UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral Resources of the Elkhorn Wilderness Study Area, Montana

A cooperative study by the
U.S. Geological Survey
and the
U.S. Bureau of Mines

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Wilderness Study Area, Montana

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Mineral Resource Assessment

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with a section on Geophysical Exploration
by William F. Hanna,
a section on Geochemical Exploration
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a section on Geological and Geochemical Evaluation
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and a section on Uranium and Thorium Potential
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Chapter B

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STUDIES RELATED TO WILDERNESS

STUDY AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The Act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of national forest land in the Elkhorn Wilderness Study Area, Montana that is being considered for wilderness designation (Public Law 94-577, October 19, 1976). The area studied is in the Helena and Deerlodge National Forests in Broadwater and Jefferson Counties.

SUMMARY

The mineral resource potential of the Elkhorn wilderness study area, Montana, was appraised by the U.S. Geological Survey and U.S. Bureau of Mines in 1976 and 1977. This appraisal consisted of a resource assessment by the Geological Survey based upon geologic, geochemical, and geophysical surveys and an economic appraisal by the Bureau of Mines based upon studies of existing mines and prospects. The area has resources of gold, silver, copper, molybdenum, lead, zinc, iron, and possibly uranium and thorium. Extensive limestone and sand and gravel deposits also occur in the area. The potential for oil, gas, coal, or geothermal resources is very low. The area studied is part of the Elkhorn Mountains, just southeast of Helena, Montana, consisting of about 332 km^2 of the officially designated wilderness study area plus 22 km^2 requested by the U.S. Forest Service.

The Elkhorn Mountains are part of an uplifted block bounded on the north, east, and probably south by major faults. The area is underlain by granitic rocks of the Boulder batholith and related satellitic plutons, by the Elkhorn Mountains Volcanics, and to a lesser extent by Precambrian, Paleozoic, and Mesozoic sedimentary rocks.

The mineral resource assessment by the U.S. Geological Survey was based principally upon geologic studies including chemical analyses of rocks, a detailed geochemical survey of stream deposits, and a detailed aeromagnetic survey. The geochemical survey involved the collection of bulk stream sediments and panned stream sediments which were analyzed for thirty elements by semiquantitative spectrographic methods and for gold, zinc, and arsenic by atomic absorption methods. Geologic studies and rock sampling were then conducted in drainage basins from which stream samples showed anomalously high metal content or in which evidence of hydrothermal alteration was known. The aeromagnetic survey served as a guide for collecting rock samples which were subsequently measured for remanent and induced magnetization for purposes of determining the range of physical properties of anomaly sources. Uranium and thorium resources were investigated by means of analysis of water and stream sediment samples and an airborne radiometric survey. Altogether, more than 1,400 samples were analyzed in the assessment.

The geologic and geochemical data indicate that the western part of the study area has a moderate to high potential for porphyry-type copper and/or molybdenum deposits. Three of these deposits, Jackson (1, fig. 1), Golconda (2, fig. 1), and Turnley Ridge (3, fig. 1), which are located adjacent to the study area, have been explored by drilling, Golconda showing the highest potential for development. On the basis of geologic studies, other areas believed to have high potential for molybdenum and/or copper include breccia pipes and dikes cemented by tourmaline, quartz, and sulfide minerals. The breccia bodies may overlie buried porphyry-type copper and/or molybdenum deposits. These breccias occur at the south (near the Skyline Mine, 4, fig. 1) and north (near and south of the Chicago Mine, 5, fig. 1) margins of the study

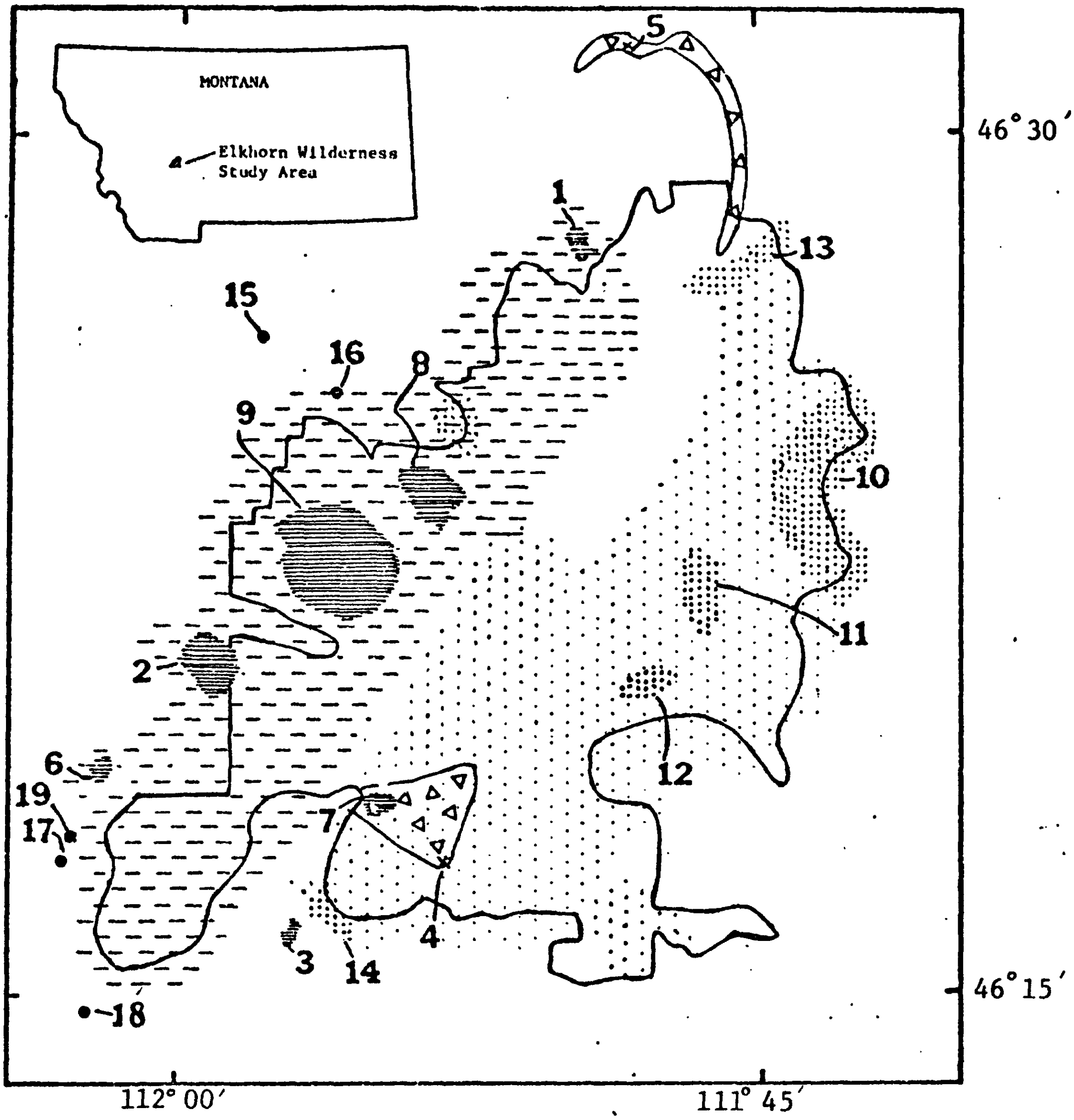

Figure 1. Mineral potential map of the Elkhorn wilderness study area.

moderate / high — Potential for porphyry copper/molybdenum mineralization (High potential areas may contain known deposits.)

moderate / high — Potential for precious base-metal vein mineralization

O aeromagnetic anomalies

Potential for breccia-pipe mineralization

INDEX OF LOCALITIES REFERRED TO IN SUMMARY

1. Jackson Creek
2. Golconda
3. Turnley Ridge
4. Skyline Mine
5. Chicago Mine
6. Nursery Creek
7. Hidden Lake
8. So. Fork of Warm Springs Cr.
9. Dutchman Creek
10. Park district
11. Longfellow Creek
12. Unnamed Creek
13. Staubach Creek
14. Elkhorn district
15. Badger Creek
16. North Fork Warm Springs
17. Rawhide Creek
18. McCarthy Creek
19. Muskrat Creek

area. A high potential for molybdenum and/or copper is also suggested on the basis of geochemical data to occur at Nursery Creek (6, fig. 1), Hidden Lake (7, fig. 1), and South Fork Warm Springs Creek (8, fig. 1), localities which show high contents of molybdenum, tin, and/or tungsten in both panned concentrates and rock samples; and Dutchman Creek (9, fig. 1), which shows high contents of molybdenum, tin, and/or tungsten in the panned concentrates alone.

A moderate potential for precious and base-metal deposits is suggested by geochemical data to occur in a broad northeast-trending zone in the southeast part of the area. Several areas of high potential for these metals are indicated within this zone (areas 10, 11, 12, 13, and 14, fig. 1). Of these, areas 10 and 14 include major mines, the workings from which have contributed to the high metal contents in the panned concentrates. The high metal contents in samples from areas 11, 12, and 13 (Longfellow Creek, an unnamed tributary to Crow Creek, and Staubach Creek, respectively) do not appear related to any major mine.

Aeromagnetic anomaly and rock magnetic data suggest that negative anomalies are in many places associated with subsurface zones of alteration and silicification in the Boulder batholith and in the Elkhorn Mountains Volcanics near the batholithic contact and that positive anomalies are in many places associated with shallowly buried plutons in Elkhorn Mountains Volcanics farther from the contact. Both the negative and positive features occur over a number of terranes which have been mined or prospected and therefore delineate subsurface regions which merit consideration for future exploration.

Anomalously high uranium in water was found at Badger Creek (15, fig. 1), Muskrat Creek (19, fig. 1), and Rawhide Creek (17, fig. 1). The entire drainage of Warm Springs Creek (8, fig. 1) was high in uranium in stream sediments. Radon in water was anomalously high in samples from Dutchman Creek (9, fig. 1), Warm Springs Creek, and Muskrat Creek. Anomalously high thorium was found in stream sediment pan concentrates from the following creeks: Rawhide, Nursery (6, fig. 1), Weimer and Anderson (2, fig. 1), Dutchman, Warm Springs, North Fork Warm Springs (16, fig. 1), and McCarthy (18, fig. 1) Creeks.

The economic appraisal by the U.S. Bureau of Mines consisted of geologic mapping, sampling, estimating tonnage and grade, and determining minability of mines and prospects in the study area.

The Elkhorn wilderness study area includes parts of the Beaver Creek, Elkhorn, and Park mining districts, and all of the Tizer-Wilson, none of which were producing ore at the time of the study (fig. 2). The area also includes part of the Warm Springs district, within which only the White Pine Mine, outside the area, was producing ore during the study. Jefferson and Broadwater County records show that 1,106 lode and 275 placer claims have been located within, and hundreds more just outside, the study area.

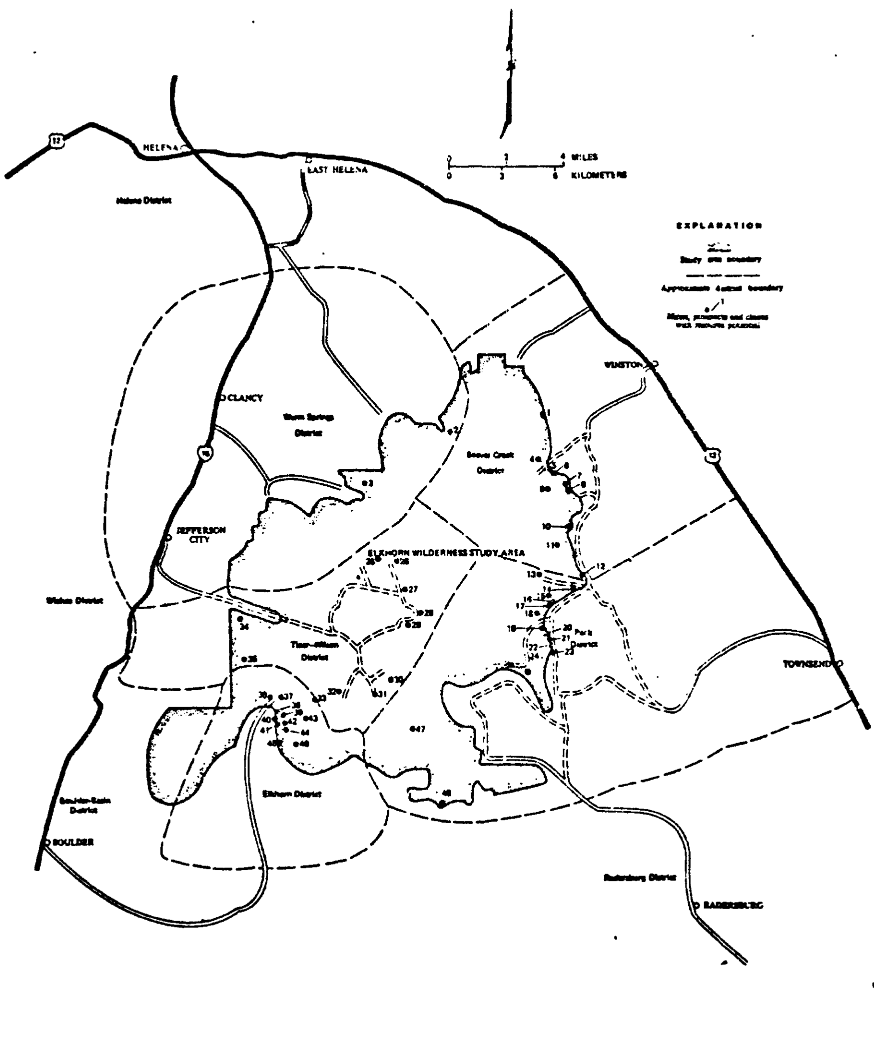

Figure 2. Mining districts in the vicinity of the Elkhorn wilderness study area.

An unnumbered table to accompany fig. 2, Mining districts in the vicinity of the Elkhorn wilderness study area.

Mines, prospects, and claims with resource potential

1. August Rust Prospect
2. Casey Meadows Prospect
3. Black Bear Claim
4. Sawmill Creek Prospect
5. Monte Cristo Group
6. G. W. No. 2 Claim (north)
7. Silver Saddle Mine
8. Last Chance Prospect
9. G. W. No. 2 Claim
10. Champion Mine
11. Silver Dyke No. 1 Claim
12. Mountain Dude Lode
13. Vulture Mine
14. Jawbone Lode Mine
15. Little Jim Nos. 1-5 Claims
16. Salt Lick Prospect
17. Eureka Creek Divide Prospect
18. McFadgen Mine
19. Golden Hope Nos. 1 and 2 Claims
20. Cross Claim Group
21. Eagle Mine
22. Roadside Prospect
23. Mamouth Lode Mine
24. Lower Eureka Creek Prospect
25. Moonlight Claims
26. Gold Series Claim
27. Belle, Best, and Last Lodes
28. Callahan Mine
29. Big Tizer-Wildcat Prospect
30. Little Tizer-Wildcat Mine
31. Ballard Mine
32. J. C. Copper Claim
33. South Hidden Lake Prospect
34. Andy Claim Group
35. Anderson Creek Prospect
36. Iron Mine
37. Elkhorn Ridge Prospect
38. Lone Bear Prospect
39. North Louise Prospect
40. Union Mine
41. Golden Moss Mine
42. Louise and Side Issue Lodes
43. Queen Ann Claim
44. C and D Mine
45. Arcturus Claim
46. Blackbird Claim
47. Ann Kinzer Mine
48. Summit Prospect

The total production of gold, silver, copper, and lead from the Beaver Creek, Elkhorn, Park, Tizer-Wilson, and Warm Springs districts is estimated to have been worth about $23 million, of which approximately $339,423 was produced from within the study area. About 68 percent ($213,418) of the study area production came from the Callahan Mine (fig. 2, no. 28), and 17 percent ($56,285) from the Ballard Mine (fig. 2, no. 31), both in the Tizer-Wilson district. Other producers included the Monte Cristo group and Silver Saddle Mine in the Beaver Creek district (fig. 2, nos. 5 and 7) ($10,314), the C and D, Colden Moss, and Iron mines in the Elkhorn district (fig. 2, nos. 44, 41, and 36) ($26,312), the Ann Kinzer, Eagle, Jawbone Lode, McFadgen, Mamouth Lode, and Vulture mines in the Park district (fig. 2, nos. 47, 21, 14, 18, 23, and 13) ($14,799), and the Gold Series claim and Little Tizer-Wildcat Mine in the Tizer-Wilson district (fig. 2, nos. 26 and 30) ($295).

Indicated and inferred resources of mines and prospects in the study area total about 6 million tons (5.4 t) of mineralized rock containing as much as 0.56 ounce gold per ton (19 g/t), 2.2 ounces silver per ton (75 g/t), 2.7 percent copper, 7.0 percent lead, 16.0 percent zinc, and 28.7 percent iron. Beaver Creek district estimated resources consist of 825,540 tons (748,930 t) of fissure vein material with as much as 0.23 ounce gold per ton (7.9 g/t) in three deposits. Resources in four mines and prospects of the Elkhorn district total 4,210,275 tons (3,819,561 t) and have as much as 0.07 ounce gold per ton (2.4 g/t), 2.2 ounces silver per ton (75 g/t), 0.21 percent copper, 7.0 percent lead, 16.0 percent zinc, and 28.7 percent iron. These are replacement, fissure vein, and breccia pipe deposits. Resources in the Park district are estimated to total 739,735 tons (661,561 t) in fissure vein deposits that contain as much as 0.13 ounce gold per ton (4.5 g/t), 1.8 ounce silver per ton (62 g/t), 2.4 percent lead, and 1.8 percent zinc. These occur in six mines and prospects. The Tizer-Wilson district has resources estimated at 286,620 tons (260,022 t) in fissure vein and replacement deposits containing as much as 0.22 ounce gold per ton (7.5 g/t), 0.1 ounce silver per ton (3.4 g/t), 2.7 percent copper, and 0.4 percent zinc. Resource estimates for this district involved only three mines and prospects. No resources were calculated for Warm Springs district because of the mineralized structures' small sizes. Forty-eight mines and prospects in the study area that are thought to have a resource potential are shown on figure 2.

The study area's stream channel and terrace gravel deposits are estimated to contain 21.3 million cubic yards (16.3 million m^3) of stream reworked, glacially-deposited gravel. Samples indicate that gold-bearing pockets of gravel occur along Crow, Wilson, and Tizer Creeks, but are small, scattered, and low-grade. The deposits could be a source of fill material and sand and gravel, but now are not competitive because alternate sources are available closer to markets. Extensive limestone beds occur along the southern edge of the study area, but other deposits are closer to markets.

Chapter A

Mineral Resource Assessment

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INTRODUCTION

The area described in this report includes the officially designated Elkhorn wilderness study area, which consists of about 332 km^2 (about 82,000 acres), and an additional 22 km^2 (5,400 acres), added at the request of the U.S. Forest Service (pl. 1). The area is in parts of Broadwater and Jefferson Counties, western Montana, and it includes parts of the Helena and Deerlodge National Forests.

In this report, the terms "Elkhorn wilderness study area" or "wilderness study area" refer to the officially designated Elkhorn wilderness study area. The terms "Elkhorn area," "study area," or "area studied" refer to the entire area that was investigated.

The wilderness study area is accessible from the east by several secondary roads leading from U.S. Highways 12 and 287. From the west it is reached by several secondary roads leading from U.S. Interstate Highway 15. Jeep trails provide access throughout Tizer Basin (pl. 1) and lower parts of the bordering slopes of the basin. From the south the wilderness study area is reached by secondary roads leading north from Montana State Highway 281 and a secondary road connecting the towns of Elkhorn and Radersburg. Forest Service trails provide access by foot or horseback to most of the area from June through October.

The Elkhorn wilderness study area includes the higher part of an isolated mountain range at the north end of the Elkhorn Mountains. Relief in the area is about 1,455 meters, ranging from an elevation of about 1,414 meters, where Warm Springs Creek leaves the area, to 2,869 meters at Crow Peak, the highest peak in the area. Although the maximum local relief is in the northern part of the area, the scenery is more spectacular in the southern part because of the glacial cirques on the flanks of Crow and Elkhorn Peaks.

The area is in the Missouri River watershed and is drained on the east mainly by Crow Creek and Beaver Creek, on the northwest by Prickly Pear Creek, Dutchman Creek, Warm Springs Creek, and McClellan Creek, and on the southwest by Muskrat Creek, Elkhorn Creek, and Dry Creek.

The wilderness study area was glaciated during Pleistocene time and glacial features include cirques on the higher peaks. The upper parts of many valleys are U-shaped, and moraine and outwash deposits fill parts of Tizer Basin and most of the major drainages.

The highest ridges and peaks of the area have talus-covered slopes with a sparse cover of whitebark pine and alpine fir (vegetation data from U.S. Dept. Agriculture Forest Service, 1976). Lower ridges and the upper slopes and basins generally are densely covered with lodgepole pine. Midslopes and valley bottoms have a mosaic of douglas fir and lodgepole pine woodlands and mountain grassland parks. On the lower slopes to the east and south, these parklands pass into open grasslands and shrub lands.

The climate of the area is modified continental with large annual and daily temperature variations (U.S. Dept. Agriculture Forest Service, 1976). Precipitation ranges from less than 30 cm per year in the valleys to over 75 cm per year at higher elevations. Average snowfall is over 250 cm per year in the high country and makes up a large part of the annual precipitation of that part of the area. The area generally has very little rain during July and August. The temperature ranges from a minimum of well below -20°C in winter to a maximum of nearly 32°C in summer and is quite variable from day to day.

The Elkhorn wilderness study area is used principally as a livestock range and for recreational fishing and hunting. Logging in the area has yielded about 20 million board feet of timber and remains a potential economic resource (U.S. Dept. Agriculture Forest Service, 1976). Mineral exploration in the wilderness study area is being conducted by individual prospectors and by companies and mine development work is being done on properties adjacent to the study area in Warm Springs Creek.

PREVIOUS STUDIES

The geology and mineral deposits of different parts of the wilderness study area have been discussed in many reports, which are listed in the references and cited elsewhere in relevant parts of this report. The geologic map of the study area (pl. 1) was compiled from the reports by Klepper, Weeks, and Ruppel (1957); Klepper, Ruppel, Freeman, and Weeks (1971); Becraft, Pinckney, and Rosenblum (1963); and Smedes (1966); and details were added locally based on our mapping. The synopsis of geology presented here is drawn largely from these papers, supplemented by subsequent summaries and topical reports by these authors and their co-workers. The spirited exchange between Hamilton and Myers (1967, 1974a,b) and Klepper, Robinson, and Smedes (1971, 1974) presented much useful information and opinion on the shape and manner of emplacement of the Boulder batholith.

PRESENT INVESTIGATION AND ACKNOWLEDGMENTS

Investigations in the study area by the Geological Survey were made during November 1976 by W. R. Greenwood and W. R. Miller, and during June, July, and August 1977 by these geologists and S. D. Ludington, assisted in 1977 by Judy Melia Allen, Enid Bittner, and David Thompson.

The field work was conducted mainly by foot traverses through the area. Jeeps were used on several trails in Tizer Basin and to gain access to sample localities on the periphery of the study area.

The mineral survey included reconnaissance geologic mapping aimed primarily at checking and updating existing maps. Most of the field effort, however, was devoted to collecting samples for geochemical analysis and searching for evidence of mineralization. Bulk stream sediment samples and panned concentrates of stream sediments were collected from all first order, or unbranched, streams. Water samples were also collected from these streams and from springs and seeps. The common rock types were sampled, as were visibly altered or mineralized rocks. Altogether, more than 1,400 samples were collected and analyzed. The spectrographic analyses of these samples were determined in a Geological Survey mobile laboratory by Jerry Motooka. Sample preparation and other chemical analyses were conducted in a mobile laboratory by John B. McHugh.

The mineral survey benefited greatly from assistance extended by local residents, Forest Service officials, claim owners, and others. In particular we would like to acknowledge help received from James W. Whipple, formerly Forest Service geologist of the Helena National Forest, and Richard I. Walker, U.S. Forest Service, who is the team leader for the Elkhorn wilderness study area project.

GEOLOGIC SETTING

The Elkhorn wilderness study area is underlain mostly by Elkhorn Mountains Volcanics and related intrusive rocks of Cretaceous age and by the Cretaceous Boulder batholith and satellitic stocks of similar age. A smaller part of the area is underlain by strata of Paleozoic to Mesozoic age. Precambrian sedimentary rocks of the Belt Supergroup crop out extensively in the Elkhorn Mountains and presumably lie beneath the Paleozoic strata in various parts of the study area. Mineral deposits occur in quartz veins, as replacement deposits, in breccia pipes, as disseminated deposits and stockworks in plutonic rocks, in skarns along intrusive contacts, and along faults that were active during Cretaceous plutonism. All these rocks were intruded by mid-Tertiary and late-Tertiary igneous dikes and stocks and locally overlain by related volcanic rocks.

The mountain range containing the study area is a tectonically uplifted block, bounded on the east and north and probably south and west by major faults. This uplifted block has been eroded by glaciers and by running water to its present form.

SEDIMENTARY ROCKS

Sedimentary rocks about 4,000 meters thick and ranging in age from late Precambrian to Cretaceous are exposed in or near the study area. These strata are overlain by Late Cretaceous Elkhorn Mountains Volcanics that in places were 3,000 to as much as 4,000 meters thick. The Cretaceous and older rocks were strongly folded and faulted prior to and during the intrusion of the Boulder batholith and related Late Cretaceous intrusive rocks.

The sedimentary rocks and volcanic units in the study area have been fully described by Klepper, Weeks, and Ruppel (1957); Klepper, Ruppel, and others (1971); Smedes (1966); and Becraft and others (1963); accordingly they are described summarily and only the details that have economic significance are discussed in this review.

Precambrian rocks

Hornstone mapped as Spokane Shale and possibly Empire Shale of the Belt Supergroup (Precambrian Y age) is exposed in the faulted core of an anticline in the Elkhorn mining district, adjacent to the southwest border of the study area (Klepper and others, 1957). Only a few mines have been developed in the Belt rocks of this district and the unit does not appear to be favorable for mineral exploration.

Paleozoic rocks

Paleozoic rocks crop out in the cores of two anticlines at the south edge of the study area and in upfolded rocks several kilometers east and north of the area. These strata consist predominantly of carbonate rocks and shale and include subordinate amounts of quartzite, phosphatic quartzite, and chert. Most of the mines of the Elkhorn mining district (Klepper and others, 1957) and some lead-zinc deposits in the Quartzite Ridge area southeast of the study area (Klepper, Ruppel, and others, 1971), have been developed in Paleozoic rocks. Many of these metal deposits formed as replacements of carbonate rocks near contacts with overlying relatively impermeable shale. Such carbonate-shale contacts are attractive exploration targets and therefore they are designated with a dashed line on plate 1. The phosphatic quartzite and chert of the Phosphoria Formation (Permian) locally contains one or two thin beds of phosphate rock as much as 0.8 m thick. Some phosphate rocks of the Phosphoria Formation of the region have anomalous uranium contents (Maughan, 1976), and such rocks are a possible exploration target.

Mesozoic rocks

At the base the Mesozoic rocks consist of marine and nonmarine sandstone and shale, in part calcareous or interbedded with limestone. These beds are overlain by dark shale and sandstone that grade upward through tuffaceous sandstone to bedded tuff interbedded with shale or mudstone. North of Johnny Gulch in the eastern part of the area, the epiclastic rocks grade upward into predominantly pyroclastic rocks of the Elkhorn Mountains Volcanics. However, south of Johnny Gulch the Elkhorn Mountains Volcanics rest with angular unconformity on tilted and eroded older rocks (Klepper, Ruppel, and others, 1971).

The pre-volcanic Mesozoic rocks contain several carbonaceous units, and one unit, the upper part of the Slim Sam Formation, contains carbonized and silicified wood in many places. Carbonaceous sedimentary rocks such as these commonly contain high, but usually not economic, amounts of metals. Several mines and prospects in the southeast part of the study area have been developed in or near those carbonaceous units, especially where they are cut by intrusive rocks. Leaching of the carbonaceous rocks by magmatic fluids may have released metals that were then concentrated in some of the ore deposits of the area. The carbonaceous units are also of economic interest as possible sites of concentration of uranium leached from the interbedded and overlying tuffs.

The pre-volcanic Mesozoic rocks also contain lenticular beds of titaniferous magnetite that appear to be lithified beach placers; near Radersburg southeast of the study area such beds have been mined for use in cement.

Cenozoic rocks

Cenozoic sedimentary rocks of the region include Tertiary fluvial and lacustrine deposits including waterlaid tuff, which are part of the basin fill in the Townsend Valley east of the study area (Klepper, Ruppel, and others, 1971).

Unconsolidated deposits of Tertiary and Quaternary age in the study area are grouped on plate 1 according to the means and amount of transportation from their source. Generally thin surficial deposits originally mapped as fan deposits, mantle, hillwash pediment gravel, and mass-waste deposits including landslides are combined in one map unit. These deposits generally are coarse grained, derived largely by mechanical erosion, and most have been transported only short distances. Glacial deposits are combined in one unit, and alluvial deposits of several ages are combined in one unit.

IGNEOUS ROCKS

Extrusive and intrusive igneous rocks underlie most of the study area. The Elkhorn Mountains Volcanics predominate in the east half of the area and the Boulder batholith underlies the west half. The Elkhorn Mountains Volcanics are intruded by many sills and dikes of porphyritic igneous rock similar in composition to the volcanics. These sills and dikes were intruded prior to and during folding and faulting of the volcanic rocks. The volcanics and associated porphyritic intrusions are intruded by the Boulder batholith and smaller, generally discordant igneous bodies that are satellitic to the batholith. Uplift and erosion of the Elkhorn Mountains Volcanics and Boulder batholith was followed by mid-Tertiary volcanism represented in the study area by a quartz latite dike swarm and related stocks. Late Tertiary volcanism is represented by a few small rhyolite flows, volcanic sandstone, and tuff, and associated intrusive rhyolite domes and breccias, and basalt flows.

The nomenclature used in this report for igneous rocks follows that of Klepper, Ruppel, and others (1971). The terminology of fragmental rocks follows that of Wentworth and Williams (1932, p. 43-53).

Elkhorn Mountains Volcanics

The Elkhorn Mountains Volcanics of Late Cretaceous age are divided into three members (Klepper and others, 1957): (1) The lower member ranges in thickness from 760 to 1,520 m and consists of rhyodacitic and trachyandesitic tuff, tuff breccia, and breccia, with subordinate flows and thin welded-tuff units; most of the finer grained tuff is finely laminated and was deposited in shallow water with minor reworking (Klepper, Ruppel, and others, 1971). (2) The middle member is as much as 2,290 m thick and consists of rhyolitic welded tuff interlayered with crystal and lithic tuff and less abundant volcanic breccia (Smedes, 1966, p. 26). (3) The upper member is about 610 m thick in its thickest preserved section near High Peak in the northern part of the study area (Smedes, 1966, p. 26); this member consists of water-laid epiclastic mudstone to conglomerate, bedded tuff, and a few thin beds of volcanic breccia.

Intrusive rocks related to Elkhorn Mountains Volcanics

Several large laccolithic, lopolithic, and irregular bodies consisting mainly of syenodiorite porphyry and granodiorite porphyry and many dikes, sills, plugs, and irregular bodies of trachyandesite porphyry and rhyodacite porphyry cut Elkhorn Mountains Volcanics and older rocks. These intrusive rocks are compositionally similar to the volcanics and probably are products of the same magma or magmas (Klepper, Ruppel, and others, 1971, p. 20). Some of the larger intrusives appear to have been intruded as a series of sill-like sheets that coalesced to form laccolithic bodies and locally these bodies of magma breached through to the surface forming laharic or mud-flow deposits (Klepper, Ruppel, and others, 1971, p. 23). These larger intrusive bodies are concentrated along the axial zones of a major syncline in the center of the study area and a major anticline in the east part of the area and may have been emplaced during the early stages of folding (Smedes, 1966, p. 61; Klepper, Ruppel, and others, 1971, p. 33).

Younger intrusive rocks

The Boulder batholith and related dikes, plugs, and stocks of Late Cretaceous age cut the Elkhorn Mountains Volcanics and related intrusive rocks. The rocks of the Boulder batholith are divided in plate 1 into mafic plutons, ranging from gabbro to dark granodiorite and calcic syenite, and intermediate to felsic plutons, ranging from granodiorite to granite. In the study area, the intermediate to felsic rocks of the Boulder batholith are mapped as phases of the Butte Quartz Monzonite; they apparently were coeval and were derived from a single magma source (Tilling, 1973); these phases are not shown separately on plate 1. Alaskite and a late leucocratic granite contemporaneous with alaskite are concentrated in a northeast-trending zone that also contains most of the major metalliferous veins in the northwest part of the study area. East of the batholith, the intermediate to felsic plutons are subdivided into two groups, (1) granodiorite and (2) rocks more felsic than granodiorite.

Although most of these younger intrusive rock bodies have discordant and steeply dipping contacts, they probably were emplaced at their present erosion levels during and following the culmination of major folding and faulting in the region. The eastern contact of the batholith conforms in trend to the trend of the major folds in the strata to the east. Furthermore, the satellitic plutons in the east part of the study area crop out in a north-trending zone that generally follows the axial zone of a major syncline. The batholith and the satellitic plutons intrude and are cut by faults that are symmetrically and probably genetically related to the major folds.

Eocene quartz latite porphyry

Dikes and stocks of quartz latite porphyry cut rocks of the Boulder batholith and older rocks in the north part of the study area. The quartz latite intrusions are at the northern end of a swarm of similar bodies that connect to the southwest with the main exposures of the quartz latitic Lowland Creek Volcanics (Smedes, 1962). The volcanics and the associated dike swarm have been dated as early Eocene (Smedes and Thomas, 1965).

Felsic flows, tuffs, and intrusive bodies

Scattered outcrops of a flow-laminated rock termed rhyolite by Klepper, Ruppel, and others (1971) occur along Crow Creek. The chemical analysis and norm of the rock (Klepper, Ruppel, and others, 1971, p. 30), along with our spectroscopic analyses (Motooka and others, 1978; samples 77BG049G through 77BG054G) indicate it to be a quartz latite or rhyodacite. The rock is gray to black, and generally dense to sparsely vesicular, but locally scoriaceous or lithophysal. It contains sparse phenocrysts of labradorite, pyroxene, and an opaque mineral, probably magnetite. The outcrops are remnants of flows (Klepper and others, 1957; Klepper, Ruppel, and others, 1971) and may, in part, be welded tuff that underwent secondary flowage.

Rhyolite with a K-Ar age of 36 m.y. (Chadwick, 1977) occurs in the northwestern part of the study area, as funnel-shaped plugs, dikes, tuff, breccia, volcanic sandstone, and lava flows. This rhyolite, flows of which are conspicuously laminated, is characterized by high contents of tin (10-15 ppm), niobium (30-100 ppm), and fluorine (0.2-0.5 percent). Phenocrysts of quartz, K-feldspar, and sodic plagioclase are present but sparse. Topaz is commonly found in miarolitic cavities.

At Lava Mountain, silver-bearing galena, sphalerite, fluorite, and quartz occur in anastomosing veinlets cementing brecciated rhyolite, as fillings in lithophysal cavities, and as local small replacement masses (Smedes, 1966, p. 107-108). The extrusive rhyolite at the exposures in the northwest is not well exposed but appears to occur as blocks that have partly foundered into the intrusive rhyolite during emplacement of the stocks (Smedes, 1966, p. 94).

Basalt flows

A few remnants of basalt flows crop out along and near Crow Creek from Sagebrush Gulch eastward. The basalt flows locally rest on sedimentary tuff considered to be of Oligocene age (Klepper, Ruppel, and others, 1971, p. 29-30) and were gently folded or tilted probably in the late Pliocene (Freeman, Ruppel, and Klepper, 1958, p. 527-528). The basalt probably is late Miocene or Pliocene in age but could be as old as Oligocene (Klepper, Ruppel, and others, 1971, p. 30).

STRUCTURAL GEOLOGY

The structural grain of the Elkhorn wilderness study area is dominated by the north-northeast-trending contact of the Boulder batholith. East of the batholith most of the pre-batholith rocks in the study area occupy a broad syncline that trends north-northeast parallel to the batholith contact. The Elkhorn mining district (pl. 3), southwest of the syncline, is located in a small north-trending anticline that is cut off to the north by the batholith. Another small north-trending anticline is cut off by the north end of the batholith, north of the study area; its axis lies about 0.5 km east of the Economy Mine (pl. 1). On the southeast, the broad syncline is flanked by a tight north-trending anticline, which dies out to the north in a system of normal faults with northeast and northwest trends. This anticline is flanked on the east by a broad north-trending syncline, which also dies out to the north.

In addition, many small folds are known. Near Beaver Creek, in the northeast part of the area, several minor folds plunge to the southwest. Northeast plunging minor folds formed on the east flank of the tight north-trending anticline near Aldrich Gulch in the southeast part of the area. In addition, minor folds of diverse trends formed on the flanks of the many intrusive bodies in the area.

Early-volcanic folding is shown by the facies changes and erosional thinning across syn-depositional anticlines in the tuffaceous Upper Cretaceous Slim Sam Formation about 5 km from the batholith contact in the north part of the study area (Smedes, 1966, p. 21). In the southeast part of the area the Slim Sam also was erosionally thinned and locally is missing below the Elkhorn Mountains Vocanics near the batholith contact on the southwest (Klepper and others, 1957; Klepper, Ruppel, and others, 1971). Along the east side of the area, a thick section of the Slim Sam grades upward into the Elkhorn Mountains Volcanics (Klepper, Ruppel, and others, 1971). This suggests that the onset of major volcanism was preceded and perhaps accompanied by folding and possibly gradual inflation of part of the area that is now occupied by the batholith.

Faults in the study area have been classified in sets according to their orientation and apparent age. The oldest fault in the area may be a steeply dipping fault the preserved part of which extends north in upper Mitchell Gulch from the northeast corner of the batholith (Smedes, 1966). This fault has a down-to-the-east offset of about 1 km. Early movement on this fault may have exposed Paleozoic limestone to erosion during the deposition of the lower member of the Elkhorn Mountains Volcanics. Such a fault scarp would explain (1) the limestone clasts (as large as 1 m in diameter) that occur in conglomerates and at the base and top of a thick welded tuff near Corral Creek at the north of the area; and (2) marble of clastic origin interbedded with andesite flows in the lower member of the volcanics at Elkhorn Peak in the south of the area. (Compare with Hamilton and Meyers, 1974a.) A large block

(10 m thick x 20 m long) of limestone enclosed in an amygdaloidal andesite flow at Elkhorn Peak appears to have been derived from a nearby scarp. The fault in Mitchell Gulch is cut by and locally offsets early rocks of the batholith (Smedes, 1966) and a fault of similar trend has been proposed as the control for the linear eastern contact of the Boulder batholith (Smedes, 1966). Younger probably syn-volcanic faults are circular to rhombohedral and appear to bound one and perhaps two cauldrons or volcanic collapse structures near the north and the south margins of the area (pl. 1) that are filled with massive welded tuff units of the middle member of the volcanics. A mafic ring dike that intrudes the rim of the northern collapse structure is cut along one margin by an intrusive breccia, the intrusive phase of which appears compositionally similar to the rhyolitic welded tuffs.

The oldest post-volcanic faults appear to have formed parallel, or longitudinally, to the major folds of north and north-northeast trend and at right angles, or normal, to these folds. Most of the longitudinal faults are steeply dipping reverse faults; the normal-trending faults dip nearly vertically and appear to have been tensional faults (Klepper, Ruppel, and others, 1971, p. 31). Klepper, Ruppel, and others noted that these early faults formed during the major folding. They also indicated that the faults offset and were intruded by the early intrusive bodies emplaced during the folding. The east- to east-southeast-trending faults of this set were sites of sulfide mineral deposition both as replacements of carbonate rocks and in quartz veins (Klepper, Ruppel, and others, 1971, p. 32).

Northeast- and northwest-trending faults in pre-batholith rocks control the alinement of many segments of the major streams in the study area. Elsewhere streams follow prominent lineaments of similar trends along which no faults are mapped. The northeast- and northwest-trending faults appear to have formed as a set of complementary shears related to compression from the west or west-northwest beginning during the final stages of emplacement of the early intrusive rocks. Major movement on these faults in pre-batholith rocks followed emplacement of these early intrusives and appears to have occurred just prior to or during the emplacement of the Boulder batholith to its final level in the crust. Left-lateral movement of as much as 610 m is reported for the northwest-trending Indian Creek Fault (Klepper, Ruppel, and others, 1971, p. 32). Small northeast-trending faults of both right-lateral and left-lateral movement east of Indian Creek have been shown (Klepper, Ruppel, and others, 1971). Most of the mapped faults in pre-batholith rocks had predominantly dip-slip movements and appear to be tensional features that formed or were reactivated during uplift or release from earlier compression.

Most faults in the batholith trend northeast and east, but a few trend northwest. Right-lateral and dip-slip movements have been demonstrated on northeast-trending faults in the batholith; the east-trending faults show left-lateral and dip-slip movements; and the few northwest-trending faults show right-lateral and dip-slip movements

(Smedes, 1966; Becraft and others, 1963). Metalliferous quartz veins that are abundant west and northwest of the study area are part of a major zone of fracturing, igneous intrusion, and vein formation that extends southwest for many tens of kilometers, lying slightly east of the medial axis of the batholith. In the general vicinity of Jefferson City the northeast-trending zone and its constituent fractures, veins, and igneous bodies turn east and pass generally north of the study area. Few of these structures extend east beyond the contact of the batholith or into the study area. The igneous bodies that help to form the zone include many small bodies of late-batholith alaskite and down-warped and down-faulted masses of Lowland Creek Volcanics and related dikes and stocks. The zone also includes down-warped and down-faulted masses of pre-batholithic rocks. The prolonged and repeated tectonic and magmatic activity in this zone suggests that it overlies an axial magma conduit or "root" that connects with a magma source at depth. Hot springs at Alhambra and near Boulder may indicate magmatic activity in and near this zone that continued into late Cenozoic time.

Range-front faults of late Tertiary to Holocene age are exposed along the northeast front of the Elkhorn Mountains (Klepper, Ruppel, and others, 1971, p. 32). The major faults of this system mostly are covered by fan gravel but probably bound the range on the north (Smedes, 1966), east (Klepper, Ruppel, and others, 1971), and southwest (Klepper and others, 1957). These faults are part of a broad system of basin and range faults that produced the north- and northwest-trending valleys south of the Lewis and Clark line, which extends through the Helena Valley (Reynolds, 1977) to the north. Extensional faulting that produced these valleys, which are filled with Cenozoic sediments, is apparently related to major right-lateral faulting in the northwest-trending Lewis and Clark line.

GEOPHYSICAL EXPLORATION

by

William F. Hanna

INTRODUCTION

The trapezoid-shaped area covered by the detailed aeromagnetic survey (pl. 2)[1/] is bisected by part of the contact between two

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[1/]Specifications of the detailed survey; flight spacing = 1/2 mi; flight elevation = 9,000 ft above sea level; compilation scale = 1:62,500; contour interval = 20 gammas; base magnetic field value (representing the earth's main magnetic field) = 57,671 gammas at an origin of lat. 46°15′07" N., long. 112°04′25" W. with an average regional gradient of 5.71 gammas per mile north and 3.68 gammas per mile east; flown by Aerial Surveys, Salt Lake City, Utah, April 1977.

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vast terranes of Late Cretaceous igneous rock: the Boulder batholith and the Elkhorn Mountains Volcanics (fig. 3). Regional aeromagnetic data (Johnson and others, 1965)[2/], generalized in figure 4,

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[2/]Specifications of the regional survey: flight spacing = 2 mi; flight elevation = 10,500 ft above sea level; compilation scale = 1:250,000; contour interval = 20 and 100 gammas; flown by U.S. Geological Survey, 1953 and 1955.

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had indicated a close association of high-amplitude positive anomalies with the Elkhorn Mountains Volcanics and plutons intrusive into the volcanics, most prominently expressed near the contact between the volcanics and the Boulder batholith. This regional survey also showed that weaker positive and negative anomalies are associated with much of the Boulder batholith, the negative features in places delineating regions of pronounced mineralization and ore deposition (Hanna, 1969). The detailed survey not only confirms the existence of these regional patterns but also discloses a number of low- and high-amplitude anomalies unseen in the original survey, permitting much improved correlations of individual anomalies with specific lithologic units. The purpose of the present investigation is to establish such correlations between the anomalies and their source rocks, specifically as an aid in assessing the mineral resource potential of the study area. Inasmuch as the casual reader may be unfamiliar with underlying principles of aeromagnetic anomaly interpretation, brief mention of the general significance of these anomalies will be made prior to discussing auxiliary gravity anomaly data, rock magnetic data, and details of the observed aeromagnetic anomalies.

Figure 3. Regional geologic map (Smedes and others, 1968) highlighting major terranes of igneous rocks and showing the trapezoidal outline of the detailed aeromagnetic survey.

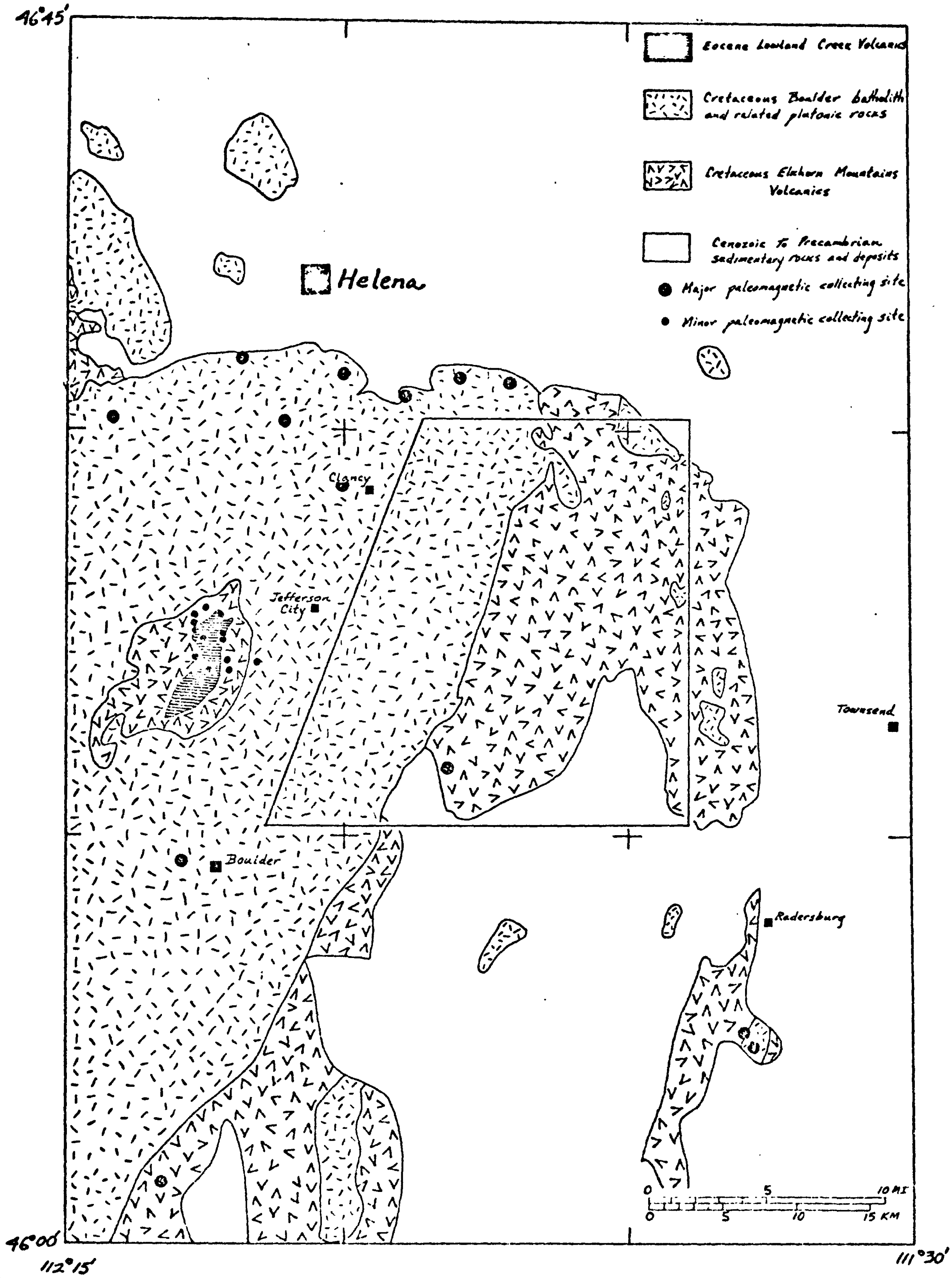
46°45'
Eocene Lowland Creek Volcanics
Cretaceous Boulder batholith and related plutonic rocks
Cretaceous Elkhorn Mountains Volcanics
Cenozoic to Precambrian sedimentary rocks and deposits
Major paleomagnetic collecting site
Minor paleomagnetic collecting site
Helena
Clancy
Jefferson City
Townsend
Boulder
Radersburg
0
5
10 MI
0
5
10
15 KM
46°00'
112°15'
111°30'

Figure 3.

Figure 4. Regional aeromagnetic map (Johnson and others, 1965) showing trapezoidal outline of detailed aeromagnetic survey discussed in text. See footnote 2 for specifications of regional survey and footnote 1 for specifications of detailed survey.

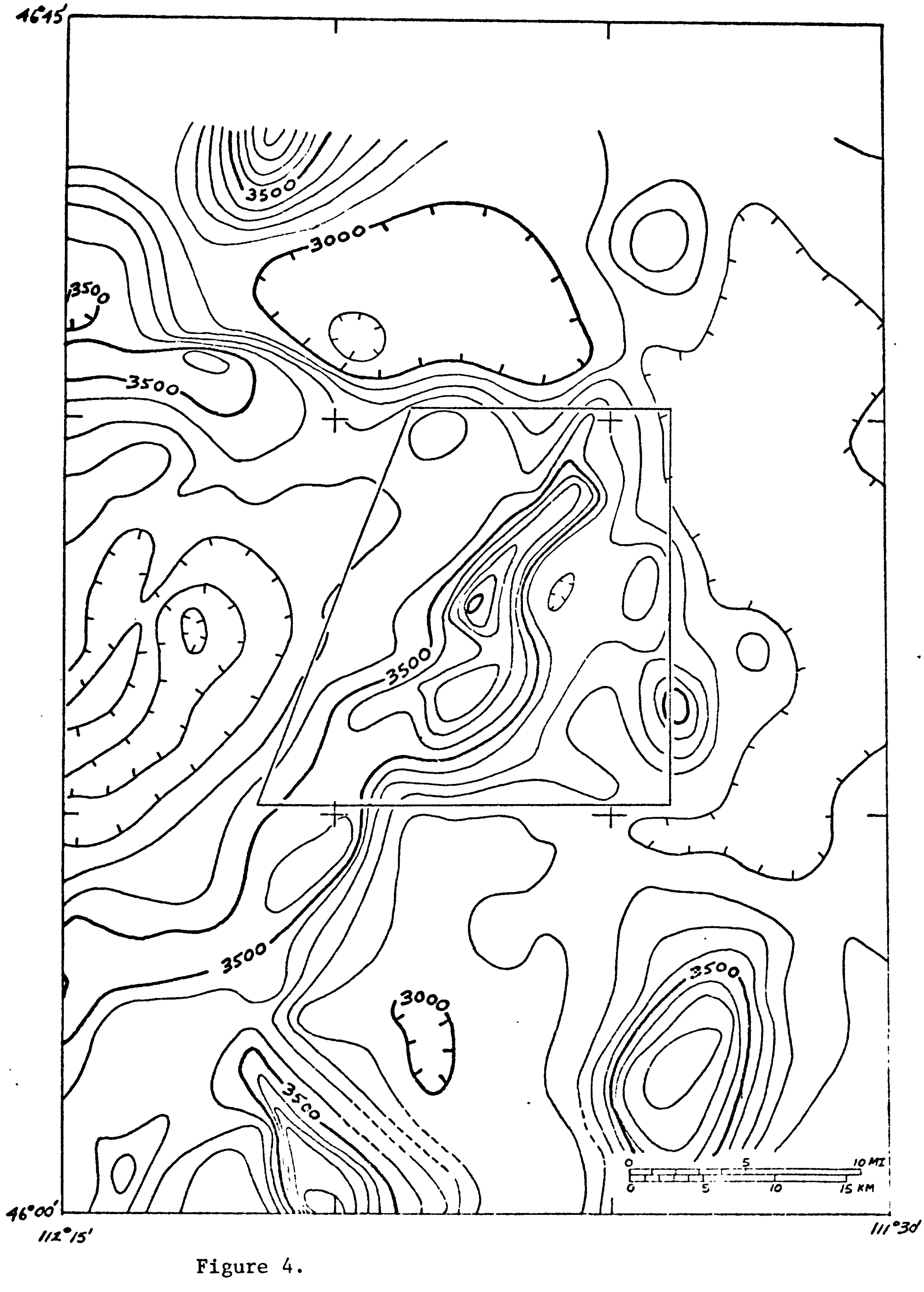
46°45'
3500
3000
3500
3500
3500
3500
3000
3500
3500
0 5 10 MI
0 5 10 15 KM
46°00'
112°15'
111°30'

Figure 4.

GENERAL SIGNIFICANCE OF ANOMALIES

Aeromagnetic anomalies are caused by contrasts of total magnetizations (vector sums of induced[3/] and remanent magnetizations)

[3/]The induced magnetization, ordinarily assumed to be constant in direction (parallel to the earth's external field) and magnitude for a geologic body of uniform magnetic mineral concentration and composition, actually varies in direction and magnitude depending upon the anisotropy of apparent magnetic susceptibility of the magnetic body. This anisotropy depends on both the shape and intrinsic magnetic susceptibility of the body, the latter depending upon the shapes and intrinsic susceptibilities of constituent magnetic mineral grains and microscopic domains (Hanna, 1977b, p. 27-28). Measurements of 106 samples fom 77 lithologic units of Elkhorn Mountains Volcanics in the Boulder batholith region (Hanna, 1965, 1977a) indicate that only 42 have measurable anisotropies and that all anisotropies are less than 6 percent. Thus, for aeromagnetic interpretation, the intrinsic susceptibilities of exposed volcanic rocks are to a good approximation isotropic; however, anisotropies associated with body shapes may be appreciable, especially if magnitudes of intrinsic susceptibilities exceed about 1,000 x 10^{-5} emu/cm^3.

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occurring within or between units of subsurface rock and thus are associated with bodies of subsurface rock whose upper surfaces may or may not be exposed as outcrops. Relative to the "normal" field generated mainly by processes operating within the earth's core, positive and negative anomalies are indicators of directions and intensities of total magnetizations as well as sizes, shapes, and locations of rock masses having the magnetization contrasts.

In general, positive or negative anomalies may develop either as active features associated with relatively magnetic rocks polarized in a normal or reversed sense or as passive features over relatively nonmagnetic terrane in the vicinity of magnetic rocks. In particular, an equidimensional magnetic rock source within the study area possessing a total magnetization nearly parallel to the earth's external field, called normal magnetization, gives rise to a positive anomaly and a weaker negative anomaly displaced to the north (polarization low).[4/] A similar magnetic rock source having a total magnetization

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[4/]The amplitude of a polarization low or polarization high depends upon the depth of the lower extremity of the magnetic anomaly source rock; the shallower this extremity, the greater the amplitude.

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nearly antiparallel to the external field, called reversed magnetization, gives rise to a negative anomaly and a weaker positive anomaly displaced to the north (polarization high). Such a reversed total magnetization would result from a reversed remanent magnetization which is stronger than the induced magnetization parallel to the external field. Thus, for each positive anomaly in the study area, the following possibilities must be considered: (1) high developed over normally magnetized rocks, (2) polarization high adjacent to a negative anomaly associated with reversely magnetized rocks, and (3) high over relatively nonmagnetic terrane in the vicinity of reversely magnetized rocks. Conversely, for each negative anomaly in the study area, the following must be considered: (1) low developed over reversely magnetized rocks, (2) polarization low adjacent to a positive anomaly associated with normally magnetized rocks, and (3) low over relatively nonmagnetic terrane in the vicinity of normally magnetic rocks. Previous inspections of aeromagnetic anomaly and rock magnetic data from the Boulder batholith region (Hanna, 1969, 1973b) suggest that positive anomalies are commonly highs developed over normally magnetized rocks and that negative anomalies are variously lows developed over negatively magnetized rocks, polarization lows, and (most important economically) lows over relatively nonmagnetic terrane in the vicinity of normally magnetized rocks.

With regard to the geologic interpretation of aeromagnetic anomalies, it is unfortunate that no unique determinations of the subsurface distribution (size, shape, location, intensity of magnetization contrast) of magnetic or nonmagnetic rock masses can be directly made from observed anomaly data alone. This constraint relative to a unique solution stems from (1) the lack of a complete data set, (2) the use of imprecise data, and (3) the absence of a general theory establishing the basis for unique inversions of observed data. In practice, however, the anomalies may be realistically interpreted in light of other geologic and geophysical information, permitting in some instances the computer modelling of magnetic rock sources (including magnetic topography for purposes of making magnetic terrain corrections) or qualitative assessment of subsurface geologic trends. In the present study, detailed geologic mapping provides the main basis for inferring extensions or independent occurrences of subsurface rocks, supported by rock magnetic data which bracket the ranges of magnetization contrasts expected in the subsurface. Reconnaissance Bouguer gravity anomaly data, commonly used to supplement magnetic anomaly information, are of limited value in the study area because of the sparseness of gravity stations and corresponding data points.

RECONNAISSANCE GRAVITY ANOMALY DATA

Reconnaissance Bouguer gravity anomaly data, imperfectly defined in the study area (fig. 5), generally reflect the margins of several well-defined regional anomalies centered in adjacent regions. The anomaly pattern within the study area is dominated by a broad high-amplitude east-trending nose of the major negative anomaly associated with relatively low-density plutonic rocks of the Boulder batholith proper.

Figure 5. Regional Bouguer gravity anomaly map showing the outline of the detailed aeromagnetic survey. Gravity map was compiled from surveys of Burfeind (1967, 1969), Davis and others (1963), Kinoshita and others (1964), and Biehler and Bonini (1969).

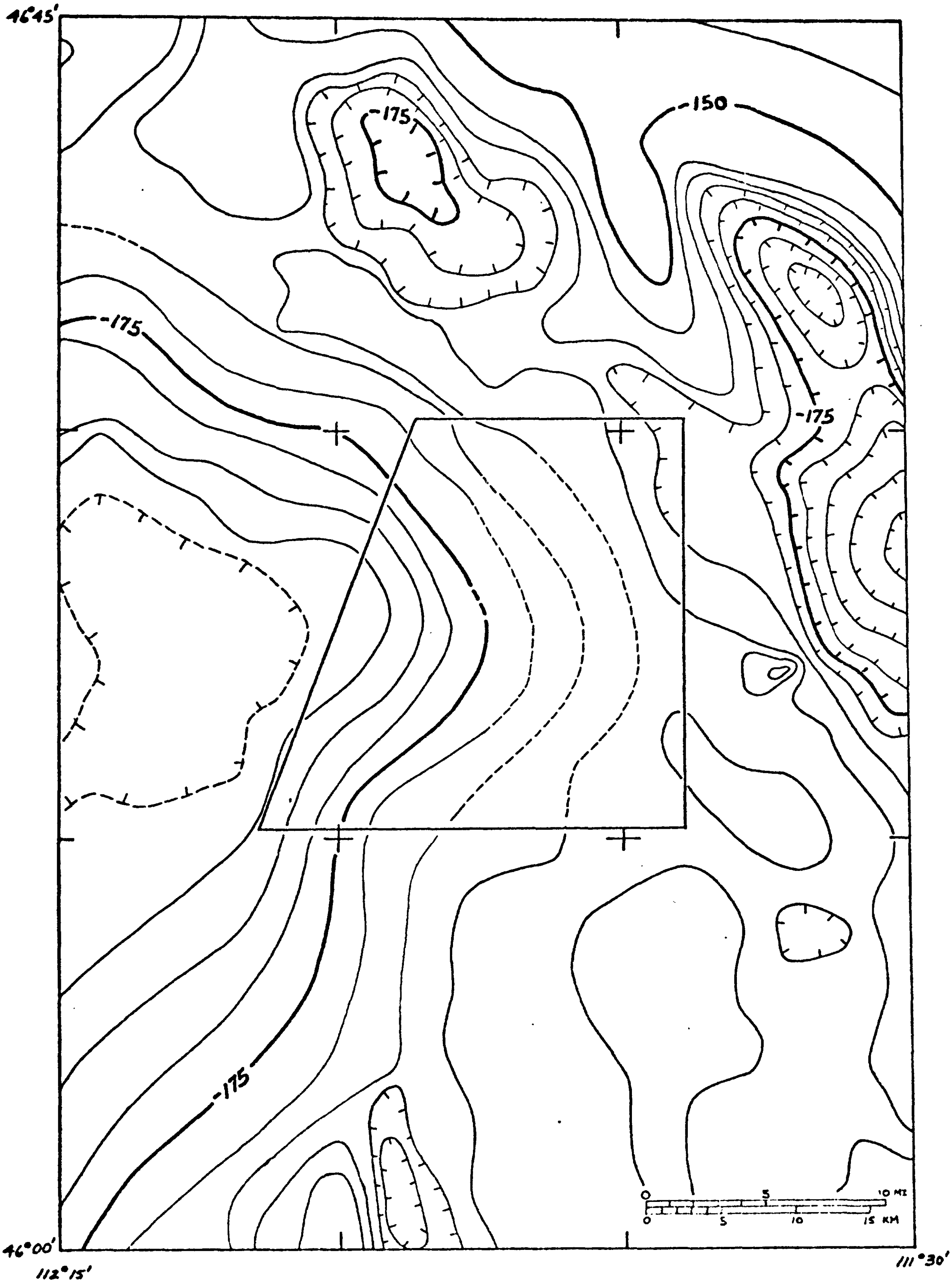

Figure 5.

In the northeastern part of the area, this nose is influenced by a negative anomaly associated with basin fill of the Townsend Valley to the east of the area. In the southeastern part of the area, the nose is interrupted by a broad gravity plateau presumably associated with a combination of Elkhorn Mountains Volcanics, rocks related to the volcanics, and older sedimentary rocks. The most significant feature within the study area, however, is the subtle northwest-trending positive nose resulting from reversal of curvature southward from the major negative nose. It, like the negative feature, clearly transects the surface contact between the Boulder batholith and sedimentary and volcanic rocks. This positive feature, which has a residual amplitude of 5 to 10 milligals and which trends vaguely northwest toward an anomalous mineralized terrane of volcanic and plutonic rocks southwest of Jefferson City, may mark occurrences of either relatively high-density mafic plutonic rocks of the Boulder batholith or Elkhorn Mountains Volcanics in contact with a west-dipping eastern margin of felsic rocks of the Boulder batholith.

Densities of 51 samples of plutonic and volcanic rocks from the study area (table 1) range from 2.35 g/cm^3 for rhyolite to 2.92 g/cm^3 for gabbro and average 2.68 g/cm^3; these are normal densities for these types of igneous rocks. Of economic interest, a number of chemically altered rocks collected from zones of mineralization have relatively low densities of less than 2.60 g/cm^3; others have nearly normal densities, depending upon their degree of silicification. The only rocks having densities greater than 2.80 g/cm^3 and not parts of highly mafic intrusive or extrusive rock units are bodies of hornfels that represent thermally metamorphosed units of volcanic and sedimentary rocks. Because of the range of rock densities encountered over relatively small regions, it is anticipated that a gravity survey sufficiently detailed for mineral resource appraisal must have a grid spacing of about 1 km and must be completely terrain corrected, a topographic surveying requirement beyond the scope of the present investigation.

ROCK MAGNETIC DATA

Remanent and induced magnetizations of the 51 samples of plutonic and volcanic rocks (table 1) range over five orders of magnitude, consistent with data from nearby (fig. 1) collecting sites in Elkhorn Mountains Volcanics, Boulder batholith, and Lowland Creek Volcanics (Hanna, 1965, 1967, 1969, 1973a,b, and 1977b). Sample localities of the 51 samples are shown on plate 2. Of special interest in magnetic anomaly interpretation are magnitudes of remanent and induced magnetization, listed in table 1 under columns denoted "REM J" and "IND J," respectively. In the study area, rocks having magnitudes of either remanent or induced magnetization exceeding 100×10^{-5} emu/cm^3 are capable of generating high-amplitude anomalies, depending upon their distribution in the subsurface, and are thus candidates for active sources of anomalies. Inspection of the table shows that 13 samples have both remanent and induced magnetizations exceeding this figure, 3 samples have remanent magnetizations alone exceeding the figure, and 10

Table 1.--Magnetization and density data for selected rocks collected from the Elkhorn wilderness study area

[Leaders (--) indicate not measured]

Sample Locality No.	Field No.	REM[1/] D	REM[2/] I	REM[3/] J	[4/] K	IND[5/] J	[6/] Q	[7/] ρ	J-type of Likely Anomaly Source[8/]	Remarks
1	77LA081	--	--	794	28.9	16.7	47.5	2.35	R	Flow-banded rhyolite, Strawberry Butte.
2	GE049P	--	--	147	256	148	0.993	2.65	R, I	Biotite quartz monzonite.
3	GE036P	--	--	3.01	38.1	22.0	0.137	2.54	NON	Weathered quartz monzonite; limonite boxworks.
4	GE035P	--	--	15.2	66.5	38.4	0.396	2.56	NON	Granite dike.
5	GE038P	--	--	79.6	242	140	0.568	2.61	I	Biotite quartz monzonite.
6	GE042P	--	--	15.2	25.1	14.5	1.05	2.36	NON	Weathered porphyritic quartz monzonite.
7	GE039P	--	--	0.415	1.90	1.09	0.381	2.51	NON	Weathered biotite quartz monzonite.
8	GE045P	--	--	34.8	207	119	0.292	2.61	I	Biotite quartz monzonite.
9	GE046P	--	--	16.6	280	162	0.102	2.66	I	Porphyritic biotite granodiorite.
10	77LA079	--	--	5.01	287	166	0.00302	2.64	I	Altered porphyritic granodiorite.
11	BG126	275.5	21.0	259	271	156	1.66	2.65	R, I	Biotite granodiorite.
12	BG130	347.4	10.7	153	256	148	1.03	2.61	R, I	Biotite granodiorite.
13	77LA078	--	--	19.6	280	162	0.121	2.66	I	Altered granodiorite.
14	77LA077	--	--	27.3	176	102	0.268	2.61	I	Altered porphyritic quartz monzonite.
15	BG274	--	--	68.0	89.8	51.8	1.31	2.77	C	Andesitic sandstone, Elkhorn Peak.
16	BG097	--	--	1600	559	322	4.97	2.76	R*, I	Breccia.
17	GE013P	--	--	13.3	58.7	33.9	0.392	2.68	NON	Altered pyrite-rich aplite.
18	GE010P	--	--	0.377	1.30	0.750	0.503	2.50	NON	Altered tourmaline-rich plutonic rock.
19	GE011P	--	--	0.199	1.80	1.04	0.191	2.49	NON	Altered aplite.
20	GE012P	--	--	0.459	7.50	4.33	0.106	2.64	NON	Altered plutonic rock.

Table 1.--Magnetization and density data for selected rocks collected from the Elkhorn wilderness study area--Continued

Sample Locality No.	Field No.	REM[1/] D	REM[2/] I	REM[3/] J	[4/] K	IND[5/] J	[6/] Q	[7/] ρ	J-type of Likely Anomaly Source[8/]	Remarks
21	GE009P	--	--	451	269	155	2.91	2.73	R, I	Diorite.
22	GE033P	--	--	44.0	292	168	0.262	2.69	I	Biotite quartz diorite.
23	GE032P	--	--	15.0	72.7	41.9	0.358	2.84	NON	Hornblende-rich basalt.
24	GE024P	--	--	20.1	23.9	13.8	1.46	2.62	NON	Weathered porphyritic volcanic intrusive(?) rock.
25	BG155	--	--	81.3	325	188	0.432	2.69	I	Quartz-dioritic granodiorite.
26	GE031P	--	--	57.4	319	184	0.312	2.78	I	Lithic fragmented tuff.
27	GE029P	--	--	10.1	49.7	28.7	0.352	2.63	NON	Altered sandy volcaniclastic rock.
28	GE025P	--	--	2.10	7.50	4.33	0.485	2.68	NON	Pyrite-rich welded tuff; Ballard Mine.
29	GE027P	--	--	4.66	6.10	3.52	1.32	2.67	NON	Altered silicified pyrite-rich welded tuff.
30	GE018P	--	--	0.369	5.50	3.17	0.116	2.75	NON	Silicified pyrite-rich andesite.
31	GE017P	--	--	0.0689	2.90	1.67	0.0412	2.67	NON	Silicified pyrite-rich volcanic(?) rock.
32	GE016P	--	--	0.320	0.900	0.519	0.616	2.38	NON	Altered pyrite-rich andesite; Cataloma Mine.
33	GE005P	--	--	0.298	1.80	1.04	0.286	2.72	NON	Argillitic.
34	GE003P	--	--	0.180	6.40	3.69	0.0488	2.73	NON	Andesitic dike.
35	GE001P	--	--	27.4	4.20	2.42	11.3	2.77	NON	Andesite.
36	GE002P	--	--	89.2	154	88.8	1.00	2.71	C	Porphyritic-lithic fragmental volcanic (andesite).
37	77LA073	346.2	-23.8	0.318	7.09	4.09	0.0778	2.92	NON	Gabbro.
38	77LA075	18.5	49.6	37.4	324	187	0.200	2.68	NON	Porphyritic quartz monzonite.
39	77LA070	302.3	-40.4	0.233	4.06	2.34	9.96	2.84	NON	Hornfels.
40	BG112	91.1	27.4	490	478	276	1.78	2.72	R, I	Slim Sam stock; granodiorite.

Table 1.--Magnetization and density data for selected rocks collected from the Elkhorn wilderness study area--Continued

Sample Locality No.	Field No.	REM[1/] D	REM[2/] I	REM[3/] J	[4/] K	IND[5/] J	[6/] Q	[7/] ρ	J-type of Likely Anomaly Source[8/]	Remarks
41	BG113	332.1	72.0	49.9	35.8	20.6	2.42	2.70	NON	South Fork stock; granodiorite.
42	77LA069	109.2	-47.3	174	24.0	13.8	12.6	2.77	R	Diabasic flow.
43	BG123	--	--	874	425	245	3.57	2.83	R, I	Porphyritic andesitic flow or crystal tuff.
44	BG120	--	--	334	675	389	0.859	2.84	R, I	Porphyritic augite-rich diorite.
45	BG125	9.3	-5.9	5700	363	209	27.3	2.84	R*, I	Hornblendic plagioclase porphyry.
46	BG118	330.5	56.1	115	513	296	0.388	2.66	R, I	Vosburg stock; quartz monzonite porphyry.
47	BG119	274.3	5.0	113	60.8	35.1	3.22	2.72	R	Hornfelsic welded tuff.
48	BG209	--	--	1000	469	271	3.69	2.89	R*, I	Amygdaloidal augite basalt.
49	BG117	24.8	-57.9	1790	1150	664	2.70	2.79	R*, I	Diabasic intrusive.
50	BG115	240.1	39.7	961	401	231	4.16	2.81	R, I	Orphan Boy intrusive; diorite-gabbro.
51	BG114	344.1	46.6	21.4	453	261	0.0820	2.66	I	Antelope Creek stock; granodiorite.
A	E1-E5	--	--	460	8.30	4.78	96.2	2.85	R	Andesitic tuff; 5 samples measured in 1962.
B	E6-E11	--	--	86	3.10	1.78	48.2	2.84	NON	Andesitic flow; 5 samples measured in 1962.
C	E16-E20	--	--	80	2.40	1.38	57.9	2.72	NON	Andesitic tuff; 5 samples measured in 1962.
D	E21-E25	--	--	50	2.90	1.67	29.9	2.71	NON	Andesitic flow; 5 samples measured in 1962.

Explanation for Table 1

1/ REM D, Declination of remanent magnetization, degrees east of north.

2/ REM I, Inclination of remanent magnetization, degrees below horizontal.

3/ REM J, Magnitude of remanent magnetization, x 10^{-5} emu/cm^3.

4/ K, Intrinsic magnetic susceptibility based upon a sample-shape demagnetization factor of $4\pi/3$, 10^{-5} emu/cm^3.

5/ IND J, Magnitude of induced magnetization, x 10^{-5} emu/cm^3.

6/ Q, Koenigsberger ratio of magnitudes of remanent magnetization to induced magnetization.

7/ ρ, Dry bulk density, g/cm^3.

8/ J-type of Likely Anomaly Source, Type of magnetization which is sufficiently strong (at least 10^{-3} emu/cm^3) to serve as a source for high-amplitude anomalies; R - remanent magnetizations; I - induced magnetization; C - combined remanent and induced magnetization, if similar in direction and sense; NON - relative nonmagnetic. Asterisks denote very strong magnetizations, that is, greater than 10^{-2} emu/cm^3.

samples have induced magnetizations alone exceeding the figure. Of the remainder, 22 samples have magnetizations sufficiently weak to be considered nonmagnetic, most having been altered, silicified, or otherwise mineralized, and are thus candidates for passive sources of negative anomalies where surrounded by normally polarized rocks. It is of interest that directions of remanent magnetization, denoted by values under columns "REM D" and "REM I" for the 14 oriented samples collected, indicate the presence of normal, reversed, and perhaps anomalous paleofield directions. Interpretations of the paleomagnetic significance of these data are limited by uncertainties about the possible overprint of secondary magnetization components acquired after the period of volcanism and plutonism and the structural history of tilting of layered volcanic rocks possessing stable remanent magnetization. For purposes of the present study, unnecessary usage of numerical values of magnetizations will be avoided by using the terms "strong" magnetizations for those from 100 to 1,000 x 10^{-5} emu/cm^3 and "very strong" magnetizations for those exceeding 1,000 x 10^{-5} emu/cm^3.

PRINCIPAL FEATURES OF ANOMALY MAP

The aeromagnetic anomaly map (pl. 2) is characterized by two principal features: (1) steep magnetic gradients that largely coincide with the outcrop of the broadly folded, thick pile of Elkhorn Mountains Volcanics, which in the study area is intruded by a number of small plutons, and (2) gentle magnetic gradients of the magnetic plateau associated with most of the Boulder batholith. Gradients are steep in the vicinity of the volcanic rock pile because total magnetizations of the volcanic and associated intrusive (K_i) rocks are generally strong to very strong and also because much of the volcanic rock terrane occurs at high topographic elevations, not far below the flight elevation at which magnetic field measurements were obtained.[5/] Gradients are gentle over

[5/]The effect of topography is in many places further enhanced by occurrences of very strong isothermal remanent magnetizations introduced by lightning discharges.

most of the Boulder batholith terrane because total magnetizations are generally weak to moderately strong and because lateral contrasts of rock types and corresponding magnetizations are relatively small, the batholith proper having a remarkably uniform composition. A notable exception is the occurrence of steep magnetic gradients which extend westward across the Boulder batholith-Elkhorn Mountains Volcanics contact in the southwestern part of the map area. These gradients appear to coincide with an increase in the Bouguer gravity anomaly field signifying occurrences of relatively dense, highly magnetic rocks in the shallow subsurface of this part of the Boulder batholith. Such rocks might belong to a westward-dipping tract of Elkhorn Mountains Volcanics or to highly mafic plutonic rocks of the Boulder batholith, intruded during an early phase of plutonism.

INTERPRETATION OF AEROMAGNETIC ANOMALIES

Many individual anomalies within the study area are clearly associated with mapped lithologic units; others are only vaguely, if at all, related to exposed rocks. Because the number of magnetic features of possible economic interest is so large, discussion of these features is facilitated by adopting a labelling system keyed to the text. In the following discussion, major anomalies or groups of anomalies are numbered, and parts of anomalies or individual anomalies in the groups are given letter symbols, starting first with high-amplitude anomalies near the contact between the Boulder batholith and Elkhorn Mountains Volcanics, and progressing to terranes of volcanic rocks to the southeast and batholithic rocks to the northwest.

Anomalies 1, 2, and 3

This northeast-trending group of positive anomalies, among the highest amplitude of those in the study area, are associated principally with topographically high exposures of intrusive rocks (K_i) belonging to the Elkhorn Mountains Volcanics. Although magnetization data for these rocks are not available, magnetizations of similar intrusive rocks (sample locality 44, 45, and 49) southeast and northeast of the topographic ridge are among the strongest in the area (table 1). Adding to the effects of the intrusive rocks are strong magnetizations of neighboring volcanic rocks which are also exposed at high elevations. For example, near the crest of anomaly 1, outcrops of amygdaloidal augite basalt (sample location 48) have very strong remanent and strong induced magnetizations; on the southwest flank of anomaly 3, exposures of volcanic breccia (sample location 16) have magnetizations even stronger than the basalt. Although part of the magnetizations of these highly elevated rocks may be attributable to surficial concentrations of strong isothermal remanent magnetization induced by lightning discharges, the observed strong induced magnetizations guarantee that these lithologic units are highly magnetic in the subsurface.

On the northwest flank of anomaly 1, the negative indentation 1A is associated with plutonic rocks exposed in the upper reaches of Jackson Creek, inferred to be a manifestation of relatively nonmagnetic altered subsurface rocks. Northeast of the anomaly, the elongate negative feature 1B appears to be the result of both a polarization low associated with anomaly 1 and a residual low nested between 2 high-amplitude positive anomalies. This negative feature widens over part of the upper drainage of Staubach Creek, indicating that magnetizations of subsurface rocks are weakest here and that possible subsurface alteration may be greatest. On the southeast flank of anomaly 1, the negative indentation 1C appears to reflect a localized zone of relatively nonmagnetic rocks not manifested by topography. In contrast, the positive indentation 1D and negative indentation 1E are clearly associated with topographic relief developed on volcanic rocks, which may or may not also reflect subsurface lithology or structure. Other features which are influenced by topography are saddles 1F and 2A, negative feature 2B, positive noses 3A and 3B, and negative indentation 3C. Features correlating at least partly with topographic expression and partly with extrusive and intrusive rocks of the Elkhorn Mountains Volcanics are positive indentation 3D and negative indentation 3E.

Anomaly 4

This broad high-amplitude positive anomaly, which tapers southwestward to the vicinity of Elkhorn Peak, occurs over a topographically high region of extrusive and intrusive rocks largely hidden by a cover of Quaternary sediments. Of the 5 samples collected from an area beneath the broader part of the anomaly (sample localities 25, 26, 27, 28, and 29), altered or mineralized welded tuffs and volcaniclastic rocks are essentially nonmagnetic whereas granodiorite and lithic tuff are strongly magnetic, containing mainly induced magnetization. Near the tapered part of the anomaly, marked by the positive closure of contour lines near Elkhorn Peak (feature 4A), andesitic sandstone (sample location 15) has a combined remanent and induced magnetization, which if coincident, is sufficiently strong to form an anomaly source. Although numerous lithologic units appear to serve collectively as an overall anomaly source, buried intrusive rocks similar to those correlated with anomalies 1, 2, and 3, may act as the predominant generator. Near Elkhorn Peak, which has an elevation approximately the same as the aeromagnetic flight elevation, a significant effect may be caused by local occurrences of magnetite-rich metamorphic rocks; two deposits in replacement bodies on the south and west slopes of Elkhorn Peak have been exploited for iron as a smelter flux (Knopf, 1913a; Klepper and others, 1957).

To the north of the broad part of the anomaly, features 4B, 4C, and 4D form closures over a region of low magnetic gradients. Of the 11 intrusive and extrusive rocks collected from this region (sample localities 17, 18, 19, 20, 21, 22, 23, 24, 30, 31, and 32), all but two may be considered nonmagnetic, much of the magnetization assumed to be present originally has diminished as a result of mineralization and chemical alteration. The two exceptions are relatively magnetic diorite and biotite quartz diorite (sample locations 21 and 22, respectively) which crop out beneath gradients on flanks of the local closures. The entire region covered by features 4B, 4C, and 4D is inferred to be underlain by relatively nonmagnetic rocks, much of the subsurface probably having been subjected to chemical alteration.

East of feature 4D, a steep north-trending magnetic gradient is interrupted by a negative indentation, feature 4E. This region between and near the margins of the lows has been extensively mined (see sites of the Callahan, Pataloma, Big Tizer Wildcat, and Golden Age Mines). Other features interrupting the steep magnetic gradient, such as 4F, 4G, 4H, and 4I, appear to be appreciably influenced by topography developed on the extrusive and intrusive rocks. Of greater interest, the negative closure 4J is centered near the site of the Little Tizer Wildcat Mine, suggesting the occurrence of altered subsurface rocks. Farther south, the negative closure 4K and the dipole feature 4L, though not associated with previous mining activity, may also mark local terranes of altered subsurface rock. Another association of a negative magnetic feature with mineralized rock occurs near the Elkhorn Skyline Mine marked by the indentation 4M; the dipole feature 4N may reflect another zone of altered volcanic rocks not exposed at the surface. The local high-amplitude negative closure 40, centered near the upper drainages of Black Canyon and Rabbit Gulch, reflects a strong polarization effect associated with topographically high volcanic rocks near Elkhorn Peak, but the anomaly itself is developed over plutonic rocks of the Boulder batholith inferred to be relatively nonmagnetic in this region. North of anomaly 40, the prominent positive indentation 4P is influenced by high topographic relief over rocks of the Boulder batholith.

Anomaly 5

This prominent negative anomaly, developed as a northwest- to west-trending trough near Elkhorn, is associated with an intensively mineralized zone which includes sites of the Heggen, Moreau, East Butte, Hardcash, and Carmody Mines as well as molybdenum-rich rock of Turnley Ridge. Although the previously mined area is almost entirely restricted to the northern flank of this anomaly (a notable exception is the Boulaway Mine site located on the anomaly axis), its westward extension to feature 5A may reflect an almost continuous subsurface zone of alteration across the contact between the Boulder batholith and Elkhorn Mountains Volcanics. The westernmost extremity of the anomaly, feature 5A, also reflects a polarization effect developed north of the high-amplitude positive feature 5B, the high presumably associated with relatively magnetic plutonic rocks of the Boulder batholith. Northeast of the magnetic trough, the southeast-trending positive nose of dipole anomaly 5C and the positive indentation 5D are associated with mafic plutonic rocks which intrude Precambrian and Paleozoic sedimentary rocks. The negative indentation 5E due north of Elkhorn is associated with intense mineralization marked by sites of the Louise, Golden Moss, C and D, and Union Mines as well as numerous unnamed excavations.

Although magnetizations of rock samples were not determined in mineralized areas near Elkhorn, previously obtained data from Elkhorn Mountains Volcanics northeast of feature 5E and south of feature 4N (sample localities A, B, C, and D) provide representative values considered to be normal for this part of the volcanic rock section (Hanna, 1965, 1967). Data from 20 samples indicate the presence of weak to strong remanent magnetizations but only weak induced magnetizations (table 1).

Anomaly 6

Near the northeastern corner of the map area, in approximate alinement with anomalies 1, 2, and 3, a broad high-amplitude positive anomaly occurs over a major exposed tract of the Antelope Creek stock, in a topographically low area drained by Antelope Creek. Although most of the anomaly is associated with granodiorite of the stock, which has an induced magnetization to serve as the anomaly source (sample locality 51), part of the anomaly is undoubtedly generated by diabasic intrusive rocks (sample locality 49) and such mafic rocks as diorite-gabbro of the Orphan Boy intrusive (sample locality 50), both of which have strong remanent and induced magnetizations.)

Northwest of the anomaly, the high-amplitude negative anomaly 6A, only partially included in the detailed survey, appears to be associated with Elkhorn Mountains Volcanics containing mineralized breccia deposits.

Anomaly 7

At the eastern margin of the map area, a very high amplitude positive anomaly is associated with plutonic rocks of the Vosburg stock and surrounding volcanic rocks. Although the eastern half of the anomaly is largely attributable to quartz monzonite porphyry (sample locality 46) of the stock having strong remanent and induced magnetization, it is also partially generated by a mixture of other lithologic units, including metamorphosed welded tuff (sample locality 47) having strong remanent magnetization and hornblendic plagioclase porphyry (sample locality 45) having very strong remanent and strong induced magnetization. The regular form of the anomaly suggests that plutonic rocks of the stock extend in the subsurface west of the mapped contact; however, it appears that rocks of the Elkhorn Mountains Volcanics also contribute to generation of the western half of the anomaly. For example, porphyritic andesite (sample locality 43) and porphyritic augite-rich diorite (sample locality 44) both have strong remanent and induced magnetizations, easily capable of contributing significantly to the feature.

North of the anomaly, the prominent magnetic trough 7A is developed over a tract of volcanic and plutonic rocks covering part of the upper drainage of Beaver Creek; quartz monzonite of the Moose Creek stock is inferred to be relatively nonmagnetic or the body is thin and extends to only shallow depth, in sharp contrast to similar plutonic rocks of the Antelope Creek and Vosburg stocks. Regardless of how much of the anomaly is a polarization effect linked with anomaly 7 and how much is a residual low developed between anomalies 6 and 7, the underlying tract of subsurface rocks is deficient in magnetite.

On the northern flank of anomaly 7, the positive indentations 7B and 7D conform somewhat to topography but may in part represent subsurface lobes of plutonic rock extending from the core of the Vosburg stock. Negative indentations 7C and 7E are residual lows over relatively nonmagnetic rocks adjacent to the positive features. Positive feature 7F at the southwest margin of anomaly 7 is associated with an exposed quartz monzonitic body allied to the Vosburg stock; positive feature 7H southeast is inferred to be associated with a similar, though completely buried, small body of quartz monzonite. Negative indentation 7G south of the anomaly occurs over the trace of a major fault; the feature may in part be caused by gouge and chemical alteration of rocks within the fault zone.

Anomalies 8, 9, and 10

West of anomaly 7, this trio of anomalies is inferred to represent the three expected polarization effects associated with the concave part of a bow-shaped outcrop pattern of Elkhorn Mountains Volcanics, convex to the north (fig. 4), having on the average a normal total magnetization. The low of anomaly 8 is associated mainly with the eastern part of the pattern; the low of anomaly 10, with the western part. The residual positive anomaly 9 results from the combined decrease in amplitude of both negative anomalies with increasing lateral distance from the sides or limbs of the pattern. Thus, these polarization effects cannot be correlated with local occurrences of mapped units; they are caused by the bulk effect of the volcanic rock pile. It may be noted that the local positive-negative interruption 10A of the western gradient of anomaly 10 is not part of the polarization effect; this feature has the characteristic of a very local east-west dipole anomaly that has an unknown source.

Anomaly 11

This very broad low-amplitude negative anomaly is associated mostly with relatively nonmagnetic Mesozoic sedimentary rocks (for example, nonmagnetic shale of sample locality 33) forming part of the core of the major anticline. The negative lobes 11A, 11B, and 11C along the northern flank of the anomaly coincide in large part with drainages of Crow Creek, Longfellow Creek, and Eureka Creek; intervening positive lobes appear to be related to exposures of intrusive rocks (K_i) of the Elkhorn Mountains Volcanics.

Anomaly 12

East of anomaly 11, at the eastern edge of the study area, a partially defined high amplitude positive anomaly appears to be associated with mapped exposures of mafic plutonic rocks and intrusive rocks (K_i) of the volcanic rock pile. One sample of diabasic lava flow (sample location 42) has expectedly strong remanent magnetization, sufficient to serve as an anomaly source. To the north, negative feature 12A appears to be a polarization and residual low developed over rocks of the lower member of the Elkhorn Mountains Volcanics. To the south, negative indentation 12B is associated with a block of highly siliceous welded tuff of the middle member of the Elkhorn Mountains Volcanics; positive indentation 12C is associated with andesitic rocks of the lower member.

Anomalies 13 and 14

Southwest of anomaly 12, the saddle-shaped high 13 is developed over quartz monzonite of the South Fork stock, the saddle interrupting an otherwise continuous magnetic trough at anomalies 11 and 14 that are associated with relatively nonmagnetic sedimentary rocks in the core of the major anticline. It is of considerable interest that, unlike most stocks which intrude the volcanic and sedimentary rocks within the study area, the South Fork stock has a very low-amplitude magnetic signature. Such a low-amplitude feature could reflect either a thin sheet of strongly magnetic plutonic rock coinciding with the topographic expression or a pluglike intrusive body consisting of weakly magnetic plutonic rock. A clue to the correct interpretation is provided by granodiorite (sample locality 41) from the stock; the remanent magnetization is weak and the induced magnetization is very weak. Thus, it is likely that this stock has a subsurface extent similar to those of other stocks in the study area; however, for an unknown reason, the rock is deficient in magnetite.

Anomaly 15

South and west of anomalies 13 and 14, anomaly 15 is a high-amplitude positive anomaly, partially within the surveyed area that occurs over the Slim Sam stock and neighboring Paleozoic sedimentary rocks. Granodiorite from the Slim Sam stock (sample locality 40) exhibits strong remanent and induced magnetization, in sharp contrast with granodiorite from the South Fork stock, only 1.6 km to the northeast. The anomaly suggests that granodiorite of the Slim Sam stock extends in the subsurface as much as 1.6 km northwest of the mapped contact beneath a thin veneer of sedimentary rocks. The anomaly abruptly terminates in a magnetically featureless region 15A, marked by the Bonanza Mine. The dipole feature 15B to the west, developed in a polarity sense reversed to others in the study area, has an unknown source.

Anomaly 16

Northwest of anomaly 15, a broad positive nose is associated with quartz monzonite of a small exposure of plutonic rock inferred to have a total magnetization, more similar to that of the Slim Sam stock than the nearby South Fork stock. The regular form of the anomaly suggests that the intrusive body may be nearly as large as the Slim Sam or South Fork stocks at depth, of possible significance to a geochemical anomaly observed in stream sediments from Jenkins Gulch. Hornfels (sample locality 39) which occurs at the intrusive rock contact, as well as andesite, gabbro, and quartz monzonite exposed farther to the north (sample localities 34, 35, 36, 37, and 38), are relatively nonmagnetic except for a fragmental volcanic rock (sample locality 36) which may have a combined remanent and induced magnetization sufficiently strong to serve as an anomaly source. The negative indentations 16A and 16B represent polarization and residual lows adjacent to the positive anomaly.

Anomaly 17

At the northwest corner of the study area, in the Boulder batholith, a broad low-amplitude positive anomaly is developed over Strawberry Butte, Shingle Butte, and lower terrain extending eastward to McClellan Creek. The closure at Strawberry Butte and the prominent nose at Shingle Butte reflect topographically high exposures of rhyolite flows, also reflected by the broad positive nose 17A on Burnt Mountain, south of Strawberry Butte. Remanent magnetization of the rhyolite (sample locality 1) is stronger than all but six of the volcanic and plutonic rocks sampled in the study area, a remarkable property considering its highly silicic composition.

Southeast of Strawberry Butte the positive nose 17B appears to be associated with topographically high exposures of porphyritic quartz monzonite. South of this feature, the negative closure 17C bears no relation to mapped geology and therefore may represent a low-amplitude residual anomaly. Biotite quartz monzonite (sample locality 2) from a region northeast of Burnt Mountain has strong remanent and induced magnetization assumed to be typical of much of the unaltered Boulder batholith and presumably accounts for feature 17A.

Anomaly 18

East of anomaly 17 and northwest of anomaly 1, a broad high-amplitude negative anomaly extends over the contact between the Boulder batholith and Elkhorn Mountains Volcanics and is considered to be associated with a large tract of altered subsurface rocks covering much of the drainage of Jackson Creek. The elongate positive nose 18A to the north may be caused by a combination of unaltered plutonic rocks of the Boulder batholith and intrusive rocks (K_i) of the Elkhorn Mountains Volcanics which crop out along the northwest gradient of the anomaly, 1.6 km southeast of Little Butte.

Anomaly 19

Southwest of anomaly 18, a northwest-trending low-amplitude magnetic trench forming closures at 19 and 19A is developed over the drainage area of the Middle Fork Warm Springs Creek. Surprisingly, the rhyolitic rocks of Lava Mountain produce no conspicuous anomaly, such as those associated with rhyolites of Strawberry Butte, Shingle Butte, and Burnt Mountain to the north. One explanation is that the rhyolites are very thin at Lava Mountain, another is that they have been altered. Also surprising is that a number of plutonic rocks collected along Warm Springs Creek and Middle Fork Warm Springs Creek (sample localities 5, 8, and 9) have strong induced magnetizations, ordinarily sufficiently strong to produce a positive anomaly; others (sample localities 3, 4, 5, and 7) which are highly silicic or intensively altered, are essentially nonmagnetic, as expected. Weathered porphyritic granodiorite (sample locality 10) from an area beneath the weak gradient separating 19C and 19D also possesses strong induced magnetization and is assumed to contribute to the anomaly source of the positive nose, which is also strongly influenced by topography. Despite the presence of some stongly magnetic plutonic rocks in the area underlying the magnetic trench, most rocks in the subsurface are inferred to be relatively nonmagnetic, perhaps as a result of extensive alteration. The broad positive noses 19B and 19E appear to be residual effects; thus the region most magnetite-deficient widens to include part of the drainage of the South Fork Warm Springs Creek at the southern margin of anomaly 19 and to include the confluence of the North, Middle, and South Forks at anomaly 19A. The region circumscribed by anomaly 19 includes the sites of numerous inactive mines, and it contains a geochemical anomaly based on stream-sediment samples.

Anomaly 20

Southwest of anomaly 19, a highly conspicuous positive-negative magnetic doublet occurs in complete isolation over a heavily wooded tract of plutonic rocks 4 km east-southeast of Jefferson City. Despite an intensive field search to find evidence of the source of this intriguing magnetic feature, the source remains unknown. Biotite granodiorite from sparse outcrops at the center of the negative spike and at the southern margin of the positive spike (sample locations 11 and 12) have strong remanent and induced magnetizations, providing no clue as to the disturbing source, which would have to be orders of magnitude more highly magnetic than these rocks. Close inspection of the aeromagnetic map shows that flight lines fail to cross either set of steep magnetic gradients defining the spikes; it is concluded that further surveying and reexamination of the anomaly map compilation are needed to confirm confidently the existence of this feature.[6/]

[6/]Recent communications with Aerial Surveys, Salt Lake City, Utah, have resulted in a reexamination of this feature by the company. The company acknowledges that this anomaly is an artifact.

Anomaly 21

East of anomaly 20, conspicuous positive noses 21 and 21A, separated by the negative indentation 21B, are significantly influenced by topography developed on granodiorite of the Boulder batholith, presumed to have strong magnetizations similar to the unaltered rock from sample location 2 to the north.

Anomaly 22

Southwest of anomaly 20, a prominent magnetic trough extending from 22 to 22A is developed over the drainages of Prickly Pear and Golconda

Creeks. Although the negative nose and closure of 22A appears to result from effects of high topography to the north and south, most of the elongate feature marks a zone of relatively nonmagnetic subsurface rocks, perhaps hydrothermally altered. The highest amplitude portion of the negative anomaly overlaps a geochemical anomaly based on stream-sediment samples and covers a region having economic interest for porphyry-copper deposits.

Anomaly 23

Southeast of anomaly 22, the east-west trending magnetic ridge 23 as well as positive noses 23A and 23B are associated with highly elevated plutonic rocks, conforming closely to topographic configuration. Indentation 23C, which follows the steep upper drainage of Muskrat Creek, is a negative expression of this same topographic relief.

Anomaly 24

Southwest of anomaly 23, the high-amplitude broad positive nose 24 extending southwestward to the positive closure 24A is developed over altered plutonic rocks not conformable with topography. Altered porphyritic quartz monzonite from an outcrop underlying anomaly 24 (sample locality 14) and altered granodiorite from an outcrop underlying feature 24A (sample locality 13) have induced magnetizations sufficiently strong to serve as anomaly sources. Negative indentations 24B, 24C, 24D, 24E, and 24F are all developed over relatively nonmagnetic rocks, a number of them associated with mineralization and alteration. Feature 24D, alined with the principal drainage of Muskrat Creek, overlaps a geochemical anomaly based on stream sediment samples. Features 24E and 24F, following part of the drainage of Rawhide Creek, may also reflect zones of subsurface mineralization.

RELATIONSHIP OF ANOMALIES TO MINERAL DEPOSITS

General

Because mineral deposits in the study area occur as veins, replacement deposits, stockworks, breccia pipe fillings, and skarns in geologic environments which are highly diverse, the relationships of aeromagnetic anomalies to these deposits may be expected to be equally diverse. In spite of this diversity, however, it is possible at the scale of the present investigation to make a select number of general observations about the relationship of anomalies to deposits which might be profitably used in future mineral exploration.

A first observation is that almost all previously discovered economic mineral deposits in the area are essentially nonmagnetic; the only notable exceptions are magnetite-rich skarn deposits in replacement bodies near Elkhorn Peak, magnetite-rich placers too localized to be reflected in the present survey, and titaniferous magnetite lenses in

Cretaceous sedimentary rocks southeast of the area. Thus, where most of the nonmagnetic deposits reside in relatively nonmagnetic terrane, such as in sedimentary rocks near the southern margin of the area, little if any magnetic expression is expected; where they occur in sufficiently large quantities in relatively magnetic, normally polarized terranes of Elkhorn Mountains Volcanics and Boulder batholith, negative anomalies can be expected.

A second observation is that, where mineral deposits themselves are too small to be detected by their magnetic signature, host rocks containing the deposits may be detected. For example, this indirect expression of deposits may take the form of a positive anomaly associated with a shallowly buried pluton hosting deposits which may extend into overlying roof rocks or a negative anomaly associated with either subsurface zones of intense alteration or intrusions of highly silicic rocks containing the deposits.

Relations between anomalies and mines

Many established mines and major prospecting excavations are associated with negative magnetic anomalies, a relationship previously noted (Hanna, 1969) on a more regional scale over the Boulder batholith. A smaller number of such areas are associated with positive anomalies, notably terranes of Elkhorn Mountains Volcanics and older sedimentary rocks which have been intruded by bodies of plutonic rock. For example, in the western part of the area, negative anomalies are associated at least in part with mines and excavations north of anomaly 23A, at 19, surrounding 5E, southeast of 5, north of 4A, at 4M, at 4J, and northwest of 4E. In the eastern part of the area, positive anomalies are associated with established mines and workings east of anomaly 6, surrounding 7, north and south of 7H, north of 12, and west of 15. Near the central part of the area, magnetic gradients forming the flanks of anomalies are associated with mines southeast of 3D and north of 4A. Thus, within the Boulder batholith and Elkhorn Mountains Volcanics near the batholith contact, negative anomalies tend to correlate with mining activity; within the Elkhorn Mountains Volcanics and intruded plutons far from the contact, positive anomalies tend to be associated with mining activity.

Magnetic anomalies and strong geochemical anomalies

Of the regions within the study area characterized by strong geochemical anomalies based on pan concentrate samples (pl. 4), most are associated with the magnetic gradients forming the flanks of positive and negative anomalies rather than with the central parts of anomalies. Regions high in gold, silver, arsenic, lead, and copper, characteristic of hydrothermal vein-type mineralization in the eastern part of the area, are associated with gradients forming the saddle on the magnetic ridge connecting 4 and 4A; the high-low-high triplet of 7, 12A, and 12; the high-low-high triplet of 1, 1B, and 6; the southeastern margin of anomaly 9; and the eastern margin of anomaly 4F. Regions high in molybdenum, tungsten, niobium, thorium, lanthanum, and yttrium, characteristic of molybdenite mineralization in the Boulder batholith, are associated with the northern flank of the magnetic trough connecting 19 and 19A; the northwestern flank of anomaly 3; the western flanks of anomalies 21 and 21B; the northern flank of anomaly 2; the southwestern flank of anomaly 4A; and the northwestern margin of anomaly 24D.

Of paramount importance in relating magnetic anomalies to geochemical anomalies is recognizing that geochemical anomalies are potential indicators of mineralization on or close to the ground surface and that magnetic anomalies are potential indicators of mineralization at depth. On the basis of observed magnetic patterns in areas delineated by intense geochemical anomalies, there is an indication that surficial mineralization is most strongly manifested in regions underlain by lateral contrasts of magnetization, a number of these contrasts possibly reflecting subsurface hydrothermal alteration. Because many of the geochemical anomalies cover regions having gradients connected with one or more positive anomalies over relatively high terrain, much surficial mineralization may be inferred to be derived from the upper flanks of these combined topographic and magnetic highs.

AEROMAGNETIC ANOMALIES POSSIBLY RELATED TO MINERALIZED ROCK

More than 50 aeromagnetic anomalies (table 2, fig. 6) within the study area may be related to mineralized rock. Negative magnetic anomalies, even if only low-amplitude negative indentations of magnetic gradients, serve as reliable guides to subsurface alteration and associated mineralization in the terrane of Boulder batholith and on both sides of the Boulder batholith-Elkhorn Mountains Volcanics contact. One example of such a negative feature in the Boulder batholith is anomaly 22 (pl. 2); examples near the contact are negative closures 4J and 4K. Positive anomalies associated with small plutonic rock bodies in the terrane of Elkhorn Mountains Volcanics serve as guides to possible subsurface mineralization within or at the margins of these bodies at depth. Examples of such features are positive noses 7F and 7H and the northwestern part of high-amplitude positive anomaly 15. These magnetic features and the many others previously discussed invite in the future a broad spectrum of geophysical, geochemical, and geologic prospecting for full discovery of subsurface mineral deposits.

Table 2.--Examples of aeromagnetic anomaly features delineating terranes which merit further geologic, geochemical, and geophysical exploration

Negative Features					Positive Features	
1A	4C	4N	19	24E	7	15B
1B	4D	40	19A	24F	7B	16
1C	4E	5	19C		7D	
1E	4G	5A	21B		7F	
1F	4I	5E	22		7H	
2A	4J	7E	22A		12	
2B	4K	15A	23C		12C	
3C	4L	17C	24C		13	
3E	4M	18	24D		15	
Saddle between 4 and 4A						

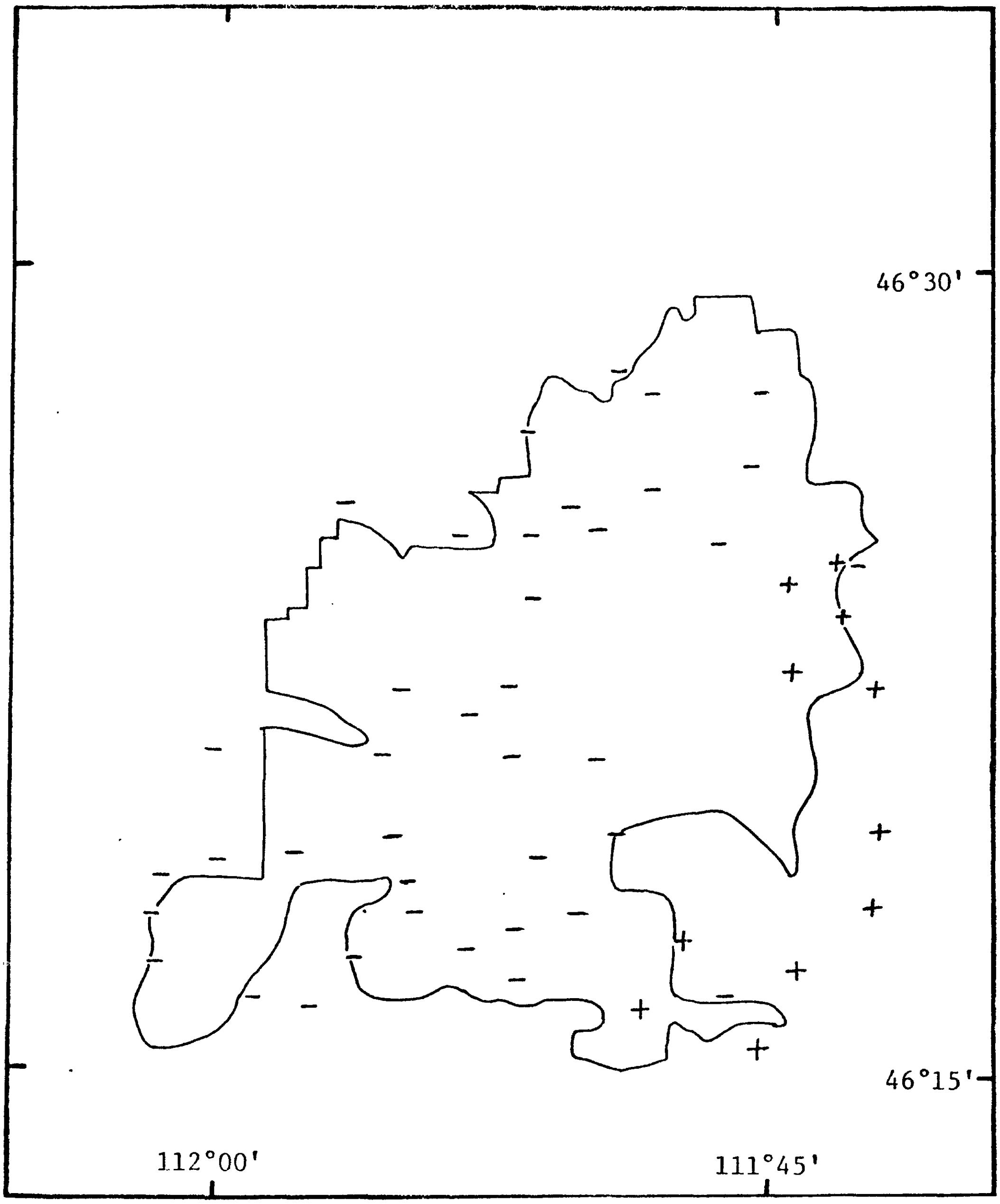

Figure 6. Aeromagnetic anomalies in and near the Elkhorn wilderness **study** area, economic significance; +, positive features; -, negative **features**. Anomaly features are listed in table 2, keyed to plate 2.

GEOCHEMICAL EXPLORATION

by

William R. Miller, Steve Ludington, and William R. Greenwood

Geochemical studies were made in the Elkhorn wilderness study area, Montana, during November 1976 and the summer of 1977 to help evaluate the mineral resource potential of the area. A geochemical orientation survey was conducted during November 1976 to determine the optimal sampling medium and spacing. The results indicated that the nonmagnetic heavy-mineral fraction of panned concentrates from stream sediments was the most useful sample medium for delineating areas of anomalous metal concentrations. In addition, the sampling of small, unbranched (first-order) streams provided the most efficient sampling density.

During the field work in 1977, rock, soil, and stream-sediment samples were collected in addition to panned concentrates. All samples were analyzed by semiquantitative emission spectrometry for thirty elements and by atomic absorption for gold, zinc, and arsenic on selected samples. Sample localities are shown on plate 3. The results of the analyses of all samples have been published by Motooka and others (1978).

Approximately 187 panned concentrates were collected, predominantly from small, unbranched streams above the confluence with major drainages. The samples were collected in active channels in the streams and panned at the sites. Approximately 10 percent of the samples were replicated. Sample density averaged approximately one sample per 1.5 km^2. The material sampled usually ranged from silt to sand and represents material that has been introduced to the stream bed from bedrock and colluvium within the drainage basin. In this area, the use of heavy mineral concentrates is particularly useful for detecting molybdenum, tin, and tungsten.

After panning, the sample was dried and sieved through a minus-18-mesh sieve. Magnetite and other highly magnetic minerals were removed using a hand magnet. The sample was then separated into two fractions using bromoform (specific gravity, 2.86). The light-mineral fraction was discarded, and the heavy-mineral fraction was passed through a Frantz Isodynamic Magnetic Separator[1/] with the current set at 0.2 amperes and the forward and side tilt settings at 15°. The magnetic fraction was discarded, and the nonmagnetic fraction was further separated at 0.6 amperes into a nonmagnetic and magnetic fraction. Each fraction was examined optically, and the mineralogy determined. The nonmagnetic fraction generally contained minerals such as zircon,

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[1/]Use of brand or manufacturers' names in this report is for illustration only and does not constitute endorsement by the U.S. Geological Survey.

monazite, apatite, sphene, and ore minerals such as sulfides and oxides. Scheelite was identified from several samples using an ultraviolet light. Both fractions were then pulverized to pass a minus-150-mesh sieve and analyzed for thirty elements by a semiquantitative spectroscopic method (Grimes and Marranzino, 1968). Based on the analysis of the replicate samples, reproducibility is usually within one reporting interval.

Because of higher background and contrast of trace element concentration, the data on the nonmagnetic fraction was used for the geochemical interpretation.

Statistical analysis of the geochemical data using the STATPAC statistical evaluation library indicates that groups of interrelated elements are present. The correlation coefficients (table 3) form the basis for delineating two groups, called here Group I and Group II. Histograms for elements of possible economic interest are shown on plate 4, one set representing streams draining the Boulder batholith, and another set representing all other streams. The histograms illustrate the geochemical differences between the two major rock terranes, and it is evident that rock type influences the background and threshold of some elements. Nevertheless, the differences are not large, and no distinction was made in the treatment of data from the two terranes.

The two groups of interrelated elements are considered separately because they seem to be related to different types, perhaps different periods, of mineralization. A normalized sum was computed for each group, because an element with large values, like arsenic, could dominate a simple summation. The normalizing process involved dividing the analytical value for an element by the threshold value of that element. Thus,

$$\text{Normalized sum} = \frac{\text{Element 1}}{\text{Threshold of element 1}} + \frac{\text{Element 2}}{\text{Threshold of element 2}} + \ldots + \frac{\text{Element n}}{\text{Threshold of element n}}$$

The threshold values were selected subjectively and are shown on plate 4. The normalized sums for each of the two groups were calculated for each sample and the results plotted on plate 4.

Group I consists of gold, silver, arsenic, copper, and lead. The normalized sum is interpreted as representing hydrothermal-vein-type mineralization. This factor delineates a major known mining district in the eastern area (A-1, see pl. 4). A slight anomaly is outlined near Lava Mountain (A-2), an area also containing several known mines. In area A-3, a sulfide-bearing vein was observed within a cirque. Other anomalies such as areas A-4 and A-5 probably represent small veins, in many cases associated with intrusives.

Group I

Correlation coefficients

Number of paired samples

	Ag	Au	As	Pb	Cu
Ag		.90	.58	.52	.70
Au	4		.74	.75	.73
As	22	3		.52	.53
Pb	32	5	42		.52
Cu	35	4	36	93	

Group II

Correlation coefficients

Number of paired samples

	La	Mo	Nb	W	Y	Th
La		.49	.68	.09	.84	.29
Mo	128		.48	.64	.56	.45
Nb	143	121		.19	.76	.06
W	74	72	69		.27	.54
Y	167	134	144	77		.65
Th	62	61	62	38	61	

Table 3. Correlation analysis of two groups of elements. Non-significant correlation at the 5 percent confidence level is indicated by circles.

Group II consists of lanthanum, molybdenum, tungsten, niobium, yttrium, and thorium. Because of the element suite, associated elements such as tin, and the greater contrast of molybdenum relative to copper, the normalized sum is interpreted as representing disseminated molybdenum mineralization. The largest anomalies appear within the Boulder batholith (B-1, pl. 4). This area appears to have a good potential for porphyry-type deposits of molybdenum. Another anomaly occurs in the eastern area (B-2, pl. 4) near the Vosburg mine. Small amounts of molybdenite have been reported from the mine (Klepper, Ruppel, and others, 1971).

A third type of mineralization appears to be present within the study area and is represented by boron. Boron is anomalous along the contact of the volcanic rocks with rocks of the Boulder batholith (pl. 4). In this area, tourmaline and sometimes pyrite are present, but there is a scarcity of economic minerals.

The most significant anomalies occur within the Boulder batholith (B-1, pl. 4) and are interpreted as reflecting disseminated molybdenite. This area is considered to have good potential for molybdenum porphyry-type deposits. Anomalies in the eastern area represented by Group I delineated a known mining district (A-1, pl. 4) and several other anomalies (A-3 and A-4, pl. 4). Group I probably represents hydrothermal vein type mineralization.

GEOLOGICAL AND GEOCHEMICAL EVALUATION

by

Steve Ludington and William R. Greenwood

INTRODUCTION

Known mineral deposits of possible current economic interest and anomalous areas suggested by the geochemical and geophysical surveys were further studied by geological reconnaissance, outcrop and soil sampling, and detailed geologic mapping of selected areas. Areas showing evidence for the existence of breccia-pipe deposits and porphyry deposits received the greatest attention in the field and will be described first. Other areas will be discussed as anomalous areas in the Boulder batholith and anomalous areas associated with satellitic intrusions. The base- and precious-metal vein deposits and replacement deposits of the area have been described in previous reports. The mine workings that expose these deposits generally were inaccessible during this study and hence the deposits were not re-examined except for the White Pine vein (pl. 2) which was being mined during 1977.

MINERAL DEPOSITS IN AND NEAR THE STUDY AREA

The major metal mines in the vicinity of the study area are concentrated in three zones (fig. 7). No mine in the study area has a recorded value of production of $300,000, although several such major mines are located immediately adjacent to its borders. Data from mines in these three zones--the east flank zone, the Elkhorn-Tizer Basin zone, and the Jefferson City zone--are summarized here to provide a background for the later discussion of geophysical, geochemical, and geologic evidence of the mineral potential of the study area. The total recorded value of metals produced from mines in these zones is about $109 million (Klepper and others, 1957; Klepper, Ruppel, and others, 1971; Smedes, 1966; Becraft and others, 1963).

East flank zone

Mines along the east flank of the Elkhorn Mountains constitute what is here called the east flank zone; they have produced metal ores worth about $17 million since 1866 (Klepper, Ruppel, and others, 1971, p. 34-35). All data on east flank mines cited in this report are from the 1971 report by Klepper, Ruppel, and others, which indicated that gold, mined chiefly in the Radersburg, Park, Hassel, and Winston (Beaver Creek) districts, accounted for about 75 percent of this $17 million total value. The remaining 25 percent represents mainly silver and subordinate lead, zinc, and copper that were produced from these districts and from the Quartzite Ridge district.

Gold and silver occur principally in pyritiferous veins within or close to several granitoid stocks that intrude the axial zone of a major

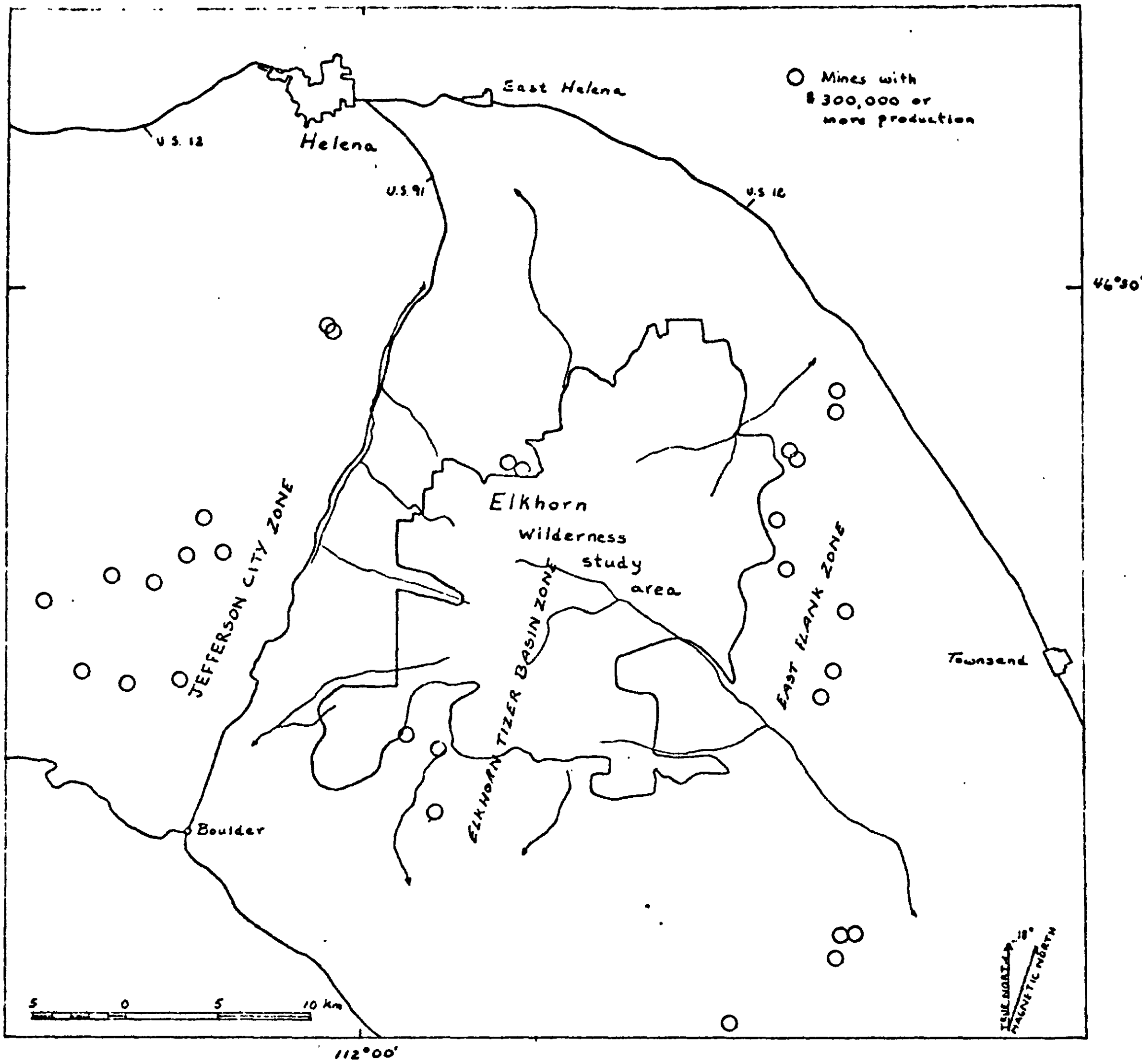


Figure 7. Location of major mines (open circles) near the Elkhorn wilderness study area.

north-trending syncline. A small amount of gold occurs locally in calc-silicate skarns adjacent to a few stocks. Gold also occurs in placers south and west of Radersburg, along Indian Creek, and along Weasel and Beaver Creeks. Silver occurs in base-metal replacements of carbonate rocks, as well as in the gold-bearing vein deposits.

Titaniferous magnetite has been mined near Radersburg from some lenticular beds in the middle of the Slim Sam Formation that probably are lithified beach concentrations. These deposits have been mined for use in making a special type of cement.

Pyritiferous veins.--Three types of precious metal-bearing pyritiferous veins are in the east flank zone: (1) early quartz-rich veins, (2) later quartz-rich veins, and (3) quartz-poor veins.

(1) Early quartz-rich veins are found north of Indian Creek associated with porphyritic felsic stocks. They dip shallowly and consist of pyrite, gold, and little molybdenite and chalcopyrite, and, locally, sparse arsenopyrite, galena, and sphalerite.

(2) Late quartz-rich veins are also found north of Indian Creek associated with porphyritic felsic stocks. They dip steeply and consist of pyrite, gold, silver, and various combinations of galena, sphalerite, arsenopyrite, chalcopyrite, and tetrahedrite. These vein minerals have replaced sheared and hydrothermally altered wall rocks; they are commonly brecciated. Most late veins trend north or east, and, in several places, cut early veins.

(3) Quartz-poor veins are south of Indian Creek where they are associated with nonporphyritic stocks of intermediate composition. They contain auriferous pyrite, sparse marcasite, very sparse chalcopyrite, and traces of pyrrhotite, galena, sphalerite, and chalcocite. Near Radersburg, veins of this type are clustered in highly altered and pyritized rock over an area of about 2.5 square kilometers. Auriferous veins south of Indian Creek dip steeply and most trend close to north or east.

Silver-lead-zinc replacement deposits.--In the Quartzite Ridge district silver-lead-zinc replacement deposits form pipes and lenses along east-trending faults in carbonate rocks. The deposits are in thin dolomite beds between quartzite beds of the Quadrant Formation, and a few are in the Mission Canyon Limestone. The ore is oxidized and consists of cerussite, pyromorphite, limonite, quartz, calcite, galena, and manganese oxides; locally it also contains smithsonite, wulfenite, sphalerite, pyrite hemimorphite, barite, cerargyrite, or fluorite.

Elkhorn-Tizer Basin zone

Mines in the Elkhorn district and to the north in the vicinity of Tizer Basin, here called the Elkhorn-Tizer Basin zone, have produced metal with a value of about $16,200,000 since 1875 (Klepper and others, 1957, p. 67-73). Of this total, silver and gold accounted for about 75 percent and 12 percent respectively. Data on mines in the Elkhorn-Tizer Basin zone cited in this report are from Klepper and others (1957) except as indicated.

Elkhorn district.--Mines in the Elkhorn district accounted for about 98 percent of the metal produced in the zone. These mines principally explored replacement deposits in Paleozoic carbonate rocks. The deposits consist of argentiferous galena associated with a small amount of auriferous pyrite and sphalerite. Chalcopyrite, tetrahedrite, bournonite, and argentite in a quartz gangue also occur in some deposits. Much of the ore occurs as tabular siliceous bodies in the uppermost bed or beds of the Pilgrim Dolomite and as pods and irregular bodies of non-siliceous ore in lower beds of the Pilgrim. Ore also occurs as tabular bodies in the Mission Canyon Limestone, Lodgepole Limestone, and Meagher Limestone. Most of these deposits formed along the crest or flanks of minor anticlines and beneath a hanging wall of silicified shale or argillite such as that of the Red Lion Formation. Some deposits occur along steeply dipping shears that cut across bedding in the carbonate rocks.

Several pipelike breccia deposits in the district have been explored. The deposits consist of clasts of volcanic rocks, sedimentary rocks, or locally granodiorite porphyry cemented or replaced by quartz, black tourmaline, galena, pyrite, sphalerite, and sparse arsenopyrite. Gold, silver, lead, and zinc have been produced from two of these breccia deposits.

Tizer Basin.--About $220,000 worth of metal production has been reported from gold-bearing veins that occur at several places on the margin of Tizer Basin and at a few places in the basin where bedrock is exposed through the glacial deposits. The veins consist of vuggy quartz, sparse pyrite, galena, sphalerite, chalcopyrite, rare flecks of native gold, and possibly tetrahedrite. Gold-bearing veins in the basin strike east-northeast to northeast and dip moderately to steeply southeast. These veins cut tuffs and other volcanic rocks. A pipelike breccia deposit cemented by pyrite and tourmaline has been discovered adjacent to the basin but has not been mined.

Small nonmechanized placer operations have been conducted at several places along Wilson and Crow Creeks. Small amounts of placer gold also are reported in Little Tizer Creek, just below Tizer Lake.

Jefferson City zone

The Jefferson City zone is comprised of mines developed in a large swarm of metalliferous quartz veins and chalcedony veins that trends northeast through the Jefferson City quadrangle (Becraft and others, 1963) and then east through the northern Elkhorn Mountains (Smedes, 1966). The zone includes all the mines in these quadrangles except for the Rimini district 17 km to the west of the study area. The mine data cited here come from these reports.

Base- and precious-metal-bearing quartz veins.--Most of the mines in the Jefferson City zone were developed on base- and precious -metal-bearing quartz veins that follow steeply dipping, east-trending shears. Recorded metal production from these quartz veins is about $67 million, chiefly from silver and to a lesser extent lead. The veins are quartz-rich, contain abundant pyrite, and locally contain galena, sphalerite, arsenopyrite, and chalcopyrite. Wall rocks along the veins show intense argillic and sericitic alteration and the veins are not conspicuously exposed. These veins are reported to be older than the Lowland Creek Volcanics (Eocene) in the Jefferson City quadrangle (Becraft and others, 1963, p. 49-50). However, there are at least two ages of quartz veins, because pyrite-bearing quartz veins are associated with volcano-tectonic breccia in the Lowland Creek Volcanics west of Alta Mountain (Becraft and others, 1963, p. 51-52).

Chalcedony veins.--Reeflike outcrops of chalcedony and microcrystalline quartz veins trend northeast through most of the Jefferson City quadrangle. These veins generally trend east in the northern Elkhorn Mountains. Some chalcedony veins follow and cut the east-trending metalliferous quartz veins. The reeflike outcrops consist of many close-spaced thin layers and stringers of chalcedony in silicified and argillically-altered batholithic rocks and Elkhorn Mountains Volcanics. The veins locally contain pyrite and barite and sparse amounts of galena, sphalerite, arsenopyrite, ruby silver, argentite, molybdenite, chalcopyrite, and cinnabar. Small uranium deposits occur in some chalcedony veins and consist of primary uraninite and the secondary uranium minerals meta-autunite, metatorbernite, phosphuranylite, uranocircite, vaglite, and rutherfordine (Wright and others, 1957). Some veins consist of a mixture of coarse quartz and chalcedony. In these veins sulfide minerals generally are associated with coarse quartz. Pitchblende associated with microcrystalline quartz locally cuts early coarse quartz and sulfide minerals in these composite veins. In the northern Elkhorn Mountains, chalcedony cements brecciated silver-bearing quartz veins and locally chalcedony veins cut Eocene quartz latite dikes (Smedes, 1966, p. 106).

The main economic interest in the chalcedony arises from the broad uranium anomaly that occurs within the northeast- and east-trending chalcedony vein swarm (Becraft and others, 1963; Roberts and Cude, 1953a,b; Smedes, 1966). The greatest radioactivity reported is at and near the W. Wilson Claims (pl. 3) on the west side of Prickly Pear Creek just south of the mouth of Warm Springs Creek. The chalcedony reef at the W. Wilson trends northeast and dips steeply. Silica impregnations and lenticular shear fillings contain ore as rich as 9.58 percent uranium in this deposit. Uranium ore was mined at the W. Wilson sporadically from 1951 to 1956 (Smedes, 1966).

Lead and zinc in brecciated Lowland Creek Volcanics.--Brecciated Lowland Creek Volcanics in the Wickes district, about 8 kilometers west of the study area, contain highly anomalous amounts of lead and zinc over an area larger than 730 meters by 365 meters (Becraft and others, 1963). Samples from exploratory workings in these rocks contain disseminated pyrite in the breccia clasts and coarsely crystalline quartz, microcrystalline quartz, sphalerite, galena, and possibly ruby silver in the matrix. A pipelike body of mineralized breccia on the north side of the Boulder River in sec. 15, T. 6 N., R. 5 W. has been explored by the Obelisk Mine. The breccia consists of abundant large clasts of quartz monzonite and subordinate clasts of alaskite and carbonate veins in a sand-size matrix. This material is cemented by calcite and locally by sphalerite, galena, quartz, and sparse pyrite and chalcopyrite forming steeply plunging pipe-like ore bodies as much as 9 meters by 12 meters across. Siderite and elsewhere rhodochrosite occur in a few veinlets and vugs in and near the breccia.

Silver, lead, and zinc in rhyolite.--Small silver-lead-zinc deposits consisting of veinlet stockworks, lithophysal fillings, disseminations and local replacements occur in rhyolitic tuff, breccia, and rhyolite at Lava Mountain (Smedes, 1966, p. 107-108). These deposits have been explored by several adits, and dump samples indicate that the ore consisted of galena, sphalerite, fluorite, topaz, and quartz. Water draining one of the adits was anomalously radioactive (Smedes, 1966, p. 108).

Placer gold deposits.--Placer gold deposits in the Jefferson City zone are along Mitchell Gulch, Lump Gulch and Prickly Pear, Spring, Clancy, Buffalo, Banner, Cataract, Overland, Big Limber, High Ore, Homestake, McClellan, East Fork of McClellan, Jackson, and Warm Springs Creeks. Extensive placer operations have been conducted along Prickly Pear and Clancy Creeks and to a lesser extent along the upper part of Mitchell Gulch.

PORPHYRY DEPOSITS

At present, no porphyry-copper deposits or porphyry-molybdenum deposits are being mined in the study area. Nevertheless, such deposits are of primary interest in this mineral survey because of their potentially great value. Three porphyry deposits are described below. The probability is high that other such deposits exist at depth in the western part of the area, where the bedrock is Butte Quartz Monzonite.

Golconda area

The Golconda area (fig. 8) is a porphyry copper-molybdenum deposit located astride the study area boundary (fig. 1) south of Prickly Pear Creek. It is significant not only for the value of any ore it may contain but also because it shows that the northern part of the Boulder batholith is favorable for the occurrence of this very important type of

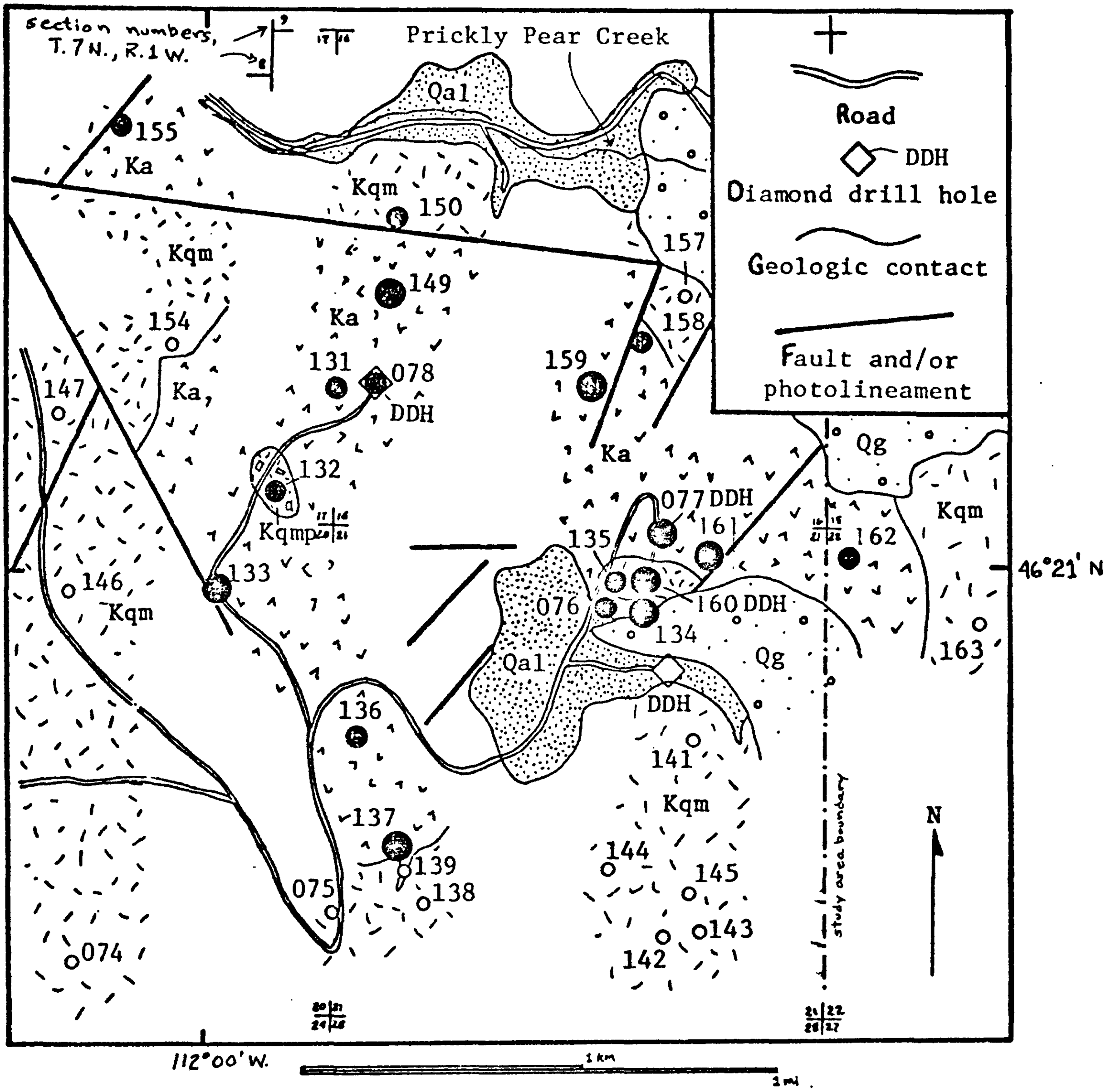


Figure 8. Golconda area, showing roads, diamond drill holes, rock sample localities, geology, and alteration. All sample numbers are prefixed by 77SL, deleted here for brevity.

Qal	Quaternary alluvium
Qg	Quaternary glacial deposits
Ka	Cretaceous aplite
Kqmp	Cretaceous quartz monzonite porphyry
Kqm	Cretaceous quartz monzonite

146 rock sample, unaltered

135 moderate phyllic alteration

159 strong phyllic alteration

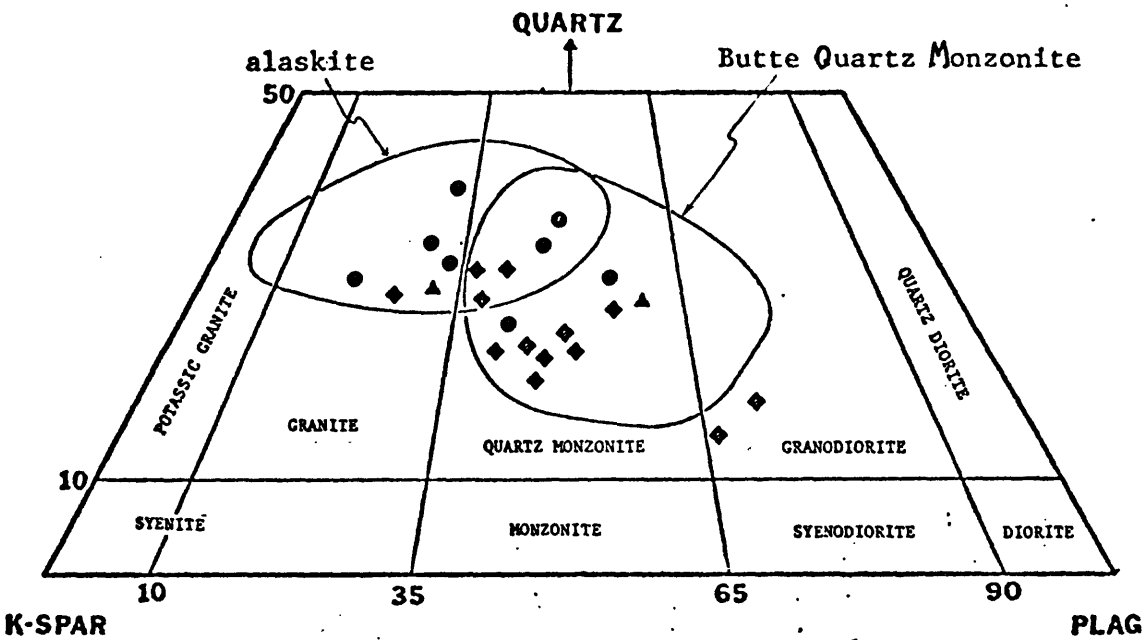


Figure 9. Modal compositions of intrusive rocks from the Golconda area. Circles - aplite; triangles - quartz monzonite porphyry; diamonds - quartz monzonite. Between 100 and 500 points were counted for each slab. Quartz and feldspar are recalculated to total 100 percent. Color index for the aplites ranges from 0 to 7 (average of 3). Color index for quartz monzonite and quartz monzonite porphyry ranges from 2 to 15 (average of 8). The solid lines delineate the fields of alaskite and Butte Quartz Monzonite as reported by Becraft and others (1963). The average mode for quartz monzonite and quartz monzonite porphyry is: qz-25, or-39, pg-36. The average mode for aplite is: qz-33, or-41, pg-26.

ore deposit. In addition it can serve as a model to which other porphyry deposits may be compared.

The deposit was discovered by geologists of the Exxon Corporation in the early 1970's. The corporation pursued a program of detailed geologic mapping and geochemical sampling, and in the summer of 1977 four diamond drill holes (fig. 8) of unknown depth were completed or in progress.

The rock in the Golconda area predominantly is Butte Quartz Monzonite that has a wide range of composition (fig. 9) and grain size. Plagioclase forms sparse phenocrysts. Biotite is the principal mafic mineral, and hornblende is present locally; together they constitute 2 to 15 percent of the rocks; the mean is 8 percent. The quartz monzonite porphyry shown on the geologic map (fig. 8) is similar but contains more abundant plagioclase phenocrysts.

Equigranular aplite, the other major rock type in the area, is host to most of the copper-molybdenum mineralization and hydrothermal alteration. The color index of the aplite ranges from 0 to 7 and averages 3.

Post-mineral faulting is indicated by the abrupt termination of intensely hydrothermally altered aplite on the west and north along prominent topographic lineaments. Physical evidence for faulting along these lineaments was not observed.

Intersecting quartz-sulfide veinlets and associated hydrothermal alteration are confined largely to the aplite. At the surface, intense leaching and oxidation of the rock have taken place, and no fresh sulfides other than pyrite were observed in any surface specimens. Iron and manganese oxides are, however, abundant in the veinlets. Samples of these rocks commonly contain anomalously high copper and molybdenum contents, the distribution of which is shown in figure 10.

Hydrothermal alteration patterns shown in figure 8 were determined by petrographic and X-ray diffraction studies. Strong phyllic alteration is characterized by nearly complete (90 percent) replacement of both potassium feldspar and plagioclase by a very fine-grained aggregate of quartz and sericite, absence of biotite or pseudomorphing of it by sericite and iron oxides, and many (1-5 percent) disseminations and veinlets of pyrite and (or) iron oxide pseudomorphs after pyrite.

Weak and moderate phyllic alteration is similar to strong phyllic alteration, but more fresh feldspar remains, and the former presence of biotite is often represented by chlorite. Rock on the fringes of the altered area contains quartz-sulfide veinlets with 1 to 5 mm selvages of strong phyllic alteration, suggesting that the strong phyllic zone is the result of coalescence of alteration envelopes around more closely spaced veinlets. The most strongly altered rocks generally have the highest copper and molybdenum values. Many of the rocks indicated as

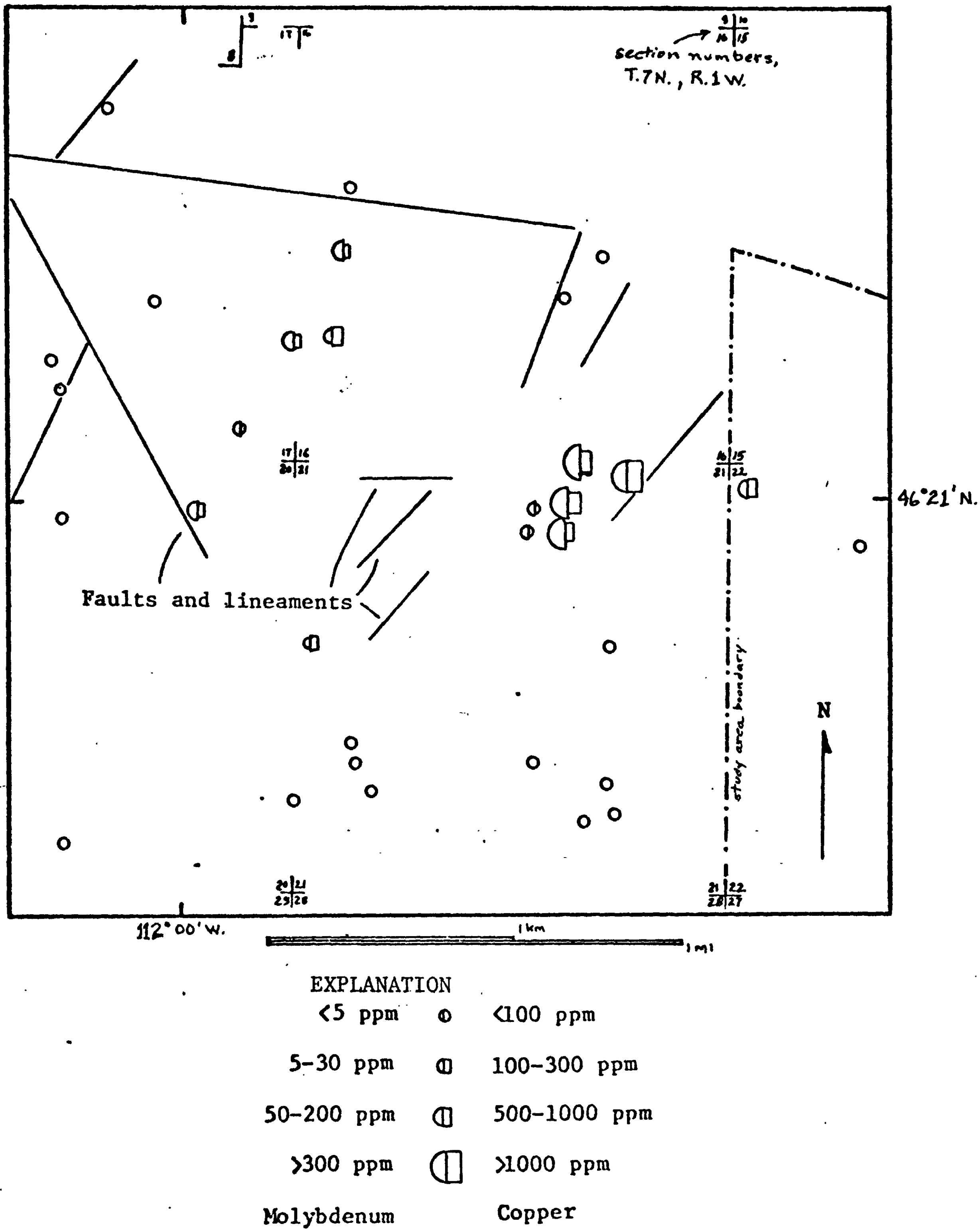


Figure 10. Copper and molybdenum content of rock samples in the Golconda area.

unaltered on figure 3 show partial replacement of biotite by chlorite, contain sparse disseminated pyrite, and probably constitute a propylitic alteration zone. Comparison of semiquantitative spectrographic analyses of altered and unaltered rocks shows that hydrothermal alteration of feldspars to quartz and sericite liberated significant amounts of calcium, but left barium and strontium largely fixed in the rock.

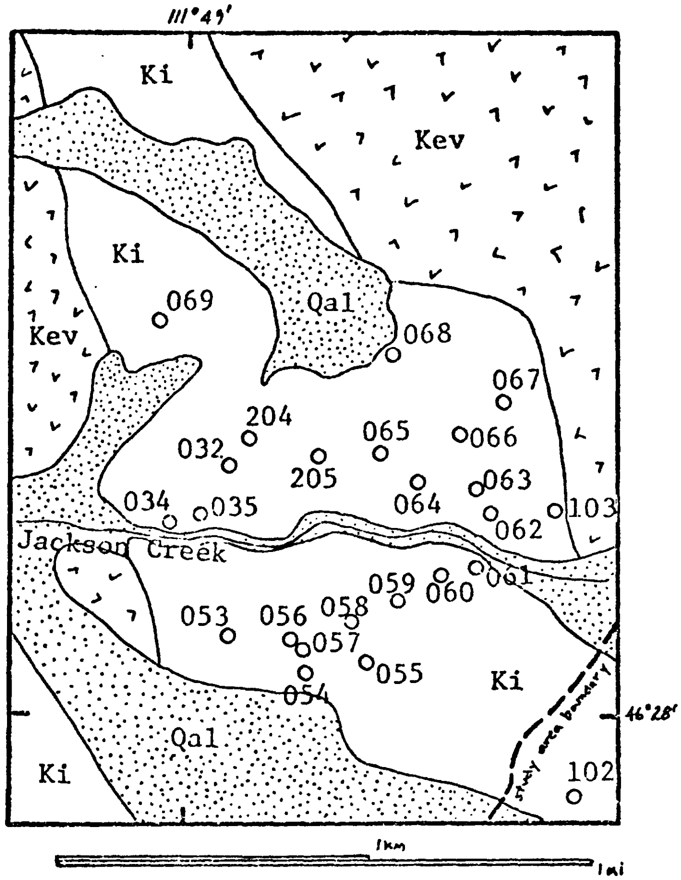
The observed characteristics of the exposed portion of the Golconda prospect agree well with those ascribed to the upper part of a model porphyry copper system (Lowell and Guilbert, 1970; Gustafson and Hunt, 1975) with one significant exception, that molybdenum to copper ratios at Golconda appear to be quite high. This feature may have two explanations: (1) The surface samples are generally highly oxidized. Copper is much more highly mobile than molybdenum in acid oxidizing waters, and so may have been significantly leached from the surface exposures. If this is true, the hypogene copper grade may be several times higher than surface sampling suggests. Also, the possibility arises that a secondary enrichment blanket may be present at depth. (2) Even if copper has been removed, the absolute values of molybdenum seem high. Three samples contain 500 ppm molybdenum. If such molybdenum contents were widespread, they would contribute materially to the value of the deposit and characterize it as a molybdenum-rich porphyry copper system.

Jackson Creek area

Rocks of the Jackson Creek area, which lies just outside the study area (fig. 1), contain anomalous amounts of copper, molybdenum, and bismuth. However, Jackson Creek does not appear to resemble a typical porphyry copper system. More detailed studies are necessary to determine the nature and origin of this deposit. Our studies indicate the area has low potential for the discovery of a significant ore deposit.

It is not known when the area first attracted the attention of modern explorationists, but the copper occurrence was known as early as 1911 (Stone, 1911, p. 86). It was tested in the mid 1960's by Rio Amex Inc. by means of four shallow (<200 m) drill holes. That drilling was not followed by further exploration.

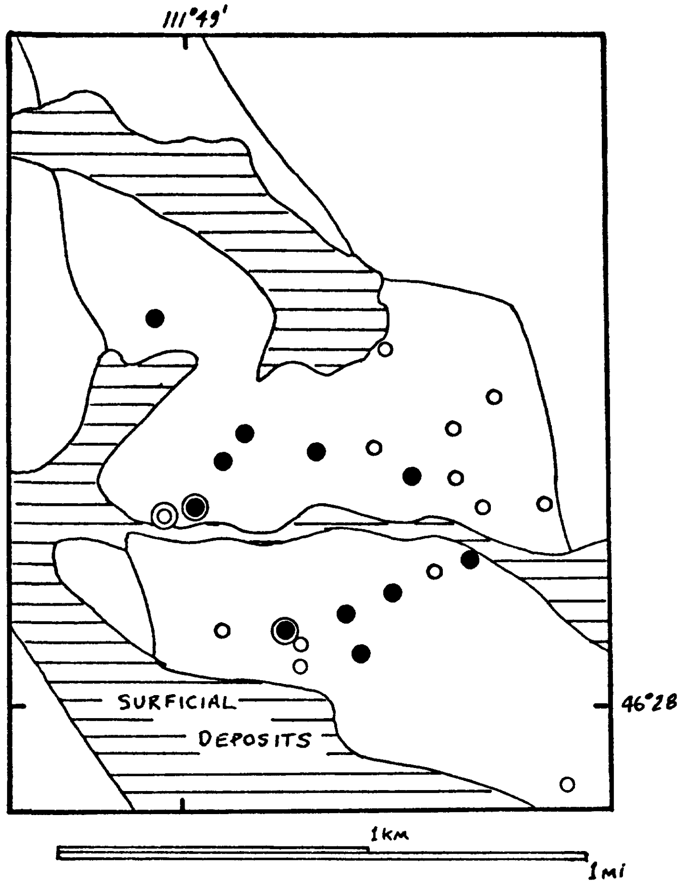
The area occupies the central part of the Jackson Creek lobe of the Boulder batholith (Smedes, 1966), a wedge of intrusive rock separated from the main part of the batholith by a screen of strongly sheared and contact-metamorphosed Elkhorn Mountains Volcanics (fig. 11). Modal analysis of stained slabs of rock indicates the presence of quartz monzonite, monzonite, granodiorite, syenodiorite, diorite and quartz diorite in the mineralized area. Outcrops are too few to determine whether the wide scatter of rock types represents an inhomogeneous pluton or a series of intrusions made up of many rock types. Accordingly, rock types are not differentiated in figure 11.



EXPLANATION

Qal	Quaternary alluvium and other surficial deposits.
Ki	Cretaceous intrusive rocks; quartz monzonite, monzonite, syenodiorite, granodiorite, diorite, and quartz diorite.
Kev	Cretaceous Elkhorn Volcanics.

Figure 11. Jackson Creek area, showing geology and rock sample localities. All sample numbers are prefixed by 77SL, deleted here for brevity.



EXPLANATION

○ 700-1500 ppm copper

● 7-50 ppm molybdenum

o unmineralized

Figure 12. Copper and molybdenum content of rock samples from the Jackson Creek area.

The modes and chemical analyses reveal that the Jackson Creek lobe contains distinctly less potassium and more sodium than most of the Boulder batholith. The spectroscopic analyses indicate that the rocks are enriched in barium and strontium relative to the batholith. They apparently belong to the sodic magma series of Tilling (1973).

Phyllic alteration in the Jackson Creek area is weak and irregularly distributed. Most specimens exhibit some sericite but none show strong phyllic alteration and most have fresh biotite.

The copper and molybdenum content of the samples is shown in figure 12. Samples 77SL034, 77SL035, and 77SL036 contain 700, 1,000, and 1,500 ppm copper respectively, but no other samples contain as much as 100 ppm. The copper in samples 77SL034 and 77SL035 occurs in large (0.1 to 1.0 mm), isolated, anhedral blebs of chalcopyrite, which show no evidence of association with sporadic quartz veinlets which cut the rock. In 77SL056, the copper occurs in an azure blue mineral.

There is a scattering of anomalous molybdenum values, the highest of which is 50 ppm. In addition to copper and molybdenum, one sample (77SL057) contains 1,000 ppm bismuth. The bismuth-bearing mineral is unknown, but it may be in the 5 to 10 percent disseminated pyrite in the rock.

The Jackson Creek copper occurrence does not resemble any reported porphyry copper system. It may represent a poorly developed example of the sort of magmatic copper occurrence described by Knopf (1913b) from the Golden Curry Mine (pl. 3) in the Elkhorn district. The likelihood that the area contains an economic copper deposit is felt to be low.

Turnley Ridge Prospect

The Turnley Ridge Prospect is in the Elkhorn mining district about 2 km south of the study area (fig. 1). It was recognized in 1969 by the Siskon Mining Corporation of Reno, Nevada. U.S. Borax completed two diamond drill holes to depths of 297 m and 210 m on the property in 1973 and 1974. The results were not encouraging, and the property was relinquished. All information presented here on the Turnley Ridge Prospect is taken from Senter (1975).

The prospect is located near the center of the Turnley Ridge stock, a quartz monzonite porphyry. Modal analyses of four specimens average quartz, 35 percent; plagioclase, 28 percent; orthoclase, 30 percent; biotite, 2 percent; sericite, 2 percent; other mafics, 2 percent; and accessory epidote, sphene, apatite, and zircon, 1 percent. The stock is believed to be an outlier of the Butte Quartz Monzonite.

The distribution and characteristics of the hydrothermal alteration in the Turnley Ridge stock are shown in figure 13. Molybdenum and minor copper occur in quartz veins in the potassic and phyllic zones, most abundantly near the interface between the two zones. The best 3 m

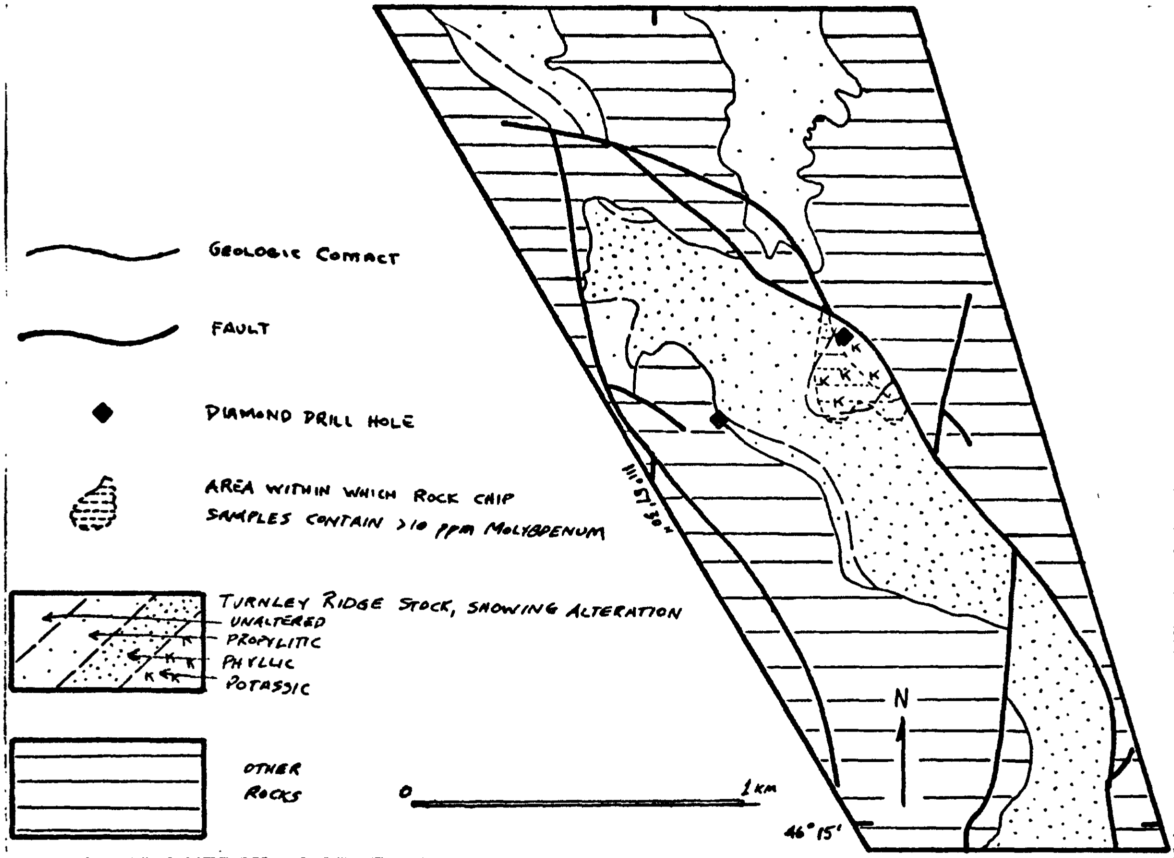


Figure 13. Alteration and mineralization map of the Turnley Ridge stock.

DESCRIPTION OF ALTERATION ZONES

POTASSIC - Stockwork of quartz veins, up to 4 cm wide; orthoclase moderately to wholly replaces plagioclase; sericite and tourmaline present; pyrite, in veinlets and disseminated, averages 0.5 to 1.0 percent.

PHYLLIC - Pervasive replacement of all silicates by sericite; 0.5 to 1.0 mm selvages of orthoclase on sparse quartz veinlets; tourmaline present; pyrite averages 2 to 3 percent, chiefly as granular and euhedral disseminations.

PROPYLITIC - Plagioclase generally fresh; biotite replaced by chlorite + secondary biotite + sphene; tourmaline and pyrite are present, but rare.

intercept in either drill hole was 0.079% Mo, with intercepts of 20 to 100 m averaging 50 to 200 ppm Mo. The fact that the orthoclase and quartz-rich central portion of the system crops out at the surface argues against the presence of better mineralization at depth, as does the observation by Senter (1975, p. 72) that "Only rarely in hand specimen or in thin sections are the quartz veinlets displaced and crosscut by other quartz veinlets." Apparently the Turnley Ridge deposit represents a single phase, relatively weak porphyry system. The grade of the rock sampled does not represent ore, but the presence of this deposit provides additional encouragement for prospecting for porphyry systems in this part of the Boulder batholith.

BRECCIA PIPE DEPOSITS

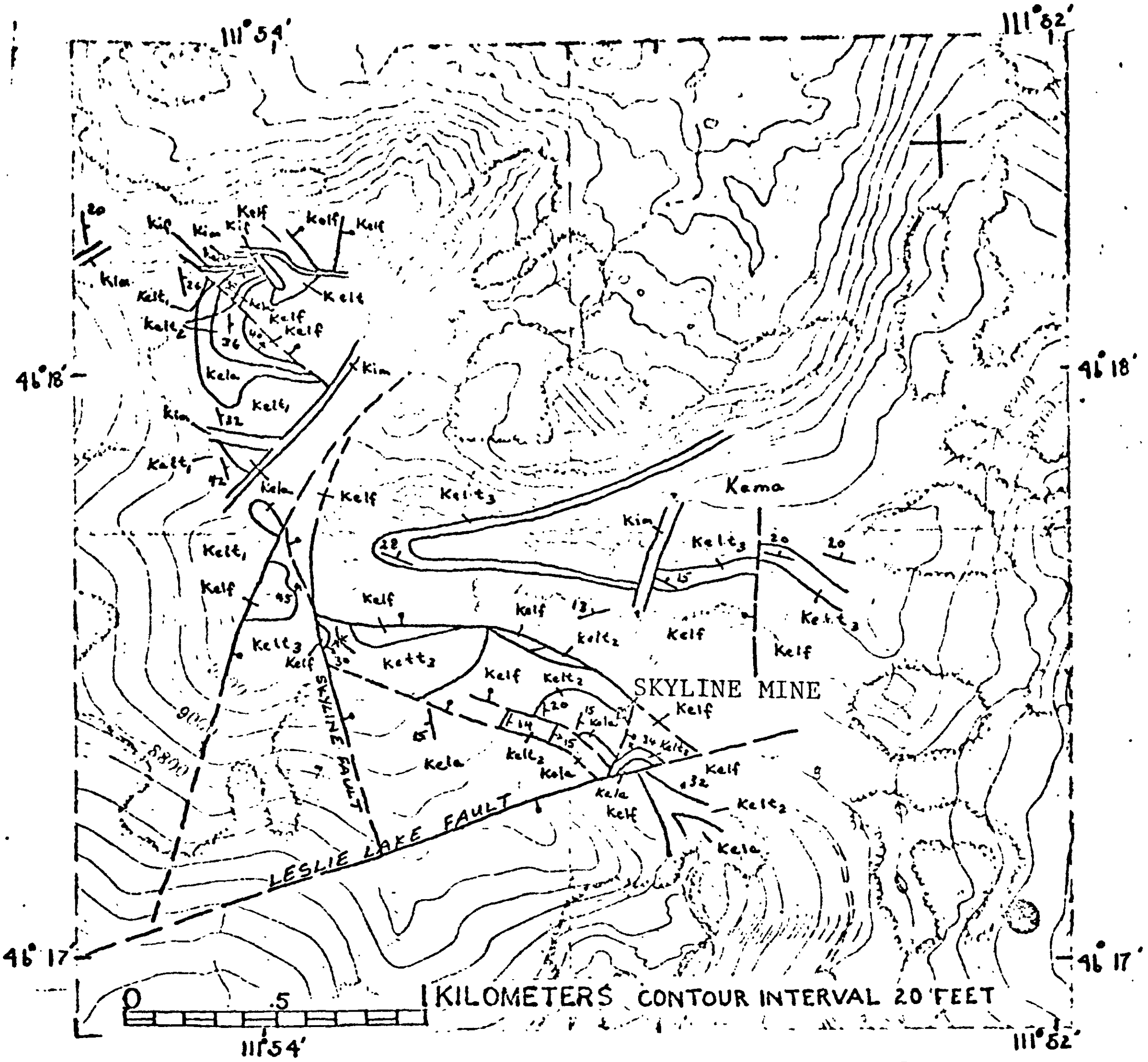
Breccia pipe deposits have produced very little of the mineral wealth of the study area, but because of the possibility that they may be indicative of mineral deposits at depth and their potential for large tonnage, they merit description.

The two major breccia pipes--the Skyline and Blackjack mines--are shown on plate 3. They were mapped and sampled in detail during the present study.

Skyline Mine

The Skyline Mine is in the cirque at the head of Queen Gulch in the southern part of the study area. It was developed in a steeply plunging breccia pipe that has a roughly triangular cross section with sides about 46 m long at the surface (fig. 14). The pipe cuts gently dipping andesite and pyroclastic quartz latite near the intersection of several normal faults. Brecciated andesite and quartz latite in the pipe are cemented by vuggy quartz and tourmaline, and locally they have been partially to totally replaced by pyrite, galena, sphalerite, and sparse chalcopyrite, arsenopyrite, and marcasite. All sulfides have been leached at the surface leaving a porous iron-stained gossan. Numerous samples of the breccia pipe contain trace amounts (5 to 100 ppm) of molybdenum, tin, and tungsten. The deposit has been explored by two short adits, one of which leads to a 51-m winze and some short subdrifts, and four diamond-drill holes. The most recent exploration (in 1953) was partially supported by the Defense Minerals Exploration Administration. The results of that exploration indicated that the volume and grade of the ore discovered did not justify further exploration at that time (McWilliams and Weeks, 1954).

The breccia pipe is located adjacent to a short north-northeast-trending normal fault that connects two major faults of northwest and east-northeast trend, respectively (fig. 14). The east-northeast-trending fault, the Leslie Lake fault, is the site of major springs; several pits and a short adit explore strongly altered, iron-stained, and tourmaline-bearing rock along this fault. The north-northeast-trending fault may be similarly altered but is poorly exposed. The



Base from U.S. Geological Survey, 1:62,500 Clancy 1950

EXPLANATION

CRETACEOUS

ELKHORN MOUNTAIN VOLCANICS

	Kim Kif	MAFIC DIKE Kim FELSIC Kif
MIDDLE MEMBER	Kema	WELDED TUFF
LOWER MEMBER	Kelt 3	lt 1, 2, 3 BEDDED TUFF
	Kelf	f - FLOW
	Kelt 2	a - WELDED TUFF
	Kela	
	Kelt 1	

True North

Magnetic North

18°

SYMBOLS

Strike and dip of beds

Mine

Contact queried where extent unknown

Fault, dashed where inferred

FIGURE 14 Geology of Skyline Mine area, Jefferson County Montana.

Geology by
William R. Greenwood, Enid Bittner, Judy M. Allen, and David F. Thompson

northwest-trending fault, the Skyline fault, was sealed, possibly by metamorphism, and is not altered or the site of springs. These data suggest that the Skyline fault is a premetamorphic and pre-ore structure; the north-northeast- and east-northeast-trending faults appear to be younger structures possibly related to the formation and mineralization of the breccia pipe. The tourmaline along the Leslie Lake fault supports this suggestion. The Skyline fault forms the southern margin of a broad northeast-trending structural depression (pl. 1), within which the middle member of the Elkhorn Mountain Volcanics consists predominantly of welded tuff, and resembles a cauldron-fill deposit. Therefore the Skyline fault could be part of the structural rim of a cauldron.

Black Jack Mine

At the Black Jack Mine, about 3 km north of the Skyline Mine, four shallow prospect shafts explore a steeply plunging breccia pipe in andesite. The roughly elliptical pipe is elongated west-northwesterly and is about 38 m long and about 18 m wide (fig. 15). The pipe is adjacent to a major fault (covered and not shown on pl. 1) that separates the andesite from cauldron-fill-type welded tuffs to the east. Brecciated andesite in the pipe is cemented by black tourmaline and quartz and lesser amounts of epidote and pyrite. Two exploration pits about 73 and 90 m south of the pipe explore north- and north-northwest-trending fractures that are partly filled and replaced by veins of quartz and tourmaline and small amounts of pyrite. Most of the pyrite in surface outcrops of breccia and along fractures has been oxidized to hematite and limonite.

Chemical analyses of andesite, breccia and vein samples show expectably high boron contents in and near the breccia pipe and in some veins. Molybdenum ranges from less than 5 ppm to 15 ppm, with a median of 5 ppm, in and near the breccia and is all less than 5 ppm in the andesite. Copper and manganese are less abundant in the breccia than in andesite. The tin and tungsten contents are less than 10 ppm and 50 ppm respectively in all samples.

The breccia pipe at the Black Jack Mine is smaller than the breccia pipe at the Skyline Mine but is cemented by the same high-temperature minerals. Both breccias have anomalous molybdenum contents although the Black Jack breccia lacks the anomalous tin and tungsten contents found in the Skyline breccia. The breccia at the Black Jack, as at the Skyline, may represent the vent of a volatile-rich intrusive that contains significant amounts of molybdenum. The lack of precious- and base-metal minerals and the lack of tin and tungsten anomalies suggest that the breccia at Black Jack is less deeply eroded than the breccia at Skyline.

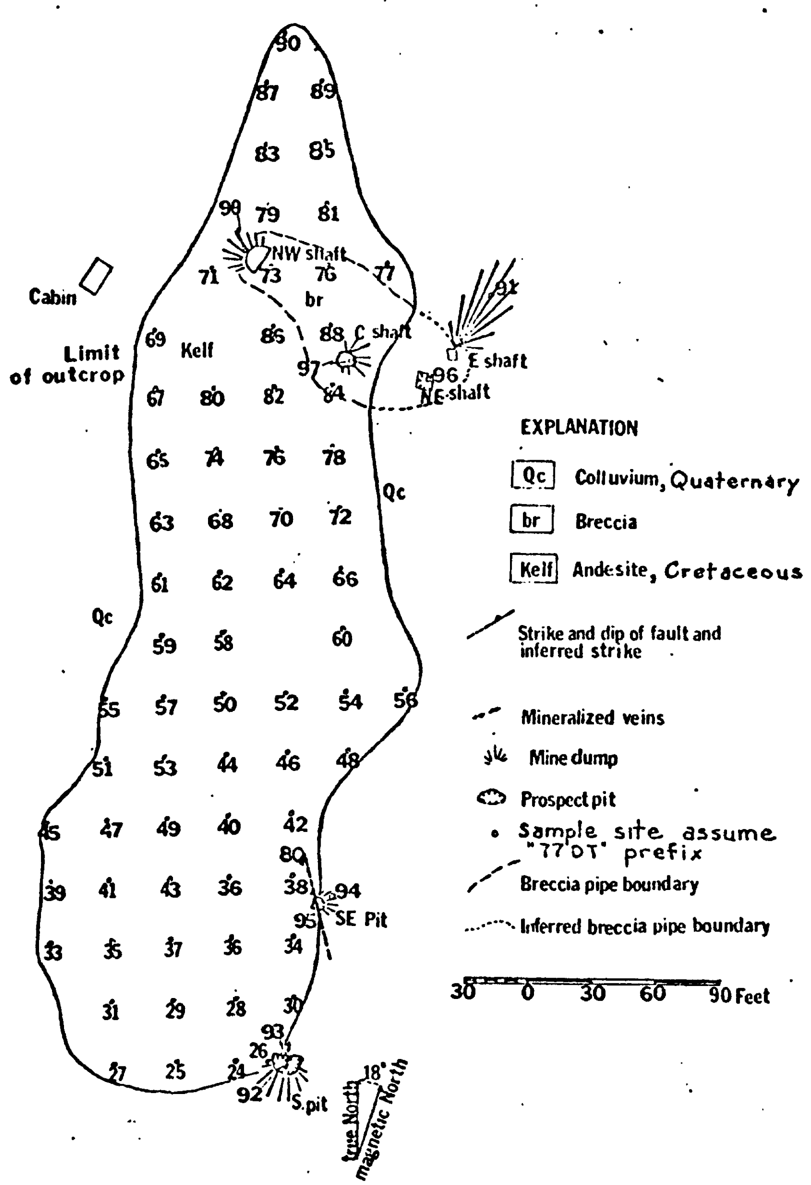


Figure 15 Geology of Black Jack Mine, Broadwater County, Montana 1977.

Geology by David F. Thompson and Enid Bittner.

Chicago and Last Hope Mines

The Chicago and Last Hope Mines, about 3 km north of the study area (pl. 3), are described by Smedes (1966, p. 106) as being developed on veins that follow the contact between the lower and middle members of the Elkhorn Mountains Volcanics. However, stratigraphic studies made in this study of the lower and middle members indicate that near the Chicago Mine these members are juxtaposed by a steep, down-to-the-south fault, which in most places is intruded by a ring dike of hornblende porphyry. This fault may be the structural rim of a volcanic cauldron. The Chicago and Last Hope Mines and many unmapped prospect pits and shafts are developed at and near the contact of the hornblende porphyry dike with rocks of the middle member. The veins consist of quartz, carbonate minerals, pyrite, arsenopyrite, and small amounts of sphalerite and chalcopyrite. Gangue minerals are diopside, hedenbergite, garnet, tourmaline, epidote, and magnetite. The vein minerals fill fissures and partially replace the wall rocks. The mines were worked for gold but also produced small amounts of silver, lead, copper, and zinc. The upper parts of the veins are oxidized and yielded high-grade gold ore. The mineralogy and structural setting at the Chicago and Last Hope Mines is similar to that of the Skyline Mine, suggesting that the Chicago and Last Hope veins may overlie one or more intrusive bodies and (or) significant mineralization at depth.

GROUP I - PRECIOUS- BASE-METAL ANOMALIES (AU-AG-AS-PB-CU)

Southeastern area

Panned concentrate samples from eleven drainages are highly anomalous with respect to the elements in this group. Seven of these drainages contain inactive precious-metal mines, as listed in table 4, and the anomalous amounts of metal in the samples were derived, at least in part, from these mines.

The other four drainages (77SL009, Longfellow Creek; 77LA008, unnamed tributary of Crow Creek; 77SL023, Staubach Creek; 77WM104, cirque east of Elkhorn Peak) contain no known deposits, but the anomalous samples suggest the presence of significant precious- base-metal veins, although no other evidence for such veins was found.

All these drainages, except Staubach Creek, are found along or to the southeast of a line connecting the East Pacific Mine and the town of Elkhorn. Thus, all of the southeast part of the study area can be considered to have moderate potential for precious- base-metal deposits. The pattern is enhanced when zinc is considered along with other group I elements, even though zinc does not show a high overall correlation with these elements. The underlying nature of this pattern is not well understood. Kleinschmidt, Champion, Marietta, Bullion King, Little Annie, Park, Eagle Basin, and St. Louis Mines are all along or near the northeasterly trending Weasel Creek fault zone of Klepper, Ruppel, and others (1971), as are a series of related quartz monzonite porphyry

Table 4.--Precious- and base-metal drainage anomalies related to known mines; group I - Au-Ag-As-Pb-Cu

Sample No.	Drainage name	Mines
77EB014	west fork of Weasel Creek	East Pacific.
77SL017	Weasel Creek-------------	Stray Horse.
77DT008	east fork of Badger Creek	Vosburg.
77SL020	west fork of Badger Creek	Champion.
77EB012	Indian Creek-------------	Marietta, Bullion King, Park.
77SL019	tributary of Indian Creek	Little Annie.
77SL002	West Fork Indian Creek---	St. Louis.

stocks, but this structure forms an acute angle with the aforementioned line, as does the contact of the Boulder batholith with the Elkhorn Mountains Volcanics. Perhaps this northeasterly trending alinement of geochemical anomalies, ore deposits, and stocks, is associated with an inhomogeneity in the Precambrian basement which is not otherwise reflected in younger rocks and structures.

Vosburg stock

The group of precious- base-metal deposits in and near the Vosburg stock on the east-central boundary of the study area is of particular interest because Klepper, Ruppel, and others (1971) reported that molybdenite is in some of the veins of the area. In addition, anomalous amounts of tungsten and molybdenum were found in some panned concentrate samples from drainages surrounding the Vosburg area. Accordingly, the area was mapped and sampled in some detail during the present investigation.

Six of twelve vein samples from the area contained detectable (>5 ppm) molybdenum, and one sample contained 150 ppm tungsten. No molybdenum or tungsten-bearing minerals were recognized in hand specimen. Neither of these metals was detected in any samples of the stock. It is believed that the observed occurrence of molybdenum and tungsten as accessory elements in the veins is sufficient to account for the geochemical anomalies.

Staubach Creek area

Six streams that drain radially from the ridge near the head of Staubach Creek at the northern end of the study area provide panned-concentrate samples (77SL023, 77EB027, 77DT005, 77LA014, 77DT006, and 77SL025) that are anomalous in a rather distinctive group of elements: gold, silver, arsenic, bismith, niobium, thorium, and possibly yttrium and lanthanum. Lead and zinc are absent. There is no known metal production in the area. The Jackson Creek Prospect is in the area, but the rock samples collected there show no particular enrichment in this distinctive suite of elements, with the exception of one sample (77SL057), which contains >1,000 ppm bismuth and 0.5 ppm silver. None of the other rock samples from these drainages are enriched in any of the elements under consideration. These anomalous samples may reflect the existence of undiscovered deposits characterized by high gold, silver, arsenic, bismuth, niobium, and thorium.

GROUP II - RARE METAL ANOMALIES (MO-W-NB-LA-Y-TH)

Introduction

The 21 panned concentrate samples which were highly anomalous in this group of elements are conveniently grouped into 6 areas: (1) South Fork Warm Springs Creek, (2) Dutchman Creek, (3) Golconda, (4) Nursery Creek, (5) Hidden Lake, and (6) Lava Mountain.

The Golconda area, already described, appears to be a copper-molybdenum porphyry system, and it seems reasonable to suspect that the rare metal anomalies detected in the panned concentrates may be related to a porphyry deposit.

South Fork Warm Springs Creek

Thirteen rock samples from this area show molybdenum contents ranging from <5 to 50 ppm and copper contents ranging from <5 to 500 ppm. Tin and tungsten were not detected. Of four samples containing 5 ppm or more molybdenum or 70 ppm or more copper, two are from precious-metal veins. One of the others (77SL099) is of aplite; it contains 50 ppm molybdenum and 30 ppm copper. Molybdenite is not uncommon as an accessory mineral in the late-stage aplites of the Boulder batholith (Becraft and others, 1963). The fourth sample (77SL108) is of a pyritic metavolcanic rock; it contains 10 ppm molybdenum and 20 ppm copper. It is believed that the anomalous molybdenum in samples from this area is present as accessory molybdenite in the precious metal veins, but possibly aplite is enriched in molybdenum; this aspect deserves further study.

Dutchman Creek

One (77SL120) of fifteen rock samples from the Dutchman Creek area in the west-central part of the study area contains detectable molybdenum. The quartz monzonite that underlies the area shows little hydrothermal alteration. The source of the geochemical anomaly is not known, but it may be the precious-metal veins in the area.

Nursery Creek

Three rock samples (77SL079, 77SL080, and 77SL082) west of the study area (fig. 1; pl. 3) show detectable tin or molybdenum. Sample 77SL082, which contains 50 ppm molybdenum, is stained by iron oxides and contains hydrothermal alteration sericite, whereas the other two samples, anomalous only in tin, appear to be fresh. Alteration is not widespread in the Nursery Creek area; however, the low but anomalous tin and molybdenum in rock samples, coupled with local hydrothermal alteration, suggest that the Nursery Creek area has some mineral potential and deserves additional study.

Hidden Lake

Analysis of eleven rock samples from the Hidden Lake area in the southern part of the study area (fig. 1; pl. 3) reveals three samples (77SL088, 77SL089, and 77BG152) with detectable molybdenum or tin. Two samples have high copper contents. A composite sample of brecciated andesite cemented by magnetite and stained by copper carbonates (77BG288) contains 15,000 ppm copper and 2,000 ppm zinc. This rock also contains 200 ppm boron, although tourmaline was not visible in the hand specimen. The breccia is exposed in the walls of a shallow exploration pit and is undercut about 15 m below by one of the adits of the Iron Mine. A sample (77SL087) of a similar rock was collected in talus just northeast of Elkhorn Peak. This sample consists of brecciated andesite cemented by what appears to be tourmaline, and it contains 300 ppm copper, 1,500 ppm lead, and 1,500 ppm zinc. Boron was not found to be high in this sample.

The copper-rich breccias and molybdenum-tin-tungsten anomaly in this area may be indicative of breccia-pipe deposits similar to that at the Skyline mine, and deserve additional study.

Lava Mountain area

Samples of extrusive and intrusive rhyolite from the Lava Mountain area, which is less than 2 km northwest of the study area, contain unusually high amounts of tin, niobium, beryllium, fluorine, and lithium. Beryllium contents for 18 samples range from less than 1 to 20 ppm (median, 10 ppm), and tin contents for the same samples range from less than 10 to 50 ppm (median, 18 ppm). Such high beryllium and tin contents appear to be characteristic of this Oligocene(?) rhyolite in the northern part of the Boulder batholith (D. R. Shawe, written commun., 1977). Although high molybdenum commonly accompanies high tin in other areas, the molybdenum contents in this rhyolite are low, ranging from less than 5 to 10 ppm (median, less than 5 ppm). Therefore the anomalously high molybdenum observed in stream sediments and panned concentrates probably was not derived from the rhyolite. The molybdenum content of 12 samples of pre-rhyolite rocks in the Lava Mountain area ranges from less than 5 to 20 ppm (median, less than 5 ppm). The five samples of pre-rhyolite rocks that contain 5 ppm or more of molybdenum (77SL028, 77SL039, 77SL041, 77SL042, 77SL114) consist of either vein material or altered Butte Quartz Monzonite adjacent to veins. These veins have high silver, lead, and zinc contents and are probably similar to the White Pine vein, south of the Middle Fork Warm Springs Creek. It is believed that the molybdenum anomaly in this area can be related to accessory molybdenite in the precious- and base-metal veins.

Silver, lead, and zinc are present in four rhyolite samples (77SL036, 77SL037, 77SL038, 77SL040) from mine dumps on the south side of Lava Mountain. Silver in these samples ranges from 3 to 20 ppm, lead from 200 to 5,000 ppm, and zinc from <200 to 5,000 ppm. This mineralization appears to be similar to the local disseminations of galena and sphalerite in the rhyolite described by Smedes (1966). This lead-zinc-silver may be the result of a younger mineralization, but it may also be due to local assimilation and redistribution of sulfides in areas where rhyolite intruded preexisting precious- and base-metal sulfide veins.

The rhyolite of Lava Mountain is a highly differentiated rock of the sort that is associated with tin and molybdenum deposits in many places; however, if such a target exists in this area, no direct expression of it appears at the surface.

BORON

The panned-concentrate drainage samples which are anomalous in boron form a particularly coherent pattern (pl. 4). In all cases, these samples represent areas underlain by Elkhorn Mountains Volcanics in a band up to 4 km wide along the contact with the Boulder batholith. This seems to be compelling evidence that boron was fixed in this band by reaction of hydrothermal fluids moving upward and outward from the cooling batholith with the surrounding wall rocks. In this region, tourmaline very commonly coats the joint faces of the volcanic rocks.

The relationship of anomalous boron to economic mineral deposits is not so clear. Knopf (1913) discussed at some length the significance of tourmaline in some of the precious- and base-metal deposits of the Greater Helena mining district. He felt that these deposits were earlier and formed at higher temperature than the other vein deposits of the area. This hypothesis fits well with the idea presented here that the batholith is the direct source of the boron, but a direct comparison cannot be made because none of the deposits Knopf discussed are near the study area, and no vein deposits in the study area are known to contain tourmaline.

Three breccia-pipe deposits characterized by tourmaline do occur in and near the study area, the Tourmaline Queen, the Skyline, and the Black Jack, discussed in an earlier section of this report. They all occur near the eastern edge of the band of anomalous boron. It would seem that those breccia pipes could have formed near the end of intrusion of the Boulder batholith.

Several geologic traverses were made within drainages that panned-concentrate samples have shown to be anomalous in boron. Some samples collected contain 100 to 2,000 ppm boron. Tourmaline occurs chiefly as coatings on joint faces, but some pieces of float were found which indicate the presence of undiscovered tourmaline-bearing breccia pipes. Several samples contained detectable molybdenum. An area west of Bullock Hill contains a large number of small trenches and prospect pits. Samples from these pits contained 1 to 2,000 ppm silver, 300 to 20,000 ppm lead, and 200 to 10,000 ppm zinc. These samples, however, did not contain anomalous boron or molybdenum and apparently belong to a different geochemical system.

URANIUM AND THORIUM POTENTIAL

by

Karen J. Wenrich-Verbeek, William R. Miller, Vivian J. Suits,

and John B. McHugh

During the summer of 1977 an evaluation was made of the uranium and thorium potential in and adjacent to the Elkhorn wilderness study area. Uranium-bearing deposits have been known in the area west of Clancy, Montana, since 1949. Clancy lies 6.5 km northwest of the study area. Despite comprehensive studies of the geology (Becraft and others, 1963) and uranium deposits (Roberts and Gude, 1953b), no significant production of uranium has occurred. In the Clancy district, the uranium is present as pitchblende and secondary minerals located near silicified fracture zones in the quartz monzonite of the Boulder batholith or the younger alaskitic dike rocks. The uranium minerals are usually in silica stringers, along fractures, or in pore spaces of the altered host rock (Roberts and Gude, 1953b). According to Tilling and Gottfried (1969, p. E6), the Boulder batholith is higher in uranium and thorium than the surrounding wall rocks. Rocks of the batholith contain as much as 10 ppm uranium, and the wall rocks generally contain less than 5 ppm uranium. The batholitic rocks contain more than 15 ppm thorium and locally as much as 42 ppm, whereas the older rocks generally contain less than 15 ppm thorium. With a few exceptions, only the alaskitic dike rocks contain more than 20 ppm thorium.

The area was studied by means of a geochemical survey, using both surface waters and panned-concentrates of stream sediments, and by an aerial gamma-ray survey. The water samples were collected only from streams draining the Boulder batholith, where the radioelement content was known to be considerably higher than in the older wall rocks. Both uranium and radon were determined in the water samples, uranium by extraction fluorimetry and radon by an alpha-scintillation technique. Thorium was determined in the panned concentrates by semiquantitative emission spectroscopy. The aerial gamma-ray survey was flown over the northwest part of the study area, over the Clancy district, and over the intervening area. The data and results from the survey are presented by Duval, Pitkin, and Macke (1978). Portions of flight lines from the aerial survey that show high eU/K and eTh/K ratios are shown on plate 5.

The thorium content of the panned concentrates delineates the contact between the Boulder batholith and its wall rocks to the east. With few exceptions the thorium content of samples from the eastern part of the study area is less than the detection limit of 200 ppm. Panned concentrates from streams draining the Boulder batholith range from less than 200 to 3,000 ppm thorium. Thorium contents greater than 2,000 ppm are considered anomalous, and areas where high thorium values were obtained have been outlined on plate 5. Two of these areas, one in Muskrat and Rawhide Creeks and the other south of Prickly Pear Creek, are coincident with an anomalously high radiometric eTh/K ratio. High eTh/K ratios were also found in the vicinity of Burnt Mountain, Strawberry Butte, and Lava Mountain, where young rhyolitic lavas cap the batholith. Two samples from the upper part of the South Fork Warm Springs Creek contain some of the highest thorium concentrations.

Three small areas underlain by the Boulder batholith contain high amounts of radon in surface water samples (pl. 5). The samples with the highest radon were collected from the upper part of Dutchman Creek--an area that straddles the study area boundary. The sample sites lie just downstream from a major northeast-trending fracture (pl. 5) identified by E. R. Verbeek (oral commun., 1977). The radon content of these surface-water samples shows no correlation with uranium concentrations. In general, the radon content in the entire area is abnormally high; radon contents elsewhere are rarely greater than 50 ρCi/l. A small area around the town of Alhambra (pl. 5) contains hot springs, hot flowing wells, and cold wells that show exceptionally high radon contents, 3,000-37,000 ρCi/l (Leonard and Janzer, 1977). These are among the highest radon contents found in the United States.

No large areas of significantly high uranium in surface water were found, although anomalous values were measured on samples from Badger Creek (13 μg/l), Rawhide Creek (13 μg/l), and an unnamed tributary of Clancy Creek (13 μg/l). All these drainages, except for the headwaters of Rawhide Creek, are outside the study area. In most areas, except for Dutchman Creek and Prickly Pear Creek, where uranium concentrations are low, uranium in the surface waters ranged from 1 to 4 μg/l. These values are above average for uranium in surface water, particularly for small, first and second order streams of moderately high U/conductivity ratios. With the exception of one sample at 7.2 μg/l the wells of high radon content around Alhambra contain less than 1 μg/l uranium. High eU/K ratios determined in the aerial radiometric survey occur sporadically over the entire area (pl. 5) and do not correlate with uranium in surface water.

Although the uranium content of surface water in the western part of the Elkhorn wilderness study area and adjacent land to the west is not extremely high, the overall radioelement content of the water and stream sediments, as well as the eU/K and eTh/K ratios, is high and merits further study. The extremely high radon content in the Dutchman Creek area might possibly be explained by southeast movement, along fractures, of radon originating perhaps from uranium occurrences in the Clancy district to the northwest. Movement of this radon may then have been impeded by the major fracture (pl. 5) located to the southeast of the anomaly. However, this high radon concentration in the surface water is more likely due to a localized source because of the short half life of Rn_{222} and the large distance between the Clancy district (about 10 km) and Dutchman Creek. The area around Muskrat and Rawhide Creeks is high in all radioelements and probably merits the most attention. Possibly, localized uranium occurrences are contributing the high radon values in the wells and hot springs at Alhambra, as well as in surface water of areas outlined in plate 5.

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Chapter B

Economic Appraisal

by

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SETTING

The Elkhorn wilderness study area is in the Elkhorn Mountains between Helena, Townsend, and Boulder, Montana. It has an area of about 82,000 acres (33,000 h) and includes the headwaters of Warm Springs, McClellan, Beaver, Crow, Elkhorn, and Prickly Pear Creeks.

Most of it is accessible by jeep road from Interstate Highway 15 and U.S. Highway 12. There are about 40 miles (64 km) of roads and 90 miles (145 km) of trails within the study area.

Most of the topography is gently-sloping, grass- or tree-covered hills and valleys. Canyons along Crow and Beaver Creeks and cirques at the heads of Warm Springs, McClellan, Tizer, and Elkhorn Creeks are steep and rugged. Elevations range between 5200 and 9414 feet (1585 and 2870 m).

The Elkhorn wilderness study area contains parts of the Warm Springs, Beaver Creek, Park, and Elkhorn mining districts, and all of the Tizer-Wilson district. The Warm Springs district has been known as the Alhambra, Mitchell, Clancy, Prickly Pear, and McClellan Creek districts. The Beaver Creek district has been known as the Winston, and the Park district as the Hassel. Only those portions of mining districts within the study area are discussed in detail.

HISTORY AND PRODUCTION

Mining in the Elkhorn wilderness study area began in the 1850's with the discovery of placer gold deposits on Crow Creek in the Tizer-Wilson and Park districts. These deposits, and the finding of placer gold in Last Chance Creek near Helena in the 1860's, were followed by discoveries of gold in other streams in the region. Placer mining was the principal industry for the following 10 to 15 years.

Lode mining started in the 1860's following the discovery of secondarily-enriched, gold-, silver-, and lead-bearing replacement and vein deposits in the Warm Springs, Beaver Creek, Park, and Elkhorn districts. The near-surface areas of most lodes contained ore from which gold and silver could be readily extracted by hand, gravity, or mercury amalgamation methods. Unrecorded amounts of ore were shipped to Swansea, Wales, for smelting. The high costs of transportation and supplies rendered the deeper, lower-grade, sulfide mineral-bearing material unprofitable. Local attempts to smelt the ore, using charcoal, failed because of low recovery and the high costs of charcoal and flux.

By 1875, placer deposits and most high-grade, easily-accessible, lodes had been depleted. Lode mining revived in 1883 when railroads were built into the region. The following 10 to 15 years, and the 7 years after the 1935 gold price increase to $35 per ounce ($1.13/g), were the region's most productive periods.

During the early days, three smelters were built west and south of the study area, and one operated until 1893. At East Helena, 15 miles (24 km) north, a smelter, built in the 1890's, is still operating.

The region's mining nearly ceased with the government's closure of gold mines in 1942, and has never fully recovered. The smelter at East Helena, a ready market for gold-silver-lead ore, has fostered the mining that has been done in recent years.

Recorded and estimated lode and placer production from deposits in the vicinity of the study area in the Beaver Creek, Elkhorn, Park, Warm Springs, Helena, Basin-Boulder, Radersburg, and Wickes districts totals over $130 million worth of gold, silver, copper, lead, and zinc.

Districts within, or partially within, the Elkhorn wilderness study area had recorded and estimated lode and placer production of $23,314,942 in gold, silver, copper, lead, and zinc (table 5). This production was from the Beaver Creek, Elkhorn, Park, Warm Springs, and Tizer-Wilson districts.

Between 1901 and 1974, those portions of the Beaver Creek, Elkhorn, Park, and Tizer-Wilson districts in the study area produced gold, silver, copper, lead, and zinc worth $339,423 (table 6). Of this, the Tizer-Wilson district accounted for approximately 85 percent, the Park 4 percent, the Elkhorn 8 percent, and Beaver Creek 3 percent. No production is recorded for the Warm Springs district.

MINING CLAIMS

The mining claim records of Jefferson and Broadwater Counties, Montana, indicate that 1,406 mining claims--1,131 lode and 275 placer--were located within the Elkhorn wilderness study area between 1867 and 1977. One hundred and ninety lode and 20 placer claims were located in the Beaver Creek district; 240 lode and 10 placer in the Elkhorn district; 320 lode and 30 placer in the Park district; 360 lode and 210 placer in the Tizer-Wilson district; and 21 lode and 5 placer in the Warm Springs district. County records also indicate that about 3,500 mining claims were located on the Helena National Forest lands surrounding the study area. Since 1970, 85 lode and 21 placer claims have been located within the study area, and 145 lode and 30 placer claims are currently held.

Bureau of Land Management and county tax records indicate that 28 lode and 3 placer claims, covering about 746 acres (302 h), are patented. All the patented land is privately-owned except for one placer claim.

Table 5.--Production from districts that are within or partially within the Elkhorn wilderness study area.

[?, unknown; --, none recorded]

District	Years	Ore (tons) 1/	Gold (ounces) 1/	Silver (ounces) 1/	Copper (pounds) 1/	Lead (pounds) 1/	Zinc (pounds) 1/	Value (dollars) 2/
Beaver Creek	1889-1900	?	?	?	?	?	?	1,120,965 3/
	1901-1965	140,657	48,656	663,408	198,014	7,859,714	1,398,736	2,625,167
Elkhorn	1875-1899	?	?	?	?	?	?	9,317,000 4/
	1900-1928	?	?	?	?	?	?	4,683,000 3/
	1934-1974	106,725	2,909	154,697	12,951	548,321	--	274,681
Park	1864-1900	?	?	?	?	?	?	900,000 5/
	1901-1968	85,855	45,306	268,877	74,409	3,707,704	3,728,645	2,685,616
Warm Springs	1865-1907	?	?	?	?	?	?	1,000,000 6/
	1908-1957	72,888	10,958	57,579	44,180	504,002	12,042	420,515 7/
Tizer-Wilson	1906-1951	11,874	8,826	14,742	10,179	86,905	1,594	287,998
Totals		417,999	116,656	1,159,303	339,733	12,706,646	5,141,017	23,314,942

1/ Metric conversions: tons x 0.9072 = tonnes; ounces x 31.103 = grams; pounds x 0.45 = kilograms.
2/ Value estimated using price paid for metals at the time of production.
3/ Pardee and Schrader
4/ Weed
5/ Klepper and others
6/ Stone
7/ Roby

Table 6.--Production from the Elkhorn wilderness study area.

[--, none recorded]

District	Years	Ore (tons) 1/	Gold (ounces) 1/	Silver (ounces) 1/	Copper (pounds) 1/	Lead (pounds) 1/	Zinc (pounds) 1/	Value (dollars) 2/
Beaver Creek	1907-1963	117	38	2,045	--	50,000	5,800	$ 10,314
Elkhorn	1902-1960	2,249	670	10,774	2,043	91,635	300	26,312
Park	1901-1968	227	78	16,626	283	78,422	400	14,799
Tizer-Wilson	1906-1951	11,874	8,826	14,742	10,179	86,905	1,594	287,998
Total		14,467	9,612	44,187	12,505	306,962	8,094	$339,423 3/

1/ Metric conversions: tons x 0.9072 = tonnes; ounces x 31.103 = grams; pounds x 0.45 = kilograms.
2/ Value estimated using price paid for metals at the time of production.
3/ Estimated to be worth about $1,716,520 at current metal prices.

ECONOMIC GEOLOGY

The eastern three-fourths of the Elkhorn wilderness study area is underlain by a synclinal roof pendant. The pendant is composed of limestone, mudstone, quartzite, and shale, overlain by pyroclastic and flow rocks of andesitic composition. The sedimentary and volcanic rocks have been intruded by andesitic to dioritic plutons, and all have been surrounded and intruded by granitic rocks. Mineral deposits are related to the intrusions.

Most mined ore came from oxidized, generally free-milling, gold- and silver-bearing lenses in thick, persistent shear zones. In the Tizer-Wilson, Park, and Beaver Creek districts, these shear zones occur in volcanic rocks. Gold, silver, lead, and iron in the Elkhorn district came from irregular replacement zones in calcareous rocks, principally limestone. A high discovery potential for fissure-lens and replacement deposits in the volcanic and sedimentary rocks of the study area is indicated by geologic factors and samples.

Fissure vein and disseminated mineral occurrences associated with fracture zones in the granitic rocks that underlie the western part of the study area have not been productive in the past. Recently, however, porphyry-type molybdenum- and copper-bearing occurrences have been discovered just west of the study area, and indications of similar occurrences within the study area exist.

Important occurrences

Forty-eight mines, prospects, and claims in the study area are on mineralized structures that are estimated to have mineral resource potential (table 7). Sixteen are on mineralized structures, mostly shear zones in volcanic rocks, that are indicated to be large enough and sufficiently mineralized to warrant an estimate of resources (table 8).

Little data are available on the porphyry-type, molybdenum-copper occurrences west of the study area. An exploration program, including mapping, sampling, and drilling, is being conducted by a major mining company, with reports that minable-grade material has been cut by drilling. At least 70 of the more than 200 claims being explored are within the study area. Sampling and geologic factors indicate that the area may have undiscovered porphyry-type deposits.

Approximately 1.6 million cubic yards (1.2 million m^3) of gravel are estimated to have been mined from placers on Wilson and Tizer Creeks. An estimated 2,530 ounces (78,691 g) of gold were produced. About 300,000 cubic yards (270,000 m^3) of gold-bearing gravel is estimated to remain along upper Wilson Creek. The average gold content of this material is worth 25.4 cents per cubic yard (33.2 cents/m^3).

Table 7.--Mines, prospects, and claims that have mineral resource potential 1/

Beaver Creek district

August Rust prospect
Champion mine
G. W. No. 2 claim
G. W. No. 2 claim (north)
Last Chance prospect
Monte Cristo group
Sawmill Creek prospect
Silver Dyke No. 1 claim
Silver Saddle mine

Elkhorn district

Arcturus claim
Blackbird claim
C and D mine
Elkhorn Ridge prospect
Golden Moss mine
Iron mine
Lone Bear prospect
Louise and Side Issue Lodes
North Louise prospect
Queen Ann claim
South Hidden Lake prospect
Union mine

Park district

Ann Kinzer mine
Cross claim group
Eagle mine

Park district (cont)

Eureka Creek divide prospect
Golden Hope Nos. 1 and 2 claims
Jawbone Lode mine
Little Jim Nos. 1-5 claims
Lower Eureka Creek prospect
McFadgen mine
Mamouth Lode mine
Mountain Dude Lode
Roadside prospect
Salt Lick prospect
Summit prospect
Vulture mine

Tizer-Wilson district

Anderson Gulch prospect
Andy claim group
Ballard mine
Belle, Best, and Last Lodes
Big Tizer-Wildcat mine
Callahan mine
Gold Series claim
J.C. Copper claim
Little Tizer Wildcat mine
Moonlight claims

Warm Springs district

Black Bear claim
Casey Meadows prospect

1/ Shown on figure 2.

Table 8.--Estimate of metallic mineral resources in the Elkhorn wilderness study area.

[Tr, trace; N, none detected]

Name	Type of occurrence	Classification	Tons 1/	Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
				Average metal content				
Beaver Creek district								
Champion mine	Shear zone in andesite----	Submarginal resource----	815,000	0.04	0.45	0.05	0.26	Tr
G. W. No. 2 claim (north)	do------------------------	Paramarginal resource----	7,000	.24	.70	N	N	N
Sawmill Creek prospect	do------------------------	Submarginal resource----	3,000	.46	N	N	N	N
		Subtotal	825,000					
Elkhorn district								
Iron mine	Replacement in andesite---	Resource----	4,200,000 2/	.03	.2	.15	N	Tr
Lone Bear prospect	Replacement in limestone--	Paramarginal resource----	7,000	Tr	.3	Tr	7.0	16.0
North Louise prospect	Vein in quartzite---------	Submarginal resource----	3,000	.02	.2	Tr	1.8	.16
		Subtotal	4,210,000					
Park district								
Ann Kinzer mine	Fracture zone in andesite	Paramarginal resource----	180,000	.06	1.8	.1	17.7	N
Cross claim group	Shear zone in andesite----	do----------	300,000	.09	.8	N	2.0	.44
Golden Hope Nos. 1 and 2 claims	do------------------------	Resource----	220,000	.017	N	N	N	N
Lower Eureka Creek prospect	Shear zone in quartzite---	Paramarginal resource----	10,000	.13	1.1	Tr	1.2	1.8
McFadgen mine	Shear zone in andesite----	Submarginal resource----	15,000	N	N	N	2.4	.4
Salt Lick prospect	do------------------------	do----------	13,000	N	N	Tr	2.3	Tr
		Subtotal	738,000					
Tizer-Wilson district								
Ballard mine	Vein in andesite----------	do----------	280,000	.10	N	N	N	N
J. C. Copper claim	Replacement in andesite---	Paramarginal resource----	5,000	N	.1	2.7	N	.41
		Subtotal	285,000					
		TOTAL	6,058,000					

1/ Metric conversions: tons x 0.9072 = tonnes; ounce per ton x 34.285 = grams per tonne; dollars per ton x 1.1 = dollars per tonne.
2/ Contains 28.7 percent iron.

MINING DISTRICTS (LODES)

Beaver Creek district

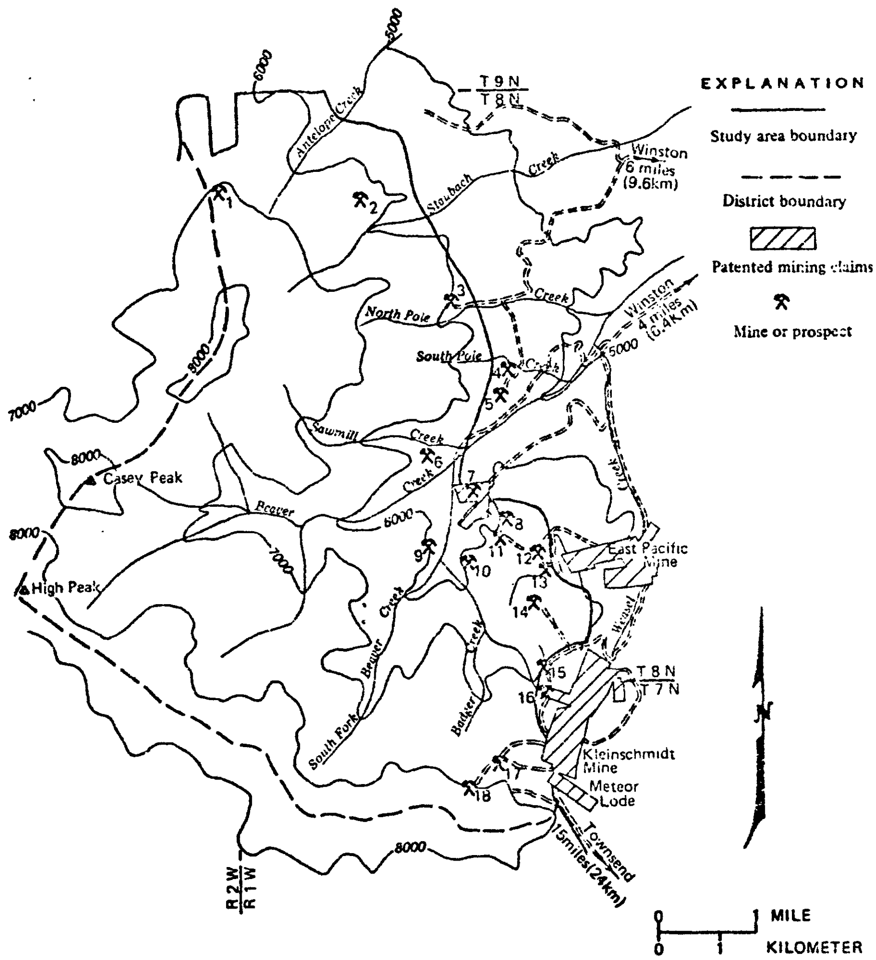
Setting

The Beaver Creek district lies on the northeastern flank of the Elkhorn Mountains. Only the part along the western edge of the district, that portion drained by the headwaters of Beaver, Pole, and Staubach Creeks is within the study area (fig. 16). Winston, on the Helena line of the Burlington Northern Railroad and U.S. Highway 12, is in the northeastern corner of the district, about 5 miles (8 km) northeast of the study area. Access is by roads from Winston up Beaver Creek, Weasel Creek, North Pole Creek, and Staubach Creek, or by mountain roads from the Park district to the south. Most mines and prospects in the study area can be reached by four-wheel-drive vehicle.

History and production

Interest in the area was stimulated by the discovery of rich placers in the mid-1860's. The East Pacific vein, the first lode discovery in the district, was claimed in 1867. Active mining did not start until the 1880's, with a majority of the significant mines being established by 1900. Total production from the greater Beaver Creek district has been approximately 150,000 tons (136,000 t) of ore worth in excess of $4,000,000 (Earll, 1964, p. 4). Recorded lode production within the study area is 117 tons (106 t) of gold- and lead-bearing ore. The district has had no lode production since 1963. No placer production has ever been recorded from the study area. Current study area activity is limited to assessment work.

About 190 lode claims were located in the Beaver Creek district between 1867 and 1970. Most were located along the divide between Weasel and Badger Creeks, from 1880 to 1910. Only seven unpatented lode claims are known to be held. All or parts of eight patented lode claims are in the study area.



F igure 16. Beaver Creek district

An unnumbered table to accompany fig. 16, Beaver Creek district

Mines and prospects in the Beaver Creek district.

1. Ridgeline prospect
2. V35 prospect
3. August Rust prospect
4. Native Silver mine
5. Buckeye prospect
6. Sawmill Creek prospect
7. Monte Cristo group
8. G.W. No. 2 claim (north)
9. PV prospect
10. Victoria claim group
11. G.W. No. 2 claim
12. Susie No. 1 claim
13. Silver Saddle mine
14. Last Chance prospect
15. Lame Deer mine
16. Vosburg mine
17. Champion mine
18. Silver Dyke No. 1 claim

Economic geology

Most of the district is underlain by flows, tuffs, and welded tuffs of andesitic composition. Several granitic stocks, dikes, and sills were intruded into the volcanic rocks along with small, irregular intrusions related to the volcanic rocks. Mineral occurrences are generally associated with east- or northeast-trending structures that crosscut both the intrusive and extrusive rocks. Economic minerals are generally found within intrusive rocks or their immediate vicinity. Veins in the district are of two types: (1) "flat-lying" that generally strike northeast and dip from 0° to 30° north and south; and (2) vertical or steeply-dipping that trend east-west. "Flat-lying" veins are exposed in the study area at the G. W. claims, Monte Cristo group, and the Silver Saddle, and Lame Deer mines. Their vein material typically consists of auriferous and argentiferous quartz, pyrite, and iron-oxide. More common are the vertical or steeply-dipping veins which are the main mineralized structures at the larger Vosburg, East Pacific, and Kleinschmidt mines outside the study area. These vertical veins contain galena, sphalerite, and chalcopyrite in addition to auriferous and argentiferous quartz, pyrite, and iron-oxide. Veins of this type within the study area are exposed on the Silver Dyke No. 1 claim, Last Chance prospect, and the Monte Cristo, and Victoria groups (fig. 16, Nos. 18, 14, 7, and 10).

Total estimated resources in the study area are 825,540 tons (748,930 t). These are in the Champion mine, G. W. No. 2 (north) claim, and Sawmill Creek prospect (fig. 16, Nos. 17, 8, and 6). Except for 7,300 tons (6,622 t) of paramarginal resources on the G. W. No. 2 (north) claim, all are submarginal.

Elkhorn district

Setting

The Elkhorn mining district includes the southwest side of the Elkhorn Mountains. Most of the district is outside the study area (fig. 17). The town of Elkhorn, Montana, about 0.5 mile (0.8 km) beyond the study area, is near the district's center.

History and production

Prospecting and small-scale placer mining was underway in the Elkhorn district by the late 1850's. Numerous lode locations were made prior to 1870, but the district came into prominence after production began at the Elkhorn mine in 1875. In its day, the Elkhorn, which is outside the study area, was among the most important silver mines in the region.

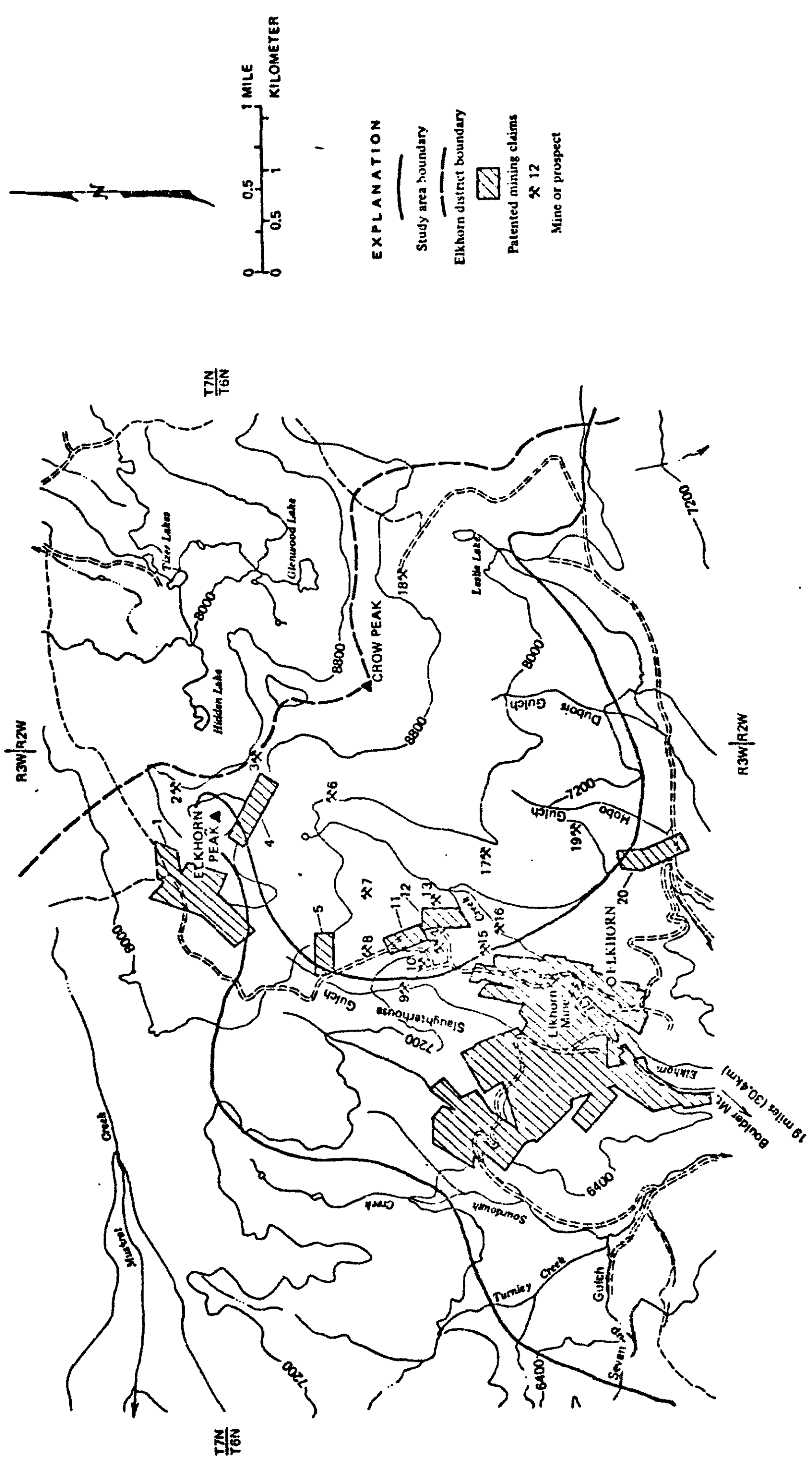


Figure 17.--Elkhorn district

An unnumbered table to accompany fig. 17, Elkhorn district

Mines and prospects in the Elkhorn district.

1. Iron mine
2. Elkhorn Ridge prospect
3. South Hidden Lake prospect
4. High Grade and Percy Lodes
5. Lone Bear prospect (Sport Lode)
6. Queen Ann claim
7. High Up claim
8. North Louise prospect
9. Union mine
10. Golden Moss mine
11. Louise and Side Issue Lodes
12. C and D mine
13. Steve claim
14. Eclipse claim
15. Arcturus claim
16. Elkhorn Creek prospect
17. Blackbird claim
18. Skyline mine
19. Hobo Gulch prospect
20. Eagle Hill and Iron Bar Lodes

The only smelter in the Elkhorn district treated ores from the C and D mine. Weed (1901, p. 413) reports that $37,817 worth of gold and silver bullion were produced from 1886 to 1888. In 1889, the Northern Pacific Railroad (Burlington Northern) built a spur from Boulder, Montana, to the town of Elkhorn, making it possible to ship silver-lead ores by rail to smelters and markets outside the district.

Production from Elkhorn district mines lying within the study area was 2,249 tons (2,040 t) of ore between 1902 and 1960. This ore yielded 670 ounces (20,839 g) gold, 10,774 ounces (335,104 g) silver, 2,043 pounds (927 kg) copper, and 91,635 pounds (41,565 kg) of lead. Additionally, several thousand tons of siliceous iron-oxide ore from the Iron, and C and D mines were shipped to the East Helena, Montana, smelter for use as flux (fig. 17, Nos. 1 and 12).

Present interest in the study area is centered around the Skyline mine near Leslie Lake where 27 claims of the Woodcock group were located in 1977 (fig. 17, No. 18). Records show that about 240 lode claims have been staked in the study area; twelve patented lode claims are in, or partially in, it.

Economic geology

The southern Elkhorn Mountains are a thick sequence of folded and faulted sedimentary and layered volcanic rocks which have been intruded by quartz monzonite and granodiorite. The sedimentary strata consist of limestone, dolomite, sandstone, and quartzite interlayered with shale. They dip generally eastward and are overlain by andesitic volcanic rocks.

At the Elkhorn mine, galena, tetrahedrite, pyrite, and sphalerite are associated with quartz in replacement deposits along bedding planes in dolomitic marble. Some deposits are also localized in crushed zones on the undersides of anticlinal folds in shale.

Contact replacement deposits at the Iron mine on the north side of Elkhorn Peak consist of lenses of magnetite, limonite, chalcopyrite, and garnet. The lenses are in andesite near the contact between the andesite and marble.

Before 1900, the Iron mine produced several thousand tons of ore which was used as flux at the East Helena smelter. Between 1908 and 1915, 256 tons (232 t) of ore from the mine yielded 10 ounces (310 g) gold, 2,924 ounces (90,945 g) silver, and 190 pounds (86 kg) of copper. An estimated 4.2 million tons (3.8 million t) of remaining resources may contain 0.03 ounce gold per ton (1.0 g/t), 0.2 ounce silver per ton (6.9 g/t), 0.15 percent copper, and 28.7 percent iron.

A breccia pipe occurs at the Skyline mine. The pipe consists of brecciated, altered andesite, which is cemented and partially replaced by quartz, tourmaline, pyrite, arsenopyrite, galena, sphalerite, and sparse chalcopyrite.

During exploration, 4 tons (3.6 t) of material from the pipe yielded 1 ounce (31.1 g) gold, 26 ounces (809 g) silver, 400 pounds (180 kg) lead, and 300 pounds (135 kg) of zinc. The prospect is estimated to contain 100 tons (91 t) of resources that average 0.07 ounce gold per ton (2.4 g/t), 2.2 ounces silver per ton (75.4 g/t), 1.8 percent lead, and 0.8 percent zinc.

A low-grade porphyry-type molybdenum-copper occurrence is in granitic rocks south and west of the town of Elkhorn (Senter, 1976). Similar granitic rocks are in the study area near the head of Turnley Creek.

The C and D has been the most productive mine in the study area. Since 1902, 1,960 tons (1,778 t) of ore yielded 641 ounces (19,937 g) gold, 7,734 ounces (240,551 g) silver, 824 pounds (374 kg) copper, and 91,235 pounds (41,383 kg) of lead.

Park district

Setting

The part of the Park mining district within the Elkhorn wilderness study area is drained by Crow Creek, the South Fork Crow Creek, and their tributaries, Dewey, Eureka, Eagle, Warner, and Swamp Creeks (fig. 18). The district is about 14 miles (22.4 km) west by dirt road from Townsend, Montana. About 33 miles (53 km) of unmaintained roads are within and along the eastern boundary of that part of the district within the study area.

History and production

Gold placer deposits along Crow and Eureka Creeks in the study area were discovered in the 1860's. They were intensively mined for 10 to 15 years after discovery and intermittently until the 1900's. Lode mines, mainly those outside the study area, including the Park, were discovered in 1870 and operated until the 1960's. The most productive period was 1870 to 1943. Klepper and others (1971, p. 34) estimated that $900,000 worth of placer and lode gold and silver were produced from the greater Park mining district from 1864 until 1900, before records were kept. Recorded production from the greater Park mining district is 85,855 tons (77,888 t) of ore containing 45,306 ounces (140,900 g) gold, 268,877 ounces (8,363,906 g) silver, 74,409 pounds (33,484 kg) copper, 3,707,704 pounds (1,677,890 kg) lead, and 3,728,645 pounds (1,677,890 kg) of zinc, valued at about $2.7 million between 1901 and 1968.

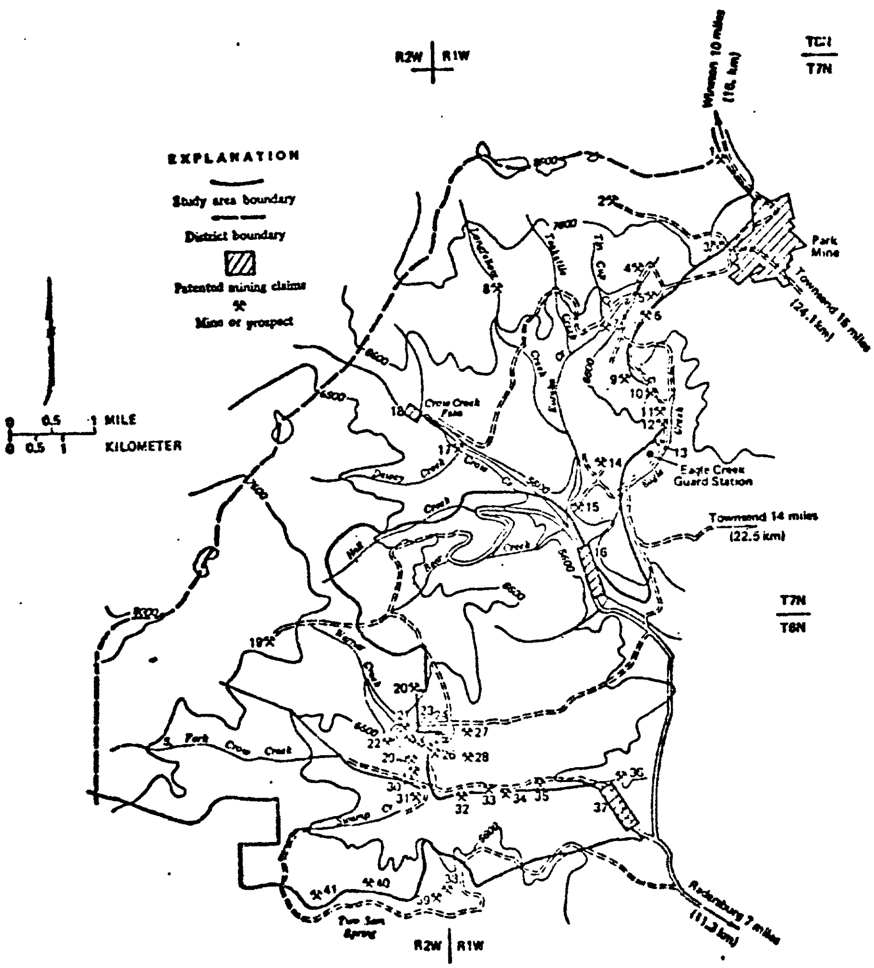


Figure 18. Park district.

An unnumbered table to accompany fig. 18, Park district

Mines and prospects shown on figure 18.

1. Mountain Dude Lode
2. Vulture mine
3. Jawbone Lode mine
4. Little Jim Nos. 1-5 claims
5. Salt Lick prospect
6. Eureka Creek divide prospect
7. McFadgen mine
8. Longfellow Creek prospect
9. Golden Hope Nos. 1 and 2 claims
10. Cross claim group
11. Eagle mine
12. Roadside prospect
13. Mamouth Lode mine
14. Eagle Station prospect
15. Lower Eureka Creek prospect
16. Hull and Zenith Placers
17. Dewey Creek prospect
18. Hawkeye placer
19. Ann Kinzer mine
20. Longhorn claim
21. Silver Hope prospect
22. LS prospect
23. Alba claim
24. UP prospect
25. Old Faithful prospect
26. QM prospect
27. Jenkins Gulch prospect
28. Last Hour prospect
29. Warner Creek prospect
30. Lower Warner Creek prospect
31. Swamp Creek prospect
32. Mid Nite No. 2 claim
33. Mid Nite No. 1 claim
34. Homestead prospect
35. Eck-O claim
36. Snowshoe prospect
37. Silverine and Wasp Lodes
38. Bonanza mine
39. Ridge prospect
40. East Summit prospect
41. Summit prospect

There is no estimate of lode and placer production from mines within the study area before 1901, and no record of placer production after 1901. Recorded lode production between 1901 and 1968 totals 227 tons (206 t) of ore that contained 78 ounces (2,426 g) gold, 16,626 ounces (517,118 g) silver, 283 pounds (128 kg) copper, 78,422 pounds (35,571 kg) lead, and 400 pounds (181 kg) of zinc worth $14,799. Study area mines that have recorded production include the Vulture, intermittently operated before 1901 until the present; the Mamouth Lode, intermittently operated from 1907 until 1923; the Eagle, mined and prospected from 1900 until the present; the Jawbone Lode, reportedly mined on a moderate scale before 1900 and mined and prospected intermittently since; the Ann Kinzer mine, mined on a small scale in the 1940's; and the McFadgen, from which a small amount of ore was produced in the 1950's (fig. 18, Nos. 2, 13, 11, 3, 19, and 7).

Broadwater County records indicate 320 lode mining claims in the Park district portion of the study area. The first claim was recorded in 1871, and the most recent in 1977. Most of the lode claims were located between 1880 and 1910 and are along Eureka, Eagle, and the South Fork Crow Creeks. Five were located in the 1970's, and 11 are currently being held. The Mamouth, Mountain Dude, Jawbone, Silverine and Wasp, and Vulture Lode claims were located and patented between 1871 and 1936 (fig. 18, Nos. 13, 1, 3, 37, and 2).

Economic geology

The northern two-thirds of the Park district is underlain by andesitic flows and breccias, water-lain tuffs, and conglomerates. The southern one-third is underlain by quartzite, shale, chert, and limestone. The rocks are faulted, fractured, sheared, and have been intruded by andesitic to granitic rocks.

Mineral occurrences in the district are of four types: (1) lenses along thick, persistent zones of fracturing and shearing that crosscut andesite; (2) replacement deposits along a narrow, irregular bedding plane, and crosscutting fractures in sedimentary rocks; (3) shear zones in sedimentary rocks; and (4) lenses in shear zones in granitic intrusions. All occurrences are related directly to structures and mineral solutions formed during emplacement of the intrusive rocks.

The lenses in andesite are along shear zones that average 10 feet (3 m), and may be as much as 37.5 feet (11.4 m), thick. They trend N. 30° E. to S. 60° E. and dip 65 to 90 degrees. The zones are usually composed of alternating bands of brecciated, leached, silicified, iron-oxide-stained andesite and vuggy, white quartz. Generally, the andesite breccia and wallrock contain disseminated pyrite, and the quartz contains disseminations as well as streaks and blebs of sulfide minerals. Five mineral occurrences in andesite, the Ann Kinzer mine, Cross claim group, Golden Hope Nos. 1 and 2 claims, McFadgen mine, and Salt Lick prospect, are estimated to contain resources totaling 729,000 tons (660,000 t) (fig. 18, Nos. 19, 10, 9, 7, and 5). The zone at the Ann Kinzer, the most significant, has resources estimated to be 180,000 tons (163,296 t) that average over $90 in gold, silver, copper, and lead per ton ($99/t).

Lenses in fractures and shear zones as well as replacements in sedimentary rocks generally are near intrusive rocks. They are as much as 4 feet (1.2 m) thick, and average 1.8 feet (0.5 m). They strike N. 55° E. to N. 10° W. and dip 45° NW. to 45° SE. Generally, the zones are small and irregular and are composed of bands of brecciated, leached, silicified, gossany quartzite or limestone, and vuggy, white quartz that contains streaks and blebs of sulfide minerals. Four occurrences of this type are thought to have resource potentials. One, the Lower Eureka Creek prospect, is estimated to contain a resource of about 10,500 tons (9,500 t) averaging over $40 in gold, silver, lead, and zinc per ton ($44/t) (fig. 18, No. 15).

Mineralized shear zones in quartz monzonite occur at the Snowshoe and two other prospects in the district (fig. 18, No. 36). They are not indicated to have any mineral resource potential.

Geologic indicators, such as the thick, persistent zones of fracturing and shearing near intrusive rocks and samples, suggest a high potential for the discovery of resources in the Park district.

Tizer-Wilson district

Setting

The Tizer-Wilson district includes the Tizer, Wilson, Little Tizer, and Crazy Creek drainages, as well as the part of Prickly Pear Creek within the study area (fig. 19). The district is about 6 miles (9.6 km) east by jeep road from Jefferson City, and about 16 miles (25.6 km) east by road and trail from Townsend, Montana. Within the district are about 20 miles (32 km) of roads.

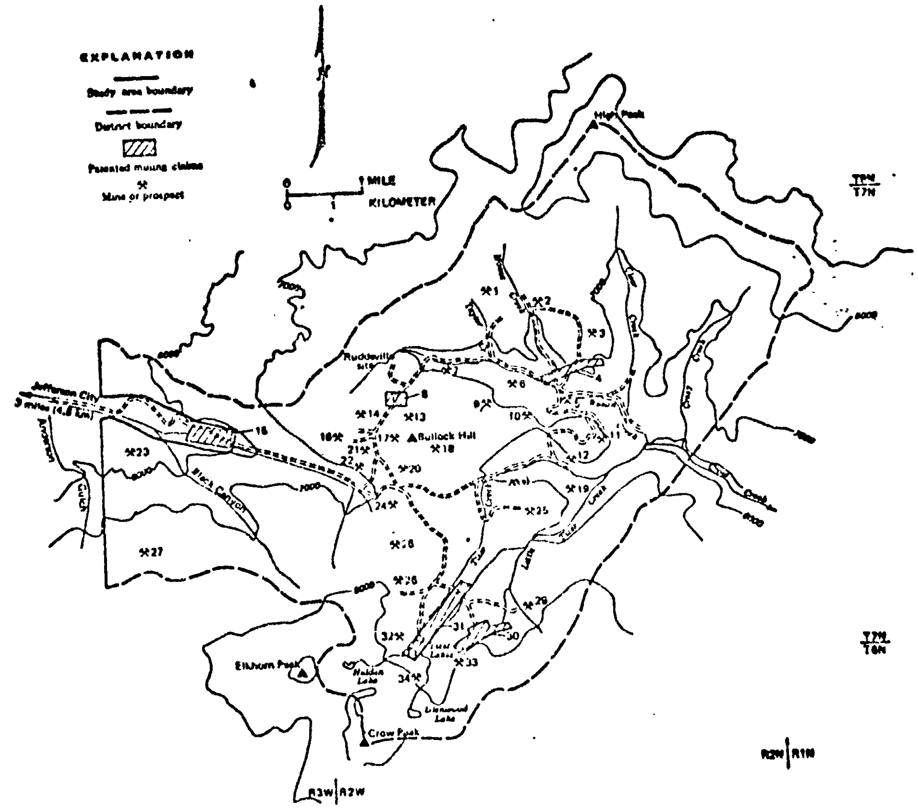


Figure 19. Tizer-Wilson district.

An unnumbered table to accompany fig. 19, Tizer-Wilson district

Mines and prospects shown on figure 19.

1. Moonlight claims
2. Gold Series (Big Mary) claim
3. Moose Creek divide prospect
4. Belle, Best, and Last Lodes
5. Golden Age mill
6. Beaver Pond prospect
7. Upper Wilson Creek prospect
8. Mastodon Lodes
9. Northeast prospect
10. Beckley prospect
11. Callahan mine
12. Big Tizer-Wildcat prospect
13. Northwest prospect
14. Saint Joseph claim
15. Wisconsin Placer
16. Zalinski prospect
17. West Ridge prospect
18. Top prospect
19. Tizer divide prospect
20. Road Junction prospect
21. Cabin prospect
22. Doe prospect
23. Andy claim group
24. Mercury and Misery claims
25. Upper Manley Park prospect
26. American Eagle claim
27. Anderson Gulch prospect
28. Ohio claim
29. Little Tizer-Wildcat mine
30. Ballard mine
31. Woodland Park Placer
32. J.C. Copper claim
33. Blackjack prospect
34. Upper Tizer Lake prospect

History and production

Gold placer deposits were being mined, and the mining community of Ruddsville at the head of Wilson Creek was settled by 1858 (Stone, 1911, p. 76). No record of production exists, but based on the number, size of workings, and sample results, an estimated 2,530 ounces (78,691 g) of gold has been produced from placers along Tizer and Wilson Creek.

The Ballard mine (fig. 19, No. 30) began in 1906; this was the district's first recorded production. The Ballard produced intermittently from 1906 to 1940. In 1921, the Callahan mine started and continued mining and milling ore until 1951 (fig. 19, No. 11). The Gold Series claim recorded some small production in the 1930's (fig. 19, No. 2). Total recorded lode production in the Tizer-Wilson district is shown in table 9.

Jefferson County records indicate 360 lode claims were located in the Tizer-Wilson district between 1878 and 1977. Most lode claims located prior to 1970, mainly in the 1890's and 1930's, were along the divide between Wilson and Tizer Creeks, along Moose Creek, and at the head of Tizer and Little Tizer Creeks. After 1970, claim locations were concentrated on the south side of Prickly Pear Creek between Golconda Creek and Black Canyon. In 1973 and 1976, a major mining company located 73 claims in that part of the study area, and in 1977 they diamond drilled potential molybdenum-copper deposits just west of the study area boundary. Since 1970, 88 lode claims have been located in the district; at least 84 are currently held. The Belle, Best, and Last Lodes, Ballard mine (Loon, Center Reef, Policy, and Black Bear Lodes), and two Mastodon Lode claims were located and patented between 1905 and 1926 and are still privately-owned.

Economic geology

The eastern two-thirds of the district, the part drained by Tizer and Wilson Creeks, is underlain by tuff, breccia, and flows of andesitic composition. In places, the volcanics have been intruded by andesite and diorite porphyries. Thin, glacial deposits cover the volcanic rocks over most of the district, and particularly along the gently sloping areas dividing Tizer and Wilson Creeks from Prickly Pear Creek. Stream action has sorted and reworked deposits along Tizer, Little Tizer, and Wilson Creeks. The western one-third of the district, the part drained by Prickly Pear Creek, is underlain by quartz monzonite and related rocks. The contact between the volcanic rocks and the quartz monzonite roughly follows the Prickly Pear-Wilson Creek divide.

Table 9.--Recorded production from the Tizer-Wilson district.

[--, none recorded]

Year	Number of Producers	Ore (tons) 1/	Gold (ounces) 1/	Silver (ounces) 1/	Copper (pounds) 1/	Lead (pounds) 1/	Zinc (pounds) 1/	Value (dollars) 2/
1906	1	43	204	468	--	2,113	--	$ 4,549
1907	1	120	1,158	3,000	--	--	--	25,526
1908	1	216	860	2,011	--	3,982	--	19,001
1909	1	27	52	283	--	426	--	1,242
1910	1	24	34	206	--	386	--	827
1911	1	29	32	177	--	813	--	785
1913	1	2	6	18	--	149	--	141
1915	1	18	17	63	--	--	--	382
1921	1	3	2	1	--	--	--	42
1923	2	17	42	60	34	589	--	953
1924	3	53	75	254	--	1,478	--	1,839
1926	1	23	40	58	--	765	--	924
1927	1	1	3	12	--	330	--	92
1931	2	41	37	90	18	--	--	792
1932	1	34	49	25	16	--	--	1,723
1933	1	18	43	37	31	487	--	1,540
1934	2	13	18	31	25	162	--	677
1935	1	9	13	18	--	50	--	484
1936	1	4,170	1,323	1,060	217	11,109	--	47,650
1937	2	1,402	571	276	25	1,700	--	20,369
1938	2	1,856	363	465	1,082	1,978	--	13,097
1939	2	670	269	628	405	3,681	--	9,885
1940	1	1,125	264	400	640	4,168	--	9,665
1941	1	300	746	831	2,742	12,249	--	27,460
1942	2	346	832	1,461	1,793	22,673	--	31,856
1943	1	140	301	848	1,083	5,436	--	11,927
1944	1	81	248	855	1,457	4,664	--	9,566
1945	1	287	116	121	105	355	314	4,185

Year	Number of Producers	Ore (tons) 1/	Gold (ounces) 1/	Silver (ounces) 1/	Copper (pounds) 1/	Lead (pounds) 1/	Zinc (pounds) 1/	Value (dollars) 2/
1946	1	285	438	298	82	1,401	--	$ 15,617
1947	1	90	63	34	20	139	--	2,255
1948	1	130	28	5	--	--	--	984
1949	1	127	172	216	135	1,865	525	6,563
1950	1	74	206	212	89	1,035	69	7,530
1951	1	100	201	220	180	2,722	686	7,870
Totals		11,874	8,826	14,742	10,179	86,905	1,594	$287,998 3/

1/ Metric conversions: tons x 0.9072 = tonnes; ounces x 31.103 = grams; pounds x 0.45 = kilograms.
2/ Value calculated using prices paid for metals at the time of production.
3/ Estimated to be worth about $1,415,695 at current metal prices.

Most of the district's ore came from narrow shear zones in the volcanic rock underlying the eastern two-thirds of the district. At the surface, the zones consist of free-milling, gold- and silver-bearing, iron-oxide-stained bands of gouge, altered pyrite-bearing andesite, and vuggy quartz lenses. The wallrock, in most places, is pyrite-bearing andesite. At the surface, most of the pyrite has been leached, leaving gossan and limonite pseudomorphs after pyrite. Below the oxidized zone, the quartz lenses contain pyrite, galena, sphalerite, chalcopyrite, and sparse gold and tetrahedrite. Ore shoots are small and generally confined to the oxidized portions of the shear zones. The metal content of the unoxidized material is distinctly lower than that of the oxidized material.

The shear zone occurrences examined are as much as 6 feet (1.9 m) thick and trend from N. 55° E. to S. 50° E. Only two have known resources. The Ballard and Little Tizer-Wildcat mines are estimated to have resources of about 280,000 tons (256,000 t) that average 0.10 ounce gold per ton (3.4 g/t) (fig. 19, Nos. 30 and 29). Seven other prospects may have resource potential.

Other metallic mineral occurrences in the district's volcanic rocks consist of four contact zones between volcanic and intrusive rocks, and one breccia pipe in andesite. The contact zones are as much as 1,300 feet (396 m) thick, and the breccia pipe has a maximum diameter of 100 feet (30.5 m). Little subsurface work has been done on the contact zones and breccia pipe; most material sampled was leached and had a low metal content. One contact zone has known resources. The J. C. Copper claim is estimated to contain resources of about 5,000 tons (4,500 t) of material that average 2.7 percent copper and 0.41 percent zinc (fig. 19, No. 32).

A porphyry-type mineral occurrence is in the granitic rocks underlying the western one-third of the district, but is outside the study area. Past interest in occurrences in granitic rocks centered on the large, single or multiple veins minable by underground methods. These veins contain pyrite, chalcopyrite, galena, sphalerite, and arsenopyrite. They were mined for their gold, silver, copper, lead, and zinc contents. The porphyry-type occurrences being explored are of interest primarily because of their molybdenum content, although some copper, silver, and gold are also present. The known mineral occurrences in granitic rocks in in the district are not significant, but limited data suggest that extensions of the molybdenum porphyry-type occurrence to the west, or similar occurrences, may exist within the study area.

Surface samples connote little or no mineral resource potential. However, these surface samples were of leached material and may not be indicative of metal content at depth. Enough of them had sufficient content to indicate a high mineral resource potential at depth.

Warm Springs district

Setting

The Warm Springs mining district described in this report includes parts of the Alhambra-Warm Springs and McClellan-Mitchell Creek districts described by Roby in 1960. The district includes the area drained by the headwaters of Dutchman, Middle and South Forks Warm Springs, McClellan, East Fork McClellan, and Jackson Creeks (fig. 20).

Except for a single jeep trail from the Middle Fork Warm Springs Creek to the South Fork, access within the study area is by foot trail or cross-country travel. Access to the area is by road from Clancy and East Helena, Montana.

History and production

Small-scale prospecting and placer mining began in the 1850's, but intensive prospecting did not follow until 1864.

None of the district's prospects within the study area has had recorded production. Roby (1960, p. 17 and 73) reports that between 1902 and 1957 district mines outside the study area produced 80,380 tons (72,920 t) of ore that yielded $697,163 worth of gold, silver, copper, lead, and zinc. Most of this was apparently from the patented claims near the boundary.

County records show that between 1878 and 1977 only 21 identified lode claims were located within the study area; a large number of vaguely-described claims may have been within it. Most of the lode claims were near the head of the Middle Fork Warm Springs Creek.

The Golden Dollar prospect (fig. 20, No. 12) is being explored. Small-scale exploration and development work is underway on patented claims outside the study area, near the head of the Middle Fork Warm Springs Creek. Indications are that these mineralized structures do not extend into the study area.

A major mining company is exploring a group of claims in the Dutchman Creek drainage, which is on the northwest edge of the study area. Although the claims extend into the study area, all active exploration and drilling have been well outside of it.

Economic geology

The district's northwest area is mainly underlain by quartz monzonite and related rhyolitic flows and intrusions. The southeast area is mainly underlain by andesitic volcanic rocks and related andesitic and basaltic intrusions.

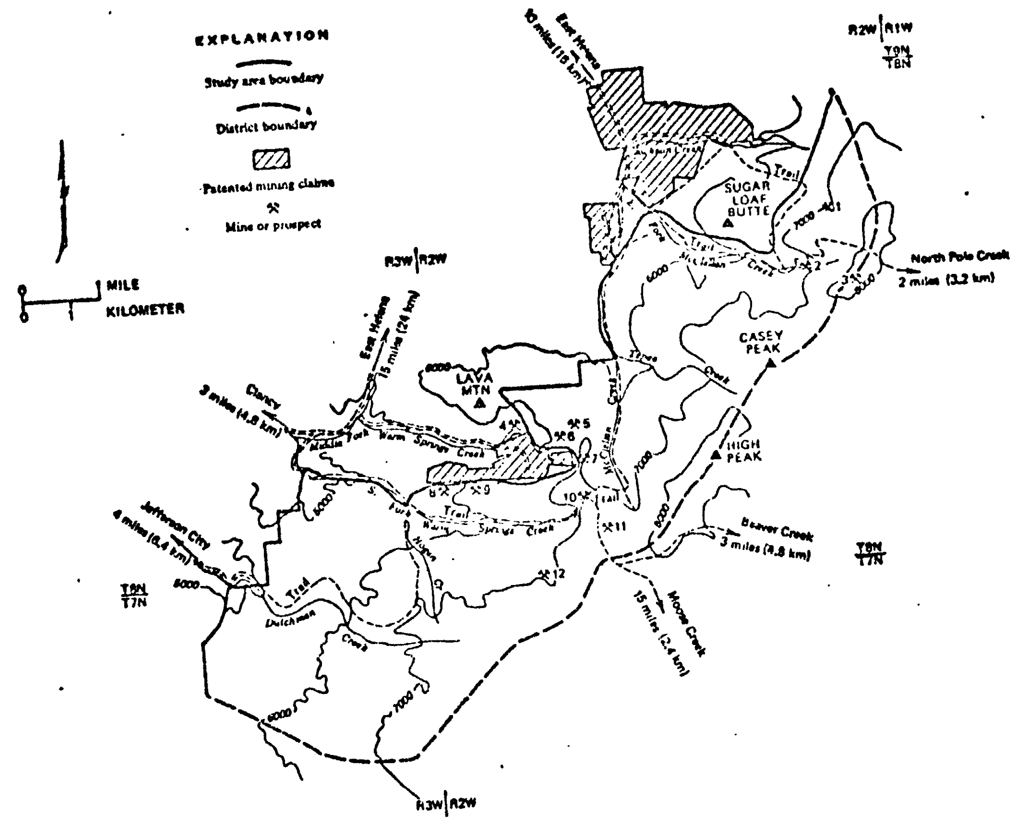


Figure 20. Warm Springs district.

An unnumbered table to accompany fig. 20, Warm Springs district

Mines and prospects shown on figure 20.

1. Mayflower claim
2. Casey Meadows prospect
3. High Ridge prospect
4. Lava Mountain prospect
5. Maverick prospect
6. Black Bear claim
7. South Black Bear prospect
8. Cabin prospect
9. Borderline prospect
10. Springs prospect
11. Upper McClellan Creek prospect
12. Golden Dollar prospect

Production from the greater Warm Springs district has been chiefly from east-west-trending, nearly-vertical, quartz veins in quartz monzonite. Ore minerals include pyrite, chalcopyrite, galena, sphalerite, and arsenopyrite (Roby, 1960, p. 17). There is no recorded production from deposits in the andesitic volcanics and related rocks.

Seven prospects are in quartz monzonite country rock. Only the Black Bear (fig. 20, No. 6) seems to have a resource potential. Of five prospects in the andesitic volcanics and related rocks, only the Casey Meadows (fig. 20, No. 2) may have a resource potential.

PLACERS

Wilson Creek

The Wilson Creek placers include gold-bearing gravel on Wilson, Moose, and Clear Creeks. The head of Wilson Creek is about 9 miles (14.4 km) east, by jeep road, from Jefferson City, Montana. The area drained by Wilson Creek and its tributaries is a gently east-sloping basin in low hills. The creek begins at 7240 feet (2206 m) elevation and joins Crow Creek 4.5 miles (7.2 km) downstream at approximately 6000 feet (1829 m). The overall stream gradient is about 275 feet per mile (52 m/km). In its higher regions, Wilson Creek has a gradient too low to transport gold. Within a mile (1.6 km) of the confluence of Wilson and Crow Creeks, there is a sharp gradient increase.

Seventy-eight placer claims were located between 1878 and 1976, with placer activity intense during the 1850's, 1860's, 1890's, 1900's, 1930's, and 1940's. In intervening and recent years, it has been sporadic or non-existent. Much early placer mining was in upper Wilson Creek's stream reworked glacial deposits. Major sluicing was carried on in the vicinity of the old town of Ruddsville. In 1947, a dry-land dredge (dragline and trommel) was used to work part of the creek above the Middle Creek Meadows. Currently this equipment is being repaired for future use.

Most of Wilson Creek's placer production was unrecorded; however, it is estimated to have been about 2,500 ounces (77,756 g) gold. This estimate is based on the volume of material mined, and the average gold content of samples from deposits remaining in the vicinity of the workings. No placer mining is currently underway, but exploration trenching is in progress along upper Wilson Creek and near the junction of Wilson and Crow Creeks.

The placers are mainly stream reworked, moderately-sorted glacial deposits, composed of gravel, silt and sand, and boulders as much as 20 inches (51 cm) in diameter. The alluvium has formed terraces from 14 to 40 feet (4 to 12 m) thick that were deposited in ponds and small lakes formed behind beaver and ice dams. These terraces are dissected by Wilson Creek and its tributaries. The alluvium and colluvium accumulations adjoining upper Wilson Creek on Bullock Hill have been explored for placer and residual gold deposits. Klepper (1957, p. 73) reports that the placer gold along the middle and upper sections of Wilson Creek is probably from the narrow veins along the andesite and quartz monzonite contact on the west side of Bullock Hill. Lower Wilson Creek placer gold probably came from veins at the Callahan mine.

Based on an average thickness of 15 feet (4.6 m), about 16 million cubic yards (12.2 million m^3) of gold-bearing gravel is estimated to occur along Wilson Creek and its tributaries. Samples from upper Wilson Creek had the highest content. They contained as much as 225.9 cents gold per cubic yard (295.5 cents/m^3) and averaged 25.4 cents per cubic yard (33.2 cents/m^3). Middle and lower Wilson Creek samples had as much as 12.2 cents gold per cubic yard (16 cents/m^3), but averaged much less. None of the samples from Moose or Clear Creeks contained gold in significant amounts.

Sampling shows the upper Wilson Creek alluvium and gravel to be a potential placer gold resource. Further work is warranted to outline minable deposits.

Tizer Creek

Tizer Basin lies about 10 miles (16 km) east of Jefferson City, Montana. Basin elevations range from 6000 feet (1829 m) at the mouth of Wilson Creek to 8200 feet (2499 m) near the head of Little Tizer Creek. Tizer Creek has an overall gradient of 286 feet per mile (51 m/km); however, the gradient in the upper 1.5 miles (2.4 km) is 133 feet per mile (25 m/km).

Small-scale placer mining began before 1900 from the mouth of Little Tizer Creek upstream for about 2 miles (3.2 km). Only gravel immediately adjacent to the stream was worked.

The 142.3-acre (57.6-h) Woodland Park Placer claim was located and patented in 1889 by Byron F. Wood. The claim extends from upper Tizer Lake northeasterly for 6,540 feet (1,993 m) along the east side of Tizer Creek. Gravel for a distance of 1 mile (1.6 km) below Tizer Lakes has been worked on a small scale by hydraulic mining methods.

Production from the Tizer-Little Tizer Creeks area is unrecorded. However, approximately 22,000 cubic yards (17,000 m^3) of gold-bearing gravel is estimated to have been mined from the Woodland Park claim. Based on samples that averaged 20 cents gold per cubic yard (26 cents/m^3), the area's production is estimated to have been about 30 ounces (933 g) of gold.

Approximately 3,000 acres (1,214 h) were claimed (Patricia Nos. 1-10 and Valerie Nos. 1-10) as placer ground in 1976 by Ira M. Tillotson and others, Helena, Montana. The claims cover nearly all of Tizer and Little Tizer Creeks as well as lower Wilson Creek, and the upper 3 miles (4.8 km) of Crow Creek. The claimants were actively sampling gravel along Tizer Creek in 1977.

Most of the area is underlain by glacial drift overlying andesite. Glaciers deposited the drift in their retreat southward to the vicinity of Elkhorn and Crow Peaks. Glacial debris fills the valleys of Tizer and Little Tizer Creeks nearly to their confluence. Below that point, Tizer Creek and its successor, Crow Creek, flow through a narrow bedrock canyon, first in volcanic rocks, then in sandstone and shale.

Ponding and sluggish drainage in Tizer Basin result from the presence of impermeable till which forms the substratum of the glacial blanket. A relatively thin layer of glacial outwash lies over the till, and it contains gold. The outwash layer is as much as 16 feet (4.9 m) in thickness, averaging 8 feet (2.4 m). The outwash gravel is poorly sorted and contains boulders as much as 3 feet (0.9 m) in diameter.

Gravel exposed by Tizer and Little Tizer Creeks has been explored by numerous shallow pits, trenches, and ditches. Hydraulic placer mining on the Woodland Park claim has resulted in a pit 300 feet (91 m) long and 200 feet (61 m) wide. Sluicing along lower Tizer Creek has widened the stream channel to an average width of about 100 feet (30 m).

Five areas of water-lain gravel of significant thicknesses have been exposed by stream action. A deposit just below the outlet of lower Tizer Lake contains approximately 313,000 cubic yards (239,000 m^3) of gravel that is shown by sampling to contain 20 cents gold per cubic yard (26 cents/m^3). Four other deposits along Tizer Creek contain approximately 872,000 cubic yards (667,000 m^3) of gravel, which probably contain less than 4 cents gold per cubic yard (5 cents/m^3).

Approximately 2,390 acres (967 h) in Tizer Basin are covered by at least 8 feet (2.4 m) of glacial outwash on top of unsorted till. The outwash's average gold content is probably less than 1 cent per cubic yard (1.3 cents/m^3).

Gold is concentrated in reworked glacial outwash along streams. Samples of this material contained as much as 106 cents gold per cubic yard (139 cents/m^3), but deposits are small and scattered. Possibly, at selected sites, small-scale placer mining might be economically feasible; however, large operations would probably not succeed because of low average gold content.

Crow Creek

Crow Creek, formed by Tizer and Wilson Creeks, is in the east-central part of the study area. It flows southeastward to the Missouri River. The upper 5 miles (8 km) of Crow Creek are within, or along, the boundary of the study area. The upper 3 miles (5 km) flow through a narrow canyon which is as deep as 800 feet (244 m). The gradient of Crow Creek between Wilson and Eagle Creeks averages 50 feet per mile (28 m/km).

Most Crow Creek placer mining was done prior to 1870. Numerous pits, trenches, and diversion ditches exist from Wilson Creek to Crow Creek Falls. An estimated 30 placer claims were located on Crow Creek and its tributaries. The Hull and Zenith placers at the mouth of Eagle Creek were located by Henry G. McIntire in 1895 and patented in 1897 (fig. 18, No. 16). The Hawkeye placer at Crow Creek Falls was patented at about the same time (fig. 18, No. 18). Dingman (1932, p. 21) states that about $500,000 worth of gold was recovered from placers along Crow Creek, mainly from those below the mouth of Eagle Creek. Placer production from within the study area is unrecorded.

Present activity consists of recreational prospecting. A suction dredge operated at Crow Creek Falls in 1977.

Gravel deposits cover the bed of upper Crow Creek, downstream as far as Crow Creek Falls. They consist mainly of poorly-sorted outwash, with boulders as much as 4 feet (1.2 m) in diameter. The deposits are estimated to average 6 feet (1.8 m) in thickness and to contain 1 million cubic yards (765,000 m^3) of gravel.

Seventeen samples were taken from upper Crow Creek; six contained as much as 177 cents gold per cubic yard (232 cents/m^3) and averaged 6.7 cents gold per cubic yard (8.8 cents/m^3).

The only significant alluvial deposits occur below the mouth of Hall Creek. They are estimated to average about 4 feet (1.2 m) in thickness and to contain at least 313,000 cubic yards (239,000 m^3). Six samples from the Hawkeye placer, in the vicinity of Crow Creek Falls, averaged 39.3 cents gold per cubic yard (51.4 cents/m^3). Six samples from the Hull and Zenith placers contained no gold.

Samples from Eureka and Eagle Creeks had insignificant amounts of gold.

In recent stream gravels, significant gold content is found only in small and scattered deposits.

Prickly Pear Creek

The Wisconsin Placer claim was located in 1890 by Cora E. Wood and patented in 1892 (fig. 19, No. 15). The 107.7-acre (43.6-h) claim lies just beyond the study area. Seven samples from the Wisconsin Placer contained as much as 10.2 cents gold per cubic yard (13.3 cents/m^3), and averaged 5.4 cents per cubic yard (7.1 cents/m^3).

The most significant Prickly Pear Creek gravel deposits are outside the study area. However, a thin veneer of glacial gravel extends upstream from the Wisconsin Placer into the study area. This material is estimated at 720,000 cubic yards (551,000 m^3), and it averages less than 10 cents gold per cubic yard (13 cents/m^3).

Other areas

As much as 1.4 million cubic yards (1.1 million m^3) of gravel is estimated to lie along the section of South Fork Crow Creek within, or adjacent to, the study area. Sampling, however, indicates that gold content is too low to be significant.

An estimated 420,000 cubic yards (321,000 m^3) of glacial gravel is along the sections of Badger, Staubach, Beaver, and South Fork Beaver Creeks within the study area. Samples indicate little placer gold resource potential.

The sections of Jackson, McClellan, Dutchman, and Middle and South Fork Warm Springs Creeks within the study area have no significant volumes of potential placer gravel.

Placer claims totaling 160 acres (65 h) in the Ninety-Cent, Slaughterhouse, and Queen Gulches, and in the Elkhorn and Sourdough Creek drainages were patented by L. G. Turnley and others in 1883. The patented claims are not in the study area; no significant volumes of potential placer gravel occur along sections of these streams that are within the Elkhorn district.

MINERAL COMMODITY HIGHLIGHTS

The principal mineral commodities in the Elkhorn wilderness study area are gold, silver and lead. Secondary mineral commodities include copper, zinc, iron, and molybdenum. Most deposits that were mined consisted of fissure vein, lens, and contact replacement deposits which were oxidized and enriched in gold to a depth greater than 100 feet (30.4 m). They contained free gold and silver and secondary iron, copper, lead, and zinc. Below the oxidized zone, small amounts of sulfide minerals, principally pyrite, galena, sphalerite, chalcopyrite, and arsenopyrite occur.

Nonmetallic resources, principally limestone and sand and gravel are within the study area. These deposits, although sizable, are not of economic importance, because there are supplies closer to markets.

Prices and supply and demand data are from Bureau of Mines Commodity Data Summaries 1977, except where noted.

Gold

In 1977, the United States produced an estimated one-quarter of the 4.6 million troy ounces (143.1 million g) of gold the nation consumed. Approximately 33 percent of all domestic production was as a byproduct of base-metal mining operations, chiefly copper. Major consumption was in jewelry, art, industry, and dentistry. Most gold imported between 1973 and 1976 came from Canada, Switzerland, and the U.S.S.R. The United States has an estimated 110 million troy ounces (3.4 billion g) of gold in ore reserves. Gold demand in the United States is expected to increase through 1985 at an annual rate of approximately 4 percent. Gold prices ranged from $136.10 per troy ounce ($4.38/g) in January to $165.70 per troy ounce ($5.33/g) in November of 1977. A gold price of $150 per troy ounce ($4.82/g) is used in this report.

Ore produced from deposits within the study area contained as much as 8 ounces of gold per ton (274.3 g/t) and averaged 0.65 ounce per ton (22.3 g/t). The largest producers were the Callahan and Ballard mines; most of the ore came from shear zone-vein type deposits that were mined underground. The gold was recovered from oxidized ore by simple gravity-amalgamation-cyanidization methods. Remaining resources contain gold-bearing sulfide minerals that will have to be mined by underground methods and concentrated by flotation methods. Forty study area prospects have potential gold resources.

Silver

In 1977, the United States produced an estimated 37 million troy ounces (1 billion g) of silver, about 22 percent of our estimated consumption of 165 million ounces (5.1 billion g). Appproximately 66 percent was a byproduct of base metal mining operations. Canada, Mexico, Peru, and the United Kingdom accounted for 85 percent of 1973-1976 imports. Photographic materials, sterling and electroplated ware, electrical, and electronic components accounted for most of the consumption. Estimated silver reserves in the United States are 1.5 billion ounces (47 billion g), including silver from base-metal ores. Demand is expected to rise at an annual rate of about 2 percent through 1985. The average price for the year was $4.60 per troy ounce ($0.15/g).

Ore from the study area contained as much as 33.2 ounces of silver per ton (1,138.3 g/t) and averaged 3.6 ounces per ton (123.4 g/t). Most of the area's silver was a byproduct of gold mining from vein deposits in shear zones in the Beaver Creek, Park, and Tizer-Wilson districts and as a primary commodity from replacement deposits in the Elkhorn district. The principal producers were the C and D, Callahan, and Ballard mines. Silver, from oxidized ore mined underground, was recovered by gravity and amalgamation methods. In the remaining resource, the silver content is generally lower and occurs in sulfide minerals that will require recovery by flotation methods. Mining will be mainly underground. Forty prospects in the study area have a silver resource potential.

Copper

In 1977, the United States produced an estimated 1.49 million short tons (1.35 million t). Consumption of refined copper was about 2.2 million short tons (2 million t). Canada, Chile, Peru, and Zambia accounted for 72 percent of 1973-1976 imports. Domestic reserves are estimated to be about 93 million short tons (84 million t). The domestic demand is forecast to increase through 1985 at an average annual rate of 3 percent. Copper prices ranged from 63.3 cents per pound ($1/39/kg) in January to 54.9 cents per pound ($1.21/kg) in November 1977.

Small quantities of copper were extracted from study area gold ore. The ore averaged 0.05 percent copper, and most of it was from the Callahan, Golden Moss, and C and D mines. Copper was not recovered until the adoption of flotation milling methods. Thirty-six prospects in the study area have copper resource potentials.

Lead-zinc

In 1977, the United States produced an estimated 589,000 short tons (534,000 t) of lead. Consumption was reported to be about 1.5 million short tons (1.4 million t). Canada, Peru, Mexico, and Australia accounted for 80 percent of 1973-1976 imports. The transportation industry was the major lead consumer, followed by batteries, gasoline additives, electrical, and ammunition. Domestic reserves are estimated to be about 28 million tons (25 t). Domestic demand is forecast to increase at an average annual rate of 1.8 percent through 1985. Lead prices ranged from 26 cents per pound (57 cents/kg) in January to 32 cents per pound (70 cents/kg) in October 1977.

In 1977, the United States produced an estimated 463,000 short tons (420,000 t) of zinc. Consumption was reported to be about 1.11 million short tons (1 million t). Construction materials, transportation equipment, electrical equipment, machinery, and chemicals accounted for most of the consumption. Major 1973-1976 zinc metal imports came from Canada, Australia, Japan, and Belgium-Luxembourg. Domestic reserves are estimated to be 30 million short tons (27.2 million t). Domestic demand is expected to increase at an annual rate of 2.6 percent through 1985. Lead prices ranged from 37 cents per pound (81 cents/kg) in January to 30.5 cents per pound (67 cents/kg) by the end of 1977. The ore mined in the study area averaged 1.2 percent lead and 0.03 percent zinc.

More than half of the lead produced in the study area came from lead oxides and carbonates selectively mined and hand-sorted from replacement deposits. The C and D mine was the largest producer. Lead and zinc were also recovered by flotation methods from the sulfide-bearing gold ore produced from the Callahan mine. Forty-one prospects in the study area have potential lead and 36 have potential zinc resources.

Molybdenum

In 1977, the United States produced an estimated 120 million pounds (55 million kg) of molybdenum. Consumption was reported to be about 54 million pounds (25 million kg). Transportation, machinery, oil and gas, and chemical industries were the major end users of molybdenum. Reserves in the United States are approximately 7.6 billion pounds (3.5 billion kg). Domestic demand is expected to increase through 1985 at an annual rate of about 5 percent. The price for molybdenum disulfide concentrates was $4.01 per pound ($8.82/kg).

The study area has produced no molybdenum; however, an outside porphyry-type molybdenum-copper occurrence in granitic rocks may extend into the study area. Samples from a study area prospect did contain molybdenum.

Iron

In 1977, the United States produced an estimated 57 million long tons (58 million t) of iron ore. Consumption was reported to be about 118 million long tons (120 million t). From 1973 until 1976, Canada Venezuela, Brazil, and Liberia were major import sources. U.S. demand is expected to increase through 1985 at an annual rate of about 2 percent. Ore averaging 51.5 percent iron was selling for $21.18 per long ton ($20.40/t).

Iron ore was produced for use as a flux at the East Helena smelter by the Iron mine between 1890 and 1900. Remaining material contains as much as 39.7 percent, and averages 28.7 percent, iron.

Nonmetallic commodities

Limestone, sand and gravel, dimension, and crushed stone resources occur in the study area but are considered to have no potential because alternate sources are closer to markets.

Economic considerations

Ore produced from the Elkhorn wilderness study area deposits contained as much as 8 ounces gold per ton (274.3 g/t), 33.2 ounces silver per ton (1,138.3 g/t), 3 percent copper, 2 percent lead, and 5 percent zinc. It averaged 0.65 ounce gold per ton (22.3 g/t), 3.6 ounces silver per ton (123.4 g/t), 0.05 percent copper, 1.2 percent lead, and 0.03 percent zinc. Production in recent years came from fissure veins and lenses, or from replacement deposits that were mined by underground methods. The ore was concentrated by a combination of gravity-amalgamation and flotation methods. Based on current mining and beneficiating costs, to be minable, vein deposits would have to contain recoverable metals worth from $26 to $50 per ton ($28 to $55/t), assuming a milling rate of 500 tons or more per day (453.6 t/d).

The porphyry-type molybdenum-copper occurrence on the west side of the study area is currently minable if it has an average recoverable metal content in excess of $8.00 per ton ($9/t), and provided it can be mined by open-pit methods and milled at a rate of more than 10,000 tons per day (9,000 t/d).

Placer deposits occur along stream channels and in terraces adjacent to, or in the vicinity of, stream channels. Some deposits could be mined by bulldozer and sluicebox methods, but most would probably require a dragline dredge. Assuming a mining rate of 3,000 cubic yards (2,300 m^3) of gravel per day, to be minable, the placer deposits would have to contain more than 80 cents of recoverable gold per cubic yard ($1.05/$m^3$).

PREVIOUS WORK

The first published work on the geology and mineral resources of what is now the Elkhorn wilderness study area was by W. H. Weed in 1901. R. W. Stone described the results of a study done in the district in 1911. J. T. Pardee and J. C. Schrader summarized the geology and ore deposits in the Beaver Creek, Elkhorn, and Park districts in 1933. In 1951, G. C. Reed described some mineral deposits in the Beaver Creek and Park districts. M. R. Klepper, R. A. Weeks, and E. T. Ruppel published a detailed geologic map and descriptions of several deposits in the Elkhorn and Tizer-Wilson districts in 1957. V. L. Freeman, E. T. Ruppel, and M. R. Klepper summarized the geology of parts of the Beaver Creek and Park districts in 1958. R. N. Roby described several deposits in the Beaver Creek, Elkhorn, and Park districts in 1960. H. W. Smedes published a detailed geologic map and summary descriptions of many deposits in the Warm Springs, Beaver Creek, and Tizer-Wilson districts in 1966. M. R. Klepper drafted a detailed geologic map and described some deposits in the Beaver Creek and Park districts in 1971.

PRESENT INVESTIGATIONS

The Bureau of Mines' field investigations of the Elkhorn wilderness study area were conducted during 1977. Investigations were made by Terry J. Close, Francis E. Federspiel, Michael M. Hamilton, Fredrick A. Spicker, Edward L. McHugh, and James G. Rigby, assisted by Robin McCulloch, Michael McCulla, Randal Cross, Karen Sweetman, Kenneth Cameron, Scott Monroe, and Jason Steckman. Approximately 650 man-days were devoted to field investigations. During investigations, all known mineral occurrences in the study area were examined.

Mining claim data were obtained from records of Jefferson and Broadwater Counties and the Bureau of Land Management. Information on several claims was taken from published and unpublished reports by the Montana Bureau of Mines, U.S. Bureau of Mines, U.S. Geological Survey, U.S. Forest Service, and private mining companies. Production records were compiled from Bureau of Mines statistical files, except where noted.

Methods of study

County, state, federal, and private records and reports were used to determine the number and location of mines, prospects, and claims. Owners, and previous owners, of mineral properties were contacted, and historic and geologic data were obtained. Most lode and placer prospects were mapped, and all were examined and sampled.

One hundred and eighteen mineral occurrences, 110 of which are in the study area, were visited. Examinations were made of 300 underground workings, most of which could not be entered, for various reasons. However, their total measured and estimated lengths were in excess of 42,000 feet (12,800 m). Three mills and 756 prospect pits and trenches were also examined.

A total of 1,150 lode samples were taken. They consisted of rock chips from across mineralized structures, wallrock, and country rock; and grab samples came from stockpiles and mine or prospect dumps. Grab samples or specimens were taken from stockpiles or mine dumps to determine the maximum values present. Two hundred and nine placer samples were taken at 145 localities. The placer samples were panned from stream channel gravel or hand-dug from pits or trenches on gravel terraces. Wherever possible, gravel on bedrock was sampled. Usually placer samples from pits and trenches contained 1 cubic foot of gravel per foot (0.03 m^3/0.3 m) of sample depth.

All samples were checked for the presence of radioactive and fluorescent minerals. Lode samples were fire assayed to determine gold and silver concentrations. The presence of other metallic constituents was determined by atomic absorption methods. At least one lode sample from each mineralized structure or zone was analyzed spectrographically. When anomalous amounts of economic elements were indicated, more accurate analyses were made. Spectrographic analyses are not shown on the sample tables.

In the field, placer samples were concentrated by panning or by washing in a sluice box. The concentrates were further processed in a laboratory on a Wilfley table. The gold in the samples was recovered by hand or by mercury amalgamation. Placer values in cents per cubic yard were calculated using a gold price of $150 per troy ounce ($4.82/g). One cent per cubic yard equals 0.0027 gram per cubic meter.

Lode resource estimates were calculated by multiplying the thickness of the mineralized structure by its measured or inferred length. The product was then multiplied by the depth, and the total product was divided by 12, the number of cubic feet of material per ton. In most cases, the depth could not be measured, so was estimated to equal one-half of the length. Placer resources were calculated by multiplying area by estimated depth.

Three terms are used in the sample analysis tables: (1) "Tr," trace, is defined as gold concentrations between 0.001 and 0.005 ounce per ton (0.03 and 0.17 g/t); for silver, between 0.1 and 0.005 ounce per ton (3.4 and 0.17 g/t); and for base metals, between 0.01 and 0.001 percent, as determined by fire assay and atomic absorption analysis. Trace in placer samples is gold concentrations of between 0.01 and 0.1 cents per cubic yard (0.01 and 0.13 cents/m^3); (2) "N," not detected, is defined as metals in concentrations below trace amounts; and (3) "--," not analyzed, generally applies to samples that were not analyzed because spectrographic analysis indicated that base metals were present in less than trace amounts. However, some of the samples taken by previous investigators do not list base metals analyzed.

Resource definitions

Resources have been classified according to the following definitions adopted by the U.S. Bureau of Mines and the U.S. Geological Survey (U.S. Bur.Mines and U.S. Geol. Survey, 1976).

Resource.--A concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Undiscovered resources.--Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory.

Reserve.--That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term <u>ore</u> is used for reserves of some minerals.

Indicated.--Reserves or resources for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance or geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outline completely or the grade established throughout.

Inferred.--Reserves or resources for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition, of which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence. Estimates of inferred reserves or resources should include a statement of the specific limits within which the inferred material may lie.

Paramarginal.--The portion of Subeconomic Resources that (1) borders on being economically producible or (2) is not commerically available solely because of legal or political circumstances.

Submarginal.--The portion of Subeconomic Resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) of a major cost-reducing advance in technology.

ACKNOWLEDGMENTS

The aid and cooperation of claim owners and Forest Service personnel were greatly appreciated. We are particularly grateful for the help and information received from Bob Newman, Bob Lovegrove, Dick Walker, Bill Straley, of the U.S. Forest Service, and from claim owners Ben Crenshaw, Edward Hildebrand, and May Thompson.

LODE MINES, PROSPECTS, AND CLAIMS

Described in alphabetical order by district are the 115 mines, prospects, and claims within or immediately adjacent to the Elkhorn wilderness study area that were examined.

Beaver Creek district

Name: August Rust prospect

Index Map No.: Fig. 16, No. 3

Location: NE1/4 NW1/4 Sec. 16, T. 8 N., R. 1 W., on the north side of North Pole Creek

Elevation: 5750 to 6100 feet (1752 to 1859 m)

Access: By road 7 miles (11.2 km) west from Winston, Montana

Geology of deposit: Country rock is blackish, andesitic tuff and basalt. No mineralized structure is exposed, but the alignment of workings indicates a northeast-trending structure (fig. 21). Dump material at sample locality No. 6 indicates an iron-oxide-stained, vuggy, quartz vein at least 10 inches (25 cm) thick. The vein material contains argentiferous galena and sphalerite in stringers and pods as much as 2 inches (5 cm) thick.

Development: There are six caved adits, aggregating an estimated 300 feet (91.4 m) of workings, and five prospect pits.

Sampling: Sample locations are shown on figure 21, and analyses are given on the accompanying table. Four grab samples of quartz vein material had as much as 0.10 ounce gold per ton (3.4 g/t), 37.3 ounces silver per ton (1,278.8 g/t), 0.06 percent copper, 2.0 percent lead, and 1.0 percent zinc.

Conclusions: The silver, lead, and zinc contents are high in vein material found on dumps. Although veins are no longer exposed, there is a resource potential.

* *

Name: Buckeye prospect

Index Map No.: Fig. 16, No. 5

Location: SE1/4 Sec. 16, and NE1/4 Sec. 21, T. 8 N., R. 1 W., at the head of the South Fork South Pole Creek, near the study area

Elevation: 5400 feet (1646 m)

Access: By road 6 miles (9.7 km) west from Winston, Montana

Previous production: Underground workings, a mill foundation, and mill tailings suggest past production, although none is recorded.

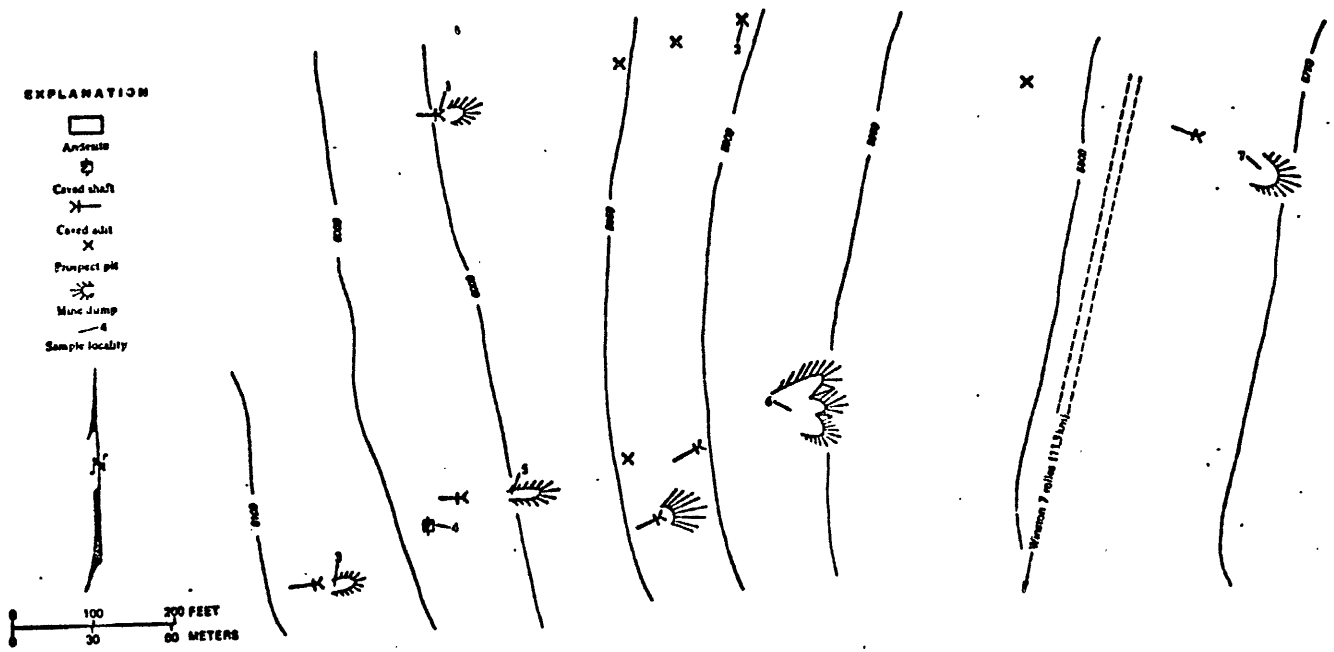


Figure 21. August Rust prospect.

An unnumbered table to accompany fig. 21, August Rust prospect

Data for samples shown on figure 21.

[N, none detected; Tr, trace; --, not analyzed]

Sample No.	Sample Type	Sample Description	Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
1	Grab	Iron-oxide-stained andesite from dump---	0.02	0.1	--	--	--
2	do--	do------------------	.01	.6	--	--	--
3	do--	do------------------	N	.1	--	--	--
4	do--	Quartz vein material from dump------------	Tr	6.5	0.02	0.79	0.11
5	do--	do------------------	N	7.3	.02	.44	.06
6	do--	do------------------	Tr	7.6	.06	.58	1.0
7	do--	do------------------	.10	37.3	.03	2.0	.43

1/ Metric conversions: ounce per ton x 34.285 = grams per tonne.

Geology of deposit: The Buckeye prospect is on a N. 40° to 50° W. striking, 40° to 55° SW. dipping shear zone in andesite (fig. 22). The shear zone, averaging 2.7 feet (0.8 m) in thickness, is composed of massive quartz fissure lenses, iron-oxide-stained gouge, and brecciated andesite. The quartz lenses are as much as 1 foot (0.3 m) thick. The shear zone and quartz lenses have been leached of their metallic sulfide minerals, leaving iron-oxide-coated boxwork. No sulfide minerals were observed.

Development: A 90-foot (27-m)-long adit (adit No. 1), two caved adits, and three shafts comprise the workings. The caved adits and shafts interconnect. Underground workings are estimated to total approximately 1,000 feet (305 m).

Sampling: Sample locations and analyses are shown on figure 22 and the accompanying table. Five chip samples (Nos. 2 and 3 and 7-9) taken across the shear zone averaged 0.06 ounce gold per ton (2.1 g/t). Three chip samples (Nos. 7-9) across the shear zone above the caved underground workings averaged 0.09 ounce gold per ton (3.1 g/t). All samples contained insignificant amounts of copper and zinc.

Resource estimate: Average thickness of the shear zone is 2.7 feet (0.8 m); apparently it extends 350 feet (107 m) along strike between sample Nos. 7-9, and has an estimated submarginal resource of about 14,000 tons (13,000 t). To the northwest, the shear zone is displaced by a crosscutting shear zone in the open adit. Additional resources probably occur at depth along the southeast extension of the zone.

Conclusions: A lens of gold-enriched material in the vicinity of the caved underground workings is indicated by sampling. Enriched material above the caved adit has probably been mined. Subsurface work might disclose additional gold-bearing material at depth along strike, and gold, silver, copper, lead, zinc, sulfide mineral-bearing material below it. The mineralized structure does not extend into the study area.

* *

Name: Champion mine

Owner: Donald Holmes, Toston, Montana

Index Map No.: Fig. 16, No. 17

Location: SE1/4 Sec. 4, T. 7 N., R. 1 W., at the head of Badger Creek

Elevation: 7600 to 7960 feet (2316 to 2426 m)

Access: By road 12 miles (19.2 km) west from Winston, Montana

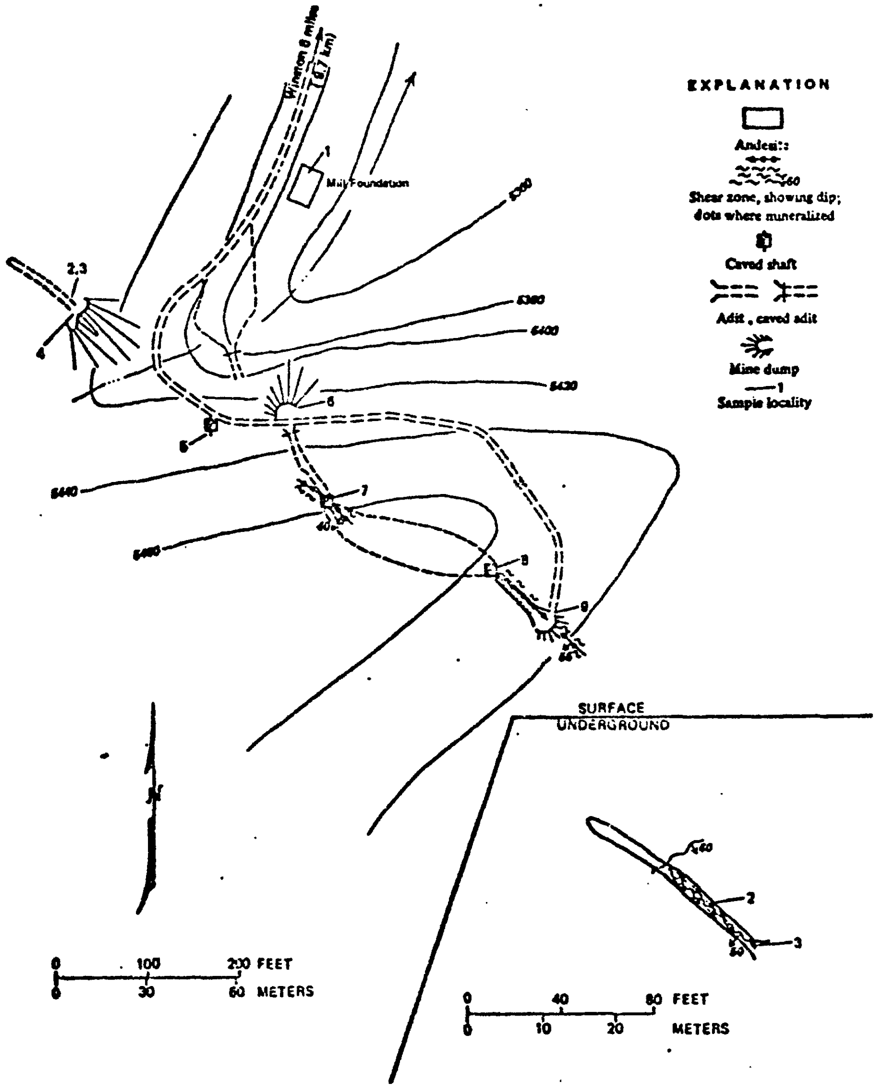


Figure 22. Buckeye prospect.

An unnumbered table to accompany fig. 22, Buckeye prospect

Data for samples shown on figure 22.

[Tr, trace; N, none detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/
No.	Type	Length (feet) 1/	Description		
1	Grab	--	Quartz lens material from ore bin-------------------	0.03	N
2	Chip	2.5	Across shear zone----------	N	N
3	do--	2.0	do------------------------	Tr	N
4	Grab	--	Quartz lens material from dump----------------------	N	N
5	do--	--	do------------------------	Tr	N
6	do--	--	Quartz lens material in ore bin-----------------------	Tr	N
7	Chip	0.5	Across shear zone----------	.11	N
8	do--	3.5	do------------------------	.04	0.1
9	do--	4.0	do------------------------	.13	.2

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

History: The Champion mine had been located, worked, and abandoned by 1900. Earll (1964, p. 27) reported that in 1962 the mine was relocated as the 1962 Lode. Subsequently, surface trenching and reopening of underground workings were attempted. In 1968, Donald Holmes relocated the prospect as the Silver Dyke Nos. 2-7 claims.

Previous production: No production records were kept prior to 1900, by which time extensive development work had been apparently done on the property. The dismantled mill also seems to confirm that the mine probably produced ore before 1900.

Geology of deposit: The mine is on two shear zones in andesite (fig. 23). The principal shear zone strikes N. 25° to 85° E. from sample locality Nos. 3 to 15 and dips from 20° SE. to 90 degrees. It is leached near the surface and is composed of iron-oxide- and malachite-stained gouge, breccia, and quartz lenses as much as 3 feet (0.9 m) thick. The leached quartz contains iron-oxide- and malachite-coated casts of metallic sulfide minerals, while the unleached quartz contains pyrite, chalcopyrite, galena, and malachite. The second shear zone trends due west to N. 70° W. from sample Nos. 1 to 2 and dips 55° N. It is composed of leached and brecciated, iron-oxide-stained andesite.

Development: Workings on the principal shear zone consist of three caved adits, estimated to total less than 1,000 feet (305 m), along with bulldozed and hand-dug pits and trenches. Workings on the second zone consist of bulldozed trenches.

Sampling: Sample locations and analyses are shown on figure 23 and the accompanying table. A sample of vein material from near sample locality No. 3, by Earll in 1963, not shown on the table, contained 0.025 ounce gold per ton (0.9 g/t), 24.3 ounces silver per ton (833 g/t), 13.75 percent lead, and a trace of zinc. He also took a combined sample from mine dumps in the area of sample locality No. 10, and it assayed 0.01 ounce gold per ton (0.3 g/t), 3.2 ounces silver per ton (110 g/t), 6.61 percent lead, and 0.01 percent zinc. During the current study, 18 samples were taken. Four chip samples across the principal shear zone (Nos. 3, 9, 14, and 15) averaged 0.04 ounce gold per ton (1.4 g/t), 0.45 ounce silver per ton (15.4 g/t), 0.07 percent copper, 0.26 percent lead, and 0.07 percent zinc. Two grab samples (Nos. 1 and 2) of shear zone material from dumps along the second zone averaged 0.5 percent lead and 0.58 percent zinc.

Resource estimate: Average thickness of the principal shear zone is 8.7 feet (2.7 m). It is 1,500 feet (457 m) long, and is estimated to contain a submarginal resource of about 815,000 tons (739,000 t). The resource averages 0.04 ounce gold per ton (1.4 g/t), 0.45 ounce silver per ton (15.4 g/t), 0.05 percent copper, and 0.26 percent lead.

Conclusions: The large mineralized shear zones are leached at the surface. Silver and base-metal content may increase, and gold content decrease, with depth. Subsurface work might disclose minable resources.

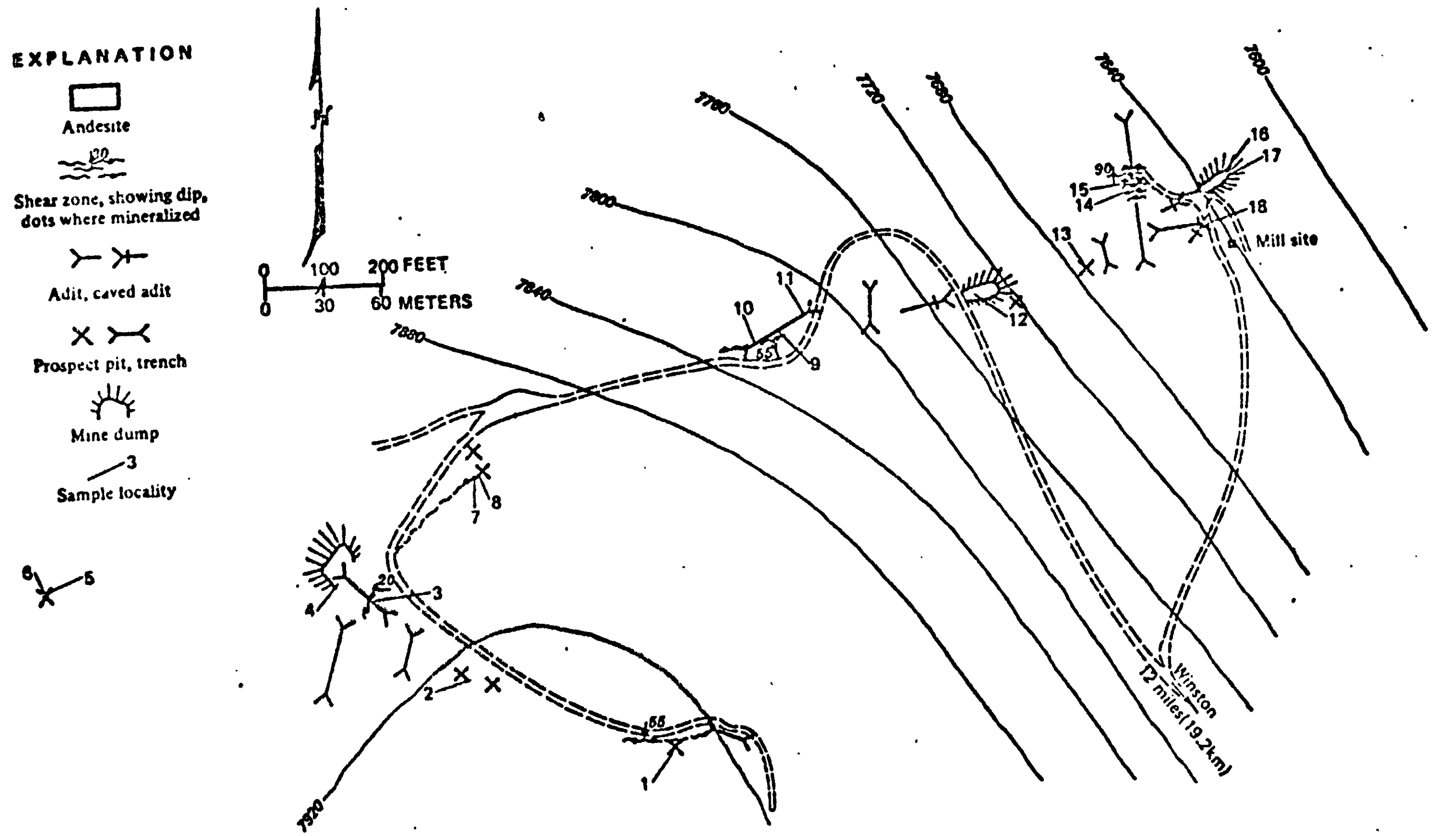


Figure 23. Champion mine.

An unnumbered table to accompany fig. 23, Champion mine.

Data for samples shown on figure 23.

[Tr, trace; N, none detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Shear zone material from dump---------------------	N	N	Tr	0.71	0.58
2	do--	--	do----------------------	N	Tr	Tr	.29	.57
3	Chip	3.0	Across shear zone---------	Tr	N	0.3	.71	.07
4	Grab	--	Quartz vein material from dump---------------------	Tr	N	.28	.67	.08
5	do--	--	Shear zone material from dump---------------------	N	0.2	.02	.31	.38
6	do--	--	Quartz vein material from dump---------------------	N	Tr	.01	.03	.02
7	do--	--	do----------------------	N	.2	Tr	.03	.04
8	do--	--	Shear zone material from dump---------------------	N	.1	.02	.01	.03
9	Chip	3.0	Across shear zone---------	0.14	3.9	.11	.58	.09

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
10	Grab	--	Quartz vein material from stockpile----------------	0.03	9.0	0.29	1.1	0.08
11	do--	--	Shear zone material from dump--------------------	.02	2.8	.11	:24	.07
12	do--	--	Quartz vein material from dump--------------------	.01	.7	.08	.05	.07
13	Grab	--	Shear zone material from dump--------------------	.03	N	Tr	.02	.07
14	Chip	10.0	Across shear zone---------	.03	N	.04	.3	.09
15	do--	10.0	do----------------------	.02	Tr	.01	N	.02
16	Grab	--	Shear zone material from dump--------------------	.014	Tr	.01	Tr	.01
17	do--	--	Quartz vein material from ore bin------------------	.07	1.7	.06	.07	Tr
18	Grab	--	Shear zone material from ore bin------------------	.01	.1	.01	.02	.08

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Name: G. W. No. 2 claim

Index Map No.: Fig. 16, No. 11

Location: NE1/4 SE1/4 Sec. 28, T. 8 N., R. 1 W., east of the South Fork Beaver Creek

Elevation: 6000 to 6350 feet (1829 to 1935 m)

Access: By road 8 miles (12.8 km) west from Winston, Montana.

History: Dee Clark and Jerry Smith located the property as the Elgatar No. 10 in 1955. F. J. Griffin and J. A. Welton relocated it as the G. W. No. 2 in 1963.

Geology of deposit: Country rock is grayish-black, fine-grained, andesitic tuff, with no mineralized structure exposed. Material on mine dumps (fig. 24, Nos. 6, 7, and 11-13) indicates a vein at least 1 foot (0.3 m) thick. The vein consists of vuggy quartz with pyrite stringers and brecciated country rock. The stringers are as much as 0.5 inch (1.3 cm) thick. Pyrite is disseminated in the country rock.

Development: Workings consist of five caved adits which are estimated to total 3,000 feet (914 m) in length, one shaft, an inclined shaft, and numerous prospect pits.

Sampling: Sample locations are shown on figure 24, and analyses are given on the accompanying table. Seventeen grab samples assayed as much as 0.33 ounce gold per ton (11.3 g/t), 0.1 ounce silver per ton (3.4 g/t), and traces of copper, lead, and zinc.

Conclusions: Quartz vein material on mine dumps suggests the presence of a mineralized structure which may contain resources.

* *

Name: G. W. No. 2 claim (north)

Index Map No.: Fig. 16, No. 8

Location: NE1/4 Sec. 28, T. 8 N., R. 1 W., east of the South Fork Beaver Creek

Elevation: 6400 to 6550 feet (1951 to 1996 m)

Access: By gravel and dirt roads 8 miles (12.8 km) west from Winston, Montana

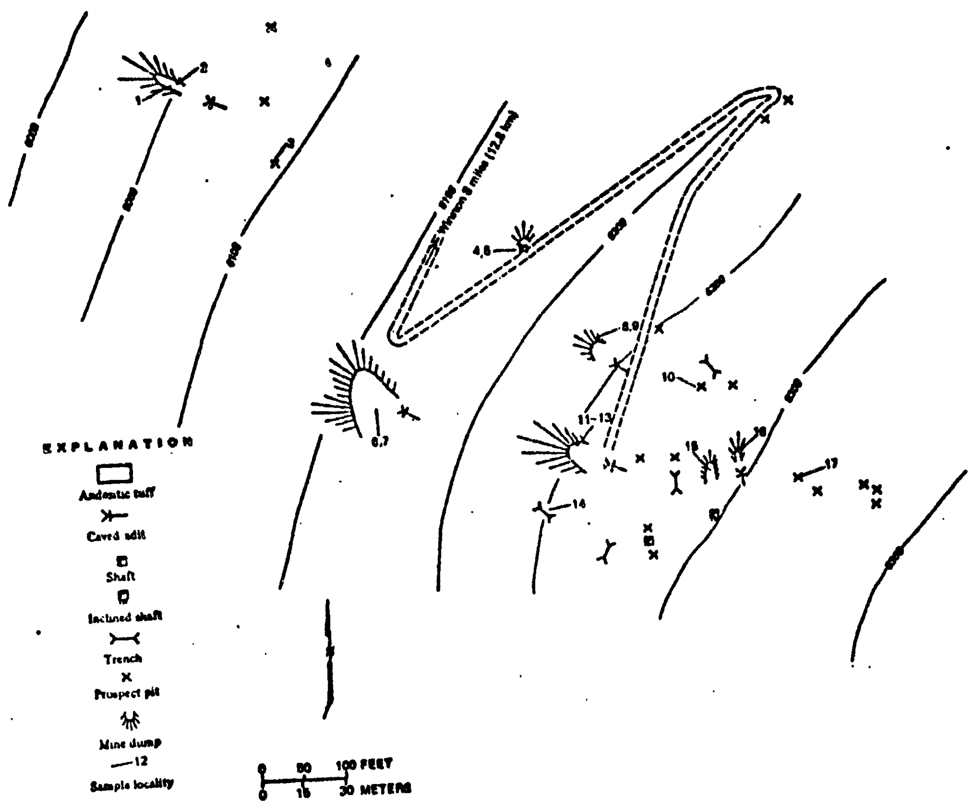


Figure 24. G. W. No. 2 claim.

An unnumbered table to accompany fig. 24, G. W. No. 2 claim.

Data for samples shown on figure 24.

[Tr, trace; N, none detected]

Sample No.	Type	Description	Gold (ounce per ton) 1/	Silver (ounce per ton) 1/
1	Grab	Iron-oxide-stained andesite with pyrite from dump----------------------------------	Tr	N
2	do--	do---	N	0.1
3	do--	do---	Tr	.2
4	do--	Iron-oxide-stained andesite with quartz from dump----------------------------------	Tr	N
5	do--	Iron-oxide-stained andesite with disseminated pyrite from dump-------------	Tr	N
6	do--	Quartz vein material from dump------------	0.01	N
7	do--	Iron-oxide-stained andesite with disseminated pyrite from dump-------------	Tr	N
8	do--	Andesite with disseminated pyrite from dump	N	N
9	do--	Iron-oxide-stained andesite from dump------	.01	.1
10	do--	do---	.01	N
11	do--	Quartz vein material from dump------------	.33	.1
12	do--	Iron-oxide-stained andesite from dump------	N	.1
13	do--	do---	.03	.1
14	do--	do---	N	N
15	do--	do---	N	Tr
16	do--	do---	N	N
17	do--	do---	.01	Tr

1/ Metric conversion: ounce per ton x 34.285 = grams per tonne.

Geology of deposit: Country rock is fine-grained andesite, with limited exposures exhibiting a prominent northeast and northwest joint pattern. The mineralized zone, exposed in adit No. 1 (fig. 25), is a persistent, flat-lying shear zone that trends northeast and dips 5° to 20° southeast. Its thickness ranges from 2 to 4 feet (0.6 to 1.2 m) and averages 2.9 feet (0.9 m). The zone is composed of highly fractured, iron-oxide-stained country rock with a silicified core as much as 4 feet (1.2 m) thick. Pyrite is finely disseminated throughout.

Development: In two adits are 320 feet (97.5 m) of accessible underground workings. Also there are three caved adits and numerous surface workings.

Sampling: Sample locations and analyses are shown on figure 25 and accompanying table. Twenty-three samples were taken. Ten chip samples from across the mineralized zone averaged 0.24 ounce gold per ton (8.2 g/t) and 0.74 ounce silver per ton (25.4 g/t).

Resource estimate: Adit No. 1 exposed the 2.9-foot (0.9-m)-thick, mineralized zone 150 feet (45.7 m) along strike, and for 90 feet (27.4 m) along dip. The zone can be seen in flooded portions of adit No. 1 and is inferred to extend one-half its measured dimensions. The zone is estimated to have about 7,000 tons (6,400 t) of paramarginal resources. Ten samples from across it averaged 0.24 ounce gold per ton (8.2 g/t) and 0.7 ounce silver per ton (24 g/t).

Conclusions: The persistent shear zone has a mineral resource potential.

* *

Name: Lame Deer mine

Owner: E. M. Koppen, Albuquerque, New Mexico

Index Map No.: Fig. 16, No. 15

Location: SW1/4 Sec. 34, T. 8 N., R. 1 W., east of Badger Creek and just beyond the study area

Elevation: 7000 to 7350 feet (2133 to 2240 m)

Access: By road 8.5 miles (13.7 km) east from Winston, Montana

History: Fred Earll located the property in 1967, and E. M. Koppen obtained ownership in 1976.

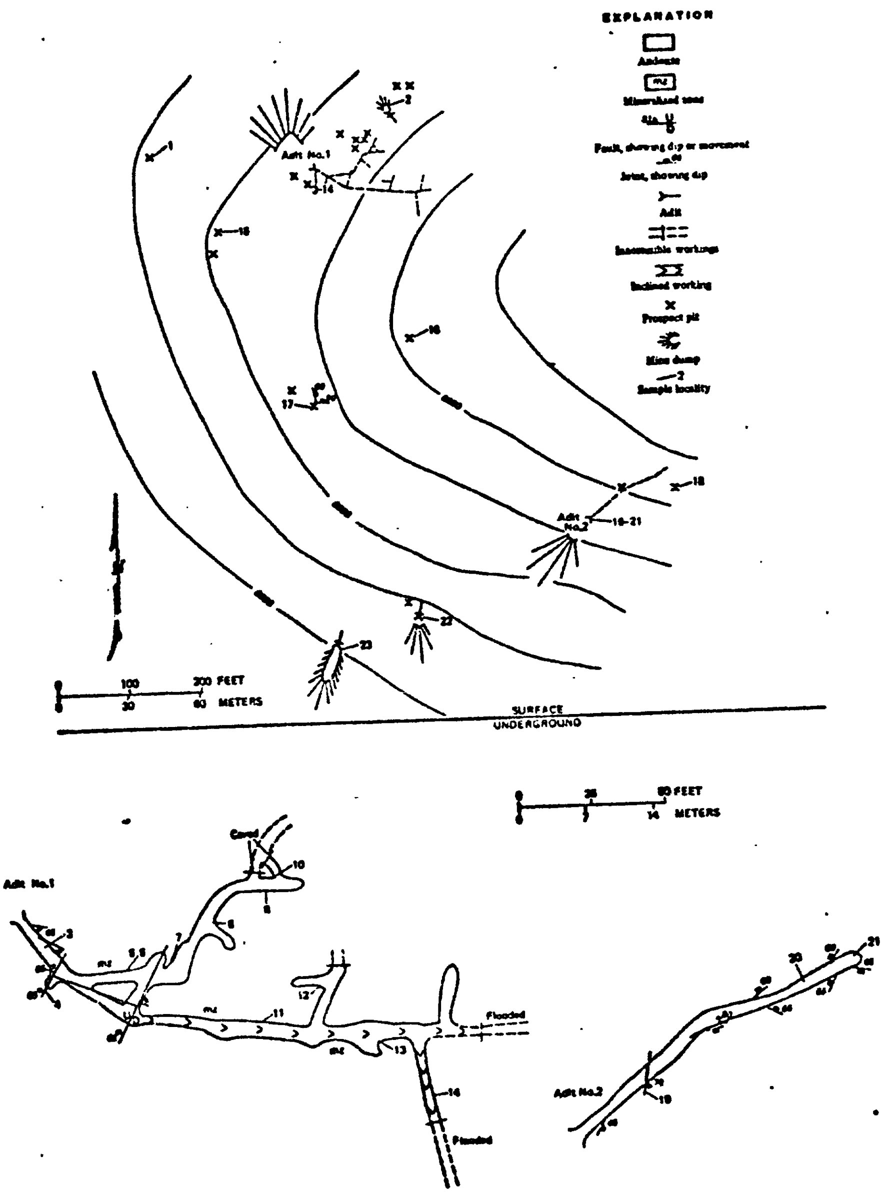


Figure 25. G. W. No. 2 claim (north).

An unnumbered table to accompany fig. 25, G. W. No. 2 claim (north)

Data for samples shown on figure 25.

[Tr, trace; N, none detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/
No.	Type	Length (feet) 1/	Description		
1	Grab	--	Iron-oxide-stained andesite from dump----------------------------	N	N
2	do--	--	do--------------------------------	0.07	Tr
3	Chip	2.0	Across fault zone----------------	.01	N
4	do--	3.0	do--------------------------------	.03	N
5 2/	do--	1.0	Across brecciated portion of mineralized zone-----------------	1.20	1.3
6	do--	1.5	Across silicified portion of mineralized zone-----------------	.26	.5
7	do--	2.0	Across mineralized zone----------	.27	.8
8	do--	3.5	do--------------------------------	.54	2.2
9	do--	2.5	do--------------------------------	.34	.9
10	do--	2.0	do--------------------------------	Tr	N
11	do--	3.0	do--------------------------------	.03	.2
12	do--	3.0	do--------------------------------	.28	.4
13	do--	4.0	do--------------------------------	.07	.8
14	do--	3.5	do--------------------------------	.03	.2
15	Grab	--	Iron-oxide-stained andesite from dump----------------------------	N	N
16	do--	--	do--------------------------------	N	N
17	Chip	4.0	Across iron-oxide-stained and jointed andesite-----------------	N	N

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/
No.	Type	Length (feet) 1/	Description		
18	Grab	--	Andesite from dump---------------	N	N
19	Chip	2.0	Across fault---------------------	N	N
20	do--	2.5	Across jointed, iron-oxide-stained, andesite----------------	N	N
21	do--	3.0	do-------------------------------	N	N
22	Grab	--	Iron-oxide-stained andesite from dump----------------------------	N	0.01
23	do--	--	do-------------------------------	N	N

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.
2/ Also contained 0.43 percent lead.

Previous production: In 1932 and 1946 a combined total of 21 ounces (653 g) of gold, 126 ounces (3,919 g) of silver, and 35 pounds (15.9 kg) of lead was recovered from 23 tons of ore. The ore averaged 0.91 ounce gold per ton (31.2 g/t) and 5.48 ounces silver per ton (187.9 g/t).

Geology of deposit: A quartz vein is along a fault that strikes N. 30° to 50° W. and dips 20° to 40° SW. in quartz monzonite porphyry (fig. 26). The vein averages 0.9 feet (0.3 m) in thickness and contains iron-oxide-stained, vuggy quartz with finely-disseminated pyrite.

Development: Workings consist of two open and three caved adits, a shallow, inclined shaft, and numerous prospect pits. Underground workings are calculated to total 270 feet (83 m).

Sampling: Sample locations and analyses are shown on figure 26 and accompanying table. The weighted average of five chip samples (Nos. 5, 6, and 9-11) across the structure is 0.09 ounce gold per ton (3.1 g/t) and 1.14 ounce silver per ton (39 g/t).

Resource estimate: The vein extends 250 feet (76.2 m) between sample Nos. 5 and 11 with an average thickness of about 0.9 feet (0.3 m). It is computed to contain about 2,000 tons (1,800 t) of paramarginal resources.

Conclusions: The structure is probably too narrow to be minable, and does not seem to extend into the study area.

* *

Name: Last Chance prospect

Index Map No.: Fig. 16, No. 14

Location: NW1/4 Sec. 34, T. 8 N., R. 1 W., on the divide between Beaver and Weasel Creeks

Elevation: 7300 feet (2225 m)

Access: By mountain road 11 miles (17.7 km) east from Winston, Montana

Geology of deposit: The prospect is on fracture zones in andesite, with the zones trending generally N. 55° W. and dipping 85° SW. They are composed of leached, pyritic, iron-oxide-stained, silicified andesite, and quartz lenses. The andesite country rock is iron-oxide-stained, containing pyrite and iron-oxide-coated pyrite casts.

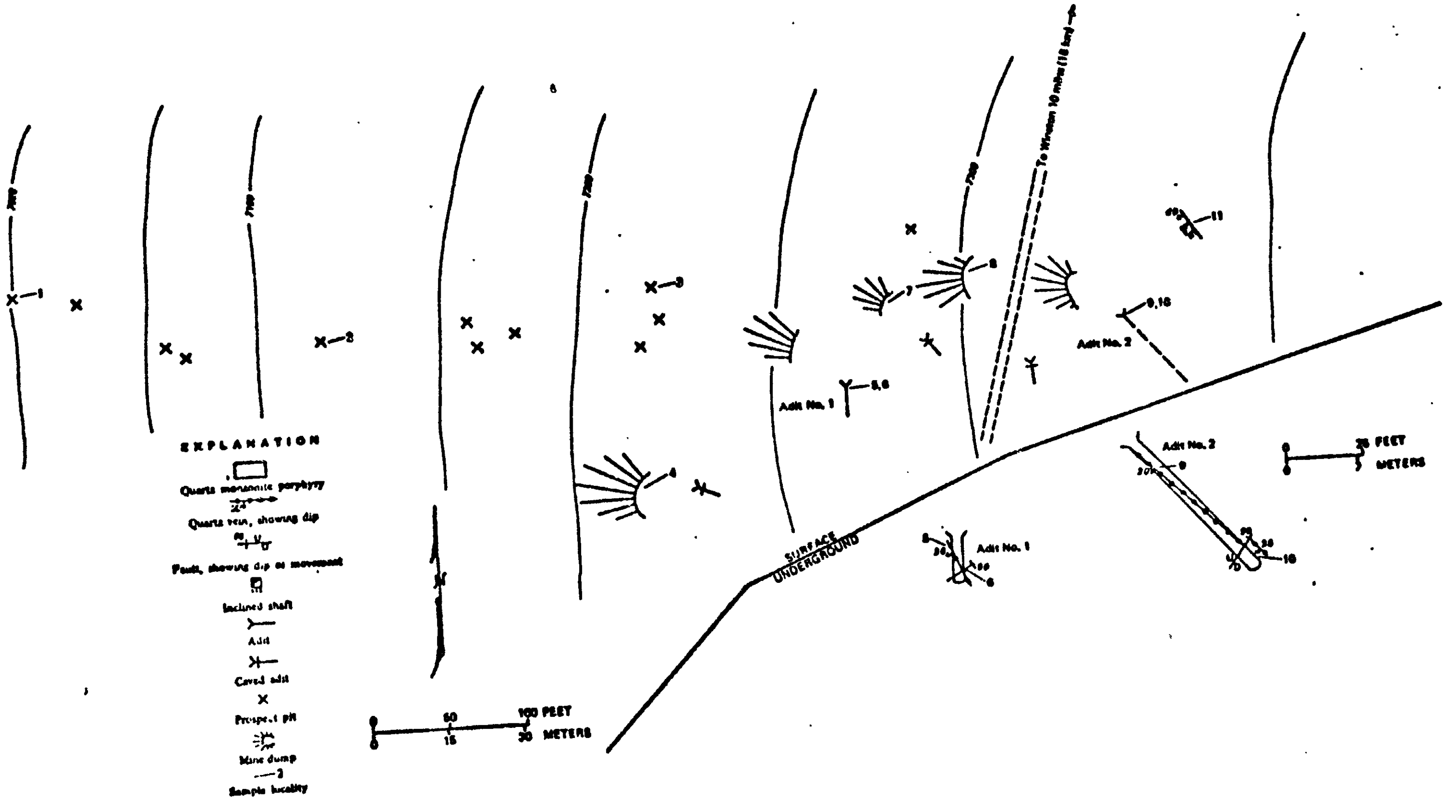


Figure 26. Lame Deer mine.

An unnumbered table to accompany fig. 26, Lame Deer mine

Data for samples shown on figure 26.

[N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/
No.	Type	Length (feet) 1/	Description		
1	Grab	--	Quartz vein material from dump---	0.01	N
2 2/	do--	--	do------------------------------	.01	3.8
3	do--	--	do------------------------------	.90	2.5
4	do--	--	do------------------------------	.26	2.1
5	Chip	1.6	Across fault with a quartz vein--	.03	.2
6	do--	.5	Across quartz vein---------------	.05	.4
7	Grab	--	Quartz vein material from dump---	.04	.8
8	do--	--	do------------------------------	.18	1.6
9	Chip	.4	Across quartz vein---------------	.01	.2
10	do--	.5	do------------------------------	.04	.2
11 3/	do--	1.3	Across fault zone with a quartz vein----------------------------	.21	2.7

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.
2/ Also contained 2.6 percent lead.
3/ Also contained 0.55 percent lead and 0.54 percent arsenic.

Development: At the prospect's south end is an east-trending caved adit and small pit. Judging from the dump's size, the adit was less than 100 feet (30.5 m) long. About 0.5 mile (0.8 km) north of the adit is a 100-foot (30.5-m)-long bulldozer trench. It is on a 20-foot (6.1-m)-thick fracture zone which is exposed for 80 feet (24.4 m) along strike. No mineralized structure is presently exposed at the caved adit.

Sampling: Three samples were taken. A sample of fracture zone material from the dump of the caved adit contained 0.16 ounce gold per ton (5.5 g/t), 0.5 ounce silver per ton (17.1 g/t), and a trace of zinc. The chip sample from a 20-foot (6.1-m)-thick fracture zone in the bulldozer trench contained 0.02 ounce gold per ton (0.7 g/t) and 0.2 ounce silver per ton (6.9 g/t). An andesitic country rock sample from the bulldozer trench contained no economic minerals.

Conclusions: Portions of the zones containing quartz lenses have gold and silver. The prospect may have a resource potential. Its mineralized structures are similar to others in the area with a history of mineral production.

* *

Name: Monte Cristo group

Owner: Grace Seekins, Helena, Montana

Index Map No.: Fig. 16, No. 7

Location: N1/2 Sec. 28, T. 8 N., R. 1 W., above South Fork Beaver Creek

Elevation: 5600 to 7000 feet (1707 to 1829 m)

Access: By road 9 miles (14.4 km) west from Winston, Montana

History: The Monte Cristo group is comprised of the Monte Cristo, Winston Miner, Mint, St. John, and Little Fern claims. All except the Little Fern were patented between 1902 and 1907.

Previous production: Seventeen tons (15.4 t) of ore were produced from the Winston Miner claim between 1907 and 1909. It yielded 34 ounces (1,058 g) of gold and 479 ounces (14,898 g) of silver.

Geology of deposit: Quartz veins occur in northeast-trending, hydrothermally-altered vertical fractures and shear zones near the contact of andesite and quartz monzonite. The veins are 1 to 3 feet (0.3 to 0.9 m) thick and contain gold, silver, and pyrite.

Development: Development on the Monte Cristo lode consists of two adits, an inclined shaft, and numerous prospect pits. Open underground workings total about 100 feet (30.5 m). The Mint lode has a few prospect pits; the Winston Miner lode, four caved adits, numerous exploration trenches and pits; the St. John lode, one caved shaft, several caved adits, and numerous exploration pits and trenches; and the Little Fern claim, two caved adits and about half a dozen prospect pits.

Sampling: Forty-one samples were taken from the Monte Cristo group, with 15 from the Monte Cristo Lode. Ten chips across mineralized and fracture zones contained as much as 0.14 ounce gold per ton (45.8 g/t) and 2.5 ounces silver per ton (85.7 g/t). Five mine dump grab samples had as much as 0.02 ounce gold per ton (0.7 g/t) and 0.5 ounce silver per ton (17.1 g/t). Six samples were taken from the Winston Miner Lode; four grab samples of dump material assayed as much as 0.01 ounce gold per ton (0.3 g/t) and 0.01 ounce silver per ton (0.3 g/t); two samples of vein material had as much as 0.09 ounce gold per ton (3.1 g/t) and 0.03 ounce silver per ton (1 g/t). The St. John Lode was the source of ten samples. Two continuous chip samples from a winze on a 7-foot (2.1-m)-thick, N. 76° E. trending vertical fracture zone contained as much as 0.2 ounce silver per ton (6.9 g/t). One continuous chip sample from a trench on an intrusive-volcanic rock contact assayed a trace gold and 0.1 ounce silver per ton (3.4 g/t). Seven grab samples of quartz vein material and altered intrusive rock from mine and prospect dumps had a trace gold and 0.2 ounce silver per ton (6.9 g/t). The Little Fern claim's ten samples, including six of altered intrusive rock, assayed as much as 0.014 ounce gold per ton (0.5 g/t) and 0.5 ounce silver per ton (17.1 g/t). Two continuous chip samples across a 2-foot (0.6-m)-thick quartz vein striking north-south had as much as 0.17 ounce gold per ton (5.8 g/t) and 0.5 ounce silver per ton (17.1 g/t).

Conclusions: The Monte Cristo group has a resource potential.

* *

Name: Native Silver mine

Index Map No.: Fig. 16, No. 4

Location: NE1/4 SE1/4 Sec. 16, T. 8 N., R. 1 W., on the south side of South Pole Creek and just outside the study area

Elevation: 5720 to 6000 feet (1743 to 1829 m)

Access: By road 5.5 miles (8.9 km) west from Winston, Montana

Previous production: Recorded production for 1941-1942 is 191 tons (173 t) of ore that contained 51 ounces (1,586 g) gold, 127 ounces (3,950 g) silver, 25 pounds (11 kg) copper, and 704 pounds (319 kg) lead.

Geology of deposit: An iron-oxide-stained, leached, silicified shear zone that trends N. 65° to 85° W. and dips 30° to 65° SW. is in andesite. The shear zone is composed of quartz lenses, gouge, and brecciated andesite; both the zone and quartz contain pyrite and iron-oxide-coated pyrite casts, with the lenses being as much as 2 feet (0.6 m) thick.

Development: Workings consist of a 160-foot (49-m)-long adit that has an inclined raise and two winzes. Numerous pits southeast of the adit were dug along the shear zone for 1,200 feet (356 m).

Sampling: Eight chip samples across the shear zone averaged 0.01 ounce gold per ton (0.3 g/t), 0.01 ounce silver per ton (0.3 g/t), 0.13 percent lead, and trace amounts of copper and zinc.

Conclusions: Samples indicate that the zone's grade is too low to be considered a mineral resource. However, the sampled material is leached, and metal content may increase with depth. Workings are indicative of a persistent structure that may contain mineral resources.

* *

Name: PV prospect

Index Map No.: Fig. 16, No. 9

Location: NE1/4 SE1/4 Sec. 29, T. 8 N., R. 1 W., above the South Fork Beaver Creek

Elevation: 6000 feet (1829 m)

Access: By road and foot travel 8 miles (12.8 km) west from Winston, Montana

Geology of deposit: Andesite, and quartz vein material which is as much as 2 inches (5.1 cm) thick, are on the pit dump.

Development: One small prospect pit

Sampling: A sample of the quartz vein material contained insignificant amounts of metals.

Conclusions: No resource potential indicated.

Name: Ridgeline prospect

Index Map No.: Fig. 16, No. 1

Location: NE1/4 NE1/4 Sec. 12, T. 8 N., R. 2 W., on the divide between Crystal Creek and Antelope Creek

Elevation: 7160 feet (2182 m)

Access: By road 2 miles (3.2 km) west from Winston, Montana, to the Crystal Creek road, then cross-country east 12 miles (19.3 km)

Geology of deposit: The prospect is in leached, iron-oxide-stained, pyrite-bearing andesite.

Development: One caved shaft estimated to have been approximately 20 feet (6.1 m) deep.

Sampling: A trace of silver was found in a grab sample.

Conclusions: No mineral resource potential indicated.

* *

Name: Sawmill Creek prospect

Index Map No.: Fig. 16, No. 6

Location: SE1/4 Sec. 20 and SW1/4 Sec. 21, T. 8 N., R. 1 W., on the divide between Sawmill and Beaver Creeks

Elevation: 5760 to 5980 feet (1756 to 1823 m)

Access: Up Beaver Creek road 6 miles (9.7 km) west from Winston, Montana, to road's end, then 0.5 mile (0.8 km) west by trail

Geology of deposit: A 5- to 40-foot (1.5- to 12.2-m)-thick shear zone in andesite trends N. 50° E. to S. 85° E. and dips 50° SE. to 70° NE. (fig. 27). The zone consists of silicified, iron-oxide-stained, and, in places, leached andesite with pyrite disseminations, blebs, and stringers. Quartz veins as much as 2 feet (0.6 m) thick occur locally in the zone and have as much as 20 percent massive pyrite.

Development: Two adits, each about 100 feet (30.5 m) long, and four prospect pits and trenches comprise the workings.

Sampling: Sample locations are shown on figure 27, and analyses are given in the accompanying table. Seven chip samples were taken from across the shear zone and a quartz vein.

Resource estimate: The quartz vein at sample site Nos. 1 and 2 has an estimated 3,000 tons (2,700 t) of submarginal resources containing 0.46 ounce gold per ton (15.8 g/t). This assumes the vein is continuous for 180 feet (55 m) along strike and that it averages 2.4 feet (0.73 m) in thickness.

Conclusions: Samples give reason to believe that gold has been enriched near the surface, and it occurs with, and near, pyrite-bearing quartz veins. Gold content of the entire shear zone appears to be low, and the indicated resource too small to be minable. However, more subsurface work would probably disclose additional resources.

* *

Name: Silver Dyke No. 1 claim

Owner: Marieanne Miller, Toston, Montana

Index Map No.: Fig. 16, No. 18

Location: SW1/4 Sec. 4, T. 7 N., R. 1 W., at the head of Badger Creek.

Elevation: 8000 feet (2438 m)

Access: By road 13 miles (21 km) west from Winston, Montana

History: The Silver Dyke No. 1 claim was located in 1968.

Geology of deposit: The claim is on a shear zone that strikes N. 70° to 80° E. and dips 70° SE. Included in the zone are iron-oxide- and malachite-stained quartz lenses as much as 1 foot (0.3 m) thick. The lenses are highly leached and contain argentiferous galena and pyrite.

Development: Workings consist of two caved adits, estimated to be less than 500 feet (152 m) long, and five hand-dug pits.

Sampling: One chip sample across a surface exposure of the shear zone had a trace of gold, 0.25 percent lead, and 0.22 percent zinc. Five samples from the shear zone, dumps, and stockpiles averaged 0.34 ounce gold per ton (11.7 g/t), 7 ounces silver per ton (240 g/t), a trace of copper, 1.8 percent lead, and 0.38 percent zinc.

Conclusions: Samples, and a strong shear zone, indicate a potential resource.

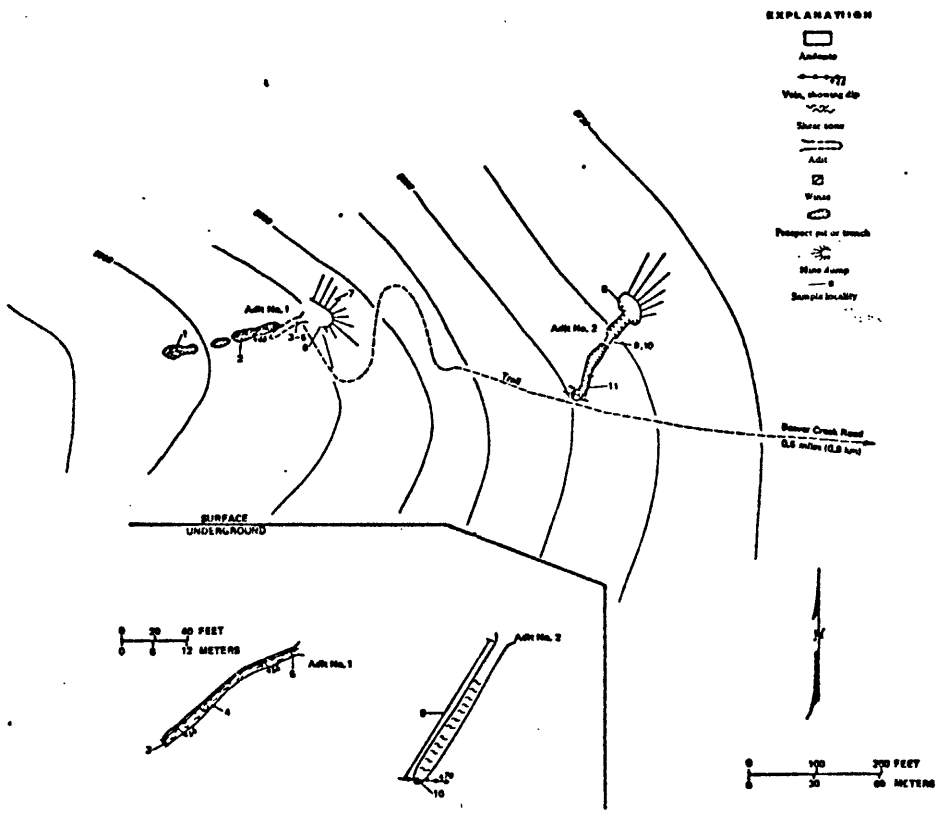


Figure 27. Sawmill Creek prospect.

An unnumbered table to accompany fig. 27, Sawmill Creek prospect

Data for samples shown on figure 27.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/
No.	Type	Length (feet) 1/	Description		
1	Chip	2.8	Across shear zone and quartz vein	0.55	N
2	do--	2.0	do------------------------------	.33	N
3	do--	3.5	Across shear zone---------------	.1	N
4	do--	1.5	do------------------------------	Tr	0.1
5	do--	4.0	do------------------------------	Tr	N
6	Grab	--	Quartz vein material from stockpile----------------------	.19	Tr
7	do--	--	Andesite from dump--------------	.01	Tr
8	do--	--	Shear zone material from dump----	.01	N
9	Chip	100.0	Across wallrock-----------------	N	.1
10	do--	2.0	Across quartz vein--------------	N	Tr
11	do--	40.0	Across shear zone---------------	.03	N

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Name: Silver Saddle mine

Index Map No.: Fig. 16, No. 13

Location: SW1/4 Sec. 27, T. 8 N., R. 1 W., on the divide between the South Fork of Beaver Creek and Weasel Creek

Elevation: 6920 to 7200 feet (2109 to 2195 m)

Access: By road 8 miles (13 km) west from Winston, Montana

History: Harold Hogan and John Hopkin intermittently operated the mine between 1954 and 1963.

Previous production: Recorded ore production between 1954 and 1963 was 100 tons (91 t), which yielded 4 ounces gold (137 g), 1,566 ounces silver (53,690 g), 50,000 pounds (22,680 kg) lead, and 5,800 pounds (2,631 kg) zinc.

Geology of deposit: The mine is on an irregular, 1,300-foot (396-m)-long, 600-foot (183-m)-wide contact zone in andesite near a diorite intrusion (fig. 28). The contact zone has 1- to 4-foot (0.3- to 1.2-m)-thick shear zones composed of iron-oxide-stained gouge, breccia, and quartz lenses which are as much as 0.5 foot (0.2 m) thick. The principal shear zone trends N. 50° to 75° E., dips from 30° SE. to horizontal, and may be along the irregular contact. The leached shear zone material may have secondary lead-zinc minerals. Unleached quartz contains massive galena, pyrite, and tetrahedrite.

Development: A flooded shaft which is inclined 30° E., an open adit about 200 feet (61 m) long, two caved adits estimated to have a total length of about 400 feet (122 m), and five bulldozer trenches comprise the workings.

Sampling: Five chip samples across shear zones (Nos. 4, 10, and 15-17) contained as much as 0.12 ounce gold per ton (4.1 g/t), 0.8 ounce silver per ton (27.4 g/t), a trace of copper, 3.6 percent lead, and 0.32 percent zinc; they averaged 0.04 ounce gold per ton (1.3 g/t) with traces of silver, copper, lead, and zinc. Grab samples of shear zone material from dumps and stockpiles had as much as 0.68 ounce gold per ton (23.3 g/t), 7.9 ounces silver per ton (270.8 g/t), a trace of copper, 11.3 percent lead, and 2.7 percent zinc.

Conclusions: The contact zone is leached. Gold content has been enriched, and base metals depleted near the surface. Base metal content will probably increase and gold content decrease with depth. Additional surface and subsurface work would probably disclose mineral resources.

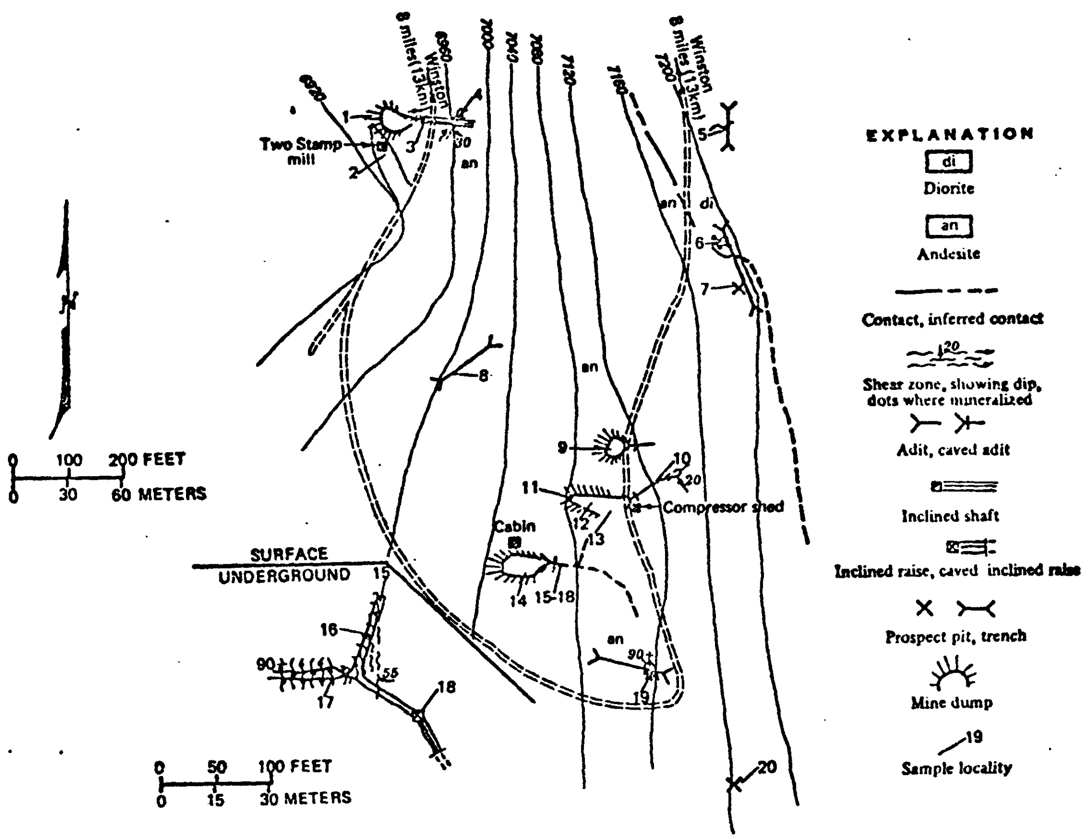


Figure 28. Silver Saddle mine.

An unnumbered table to accompany fig. 28, Silver Saddle mine

Data for samples shown on figure 28.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description				
1	Grab	--	Andesite and shear zone material from dump----------------------------------	0.02	Tr	N	0.02
2	do--	--	Shear zone material from stockpile---	.14	N	0.02	.02
3	do--	--	Shear zone material from dump--------	.18	N	.02	.02
4	Chip	1.0	Across shear zone-------------------	.12	N	3.6	.28
5	Grab	--	Pyritic intrusive rock from dump-----	N	0.1	N	.05
6	do--	--	do-----------------------------------	Tr	N	N	.03
7	do--	--	Shear zone material from dump--------	Tr	N	.09	.47
8	do--	--	Pyritic andesite from dump-----------	N	N	.02	.01
9	do--	--	do-----------------------------------	Tr	N	.04	N
10	Chip	3.0	Across shear zone-------------------	.11	.8	.36	.32
11	Grab	--	Shear zone material from stockpile---	Tr	N	.57	.51
12	do--	--	do-----------------------------------	N	N	11.3	.27

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description				
13	Grab	--	Shear zone material from dump--------	N	N	3.7	2.7
14	do--	--	Shear zone material from stockpile---	0.03	0.2	.04	.05
15	Chip	4.0	Across shear zone--------------------	Tr	Tr	N	.05
16	do--	3.5	do-----------------------------------	.02	Tr	N	.08
17	do--	4.0	do-----------------------------------	.02	.1	N	.02
18	Grab	--	Shear zone material from stockpile---	.01	N	.03	.07
19	do--	--	Pyritic andesite from dump-----------	.1	N	.01	N
20	do--	--	Shear zone material from dump--------	.68	7.9	.01	N

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Name: Susie No. 1 claim

Index Map No.: Fig. 16, No. 12

Location: SW1/4 Sec. 27, T. 8 N., R. 1 W., on the divide between South Fork Beaver Creek and Weasel Creek

Elevation: 7100 feet (2164 m)

Access: By road 7 miles (11.2 km) west from Winston, Montana

History: The claim was located in 1960 by Walt Theirous.

Geology of deposit: Andesite underlies the claim. Pieces of vuggy, iron-oxide-stained quartz as much as 1 foot (0.3 m) thick are on prospect dumps. No structure is exposed, but the alignment of workings suggests it is northeast-trending.

Development: Six prospect pits

Sampling: A trace of gold and as much as 0.1 ounce silver per ton (3.4 g/t) were found in three samples of quartz material from dumps.

Conclusions: No resource potential is indicated.

* *

Name: V35 prospect

Index Map No.: Fig. 16, No. 2

Location: SW1/4 Sec. 5, T. 8 N., R. 1 W., on the divide between Antelope and Staubach Creeks

Elevation: 6420 feet (1957 m)

Access: By road and trail 14 miles (22.5 km) southeast from East Helena, Montana

Geology of deposit: The prospect is on a zone of white, intensely silicified, locally pyritic andesite. Iron-oxides occur along fractures and as pseudomorphs after pyrite.

Development: Two prospect pits

Sampling: A grab sample of the iron-oxide-stained, silicified rock assayed a trace of gold and silver.

Conclusions: No resource potential indicated.

Name: Victoria claim group

Index Map No.: Fig. 16, No. 10

Location: S1/2 S1/2 Sec. 28, T. 8 N, R. 1 W., east of Badger Creek

Elevation: 6250 feet (1905 m)

Access: By road 9 miles (14.4 km) west from Winston, Montana

History: First located by A. Lord in 1896 and last located in 1963 by J. Wilton and F. Griffin

Geology of deposit: The claim group is on several northwest-trending shear zones in andesite. The shear zones range in thickness from 1 to 3 feet (0.3 to 0.9 m), and consist of alternating bands of clay and fractured, iron-oxide-stained, pyrite-bearing country rock. Vuggy, pyrite-bearing quartz stringers as much as 3 inches (7.6 cm) thick occur locally. The country rock contains disseminated pyrite adjacent to the shear zones.

Development: Two open adits with a combined total length of 150 feet (45.7 m), 4 caved adits, 1 caved shaft, 47 prospect pits, and 13 trenches.

Sampling: Of 39 samples taken, 27 were samples of mineralized mine dump material which contained as much as 0.25 ounce gold per ton (8.6 g/t), 0.4 ounce silver per ton (14 g/t), and traces of copper, lead, and zinc. Three dump material grab samples had a trace gold and 0.2 ounce silver per ton (6.9 g/t). Nine chip samples across mineralized shear zones and joints assayed as much as 0.1 ounce gold per ton (3.4 g/t) and 0.2 ounce silver per ton (6.9 g/t).

Conclusions: The potential for the discovery of resources is low.

* *

Name: Vosburg mine

Owner: E. M. Koppen, Albuquerque, New Mexico.

Index Map No.: Fig. 16, No. 16

Location: NW1/4 NW1/4 Sec. 3, T. 8 N., R. 1 W., at head of Badger Creek, adjacent to the study area

Elevation: 7000 to 7450 feet (2134 to 2271 m)

Access: By road 9 miles (14 km) west from Winston, Montana

History: First located in 1931 by Al Dance as the Tramway claim and relocated by E. M. Koppen in 1976.

Previous production: Between 1933 and 1946, recorded production was 24,000 tons (21,772 t) of ore which averaged 0.28 ounce gold per ton (9.6 g/t) and 15 ounces silver per ton (514 g/t). Minor amounts of lead, zinc, and copper were also recovered.

Geology of deposit: The mineralized structure is not exposed. However, Earll (1964, p. 23) reported that the mine is on a narrow quartz vein that strikes N. 15° to 30° W. and dips 33° to 53° SW. in a quartz monzonite stock. Vein material includes pyrite, limonite, galena, and sphalerite.

Development: Workings consist of one open adit which is about 300 feet (91.4 m) long, eight caved adits, three caved shafts, and numerous prospect pits (fig. 29). A 50-ton-per-day (45-t/d) cyanide mill built in 1935 has been dismantled.

Sampling: Five grab samples from mill tailings averaged 0.02 ounce gold per ton (0.7 g/t), 1.28 ounces silver per ton (43.9 g/t), and 0.57 percent lead. Twelve samples from structures, host rocks, and mine dumps contained minor amounts of gold, silver, lead, and zinc.

Resource estimate: The mill tailings contain about 30,000 tons (27,000 t) of submarginal resources.

Conclusions: The mill tailings warrant further investigation, as shown by assay results. The siliceous dump material may be suitable for direct use as smelter flux. Also, it could possibly be concentrated and the concentrates sold to smelters. The vein may extend into the study area.

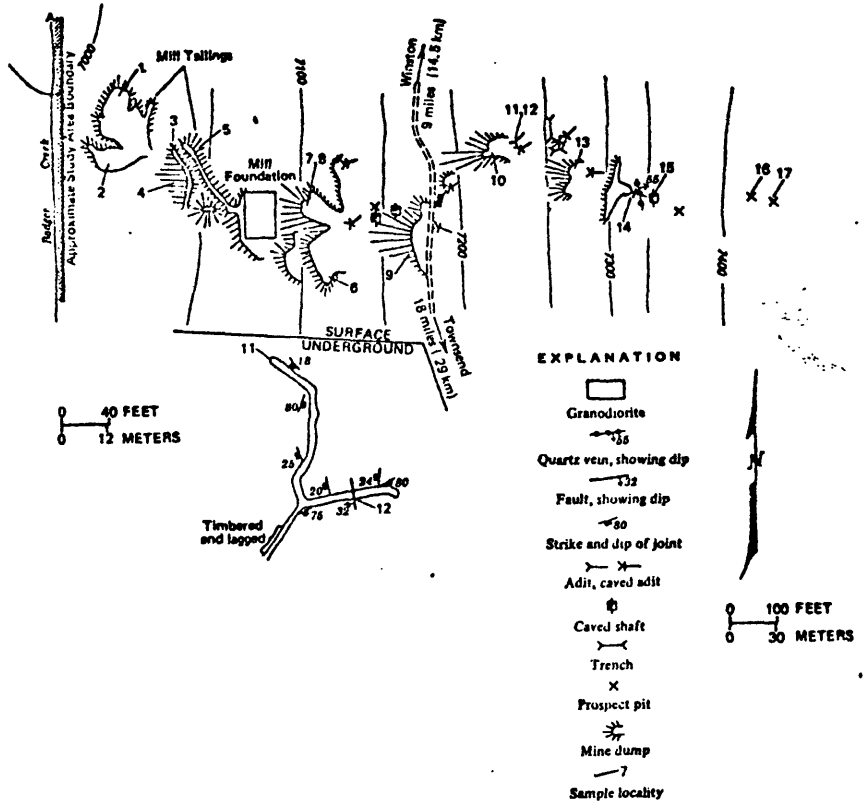


Figure 29. Vosburg mine.

An unnumbered table to accompany fig. 29, Vosburg mine

Data for samples shown on figure 29.

[Tr, trace; N, none detected; --, not analyzed]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Mill tailings----------------------	0.02	0.8	0.07	0.41	0.06
2	do--	--	do----------------------------------	.03	1.3	.10	.48	.07
3	do--	--	do----------------------------------	.03	2.8	.09	.72	.06
4	do--	--	do----------------------------------	N	1.5	.08	.78	.06
5	do--	--	do----------------------------------	N	N	.07	.44	.06
6	do--	--	Intrusive rock from dump-----------	N	N	.09	.11	.04
7	do--	--	Quartz vein material with sulfides from dump-------------------------	N	N	.12	2.1	.04
8	do--	--	Mineralized country rock and quartz vein material from dump------------	N	N	.05	.21	.05
9	do--	--	Iron-oxide-stained quartz vein material from dump-----------------	N	N	.08	.06	Tr
10	do--	--	Country rock from dump-------------	N	.1	--	--	--
11	Chip	3.0	Across unaltered intrusion---------	Tr	.1	Tr	Tr	Tr

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
12	Chip	0.5	Across shear zone------------------	Tr	0.1	0.05	0.09	0.16
13	Grab	--	Iron-oxide-stained quartz vein material from dump-----------------	Tr	.1	.08	1.0	.05
14	Chip	2.3	Across iron-oxide-stained quartz vein-------------------------------	N	.2	.08	.26	.06
15	Grab	--	Iron-oxide-stained quartz vein material--------------------------	N	.1	--	--	--
16	do--	--	do-------------------------------	N	.1	--	--	--
17	do--	--	do-------------------------------	N	N	--	--	--

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Elkhorn district

Name: Arcturus claim

Index Map No.: Fig. 17, No. 15

Location: SE1/4 Sec. 11, T. 6 N., R. 3 W., near Elkhorn Creek

Elevation: 6900 feet (2103 m)

Access: By road 0.5 mile (0.8 km) north from Elkhorn, Montana

History: The claim was first located as the Arcturus by J. Stabler in 1908. Subsequent relocations include the Mount McKinley by J. Williams in 1910, the Wigsness by D. Anderson in 1916, and the Laureen by D. Walker in 1922.

Geology of deposit: The area is underlain by limestone, sandstone, and shale that trend generally north and dip 30° to 80° east. Contacts between the sedimentary rocks are sites of local lead-silver mineral emplacement. High-grade gold ores may be present in the contact zones between limestone and shale. Sparsely-disseminated pyrite, arsenopyrite, galena, and chalcopyrite occur in silicified sandstones and limestones. Malachite encrustations are common on sandstones and iron-oxide-stained limestones.

Development: Numerous pits and several bulldozer and backhoe trenches were dug over an area of more than 60 acres (24 h).

Sampling: Seven samples, chip and grab, were taken from an area approximately 250 feet (76 m) long and 100 feet (30 m) wide, near the shale-limestone contact. They contained as much as 0.65 percent copper and 2.2 percent zinc; they averaged a trace of gold, 0.1 ounce silver per ton (3.4 g/t), 0.29 percent copper, 0.01 percent lead, and 0.57 percent zinc. Three chip samples from pits 1,100 feet (335 m) south assayed 0.23 percent zinc, and a trace of copper and lead. Seven additional samples from workings in the area had as much as a trace gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: The low metal content indicated by sampling does not preclude the presence of gold-silver-lead resources. A resource potential is indicated by similarity to other mines and metal-bearing occurrences in the district.

Name: Blackbird claim

Index Map No.: Fig. 17, No. 17

Location: NE1/4 SW1/4 Sec. 12, T. 6 N., R. 3 W., on Elkhorn Creek.

Elevation: 7800 feet (2377 m)

Access: By trail along Elkhorn Creek 1.5 miles (2.4 km) north from Elkhorn, Montana

History: The Blackbird claim was located by P. Buck in 1885.

Geology of deposit: A 6.5-foot (2-m)-thick, iron-oxide-stained shear zone is in quartzite which contains sparsely disseminated pyrite, arsenopyrite, and galena. The zone strikes N. 20° W. and dips 42° SW.

Development: A caved adit, estimated to have had 80 feet (24 m) of workings, a pit 75 feet (23 m) above the adit on the shear zone, and a second pit about 1,200 feet (366 m) southwest of and 150 feet (46 m) below the adit.

Sampling: Five samples were taken. One grab sample of quartzite with disseminated galena and arsenopyrite from the caved adit dump contained 0.02 ounce gold per ton (0.7 g/t), 0.6 ounce silver per ton (20.6 g/t) and 0.69 percent lead. Another of quartzite without visible sulfides had 0.1 ounce silver per ton (3.4 g/t). A continuous chip across the shear zone in the pit above the adit had a trace of silver. A quartzite sample with disseminated pyrite from the same pit assayed a trace of gold, 1.4 ounce silver per ton (48 g/t), 0.52 percent lead, and 0.07 percent copper. A continuous chip across quartzite with disseminated pyrite in the face of the second pit contained 0.01 ounce gold per ton (0.3 g/t) and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: A mineral potential is indicated. Subsurface work might disclose resources.

* *

Name: C and D mine

Owner: Dutton Clarke, Helena, Montana, and David D. Walker, Butte, Montana

Index Map No.: Fig. 17, No. 12

Location: E1/2 NE1/4 Sec. 11, T. 6 N., R. 3 W., on Elkhorn Creek

Elevation: 7200 to 7500 feet (2195 to 2286 m)

Access: By road 1.25 miles (2 km) north from Elkhorn, Montana

History: The C and D lode was located by W. Dunstone in May 1884, surveyed for patent in 1885, and patented later. The mine was last operated in 1942 in conjunction with the Louise lode by Dutton Clarke and J. Kalstead (Roby, 1960, p. 58). A smelter built near Queen Siding in 1886 treated the C and D ore. The low-grade oxide ore was used as flux at the East Helena smelter in the 1890's.

Previous production: Weed (1901, p. 413) reported the 1866 gold and silver production was worth $4,068. In 1887, the gold value was $10,335 and silver $10,320. In 1888, production totaled $2,661 in gold and $10,433 in silver. In 1898, "a considerable number of carloads of ore were shipped, although the ore ran only from $1.50 to $2 per ton ($1.65 to $2.20/t) in gold and was low in silver. Several carloads of galena have been shipped..." (Weed, 1901, p. 505). Between 1902 and 1942, 1,960 tons (1,778 t) of ore were produced from the C and D which yielded 641 ounces (19,937 g) gold, 7,748 ounces (240,986 g) silver, 824 pounds (373.8 kg) copper, and 91,235 pounds (41,383.5 kg) of lead.

Geology of deposit: The mine is in limestone near quartz monzonite. The limestone contains a 3-foot (0.9-m)-thick, iron-oxide-stained, replacement mineralized zone along bedding. The bedding strikes N. 35° E. and dips 45° SE. to 90° (Roby, 1960, p. 58). The zone consists of brecciated quartz and limestone with pods of argentiferous galena and cerrusite in an iron-oxide matrix (figs. 30 and 31).

The mineralized zone may terminate near the face of the open adit in an intensely-brecciated limestone that has some clay seams.

Klepper and others (1957, p. 69) report a steeply-dipping, silver-bearing vein which may also terminate in the breccia zone. A crosscut to the granite contact disclosed a pyritic zone which was too low in metal content to be minable (Weed, 1901, p. 505).

Development: One adit, three caved shafts, and numerous prospect pits comprise the workings. A shaft on the Louise lode, about 750 feet (229 m) northwest of the adit, was dug to intersect the mineralized zone. Only a part of the adit was accessible in 1977. It is in the footwall of the mineralized zone and trends generally northward, ending in a large, partially collapsed stope that is 75 feet (23 m) long, 30 feet (9 m) wide, and 40 feet (12 m) high in places.

A pit on the slope above the inclined shaft (sample locality No. 2) exposes a 2-foot (0.6-m)-thick, oxidized section of the mineralized zone which trends N. 35° E. and dips 52° SE. A caved, inclined shaft above the discovery pit, which is at least 15 feet (4.6 m) deep, apparently does not intersect mineralized rock (sample locality No. 1).

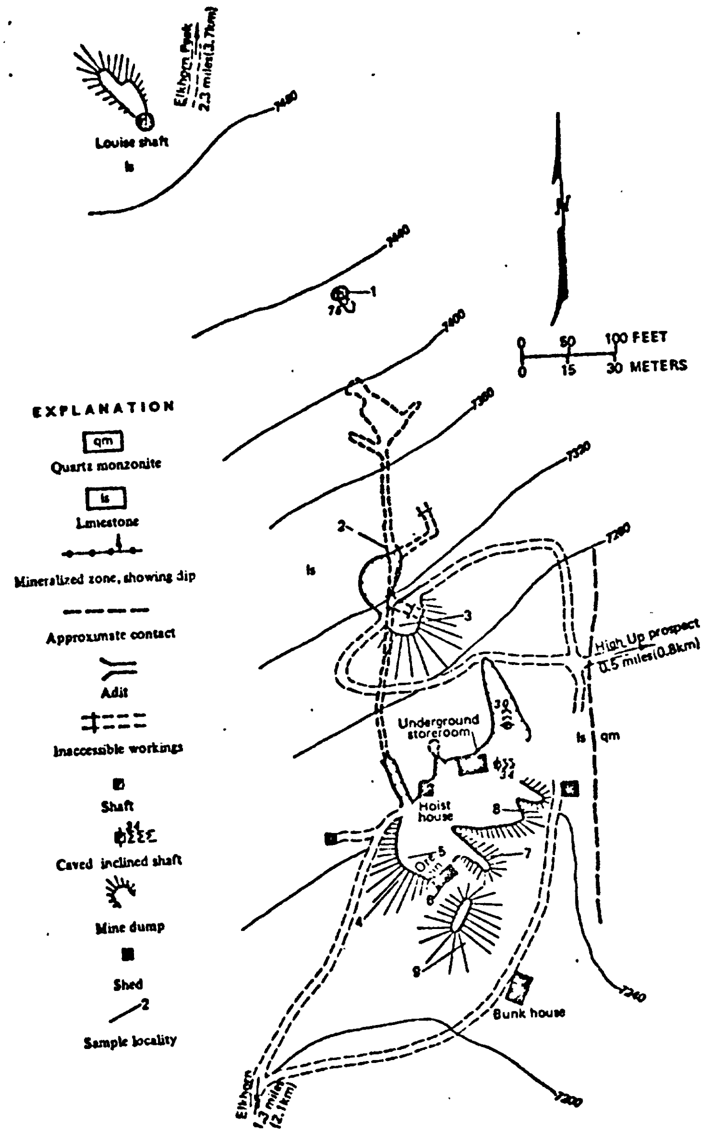


Figure 30. C and D mine and Louise shaft.

An unnumbered table to accompany fig. 30, C and D mine and Louise shaft

Data for samples shown on figure 30.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Gossany limestone from dump--------	N	0.1	0.04	0.15	0.03
2	Chip	2.0	Across gossan in limestone---------	0.01	.1	.25	4.9	.56
3	Grab	--	Gossan with pyrite in limestone from dump-------------------------	N	.1	.37	2.8	.79
4	do--	--	Black limestone with iron-oxide stain from dump-------------------	N	.1	.07	.53	.04
5	do--	--	Gossan from stockpile-------------	.13	1.5	.06	.48	.03
6	do--	--	Gossan in recrystallized limestone from stockpile--------------------	N	.1	.15	.18	.15
7	do--	--	Gray limestone from dump-----------	N	.1	Tr	Tr	Tr
8	do--	--	Black limestone with partial iron-oxide stain from dump-------------	.078	.5	.02	.11	.02
9	do--	--	do---------------------------------	.05	2.7	.037	.44	.05

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

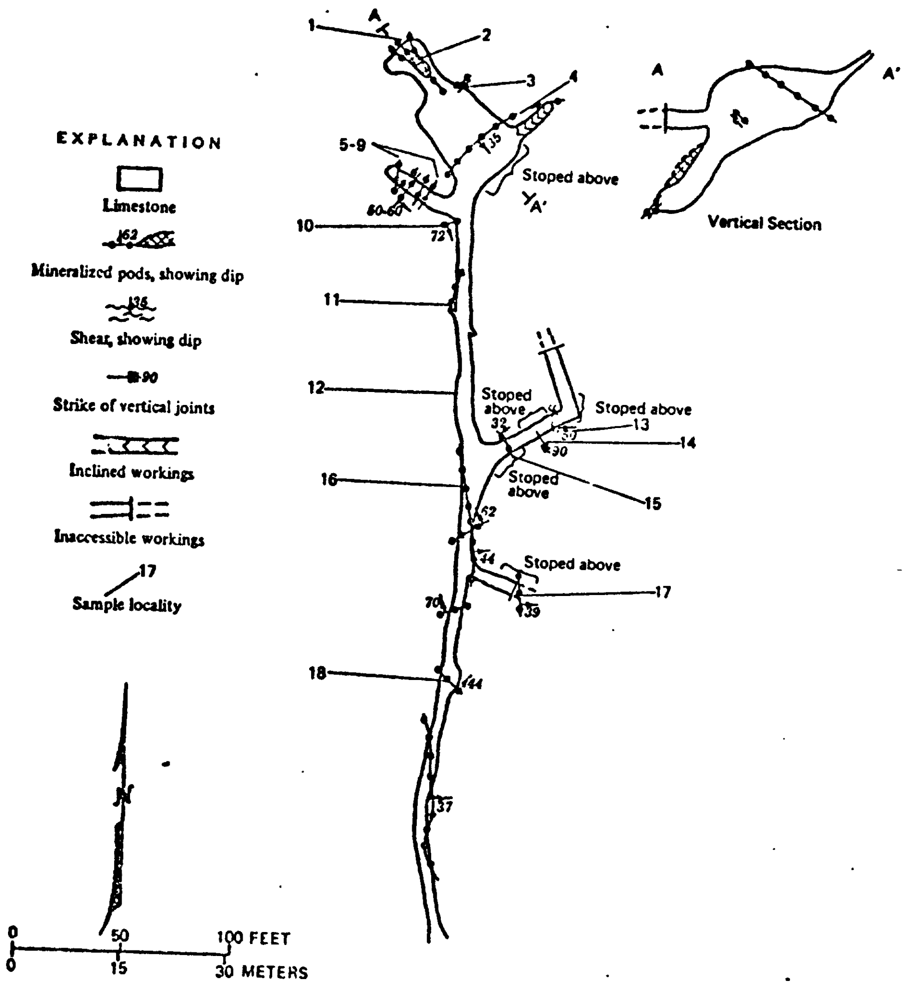


Figure 31. C and D mine, main adit.

An unnumbered table to accompany fig. 31, C and D mine, main adit

Data for samples shown on figure 31.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Chip	12.0	Across gossany breccia zone---------	0.02	0.1	0.091	1.2	0.13
2	do--	2.0	Across gossany pod caved from back of stope--------------------------	N	.2	.13	3.9	.02
3	Grab	--	Banded clay and gossan pod----------	N	.1	.50	.06	.14
4	Chip	3.0	Across gossany breccia zone---------	.02	.1	.03	.10	.14
5	do--	5.0	Across stringers of gossan and clay layers in marble-------------------	N	N	Tr	Tr	.02
6	do--	4.0	do----------------------------------	N	N	Tr	Tr	Tr
7	do--	5.0	do----------------------------------	Tr	N	N	.01	.01
8	do--	4.0	do----------------------------------	Tr	N	Tr	.02	.02
9	do--	4.0	do----------------------------------	N	N	Tr	.02	.02
10	do--	4.0	Across gossan with clay in fractures	N	N	Tr	.02	.02
11	do--	1.5	Across gossan zone-----------------	N	N	Tr	Tr	.02

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
12	Grab	--	Iron-oxide-stained clay in filled solution channel-------------------	N	N	0.03	0.02	0.07
13	Chip	2.3	Across shear zone------------------	N	N	.13	.31	.03
14	do--	1.0	Across copper-stained fracture------	N	N	2.7	.09	.5
15	do--	4.0	Limestone breccia zone with gossan stringers-------------------------	Tr	N	.02	.13	.06
16	do--	4.0	Across gossan stringers in limestone breccia zone--------------	Tr	0.2	Tr	Tr	.03
17	do--	2.0	Across pod of gossan----------------	Tr	.1	.16	.05	4.2
18	do--	2.0	Across gossan and clay-filled fracture--------------------------	Tr	.2	Tr	.03	.06

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Sampling: Eighteen samples from structures in the adit contained as much as 0.02 ounce gold per ton (0.7 g/t) and 0.2 ounce silver per ton (6.9 g/t). The average metal content was a trace of copper, 0.38 percent lead, and 0.19 percent zinc. Two samples (Nos. 1 and 2) were from areas in the accessible stope where material of shipping grade might be expected. They averaged 1.59 percent lead with insignificant amounts of gold, silver, and copper.

Eight mine dump samples assayed as much as 0.13 ounce gold per ton (4.5 g/t) and 2.7 ounces silver per ton (92.6 g/t).

A sample from the oxidized, mineralized portion of the zone in the pit (sample locality No. 2) contained 0.01 ounce gold per ton (0.3 g/t), 0.1 ounce silver per ton (3.4 g/t), 0.25 percent copper, 4.9 percent lead, and 0.56 percent zinc.

Conclusions: Ore from the C and D mine historically has been a low-grade, oxidized material used at the smelter chiefly as a flux. Small, metal-bearing structures occur within the low-grade material. Deposits of higher grade lead-silver may be present. The limestone-quartz monzonite contact zone is a favorable site for the discovery of additional resources.

* *

Name: Eagle Hill and Iron Bar Lodes

Index Map No.: Fig. 17, No. 20

Location: W1/2 Sec. 13, T. 6 N., R. 3 W., on the divide west of Hobo Gulch, south of the study area

Elevation: 6700 feet (2042 m)

Access: By road 1 mile (1.6 km) east from Elkhorn, Montana

History: The Eagle Hill and Iron Bar lode claims were located by Louis Stegmiller in 1905 and patented in 1906.

Geology of deposit: The claims are on a north-trending, easterly-dipping replacement zone that is near a limestone-quartz monzonite contact. The zone is composed of limestone and iron-oxide-stained, vuggy, pyrite-bearing quartz. This structure seems to be a southeast extension of the replacement zone on the Union and C and D mines.

Development: Two caved adits and one caved shaft with total workings estimated to be 500 feet (152 m) in length.

Sampling: Five grab samples of replacement zone material, quartz, limestone, and quartz monzonite were taken from prospect dumps. They assayed as much as 0.02 ounce gold per ton (0.7 g/t), 0.1 ounce silver per ton (3.4 g/t), and trace amounts of copper, lead, and zinc.

Conclusions: The deposit may extend northerly into the study area, and may be a potential mineral resource.

* *

Name: Eclipse claim

Index Map No.: Fig. 17, No. 14

Location: SE1/4 NE1/4 Sec. 11, T. 6 N., R. 3 W., on Elkhorn Creek

Elevation: 7160 feet (2182 m)

Access: By road 1 mile (1.6 km) north from Elkhorn, Montana.

History: Located in 1891 by Duncan McDougall

Geology of deposit: Grayish-white, fine-grained limestone contains finely-disseminated pyrite. No mineralized structure is exposed on the claim.

Development: Two shallow bulldozer trenches

Sampling: One grab sample of material from the larger trench contained 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated.

* *

Name: Elkhorn Creek prospect

Index Map No.: Fig. 17, No. 16

Location: SE1/4 Sec. 11, T. 6 N., R. 3 W., on Elkhorn Creek.

Elevation: 6900 feet (2103 m)

Access: By walking cross-country 0.5 mile (0.8 km) north from Elkhorn, Montana

Geology of deposit: Dark gray limestone

Development: One caved adit less than 20 feet (6 m) long

Sampling: A grab sample of limestone from the prospect dump had 0.1 ounce silver per ton (3.4 g/t) and trace amounts of copper and lead, and 0.01 percent zinc.

Conclusions: No mineral resource potential indicated.

* *

Name: Elkhorn Ridge prospect

Index Map No.: Fig. 17, No. 2

Location: SE1/4 Sec. 36, T. 7 N., R. 3 W., 0.5 mile (0.8 km) northeast of Elkhorn Peak

Elevation: 8800 feet (2682 m)

Access: By road and walking cross-country 5 miles (8 km) northeast from Elkhorn, Montana

Geology of deposit: A shear zone trends northwesterly in diorite and andesite. Using dump material as an indicator, the zone seems to be as much as 1.5 feet (2.4 m) thick. The zone is composed of leached, brecciated, silicified andesite and quartz. The shear zone and diorite wallrock are coated by malachite and contain pyrite and arsenopyrite.

Development: A caved adit, estimated to have been about 100 feet (30.5 m) long, and six trenches constitute the workings. They extend for about 600 feet (183 m) along a northwest trend.

Sampling: Two grab samples of copper-stained shear zone material from prospect dumps averaged 2.6 ounces silver per ton (89.1 g/t), 0.43 percent copper, 0.1 percent lead, and 0.13 percent zinc.

Conclusions: Additional surface and subsurface work might disclose resources.

Name: Golden Moss mine

Owner: John H. Williams, Boulder, Montana

Index Map No.: Fig. 17, No. 10

Location: SW1/4 NE1/4 Sec. 11, T. 6 N., R. 3 W., between Elkhorn Creek and Slaughterhouse Gulch

Elevation: 7000 feet (2134 m)

Access: By road 1 mile (1.6 km) north from Elkhorn, Montana

History: The Golden Moss was located by Jacob Switzer in August 1889 and surveyed for patent in October of the same year. It was operated as part of the Peacock group from 1905 to 1938.

Previous production: Between 1910 and 1938 the Golden Moss mine produced 29 tons (26 t) of ore, which yielded 18 ounces (559.9 g) of gold, 76 ounces (2,363.8 g) of silver, and 1,029 pounds (466.7 kg) of copper. Between 1905 and 1925, production from the Peacock group was 415 tons (376 t) of ore. Four hundred nine ounces (12,721.3 g) of gold, 279 ounces (8,677.9 g) of silver, 748 pounds (339.3 kg) of copper, and 1,611 pounds (730.7 kg) of lead were recovered.

Geology of deposit: The Golden Moss is on a contact between silicified shale and limestone which strikes N. 9° E. and dips 63° SE. The shale is leached, intensely fractured and heavily encrusted with iron-oxides. Prominent joints in the light gray limestone strike N. 46° E., dip 69° NW., and are filled with secondary copper minerals. Quartzite float, with finely disseminated pyrite, is in trenches south of the shaft.

Development: A shaft was sunk on the shale-limestone contact. Although now inaccessible, it reportedly was 100 feet (30.5 m) deep (Roby, 1960, p. 61). A 36-foot (11-m)-long adit was driven S. 60° E. in limestone. The adit is in Slaughterhouse Gulch about 400 feet (122 m) northwest of the shaft. Several shallow pits are near the shaft; three bulldozer trenches are south of it.

Sampling: Three samples of silicified shale and fractured, copper-stained limestone from the shaft dump had trace amounts of gold and silver, 0.02 to 0.39 percent copper, and less than 0.04 percent lead and zinc. Two samples of limestone from the adit contained trace amounts of gold and silver. Two grab samples from dumps of the trenches south of the shaft assayed traces of gold and silver; one contained 0.49 percent copper and 0.03 percent zinc.

Conclusions: Judging from sample results, the mine has a low mineral resource potential.

Name: High Grade and Percy Lodes

Owner: Robert L. McLeod, Butte, Montana, and Lewis Zundel, Marlin, Washington

Index Map No.: Fig. 17, No. 4

Location: The Bureau of Land Management (BLM) plat of survey shows that the lode claims are on the south side of Elkhorn Peak in the NE1/4 Sec. 1, T. 6 N., R. 3 W. No workings were found in the area indicated by the plat. The Queen Ann prospect (fig. 17, No. 6), 0.4 mile (0.6 km) to the south, may be the High Grade and Percy Lodes.

Elevation: 8800 feet (2682 m)

Access: By road and trail 3 miles (4.8 km) northeast from Elkhorn, Montana

History: The claims were located and patented by John L. Templeman in 1920. They cover about 41 acres (16.9 h).

Geology of deposit: The area is underlain by andesite with recrystallized limestone reefs. The rocks are fractured and altered. The area is on the trend of hematite-magnetite replacement lenses of the Iron mine (fig. 17, No. 1).

Development: Four adits and one inclined shaft totaling about 380 feet (116 m) of underground workings are shown on the plat of survey for the High Grade and Percy Lodes, but no workings, or other indications of mine development, were found.

* *

Name: High Up claim

Index Map No.: Fig. 17, No. 7

Location: SW1/4 SW1/4 Sec. 1, T. 6 N., R. 3 W., above Elkhorn Creek

Elevation: 7640 feet (2329 m)

Access: By road 1.5 miles (2.4 km) north from Elkhorn, Montana.

History: Located in 1927 by J. Williams.

Geology of deposit: Limestone and quartzite are in contact with quartz monzonite. The gray to white limestone is partially recrystallized and iron-oxide-stained. It contains sparsely-disseminated pyrite, chalcopyrite, arsenopyrite, and galena. The gray to black quartzite is partially iron-oxide-stained and has finely-disseminated arsenopyrite and pyrite.

Development: Workings consist of three caved adits and two small pits. The largest adit is thought to have been 500 feet (152 m) long. The other adits are estimated to have totaled 95 feet (29 m) of workings.

Sampling: Seven samples from dumps of the pits and caved adits had as much as a trace of gold, 0.2 ounce silver per ton (6.9 g/t), 0.01 percent copper, 0.27 percent lead, and 0.1 percent zinc.

Conclusions: The mineral resource potential is low.

* *

Name: Hobo Gulch prospect

Index Map No.: Fig. 17, No. 19

Location: Center N1/2 Sec., 13, T. 6 N., R. 3 W., in Hobo Gulch.

Elevation: 7240 feet (2207 m)

Access: By road 2 miles (3.2 km) north from Elkhorn, Montana, then by foot 0.8 mile (1.3 km).

Geology of deposit: The prospect is near a limestone-quartzite contact. The sedimentary rock trends generally north and dips 27° to 54° east. Dark brown to black, coarse-grained diorite float is in the vicinity of the prospect.

Development: A caved adit, probably no more than 15 feet (4.6 m) long, in quartzite, and a trench in limestone

Sampling: Two grab samples from dumps of both the caved adit and trench averaged a trace of copper, 0.02 percent lead, and 0.02 percent zinc.

Conclusions: No mineral resource indicated.

Name: Iron mine

Index Map No.: Fig. 17, No. 1

Location: SW1/4 Sec. 36, T. 7 N., R. 3 W., on the northwest side of Elkhorn Peak

Elevation: 8300 to 8720 feet (2530 to 2658 m)

Access: By unmaintained mountain road 4.5 miles (7.2 km) north from Elkhorn, Montana.

History: The Iron mine is comprised of the Black Diamond, Du Page, Monarch, and Montana lode claims which were located in 1887 and 1890 and later patented. The claims cover approximately 75 acres (30 h).

Previous production: Roby (1960, p. 59) reports that iron ore used as flux at the East Helena smelter between 1890 and 1900, was mined at the rate of 75 to 100 tons per day (68 to 91 t/d). U.S. Bureau of Mines production records show 256 tons (232 t) of ore, having 10 ounces (310 g) of gold, 2,924 ounces (90,995 g) of silver, and 190 pounds (86 kg) of copper were produced between 1908 and 1915.

Geology of deposit: The Iron mine is in a mineralized zone of replacement lenses along bedding and fractures in andesite which is overlain by limestone (fig. 32). The mineralized lenses are near the contact. Alaskite, aplite, and related rocks underlie and intrude the andesite and limestone. The lenses are as much as 65 feet (19.8 m) thick. They consist of brecciated andesite with massive hematitic magnetite, garnet, and sparse pyrite with chalcopyrite which are, in places, malachite-stained. The overlying limestone is unmineralized.

East-trending mineralized shear zones occur in the andesite surrounding the limestone. The replacement lenses and shear zones are leached and iron-oxide-stained at the surface; the magnetite as well as metallic sulfide minerals, have been largley replaced by hematite and limonite.

Development: The principal workings, consisting of a number of adits and pits, are along the zone of replacement lenses on the northwest side of Elkhorn Peak. Two adits on the extension of the zone are on Elkhorn Peak's southwest side. East and west of the main zone are seven caved adits, pits, and trenches on mineralized shear zones in andesite. Underground workings are estimated to total about 1,500 feet (457 m).

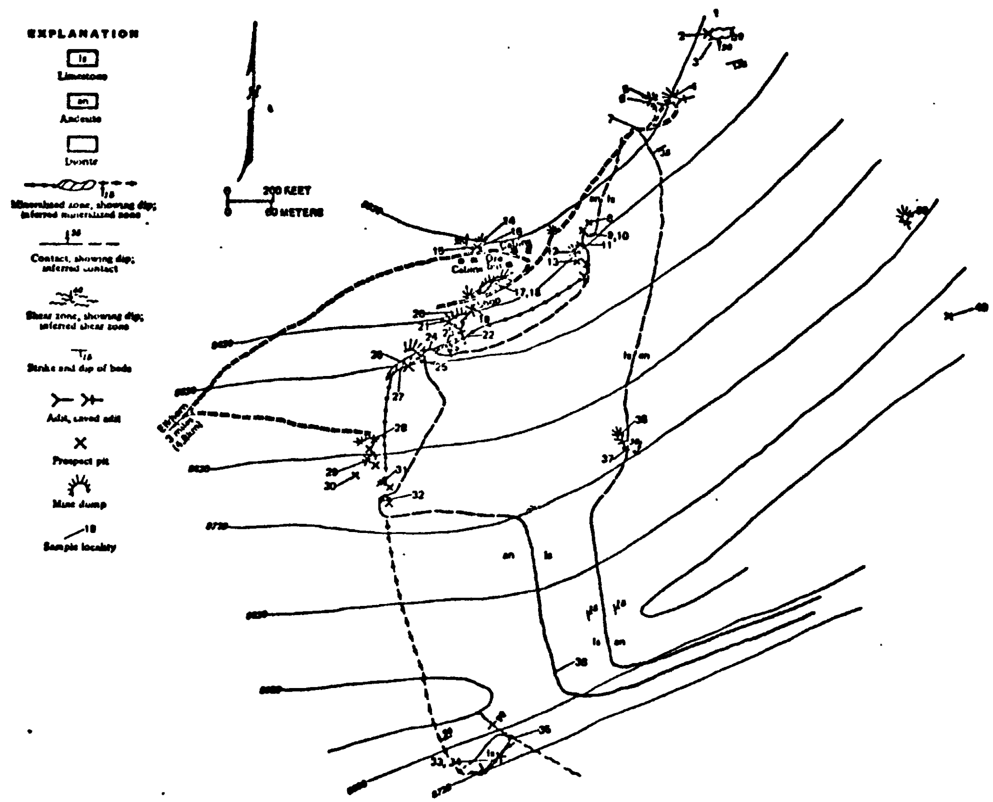


Figure 32. Iron mine.

An unnumbered table to accompany fig. 32, Iron mine

Data for samples shown on figure 32.

[Tr, trace; N, not detected; --, not analyzed]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)	Iron (percent)
No.	Type	Length (feet) 1/	Description						
1	Chip	0.5	Across shear zone--------	Tr	0.1	0.01	0.02	0.01	6.8
2	do--	1.5	do----------------------	0.02	.1	.04	.46	.43	6.9
3	Grab	--	Shear zone material from stockpile----------------	.03	.1	.02	.4	1.1	5.6
4	do--	--	Shear zone material from dump--------------------	.01	.1	Tr	.06	.12	3.8
5	do--	--	Andesite from dump-------	.01	.1	Tr	.02	.03	3.1
6	do--	--	Diorite from dump--------	Tr	.1	Tr	Tr	.01	3.2
7	Chip	100.0	Across limestone---------	N	N	Tr	Tr	Tr	.43
8	do--	7.0	Across diorite-----------	Tr	N	.05	Tr	.16	--
9	Grab	--	Diorite from dump--------	.02	.1	.06	.01	.07	--
10	Chip	5.0	Across diorite-----------	N	N	.04	Tr	.3	8.7

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)	Iron (percent)
No.	Type	Length (feet) 1/	Description						
11	Chip	4.0	Across limestone---------	N	N	Tr	Tr	0.07	0.31
12	Grab	--	Limestone from dump------	Tr	N	Tr	Tr	Tr	.26
13	Grab	--	Lens material from dump--	Tr	0.1	0.03	0.02	.02	24.9
14	do--	--	Andesite from dump-------	Tr	.1	.01	.02	.02	5.7
15	do--	--	Shear zone material from dump--------------------	Tr	.1	.42	.02	.01	32.3
16	do--	--	do----------------------	Tr	.1	.12	.03	.01	36.7
17	do--	--	Andesite from dump-------	N	.1	N	.03	.08	4.3
18	do--	--	Lens material from dump--	Tr	1.1	Tr	.18	.15	29.7
19	do--	--	Magnetite from stockpile	Tr	.1	.1	.02	.02	53.1
20	do--	--	Lens material from dump--	0.045	.3	Tr	.03	.03	25.4
21	do--	--	Magnetite from stockpile	.07	.1	.11	.02	.05	56.8
22	Chip	10.0	Across lens--------------	Tr	.2	Tr	.02	.02	16.9
23	do--	10.0	do----------------------	.01	.2	.1	.02	.05	18.7

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)	Iron (percent)
No.	Type	Length (feet) 1/	Description						
24	Chip	--	Across limestone---------	0.01	0.1	Tr	0.02	0.02	0.8
25	do--	65.0	Across lens--------------	.03	.3	.17	Tr	.06	--
26	do--	20.0	do----------------------	.01	.1	.16	.03	.09	39.7
27	Grab	--	Lens material from dump--	.01	.3	.29	.02	.08	3.3
28	do--	--	do----------------------	Tr	.2	1.8	Tr	.07	--
29	do--	--	do----------------------	Tr	.2	.33	.02	.05	46.8
30	do--	--	do----------------------	Tr	.1	2.1	.02	.08	15.8
31	do--	--	do----------------------	.01	.1	.12	.02	.02	20.2
32	do--	--	do----------------------	Tr	.1	.66	.02	.06	13.9
33	Chip	--	Across limestone---------	Tr	.2	Tr	Tr	Tr	--
34	do--	8.0	Across lens--------------	.11	.1	.25	Tr	.08	--
35	do--	--	Across limestone---------	Tr	.2	Tr	.02	.1	.94
36	Grab	--	Limestone from dump------	N	.1	Tr	.05	.02	.72
37	Chip	1.0	Across shear zone--------	N	.2	1.8	.06	.63	41.4

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)	Iron (percent)
No.	Type	Length (feet) 1/	Description						
38	Grab	--	Magnetite from stockpile	Tr	0.1	0.1	0.02	0.16	43.1
39	Chip	75.0	Across andesite----------	N	Tr	.01	.02	.02	--
40	do--	--	Shear zone material from dump--------------------	Tr	.1	.03	.53	.18	--

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Sampling. Sample locations and analyses are shown in figure 32 and the accompanying table. Five samples chipped across replacement lenses (Nos. 22, 23, 25, 26, and 34) averaged 0.03 ounce gold per ton (1 g/t), 0.2 ounce silver per ton (6.9 g/t), 0.15 percent copper, 0.06 percent zinc, and 28.7 percent iron. Six grab samples of lens material, including massive magnetite (Nos. 19-21, 29, 30, and 38), averaged a trace of gold, 0.53 percent copper, 0.02 percent lead, 0.07 percent zinc, and 39.6 percent iron. Three chip samples across shear zones in andesite (Nos. 1, 2, and 37) averaged a trace of gold, 0.1 ounce silver per ton (3.4 g/t), 0.6 percent copper, 0.23 percent lead, 0.43 percent zinc, and 18 percent iron.

Resource estimate: The replacement lenses are 8 to 65 feet (2.4 to 19.8 m) thick, and average 15 (4.6 m). They occur along a zone that is approximately 2,600 feet (790 m) long in a north-south direction, and is estimated to contain a mineral resource of about 4.2 million tons (3.8 million t). Additional mineral resources probably occur along and near the downdip extensions of the zone to the east, and under the summit of Elkhorn Peak.

Mineralized shear zones in the andesite are 0.5 to 1.5 feet (0.15 to 0.46 m) thick, averaging 1 foot (0.3 m). At least three zones are indicated, but they are undeveloped and too poorly exposed to justify a resource estimate.

Conclusions: The Iron mine contains a small iron resource which is enhanced by near-minable-grade gold, silver, lead, and zinc. Subsurface work on the zone of replacement lenses and in the area of andesite shear zones could disclose minable resources.

* *

Name: Lone Bear prospect (Sport Lode)

Owner: Roman A. Fautsch

Index Map No.: Fig. 17, No. 5

Location: South center of the NE1/4 Sec. 2, T. 6 N., R. 3 W., at the head of Slaughterhouse Gulch

Elevation: 8050 feet (2454 m)

Access: By unmaintained mountain road 1.5 miles (2.4 km) north from Elkhorn, Montana

History: The Lone Bear prospect was located by Roman A. Fautsch in 1976. The 20-acre (8-h) patented Sport Lode was located in 1897.

Geology of deposit: The prospect is on a series of replacement lenses in limestone which is intruded by quartz monzonite. The limestone strikes N. 45° W. and dips 60° southwest. The lenses are controlled by bedding planes and crosscutting joints and fractures. At the surface, the lenses are leached and oxidized, and composed of limonite-stained, silicified limestone, jasper, hematite-limonite, and sparse garnet and magnetite. An exposure of a lens in the bottom of a 25-foot (7.6-m)-deep shaft contains lead sulfide and secondary lead-zinc minerals.

Development: Workings extend a distance of 1,700 feet (518 m) from quartz monzonite exposed on the north, across limestone to quartz monzonite exposed on the south. They consist of two open shafts 20 and 25 feet (6.1 and 7.6 m) deep, four caved adits estimated to total less than 1,000 feet (305 m) in length, and nine prospect pits and trenches.

Sampling: Fifteen samples were chipped from replacement zone outcrops and grabbed from stockpiles and mine dumps. Samples of oxidized surficial replacement material assayed as much as a trace of gold, 0.3 ounce silver per ton (10.3 g/t), 0.11 percent copper, 0.14 percent lead, and a trace of zinc. Replacement zones in the bottom of the 25-foot (7.6-m)-deep shaft were the sources of two chip samples which assayed a trace of gold, 0.3 ounce silver per ton (10.3 g/t), 7 percent lead, and 16 percent zinc. A sample from a stockpile at a nearby 20-foot (6.1-m)-deep shaft contained traces of gold and copper, 0.3 ounce silver per ton (10.3 g/t), 2.8 percent lead, and 8 percent zinc.

Resource estimate: The replacement lens, exposed in the 25-foot (7.6-m)-deep shaft, is 16.5 feet (5 m) thick and 100 feet (30.5 m) long. It was computed to contain a paramarginal resource of about 7,000 tons (6,400 t). Additional resources probably occur in other lenses in the limestone.

Conclusions: The replacement lenses exposed at the surface at the Lone Bear prospect are leached and barren. However, an enrichment and a primary zone is indicated to occur 20 to 30 feet (6.1 to 9.1 m) below the surface. Most likely the lenses would be high-grade, but small. Subsurface work on the prospect is warranted, and would probably disclose additional mineral resources.

* *

Name: Louise and Side Issue Lodes

Owner: May A. Quaintance, Great Falls, Montana

Index Map No.: Fig. 17, No. 11

Location: NE1/4 Sec. 11, T. 6 N., R. 3 W., on the divide between Elkhorn Creek and Slaughterhouse Gulch

Elevation: 7480 feet (2280 m)

Access: By road 2 miles (3.2 km) north from Elkhorn, Montana

History: The Louise and Side Issue Lodes were located in 1884 and 1887, respectively, by T. Nicholson. Both were relocated by A. Quaintance for the Louise Mining Co. in 1889 and surveyed for patent the same year. A patent for both claims was issued later.

Geology of deposit: Siliceous, oxidized, replacement lenses are in limestone near the contact with quartz monzonite. The Louise shaft was sunk to intersect extensions of the C and D mine deposits that are 750 feet (229 m) south (fig. 20). However, the shaft did not intersect the replacement deposit. The C and D deposit strikes generally N. 35° E. and dips from near vertical to 45° SE. A small stockpile of vuggy, oxidized, quartz vein material with less than 1 percent finely disseminated galena lies near the shaft collar.

A band of vuggy red to yellow jasper is exposed in a prospect pit on the Side Issue claim south of the Louise shaft. The band of jasper is as much as 3 feet (0.9 m) thick and exposed for a length of 15 feet (4.6 m). It strikes N. 65° E. and dips 70° NW.

A shear zone in quartz monzonite, striking east and dipping 85° S., crops out 900 feet (274 m) north of the Louise shaft. The zone contains magnetite and malachite and is 7 feet (2.1 m) thick in places.

Development: The Louise shaft is reportedly 205 feet (62 m) deep (Roby, 1960, p. 58). An 80-foot (24-m)-long open cut, a 7-foot (2.1-m)-deep shaft, and a short adit (now caved) are about 900 feet (274 m) north of the shaft. The Side Issue Lode has been explored by three shallow prospect pits.

Sampling: Five samples were taken from workings on the two claims. The Side Issue claim's pit was the source of an 8-foot (2.4-m)-long continuous chip of vuggy jasper which, along with a grab sample from the dump of the same pit, contained a trace of gold, 0.1 ounce silver per ton (3.4 g/t), and less than 0.02 percent copper, lead, and zinc. A grab sample from the stockpile near the Louise shaft had 0.1 ounce silver per ton (3.4 g/t), 0.08 percent copper, 0.08 percent lead, and 0.04 percent zinc. A dump sample from the cut north of the shaft assayed a trace of gold, 30.8 percent iron, 0.09 percent copper, 0.02 percent lead, and 0.06 percent zinc. A continuous 7-foot (2.1-m) chip sample from across the shear zone in quartz monzonite contained a trace of gold, 0.3 ounce silver per ton (10.3 g/t), 17.7 percent iron, 0.63 percent copper, 0.02 percent lead, and 0.06 percent zinc.

Conclusions: The Louise and Side Issue Lodes are on the trend of the C and D mineralized zone; deep subsurface work would probably disclose mineral resources.

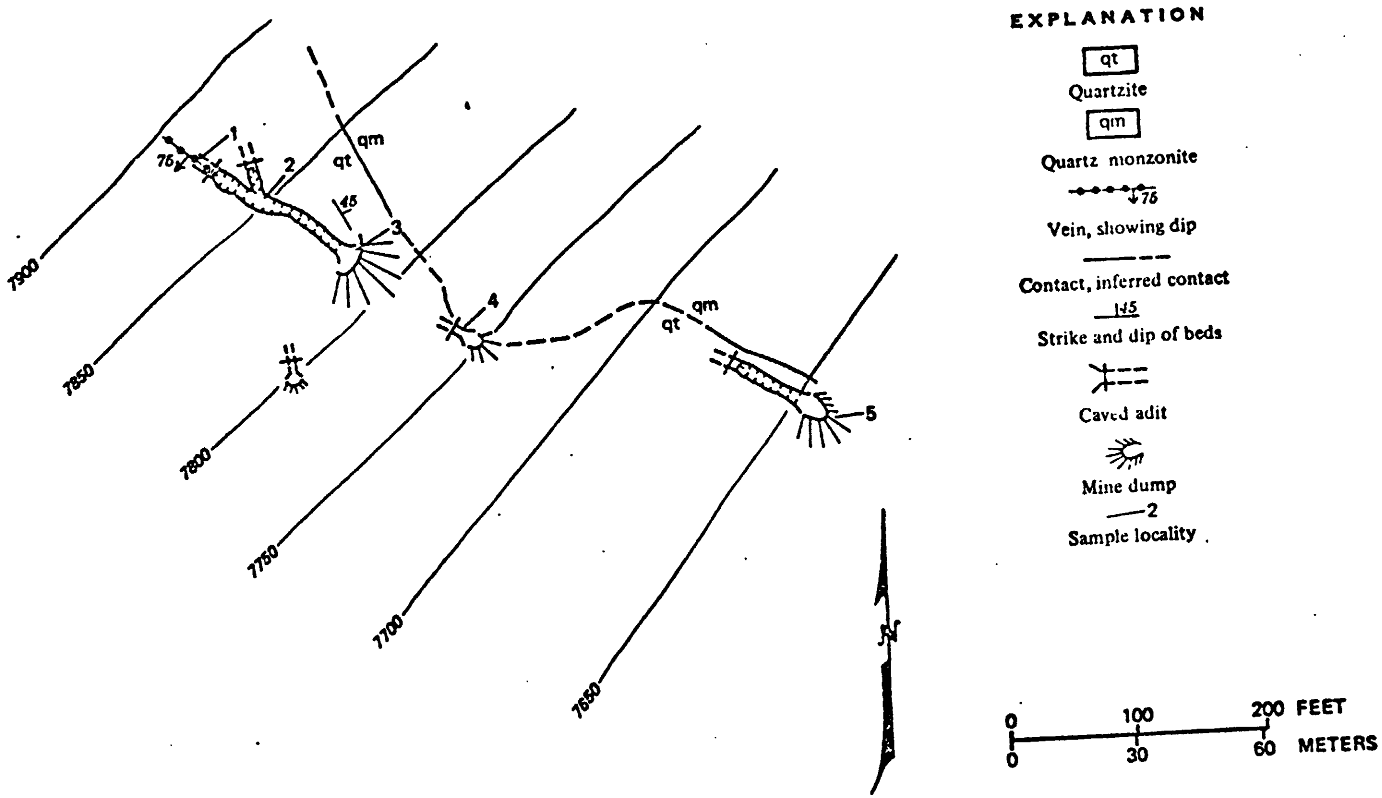


Figure 33. North Louise prospect.

An unnumbered table to accompany fig. 33, North Louise prospect

Data for samples shown on figure 33.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Chip	2.0	Across vein------------------------	0.02	0.2	0.01	1.8	0.16
2	Grab	--	Vein material from dump------------	N	.1	.05	7.8	.96
3	do--	--	do---------------------------------	N	.1	.04	31.3	.40
4	do--	--	do---------------------------------	N	.1	.02	17.4	.38
5	do--	--	Quartzite from dump----------------	Tr	.1	Tr	.05	Tr

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Name: North Louise prospect

Index Map No.: Fig. 17, No. 8

Location: SW1/4 SW1/4 Sec. 1, T. 6 N., R. 3 W., on the divide between Elkhorn Creek and Slaughterhouse Gulch

Elevation: 7650 to 7900 feet (2332 to 2408 m)

Access: By road 2 miles (3.2 km) north from Elkhorn, Montana

Geology of deposit: The North Louise prospect is on a N. 55° W. striking, 75° SW. dipping quartz vein in quartzite (fig. 33). The vein is near an irregular quartzite and quartz monzonite contact, and contains hematite and galena. Secondary lead and zinc minerals coat the vein and adjacent wallrock.

Development: Workings consist of four caved adits estimated to aggregate about 300 feet (91 m).

Sampling: Sample locations and analyses are shown on figure 33 and accompanying table. One chip sample across the vein (No. 1) assayed 0.02 ounce gold per ton (0.7 g/t), 0.2 ounce silver per ton (6.9 g/t), 0.01 percent copper, 1.8 percent lead, and 0.16 percent zinc.

Resource estimate: The North Louise vein, 2 feet (0.6 m) thick, is projected 200 feet (61 m) along strike, and estimated to contain a submarginal resource of about 3,000 tons (2,700 t). Additional resources probably occur on vein extensions.

Conclusions: The vein is too small to be minable, but mineral resources would probably be disclosed by additional surface and subsurface work.

* *

Name: Queen Ann claim

Index Map No.: Fig. 17, No. 6

Location: SE1/4 Sec. 1, T. 6 N., R. 3 W., east of Elkhorn Creek

Elevation: 8000 feet (2438 m)

Access: By trail 2 miles (3.2 km) north from Elkhorn, Montana

History: Located by E. Hardin in 1893

Geology of deposit: Dump material from workings now covered by andesitic talus indicates that country rock is limestone and andesite. The limestone contains disseminated pyrite, arsenopyrite, and limonite stringers, some of which are 0.5 inch (1.3 cm) thick. Vuggy vein quartz, as much as 1 foot (0.3 m) thick, was also found on the mine dump.

Development: Three adits, one shaft, one large trench, and numerous small pits and trenches constitute the workings. The main adit, caved 51 feet (15.5 m) from the portal, is filled with ice for at least the next 50 feet (15.2 m). The accessible portion is timbered or lagged, with the ribs and floor covered by ice. The adit is estimated to have about 400 feet (122 m) of workings.

The two other adits are completely caved; the upper one, 62 feet (19 m) east and uphill from the main adit, was probably about 100 feet (30 m) long. The lower one, about 160 feet (49 m) west and downhill from the main adit at the foot of the talus slope, was less than 50 feet (15 m) long. The shaft, near the lower adit, is 4 feet (1.2 m) deep. The large trench was cut obliquely into the talus slope above the lower adit. Although nearly filled with andesite talus, it was probably 8 feet (2.4 m) deep.

Sampling: Four grab samples from dumps of caved workings assayed as much as a trace of gold, 0.2 ounce silver per ton (6.9 g/t), 0.31 percent lead, 0.01 percent copper, and 0.02 percent zinc. A sample of iron-oxide-stained quartz vein material in andesite from a small stockpile near the lower adit contained 0.26 ounce gold per ton (8.9 g/t), 16.5 ounces silver per ton (565.7 g/t), 1.4 percent lead, and trace amounts of copper and zinc.

Conclusions: The lower adit sample indicates high gold and silver content. Although mineralized structures are not exposed, a potential resource seems to be indicated.

* *

Name: Skyline mine

Owner: Robert McNeil, Helena, Montana

Index Map No.: Fig. 17, No. 18

Location: NW1/4 Sec. 8, T. 6 N., R. 2 W., 0.5 mile (0.8 km) north of Leslie Lake

Elevation: 8400 feet (2560 m)

Access: By mountain road 4 miles (6.4 km) northeast from Elkhorn, Montana

History: Located in the early 1900's, but the first recorded development was in the 1940's, at which time a road was constructed and diamond drilling and underground development were undertaken. In the 1950's, additional underground development work, including the sinking of a winze and the driving of drifts from the winze, was done under a Defense Minerals Exploration Administration (DMEA) contract. In 1977, the mine was relocated as the Woodcock claims by Robert McNeil.

Previous production: Reportedly, in the early days, 4 tons (3.6 t) of ore were packed by horse to the East Helena smelter. U.S. Bureau of Mines records for 1951 show a production of 3 tons (2.7 t) of ore that yielded 1 ounce (31 g) of gold and 16 ounces (498 g) of silver; for 1960, 1 ton (0.9 t) that yielded 10 ounces (310 g) of silver, 400 pounds (180 kg) of lead, and 300 pounds (135 kg) of zinc.

Geology of deposit: The Skyline mine is underlain by folded and faulted andesite. Most workings were dug to explore an elliptical-shaped breccia pipe, the top of which is composed of limonite-stained gossan (figs. 34 and 35). The pipe consists of fragmented, kaolinized, and epidotized andesite that has been partially replaced and cemented by vuggy quartz-tourmaline and sulfide minerals. Around the pipe is a halo of pyrite-bearing andesite which contains lenses and disseminations of arsenopyrite, galena, sphalerite, and chalopyrite.

Development: Workings include three adits, two of which are caved; a caved shaft; and four prospect pits and trenches. Adits Nos. 1 and 2 were driven into the breccia pipe. Adit No. 1, along with a winze sunk to explore a pod crosscut in the adit, were mapped and sampled by the Bureau of Mines in 1953 in connection with a DMEA contract. Those data are used in this report.

Adit No. 3 probably extends about 70 feet (21.3 m) on a shear zone in andesite.

Sampling: Eighty-one samples were taken from the breccia pipe, sulfide mineral-bearing lenses, andesite wallrock, stockpiles, and mine dumps in 1953 and 1977. Two chip samples across the leached, gossany surface exposure of the breccia pipe (Nos. 2 and 5) averaged 0.007 ounce gold per ton (0.24 g/t), 0.04 ounce silver per ton (1.4 g/t), 0.13 percent copper, 0.82 percent lead, and 0.05 percent zinc. Nine chip samples of breccia containing metallic sulfide lens material (Nos. 7-10, 13, and 26-29) averaged 0.07 ounce gold per ton (2.4 g/t), 2.2 ounces silver per ton (75.4 g/t), 1.8 percent lead, and 0.8 percent zinc. Twenty-three chip samples of breccia from underground workings (Nos. 1-6, 11 and 12, 14-25, and 30-32) averaged a trace of gold, 0.3 ounce silver per ton (10.3 g/t), 0.6 percent lead, and 0.2 percent zinc. Three stockpile grab samples (Nos. 1, 4, and 6) averaged 0.11 ounce gold per ton (3.8 g/t), 2.1 ounces silver per ton (72 g/t), 0.1 percent copper, 12.3 percent lead, and 2.5 percent zinc. Samples from mine dumps, of andesite, and shear zone material had low metal contents.

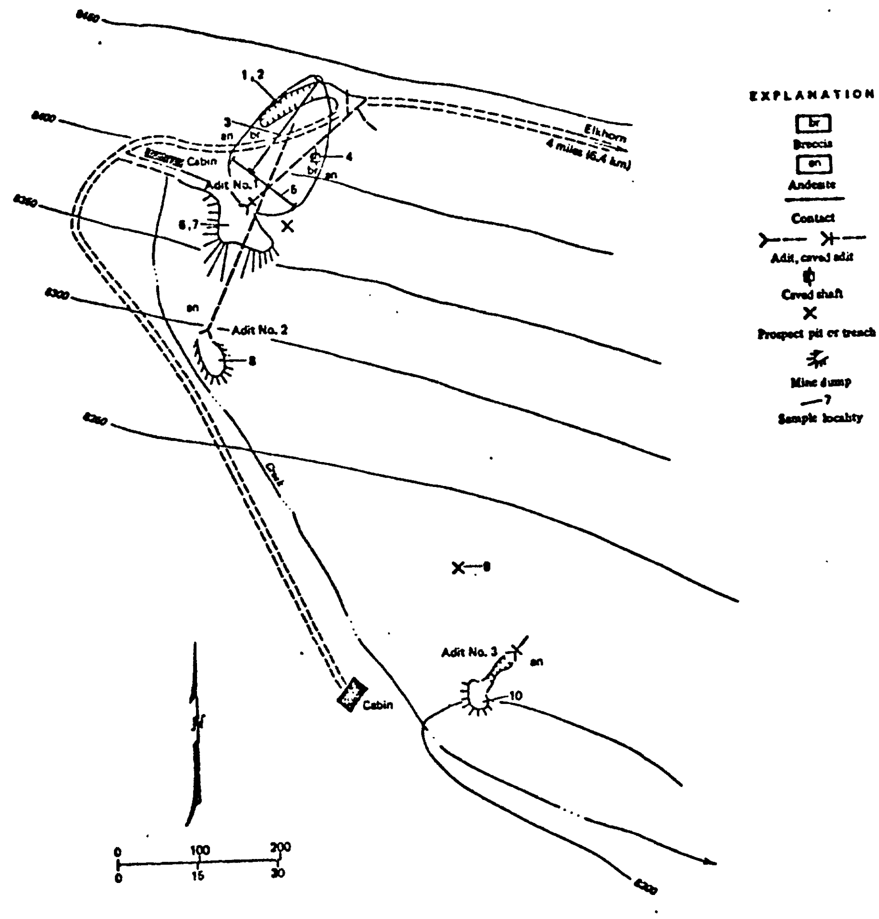


Figure 34. Skyline mine.

An unnumbered table to accompany fig. 34, Skyline mine

Data for samples shown on figure 34.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Breccia from stockpile------------	N	0.1	Tr	Tr	Tr
2	do--	--	Andesite from dump----------------	N	Tr	Tr	0.01	Tr
3	Chip	140.0	Across breccia pipe---------------	Tr	Tr	Tr	.04	0.03
4	Grab	--	Breccia from dump-----------------	N	.1	0.03	21.8	2.1
5	Chip	100.0	Across breccia pipe---------------	0.01	.1	Tr	1.9	.08
6	Grab	--	Breccia from stockpile------------	.22	4.1	.2	2.8	3.0
7	do--	--	Breccia from dump-----------------	.1	.7	.03	.57	.16
8	do--	--	Andesite from dump----------------	N	N	.02	.03	.04
9	do--	--	Shear zone material from dump-----	.02	.1	Tr	Tr	.02
10	do--	--	do--------------------------------	.01	.1	Tr	Tr	Tr

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

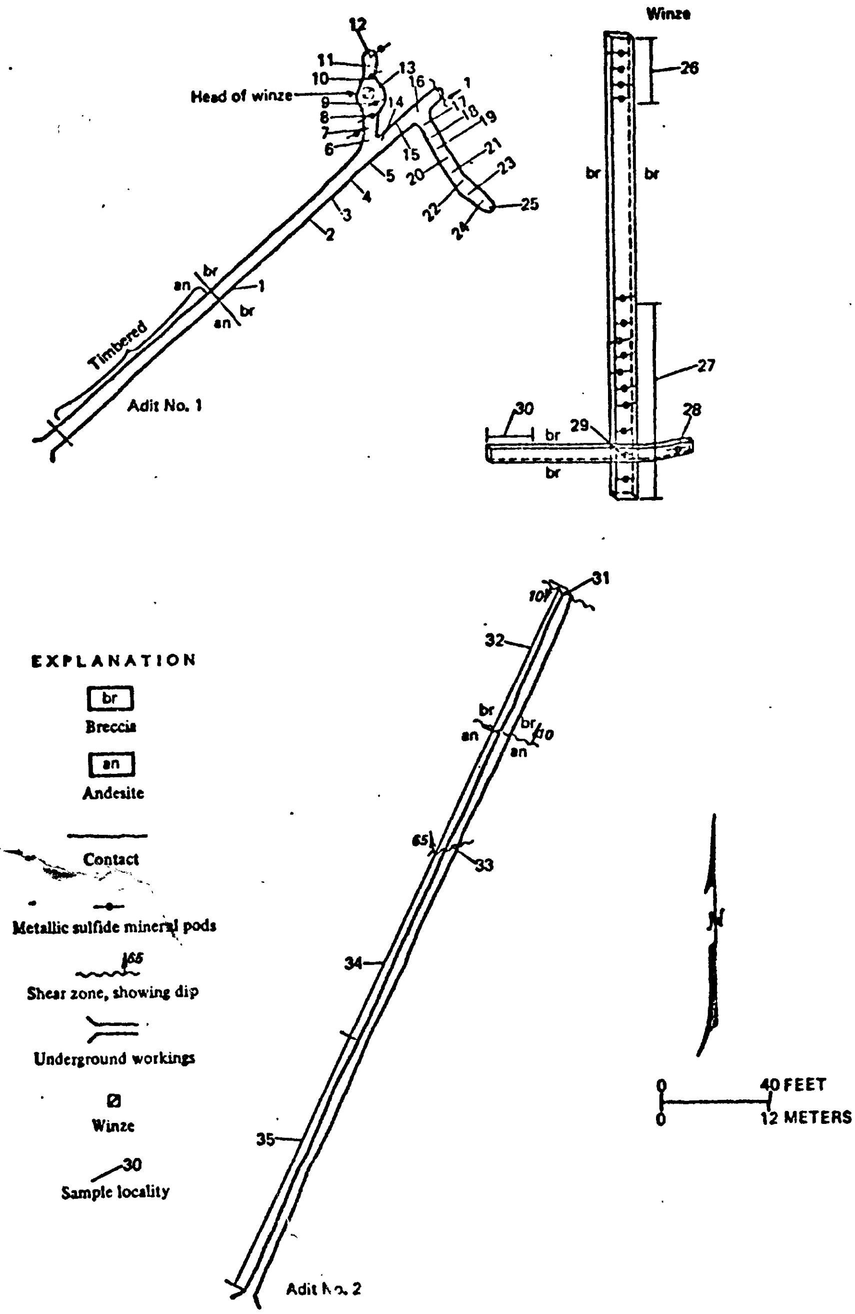


Figure 35. Skyline mine, underground workings.

An unnumbered table to accompany fig. 35, Skyline mine, underground workings

Data for samples shown on figure 35.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description				
1	Chip	10.0	Across breccia----------------------------	Tr	0.2	0.6	0.4
2	do--	10.0	do--	0.01	.4	.6	.1
3	do--	10.0	do--	Tr	.2	.4	.3
4	do--	10.0	do--	.01	.4	.6	.2
5	do--	10.0	do--	Tr	.2	.4	.4
6	do--	4.5	do--	Tr	.3	.6	.4
7	do--	4.5	Across breccia and sulfide mineral lens---	.02	1.2	.8	.9
8	do--	4.5	do--	.26	3.4	3.0	1.4
9	do--	5.5	do--	.11	4.1	4.0	2.8
10	do--	3.5	do--	.05	2.1	1.8	.6
11	do--	2.9	Across breccia----------------------------	.01	.4	.8	.3
12	do--	3.0	do--	.005	.5	.6	.2

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description				
28	Chip	3.0	Across breccia and sulfide mineral lens---	0.06	1.0	0.4	0.1
29 4/	do--	5.0	do------------------------------------	.05	4.7	3.8	.6
30 5/	do--	16.0	Across breccia--------------------------	Tr	.3	.4	.5
31	do--	5.0	do------------------------------------	Tr	.1	.03	.05
32	do--	55.0	do------------------------------------	N	.1	.09	.07
33	do--	1.0	Across shear zone-----------------------	N	.1	Tr	.03
34	do--	100.0	Across andesite-------------------------	N	.1	.02	.04
35	do--	100.0	do------------------------------------	N	N	.05	.02

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.
2/ Average of 10 chip samples.
3/ Average of 23 chip samples.
4/ Average of four chip samples.
5/ Average of three chip samples.

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description				
13	Chip	12.0	Across breccia and sulfide mineral lens---	0.14	2.5	2.2	0.8
14	do--	7.0	Across breccia---------------------------	Tr	.4	.8	.2
15	do--	10.5	do---------------------------------------	Tr	.2	.6	.1
16	do--	10.0	do---------------------------------------	Tr	.4	.8	.2
17	do--	4.2	do---------------------------------------	Tr	Tr	.4	.2
18	do--	3.9	do---------------------------------------	Tr	.1	.4	N
19	do--	4.2	do---------------------------------------	Tr	.2	.6	N
20	do--	4.2	do---------------------------------------	Tr	Tr	.6	N
21	do--	3.6	do---------------------------------------	.02	.6	.8	.2
22	do--	3.4	do---------------------------------------	.02	.4	.6	.4
23	do--	3.4	do---------------------------------------	.01	.4	.6	.4
24	do--	4.0	do---------------------------------------	.2	.4	.6	.1
25	do--	3.0	do---------------------------------------	Tr	.3	.6	.4
26 2/	do--	24.0	Across breccia and sulfide mineral lens---	.16	5.2	4.4	1.8
27 3/	do--	70.0	do---------------------------------------	.022	.8	.6	.4

Resource estimate: At the surface, the breccia pipe has the form of a crude equilateral triangle with about 150-foot (46-m)-long sides. Grade of material in the pipe is too low for it to be considered a resource. The two sulfide mineral-bearing pods exposed by the winze in adit No. 1 are each about 20 feet (6.1 m) long, 10 feet (3 m) thick, 3 feet (0.9 m) deep, and are estimated to contain a paramarginal resource of about 100 tons (91 t) which averages 0.07 ounce gold per ton (2.4 g/t), 2.2 ounces silver per ton (74.4 g/t), 1.8 percent lead, and 0.8 percent zinc.

Conclusions: The Skyline breccia pipe is too small and its grade too low to be minable. The lenses, although they contain high metal values, are small and scattered. The breccia pipe has been explored to a depth of approximately 300 feet (91 m), and the likelihood of finding minable material in this area is low.

* *

Name: South Hidden Lake prospect

Index Map No.: Fig. 17, No. 3

Location: SW1/4 NW1/4 Sec. 6, T. 6 N., R. 3 W., on the divide between Elkhorn Creek and Hidden Lake

Elevation: 9000 feet (2743 m)

Access: By road and cross-country 5.5 miles (8.8 km) north from Elkhorn, Montana

Geology of deposit: The prospect is on a N. 70° E. striking, 30° SE. dipping shear zone in andesite. The andesite is oxidized and leached, strikes N. 10° W., and dips 20° NE. Mine dump material suggests that locally the shear zone has concentrations of pyrite and specular hematite. Prospect workings and float indicate the shear zone extends for a minimum distance of 500 feet (152 m) along strike, and is at least 1 foot (0.3 m) thick.

Development: Two prospect pits, about 200 feet (61 m) apart, constitute the workings.

Sampling: A grab sample of leached shear zone material from the dumps contained 0.1 ounce silver per ton (3.4 g/t), a trace of copper and zinc, and 0.14 percent lead.

Conclusions: The South Hidden Lake shear zone, as exposed, is too small and its grade too low to be minable. However, surface and subsurface work might disclose resources.

Name: Steve claim

Index Map No.: Fig. 17, No. 13

Location: SW1/4 NW1/4 Sec. 12, T. 6 N., R. 3 W., on the west side of Elkhorn Creek

Elevation: 7280 feet (2219 m)

Access: By road and cross-country 1.5 miles (2.4 km) north from Elkhorn, Montana

History: Located by S. C. Kennett in 1955

Geology of deposit: Andesite and andesite breccia overlie quartz monzonite. No mineralized rocks or prominent structures were found in the vicinity.

Development: Three small pits, one trench, and a 30-foot (9.1-m) trench or caved adit.

Sampling: One grab sample from the prospect dump contained 0.1 ounce silver per ton (3.4 g/t), a trace of copper, 0.01 percent lead, and 0.01 percent zinc.

Conclusions: No resource potential indicated

* *

Name: Union mine

Owner: David Walker, Butte, Montana

Index Map No.: Fig. 17, No. 9

Location: NW1/4 NE1/4 Sec. 11, T. 6 N., R. 3 W., in Slaughterhouse Gulch

Elevation: 6900 feet (2103 m)

Access: By mountain road 1 mile (1.6 km) north from Elkhorn, Montana

History: Located in 1880 and patented in 1890. Most of the underground work was done in the 1880's. Development was intermittent from the 1890's until the 1950's. In the 1950's, a 280-foot (85-m)-deep winze was dug in the Union adit.

Previous production: No recorded production, but Weed (1901, p. 506) reports that several railroad carloads of silver-lead ore were produced before 1900.

Geology of deposit: The Union lode is on a contact replacement zone, between limestone and andesite, which strikes N. 50° W., and dips 70° NE. Slightly northwest of the Union adit, granodiorite has intruded the zone. The contact zone is exposed for 320 feet (98 m) along strike, and averages 7 feet (2.1 m) in thickness. It is composed of heavily iron-oxide-stained, brecciated andesite, limestone, and granodiorite, and contains small, irregular fissure veins and lenses of siderite, ankerite, galena, sphalerite, pyrite, and azurite.

Development: Union mine workings extend southwesterly from the adit for 2100 feet (640 m) and southeasterly for 1200 feet (366 m). The adit is 320 feet (98 m) long. In it are a 280-foot (85-m)-deep, flooded winze, and an 85-foot (26-m)-long raise to a glory hole above. There are also four open adits that have a combined length of 235 feet (72 m), one 10-foot (3-m)-deep shaft, and 15 bulldozed and hand-dug pits and trenches. Only the Union adit is in a metal-bearing structure. The other workings are in barren shear zones, andesite, limestone, or granodiorite.

Sampling: Thirty-seven samples were chipped from the contact zone, shear zones, and country rock, or grabbed from stockpiles and prospect dumps. Only samples from the contact zone exposed in and above the adit contained metals. Seven samples chipped from across the contact zone contained as much as 0.01 ounce gold per ton (0.3 g/t), 2.7 ounces silver per ton (92.6 g/t), a trace of copper, 2.4 percent lead, and 1.3 percent zinc. They averaged a trace of gold, 0.5 ounce silver per ton (17.1 g/t), a trace of copper, 0.7 percent lead, and 0.6 percent zinc.

Conclusions: The metals occur in irregular lenses that are too small and scattered to be minable. However, the zone is similar to zones at the Elkhorn and C and D mines. Subsurface work might disclose resources.

Park district

Name: Alba claim

Owner: Edward Hildebrand, Cleo Springs, Oklahoma

Index Map No.: Fig. 18, No. 23

Location: NE1/4 SW1/4 Sec. 12, T. 6 N., R. 2 W., near Warner Creek

Elevation: 6600 feet (2012 m)

Access: By road 14.5 miles (23.2 km) northwest from Radersburg, Montana

History: Located in 1970

Geology of deposit: The prospect is on a 1-foot (0.3-m)-thick, iron-oxide-bearing quartz vein and silicified zone in limestone.

Development: One prospect pit.

Sampling: A chip sample across the vein and silicified zone assayed 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource indicated.

* *

Name: Ann Kinzer mine

Owner: Edward Hildebrand, Cleo Springs, Oklahoma

Index Map No.: Fig. 18, No. 19

Location: Sec. 2, T. 6 N., R. 2 W., at the head of Warner Creek

Elevation: 7660 to 7920 feet (2335 to 2414 m)

Access: By mountain road 15 miles (24 km) west from Radersburg, Montana

History: Located in the early 1900's and relocated as the Hardmore Nos. 1-4 lode claims in the 1940's by Hildebrand. He explored the claims until the 1960's. In the late 1960's and 1970's, lessees did some underground exploration work.

Previous production: Eleven tons (10 t) of ore that contained 2,466 pounds (1,119 kg) of lead, 400 pounds (181 kg) of zinc, 100 pounds (45 kg) of copper, 83 ounces (2,581 g) of silver, and 1 ounce (31 g) of gold were produced between 1942 and 1968.

Geology of deposit: Presently, no mineralized structures are exposed, but reports by the Bureau of Mines in 1944, and the Forest Service in 1971, describe a 10-foot (3-m)-thick fracture zone striking N. 80° E. and dipping vertically in andesite (fig. 36). The zone is reported as being silicified and iron-oxide-stained and containing a 3-foot (0.9-m)--thick quartz vein. The zone and vein are leached and oxidized from the surface to a depth of from 45 to 90 feet (13.7 to 27.4 m). In the quartz below the oxidized zone, galena, pyrite, and chalcopyrite occur in blebs and streaks.

Development: All underground workings were caved or flooded in 1977. However, when the prospect was examined by the Bureau of Mines in 1944, and by the U.S. Forest Service in 1971, they were open. Workings include the principal shaft, 5 caved shafts, as well as 11 bulldozer and hand-dug pits and trenches. The principal shaft, at sample locality No. 4, was examined by the U.S. Forest Service, who reported that it was 96 feet (29.3 m) deep with drifts extending 30 feet (9.7 m) to the east and 40 feet (12.2 m) to the north.

Sampling: A sample taken by the U.S. Forest Service across a vein exposure in the principal shaft contained 0.06 ounce gold per ton (2.1 g/t), 16.8 ounces silver per ton (576 g/t), 0.1 percent copper, and 17.7 percent lead. Seven samples taken during the current study (Nos. 1, 2, 3, 5, 6, 13, and 15) of vein material from stockpiles and dumps averaged 0.014 ounce gold per ton (1.4 g/t), 10.1 ounces silver per ton (346.3 g/t), 0.96 percent copper, 8.1 percent lead, and 3.0 percent zinc. Seven samples of andesite from dumps (Nos. 7-12 and 14) averaged a trace of gold, silver, and copper, 0.4 percent lead, and 0.2 percent zinc.

Resource estimate: Alignment of the workings and the mineralized rock on mine dumps suggests a vein 1,200 feet (366 m) long, which is reported to be 2 to 4 feet (0.6 to 1.2 m) thick. About 180,000 tons (153,000 t) of mineralized material can be inferred as in the vein.

Conclusions: Additional subsurface work to outline resources and determine overall grade is warranted. Additional work would probably disclose resources.

* *

Name: Bonanza mine

Index Map No.: Fig. 18, No. 38

Location: SW1/4 Sec. 19, T. 6 N., R. 1 W., on the divide south of South Fork Crow Creek and just south of the study area

Elevation: 6800 to 7150 feet (2073 to 2179 m)

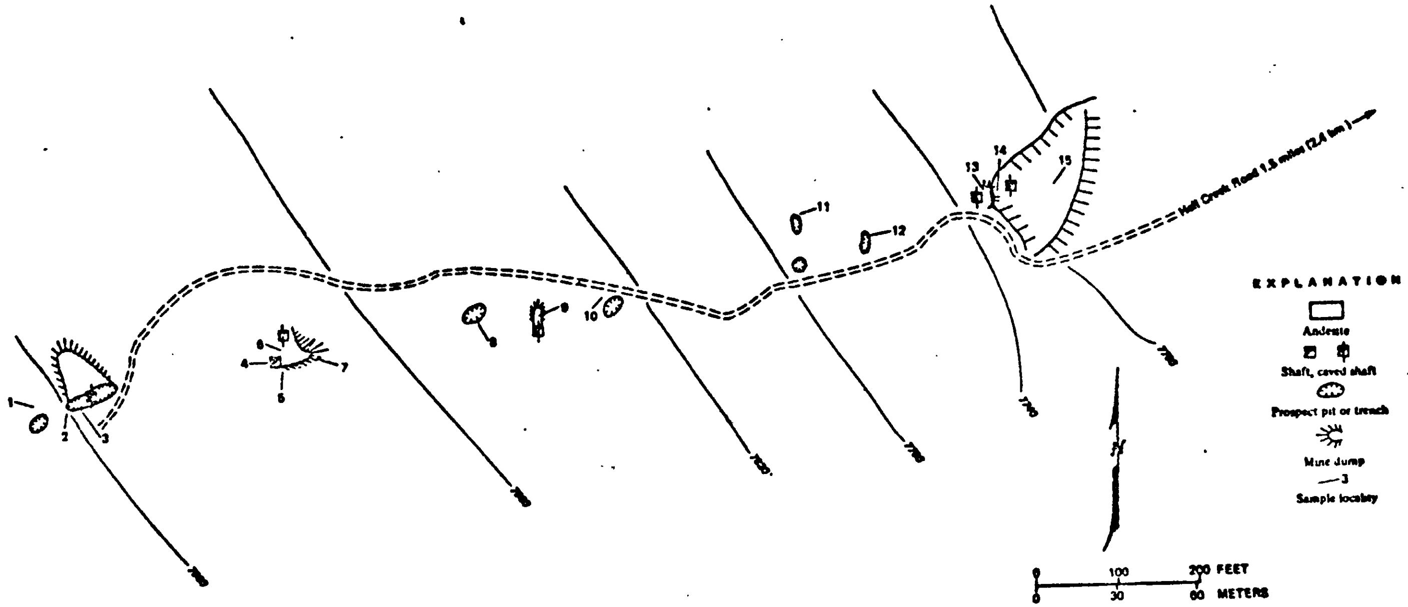


Figure 36. Ann Kinzer mine.

An unnumbered table to accompany fig. 36, Ann Kinzer mine

Data for samples shown on figure 36.

[Tr, trace; N, not detected; --, not analyzed]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Quartz vein material from dump---	Tr	0.1	Tr	0.11	0.06
2	do--	--	Quartz vein material from stockpile-----------------------	0.04	10.1	0.11	7.1	2.8
3	do--	--	Quartz vein material and andesite from dump-----------------------	.01	.2	Tr	.26	.17
4 2/	Chip	3.0	Across quartz vein---------------	.06	16.8	.1	17.7	--
5	Grab	--	Quartz vein material from stockpile-----------------------	.01	2.3	.02	2.8	3.0
6	do--	--	do------------------------------	Tr	.1	.96	8.1	3.0
7	do--	--	Andesite from dump---------------	Tr	Tr	.1	1.6	.44
8	do--	--	do------------------------------	Tr	Tr	Tr	.06	.11
9	do--	--	do------------------------------	Tr	N	Tr	.04	.03
10	do--	--	do------------------------------	Tr	N	Tr	.39	.14
11	do--	--	do------------------------------	Tr	.2	Tr	.31	.15

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
12	Chip	--	Andesite from dump---------------	Tr	0.1	0.01	0.38	0.17
13	Grab	--	Quartz vein material from stockpile-----------------------	N	Tr	.02	2.7	.36
14	do--	--	Andesite from dump---------------	Tr	.1	Tr	.06	.09
15	do--	--	Quartz vein material from dump---	0.01	.1	Tr	.95	.1

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.
2/ Sample taken by U.S. Forest Service in 1971.

Access: By road 8.5 miles (13.7 km) northwest from Radersburg, Montana

Geology of deposit: Workings are on a northeast-trending quartz vein, and mineralized zone in quartz monzonite; a northeast-trending fracture-filling, and replacement bodies in limestone; and a tactite zone along the quartz monzonite and limestone contact (fig. 37). The dumps of workings in the intrusive rocks have quartz vein material, some of which is 10 inches (25.4 cm) thick. A gossan zone at least 5 feet (1.5 m) thick is exposed in the pit at sample locality 6. Dumps of workings in the limestone were the source of pieces of galena- and sphalerite-bearing quartz and calcite as much as 4 inches (10.2 cm) thick. None of the material was seen in place; however, Stone (1911, p. 91) reported that "The ore seems to be on the bedding plane, which dips 25° N." The tactite along the contact is best exposed near the open adit. It consists of diopside, epidote, calcite with local quartz pods which are sometimes 1 foot (0.3 m) in diameter, and iron-oxide-bearing gouge zones as much as 1 foot (0.3 m) in thickness.

Development: Workings consist of a 73-foot (22.3-m)-long open adit, 10 caved adits, a 12-foot (3.7-m)-deep shaft, 5 caved shafts, and 18 prospect pits.

Sampling: Sample localities and analyses are shown on figure 37 and accompanying table. A total of 28 grab samples were taken from dumps. Nine samples (Nos. 4, 20, and 23-29) were of galena-bearing quartz and calcite and contained between 1.4 and 22.6 ounces silver per ton (48 and 774.8 g/t), between 2.5 and 19.3 percent lead, and between 0.32 and 0.88 percent zinc. Five chip samples (Nos. 14, 15, and 17-19) from tactite had trace amounts of gold and as much as 0.1 ounce silver per ton (3.4 g/t).

Conclusions: The assays of galena-bearing quartz and calcite samples from the dumps of the limestone workings indicate the possibility of resources. The location and trend of the workings suggest that the mineralized structures do not extend into the study area.

* *

Name: Cross claim group

Owner: L. W. Doggett, B. Skjagstad, F. J. Beniger, and C. M. Kokoruda, Townsend, Montana

Index Map No.: Fig. 18, No. 10

Location: S1/2 Sec. 21 and NW1/4 Sec. 28, T. 7 N., R. 1 W., at the head of Eagle Creek

Elevation: 6440 feet (1963 m)

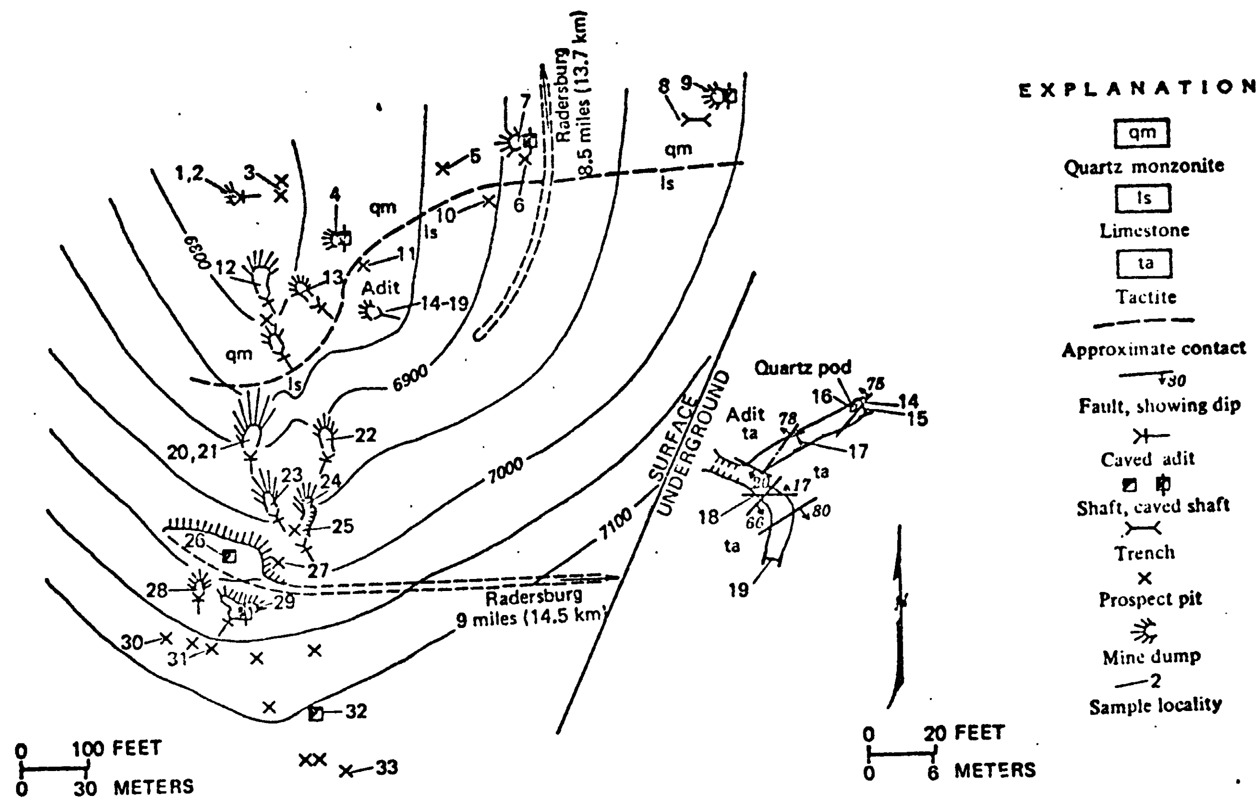


Figure 37. Bonanza mine.

An unnumbered table to accompany fig. 37, Bonanza mine

Data for samples shown on figure 37.

[Tr, trace; N, not detected; --, not analyzed]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab--	--	Iron-oxide-bearing quartz from dump--	Tr	N	--	--	--
2	Chip--	5.0	Across quartz monzonite--------------	N	N	--	--	--
3	Grab--	--	Iron-oxide-bearing quartz from dump--	N	0.1	--	--	--
4	do----	--	Iron-oxide- and galena-bearing quartz from dump---------------------------	0.07	10.6	0.08	14.4	0.78
5	do----	--	Iron-oxide-bearing quartz monzonite country rock from dump--------------	N	N	--	--	--
6	Chip--	10.0	Across gossan zone------------------	N	N	Tr	.2	.01
7	Grab--	--	Iron-oxide-bearing quartz from dump--	Tr	N	Tr	.1	.02
8	do----	--	do----------------------------------	Tr	.2	--	--	--
9	do----	--	do----------------------------------	Tr	.4	--	--	--
10	do----	--	Tactite from dump-------------------	N	.1	--	--	--
11	Chip--	2.0	Across iron-oxide-bearing fault gouge	Tr	Tr	--	--	--

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
12	Grab--	--	Iron-oxide-bearing quartz monzonite from dump----------------------------	Tr	0.1	--	--	--
13	do----	--	Iron-oxide-stained calcite from dump	N	.1	--	--	--
14	Chip--	3.0	Across tactite-----------------------	Tr	.1	--	--	--
15	do----	.33	Across iron-oxide zone in tactite----	Tr	Tr	--	--	--
16	do----	--	Across iron-oxide-bearing quartz pod	N	Tr	Tr	0.49	0.11
17	do----	3.0	Across tactite-----------------------	N	Tr	--	--	--
18	do----	1.0	Across iron-oxide zone in tactite----	Tr	N	--	--	--
19	do----	3.0	Across tactite-----------------------	Tr	N	--	--	--
20	Grab--	--	Iron-oxide- and galena-bearing quartz from dump----------------------------	Tr	3.5	Tr	4.6	.51
21	do----	--	Limestone from dump------------------	0.01	Tr	--	--	--
22	do----	--	Iron-oxide-stained limestone from dump----------------------------------	.01	.2	--	--	--
23	do----	--	Iron-oxide- and galena-bearing quartz from dump----------------------------	Tr	11.9	0.03	13.0	.33
24	do----	--	Galena-bearing calcite from dump-----	.01	22.6	.03	19.3	.39

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
25	Grab--	--	Galena-bearing quartz from dump------	Tr	11.5	0.02	12.1	0.88
26	do----	--	Iron-oxide- and galena-bearing quartz from dump---------------------------	0.01	11.7	.02	6.8	.7
27	do----	--	do----------------------------------	.02	1.4	.01	2.5	.32
28	do----	--	Galena-bearing calcite and quartz from dump---------------------------	.01	10.1	.02	9.5	.76
29	do----	--	Iron-oxide- and galena-bearing quartz from dump---------------------------	Tr	16.1	.02	18.1	.73
30	do----	--	Iron-oxide-stained limestone from dump--------------------------------	N	N	--	--	--
31	do----	--	do----------------------------------	N	N	Tr	.15	.01
32	do----	--	do----------------------------------	N	N	--	--	--
33	do----	--	do----------------------------------	N	N	--	--	--

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Access: By road 1.1 miles (1.8 km) north from Eagle Creek guard station

History: The seven claims were located in 1971.

Previous production: Reportedly mined in the 1920's for zinc; according to the present owners, ore worth $200 per ton ($220/t) was shipped in 1946. No production is recorded.

Geology of deposit: The claims are on a mineralized shear zone that strikes N. 60° W. and dips 75° SW. The shear zone consists of 3 feet (0.9 m) of brecciated, bleached, fine-grained andesite country rock. Shear zone material is iron-oxide-stained and contains vuggy quartz, galena, sphalerite, pyrite, arsenopyrite, and chalcopyrite.

Development: Three adits and one trench are on the shear zone. Several pits are at other locations on the hillside. Estimated lengths of the adits are 800 feet (244 m) for the lower, 400 feet (122 m) for the middle, and at least 100 feet (30 m) for the upper. A trench above the upper adit explored a pod of galena in the shear zone.

Sampling: Four grab samples were taken from stockpiles and mine dumps, and one was chipped from the shear zone. The shear zone sample assayed 0.9 ounce gold per ton (30.9 g/t), 0.80 ounce silver per ton (27.4 g/t), 2 percent lead, and 0.4 percent zinc. The grab samples had as much as 0.08 ounce gold per ton (2.7 g/t), 0.8 ounce silver per ton (27.4 g/t), 7.6 percent lead, and 0.8 percent zinc.

Resource estimate: The mineralized zone is 3 feet (1 m) thick, 1,550 feet (472 m) long, and is computed to contain a submarginal resource of 300,313 tons (272,444 t). The mineralized zone appears to be bounded by a crosscutting fault.

Conclusions: Additional work would probably disclose resources.

* *

Name: Dewey Creek prospect

Index Map No.: Fig. 18, No. 17

Location: SW1/4 NW1/4 Sec. 30, T. 7 N., R. 1 W., about 400 feet (122 m) northwest from Dewey Creek

Elevation: 5600 feet (1707 m)

Access: By trail and cross-country 2 miles (3.2 km) northwest from Eagle Creek guard station

Geology of deposit: No mineralized structures are exposed, but material on an adit dump suggests a 0.25- to 3-inch (0.6- to 7.6-cm)-thick, iron-oxide-stained quartz vein in andesite.

Development: One caved adit was driven southwest about 30 feet (9.1 m).

Sampling: A grab sample from the adit dump contained a trace of gold.

Conclusions: No mineral resource potential indicated.

* *

Name: Eagle mine

Owner: Mary Thompson and John Miller, Townsend, Montana

Index Map No.: Fig. 18, No. 11

Location: NE1/4 Sec. 28, T. 7 N., R. 1 W., along Eagle Creek

Elevation: 6000 feet (1829 m)

Access: By road 1 mile (1.6 km) north from Eagle Creek guard station

History: The Eagle mine consists of three claims that were located in 1955 and 1956.

Previous production: In 1926, 9 tons (8.2 t) of ore yielded 3 ounces (93 g) gold, 124 ounces (3,857 g) silver, and 2,189 pounds (991 kg) of lead. The owners report that 20 tons (18 t) of ore containing mainly gold and lead were mined in 1958 and 1959.

Geology of deposit: The mine is on northeast- and northwest-trending, mineralized shear zones. A 2.5-foot (0.8-m)-thick shear zone that strikes N. 70° W. and dips 80° NE. is followed by the mine's lowest adit. The zone consists of quartz stringers with iron-oxide-stained, brecciated andesite country rock and about 1 foot (0.3 m) of gouge. A 1-foot (0.3-m)-thick vertical shear zone that strikes N. 30° E. is intersected 200 feet (61 m) from the portal of the open adit.

Shear zone material on the middle adit dump contains pyrite, arsenopyrite, galena, and sphalerite in quartz veinlets that are about 1 inch (2.5 cm) thick.

Development: Three adits, estimated to total 540 feet (165 m), constitute the workings. Two adits are caved; only in the lowest are mineralized shear zones exposed.

Sampling: Five samples were taken, four of which were chip samples from across the shear zones in the lower adit. They contained as much as 0.03 ounce gold per ton (1.0 g/t), 0.1 ounce silver per ton (3.4 g/t), and a trace zinc. One grab sample of sulfide material from the middle adit dump assayed 0.08 ounce gold per ton (2.8 g/t), 0.4 percent lead, 8.7 percent zinc, 1.1 percent arsenic, and trace amounts of copper and cadmium.

Conclusions: Vein material on dumps suggests the mine may have a resource potential.

* *

Name: Eagle Station prospect

Index Map No.: Fig. 18, No. 14

Location: SW1/4 SE1/4 Sec. 29, T. 7 N., R. 1 W.

Elevation: 5900 feet (1798 m)

Access: By mountain road 0.5 mile (0.8 km) northwest from Eagle Creek guard station

History: Located as the Mercury lode claim in 1916 and as the Dirty Dick lode claim in 1946.

Geology of deposit: The prospect is on a N. 20° E. striking, 55° SW. dipping shear zone in iron-oxide-stained, pyrite-bearing andesite. The shear zone is exposed for 120 feet (36.6 m) along strike, and is 11 feet (3.4 m) thick. The zone is composed of a 0.8-foot (0.2-m)-thick quartz vein and heavily iron-oxide-stained, brecciated andesite.

Development: Workings consist of three prospect pits. Two are on the lower exposure of the shear zone; one is on another exposure 120 feet (36.6 m) east and 40 feet (12.2 m) above the lower pits.

Sampling: Three samples taken. Two chip samples across the quartz vein and shear zone had insignificant amounts of metals. A grab sample of quartz vein material from dumps assayed 0.01 ounce gold per ton (0.3 g/t) and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated.

Name: East Summit prospect

Index Map No.: Fig. 18, No. 40

Location: NE1/4 SE1/4 Sec. 23, T. 6 N., R. 2 W., on the divide south of Swamp Creek

Elevation: 7300 feet (2225 m)

Access: By road and cross-country 0.5 mile (0.8 km) north from Two Sam Spring

Geology of deposit: The prospect is on cherty quartzite that strikes N. 30° E. and dips 35° SE. In places, it contains iron-oxide-stained quartz in bedding plane fractures.

Development: A prospect pit and a trench, 300 feet (91 m) apart

Sampling: Two grab samples of quartzite and iron-oxide-stained quartz material contained no economic minerals.

Conclusions: No mineral resource potential indicated

* *

Name: Eck-O claim

Owner: Ollie Eck

Index Map No.: Fig. 18, No. 35

Location: SE1/4 NW1/4 Sec. 17, T. 6 N., R. 1 W., north of South Fork Crow Creek

Elevation: 5600 feet (1707 m)

Access: By road 9 miles (14.4 km) northwest from Radersburg, Montana

History: Located September 2, 1970

Geology of deposit: Iron-oxide-bearing quartzite is on the dump of a caved adit. Quartz vein material, gossan, quartzite, and limestone are in a caved pit.

Development: A caved adit, estimated to be 25 feet (7.6 m) long, and a prospect pit constitute the workings.

Sampling: A grab sample of iron-oxide-bearing quartzite from the adit dump assayed a trace of gold and 0.1 ounce silver per ton (3.4 g/t). A sample of quartz vein and gossan from the dump of the prospect pit assayed a trace of gold and 0.3 ounce silver per ton (10.3 g/t).

Conclusions: No mineral resource potential indicated.

* *

Name: Eureka Creek divide prospect

Index Map No.: Fig. 18, No. 6

Location: NE1/4 NW1/4 Sec. 21, T. 7 N., R. 1 W., on ridge between Eagle and Eureka Creeks

Elevation: 6880 feet (2097 m)

Access: By mountain road 2.5 miles (4 km) north from Eagle Creek guard station

Geology of deposit: An altered, east-west-trending, vertical shear zone in andesite contains a 6-inch (15-cm)-thick quartz vein. No sulfide minerals were observed. Sample data indicate the presence of secondary lead minerals.

Development: One prospect pit

Sampling: One chip across the shear zone had 2.3 percent lead, and traces of copper and zinc. One chip across the quartz vein contained traces of copper, lead, and zinc.

Conclusions: A low mineral resource potential is indicated.

* *

Name: Golden Hope Nos. 1 and 2 claims

Index Map No.: Fig. 18, No. 9

Location: W1/2 NW1/4 Sec. 21, T. 7 N., R. 1 W., on the ridge between Eagle and Eureka Creeks

Elevation: 6920 feet (2109 m)

Access: By road 1.3 miles (2.1 km) north from Eagle Creek guard station

History: Located by Mack Mason and Earl Nott in 1961

Geology of deposit: The claims are along a northwest-trending, steeply southwest-dipping mineralized shear zone in andesite (fig. 38). The zone is as much as 33 feet (10 m) thick and consists of bleached, iron-oxide-stained andesite with disseminated pyrite, pyrite casts, and sparse quartz stringers. The zone is probably a slightly offset, westward continuation of the zone that has been explored at the Cross claim group (fig. 18, No. 10).

Development: Three caved shafts and 11 prospect pits

Sampling: Sample localities are shown on figure 38, and analyses given on accompanying table.

Resource estimate: The shear zone (Nos. 3-8) can be traced and inferred for 1,000 feet (300 m). A 400-foot (122-m) section (Nos. 7 and 8) on the southeastern end constitutes a resource. The section averages 33 feet (10 m) in thickness and is estimated to contain submarginal resources of 220,000 tons (200,000 t) that average 0.02 ounce gold per ton (0.7 g/t).

Conclusions: The shear zone contains irregular gold-bearing lenses. Samples were of near-surface material that may be enriched in gold but leached of base metals. The zone, and possible nearby zones, are similar to zones in the area that contain lenses of gold-, silver-, lead-, and zinc-bearing material. The zone is thick and persistent, and subsurface work would probably disclose additional resources.

* *

Name: Homestead prospect

Owner: Edward Hildebrand, Cleo Springs, Oklahoma

Index Map No.: Fig. 18, No. 34

Location: SE1/4 NE1/4 Sec. 18, T. 6 N., R. 1 W., on south side of the South Fork Crow Creek

Elevation: 5760 feet (1756 m)

Access: By gravel road 11 miles (17.6 km) northwest from Radersburg, Montana

Geology of deposit: A malachite- and iron-oxide-bearing quartz vein along a silicified zone as much as 1.3 feet (0.4 m) thick is exposed in workings in limestone. The vein strikes N. 5° E. and dips 50° SE.

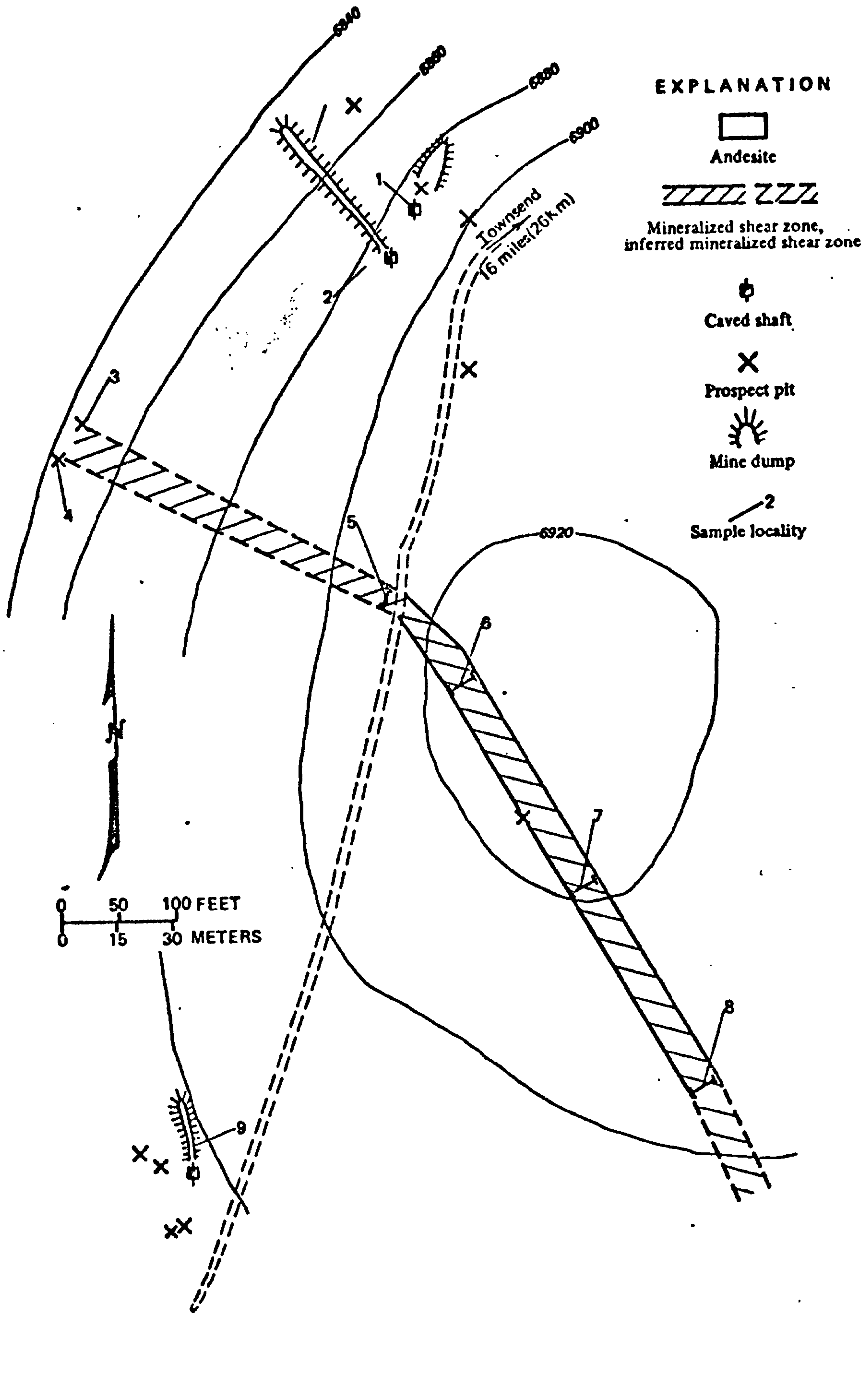


Figure 38. Golden Hope Nos. 1 and 2 claims.

An unnumbered table to accompany fig. 38, Golden Hope Nos. 1 and 2 claims

Data for samples shown on figure 38.

[Tr, trace; N, none detected; --, not analyzed]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Quartz veins in pyrite-bearing andesite from dump----------------	0.01	Tr	0.01	N	0.01
2	do--	--	Altered, iron-oxide-stained andesite from stockpile-----------	.12	0.1	.02	Tr	.29
3	do--	--	Bleached, iron-oxide-stained andesite with pyrite casts from dump------------------------------	.48	.4	--	0.5	.21
4	do--	--	do-------------------------------	N	N	--	N	--
5	Chip	27.0	Across bleached, iron-oxide-stained andesite with pyrite casts---------	N	Tr	--	N	--
6	do--	28.0	do-------------------------------	N	.1	--	N	--
7	do--	33.0	do-------------------------------	.017	Tr	--	Tr	.04
8	do--	33.0	do-------------------------------	.017	Tr	--	Tr	.03
9	Grab	--	Altered, bleached andesite from dump	.03	.8	.04	1.4	.66

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Development: One 28-foot (8.5-m)-long adit and two prospect pits are on the vein.

Sampling: Five chip samples across the quartz and silicified zone contained as much as a trace of gold, 0.1 ounce silver per ton (3.4 g/t), 0.51 percent copper, and averaged 0.1 percent copper.

Conclusions: A low mineral resource potential indicated.

* *

Name: Jawbone Lode mine

Owner: Howard M. White

Index Map No.: Fig. 18, No. 3

Location: NW1/4 Sec. 15, T. 7 N., R. 1 W., west of the Park mine

Elevation: 7600 feet (2316 m)

Access: By jeep road 1,000 feet (305 m) northwest from the Park mill.

History: The 5-acre (2-h) Jawbone Lode and 5-acre (2-h) Jawbone Millsite were located and patented in 1871 and 1885, respectively.

Previous production: Two tons (1.8 t) of dump material that contained 2 ounces (62 g) of gold were produced in 1937.

Geology of deposit: The Jawbone mine is underlain by N. 30° W. striking, 80° SW. dipping, iron-oxide-stained andesite porphyry flows and breccia which along fractures contain disseminated pyrite, as well as blebs and streaks of massive pyrite. A principal fractured zone in the andesite strikes N. 65° W. and dips 85° NE. The explored portion of the Jawbone fracture zone is 1,900 feet (579 m) long and 450 feet (137 m) wide. Two secondary subparallel fracture zones along the principal zone have been explored by workings. These two zones are leached and silicified and contain lenses of metallic sulfide- and oxide-bearing andesite and quartz. Lens material in place is presently exposed at only one location, but material from the exposure and from stockpiles and adit dumps suggest that the lenses are as much as 1 foot (0.3 m) thick. Some lenses are coated by malachite and contain massive pyrite.

Development: The principal fracture zone has been explored by 10 adits, now caved, and 12 shafts, pits, and trenches. From the size of the dumps, the length of caved workings is inferred to be about 3,000 feet (914 m).

Sampling: Sixteen samples were taken, of which five of country rock on mine dumps contained no significant metal concentrations. Ten samples of metallic sulfide and oxide mineral-bearing material from stockpiles and dumps had as much as 0.6 percent copper and trace amounts of lead and zinc, but generally contained no metals. A chip sample across the only structure exposed had no economic minerals.

Conclusions: Samples indicate that the prospect has a low mineral resource potential. However, the material sampled, and most near-surface rock in the area, has been leached and metallic minerals removed. The similarity of the fracture to other mineralized zones in the area may warrant subsurface exploration of the fracture below the leached zone. This might disclose mineral resources.

* *

Name: Jenkins Gulch prospect

Index Map No.: Fig. 18, No. 27

Location: SW1/4 Sec. 7, T. 6 N., R. 1 W., south of Jenkins Gulch and just outside the study area

Elevation: 6200 feet (1890 m)

Access: By road 13 miles (20.8 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is on a zone of quartz and gossan that is at least 3 feet (0.9 m) thick in shale and quartzite.

Development: Three prospect pits

Sampling: Four dump samples of quartz and gossan were taken. They contained as much as 0.014 ounce gold per ton (0.3 g/t) and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated.

* *

Name: Last Hour prospect

Owner: Edward Hildebrand, Cleo Springs, Oklahoma

Index Map No.: Fig. 18, No. 28

Location: SW1/4 SW1/4 Sec. 7 and NW1/4 NW1/4 Sec. 18, T. 6 N., R. 1 W., on the north side of South Fork Crow Creek and beyond the study area

Elevation: 6400 feet (1951 m)

Access: By road 11 miles (17.7 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is on a fracture-filling and replacement zone in limestone. The zone is at least 4 feet (1.2 m) thick and mainly consists of gossan with quartz veinlets as much as 1 inch (2.5 cm) thick.

Development: Four prospect pits

Sampling: Three samples were taken across the zone. They contained as much as 0.01 ounce gold per ton (0.3 g/t) and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated.

* *

Name: Little Jim Nos. 1-5 claims

Index Map No.: Fig. 18, No. 4

Location: NE1/4 Sec. 16, T. 7 N., R. 1 W., near the head of Eureka Creek

Elevation: 6720 feet (2048 m)

Access: By road 4 miles (6.4 km) north from Eagle Creek guard station

History: The five Little Jim claims were located in 1952 by Sherlock Nave.

Geology of deposit: The claims are on two shear zones in andesite. The north shear zone (covered by the Little Jim No. 5 claim) strikes N. 70° E. and dips vertically (fig. 39). It is composed of fractured, iron-oxide-stained, pyrite-bearing, leached andesite which has lenses of vuggy, pyrite-, chalcopyrite-, and galena-bearing quartz. The south shear zone (covered by the No. 3 and 4 claims) strikes N. 80° E. and contains quartz lenses with pyrite and arsenopyrite.

Development: Workings consist of two caved adits, one caved shaft, and six bulldozer trenches. The size of dumps indicates that workings total about 500 feet (152 m).

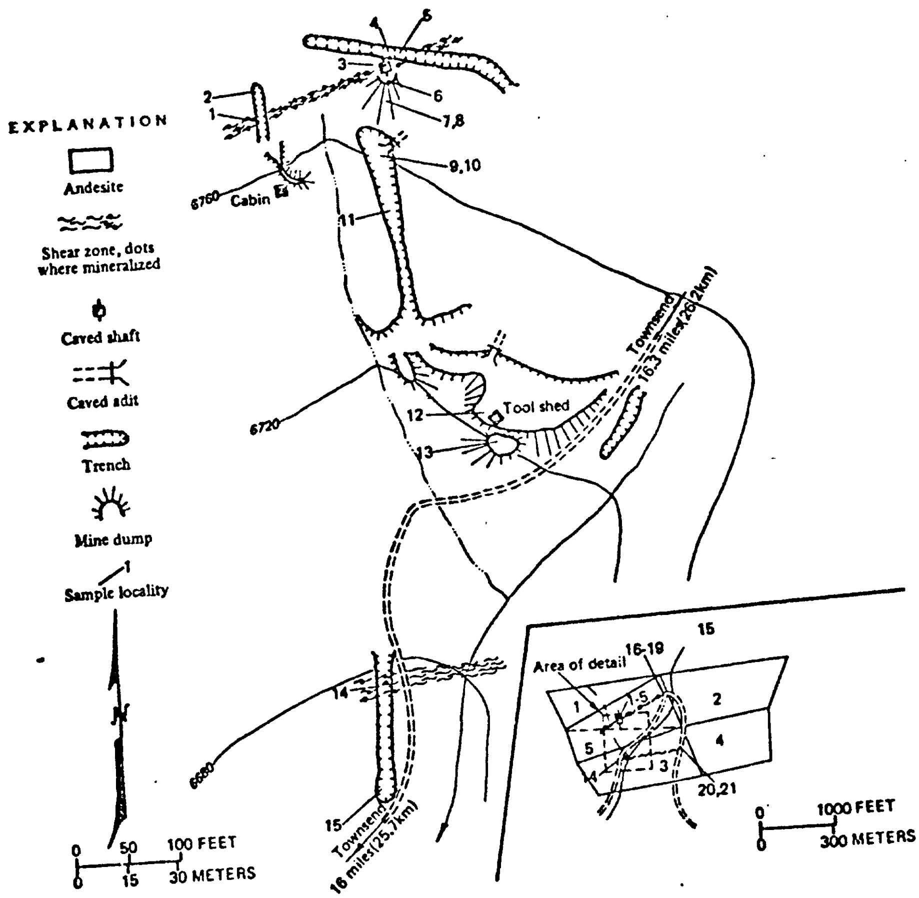


Figure 39. Little Jim Nos. 1-5 claims.

An unnumbered table to accompany fig. 39, Little Jim Nos. 1-5 claims

Data for samples shown on figure 39.

[Tr, trace; N, none detected; --, not analyzed]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Chip	1.0	Across iron-stained-oxide, silicified andesite and quartz-----	Tr	0.1	--	--	--
2	Grab	--	Shear zone and wallrock from dump--	N	.1	--	--	--
3	Chip	25.0	Across shear zone-----------------	0.02	.4	0.03	0.77	0.11
4	do--	2.5	do--------------------------------	N	.6	.05	.57	N
5	do--	10.0	do--------------------------------	.02	1.1	.04	1.1	.11
6 2/	Grab	--	Vein quartz with pyrite and galena from stockpile--------------------	.02	2.9	.16	6.1	2.8
7 3/	do--	--	Quartz vein with sulfide minerals from dump------------------------	.01	N	.1	4.3	2.5
8 4/	do--	--	Dump material---------------------	.02	.5	.04	1.2	.56
9	do--	--	Iron-oxide-stained andesite from dump------------------------------	N	N	--	--	--
10	do--	--	Light gray andesite with disseminated pyrite from dump------	N	N	Tr	.02	.01

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
11	Grab	--	Quartz vein with pyrite and bleached andesite from dump--------	N	N	0.02	2.0	0.16
12	do--	--	do--------------------------------	N	0.02	--	--	--
13	do--	--	Gray-black andesite with disseminated pyrite from dump------	N	N	--	--	--
14	Chip	1.4	Across shear zone-----------------	N	N	--	--	--
15	do--	2.0	do--------------------------------	N	.2	--	--	--
16	Grab	--	Andesite from dump----------------	N	N	--	--	--
17	do--	--	Silicified andesite with finely-disseminated pyrite from dump------	N	N	--	--	--
18	Chip	20.0	Across fractured, iron-oxide-stained, silicified shear zone-----	N	N	--	--	--
19	do--	.3	Across lens of iron-oxide-stained quartz in shear zone--------------	N	N	--	--	--
20	do--	3.0	Across shear zone ----------------	N	N	--	--	--
21	do--	1.0	Across iron-oxide-stained quartz-limonite fracture-filling in shear zone-------------------------------	N	N	--	--	--

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.
2/ 2.7 percent arsenic.
3/ Trace cadmium, 1.9 percent arsenic.
4/ 0.73 percent arsenic.

Sampling: Sample locations and analyses are shown on figure 39 and accompanying table. Chip samples from across the north shear zone in the vicinity of the caved shaft (Nos. 3-5) averaged 0.02 ounce gold per ton (0.7 g/t), 0.6 ounce silver per ton (20.6 g/t), 0.55 percent lead, and 0.1 percent zinc. All samples from the zone (Nos. 1-5, 17, and 18) averaged trace amounts of gold, silver, lead, and zinc. One chip sample from the southern shear zone contained 0.2 ounce silver per ton (6.9 g/t). Other zone samples had no metals.

Conclusions: Sampling indicates that metal content is confined to lenses in the north shear zone in the area of the shaft on the Little Jim No. 5 claim. Metal content is too low and scattered to be minable. However, the samples taken were of leached material that may not be indicative of metal content at depth. The shear zones are thick and persistent and probably contain resources.

*

Name: Longfellow Creek prospect

Index Map No.: Fig. 18, No. 8

Location: SW1/4 NE1/4 Sec. 18, T. 7 N., R. 1 W., on the west bank of Longfellow Creek

Elevation: 7050 feet (2149 m)

Access: By trail 1 mile (1.6 km) west from Eureka Creek

Geology of deposit: The prospect is in quartz monzonite near its contact with greenish-gray andesite. The quartz monzonite has iron-oxides.

Development: Workings consist of a caved adit estimated to have been about 35 feet (10.7 m) long and two caved prospect pits.

Sampling: Grab samples of iron-oxide-bearing quartz monzonite from the adit's dump and the dump of the larger prospect pit assayed trace amounts of gold and as much as 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No resource potential indicated.

Name: Longhorn claim

Owner: Edward Hildebrand, Cleo Springs, Oklahoma

Index Map No.: Fig. 18, No. 20

Location: NE1/4 Sec. 12, T. 6 N., R. 2 W., on Warner Creek

Elevation: 6200 feet (1890 m)

Access: By road 12 miles (19.2 km) northwest from Radersburg, Montana

History: The location notice was posted in 1966.

Geology of deposit: Malachite and iron-oxide-bearing quartz vein and silicified zone 4 inches (10 cm) thick occur in limestone.

Development: One prospect pit

Sampling: A chip sample across the vein and silicified zone assayed 0.1 ounce silver per ton (3.4 g/t) and 0.15 percent copper.

Conclusions: No mineral resource potential indicated

* *

Name: LS prospect

Index Map No.: Fig. 18, No. 22

Location: SW1/4 Sec. 12, T. 6 N., R. 2 W., near Warner Creek

Elevation: 6300 feet (1920 m)

Access: By road 12 miles (19.2 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is on pyrite-bearing gossan with quartz veinlets, some of which are 0.15 inch (0.38 cm) thick in limestone.

Development: One prospect pit

Sampling: A grab sample from the pit assayed 0.01 ounce gold per ton (0.3 g/t), 0.1 ounce silver per ton (3.4 g/t), and 0.31 percent copper.

Conclusions: Sample data indicates a low resource potential.

Name: Lower Eureka Creek prospect

Index Map No.: Fig. 18, No. 15

Location: NE1/4 Sec. 32, T. 7 N., R. 1 W., about 0.25 mile (0.4 km) northeast from the mouth of Eureka Creek

Elevation: 5800 feet (1768 m)

Access: By mountain road 0.5 mile (0.8 km) southwest from Eagle Creek guard station

History: Included are the Golden Eagle, Eureka, and Kin Con claims that were located in 1889.

Geology of deposit: The prospect is on the contact of quartz monzonite with mudstone and quartzite (fig. 40). The sedimentary rocks strike N. 40° E. and dip 35° NW., and are sheared, highly altered, silicified, and locally heavily stained by iron-oxides.

A 3-foot (0.9-m)-thick mineralized shear zone trends N. 10° W. and dips 20° SW. in the sedimentary rocks. It is made up of leached, silicified wallrock and 3-inch (7.6-cm)-thick quartz-calcite fissure fillings. The shear zone and fissure fillings are leached, and most of the original metallic sulfide minerals have been replaced by iron-oxides and secondary lead-silver-zinc minerals. Dumps of underground workings have some pyrite and galena.

Development: Workings consist of two open adits (Nos. 1 and 2), two shafts (one caved), two caved adits, and four prospect pits. Dump material suggests that the two caved adits intersected the shear zone at depth. The underground workings total about 300 feet (91 m).

Sampling: Sample localities and analyses are shown on fig. 40 and on accompanying table. Two chip samples across the shear zone (Nos. 8 and 9) averaged 0.13 ounce gold per ton (4.5 g/t), 1.1 ounces silver per ton (37.7 g/t), 0.02 percent copper, 1.2 percent lead, and 1.8 percent zinc. Four shear zone material samples (Nos. 3-6) from dumps and a stockpile averaged 0.06 ounce gold per ton (2.1 g/t), 1.5 ounce silver per ton (51.4 g/t), 1.2 percent lead, and 0.2 percent zinc.

Resource estimate: The mineralized shear zone is 3 feet (0.9 m) thick, is inferred along strike from adit No. 2 to adit No. 3, a distance of 140 feet (43 m), and is inferred along the dip from the inclined shaft to adit No. 1, a distance of 350 feet (107 m). It contains paramarginal resources of 10,000 tons (9,000 t). Additional resources probably occur along the dip and strike of the shear zone to the south and west.

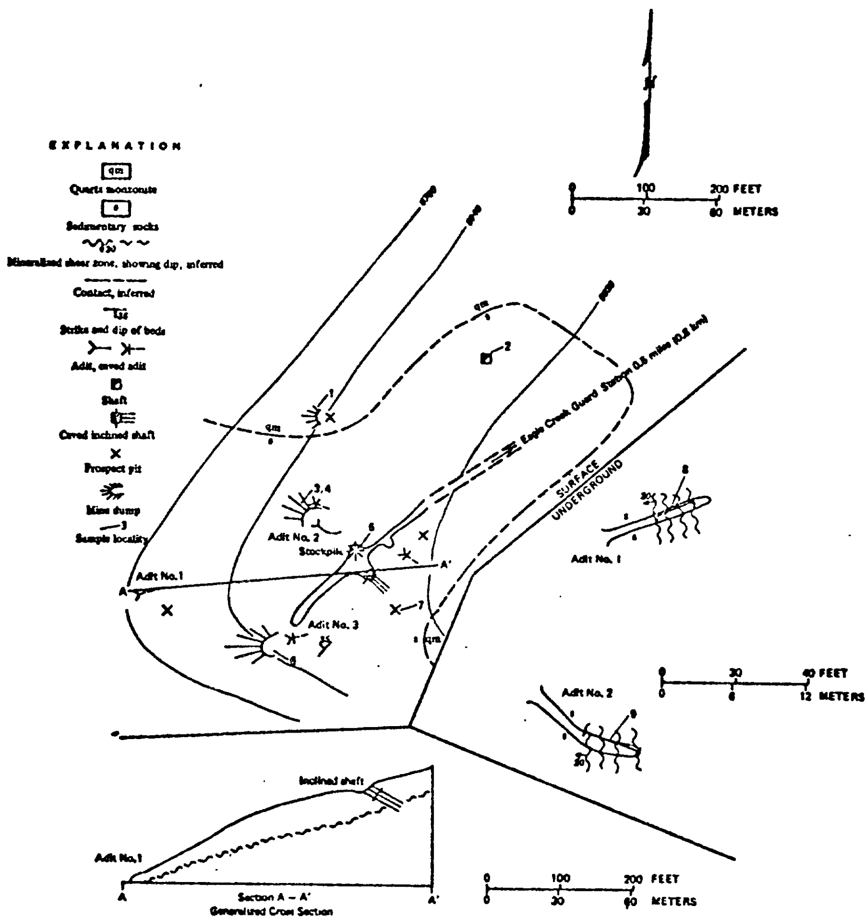


Figure 40. Lower Eureka Creek prospect.

An unnumbered table to accompany fig. 40, Lower Eureka Creek prospect

Data for samples shown on figure 40.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Altered limonite-stained mudstone and quartz monzonite from dump-------	0.01	N	Tr	Tr	0.02
2	do--	--	Silicified mudstone and quartzite from dump---------------------------	Tr	N	0.01	0.04	.02
3	do--	--	Quartz and calcite from dump---------	.01	0.1	Tr	.04	.61
4	do--	--	Shear zone material from dump--------	.1	.5	Tr	.18	.09
5	do--	--	Quartz containing pyrite and galena from stockpile----------------------	.05	1.2	.02	.9	.18
6	do--	--	Shear zone material containing quartz from dump---------------------------	.09	4.2	.03	3.8	.13
7	do--	--	Altered quartz monzonite from dump---	Tr	N	Tr	.01	.02
8	Chip	3.0	Across shear zone--------------------	.25	1.0	.02	1.0	1.8
9	do--	3.0	do-----------------------------------	N	1.3	.03	1.4	1.7

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Conclusions: Sample data and mineralized dump material indicate a leached zone at the surface, a higher grade zone of enrichment just below the surface, and a zone of primary metallic sulfide minerals below the enrichment zone. Work to outline additional resources is warranted.

* *

Name: Lower Warner Creek prospect

Index Map No.: Fig. 18, No. 30

Location: NW1/4 NE1/4 Sec. 13, T. 6 N., R. 2 W., on the north side of South Fork Crow Creek

Elevation: 6000 feet (1829 m)

Access: By road 11 miles (17.7 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is in locally iron-oxide-stained, thin-bedded limestone with occasional chert lenses.

Development: One prospect pit

Sampling: A grab sample came from the pit, and two chip samples from limestone. Both chip samples assayed a trace of gold, and one assayed 0.1 ounce silver per ton (3.4 g/t). The grab sample assayed 0.2 ounce silver per ton (6.9 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: McFadgen mine

Index Map No.: Fig. 18, No. 7

Location: NE1/4 Sec. 20, T. 7 N., R. 2 W., on Eureka Creek

Elevation: 6350 feet (1935 m)

Access: By road 3.5 miles (5.6 km) north from Eagle Creek guard station

History: The mine was located as the Golden Era claim in 1938 by H. McFadgen and as the Leadore Nos. 1-8 claims by S. Nave and H. McFadgen in 1951.

Previous production: Twelve tons (11 t) of ore produced in 1952 and 1953 had 23 ounces (715 g) gold, 4 ounces (124 g) silver, and 200 pounds (91 kg) of lead.

Geology of deposit: The McFadgen mine is underlain by iron-oxide-stained, pyrite-bearing andesite flows which strike N. 30° W. and dip 80° NE. The andesite is cut by a N. 80° W. striking, steeply-dipping zone of shearing. The shears contain pyrite-, galena-, and sphalerite-bearing quartz lenses (fig. 41). Two principal mineralized shears within the zone are exposed at the surface and indicated by mine dump material. They are at least 1.5 feet (0.5 m) thick, leached at the surface, and composed of alternating bands of silicified andesite and vuggy quartz that at depth contains limonite after pyrite and streaks and blebs of pyrite, galena, sphalerite, and malachite.

Development: Workings extend a distance of about 2,600 feet (760 m) from Eureka Creek northwest along the divide between Tin Cup and Teakettle Creeks. Major workings are near Eureka Creek. They consist of three caved adits with an estimated total length of about 400 feet (122 m), and six bulldozer cuts and trenches that are on the west mineralized shear zone. One caved adit, calculated to be 100 feet (30 m) long, and a bulldozer cut are on the east mineralized fracture zone. Workings (not shown on the map) along the northerly extension of the zone of shearing, on the divide between Tin Cup and Teakettle Creeks, consist of six prospect pits, the deepest of which is 10 feet (3 m).

Sampling: Sample locations and analyses are shown on figure 41 and accompanying table. Nine samples were taken from surface outcrops of mineralized shear zones and adit dumps. Most of the material sampled was leached and contained no primary sulfide minerals. Analysis indicated the presence of secondary lead-zinc minerals. A chip sample, 40 feet (12.2 m) across the west zone and adjoining wallrock (No. 5), contained 0.34 percent lead and 0.05 percent zinc. Another chip sample taken for 1.5 feet (0.5 m) across the zone (No. 4) contained 2.4 percent lead and 0.4 percent zinc. A third chip from 1.5 feet (0.5 m) across the east zone (No. 1) had 0.2 percent lead and 0.6 percent zinc. Six samples from the workings on the north extension of the zone of shearing, on the divide between Tin Cup and Teakettle Creeks, assayed traces of copper, lead, and zinc.

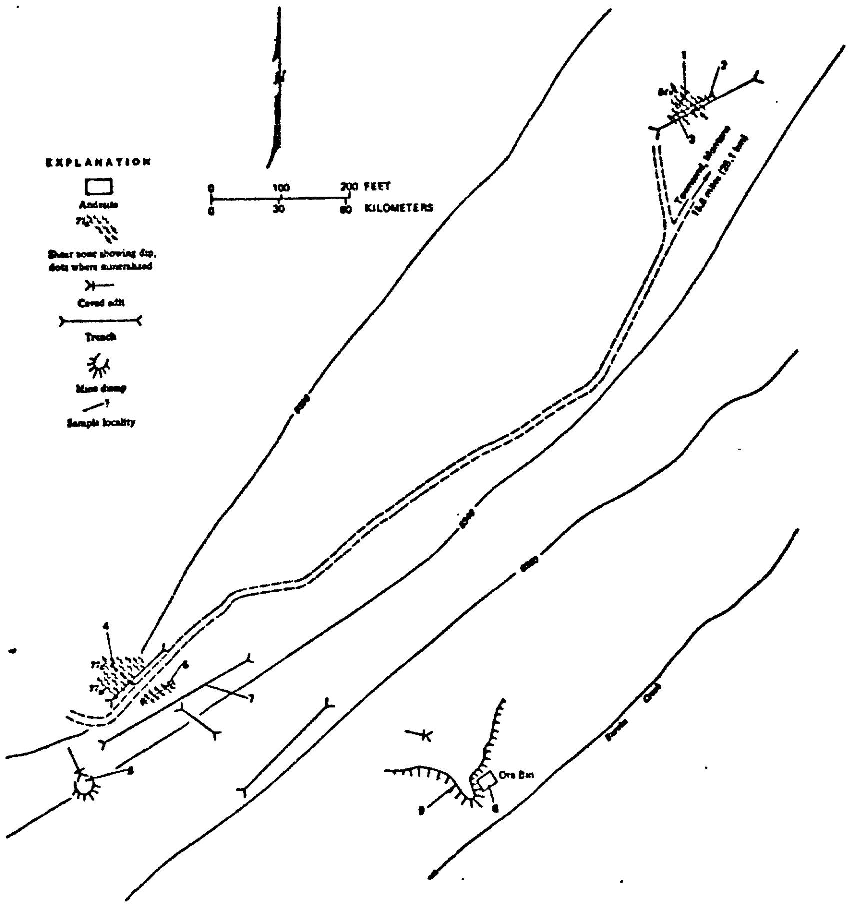


Figure 41. McFadgen mine.

An unnumbered table to accompany fig. 41, McFadgen mine

Data for samples shown on figure 41.

[Tr, trace, N. none detected]

Sample				Lead	Zinc
No.	Type	Length (feet) 1/	Description	(percent)	(percent)
1	Chip--	1.5	Across mineralized fracture----	0.17	0.56
2	do----	70.0	Across shear zone--------------	.03	.05
3	do----	20.0	Across hanging wall of shear zone--------------------------	.04	.12
4	do----	1.5	do----------------------------	2.4	.4
5	do----	40.0	Across mineralized shear zone--	.34	.05
6	Grab--	--	Quartz vein material from dump	2.0	.11
7	do----	--	Bleached, silicified shear zone material-----------------	2.9	.13
8	do----	--	Vein material from ore bin-----	5.2	3.2
9	do----	--	Andesite and vein material from dump--------------------------	N	N

1/ Metric conversion: feet x 0.3048 = meters.

Resource estimate: The zone of shearing is a continuation of the mineralized zone trending northwest from Eagle Creek and the Cross mine, over the divide to Eureka Creek, and through the McFadgen mine to Longfellow Creek. At the McFadgen mine, the zone has been prospected from Eureka Creek to the top of the divide between Tin Cup and Teakettle Creeks, a distance of about 2,600 feet (792 m) along the strike, and about 1,600 feet (488 m) across it. Of the area's two mineralized shear zones which have been explored, the west is the only one sufficiently mineralized to warrant an estimate of resources. It is at least 1.5 feet (0.5 m) thick, has been exposed along strike for 500 feet (152 m), and is computed to have a submarginal resource of about 15,000 tons (14,000 t) that averages 1.3 percent lead. Additional resources probably occur elsewhere in the zone.

Conclusions: The explored mineralized fracture is too small to be minable. However, the zone of fracturing is thick and persistent; additional subsurface work on it would probably disclose additional resources.

* *

Name: Mamouth Lode mine

Owner: James Franchi, Boulder, Montana

Index Map No.: Fig. 18, No. 13

Location: Center of Sec. 28, T. 7 N., R. 1 W., on the west side of Eagle Creek

Elevation: 6000 feet (1829 m)

Access: By road 1 mile (1.6 km) north from Eagle Creek guard station

History: Located by Theodore L. Lammers in 1892 and patented in 1895

Previous production: Intermittent production between 1907 and 1923 totaled 41 ounces (1,275 g) gold, 4,369 ounces (135,889 g) silver, 183 pounds (83 kg) copper, and 72,683 pounds (32,968 kg) of lead from 125 tons (113.4 t) of ore.

Geology of deposit: No mineralized structures are exposed, but a report (Reed, 1951, p. 52) describes a steeply-dipping, N. 80° W. trending quartz vein in andesite near a small intrusion. The vein continues across the contact into the intrusive rocks, and has galena, pyrite, arsenopyrite, sphalerite, and hematite. Wallrock is altered, iron-oxide-stained, leached, and contains sparse disseminated pyrite.

Development: Two caved adits and one caved shaft, probably aggregate 3,000 feet (900 m) of workings.

Sampling: One sample of vein material from an adit dump assayed 0.03 ounce gold per ton (1 g/t), 0.92 percent lead, and 0.84 percent zinc.

Conclusions: Stone (1911) reported that ore from the immediate vicinity was netting $56 a ton ($61.60/t), including 2 ounces gold per ton (68.6 g/t). Significantly mineralized material may remain. Subsurface work would probably disclose resources.

* *

Name: Mid Nite No. 1 claim

Owner: Edward Hildebrand, Cleo Springs, Oklahoma

Index Map No.: Fig. 18, No. 33

Location: SW1/4 NW1/4 Sec. 18, T. 6 N., R. 1 W., on the north side of South Fork Crow Creek

Elevation: 5800 feet (1768 m)

Access: By road 10 miles (16 km) northwest from Radersburg, Montana

History: Located June 11, 1965

Geology of deposit: A 2-foot (0.6-m)-thick gossan zone containing quartz and silicified limestone is along a quartz monzonite-limestone contact. The zone strikes N. 45° E. and dips vertically.

Development: Two small prospect pits less than 50 feet (15 m) apart

Sampling: A 2-foot (0.6-m) chip sample across the gossan zone assayed a trace of silver.

Conclusions: No mineral resource potential indicated

* *

Name: Mid Nite No. 2 claim

Owner: Edward Hildebrand, Cleo Springs, Oklahoma

Index Map No.: Fig. 18, No. 32

Location: NE1/4 SE1/4 Sec. 13, T. 6 N., R. 2 W., on the south side of South Fork Crow Creek

Elevation: 5960 feet (1817 m)

Access: Cross-country 1,000 feet (305 m) from the road along South Fork Crow Creek

History: The claim was located October 18, 1948.

Geology of deposit: The claim is on a 1-foot (0.3-m)-thick iron-oxide-bearing quartz vein in limestone. The vein is conformable to bedding and strikes N. 10° E. and dips 50° NW.

Development: One small prospect pit

Sampling: A chip sample across the vein contained a trace of gold, 0.1 ounce silver per ton (3.4 g/t), and 0.11 percent copper.

Conclusions: No mineral resource potential indicated.

* *

Name: Mountain Dude Lode

Owner: Oma W. Johnson

Index Map No.: Fig. 18, No. 1

Location: NW1/4 Sec. 10, T. 7 N., R. 1 W., at the head of Whitehorse Creek

Elevation: 7800 feet (2377 m)

Access: By road 2 miles (3.2 km) north from the Park mine

History: Located by Seth Wyland in 1889. The 20.66-acre (8.3-h) claim was surveyed and later patented.

Geology of deposit: No mineralized structure is exposed. However, alignment of workings, float, and dump material indicate a northeast-trending, iron-oxide-stained shear zone in andesite. The zone consists mainly of leached andesite and quartz lenses. The country rock strikes N. 30° W. and dips 70° NE.

Development: Workings consist of two caved adits, one trench, and two pits. Underground workings are estimated to be 600 feet (183 m) long.

Sampling: Four grab samples of shear zone material from adit dumps and stockpiles assayed as much as 0.06 ounce gold per ton (2.1 g/t), 2.2 ounces silver per ton (74 g/t), 0.06 percent copper, 2.1 percent lead, and 0.56 percent zinc, and averaged 0.02 ounce gold per ton (0.7 g/t), and 1.1 ounce silver per ton (38.6 g/t). No significant metal content was noted in three grab samples of andesite from dumps.

Conclusions: Where indicated, the shear zone is too thin and grade too low to be minable; however, additional work might disclose resources.

* *

Name: Old Faithful prospect

Index Map No.: Fig. 18, No. 25

Location: SE1/4 SE1/4 Sec. 12, T. 6 N., R. 2 W., north of South Fork Crow Creek

Elevation: 6400 feet (1951 m)

Access: By road 12 miles (19.2 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is on a gossan with quartz veinlets as much as 0.15 inch (0.38 cm) thick in limestone.

Development: One prospect pit

Sampling: A sample of the gossan contained a trace of silver and 0.8 percent copper.

Conclusions: A low resource potential indicated.

* *

Name: QM prospect

Index Map No.: Fig. 18, No. 26

Location: NE1/4 Sec. 13, T. 6 N., R. 2 W., on the north side of South Fork Crow Creek

Elevation: 5900 feet (1798 m)

Access: By road 13 miles (19.2 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is on weathered, iron-oxide-stained quartz monzonite. No sulfide minerals are visible.

Development: One prospect pit

Sampling: A sample of quartz monzonite from the pit had no significant metal content.

Conclusions: No mineral resource potential indicated.

* *

Name: Ridge prospect

Index Map No.: Fig. 18, No. 39

Location: NW1/4 SW1/4 Sec. 19, T. 6 N., R. 2 W., on the divide south of South Fork Crow Creek and outside the study area

Elevation: 7360 feet (2243 m)

Access: By road 12 miles (19.2 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is in limestone with minor iron-oxide staining along fractures.

Development: One small prospect pit

Sampling: A sample of iron-oxide-stained limestone from the prospect had no significant metal content.

Conclusions: No mineral resource potential indicated.

* *

Name: Roadside prospect

Index Map No.: Fig. 18, No. 12

Location: NW1/4 NE1/4 Sec. 28, T. 7 N., R. 1 W., just west of Eagle Creek

Elevation: 6200 feet (1890 m)

Access: By road 1.5 miles (2.4 km) north from Eagle Creek guard station

Geology of deposit: Dump material indicates a contact zone between mafic intrusive rock and andesite, with the intrusive rock having quartz veinlets with pyrite.

Development: One caved adit with an estimated 50 feet (15 m) of underground workings.

Sampling: One sample of mafic intrusive material assayed 0.04 ounce gold per ton (1.4 g/t), trace copper, 1.3 percent lead, and 0.55 percent zinc.

Conclusions: Sample analysis indicates a resource potential.

* *

Name: Salt Lick prospect

Index Map No.: Fig. 18, No. 5

Location: NW1/4 SE1/4 Sec. 16, T. 7 N., R. 1 W., on the divide between Eureka and Eagle Creeks

Elevation: 7120 feet (2170 m)

Access: By road 4 miles (6.4 km) north from the Eagle Creek guard station

Geology of deposit: The prospect is on a brecciated, quartz-filled shear zone that strikes N. 60° W. and dips 80° SW. in pyrite-bearing andesite. The zone is 8 feet (2.4 m) thick and filled by 1-foot (0.3-m)-thick, vuggy, iron-oxide-stained, laminated quartz lenses containing galena stringers.

Development: One 11-foot (3.4-m)-deep shaft

Sampling: A sample across the shear zone contained traces of copper and zinc and 2.3 percent lead.

Resource estimate: The zone can be traced 200 feet (61 m) along strike before disappearing beneath overburden. If the zone's metal content, as indicated by the sample, persists then it contains a submarginal resource of about 13,000 tons (12,000 t).

Conclusions: The resource seems small and low-grade. However, further work might disclose additional resources.

Name: Silver Hope prospect

Index Map No.: Fig. 18, No. 21

Location: NE1/4 SW1/4 Sec. 12, T. 6 N., R. 2 W., near Warner Creek

Elevation: 6300 feet (1920 m)

Access: By road 12 miles (19.2 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is on slightly iron-oxide-stained limestone.

Development: One prospect pit.

Sampling: A sample of limestone had no significant metal content.

Conclusions: No mineral resource potential indicated.

* *

Name: Silverine and Wasp Lodes

Owner: Chester Aldrich, Helena, Montana

Index Map No.: Fig. 18, No. 37

Location: SW1/4 Sec. 16 and SE1/4 Sec. 17, T. 6 N., R. 1 W., on the south side of South Fork Crow Creek

Elevation: 5800 feet (1768 m)

Access: By road 9 miles (14.5 km) northwest from Radersburg, Montana

History: The two claims were surveyed for patent in 1937 and later patented.

Geology of deposit: The lodes are on narrow galena- and iron-oxide-bearing quartz veins in quartzite. The maximum thickness, judged by material on the mine dumps, is 5 inches (13 cm). Some quartz contains as much as 10 percent galena, but most of it has considerably less.

Development: A caved adit, a caved shaft, and seven prospect pits constitute the workings. The patent survey plat shows the adit to have been 240 feet (73 m) long and to contain two winzes. The estimated depth of the shaft is 100 feet (30 m).

Sampling: Five mine dump samples of quartz vein material assayed as much as 0.79 ounce gold per ton (27 g/t), 5.9 ounces silver per ton (202.3 g/t), and 4.8 percent lead. They averaged 0.195 ounce gold per ton (6.7 g/t), 1.74 ounces silver per ton (59.7 g/t), and 1.3 percent lead.

Conclusions: A resource potential seems to exist; however, vein widths are indicative of a small tonnage.

* *

Name: Snowshoe prospect

Owner: Edward Hildebrand, Cleo Springs, Oklahoma

Index Map No.: Fig. 18, No. 36

Location: NW1/4 Sec. 16, T. 6 N., R. 1 W., on South Fork Crow Creek just outside of the study area

Elevation: 5600 feet (1707 m)

Access: By road 9 miles (14.4 km) northwest from Radersburg, Montana

History: Located in 1972

Geology of deposit: The prospect is on at least two quartz veins which are about 400 feet (120 m) apart, both in quartz monzonite. The northern vein is emplaced along a joint striking N. 85° W. and dipping 40° SW. It is 2 to 3 inches (5 to 7.6 cm) thick, with a 12- to 14-inch (30.5- to 35.6-cm) alteration zone. The quartz is vuggy and locally has galena, pyrite, and iron-oxides.

The southern vein is not exposed, but there are pieces of quartz, some of which are 4 inches (10 cm) thick, on the dump of a shaft. The quartz contains pyrite, pyrrhotite, chalcopyrite, malachite, and iron-oxides. Similar material was observed in a shallow prospect pit southwest of the shaft about 800 feet (244 m). This may represent a third vein or be an extension of the southern vein.

Development: The northern vein is exposed in a 30-foot (9.1-m)-deep inclined shaft. On the southern vein is a caved shaft estimated to have been about 80 feet deep (24 m). A shallow prospect pit in the road cut is about 800 feet (240 m) southwest of the caved shaft.

Sampling: A northern vein chip sample assayed 0.01 ounce gold per ton (0.3 g/t). Another chip across the vein and alteration zone had 0.01 ounce gold per ton (0.3 g/t) and 0.1 ounce silver per ton (3.4 g/t). A southern vein grab sample from the dump of the caved shaft contained 0.01 ounce gold per ton (0.3 g/t), 4.2 ounces silver per ton (144 g/t), 1.3 percent copper, and 0.27 percent lead. A grab sample from the prospect pit assayed 0.01 ounce gold per ton (0.3 g/t), 4.1 ounces silver per ton (140.6 g/t), 0.14 percent copper, and 2.0 percent lead.

Conclusions: The veins do not extend into the study area; they are narrow and have a low mineral resource potential.

* *

Name: Swamp Creek prospect

Index Map No.: Fig. 18, No. 31

Location: SW1/4 NE1/4 Sec. 13, T. 6 N., R. 2 W., on the divide between Swamp and South Fork Crow Creeks

Elevation: 6100 feet (1859 m)

Access: By cross-country 300 feet (91 m) west from the road along Swamp Creek

Geology of deposit: A 3-foot (0.9-m)-thick, vuggy, iron-oxide-bearing quartz vein and a 5-foot (1.5-m)-thick garnet-epidote tactite zone are in limestone.

Development: Two prospect pits that are less than 10 feet (3 m) apart

Sampling: A chip sample across the quartz assayed 0.02 ounce gold per ton (0.7 g/t) and 0.2 ounce silver per ton (6.9 g/t). A chip sample across the tactite zone had no significant metal content.

Conclusions: No mineral resource potential indicated.

* *

Name: Summit prospect

Index Map No.: Fig. 18, No. 41

Location: Center of Sec. 23, T. 6 N., R. 2 W., near the head of Swamp Creek

Elevation: 7400 feet (2256 m)

Access: By road 0.5 mile (0.8 km) northeast, then cross-country from Two Sam Spring

History: The prospect was located in 1884 by S. Hyde and visited by Stone in 1911 (p. 92), and Klepper and others in 1957 (p. 74).

Geology of deposit: The prospect is on a zone of bedding plane and low-angle crosscutting fractures in interbedded mudstone and quartzite. Workings suggest the zone of fracturing is 50 to 100 feet (15 to 30 m) thick and 1,400 feet (430 m) long. The sedimentary rocks trend N. 10° to 30° E. and dip 35° to 85° NW. The fractures are 0.3 to 1 foot (0.1 to 0.3 m) thick and are filled with stringers of gossany chalcedony and massive quartz, which are generally less than 3 inches (7.6 cm) thick. Some stringers contain hematite-limonite pseudomorphs after pyrite, and samples show they have secondary lead and zinc minerals.

Development: Workings consist of one northeast-trending caved adit that is less than 200 feet (61 m) long, three caved shafts which total about 500 feet (150 m), and ten hand-dug and bulldozer-dug prospect pits.

Sampling: Seventeen samples of fracture-filling and dump material had as much as a trace of gold, 0.1 ounce silver per ton (0.3 g/t), a trace of copper, 5.2 percent lead, 0.69 percent zinc, and 0.4 percent arsenic.

Conclusions: Sampling shows the metal content of the Summit zone to be low. However, high values may occur at depth, and subsurface exploration might disclose resources.

* *

Name: UP prospect

Index Map No.: Fig. 18, No. 24

Location: NW1/4 SE1/4 Sec. 12, T. 6 N., R. 2 W., on Warner Creek

Elevation: 6300 feet (1920 m)

Access: By road 12 miles (19.2 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is on a 1-foot (0.3-m)-thick quartz vein and silicified zone in pyrite-bearing limestone.

Development: Two prospect pits and a shallow caved trench

Sampling: A chip sample across the vein and silicified zone assayed a trace of gold and silver. A grab sample of the pyrite-bearing limestone assayed a trace of gold.

Conclusions: No mineral resource potential indicated

* *

Name: Vulture mine

Owner: R. G. Bayles, Bozeman, Montana

Index Map No.: Fig. 18, No. 2

Location: SE1/4 Sec. 8 and SW1/4 Sec. 9, T. 7 N., R. 1 W., at the head of Eureka Creek

Elevation: 7500 to 8500 feet (2285 to 2591 m)

Access: By road 16 miles (25.6 km) west from Townsend, Montana

History: The mine operated intermittently from 1901 to 1941. The Vulture Lode, which is now patented, was located in 1910. It was examined in 1907 and 1929 by consulting mining engineers, and in 1949 by the U.S. Bureau of Mines. Work is currently underway in the shaft.

Previous production: An unpublished mining engineer's report in 1929 lists the following production data:

Year	Tons	Gold (ounces)	Silver (ounces)	Lead (pounds)
1901	115	2.97	305.6	205.2
1902	122	1.6	351.7	236.3
1903	56	.25	168.1	114.4

U.S. Bureau of Mines production records show the following:

Year	Tons	Gold (ounces)	Silver (ounces)	Lead (pounds)
1901	60	6.0	12,000.0	--
1935	3	1.0	29.0	518.0
1936	2	1.0	6.0	168.0
1941	3	--	11.0	198.0

A 750-pound (340.2-kg) shipment was made to the East Helena smelter on October 13, 1976. The smelter assay was 0.105 ounce gold per ton (3.6 g/t), 136.8 ounces silver per ton (4,689.9 g/t), 0.1 percent copper, 69.8 percent lead, and 0.5 percent zinc.

Geology of deposit: The main workings are on a quartz vein in intensely silicified andesite (figs. 42 and 43). The vein strikes from east to N. 40° E., dips from about 15° to 55° NW., and is 1 to 4.5 feet (0.3 to 1.4 m) thick. Iron-oxides are throughout, and lenses of massive galena are present locally. The largest galena lens observed was 5 feet (1.5 m) long and 5 inches (12.7 cm) thick. Mr. Bayles reports (oral commun.) that additional drifting and stoping were done near sample localities 1, 2, and 3 after Bureau of Mines examination in 1977. The work has exposed a 3-foot (0.9-m)-thick zone containing abundant galena.

Dump material indicates other quartz veins and mineralized structures occur in both andesitic and dioritic intrusive country rock near the principal vein. None were observed in place, but dump vein material ranged from less than 1 inch (2.5 cm) to 8 inches (20.3 cm) in thickness. The owner reports recent backhoe work exposed mineralized veins north and south of the principal vein.

Development: At the time of this examination, workings consisted of an inclined shaft, at which exploration and development were in progress, 4 caved adits, 3 caved shafts, and 23 prospect pits.

Sampling: Sample localities and analyses are shown on figures 42 and 43 and accompanying tables.

Conclusions: Samples show that exposures of the principal vein in the inclined shaft are significantly mineralized. Those from workings on other veins and mineralized structures near the principal vein have no significant metal contents. The mineralized veins reported to have been exposed by backhoe work were not examined, and their resource potential is unknown.

The shaft sample data indicate metals are in pods and lenses. Further exploration along this vein, and the others, would probably disclose mineral resources.

* *

Name: Warner Creek prospect

Index Map No.: Fig. 18, No. 29

Location: SW1/4 SE1/4 Sec. 12, T. 6 N., R. 2 W., on Warner Creek

Elevation: 6200 feet (1890 m)

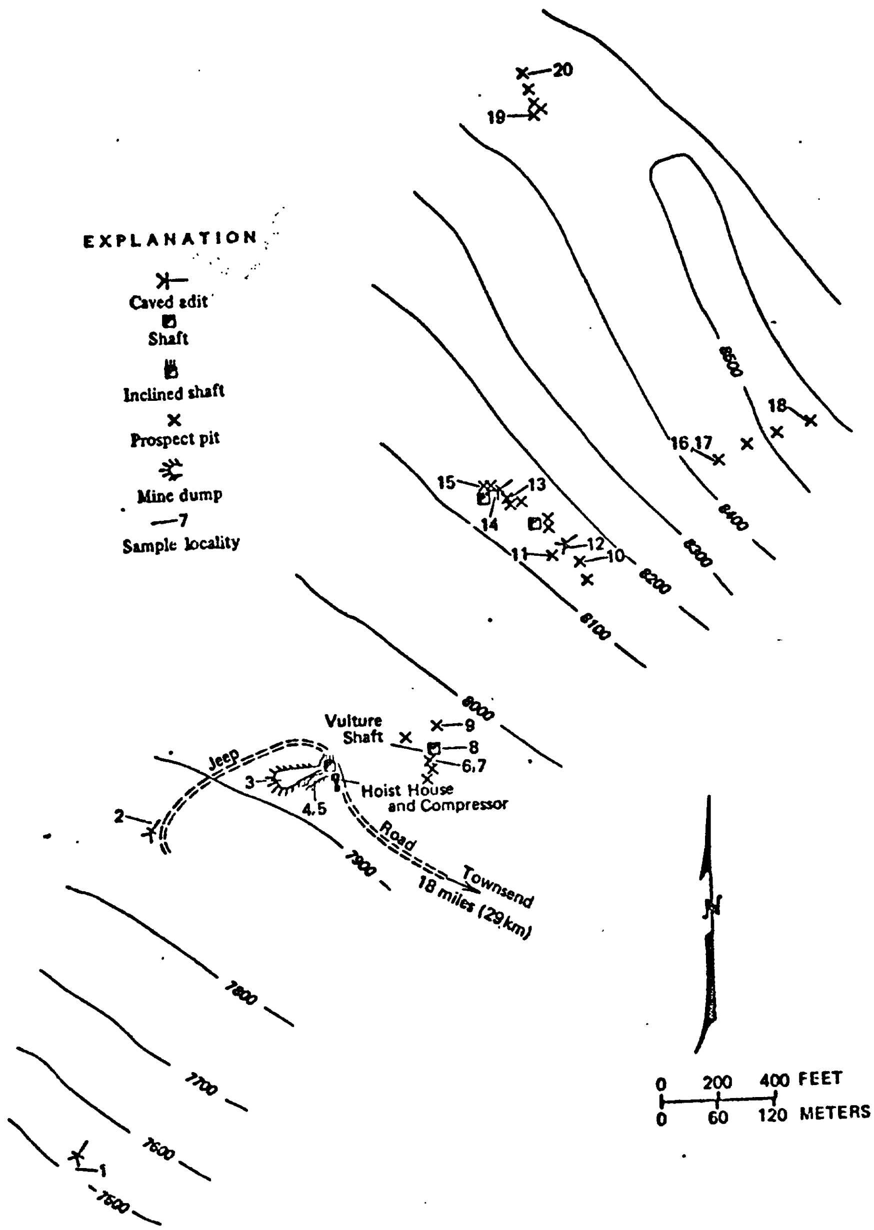


Figure 42. Vulture mine.

An unnumbered table to accompany fig. 42, Vulture mine

Data for samples shown on figure 42.

[Tr, trace; N, not detected; --, not analyzed]

Sample			Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Description					
1	Grab	Silicified, iron-oxide-stained fault gouge with quartz veinlets from dump--------------	N	N	0.01	0.27	0.89
2	do--	Iron-oxide-bearing quartz from dump---------	Tr	Tr	Tr	.05	.04
3	do--	Altered, iron-oxide, pyrite-, and quartz-bearing andesite from dump-----------------	N	N	Tr	.45	.2
4	do--	Vuggy, iron-oxide- and galena-bearing quartz from dump----------------------------------	N	N	.01	.28	.05
5	do--	do--	N	N	.07	1.1	.02
6	do--	Iron-oxide-bearing quartz from dump---------	Tr	N	Tr	.01	Tr
7	do--	Andesitic volcanic country rock from dump---	Tr	N	--	--	--
8	do--	Iron-oxide-bearing fault gouge from dump----	Tr	N	Tr	Tr	Tr
9	do--	do--	Tr	N	--	--	--
10	do--	Andesitic volcanic country rock from dump---	N	N	Tr	Tr	Tr

Sample			Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Description					
11	Grab	Iron-oxide-bearing, altered andesitic volcanic rock from dump--------------------	N	N	Tr	0.01	0.06
12	do--	Iron-oxide-bearing quartz from dump---------	N	N	0.01	.01	.28
13	do--	Iron-oxide-bearing, altered andesitic volcanic rock from dump--------------------	N	N	.01	.08	.17
14	do--	Altered igneous rock from dump--------------	N	Tr	.01	.21	.06
15	do--	do--	N	N	Tr	Tr	.07
16	do--	Iron-oxide-bearing quartz from dump---------	N	N	.09	.56	.16
17	do--	Andesitic volcanic country rock from dump---	N	N	--	--	--
18	do--	Altered, iron-oxide-bearing andesitic volcanic rock from dump--------------------	N	N	--	--	--
19	do--	Iron-oxide-bearing quartz from dump---------	N	N	--	--	--
20	do--	Iron-oxide- and pyrite-bearing quartz from dump---	N	N	--	--	--

1/ Metric conversion: ounce per ton x 34.285 = grams per tonne.

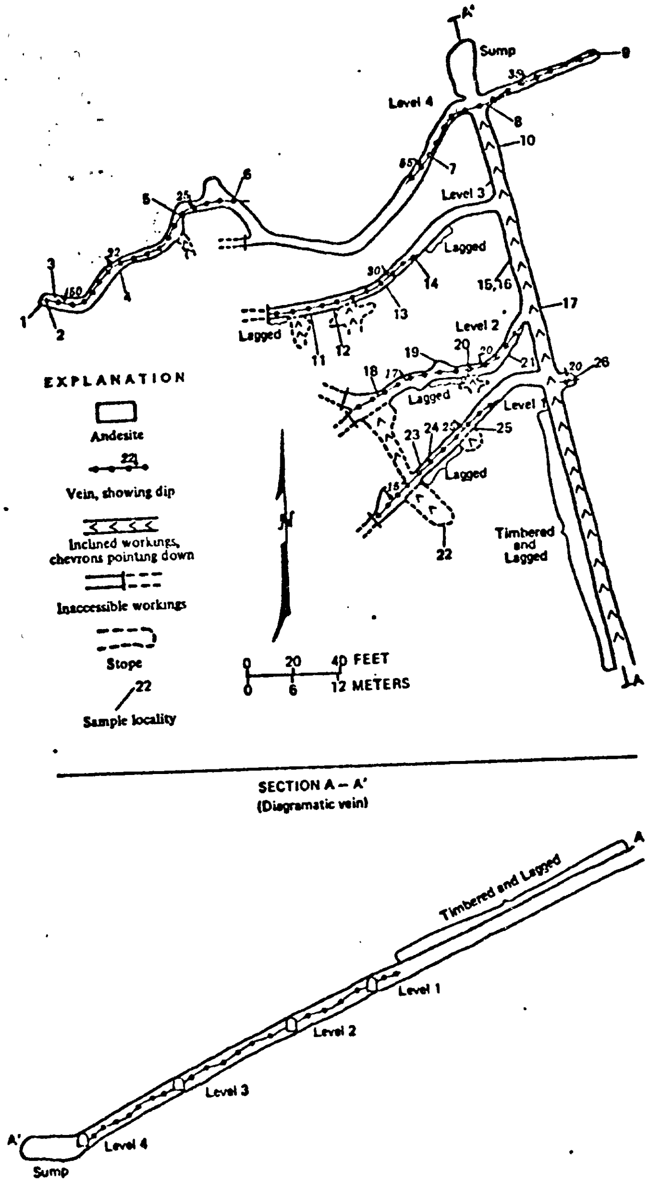


Figure 43. Vulture mine, shaft.

An unnumbered table to accompany fig. 43, Vulture mine, shaft

Data for samples shown on figure 43.

[Tr, trace; N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Chip	--	Across galena lens------------------	0.21	112.5	0.01	72.2	0.05
2	do--	3.5	Across vein-------------------------	.01	1.0	Tr	1.7	.03
3	do--	3.0	do----------------------------------	.02	1.5	Tr	1.1	.02
4	do--	4.0	do----------------------------------	.07	1.8	.02	2.5	.16
5	do--	1.1	do----------------------------------	.05	2.1	.03	1.8	.48
6	do--	.5	do----------------------------------	.11	5.3	.06	4.0	.18
7	do--	.8	do----------------------------------	.01	.1	Tr	.08	.08
8	do--	2.0	do----------------------------------	.31	1.0	.02	.58	.38
9	do--	1.5	do----------------------------------	.06	.1	.02	.04	.08
10	do--	3.0	do----------------------------------	.01	.2	Tr	.22	.32
11	do--	2.0	do----------------------------------	N	N	.01	1.2	.22
12	do--	1.7	do----------------------------------	.04	.7	Tr	1.8	.26

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
13	Chip	1.7	Across vein------------------------	0.01	N	Tr	0.07	0.1
14	do--	4.4	do----------------------------------	.02	0.1	Tr	.03	.1
15	do--	3.5	do----------------------------------	.01	.1	Tr	.02	.05
16	do--	1.5	Across quartz part of vein only-----	.01	.1	Tr	.01	.04
17	do--	2.2	Across vein------------------------	.02	Tr	Tr	.12	.23
18	do--	1.0	do----------------------------------	Tr	N	0.03	1.76	.12
19	do--	3.0	do----------------------------------	Tr	N	.12	1.9	.20
20	do--	1.2	do----------------------------------	N	N	.05	.23	.18
21	do--	1.2	do----------------------------------	N	Tr	Tr	.05	.12
22	do--	3.5	do----------------------------------	Tr	.1	.03	8.1	.11
23	do--	--	Across galena lens------------------	Tr	.1	.02	44.4	.08
24	do--	2.7	Across vein------------------------	Tr	.2	.06	4.7	.29
25	do--	1.3	do----------------------------------	Tr	.1	.14	1.5	.53
26	do--	1.3	do----------------------------------	.01	.1	Tr	.04	.13

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Name: Warner Creek prospect

Index Map No.: Fig. 18, No. 29

Location: SW1/4 SE1/4 Sec. 12, T. 6 N., R. 2 W., on Warner Creek

Elevation: 6200 feet (1890 m)

Access: By gravel road 11 miles (17.7 km) northwest from Radersburg, Montana

Geology of deposit: The prospect is on a malachite and iron-oxide-bearing quartz vein and silicified zone as much as 7 inches (17.8 cm) thick in limestone. The vein strikes N. 80° W. and dips 65° NE. A 3- to 5-foot (0.9- to 1.5-m)-thick fault zone consisting of iron-oxide-bearing gouge is exposed in the upper adit.

Development: Workings consist of a 55-foot (16.8-m)-long open adit and a caved adit estimated to be about 50 feet (15 m) long.

Sampling: Two chip samples across the vein and silicified zone in the open adit assayed as much as 0.02 ounce gold per ton (0.7 g/t), 0.1 ounce silver per ton (3.4 g/t), 1.5 percent copper, 2.0 percent lead, and 0.58 percent zinc. A grab sample of mineralized material from the caved adit dump assayed 0.1 ounce silver per ton (3.4 g/t), 0.58 percent copper, 2.0 percent lead, and 1.4 percent zinc. Chip samples of country rock and the fault zone had no significant metal content.

Conclusions: The thin vein and silicified zone indicate a low mineral resource potential.

Tizer-Wilson district

Name: American Eagle claim

Index Map No.: Fig. 19, No. 26

Location: Center E1/2 NE1/4 Sec. 30, T. 7 N., R. 2 W., east of Rabbit Gulch

Elevation: 7320 feet (2231 m)

Access: By road 9 miles (14.4 km) east from Jefferson City, Montana, then 0.5 mile (0.8 km) southwest on the Rabbit Gulch driveway

History: Located by J. Templeman in 1917

Geology of deposit: Bedrock is not exposed in the area of the prospect. Prospect dump material consists of andesite that is sheared, leached, brecciated, and iron-oxide-stained.

Development: One caved shaft, probably no more than 30 feet (10 m) deep, is adjacent to a small prospect pit.

Sampling: One sample from the dump contained trace amounts of silver, copper, lead, and zinc.

Conclusions: No mineral resource potential indicated

* *

Name: Anderson Gulch prospect

Index Map No.: Fig. 19, No. 27

Location: SW1/4 NW1/4 Sec. 27, T. 7 N., R. 3 W., at the head of Anderson Gulch

Elevation: 7800 feet (2377 m)

Access: By road 7.5 miles (12 km) east from Jefferson City, Montana, then about 1 mile (1.6 km) east by cross-country travel.

Geology of deposit: No mineralized structures are exposed, but material on prospect dumps indicate quartz veins as much as 3 inches (8 cm) thick in quartz monzonite. The vein material has pyrite and sparsely disseminated arsenopyrite and malachite.

Development: Two adits are caved; the longest may have been 150 feet (45.7 m) long. There are also two shafts and two small prospect pits.

Sampling: Five samples from prospect dumps had a trace gold and 0.1 ounce silver per ton (3.4 g/t). A sample of quartz vein material, with visible pyrite and arsenopyrite, assayed 0.85 percent copper, 0.26 percent lead, 0.07 percent zinc, and 0.02 percent molybdenum. Four other samples contained traces of copper, lead, and zinc.

Conclusions: Available data indicate little mineral resource potential. The prospect may, however, be on an extension of Exxon's porphyry-type molybdenum-copper occurrence to the north. Additional work might disclose mineral resources.

* *

Name: Andy claim group

Owner: Exxon Company, USA

Index Map No.: Fig. 19, No. 23

Location: Secs. 14, 15, 16, 17, 20, 21, 22, 23, 26, 27, and 28, T. 7 N., R. 3 W., along tributaries south of Prickly Pear Creek, including Golconda Creek, Anderson Gulch, Weimer Creek, and Black Canyon

Elevation: 5400 to 7600 feet (1646 to 2316 m)

Access: By road 11 miles (18 km) east from Jefferson City, Montana

History: The Andy Nos. 1-145 claims were located in 1976 by Exxon, USA. Between 1921 and 1957, mines in the vicinity of the claims produced gold, silver, lead, and zinc, valued at more than $35,000. Most of their production was from narrow veins and from gold-bearing stockworks in quartz monzonite (Roby, 1960, p. 66).

Geology of deposit: Molybdenite, disseminated and in stringers, is associated with pyrite, chalcopyrite, arsenopyrite, and sphalerite in porphyritic granodiorite of the Boulder batholith. Coarse-grained alaskite bodies also occur in the area. Sericitized, granitic breccias crop out near the head of the West Fork of Anderson Gulch.

Development: Within the study area, the Andy claims have no workings or exposed metallic mineral-bearing structures. A stream sediment survey by Exxon, USA, indicated a molybdenum-copper anomaly; resistivity surveys were inconclusive. In 1977, three diamond drill holes were put down outside the study area in Anderson Gulch. Total footage drilled was in excess of 2,000 feet (610 m), with one hole accounting for about 1,000 feet (305 m). Drilling was continuing after our examination.

Sampling: Data on the metal content of rock intersected in the drill holes, or of surface samples, taken by Exxon are not available.

Resource estimate: No mineral resource data have been released.

Conclusions: Exploration was prompted by the possibility that a porphyry copper-molybdenum occurrence may exist in the claimed area; such a deposit could extend into the study area.

* *

Name: Ballard mine

Owner: Roger L. and Barbara Foster, Townsend, Montana; Giles Mead, Rocklin, California; Laura Mead Enerson, Whitefish, Montana; Hazel M. Mentch, Sacramento, California; and Michael Wikstrom, Bozeman, Montana

Index Map No.: Fig. 19, No. 30

Location: SE1/4 Sec. 32 and SW1/4 Sec. 33, T. 7 N., R. 2 W., near the head of Little Tizer Creek

Elevation: 7700 to 7940 feet (2347 to 2420 m)

Access: By road 11 miles (17.6 km) east from Jefferson City, Montana

History: The Ballard's four principal claims (the Loon, Center Reef, Policy, and Black Bear) were located between 1903 and 1905 by Felix Ballard and others; patents were issued for them in 1906. The mine was worked, on a small scale, by the Ballard brothers until their deaths. Ore was transported by wagon to Jefferson City, Montana, then by railroad to the East Helena smelter. Four men were working the claim in 1910. By May 1934, adit No. 1 (figs. 44 and 45) had been advanced to 305 feet (93 m); since then, it has been extended to intersect the vein in adit No. 2.

Previous production: Between 1906 and 1940, 975 tons (884.5 t) of ore were produced, which yielded 2,725 ounces (84,700 g) of gold, 7,173 ounces (22,300 g) of silver, 154 pounds (69.9 kg) of copper, and 9,830 pounds (4,459 kg) of lead. This indicates an average of 2.79 ounces gold per ton (95.7 g/t), 7.4 ounces silver per ton (252 g/t), 0.008 percent copper, and 0.5 percent lead.

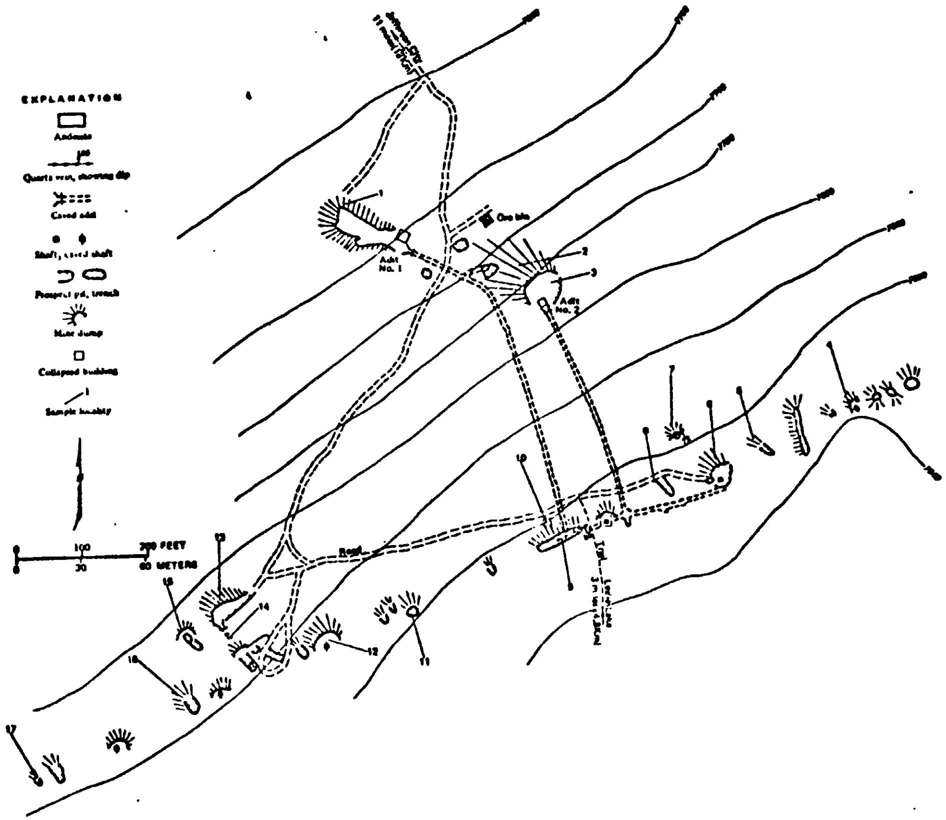


Figure 44. Ballard mine.

An unnumbered table to accompany fig. 44, Ballard mine

Data for samples shown on figure 44.

[Tr, trace, N, none detected; --, not analyzed]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Iron-oxide-stained, silicified andesite from dump--------------	0.01	0.1	Tr	0.07	0.07
2	do--	--	do------------------------------	N	.1	Tr	.06	.09
3	do--	--	Iron-oxide-stained, silicified andesite with quartz stringers and some copper stain from stockpile----------------------	Tr	Tr	0.01	.14	.05
4	do--	--	do------------------------------	N	.1	Tr	.29	.04
5 2/	do--	--	Iron-oxide-stained quartz from dump---------------------------	.09	.2	--	--	--
6	do--	--	Iron-oxide-stained, silicified andesite from stockpile---------	N	.1	Tr	.29	.06
7	Chip	4.3	Across iron-oxide-stained shear zone---------------------------	N	.1	Tr	Tr	.02
8	Grab	--	Iron-oxide-stained, silicified andesite with black tourmaline from stockpile-----------------	N	.1	.01	.27	.11

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
9	Chip	5.0	Across shear zone----------------	N	0.1	Tr	0.28	0.07
10	Grab	--	Vuggy vein quartz from dump------	0.01	Tr	0.02	.48	.03
11	do--	--	Quartz vein material containing galena from dump-----------------	.01	.1	.01	.08	.2
12	do--	--	Iron-oxide-stained, vuggy vein quartz from stockpile------------	.01	.1	.03	.7	.06
13	do--	--	do------------------------------	.25	1.8	.02	.36	.05
14 2/	Chip	4.5	Heavily oxidized, sheared country rock----------------------------	.04	.06	--	--	--
15	Grab	--	Sheared, silicified andesite with iron-oxide-filled fractures from dump----------------------------	.01	.8	.02	.27	.03
16	do--	--	Chloritized andesite with pyrite in stringers from dump-----------	.27	3.3	N	.04	.02
17	do--	--	Brecciated, silicified andesite with stringers of black tourmaline from dump-------------	N	.1	Tr	.02	.01

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.
2/ Bothwell, 1935.

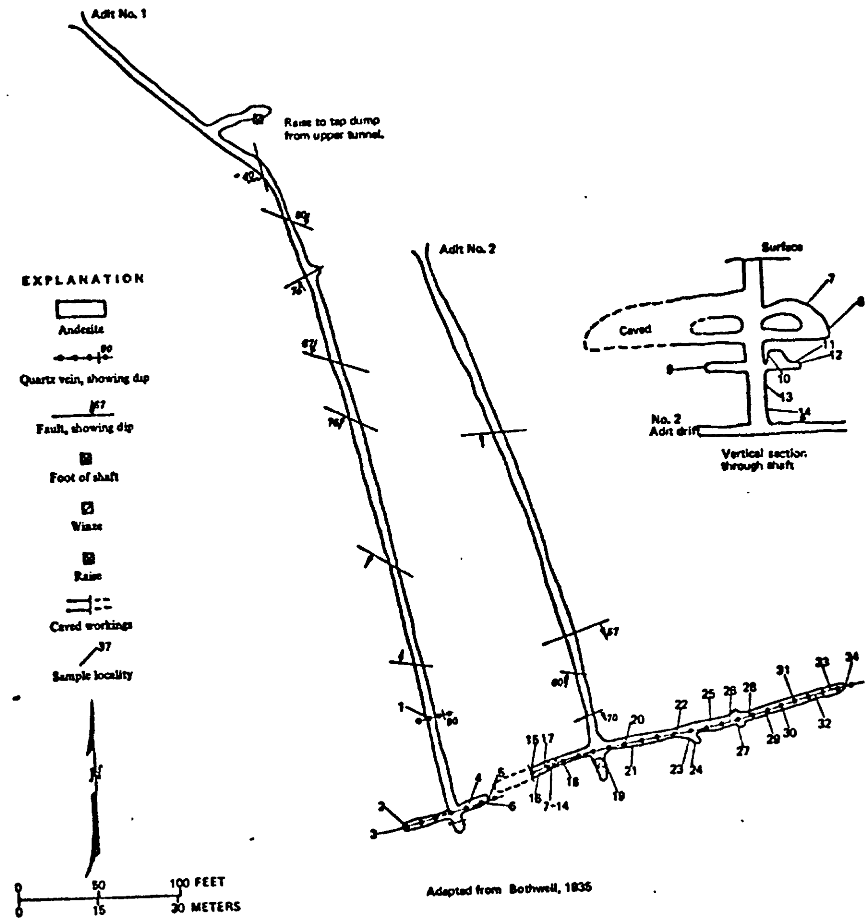


Figure 45. Ballard mine, underground workings.

An unnumbered table to accompany fig. 45, Ballard mine, underground workin[illegible]

Data for samples shown on figure 45.

[Tr, trace; N, not detected; --, not analyzed]

Sample No.	Type	Length (feet) 1/	Description	Gold (ounce per ton) 1/	Silver (ounce per ton) 1/
1 2/	Chip	1.7	Across silicified shear zone in andesite------------------------	11.30	23.5
2 2/	do--	5.0	Across face---------------------	.16	.3
3 2/	do--	5.0	Across quartz vein with some sulfides------------------------	.07	.15
4 2/	do--	4.5	Across decomposed vein material--	.025	.05
5 2/	do--	3.0	Across face, altered andesite in footwall-----------------------	.05	.1
6 2/	do--	2.5	Across face, andesite in hanging wall---------------------------	.02	.05
7 2/	do--	6.0	do------------------------------	.10	.21
8 2/	do--	4.0	do------------------------------	.09	.15
9 2/	do--	3.0	Across face, next to footwall----	.04	.07
10 2/	do--	4.5	Across fractured vein material---	.61	1.25
11 2/	do--	1.5	Across gouge-filled shear zone with quartz stringers-----------	.02	.05
12 2/	do--	2.8	do------------------------------	1.34	2.8
13 2/	do--	3.0	Across shear zone---------------	.015	.05
14 2/	do--	3.0	do------------------------------	.06	.13
15 2/	do--	2.0	Across quartz vein--------------	.03	.07
16 2/	do--	2.0	do------------------------------	.32	.65
17 2/	do--	2.0	Across quartz vein material------	.87	1.7

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/
No.	Type	Length (feet) 1/	Description		
18 2/	Chip	2.0	Across quartz vein material------	0.08	0.15
19 2/	do--	8.0	Across altered andesite----------	.05	.1
20 2/	do--	3.0	Across quartz vein in sheared andesite------------------------	.025	.05
21 2/	do--	3.3	Across shear zone in andesite----	.03	.07
22 2/	do--	3.0	do-------------------------------	.06	.1
23 2/	do--	8.0	do-------------------------------	.08	.15
24 2/	do--	3.0	do-------------------------------	.06	.1
25 2/	do--	5.0	Across quartz vein and gouge in altered andesite-----------------	.04	.06
26 2/	do--	3.0	Across gouge-line shear zone in andesite-------------------------	.07	.15
27 2/	do--	2.8	Across oxidized quartz veins in sheared andesite-----------------	.08	.17
28 2/	do--	3.0	Across 12-inch-wide quartz vein and andesite---------------------	.24	.51
29 2/	do--	4.0	Across silicified, oxidized andesite-------------------------	.06	.1
30 2/	do--	3.0	Across quartz vein material and iron-oxide-stained andesite------	.29	.6
31 2/	do--	2.7	Across sheared andesite----------	.05	.08
32 2/	do--	7.0	Bluish quartz vein material------	.06	.13
33 2/	do--	5.8	Across gouge-lined, quartz-filled shear zone----------------------	.08	.15
34 2/	do--	5.0	do-------------------------------	0.06	0.11

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

2/ Bothwell, 1935.

Geology of deposit: The mine is on a gold-bearing quartz vein in andesite and andesite breccia. The vein strikes N. 70° E., dips 70° SE. to 90°, and is 3 feet (0.9 m) thick. It has been explored in workings for 1,500 feet (457.2 m) along strike and for 240 feet (73.1 m) along dip. The vein reportedly can be traced at least 3,500 feet (N. D. Bothwell, unpublished report). Oxidation of the vein has been complete to a depth of 110 feet (33.6 m). Quartz vein material on mine dumps contains finely-disseminated pyrite and sphalerite; galena pods as much as 1 inch (2.54 cm) across are in the iron-oxide-stained material. The many openings on the vein suggest the ore shipped was from small, high-grade ore bodies.

Development: All underground workings are inaccessible. However, N. D. Bothwell mapped and sampled them in 1935 for the Britannia Mining and Smelting Co., Canada. His unpublished report was used extensively.

Three adits, 7 shafts ranging from 30 to 80 feet (9 to 24 m) deep, and more than 20 prospect pits and trenches explore the vein (fig. 44). Additional workings within 0.5 mile (0.8 km) of adit Nos. 1 and 2, which are not shown on figures 44 and 45, include three caved adits, one open adit 30 feet (9 m) long, one caved shaft, and several pits and trenches.

Sampling: Twenty-one samples were taken in 1977, chiefly from mine dumps and stockpiles. Bothwell (1935) took 48 samples from both the surface and underground; 36 are shown on figures 44 and 45 and accompanying tables. Six samples from the workings outside the mapped area had no significant metal content.

Resource estimate: The vein in the area of the main workings is traceable for 210 feet (64 m) along strike and 164 feet (50 m) along dip. It averages 3 feet (0.9 m) in thickness and is estimated to contain a paramarginal resource of 10,000 tons (9,000 t) which averages 0.15 ounce gold per ton (5.1 g/t).

Shallow surface workings suggest a strike length of 1,500 feet (460 m). However, samples of the additional sections of the vein average only 0.01 ounce gold per ton (3.4 g/t).

Conclusions: Gold and silver content is highest in the oxidized zone of the vein explored by the main workings. Samples from the lower level drift, beneath the level of oxidation (Klepper and others, 1957, p. 73), averaged only 0.07 ounce gold per ton (2.4 g/t) over a thickness of 4 feet (1.2 m). One sample (fig. 45, No. 1) from an isolated shear 240 feet (73 m) below the surface indicates that gold and silver concentrations occur locally.

The persistent nature of the vein, in both strike and dip, enhances its mineral potential. Shipped ore was apparently of much higher grade than shown by most samples. This may indicate the presence of small, high-grade lenses.

Name: Beaver Pond prospect

Index Map No.: Fig. 19, No. 6

Location: NW1/4 Sec. 16, T. 7 N., R. 2 W., on the south side of Wilson Creek

Elevation: 6800 feet (2073 m)

Access: By jeep road 12 miles (19.2 km) east from Jefferson City, Montana

Geology of deposit: The prospect is on leached, iron-oxide-bearing andesite.

Development: A caved adit, estimated to have been about 75 feet (22.9 m) long, and one prospect pit

Sampling: Samples from the prospect dumps assayed as much as a trace of gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Beckley prospect

Owner: John S. Stackhouse

Index Map No.: Fig. 19, No. 10

Location: SE1/4 Sec. 16, T. 7 N., R. 2 W., south of Wilson Creek

Elevation: 6700 feet (2042 m)

Access: By jeep road 12 miles (19.2 km) east from Jefferson City, Montana

History: Located July 15, 1961

Geology of deposit: The claim is on leached, iron-oxide-bearing andesite.

Development: A 15-foot (4.6-m)-deep shaft and two prospect pits

Sampling: Two samples of material from prospect dumps contained 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

Name Belle, Best, and Last Lodes

Owner: Jim Erickson, Anaheim, California

Index Map No.: Fig 19, No. 4

Location: NW1/4 Sec. 15, and NE1/4 Sec. 16, T. 7 N., R. 2 W., northeast of the mouth of Moose Creek

Elevation: 6700 feet (2042 m)

Access: By jeep road 13 miles (20.8 km) east from Jefferson City, Montana

History: The claims cover about 60 acres (24 h). They were located in 1924 and 1926 by John L. Templeman, and patented in 1926.

Previous production: No production has been recorded, but Klepper and others (1957, p. 73) report about $16,000 worth of ore that averaged 0.77 ounce gold per ton (26 g/t), 17 ounces silver per ton (583 g/t), and 17 percent lead was produced.

Geology of deposit: The claims are on a shear zone which is as much as 6 feet (1.8 m) thick and that strikes N. 75° to 80° E. and dips 50° SE. Country rock is pyrite-bearing andesite. The shear zone can be traced for 1,800 feet (549 m). It contains quartz-calcite lenses that are as much as 6 inches (15 cm) thick. The lenses are oxidized and leached at the surface and contain lead carbonates and malachite; at depth, they contain pyrite, galena, and chalcopyrite.

Development: Workings include a 700-foot (213-m)-long caved adit which was stoped for more than 160 feet (49 m), 4 adits and shafts which are caved and estimated to total about 250 feet (76 m), and 20 bulldozed and hand-dug pits and trenches.

Sampling: Fifteen samples were taken from the shear zone, quartz lenses, wallrock, stockpiles, and mine dumps. They assayed as much as a trace of gold, 0.1 ounce silver per ton (3.4 g/t), a trace of copper, 0.33 percent lead, and 0.24 percent zinc. Weeks (unpublished map, 1950) reported that vein material in the stopes of the caved, 700-foot (213-m)-long adit contained, at 1950 metal prices, as much as $20 in gold and silver per ton ($22/t) and 3 percent lead.

Conclusions: The shear zone's surface exposure is leached and contains minor amounts of metals; however, metal-bearing quartz-calcite lenses are indicated to occur at depth. Subsurface work might disclose resources.

Name. Big Tizer-Wildcat prospect

Index Map No.: Fig. 19, No. 12

Location: SW1/4 NW1/4 Sec. 22, T. 7 N., R. 2 W., just north of Tizer Creek

Elevation: 6800 feet (2073 m)

Access: By poor mountain road 12 miles (19.2 km) east from Jefferson City, Montana

Previous production: No recorded production, but a mill, and stopes in underground workings, suggest a production of about 1,000 tons (900 t).

Geology of deposit: The prospect is on a N. 55° E. trending, vertical shear zone in pyrite-bearing andesite. The shear zone averages 2.1 feet (0.6 m) in thickness. It has been explored by workings for about 1,000 feet (305 m) along strike. It is composed of leached, silicified, iron-oxide-stained gouge, brecciated andesite, and an irregular quartz vein. At the surface, the quartz vein contains iron-oxide-coated casts of metallic sulfide minerals. Quartz from the underground workings contains pyrite and galena. The shear zone is probably a southerly extension of the Callahan zone.

Development: Workings are scattered for about 1,000 feet (300 m) along the zone. They consist of an adit, about 300 feet (90 m) long, with stopes to the surface; a caved adit that seems to have been 400 feet (120 m) long; four prospect pits, and a dismantled stamp mill that had a capacity of about 50 tons per day (45 t/d).

Sampling: Seven chip samples across the shear zone and quartz vein contained as much as 0.04 ounce gold per ton (1.4 g/t), 2.2 ounces silver per ton (75 g/t), a trace of copper, 0.74 percent lead, and 0.22 percent zinc. They averaged trace amounts of gold, silver, copper, lead, and zinc. Four samples from wallrock, dumps, stockpiles, and an ore bin averaged a trace of gold, 0.1 ounce silver per ton (3.4 g/t), and trace amounts of copper, lead, and zinc.

Conclusions: The samples were generally of leached material; base metal content can be expected to increase, while precious metals decrease, with depth. The zone is persistent and typical of others in the area. Subsurface work might disclose mineral resources.

Name: Blackjack prospect

Index Map No.: Fig. 19, No. 33

Location: SW1/4 SE1/4 Sec. 32, T. 7 N., R. 2 W., near the head of Tizer Creek

Elevation: 7640 feet (2329 m)

Access: By jeep road 12 miles (19.2 km) east from Jefferson City, Montana

Geology of deposit: Vuggy, iron-oxide-stained quartz and pink feldspar occur with black tourmaline in a breccia pipe within pyritized andesite. The pipe is 100 feet (30.5 m) long, 45 feet (13.7 m) wide, and is elongated along a N. 55° W. trend. Pyrite, largely oxidized, is finely disseminated in quartz. Pyrite is also in quartz-filled vugs and within pyroxene grains.

A vertical, 5.5-foot (1.7-m)-thick, north-trending breccia zone crops out 260 feet (79.2 m) south of the pipe. It is about 110 feet (33 m) long.

Development: Two shafts and a pit are at the breccia pipe-andesite contact. A third shaft is near the center of the breccia pipe. The shafts are caved or flooded, but reportedly (Stone, 1911, P. 92) were 30 to 60 feet (10 to 18 m) deep. The pit is at least 15 feet (5 m) deep. Two trenches are about 200 feet (61 m) northwest of the pipe. Two shallow pits explore the andesite breccia zone south of the shaft area.

Sampling: Eleven samples of breccia and country rock contained as much as 0.01 ounce silver per ton (3.4 g/t), and averaged trace amounts of gold, copper, lead, and zinc.

Conclusions: No mineral resource potential indicated

* *

Name: Cabin prospect

Index Map No.: Fig. 19, No. 21

Location: N1/2 Sec. 19, T. 7 N., R. 2 W., southeast of Bullock Hill

Elevation: 7500 feet (2286 m)

Access: By jeep road 8 miles (12.8 km) east from Jefferson City, Montana

Geology of deposit: The prospect is on an iron-oxide-stained quartz vein as much as 3 inches (7.6 cm) thick in quartz monzonite.

Development: One caved shaft thought to be 12 feet (3.7 m) deep, and 13 prospect pits.

Sampling: Six samples of vein material from prospect dumps each contained 0.1 ounce silver per ton (3.4 g/t) and less than 0.02 percent copper. Average lead content was 1.06 percent, and the average zinc content was 0.17 percent.

Conclusions: A low mineral resource potential

* *

Name: Callahan mine

Owner: Edgar D. Malicote and David H. Dennis, Jefferson City, Montana

Index Map No.: Fig. 19, No. 11

Location: S1/2 Sec. 15 and N1/2 Sec. 22, T. 7 N., R. 2 W., on the divide ?etween Wilson and Tizer Creeks

Elevation: 7000 to 7440 feet (2134 to 2268 m)

Access: By jeep road 10 miles (16 km) east from Jefferson City, Montana

History: In 1911, Stone (p. 92) reported that prospects had been opened in Sec. 22, on the hill between Big Tizer and Wilson Creeks. He also said that a 150-foot (46-m)-long adit was driven in 1910. In the 1920's, the Callahan Gold Mining Co. located the Golden Age group which were mined on a small scale until 1936. The 25 ton-per-day (23-t/d) Golden Age cyanide-flotation mill was built in 1936. The mine and mill operated until 1951. Since 1951, only assessment work has been done. Part of the Callahan mine was relocated as the Golden Age Nos. 1 and 2 claims by Edgar D. Malicote in 1956, and as the Linda Jo claim by David H. Dennis in 1969.

Production: Records list the production of 10,893 tons (9,882 t) of ore that contained 6,093 ounces (189,510 g) gold, 7,552 ounces (234,890 g) silver, 10,000 pounds (4,535.9 kg) copper, 76,913 pounds (34,887.1 kg) lead, and 1,594 pounds (723 kg) of zinc.

Geology of deposit: The Callahan mine is on a N. 50° E. trending zone of shearing in pyrite-bearing andesite. Three parallel shears within the zone have been followed by underground workings (fig. 46), and the two southern zones (Nos. 15-26) have produced ore. The mined shear zones are about 75 feet (23 m) apart and dip about 70° SE. The unmined zone (Nos. 4-11), about 900 feet (270 m) north, dips 60° to 80° SE. Most of the mined shear zone material was oxidized and iron-oxide-stained, and consisted of gouge, pyritic andesite, and vuggy quartz. The oxidized zones contained narrow, high-grade, gold-bearing lenses; however, the average grade over the minable width was about 0.5 ounce gold per ton (17 g/t) (Robu. 1907, p. 79). Below the oxidized zone, the material contains sparse pyrite, galena, sphalerite, chalcopyrite, and tetrahedrite. The low metal content precluded mining.

Development: The mined shear zones were developed by two adits, now caved, and two intermediate levels between the adits. Klepper mapped the adits, but took no samples. The adits total about 5,000 feet (1,500 m). Additional shallow workings include 4 caved adits, estimated to total about 300 feet (90 m), and 20 prospect pits, shafts, and trenches. The unmined shear zone was developed by an open adit which is about 285 feet (87 m) long, and four prospect pits and trenches. Ore from the mine was trucked 1 mile (1.6 km) north to the Golden Age site, ground in the ball mill, and concentrated by mercury amalgamation, cyanidization, and flotation. The mill is partially dismantled.

Sampling: Twenty-eight chip and grab samples were taken. They were from shear zones, wallrock, stockpiles, and mine dumps. The sampled material was oxidized and probably not representative of material at depth. They assayed as much as 0.049 ounce gold per ton (1.7 g/t), 0.53 ounce silver per ton (18.2 g/t), 0.09 percent copper, 1.6 percent lead, and 0.26 percent zinc. They averaged trace amounts of gold, silver, lead, and zinc. Two samples from the 10,000 tons (9,072 t) of tailings at the Golden Age mill contained trace amounts of gold and silver, 0.67 percent lead, and 0.13 percent zinc.

Resource estimate: Roby (1960, p. 79) reported that the shear zones are as much as 6 feet (1.8 m) thick, averaging 2.5 feet (0.8 m), and have been explored for at least 900 feet (274 m) along strike and for at least 400 feet (122 m) along dip. The third (unmined) zone averages 3 feet (0.9 m) in thickness and can be inferred for about 450 feet (137 m) along strike. The zone of shearing is at least 900 feet (270 m) wide and may extend from the Callahan mine to, and beyond, the Big Tizer-Wildcat prospect, a distance of at least 3,700 feet (1,130 m). If the zone of shearing extends to the Big Tizer-Wildcat prospect, there is a considerable mineral resource potential.

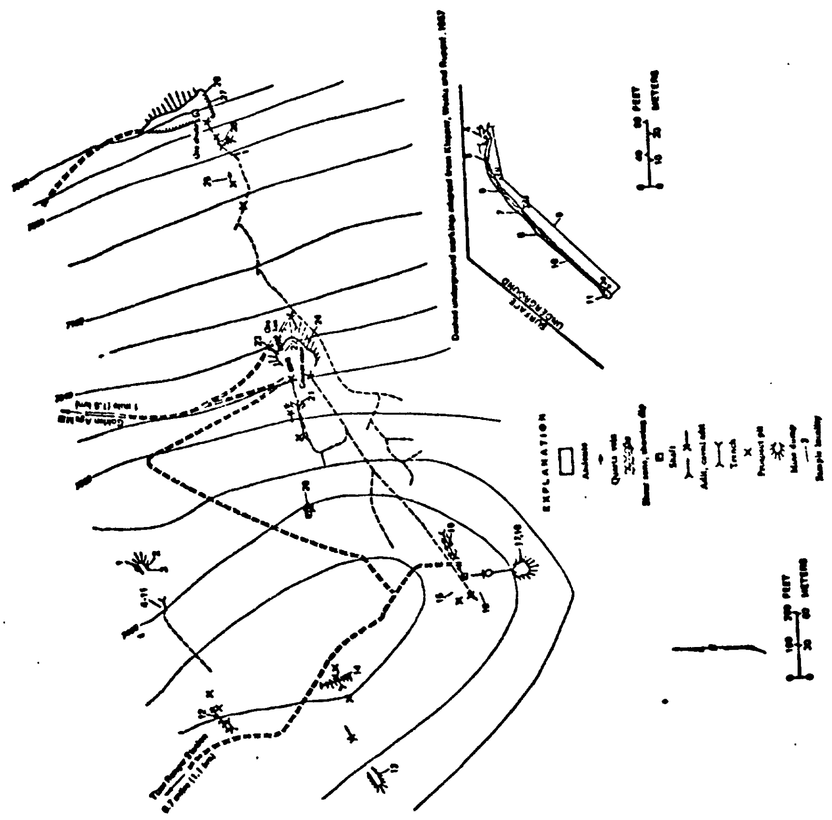


Figure 46. Callahan mine.

An unnumbered table to accompany fig. 46, Callahan mine

Data for samples shown on figure 46.

[Tr, trace, N, not detected]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Shear zone material from dump------	N	Tr	Tr	0.08	0.02
2	do--	--	Shear zone material from stockpile	N	0.1	Tr	.09	Tr
3	do--	--	Quartz vein material from stockpile	N	.1	0.01	.52	Tr
4	Chip	20.0	Across sheared andesite wallrock---	Tr	.1	Tr	Tr	Tr
5	do--	3.0	Across shear zone-----------------	Tr	.1	Tr	Tr	.03
6	do--	3.0	do--------------------------------	Tr	.1	Tr	Tr	.01
7	do--	3.0	do--------------------------------	Tr	.1	Tr	.12	.02
8	do--	2.0	do--------------------------------	Tr	.1	.01	.56	.02
9	do--	285.0	Pyrite-bearing andesite wallrock---	Tr	Tr	.01	N	.02
10	do--	2.0	do--------------------------------	0.01	.1	Tr	Tr	Tr
11	do--	2.0	do--------------------------------	Tr	.1	Tr	.03	Tr
12	do--	93.0	Across shear zone material---------	N	Tr	Tr	Tr	Tr
13	Grab	--	Shear zone material from stockpile	Tr	.1	.01	.21	Tr

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
14	Chip	100.0	Across shear zone------------------	Tr	0.1	Tr	N	Tr
15	Grab	--	Quartz vein material from stockpile	0.03	.1	0.02	0.04	Tr
16	do--	--	do----------------------------------	Tr	.1	.02	.14	Tr
17	do--	--	do----------------------------------	Tr	Tr	.02	.13	0.06
18	do--	--	Shear zone material from stockpile	Tr	Tr	.04	.13	.04
19	Chip	3.0	Across shear zone------------------	Tr	Tr	.04	.24	.03
20	Grab	--	Shear zone material from dump-------	N	.1	.02	.04	Tr
21	do--	--	do----------------------------------	N	N	Tr	.13	.01
22	do--	--	Quartz vein material from dump-----	Tr	.1	.01	.02	.03
23	do--	--	Pyrite-bearing andesite from dump--	Tr	.1	.03	.23	.10
24	do--	--	Shear zone material from dump-------	N	.1	Tr	1.6	.15
25	do--	--	Quartz vein material from dump-----	Tr	.1	.01	.02	.03
26	Chip	30.0	Across shear zone------------------	Tr	N	Tr	.01	.01
27	Grab	--	Andesite from dump------------------	Tr	N	.01	.2	.19
28	do--	--	Shear zone material from dump-------	.049	.53	.09	.35	.23

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.

Conclusions: Sampling indicates that the surface and near-surface exposures of the shear zones in the vicinity of the Callahan mine are leached and contain only minor amounts of metallic minerals. However, small, enriched, oxidized, metal-bearing lenses were mined. Metallic sulfide mineral-bearing material occurs below the oxidized zone, but because of low metal content, was not mined. Additional subsurface work along the zone of shearing would probably disclose mineral resources.

* *

Name: Doe prospect

Index Map No.: Fig. 19, No. 22

Location: NE1/4 Sec. 19, T. 7 N., R. 2 W., southwest of the summit of Bullock Hill

Elevation: 7400 feet (2256 m)

Access: By jeep road 8 miles (12.8 km) east from Jefferson City, Montana

Geology of deposit: Gossan material, some of which is 1 foot (0.3 m) thick, and has quartz veins as much as 2 inches (5.08 cm) thick, is on the dumps. Country rock is quartz monzonite.

Development: A caved adit, calculated to have had about 125 feet (38 m) of workings, a caved shaft, thought to have been about 40 feet (12 m) deep, and six pits are on the prospect.

Sampling: Three grab samples of gossan and vein material assayed a trace trace of gold and as much as 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Gold Series claim (Big Mary claim)

Owner: Dorothy Molitor, Jefferson City, Montana; Horace Wilson, Helena, Montana

Index Map No.: Fig. 19, No. 2

Location: NE1/4 Sec. 9, T. 7 N., R. 2 W., along Moose Creek, approximately 1.3 miles (2.1 km) from its mouth

Elevation: 7200 feet (2194 m)

Access: By jeep road 14 miles (22.4 km) east from Jefferson City, Montana

History: The claim was located and explored in the late 1800's and again in the 1950's. The Gold Series claim was located in 1951 and relocated in 1958.

Previous production: In 1934, 2 tons (1.8 t) of ore containing 4 ounces (124 g) gold, 14 ounces (435 g) silver, 25 pounds (11.3 kg) copper, and 162 pounds (73.5 kg) of lead were produced.

Geology of deposit: The claim is on a 4-foot (1.2-m)-thick, east-trending, 80° south dipping, iron-oxide-stained breccia zone in pyrite-bearing andesite. The breccia zone is about 4 feet (1.2 m) thick and at least 2,900 feet (880 m) long. The zone contains casts of pyrite, and leached quartz lenses, which are less than 0.5-foot (0.3-m)-thick.

Development: Workings include two flooded shafts which are 15 and 30 feet (5 and 9 m) deep, two caved adits estimated to have a total of 400 feet (120 m) of workings, three caved shafts, and six bulldozer trenches.

Sampling: Sixteen samples taken across the zone and from prospect dumps assayed as much as a trace of gold, 0.1 ounce silver per ton (3.4 g/t), 0.24 percent lead, and a trace of zinc.

Conclusions: The leached material which was sampled may not be indicative of metal content at depth. The zone is similar to others in the area, and subsurface work might disclose mineral resources.

* *

Name: J. C. Copper claim

Owner: Steve Reilly, Jefferson City, Montana

Index Map No.: Fig. 19, No. 32

Location: SE1/4 SE1/4 Sec. 31, T. 7 N., R. 2 W., about 0.2 mile (0.32 km) west of upper Tizer Lake

Elevation: 7700 feet (2347 m)

Access: By jeep road 11 miles (17.6 km) east from Jefferson City, Montana, then by trail 0.2 (0.32 km) west from the Tizer Lake road.

History: Located in 1975

Geology of deposit: The claim is on a fractured, northeast-trending contact replacement zone between pyrite-bearing andesite and fine-grained dioritic intrusive rocks. Along the contact, the fractured andesite has, in places, been replaced by pods of garnet, magnetite, and chalcocite. At the surface, the pods and nearby rock are coated by malachite and azurite.

Development: Workings extend about 1,100 feet (330 m) in a northeast, direction and about 500 feet (150 m) in a northwest, direction. They consist of three caved adits estimated to total 600 feet (180 m), two shafts, 15 and 20 feet (5 and 6 m) deep, and eight hand-dug prospect pits.

Sampling: Twelve samples were taken. Five chip samples from across replacement pods averaged 0.1 ounce silver per ton (3.4 g/t), 2.7 percent copper, and traces of lead and zinc; one contained 4.5 percent copper and 0.41 percent zinc. Three andesite and diorite wallrock samples assayed 0.1 ounce silver per ton (3.4 g/t), and trace copper, lead, and zinc. Four mine dump and stockpile samples contained as much as 4.1 percent copper.

Resource estimate: At least two copper-bearing pods are present; they average 6.2 feet (1.9 m) in thickness and are as much as 100 feet (30 m) long. They are estimated to have a paramarginal resource of about 5,000 tons (4,500 t).

Conclusions: The pods are small and scattered. The extent of the contact zone has not been fully determined. Additional mineral resources would probably be disclosed by subsurface work in the exposed and buried portions of the contact zone.

* *

Name: Little Tizer-Wildcat mine

Owner: John Pasini, Boulder, Montana; Victor Kunish, Great Falls, Montana

Index Map No.: Fig. 19, No. 29

Location: NE1/4 Sec. 33, T. 7 N., R. 2 W., near the head of Little Tizer Creek

Elevation: 7600 feet (2316 m)

Access: By jeep road 12 miles (19.2 km) east from Jefferson City, Montana

History: The Wildcat and Line claims were located by John Pasini in 1930 and 1932, respectively, and the Wildcat No. 2 in 1933. In 1962, applications for patent were filed; patents were denied. In connection with the patent applications, Forest Service personnel examined the claims on two occasions (Hintzman, 1962, unpublished report, and Morrison, 1968, unpublished report).

Previous production: Between 1937 and 1939, 4 tons (3.6 t) of ore yielded 4 ounces (124 g) gold and 3 ounces (93 g) silver. The patent application states that 50 tons (45.4 t) of ore worth $25 per ton ($27.50/t) were produced.

Geology of deposit: The mine is on narrow, locally mineralized shear zones in andesite and andesite breccia. The zones strike N. 50° to 85° W., dip from 30° to 85° SW., and range in thickness from 0.3 to 2 feet (0.1 to 0.6 m). The zones generally contain gouge and are heavily iron- and manganese-oxide-stained. Wallrock is leached, chloritized, and intensely fractured. Pyrite is the only visible metallic sulfide mineral.

The most continuous shear zone is intersected at the face of the Wildcat Adit No. 2. It strikes N. 70° W. and dips 70° SW. (fig. 47). It is assumed to be continuous from its exposure in the adit to the Wildcat shaft, a distance of 45 feet (14 m).

Development: Three partially caved adits estimated to aggregate about 800 feet (240 m), a caved shaft, 58 feet (18 m) deep, and a number of shallow, caved prospect pits and trenches constitute the workings.

Sampling: Sample localities and analyses are shown on figure 47 and accompanying table. Of the eight samples taken during the current study, five were from mine dumps and stockpiles, and three from Line adit No. 2. In 1962, Hintzman took one sample (No. 10) from the Wildcat shaft and three (Nos. 2, 4, and 5) from accessible parts of the Wildcat adit No. 2. In 1968, Morrison took three more samples (Nos. 3, 6, and 7) from the Wildcat adit No. 2. Three samples (Nos. 12, 14, and 16) taken from the Line adit No. 2 by Morrison in 1968 were from the same structures and had approximately the same values as those taken in 1977.

Chip samples from the Wildcat shaft and No. 2 adit shear zone averaged 0.63 feet (0.2 m) in width, assayed 0.115 ounce gold per ton (3.9 g/t), and 0.24 ounce silver per ton (8.2 g/t). Samples from the Line No. 2 adit averaged 0.003 ounce gold per ton (0.1 g/t), 0.14 ounce silver per ton (4.8 g/t), and 0.14 percent lead. Normal sample width was 2 feet (0.6 m).

Seven samples, not shown on the map, were from dumps of prospect workings on the Wildcat No. 2 claim. They contained as much as a trace of gold, 0.1 ounce silver per ton (3.4 g/t), and trace amounts of copper, lead, and zinc.

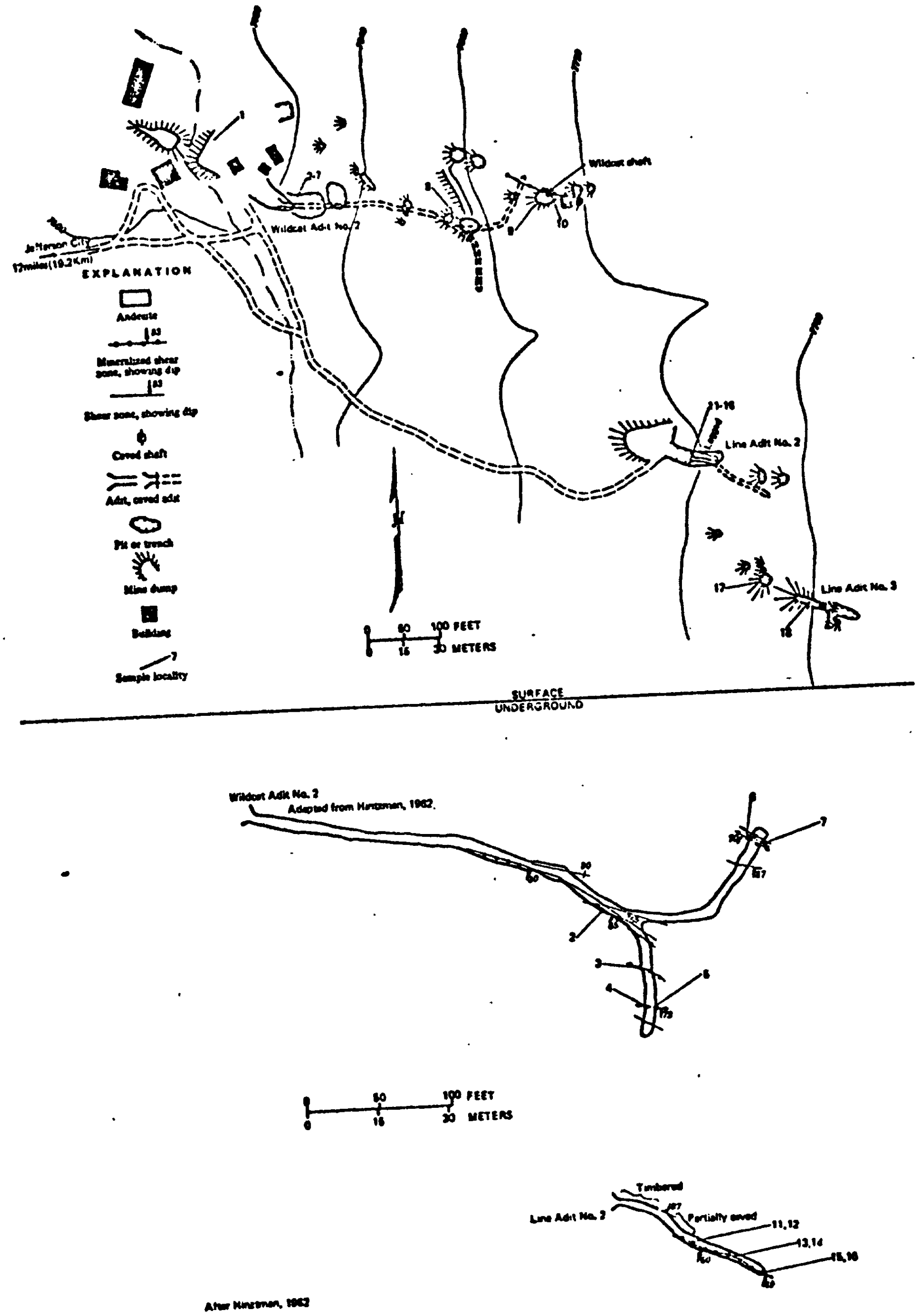


Figure 47. Little Tizer-Wildcat mine.

An unnumbered table to accompany fig. 47, Little Tizer-Wildcat mine

Data for samples shown on figure 47.

[Tr, trace; N, none detected; --, not analyzed]

Sample				Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Length (feet) 1/	Description					
1	Grab	--	Siliceous iron-oxide-stained shear zone material from stockpile-------	Tr	0.1	Tr	1.40	0.06
2 2/	Chip	0.33	Across iron-oxide-stained shear zone in andesite-----------------	0.04	.2	--	--	--
3 3/	do--	.67	Across shear zone and manganese-oxide-stained gouge---------------	Tr	.3	--	.21	--
4 2/	do--	.33	Across iron- and manganese-oxide-stained shear zone, some pyrite----	.18	Tr	--	--	--
5 2/	do--	1.25	do-------------------------------	.02	.3	--	--	--
6 3/	do--	.58	do-------------------------------	.60	.4	--	.21	--
7 3/	do--	.75	do-------------------------------	.04	.1	--	.21	--
8	Grab	--	Bleached, brecciated andesite from dump------------------------------	N	.1	Tr	N	Tr
9	do--	--	Iron-oxide-stained andesite breccia from dump------------------------	N	.1	Tr	Tr	.03

Sample				Gold	Silver			
No.	Type	Length (feet) 1/	Description	(ounce per ton) 1/	(ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
10 2/	Chip	0.5	Across mineralized shear zone in shaft------------------------------	0.06	0.2	--	--	--
11	do--	1.0	Across shear zone, gouge, and leached andesite with some iron-oxide stain-----------------------	Tr	.1	Tr	0.03	0.06
12 3/	do--	.5	do-----------------------------------	.005	.15	--	.10	--
13	do--	2.0	do-----------------------------------	Tr	.1	0.02	.06	.10
14 3/	do--	2.0	do-----------------------------------	Tr	.4	--	.31	--
15	do--	4.0	do-----------------------------------	N	.1	Tr	Tr	Tr
16 3/	do--	2.5	do-----------------------------------	.005	.15	--	.31	--
17	Grab	--	Iron-oxide-stained, chloritized andesite from dump-----------------	N	.1	Tr	.02	.05
18	do--	--	do-----------------------------------	N	.1	Tr	.14	.12

1/ Metric conversions: feet x 0.3048 = meters; ounce per ton x 34.285 = grams per tonne.
2/ Hintzman, 1962.
3/ Morrison, 1968.

Resource estimate: Three samples (Nos. 6, 7, and 10) from the shear zone exposed in the Wildcat shaft and at the face of the Wildcat adit No. 2 averaged 0.22 ounce gold and 0.22 ounce silver per ton (7.5 g/t). The shear zone averaging 0.6 foot (0.2 m) in thickness is assumed to be continuous between the two exposures. Inferring 45 feet (14 m) of strike length and about 75 feet (22.9 m) of dip length, it is calculated to constitute 170 tons (150 t) of resources.

The shear zone in the Line adit No. 2 is exposed for at least 65 feet (20 m) and averages 2 feet (0.6 m) in thickness. Samples show, however, that the grade is too low to be considered a resource.

Conclusions: Some minable-grade gold and silver materials are in the shear zones. The structures with the most potential have very limited exposures, and additional work would probably disclose additional mineral resources; however, the zone is probably too narrow to be minable.

* *

Name: Mastodon Lodes

Owner: Raymond Neuberg, Townsend, Montana

Index Map No.: Fig. 19, No. 8

Location: W1/2 Sec. 17 and E1/2 Sec. 18, T. 7 N., R. 2 W., on the northwest side of Bullock Hill

Elevation: 7240 to 7400 feet (2207 to 2256 m)

Access: By jeep road 10 miles (16 km) from Jefferson City, Montana

History: The Mastodon and South Mastodon claims were patented after 1926.

Geology of deposit: Workings are on white, silicified, iron-oxide-bearing andesite with quartz lenses as much as 3 inches (8 cm) thick and dark gray to black, silicified, pyrite-bearing andesite. Pieces of gossan occur locally.

Development: The 1926 patent survey plat shows two discovery cuts, two shafts, and one adit. Five prospect pits, a 400-foot (122-m)-long bulldozer cut, a 200-foot (61-m)-long bulldozer cut, and a caved shaft were examined in 1977. The larger bulldozer cut obliterated the adit and one shaft.

Sampling: Ten samples were taken from the workings. They assayed as much as a trace of gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

Name: Mercury and Misery claims

Index Map No.: Fig. 19, No. 24

Location: SW1/4 SE1/4 Sec. 19, T. 7 N., R. 2 W., along Prickly Pear Creek

Elevation: 6960 feet (2121 m)

Access: By jeep road 8 miles (12.8 km) east from Jefferson City, Montana

History: The last known claim location was in 1965 by Albert and Edwin Erickson.

Geology of deposit: No mineralized structures were seen. Prospect dump material suggests that a vuggy, iron-oxide-stained quartz vein at least 3 inches (8 cm) thick is in fine-grained, pyritic andesite.

Development: Three caved adits, consisting of less than 200 feet (60 m) of workings, and four shallow prospect pits and trenches

Sampling: Five samples of quartz vein material and altered country rock from prospect dumps contained as much as 0.1 ounce silver per ton (3.4 g/t), and trace amounts of gold, copper, lead, and zinc.

Conclusions: No mineral resource potential indicated

* *

Name: Moonlight claims

Index Map No.: Fig. 19, No. 1

Location: W1/2 Sec. 9, T. 7 N., R. 2 W., near the head of Taylor Creek

Elevation: 7400 feet (2256 m)

Access: By jeep road 12 miles (19.2 km) west from Jefferson City, Montana

Geology of deposit: The claims are on a poorly exposed, north-trending, brecciated contact zone. Rhyolitic to andesitic volcanic flow rocks are west of the contact, and dioritic intrusive rocks are east of it. Limited contact zone exposures consist of leached, altered, iron-oxide-stained and silicified rocks that contain limonite-coated pyrite casts. Unaltered breccia contains pyrite.

Development: Workings extend north-south along the breccia zone for 3,000 feet (914 m), and across it for 1,300 feet (396 m) into the volcanic flows and intrusive rocks on either side. The workings include 2 caved adits whose total lengths are about 100 feet (30 m), and 20 shallow shafts and prospect pits.

Sampling: Two chip samples of breccia averaged trace amounts of gold, silver, and lead. Thirteen grab samples contained as much as a trace of gold, 3.6 ounces silver per ton (123 g/t), 1.7 percent lead, and traces of copper and zinc; they averaged trace amounts of gold, silver, lead, and zinc.

Conclusions: The sampled material was leached and is not indicative of metal content of the zone at depth. The samples show that where metals occur, they are in irregular lenses and pods. The breccia zone is a large exploration target, and its similarility to other zones in the vicinity suggests that subsurface exploration might disclose mineral resources.

* *

Name: Moose Creek Divide prospect

Index Map No.: Fig. 19, No. 3

Location: Center of Sec. 10, T. 7 N., R. 2 W., on the divide between Moose and Clear Creeks

Elevation: 7300 feet (2225 m)

Access: By jeep road 15 miles (24 km) west from Jefferson City, Montana

Geology of deposit: The prospect is on a 4-foot (1.2-m)-thick, leached, brecciated, gossany shear zone in pyrite-bearing andesite.

Development: Two shafts, less than 5 feet (1.5 m) deep, and 1,000 feet (300 m) apart constitute the workings.

Sampling: One chip and one grab sample of gossany shear zone material assayed 0.1 ounce silver per ton (3.4 g/t).

Conclusions: The zone is similar to others in the district. The low metal content of the surficial material may not be indicative of the metal content at depth. Additional work may disclose mineral resources.

Name: Northeast prospect

Index Map No.: Fig. 19, No. 9

Location: SE1/4 Sec. 17, T. 7 N., R. 2 W., on the northeast side of Bullock Hill

Elevation: 7000 to 7400 feet (2134 to 2256 m)

Access: By jeep road 10 miles (16 km) east from Jefferson City, Montana, then by cross-country travel 0.5 mile (0.8 km) south from Wilson Creek

Geology of deposit: The prospect is in leached, iron-oxide- and pyrite-bearing andesite.

Development: Eighteen prospect pits

Sampling: Seven samples of andesite from prospect dumps assayed as much as a trace of gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Northwest prospect

Index Map No.: Fig. 19, No. 13

Location: SE1/4 Sec. 18, T. 7 N., R. 2 W., on the northwest side of Bullock Hill

Elevation: 7600 feet (2316 m)

Access: By jeep road 9 miles (14.4 km) east from Jefferson City, Montana

Geology of deposit: The prospect is on silicified, bleached, iron-oxide- and pyrite-bearing andesite.

Development: Twenty closely-spaced prospect pits

Sampling: Six samples of pyrite-bearing andesite assayed as much as a trace of gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

Name: Ohio claim

Index Map No.: Fig. 19, No. 28

Location: Center SW1/4 Sec. 29, T. 7 N., R. 2 W., on the west side of Tizer Creek

Elevation: 7560 feet (2304 m)

Access: By jeep road 10 miles (16 km) east from Jefferson City, Montana

History: Located by C. O'Connell in 1908

Geology of deposit: A 2- to 3-foot (0.3- to 0.9-m)-thick quartz-filled shear zone in andesite strikes N. 56° W. and dips 25° NE. The quartz is vuggy and heavily iron-oxide-stained.

Development: A 20-foot (6-m)-long adit and a shallow pit are on the zone.

Sampling: A grab sample of quartz from the prospect dump assayed 0.1 ounce silver per ton (3.4 g/t), 0.49 percent lead, 0.52 percent zinc, and trace amounts of gold and copper.

Conclusions: No mineral resource potential indicated

* *

Name: Road Junction prospect

Index Map No.: Fig. 19, No. 20

Location: NE1/4 Sec. 19, T. 7 N., R. 2 W., on the southwest side of Bullock Hill

Elevation: 7400 feet (2256 m)

Access: By jeep road 9 miles (14.4 km) east from Jefferson City, Montana

Geology of deposit: The prospect is on silicified, leached, iron-oxide- and pyrite-bearing andesite. Several pieces of vuggy, iron-oxide-bearing quartz vein material were seen on one pit.

Development: Eleven prospect pits

Sampling: Seven samples were taken of andesite and one of quartz vein material. Samples of andesite assayed as much as 0.01 ounce gold per ton (0.34 g/t) and 0.1 ounce silver per ton (3.4 g/t). The quartz sample assayed a trace of gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Saint Joseph claim

Index Map No.: Fig. 19, No. 14

Location: SE1/4 Sec. 18, T. 7 N., R. 2 W., on the west side of Bullock Hill

Elevation: 7440 feet (2268 m)

Access: By jeep road 9 miles (14.4 km) east from Jefferson City, Montana

History: Located in 1940

Geology of deposit: The claim is on an aplitic dike that contains sparse iron-oxides and tourmaline.

Development: Two caved prospect pits are 10 feet (3 m) apart.

Sampling: A grab sample of dike rock assayed a trace of gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Tizer Divide prospect

Index Map No.: Fig. 19, No. 19

Location: SE1/4 Sec. 21 and SW1/4 Sec. 22, T. 7 N., R. 2 W., on the divide between Tizer and Little Tizer Creeks

Elevation: 7000 feet (2134 m)

Access: By road 12 miles (19.2 km) east from Jefferson City, Montana, then by trail 0.9 mile (1.3 km) southeast from Tizer guard station

Geology of deposit: The dumps are composed of silicified, leached, iron-oxide-bearing andesite with vuggy quartz veinlets which are 3 inches (8 cm) thick.

Development: Two caved adits, estimated to be 130 feet (40 m) long, comprise the workings.

Sampling: A sample from each dump assayed 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Top prospect

Index Map No.: Fig. 19, No. 18

Location: NW1/4 Sec. 20, T. 7 N., R. 2 W., near the top of Bullock Hill

Elevation: 7800 feet (2377 m)

Access: By jeep road 9 miles (14.4 km) east from Jefferson City, Montana

Geology of deposit: The prospect is on silicified, leached, iron-oxide-bearing andesite.

Development: Two prospect pits

Sampling: Two samples of andesite were taken. One assayed a trace of gold, and one 0.01 ounce gold per ton (0.34 g/t); both assayed 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Upper Manley Park prospect

Index Map No.: Fig. 19, No. 25

Location: N1/2 Sec. 28, T. 7 N., R. 2 W., on the north edge of Manley Park

Elevation: 7300 feet (2225 m)

Access: By jeep road 10 miles (16 km) east from Jefferson City, Montana

Geology of deposit: The prospect is on silicified, leached, iron-oxide-bearing andesite.

Development: Four prospect pits

Sampling: Samples of andesite from each pit assayed 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Upper Tizer Lake prospect

Index Map No.: Fig. 19, No. 34

Location: NE1/4 NE1/4 Sec. 6, T. 6 N., R. 2 W., on the ridge southeast of upper Tizer Lakes

Elevation: 8200 feet (2499 m)

Access: By jeep road 11 miles (17.6 km) east from Jefferson City, Montana, then by foot 0.3 mile (0.5 km) south from upper Tizer Lake

Geology of deposit: The prospect is on an altered contact zone between andesite flows. The zone contains finely-disseminated pyrite, epidote, garnet, and pyroxene.

Development: A 35-foot (11-m)-long adit that was driven S. 80° W. in andesite, and a prospect pit which is 35 feet (11 m) above the adit.

Sampling: Two grab samples from dumps contained trace amounts of silver and copper, 0.02 percent lead, and 0.02 percent zinc.

Conclusions: No mineral resource potential indicated

* *

Name: Upper Wilson Creek prospect

Index Map No.: Fig. 19, No. 7

Location: NE1/4 Sec. 17, and NW1/4 Sec. 16, T. 7 N., R. 2 W., on the south bank of Wilson Creek

Elevation: 6800 feet (2073 m)

Access: By jeep road 11 miles (17.6 km) east from Jefferson City, Montana

Geology of deposit: The prospect is on silicified, leached, iron-oxide-bearing andesite.

Development: A caved adit, estimated to have been less than 10 feet (3 m) long, and one prospect pit.

Sampling: Two prospect dump samples of iron-oxide-bearing rock were taken. One assayed 0.02 ounce gold per ton (0.69 g/t), and both assayed 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: West Ridge prospect

Index Map No.: Fig. 19, No. 17

Location: SE1/4 Sec. 18, T. 7 N., R. 2 W., on the west side of Bullock Hill

Elevation: 7500 to 7700 feet (2286 to 2347 m)

Access: By jeep road 9 miles (14.4 km) east from Jefferson City, Montana

Geology of deposit: Silicified, iron-oxide- and pyrite-bearing andesite contains 3-inch (8-cm)-thick quartz veinlets.

Development: A 15-foot (5-m)-deep caved shaft, a trench, and nine prospect pits

Sampling: Seven samples of mineralized andesite assayed as much as 0.01 ounce gold per ton (0.34 g/t) and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Zalinski prospect

Index Map No.: Fig. 19, No. 16

Location: NW1/4 Sec. 19, T. 7 N., R. 2 W., on the divide between Prickly Pear and Wilson Creeks

Elevation: 7600 feet (2316 m)

Access: By jeep road 10 miles (16 km) east from Jefferson City, Montana

Geology of deposit: The prospect is on an iron-oxide-bearing quartz vein in quartz monzonite. Pieces of material on the dumps suggest that the vein is from 1 to 12 inches (2.5 to 31 cm) thick. Workings indicate a strike of about N. 60° W. For about 1,270 feet (387.1 m) along the trend are prospect dumps containing vein material.

Development: There are 4 shafts, estimated to have been between 10 and 90 feet (3 and 27 m) deep, 3 trenches, and about 85 prospect pits along the strike of the vein. An additional 19 prospect pits below and to the northeast are apparently in float from the vein.

Sampling: Ten grab samples of vein material from prospect dumps contained as much as a trace of gold, 0.1 ounce silver per ton (3.4 g/t), 9 percent lead, and 1.2 percent zinc, but generally they had no significant metal content.

Conclusions: Low assay results, combined with a narrow vein, indicate a low mineral resource potential.

Warm Springs district

Name: Black Bear claim

Index Map No.: Fig. 20, No. 6

Location: Sec. 29, T. 8 N., R. 2 W., at the head of Middle Fork Warm Springs Creek

Elevation: 5800 to 6800 feet (1768 to 2073 m)

Access: By road 5.5 miles (8.9 km) east from Alahambra, Montana

History: Located by O. Smith in 1911

Previous production: Stone (1911, p. 87) reported that the veins on the Black Bear claim were worked from several small shafts and produced ore containing 12 ounces silver per ton (411 g/t) and 0.08 ounce gold per ton (2.7 g/t). No production has been recorded.

Geology of deposit: At least three east-trending, mineralized shear zones are indicated on the claim. The zones consist of altered, brecciated, quartz monzonite with iron-oxide-stained quartz and siderite veins as much as 8 inches (20 cm) thick (fig. 48). Pyrite, arsenopyrite, chalcopyrite, galena, and sphalerite occur along the shear zones.

Development: Workings include 13 caved adits and 3 caved shafts whose total length is thought to be 700 feet (213 m), and 34 prospect pits and trenches.

Sampling: Sample locations and analyses are shown on figure 48 and accompanying table. The shear zones were observed in several shafts but were not accessible for direct sampling. Ten grab samples from workings on zone No. 2 (Nos. 2, 4-7, 9-13) averaged 0.016 ounce gold per ton (0.3 g/t), 0.08 ounce silver per ton (2.8 g/t), 0.45 percent lead, and 0.37 percent zinc. Grab samples from workings along the 500-foot (152-m) extension of zone No. 2 (Nos. 14-18) had a slightly higher gold content, averaging 0.28 ounce gold per ton (1 g/t). Seven grab samples from workings on zone No. 3 (Nos. 19, 21-26) averaged 0.068 ounce gold per ton (2.3 g/t), 0.26 ounce silver per ton (8.9 g/t), and 0.06 percent lead. A grab sample from the zone No. 3 (No. 22) had 0.4 ounce gold per ton (14 g/t) and 1.2 ounces silver per ton (41 g/t). Three grab samples from dumps along zone No. 1 (Nos. 1, 3, and 8) averaged 0.068 ounce gold per ton (2.3 g/t), 0.26 ounce silver per ton (8.9 g/t), and 0.63 percent lead.

Conclusions: The three zones (Nos. 1, 2, and 3) can be inferred by vein material on dumps or float for 2,600, 1,100, and 1,100 feet (790, 330, and 330 m), respectively. Silver content reported by Stone (1911, p. 87) was not confirmed by assays of mine dump material. Average assay values for the zones point to submarginal mineral resources. Judged by sample analyses and persistence of mineralzed structures, the Black Bear claim seems to have a resource potential.

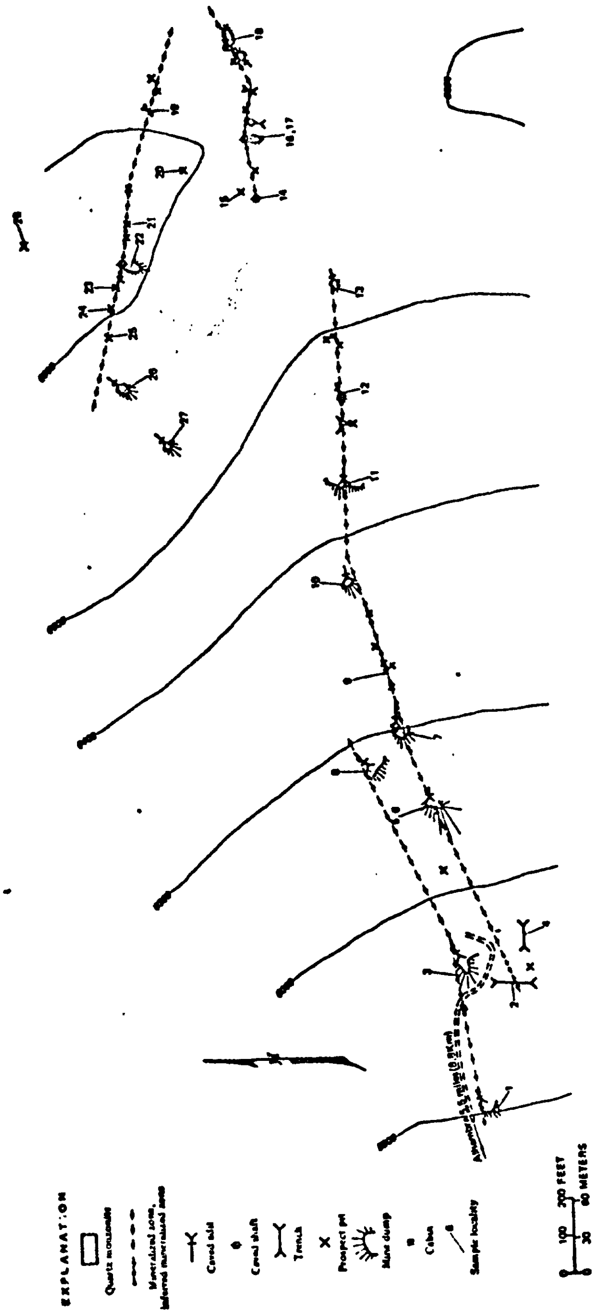


Figure 48. Black Bear claim.

An unnumbered table to accompany fig. 48, Black Bear claim

Data for samples shown on figure 48.

[Tr, trace; N, not detected; -- not analyzed]

Sample			Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Description					
1	Grab	Wallrock and shear zone material from dump--	Tr	0.1	--	--	--
2	do--	Altered quartz monzonite with remnant pyrite and small quartz veins from dump------------	0.01	.1	--	0.24	--
3	do--	Vein quartz with pyrite and galena from dump	Tr	N	0.02	.24	0.22
4	do--	Altered quartz monzonite with quartz from dump--	.02	.3	--	--	--
5	do--	Vein quartz with pyrite, galena, sphalerite, and arsenopyrite from dump-----------------	Tr	.1	.02	4.1	.14
6	do--	Iron-stained, altered quartz monzonite with pyrite from dump---------------------------	Tr	Tr	--	--	--
7	do--	Altered quartz monzonite with quartz vein and pyrite, galena, sphalerite, arsenopyrite from dump----------------------------------	Tr	.1	.14	4.4	3.7
8	do--	Wallrock from dump------------------------	Tr	.1	--	--	--
9	do--	Vein quartz with pyrite, galena, and arsenopyrite from dump--------------------	.069	.13	.01	.12	.05

Sample			Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Description					
10	Grab	Iron-oxide-stained quartz monzonite from dump	Tr	N	--	--	Tr
11	do--	do--	Tr	0.1	--	--	Tr
12	do--	do--	Tr	.1	--	--	--
13	do--	do--	Tr	N	--	--	--
14	do--	Vein quartz with siderite and pyrite from dump--	Tr	.1	N	0.12	0.03
15	do--	Brecciated, altered quartz monzonite with siderite veinlets and pyrite from dump------	Tr	N	N	.02	N
16	do--	Vuggy vein quartz with pyrite, galena, sphalerite, and arsenopyrite from dump------	0.06	.01	0.02	.32	1.1
17	do--	Vuggy, iron-oxide-stained quartz and altered quartz monzonite from dump-----------------	.05	Tr	.01	.17	.10
18	do--	do--	.03	Tr	.01	.36	.03
19	do--	Iron-oxide-stained quartz monzonite from dump--	.02	N	--	--	--
20	do--	Iron-oxide-stained, altered quartz monzonite with quartz from dump----------------------	Tr	N	--	--	--
21	do--	Iron-oxide-stained, altered quartz from dump--	.05	.2	N	.08	.05

Sample			Gold (ounce per ton) 1/	Silver (ounce per ton) 1/	Copper (percent)	Lead (percent)	Zinc (percent)
No.	Type	Description					
22	Grab	Vuggy vein quartz with abundant pyrite and lenses of galena from dump------------------	0.409	1.21	0.02	0.44	0.01
23	do--	Iron-oxide-stained, altered quartz monzonite from dump------------------------------------	N	.1	--	--	Tr
24	do--	do---	Tr	.1	--	--	--
25	do--	do---	Tr	.1	--	--	--
26	do--	Iron-oxide-stained vein quartz with remnant pyrite from dump----------------------------	Tr	.1	--	--	--
27	do--	Quartz monzonite from dump------------------	Tr	Tr	--	--	--
28	do--	Iron-oxide-stained quartz monzonite from dump---	N	Tr	--	--	--

1/ Metric conversion: ounce per ton x 34.285 = grams per tonne.

Name: Borderline prospect

Index Map No.: Fig 20, No. 9

Location: NW1/4 NE1/4 Sec. 31, T. 8 N., R. 2 W., south of Middle Fork Warm Springs Creek

Elevation: 6000 feet (1829 m)

Access: By road about 5 miles (km) east from Clancy, Montana, then by road 1 mile (1.6 km) south from Warm Springs Creek.

Geology of deposit: No mineralized structure is exposed, but prospect dump material and the alignment of workings indicate a 1-foot (0.3-m)-thick, quartz vein trending east in quartz monzonite. Small amounts of iron-oxides and pyrite occur in the quartz and country rock.

Development: One caved shaft with an estimated depth of 25 feet (8 m), one bulldozer trench, and four prospect pits.

Sampling: Three grab samples were taken. One of iron-oxide-stained quartz monzonite from a mine dump adjacent to the caved shaft assayed 0.1 ounce silver per ton (3.4 g/t). One of quartz vein material and another of quartz monzonite from the bulldozer trench assayed a trace gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Cabin prospect

Index Map No.: Fig. 20, No. 8

Location: NE1/4 NW1/4 Sec. 31, T. 8 N., R. 2 W., on the ridge line between Middle Fork and South Fork of Warm Springs Creek

Elevation: 5840 feet (1780 m)

Access: By road 6 miles (9.6 km) east from Clancy, Montana

Geology of deposit: The prospect is on iron-oxide-stained, slightly-altered quartz monzonite.

Development: One caved shaft with an estimated depth of 40 feet (12 m) and one pit

Sampling: One chip sample of quartz monzonite assayed 0.1 ounce silver per ton (3.4 g/t), and one grab sample of highly-weathered dump material assayed 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: Casey Meadows prospect

Index Map No.: Fig. 19, No. 2

Location: W1/2 Sec. 13 and E1/2 Sec. 14, T. 8 N., R. 2 W., near Casey Meadows

Elevation: 7000 feet (2134 m)

Access: By road 9 miles (14.4 km) south from East Helena, Montana, then by trail 2 miles (3.2 km) east from the Jackson Creek road

Geology of deposit: A zone of intensely silicified, leached, pyrite-bearing andesite, as much as 34 feet (10.4 m) thick, is in irregular contact with quartz monzonite.

Development: Workings on the zone consist of a 64-foot (20-m)-long adit, a 20-foot (6-m)-deep, caved, inclined shaft, and four prospect pits in one group, and another pit about 750 feet (230 m) west.

Sampling: Two chip samples taken across the contact zone in the adit assayed as much as 0.1 ounce silver per ton (3.4 g/t). Three chip samples from other exposures of the zone assayed 0.1 ounce silver per ton (3.4 g/t). A grab sample from the mine shaft dump contained 0.18 ounce gold per ton (6.2 g/t), and 0.2 ounce silver per ton (6.9 g/t). A sample from the prospect pit to the west assayed a trace of silver.

Conclusion: Sampling shows a low mineral resource potential.

* *

Name: Golden Dollar claim

Owner: Randolf Benson, Helena, Montana

Index Map No.: Fig. 20, No. 12

Location: NW1/4 Sec. 5, T. 7 N., R. 2 W., on a tributary of South Warm Springs Creek

Elevation: 6900 feet (2103 m)

Access: By road 5 miles (8 km) east from Clancy, Montana, then by cross-country travel 3.5 miles (5.6 km) south from South Fork Warm Springs Creek.

History: Located by Randolf Benson in 1977

Geology of deposit: The claim is on weathered, iron-oxide-stained quartz monzonite. No mineralized structure is exposed.

Development: Three prospect pits and a bulldozer trench.

Sampling: Three grab samples of iron-oxide-stained quartz monzonite from the prospect pits assayed a trace of gold and copper, and as much as 0.71 percent lead, and 0.27 percent zinc.

Conclusions: The prospect has a low mineral resource potential.

* *

Name: High Ridge prospect

Index Map No.: Fig. 20, No. 3

Location: SW1/4 SE1/4 Sec. 13, T. 8 N., R. 2 W., near the head of Jackson Creek

Elevation: 8140 feet (2481 m)

Access: By road 9 miles (14.4 km) south from East Helena, Montana

Geology of deposit: The prospect is on a quartz vein as much as 1 foot (0.3 m) thick in andesitic to basaltic intrusive rock. The vein is vuggy and contains iron-oxides and pyrite. The alignment of the workings indicates the vein trends northwest.

Development: Three prospect pits

Sampling: A sample of vein material from each pit assayed a trace of gold and 0.6 ounce silver per ton (20.6 g/t).

Conclusions: A low mineral resource potential indicated

Name: Lava Mountain prospect

Index Map No.: Fig. 20, No. 4

Location: NW1/4 Sec. 29, T. 8 N., R. 2 W., on the north side of Middle Fork Warm Springs Creek

Elevation: 5700 feet (1737 m)

Access: By road 7 miles (11.2 km) east from Clancy, Montana

Geology of deposit: Country rock is quartz monzonite. Many dumps consist of iron-oxide-bearing, weathered country rock. Quartz vein material containing pyrite, galena, and sphalerite was observed on several dumps. The largest piece found was 5 inches (13 cm) thick, but the majority were less than 3 inches (8 cm). A 1-foot (0.3-m)-thick, silicified fault zone is exposed at one locality.

Development: Workings consist of 8 caved adits, estimated to total more than 500 feet (150 m), 3 trenches, and 21 prospect pits.

Sampling: Eight grab samples of quartz vein material assayed as much as 0.08 ounce gold per ton (2.7 g/t), 0.1 ounce silver per ton (3.4 g/t), 1.5 percent lead, and 1.7 percent zinc. Nine samples of quartz monzonite assayed as much as a trace of gold and 0.1 ounce silver per ton (3.4 g/t). A chip sample across the fault zone assayed a trace of gold.

Conclusions: A low mineral resource potential indicated

* *

Name: Maverick prospect

Index Map No.: Fig. 20, No. 5

Location: NE1/4 NE1/4 Sec. 29, T. 8 N., R. 2 W., on the ridge between Warm Springs Creek and Beaver Creek

Elevation: 6500 feet (1981 m)

Access: By road 5 miles (8 km) east from Clancy, Montana, then by cross-country travel 1 mile (1.6 km) east from the Middle Fork Warm Springs Creek road

Geology of deposit: The prospect is on iron-oxide-stained quartz monzonite that contains an east-trending zone of quartz veinlets and pyrite.

Development: Five prospect trenches and pits

Sampling: Two grab samples of altered quartz monzonite with quartz veinlets and pyrite averaged trace amounts of gold and 1.5 ounces silver per ton (51 g/t).

Conclusions: A low mineral resource potential indicated

* *

Name: Mayflower claim

Index Map No.: Fig. 20, No. 1

Location: SE1/4 SW1/4 Sec. 12, T. 8 N., R. 2 W., near the head of Jackson Creek

Elevation: 7000 feet (2134 m)

Access: By road 9 miles (14.4 km) south from East Helena, Montana, then By cross-country travel 2 miles (3.2 km) east.

History: Claimed by H. Stevenson in 1890

Geology of deposit: The claim is on a contact zone between quartz monzonite and volcanic rocks. The volcanic rocks are slightly altered and contain disseminated pyrite.

Development: One small pit

Sampling: Three grab samples of altered volcanic rocks with disseminated pyrite contained a trace of gold, 0.1 ounce silver per ton (3.4 g/t), and traces of copper, lead, and zinc.

Conclusions: No mineral resource potential indicated

* *

Name: Springs prospect

Index Map No.: Fig. 20, No. 10

Location: SE1/4 NE1/4 Sec. 32, T. 8 N., R. 2 W., near the head of South Fork Warm Springs Creek

Elevation: 7240 feet (2207 m)

Access: By road 5 miles (8 km) east from Clancy, Montana, then by trail 3 miles (4.8 km) east.

Geology of deposit: The prospect is in andesite with iron-oxides along fractures.

Development: One caved prospect pit

Sampling: A grab sample of the andesite from the dump assayed a trace of gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

* *

Name: South Black Bear prospect

Index Map No.: Fig. 20, No. 7

Location: SE1/4 SE1/4 Sec. 29, T. 8 N., R. 2 W., near the head of the Middle Fork Warm Springs Creek

Elevation: 7000 feet (2134 m)

Access: By road 5 miles (8 km) east from Clancy, Montana, then by cross-country travel 1 mile (1.6 km) east.

Geology of deposit: The prospect is on a zone as much as 5 inches (13 cm) thick of silicified, iron-oxide-bearing quartz monzonite. Quartz veinlets as much as 2 inches (5 cm) thick occur in the zone.

Development: Workings consist of three prospect pits that are about 10 feet (3 m) apart and one caved adit. The adit was probably not more than 15 feet (5 m) long.

Sampling: Two grab samples of mineralized quartz monzonite with quartz veinlets from the prospect dumps averaged a trace of gold and 0.1 ounce silver per ton (3.4 g/t).

Conclusions: No mineral resource potential indicated

Name: Upper McClellan Creek prospect

Index Map No.: Fig. 20, No. 11

Location: SW1/4 Sec. 33, T. 8 N., R. 2 W., near the head of McClellan Creek

Elevation: 7560 feet (2304 m)

Access: By road 5 miles (8 km) east from Clancy, Montana, then by trail about 3 miles (4.8 km) east.

Geology of deposit: The prospect is on silicified welded tuff containing quartz veinlets that are as much as 0.25 inch (0.64 cm) thick. Iron-oxides are disseminated in the tuffs and occur along fractures.

Development: One caved prospect pit

Sampling: A grab sample assayed a trace of gold and silver.

Conclusions: No mineral resource potential indicated

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APPENDIX A.--Placer tables.

A total of 209 placer samples were taken from 159 localities in the study area. Most of them were from along Tizer, Wilson, and Crow Creeks, which drain the center of the study area (fig. A-1 and accompanying tables). These drainages also contain the largest volumes of gravel. Other drainages in the study area contain no significant gravel deposits.

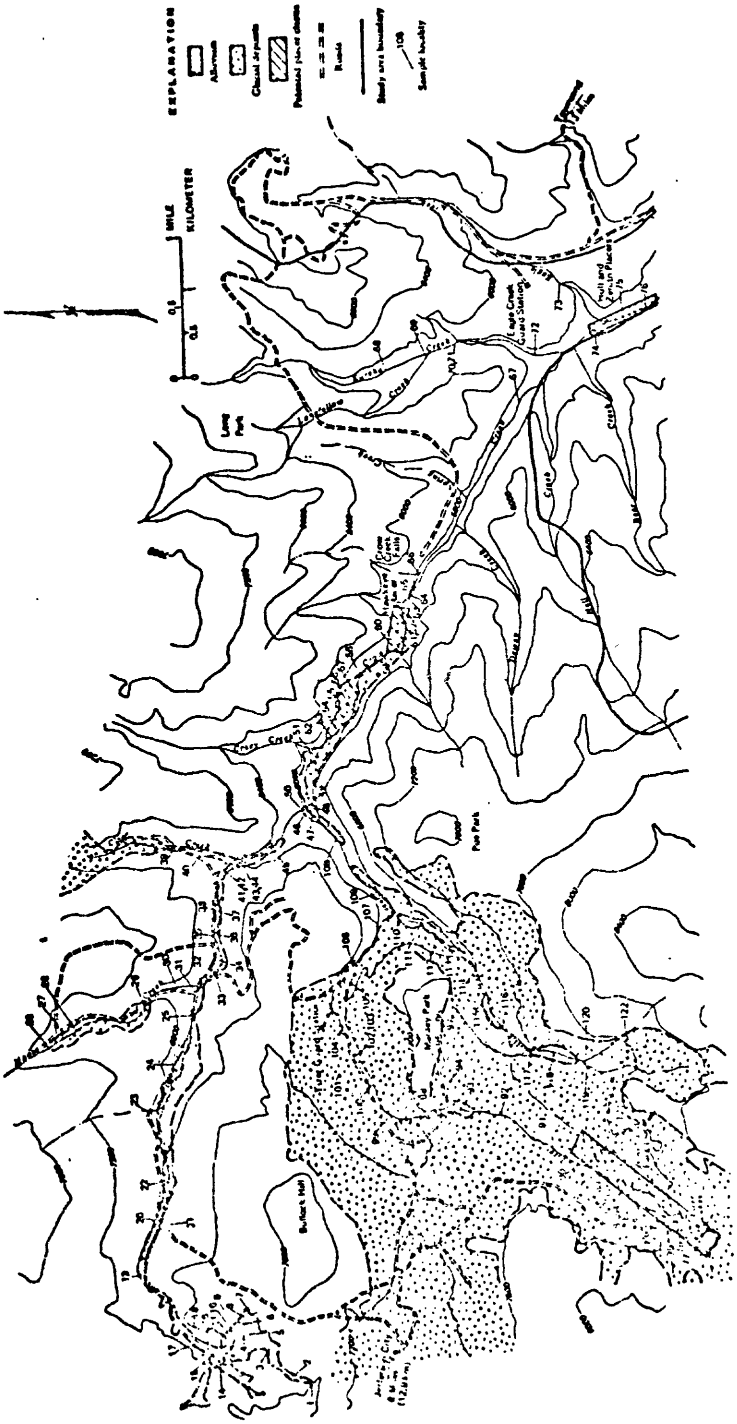

Figure A-1. Placers along Crow, Wilson, and Tizer Creeks.

An unnumbered table to accompany fig. A-1, Placers along Crow, Wilson, and Tizer Creeks

Analyses of placer samples shown on figure A-1.

[Tr, trace; N, not detected]

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
1	Pan---	0 - 1.5	0.3	Terrace gravel--------------------	18.1	51.6
2	Trench	0 - 5.0	5.0	do----------------------------------	3.0	12.9
		5.0 - 10.0	5.0	do----------------------------------	57.6	61.1
3	do----	0 - 5.7	5.7	do----------------------------------	.8	3.2
4	do----	0 - 4.7	4.7	do----------------------------------	N	3.4
5	do----	0 - 4.2	4.2	do----------------------------------	4.0	9.1
6	do----	0 - 3.0	3.0	do----------------------------------	N	10.8
7	do----	0 - 1.7	1.7	do----------------------------------	.9	11.0
8	do----	0 - 3.2	3.2	Residual gravel-------------------	14.9	13.3
9	do----	0 - 4.0	4.0	do----------------------------------	13.2	6.0
10	do----	0 - 2.9	2.9	do----------------------------------	2.5	6.9
11	do----	0 - 1.3	1.3	do----------------------------------	1.3	24.6

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
12	Trench	0 - 0.7	0.7	Terrace gravel-------------------	N	18.6
13	Trench	0.7 - 3.7	3.0	do--------------------------------	0.7	27.4
		3.7 - 6.7	3.0	do--------------------------------	9.9	17.8
14	do----	0 - 3.7	3.7	do--------------------------------	10.4	12.8
		3.7 - 11.3	7.7	do--------------------------------	12.1	26.4
15	do----	0 - 5.5	5.5	do--------------------------------	N	7.9
		5.5 - 8.0	2.5	do--------------------------------	.3	70.8
16	do----	0 - 4.0	4.0	do--------------------------------	N	3.4
		4.0 - 7.0	3.0	do--------------------------------	1.9	10.9
17	do----	0 - 3.5	3.5	do--------------------------------	225.9	38.7
		3.5 - 5.5	2.0	do--------------------------------	49.7	27.5
18	do----	0 - 4.2	4.2	do--------------------------------	22.0	22.7
		4.2 - 8.2	4.0	do--------------------------------	61.3	49.1
19	Pan---	0	.1	Stream gravel--------------------	149.8	220.3
20	Trench	0 - 2.0	2.0	Terrace gravel-------------------	N	5.1
		2.0 - 6.7	4.7	do--------------------------------	0.4	8.6
21	Pan--	0	.3	Stream gravel--------------------	N	22.0

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
22	Trench	0 - 5.0	5.0	Terrace gravel-------------------	N	6.6
		5.0 - 7.0	2.0	do--------------------------------	Tr	7.4
		7.0 - 10.0	3.0	do--------------------------------	Tr	43.4
		10.0 - 15.0	5.0	do--------------------------------	12.2	22.1
23	Pan---	0	.1	Stream gravel--------------------	N	38.2
24	Trench	0 - 4.7	4.7	Terrace gravel-------------------	N	2.7
25	do---	0 - 2.5	2.5	do--------------------------------	N	3.8
		2.5 - 3.8	1.3	do--------------------------------	N	14.7
26	Pan---	0	.4	Stream gravel--------------------	N	4.3
27	do----	0	.5	do--------------------------------	N	6.5
28	do----	0	.5	do--------------------------------	N	3.7
29	do---	0	.5	do--------------------------------	Tr	7.0
30	do---	0	.5	do--------------------------------	N	5.8
31	do---	0	.5	do--------------------------------	N	7.3
32	Pan---	0	.3	Terrace gravel-------------------	N	15.3

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
33	Trench	0 - 5.5	5.5	Terrace gravel----------------------	Tr	0.8
		5.5 - 8.5	3.0	do----------------------------------	Tr	4.4
		8.5 - 12.2	3.7	do----------------------------------	N	3.2
		12.2 - 15.9	3.7	do----------------------------------	Tr	1.5
34	Pan---	0	.3	do----------------------------------	N	14.3
35	do----	0	.5	do----------------------------------	N	14.2
36	do----	0	.3	do----------------------------------	N	78.0
37	do----	0	.5	Stream gravel-----------------------	N	30.8
38	do----	0	.3	Terrace gravel----------------------	N	35.8
39	Trench	0 - 1.5	1.5	do----------------------------------	N	13.1
		1.5 - 3.3	2.8	do----------------------------------	Tr	5.7
40	do----	0 - 4.5	4.5	do----------------------------------	0.85	2.7
41	do----	0	.3	Stream gravel-----------------------	N	15.3
42	do----	0	.3	do----------------------------------	N	42.3
43	Pan---	0	.3	Terrace gravel----------------------	N	15.7
44	do----	0	.4	Stream gravel-----------------------	N	61.4
45	do----	0	.3	Terrace gravel----------------------	N	27.5

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
46	Trench	0 - 4.0	0.3	Terrace gravel-------------------	N	24.7
		4.0 - 8.0	.3	do--------------------------------	N	38.5
		8.0 - 10.0	.1	do--------------------------------	N	58.6
47	Pan---	0 - 1.5	.3	Stream gravel--------------------	N	32.3
48	do----	0 - 1.0	.1	do--------------------------------	N	16.4
49	do----	0 - 1.0	.1	do--------------------------------	N	30.5
50	do----	0 - 1.0	.3	Terrace gravel-------------------	N	22.2
51	do----	0 - 1.0	.1	Stream gravel--------------------	N	19.9
52	do----	0 - 2.0	.4	do--------------------------------	1.6	20.4
53	do----	0 - 1.0	.4	Stream gravel on bedrock----------	N	24.3
54	do----	0 - 1.0	.1	Stream gravel--------------------	177.0	20.4
55	do----	0 - 1.0	.3	do--------------------------------	N	21.6
56	do----	0 - 2.0	.4	do--------------------------------	N	12.6
57	do----	0 - 1.0	.1	do--------------------------------	1.5	46.8
58	do----	0 - 1.0	.4	do--------------------------------	1.9	15.6
59	do----	0 - 1.0	.1	do--------------------------------	N	19.4

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
60	Pan---	0 - 1.0	0.4	Stream gravel--------------------	9.0	18.3
61	do----	0 - 1.0	.3	do--------------------------------	N	29.8
62	do----	0 - 1.0	.4	do--------------------------------	103.0	15.5
63	do----	0 - 1.0	.1	do--------------------------------	N	75.3
64	do----	0 - 1.0	.1	do--------------------------------	2.2	57.4
65	do----	0 - 1.0	.1	do--------------------------------	N	55.9
66	do----	0 - 1.0	.1	do--------------------------------	2.9	34.3
67	do----	0 - 1.0	.1	do--------------------------------	433.9	52.2
68	do----	0 - 1.5	.3	do--------------------------------	N	24.3
69	do----	0 - 1.0	.3	do--------------------------------	N	32.3
70	Trench	0 - 3.0	.8	Terrace gravel-------------------	N	7.2
		3.0 - 6.0	.8	do--------------------------------	.4	11.3
		6.0 - 8.0	.5	do--------------------------------	N	17.1
		8.0 - 10.0	.5	do--------------------------------	N	25.6
71	do----	0 - .5	.3	Glacial till on bedrock-----------	N	25.5
72	Pan---	0 - 1.0	.3	Stream gravel--------------------	N	24 4

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
73	Trench	0 - 5.0	1.3	Terrace gravel-------------------	N	6.0
		5.0 - 10.0	1.3	do-------------------------------	0.8	4.8
		10.0 - 15.0	1.3	do-------------------------------	1.0	6.2
74	do----	0 - 5.0	1.3	do-------------------------------	N	4.3
		5.0 - 10.0	1.3	do-------------------------------	N	3.9
		10.0 - 13.0	.8	do-------------------------------	N	6.0
		13.0 - 14.0	.3	do-------------------------------	N	13.0
75	do----	0 - 1.5	.3	Stream gravel--------------------	N	27.9
76	do----	0 - 1.5	.7	Stream gravel on bedrock----------	N	14.2
77	Pan---	0 - 1.0	.1	do-------------------------------	N	34.2
78	Pan---	0 - 1.0	0.1	Stream gravel--------------------	N	18.1
79	do----	0 - 1.0	.3	do-------------------------------	N	12.8
80	do----	0 - 1.0	.3	do-------------------------------	105.9	11.0
81	Pit---	2.0 - 3.0	.3	do-------------------------------	N	23.5
82	Trench	0 - 5.1	5.1	Terrace gravel-------------------	38.6	3.4
		5.1 - 10.6	5.5	do-------------------------------	9.9	3.3
		10.6 - 16.5	5.9	do-------------------------------	65.5	3.9
83	do----	0 - 9.0	9.0	Terrace gravel-------------------	.1	2.6
		9.0 - 15.3	6.3	Glacial till---------------------	N	2.3

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
84	Trench	0 - 3.0	0.3	Terrace gravel-------------------	N	13.6
85	Pan---	0 - 1.0	.3	Stream gravel--------------------	61.4	29.5
86	Trench	0 - 7.3	1.8	Terrace gravel-------------------	5.8	9.1
		7.3 - 10.1	.7	do-------------------------------	N	8.8
87	Pan---	0 - 1.0	.3	Stream gravel--------------------	4.2	20.5
88	do----	0 - 1.0	.3	do-------------------------------	68.1	28.8
89	do----	0 - 2.0	.3	do-------------------------------	2.6	26.1
90	do----	0 - 1.0	.3	do-------------------------------	N	21.3
91	do----	0 - 1.0	.3	do-------------------------------	N	22.0
92	do----	0 - 1.0	.3	do-------------------------------	N	20.2
93	Trench	0 - 7.5	7.5	Terrace gravel-------------------	N	2.9
		7.5 - 14.9	7.4	do-------------------------------	1.01	2.6
		14.9 - 20.2	5.3	Terrace gravel and glacial till---	N	4.3
94	Pit----	0 - 2.0	.1	Glacial till---------------------	N	15.2
95	Pan---	0 - 1.0	.1	Stream gravel--------------------	N	28.5

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
96	Pan---	0 - 1.0	0.1	Stream gravel--------------------	N	11.3
97	do----	0 - 1.0	.1	do-------------------------------	N	9.5
98	do----	0 - 1.0	.1	do-------------------------------	N	25.5
99	Trench	0 - 9.0	9.0	Terrace gravel-------------------	2.05	1.2
100	Pan---	0 - 1.0	.1	Stream gravel--------------------	N	31.0
101	Pit---	0 - 4.0	2.0	Terrace gravel-------------------	N	.9
102	Trench	0 - 7.4	7.4	do-------------------------------	.9	1.4
103	do----	0 - 5.7	5.7	do-------------------------------	N	1.1
104	do----	0 - 3.2	3.2	Soil and cobbles-----------------	N	3.5
		3.2 - 8.7	5.5	Glacial till---------------------	N	2.3
		8.7 - 14.7	6.0	do-------------------------------	N	.8
		14.7 - 21.4	6.7	do-------------------------------	N	.8
		21.4 - 24.4	3.0	do-------------------------------	N	2.2
105	Pan---	0 - 1.0	.4	Stream gravel--------------------	N	17.4
106	Trench	0 - 1.3	6.3	Glácial till---------------------	2.1	1.4
107	Pan---	0 - 1.0	.4	Stream gravel near bedrock--------	N	17.9
108	do----	0 - 1.0	.5	Stream gravel--------------------	N	7.8

Sample						
No.	Type	Depth Interval (feet) 1/	Volume (cubic feet) 1/	Description	Gold content (cents per cubic yard) 2/	Black sand (pounds per cubic yard) 1/
109	do----	0 - 1.0	.4	Stream gravel on bedrock----------	N	10.8
110	do----	0 - 1.0	.4	Stream gravel--------------------	N	12.3
111	do----	0 - 2.0	.4	Subangular gravel in clay matrix--	N	8.0
112	Trench	0 - 1.3	6.6	Subangular cobbles and boulders in gravelly sand, lower 5.4 ft. in clay matrix (glacial till)--------	3.96	1.2
113	Pan---	0 - 1.0	.3	Stream gravel--------------------	N	21.2
114	do----	0 - 1.0	.3	Sand accumulated in root mats at stream level--------------------	N	26.8
115	do----	0 - 1.0	.3	Stream gravel--------------------	N	31.2
116	do----	0 - 1.0	.3	do--------------------------------	N	42.9
117	do----	0 - 1.0	.3	do--------------------------------	N	44.5
118	Trench	0 - 1.6	7.9	Terrace gravel-------------------	1.7	2.2
119	Pan---	0 - 1.0	.3	Stream gravel--------------------	N	33.2
120	do----	0 - 1.0	.3	do--------------------------------	N	18.5