

Mineral Resources of the Roberts Wilderness Study Area, Eureka County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1731-K



Chapter K

Mineral Resources of the Roberts Wilderness Study Area, Eureka County, Nevada

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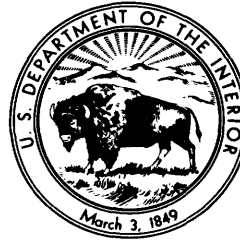
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U.S. GEOLOGICAL SURVEY BULLETIN 1731-K

MINERAL RESOURCES OF WILDERNESS STUDY AREAS: CENTRAL NEVADA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director



UNITED STATES GOVERNMENT PRINTING OFFICE : 1986

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center, Box 25425
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Mineral Resources of the Roberts Wilderness Study
Area, Eureka County, Nevada.

U.S. Geological Survey Bulletin 1731-K

Bibliography: p. K9

Supt. of Docs. No.: I 19.3:1731-K

1. Mines and mineral resources—Nevada—Roberts
Mountains Wilderness. 2. Geology—Nevada—Roberts
Mountains Wilderness. 3. Roberts Mountains
Wilderness (Nev.) I. McKee, Edwin H. II. Series.

QE75.B9 No. 1731-K 557.3 s 86-600141
[TN24.N3] [553'.09793'32]

STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Area

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine their mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the Roberts Wilderness Study Area (NV-060-541), Eureka County, Nevada.

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SUMMARY

Abstract

The Roberts Wilderness Study Area (NV-060-541) encompasses 15,090 acres and includes Roberts Creek Mountain, Cooper Peak, and Western Peak, three of the highest peaks in the Roberts Mountains, Eureka County, Nev. Field work for this report was carried out between May and August 1984 and augmented geologic mapping and other geologic studies that have continued for more than 20 years. Stream-sediment samples from the Kelley Creek drainage contain anomalous amounts of silver, lead, and zinc; the area including this drainage has low mineral resource potential for these metals in hydrothermal veins that follow faults and shear zones in carbonate host rock. The abandoned Kelley mine produced 397 tons of silver, lead, and zinc ore prior to 1940. Some rock samples from outcrops along the east edge of the study area contain anomalous amounts of gold and silver, as well as a suite of volatile elements including arsenic, antimony, and mercury that locally are indicators of precious-metal mineralization. These samples are associated with silicified zones that formed in dolomitic rock beneath the Roberts Mountains thrust fault. These zones have high, moderate, and low resource potential for gold and silver. Two similar areas of silicified and altered dolomite in the southwest part of the study area have moderate-to-low resource potential for gold and silver. An east-west trending zone in the central part of the study area and two areas near its western edge contain anomalous amounts of gold and silver in altered dolomite and limestone associated with major faults and shear zones. These areas have moderate-to-low potential for gold and silver resources. Several mining companies have done extensive exploration for gold and silver and have claim blocks that extend into the study area from the east, west, and south (pl. 1; Benjamin and Johnson, 1986). The areas claimed are

included in areas of high and moderate resource potential in this report.

Character and Setting

The Roberts Wilderness Study Area includes about one-third of the Roberts Mountains in Eureka County, Nevada. The area is about 30 mi northwest of Eureka and 50 mi south of Carlin (fig. 1). The study area is underlain by a folded and faulted sequence of marine sedimentary rocks of Cambrian through Devonian age (about 570 to 360 million years ago) capped in places by Tertiary (about 65 to 2 million years ago) lava and ash flows and intruded by many Tertiary basalt dikes. Most of the Cambrian through Devonian rocks in the study area are limestone and dolomite. The Roberts Mountains thrust, an important regional structural feature, is present in the southeast part of the wilderness study area.

The Antelope mining district extends into the wilderness study area and is represented by the Kelley mine, a silver, lead, and zinc mine inactive since 1937. Other mines in this district lie outside the wilderness study area. There are extensive mining claims around the study area, and some extend into it.

Identified Resources

The Kelley mine produced 397 tons of silver, lead, and zinc ore prior to being abandoned in 1937. No resources were identified at this mine during this study. Anomalous amounts of gold and silver were detected in some rock samples collected elsewhere in the study area, but no identified resources were found.

Mineral Resource Potential

There are three areas of high mineral resource potential for gold and silver with gradational areas of

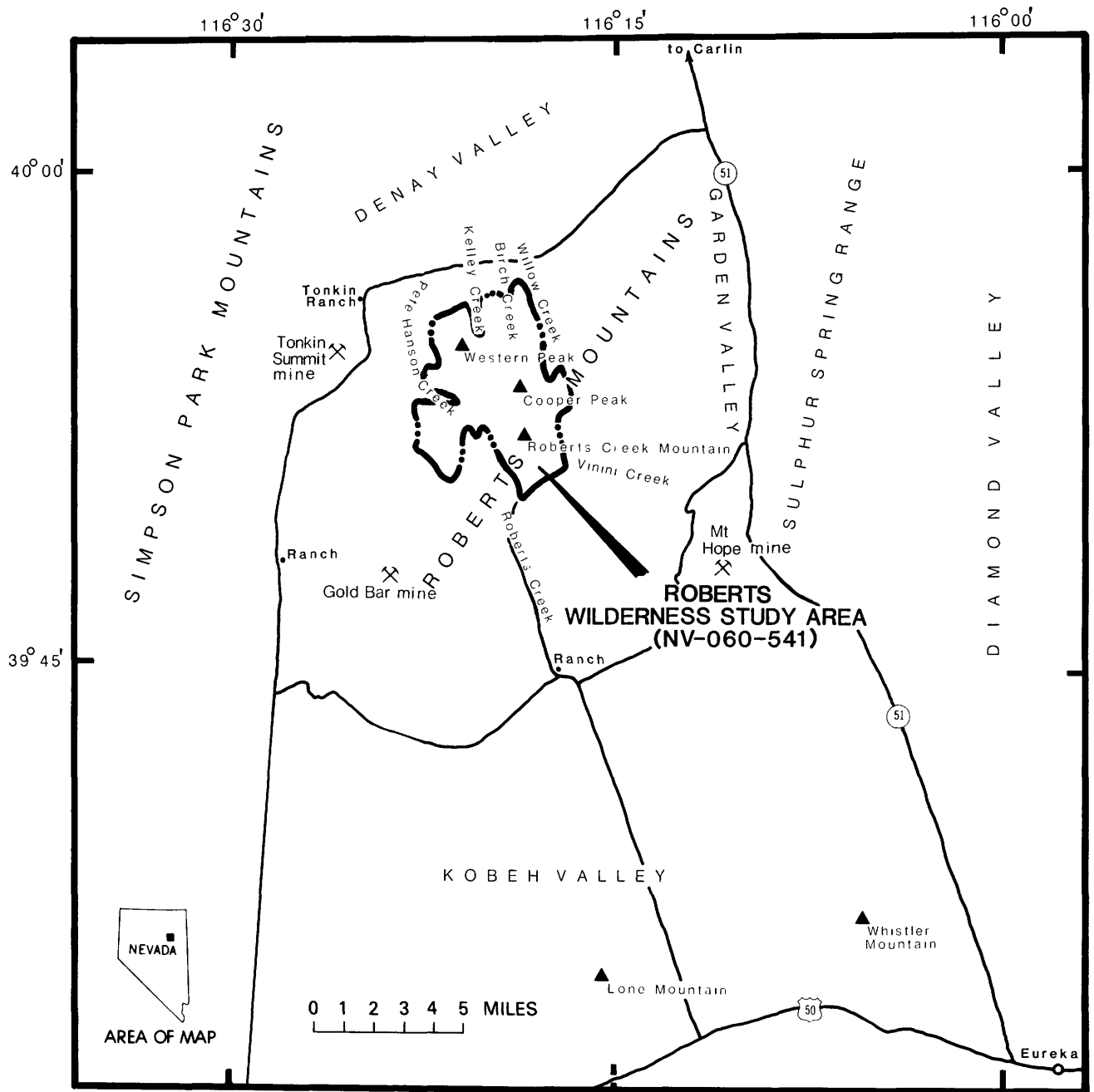


Figure 1. Index map showing location of the Roberts Wilderness Study Area, Eureka County, Nevada.

moderate and low resource potential in silicified dolomite beneath the Roberts Mountains thrust along part of the eastern edge of the wilderness study area (fig. 2; plate 1). Silica and metals, including gold and silver, are concentrated in irregular replacement bodies in dolomite beneath the silicic rocks of the upper plate of the Roberts Mountains thrust. Silicic shales, cherts, and quartzites of the Vinini Formation in the upper plate of the Roberts Mountains thrust contain anomalous amounts of trace elements and are a possible source for the silica and other elements that mark the sole of the thrust. Silicification took place prior to Tertiary or older high-angle faulting that offsets the siliceous bodies. Silicified and altered dolomite in an area about 2 1/2 mi west of Roberts Creek Mountain has moderate-to-low resource potential for gold and silver (fig. 2; plate 1); and an area along the southwest edge of the study area about 3 1/2 mi west of Roberts Creek Mountain has moderate resource potential for gold and silver in the same geologic setting (fig. 2; plate 1). Gold and silver mineralization in altered dolomite and limestone associated with faulting that is younger than the Roberts Mountains thrust is found in the central part of the wilderness study area and near several large faults in the western part of the study area. These areas have moderate potential for gold and silver resources (fig. 2; plate 1). Silver, lead, and zinc have low mineral resource potential in the Kelley Creek drainage east of Western Peak (fig. 2; plate 1). The mineralization in this area is in veins in faulted and sheared dolomite that formed by hydrothermal solutions possibly related to the intrusive system of Miocene age (about 25 to 5 million years ago) that underlies the area. No known energy mineral deposits exist in the wilderness study area and there is little or no likelihood of hydrocarbon resources in or beneath the study area.

INTRODUCTION

Area Description

The Roberts Wilderness Study Area (NV-060-541) covers 15,090 acres in the north-central part of the Roberts Mountains in central Nevada (fig. 1). The terrain is rugged and the relief is as much as 3,700 ft. Elevation ranges from 10,133 ft above sea level at Roberts Creek Mountain to about 6,400 ft above sea level along the north edge of the mountains at the mouth of Birch Creek. The climate is semiarid and the vegetation is typical of the transition climatic zone that supports pinon pine, juniper, and mountain mahogany. Perennial riparian vegetation includes willow, aspen, wild rose, and lush grasses and wildflowers.

The Roberts Mountains are about 30 mi northwest of Eureka, Nev., and 50 mi south of Carlin, Nev. Access to the wilderness study area is by unimproved dirt roads that branch from maintained county roads located along the north edge of the Roberts Mountains and along Roberts Creek in the southern part of these mountains. There are no maintained roads within the wilderness study area, although four-wheel-drive vehicle trails reach high

elevations near Roberts Creek Mountain.

Previous and Present Investigations

The geology of the Roberts Mountains is mapped on a 1:31,250 scale map (Murphy and others, 1978) and represents the cumulative work of many geologists and students over a period of about 20 years. A map and summary report on the geology of the Roberts Wilderness Study Area was published by McKee (1986).

The first modern general geologic study of the Roberts Mountains was the classic study of Merriam and Anderson (1942), in which the occurrence of contrasting facies of Paleozoic strata was noted and the concept of telescoping of terrain on regional thrust faults was hypothesized. The name "Roberts Mountains thrust" was applied to the fault on which the telescoping took place. In subsequent years, this fault was recognized at many places in central Nevada.

The earliest paleontological work in the area was that of Merriam (1940). Some later paleontological studies were done by Johnson (1962a,b, 1966, 1972, and 1977), Berry and Murphy (1975), Murphy (1977), Gregory and others (1977), and Klapper and Johnson (1977). Studies by Winterer and Murphy (1960) established the existence of a reef complex of Silurian and Devonian age in the Roberts Mountains. Papers dealing with the stratigraphy of the region are by Merriam (1940), Murphy and Gronberg (1970), Murphy and Dunham (1977), and Murphy and others (1978). The unique structural features of the Roberts Mountains and a reasonable hypothesis for their development is presented by Winterer (1968). A study by Murphy and others (1984) focuses on the age and internal structure of the Roberts Mountains allochthon.

Vanderburg (1938) reported on mines in the Roberts Mountains. Stream-sediment sample data in Wagoner (1978), and rock-sample data in Mitchell and Quade (1982) include analyses of rocks from the Roberts Mountains. Additional geochemical information is in the U.S. Bureau of Land Management Great Basin Geology Energy Mineral (G.E.M.) Joint Venture, Roberts G.E.M. resources area Technical Report (1983). An aerial radiometric and magnetic survey that includes the Roberts Mountains was prepared for the U.S. Department of Energy by Geodata International (1979), and an aeromagnetic map of the Roberts Mountains was published by Philbin and others (1963), and interpretations of the aeromagnetic survey are in Mabey (1966) and Robinson (1970).

The U.S. Geological Survey carried out field investigations in the study area during the summer of 1984. The work included field checking of existing geologic maps and geochemical sampling. Samples were collected from areas of observed alteration to obtain information about mineral suites and trace-element signatures associated with mineralizing systems.

In 1984, the U.S. Bureau of Mines conducted a literature search of Eureka County, State of Nevada, U.S. Bureau of Mines, and U.S. Bureau of Land Management mining-claim and mineral-lease records. Field studies in 1984 included a search for all mines,

prospects, and claims within the wilderness study area, and examination and sampling of those found.

APPRAISAL OF IDENTIFIED RESOURCES

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Methods and scope of Investigation

An effort was made to examine, map, and sample claim areas (plate 1). Special attention was given to areas with known metal anomalies or with visible alteration or mineralization.

Four-hundred fifty-eight chip and grab samples were collected in or near the wilderness study area. Four-hundred thirty-six of the samples were analyzed for gold and silver, 14 were analyzed for gold, silver, lead, zinc, and barium, seven were analyzed for gold, silver, and barium, and one sample was analyzed for vanadium. Detailed information on these samples is in Benjamin and Johnson (1986) and in the U.S. Bureau of Mines files at the Western Field Operations Center, Spokane, Wash.

History and Production

Mining in the area began in the early 1900's with the location of the Kelley claim (fig. 2; plate 1). The Belmont claim, 1.7 mi east of the wilderness study area, was established at about the same time. Both of these mines are in the Antelope mining district. According to Vanderburg (1938), 350 tons of ore was shipped from the Kelley mine in its early stages. The property lay idle from the early 1900's until 1937 when 47 tons of ore was high-graded from the dumps. It was assayed at 0.8 oz/ton silver, 9.6 percent lead, and 39.8 percent zinc. From the condition of the property in 1984, it appears that no work has been done since the late 1930's. From the 1930's until the early 1960's, only small-scale prospecting, including vanadium exploration in the 1950's, was done in the Roberts Mountains. Since the discovery in the early 1960's of the Carlin gold mine, a large gold producer about 60 mi north of the Roberts Mountains, extensive precious-metals exploration has gone on throughout Nevada, including the Roberts Mountains.

In the past five years, major metal deposits have been found in central Nevada not far from the Roberts Mountains. These include a large molybdenum deposit about 7 mi south of the wilderness study area at Mt. Hope (fig. 1) (Tingley and Smith, 1982), a gold deposit near Tonkin Summit 4 mi west of the study area (fig. 1), and a gold deposit called the Gold Bar gold property (fig. 1), (Skillings' Mining Review, 1984) about 5 mi south of the study area.

During the late 1970's and early 1980's, exploration for barite was widespread in the Roberts Mountains. Three barite mines were developed within a few miles of the wilderness study area: 10,000 tons of barite was mined from the Bat and Bar claims near the northeast edge of the study area and several hundred tons were mined from the Firecracker claim group near the southwest edge of the study area. As

of 1985, there was no activity at these mines.

Mineral deposits

The Kelley mine produced 397 tons of silver, lead, and zinc ore prior to 1937. No production has been reported since and no resources were identified at the mine during this study. Fourteen chip samples were taken from the mine. Samples from ore zones average 0.02 parts per million (ppm) gold, 8.02 ppm silver, 2.13 percent lead, and 3.85 percent zinc.

Two-hundred thirty-one random chip or grab samples were collected at sites in or near active gold-silver claim blocks (these sites are located in the areas of high, moderate, and low mineral resource potential shown on fig. 2 and pl. 1). Eighty-one of these samples contained no detectable gold or silver, 50 had gold above the detection limit (0.007 ppm), 71 had silver above the detection limit (0.3 ppm), and 29 had both gold and silver above the detection limit. Low-grade precious-metal resources may be present at these sites, but many more samples must be collected (including drill samples) before any mineral resources can be delineated.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Edwin H. McKee, Harlan N. Barton, and
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Geology

The rocks in the Roberts Mountains range in age from Cambrian to Holocene. The wilderness study area occupies a part of these mountains and is comprised mostly of lower Paleozoic strata and some Tertiary volcanic rocks, primarily basalt dikes and lava flows.

The Paleozoic rocks consist of two contrasting sedimentary assemblages deposited in different marine environments. One assemblage, consisting mostly of carbonate rocks, was deposited on a broad continental shelf. Variations in these carbonate strata are related to the distribution of reefs, shallow subtidal regions, and deeper basins on the continental shelf. A complex, intertonguing relationship between coarse-grained algal, coral-rich limestone-dolomite (ancient reef), and thin-bedded, finely laminated limey mudstones with interbeds rich in reef debris (shelf-basin deposits) clearly define the continental shelf with its great variety of subenvironments. The other assemblage consists of the following lithologies: dark graptolite-bearing shale; bedded chert; thin, clean sandstone beds; thin, dark fine-grained limestone; a small amount of bedded barite; and massive, lenticular volcanic breccias. These rocks were deposited in deep water, probably many miles from the edge of the continental shelf and the continental slope. The two rock assemblages, representing different environments that must have once been many miles apart, have been brought together in the Roberts Mountains by the Roberts Mountains thrust, which was active in central Nevada in Late Devonian and Mississippian time. At a few places in the Roberts Mountains (but not within the wilderness study area) and the surrounding region,

there are coarse conglomeratic deposits of Pennsylvanian and Permian age that were derived from the upper plate (deep-water assemblage) of the Roberts Mountains thrust. Presumably, these rocks eroded from the thrust plate and define the youngest age of thrusting.

Tertiary rocks within the wilderness study area are mostly volcanic or hypabyssal types ranging in composition from rhyolite to basalt. Rhyolitic and dacitic rocks occur as isolated outliers of regionally extensive ash-flow sheets, air-fall tuffs, or reworked tuffs that contain a large proportion of nonvolcanic detritus. Small lava flows are present as well. Other silicic igneous rocks are largely or entirely intrusive, forming small stocks, plugs, or domes. These intrusive bodies, now deeply eroded, may have once extended to the surface and been the source for some of the ash or lava that occurs in the region. Radiometric ages of a number of the rhyolitic or dacitic rocks in the Roberts Mountains indicate that most are of Oligocene age. Basalts and basaltic andesites are the most abundant igneous rock type in the wilderness study area. The Roberts Mountains are the site of one of the best-exposed basaltic dike swarms in the western United States. These dikes trend north-northwest across the western and west-central part of the mountains; many individual dikes can be traced for a mile or more. From the air, this dike swarm is especially well expressed, giving the landscape a strongly striped appearance. Some basaltic lava flows also occur in the area; radiometric dating indicates that these basalts are middle Miocene in age (McKee and Noble, 1986).

Geochemical Studies

The reconnaissance geochemical study is based on analysis and evaluation of rock samples and heavy-mineral concentrates of stream-sediment samples.

Rock samples collected from silicified rocks at sites in the Roberts Mountains were analyzed for 31 elements by a six-step semiquantitative emission-spectrographic method (Grimes and Marranzino, 1968). Samples were also analyzed for arsenic by colorimetric methods, for antimony and gold by atomic absorption spectrophotometry, and mercury by an instrumental technique. The analytical data are in Barton and others (1986).

Samples of heavy-mineral concentrates provide information about the chemistry of a limited number of minerals in rock material eroded from the drainage basin upstream from each sample site. The selective concentration of minerals permits determination of some elements that are not easily detected in stream-sediment samples. Results of the analysis of heavy-mineral concentrates by the semiquantitative spectrographic method are reported in Day and Barton (1986). These samples contain material from rock units of drainage basins up to one mi².

Areas or drainages with anomalous concentrations of metallic or metal-related elements were identified by inspection of the data for enrichment relative to crustal abundance. Most often these anomalies reflect known mining activity, but in some instances they indicate areas of undisclosed or previously unrecognized mineralization.

Geochemical anomalies in silver, cadmium, lead, zinc, and barium were found in concentrates from stream-sediment samples from Kelley Creek. Anomalies from samples collected downstream from the Kelley mine probably reflect this mine; anomalies from the eastern tributary to Kelley Creek indicate eroded rock containing these metals. This elemental suite is typical of hydrothermal silver, lead, and zinc deposits hosted by carbonate rocks.

Anomalous amounts of gold, silver, arsenic, antimony, and mercury are found in samples of silicified dolomite collected at many places in the Roberts Mountains. This suite of precious and volatile elements in close association with silicified rocks (jasperoid) is typical of disseminated, fine-grained gold deposits.

Geophysical Studies

Gravity data

A regional Bouguer gravity map that includes the wilderness study area shows a distinct gravity high over the Roberts Mountains (Erwin and Bittleston, 1977). The amplitude of the high is about 5 to 8 mGal and reflects the relatively dense Paleozoic stratified rocks and Tertiary basalts exposed in the Roberts Mountains. A steep gravity gradient of about 7 to 10 mGal/mi is coincident with the northwest front of the Roberts Mountains and indicates a near-vertical boundary with Denay Valley. In general, gravity lows adjacent to the Roberts Mountains reflect an increase in thickness of low-density sediments and volcanic rocks in surrounding valleys. Southeast of the study area, a circular gravity low of about 2 mGal occurs over Mount Hope. This low probably reflects lower-density rhyolite porphyry intruding the Paleozoic rocks at Mount Hope.

Aeromagnetic data

A total-intensity aeromagnetic survey was flown in 1960 and 1961 at a constant barometric flight elevation of 9,000 ft and with a north-south flight-line spacing of 1 mi (Philbin and others, 1963). The most prominent magnetic feature in the wilderness study area is a linear magnetic high trending north-northwest that bisects the Roberts Mountains. The anomaly has a maximum amplitude of over 500 gammas and overlies the basalt dike swarm exposed in the northern part of the Roberts Mountains. Three-dimensional modeling of the magnetic anomaly overlying the basalt dikes suggests that the causative body is about 2 mi wide and extends to a depth of about 8 mi (Robinson, 1970). This magnetic anomaly is the southern part of a much larger linear magnetic feature (Mabey, 1966).

The dimensions of the dike swarm beneath the Roberts Mountains inferred from geologic mapping and aeromagnetic and gravity data may provide information relevant to mineral deposits. An igneous system as large as the one beneath the Roberts Mountains may have been directly or indirectly responsible for some of the mineralization in the wilderness study area. Hydrothermal mineralization

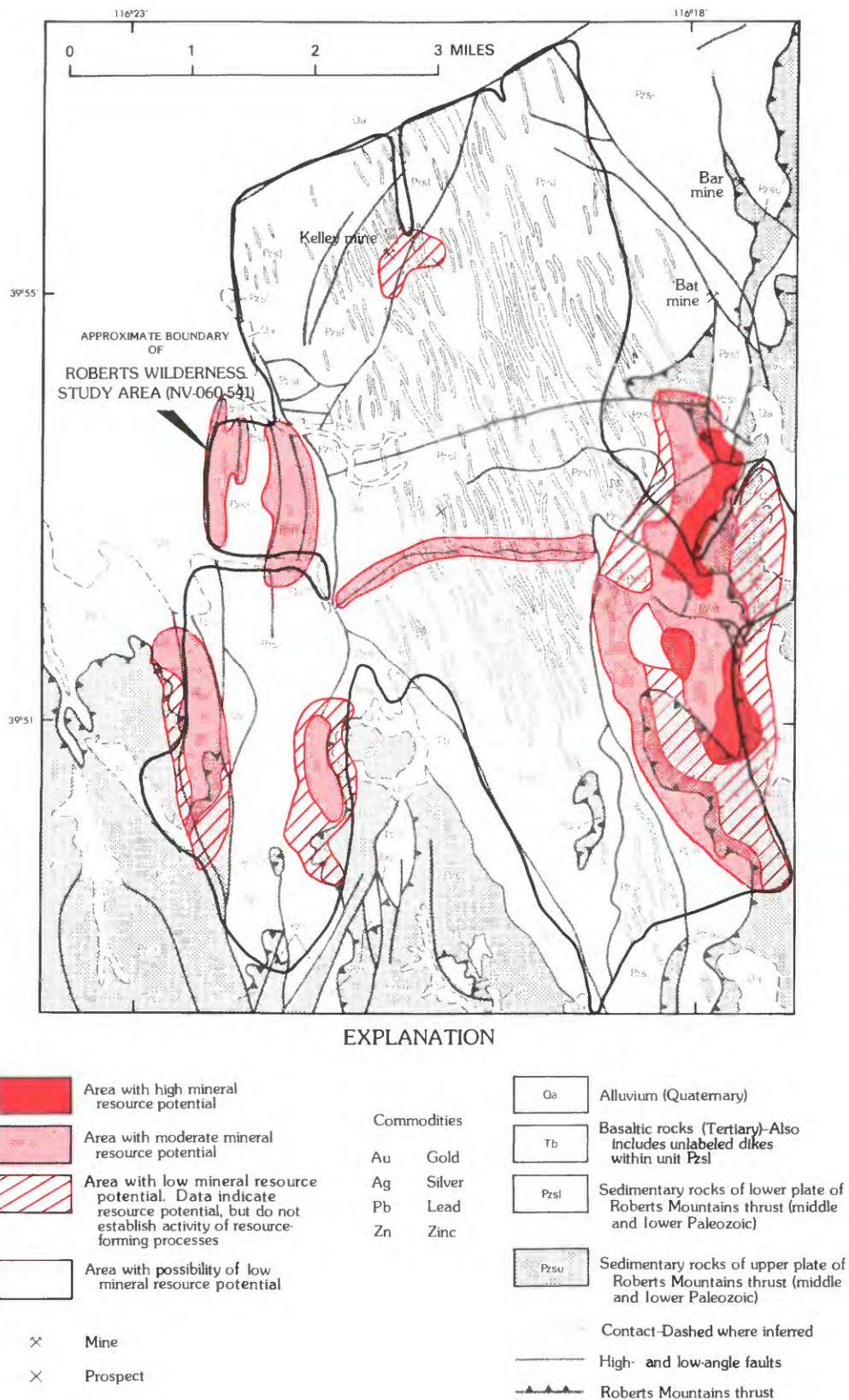


Figure 2. Map showing mineral resource potential of the Roberts Wilderness Study Area.

localized along faults cut by dikes in the central part of the wilderness study area could be related to hydrothermal solutions from the magma system, or indirectly caused by heating and mobilization of fluids in the rocks due to the emplacement of the dike swarm.

Mineralization

Metallic and nonmetallic elements present in anomalous amounts in the heavy-mineral concentrate of stream-sediment and rock samples indicate two types of mineralization exist in the wilderness study area. Additional types of mineralization, such as barium in bedded barite, occur within a few miles of the study area.

Gold and silver in silicified dolomite beneath the Roberts Mountains thrust offers the greatest mineral resource potential in the wilderness study area. The silicified dolomite forms irregular bodies as much as 100 ft thick and covering as much as one-half mi². These bodies consist of massive to lattice-like, highly iron-stained silica, that locally contain anomalous amounts of arsenic, antimony, and mercury, and trace amounts of gold and silver. Dark silicic shale, chert, and quartzite of the Vinini Formation of the upper plate of the Roberts Mountains thrust contain abundant trace elements and metals, and are a possible source of the silica and trace elements found in the sole of the thrust. Mobilization of these elements was on a regional scale at moderately high temperatures. Silicification and mineralization are older than many of the high-angle faults in the region that cut the Roberts Mountains thrust and the silicified dolomite.

A second type of mineralization that occurs in the wilderness study area is gold, silver, lead, and zinc-bearing calcite and quartz veins that formed by hydrothermal solutions in dolomite. Faults and shear zones in the dolomite probably acted as conduits for the hydrothermal solutions and tend to be sites of mineralization. Geochemical anomalies in these metals, as well as barium and cadmium, are found in the Kelley Creek drainage. The Kelley mine, a silver, zinc, and lead mine in Kelley Creek, is in dolomite. The source of the hydrothermal solutions is not known.

CONCLUSIONS

Information from geologic studies, geochemical sampling, and examination of mines, prospects, and mineralized areas indicates that there are two types of mineralization in the Roberts Wilderness Study Area. There are additional types of mineralization (bedded barite and molybdenum porphyry) known to be present in surrounding areas within a few miles of the study area, but there is no indication that they exist in the study area.

The most promising type of mineralization in the wilderness study area is gold and silver in silicified dolomite. Anomalous amounts of gold and silver are found in selected samples of silicified and iron-stained dolomite that forms irregular bodies beneath the Roberts Mountain thrust at many places in the Roberts Mountains. A suite of volatile elements (arsenic, antimony, and mercury), commonly associated with

precious-metal concentrations, is present in anomalous amounts in these silicified rocks as well. The silicified zones are clearly located on the sole of the Roberts Mountains thrust. Other geologic features do not have an apparent relationship to the silicification. Rocks in the upper plate of the Roberts Mountains thrust, and hence everywhere above the silicified zones, are silicic sedimentary types rich in trace elements. These rocks are a possible source of the trace elements, including gold and silver, that are enriched in the silicified zones. Heat necessary to mobilize the elements was of regional extent as the siliceous bodies are found at widely separated localities in the Roberts Mountains. The silicified zones are cut by Tertiary and older faults. Areas along the east side of the study area east of Roberts Creek Mountain and Cooper Peak have high, moderate, and low resource potential, with a certainty level of C for gold and silver in bodies of silicified dolomite (fig. 2; pl. 1). See Appendix 1 and figure 3 for the definition of levels of mineral resource potential and certainty of assessment. Silicified and altered dolomite in an area about 2 1/2 mi west of Roberts Creek Mountain has moderate-to-low resource potential, certainty level B for gold and silver (fig. 2; pl. 1). An area along the southwest edge of the wilderness study area about 3 1/2 mi west of Roberts Creek Mountain has a moderate resource potential (certainty level B) for gold and silver (fig. 2; pl. 1).

The second type of mineralization is hydrothermal, carbonate-hosted silver, lead, and zinc vein deposits that form along faults and shear zones. The Kelley mine, on the west fork of Kelley Creek, is a good example of this type of deposit. The area east of Western Peak, including the drainage of both forks of Kelley Creek (fig. 2; pl. 1), has low resource potential (certainty level C) for silver, lead, and zinc in veins or stockworks in dolomite. Gold and silver mineralization in altered dolomite and limestone associated with faulting younger than the Roberts Mountains thrust and older than Tertiary basin and range faults is found in the central part of the wilderness study area and near several large faults in the western part of the study area. These areas have moderate potential for gold and silver resources with a B certainty level (fig. 2; pl. 1).

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APPENDIX 1. Definition of levels of mineral resource potential and certainty of assessment

Mineral resource potential is defined as the likelihood of the presence of mineral resources in a defined area; it is not a measure of the amount of resources or their profitability.

Mineral resources are concentrations of naturally occurring solid, liquid, or gaseous materials in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Low mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment where the existence of resources is unlikely. This level of potential embraces areas of dispersed mineralized rock as well as areas having few or no indications of mineralization. Assignment of low potential requires specific positive knowledge; it is not used as a catchall for areas where adequate data are lacking.

Moderate mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable chance for resource accumulation, and where an application of genetic and (or) occurrence models indicates favorable ground.

High mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resources, where interpretations of data indicate a high likelihood for resource accumulation, where data support occurrence and (or) genetic models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential requires positive knowledge that resource-forming processes have been active in at least part of the area; it does not require that occurrences or deposits be identified.

Unknown mineral resource potential is assigned to areas where the level of knowledge is so inadequate that classification of the area as high, moderate, or

low would be misleading. The phrase "no mineral resource potential" applies only to a specific resource type in a well-defined area. This phrase is not used if there is the slightest possibility of resource occurrence; it is not appropriate as the summary rating for any area.

Expression of the certainty of the mineral resource assessment incorporates a consideration of (1) the adequacy of the geologic, geochemical, geophysical, and resource data base available at the time of the assessment, (2) the adequacy of the occurrence or the genetic model used as the basis for a specific evaluation, and (3) an evaluation of the likelihood that the expected mineral endowment of the area is, or could be, economically extractable.

Levels of certainty of assessment are denoted by letters, A-D (fig. 3).

A. The available data are not adequate to determine the level of mineral resource potential. Level A is used with an assignment of unknown mineral resource potential.

B. The available data are adequate to suggest the geologic environment and the level of mineral resource potential, but either evidence is insufficient to establish precisely the likelihood of resource occurrence, or occurrence and (or) genetic models are not known well enough for predictive resource assessment.

C. The available data give a good indication of the geologic environment and the level of mineral resource potential, but additional evidence is needed to establish precisely the likelihood of resource occurrence, the activity of resource-forming processes, or available occurrence and (or) genetic models are minimal for predictive applications.

D. The available data clearly define the geologic environment and the level of mineral resource potential, and indicate the activity of resource-forming processes. Key evidence to interpret the presence or absence of specified types of resources is available, and occurrence and (or) genetic models are adequate for predictive resource assessment.

LEVEL OF RESOURCE POTENTIAL	U/A	H/B	H/C	H/D
		HIGH POTENTIAL	HIGH POTENTIAL	HIGH POTENTIAL
	UNKNOWN POTENTIAL	M/B	M/C	M/D
		MODERATE POTENTIAL	MODERATE POTENTIAL	MODERATE POTENTIAL
		L/B	L/C	L/D
		LOW POTENTIAL	LOW POTENTIAL	LOW POTENTIAL
				N/D
				NO POTENTIAL
	A	B	C	D
	LEVEL OF CERTAINTY			

Figure 3. Major elements of mineral resource potential/certainty classification.

Table 1. Sample description and analyses of chip samples from Kelley mine

Length (ft)	Description	Gold (ppm)	Silver (ppm)	Lead (percent)	Zinc (percent)	BaSO ₄ (percent)
4.4	Shear zone: partly oxidized broken carbonate rock, galena, barite crystals-----	0.017	22.62	6.7	10.8	18.5
3.0	Shear zone: partly oxidized, galena, sphalerite, barite-----	<.007	3.16	1.04	4.2	19.1
3.0	Shear zone: mostly black oxide in a white quartz matrix-----	<.007	.43	.055	.242	.09
1.5	-----do-----	.085	13.89	2.86	4.0	6.5
2.3	Shear zone: brecciated carbonate rock-----	<.007	<.3	.016	.018	.03
2.0	Hanging wall; brecciated carbonate rock-----	<.007	.87	.187	.96.	.25
3.0	-----do-----	<.007	1.22	.135	1.4	<.02
4.0	Footwall: carbonate rock with minor calcite stringers	<.007	3.9	.88	2.04	1.68
3.0	Footwall: silicified carbonate-----	<.007	.49	.042	.057	.08
4.0	Footwall: fractured carbonate rock, minor calcite stringers-----	<.007	<.3	.004	.004	<.02
2.0	Basalt dike: black, fine-grained, looks fresh	<.007	<.3	.012	.079	.09
2.0	Basalt-carbonate rock contact: fractured, minor calcite veining-----	.012	<.3	.013	.1	.21
1.0	Basalt-carbonate rock contact: brecciated carbonate rock, strong iron oxide boxwork texture, fine-grained galena and sphalerite-----	.046	16.54	1.33	9.2	<.02
1.0	Basalt-carbonate rock contact: fractured, silicified carbonate rock-----	<.007	<.3	.007	.004	<.02