73	--	3,000	--
1954	Deer Trail-----	59	--	114	--	9,500	7,900
1957	Rupert (F.D.R.)	2	--	20	--	1,000	--
1957	Deer Trail-----	110	1	2,337	600	2,000	2,700
	Total----------	190	2	3,118	633	25,103	10,600

Four properties in the district have good potential for becoming future metal producers. The Deer Trail mine is marginal at 1973 zinc-lead prices The Rupert (F.D.R.), Meadow View, and Timberline deposits are considered submarginal, primarily because indicated tonnages are insufficient to support large mining operation However, a good possibility exists for developing additional tonnages Two other properties, the Confidence and Silver Dollar, also have potential for discovery of minable deposits

Small sulfide-rich zones that contain high values of silver, lead, zinc, and antimony occur at the Patty Flynn, Shiner, and White Cloud prospects. Tonnages at these three properties are relatively small, and geologic evidence to support extensions of the mineralized zones is sparse

Individually, known lode deposits in the Fourth of July Creek district are either too low grade or too small to be mined at present economic conditions. Collectively, however, these deposits represent a potential resource of zinc, silver, and lead Antimony, tungsten, copper, molybdenum, gold, and tin are present in some deposits and represent possible byproducts Indicated resource tonnages are insufficient to justify building a mill at each property, but a centrally located custom mill might be feasible

DEER TRAIL MINE

The Deer Trail mine is southwest of Blackman Peak (pl. 3, 109). The original Deer Trail and Deer Trail Fraction claims were staked by George Blackman in 1883 The property is presently owned by Miss Frances Comer and leased to Mr Elmer Enderlin Most development work at the mine was done under a DMEA contract (1955–1956), when the property was held by Highland-Surprise Consolidated Mining Co. Much of the following data, including resource estimates, is based on maps, diamond drill logs, and other DMEA material (unpub. data) Recorded metal production for the years 1954 and 1957 is shown in table 15

The principal host rocks are tactite, limestone, and argillite, which form a roof pendant in quartz monzonite that was intersected by drifting and diamond drilling near the face of the main Deer Trail adit (fig 59) A breccia zone that contains xenoliths of black argillite separates the sedimentary rocks from the quartz monzonite near the face of the adit Sulfide-rich lenses are mostly confined to tactite zones in argillite and limestone Sulfides also are present along faults and shear zones Sulfide minerals, including sphalerite, galena, and trace amounts of chalcopyrite, occur as massive lens-shaped pods and as fine disseminations Common gangue minerals are pyrite, pyrrhotite, epidote, and garnet

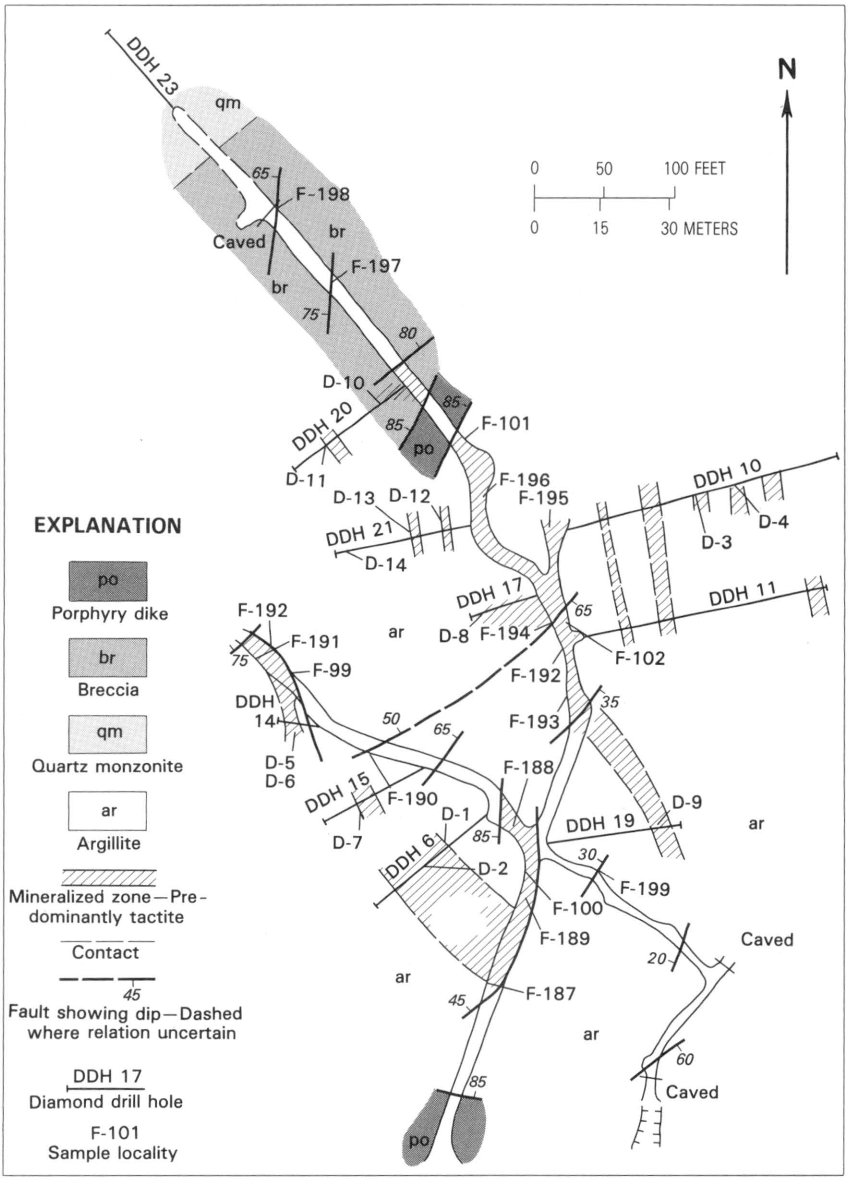

FIGURE 59.—Deer Trail adit (modified from DMEA unpub. data).

Data for samples shown on figure 59

[All F samples, chip all D-samples, DMEA diamond-drill samples 1956 Tr, trace, N, none detected, leaders (-), not analyzed, 1 ft=0 3048 m 1 troy oz/ton=34 285 g/t]

Sample No.	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Copper (percent)	Lead (percent)	Zinc (percent)
F-99	55 0	Mineralized tactite-	N	N	0.06	0.16	2.40
F-100	60.0	----do---------------	N	0 6	16	0.37	9.00
F-101	20.0	----do---------------	Tr	4	--	1 40	6 00
F-102	12.0	----do---------------	N	.1	--	.40	.99
F-187	10.0	----do---------------	Tr	5	--	.31	1.22
F-188	10.0	----do---------------	Tr	.2	01	.10	1.10
F-189	12.0	----do---------------	Tr	5	--	.34	8.40
F-190	4 0	Argillite and fault gouge.	Tr	.4	--	.08	.19
F-191	15 0	Mineralized tactite-	Tr	.5	.37	09	1 28
F-192	35.0	----do---------------	Tr	N	--	11	1 48
F-193	12.0	----do---------------	Tr	.3	01	1 75	2 40
F-194	15.0	----do---------------	Tr	.9	12	2 65	2 40
F-195	8.0	----do---------------	Tr	Tr	--	.01	.04
F-196	20.0	----do---------------	Tr	1.4	--	2.96	12 80
F-197	10.0	Granitic breccia containing sulfides.	Tr	.15	--	1 36	1 02
F-198	3 0	Granitic breccia----	Tr	.2	03	09	09
F-199	1.0	Fractured and silicified zone	Tr	1	--	02	.02
F-203	3.0	Fractured, limy argillite.	Tr	.1	--	.006	.01
F-204	4.0	Calcareous argillite with sulfides	Tr	3.1	--	7 7	1 5
F-205	3.0	Altered argillite---	Tr	N	--	02	.04
F-208	4.0	Fractured argillite-	Tr	2	--	.02	.04
F-209	5.0	----do---------------	Tr	N	--	.03	.08
D-1	10 0	Tactite--------------	--	--	--	.2	1.0
D-2	22.0	----do---------------	--	--	--	.2	1.1
D-3	4 0	Fractured argillite-	--	--	--	1 6	.3
D-4	10 0	Tactite--------------	--	--	--	4.4	.25
D-5	5.5	Sulfide-rich zone---	--	--	--	Tr	4.0
D-6	5.0	----do---------------	--	--	--	Tr	7.2
D-7	5 0	Tactite--------------	--	--	--	.3	5
D-8	10.0	----do---------------	--	--	--	.15	.3
D-9	5 0	Sulfide-rich zone---	--	--	--	4.2	7.8
D-10	5 0	----do---------------	--	--	--	.2	2 5
D-11	5 2	----do---------------	--	--	--	.3	12 5
D-12	7.0	----do---------------	--	--	--	7 3	5 0
D-13	3.0	----do---------------	--	--	--	2	4 4
D-14	6.5	Tactite--------------	--	--	--	2	7

The two major tactite zones, shown in cross section *A-A′* (fig 60), have been delineated by underground workings, diamond drilling and shallow surface pits and cuts (figs 59-61). The tactite zones are probably confined to the roof pendant of limestone and argillite. The thickness of the roof pendant is uncertain; however, for estimating resources, a depth of 200 ft (60 m) was assumed.

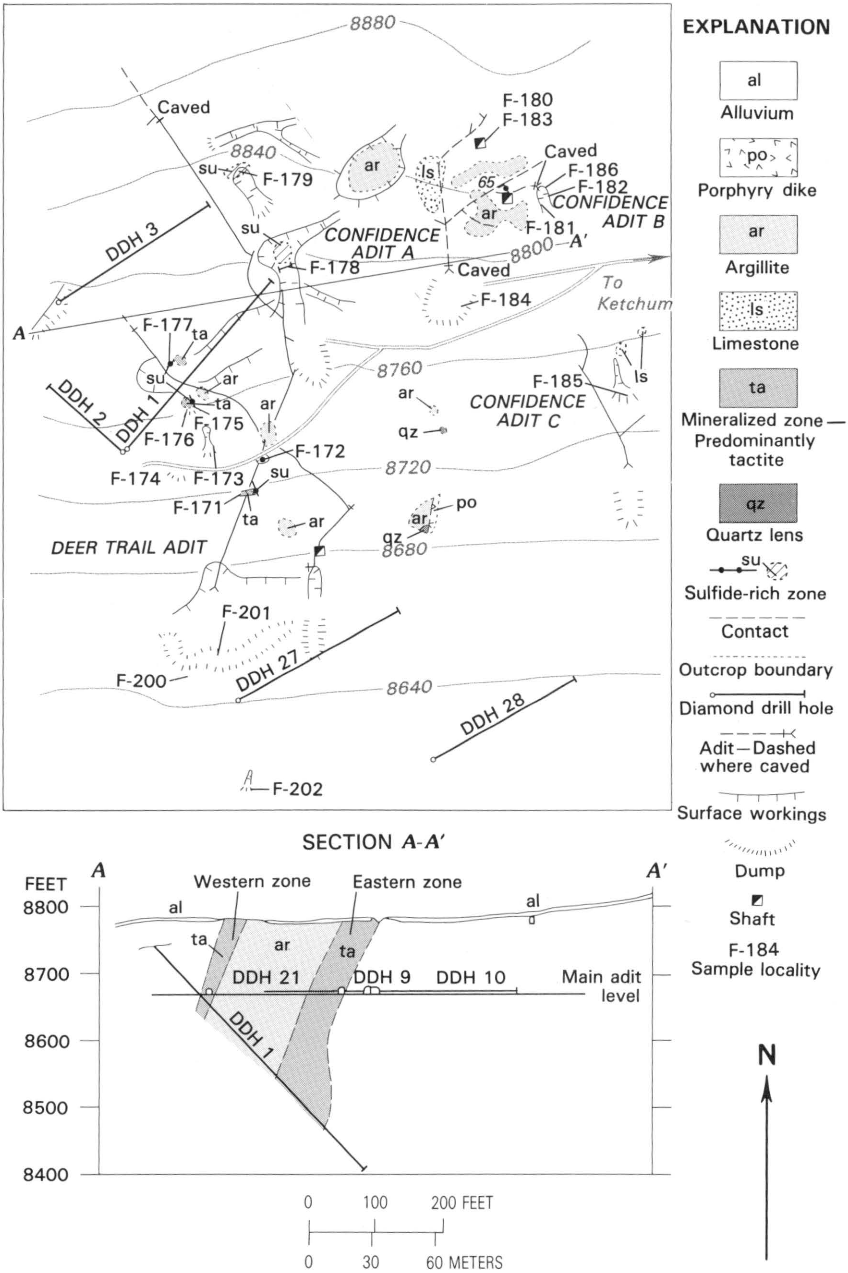

FIGURE 60.—Deer Trail and Confidence properties (modified from DMEA unpub. data). Contour interval 40 ft; elevations in feet; 1 ft=0.3048 m.

Data for samples shown on figure 60

[Tr, trace, 1 troy oz/ton=34 285 g/t]

No	Sample: Type	Sample: Length (ft)	Sample: Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)
F-171	Chip--	6	Mineralized tactite----------	Tr	Tr	0.01	0 03
F-172	--do--	10	Sulfide-rich zone in tactite-	0 01	0 4	10	2 8
F-173	Select	([1])	Gossan-----------------------	01	2	09	1 17
F-174	--do--		Mineralized tactite----------	Tr	.1	01	08
F-175	Chip--	3	Iron-oxide-stained shear zone	Tr	4	.02	.24
F-176	--do--	16	Mineralized tactite----------	Tr	2	.05	.69
F-177	--do--	10	Sulfide-rich zone in tactite-	Tr	1	.02	6 7
F-178	--do--	15	---do------------------------	Tr	1.1	4 1	4 2
F-179	--do--	15	---do------------------------	Tr	7	1 92	2 48
F-180	Select		Sulfide-rich material (dump)-	Tr	2 4	4 32	4 80
F-181	Chip--	2	Across mineralized shear zone	Tr	1.5	4 32	84
F-182	--do--	3	---do------------------------	Tr	.4	96	.48
F-183	--do--	1 5	---do------------------------	Tr	5.7	13.6	.36
F-184	Select		Sulfide-rich material (dump)-	Tr	5 9	15.4	2 24
F-185	--do--		Altered argillite------------	Tr	.1	.03	.02
F-186	Chip--	2	Across mineralized shear zone	Tr	.2	02	01
F-200	Select		Brecciated porphyry dike-----	Tr	.1	02	02
F-201	--do--		Mineralized tactite----------	Tr	2	.30	58
F-202	--do--		Carbonaceous argillite-------	Tr	1	01	.02

[1] Blank, not measured.

The known mineralization in the western tactite zone is 400 ft (120 m) long and averages about 40 ft (12 m) wide. The zone is estimated to contain 270,000 tons (245,000 t) averaging 3.66 percent zinc, 0.17 percent lead, 0.26 oz silver per ton (8.9 g/t), and a trace gold. Diamond drilling (DDH Nos 22, 27, and 28, fig. 60) shows the western tactite zone to extend another 400 ft (120 m) southeast, but only trace amounts of lead and zinc were detected.

The mineralized part of the eastern tactite zone is about 300 ft (90 m) long and 40 ft (12 m) wide. Resources in the zone are estimated to be 200,000 tons (181,000 t) averaging 3.84 percent zinc, 1 62 percent lead, 0 6 oz silver per ton (20.6 g/t), and a trace gold.

Higher grade lenses of sulfide minerals within the two mineralized tactite zones are short and discontinuous, and vary widely in metal content over short distances These factors make resource calculations difficult and unreliable, but total estimated resources are between 30,000 and 50,000 tons (27,000–45,000 t), averaging about 8 5 percent zinc, 1.8 percent lead, 1.0 oz silver per ton (34 g/t), and trace amounts gold and copper These high-grade lenses might be selectively mined at a profit during periods of high zinc and lead prices

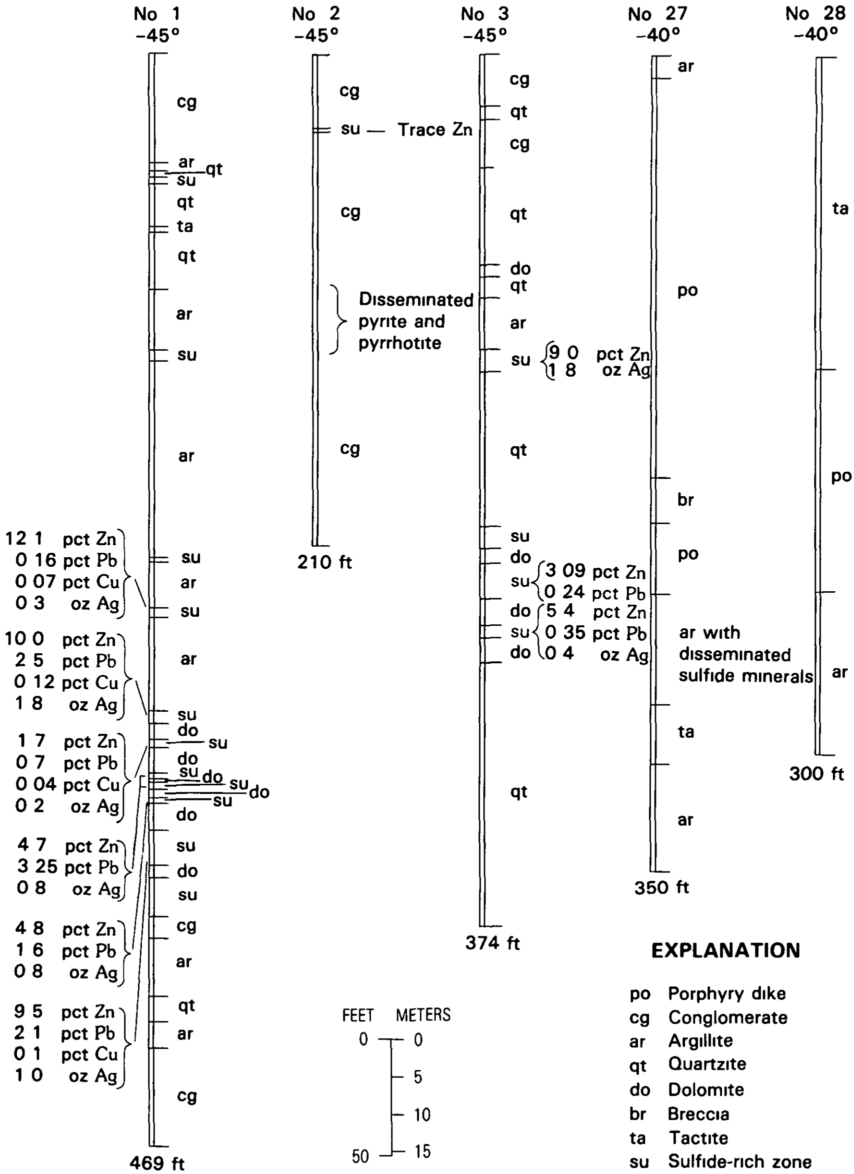

FIGURE 61 —Surface diamond drill core logs, Deer Trail mine (modified from DMEA unpub data)

CONFIDENCE (LUCKY STRIKE) PROPERTY

The Confidence property, formerly known as the Lucky Strike, adjoins the Deer Trail claim (pl. 3, 110). The claims were originally staked for lead and zinc about 1900. Production from the property is listed in table 16

The Confidence deposit resembles the Deer Trail deposit in many respects Country rock is predominantly argillite with interbedded limestone and quartzite that strikes northwest and dips southwest. Some calcareous zones grade into tactite. Galena and sphalerite occur along fractures in the argillite. One set of fractures strikes northeast and dips 60°-75° NW., a second set strikes northwest and dips steeply southwest

Mine development consists of 800 ft (240 m) of crosscuts and drifts, two shafts, and a prospect pit (fig. 62). Adit A was caved at the portal and was not safely accessible from a shaft above the adit. The portal of adit B was caved, but a shaft intersecting the adit near the face made about 40 ft (12 m) of it accessible.

Adit C was in good condition. The wall rock is carbonaceous argillite with several narrow, interbedded calcareous beds exposed near the face. Both the bedding planes and fractures strike northwest and dip steeply southwest. Finely disseminated sphalerite and pyrite occur along fault and shear zones in calcareous beds. Samples (F-203, F-208, and F-209) across shear zones averaged 0.1 oz silver per ton (3.4 g/t), 0 02 percent lead, and 0 03 percent zinc.

The first 50 ft (15 m) of adit B was caved and has been excavated to form an open trench. Argillite with interbedded altered limestone forms the walls of the trench. Near the face of the trench are three shear zones. Two zones on the east wall strike northeast, dip steeply, and are 2-3 ft (0.6-0.9 m) thick; and the third on the west wall is 2 ft (0.6 m) thick, strikes N. 75° W., dips 75° NE., and contains finely disseminated galena and pyrite. A sample (F-181) across the third zone assayed 1.5 oz silver per ton (51.4 g/t), 4.32 percent lead, and 0.84 percent zinc.

A 10-ft (3-m)-deep shaft, 50 ft (15 m) west of the caved portal, intersects adit B near the face. A 1.5-ft (0.46-m)-thick mineralized shear zone at the collar of the shaft strikes N 10° W., dips 65° SW , and contains highly oxidized, disseminated sulfide minerals. A sample (F-183) across the zone assayed 5.7 oz silver per ton (195 g/t) and 13.6 percent lead.

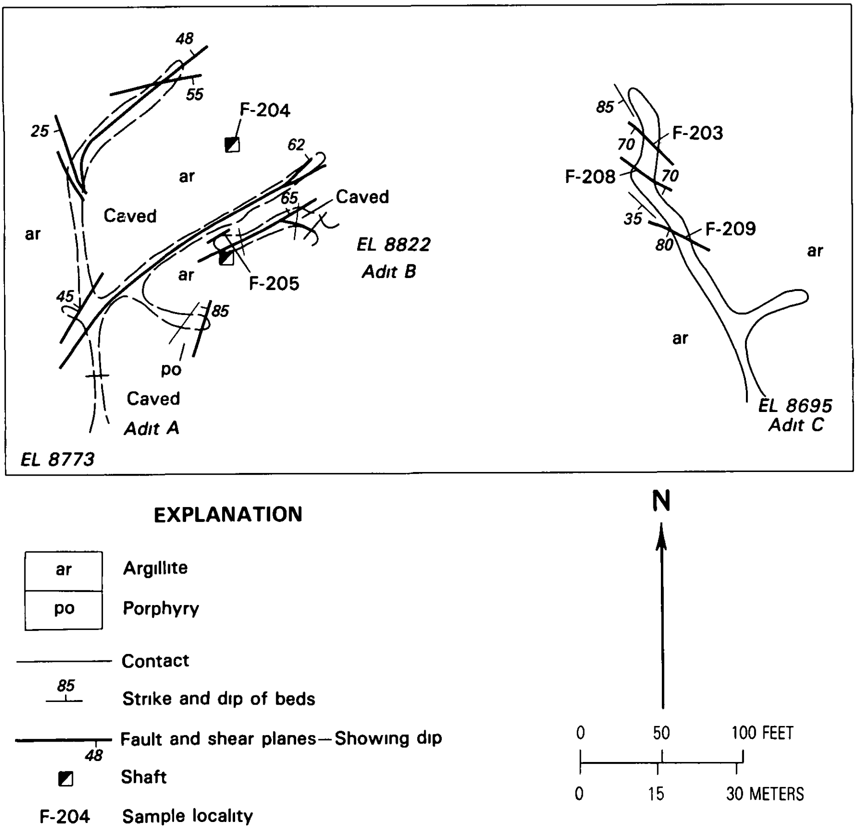

FIGURE 62.—Confidence adits (modified from DMEA unpub data) Elevations in feet, 1 ft=0 3048 m

Data for samples shown on figure 62

[All samples chip Tr, trace, N, none detected, 1 troy oz/ton=34 285 g/t]

Sample No.	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)
F-203	2	Sheared calcareous argillite.	Tr	0.1	0.01	0.01
F-204	4	Sulfide-rich shear zone	Tr	3.1	7.7	1.5
F-205	3	Altered argillite------	Tr	N	.02	.04
F-208	4	Sheared argillite------	Tr	.2	.02	.01
F-209	5	---do-----------------	Tr	N	.03	.08

Adit A has more than 400 ft (120 m) of crosscuts and drifts (DMEA file report (unpub data)) It is about 150 ft (46 m) southwest of adit B and is caved 40 ft (12 m) from the portal Wall rock is argillite and altered limestone that strikes northwest and dips southwest The adit crosscuts and follows northeast-trending shear zones. A sample (F-184) of massive sulfides from the ore bin assayed 5.9 oz silver per ton (202 g/t), 15 4 percent lead, and 2 24 percent zinc.

A shaft about 150 ft (46 m) northeast of adit A was accessible for 30 ft (9 m) (fig 62) and exposed a 4-ft (1.2-m)-thick shear zone that strikes N 25° W, dips vertically, and contains massive galena, sphalerite, and pyrite. A sample (F-204) across the zone assayed 3.1 oz silver per ton (106 g/t), 7.7 percent lead, and 1.5 percent zinc.

Potential resources, assuming an average thickness of 2.5 ft (0.76 m) for the mineralized shear zone exposed in the two shafts, are estimated to be 2,000 tons (1,800 t). Samples (F-183 and F-204) across the zone averaged 4 4 oz silver per ton (151 g/t), 10.65 percent lead, and 0.93 percent zinc The property has potential for discovery of additional resources

RUPERT (F.D R.) MINE

The Rupert mine (pl 3, 113) was originally located as the F.D R mine Recorded metal production for the mine is shown in table 15.

Country rock at the mine is highly fractured carbonaceous argillite with interbedded and altered quartzite; the rocks trend northerly. Quartz monzonite intrudes the sediments on the southeast side of the property.

Ore minerals occur in northwest- to northeast-trending, steeply dipping shear zones that range from a few inches to 10 ft (several centimeters to 3 m) in thickness. Principal ore minerals are finely disseminated galena and sphalerite Crystals of galena as large as 1 in (2 54 cm) across also were observed Principal gangue minerals are quartz, pyrite, and pyrrhotite.

Mine development consists of two adits, two inclined shafts, and several prospect pits (fig 63) The lower adit was open and in good condition The upper adit was in highly fractured argillite and unsafe. Both shafts are inclined 45° and are inaccessible

The lower adit, 240 ft (73 m) long, is mainly in argillite but intersects quartz monzonite near the face (fig 64). The adit also intersects shear zones that range from 0.5 to 4 ft (0.15 to 1 2 m) thick and contain much gouge and sparsely disseminated sulfide minerals Two stopes and a waterfilled winze near the face are on mineralized structures. The winze and adjacent inaccessible stope were driven on intersecting shear zones that contain finely disseminated pyrite and galena. One shear zone is 3 ft (0 9 m) thick, strikes N. 40° E., and dips vertically; the other is 0 50 ft (0 15 m) thick, strikes N 30° W., and dips 65° NE.

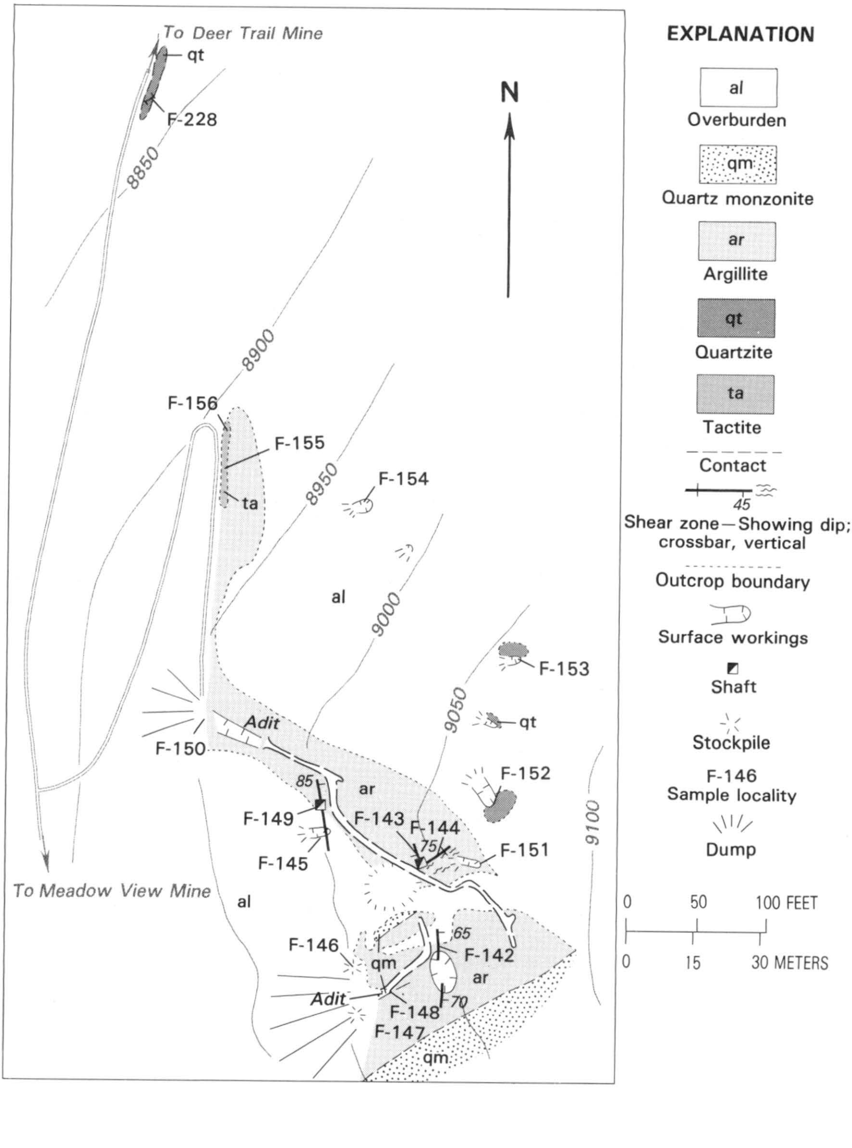

FIGURE 63.—Rupert (F.D.R.) mine. Contour interval 50 ft.

A shear zone in the stope nearer the face strikes N. 40° E., dips 70° SE., and is 1.5 ft (0.45 m) thick. Five samples taken across shear zones at least 1.5 ft (0.45 m) thick had an average grade of 0.67 oz silver per ton (23 g/t), 2.52 percent lead, and 1.06 percent zinc.

Data for samples shown on figure 63

[All samples chip except F-146, 147, 150, select Tr, trace, N, none detected, <, less than shown, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver	Lead	Zinc
No.	Length (ft)	Description	(oz/ton)		(percent)	
F-142	3.0	Across shear zone---	N	0.8	2.3	1.1
F-143	3.0	---do---------------	N	3.0	7.6	1.6
F-144	10.0	---do---------------	N	1.4	3.8	1.6
F-145	3.0	---do---------------	N	1.0	3.1	2.4
F-146	([1])	Massive sulfides----	N	1.7	5.6	.68
F-147		---do---------------	N	2.8	5.8	.65
F-148	3.0	Argillite-quartz monzonite contact.	N	.1	.043	.020
F-149	4.0	Shear zone----------	N	.2	.64	.52
F-150		Mineralized argillite	N	.7	2.80	3.20
F-151	3.0	Aplite dike---------	N	.1	.031	.052
F-152	6.0	Mineralized quartzite	N	.4	.74	.38
F-153	6.0	---do---------------	N	.3	.35	.33
F-154	4.0	Altered argillite---	N	.2	.028	.13
F-155	6.0	Tactite-------------	N	.1	.025	.34
F-156	7.0	---do---------------	N	Tr	.081	.27
F-228	8.0	Fracture quartzite--	Tr	N	<.01	.02

[1] Blank, not measured.

A 0 5-ft (0.15-m)-thick shear zone in the upper adit strikes N. 15° W., dips 70° SW., and has been stoped about 15 ft (4.6 m) high near the face. Another caved stope is probably connected to a sloughed glory hole on the surface (fig. 64). A sample (J-89) across the shear zone assayed 0.3 oz silver per ton (10.3 g/t), 0.19 percent lead, and 0.98 percent zinc Stockpile samples (F-146 and F-147) averaged 1 74 oz silver per ton (60 g/t), 5.7 percent lead, and 0.67 percent zinc. According to the owner, the stockpiled material came from the caved stope.

A shear zone that is 4 ft (1.2 m) thick strikes N. 5° W. and dips 85° NE at the collar of an inaccessible inclined shaft (fig. 63, F-149). The zone also is exposed in a trench (fig. 63, F-145) 20 ft (6 m) south of the shaft.

The upper inclined shaft (fig. 63, F-143) and a glory hole (F-142) expose a 3-ft (0.9-m)-thick shear zone that strikes N. 15° W. and dips 75° SW Galena and sphalerite occur in lenses in the shear zone.

Northeast of the upper shaft is a 10-ft (3-m)-thick, vertical, mineralized shear zone that strikes N. 65° E. (fig. 63) and contains small galena and sphalerite crystals. A sample (F-144) across the zone

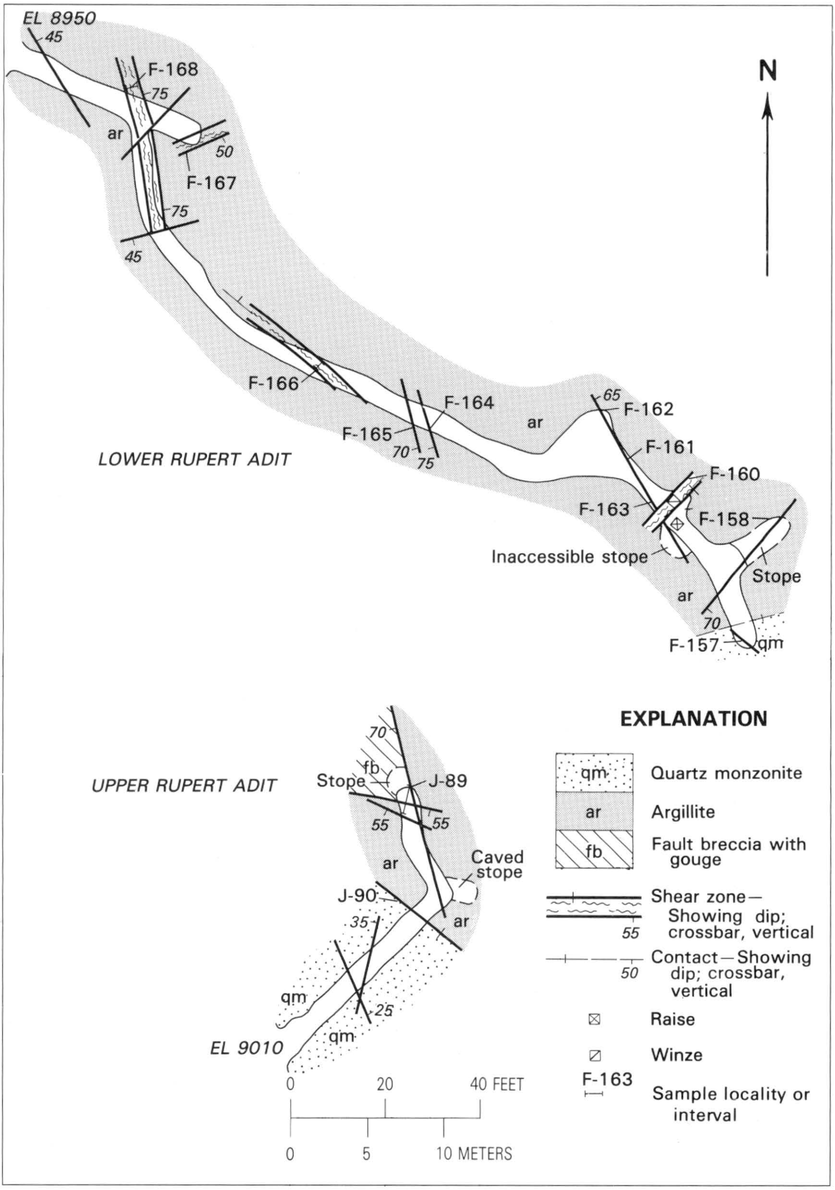

FIGURE 64.—Underground workings, Rupert (F.D.R.) mine. Elevations in feet; 1 ft =0.3048 m.

assayed 1.4 oz silver per ton (48 g/t), 3.8 percent lead, and 1.6 percent zinc.

Three prospect pits east of the lower adit expose greenish quartzite

Data for samples shown on figure 64

[All samples chip except F-163, select N, none detected 1 troy oz/ton=34 285 g/t]

Sample No	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)
F-157	0 5	Shear zone---------------	N	0 1	0 44	0 20
F-158	1 5	---do--------------------	N	2 4	9 2	93
F-160	3 0	---do--------------------	N	2	31	36
F-161	5	---do--------------------	N	1	40	49
F-162	5	---do--------------------	N	1	36	48
F-163	([1])	Sulfide-rich, fractured argillite	N	1 2	5 5	1 4
F-164	5	Shear zone---------------	N	2	43	44
F-165	5	---do--------------------	N	N	45	1 02
F-166	3 0	---do--------------------	N	8	5 20	2 80
F-167	3 0	---do--------------------	N	4	16	04
F-168	4 0	---do--------------------	N	5	1 55	1 40
J-89	8 0	Fractured argillite------	N	3	19	98
J-90	5	Contact zone-------------	N	1	15	99

[1]Blank, not measured

that contains finely disseminated galena and sphalerite. Samples F-152 and F-153 across two quartzite exposures averaged 0.35 oz silver per ton (12 g/t), 0.55 percent lead, and 0.36 percent zinc. Other pits in the mapped area are partially soughed and do not expose mineralized structures

Two samples (F-155 and F-156) across a tactite zone in a roadcut averaged 0 1 oz silver per ton (3 4 g/t), 0.31 percent zinc, 0.03 percent molybdenum, and a trace of lead About 225 ft (70 m) northwest of the tactite zone is an 8-ft (2.4-m)-thick barren shear zone (F-228).

Taken together, the Rupert workings expose a poorly defined mineralized zone that extends about 650 ft (200 m) northwesterly from the quartz monzonite-argillite contact (fig. 63). The highest metal values were obtained from shear zones near the contact The resource estimates assume that the principal exposures are displaced segments of essentially the same two shear zones One strikes northwest and is represented by samples F-142, F-143, F-145, F-149, F-166, and F-168 The other shear zone strikes northeast and is represented by samples F-144, F-158, F-160, and F-167 With an inferred length of 250 ft (76 m) and an average width of 3 5 ft (1 m), resources in the two zones are estimated to be 18,000 tons (16,000 t) averaging 1 05 oz silver per ton (36 g/t), 3.13 percent lead, and 1.30 percent zinc The deposit has potential for discovery of additional resources, but probably in small ore bodies

MEADOW VIEW PROPERTY

The Meadow View property is about 2 mi (3.2 km) by road south of the Deer Trail mine (pl 3, 117) Mine development consists of an 840-ft (256-m) adit, driven under DMEA contract between 1952 and 1955 No production has been reported

The deposit is in a roof pendant of sedimentary rocks in quartz monzonite Outcrops of intensely folded carbonaceous argillite and limestone strike northwest and dip 50°-60° SW. Tactite has formed in many calcareous horizons An undifferentiated zone, composed of argillite, tactite, quartz veins, and aplite dikes, crops out southeast of Meadow View adit (fig. 65).

Three replacement veins capped by gossan crop out near the Meadow View adit (fig 66). The veins strike northwest and dip 50°-60° SW They contain sphalerite, galena, scheelite, and chalcopyrite in a gangue of pyrite, pyrrhotite, quartz, and calcite. The sulfide minerals generally occur as finely disseminated grains, but masses, pods, and stringers of sulfide minerals also are present.

The No 1 vein, which is explored by a short drift about 60 ft (18 m) from the portal of the Meadow View adit (fig. 67), is conspicuously exposed for 130 ft (39.6 m) on the surface. It is entirely in tactite and contains pyrite, pyrrhotite, and sphalerite. The vein ranges in thickness from 1 to 15 ft (0 3 to 4 6 m) and averages 6.5 ft (2 m). Indicated resources for the No 1 vein total 4,500 tons (4,100 t), averaging 0.19 oz silver per ton (6.5 g/t), 3.3 percent zinc, and 0.12 percent WO_3.

The No 2 vein, which is exposed for about 150 ft (46 m) above the Meadow View adit, ranges in thickness from 3 to 12 ft (0.9-3 7 m) and averages 6 ft (1 8 m). Sphalerite, pyrite, pyrrhotite, and minor scheelite occur in the vein and are finely disseminated in the tactite wall rock Samples across the No. 2 vein underground averaged 6.5 percent zinc, 0 28 percent WO_3, and 0.25 oz silver per ton (8.6 g/t). Samples (D-20, F-323) from the only prominent outcrop (fig. 68) were leached and altered vein material and were lower grade than underground samples. Resources for the No 2 vein are at least 10,000 tons (9,100 t).

The No. 3 vein, a possible extension of the No. 2 vein, crops out intermittently in argillite northwest of the adit portal (fig 66). The vein averages 3 ft (0.9 m) thick and contains disseminated sulfides. Samples across the leached vein outcrops contain minor amounts of zinc, tungsten, and silver

Most samples from the Meadow View prospect were assayed for gold and lead, and selected samples were analyzed for molybdenum and uranium, but none of these elements were detected. Most samples of vein material assayed less than 0.06 percent copper, but one (F-120) from the No 1 vein contained 0 28 percent.

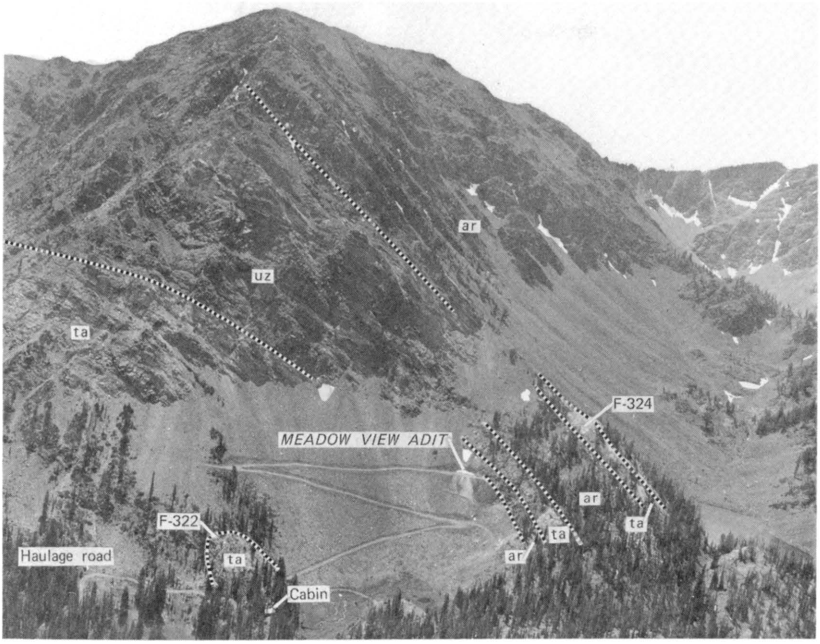

FIGURE 65.—Meadow View property, viewed toward the south. Adit intersects sulfide-rich veins and tactite (ta) between beds of argillite (ar). An undifferentiated zone (uz) composed of argillite, tactite, quartz veins, and aplite dikes crops out southeast of the Meadow View adit. Chip samples F-322 and F-324 contained <0.01 WO_3.

TIMBERLINE PROSPECT

The Timberline prospect is north of Blackman Peak on the east side of the ridge between Ants and Strawberry Basins (pl. 3, 99). Elmer Enderlin and James Getty hold the claim. The prospect has no record of production.

All workings are on a vein in grayish-black argillite with interbedded limestone and quartzite west of a high-angle fault that strikes northerly (fig. 68). The workings appear to be near the axial plane of a north-trending anticline with steeply dipping limbs.

The vein material consists of quartz stained by iron oxide and contains fine-grained sulfides and local malachite stain. The vein strikes northerly, dips steeply, and is 1–4 ft (0.3–1.2 m) thick.

Three open adits, two caved adits, and two prospect pits expose the vein (fig. 69). Adit No. 1 follows the vein for about 210 ft (64 m) where it is cut off by a northwest-trending fault. In the adit the vein strikes N. 5°–15° W., dips 45°–75° NE., and is 1.5–4 ft (0.47–1.2 m) thick. The

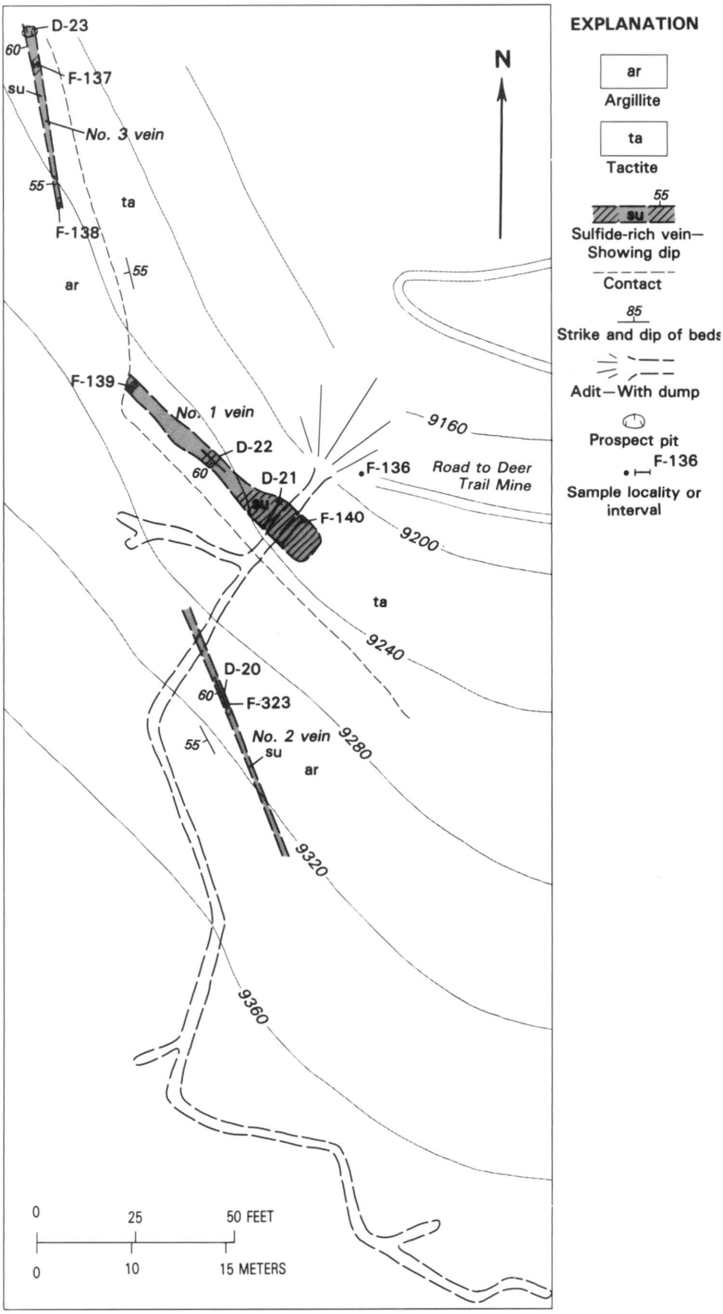

FIGURE 66.—Meadow View property (modified from DMEA unpub. data). Contour interval 40 ft.

Data for samples shown on figure 66

[All samples chip except F-136, select D-20 through D-23, DMEA samples Tr trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample			Silver	Zinc	WO_3
No.	Length (ft)	Description	(oz/ton)	(percent)	
F-136	([1])	Sulfide-rich vein material (stockpile).	0.1	5.00	0.11
F-137	8.0	Across sulfide-rich vein.	N	.041	.10
F-138	1.5	----do----------------	N	.70	.01
F-139	8.0	----do----------------	Tr	1.70	.01
F-140	15.0	----do----------------	.2	1.10	.13
F-323	4.5	----do----------------	.1	1.66	--
D-20	3.5	----do----------------	--	4.60	.05
D-21	14.0	----do----------------	--	1.20	.03
D-22	3.5	----do----------------	--	6.50	.11
D-23	6.5	----do----------------	--	--	.03

[1]Blank, not measured.

vein also is exposed on the surface by two prospect pits, in one of which (F-77) it is profusely stained by malachite.

In Adit No 2, the vein strikes N 5° E. to N. 10° W., dips 55°-75° W, and is 2-3 ft (0 6-0 9 m) thick, where exposed in two 15-ft (4.6-m)-high stopes It is intermittently exposed for 240 ft (72 m) north of the portal and pinches and swells from 1 to 3 ft (0.3-0.9 m) in thickness

The vein is traceable along the surface and in underground workings for a total length of about 500 ft (150 m) and averages about 2 6 ft (0 8 m) in thickness Potential resources are estimated to be 27,000 tons (25,000 t) averaging 0 01 oz gold per ton (0.34 g/t), 9.3 oz silver per ton (319 g/t), 0.25 percent copper, 1.96 percent lead, 2 28 percent zinc, 0 63 percent antimony, and 0.48 percent tin. Cassiterite and stannite were identified by the U S Geological Survey in a selected sulfide-rich sample that contained 6 percent tin. The property has potential for discovery of additional resources

SILVER DOLLAR PROPERTY

The Silver Dollar property (pl. 3, 101), on the west side of Strawberry Basin, was first located in 1886, relocated as the Silver Dollar in 1938, and is now staked as the Strawberry claim. No mineral production is known and present activity is limited to assessment work.

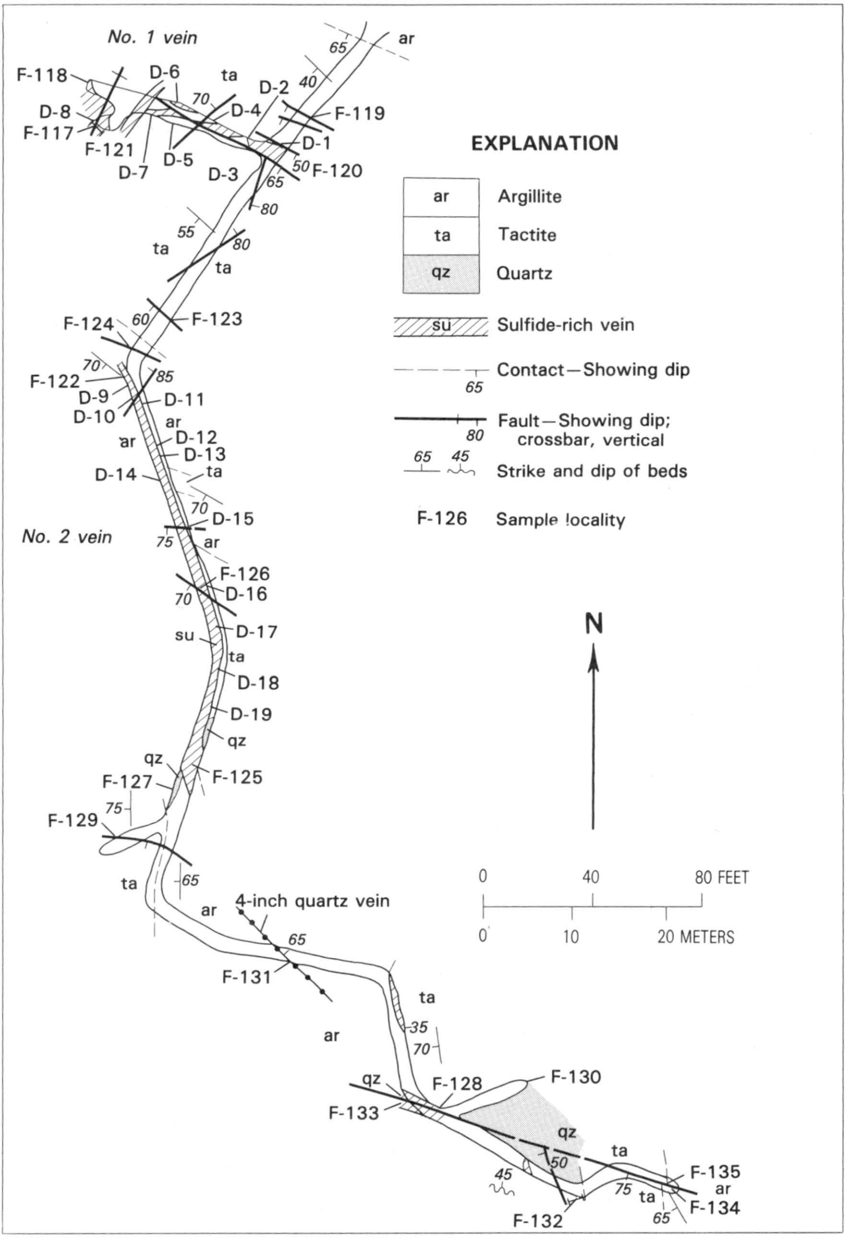

FIGURE 67.—Meadow View adit (modified from DMEA unpub. data).

Data for samples shown on figure 67

[All F samples chip All D-samples channel, DMEA. Tr, trace, N, none detected, <, less than shown, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample No.	Length (ft)	Description	Silver (oz/ton)	Zinc (percent)	WO_3 (percent)
F-117	7.0	Sulfide-rich vein-------	N	2.6	0.06
F-118	5.0	---do-------------------	N	8.2	.05
F-119	1.0	Fractured tactite-------	N	.07	<.01
F-120	7.0	Across sulfide-rich vein	N	6.4	.04
F-121	4.0	---do-------------------	N	3.3	.08
F-122	3.0	---do-------------------	N	1.3	.23
F-123	.75	Fractured tactite-------	Tr	.02	<.01
F-124	2.0	Fractured argillite-----	Tr	.021	<.01
F-125	8.0	Across sulfide-rich vein	0.1	2.3	.14
F-126	5.0	---do-------------------	N	1.5	.28
F-127	15.0	Across quartz vein------	N	.01	<.01
F-128	6.0	Sulfide-rich vein-------	Tr	.015	<.01
F-129	2.0	Across fractured tactite	N	.017	<.01
F-130	4.0	Tactite-----------------	N	.04	<.01
F-131	6.0	Along quartz vein-------	N	.03	<.01
F-132	10.0	Across quartz vein------	.1	.02	<.01
F-133	8.0	---do-------------------	N	.01	<.01
F-134	1.5	Altered argillite and fault gouge.	N	.04	<.01
F-135	3.0	---do-------------------	.2	.12	<.01
D-1	7.0	Sulfide-rich vein-------	.4	2.8	.02
D-2	4.0	---do-------------------	.22	3.7	.38
D-3	4.5	---do-------------------	.26	2.7	.21
D-4	2.0	---do-------------------	.32	6.1	.33
D-5	6.0	---do-------------------	.38	8.7	.20
D-6	5.0	---do-------------------	.26	3.4	.36
D-7	2.0	---do-------------------	.32	6.4	.12
D-8	10.0	---do-------------------	([1])	3.5	.19
D-9	5.0	---do-------------------	.36	8.7	.35
D-10	6.1	---do-------------------	.40	8.8	.37
D-11	4.1	---do-------------------	.40	5.3	.22
D-12	5.0	---do-------------------	.36	6.5	.44
D-13	7.0	---do-------------------	.34	5.6	.18
D-14	4.5	---do-------------------	.30	10.4	.30
D-15	5.0	---do-------------------	.05	3.7	.19
D-16	6.0	---do-------------------	.1	9.5	.18
D-17	7.0	---do-------------------	.3	11.8	.38
D-18	7.0	---do-------------------	.4	8.7	.41
D-19	3.0	---do-------------------	.2	.7	.27

[1] Blank, not analyzed.

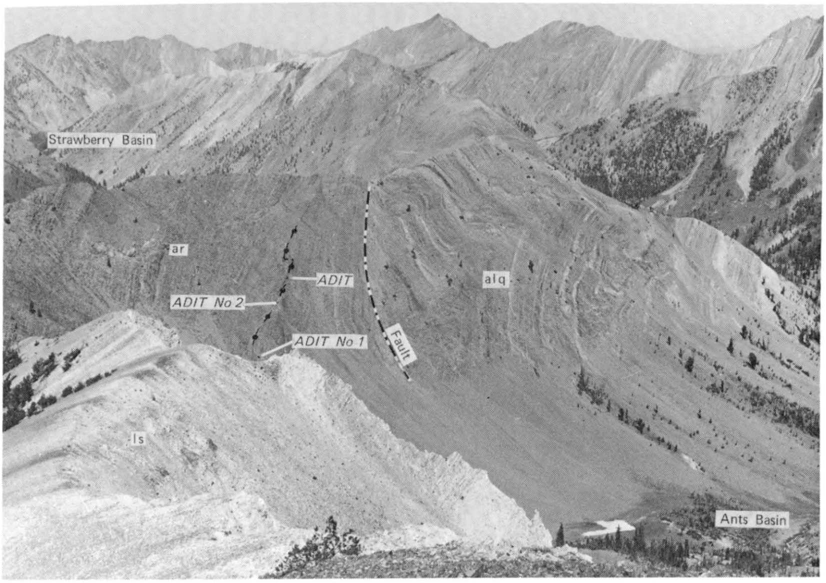

FIGURE 68.—Timberline prospect, viewed toward the north. Adits were driven on a calcite-quartz vein (dot-line symbol) in argillite (ar). Highly folded argillite, limestone, and quartzite beds (alq) are to right of fault; limestone with calc-silicate minerals (ls) is in the foreground.

Exploration is in a block of interbedded carbonaceous argillite and shale, more than 2,000 ft (600 m) thick that strikes northerly, dips 55°–65° W., and is stained by iron and manganese oxides (fig. 70). Narrow, discontinuous, irregular, north-trending quartz veins that range in thickness from less than 1 in. to 6 in. (2–15 cm) occur along fault and shear zones. Sulfide minerals, including galena, jamesonite, chalcopyrite, bornite, and pyrite, occur as small lenses in some quartz veins.

Prospect workings include four adits, totaling about 350 ft (106 m) of excavations (fig. 71). Artificial support is required where wall rock has been intensively sheared and faulted. Much talus covers the steeply dipping strata on the surface.

Sulfide minerals are associated with quartz in faults and shears in the Middle and South adits, but none were observed in the North adit. A 1–2-in. (2–5-cm)-thick sulfide-rich vein in the Middle adit contains massive galena and jamesonite, minor chalcopyrite, and pyrite crystals up to one-sixteenth inch across. Quartz vein material in an ore car indicates part of the vein was at least 6 in. (15 cm) thick.

A narrow, sulfide-rich quartz vein occurs intermittently along a 1-ft (0.3-m)-thick fault zone in the South adit. Near the winze, a 3-ft

(0 9-m)-long, 3-in (7-cm)-thick, high-grade (sample J-98) segment of the vein contains massive and disseminated pyrite, and some jamesonite, bornite, and chalcopyrite. The U.S. Geological Survey found 3 percent tin in a sample of massive sulfides from the bottom of the winze (table 7, T574) The quartz vein near the raise in the east wall of the adit is 4 in. (10 cm) thick and contains no visible sulfides. It follows the fault zone for 10 ft (3 m) along the back of the adit and was traced 8 ft (2 4 m) up the raise. The same 1-ft (0 9-m)-thick fault zone is exposed on the surface but contains no quartz or visible sulfides. The inaccessible south-trending winze reportedly connects with the Middle adit, by way of an intermediate level, and may follow a mineralized zone

A 25-ft (7 6-m) adit about 600 ft (180 m) southeast of the mapped area exposes a 6-in (15-cm)-thick, 10-ft (3-m)-long sulfide-rich quartz vein A sample taken along the vein assayed 0 17 oz gold per ton (5 8 g/t), 39.3 oz silver per ton (1,347 g/t), 1.60 percent lead, 1.03 percent copper, 0.26 percent zinc, and 1 14 percent antimony.

Some high-grade ore could be hand-sorted from the narrow, discontinuous quartz veins exposed at the Silver Dollar property The indicated tonnage, however, would not support a large mining operation Discovery of additional, small sulfide-rich quartz veins in the fault block of carbonaceous argillite-shale is likely.

PATTY FLYNN PROSPECT

The Patty Flynn prospect is about 3 mi (4.8 km) northwest of Blackman Peak (pl. 3, 104).

A 110-ft (34-m) adit exposes numerous faults that strike northeast and dip northwest in siliceous and calcareous argillite (fig. 72) A fissure vein is exposed in a prospect pit above the adit. The vein strikes N 23° E , dips 40°-50° NW , and is traceable for about 60 ft (18 m). It averages less than a foot thick and is comprised of limonite-stained, silicified material. A sulfide-rich portion of the vein exposed at the south end of the pit consists of 12 in. (30 cm) of massive galena and jamesonite and 3 in. (7.6 cm) of disseminated pyrite in quartz Other parts of the vein contain less sulfide minerals

The adit failed to intersect the sulfide-rich vein at depth, however, the vein may be displaced by a fault. A spectrographic analysis of a composite sample from fault zones in the adit indicated only very small amounts of economic metals

No evaluation can be made on the basis of the single ore-grade occurrence, but additional high-grade silver-lead-antimony occurrences are considered possible.

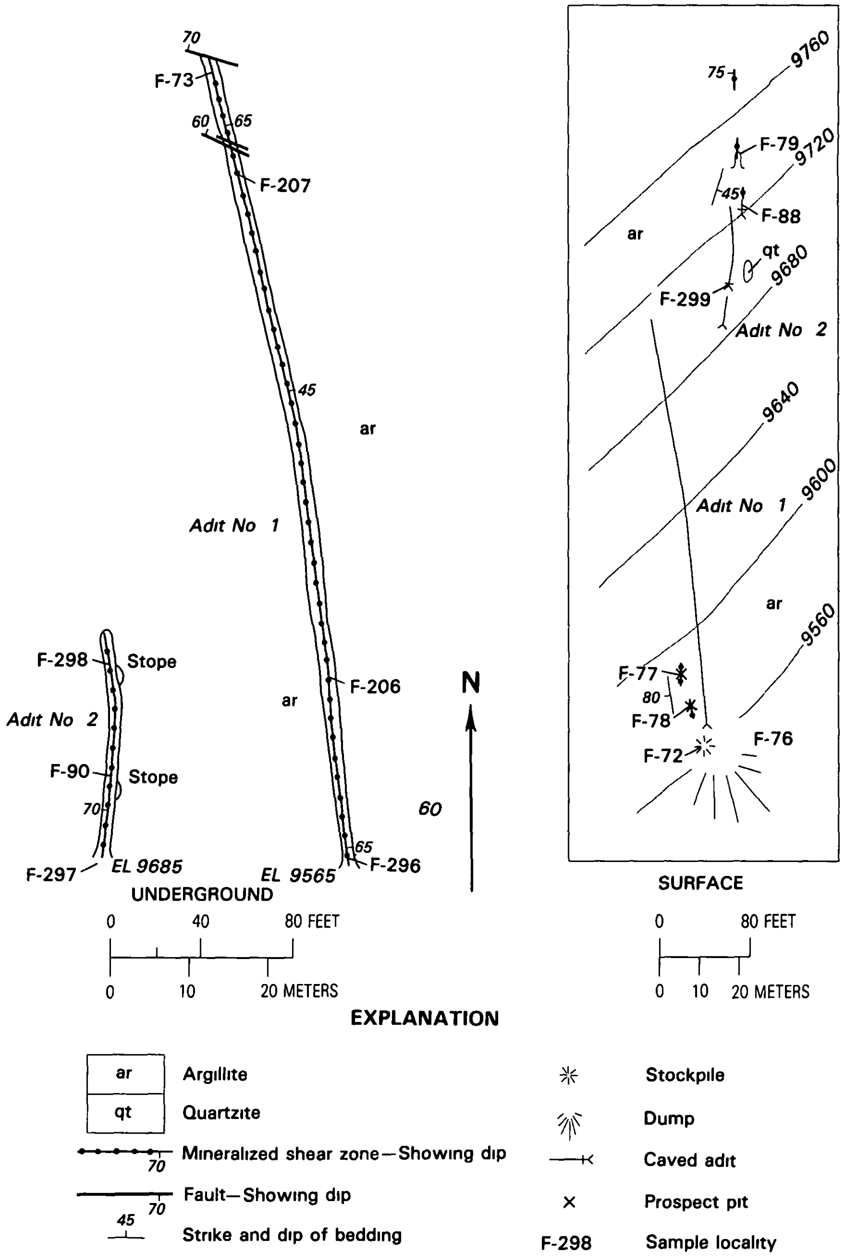

FIGURE 69.—Timberline prospect. Contour interval 40 ft, elevations in feet, 1 ft= 0.3048 m

Data for samples shown on figure 69

[All samples chip except F-72, select; F-76, grab; Tr, trace; N, none detected; leaders (-), not analyzed; 1 troy oz/ton=34.285 g/t]

Sample			Gold	Silver	Copper	Lead	Zinc	Antimony	Tin
No.	Length (ft)	Description	(oz/ton)		(percent)				
F-72	([1])	Vein material (stockpile).	0.01	13.4	0.35	2.90	4.40	--	--
F-73	4.0	Fractured argillite.	N	.2	.01	.02	.09	0.01	--
F-76		Dump material	N	1.4	.01	.28	.48	--	--
F-77	1.5	Across vein--	.01	13.4	.3	4.00	2.80	1.78	0.54
F-78	2.0	---do--------	N	6.2	.16	1.90	2.80	.67	--
F-88	2.5	---do--------	Tr	.1	N	.01	.04	.05	--
F-89	2.5	---do--------	N	14.9	.20	2.45	3.80	.87	.36
F-90	3.0	---do--------	Tr	7.4	.14	1.75	1.80	.76	--
F-206	2.0	---do--------	.01	2.8	.04	.11	2.00	.13	--
F-207	4.0	---do--------	Tr	8.7	.14	2.30	2.30	.38	--
F-296	3.5	---do--------	.03	8.2	.65	1.43	3.02	.65	--
F-297	3.5	---do--------	Tr	5.6	.45	.98	2.80	.36	--
F-298	2.0	---do--------	Tr	7.0	.12	1.35	1.60	.38	--
F-299	2.5	---do--------	.03	29.6	.30	6.00	1.80	1.37	.57

[1]Blank, not measured.

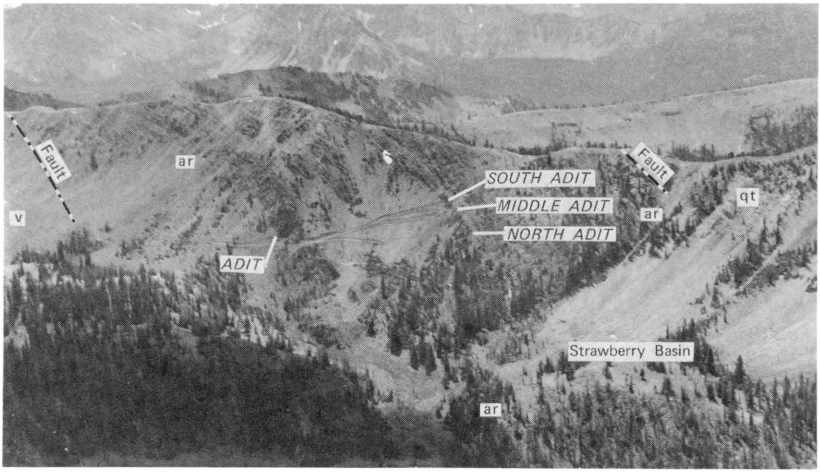

FIGURE 70.—Silver Dollar property, looking southwest; ar, argillite and shale; qt, quartzite; v, volcanics.

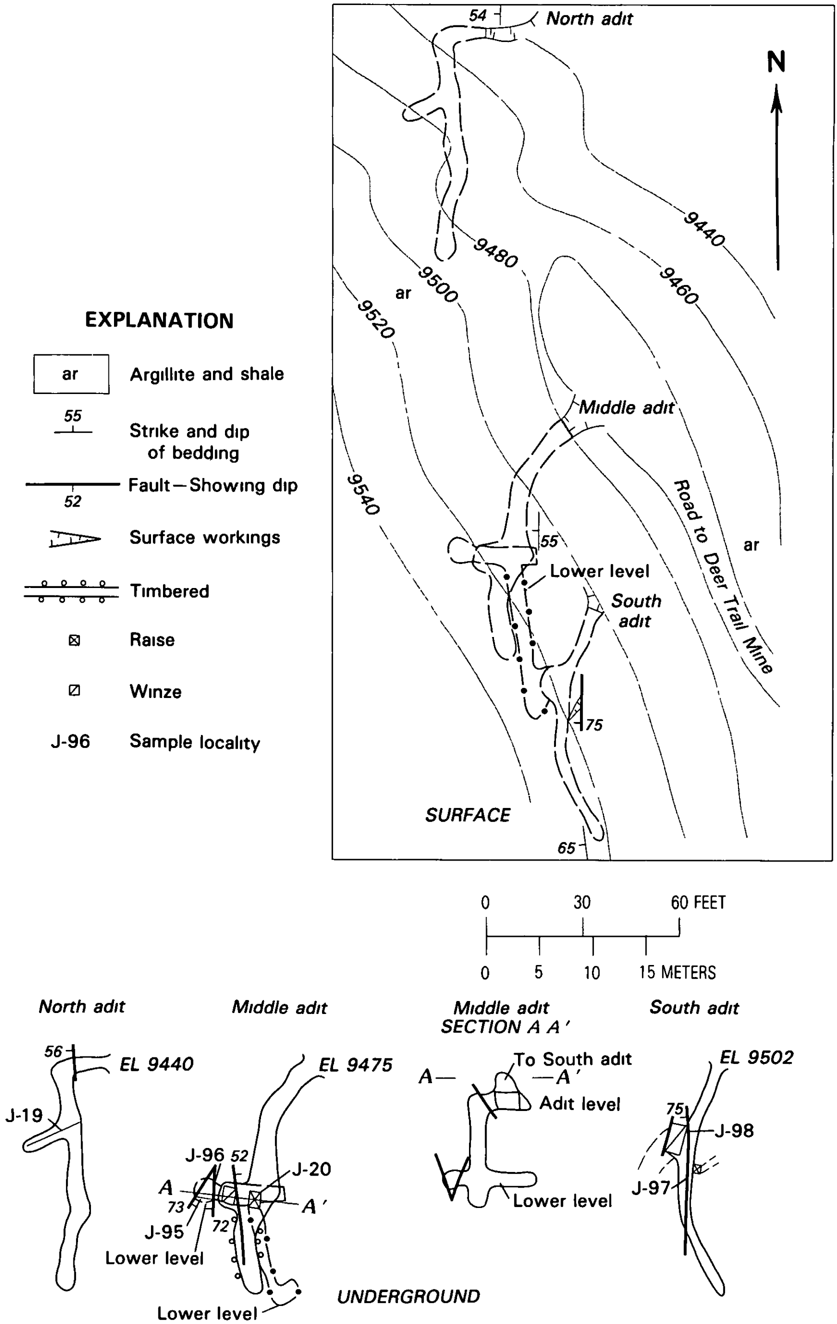

FIGURE 71 —Silver Dollar property Contour interval 20 ft, elevations in feet, 1 ft= 0 3048 m

Data for samples shown on figure 71

[All samples chip except J-20, grab, leaders (-), not analyzed, Tr, trace, N, none detected, 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver	Copper	Lead	Zinc	Anti-mony	Arsenic	Tin
No	Length (ft)	Description	(oz/ton)		(percent)					
J-19	15 0	Wall rock----	Tr	0 2	--	0.03	--	--	--	--
J-20	([1])	Vein material (ore car)	0.12	46 5	0 89	5 20	5 00	2 68	0 12	0 88
J-95	5 0	Wall rock----	Tr	.4	--	--	--	--	--	--
J-96	6 0	Along quartz veinlet	11	15.4	48	1.75	--	62	--	27
J-97	1 0	Across quartz vein and fault zone	Tr	1 3	01	25	01	--	--	--
J-98	2 0	Along sulfide-rich quartz vein	60	153 4	44	16 0	1 80	5 50	--	1 00

[1]Blank, not measured

SHINER PROSPECT

The Shiner prospect is about a mile (1.6 km) south of Blackman Peak (pl 3, 111)

Two shear zones and an associated quartz vein in calcareous quartzite have been explored by a 20-ft (6-m) vertical shaft and six small prospect pits All three structures strike northeast and dip nearly vertical. One shear zone exposed by the shaft and five pits can be traced for 200 ft (60 m) The shear zone is 14 in (35 cm) thick at the shaft collar and contains iron-oxide-stained breccia and fault gouge with finely disseminated sphalerite, galena, and pyrite. A sample across this exposure assayed 1.4 oz silver per ton (48 g/t), 2.9 percent lead, and 4.2 percent zinc. Adjacent to the shaft, the shear zone abuts a 6-ft (1.8-m)-thick tactite zone that contains disseminated pyrite, and no more than 0.1 oz silver per ton (3.4 g/t). No other significant metals were detected in samples of the tactite.

Another, apparently unrelated, shear zone in a pit contains a 5-ft (1 5-m)-thick quartz vein. Both the quartz vein and sheared material are moderately iron oxide stained and contain finely disseminated pyrite, but no economic metals.

WHITE CLOUD PROSPECT

The White Cloud prospect is about 2 mi (3.2 km) north of Blackman Peak, in the floor of Strawberry Basin (pl 3, 102)

A prospect pit exposes a fault zone containing a sulfide-bearing

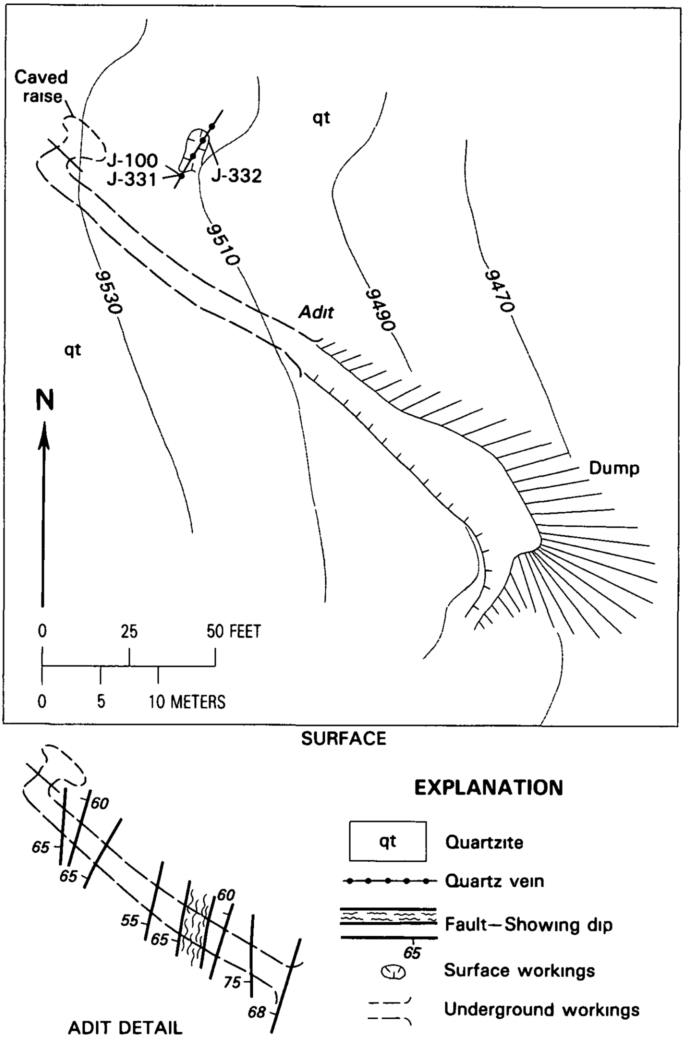

FIGURE 72.—Patty Flynn prospect. Contour interval 20 ft, 1 ft=0.3048 m

Data for samples shown on figure 72

[Tr, trace, leaders (--), not analyzed, 1 troy oz/ton=34.285 g/t]

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Antimony (percent)
J-100	Chip--	0.5	Across vein	0.03	4.7	13.0	--	4.68
J-331	--do--	1.3	---do------	Tr	12.4	18.9	0.01	2.5
J-332	--do--	.7	---do------	.01	1.0	2.15	.12	.80

quartz vein. The fault zone strikes northeast, dips steeply, and is 0.5–2 ft (0.15–0.6 m) thick over a 30-ft (9-m)-long exposure. The quartz vein locally contains massive jamesonite, sphalerite, galena, and pyrite. Altered quartzite, adjacent to the quartz vein, contains finely disseminated sulfides, mainly pyrite. A chip sample across the quartz vein assayed 0.02 oz gold per ton (0.69 g/t), 12.8 oz silver per ton (439 g/t), 6.4 percent zinc, and 1.99 percent antimony. Samples of altered quartzite assayed as much as 0.4 oz silver per ton (13.7 g/t), 0.2 percent lead, and 0.04 percent zinc.

The single vein exposure is insufficient to delineate potential mineral resources. Further exploration work along the fault zone may disclose additional mineralized rock.

MISCELLANEOUS PROSPECTS

Other prospects in the district either have no mineral resource potential or else are not sufficiently exposed to evaluate. Descriptions of these properties are summarized in table 16.

BIG BOULDER CREEK DISTRICT

The Big Boulder Creek district is near the eastern boundary of the study area (pl. 3; fig. 34). On the basis of past production from the Livingston mine, the number of mining claims (table 17), and present prospecting activity, it is one of the more important districts in the study area.

The eastern and northeastern portions of the district are capped by Tertiary volcanics. The western portion is underlain by granitic rocks, argillite, and quartzite. Railroad Ridge, one of the more conspicuous physiographic features in the area, is covered by glacial drift.

The mineral deposits are fissure fillings in the argillite and fissure-filling and replacement bodies in quartzite and dike rocks. The argillite and quartzite have been intensely contorted. Ore minerals consist principally of jamesonite, galena, sphalerite, and tetrahedrite.

Until 1923, mineral production was limited to occasional small loads of high-grade lead-silver ores carried by pack trains to the old Clayton smelter. Only the Livingston mine has been developed to the extent that a mill was constructed and concentrates shipped.

The Livingston mine and Lakeview claims are the only properties in the district that have sufficient exposures of mineralized material to permit estimations of resources. The Livingston deposit is estimated to contain about 50,000 tons (45,000 t) averaging 0.005 oz gold per ton (0.17 g/t), 4 oz silver per ton (137 g/t), 4 percent lead, 5 percent zinc, and

TABLE 16 —*Miscellaneous properties, Fourth of July Creek district*

[1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
96	Gold Leaf	A northeast-trending biotite-rich porphyry dike in iron-oxide-stained granitic rocks. Stockpiles contain mineralized argillite, not exposed on the surface.	Seven prospect pits, one caved adit.	Three dump grabs and one chip sample of country rock, as much as 0.1 oz silver per ton, trace of copper and lead. One select grab sample from small stockpiles, 0.01 oz gold per ton, 0.8 oz silver per ton, minor copper, lead, and zinc.
97	Gold Leaf Extension	Iron-oxide-stained granitic rocks cut by northeast-trending biotite-rich porphyry dikes.	Three prospect pits-----	Two select dump samples from small stockpiles, as much as trace gold, 0.2 oz silver per ton, minor lead and zinc. One chip across dike-granitic rock contact, no gold or silver.
98	Blackman Peak prospects	Four, 1.0- to 2.0-ft-thick shear zones contain less than 1.0 percent finely disseminated galena and sphalerite. One exposure is in iron-oxide-stained calcareous quartzite, the other three occur in adjacent granitic rocks.	Ten pits---------------	One chip sample across shear zone in quartzite, 0.36 percent lead, 0.42 percent zinc. Two select grab samples of small stockpiles of mineralized sedimentary rocks, as much as 4.2 oz silver per ton, 2.0 percent lead, 21.2 percent zinc. Other samples of

				sedimentary rocks, no economic metal values. Three chip samples from shear zones in granitic rocks, as much as 0.2 oz silver per ton, 0.23 percent lead, 0.45 percent zinc. A select grab sample of altered granitic rock on dump, 0.1 oz silver per ton and trace lead.
101	Mountain Home quartz vein	A 3-ft-thick quartz vein striking N. 10° W., dipping vertically, is traceable for 300 ft. No metallic minerals seen.	None--------------------	One chip sample across vein, 0.1 oz silver per ton.
103	Prospect	Tabular quartz body up to 20 ft thick, can be traced along its strike for about 2,000 ft. Dip is generally 60° N. Body is brecciated and contains large amounts of secondary quartz including quartz crystals up to 1 in. across. Country rock is light colored quartzite.	One pit-----------------	Two chip samples across body taken 1,600 ft apart, no mineral values detected.
107	Stella	A 0.5- to 1.5-ft-thick silicified shear zone contains finely disseminated pyrite. It strikes northeast, dips vertically, and is exposed for 10 ft.	Ten-foot adit-----------	One chip sample across shear zone, trace gold and 0.3 oz silver per ton.

TABLE 16.—*Miscellaneous properties, Fourth of July Creek district*—Continued

Map No. (pl. 3)	Property Name	Summary	Number and type of workings	Sample data
108	H & S No. 5	Working exposes bleached biotite-rich rhyolite. No metallic minerals were observed.	Fifty-foot dozer cut----	One chip sample, no significant metals detected.
112	Rupert No. 2	Dumps contain iron-oxide-stained granitic rocks. No ore minerals were observed.	Two dozer cuts and two sloughed pits.	One random dump sample; no significant metals detected.
114	Red Robin No. 1	A 0.5- to 1-ft-thick quartz vein with related quartz veinlets is traceable for 300 ft along strike, sporadic, finely disseminated molybdenite occurs along adjacent northwest-trending joints.	One pit-----------------	Three chip samples of quartz vein, no gold or silver and trace molybdenum. Select grab sample of small stockpile, as much as 0.05 percent molybdenum.
115	Red Robin No. 3	A 30-ft-thick tactite zone trends northwest and is exposed for 100 ft. A 2-in.-thick north-trending quartz vein contains minor blebs of molybdenite. The quartz vein is exposed for 90 ft.	One dozer cut-----------	Three chip samples of tactite, as much as 0.10 percent molybdenum, 0.52 percent WO_3, and trace zinc. One chip sample of quartz vein, trace silver and molybdenum.
116	Six Lakes Basin altered zones	Altered quartzite, limestone, and volcanic rocks. No metallic minerals were seen. Quartzite-basaltic dike contact with disseminated sulfides.	None-------------------	Four chip samples, no significant metal values detected. One chip sample across quartzite-dike contact, trace lead.

TABLE 17.—*Summary of mining claims recorded, including relocations, 1880-1971, Big Boulder Creek district*

Decade	Number of lode claims
1880-1889	25
1890-1899	12
1900-1909	2
1910-1919	6
1920-1929	50
1930-1939	10
1940-1949	--[1]
1950-1959	16
1960-1969	24
1970-1971	--
Total------	145

[1]Leaders (--), none recorded.

0.02 percent copper. Resources at the Lakeview claims are estimated to be 20,000 tons (18,000 t) averaging 1.0 oz silver per ton (34 g/t), 1.3 percent lead, 0.08 percent zinc, and 0.82 percent antimony.

Mineral deposits in the Big Boulder Creek district have been described by Kern (1972), in an unpublished DMEA report (1959), and by Kilsgaard (1949) and Ross (1937). These sources were freely used in the following mine descriptions.

LIVINGSTON MINE

The Livingston mine is at an altitude of 9,300 ft (2,835 m) in a cirque at the head of Jim Creek (pl. 3, 90; fig. 73). The Livingston mill is at the confluence of Jim Creek and Big Boulder Creek about 2,000 ft (610 m) lower and 4 mi (6.4 km) west by road from the mine (fig. 74).

The claims covering the mine were located by A. S. and W. S. Livingston on July 28, 1882. Some rich lead-silver ore was reportedly shipped by pack train. In 1922, a road was constructed to the mine and a 200-ton/day mill, a 3-mi (4.8-km) aerial tram, and a hydroelectric plant were installed; by 1923, the property was in production. Production was fairly continuous until 1930 (table 18). From 1930 to the present time, the mine has changed ownership several times. Mining and milling equipment was removed, reinstalled, and some of it removed again. In 1951 and 1952, 60,000 tons (54,000 t) of mill tails were rerun. During the period from July 1953 to September 1958, the mine was explored under a DMEA contract.

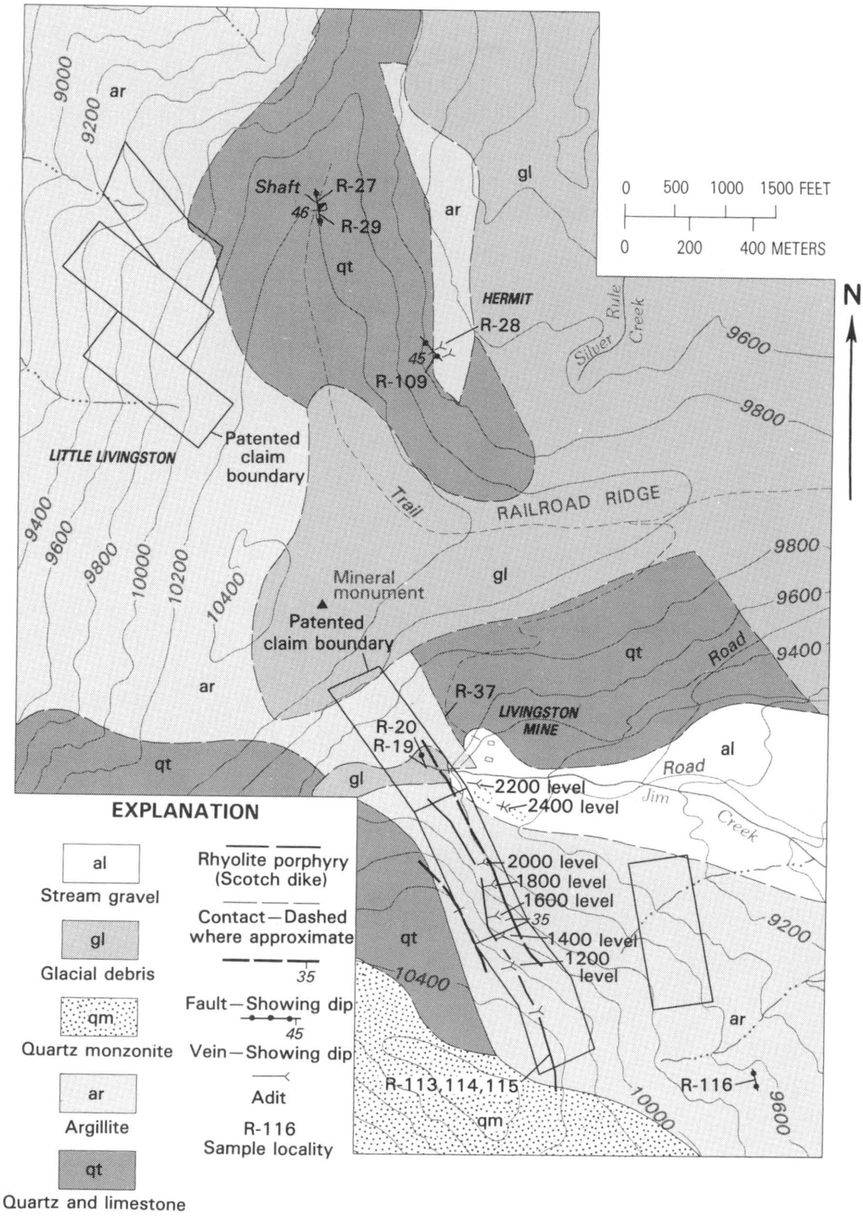

FIGURE 73.—Livingston-Little Livingston-Hermit mines area. Contour interval 200 ft.

The mine is owned by Elmer Swanson of Clayton, Idaho. The property includes 4 patented mining claims, a number of millsite claims, and about 77 unpatented mining claims extending to the Little Livingston mine. A patent application is pending on the millsites.

Data for samples shown on figure 73

[All samples chip except R-28, R-37, select. Tr, trace, N, none detected, leaders (-), not analyzed, <, less than shown 1 ft=0 3048 m. 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver	Copper	Lead	Zinc	Antimony	Arsenic	Cadmium
No	Length (ft)	Description	(oz/ton)		(percent)					
R-19	10 0	Across vein (shear zone)	N	0 5	--	0 41	0 26	0 02	--	--
R-20	10 0	---do-------------	N	6	--	1 05	68	13	--	--
R-27	5	Across vein-------	N	5	0 002	14	01	02	--	0 002
R-28	([1])	Stockpile---------	Tr	12 8	001	75	--	--	--	--
R-29	5	Across altered zone	N	4	003	36	--	09	--	--
R-37		Across argillite--	N	N	03	N	N	005	--	--
R-109	2 0	Across shear zone-	N	3	N	04	03	< 005	--	--
R-113	2 0	Across mineralized rhyolite dike	N	4 0	--	12 0	05	65	0 37	--
R-114	4 0	Across argillite-mineralized dike contact	N	13 6	--	21 0	50	2 60	1 74	--
R-115	2 0	---do-------------	0 02	2 1	--	2 90	01	09	--	--
R-116	10 0	Across quartz vein	N	Tr	--	14	01	005	--	--

[1]Blank, not measured

A total of more than 3 mi (4.8 km) of underground workings has been driven on the nine main levels (fig. 75) The mine is flooded to the 2400 level Above this level, the ground stands exceptionally well. Some portals and many underground workings along fault zones are caved, but hundreds of feet of workings stand open with a minimum of ground support, including the large Christmas stope.

The country rock is black carbonaceous argillite, with some interbedded limestone and quartzite (figs. 73, 76). A west-trending fault that dips 33° N. is exposed both in the mine workings and on the ridge south of the mine, where it is traceable northwestward down the cirque face to glacial debris on the valley floor. This structure, called the Livingston fault or vein, apparently was the main channel for ore-forming solutions that deposited sulfide minerals in fractures along and near the fault and formed replacement bodies in the wall rock. The Livingston fault is a reverse fault with a right-lateral component of movement; it is terminated on the west and east by north-trending, west-dipping, pre-mineral bounding faults. The known strike length between the near-vertical West and East bounding faults (fig. 76) ranges from 250 to 600 ft (76 to 180 m). The fault has been explored for 2,700 ft (823 m) downdip, a vertical distance of 1,400 ft (427 m) (figs. 74, 77).

The principal ore minerals are jamesonite, galena, sphalerite, and tetrahedrite Jamesonite, the dominant ore mineral, occurs throughout the mine from the highest outcrops to the lowest working without any noticeable change in character (Kiilsgaard, 1949, p. 18). Galena is particularly abundant on and above the 1400 level. Sphalerite is more abundant from the 1800 level to the lower mine levels.

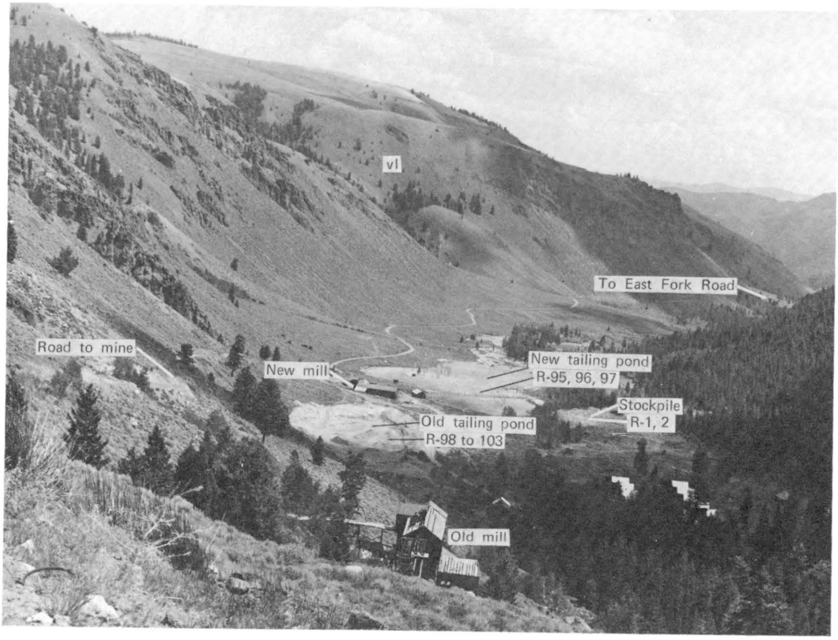

FIGURE 74.—Livingston mine camp in volcanic rocks (vl), showing sample localities.

Data for samples shown on figure 74

[All samples channel except R-1, R-2, grab. Tr, trace; N, none detected; leaders (--), not analyzed; 1 ft=0.3048 m; 1 troy oz/ton=34.285 g/t]

Sample No.	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Cadmium (percent)	Antimony (percent)
R-1	([1])	Stockpile	N	2.3	2.75	3.20	0.020	0.55
R-2		---do----	N	5.1	3.25	5.60	.030	.36
R-95	2.0	Tailings-	Tr	1.3	1.85	.18	--	--
R-96	2.0	---do----	N	1.1	1.20	.20	--	--
R-97	2.0	---do----	N	.9	1.10	.24	--	--
R-98	1.0	---do----	N	1.3	1.05	.15	--	--
R-99	1.0	---do----	N	1.5	3.10	.35	--	--
R-100	1.0	---do----	N	.3	.50	.30	--	--
R-101	1.0	---do----	N	.6	.65	.64	--	--
R-102	1.0	---do----	N	1.3	1.90	1.18	--	--
R-103	1.0	---do----	N	.2	.47	.21	--	--

[1] Blank, not measured.

The major ore shoots in the Livingston vein do not follow the dip of the fault but rake 26° NW. Major replacement ore shoots occur along the contact of the vein and a steeply southwesterly dipping rhyolite porphyry dike (Scotch dike) that cuts the fault zone. Most production came from a continuous ore shoot along the intersection of the vein and

TABLE 18 —*Recorded metal production, 1902-1954, Livingston mine*

[U S Bureau of Mines production records Records not available for some years Some figures represent total metal content, others represent recoverable metals Figures may include minor production from the Little Livingston mine, 1 ton =0 9 t, 1 troy oz=31 1 g; 1 lb=0 45 kg; leaders (-), none recorded]

Year	Ore (tons)	Gold (oz)	Silver (oz)	Copper (lb)	Lead (lb)	Zinc (lb)
1902	27	6.0	2,134	--	18,100	--
1903-22	--	--	--	--	--	--
1923	44	11.49	5,723	104	36,984	--
1924	192	24.38	10,358	708	126,560	--
1925	899	10.88	11,505	1,247	441,299	--
1926	16,208	73.22	86,558	7,552	3,485,896	41,154
1927	31,219	84.84	90,253	3,158	3,240,887	--
1928	3,263	85.94	73,081	8,721	2,196,805	952,879
1929	25,577	128.03	149,400	3,200	4,556,745	--
1930	1,326	5.28	8,296	--	336,444	--
1931-34	--	--	--	--	--	--
1935	86	5.60	3,911	--	69,075	--
1936-38	--	--	--	--	--	--
1939	[1]86	5.0	3,051	--	58,876	--
1940	81	1.0	1,029	--	38,737	--
1941	114	2.0	855	--	27,710	--
1942-44	--	--	--	--	--	--
1945	352	6.0	3,162	536	109,516	41,332
1946	500	4.0	3,686	780	145,750	66,680
1947	1,295	12.0	7,693	1,628	280,660	137,878
1948	2,172	24.0	12,330	2,957	363,046	206,680
1949	1,027	10.0	5,985	1,644	165,533	162,050
1950	50	1.0	1,158	--	19,600	4,406
1951	[1]23,680	20.0	13,967	4,087	375,503	541,099
1952	[1]36,320	63.0	36,749	11,008	908,975	1,852,331
1953	--	--	--	--	--	--
1954	150	1.0	437	--	5,500	3,800
Total--	144,668	584.66	531,321	47,340	17,008,201	4,010,289

[1]Tailings.

the dike This ore shoot extended as far as 210 ft (64 m) along the strike, was as much as 30 ft (9 m) thick, and was mined for more than 400 ft (120 m) downward This mined-out area is known as the Christmas stope. The average material produced from the mine, according to production records, contained about 0.005 oz gold per ton (0 17 g/t), 4.1 oz silver per ton (141 g/t), 6.7 percent lead, 3.0 percent zinc, and 0 02 percent copper. The grade of the ore is not correctly reflected by production records because material containing predominantly sphalerite often was bypassed, dumped in open stopes,

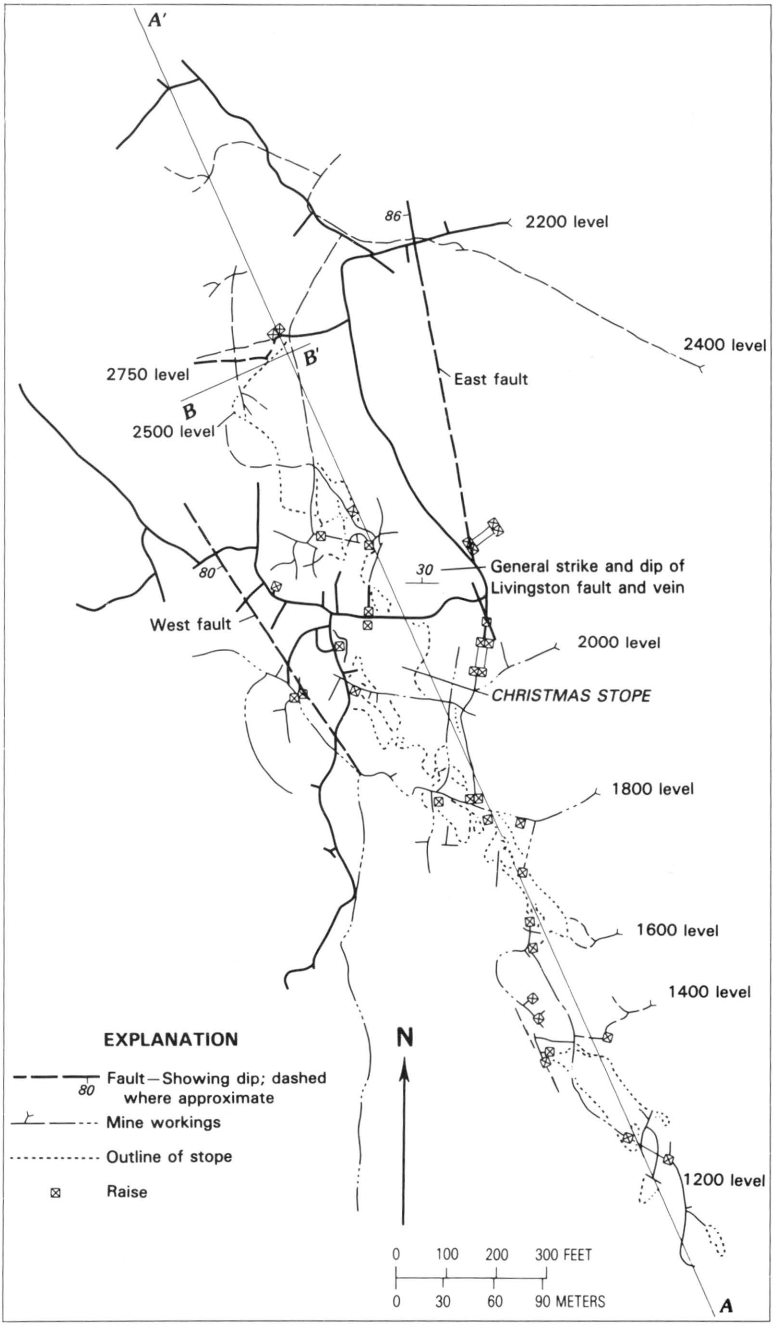

FIGURE 75.—Main workings, Livingston mine. Cross sections *A*-*A'* and *B*-*B'* on figures 77 and 78.

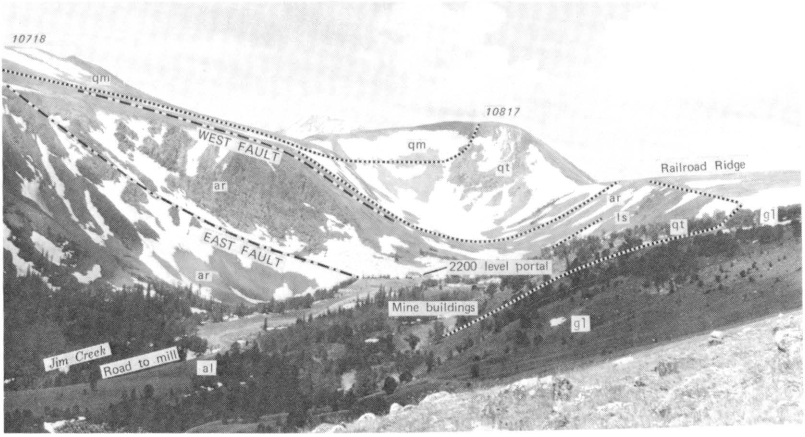

FIGURE 76.—Livingston mine area, looking northwest; al, stream gravel; gl, glacial debris; qm, quartz monzonite; ar, argillite; qt, quartzite; ls, limestone. Short-dashed lines are contacts. Spot elevations in feet.

or used for backfill. Furthermore, although jamesonite contains 80 percent as much antimony as lead, no antimony production is recorded (table 18).

Other veins in the mine include the Little Falls, Blumenthal, and small offshoots; these veins are extensively described by Kiilsgaard (1949, p. 16–18). The Little Falls vein is exposed west of the mine buildings and in the 2200 and 2400 levels. The thickness is less than 2 ft (0.6 m). Lead ore with a high silver content was reportedly mined from small stopes along the vein (Kiilsgaard, 1949), but samples R–19 and R–20 (fig. 73) from the surface exposures contained only 0.5 and 0.6 oz silver per ton (17 and 21 g/t), respectively. The Blumenthal vein is a mineralized porphyry dike exposed in the 2402 crosscut. Judging from hand specimens, the value is very low (Kiilsgaard, 1949, p. 17). The small size, discontinuous nature, and low grade of the small offshoot veins, which occur at various distances from the Livingston vein, discouraged exploration. A relatively large, barren quartz vein (sample R–116, fig. 73) crops out 2,000 ft (610 m) east from the south end of the Livingston vein. The vein is 10 ft (3 m) thick and is exposed for about 300 ft (90 m) in a trench.

In 1953, a project to explore the possible downward (northern) extension of the mineralized zone was conducted under a DMEA contract. The work completed includes a 250-ft (76-m) extension of the vertical two-compartment winze, a 245-ft (75-m)-long crosscut on the 2750 level, and 20 diamond drill holes aggregating 2,863 ft (873 m) (fig. 78). Lead and zinc minerals were encountered in two holes and one other

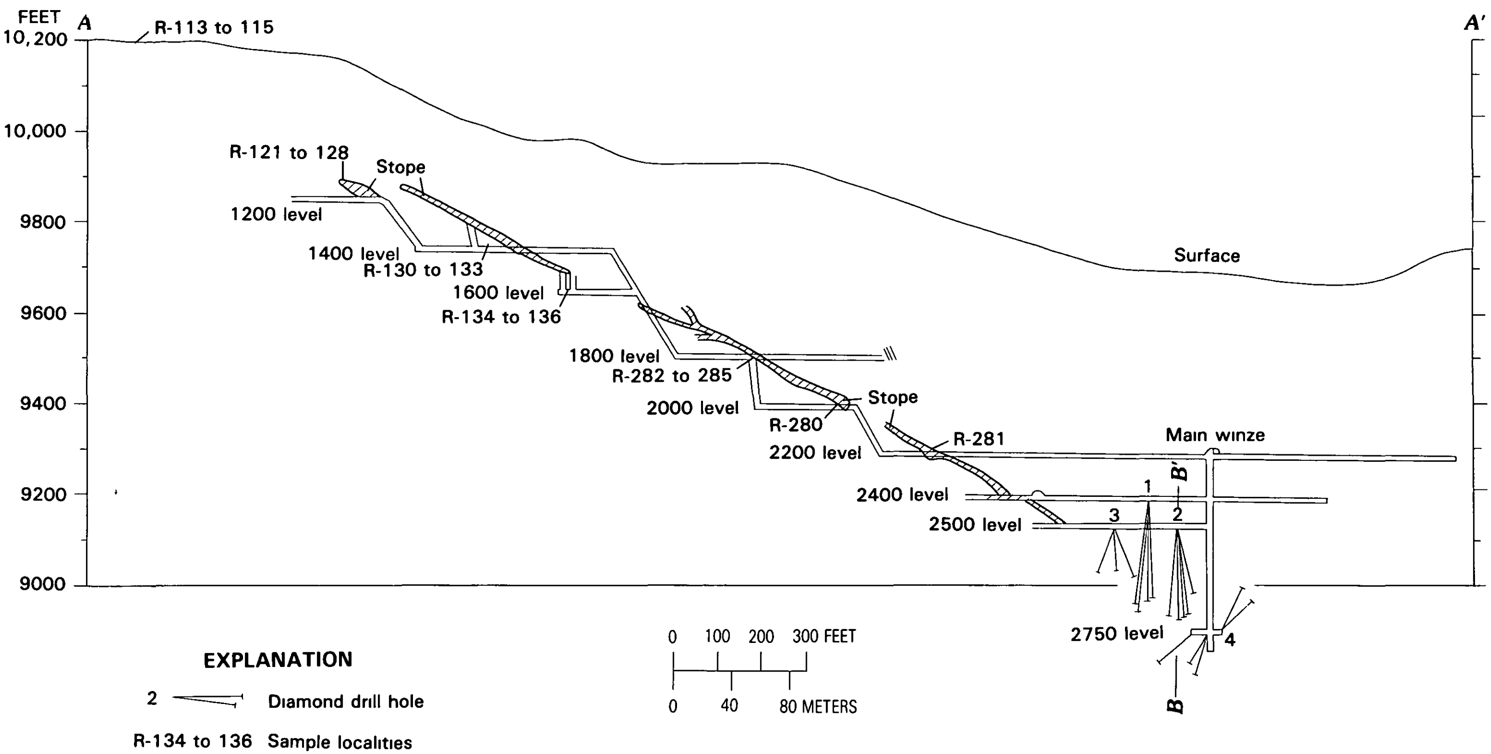

FIGURE 77.—Section *A-A′*, Livingston vein (modified from DMEA unpub. data). Elevations in feet, 1 ft=0.3048 m.

Data for samples shown on figure 77

[Tr, trace, N, none detected, leaders (--), not analyzed, 1 troy oz/ton=34 285 g/t]

Sample No	Sample Type	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Copper (percent)	Lead (percent)	Zinc (percent)	Cadmium (percent)	Antimony (percent)	Arsenic (percent)
R-113	Chip--	2	Across mineralized rhyolite dike	N	4 0	--	12 0	0 05	--	0 65	0 37
R-114	--do--	4	Across mineralized rhyolite dike-argillite contact	N	13.6	--	21 0	50	--	2 60	1 47
R-115	--do--	2	---do------------------	0 02	2.1	--	2 90	01	--	09	--
R-121	--do--	1 2	Across part of vein-----	N	11 1	--	--	--	--	--	--
R-122	--do--	2 0	---do------------------	N	6 0	--	--	--	--	--	--
R-123	--do--	6	Across fault gouge------	N	2 7	--	--	--	--	--	--
R-124	--do--	1 0	Across part of vein-----	N	18 5	--	--	--	--	--	--
R-125	--do--	5	---do------------------	02	48 5	--	48 00	18	--	1 78	--
R-127	--do--	1 0	---do------------------	N	13 4	--	16 00	07	--	26	--
R-128	--do--	1 0	---do------------------	N	1 0	--	6 0	12 40	--	2 24	--
R-126	--do--	5	---do------------------	N	48 5	--	--	--	--	--	--
R-130	--do--	5	Across fault gouge------	Tr	25 8	--	39 00	13	--	61	--
R-131	--do--	1 5	---do------------------	.02	9 2	03	9 40	10	0 004	1 02	--
R-132	Select	([1])	Pillar (mineralized)----	.02	2 4	--	50	5 60	--	09	--
R-133	--do--		Pillar (not mineralized)	N	N	--	13	28	--	005	--
R-134	Grab--		Loading chute-----------	N	1 7	--	70	3 60	--	10	--
R-135	--do--		Caved material----------	N	1 9	--	1 65	8 40	--	15	--
R-136	--do--		---do------------------	N	3 5	--	2 70	8 20	--	--	--
R-282	--do--		Quartzite-argillite contact	N	N	01	38	14	--	--	--
R-283	Chip--	5	Iron sulfide in quartzite	N	1	15	10	03	--	--	--
R-284	Grab--		Caved material from dike-argillite contact	N	N	18	01	5 20	--	--	--
R-285	Select		---do------------------	08	4	18	15	52 00	52	02	02
R-280	--do--		Broken material dumped in old stope	Tr	5.9	05	5 20	11 00	--	--	--
R-281	Chip--	5	High-grade zone in pillar	N	19 5	06	44 00	3 60	--	--	--

[1]Blank, not measured

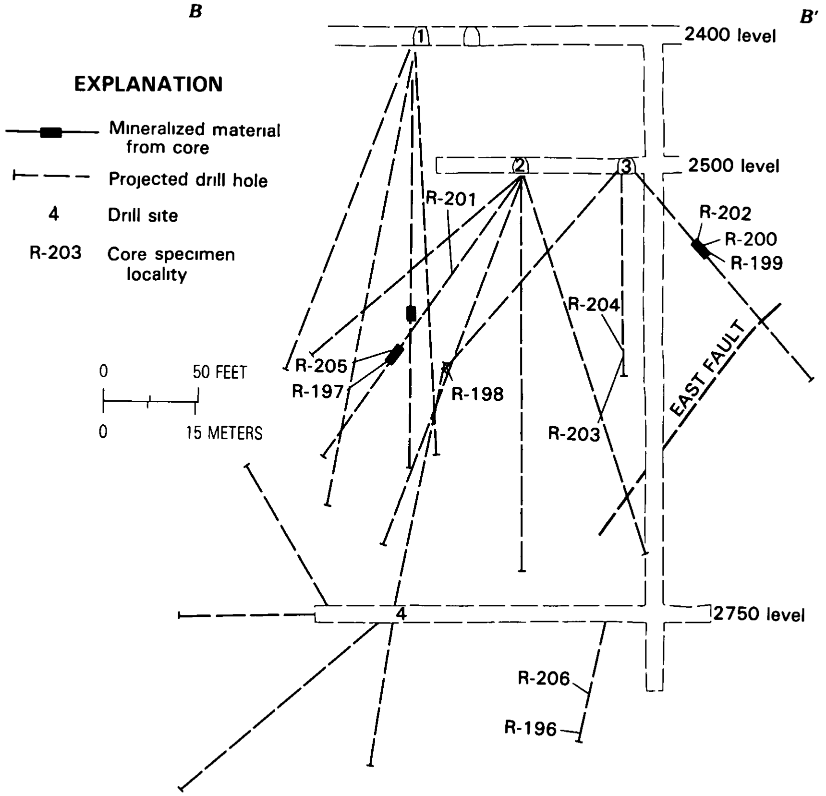

FIGURE 78 —Section *B-B′*, diamond-drill holes projected to plane of section, Livingston vein (modified from DMEA unpub data)

Data for samples shown on figure 78

[All samples drill-core specimens Tr, trace, >, greater than shown, 1 troy oz/ton=34 285 g/t]

Sample No.	Gold	Silver	Copper	Lead	Zinc	Cadmium	Antimony
	(oz/ton)		(percent)				
R-196	Tr	0.048	0.001	0.003	0.004	0.0003	0.0004
R-197	0.005	.410	.011	.080	7.000	.0700	.0300
R-198	.02	1.390	.004	.290	7.400	.0560	.0800
R-199	007	1 670	.016	1.900	6 600	0680	> 5
R-200	Tr	2.880	.240	1.500	16.000	.1160	> 5
R-201	Tr	.168	.040	004	.018	.0004	.0060
R-202	.008	.910	.042	120	20.000	.1890	.0600
R-203	Tr	.142	.020	.009	.016	.0004	.0010
R-204	Tr	.096	.009	.010	.062	.0007	.0020
R-205	Tr	1.290	.016	.920	17.000	.1660	>.5
R-206	Tr	.050	.003	.004	.005	.0003	Tr

hole showed abundant mineralized material, but the mineralized showings are thought to be small, widely separated pods because core from nearby holes was barren

The extended winze did not intersect the Livingston fault, which indicates that the fault may have steepened. The six drill holes from a crosscut on the 2750 level (fig 78) encountered a large amount of water, which may indicate proximity of the Livingston fault or a subsidiary structure; but ore minerals or favorable indications for the occurrence of an ore body were almost completely lacking (DMEA unpub. data, 1959).

Diamond drilling on the 2,400-ft level (figs. 77, 78, site No. 1) consisted of four down holes that totaled 881 ft (269 m) in length. The only significant mineralization encountered was in the vertical hole, where an 8-ft (2.4-m) zone of low-grade mineralization containing jamesonite, sphalerite, and pyrrhotite was encountered between 135 and 143 ft (41 and 43 m) below the collar (DMEA report). The zone was not sampled by the U S Bureau of Mines during this study.

Eight holes aggregating 1,294 ft (394 m) were drilled on the 2500 level. Only two widely separated and diverging holes penetrated noteworthy mineralized material. A drill hole from site No. 2 encountered sphalerite at a depth of 110 to 120 ft (34 to 37 m). The 10-ft (3-m) interval averaged 0.9 oz silver per ton (30.9 g/t), 9.1 percent zinc, and no lead. A drill hole from site No 3 intersected a mineralized zone of sphalerite and jamesonite from 50.0 to 60.0 ft (15 to 18 m) below the collar that averaged 4 6 oz silver per ton (158 g/t), 4.4 percent lead, 7.5 percent zinc, and 1 percent antimony Selected specimens split from the remaining drill core indicated that as much as 0 189 percent cadmium and 0.24 percent copper occur in the mineralized material.

Seven samples were taken from outcrops, 21 from underground workings (2200 level and above), 11 from drillcores, 9 from tailings ponds near the mill, and 2 from a stockpile near the mill. Values ranged to 0 08 oz gold per ton (2.74 g/t), 48.5 oz silver per ton (1,663 g/t), 0.24 percent copper, 48 percent lead, 52 percent zinc, 0.189 percent cadmium, 2 6 percent antimony, and 1.74 percent arsenic. Sample averages by location are listed in table 19. They coincide favorably with previously published data.

High-grade ore containing as much as 48 oz of silver per ton (1,645 g/t) was left in place because some material had to be handled as much as five times between the 1200 level and the portal on the 2200 level The section of the Livingston fault from the 1200 level to the surface, a projected distance of 650 ft (198 m), has not been explored. The remaining quantity of mineralized material within the known extent of the Livingston vein is estimated to be about 50,000 tons (45,000 t), containing 0.005 oz gold per ton (0.17 g/t), 4 oz silver per ton (137 g/t), 4 percent lead, 5 percent zinc, and 0.02 percent copper. Additional material is present in narrow stringers.

TABLE 19 —*Average grade of samples by mine level or location, Livingston mine*

[N, none detected, leaders (–), not analyzed, 1 troy oz/ton=34 285 g/t]

Location	Sample number or sequence	Remarks	Silver (oz/ton)	Copper (percent)	Lead (percent)	Zinc (percent)	Cadmium (percent)	Antimony (percent)
Surface	R-113 to 115	Weighted average---	8.33	N	14.23	--	--	1.49
1200 level	R-121 to 130	---do---------------	14.6	N	21.5	4.21	--	.92
1400 level	R-131 to 133	Numerical average--	3.8	N	3 34	1 99	--	.4
1600 level	R-134 to 136	---do---------------	2.4	N	1.68	6.73	--	12
1800 level	R-284, 285	---do---------------	.1	0.13	.16	14.34	0.21	.02
2000 level	R-280	One selected sample	5.9	.05	5.20	11.0	.13	--
2200 level	R-281	---do---------------	19 5	06	44 0	3.6	03	--
2400 to 2750 level	R-196 to 206	Numerical average, selected specimens of drill core.	.82	N	45	6.74	06	--
Tailing pond	R-95 to 103	Weighted average---	.98	N	1 41	.37	--	--
Stockpile	R-1 and 2	Numerical average--	3.7	N	3 0	4.4	03	.45

LITTLE LIVINGSTON MINE

The Little Livingston mine (pl. 3, 88) is covered by three patented mining claims, located August 6, 1884, and patented February 3, 1894 The surrounding ground is covered by unpatented mining claims

Production records do not differentiate between the Livingston and the Little Livingston mines. Part of the early ore shipments credited to the Livingston (table 18) probably came from the Little Livingston mine (Ross, 1937, p 152)

Adits several hundred feet in total length had been driven by 1928 (Ross, 1937, p. 152), but a 550-ft (167-m) adit in barren argillite was the only one accessible in 1972 This adit is far below the argillite-quartzite contact reportedly associated with ore (Ross, 1937, p 152) Extensive bulldozing has virtually obliterated all the other old workings (fig. 79).

Country rocks in the mine area are carbonaceous and calcareous argillite and argillaceous limestone overlain by the Hailey conglomerate and quartzite. The argillite beds generally strike N 45°-50° W. and dip 20°-30° N. According to Ross (1937, p. 152), a mineralized fault zone that strikes N. 25°-30° W. and dips 45° S. was exposed in the mine Reportedly, the rock between the faults was broken and subsequently silicified; pockets of ore were irregularly distributed in the breccia.

Small irregularly distributed pods of quartz and limonite-stained brecciated zones occur near the contact of the argillite and quartzite on the surface. They probably are in the same zone that contained ore underground. The pods are generally less than 2 ft (0 6 m) thick and less than 10 ft (3 m) long. The limonite-stained zones are less than 4 ft (1 2 m) thick A selected sample (R-11) from one zone contained 13 7 oz silver per ton (470 g/t) and 19 4 percent lead Other samples from the

FIGURE 79.—Little Livingston mine area, looking east, showing recent bulldozer trenches and sample localities; ar, argillite; qt, quartzite. Dotted line, contact.

Data for samples shown on figure 79

[Tr, trace; N, none detected; leaders (–), not analyzed; <, less than shown; 1 troy oz/ton=34.285 g/t]

Sample No.	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Copper (percent)	Lead (percent)	Zinc (percent)	Cad-mium (percent)	Ant-imony (percent)
R-5	Chip--	2	Across quartz lens	N	Tr	0.006	0.12	0.07	--	0.01
R-6	--do--	10	Along quartz lens-	N	N	.002	.03	N	--	N
R-7	--do--	6	---do-------------	N	Tr	.003	.01	.04	--	.006
R-8	Select	(1)	Iron-oxide-stained quartzite breccia containing quartz.	N	3.4	.007	.55	.28	--	.64
R-9	--do--		---do-------------	N	1.1	.004	.49	.11	0.005	.20
R-10	Chip--	2.5	---do-------------	N	Tr	.002	.05	.09	--	.01
R-11	Select		---do-------------	N	13.7	.02	19.40	.24	.075	2.76
R-22	Chip--	.5	Quartz stringer---	N	3.8	.02	3.90	.94	--	3.01
R-23	--do--	.3	---do-------------	N	2.6	.02	1.22	.11	--	--
R-24	--do--	.1	---do-------------	N	3.3	.02	2.25	--	--	.12
R-25	--do--	.1	---do-------------	Tr	1.44	.06	.46	.45	N	.08
R-26	--do--	2	Quartz lens-------	N	N	.001	<.01	.11	<.002	<.005
R-30	--do--	3	---do-------------	N	2.2	.004	.95	.01	--	--
R-31	--do--	1	Iron oxide stained around quartz lens.	N	N	.002	<.01	--	--	<.005
R-32	--do--	1	---do-------------	N	.05	.003	.01	.25	--	.003
R-33	--do--	.05	Quartz stringer---	N	.04	.001	.01	<.01	--	.003
R-34	Select		Propylitized zone-	N	N	.002	.01	.01	<.002	<.005
R-35	Chip--	2	Quartz bleb-------	N	.4	.02	.43	.59	.002	.03
R-36	--do--	2	Iron oxide stained around quartz bleb.	N	.4	.004	.10	.14	N	.03

[1] Blank, not measured.

quartz pods or limonite-stained zones generally contained less than 3 oz silver per ton (103 g/t) and less than 1 percent lead.

HERMIT MINE

The Hermit mine (pl. 3, 87) is about a mile (1 6 km) north of the Livingston mine near the headwaters of Silver Rule Creek. The property was first located in 1885 as the Native Silver. A report by Bell (1918, p. 49) of mining activity during 1916 mentions a high-grade lead ore streak very rich in silver. A small shipment of lead reportedly was made from the bottom of the winze, but no records of its value remain (Ross, 1937, p. 154). Principal development consists of two adits connected by an inclined raise, two winzes below the lower level, and a short sublevel between the two adit levels (fig. 80), a total of about 1,000 ft (300 m) of workings. The winzes were flooded, but the remainder of the workings were open.

Most of the workings are in a carbonaceous argillite near the contact with Hailey Conglomerate Member of the Wood River Formation. Workings explore a shear zone that strikes N 35°–45° W. and dips about 45° SW. The shear zone is 1.5–2 ft (0.45–0.6 m) thick and is traceable on the surface for about 100 ft (30 m) southeastward beyond the underground workings, but it is covered by talus northwestward.

Pods of fragmented quartz within the shear zone contain small amounts of pyrite and sphalerite. Chip samples across these pods had a weighted average of 1.15 oz silver per ton (39.4 g/t), 0.36 percent lead, and 0.70 percent zinc A selected sample from a small "ore pile" on the dump contained 12.8 oz silver per ton (439 g/t).

An inclined shaft about 20 ft (6 m) deep and two pits about 1,800 ft (550 m) northwest of the adits were dug on a fault zone striking N. 10° W. and dipping 46° SW., which may be a continuation of the structure in the adits The zone contains a lens of massive quartz as much as 2 ft (0.6 m) thick and iron-oxide-stained fault gouge Small amounts of pyrite and sphalerite occur in the quartz and gouge

LAKEVIEW (CRATER LAKE) CLAIMS

The Lakeview claims (pl. 3, 89) extend from the mine workings in Crater Lake cirque, northward about 1.5 mi (2.4 km) along Livingston Creek and southward about 1.5 mi (2.4 km) across the ridge into the Big Boulder Creek drainage. The property was located in 1924 as the "Crater Lake" claims. It has no history of production. An adit with two winzes, a 15-ft (4 6-m) shaft, and several open cuts are on the property (fig. 81). The adit is open, but the winzes and shaft are flooded

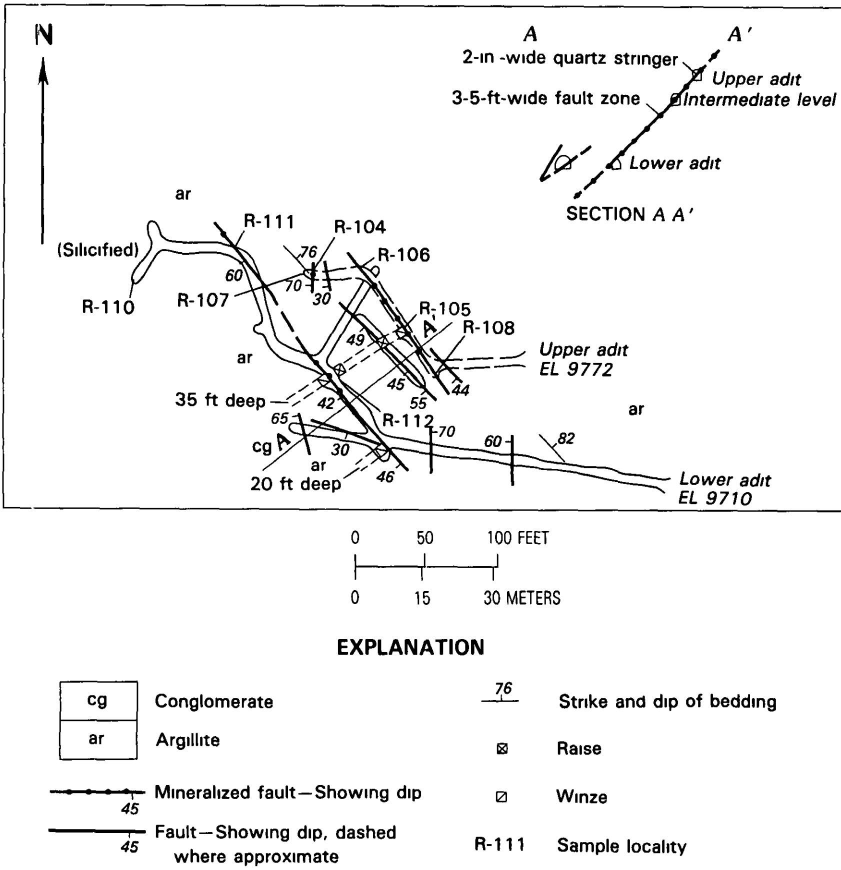

FIGURE 80.—Hermit mine (modified from Kulsgaard, 1949). Elevations in feet, 1 ft= 0.3048 m

Data for samples shown on figure 80

[All samples chip except R-107, grab. Tr, trace; N, none detected; <, less than shown; 1 troy oz/ton=34.285 g/t]

Sample No.	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Antimony (percent)
R-104	0.5	Across fault zone	N	0.1	0.1	0.03	<0.005
R-105	1.5	---do------------	N	.3	.75	2.40	.02
R-106	2.0	---do------------	N	3.6	.55	.28	<.005
R-107	([1])	Argillite--------	N	.01	.01	.01	<.005
R-108	.5	Across fault zone	N	2.9	.55	.02	<.005
R-110	2.0	Argillite--------	N	N	N	N	<.005
R-111	1.5	Across fault zone	N	Tr	<.01	.05	<.005
R-112	2.0	---do------------	N	.01	.16	.65	<.005

[1]Blank, not measured.

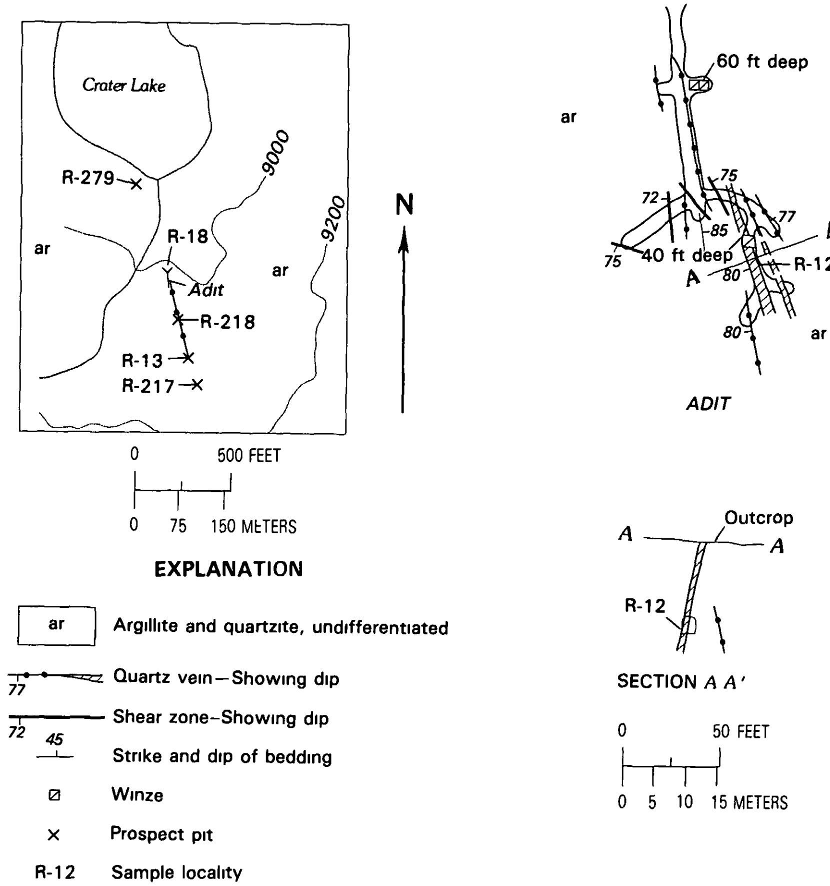

FIGURE 81 —Lakeview (Crater Lake) mine (modified from Kilsgaard, 1949) Contour interval 200 ft

Data for samples shown on figure 81

[Tr, trace, N none detected leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc	Antimony
No	Type	Length (ft)	Description	(oz/ton)		(percent)		
R-12	Chip--	4 0	Across vein------	N	0.8	0.7	0.02	0.2
R-13	-do---	6.0	---do------------	N	1 5	2.4	Tr	.5
R-18	Select	([1])	Stockpile--------	N	5 9	1.9	.91	5
R-217	-do---		Numerous small stringers	N	N	.15	.20	--
R-218	-do---	2 0	Across vein------	N	1 9	2 25	.20	3 0
R-279	-do---	4 0	Across iron-oxide-stained zone	N	N	Tr	.18	--

[1]Blank, not measured

The country rock is carbonaceous, calcareous argillite with lenses of quartzite, which strikes north and dips steeply to the southwest. A mineralized zone in the argillite is traceable for about 1,000 ft (300 m) south from Crater Lake The zone contains limonite-stained fractures and quartz stringers for about 500 ft (150 m) south from the lake. Farther south, erratically distributed pods of pyrrhotite, sphalerite, and jamesonite are found in quartz veins along fractures and bedding planes. The most extensive exposure consists of six pods as much as 4 ft (1.2 m) thick and 10 ft (3 m) long that extend about 50 ft (15 m) along the zone. The prospect workings expose mineralized stringers parallel to bedding planes, but none are more than a few inches (several centimeters) thick (Kiilsgaard, 1949, p. 24, 25)

Selected samples of vein material contained as much as 5 9 oz silver per ton (202 g/t), 2.4 percent lead, 0.91 percent zinc, and 3 percent antimony; but chip samples across the mineralized zone had a weighted average of 1 oz silver per ton (34 g/t), 1.3 percent lead, 0.08 percent zinc, and 0.82 percent antimony. Assuming an average width of 2 ft (0.6 m), a length of 500 ft (150 m), and a depth of 250 ft (76 m), the estimated low-grade resources are 20,000 tons (18,000 t)

ASARCO PROSPECT

The ASARCO molybdenum prospect (pl 3, 91), about 2 mi (3.2 km) southwest of the Livingston mine, was located and explored during the 1968–1969 surge of interest in the area. A pit about 6 ft (1.8 m) across was excavated on the edge of a meadow along Big Boulder Creek. The prospect is in quartz monzonite bounded on the west by argillite and on the east by volcanic rocks. No sulfide minerals were noted. A grab sample of angular fragments from the pit contained less than 0 017 percent MoS_2, less than 0.1 oz gold per ton (3 4 g/t), and less than 0 01 oz silver per ton (0 34 g/t). A 40-ft (12-m)-long chip sample of quartz monzonite contained 0.017 percent MoS_2, less than 0.1 oz gold per ton (3 4 g/t), and 0 01 oz silver per ton (0.34 g/t).

VALLEY CREEK DISTRICT

The Valley Creek district is in the northern part of the study area and is underlain by rocks of the Idaho batholith. Past production has been gold and silver principally, from placer deposits mainly along Stanley and Nip and Tuck Creeks within the study area and Kelly Creek and Joes Gulch just east of it, and in much smaller amounts from veins in the Valley Creek, Buckskin, and Bronco (Mountain Girl) mines (pl 3). The district has large potential placer resources that contain gold, silver, and radioactive heavy minerals These potential resources are described in the sections of this report on gold and placer deposits The productive veins contain gold, silver, lead, and relatively unimportant amounts of copper, zinc, and antimony. Only oxidized ores have been mined. Brannerite, cinnabar, and stibnite veins have been reported from the headwaters of Stanley Creek (Choate, 1962), but only one stibnite vein was found during this study. A large resource of low-grade graphite is present in Precambrian(?) schist on Elk Mountain

Production from the gold placers before 1904 is unknown, but probably exceeded $300,000 (at $20/oz), mostly from Buckley bar on Stanley Creek (Choate, 1962, p. 114) Since 1904, veins in the district have produced 1,583 oz (54 3 kg) of gold, 33,949 oz (1,164 kg) of silver, and 73,050 lb (33,135 kg) of lead according to incomplete records (table 20) Production ceased with the closure of the Valley Creek mine in 1942

Gold was first discovered in 1863. The first lode claims were located in 1872, but placer claims were not recorded until nearly 10 years later Most activity was near the turn of the century (table 21) and during the 1930's in response to the Depression Six lode claims have been patented.

Veins in the Valley Creek district are estimated to contain 295,000 to 410,000 tons (268,000–372,000 t), with average grades ranging from 0 06 to 0.25 oz gold per ton (2 1 to 8.6 g/t), 1.8 to 4.12 oz silver per ton (62 to 141 g/t), and from 1 9 to 2 8 percent lead. Arsenic content in the Valley Creek and Buckskin deposits ranges from 1 to 5 percent and would not affect gold recovery by cyanidation Graphite resources are estimated at 310,000 tons (281,000 t) of material averaging about 2.5 percent graphite, but the size of the deposit could be on the order of a few million tons if graphite-bearing strata are continuous between exposures

BUCKSKIN MINE–POTATO MOUNTAIN AREA

The greatest density of workings and the only patented lode claims in the Valley Creek district are in the area that extends from Potato Mountain at the headwaters of Stanley Creek to the Buckskin mine (pl 3, fig 34)

The area is underlain by quartz monzonite of the Idaho batholith, which is intruded by numerous dikes and northeasterly trending quartz veins that are the major source of the placer gold found along Stanley Creek and other tributaries of Valley Creek

TABLE 20 —*Recorded metal production, 1904-1942, from lode deposits, Valley Creek district*

[Data from U S Bureau of Mines production records Mountain Girl mine now known as Bronco mine, Valley Creek 1940-1942 includes production from the Buckskin mine 1 ton=0 9 t, 1 troy oz=31 1 g; 1 lb=0 45 kg]

Year	Mine	Ore (tons)	Gold (oz)	Silver (oz)	Copper (lb)	Lead (lb)
1904	Valley Creek	145	142	81	--	--
1905	Valley Creek	160	74	45	--	--
1907	Valley Creek	150	124	--	--	--
1909	Valley Creek	905	404	520	--	--
1919	Mountain Girl	19	10	65	235	2,350
1932	Mountain Girl	3	7	18	--	500
1940	Valley Creek	1,574	400	27,040	1,500	56,900
1941	Valley Creek	328	116	3,136	318	13,300
1942	Valley Creek	2,000	306	3,044	--	--
Total-------		5,284	1,583	33,949	2,053	73,050

TABLE 21 —*Summary of mining claims recorded, including relocations, 1870-1971, Valley Creek district*

Decade	Number of lode claims	Number of placer claims
1870-1879	3	([1])
1880-1889	46	6
1890-1899	67	37
1900-1909	154	49
1910-1919	52	3
1920-1929	35	10
1930-1939	72	31
1940-1949	44	10
1950-1959	46	5
1960-1969	65	10
1970-1971	1	11
Total------	585	172

[1]None recorded

VALLEY CREEK MINE

The Valley Creek mine, in the northern part of the Valley Creek district, 13 mi (21 km) northwest of Stanley (pl. 3, No. 3), is the most important mine in the district.

Gold was discovered at the Valley Creek mine in 1895 (Umpleby and

Livingston, 1920). From 1902 to 1909 the mine was worked for gold and silver (table 20), and during 1939–1942, copper and lead also were recovered. The mine was shut down by order of the War Production Board in 1942, and activity since then has been limited to assessment work

The Valley Creek group consists of three patented claims and six unpatented claims. A 1902 claim map (Mineral Survey No. 1764) indicates that underground workings totaled about 2,000 ft (600 m), but the workings were inaccessible in 1972 and their exact extent is not known. A map furnished by the present owners shows 2,100 ft (630 m) of adits and drifts, and an additional 100 ft (30 m) of bulldozer cuts At least eight levels, the longest about 790 ft (240 m), were opened along a shear zone between elevations of 6,950 and 7,450 ft (2,118 and 2,271 m). Surface workings consist of trenches and hand-dug pits, all of which were sloughed when examined. The most extensive surface working is a glory hole 300 ft (90 m) long, 250 ft (76 m) wide, and 78 ft (24 m) deep Some wooden structures, the foundation of a 20-stamp mill, a few pieces of mining equipment, and two metal tanks at a burned cyanidation mill are all that remain of the mine plant and mill. Several buildings are in good condition, two are used for storage and four as living quarters.

The Valley Creek deposit consists of near-vertical mineralized shear zones within a fracture zone that trends N. 70°–85° E., in highly altered quartz monzonite Latite and pegmatite dikes 6–8 ft (1.8–2 4 m) thick also follow the fracture zone, which generally is from 10 to 26 ft (3 to 8 m) thick (Umpleby and Livingston, 1920), but which reaches a maximum thickness of 60 ft (18 m) Mineralized shears and quartz veins within the fracture zone are 1–4.5 ft (0.3–1 4 m) thick and contain oxidized metallic minerals in vuggy, iron-oxide-stained quartz and broken quartz monzonite.

A mineralized shear zone was intermittently exposed in underground workings and can be seen in prospect pits for a length of 2,000 ft (600 m) and a difference in elevation of more than 400 ft (120 m) on the surface. Silicified quartz monzonite and quartz in a shallow trench, 250 ft (76 m) higher than the upper mine workings (sample M–1, fig 82), indicate that the mineralized zone extends northeast Secondary copper minerals occur erratically in the mineralized zone but no concentrations were observed. U S. Bureau of Mines production records for 1904, 1905, 1907, and 1909 (table 20) indicate the ore contained 0.55 oz gold per ton (18.9 g/t) and 0.53 oz silver per ton (18.2 g/t).

Chip and grab samples collected by the U.S. Bureau of Mines during this study averaged 0.19 oz gold per ton (6.5 g/t), 1 8 oz silver per ton (60 2 g/t), and 2 0 percent lead (fig 82). Higher grade material occurs in the zone, as shown by past production records (table 20) and by some analyses (fig. 82) Grades and inferred reserves from various sources are given in table 22.

Additional studies in the Valley Creek mine area by the U.S Geological Survey included analyses of selected grab samples and four electromagnetic (turam) traverses (fig. 82).

Most of the adits and other workings at the Valley Creek mine trend in a northeasterly direction and probably followed veins related and close to the latite dikes. The same northeast-trending swarm of Tertiary dikes (mostly latite) and alteration zones extend through both the Valley Creek and Buckskin mines (pl. 1), the latter about 1.25 mi (2 km) to the southwest. These associations suggest a possible genetic relation of the gold-silver veins to the dikes and alteration zones and may indicate areas favorable for prospecting along the zone connecting the two mines and elsewhere along other parallel Tertiary dikes north of Stanley Creek (pl 1) Most prospects, however, are northeast of the mapped dikes. Gold mineralization has been found in some dikes in Joes Gulch (Choate, 1962, p. 116), and the Mountain Girl vein is only a few feet from a dike.

Samples collected by both agencies indicate a mineralized zone northeast of the Valley Creek mine workings that contains high gold and silver values locally. The zone is parallel to the latite dikes and extends from the glory hole at least 2,000 ft (600 m) to near the center of the Y A M claim (fig 82) Turam traverses across the zone indicate at least seven separate electromagnetic conductors, two of which correlate with known gold-silver veins. The other conductors probably reflect dikes, mineralized veins, or altered zones of unknown gold and silver content. The overall width of the zone known to contain measurable gold and silver is 450–600 ft (137–183 m), but significant metal values may be confined to several veins separated by wide intervals of essentially barren rock.

Samples containing the most gold and silver are from the glory hole area and from trenches and pits about 1,300 ft (396 m) to the northeast. Selected samples from the glory hole area (fig. 82, A-272, A-275, A-276) averaged 2 oz gold per ton (68.8 g/t) and 11 oz silver per ton (377 g/t). Twelve chip and grab samples collected by the owners in 1949 from the glory hole averaged 0.77 oz gold per ton (26 g/t), 2.99 oz silver per ton (103 g/t), and 5.37 percent lead. An overall average grade of 0 19 oz gold per ton (6.5 g/t), 1.8 oz silver per ton (61.7 g/t) and 2 percent lead (fig. 82, samples M-4, M-10, and M-15) probably is more representative of the deposit.

The mineralized zone northeast of the glory hole also contains high values in gold and silver. High-grade material collected at two points (A-278, A-279) by the U.S Geological Survey averaged 1.46 oz gold per

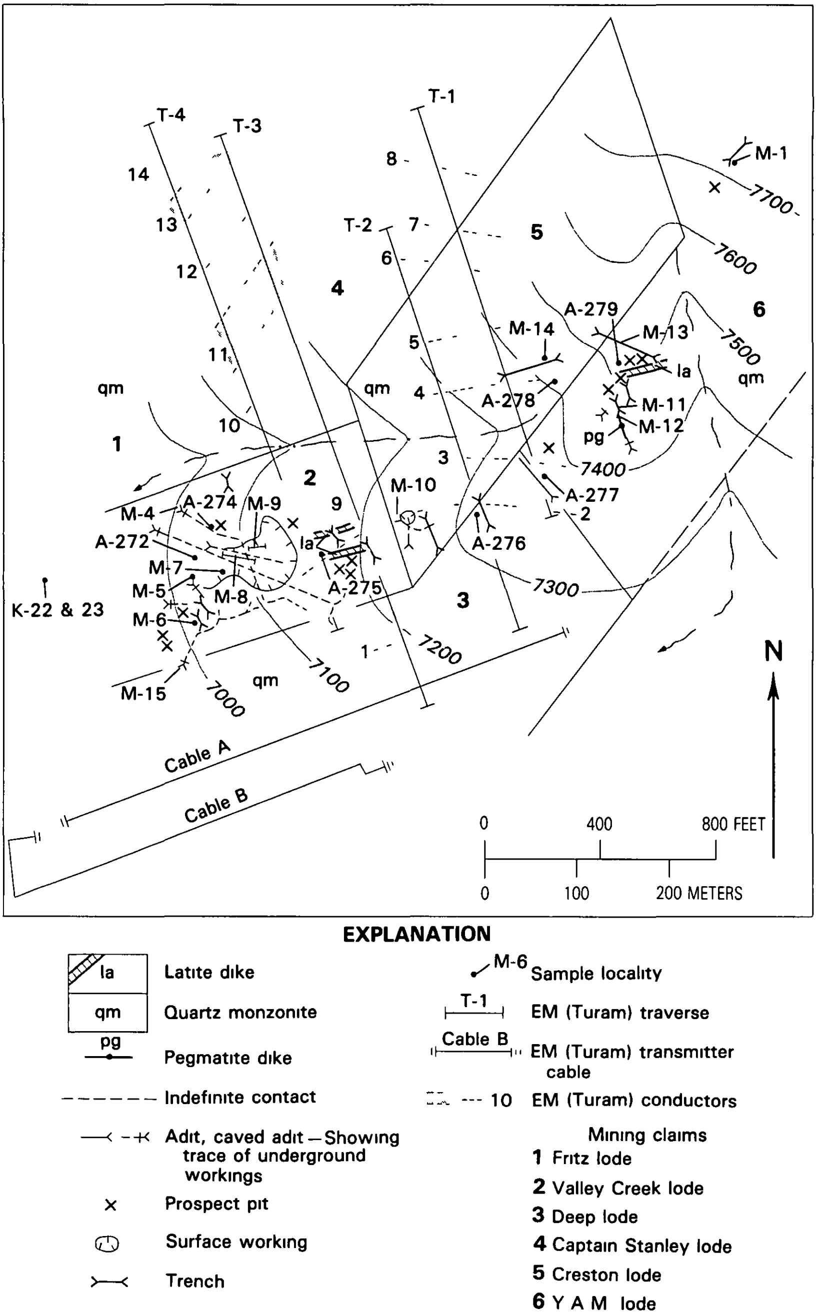

FIGURE 82.—Valley Creek mine, showing claims, workings, sample localities, and electromagnetic (EM) information. Contour interval 100 ft.

Data for samples shown on figure 82

[Sample Nos M-1 through M-15, U S Bureau of Mines Sample Nos A272-A279 and K22, K23, U S Geological Survey Tr, trace, N, not detected leaders (-), not analyzed 1 ft=0 3048 m, 1 oz/ton=34 285 g/t. For U S Geological Survey samples all analyses in ppm Determinations by atomic absorption except mercury (instrumental vapor detector), arsenic (color spot-Gutzeit), and antimony (colorimetric), L, detected but in amounts too small to measure, G, greater than value given]

Sample				Gold	Silver	Lead	Copper
No.	Type	Length (ft)	Description	(oz/ton)		(percent)	
M-1	Select	([1])	Altered quartz monzonite (dump)	N	0 1	--	--
M-4	--do---		----do----------------	0 30	2 9	2 23	--
M-5	--do---		Altered quartz monzonite and quartz (stockpile)	N	3	--	--
M-6	--do---		Iron-oxide-stained quartz (stockpile)	66	.5	--	--
M-7	--do---		Altered quartz monzonite and quartz (stockpile).	14	7	--	0 10
M-8	Random chip	115 0	Altered quartz monzonite and quartz	33	1 2	1 30	--
M-9	Chip---	50 0	----do----------------	Tr	1	48	--
M-10	Select-		Altered quartz monzonite and quartz (dump).	14	9	3.45	11
M-11	Chip---	1 0	Altered quartz monzonite and quartz	35	3 2	2 90	--
M-12	--do---	2 5	Pegmatite dike--------	N	N	01	--
M-13	--do---	1.6	Iron-oxide-stained quartz monzonite and quartz	36	7 3	6 00	--
M-14	Select-		----do----------------	N	1	22	--
M-15	--do---		Iron-stained quartz monzonite (dump).	25	6 1	1 45	--

Sample No	Type and description	Au	Ag	Pb	Cu	Zn	Sb	As	Hg
A272	Grab, mineralized rock	80	650	15,000	450	15	60	10,000	0 8
A273	Grab, wall rock	.15	2 0	7,500	45	5.0	5.0	2,000	16
A274	---do------------	N	5	70	L	90	2 0	10	10
A275	Grab, float and outcrop	70	110	100,000	1,000	130	80	50,000	2 0
A276	Grab, iron-oxide-stained vein quartz with pyrite	60	400	55,000	1,200	55	90	30,000	5
A277	Grab, wall rock	L	3.0	1,100	500	6,000	2 0	40	16
A278	Grab, outcrop and mineralized float	45	260	18,000	450	1,000	30	10,000	3.0
A279	Grab, float near vein.	55	130	13,000	75	700	100	12,000	2 0
K22	Grab, ore fragments from pile at old stamp mill	1 4	8.0	9,800	50	10	5 0	10,000	26
K23	Grab, ore fragments from beneath stamps, at old mill.	38	200	4,000	1,700	150	150	10,000G	.05

[1]Blank, not measured

TABLE 22.—*Estimates of gold, silver, and lead content, silver/gold ratios, and reserves from various sources for the Valley Creek and Buckskin mines, Sawtooth National Recreation Area, Idaho*

[Leaders (--), not recorded. 1 troy oz/ton=34.285 g/t. 1 ton=0.9 t]

Source of information	Au (oz/ton)	Ag (oz/ton)	Pb (pct.)	Silver-to-gold ratio	Estimated ore reserves (tons)	Comments
			Valley Creek mine			
Umpleby and Livingston (1920).	0.275	1.5	--	5.45	200,000-300,000	Gold content calculated from a gold value of $5.50/ton of highest grade milled ore at $20/oz. Average value of the reserves is given as $3.50/ton at 1912 prices.
U.S. Bureau of Mines production records for 1904, 1905, 1907, 1909.	.547	.534	--	.97	--	
U.S. Bureau of Mines estimate of ore reserves, 1953.	.25	.27	4.0	1.08	250,000	Metal content calculated from sample 5, collected by U.S. Bureau of Mines, this study.
U.S. Bureau of Mines, present study.	.19	1.8	2.0	9.47	--	Metal contents are weighted averages of U.S. Bureau of Mines chip and grab samples.
U.S. Geological Survey, present study.	1.02	5.14	2.59	5.04	--	Metal contents are averages of U.S. Geological Survey selected high-grade grab samples.
F. W. Schinder and C. E. Oswald, 1949.	.77	2.99	5.37	3.88	--	Metal contents are averages of analytical results of 12 chip and grab samples from the glory hole.
Stanley and William Shindler (owners).	1.17	3.1	9.2	2.65	--	Metal contents are those of a test shipment of ore shipped to the smelter, 1947. Net

						return after smelter charges would have been $50/ton.
The [Challis] Challenger, 1942.	--	--	--	--	100,000-750,000	
			Buckskin and Valley Creek mines			
U.S. Bureau of Mines production records for 1940, 1941, and 1942.	0.211	8.51	1.8	40.3	--	Includes ore from both mines, which was milled in the Valley Creek mill.
			Buckskin mine			
U.S. Bureau of Mines, present study.	0.067	4.87	2.27	72.69	--	Metal contents are averages of U.S. Bureau of Mines chip and grab samples.
Do------------	.11	4.12	1.97	37.45	80,000	Metal contents are weighted averages of U.S. Bureau of Mines chip and grab samples from four veins on the Buckskin mine claim.
Do------------	.06	2.4	2.8	40.00	15,000-30,000	Metal contents are weighted averages of U.S. Bureau of Mines chip and grab samples from two veins along a small, southerly oriented drainage west and northwest of the Buckskin mine claim.
U.S. Geological Survey, present study.	.093	5.48	.95	58.92	--	Metal contents are averages of U.S. Geological Survey selected high-grade grab samples excluding one enriched(?) sample (K8).

ton (50 g/t), and 1.9 oz silver per ton (65.1 g/t), but a more representative average of 0 355 oz gold per ton (12.2 g/t), 5.25 oz silver per ton (180 g/t), and 4 45 percent lead was computed from samples M-11 and M-13, which were collected by the U.S. Bureau of Mines

Extensive drilling and underground sampling would be required to establish reliable reserve estimates at the Valley Creek mine, but the resource potential is good and low-grade deposits may be present that would be amenable to open-pit mining methods. Electromagnetic data suggest that mineralized material is oxidized to a depth of about 250 ft (45 m)

ELECTROMAGNETIC SURVEYS OF THE VALLEY CREEK MINE

By F C Frischknecht, U S Geological Survey

Turam and AFMAG electromagnetic measurements were made at the Valley Creek mine to try to determine the extent of the known gold-silver veins and to detect possible nearby veins The AFMAG measurements were unsuccessful because of interference from a powerline about a mile away and are not presented. Turam measurements along traverses 1 and 2 (fig. 82) used a grounded transmitting cable at location A but are plotted from location B. Later measurements along traverses 3 and 4 used a cable at location B to obtain a greater depth of penetration by placing the cable as far as feasible from the known mineralized body. Turam measurements used 800 Hz. Measurements for horizontal and vertical control were made using a Brunton compass and measured cable lengths to connect the Turam loops. Slopes as steep as 30° and brush and trees in some places caused small errors in plotting the horizontal and vertical position of the traverses

The attitude and length of the transmitting cable and vertical and horizontal position of each coil were used to calculate ideal normal ratios, over most of the area, the normalized field ratios (fig. 83) are greater than 1.00 This is abnormally high and may be caused partly by surveying errors near the transmitting cable. The main cause, however, probably is a system of galvanic currents flowing around the area. For these reasons, the interpretation is based on the normalized ratio and phase difference profiles instead of normalized field profiles.

Numbered locations of electromagnetic conductors, as deduced from field amplitude ratios and phase differences, are plotted on the profiles (fig. 83) and on the map (fig. 82). Of most economic interest is a broad anomaly with some small sharp superimposed anomalies (fig. 83) along part of the gold-bearing fracture zone east of the glory hole. As interpreted here, this broad arcuate anomaly (fig 82, No. 2) is caused by a

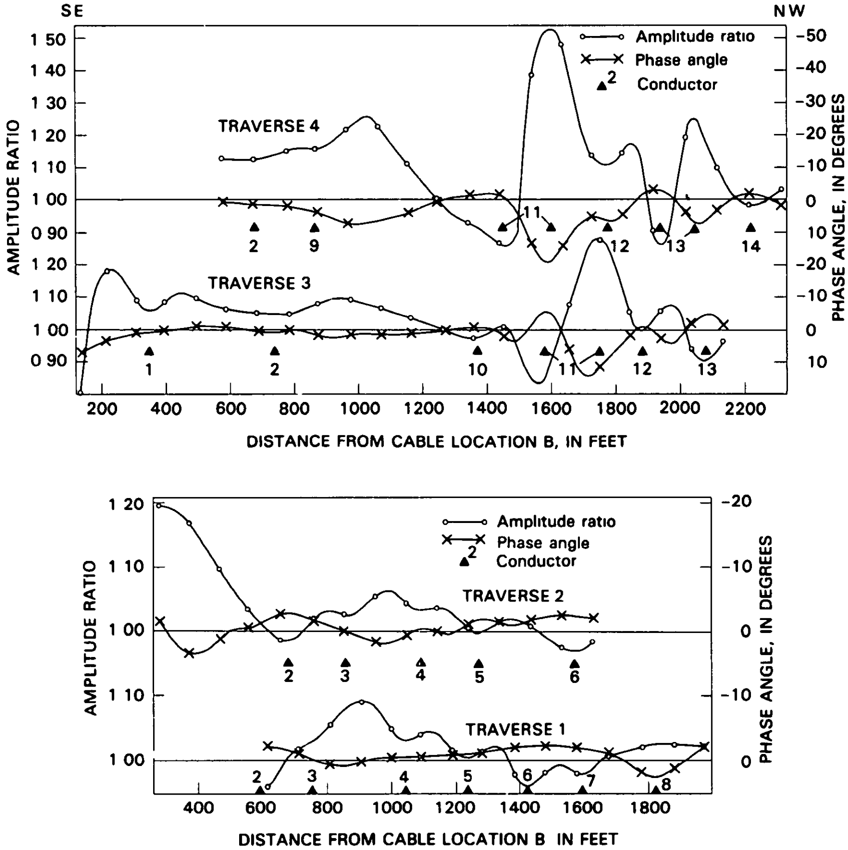

FIGURE 83 —Electromagnetic (turam) profiles along traverses 1-4, Valley Creek mine Distances in feet, 1 ft=0 3048 m

good conductor, the top of which is at a depth of about 150 ft (46 m), with one or two minor shallower conductors. The complex anomaly might possibly be caused by a near-surface rock unit of variable intermediate conductivity carrying a considerable galvanic current, however, larger phase differences over this sort of model would be expected

The estimated 150-ft (46-m) depth possibly represents the top of the unoxidized sulfide minerals Analyses of oxidized ore suggest that the total percentage of sulfides in the unoxidized mineralized material ranges from about 7 to 40 percent and may average 15–25 percent. The most probable primary minerals are abundant iron sulfide, smaller amounts of galena, and minor amounts of arsenopyrite and sphalerite Depending on the texture of the sulfide material, a total content of 15–25 percent iron sulfides and galena may make it highly conductive to electromagnetic currents. Although there may be sufficient clay minerals in the altered fracture zone to make it conductive, it is highly probable that the broad anomaly is caused mainly by unoxidized sulfides. The geophysical data are inadequate to estimate the volume of the conductor.

The position of the broad arcuate anomaly (Turam conductor No. 2) on traverses 2, 3, and 4 (fig. 82) coincides with the apparent location of some underground workings but is south of the adit crossed by traverse 1. The apparent magnitude is greatest on traverse 1, but the traverse does not extend sufficiently far south to completely define the anomalous zone

A small anomaly (fig. 83, No 1, traverse 3), caused by a near-surface source, is south of the known ore zone. Several anomalies on traverses 3 and 4, north of the ore zone, are much larger than those on traverses 1 and 2 The shapes of the profiles of traverses 1 and 2 are similar, and so the inferred correlation between conductors is highly probable. Anomaly (conductor) No. 4 (fig. 82) projects into an area that contains veins with high gold, silver, and lead values (A278, fig 82), which suggests that other conductors also may be mineralized veins. In addition to the discrete conductors indicated on the map and profiles, a wide zone of intermediate conductivity is centered at about 1,500 ft (457 m) from cable B on traverse 1 and 1,550 ft (472 m) on traverse 2 (fig. 83)

The notable differences in amplitude ratio, phase angle, and apparent strike of conductors measured on traverses 1, 2, 3, and 4 present difficulties in interpretation The larger size of the anomalies at the north ends of traverses 3 and 4 compared to those at the north ends of 1 and 2 suggests that the former are caused by galvanic currents. For some unexplainable reason, transmitter cable location B was much more favorable than cable location A for energizing the conductors in this area with galvanic currents, although the induction fields from the two cables would be nearly the same.

Interfering signals from a power line were noticed near the large anomalies on traverses 3 and 4. Although this phenomenon is characteristic of very long conductors energized by a power line, the form of the anomalies, particularly the peak amplitude ratios at 1,750 ft (533 m) and 1,600 ft (488 m) on traverses 3 and 4, respectively, is atypical for a conductor carrying mostly galvanic current.

Qualitatively, the above-mentioned large field amplitude ratio peaks and the coincident positive phase angle difference peaks, together with the field amplitude ratio lows immediately south of the peaks, could be caused by a conductor that dips gently south. Model data, however, are not available to determine if this interpretation is quantitatively possible. For such a model, the upper edge of the conductor would be near the peak in the field amplitude ratio profile, the sharpness of the anomalies indicates that the source is rather shallow and the relatively large phase angle differences indicate that it is not highly conductive. The source could be sulfide minerals, but if so, it is surprising that no gossan or other surface manifestation occurs, because bedrock is at or near the surface in most of the area. These anomalies probably represent highly altered shear or fracture zones. The apparent change in strike of conductors between traverses 2 and 3 could be significant because an intersection of the two systems would be a likely location for mineralization.

BUCKSKIN MINE

The Buckskin mine (pl. 3, No. 5) is 0.25 mi (0.4 km) west of Valley Creek and 1.25 mi (2 km) southwest of the Valley Creek mine. The Buckskin, Buckskin East, and Early Bird claims were patented in 1890, following initial discovery on the Buckskin claim in 1883. At the time the property was patented, mine workings on the Early Bird claim apparently consisted of 565 ft (172 m) of adits, 183 ft (56 m) of drifts, and 116 ft (35 m) of shafts (Mineral Survey No. 861). The main adit on the Early Bird claim probably was driven to crosscut the mineralized zone at depth. The workings, caved at the time of our investigation, are south of and 150 ft (46 m) lower in elevation than the principal open pit workings on the Buckskin claim.

Mine workings (fig. 84) were dug on northwest-trending quartz veins in a zone of highly altered and fractured quartz monzonite that is traceable for 1,800 ft (550 m) at the outcrop. Four quartz veins crop out on the Buckskin claim. The quartz veins are 1–3.2 ft (0.3–1 m) thick, strike N. 50°–65° E generally, and dip steeply. One vein strikes N 80° W Vugs in the quartz contain hematite and pyrite Galena was observed in a few prospect pits.

Local residents report that most of the gold has come from the Buckskin claim. Ore from the mine was milled at the Valley Creek mill during 1940–1942 (table 20) and apparently was the source of much of the silver produced from the district in those years.

Six hundred feet (180 m) west of the principal workings on the Buckskin claims are two short adits on opposite sides of a small stream. The adits follow a vertical quartz vein that strikes N. 80° W. (fig. 84, M-91–93). Bulldozer cuts west of the adits expose quartz veins intermittently for 600 ft (180 m). Samples with the best gold and silver values are from veins in the western bulldozer cut (M-95). The quartz veins are 0.9–2.5 ft (0.3–0.75 m) thick and contain iron oxides and as much as 20 percent pyrite. Samples collected by the U.S. Bureau of Mines from the veins and the altered wall rock averaged 0.08 oz gold per ton (2.7 g/t) and 2.2 oz silver per ton (75 g/t), but much higher values are present locally (table 23, samples K-8, K-197 and K-199).

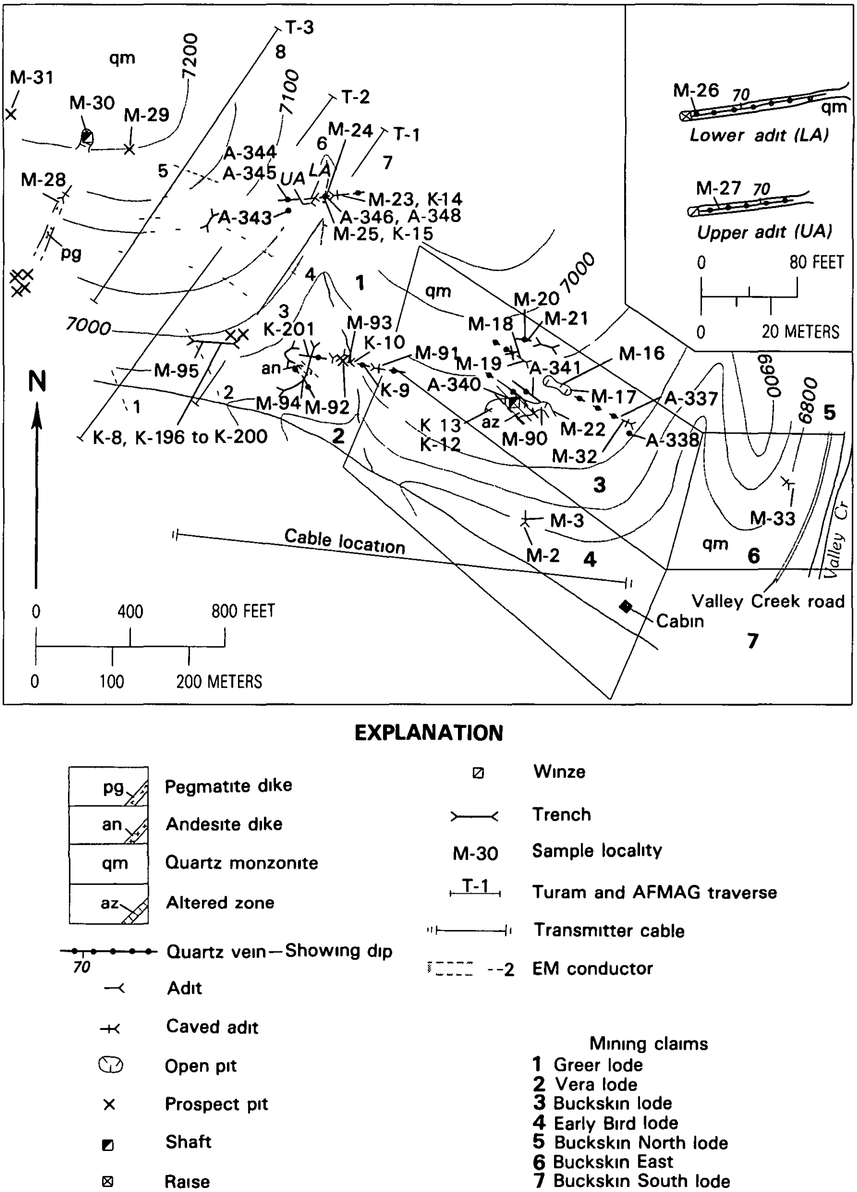

FIGURE 84.—Buckskin mine, showing claims, workings, sample localities, and electromagnetic (turam and AFMAG) data. Contour interval 50 ft.

Seven hundred feet (210 m) north of the western adits, up the small gulley, are three adits on a partially exposed shear zone that strikes N. 80° E. and dips 70°–75° NW. (fig. 84). The adit east of the creek was caved. The two adits west of the gulley are connected by a raise.

Data for samples shown on figure 84

[Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

No	Sample: Type	Sample: Length (ft)	Sample: Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Copper (percent)
M-2	Select	([1])	Vuggy, iron-oxide-stained quartz (stockpile).	0 11	7 5	0 72	--
M-3	--do--		Vuggy quartz and altered quartz monzonite (dump)	Tr	1 6	74	--
M-16	Chip--	4 5	---do---	09	6 1	2 55	--
M-17	Select		Vuggy quartz (dump)---	07	2 7	1.60	--
M-18	Chip--	2 0	Vuggy quartz vein---	29	5 0	3 05	0 19
M-19	--do--	10.5	Altered quartz monzonite with iron-oxide-filled shears	11	3 4	2 00	--
M-20	--do--	0 3	Quartz-filled shear zone---	.07	4 0	1 85	--
M-21	--do--	5 0	Mineralized shear zone and altered quartz monzonite.	Tr	1 9	90	--
M-22	Select		Vuggy quartz and bleached quartz monzonite (floor of pit)	11	4 8	2 30	--
M-23	Chip--	2 0	Vuggy quartz-filled shear zone--	Tr	1	--	--
M-24	Select		Quartz with 20 percent pyrite (stockpile)	.06	3 2	1 28	--
M-25	--do--		Quartz (stockpile)---	.03	9	1.72	--
M-26	Chip--	2.0	Shear with vuggy hematite and pyrite-filled quartz, 15 percent pyrite	08	5 5	2.42	.07
M-27	--do--	1 0	---do---	05	3 3	10 20	--
M-28	Select		Iron-oxide-stained quartz and pegmatite (dump)	N	2	--	--
M-29	--do--		Altered quartz monzonite with quartz veinlets (stockpile)	N	12 4	--	--
M-30	--do--		---do---	N	22 4	--	--
M-31	--do--		---do---	.04	18 4	--	--
M-32	Chip--	1 1	Shear zone with vuggy, hematite-filled quartz	20	4 7	--	--
M-33	Select		Altered quartz monzonite with 5 percent pyrite (stockpile)	04	5	--	--
M-90	Chip--	3 2	Shear zone in altered quartz monzonite with vuggy iron-oxide-filled quartz	N	7	1 10	--
M-91	--do--	2 5	---do---	Tr	1 7	.82	--
M-92	--do--	1 7	---do---	17	6.2	6 20	--
M-93	--do--	2 0	Altered quartz monzonite with quartz veinlets	02	2	2.40	--
M-94	--do--	1 2	Altered quartz monzonite with quartz veinlets, sulfide minerals	Tr	.1	10	--
M-95	Select		Vuggy, hematite-filled quartz (dump).	20	9 1	1.15	10

[1]Blank, not measured

The shear zone exposed in the workings is as much as 5 ft (1.5 m) wide Quartz with hematite-filled casts and pyrite occurs as lenses 0.1–2 ft (0.03–0 6 m) thick along the hanging wall, and some quartz contains as much as 20 percent pyrite. Assays of samples from the mineralized zone in the adits and from stockpiles averaged 0.04 oz gold per ton (1.4 g/t) and 2.6 oz silver per ton (89 g/t) One sample (fig. 84, K-15) of pyrite-rich vein quartz contained 0.583 oz gold per ton (20 g/t) and 6 38 oz silver per ton (219 g/t)

About 1,000 ft (300 m) west of the three adits, dumps of a group of

TABLE 23 —*Analyses of mineralized samples from the Buckskin mine, collected by the U S Geological Survey*

[All analyses are in ppm Determinations are by atomic absorption except mercury (instrumental vapor detector), arsenic (color spot Gutzeit, except samples prefixed by the letter K which are semiquantitative spectrographic), and antimony (colorimetric) N, not detected, L, detected but in amounts too small to measure, G, greater than value given]

Sample No	Type and description	Au	Ag	Pb	Zn	Cu	Sb	Hg	As
A337	Grab, quartz monzonite with pyrite	N	1 5	400	400	5 0	1 0	08	10
A338	Grab, iron-oxide-stained mineralized rock	12	900	20,000	600	400	150	10 5	12,000
A340	Grab, outcrop	N	6.0	650	190	40	4 0	75	30
A341	Grab, iron-oxide-stained rock	N	12	2,600	900	100	15	75	600
A343	Grab, wall rock 6 ft from vein	N	L	500	500	5 0	1 0	.10	10
A344	Grab, mineralized vein	05	2 0	1,600	230	65	4 0	28	60
A345	Grab, wall rock next to vein	1	10	4,000	300	55	10	40	400
A346	Grab, vein	N	1 5	450	500	30	3 0	75	600
A348	Grab, mineralized rock	L	5 5	65	50	5 0	3 0	.35	200
K8	Grab, iron-oxide-stained vuggy quartz and gossan	5 0	9,000	1,300	310	85	400	10	1,000
K9	1 7-ft chip, iron-oxide-stained quartz vein	2 0	30	9,500	2,500	100	30	2 4	10,000G
K10	1.7-ft chip, iron-oxide-stained quartz vein and gossan	1 8	28	80,000	1,200	70	300	4 5	10,000G
K12	Grab, iron-oxide-stained quartz	1 3	130	7,000	700	150	60	6.0	1,500
K13	Grab, quartz with small sulfide crystals	9.5	1,000	10,000	220	200	400	22	10,000G
K14	1.2-ft chip, quartz vein	.06	4.0	1,400	760	20	2 0	.7	1,000
K15	Grab, iron-oxide-stained quartz with abundant pyrite	20	220	13,000	2,000	700	200	30	10,000G
K196	Grab, green crusted mineral, oxidized, gossan	1 0	100	11,000	560	900	200	8 5	10,000
K197	Grab, same as K196, brownish-yellow-stained, oxidized, dry bone appearence	11	660	1,800	220	300	400	32	1,000
K198	Grab, iron-oxide-stained gossan	4 0	680	19,000	1,300	2,600	2,000	45	10,000
K199	10-ft chip, gossan	2	4 0	10,000	340	60	20	4 5	200
K200	8-ft chip, gossan	4	4.0	14,000	660	600	80	4 5	2,000
K201	18-ft chip, gossan with three 0 5- to 1-in quartz veins	1 0	170	480	240	25	80	2 8	1,000

old workings contain quartz with hematite-filled casts (fig. 84). Some quartz fragments as much as 1 ft (0 3 m) thick contain galena. Alinement of the principal workings indicates a northwest-trending vein. Selected samples (M-29–M-31) taken from the dumps averaged 0 01 oz gold per ton (0.34 g/t), 17.7 oz silver per ton (607 g/t), and 2.2 percent lead.

The four veins exposed on the Buckskin claim are estimated to contain 80,000 tons (73,000 t) of mineralized rock that has a weighted average of 0.11 oz gold per ton (3.8 g/t), 4.12 oz silver per ton (141 2 g/t), and 1 97 percent lead The two veins developed by the two groups of adits along the small south-flowing gulley west and northwest of the Buckskin claim contain an estimated 15,000–30,000 tons (14,000–27,000 t) of mineralized rock with a weighted average of 0 06 oz gold per ton (2 1 g/t), 2.4 oz silver per ton (82.3 g/t), and 2.8 percent lead. The mineralized vein in the northwest corner of the mapped area (fig. 84, sample sites M-29–31), is not well enough defined to permit resource estimates to be made.

Data from additional studies of the Buckskin mine by the U.S. Geological Survey are presented in table 23.

The geologic setting of the Buckskin mine is similar to that of the Valley Creek mine, but significant differences exist in the strike of some veins (figs. 82 and 84), the composition of the mineralized material, and the degree of oxidation. The higher silver/gold ratios and mercury contents (table 23 and fig. 84) suggest that the silver-rich Buckskin veins may grade down into richer gold ores like those in the Valley Creek mine. Sulfide minerals were not seen in the Valley Creek mine, but pyrite is abundant locally in the veins west of the Buckskin claim and galena was seen in some workings. The depth of oxidation inferred from the geophysical data is 130 ft (40 m) south of the Buckskin claim, as compared to 150 ft (46 m) in the Valley Creek mine area.

Most samples collected by the U.S. Geological Survey represent the highest grade material available The highest silver content on the Vera claim (fig. 84, K-8) represents material that contains about nine times as much silver as the next richest sample. Other samples from the same bulldozer cut, however, have a greenish-yellow silver bloom and a high content of silver.

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Three turam traverses were made west of the principal workings of the Buckskin mine (fig. 84). AFMAG measurements were taken along traverses 1 and 2 using natural fields, and along traverse 1 using the turam cable energized with 140 Hz (figs. 84, 85), but the data using natural fields are not presented because they appear to be affected by fields from nearby power lines.

Two of the eight electromagnetic conductors (fig. 84, 2 and 5) are near intersecting mineralized veins. These two linear conducting zones and a third similar conductor (fig. 84, 4), across which is an unsampled bulldozer trench, should be investigated to determine if significant gold and silver values are present, particularly near the intersections of the conducting zones and two veins that contain gold and silver values (fig 84, M-95, M-23 to M-25, and A-345). The other five conductors probably are parallel linear zones of relatively conductive rocks near the surface. No mineralization or mine workings are known along these conductors, but they also could be veins or fracture zones that more or less parallel the four veins on the Buckskin and Early Bird claims.

The largest anomaly found in the Buckskin area, conductor No. 1, is

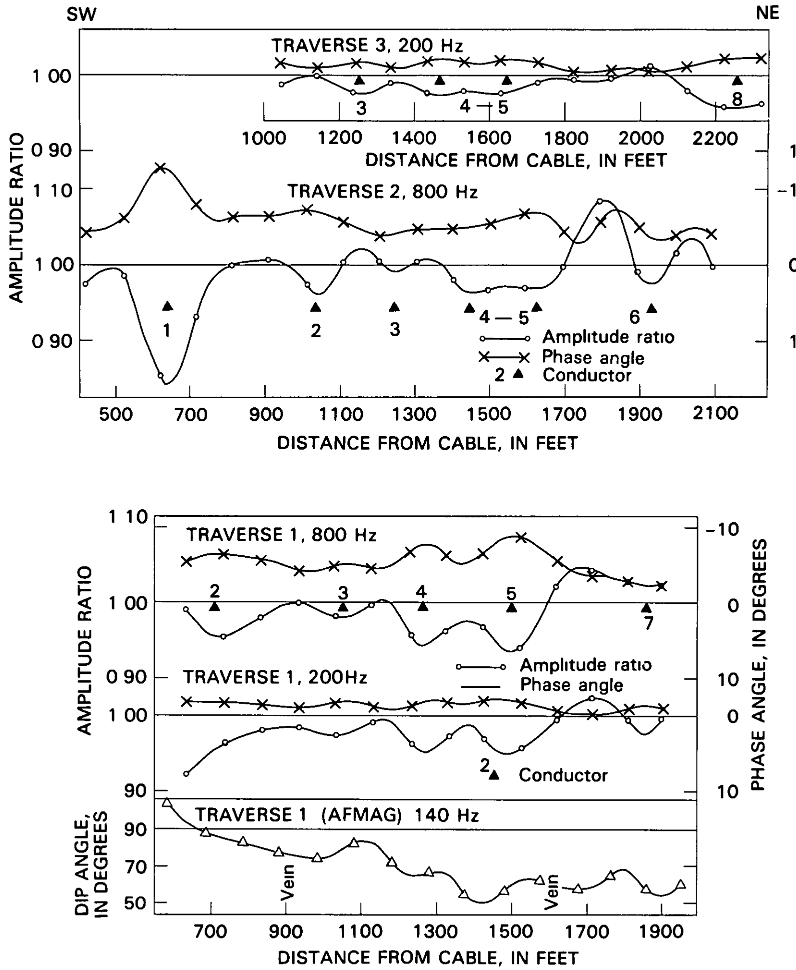

FIGURE 85.—Electromagnetic (turam and AFMAG) profiles along traverses 1–3, Buckskin mine. Distances in feet, 1 ft=0.3048 m.

at the south end of traverse 2 (figs. 84, 85). The 200 Hz amplitude ratios and the dip angle greater than 90° on the AFMAG profile on traverse 1 also suggest an anomaly south of the south end of traverse 1 that may reflect the southeast extension of conductor 1. Relatively large measured phase differences and changes in amplitude ratios suggest that the conductivity is rather low. This anomaly could be caused by a highly conductive dike-like body with the top at a depth of about 130 ft (40 m) or less, or by a wide zone of overburden that has greater than normal conductivity.

The positions of conductors shown on figure 84 were deduced from the turam profiles (fig. 85); the correlation between traverses is uncertain. The conductors that correlate best are anomalies 4 and 5 on traverse 1, which appear to coalesce westward into one broad anomaly on traverses 2 and 3. If projected along strike, this zone would pass eastward into the parallel vein system on the Buckskin claim and westward into the westernmost workings (M-29 through M-31). Conductors 6, 7, and 8 (fig. 84) possibly represent a single arcuate conductor. Another possibility is that these are short separate conductors that represent local increases in the conductivity of the overburden.

The relatively large and constant turam phase angles indicate that the rock conductivity generally is high To estimate the conductivity, cumulative phase angles for both 200 and 800 Hz on traverse 1 were plotted on semilog paper as a function of the distance from the cable (fig 86). The field curves were then matched to theoretical curves for a line source over both a homogeneous and a two-layer horizontally stratified earth. The fit between the first part of the 800-Hz field curve and a homogeneous earth having a resistivity of 50 ohm-meters is fairly close. The first part of the 200-Hz field curve also roughly fits the theoretical curve for a homogeneous earth having a resistivity of 172 ohm-meters These results indicated that a two-layer model should be used The field data fit remarkably well a two-layer model in which the surface layer is 131 ft (40 m) thick and has resistivities of 25 and 40 ohm-meters at 800 and 200 Hz, respectively. In both cases the resistivity of the lower layer was assumed to be infinite, although it could have been assumed to be of several hundred ohm-meters without changing the results significantly.

The discrepancy between the theoretical and observed 200 and 800 Hz curves probably results primarily from lateral variations in the conductivity and thickness of the upper layer and secondarily from instrumental error and the assumption of an infinite rather than a finite cable In any case, the presence of a relatively thick and conductive surface layer is a significant impediment to electrical prospecting methods

POTATO MOUNTAIN URANIUM PROSPECTS

Four uranium claims outside the study area were examined to determine if mineralized structures might cross into the study area. The claims are on or near Potato Mountain on the north end of a uranium belt that extends southeast to the Salmon River (Kern, 1959). These claims, the Main Diggings, Bell Cross, H & M, and Baker (pl. 3, Nos. 12, 13, 11, and 10, respectively), were located on pegmatite, aplite, and granite porphyry dikes that are intrusive into quartz monzonite

Uranium minerals apparently are localized along northwest-trending fractures and are associated with chalcedony. Siliceous aplite appears

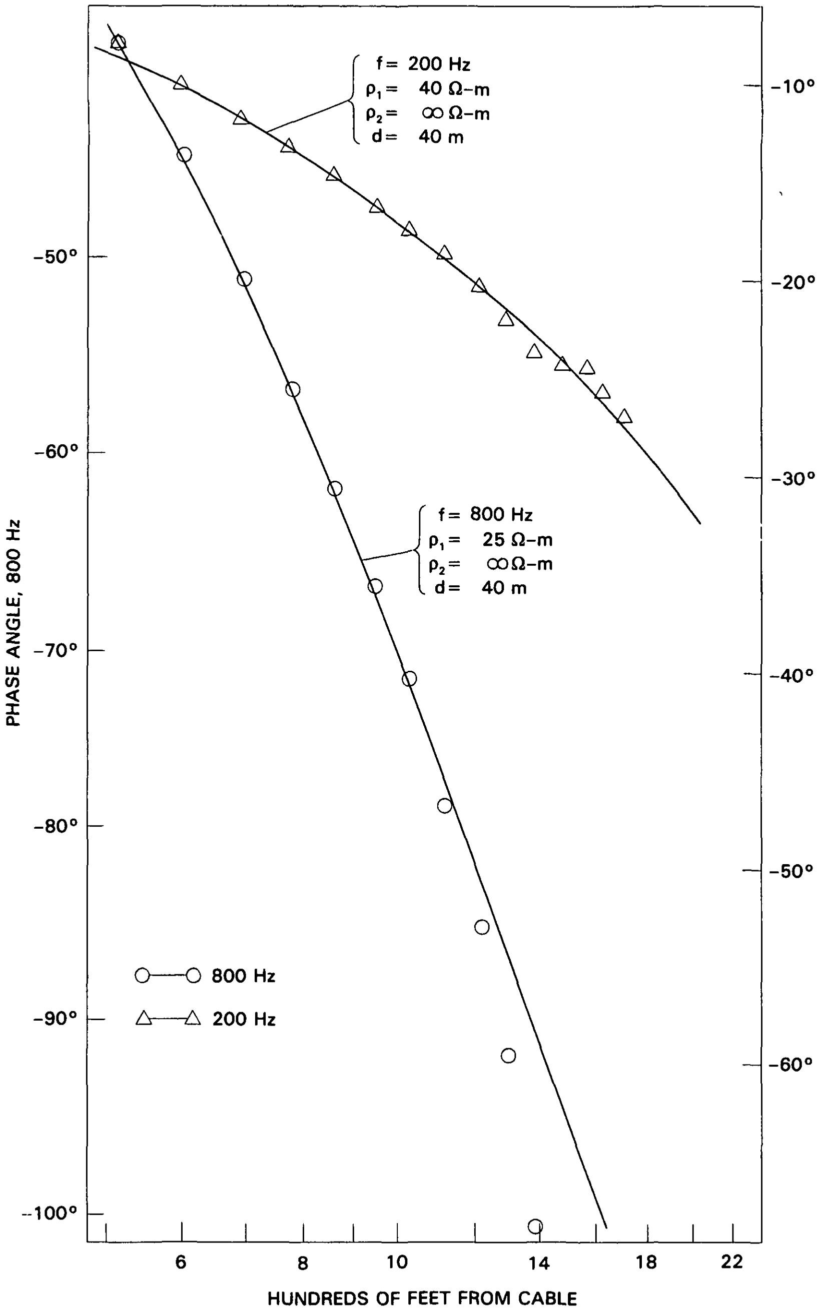

FIGURE 86 —Comparison of phase-angle results with two-layer theoretical curves along traverse 1, Buckskin mine Distances in feet, 1 ft=0 3048 m, f, field, ρ, resistivity, d, distance between points

to be the favorite host rock, but radioactivity near pegmatite dikes and associated narrow shears on the Baker claim measured as high as 10 times background. Small autunite scales were found as coatings along one shear zone. Weak radioactivity was detected in most of the cuts on the Main Diggings, Bell Cross, and H & M prospects. One reading of radioactivity measured five times background at the Bell Cross property. The uranium belt does not appear to continue into the study area.

ELK MOUNTAIN AREA

The Elk Mountain area is in the southwestern part of the Valley Creek district (pl. 3) A contact between Precambrian metasediments on the east and quartz monzonite of the Idaho batholith on the west trends north-northwest approximately along the crest of Elk Mountain (pl. 1) Along the contact is a silicified zone containing iron-oxide-stained quartz that is traceable for about 0.5 mi (4 km). The contact, at the northern and southern flanks of the mountain, to an elevation of about 6,800 ft (2,070 m), is covered by glacial debris. The silicified zone grades successively into zones of pegmatite, gneiss, and schist eastward from the batholith. Sparse galena and pyrite were observed in boxwork structures within the silicified zone. The pegmatite zone is predominantly quartz, microcline, and perthite. Malachite and chrysocolla occur locally near the top of this zone. The pegmatite zone is generally 10–20 ft (3–6 m) thick on the south end of the mountain.

The highly silicified contact zone between the metasediments and the batholith has been explored locally along the entire length of the mountain, largely by shallow prospect pits. The Stanley Ace No. 1 and the Shorty (old Gem State No. 2) are the principal claims along the silicified contact at the south and north ends of the mountain, respectively Samples indicate that parts of the silicified zone locally contained as much as 0.27 oz gold per ton (9.3 g/t) and as much as 3.7 oz silver per ton (127 g/t). Potential resources of low-grade graphite occur in the schist at both ends of Elk Mountain. Samples reportedly contain as much as 4.7 percent graphite (Vernon Taylor III, oral commun., 1971) Idocrase in pegmatites at the south end of the mountain contains as much as 0.15 percent beryllium (Pattee and others, 1968) but is of no economic importance.

SHORTY (GEM STATE) GROUP

The Shorty group (pl. 3, No. 7) consists of nine unpatented claims located in 1968 and includes the old Gem State group originally located in 1929. Work conducted on the Gem State claims during the

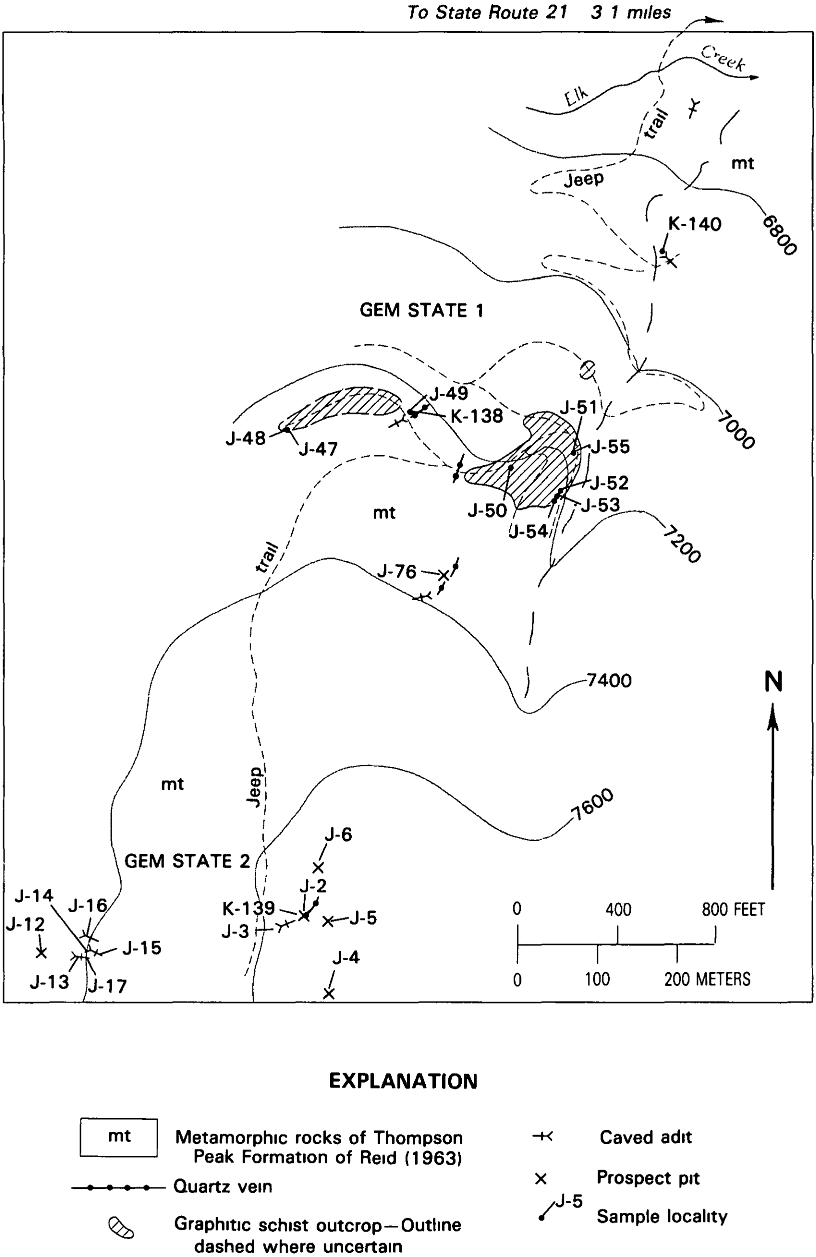

FIGURE 87 —North end of Elk Mountain Contour interval 200 ft

years 1931-1942 included 366 ft (112 m) of adits on two unpatented claims (Idaho Bureau of Mines and Geology, 1942). The claims were located for gold, but no record of production is known. The lower adit

Data for samples shown on figure 87

[Tr, trace, N, none detected, leaders (-), not analyzed, 1 troy oz/ton=34 285 g/t, 1 ft=0 3048 m]

Sample				Gold	Silver	Lead	Zinc	Copper	Organic carbon
No.	Type	Length (ft)	Description	(oz/ton)		(percent)			
J-2	Select	([1])	Iron-oxide-stained quartz (stockpile).	Tr	0.3	--	--	--	--
J-3	Grab--		Quartz stringers in gneiss (dump).	N	N	--	--	--	--
J-4	-do---		---do---------	N	N	--	--	--	--
J-5	-do---		---do---------	N	N	--	--	--	--
J-6	-do---		---do---------	N	.1	--	--	--	--
J-12	Select		Iron-oxide-stained quartz (stockpile).	0.14	2.0	0.29	--	--	--
J-13	-do---		---do---------	.25	.5	.15	--	--	--
J-14	-do---		---do---------	.27	.8	.20	--	--	--
J-15	-do---		---do---------	.03	.9	.36	--	0.16	--
J-16	-do---		---do---------	Tr	1.1	.29	0.09	--	--
J-17	-do---		---do---------	.25	.4	.05	--	--	--
J-47	Grab--		Carbonaceous soil.	N	N	--	--	--	1.99
J-48	-do---		---do---------	N	N	--	--	--	--
J-49	Select		Copper-carbonate-stained quartz (dump).	N	2.5	--	--	0.98	--
J-50	Random chip.		Graphitic schist	N	N	--	--	--	--
J-51	Select chip.		---do----------	0.01	--	--	--	--	3.00
J-52	Chip--	6.0	---do----------	--	--	--	--	--	2.07
J-53	-do---	9.0	---do----------	--	--	--	--	--	2.51
J-54	-do---	10.0	---do----------	--	--	--	--	--	2.54
J-55	Select		---do----------	--	--	--	--	--	2.60
J-76	Grab--		Quartz (dump)	Tr	0.3	--	--	--	--
K-138	Select		Copper-carbonate stained quartz (stockpile).	.01	1.46	0.15	0.12	0.30	--
K-139	Chip--	30.0	Iron-oxide-stained quartz.	.023	.44	.004	.04	.004	--
K-140	Select		Iron-oxide-stained quartz (stockpile).	.087	.058	.002	.001	.007	--

[1]Blank, not measured.

on the Gem State No. 1 claim was reported to have produced silver. All the adits were caved and inaccessible at the time of investigation

The old Gem State No 1 workings (fig. 87) explore at least two north-trending quartz veins in gneissic rocks that also contain interlayered schist Sparse specks of malachite and chrysocolla were observed in the quartz veins, but no sulfide minerals were seen. A boxwork of iron oxides indicates that pyrite and possibly galena have been leached from the veins. Dimensions of the mineralized structures are not known, but judging from dump and stockpile material, the width of the main vein probably did not exceed 2 ft (0.6 m). The lower adits on the Gem State No 2 claim apparently were dug to explore the silicified zone between the metasediments and batholith rocks. The zone is at least 50 ft (15 m) thick and is composed of iron-oxide-stained, vuggy vein quartz containing as much as 10 percent voids. All sulfides except an occasional grain of pyrite have been leached from the rock, leaving only a coating of hematite.

Graphitic schist is exposed in roadcuts at the old Gem State No 1 claim. The schist is medium to fine grained and contains elongated flakes of graphite that range from minus 35 to plus 200 mesh in size. Minor amounts of tremolite, calcite, muscovite, and chlorite, and sparse grains of zoisite, pyrite, garnet, and rutile also were identified. It is estimated that the rock would have to be ground to about 100 mesh to liberate most of the graphite

The continuity of graphitic schist is not known because of a moderately thick soil overburden. Only three localities on the north end of the mountain were exposed, where the thickest section is 25 ft (7.6 m). The bedding at this site trends N. 70° E. and dips 51° NW. The graphitic zone may continue to the south end of Elk Mountain, where an isolated outcrop of graphitic schist was sampled on the Stanley Ace No. 2 lode claim.

Six samples contained 1.99–3.00 percent carbon (fig. 87) (determined by microscopic methods). A testing laboratory reportedly analyzed samples from this locality and obtained results ranging from 3.3 to 4.7 percent graphite (Vernon Taylor III, oral commun., 1971) A sample taken from the Stanley Ace No 2 property on the south end of Elk Mountain contained 2.59 percent graphite.

Assuming an average thickness of 25 ft (7.6 m) underlying the three outcrops shown on figure 87, a total of 310,000 tons (221,000 t) of graphitic schist is indicated. The unweighted average carbon content of five samples is 2.54 percent. The metamorphic sequence of rock types appears to be consistent from the north to the south end of the mountain, and if the zone is continuous the potential resources would be on the order of a few million tons.

STANLEY BASIN AREA

Stanley Basin area is in the eastern part of the Valley Creek district, 3 mi (4 8 km) northwest of Stanley (pl. 3).

Tributary valley floors in the area consist mostly of alluvial gravels that contain gold placers. The area is principally underlain by quartz monzonite and associated granitic rocks of the Idaho batholith. Quartz veins in regional fractures trend both northwest and northeast in the granitic rocks.

The discovery of placer gold in 1863 led early prospectors to search the surrounding hills, where quartz veins, largely of replacement type, were found to contain small amounts of gold, silver, and lead.

BRONCO (MOUNTAIN GIRL) MINE

This property is 2 mi (3.2 km) northwest of Stanley (pl. 3, 25). County records indicate the property was first recorded in 1895 as the Mountain Girl, and has been relocated over the years as the Apex, Gold Nugget, and Bronco The property is listed as the Mountain Girl in table 20.

The mine workings are in quartz monzonite and follow a northeast-trending quartz vein along a fault. The vein, mostly massive quartz and stringers of comb quartz, has been brecciated and recemented with quartz Chrysocolla and malachite coat fragments of quartz, and a limonitic boxwork indicates that an iron sulfide, probably chalcopyrite, has been leached No sulfides were observed. The vein ranges from a few inches to 3 ft (several centimeters to 0.9 m) in thickness, and was traced 2,100 feet (640 m) southwest of the mine.

The underground workings were caved or water-filled, but Choate (1962) reported a 225-ft (68-m) adit with two raises to the surface, and two winzes below the adit level. The workings follow the vein, which dips about 40° SE and trends N. 30° E. Material from the mine was treated at a five-stamp mill formerly located on Nip and Tuck Creek.

A total of 24 samples was taken on the two Bronco claims, most from the dumps of shallow exploration pits along the ridge to the northeast and southwest of the main workings. Nineteen selected dump samples contained as much as 0.35 oz gold per ton (12 g/t), 2.63 oz silver per ton (90 g/t), 5.5 percent lead, 0.06 percent zinc, and 0 41 percent copper Five chip samples across vein exposures contained only a trace of gold and silver and as much as 5.5 percent lead, 0 9 percent zinc, and 0.09 percent copper. Two chip samples taken in the adit by Choate (1962, p 92) indicated 0.42 oz gold per ton (14.4 g/t) and 2.46 oz silver per ton (84.3 g/t) in the oxidized portion of the vein. Small mineral resources may exist on this property.

SILVER DOLLAR PROSPECT

The property is on the divide between Doran Gulch and Kelly Creek, about 4 mi (6.5 km) due north of Stanley (pl. 3, 20).

Choate (1962, p. 98) reported that the 35-ft (10.6-m) shaft, which is

TABLE 24 —*Miscellaneous prospects, Valley Creek district*

[1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
1	Prospect	No metallic minerals observed. Workings expose weathered quartz monzonite, some having a pegmatitic texture.	Three dozer cuts and two small sloughed pits.	Four select samples, as much as 0.1 oz silver per ton and trace copper and lead.
2	Fritz	A shear zone 1.5 ft wide is along the east side of a 5-ft-thick latite dike that strikes N. 10° W. and dips 20° SW. in quartz monzonite. An altered zone extends 4 ft into the quartz monzonite from the shear zone. The shear and altered zones are heavily iron oxide stained.	One dozer cut-----------	One chip sample across the dike and one across altered zone, as much as 0.02 oz gold per ton and trace copper and lead.
4	Trail	Workings expose an iron-oxide-stained and fractured andesite dike.	One trench and one pit--	Two select samples of iron-oxide-stained material in pit, as much as 0.1 oz silver per ton and trace copper and lead.
6	Prospect	A thin iron-oxide-stained quartz vein in quartz monzonite striking N. 6° E., dipping steeply SE.	One sloughed pit--------	A select sample, trace gold, 0.4 oz silver per ton, 0.14 percent lead, 0.03 percent zinc.
8	Gold Coin	Quartz veins and stringers in gneissic country rock. A contact between metamorphic and batholithic rocks is slightly silicified. Some malachite coating on quartz fragments.	Approximately a dozen small pits.	Three samples, trace or less gold and silver. One sample, 0.05 oz silver per ton and 0.26 percent percent copper.
9	Stanley Ace	Pyrite, galena, and tetrahedrite (?) finely disseminated in quartz adjacent to the batholith-metamorphic rock contact. Flecks of malachite and chrysocolla occur as coatings. A gneissic zone adjacent to the quartz contains beryllium-bearing idocrase in pegmatites.	Four cuts, three trenches, and seven sloughed pits.	One sample, 2.59 percent graphite. Two of ten samples, 0.1 and 3.7 oz silver per ton. No gold detected. Pegmatites contain up to 0.015 percent beryllium.

14	South Potato Mountain prospects	Silicified, iron-oxide-stained quartz monzonite and some quartz float.	One caved adit, one sloughed pit, a sloughed trench, and four dozer cuts.	One select sample, 0.1 oz silver per ton and a trace of copper. Four chip samples, trace gold, silver, lead, and copper.
15	Blind Ledge North	One dump contains iron-oxide-stained, fractured quartz monzonite and a few small pieces of quartz.	Three pits and a trench, all sloughed.	All select dump samples, 0.48 oz gold per ton and trace of silver and lead. Other samples trace amounts of gold, silver, and lead.
16	Blind Ledge	A quartz vein, 0.5 to 1.0 ft wide, is intermittently exposed for 150 ft in quartz monzonite. The vein strikes northerly and dips 65° E. The quartz is massive, iron oxide stained and contains about 1.0 percent finely disseminated pyrite.	Six backhoe pits in a decomposed quartz monzonite, 1,000 ft north, four hand-dug pits expose the quartz vein.	Six grab samples from the backhoe pits, trace gold, copper, and lead, as much as 0.2 oz silver per ton. Two samples across quartz vein, as much as 0.20 oz gold per ton, 0.7 oz silver per ton, and 0.3 percent lead.
17	Rodman	The vein is not exposed. Chunks of quartz vein material up to 2 ft thick are on dumps. The quartz is vitreous, blue gray, and contains less than 1.0 percent finely disseminated pyrite.	Two hand-dug pits and three dozer cuts.	Two select samples of quartz vein material 0.04 oz gold and 0.2 oz silver per ton, 0.18 oz gold and 1.0 oz silver per ton. Both contained traces of copper and lead.
18	Mamouth No.2	A 5-ft-thick andesite dike in quartz monzonite striking N. 60° E., dipping 45° NW. No ore minerals were observed.	One sloughed pit---------	One sample across dike-quartz monzonite contact, 0.1 oz silver per ton, trace gold, copper, and lead.
19	Mamouth No.1	A 0.5-ft-thick quartz vein striking S. 15° W. and dipping vertically is exposed in a pit.	One pit------------------	One sample across the vein, 0.11 oz gold and 0.2 oz silver per ton and trace copper and lead.
21	Mountain vein	A narrow, iron-oxide-stained shear zone in quartz monzonite trends northwest and dips northeast. No ore minerals were observed.	Two adits, totaling 50 ft long.	Sample across the zone ranged from 0.1 to 0.9 oz silver per ton and traces of lead, zinc, and copper.
22	E. Storlie	No metallic minerals observed. Workings expose decomposed quartz monzonite.	Three dozer cuts and one sloughed pit.	Four dump grab samples, trace gold, copper, and lead, and as much as 0.1 oz silver per ton.
23	Klondyke	Vuggy quartz was observed in the vicinity of the workings.	Two sloughed trenches----	One select sample, 0.02 oz gold and 2.5 oz silver per ton.

TABLE 24 —*Miscellaneous prospects, Valley Creek district*—Continued

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
24	Mountain View group	Graphitic gneiss is underlain by quartz monzonite. Quartz veins and stringers in the granitic rock are iron oxide stained and vuggy.	Four dozer trenches and five pits.	Twelve samples, 0.1 to 0.3 oz silver per ton and trace gold, copper, lead, and zinc. Twelve samples of graphitic gneiss, 0.043 to 2.30 percent total carbon with an unweighted average of 0.61 percent total carbon.
26	Nip & Tuck	An iron-oxide-stained shear zone in quartz monzonite consists of quartz stringers and altered wall rock. No sulfide minerals were visible.	One partially caved adit, accessible for 30 ft.	Seven samples assayed as much as 0.5 oz silver per ton, traces of gold. Traces of mercury, antimony, and copper in some samples.
27	Prospect	Iron-oxide-stained quartz monzonite is exposed. No visible structure or sulfide minerals.	One sloughed pit---------	One sample, no gold or silver.
28	Aspen	Workings along a contact zone containing a quartz vein between a mafic dike and quartz monzonite. Quartz material is iron oxide stained and vuggy. No visible sulfide minerals.	Two adits and seven pits-	Ten samples, trace to 0.02 oz silver per ton, trace to 0.46 percent lead, and trace copper and zinc. One sample of tailings from the stamp mill, 0.05 oz gold per ton.
29	Poorman	Iron-oxide-stained quartz monzonite with small amount of malachite coating. No visible sulfide minerals.	One pit------------------	Two samples, 0.1 and 0.7 oz silver per ton, no gold, and as much as 0.06 percent lead, 0.05 percent zinc and 0.03 percent copper.
30	Prospect	Iron-oxide stain occurs on quartz monzonite country rock.	One shallow test pit-----	One sample, no gold or silver.
31	Prospect	An iron-oxide-stained aplite dike in quartz monzonite. No visible sulfide minerals.	Four sloughed pits-------	Do.
32	Fran Clara	Iron-oxide- and copper-carbonate-stained quartz monzonite on the dump.	One 58-ft-deep shaft, waterfilled.	Two dump grab samples, no gold or silver, trace lead, zinc, copper.

now caved, was sunk on a paper-thin stibnite vein trending N. 65° E. and dipping steeply to the northwest. The vein is parallel to a regional fracture system that can be traced for more than 1.5 mi (2.4 km) east. The original owner of the claim told Choate that the vein contained massive stibnite with quartz gangue occurring only on the margins of 3-ft (0.9-m)-thick vein exposed in a crosscut at the 25 ft (7.6 m) level of the shaft. Ore from this vein reportedly contained $56 of antimony per ton. Stibnite was reported at two other localities along the strike of the vein (Choate, 1962, p. 98).

A selected sample from a stockpile assayed 0.2 oz silver per ton (6.9 g/t) and 14 6 percent antimony Three chip samples across vein outcrops contained no gold or silver, and only 0.02 and 1.0 percent antimony.

MISCELLANEOUS PROSPECTS

Other properties in the district that have no potential resources or were not sufficiently exposed to determine their potential are summarized in table 24.

GALENA DISTRICT

The Galena district as here described is in the southern part of the study area (pl. 3; fig. 34) but does not coincide completely with the Galena mining district of Ross (1941). Several properties contain potential resources of silver, lead, and zinc.

Most of the workings are above 9,000 ft (2,700 m) elevation, where slopes are generally steep and support little vegetation. The district is drained by tributaries of the Wood River, which dry up early in the summer when water is abundant only at low elevations.

Almost without exception the mine workings follow or crosscut shear zones in sedimentary rocks. The mineral deposits are fissure-filled veins or lenses within the shear zones, which trend N. 40° E. and N. 65° W Pyrite is the predominant sulfide mineral, and galena, sphalerite, and argentite are the main ore minerals. Principal gangue minerals are quartz and (or) calcite, which generally nearly fill the shear zones. Only minor alteration and replacement of wall rock occur.

The major metals sought by the early miners were gold and silver. Lead, copper, and zinc were then of secondary importance. During this study many veins were found to contain significant amounts of tin (table 7) County records show that lode mining claims were located as early as 1879 (table 25). Most if not all production has come from the

TABLE 25.—*Summary of mining claims recorded, including relocations, 1879-1971, Galena district*

Decade	Number of lode claims	Number of placer claims
1879	19	--[1]
1880-1889	192	11
1890-1899	22	--
1900-1909	29	3
1910-1919	8	--
1920-1929	3	--
1930-1939	4	--
1940-1949	6	--
1950-1959	25	--
1960-1969	33	--
1970-1971	2	--
Total-----	343	14

[1]Leaders (--), none recorded.

14 patented claims They were developed before accurate production records are kept; therefore, total production is not known. A 30 ton/day (27 t/day) smelter was built at the town of Galena in the early 1880's The U.S Geological Survey (1886) reported that "* * * small quantities of high-grade ores have been shipped, and in some cases transportation facilities have been improved, so that there is some outlook for a larger and steadier supply." Recorded production for the district is shown in table 26 Current activity in the district is limited to prospecting and assessment work.

Four properties have an estimated 19,000-27,000 tons (17,000-24,000 t) of resources that average about 4 oz silver per ton (137 g/t) and 5 percent lead The Highland Chief claim has an additional 188,000 tons (171,000 t) of estimated submarginal resources that average about 0 4 oz silver per ton (13.7 g/t), 1.0 percent lead, and 2 8 percent zinc. Other properties may contain additional resources, but data on them were insufficient to make estimates. Two of these, the Senate and Lone Trail properties, were developed extensively. Many properties in the district have a potential for discovery of high-grade ore shoots.

HIDDEN TREASURE CLAIM

The Hidden Treasure claim (pl. 3, 201) was located in 1880. Records are incomplete, but 5 tons (4.5 t) of ore were shipped in 1933

The mine workings (fig. 88) were driven along shear zones and quartz

TABLE 26 —*Recorded metal production, 1902-1957, Galena district*

[Data from U S Bureau of Mines production records Leaders (--), none recorded 1 ton=0 9 t, 1 troy oz=31 1 g; 1 lb=0 45 kg]

Year	Mine	Ore (tons)	Gold (oz)	Silver (oz)	Copper (lb)	Lead (lb)
1902	Black Carbonate-	6	1	510	--	7,800
1903	---do-----------	7	3	1,600	--	5,000
1904	---do-----------	5	1	746	--	6,600
1905	---do-----------	2	--	630	--	4,000
1907	---do-----------	1	--	75	--	1,200
1908	---do-----------	49	3	1,217	--	14,714
1928	Chief-----------	2	1	158	--	2,459
1929	---do-----------	1	1	2	--	10
1941	Red Cloud-------	36	7	205	--	2,278
1942	---do-----------	771	96	2,962	850	32,416
1957	Coffee Pot group	1	--	56	--	300
	Total-----------	881	113	8,161	850	76,777

veins in quartzite. A quartz fissure vein trending N. 55° E and dipping 65° SE. is exposed in the shaft and one trench. The vein is exposed intermittently for 175 ft (53 m) and can be inferred for 185 ft (56 m) farther by pit dumps. It pinches and swells but averages 16 in (40 cm) thick. Pyrite and other sulfides occur in quartz, calcite, and gouge. Samples across the vein, weighted by length, averaged 3.9 oz silver per ton (134 g/t), 1 4 percent lead, 0.11 percent copper, and trace gold. Spectrographic analyses show that all samples contained minor amounts of zinc.

An adit near the shaft crosscuts a 1.5-ft (0.45-m)-wide shear zone but does not intersect the quartz vein. A selected sample of breccia, possibly from the shear zone, taken from the dump contained 19 oz silver per ton (651 g/t) and 11 percent lead.

Assuming the vein persists downdip for half the inferred strike length, resources are estimated to be 6,700 tons (6,000 t). The large quantity of sulfide-bearing vein material on the dumps of the caved workings indicates that additional subparallel veins may occur. Samples from these dumps averaged 2.9 oz silver per ton (99 4 g/t), 0.5 percent lead, 0 2 percent copper, and trace gold.

RED CLOUD CLAIM

The Red Cloud claim (pl. 3, 205) was patented in 1888 by the Alturas Senate Mining Co Current ownership is not known. Production records are not complete, but a total of 807 tons (732 t) of ore contain-

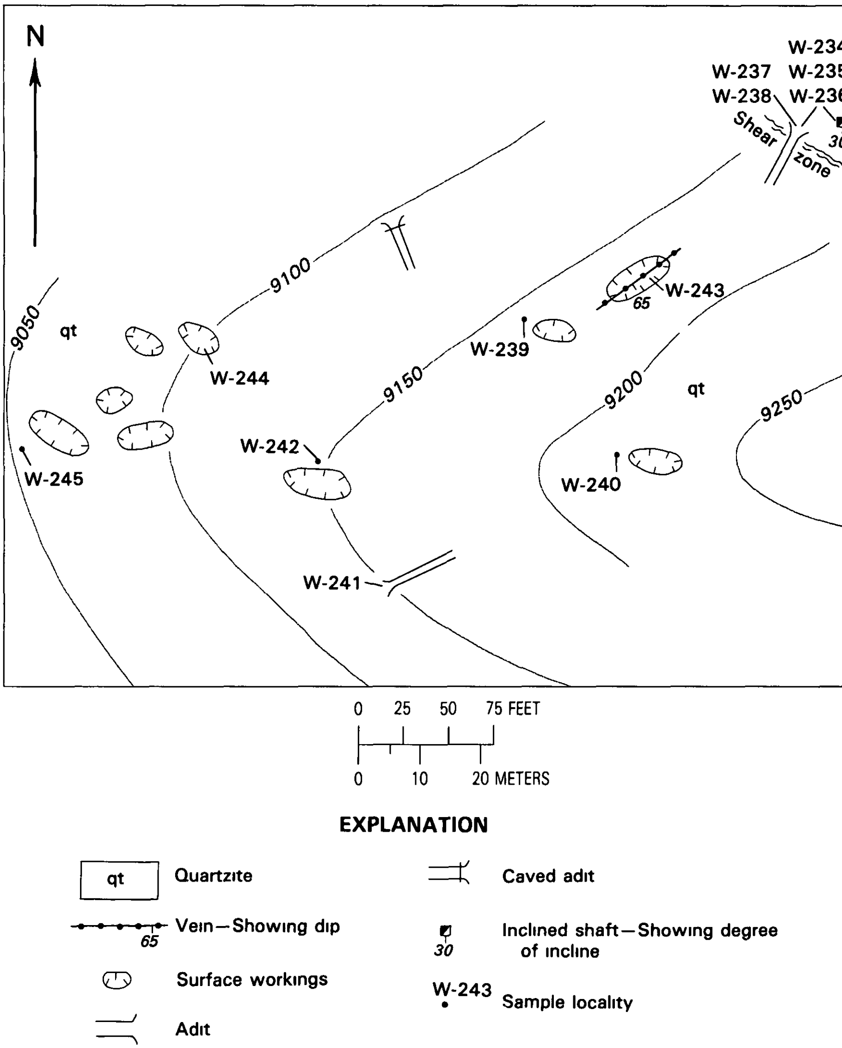

FIGURE 88 —Hidden Treasure claim Contour interval 50 ft

ing 103 oz (3 5 kg) of gold, 3,167 oz (108.6 kg) of silver, 850 lb (386 kg) of copper, and 34,694 lb (15,737 kg) of lead was shipped in 1941 and 1942 (table 26)

The workings (fig. 89) were driven along shear zones in quartzite that are highly oxidized and contain quartz veins, gouge, and brecciated quartzite. Sulfide minerals occur in the quartz and the sheared quartzite. The largest shear zone is exposed in a T-shaped adit (fig 89) 76 ft (23 m) along strike, but it was not seen on the surface. The zone averages 37 in. (0 9 m) in width and narrows to the north. Ore has been

Data for samples shown on figure 88

[Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

No	Sample Type	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Copper (percent)
W-234	Chip--	1 0	Across vein-------------	N	0.9	0 09	--	0 04
W-235	--do--	5	---do-------------------	0 01	5 2	38	--	.18
W-236	--do--	1 1	---do-------------------	Tr	6 4	3 9	--	14
W-237	--do--	1.5	Shear zone--------------	.01	4 4	4 1	--	10
W-238	Select	([1])	Gouge and quartzite breccia (dump).	.03	19.0	11 0	--	24
W-239	Grab--		Quartz vein material (dump)	Tr	2 2	1 0	--	79
W-240	--do--		---do-------------------	Tr	6 6	70	--	.13
W-241	--do--		Granitic rock (dump)----	Tr	2	.20	--	--
W-242	--do--		Quartz (dump)-----------	Tr	2 7	.37	--	06
W-243	Chip--		Across vein-------------	Tr	3 4	73	--	10
W-244	--do--		Iron-oxide-stained zone-	Tr	9	10	0 1	--
W-245	Grab--		Quartzite and quartz (dump)	Tr	2 7	30	--	--

[1] Blank, not measured

stoped from a raise in the zone (W-182). Samples across the shear zone in the adit, weighted by length, averaged 3 5 oz silver per ton (120 g/t), 1.0 percent zinc, and 0.05 percent lead. Samples from other structures on the property averaged 1.3 oz silver per ton (44.6 g/t), 0.9 percent lead, 0.8 percent zinc, and 0.07 percent copper. Most samples contained minor amounts of zinc and copper, according to spectrographic analyses.

The potential submarginal resource near the T-shaped adit is 1,500 tons (1,360 t), assuming that the mineralized zone extends 110 ft (34 m) along the strike and downward a distance of one-half the strike length. The grade of the potential resources is estimated at 3.5 oz silver per ton (120 g/t)

BLACK CARBONATE CLAIM

The Black Carbonate claim (pl 3, 217) was patented in 1903 by the Carbonate Hill Mining Co. Production records are not complete, but 70 tons (64 t) containing 8 oz (274 g) of gold, 4,778 oz (163.8 kg) of silver, and 35,714 lb (16,200 kg) of lead were shipped from the property between 1902 and 1908 (table 26).

An inclined shaft (fig. 90) crosscuts a shear zone that strikes N. 44° E. and dips 30° SE. in limonite-stained quartzite. The quartzite is sheared throughout the excavation, but a prominent zone is exposed 100 ft (30 m) along strike on one underground level. Its thickness ranges from 2 to 20 in. (5 to 50 cm), averages 12 in. (30 cm), and narrows to the southwest. Sulfide minerals occur in the gouge and quartz

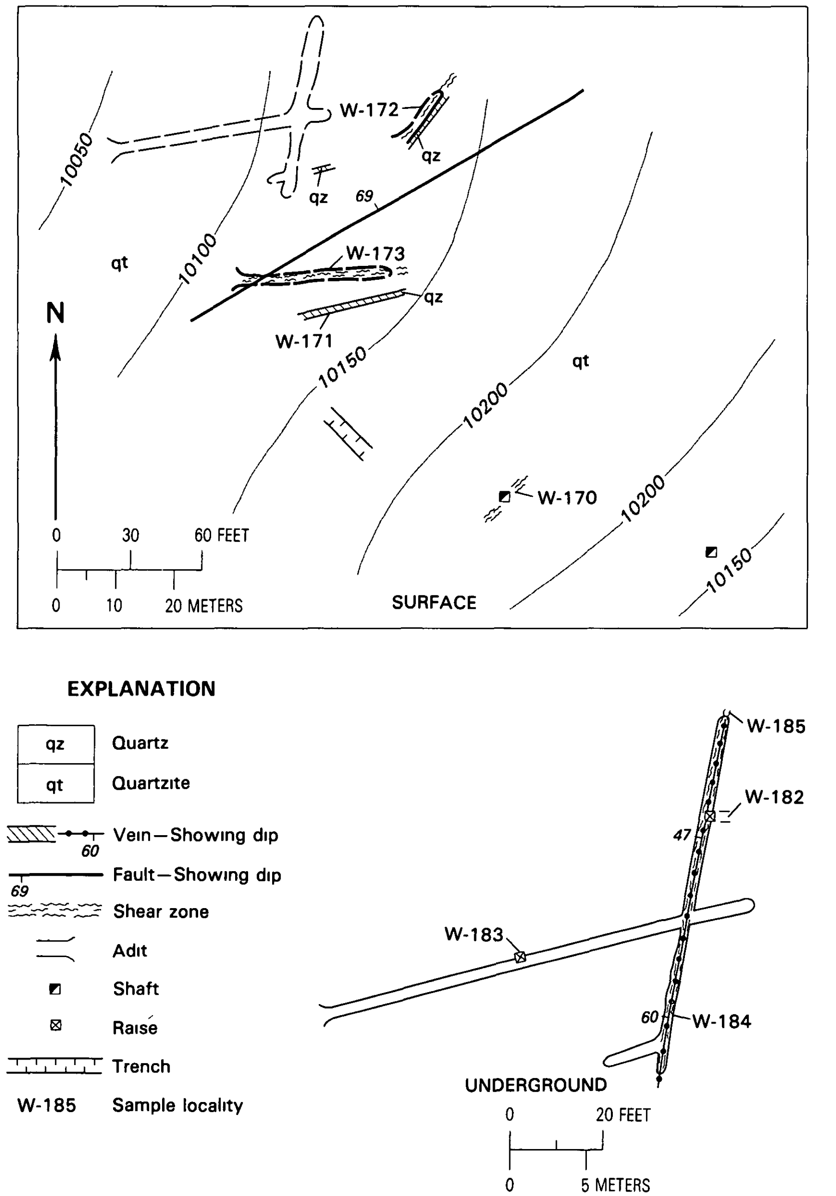

FIGURE 89 —Red Cloud claim Contour interval 50 ft

veins and veinlets in the shear zone Samples across the zone, weighted by length, averaged 11 4 oz silver per ton (321 5 g/t), 3.5 percent lead, 4 7 percent zinc, and trace gold Minor amounts of copper were de-

Data for samples shown on figure 89

[All samples chip Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver	Lead	Zinc	Copper
No.	Length (ft)	Description	(oz/ton)		(percent)		
W-170	3.4	Across shear zone-------	N	2.8	3.2	0.50	0.20
W-171	3.5	Across quartz vein------	N	Tr	Tr	1.0	--
W-172	8.0	Across shear zone (adit)	N	.30	.60	1.0	--
W-173	2.0	---do-------------------	N	.40	.30	--	--
W-182	2.5	Across quartz vein------	N	12.1	--	2.0	--
W-183	1 5	Across oxidized zone----	Tr	7.1	--	--	--
W-184	6.0	Across shear zone-------	N	.30	--	--	--
W-185	.6	Across quartz vein------	N	20	--	--	--

tected in all samples by spectrographic analysis. The sample with the highest silver, lead, and zinc values contains 0.22 percent tin.

Only a few hundred tons of potential resources can be estimated to occur at this property because of limited exposures. The property, however, has a good potential for discovery of shoots containing high silver values (W-153)

CHIEF CLAIM

The Chief claim (pl. 3, 202) was patented in January 1888 by the Alturas Senate Mining Co. Present ownership is not known. Recorded production is 2 tons (1.8 t) in 1928 and 1929 (table 26).

Workings are mostly along shear zones that trend N. 30° E. in quartzite (fig 91) The zones are highly oxidized, and many are filled with quartz locally containing pyrite, galena, and chalcopyrite. The largest vein, exposed in the two lowest adits, averages 13 in. (33 cm) in thickness and can be traced underground for 150 ft (46 m) along strike and 20 ft (6 m) downdip; it narrows northward. Ore has been stoped between the adits and above the upper adit Samples across the zone, weighted by length, averaged 5.5 percent lead, 2 8 oz silver per ton (96 g/t), and 0.01 oz gold per ton (0 34 g/t). Spectrographic analyses show that all samples contained minor amounts of zinc and copper. Two samples (W-196, W-186) contained 0.78 and 0.24 percent tin, respectively (table 7).

Potential resources in the lower adits are estimated to be about 1,000 tons (907 t), assuming a dip length of half the exposed strike length. Additional resources probably occur in the caved north workings, where grab samples indicate pods containing higher values than in the lower adits.

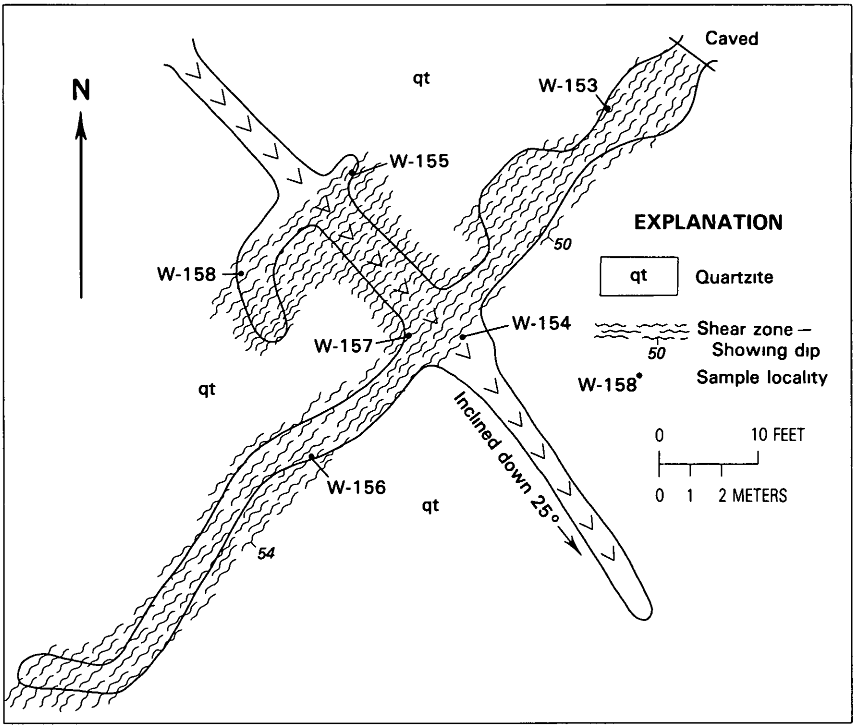

FIGURE 90 —Black Carbonate claim

Data for samples shown on figure 90

[Samples chip except W-154, random chip N, none detected, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver	Lead	Zinc
No.	Length (ft)	Description	(oz/ton)		(percent)	
W-153	1.5	Across shear zone	N	39.8	10.1	8.0
W-154	([1])	Quartz stringer--	0.14	5.7	.60	2.0
W-155	1.0	Across shear zone	N	1.7	2.0	.10
W-156	1.5	---do------------	N	3.8	1.0	8.0
W-157	1.5	---do------------	N	4.3	2.0	4.0
W-158	1.0	---do------------	N	.3	1.0	.50

[1]Blank, not measured.

BIG FIVE CLAIMS

Ore has been mined from the Big Five claims (pl. 3, 186), but the production was not recorded. The workings follow north-trending shear zones in quartzite. The zones are 2–42 in. (5 cm–1 m) wide, average 15 in. (38 cm) in width, and are 50–150 ft (15–46 m) long They are highly oxidized and contain finely crushed quartzite, quartzite breccia, and some calcite and quartz. Sulfide minerals are found throughout the zones but are especially common in the quartz-rich portions. The best exposures are in the lower adit and an adit to the northeast (sample W–269).

The shear zones in the lower adit (fig. 92) are the most significant. The main shear zone can be traced northward on the surface 80 ft (24 m) to a pit, making the total strike length 130 ft (40 m). It averages 1 2 ft (0 37 m) in width and contains a weighted average content of 1.4 oz silver per ton (48 g/t), 0.07 percent lead, and trace gold. This zone and six others together average 1.4 oz silver per ton (48 g/t), 0.73 percent lead, and trace gold. Most samples contained minor amounts of zinc, copper, and tin (table 7), according to spectrographic analyses.

A second shear zone (W–269), 200 ft (60 m) northeast from the lower adit, is 1 ft thick and can be traced in an adit and north to a pit, a distance of 130 ft (40 m). A sample from the adit contained 4.1 oz silver per ton (140 g/t), and 1.8 percent lead. The other zones or veins observed on the property are smaller and contain lower values.

Although the grade of the shear zones and veins is too low generally to be minable, sample analyses indicate some potential for higher values in the workings described and those to the east (fig. 92).

SENATE LODE

The Senate property (pl. 3, 200) was patented by the Alturas Senate Mining Co. in 1888, and contains nine adits (fig. 93) that total about 2,100 ft (640 m) in length. Ore was mined from the property, but the amount was not recorded.

The deposits are difficult to evaluate because all the adits are caved and surface exposures are poor, but scattered outcrops indicate that workings are on shear zones in quartzite. The alinement of the workings suggests northwest trends north of the ridge and northeast trends south of it. Mineralized structures may extend for 1,000 ft (300 m). The dumps consist of quartzite, highly oxidized gouge and breccia, and barren quartz. Some quartzite contains pyrite. Samples averaged 2.0 oz

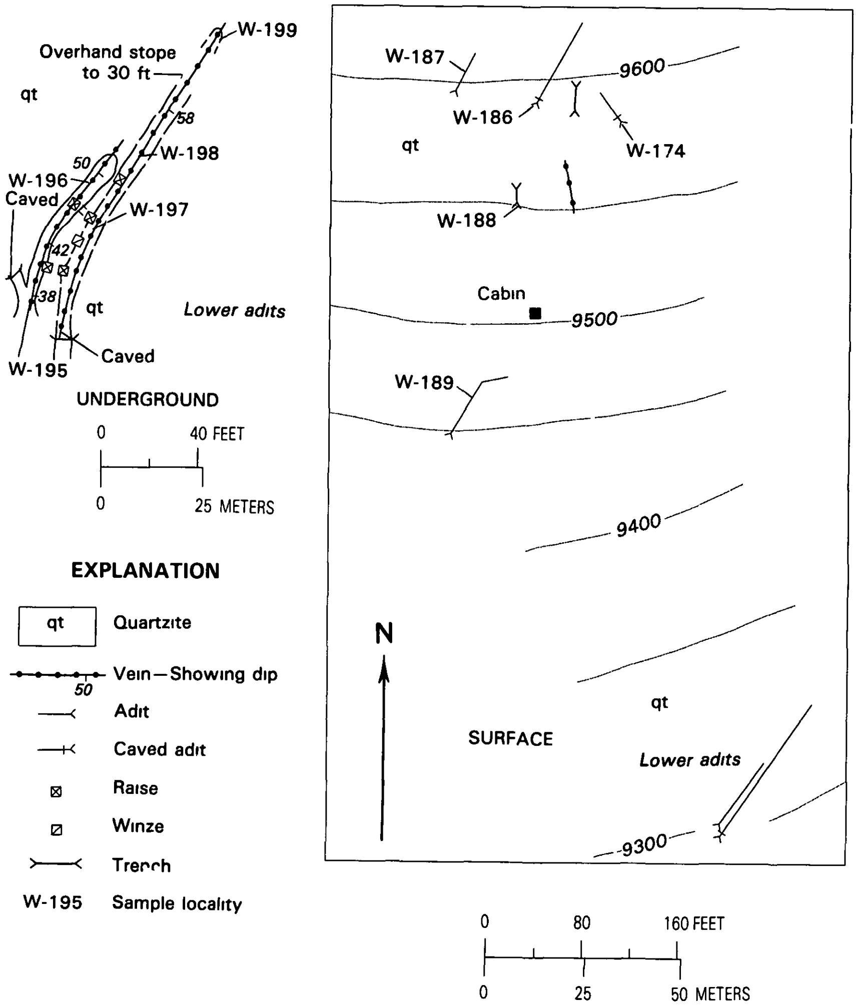

FIGURE 91 —Chief claim Contour interval 50 ft

silver per ton (69 g/t), 3 5 percent lead, and trace gold. Copper and zinc were detected in most samples by spectrographic analysis.

HIGHLAND CHIEF CLAIM

The Highland Chief claim (pl. 3, 209) was located in 1881 and restaked in 1890 and 1910 There has been no metal production from the claim, possibly because zinc is the predominant metal in the mineralized zones and gold, silver, and lead values are very low.

Data for samples shown on figure 91

[Tr, trace, N, none detected, leaders (-), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc	Copper
No.	Type	Length (ft)	Description	(oz/ton)		(percent)		
W-174	Grab--	([1])	Quartz (dump)---	Tr	7.4	12.5	3.0	0.13
W-186	--do--		---do-----------	N	12.1	15 0	--	45
W-187	Chip--	6.0	Across quartz vein.	Tr	30	10	--	--
W-188	Grab--		Quartzite (dump)	Tr	1.9	.60	30	--
W-189	Chip--	3.0	Across quartz vein.	Tr	Tr	20	--	--
W-195	--do--	2.0	---do-----------	Tr	.40	27	--	.34
W-196	--do--	1.1	---do-----------	0.03	6.4	18.7	--	.40
W-197	--do--	1.0	---do-----------	.01	4.3	96	--	--
W-198	--do--	.6	---do-----------	Tr	2 9	7 8	--	--
W-199	--do--	5	---do-----------	.01	1 7	1.2	--	--

[1]Blank, not measured.

Mine workings consist of three adits and a shaft that were driven along mineralized shear zones in quartzite (fig. 94). The two larger shear zones average 12 ft (3.7 m) thick and are traceable at the outcrop for about 500 ft (152 m).

The upper adit and shaft were driven along the west shear zone, which is 1 ft (0.3 m) thick and contains gouge, quartz, sphalerite, and galena. A sample (Z-91) across the zone contained 16 percent zinc.

The middle adit and two prospect pits explore the large middle shear zone (fig 94), which contains gouge, quartz, and sulfide minerals. A 14-ft (4 3 m) sample (Z-90) across the north end of the zone contained 16 percent zinc, 0 4 oz silver per ton (13.7 g/t), and 0.12 percent lead, and samples of the zone from the adit (fig 95), weighted by length, averaged 4.4 percent zinc, 0.5 oz silver per ton (17 g/t), and 0.40 percent lead.

The lower adit is along the west shear zone, which is 4-7 ft (1.2-2.1 m) wide. One sample (Z-98) from the zone contained 1 percent lead and 1 percent zinc.

Assuming the mineralized zone persists to depths equal to half the indicated lengths, potential low-grade resources in the upper and middle adits are estimated at 180,000 tons (163,000 t), the average grade of which is 0.4 oz silver per ton (13.7 g/t), 2.8 percent zinc, and 1.0 percent lead Higher zinc content in samples from the west and middle shear zones, near the granitic dike, suggest that zinc mineralization may be related to the dike, and if so, higher grade zinc reserves may exist in the northern part of the zones and farther north beneath the talus

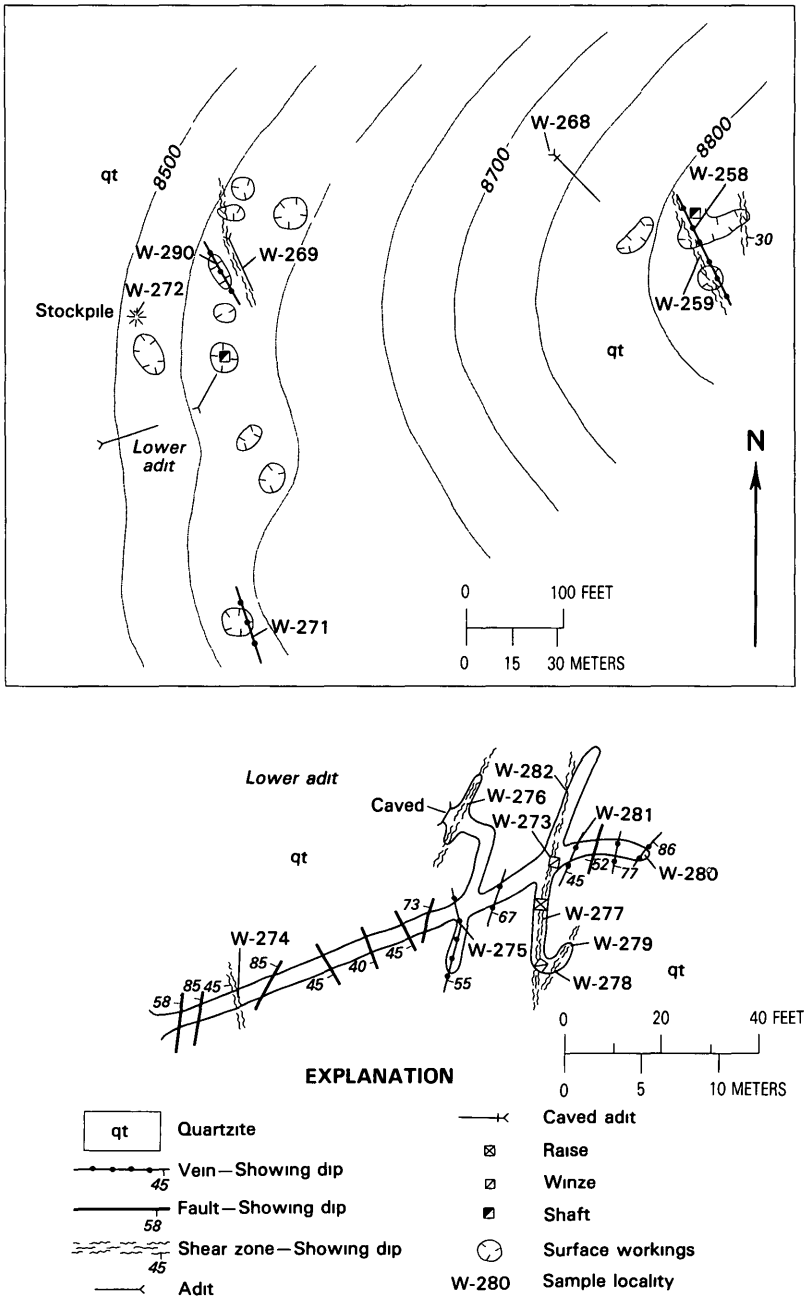

FIGURE 92.—Big Five claims. Contour interval 50 ft.

Data for samples shown on figure 92

[Tr, trace, N, none detected, leaders (-), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc	Copper
No.	Type	Length (ft)	Description	(oz/ton)		(percent)		
W-258	Chip--	0.5	Across calcite vein	N	0.10	0.04	--	--
W-259	--do--	1.0	Across shear zone--	Tr	1.1	.60	--	--
W-268	Grab--	([1])	Quartz (dump)------	Tr	5.2	3.2	--	--
W-269	Chip--	1.0	Across shear zone (adit).	Tr	4.1	1.8	--	--
W-271	--do--	3.5	Across quartz vein-	Tr	.10	--	--	--
W-272	Grab--		Quartz (dump)------	0.01	12.6	2.0	--	--
W-273	Chip--	2.0	Across shear zone--	Tr	.50	.17	--	--
W-274	--do--	1.3	---do--------------	Tr	.20	--	--	--
W-275	--do--	1.2	Across quartz vein-	Tr	5.3	1.1	--	--
W-276	--do--	1.3	Across shear zone--	Tr	1.2	.15	--	--
W-277	--do--	.6	---do--------------	Tr	3.5	2.6	--	--
W-278	--do--	1.0	Intersection of two zones.	Tr	3.4	3.3	--	--
W-279	--do--	2.5	Across shear zone--	Tr	1.7	2 5	--	--
W-280	--do--	1.0	Across quartz vein-	Tr	.20	--	--	--
W-281	--do--	.1	---do--------------	.01	11.5	1 5	--	0.17
W-282	--do--	5.0	---do--------------	Tr	1.1	.13	--	--
W-290	--do--	1.0	Across calcite vein	Tr	Tr	.07	--	--

[1] Blank, not measured.

LONE TRAIL GROUP

The Lone Trail group (pl. 3, 181) consists of six claims The mine workings (fig 96) are along shear zones in porphyry or quartzite. Most zones strike either N. 65° E. or N. 20° W.; dips range from 40° to vertical The zones are from 5 in. to 9 ft (12.7 cm to 2.7 m) thick and average 36 in (0.9 m) Exposed strike lengths are as much as 200 ft (60 m). The zones contain sulfides disseminated through an iron- and manganese-oxide-stained gangue of quartz, and crushed or brecciated wall rock. Some samples contained high values, but chip samples across the shear zones, weighted by length, averaged 2.7 oz silver per ton (93 g/t), 1.2 percent lead, and 0.02 oz gold per ton (0.69 g/t). Three samples contained as much as 1 03 percent tin (table 7). Spectrographic analysis showed that most samples contained minor amounts of zinc and copper.

Continuity between individual exposures is poor Therefore, potential resources cannot be reliably estimated, but the property has a good potential for discovery of high-grade shoots.

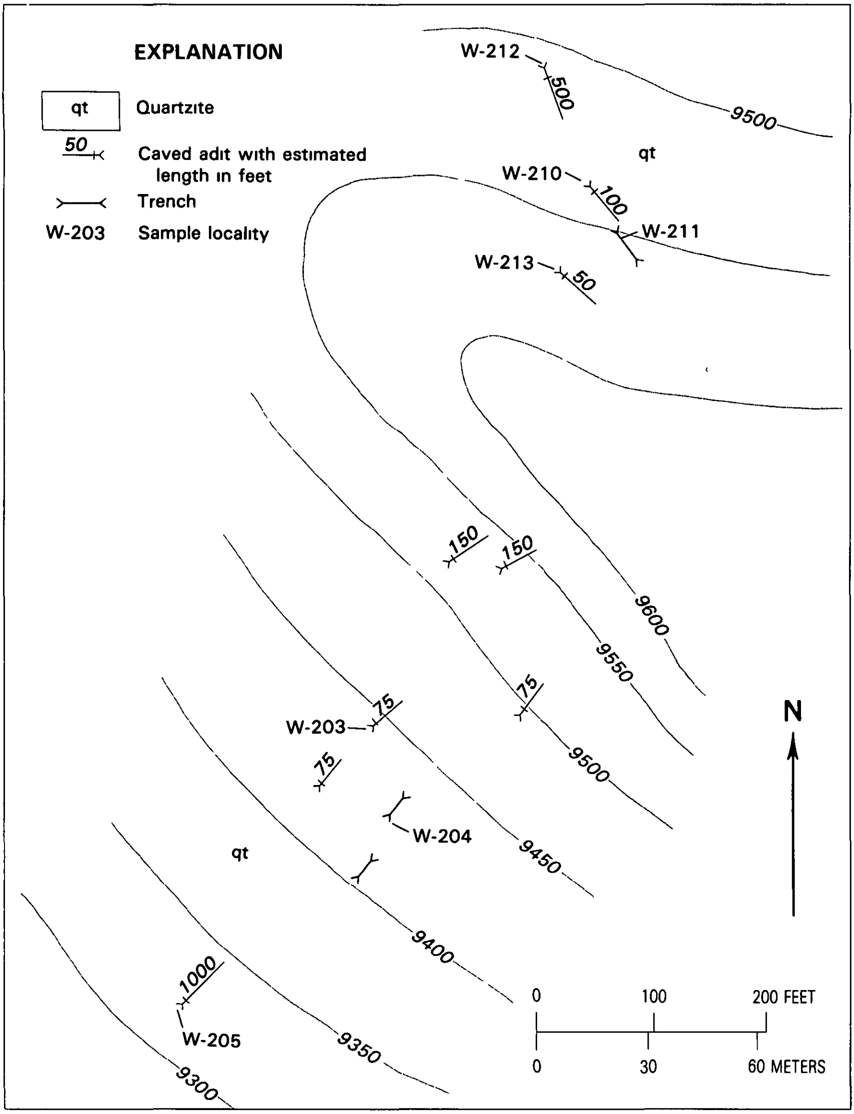

FIGURE 93 —Senate lode Contour interval 50 ft

GLADIATOR MINE

The Gladiator mine (pl. 3, 182) is on the patented Gladiator claim, owned by William and John Rember of Stanley, Idaho Mine workings consist of a main adit, from which a raise has been driven 400 ft (120 m) along the vein to the surface (fig 97) About 1,500 tons (1,350 t) of

Data for samples shown on figure 93

[Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc	Copper
No.	Type	Length (ft)	Description	(oz/ton)		(percent)		
W-203	Grab--	([1])	Iron-oxide-stained quartzite (dump).	Tr	2.6	5.0	--	0.10
W-204	--do--		---do---------------	Tr	1.2	1.0	--	--
W-205	--do--		---do---------------	Tr	1.3	3.0	0.50	--
W-210	Chip	2.0	Across oxidized zone	N	1.9	2.1	.30	--
W-211	--do--	1.1	---do---------------	N	4.0	3.0	--	.50
W-212	Grab--		Iron-oxide-stained quartzite (dump).	Tr	3.2	4.5	--	.43
W-213	--do--		---do---------------	Tr	Tr	6.3	--	.13

[1]Blank, not measured.

material have been mined from the main adit and overhand stope. Mine workings explore a shear zone in quartzite. The zone, exposed intermittently for 900 ft (270 m) on the surface and underground averages 26 in. (0.6 m) in width and is composed of gouge, brecciated quartzite, quartz, and calcite. Pyrite is the predominant sulfide mineral, but pockets of galena and sphalerite occur in quartz. The metallic minerals are highly oxidized at the surface. Samples from a stope above the main adit averaged a trace gold, 2 2 oz silver per ton (75 g/t), and 1.6 percent lead. Samples from the entire exposed shear zone, weighted by length, averaged a trace gold, 0.8 oz silver per ton (27.4 g/t), and 0.7 percent lead (fig. 97). One sample contained 3 percent zinc. The sample with the highest silver and lead content contained 0.31 percent tin.

The shear zone is exposed for 400 ft (120 m) along the dip, between the adit and the surface (fig. 97). One sample (Z-164) from the stope showed that good grade ore occurred in the vein and may indicate a potential for the discovery of more.

LUCKY GROUP

The Lucky group (pl. 3, 185) consists of five claims extensively explored by workings dug along shear zones in quartzite (fig. 98). Ore may have been shipped, but production figures are not available

The most common trends of the shear zones are N 70° E. and N. 45° W ; they dip steeply The zones are 2-48 in. (5 cm-1.2 m) thick, averaging 12 in (30 cm), and some are traceable for more than 150 ft (46 m). They contain gouge, brecciated quartzite, calcite, and quartz. Sulfide minerals are present in some gouge and quartz. Samples (W-283 to

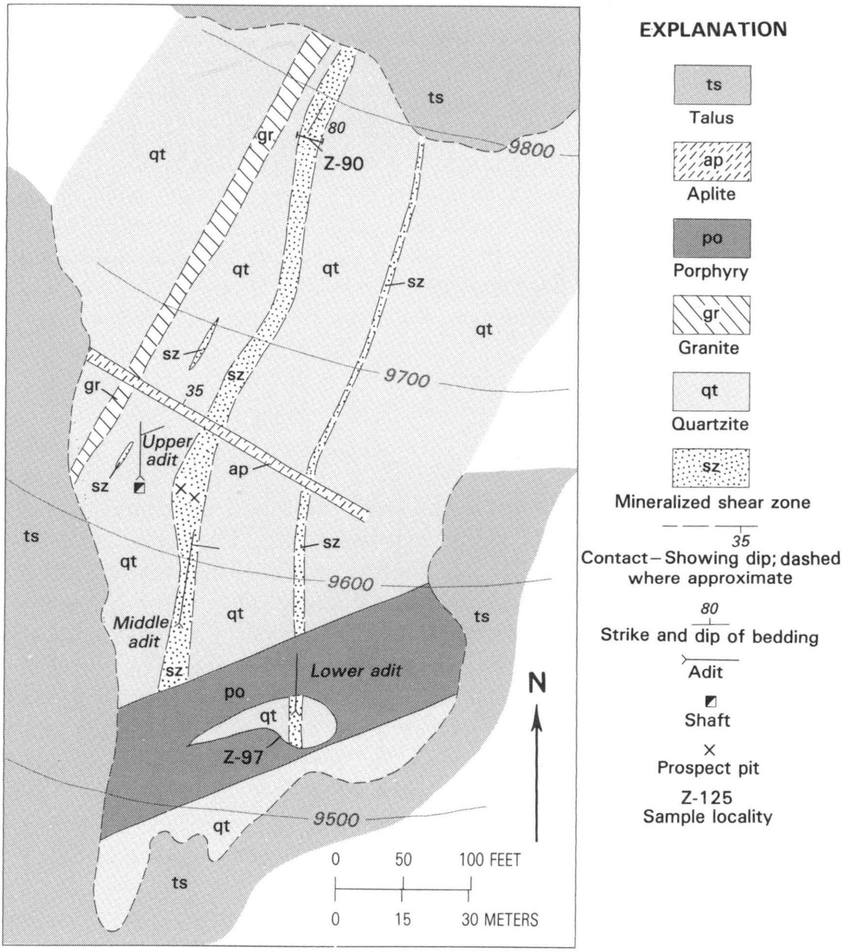

FIGURE 94.—Highland Chief claim, surface workings. Contour interval 100 ft.

Data for samples shown on figure 94

[Samples chip. Tr, trace; N, none detected; 1 ft=0.3048 m; 1 troy oz/ton=34.285 g/t]

Sample			Gold	Silver	Lead	Zinc
No.	Length (ft)	Description	(oz/ton)		(percent)	
Z-90	14.0	Across shear zone-	N	0.40	0.12	16.0
Z-97	4.0	Across contact----	N	Tr	.10	.10

W-289) from the lower working averaged a trace gold, 4.3 oz silver per ton (147 g/t), 7.3 percent lead, and 3.1 percent zinc. Spectrographic analyses showed that minor amounts of copper occur in most samples. Four samples contained 0.11-0.24 percent tin (table 7).

Potential resources near the lower workings are estimated at 7,000 tons (6,300 t). This estimate is based upon continuity of a zone averaging 12 in. (30 cm) in thickness through 400 ft (120 m) of strike length and persistence to a depth equal to half the strike length. Additional resources are indicated near the eastern workings, but data are insufficient to make tonnage estimates.

MAGGIE CLAIM

The Maggie claim (pl 3, 215) was patented in January 1904. Three adits, caved at the time of the present investigation, were driven along mineralized shear zones and quartz veins in quartzite. One caved adit apparently crosscut a quartzite-granite contact. Sulfides were observed in the iron-oxide-stained material on some dumps. Four grab samples averaged 0.21 oz gold per ton (7.2 g/t), 51.7 oz silver per ton (1,773 g/t), and 3.9 percent lead. Two samples contained 0.20 and 0.73 percent tin. A potential resource may exist on the silver-enriched property

BALTIMORE CLAIM

The Balimore claim (pl. 3, 189) was patented in January 1885. No production is recorded from the claim.

Two adits apparently were driven along a quartz vein that trends N. 15°-20° W. in quartzite The adits were caved, but quartz on the dumps contains residual sulfides that are highly oxidized. Grab samples averaged 3.0 oz silver per ton (103 g/t) and 3.9 percent lead.

LUCY GROUP

The Lucy group of four claims (pl. 3, 197) was located in 1966 Five pits were dug on highly oxidized and fractured quartzite. Stringers and pods of quartz fill many of the fractures. Some quartz contains galena, pyrite, and bornite. Four grab samples from the dumps averaged 7.7 oz silver per ton (264 g/t) and 9.3 percent lead. Tin content of the four samples ranged from 0.11 to 0 24 percent.

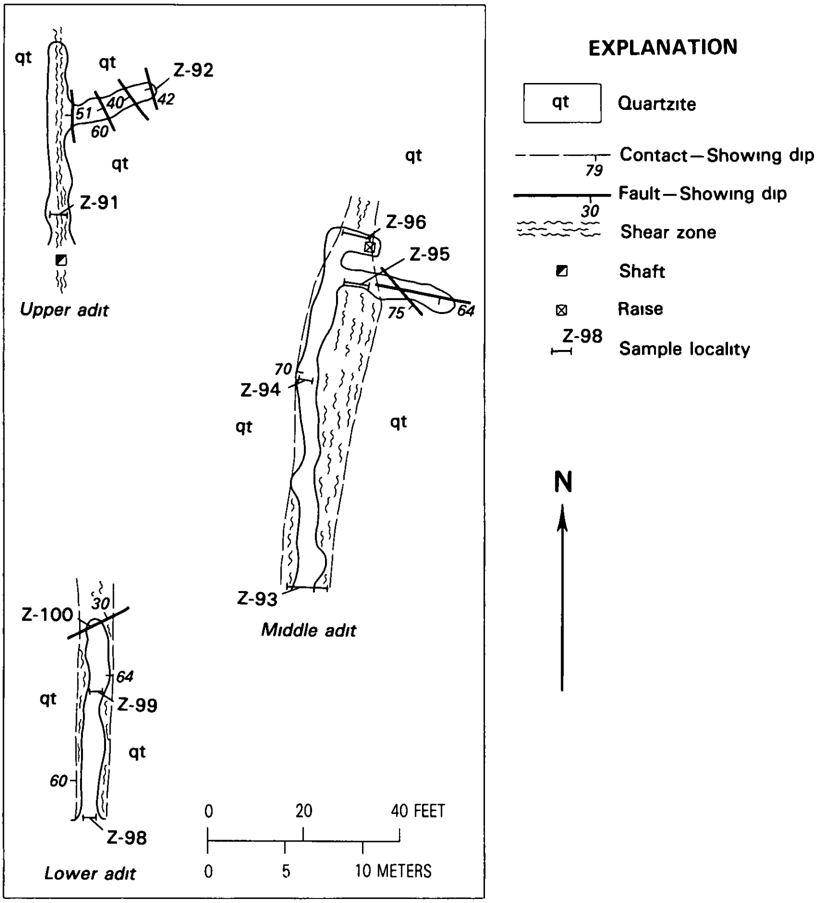

FIGURE 95 —Highland Chief claim, underground workings

COFFEE POT GROUP

The Coffee Pot group of seven claims (pl 3, 187) was located in 1956. One ton (0 9 t) of ore that contained 56 oz (1,920 g) of silver and 300 lb (136 kg) of lead was shipped in 1957.

Trenches were excavated along a granite-quartzite contact. In the quartzite are sporadic oxidized zones and small quartz veins. No ore minerals were observed, but pyrite was seen in the granite Chip samples from the zones, veins, and host rocks contained as much as a trace gold and 0.3 oz silver per ton (10.2 g/t).

Data for samples shown on figure 95

[All samples chip, all taken across shear zone Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample No.	Sample Length (ft)	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)
Z-91	1.0	N	0.40	0.12	16.0
Z-92	4.0	Tr	.10	.06	.17
Z-93	9.6	Tr	.50	.40	5.0
Z-94	4.0	Tr	.30	.56	.13
Z-95	8.0	0.02	.70	.23	8.0
Z-96	4.0	Tr	.30	.60	.20
Z-98	4.0	N	N	1.0	1.0
Z-99	4.5	N	N	N	--
Z-100	1.5	Tr	N	.50	--

SUMMIT VIEW CLAIM

Ten soughed pits were dug along oxidized and mineralized zones in quartzite (pl. 3, 199) No veins or shear zones are exposed. Material on the dumps consists of pyrite-bearing quartzite containing small quartz stringers and pods. Six grab samples from the dumps averaged 26 6 oz silver per ton (912 g/t) and 5 0 percent lead

STRAWBERRY HILL CLAIM

At the Strawberry Hill claim, an interconnected adit and tunnel were driven on a shear zone in quartzite (pl 3, 207) The zone strikes N 65°-75° W., dips 15°-25° SW., is 2 ft (0 6 m) wide, and is exposed for 25 ft (7 6 m) along strike and 10 ft (3 m) downdip. The iron-oxide-stained zone contains gouge, quartzite breccia, and quartz stringers Six chip samples averaged 7 1 oz silver per ton (243 g/t) and 4.0 percent lead Two samples contained about 0.30 percent tin (table 7). The property has some potential for additional mineral discoveries.

SILVER BELL CLAIM

Four trenches on the Silver Bell claim (pl 3, 206) are apparently along shear zones filled with quartz stringers and pods in quartzite Oxidized vuggy quartz was observed on the dumps Two grab samples

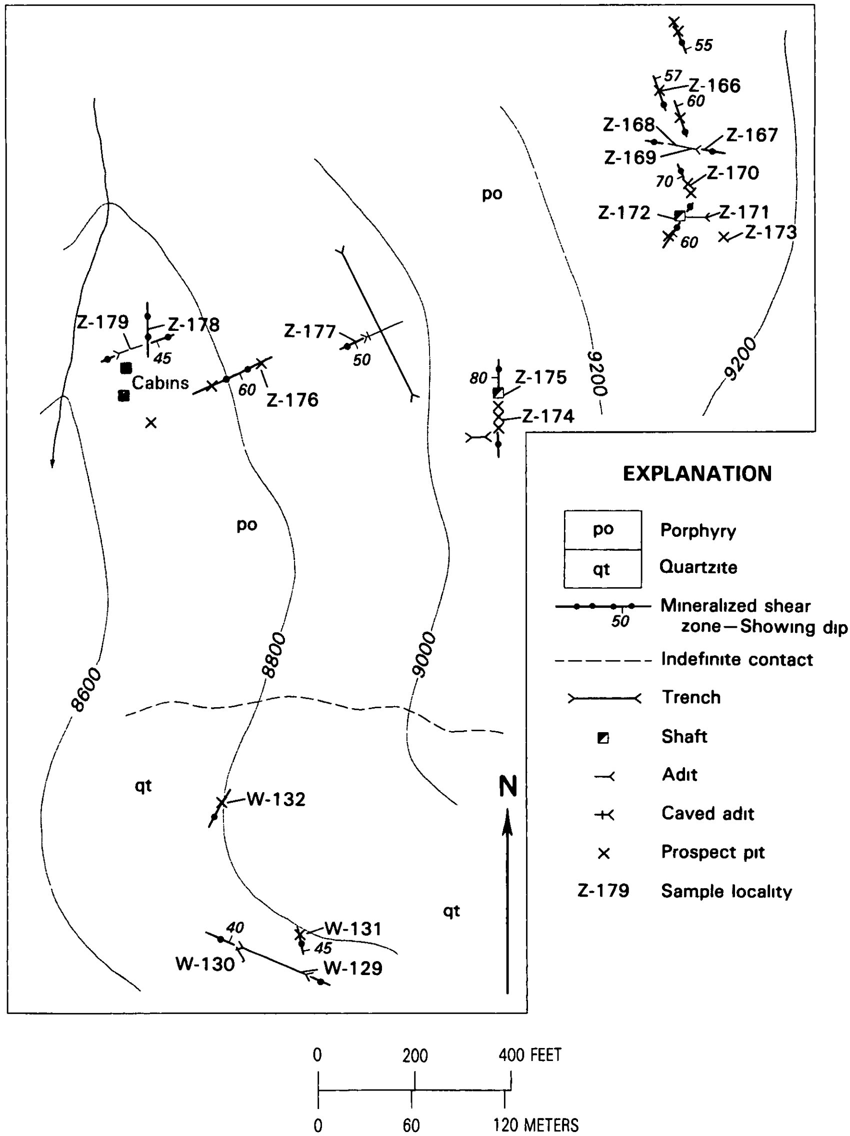

FIGURE 96 —Lone Trail group Contour interval 200 ft

contained 6.2 and 2.4 oz silver per ton (212 and 82 g/t), 9.5 and 3.6 percent lead, and 4.0 and 0.1 percent zinc. The assays indicate that a potential resource may exist on the property.

Data for samples shown on figure 96

[Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc	Copper
No.	Type	Length (ft)	Description	(oz/ton)		(percent)		
W-129	Chip--	9.0	Across shear zone	N	N	0.07	--	--
W-130	--do--	3.0	---do------------	N	1.2	.96	2.0	--
W-131	--do--	2.0	---do------------	N	N	--	--	--
W-132	--do--	8.0	---do------------	Tr	.20	.29	--	--
Z-166	Grab--	([1])	Quartz (dump)----	Tr	.02	6.4	--	--
Z-167	--do--		---do------------	Tr	10.4	5.0	--	--
Z-168	Chip--	5.5	Across shear zone (adit).	Tr	.02	1.0	--	--
Z-169	--do--	1.6	---do------------	Tr	.10	.20	--	--
Z-170	Select		Quartz (dump)----	0.03	19.6	12.7	1.0	--
Z-171	--do--		---do------------	.04	26.0	18.9	--	--
Z-172	Chip--	.5	Across shear zone (shaft).	.07	9.6	17.6	5.0	--
Z-173	Grab--		Porphyry (dump)--	Tr	.20	.07	1.0	--
Z-174	Chip--	.9	Across shear zone	.03	8.2	9.9	--	--
Z-175	--do--	.9	---do------------	.01	4.3	.02	--	--
Z-176	Random chip.		---do------------	Tr	0.20	.07	0.50	--
Z-177	--do--		---do------------	.07	26.5	.04	8.0	0.13
Z-178	Chip	1.0	Across shear zone (adit).	Tr	Tr	--	--	--
Z-179	--do--	3.0	---do------------	.05	2.2	.08	--	--

[1] Blank, not measured.

MISCELLANEOUS PROPERTIES

Several properties in the district that have little or no economic potential or are not sufficiently exposed to indicate their potential are listed in table 27. Tin was found in samples from seven of these properties (table 7)

NORTH FORK BIG WOOD RIVER DISTRICT

The North Fork Big Wood River study district (pl. 3; fig. 34) is at the southeast corner of the study area and is the northern part of the much larger Warm Springs mining district described by Umpleby (1915, p 241–244) and others. The district, based on past production and potential resources in Boulder Basin, is one of the more important districts in the study area. Significant quantities of gold, silver, copper, lead, and zinc occur in several mines in the district.

The major rock type of the district is quartzite with interbedded

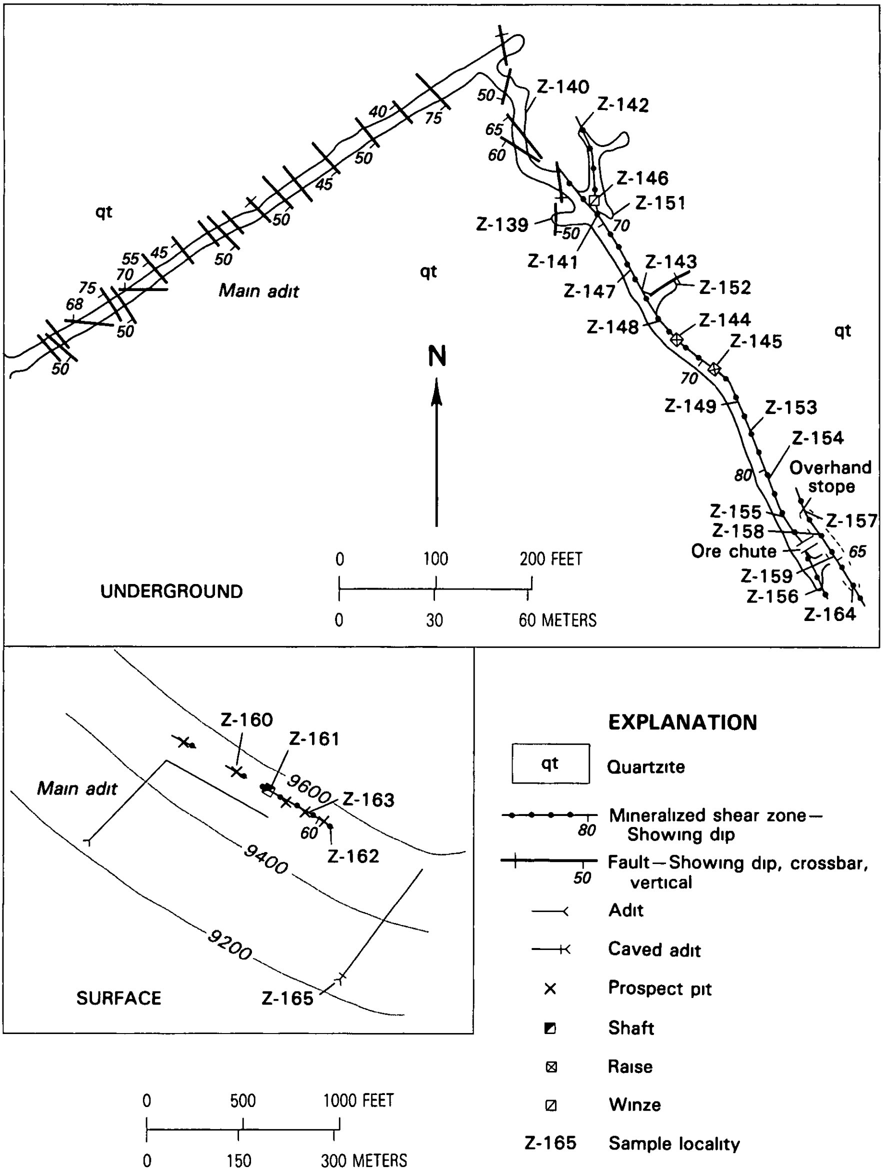

FIGURE 97 —Gladiator mine Contour interval 200 ft

argillite, slate, and limestone. Numerous Tertiary dikes varying in composition from rhyolite to lamprophyre are found throughout the district and have both spatial and genetic relationships to ore mineralization. Although many dikes are mineralized, the only significant

Data for samples shown on figure 97

[All samples chip except Z-147, 163, 165, grab Tr, trace, leaders (--), not analyzed. 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver	Lead	Zinc
No. Z-	Length (ft)	Description	(oz/ton)		(percent)	
139	8.0	Quartzite gouge (adit)	Tr	Tr	0.02	--
140	5.0	Quartzite (adit)------	Tr	.20	.07	--
141	1.1	Across shear zone (adit).	Tr	.30	.20	--
142	4.0	---do---------------	Tr	.20	--	--
143	2.0	---do---------------	Tr	1.8	.74	--
144	3.3	---do---------------	Tr	.20	.50	--
145	1.0	---do---------------	Tr	1.2	.07	--
146	1.5	---do---------------	Tr	.20	.40	--
147	([1])	---do---------------	Tr	.50	1.0	0.50
148	1.2	---do---------------	Tr	1.3	1.5	3.0
149	1.3	---do---------------	0.01	5.9	6.0	--
151	3.0	Quartzite (adit)-----	Tr	.20	.10	--
152	3.4	---do---------------	Tr	.20	.20	.20
153	2.5	Across shear zone (adit).	Tr	.20	1.0	1.0
154	4.3	---do---------------	Tr	.80	.30	1.0
155	2.2	---do---------------	Tr	.70	2.0	--
156	3.3	---do---------------	Tr	.10	1.0	--
157	2.0	---do---------------	Tr	.30	--	--
158	2.5	---do---------------	Tr	.40	.60	--
159	3.0	---do---------------	Tr	.10	.50	--
160	.9	Across shear zone----	Tr	.20	1.0	--
161	3.3	---do---------------	Tr	.80	2.0	--
162	3.0	---do---------------	Tr	.20	.70	--
163		---do---------------	Tr	.60	1.0	1.0
164	2.0	---do---------------	.01	9.6	6.0	.30
165		Quartzite and quartz (dump).	Tr	.30	--	--

[1]Blank, not measured.

deposits are in sedimentary rocks. Lode deposits occur primarily as veins and lenses in shear zones. The shear zones have a wide range of attitudes, but the more prominent and highly mineralized ones strike northeast and dip south. All lode deposits are fissure-fillings with minor alteration and replacement of wall rock. Pyrite is the dominant sulfide mineral; galena, tetrahedrite, chalcopyrite, and sphalerite are the principal ore minerals.

County records show that lode mining claims were staked as early as 1879 in Boulder Basin. About 433 mining claims have been located in the district (table 28). Many of these probably are relocations of older claims. More than half the claims were located before 1900, during development of the Golden Glow and Boulder Consolidated properties

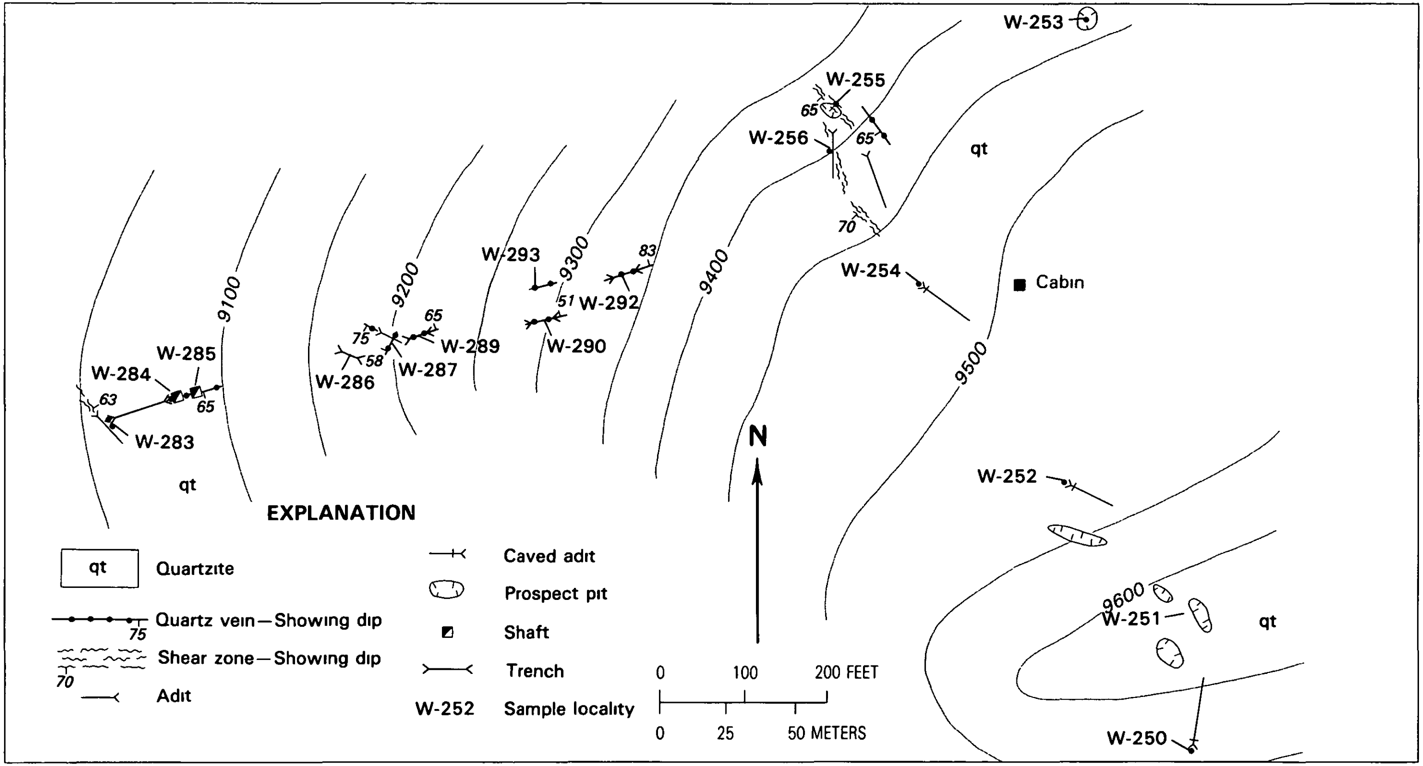

FIGURE 98 —Lucky group Contour interval 50 ft

Data for samples shown on figure 98

[Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc
No.	Type	Length (ft)	Description	(oz/ton)		(percent)	
W-250	Grab	([1])	Quartzite (dump)-----	Tr	4 3	5.0	--
W-251	-do-		---do----------------	Tr	70	.37	--
W-252	-do-		---do----------------	N	30	1.0	--
W-253	Chip	0 5	Across shear zone----	N	20	--	--
W-254	Grab		Quartzite and quartz (dump).	0 01	6 9	6.1	--
W-255	Chip	.3	Across shear zone----	Tr	1 0	.60	0 40
W-256	-do-	.3	Across shear zone (adit).	N	10	--	--
W-283	-do-	1 0	---do----------------	Tr	1.4	4 0	50
W-284	Grab		Quartz---------------	Tr	20	--	--
W-285	Chip	1 5	---do----------------	Tr	8.4	10.0	14 0
W-286	Grab		Quartz (dump)--------	Tr	3 8	7.4	45
W-287	Chip	1.0	Across quartz--------	Tr	.10	--	--
W-289	-do-	.1	---do----------------	Tr	9.9	15.0	46
W-290	-do-	1.0	---do----------------	Tr	Tr	--	--
W-292	-do-	.3	---do----------------	Tr	.40	.46	--
W-293	-do-	4 0	---do----------------	N	.20	60	--

[1]Blank, not measured

TABLE 27.—*Miscellaneous properties, Galena district*

[1 in.=2.54 cm, 1 ft=0.3048 m, 1 troy oz/ton=34.285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
179	Deer	Iron-oxide-stained, pyritized quartz lens 125 ft long and as much as 30 ft thick at contact of volcanic rocks and quartzite.	One trench----------------	Two chip samples, as much as trace gold, 0.3 oz silver per ton, 0.2 percent lead, and a trace of zinc.
180	Westernhome	An adit was driven into a heavily iron-oxide zone striking S. 64° E. and dipping 35° S. in quartzite. The zone is 4 ft thick and can be traced for 33 ft. A dump has vuggy quartz. No sulfides observed.	Caved adit, probably between 50 and 100 ft long.	Two chip samples, no gold or silver.
183	Wednesday	Iron-oxide-stained quartz and calcite in talus. Country rock is calcareous argillite.	Caved adit----------------	Two grab samples, the best contained trace gold, 0.1 oz silver per ton, 0.09 percent lead, 0.04 percent zinc.
84	Lucky Anti group	Several quartz veins occur in quartzite and argillite. The veins trend N. 20° W. and contain oxidized and stained portions. Various sulfides occur in the quartz but only pyrite occurs in the quartzite. The veins are up to 2 ft thick.	One 400-ft adit, one caved adit, and five pits.	Two samples from quartz veins averaged 0.3 oz silver per ton. Five samples of quartzite averaged 0.2 oz silver per ton. Three grab samples of oxidized material on the dumps averaged 1.7 oz silver per ton, and 2.0 percent lead.
88	Pacific	Workings are along quartz veins in quartzite east of porphyry outcrops. Largest vein is 8 ft thick, it is exposed for 20 ft along N. 37° W. strike and 64° NE. dip. Quartz, calcite, and pyrite are in the veins.	Seventy-two trenches, mostly caved.	Two samples, trace to 0.1 oz silver per ton.

190	June Morning	Pits reveal a quartz-filled shear zone striking N. and dipping 75° W. in quartzite. The zone is 3.5 ft thick and exposed 12 ft along strike. The quartz is highly stained with iron oxides, vuggy, and contains pyrite and chalcopyrite at the quartz-quartzite contact. Quartz outcrops nearby.	Two pits-----------------	Five chip samples across the quartz vein, as much as 0.2 oz silver per ton.
191	Orient	A 3-ft-thick, fissure-filling quartz vein strikes N. and dips 76° W. in quartzite. The zone is several hundred feet long and at least 300 ft deep. Quartzite near the vein is manganese oxide stained and contains many quartz stringers.	One adit and one pit-----	Two samples, 0.5 and 1.4 oz silver per ton and trace gold. One contained 0.03 percent lead.
192	Holiday	Workings apparently driven on a shear zone in quartzite. Oxidized material on the dumps.	Sloughed pit and trench--	Select sample from dump, 4.1 oz silver per ton and 2.0 percent lead.
193	President	Adits along shear zones in quartzite, none are exposed at the surface. Zones are from 8 in to 36 in thick and strike northeast and northwest. They contain quartz, mylonite, and breccia.	Two adits----------------	Four samples, 0.1 to 2.3 oz silver per ton, trace to 1 percent lead, as much as 0.3 percent zinc, and trace gold.
194	Occident	A shear zone strikes N. 60° W. and dips 45° S. in quartzite. The zone is 2 ft thick and can be traced traced 12 ft along strike and 8 ft downdip.	One pit------------------	One chip sample across shear zone, 1.4 oz silver per ton, 2.0 percent lead, and 0.3 percent zinc.
195	Mountain Goat	An iron-oxide-stained quartz vein in a pit strikes N. 15° E. in quartzite. The vein contains pyrite.	One pit------------------	One sample, 0.3 oz silver per ton, 0.1 percent lead, and trace gold.
196	Star	A pit exposes a 3-in.-thick quartz vein striking N. 53° E. and dipping vertically in quartzite.	One pit------------------	A sample across the vein, 0.2 oz silver per ton, 0.2 percent lead, and trace gold.

TABLE 27 —*Miscellaneous properties, Galena district*—Continued

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
198	Farragut	Workings are along shear zones containing gouge, quartz stringers, and some galena and pyrite in quartzite country rock. Upper zone exposed in adit strikes N. 27° W. and dips 36° NE., it is 36-in. thick at the face. A shaft, inclined 30° downward, crosscuts a 24-in.-thick, 20-ft-long shear zone striking N. 5° W. and dipping 40° SW.	Two adits and one shaft--	Four samples, 0.2 to 9.3 oz silver per ton, nil to 6.7 percent lead and trace to 0.03 oz gold per ton.
203	Conway Castle	Pits expose iron-oxide-stained quartz veins in quartzite. Largest vein is 6 ft thick, it is exposed for 30 ft along a N. 37° W. strike and dips steeply. Another vein, 2 ft wide, dips 65° SW. and is exposed for 12 ft along N. 15° W. strike. Quartz contains galena.	Six pits----------------	Two select samples, 2.1 and 64 oz silver per ton and 7 and 34 percent lead. Two samples from vein, as much as 0.8 oz silver per ton, 0.07 percent lead.
204	Last Chance	Quartz and quartzite on dump-----------	One caved adit, probably 50 ft long.	One grab sample of oxidized material on the dump, 2.8 oz silver per ton.
208	Cherry Creek	A 2-ft-thick, iron-oxide-stained shear zone in quartzite. The zone contains gouge and quartz stringers.	Six-foot adit-----------	One chip sample, trace metals.
210	Ford	Trenches expose a series of quartz veins, trending N. 72° W., and pods in quartzite. The quartz is iron oxide stained and vuggy. No ore minerals were seen but the quartzite contains pyrite.	Four trenches-----------	Two chip samples across veins, 0.1 and 1.1 oz silver per ton, 0.07 and 0.3 percent lead. Two select grab samples, 3.8 and 4.7 oz silver per ton, 0.6 and 1.0 percent lead, 0.1 and 0.2 percent antimony.

211	Buick	The workings are along a quartz vein striking N. 30°-40° E. and dipping 60° W. in quartzite. The vein varies from 1 to 2 ft thick and is intermittently exposed for 700 ft along strike and 200 ft downdip. The vein pinches and swells and is iron oxide stained and vuggy.	Caved pits and adits-----	Three chip samples across the quartz vein, as much as 3.6 oz silver per ton. Two select stockpile samples, 18.2 and 24.0 oz silver per ton and 0.7 and 0.2 percent lead, respectively.
212	Argentine	Pits expose a vuggy quartz vein in limestone. The vein is iron oxide stained, 1.5 ft thick, and traceable for 50 ft.	Two pits----------------	One select sample, 0.04 oz gold and 21.4 oz silver per ton. One chip sample, no gold or silver.
213	Argosy	A large outcrop of quartzite contains quartz veins and veinlets. They strike N. 25° E. and dip 60° W. Some iron oxide staining but no visible sulfides.	Several caved pits-------	One chip sample across the outcrops, no gold, silver, or lead.
214	Portland	Adit trends S. 68° E. on shear zone in limestone. Quartz occurs as stringers and pods in sheared calcareous rock.	One caved adit, probably 1,200 ft long.	One dump sample, traces of gold and silver.
216	Galena Belle	Adits probably intersected quartz pods near quartzite-volcanic rock contact, 3-ft-wide zone of pods and stringers is exposed on the surface.	Three caved adits, total length 300-400 ft.	Sample across 3-ft-wide zone, 0.1 oz silver per ton and 0.07 percent lead. Select stockpile sample, 11.5 oz silver per ton, 6.0 percent lead, and 0.1 percent zinc.
218	Combination	One shaft driven on the intersection of a shear zone striking N. 47° E. and dipping vertically and a shear zone striking N. 73° W. and dipping 13° SW. Another shaft, 300 ft downhill, follows a shear zone striking N. 84° W. and dipping 25° S. The zones are from 4 to 18 in. thick and traceable for 15 ft in quartzite. The zones contain gouge and stringers and pods of quartz. No sulfides seen in place but some observed in dump material.	One 23-ft shaft, one 31-ft shaft, and one pit.	Two chip samples, 0.2 and 0.9 oz silver per ton, 0.2 and 0.4 percent lead, 2.0 and 8.0 percent zinc. Three select samples, as much as 9.4 oz silver per ton, 9.8 percent lead, and 4.0 percent zinc.

TABLE 27 —*Miscellaneous properties, Galena district*—Continued

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
219	Overland	Altered zone in quartzite. Altered, iron-oxide-stained quartzite on the dump.	One pit------------------	One select sample from stockpile; 7.1 oz silver per ton and 7.0 percent lead.
220	Spring Creek occurrence	High-grade argentiferous galena float with quartzite covering an area 200 ft long and 70 ft wide.	None---------------------	One select sample, 204 oz silver per ton and 60 percent lead. One grab sample, 1 oz silver per ton, and 2.5 percent lead.
221	Lone Star	A 20-ft-thick, 200-ft-long shear zone strikes N. 20° E. and dips 55° SE. in quartzite and phyllite. Calcite and quartz in shear planes contain galena and sphalerite.	Three caved adits-------	Three samples, 0.1 to 0.5 oz silver per ton. Two select samples, 9.0 and 26.7 oz silver per ton, 8.5 and 50.0 percent lead.
222	King Creek	A fault at an adit portal trends N. 30° W. in gray quartzite. A 2-ft-thick quartz vein occurs in a pit 10 ft east of the adit. Sulfide-bearing float occurs sporadically along the ridge to the south of the adit.	One caved adit and one pit.	One chip sample from the quartz vein, 1.0 oz silver per ton and 0.35 percent lead. Three samples of float averaged 0.9 oz silver per ton and 0.64 percent lead.

TABLE 28.—*Summary of mining claims, including relocations, 1879–1971, North Fork Big Wood River*

[Leaders (--), none recorded]

Decade	Number of lode claims	Number of placer claims	Number of patented claims
1879-	1	--	--
1880-1889	190	2	2
1890-1899	30	1	6
1900-1909	41	2	--
1910-1919	5	1	--
1920-1929	58	5	12
1930-1939	15	10	--
1940-1949	9	3	--
1950-1959	22	3	--
1960-1969	11	3	--
1970-1971	1	--	--
Total-----	383	30	20

described in this report as the Boulder mines. Most if not all production has come from these patented properties. Production records are incomplete, but it is estimated that intermittent activity up to 1923 resulted in over $1 million worth of ore being shipped (Umpleby, 1915). A small amount of development took place during World War II. Recent activity on other lode properties in the district has been limited to assessment work Placer claims apparently have been located continuously since 1881, primarily along the North Fork Big Wood River. No workings are visible on the placer claims, nor is there a record of production.

Accessible parts of the Boulder mines have indicated and inferred reserves totaling about 4,000 tons (3,600 t), containing 0.05 oz gold per ton (1.7 g/t), 21 7 oz silver per ton (744 g/t), 8.7 percent lead, and 1.5 percent zinc An additional several thousand tons of potential silver and lead resources are estimated to occur at the Boulder mines and other mines in the district. No significant concentration of gold or other detrital minerals was found on the placer claims.

BOULDER MINES

The Boulder mines (pl. 3, 229) in Boulder Basin have divided ownership and consist of the Golden Glow and Boulder Consolidated groups of claims. The claims range from 8,000 to 10,000 ft (2,440–3,050 m) in

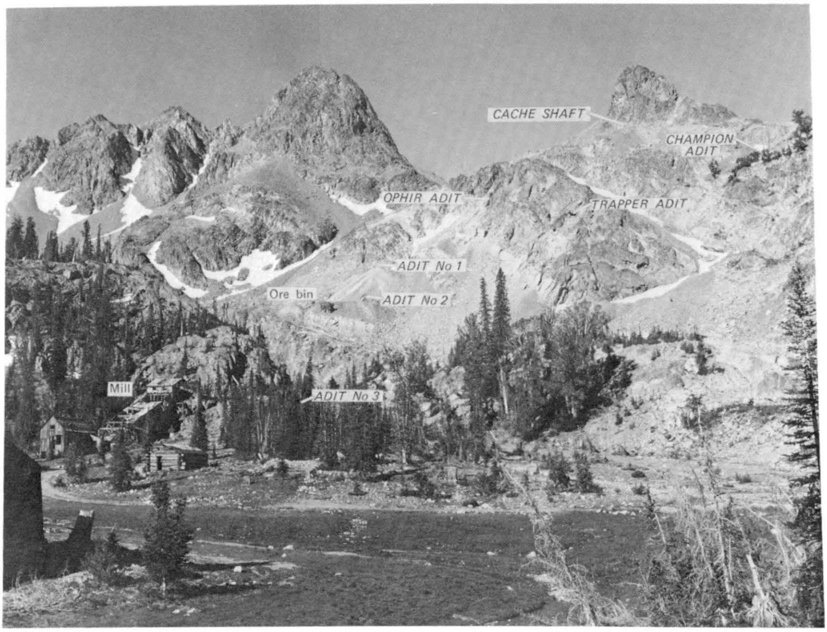

FIGURE 99.—Boulder mines area, showing most of the mine workings.

altitude and can be reached by 5 mi (8 km) of jeep road from U.S. Highway 93. An upper camp, near the mines, consists of several buildings and the remains of a steam-powered mill from which all mining and milling equipment has been removed except the boiler. A lower camp with a few buildings is on Boulder Creek. The nearest railroad, at Ketchum, is 15 mi (24 km) from the mines. Water and timber are abundant on the claims.

The Golden Glow group consists of the Ophir, Bazouk, Louisa, Ohio, and Sunrise claims patented between 1883 and 1892 and now under the divided ownership of Ruth Halvorsen and George Castle (figs. 99, 100). The Golden Glow Mining Co. also held easement rights on the Trapper, Tip Top, and Sullivan claims, which were patented in 1891 and are now owned by the L.D.S. church. The Boulder Consolidated group borders the Golden Glow group and consists of the Champion, Revenue, Climax, Mint, Mascot, Triumph, Calamine, Summit, Sunset, Daisy, Puritan, and Crown Point claims. The group was patented in 1929 and is now owned by George Castle. The divided ownership of the claims has hampered development. Eleven unpatented claims, adjoining the Crown Point claim, were located in 1935 by J. A. Schultz of

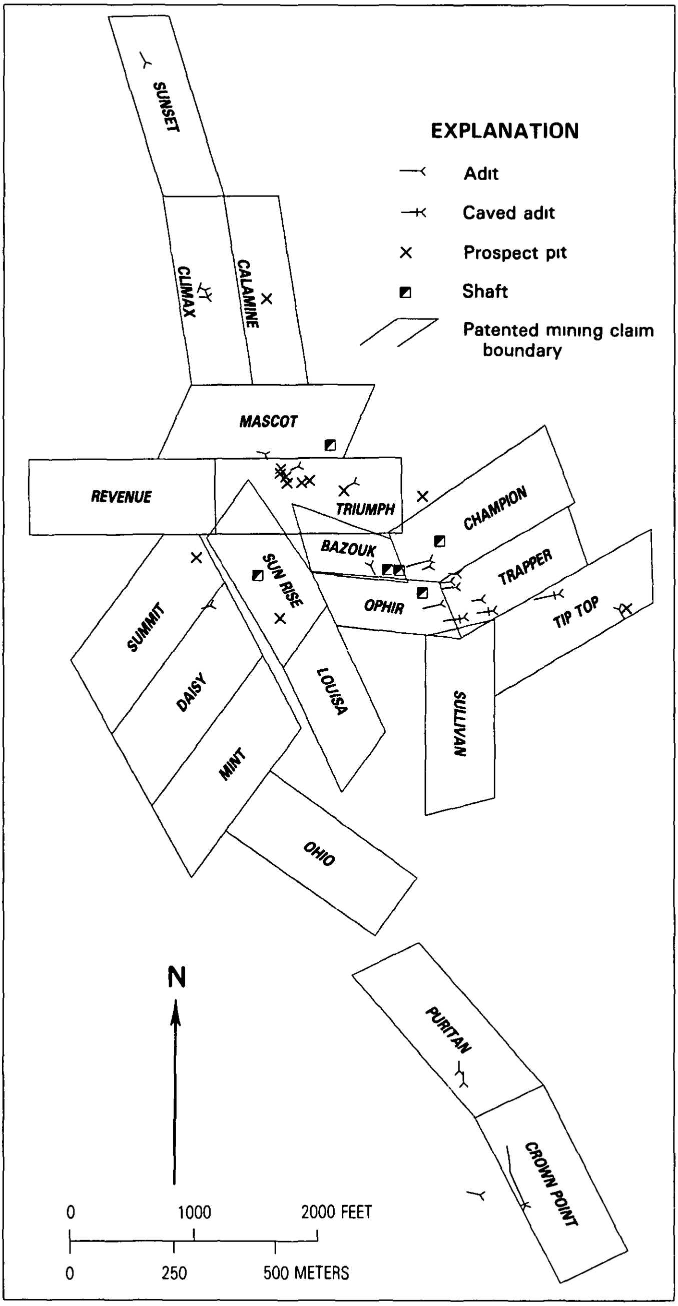

FIGURE 100 —Claim map of the Boulder mines

TABLE 29.—*Recorded metal production, 1902-1949, Boulder mines*

[Data from U S Bureau of Mines production records, 1 ton=0 9 t, 1 troy oz=31 1 g; 1 lb=0 45 kg Leaders (--), none recorded]

Year	Ore	Gold	Silver	Copper	Lead	Zinc
	(tons)	(oz)		(lb)		
1902	70	1	3,942	--	84,000	--
1911	219	60	11,903	5,544	159,432	--
1913	270	18	2,734	1,268	37,336	--
1918	23	--	286	--	--	--
1919	388	55	21,022	9,635	302,795	--
1920	509	178	25,959	15,280	235,940	84,500
1921	273	95	13,293	8,200	180,200	45,320
1925	37	21	2,374	580	31,493	--
1927	27	2	383	148	16,325	--
1929	19	5	545	168	10,206	--
1936	7	--	3	127	3,579	--
1939	21	19	104	--	6,119	7,758
1940	34	19	1,340	426	15,106	--
1941	350	17	2,156	653	17,261	10,000
1942	64	14	1,063	326	7,635	--
1949	4	2	378	23	2,390	--
Total--	2,315	506	87,485	42,378	1,109,817	147,578

Ketchum The Boulder Consolidated group has been intermittently active since 1880, but little ore has been produced. Golden Glow operations began in 1879, and production was continuous until 1890. Intermittent activity continued to 1923, when operations ceased. Except for a few years between 1901 and 1950, production was not recorded, but production before 1890 is estimated to have been about $1 million (Umpleby, 1915). Recorded production is shown in table 29. Negotiations for a lease agreement to reopen the mine reportedly were in progress at the time of the examination.

The area is underlain predominantly by quartzite. Numerous sills and dikes that intrude the sedimentary rocks make up about 50 percent of the surface exposures. Several extensive faults cut the area. The mineral deposits are along shear zones that strike northeast and dip steeply southeast. The shear zones occur in both the intrusive and sedimentary rocks, but mineralization is confined largely to those in the sedimentary rocks. The shear zones are from 0 5 to 6.0 ft (0.15 to 1.8 m) wide and are exposed intermittently by workings for as much as 1,200 ft (370 m) along the strike and 600 ft (180 m) or more downdip. Ore occurs as sharply defined lenses, pods, and stringers randomly distributed throughout the gouge-filled shear zones. Known ore bodies range from 6 in. to 6 ft (15 cm to 1.8 m) in width and average about 20 in. (0.5 m). The longest ore shoot is 125 ft (38 m). The veins were emplaced by both fissure-filling and replacement. Ore minerals also were observed in stringers in the shear zones and as small masses in the adjacent wall rock. Vein minerals, in approximate order of abundance, are quartz, argentiferous galena, pyrite, limonite, hematite, cerussite, sphalerite, calcite, siderite, malachite, chalcopyrite, tetrahedrite, and bornite. The first four minerals are by far the most common. Average proportion of silver to lead is 1.5 oz silver per ton (51.4 g/t) to 1.0 percent lead. Gold values appear to be associated with pyrite, tetrahedrite, and sphalerite. Most of the ore was mined from the main shear zone developed by workings on the Ophir and Trapper claims.

Development consists of a shaft and four interconnected adit levels that are now mostly caved (figs. 101, 102).

The Cache Shaft is 125 ft (38 m) deep but was filled with water to 40 ft (12 m) from the collar (fig. 102). In the shaft the main shear zone averages 2.5 ft (0.76 m) in width and is profusely limonite stained. It strikes N. 80° E. and dips 68° SE. Small masses of galena, pyrite, and sphalerite occur locally in the quartzite wall rock. An ore shoot that measures 90–130 ft (27–40 m) long, 1.5 ft (0.46 m) wide, and 110 ft (34 m) deep was mined out and reportedly averaged 3 oz gold per ton (103 g/t), 360 oz silver per ton (12.3 kg/t), and 55 percent lead (Umpleby, 1915). Samples taken across the shear zone, weighted by length, averaged 0.34 oz gold per ton (11.7 g/t), 61.9 oz silver per ton (2,122 g/t), and 21.2 percent lead (fig. 102). Zinc and copper were detected in minor amounts in all samples by spectrographic analysis.

The uppermost adit, known as the Ophir adit (fig. 103), is 90 ft (27 m) long and is connected to Adit No. 1 by a 120-ft (37-m) inclined winze with levels at 20-ft (6-m) intervals that all follow the main shear zone. The shear zone in the Ophir adit strikes N. 76° E., dips 69° S., and averages 1.3 ft (0.4 m) in width. A small amount of ore was stoped from the adit. The principal ore minerals were galena, pyrite, and cerussite, but chalcopyrite occurs in the malachite-stained parts of the iron-oxide-stained gouge. Four samples from the adit and winze, weighted by length, averaged 0.04 oz gold per ton (1.4 g/t), 12.8 oz silver per ton (439 g/t), 13.4 percent lead, and 0.2 percent zinc. Selected material collected by the U.S. Geological Survey from the dump contained no gold, 5,000 ppm silver, 5,000 ppm zinc, 7,000 ppm copper, 15,000 ppm antimony, and more than 10 percent lead.

Adit No. 1 is connected to Adit No. 2 by a 60-ft (18-m) winze (fig. 102). Adit No. 1 was driven along the main shear zone that strikes N. 75° E. locally and dips 65° E. Ore was stoped near the face, leaving an inaccessible irregular opening about 120 ft (37 m) long, 3 ft (0.9 m) wide, and 120 ft (37 m) deep. A sample (Z–76) across the shear zone (fig.

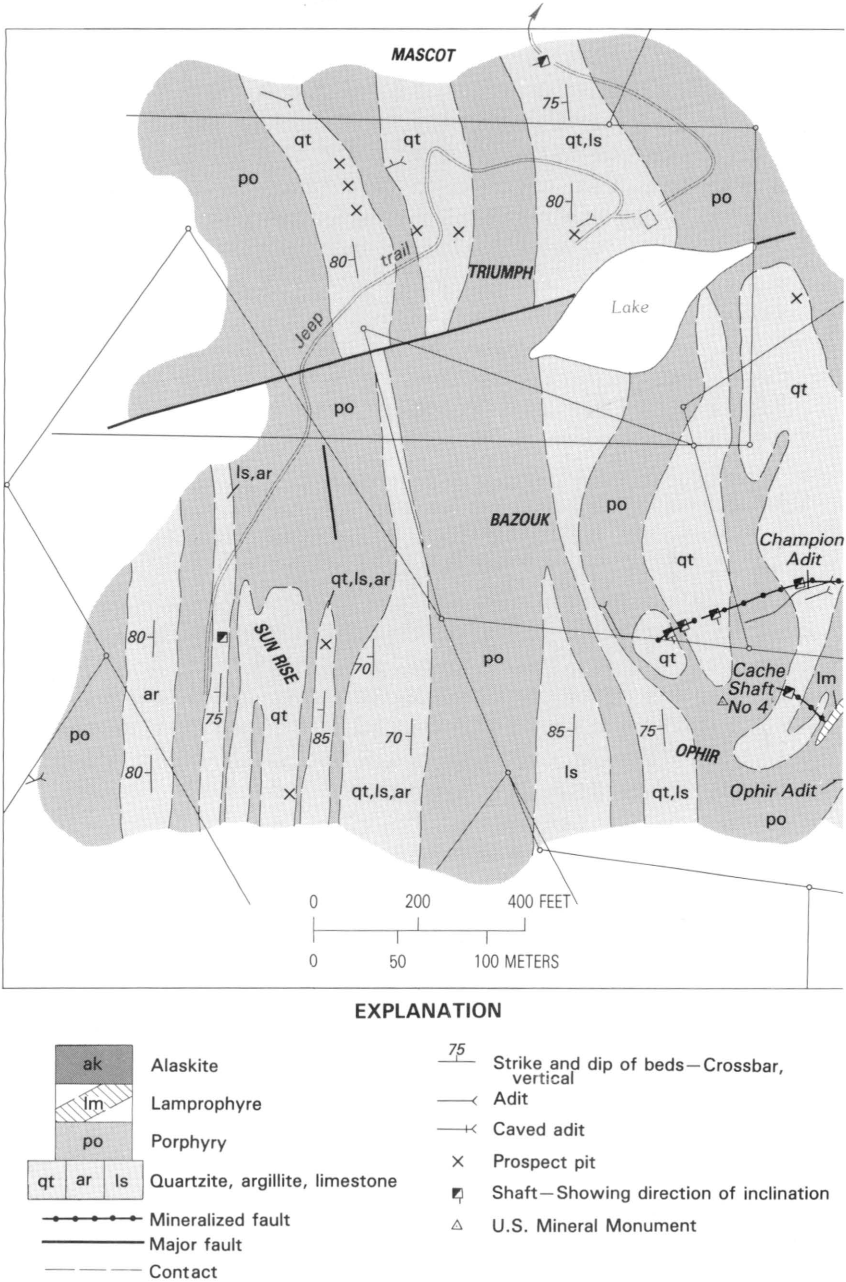

FIGURE 101.—Main workings, Boulder mines.

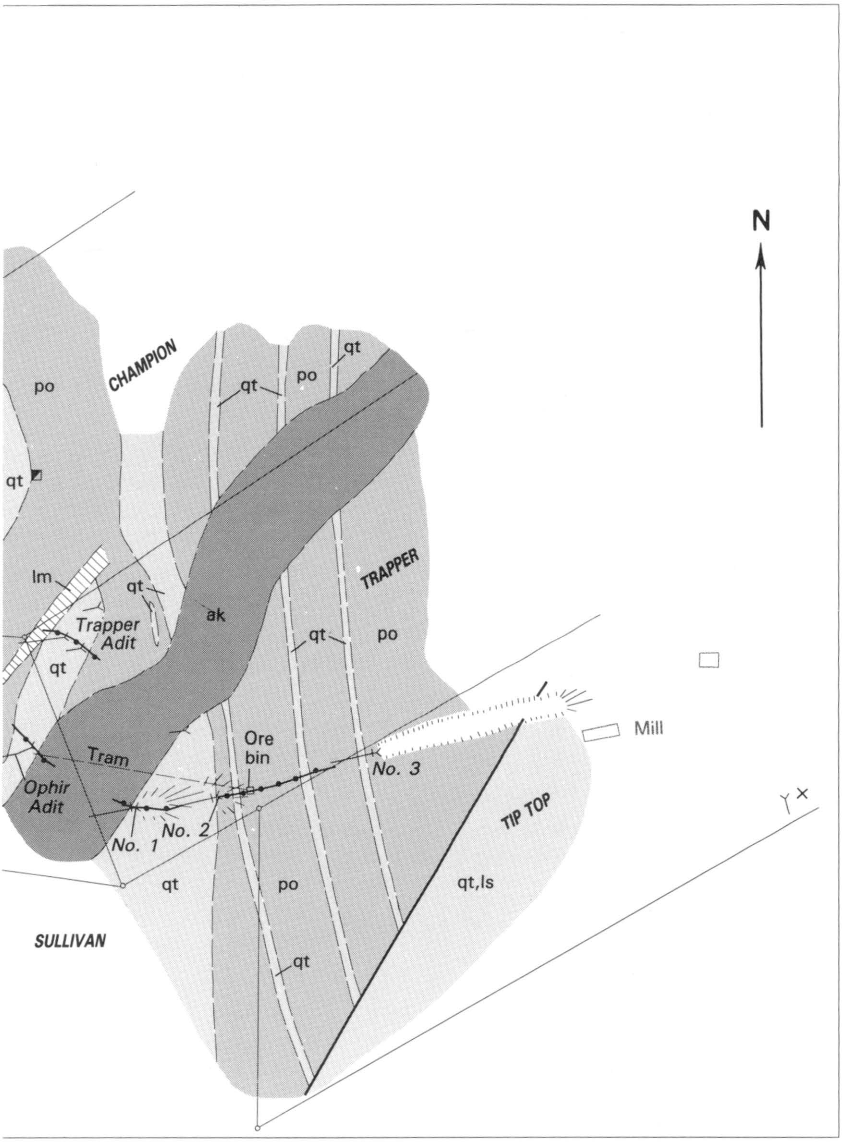

FIGURE 101.—Main workings, Boulder mines—Continued

103) contained 0.32 oz gold per ton (11 g/t), 38.2 oz silver per ton (1,310 g/t), 42.0 percent lead, 0.12 percent zinc, and 0.96 percent copper. A random dump sample assayed 0.09 oz gold per ton (3.1 g/t), 6.4 oz silver per ton (219 g/t), 5.1 percent lead, and 0.24 percent zinc.

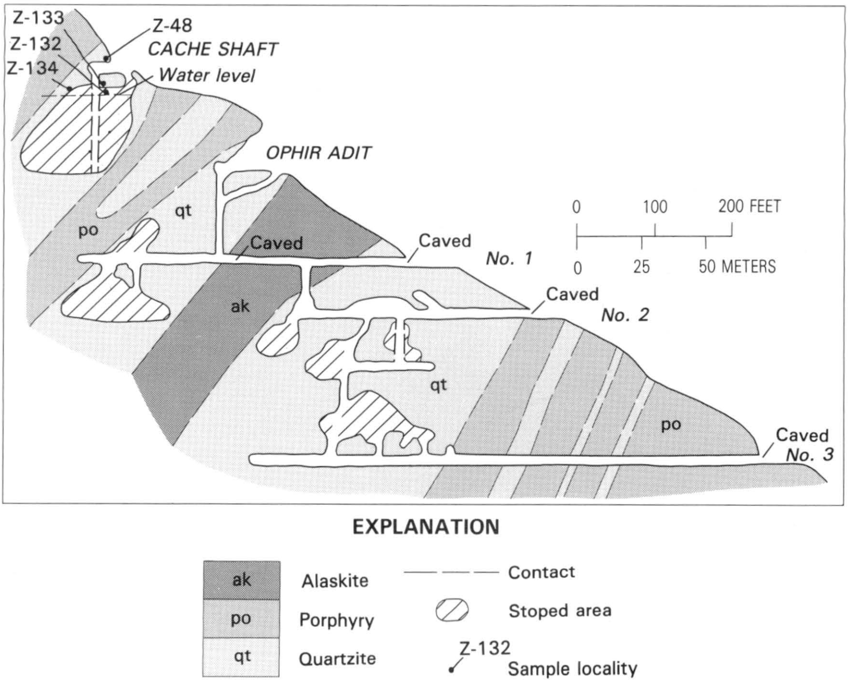

FIGURE 102.—Section in plane of main vein, Boulder mines (modified from company data).

Data for samples shown on figure 102

[All samples chip; all taken across shear zone. N, none detected; 1 ft=0.3048 m; 1 troy oz/ton=34.285 g/t]

Sample No.	Sample Length (ft)	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)
Z-48	1.0	N	4.4	5.0
Z-132	3.0	0.50	152.5	31.0
Z-133	2.5	.21	8.7	16.0
Z-134	2.0	.45	21.5	21.0

Internal access to Adit No. 2 is unsafe and the portal is caved, but company records indicate that the adit is 335 ft (102 m) long and is connected to Adit No. 3 by several stopes and an intermediate level (fig. 102). According to companay records, the ore shoot averaged 100 ft (30 m) long, 2 ft (0.6 m) wide, and 150 ft (46 m) deep and produced the largest amount of ore in the mine. The shear zone strikes N. 70° E. and dips 70° S. A random dump sample of quartz that contained galena, pyrite, limonite, and hematite assayed 2.4 oz silver per ton (82.3 g/t) and 2.0 percent lead. A selected dump sample collected by the U.S. Geological Survey contained 20 ppm lead, 15,000 ppm copper, and more than 10 percent lead and zinc.

Adit No. 3 is inaccessible but, according to company records, it has 1,052 ft (320 m) of drifts and cross cuts and was used mainly as a haulage level. The main shear zone strikes N. 75° E. and dips 65° S. at the portal. A stockpile grab sample composed of galena, pyrite, hematite, chalcopyrite, bornite, quartz, calcite, and gouge assayed 0.43 oz gold per ton (14.7 g/t), 40.9 oz silver per ton (1,402 g/t), 31.1 percent lead, 1.61 percent copper, and 2.40 percent zinc. A random dump sample assayed 22.4 oz silver per ton (768 g/t), 6.0 percent lead, 0.5 percent zinc, and 0.1 percent copper

Evaluation of the mineral potential of the main shear zone is difficult because the ore occurs in large randomly distributed lenses and pods. Known high-grade shoots have been nearly mined out, but the total structure has not been explored and considerable amounts of lower grade material may remain in the inaccessible stopes. About 20 percent of the developed zone was in ore. An inferred reserve of 2,400 tons (2,200 t) and resources of about 10,000 tons (9,100 t) are estimated within 300 ft (90 m) beneath the lowest adit. Reserves above Adit No. 3 are indicated to be 750 tons (680 t) averaging 0.08 oz gold per ton (2.74 g/t), 20.7 oz silver per ton (910 g/t), 9.6 percent lead, and 0.2 percent zinc. Several thousand tons of lower grade resources remain above the lowest adit.

A second group of workings develop another major structure on the Bazouk and Champion claims (fig. 100). Development consists of three adits and four shafts. The main or Champion adit is 180 ft (55 m) long (fig 103) and follows a mineralized shear zone that strikes N. 45°-80° E. and dips 54°-61° SE. in quartzite. The zone averages 3 ft (0.9 m) in width and has been stoped at three locations. A stope along a raise that connects to the surface extends 10 ft (3 m) in width and has been stoped at three locations. A stope along a raise that connects to the surface extends 10 ft (3 m) along strike. An underhand and an overhand stope are near the face of an intermediate level, 10 ft (3 m) below the adit. The overhand stope is 20 ft (6 m) long, 3 ft (0.9 m) wide, and 20 ft (6 m) deep; the underhand stope is 60 ft (18 m) long and 3 ft (0.9 m) wide, and was full of water below 30 ft (9 m). The zone averaged 2 ft (0 6 m) thick in the stope. Blebs of galena and sphalerite occur on the hanging wall, and disseminated grains of galena, pyrite, cerussite, and chalcopyrite were observed in a gangue of gouge, calcite, quartz, and siderite Samples taken across the zone averaged, weighted by length, 0.15 oz gold per ton (5.1 g/t), 54.4 oz silver per ton (1,865 g/t), 15.4 percent lead, and 0.1 percent zinc.

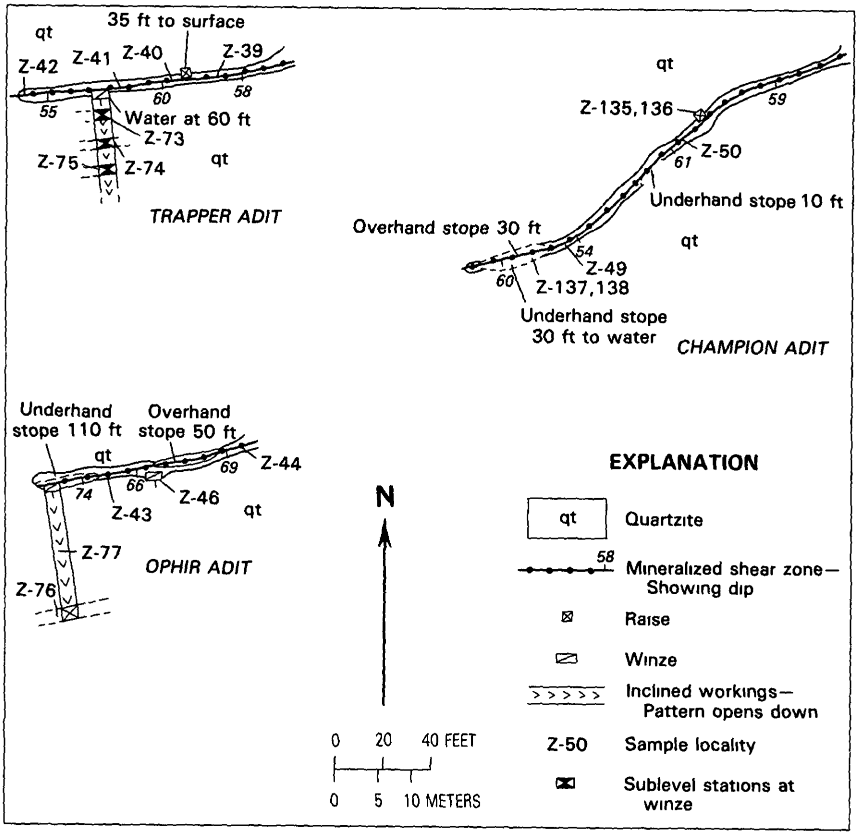

FIGURE 103 —Ophir Champion, and Trapper adits, Boulder mines

The mineralized shear zone is exposed in three shafts and for about 440 ft (135 m) in one adit west of the Champion adit (fig. 101). The westernmost shaft and the adit were accessible. An intermediate level, from the shaft, 30 ft (9 m) from the surface, extends 45 ft (13.7 m) southwest along the shear zone. A 40-ft (12-m)-long intermediate lateral extends to a winze that connects to the adit 80 ft (24 m) below. The adit crosscuts the shear zone, which averages 1.5 ft (0.46 m) in width and is traceable for 400 ft (120 m) along the strike on the surface. Galena and pyrite occur in a gangue of gouge, quartz, calcite, and limonite Four chip samples taken across the zone averaged 0.02 oz gold per ton (0.69 g/t), 3.6 oz silver per ton (123 g/t), 1.2 percent lead, 0.1 percent zinc, and 0.03 percent copper. Assuming ore shoot distribution similar to exposures, reserves of 500 tons (450 t) that contain a trace gold, 30.0 oz silver per ton (1,029 g/t), 8.3 percent lead, and 0.1 percent zinc are estimated to remain in this mineralized shear zone on the Champion and Bazouk claims.

Data for samples shown on figure 103

[All samples chip Tr, trace, N, none detected, leaders (-), not analyzed, 1 ft=0.3048 m, 1 troy oz/ton=34 285 g/t]

Sample No.	Sample Length (ft)	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)	Copper (percent)
Z-39	1.0	0.06	4.8	8.0	0.30	0.06
Z-40	.7	N	4.2	3.0	8.0	--
Z-41	.8	N	2.8	2.0	10.0	.28
Z-42	3.0	N	1.1	2.0	.30	--
Z-43	1.2	Tr	10.6	3.0	.30	.45
Z-44	.8	N	2.3	2.9	--	--
Z-46	2.0	N	1.6	4.0	.30	--
Z-49	2.3	.12	18.1	7.4	--	--
Z-50	.7	.16	15.0	7.0	.30	.49
Z-73	2.0	N	.04	1.3	1.7	.16
Z-74	1.5	.28	4.5	2.9	--	--
Z-75	1.5	.04	60.7	36.0	.52	.44
Z-76	2.0	.32	38.2	42.0	.12	.96
Z-77	1.4	N	.30	1.0	--	--
Z-135	2.5	.17	16.4	4.0	--	--
Z-136	1.5	.06	124.7	37.0	.18	--
Z-137	2.0	.03	14.6	7.0	.49	--
Z-138	2.0	.35	144.6	34.0	.01	--

A shaft 175 ft (53 m) northeast of the Champion adit is on a limonite-stained zone at an intrusive rock-quartzite contact. The zone is 20 in. (0.5 m) wide and is traceable for 35 ft (10.7 m) on a N. 20° E. trend. Quartz veinlets occur in fractured quartzite along the contact. A selected sample from the veinlets contained 1.3 oz silver per ton (44.6 g/t) and 1.0 percent lead.

A third shear zone is exposed 115 ft (35 m) along the Trapper adit (fig. 103) and 40 ft (12 m) along a short adit. It strikes N. 80° E. and dips 55°-60° SE. in quartzite. Intermittent exposures indicate a length of 200 ft (60 m) and a depth of 110 ft (34 m). The thickness averages 10 in. (25 cm). Ore, mainly galena bearing quartz in gouge, has been removed through the Trapper adit. Stoping extended along strike from an inclined raise to the surface and from at least three levels below the adit. Samples taken across the zone averaged 0.05 oz gold per ton (1.7 g/t), 10.6 oz silver per ton (363 g/t), 7.5 percent lead, and 1.9 percent zinc Reserves of 300 tons (270 t) are estimated for the zone.

Two 25-ft (8-m) adits, also on the Trapper claim, follow minor shear zones striking about N. 75° E. and dipping 70° SE. and crosscut an intrusive rock-quartzite contact. A small amount of ore has been mined from small stringers of pyrite and galena in gouge and quartz. A chip sample from the northerly adit assayed 1.0 percent lead; another from the other adit contained 14.0 oz silver per ton (480 g/t), 9.6 percent lead, and 6 4 percent zinc. The structures are too small to be economically significant.

A 40-ft (12-m) adit on the Triumph claim (fig. 101) explores two intersecting shears with attitudes N. 60° E., 56° SE., and N. 30° W., 48° SW. The quartzite country rock is mineralized around the intersection, which is exposed by a 20-ft (6-m)-deep winze. Disseminated pyrite and galena occur in the shears and in the wall rock. Three samples from the winze averaged 0.5 percent lead and 0.3 percent zinc. A 20-ft (6-m) drift southeast of this adit follows a barren shear zone that trends S. 70° W.

A 12-ft (3.7-m) adit on the Sunset claim (fig. 100) trends N. 30° W. in quartzite that contains limonite-stained shears and fractures. A large shear zone at the portal averages 2.5 ft (0.76 m) in thickness, and is exposed 15 ft (4.6 m) along a strike of N. 60° E Pyrite and galena occur in lenses as much as 1 in. (2.5 cm) long in the gouge. A chip sample contained 0.5 oz silver per ton (17 g/t), 1.8 percent lead, and 0.2 percent zinc.

An inclined shaft on the Mascot claim (fig. 101) follows a shear zone that trends N. 30° W and dips 25° SW. in quartzite. The owner reports that ore has been removed and that some remains. The zone is 40 in. (1 m) thick at the collar of the shaft, but elsewhere is covered by talus or flooded A chip sample across the zone assayed 0.66 oz gold per ton (22 6 g/t), 12.8 oz silver per ton (439 g/t), and 5.0 percent lead. A 55-ft (17-m) adit west of the shaft follows a 2-ft (0.6-m)-wide shear zone in fractured quartzite that strikes N. 66° W. and dips 67° SW. Thin stringers of sulfide-bearing quartz occur along shear planes. Two samples taken across the zone averaged 1.3 oz silver per ton (44.6 g/t), 0 8 percent lead, and 0.7 percent zinc.

On the Climax claim, which adjoins the Mascot claim (fig. 100), a 20-ft (6-m) adit with a 50-ft (15-m) winze follows a 3-ft (0.9-m)-wide shear zone that trends N. 80° W. The zone is in breccia, is stained by iron oxides, and contains stringers of quartz and calcite in which are disseminated galena and sphalerite. A sample from the zone contained 0.7 oz silver per ton (24 g/t), 0.4 percent lead, and 6.1 percent zinc. Potential resources are estimated to be at least 250 tons (225 t) of mineralized material. A T-shaped adit immediately to the north follows a 26-in. (0.66-m)-wide shear zone that strikes N. 20° E., dips 70° NW., and is traceable for 45 ft (13.7 m) along strike and 10 ft (3 m) downdip. Thin stringers of galena and pyrite occur in the gouge. A sample from the zone contained 0.7 oz silver per ton (24 g/t) and 5.8 percent lead.

A 10-ft (3-m) shaft and two pits on the Sunrise claim were sunk on quartz veins along a porphyry-sedimentary rock contact. The veins strike N. 10° W. and dip 50°-60° NE. The largest is 50 ft (15 m) long and as much as 9 ft (2.7 m) thick. Disseminated pyrite was the only sulfide mineral observed in the veins, samples from which averaged 0.3 oz silver per ton (10.3 g/t) and 0.2 percent lead.

A pit on the Summit claim was dug on a barren 30-in. (0.76-m) shear zone that parallels a quartzite-intrusive contact.

A flooded, inclined adit southeast from the mill on the Tip Top claim was driven in quartzite along a shear zone that strikes N. 76° E. and dips 33° SE. The zone is 17 in. (43 cm) thick, and is exposed 40 ft (12 m) along strike and 10 ft (3 m) downdip. Two samples across the zone averaged 1.7 oz silver per ton (58 g/t) and 0.5 percent lead.

On the Sullivan claim, a 40-ft (12-m) adit crosscuts a 5-ft (1.5-m)-thick shear zone that trends north in andesite porphyry. A sample from a quartz pod at the portal contained 2.3 oz silver per ton (79 g/t), but other samples from the zone contained nil values.

An adit on the Daisy claim was driven to explore the intersection of a horizontal shear zone and a N. 70° E.-trending shear zone in intrusive rock. Disseminated pyrite, galena, chalcopyrite, and sphalerite occur at the highly brecciated junction of the shears. Two samples of the material averaged 0.3 oz silver per ton (10.3 g/t) and 0.7 percent combined lead and zinc.

Many shear zones in limonite-stained andesite porphyry are exposed on the Puritan claim south of Boulder Basin (fig. 100). The highly altered andesite covers about 70,000 ft^2 (6,500 m^2). The zones strike north, dip 50°–80° W., and are 1.5–3 ft (0.45–0.9 m) wide and 40–100 ft (12–30 m) long. Stringers of sulfide-bearing quartz occur in the zones, and bleached zones extend 1.5 ft (0.45 m) into the wall rock. Two adits and one trench were dug on three of the shears. Three chip samples across the zones in the workings averaged 1.9 oz silver per ton (65 g/t), 3 7 percent lead, and 4.0 percent zinc. A stockpile sample contained 9.0 oz silver per ton (309 g/t), 10.0 percent lead, and 20.0 percent zinc, and a chip sample of the limonite-stained andesite porphyry assayed 0 07 percent lead.

An adit known as the Hardrock Tunnel was driven in the early days toward Boulder Basin from the Crown Point claim (fig. 100) on Boulder Creek near the lower camp. The adit was caved at the portal at the time of the examination but trends N. 65° W. for 1,000 ft (300 m). According to the owner, it was driven to crosscut the main shear zone at a depth of 1,320 ft (402 m) below Adit No. 3, but was not completed. No ore bodies were discovered in the adit. Random dump samples averaged 0.05 oz silver per ton (1.7 g/t), 0.04 percent lead, and 0.01 percent copper.

An adit (fig. 100) about 350 ft (107 m) west from the Hardrock adit extends N. 80° E. for 15 ft (4.6 m) on a 20° NW.-dipping shear zone in andesite porphyry. The zone is 2 ft (0.6 m) thick, exposed intermittently for 75 ft (23 m). Gouge and quartz in the zone contain pods of pyrite and galena as much as 4 in. (10 cm) in diameter. A sample taken across the zone in the adit assayed 1.4 oz silver per ton (48 g/t), 1.8 percent lead, and 4.0 percent iron; but samples from pits contained only

TABLE 30.—*Miscellaneous properties, North Fork Big Wood River district*

[1 in.=2.54 cm, 1 ft=0.3048 m, 1 troy oz/ton=34.285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
232	Sultan	A quartzite block bounded on two sides by large, N. 45° E.-trending dikes has a 4-ft-thick shear zone striking N. 70° E. and dipping 70° SE. The zone is about 90 ft long and terminated at both ends by the dikes. The zone contains sulfide-bearing quartz stringers as much as 6 in. thick in gouge and breccia.	A 20-ft inclined shaft and three pits.	Three samples across the zone averaged 0.01 oz gold per ton, 1.6 oz silver per ton, and 0.7 percent lead.
233	Jaukow	Shear zones striking N. 80°-88° W. and steeply dipping occur in and near a granititic dike trending N. 45° E. in contact metamorphosed quartzite. The zones are 6-30 in. thick, 35-80 ft long, and exposed through a depth of 40 ft. Pyrite, pyrrhotite, galena, and hematite occur as blebs in the gouge and breccia filling the zones.	Four short upper adits and a lower caved adit estimated to have been 100 ft long.	Five samples of the zones averaged 1.1 oz silver per ton, 1.2 percent zinc, and 0.4 percent lead.

234	Million	Shear zones crosscut a contact between granite and metamorphosed limestone, quartzite, and argillite. Three zones exposed in workings, 1-5 in. thick, contain oxidized pyrite and galena in a gangue of quartz, calcite, and gouge.	A 70-ft and a 230-ft adit, and four prospect pits.	Five samples across the shear zones averaged 0.7 oz silver per ton, 0.7 percent lead, and 0.01 percent zinc.
235	Fox Tail	An iron-oxide-stained shear zone parallels the bedding of slate, strikes N. 40° E. and dips vertically. The zone is 52 in. thick and traceable on the surface for 60 ft. The zone is composed of breccia, gouge, and quartz stringers containing minor sulfides.	Two caved adits.	Two samples across the zone averaged 0.2 oz silver per ton and 0.04 percent lead.
236	Boulder Ridge occurrence.	A quartz-carbonate vein contains sparsely disseminated chalcopyrite, galena, azurite, tenorite, and malachite. The vein is 2 ft thick and partly follows the bedding of the phyllite country rock.	None.	One select chip sample, 0.2 oz gold per ton, 5.8 oz silver per ton, 0.8 percent copper, and 0.6 percent lead.

traces of metals. A sample from a stockpile contained 4.3 oz silver per ton (147 g/t), and 5.6 percent lead.

UTAH GROUP

The Utah group (pl. 3, 231) of three claims was located in 1927 and relocated in 1941. Development consists of two adits and two pits. A shop, cabins, and a water-driven 25 ton/day capacity mill are near Boulder Creek on the claims. The mill and workings are connected by a tram. Mineral production from the group is unknown.

One adit was driven 39 ft (12 m) southerly in andesite along a shear zone 3 ft (0.9 m) thick that strikes N. 40° E. and dips 65° SE.; the other crosscuts a small perpendicular shear Pits dug along the main zone indicate a length of at least 150 ft (46 m). The zone contains small amounts of limonite, pyrite, and galena in quartz and gouge. Three samples across the zone averaged 0.3 oz silver per ton (10.3 g/t), 2.0 percent lead, and 0.3 percent zinc. A few thousand tons of resources are estimated for the property.

SNUG PROSPECT

The Snug prospect (pl. 3, 230), about 3,400 ft (1,035 m) northeast of the Hardrock Tunnel, consists of three adits and a shaft along steeply dipping shear zones in quartzite near a rhyolite dike. The more prominent shear trend is N. 70° W. A secondary trend is N. 32° E. The two lower adits expose narrow shear zones 0.5–1.5 in. (1.3–3.8 cm) thick. The upper adit extends 55 ft (17 m) and is connected to a 30-ft (9-m) shaft. The workings expose a 1- to 10-in. (2.5-25-cm)–wide shear zone that consists of iron-oxide-stained gouge and quartz. Pyrite, galena, and sphalerite are disseminated in the shear zones and in three pod-shaped outcrops of altered quartzite breccia at the dike contacts. Two samples across the more prominent shear zone averaged 0.06 oz gold per ton (2 g/t), 5.1 oz silver per ton (17 g/t), 0.9 percent lead, and 2.0 percent zinc. One sample from the pods at the contact assayed 0.03 oz gold per ton (1.03 g/t), 1.5 oz silver per ton (51.4 g/mt), and 0.6 percent lead. Two samples from the other workings averaged a trace gold and 0.02 percent lead

MISCELLANEOUS PROPERTIES

Several properties in the district that have little or no economic potential, or are not sufficiently exposed to indicate their potential, are listed in table 30.

CASINO CREEKS DISTRICT

Casino Creeks district, in the northern part of the study area (pl. 3, fig. 34), is underlain by granitic rocks of the Idaho batholith. Lode deposits include fluorite-quartz veins emplaced as fracture fillings in shear zones both north and south of the Salmon River. The main deposit is the Giant Spar fluorite zone near the mouths of Big and Little Casino Creeks. Fluorite-quartz veins of this northeast-trending zone are traceable in prospect workings and by float for about 7,600 ft (2.3 km) on the Giant Spar, Gold Chance, Homestake, and Vaught (Gold Coin) claims (fig. 104). Other fluorite-quartz veins occur north of the Salmon River on the Bright Star claims and in the Hide Out group north of the study area.

County records indicate that about 120 lode and 140 placer claims were recorded between 1891 and 1970 (table 31). Four lode claims have been patented and are part of the Giant Spar group. In 1971 and 1972, Humble Oil Co. staked more than 300 uranium claims north and east of Stanley, Idaho, some within the study area.

The first reported mine development was between 1893 and 1910, when two adits were driven at a gold prospect on the Gold Chance claims In the early 1900's, 175 ft (53 m) of the lowest Homestake adit were driven; the remaining 725 ft (221 m) were completed by 1942. Also in the early 1900's, the Giant Spar property was worked for gold, but in the 1940's it was sold to the Aluminum Company of America (ALCOA), who explored the property for fluorite. Most placer mining was done between 1910 and 1920 and in the mid-1930's (Choate, 1962, p 82–86).

According to Choate (1962, p. 84, 86) two lode mines of the district have yielded more than $7,000 of gold and silver. A few truck loads of fluorite were mined from the Giant Spar property. Gold valued between $23,000 and $28,000 (gold at $20/oz) has been produced from placer deposits in the district, mainly from Rough Creek (Umpleby and Livingston, 1920, p. 18).

GIANT SPAR FLUORITE ZONE

The Giant Spar fluorite zone is mostly on the Giant Spar group of claims, which originally were staked for gold. In the 1940's, ALCOA evaluated the fluorite potential of the property by diamond drilling and trenching, and in 1955 the company patented the Giant Spar group (Giant Spar, Giant Spar No. 2, Giant Spar No. 3, and Metallic No. 2) The property was inactive in 1972.

Veins and veinlets of fluorite trend northeast through the area, and

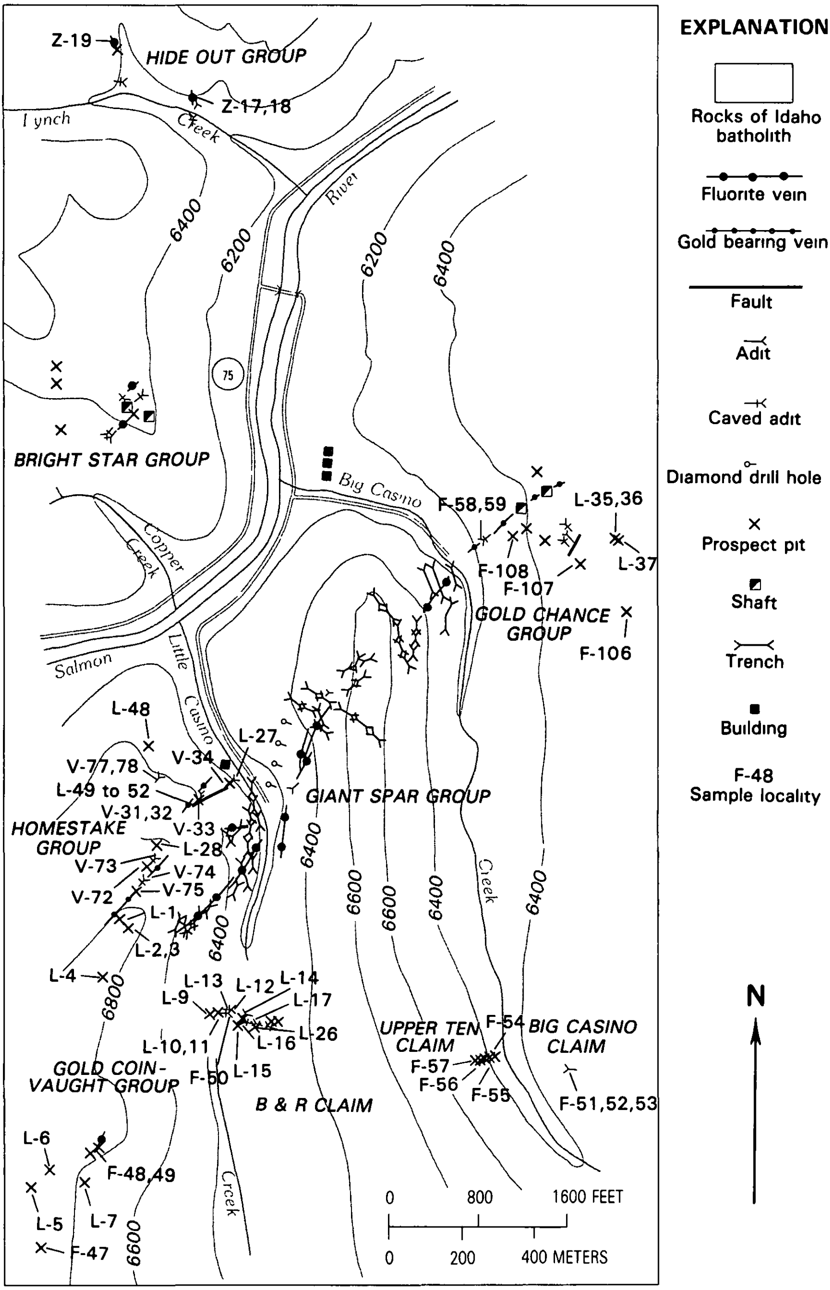

FIGURE 104 —Prospects in lower Casino Creeks area. Contour interval 200 ft

Data for samples shown on figure 104

[Tr, trace, N, none detected, leaders (-), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample No	Type	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)
L-1	Select	(1)	Vein quartz----	N	N
L-2	Chip--	3 5	Across quartz vein	N	N
L-3	Select		Vein quartz---	N	0 2
L-4	--do--		---do---------	N	N
J-5	--do--		Altered granitic rock	N	N
L-6	--do--		---do---------	N	N
L-7	--do--		Vein quartz----	N	N
L-9	Chip--	1 0	Across quartz vein	N	N
L-10	--do--	3 5	---do----------	0 01	1
L-11	Select		Vein quartz----	08	1
L-12	--do--		Altered granitic rock	N	N
L-13	Chip--	5 0	---do----------	N	N
L-14	--do--	2 0	Fractured quartz	N	N
L-15	--do--	2 0	Altered granitic rock	N	N
L-16	Select		Vein quartz----	05	6
L-17	--do--		---do----------	--	--
L-26	--do--	15 0	Altered quartzite	N	N
L-27	--do--	4 0	Vein quartz----	N	6
L-28	Select		---do----------	Tr	N
L-35	--do--	6 0	Altered granitic rock	Tr	N
L-36	--do--		---do----------	10	5
L-37	--do--		---do----------	27	Tr
L-48	--do--		Vein quartz----	N	2
L-49	Chip--	3 5	Across quartz vein and fractured granitic rock	N	N
L-50	--do--	2 0	Across quartz vein	Tr	1
L-51	--do--	2 0	---do----------	02	1
L-52	--do--	4 0	Siliceous dike	02	N
V-31	--do--	8	Fault gouge----	N	N
V-32	--do--	1 0	Fractured, altered quartz	N	Tr
V-33	Select	(1)	Vein quartz----	N	0 1
V-34	Chip--	2 5	Fractured, altered quartz	N	N
V-72	Select		Vein quartz----	N	N
V-73	--do--		---do----------	N	6
V-74	--do--		---do----------	N	3
V-75	--do--		---do----------	0.05	1
V-76	Chip--	3 0	Siliceous dikelets	N	N
V-77	--do--	3 0	Across quartz vein	N	N
V-78	--do--	4 0	Fractured granitic rock	N	Tr
F-47	Select		Altered granitic rock	N	N
F-48	Chip--	5 0	Across shear zone	N	N
F-49	Select		Quartz-fluorite vein material	N	N
F-50	--do--		Vein quartz----	N	N
F-51	Chip--	3 0	Altered granitic rock	N	N
F-52	Select		---do----------	17	1 5
F-53	Chip--	4 0	---do----------	N	N
F-54	Select		---do----------	N	N
F-55	Chip--	5 0	Fractured granitic rock	N	N
F-56	Select		Altered granitic rock	N	N
F-57	Chip--	6 0	Fractured granitic rock	Tr	N
F-58	--do--	8 0	---do----------	N	N
F-59	Select		Vein fluorite--	Tr	1
F-106	--do--		Altered granitic rock	Tr	Tr
F-107	Chip--	9 0	---do----------	Tr	Tr
F-108	Select		---do----------	Tr	10
Z-17	--do--		Quartz pod-----	N	1
Z-18	Chip--	10 0	Along quartz vein	N	N
Z-19	--do--	6 0	Altered granitic rock	N	N

[1]Blank, not measured

can be traced for about 2,800 ft (850 m) between Big and Little Casino Creeks. Float and outcrops indicate that the fluorite zone extends an additional 1,200 ft (370 m) northeast on the Gold Chance property and 3,200 ft (975 m) southwest on the Vaught prospect and Homestake claims. The veins are poorly exposed, but thicknesses as much as 3 ft (0.9 m) were observed; most are much less. Veins as much as 14.8 ft (4.5 m) thick, however, are reported by Choate (1962, p. 83).

Fluorite on the Giant Spar claims was explored by a 150-ft (46-m)

TABLE 31 —*Summary of recorded mining claims, including relocations, 1891-1970, Casino Creeks district*

Decade	Number of lode claims	Number of placer claims
1891-1900	(1)	18
1901-1910	29	16
1911-1920	1	3
1921-1930	9	19
1931-1940	46	52
1941-1950	20	7
1951-1960	12	10
1961-1970	3	14
Total-----	120	139

[1]None recorded.

adit, 19 bulldozer cuts, six prospect pits, and four diamond drill holes (fig. 104, 105). All surface workings are sloughed, and fluorite float was found in only a few pits. The best exposure is at the portal of the Giant Spar adit, where two fluorite veins, each 3 ft (0.9 m) thick, are separated by a 3-ft (0 9-m)-thick zone of iron-oxide-stained quartz, granitic rock, and fluorite. The fluorite is mostly lavender, but greenish and white varieties occur. Three chip samples (L–30, L–31, and W–293) across the 9-ft (2.7-m) zone averaged 76.26 percent CaF_2 (fig. 105).

The Giant Spar adit is along the vein zone in altered granitic rocks. The west-wall vein is exposed for 10 ft (3 m), and the east-wall vein, which may be only a lens, is exposed for only 5 ft (1.5 m) in the adit. Narrow, fluorite-quartz veins occur several places in the remainder of the adit. A chip sample (L–29) taken across one of these veins assayed 46.2 percent CaF_2 (fig 105)

Assuming an average thickness of 3 ft (0.9 m), length of 2,800 ft (853 m), and a minimum 280-ft (85-m) depth as indicated by drilling (Choate, 1962, p. 82), potential resources of fluorite-bearing rock are estimated to be at least 200,000 tons (180,000 t) between Big and Little Casino Creeks. The average grade of this tonnage cannot be calculated because of the lack of sufficient data.

HOMESTAKE GROUP

The Homestake mine workings (fig. 104) are southwest of the Giant Spar property (pl. 3, 40). Arnold Wollard located the Homestake group of claims in the early 1930's for gold, and most mine development was done in that decade; the property was inactive in 1972. Hand-cobbed gold ore valued between $1,000 and $1,600 reportedly was produced from the three open adits (Choate, 1962, p. 84). U.S. Bureau of Mines records indicate that 11 tons (10 t) of ore, produced between 1934 and 1938, contained 35 oz (1,200 g) of gold and 50 oz (1,714 g) of silver.

Mine workings include three adits, aggregating 1,400 ft (430 m), 2 caved adits, and 13 prospect pits. The open adits expose quartz and quartz-fluorite fissure veins in northeast-trending shear zones, which are traceable for more than 100 ft (30 m) and may be part of the Giant Spar fluorite zone. Host rocks are altered granitic rocks and siliceous dikes.

Dumps of workings uphill from the open adits contain pyrite-bearing quartz that probably came from veins that average less than 6 in. (15 cm) in thickness. Six small prospect pits were dug about 3,000 ft (900 m) south of the main adit. One pit exposes a 6-in. (15-cm)-thick fluorite-quartz vein in a 5-ft (1.5-m)-thick shear zone. Chip sample F-48 (fig. 104) across the zone assayed 33.6 percent CaF_2. The other pits expose altered granitic rocks.

Assays indicate that the property has very little gold potential, but it does have a potential for discovery of fluorite veins that might be developed in conjunction with those of the Giant Spar group.

GOLD CHANCE GROUP

The Gold Chance mine (pl. 3, 42), east of Big Casino Creek, originally was located in 1893 for gold, and most development work was done in the early 1900's. A pocket of gold ore valued at $6,000 was mined (Choate, 1962, p. 86), but no other production information is available. In 1972, the property was part of Humble Oil Co.'s group of uranium claims.

Mine workings expose quartz veins, quartz-fluorite veins, and porphyry and pegmatite dikes that cut the Idaho batholith and may be the northeast extension of the Giant Spar fluorite zone. Workings consist of an open adit, three caved adits, two caved shafts, and six partially sloughed prospect pits.

The open adit was driven in limonite-stained granitic rocks and contains 760 ft (232 m) of workings, including a 25-ft (7.6-m) raise and 60-ft (18-m) upper level (fig. 106). Near the portal of the adit, a drift follows a porphyry dike that averages 2.5 ft (0.76 m) in thickness, contains finely disseminated sulfides, and is 10 times background count in radioactivity. Sample L-42 from the dike assayed 0.01 percent U_3O_8 and 0.08 oz gold per ton (2 7 g/t). Samples from other structures in the adit contained insignificant values. A selected sample (L-41) of altered granitic rock from a stockpile contained 0.01 oz gold and 1.1 oz silver per ton (0.34 and 37 g/t).

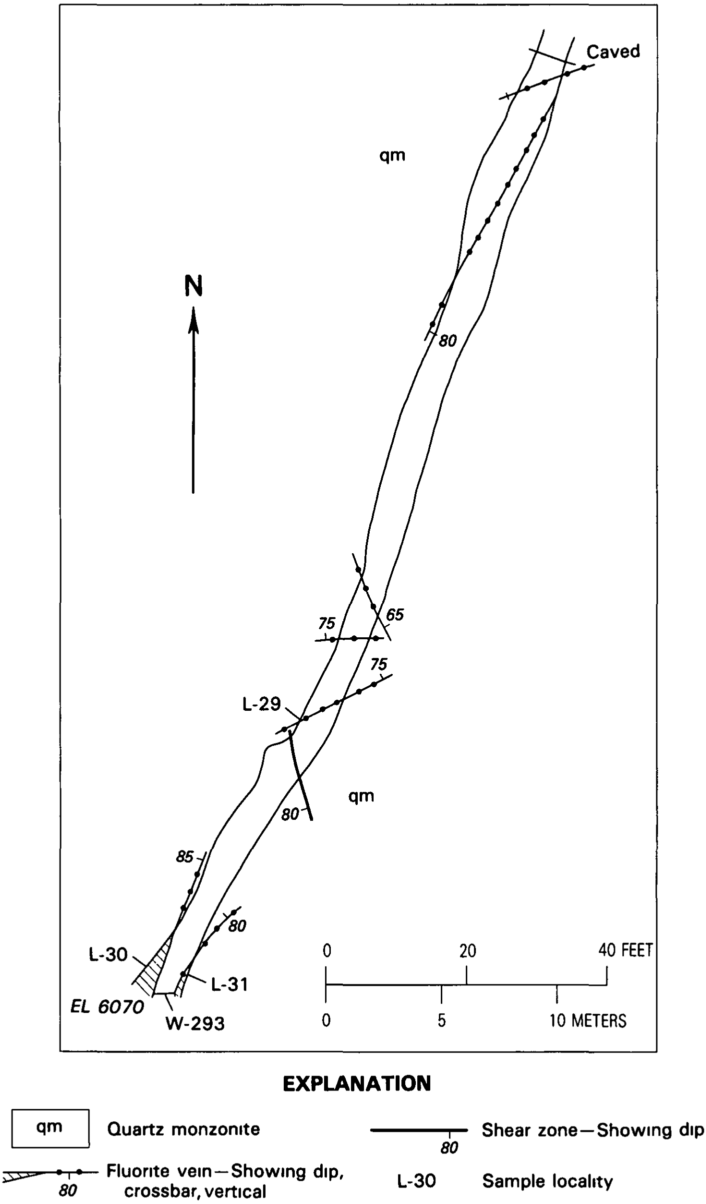

FIGURE 105.—Giant Spar adit (modified from Choate, 1962). Elevation in feet

Data for samples shown in figure 105

[All samples chip Tr, trace, N, none detected, leaders (-), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample No.	Sample Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	CaF_2 (percent)
L-29	1.0	Across fluorite vein-	Tr	N	46.2
L-30	3.0	---do----------------	N	N	86.1
L-31	3.0	---do----------------	N	N	87.3
W-293	3.0	Fluorite and granitic rock.	--	--	55.37

The caved lower adit, 200 ft (60 m) lower in elevation and west of the open adit (fig. 104) exposed a 1-ft (0.3-m)-thick northwest-trending quartz vein and a narrow porphyritic rhyolite dike (Choate, 1962, p. 86) A selected sample (F-59, fig. 104) of purple fluorite and quartz containing pyrite from the dump assayed 45.0 percent CaF_2, a trace gold, and 0.1 oz silver per ton (3.4 g/t).

Other workings were caved or badly sloughed, but quartz, fluorite, and pyrite were observed on the dumps. Select samples contained as much as 0.10 oz gold per ton (3.4 g/t) and 0.5 oz silver per ton (17 g/t) (fig. 104).

Gold, silver, and uranium potential appears to be very small, but the property has a potential for discovery of fluorite veins.

BRIGHT STAR GROUP

The Bright Star prospect (fig. 104) is three-fourths mile (1.2 km) north of the Giant Spar claims. The claim was originally staked for gold in 1895, but most mine development was done in the 1940's and 1950's. The J. R. Simplot Co. explored the property in the late 1950's for fluorite, and Humble Oil Co. was prospecting it for uranium in 1972. No production records for the property are available.

Mine workings expose a northeast-trending fracture zone indicated by Choate (1962, p. 81) to be 60-120 ft (18-37 m) thick. An adit, reported to be 500 ft (150 m) long, is caved 90 ft (27 m) from the portal (fig. 107). It was driven along a 1-ft (0.3-m)-thick shear zone filled with fractured, limonite-stained quartz. Chip sample Z-20 along the zone contained only trace gold and no detectable silver.

A northeast-trending, 18-in. (0.4-m)-thick fluorite vein is exposed inside the portal of a caved adit northeast of the open adit. A chip sample (fig. 107, Z-26) across the vein assayed 91.5 percent fluorite. Quartz

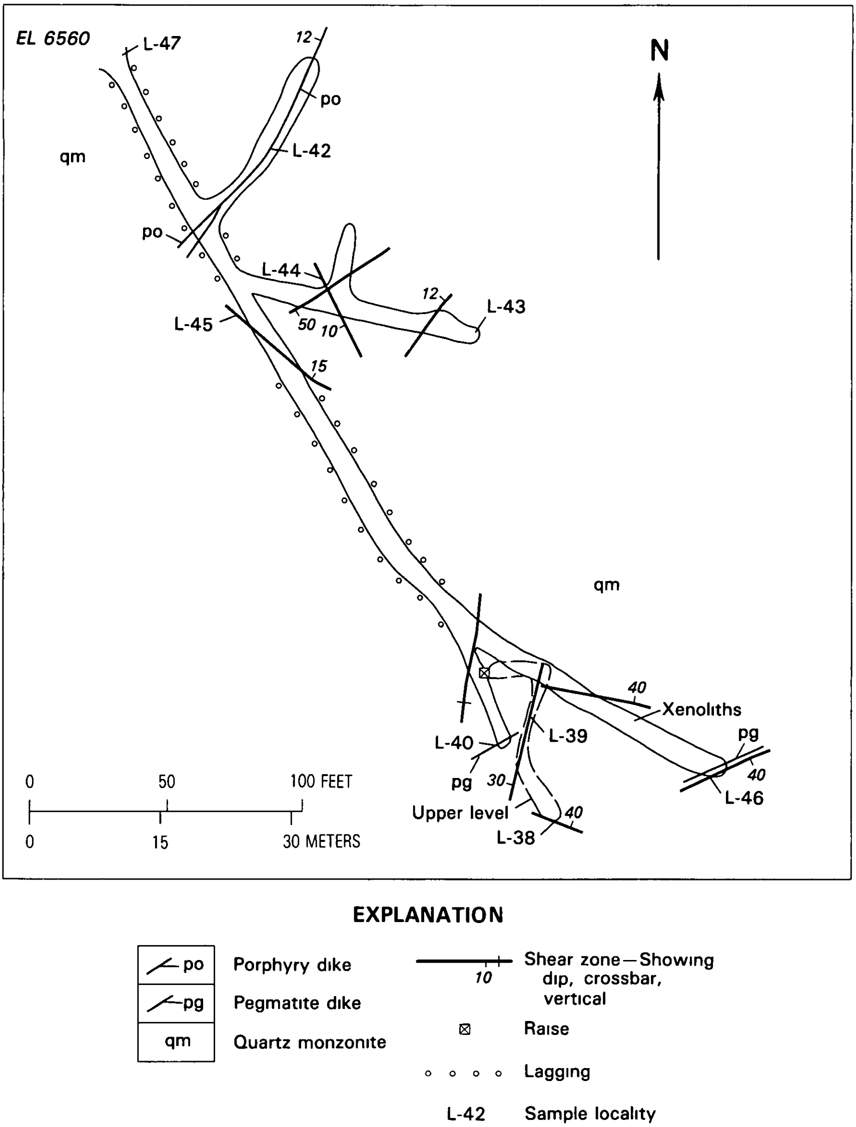

FIGURE 106.—Gold Chance adit. Elevation in feet.

and fluorite were seen on dumps of shaft Nos. 1 and 2, 30 and 90 ft (9 and 27 m) deep, respectively, and the other two caved adits. Two stockpile grab samples (Z-27 and Z-28) from shaft No. 1 and from the

Data for samples shown on figure 106

[All samples chip except L-41, select. Tr, trace, N, none detected, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample			Gold	Silver
No.	Length (ft)	Description	(oz/ton)	
L-38	5.0	Altered granitic rock--------	N	0.1
L-39	2.5	Granitic rocks with fault gouge.	N	.2
L-40	2.5	Across pegmatite dike-------	N	.1
L-41	([1])	Altered granitic rock-------	0.01	1.1
L-42	2.5	Across porphyry dike--------	.08	.2
L-43	2.0	Across silicified shear zone	.02	.2
L-44	1.0	Fractured quartz------------	N	Tr
L-45	2.0	---do-----------------------	Tr	.1
L-46	4.0	Pegmatite dikelets and granitic rock.	N	.1
L-47	2.5	Altered granitic rock-------	.06	.8

[1] Blank, not measured.

northernmost caved adit contained 0.15 and 0.27 oz gold per ton (5.1 and 9.8 g/t) and 1.1 oz silver per ton (38 g/t) (fig. 107). The mineralized structures are not sufficiently exposed to estimate their resource potential. No anomalous radioactivity was detected.

MISCELLANEOUS PROSPECTS

Other prospects in the district that have no mineral resource potential or are not sufficiently exposed to indicate potential ore bodies are summarized in table 32.

WARM SPRINGS CREEK DISTRICT

The Warm Springs Creek district in the north-central part of the study area (fig. 34; pl. 3) should not be confused with the Warm Springs mining district described by Umpleby (1915, p. 241–244) and others. Significant mineral deposits are limited mainly to placer deposits that are described in a succeeding section.

Major rock types of the district are Paleozoic argillite, quartzite, limestone, dolomite, and intrusive rocks of the Idaho batholith. The batholith and related intrusive rocks predominate west of Warm Springs Creek. The country rocks are cut by many northeast-trending faults, some of which are mineralized.

County records show a total of 120 placer claims and 31 lode claims

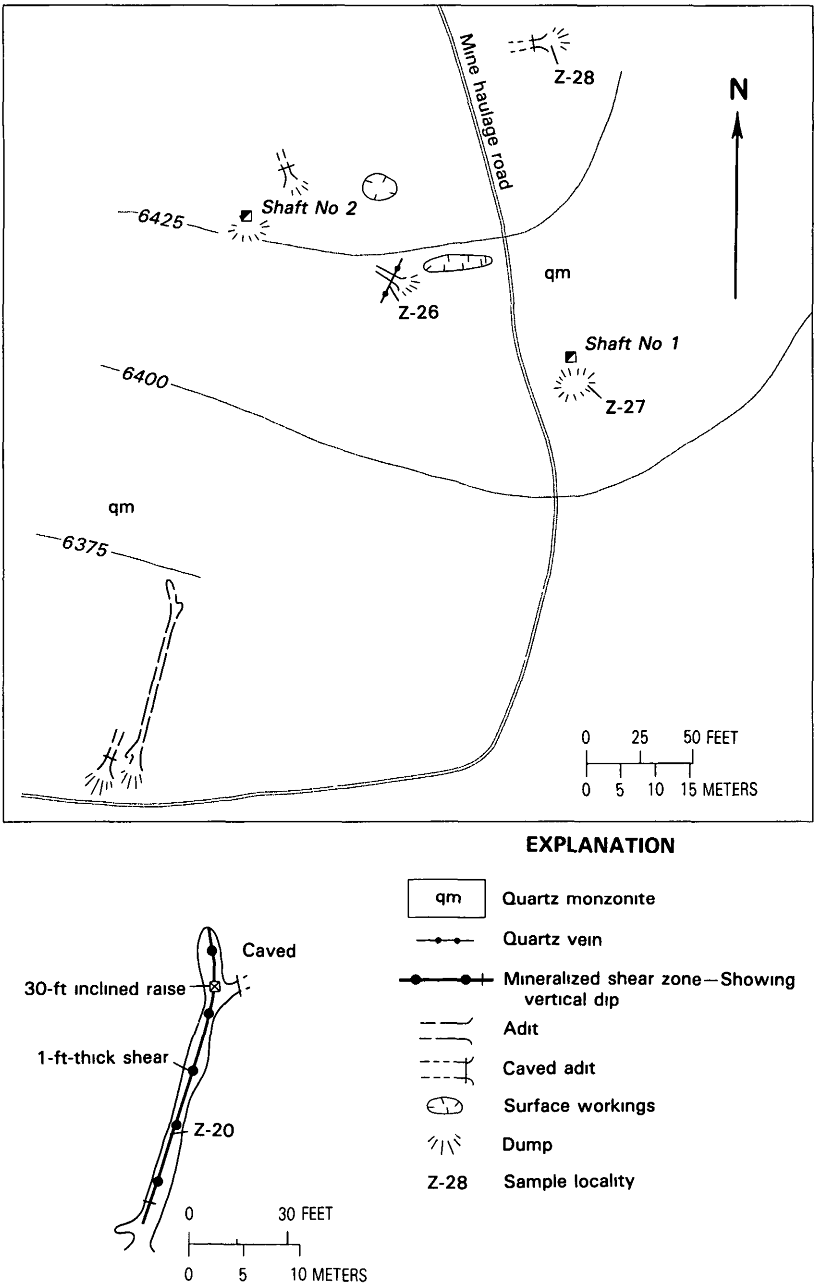

FIGURE 107 —Bright Star group Contour interval 25 ft

Data for samples shown on figure 107

[Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

No.	Sample Type	Sample Length (ft)	Sample Description	Gold (oz/ton)	Silver (oz/ton)	Fluorite (percent)
Z-20	Chip--	10.0	Along quartz vein---	Tr	N	--
Z-26	--do--	1.5	Across fluorite vein	Tr	N	91.5
Z-27	Select	([1])	Vein quartz---------	0.15	1.1	--
Z-28	--do--		---do---------------	.27	1.1	--

[1]Blank, not measured.

in the district, most of which were located before 1890. Placer gold was discovered at Robinson Bar in the 1860's. As much as $200,000 worth of placer gold (at $20/oz) has been recovered from the district (Choate, 1962). The only recorded lode production since 1902 has been from the Aztec mine.

AZTEC MINE

The Aztec mine, near the head of Fisher Creek and near the southern boundary of the Warm Springs Creek district (pl. 3, 106), is accessible from State Highway 75 by 12 mi (19 km) of seasonal road along Fisher Creek.

The five lode claims that make up the property, which was originally known as the Fisher gold mine, were first located in 1880. On October 3, 1885, the Ketchum Keystone newspaper reported: "* * * the operator has five men on the mine, who furnish sufficient ore to keep the five-stamp mill in operation with the capacity of 8 tons daily. The ore is abundant and will assay in free gold from $25 to $250 per ton." On April 24, 1886, the same newspaper reported "* * * 100 tons of ore on dump, reduced at Fisher mill, gold $25, silver $10." The claims were surveyed for patent in 1902 and again in 1969. Total recorded production from 1901 to 1941 is about 105 tons (95 t) of ore, which contained 75 oz (2,333 g) gold, 247 ounces (7,682 g) silver, and 1,189 lb (539 kg) lead (U.S. Bureau of Mines unpublished production records).

The owner, J. J. Fisher (oral commun., 1971), advised that principal underground workings (fig. 108) consist of a 700-ft (210-m) inclined shaft (caved near the collar) and several connecting drifts. These inaccessible workings were reported by Campbell (1932) to total 1,750 ft (533 m). Accessible workings include two short adits, 20 and 50 ft (6 and 15 m) long, a 15-ft (4.6-m) inclined shaft, and several exploration

TABLE 32.—*Miscellaneous prospects, Casino Creeks district*

[Locations and sample sites for 36, 37, 38, 39, 44 are shown on figure 104, 1 in =2 54 cm, 1 ft=0 3048 m, 1 oz/ton=34 285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
33	Grand Prize	A northwest-trending 18-in.-thick, sulfide-bearing quartz vein in granitic rock is exposed for 40 ft along strike.	Five small prospect pits and one short trench.	Two stockpile grab samples averaged 0.045 oz gold per ton and 23.8 oz silver per ton.
34	Little Pete	A quartz vein and pegmatitic dikelets in granitic rock.	Outcrop-----------------	One chip sample, no mineral values.
35	White Sar No. 1	Iron-oxide-stained granitic rock on dump, nothing in place.	Prospect pit------------	One dump grab sample, no mineral values.
36	Vaught (Gold Coin)	A 4-ft-thick quartz vein containing disseminated pyrite in altered granitic rock. Quartz and minor fluorite on dumps of caved adits.	Two caved adits and four prospect pits.	One stockpile grab sample of vein quartz, 0.08 oz gold per ton and 0.1 oz silver per ton.
37	B and R	Adit along a 6-in.-thick, quartz-fluorite-filled shear zone. Altered quartzite crops out east of caved adits. Vein quartz with disseminated sulfides on dumps.	Ten-foot adit, three caved adits, and four prospect pits.	Three chip samples and one grab sample, no mineral values. One grab of quartz from dump, 0.05 oz gold per ton, and 0.6 oz silver per ton.
38	Upper Ten	Two narrow east-west-trending shear zones in granitic rock, rhyolite on all dumps.	Six small partially sloughed prospect pits.	Four samples, no mineral values.
39	Big Casino	Two narrow east-west-trending shear zones in iron-oxide-stained granitic rock.	Six-foot adit------------	One stockpile sample, 0.17 oz gold per ton and 1.5 oz silver per ton.
44	Hideout	Adit along a 2-3-ft-thick, northerly trending silicified shear zone. One prospect pit exposes 2-ft-thick shear zone that strikes N. 20° W., dips 80° SW., contains quartz and fluorite.	One hundred and twenty-foot adit, two caved adits, two prospect pits and several bulldozer cuts.	One chip sample of a silicified shear zone in adit, no mineral values. Chip sample across quartz-fluorite zone in pit, 39.7 percent CaF_2.
45	P & B (Rocket)	Adit along 18-in.-thick, silicified, radioactive shear zone Prospect pits dug on northwest-trending basalt dike.	Thirty-five-foot adit and six prospect pits.	One chip sample of shear zone, no gold or silver, 0.32 percent U_3O_8

pits and trenches. Little remains of the old mill and buildings; the hoist house was standing but hoisting equipment had been removed.

The workings expose aplite dikes and shear zones in porphyritic quartz monzonite of the Idaho batholith. According to Ross (1937), the main shaft follows a 1.5-ft (0.45-m) shear zone that strikes N. 60° W. and dips 60° SW. The owner reported good gold and copper values below the 600-ft (183-m) level. A selected sample of probable vein material, spilled at the collar of the caved shaft, assayed 1.48 oz gold per ton (50.7 g/t) and 2.2 oz silver per ton (75 g/t). The 50-ft (15-m) adit, 400 ft (120 m) northwest of the main shaft, follows a narrow aplite dike trending N. 60° W. Samples across the dike and adjacent limonite-stained wall rock contained minor values in silver. The 20-ft (6-m) adit, about 1,300 ft (400 m) north of the main shaft, follows a barren iron oxide-stained shear zone that trends N. 20° W. Pits and trenches expose small shear zones and aplite dikes that trend N. 35°–75° W., and samples from some of these contained minor amounts of gold and silver. The 15-ft (4.6-m) inclined shaft, northwest of the main shaft, exposes several small aplite dikes in partially decomposed quartz monzonite A sample of the aplite assayed 0.04 oz gold per ton (1.37 g/t), 3.1 oz silver per ton (106 g/t), and 2.0 percent lead.

Near-surface workings have not exposed a minable ore deposit, and resource estimates could not be made from the few data available. Reported metal production has been small and, presumably, the ore mined from the deeper caved workings was insufficient to support a profitable mining operation.

BLUEBIRD GROUP

The Bluebird group of three claims (pl. 3, 46), just north of the Salmon River, was relocated in 1970. There is no record of production from the property.

Workings consist of one cut, a shallow exploration pit, and two adits with a total length of 275 ft (84 m) (fig. 109).

Quartz monzonite of the Idaho batholith underlies the prospect area and is cut by a shear zone that strikes N. 60° E. and dips 51° NW. The upper adit, driven on the shear zone, follows a quartz vein that has a maximum thickness of 10 in. (25 cm) and pinches out 40 ft (12 m) from the portal. The quartz vein contains pyrite crystals, disseminated and massive galena, tetrahedrite, and disseminated sphalerite. Some sulfide minerals have been leached, leaving boxwork structures. The

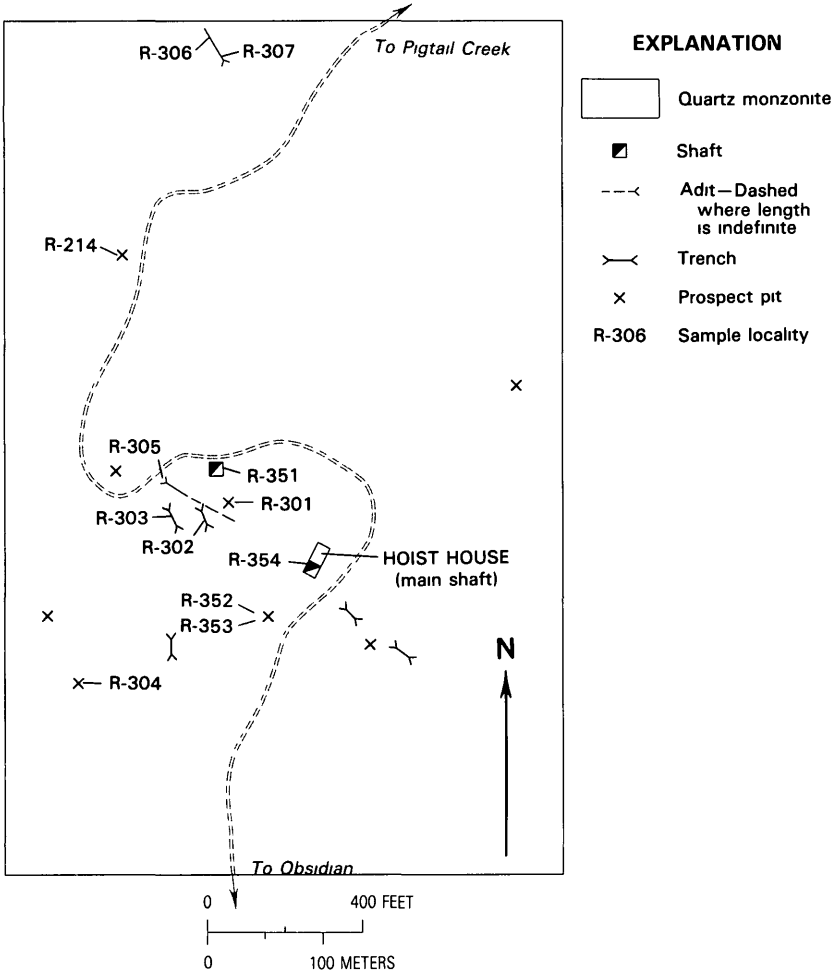

FIGURE 108.—Aztec mine area.

wall rock is altered to sericite and is iron stained 2.5 ft (0.75 m) on either side of the shear zone. The pale-yellow altered zone can be traced along strike for one-fourth mile (0.4 km). The lower adit crosscuts a zone of shearing about 100 ft (30 m) from the portal, which probably is the down-dip projection of the shear zone followed by the upper adit.

Two samples of vein quartz from a stockpile averaged 0.035 oz gold per ton (1.2 g/t), 10.5 oz silver per ton (360 g/t), and 23.4 percent lead. A sample from the discontinuous quartz vein explored by the upper adit contained 12.8 oz silver per ton (439 g/t). Samples from the shears lacking vein quartz contained no more than 0.1 oz silver per ton (3.4 g/t) and a trace lead and zinc.

Data for samples shown on figure 108

[Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

No.	Sample Type	Sample Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Copper (percent)
R-301	Chip--	2.0	Aplite dike-----------	N	N	--	--
R-302	--do--	3.0	---do-----------------	N	N	--	--
R-303	--do--	2.0	---do-----------------	Tr	0.3	--	--
R-304	--do--	4.0	---do-----------------	N	Tr	--	--
R-305	--do--	2.0	Iron-oxide-stained quartz monzonite.	N	.1	--	--
R-306	--do--	5.0	Across aplite dike swarm.	N	N	--	--
R-307	--do--	.5	Aplite dike-----------	N	N	--	--
R-351	Grab--	([1])	Aplite dikelets-------	0.04	3.1	2.0	Tr
R-352	Chip--	1.0	Two 6-in.-thick aplite dikes.	Tr	.1	Tr	Tr
R-353	--do--	3.5	Aplite dikes and adjacent wall rock.	Tr	N	.1	Tr
R-354	Grab--		Ore spillage, near collar of main shaft.	1.5	2.2	.2	0.1
R-214	--do--		Quartz monzonite (dump).	N	N	--	--

[1]Blank, not measured.

Concentrations of silver, lead, and gold are confined to narrow, discontinuous quartz veins. Indicated resources are too small to support a profitable mining operation; however, the property has potential for discovery of additional silver-lead resources.

MISCELLANEOUS PROPERTIES

Other prospects in the district that have no mineral resource potential or are not sufficiently exposed to indicate potential ore bodies are summarized in table 33.

UPPER EAST FORK SALMON RIVER DISTRICT

The Upper East Fork Salmon River district is in the eastern part of the study area (fig. 34). Although mining claims were located in the district as early as 1881, it is one of the less important localities in the study area. Iron-stained pyritized zones in the Tertiary igneous rocks attracted early attention.

Upper Paleozoic argillite, limestone, and quartzite crop out along both the East Fork Salmon River and West Pass Creek. Deposits of galena and sphalerite occur in these sedimentary rocks in two areas: near the mouth and at the head of West Pass Creek.

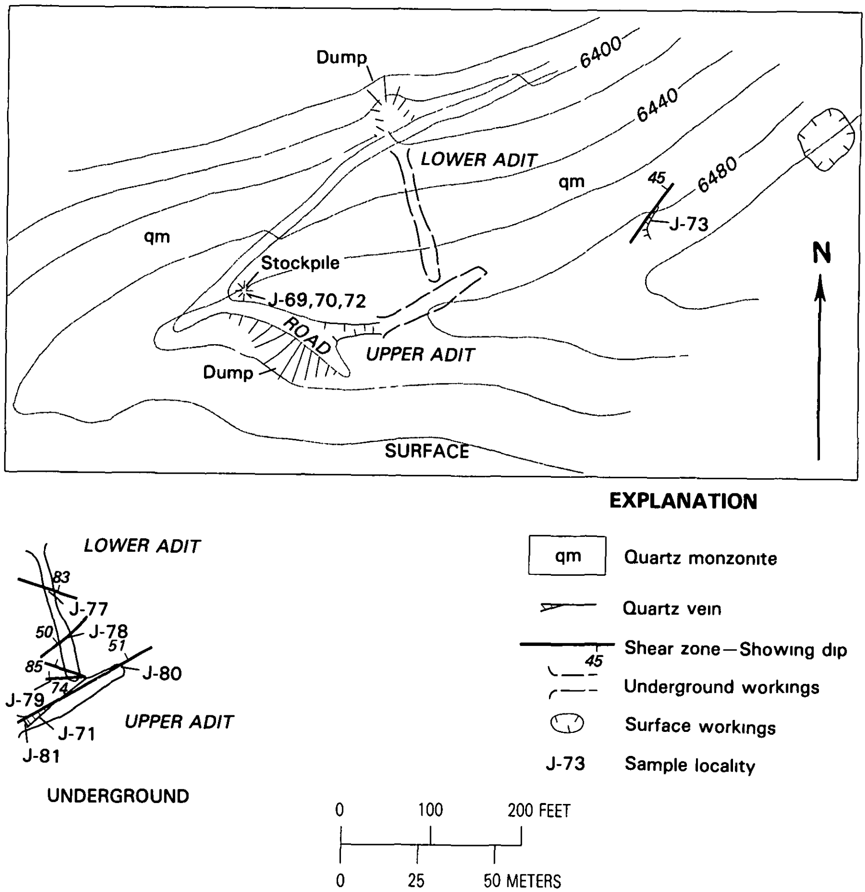

FIGURE 109.—Bluebird group. Contour interval 20 ft.

The Falling Star–West Pass group of claims, near the head of West Pass Creek, contains tactite bodies with disseminated galena and sphalerite. A resource of 10,000 tons (9,100 t) of material that contains as much as 1.43 oz silver per ton (49 g/t), 5.86 percent lead, and 5.48 percent zinc is estimated for the property.

The mineral occurrences and hot springs near the mouth of West Pass Creek are associated with northeasterly trending faults that can be traced or projected for thousands of feet. Weakly mineralized, discontinuous quartz-calcite veins are associated with the faults. The veins can be traced from a few feet to a few hundred feet along strike. Sphalerite and galena occur in the veins as fracture-fillings and in limestone as small replacement bodies. Thin films of malachite were observed occasionally.

Data for samples shown on figure 109

[Tr, trace, N, none detected, leaders (-), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample				Gold	Silver	Lead	Zinc
No.	Type	Locality or length (ft)	Description	(oz/ton)		(percent)	
J-69	Grab--	Stockpile	Quartz vein material	0.02	11.7	24.8	--
J-70	--do--	---do----	---do---------------	.05	9.3	22.0	--
J-71	Chip--	2.0	Quartz vein and altered wall rock.	Tr	.6	1.4	--
J-72	Grab--	Stockpile	Quartz vein material	Tr	2.4	5.0	--
J-73	Chip--	4.0	Across shear zone---	N	.1	N	N
J-77	--do--	.5	---do---------------	N	.1	Tr	Tr
J-78	--do--	.7	---do---------------	N	N	N	N
J-79	--do--	.3	---do---------------	N	N	N	N
J-80	Random chip.	(1)	Shear zone----------	N	N	Tr	N
J-81	Chip	1.0	Quartz vein---------	Tr	12.8	.4	N

[1]Blank, not measured.

FALLING STAR-WEST PASS GROUP

The Falling Star-West Pass group (pl. 3, 226) is about 6 mi (10 km) up West Pass Creek. Twenty-two mining claims, including relocations, have been located since 1882, 13 within the last 17 years. There has been no production.

At the prospect, quartzite and limestone have been intruded by a small body of diorite porphyry that produced tactite, containing abundant diopside. The tactite occurs in the limestone near the intrusion as small, disconnected, and irregularly shaped masses that range in size from a fraction of an inch thick and a few inches long to 4 ft (1.2 m) thick and 20 ft (6 m) long. Sphalerite and galena are sparsely disseminated through the tactite but are more concentrated near tight fractures of short, lateral extent, which are not mineralized except in tactite.

A 40-ft (12-m) adit and several open cuts expose a quartzite-limestone contact with the relatively impermeable quartzite forming the hanging wall (fig. 110). The contact is traceable for about 200 ft (60 m).

Fourteen chip samples, weighted by length, averaged 1.43 oz silver per ton (49.0 g/t), 5.86 percent lead, and 5.48 percent zinc. They represent the grade of material that could be sorted from the high-grade streaks There might be 100 tons (91 t) of such material in sight.

TABLE 33.—*Miscellaneous properties, Warm Springs Creek district*

[1 in.=2.54 cm, 1 ft=0.3048 m, 1 troy oz/ton=34.285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
47	Warm Springs occurrence	An iron-oxide-stained zone occurs along bedding planes in light-colored argillite. The zone strikes N. 38° W., dips 45° SW., and averages 5 ft wide. It is exposed 100 ft long and 85 ft deep. No sulfide minerals were observed.	None----------	Two chip samples across zone; 0.1 and 0.2 oz silver per ton.
48	Swimm Lake occurrence	A tactite zone 3 to 5 ft thick occurs along the contact between gneissic quartz monzonite and interbedded argillite, quartzite, and limestone. The zone strikes northeast, dips northwest, and is traceable along strike for about 500 ft. Finely disseminated sulfide minerals occur in the zone and the quartz monzonite.	None----------	One chip sample across tactite zone; trace gold and 0.2 oz silver per ton. One random chip sample from quartz monzonite; 0.1 oz gold per ton and 0.5 percent lead.
105	Free Silver	One dump contains iron-oxide-stained quartz with finely disseminated sulfide minerals and limestone.	Two pits------	One grab sample from a small stockpile; 0.02 oz gold per ton and 4.8 oz silver per ton.

MISCELLANEOUS PROPERTIES

Several properties that have little or no economic potential, or are not sufficiently exposed to indicate their potential, are listed in table 34.

VIENNA DISTRICT

The Vienna district, in the southern part of the study area (fig. 34; pl. 3), includes the north half of the Vienna mining district described by Ross (1927) and Shannon (1971). The district is accessible from State Highway 75 by roads along Smiley and Frenchman Creeks.

Principal mineral deposits are in northwest- and east-trending shear zones in granitic rocks. The deposits are fissure-filled bodies that locally replace silicified, sericitized, or chloritized granitic wall rock. Pyrite is the most common metallic mineral, but galena, sphalerite, chalcopyrite, bornite, stibnite, and scheelite also occur. Gangue is predominantly quartz and altered wall rock.

Ore deposits were discovered in the Vienna mining district in 1879 on Smiley and Beaver Creeks (Ross, 1927). Most mining activity occurred during the period 1879–1895, when at least 15 mines produced silver ore worth about $1 million (Umpleby, 1915). Production from 1912 to 1932 was small. Ore produced since 1932 totaled 4,569 tons (4,145 t) containing 59,921 oz (1,863.5 kg) silver, 88,618 lb (40,197 kg) lead, and 884 oz (27,492 g) gold. All metal production has come from mines outside the study area.

County records indicate that approximately 157 mining claims have been located in the part of the Vienna district within the study area (table 35). Activity on these claims has been limited to exploration and assessment work and no minable mineral deposits have been found. However, close proximity to the old silver-lead-gold mines to the south suggests a potential for discovery of deposits similar to those that have been mined.

URA GROUP

The Ura group (pl. 3, 171) consists of 12 unpatented claims that were located about 1955. Workings consist of a few shallow pits.

A large pendant of Paleozoic quartzites and limestones is intruded by tongues and irregular masses of granite and aplite along bedding planes, joints, and minor faults. Tactite, composed of red garnet, epidote, wollastonite, quartz, and fine-grained scheelite, occurs near limestone-granitic rock contacts. Two tactite zones are about 2,600 ft

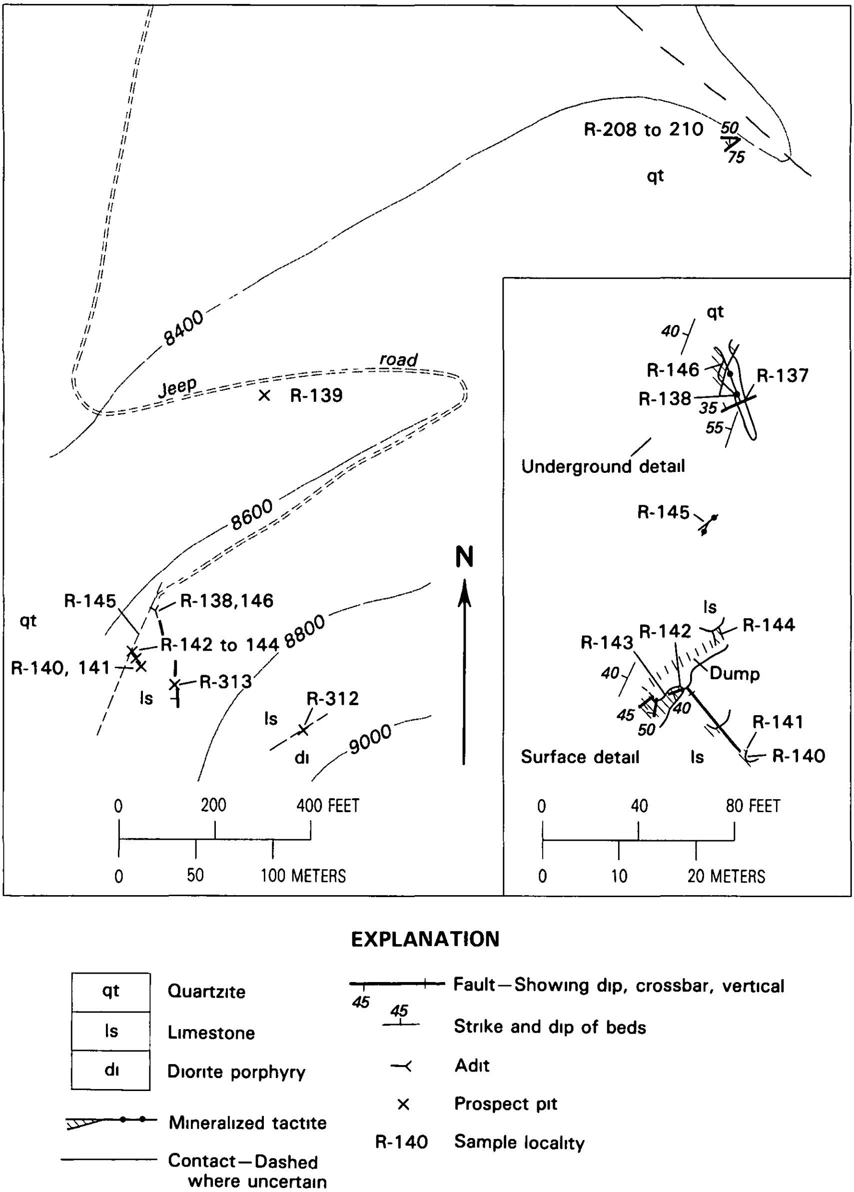

FIGURE 110 —Falling Star-West Pass group Contour interval 200 ft

(790 m) apart (fig. 111). Each is 250 ft (76 m) long and 5-25 ft (1.5-7.6 m) wide. The zones are separated by pods and stringers of granite and limestone.

Thirteen samples from the two tactite zones contained as much as

Data for samples shown on figure 110

[All samples chip except R-313, select. N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

Sample No.	Length (ft)	Description	Gold (oz/ton)	Silver (oz/ton)	Lead (percent)	Zinc (percent)
R-137	2.0	Along tactite lens-	N	10	3.20	5.00
R-138	2.0	---do---------------	N	.2	2.95	4.00
R-139	2.5	Across tactite lens	N	1.4	.55	3.40
R-140	2.0	Along tactite lens-	N	N	.12	.40
R-141	2.0	Across tactite lens	N	.4	8.20	6.40
R-142	2.0	---do---------------	N	N	.60	.30
R-143	3.0	---do---------------	N	1.3	7.40	6.00
R-144	7.0	Along tactite lens-	N	.8	9.40	8.40
R-145	.5	Across tactite lens	N	3.8	13.00	5.48
R-146	2.0	---do---------------	N	1.8	2.00	2.80
R-208	.8	Across fracture in quartzite.	--	.7	4.20	4.80
R-209	.3	---do---------------	--	.7	70	.48
R-210	.3	---do---------------	--	.2	1.30	.56
R-312	2.0	Across tactite lens	--	.8	19.20	15.60
R-313	([1])	Tactite fragments--	--	11.8	5.40	2.60

[1]Blank, not measured.

1.16 percent WO_3 and had a weighted average grade of 0.16 percent WO_3. The two tactite zones are small and irregular. Other concealed tactite zones probably occur along the limestone-granite contacts. The property has a very small potential for discovery of a minable tungsten deposit.

MISCELLANEOUS PROSPECTS

Other prospects that have no mineral resource potential or are not sufficiently exposed to evaluate are summarized in table 36. The Balloon, Goodhope, Ajax, Eureka, P & D, and Stibnite properties are slightly outside the study area.

PLACER DEPOSITS

This section summarizes the quantitative data on the production, volumes, and near-surface grades of placer deposits that contain gold and black sand. Qualitative evaluations of the potential resources and subsurface grades inferred from geochemical and geological data are given in the sections on gold, niobium, uranium and thorium, and titanium.

TABLE 34.—*Miscellaneous properties, Upper East Fork Salmon River district*

[1 in.=2.54 cm, 1 ft=0.3048 m, 1 troy oz/ton=34.285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
223	American Eagle and Michelle Spreier	Pyritized volcanic rocks and white iron-oxide-stained quartzite.	None----------	Three samples, no gold, silver, or copper detected.
224	Blue Buoy	Quartz-calcite vein and stringers in argillaceous limestone.	Prospect pits and trenches.	Four samples, weighted average of 0.09 percent copper, 0.02 percent lead, 0.34 percent zinc.
225	Warm Springs group	Sulfides, carbonates, and oxides of lead, zinc, and copper in quartz veinlets and lenses along shear zones in calcareous argillite.	Two adits, 85 and 145 ft long.	Six samples were taken from the longer adit. A select grab contained 3.2 oz silver per ton, 0.21 percent copper, 0.86 percent lead, and 5.6 percent zinc. Five chip samples contained a trace or less silver, 0.0017 percent or less copper, 0.08 percent or less lead, and 0.34 percent or less zinc.
227	George Washington	Pyritized zones in volcanic rocks-----	None----------	One sample; no gold, silver, or copper detected.
228	Independent group	Pyritized zones in volcanic rocks and iron-oxide-stained aplite dikes.	None----------	Two samples; 4 percent iron and only a trace of other metals.

TABLE 35 —*Summary of mining claims recorded, including relocations, 1879-1971, Vienna district*

Decade	Number of lode claims
1879	--[1]
1880-1889	34
1890-1899	5
1900-1909	--
1910-1919	--
1920-1929	1
1930-1939	2
1940-1949	9
1950-1959	12
1960-1969	79
1970-1971	15
Total-----	157

[1]None recorded.

Large alluvial deposits along the Salmon and Wood Rivers and Valley Creek, and smaller deposits along several of their tributaries, were investigated during this study (pl. 3). Deposits north of Salmon River downstream from Joes Gulch, however, were not studied. Portions of these alluvial deposits have been worked intermittently for placer gold since the 1860's. Some still contain enough gold and radioactive black sand to be potential resources, but detailed examinations of all the potential placer ground could not be made during the limited field time for this study. More importantly, an adequate evaluation of the potential gold placer resources was severely hampered because the expectable concentrations of coarse gold on bedrock could be sampled only in very few places. The surface or near-surface samples that were taken at most places do not reflect true values at depth. Generally, samples could not be collected more than a foot or so below the water table, whereas most of the large alluvial deposits along stream bottoms are between 15 and 42 ft (4.6 and 12.8 m) deep, and well below the water table. Considering the coarse gold typical of the study area, and its usual concentration within a few feet of bedrock in old stream channels, the average content of such pay streaks may be many times greater than the content indicated by surface samples. The principal placers are shown and numbered on plate 3. These reference numbers are also used in the summary table (table 37). Federal and State laws and regulations concerning pollution,

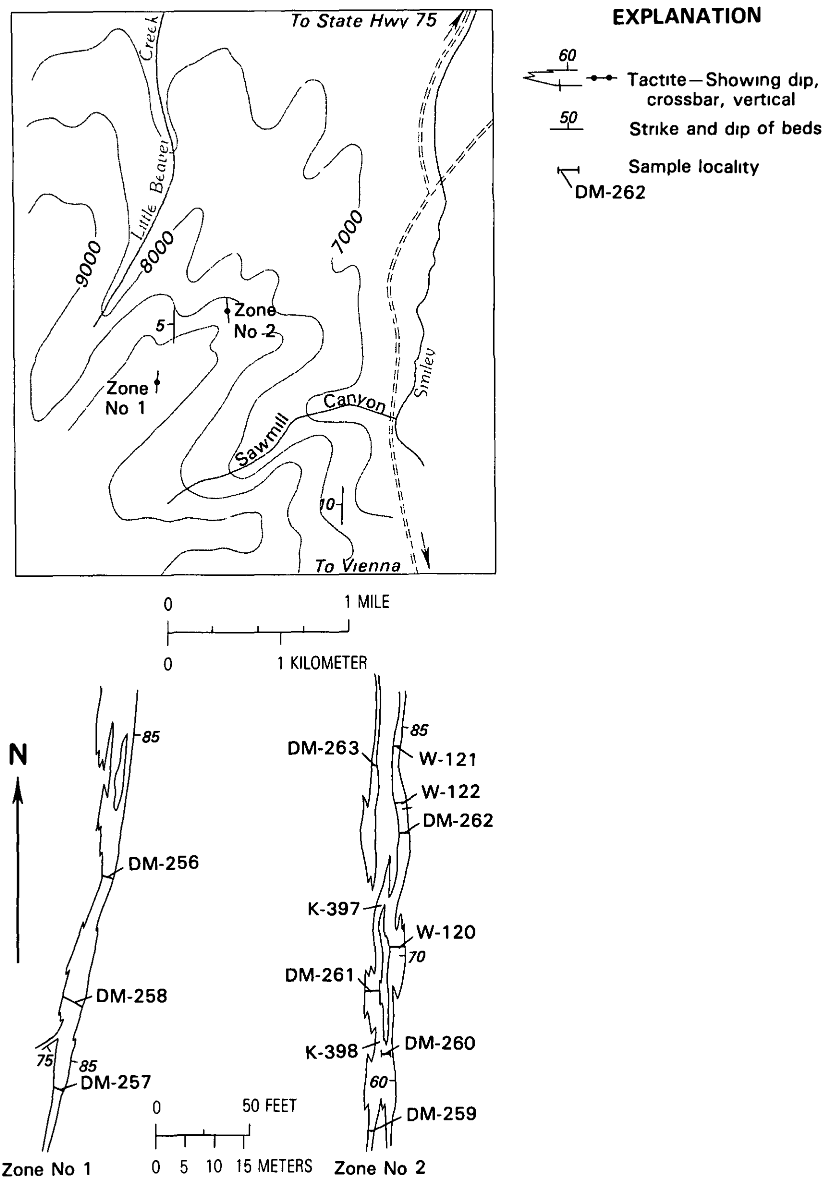

FIGURE 111—Ura group (modified from DMEA unpub data) Contour interval 1,000 ft

restoration, and administrative withdrawals are a major factor affecting development.

The first discovery of placer gold was by Capt. John Stanley in July 1863 in Stanley Basin (Choate, 1962, p. 4) Most gold placer mining activity occurred in the 1870's and 1880's, and on a smaller scale during

Data for samples shown on figure 111

[All samples chip Tr, trace, N, none detected, leaders (--), not analyzed, 1 ft=0 3048 m, 1 troy oz/ton=34 285 g/t]

No.	Sample Length	Gold	Silver	Zinc	WO_3
	(ft)	(oz/ton)		(percent)	
W-120	18.0	N	0.1	--	0.01
W-121	12.0	Tr	N	--	.01
W-122	1.0	N	.2	--	.01
DM-256	1.5	--	--	--	.05
DM-257	4.0	--	--	--	N
DM-258	11.0	--	--	--	.08
DM-259	3.5	--	--	--	1.16
DM-260	6.0	--	--	--	.40
DM-261	7.0	--	--	--	.35
DM-262	6.0	--	--	--	.40
DM-263	2.0	--	--	--	.17
[1]K-397	5.0	Tr	Tr	0.07	.04
[1]K-398	6.0	Tr	Tr	.08	.08

[1]Semiquantitative spectrographic analyses by U.S. Geological Survey.

the 1930's. Many claims were staked between 1951 and 1960 for radioactive black sand minerals. County records indicate that at least 930 placer claims have been staked in the study area.

The first placer claims probably were staked on terraces along the Salmon River near Robinson Bar. The Great Centennial placer on Robinson Bar (pl. 3, 16) produced about $100,000 (Choate, 1962, p. 104). (All production values before 1932 are based on a gold price of $20/oz.) Other important properties are the Centauras workings (pl. 3, 14) just north of the river and the Taylor workings (pl. 3, 15) on the south bank, both just upstream from Robinson Bar. The Centauras property, which was staked about 1870 and was worked until the early 1900's, produced $80,000 to $100,000 in gold (Choate, 1962, p. 104). The Taylor property was worked by Chinese (Choate, 1962, p. 103); gold production is unknown.

Placers in Joes Gulch (pl. 3, No. 8) also were worked, first by drifting and later by hydraulicking. Umpleby and Livingston (1920, p. 16) reported that the gravels yielded $3.60 of 717 fine gold per square yard of bedrock surface and that $70,000 to $80,000 was probably produced. The Lucky Strike and Hot Stuff placers on Joes Gulch were worked from 1934 to 1941, when the gold price was $35/oz. Recoveries

TABLE 36 —*Miscellaneous prospects, Vienna district*

[1 in.=2.54 cm, 1 ft=0.3048 m, 1 troy oz/ton=34.285 g/t]

Map No. (pl. 3)	Property name	Summary	Number and type of workings	Sample data
165	Balloon group	Six claims are on quartz veins in granite. The veins range in thickness from 4 in. to 2.5 ft.	Several pits------------	Two samples, 0.07 percent lead.
166	Eureka	An iron-oxide-stained quartz vein strikes N. 25° E. and dips 36° NW. in granite. The 4-ft-thick vein is exposed for 200 ft along strike.	Three pits--------------	Two samples, trace gold and minor amount of lead and copper.
167	Ajax	A 4-ft-thick, poorly exposed alteration zone in granite. The zone is iron oxide stained and intruded with vuggy, pyrite-bearing quartz stringers.	A caved adit and two pits.	Three samples, trace gold and minor amounts of lead and molybdenum.
168	Sawtooth City	A quartz vein strikes N. 60° W. and dips 70° NE. in quartzite and siltite. The 2-ft-thick, fissure-filling vein is composed of quartz and minor amounts of gouge crushed wall rock, and pyrite.	One caved adit----------	One sample, no valuable metals detected.
169	Beaver Creek	Iron-oxide-stained granite float occurs. Bedrock is not exposed.	One dozer trench and one pit.	One sample, trace gold.
170	P & D	A 3-ft-thick vein strikes N. 55° E. and dips 45° NW. in black argillaceous quartzite near a contact with quartz monzonite. The vein is composed of iron-oxide-stained quartz and pyrite.	Two dozer trenches and one pit.	Four chip samples, as much as 0.48 oz gold and 4.8 oz silver per ton, and as much as 4.0 percent antimony. One select grab sample, 3.0 percent lead and 0.06 percent copper.
172	Stibnite	A 3-ft-thick vein strikes N. 10° E. and dips 40° NW. in quartzite and siltite. The vein contains iron-oxide-stained quartz, crushed wall rock, specks of pyrite, and occasional blades of stibnite.	A dozer trench and one pit.	Three samples, 0.02 to 0.09 percent zinc, 0.01 to 0.5 percent antimony, and as much as 0.07 percent mercury.

173	Goodhope	A 2-ft-thick quartz vein strikes N. 80° W. and dips 45° NE. in granite. Locally the vein contains occurrences of pyrite, sphalerite, and galena.	Two dozer trenches------	Six samples, trace to 0.03 oz gold per ton, as much as 0.56 percent lead, and 0.79 percent zinc.
174	Rabbit Foot	An iron-oxide stained shear zone strikes N. 65° E. and dips 63° NW. in quartz monzonite. The 20-in-thick zone is filled with quartz, gouge, and brecciated country rock, and can be traced for 20 ft along strike.	Two trenches------------	Three samples, trace gold, as much as 0.1 oz silver per ton, and 0.6 percent lead.
175	E & D group	Iron-oxide-stained shear zones and quartz veins, as much as 6 ft thick, occur in quartz monzonite of the Idaho batholith. Pyrite was the only sulfide mineral seen.	Five dozer trenches-----	Ten chip samples average, 0.085 oz gold per ton, 0.46 oz silver per ton, and 0.76 percent lead.
176	Frenchie group	A silicified, iron-oxide-stained zone occurs in granite. No sulfide minerals were seen.	None--------------------	One sample, 0.2 oz silver per ton and 0.6 percent lead.
177	Salmon River	A 100-ft-long adit was driven S. 40° W. in an attempt to crosscut a fault zone striking N. 70° E. and dipping 45° SE. in quartzite. No sulfide minerals were seen.	One adit----------------	Two samples, no valuable metals detected.
178	Galena Pass	A 4-ft-thick shear zone strikes N. 25° E. and dips 65° NW. in silty argillite. The zone can be traced intermittently for about 1,000 ft. The shear contains stringers of iron-oxide-stained quartz as much as 1 ft thick. No sulfide minerals were seen.	Two pits and one shaft--	Three samples, trace gold and as much as 7.7 oz silver per ton and 0.05 percent lead.

of 147 oz (4,572 g) from 9,500 yd^3 (7,264 m^3) and 101 oz (3,141 g) from 5,200 yd^3 (3,976 m^3) were made. Most of the placer ground has been worked.

Other less productive deposits along or near Salmon River between Joes Gulch and Robinson Bar (pl. 3) include: Little and Big Casino Creeks (pl. 3, 11, 12), Mormon Bend (pl. 3, 10), and Rough Creek (pl. 3, 13). The two main placers on Rough Creek were the Rough Creek placer and the Grubstake. Gold produced at Rough Creek probably did not exceed $500 in value annually from 1915 to 1933, but $1,526 was produced in 1934 (Choate, 1962, p. 118). During the same period, $8,500 worth of 880 to 895 fine gold was recovered from gravels averaging $0.46/$yd^3$ ($0.60/$m^3$) at the Grubstake (Choate, 1962, p. 118). The Pee-Wee placer on Rough Creek has produced 3.5 oz (109 g) of gold from 400 yd^3 (306 m^3) of gravel. According to Umpleby and Livingston (1920, p. 18), $15,000 to $20,000 worth of gold was produced from Rough Creek before 1920. About $8,000 worth of gold was mined from Big Casino Creek and an unknown amount from Little Casino Creek (Umpleby and Livingston, 1920, p. 18). Mormon Bend on the Salmon River was placered in the early days, but the amount of gold produced is unknown. Nip and Tuck Creek (pl. 3, 7) near Stanley produced only 20 oz (622 g) in 1938 and 1939. Placers on Pigtail Creek (pl. 3, 24) at the head of Warm Springs Creek were worked by Chinese, but gold production is unknown. Treon Creek bar (pl. 3, 18) was mined in 1940, 1941, and 1955 producing a total of 6 oz (187 g) from 360 yd^3 (275 m^3). The famous placers on Yankee Fork and American Creek just north of the study area also were worked extensively (pl. 3).

The first placer operations northwest of Stanley were the Spring Gulch, Sturkey, and Willow Flat placers, and the Chinese workings on Kelly Creek just outside the study area (pl. 3). Most of the gold recovered from Stanley Creek was from the Doran Gulch, Ham Fat, and Buckley Bar placers, and the Willis workings (pl. 3, 5). The Buckley operation reportedly (Choate, 1962, p. 114) produced about $250,000 by ground sluicing gravel containing $3.40 gold/$yd^3$ ($4.45/$m^3$) (at $20/oz). The Ham Fat and Doran Gulch placers were mined, but no production figures are available. The Willis diggings produced $23,000 between 1933 and 1938 (Choate, 1962, p. 116). The Stanley Five Bars property on lower Stanley Creek (pl. 3, 6) produced 172 oz (5,350 g) from 46,000 yd^3 (35,172 m^3) between 1937 and 1939.

A dredge with a capacity of 2,000 yd^3/day (1,529 m^3/day) was operated intermittently along Stanley Creek by various owners between 1900 and 1914 (Choate, 1962, p. 114–115). The gravel contained from $0.30 to $1 of 650 fine gold per cubic yard (at $20/oz), but clay hampered recovery. Total production is unknown, but about $5,000 apparently was produced in September 1900.

Other placers have been staked on Valley Creek and its tributaries, Meadow Creek, upper Warm Springs Creek, Germania Creek, the upper Salmon River, Big Wood River, and North Fork Big Wood River; but only a small amount of gold has been produced from them.

Between 1949 and 1955, a survey of radioactive placer minerals in Idaho was made by the U.S. Bureau of Mines for the then U.S. Atomic Energy Commission (Eilertsen and Lamb, 1956). The gold and silver content was not determined. Churn drill holes tested the placers on Valley, Meadow, and Stanley Creeks, and both churn drilling and backhoeing were used to sample the Gold and Williams Creeks deposits. Reconnaissance samples were taken throughout the region; analysis of these indicated anomalous radioactive mineral concentrations on Warm Springs, Pigtail, and Martin Creeks (Storch and Holt, 1963). Sampling was done on The Meadows on Warm Springs Creek in 1957 with a churn drill, under a DMEA (Defense Minerals Exploration Administration) contract.

Field investigations during the present project included reconnaissance sampling of small deposits and test pitting and trenching of gold placers believed to have the best potential. Only deposits with previous mining activity were sampled, especially those from which gold production is recorded. Test pits and trenches ranged in depth from 1 to 6 ft (0.3 to 1.8 m). The longest channel sample was 88 ft (26.8 m). Generally, 1 ft^3 (0.028 m^3) of sample per foot (0.3 m) of depth was taken from each excavation. Large samples were washed in a vibrating sluice box and further concentrated on a Wilfley table. The gold contents of concentrates were determined by amalgamation or fire assay. The mineral constituents of selected samples were separated and identified through the use of magnetic and petrographic techniques. A total of 268 samples was analyzed. Generalized sample and drill-hole locations are shown on plate 3.

Gold values in the samples ranged from trace to 257.9 cents[1] per cubic yard, and the weight of raw placer gold from trace to 0.0228 oz/yd^3 (928 mg/m^3). In general, most of the gold is less than 3 ft (0.9 m) above bedrock and is commonly concentrated in buried stream channels on bedrock or on "false bedrock" clay seams. Early miners drifted along old stream channels at the base of thick terrace deposits. The gold ranges from flour- to wheat-sized particles. Gold particles smaller than flax seed were not recovered before 1912. Fineness of the gold ranges from 600 to 902.

Heavy minerals other than gold in the placers were derived from erosion of granitic and volcanic rocks. The black sand content of the

[1]Value of gold at $128 50 per ounce calculated from weight of raw placer gold having an average fineness of 880

alluvial deposits sampled ranged from trace amounts to 144 lb/yd^3 (85 kg/m^3); most was under 20 lb/yd^3 (12 kg/m^3). The black sand concentrates contained widely ranging amounts of magnetite, ilmenite, hematite, zircon, monazite, garnet, sphene, and ferromagnesian silicates Mimetite $Pb_5Cl(AsO_4)_3$ was found in one sample. Trace amounts of brannerite and mercury were found in samples from Stanley Creek.

Fifty samples were taken at 14 sites from six alluvial benches (terraces) along Salmon River (pl. 3, 16–21). The six benches range in area from 5 to 55 acres (2 to 22 ha) and contain 310,000–4,400,000 yd^3 (240,000–3,400,000 m^3) of material (table 37). Gold values ranged from a trace to 122 8 cents per cubic yard (297 mg/yd^3; 389 mg/m^3) (table 37). Gold was found in all samples, and the values generally increased with depth. The highest values were on bedrock at Robinson Bar (pl. 3, 16), but the average for all samples from the bar was 10.2 cents (24.6 mg) gold per cubic yard (32.3 mg/m^3) for samples from Cold Creek bar (pl. 3, 19). The black sand content of all samples ranged from 1.2 to 9.0 lb/yd^3 (0.71 to 5.34 kg/m^3). The highest average content is 5.6 lb/yd^3 (3.3 kg/m^3) at Easy bar (pl. 3, 17). Much of the gold on Cold Creek and Treon Creek bars is coated by iron- and manganese-oxides and requires a sulfuric acid wash prior to amalgamation.

The gold values in near-surface samples from placers on the tributaries south of the Salmon River range from a trace to 257.9 cents per cubic yard (624.4 mg/yd^3; 816.8 mg/m^3) and are generally erratic. The volume of the placers (table 37) ranges from less than 100,000 to 35 million yd^3 (76,460 to 27 million m^3) (pl. 3, 23, The Meadows). The highest average gold content was 25.5 cents per cubic yard (61.8 mg/yd^3; 80.8 mg/m^3) on Rough Creek (pl 3, 13). The highest average black sand content was 58.8 lb/yd^3 (34.9 kg/m^3) on Little Casino Creek (pl. 3, 11). Samples from Slate Creek (pl. 3, 22) contained as much as 0.15 percent lead, 0.07 percent zinc, and 0.02 percent antimony, apparently from sulfide deposits upstream. The black sands along Pigtail Creek (pl. 3, 24) contained as much as 60 percent sphene but only minor monazite and gold. Nineteen holes were drilled in The Meadows (pl. 3, 23) on Warm Springs Creek as part of a DMEA project investigating radioactive placer minerals. Samples contained no detected gold, and the average black sand content was 14 lb/yd^3 (8.3 kg/m^3).

Fifty-three samples were taken at 38 sites on Valley Creek and its tributaries, Stanley and Elk Creeks. Sampling depths were limited at many sites by a high water table. The gold content ranged from a trace to 249.9 cents per cubic yard (605.0 mg/yd^3; 791.3 mg/m^3), and generally increased with depth. The highest values were from upper Valley

TABLE 37 —*Summary data on placers investigated, Sawtooth National Recreation Area, Idaho*[1]

[The Meadows and Gold and Williams Creek placers explored for rare-earth minerals Tr, trace, NE, not estimated, leaders (--), not analyzed, 1 acre=0 4047 ha, 1 ft =0 3048 m, 1 yd³=0 7646 m³; 1 mg/yd³=1 308 mg/m³; 1 lb=0 536 kg; 1 ¢/yd³=1 308 ¢/m³; 1 lb/yd³=0 5934 kg/m³]

No (pl.3)	Placer deposit	Size (acres)	Estimated depth (ft)	Estimated volume (thousand yd³)	Range of gold content (mg/yd³)	Range of gold values[1] (¢/yd³)	Average gold content (mg/yd³)	Average gold value[1] (¢/yd³)	Range of black sand (lb/yd³)
1-2	Valley Creek	150	42	10,000	Tr-605.0	Tr-249.9	92.1	38.1	7.4-12.0
3	Meadow Creek	250	22	8,800	Tr	Tr	Tr	Tr	5.5-6.8
4	Elk Creek	40	15	750	Tr-122.2	Tr-50.5	24.6	10.2	0.8-14.4
5-6	Stanley Creek	110	33	5,900	Tr-561.4	Tr-231 9	52.9	21.8	0.5-34.8
7	Nip and Tuck Creek	NE	NE	Small	--	--	--	--	--
8	Joes Gulch	7	4	45	Tr	Tr	Tr	Tr	5.0-10.0
9	Four Aces	NE	NE	Small	--	Tr	--	--	25.2-38 8
10	Mormon Bend	NE	NE	355	--	--	--	--	--
11	Little Casino Creek	15	10	240	Tr-22.0	Tr-9.1	12.6	5.2	3.0-144.0
12	Big Casino Creek	12	25	480	Tr-4.1	Tr-1.7	.6	1.9	6.7-56.7
13	Rough Creek	7	21	240	Tr-624.4	Tr-257 9	61.8	25.5	6.7-51.5
14	Centauras	NE	NE	NE	--	--	--	--	--
15	Taylor	NE	NE	NE	--	--	--	--	--
16	Robinson Bar	55	50	4,400	Tr-183.3	Tr-75.7	24.6	10.2	1.3-6.0
17	Easy Bar	5	40	320	3.8-14.3	1.4-5.9	10.7	4.4	3.1-9.0
18	Treon Creek Bar	14	30	678	3.3-85.7	1.4-35.4	28.3	11.7	1.3-6.0
19	Cold Creek Bar	11	21	370	3.2-297.4	1.5-122.8	61.0	25.2	1.5-5.6
20	Burnt Bar	6	32	310	2 4-208 7	1.0-86.2	36.7	15 2	1.2-3.6
21	Mill Creek Bar	23	23	850	3.0-26 3	1.2-10.9	10.7	4.4	1.4-2.0
22	Slate Creek	4	15	100	Tr-2.4	Tr-1.0	.2	.1	0.3-38.8
23	The Meadows	900	24	35,000	Tr	Tr	Tr	Tr	4.1-51.0
24	Pigtail Creek	40	4	260	Tr-1 9	Tr-0.8	.4	.2	0.8-16.0
25	Gold and Williams Creek.	227	21 to 42	12,524	Tr	Tr	Tr	Tr	[2]1.0-46.5
26	Germania Creek	NE	NE	NE	Tr-12.2	Tr-5.0	1.0	.4	Tr-3.5
27-33	Upper Salmon River	NE	NE	NE	Tr	Tr	Tr	Tr	Tr-8.4
34-45	Wood River	NE	NE	NE	Tr-4 4	Tr-1.8	.1	.1	Tr-7.0

[1]Based on a price of $128.50/oz of gold, May 15, 1973, and an average fineness of 880.

[2]Contains an average of 0.89 lb monazite, 3.5 lb ilmenite, 0.2 lb zircon, and 0 34 lb niobium-tantalum pentoxide per cubic yard.

Creek (pl. 3, No. 1). The black sand content of the Valley Creek drainage deposits ranged from 0.5 to 34.8 lb/yd^3 (0.3 to 20.6 kg/m^3). The highest average black sand content was 18.8 lb/yd^3 (11.2 kg/m^3) on upper Stanley Creek (pl. 3, No. 5). Graphite was found in some samples along Elk Creek (pl. 3, No. 4).

In 1952, the U.S. Bureau of Mines drilled five holes from 14 to 75 ft (4.3 to 23 m) deep along Stanley Creek (pl. 3, Nos. 1–2) as part of the survey of radioactive black sand placers. Samples from the holes averaged 36.7 cents gold per cubic yard (gold at $128.50/oz) (88.7 mg/yd^3; 116 mg/m^3), 8.9 lb/yd^3 (5.3 kg/m^3) of black sand, and 0.15 lb/yd^3 (0.09 kg/m^3) monazite. The black sand concentrates average 47 percent ilmenite. Three holes were drilled on Valley Creek and on Meadow Creek (pl. 3, No. 3). The black sand concentrates had a high magnetite content (68 percent), but small amounts of gold and monazite.

In 1952, the U.S. Bureau of Mines drilled 32 holes ranging in depth from 10 to 88 ft (3 to 27 m) and excavated 13 trenches on Gold and Williams Creeks (pl. 3, 25). Samples contained only small amounts of gold and averaged 33 lb/yd^3 (19.6 kg/m^3) of black sand. The amount of magnetite (75 percent) and monazite (2.7 percent) in the concentrates was relatively large. A reserve of 5,575 tons (5,060 t) of monazite and 2,150 tons (1,950 t) of $(Nb, Ta)_2O_5$ in 12.5 million yd^3 (9.56 million m^3) of gravel was indicated (U.S. Bureau of Mines unpub. data).

Reconnaissance samples were taken at 68 localities on the upper parts of the Salmon and Big Wood Rivers and their tributaries and in Germania and Washington Basins. The best samples contained less than 0.5 cents gold per cubic yard (<1.2 mg/yd^3) (<1.6 mg/m^3) at Russian John Guard Station (pl. 3, 41) and 8.4 lb/yd^3 (5 kg/m^3) of black sand along Pole Creek (pl. 3, 30).

Large-scale placer mining of deposits with the average grades shown in table 37 probably is not feasible, but some deposits, such as the Valley Creek deposit, may have much higher average grades. The mining of small concentrations of placer gold in some deposits probably would be profitable.

THERMAL SPRINGS

Few thermal springs in the United States are the surface expression of large, high-temperature, deep-seated stream reservoirs that can be used to produce electrical power. The possibility of relatively inexpensive, environmentally safe power has, however, led to an intensified search for potential geothermal sites. Of about 15 known thermal springs in the Sawtooth National Recreation Area, 12 were studied during the present investigation. Seven are along the Salmon River, two along the Big Wood River, and three along tributaries of the Salmon River (pl. 3). Some springs have been utilized as sources of hot water for swimming, such as at Robinson Bar, Sullivan Creek (outside the study area), and Easley recreational area, but their geothermal potential was not evaluated before this study.

The following criteria were used to evaluate geothermal potential: (1) relatively recent igneous activity, (2) a suitable structural conduit for transfer of hot fluids from deep-seated heat sources to the surface, (3) sufficient fluid discharge, (4) adequate reservoir size, (5) a drilling depth of less than 10,000 ft (3,048 m), and (6) boiling subsurface temperatures capable of sustained production of steam. White, Muffler and Truesdell (1971, p. 77, 78) stated that"* * * near-boiling hot waters of moderate to high discharge are always characterized by relatively high contents of alkali chlorides, silica, boron, and arsenic * * *" and that silica is usually precipitated near the surface. Springs with these characteristics are potential sources of geothermal power, but the springs in the study area lack such characteristics and, therefore, such potential. The most recent igneous activity in the study area is probably older than about 38 m.y.

The amount of discharge, surface temperature, area, and probable bedrock of 12 thermal springs are shown in table 38, the chemical analyses in table 39. The potential reservoir size as indicated by the surface area was estimated using magnetic surveys, structural interpretation, and surface area influenced by past and present discharge.

The thermal springs in the study area are located in Paleozoic sedimentary strata, Cretaceous rocks of the Idaho batholith, and Tertiary Challis Volcanics. All springs are along extensive joint and fault systems. Several springs on the same structure suggest a potentially larger fluid system and geothermal potential. The largest system extends along a 6-mi (9.6-km) shear zone (fig. 2, Mormon Bend fault) from Stanley Hot Spring through Elkhorn, Mormon Bend, and Basin Creek springs (Choate, 1962, p. 100–101). Bowery and West Pass springs are controlled by a fault system in the East Fork valley and Easley and Russian John springs may be along faults in the Big Wood River valley.

The Sunbeam and Stanley springs are the largest in the study area with estimated reservoir sizes of 5 and 38 acres (2 and 15 ha), respectively. They are also the only two with large discharges, indicating systems of significant size, permeability, and fluid content. In general, spring outlets at ground or surface water levels discharge most of the hot water in the system (White, 1961). Sunbeam Hot Spring, however, may have outlets under the Salmon River and a greater discharge than measured.

The temperatures of water at depth can be estimated from Na/K

TABLE 38.—*Physical data, thermal springs, Sawtooth National Recreation Area, Idaho*

[1 gallon=4.5 liters, 1 acre=0.4 hectare]

Map No. (pl. 3)	Name	Discharge (gal/min)	Surface temperature °F (°C)	Surface expression of reservoir (acres)[1]	Host bedrock	Location Sec.	T.N.	R.E.
1	Stanley-----	400	120 (48.9)	38	Quartz monzonite.	3	10	13
2	Elkhorn-----	13	140 (60.0)	1	---do-----	25	11	13
3	Mormon Bend-	1	100 (37.8)	1	---do-----	20	11	14
4	Basin Creek-	7	140 (60.0)	1	---do-----	21	11	14
5	Sunbeam-----	330	150 (65.6)	5	---do-----	19	11	15
6	Robinson Bar	40	120 (48.9)	--	---do-----	26	11	15
7	Slate Creek-	24	120 (48.9)	2	Paleozoic argillite.	19	10	16
8	Pierson-----	13	140 (60.0)	1	Quartz monzonite.	27	8	14
9	Bowery------	20	110 (43.3)	--	Paleozoic sedimentary rocks.	6	7	17
10	West Pass---	36	120 (48.9)	--	---do------	32	8	17
11	Russian John	1	95 (35.0)	1	Challis Volcanics.	33	6	16
12	Easley------	18	100 (37.8)	1	---do------	10	5	16

[1]Leaders (--), not determined.

TABLE 39.—*Chemical data, thermal springs, Sawtooth National Recreation Area, Idaho*

[Analyses in milligrams per liter by U.S. Geological Survey laboratory, Salt Lake City, Utah]

Name	SiO_2	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	Na/K	Cl/SO_4	Cl/F	pH
Stanley	55.0	2.2	0.1	60.0	0.5	30.0	28.0	31.0	5.0	14.0	195	0.43	0.19	8.6
Elkhorn	75.0	1.0	3	72.0	2.4	20.0	30.0	32.0	6.0	15.0	51	51	21	9.0
Mormon Bend	89.0	2.2	1	62.0	1.3	23.0	35.0	38.0	4.4	14.0	63	31	17	8.8
Basin Creek	90.0	2.0	1	75.0	3.2	40.0	40.0	45.0	6.0	15.0	39	36	21	9.0
Sunbeam	91.0	1.5	0	85.0	2.4	119.0	0	54.0	12.0	15.0	60	60	43	8.3
Robinson Bar	80.0	2.0	4	77.0	3.6	28.0	41.0	57.0	6.0	12.0	36	28	28	9.3
Slate Creek	86.0	8.1	1	83.0	4.5	110.0	0	110.0	7.0	8.7	31	17	43	8.1
Pierson	70.0	1.8	1	73.0	1.0	31.0	35.0	31.0	7.8	19.0	123	68	21	9.0
Bowery	62.0	22.0	4.5	84.0	8.4	139.0	0	110.0	12.0	12.0	16	30	53	7.3
West Pass	43.0	20.0	5.3	100.0	13.0	234.0	0	94.0	26.0	8.4	13	75	1.66	6.8
Russian John	54.0	2.3	1	70.0	6	25.0	29.0	46.0	6.5	19.0	195	38	19	8.8
Easley	54.0	3.8	1	69.0	6	24.0	28.0	46.0	5.9	21.0	192	35	15	9.2

ratios, and fluid silica content (table 39). These data for Stanley and Sunbeam springs indicate a reservoir temperature up to 245° F, which is not considered adequate for extensive steam production. A low Na/K ratio (<20) indicates a rapid temperature increase with depth (White, 1961) and a shallow heat source (Ellis, 1961), but the ratio is 195 at Stanley and 60 at Sunbeam. The Slate Creek, Bowery, and West Pass hot springs have low ratios, but below average surface temperatures. All localities show relatively low Cl/SO_4 ratios, indicating the presence of dry steam (Wilson, 1961), and the proximity of the springs to large quantities of surface water suggests that some dilution and modification of the chemical content is possible. Ross (1934, p. 105–106) estimated from a regional temperature gradient of 1° per 60 ft that the sources of springs just north of the study area were a maximum of 6,400 ft (1,951 m) below the surface, but modern data and interpretations suggest that the depths to reservoirs in the study area are probably shallower and temperature gradients are probably greater than Ross's estimates.

The thermal springs of the Sawtooth National Recreation Area do not show promise for the development of a major geothermal resource. However, low boiling-point carriers, such as freon and isobutane, are possible heat-transfer agents that might be used to derive economical energy from these low-enthalpy springs on a small scale for local use.

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