Mineral Resources of the Bristol/ Granite Mountains Wilderness Study Area, San Bernardino County, California

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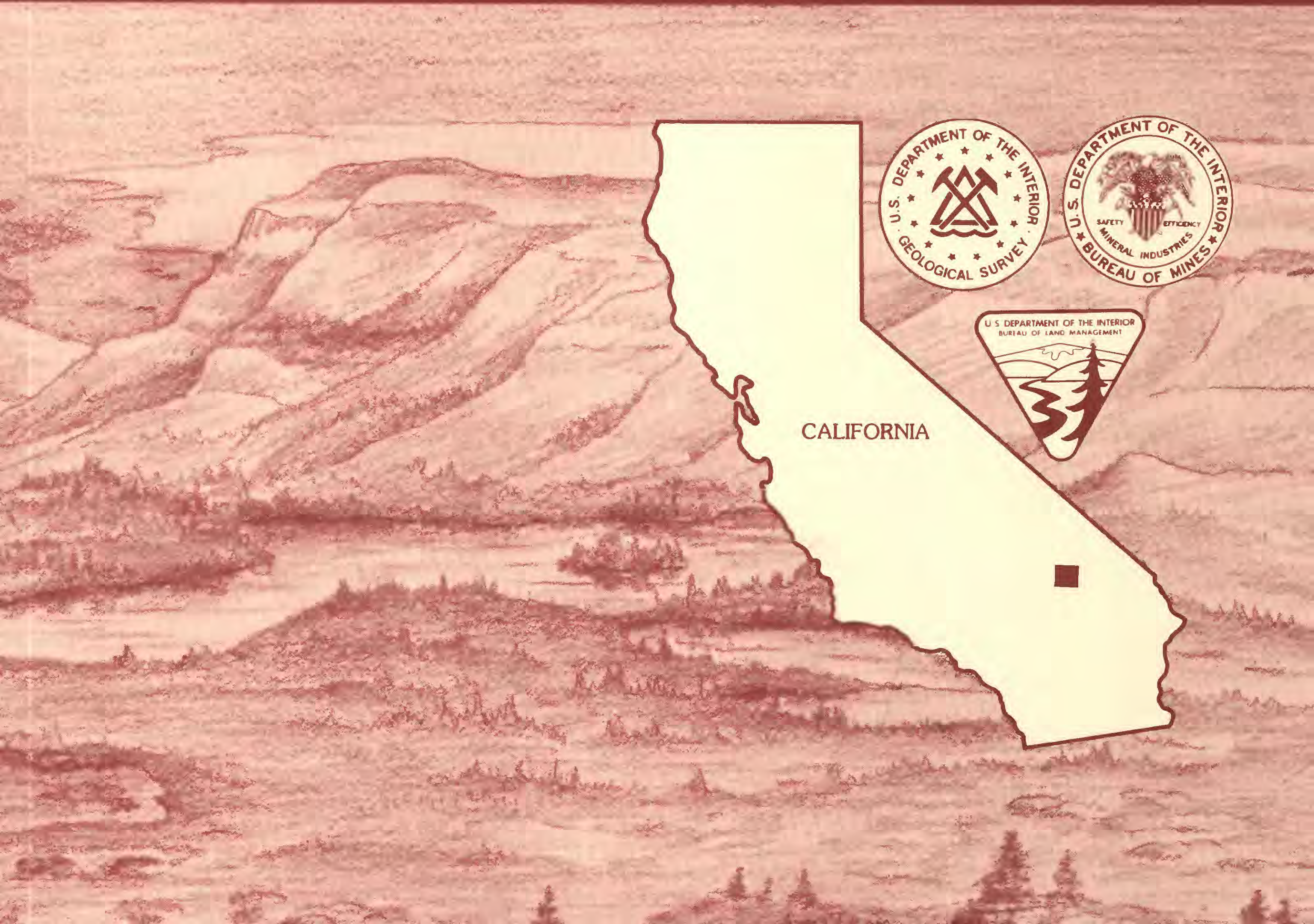

Chapter C

Mineral Resources of the Bristol/Granite Mountains Wilderness Study Area, San Bernardino County, California

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
CENTRAL CALIFORNIA DESERT CONSERVATION AREA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

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 the 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 part of the Bristol/Granite Mountains Wilderness Study Area (CDCA-256), California Desert Conservation Area, San Bernardino County, California.

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Mineral Resources of the Bristol/Granite Mountains Wilderness Study Area, San Bernardino County, California

By Keith A. Howard, James E. Kilburn, Robert W. Simpson,
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SUMMARY

Abstract

At the request of the Bureau of Land Management, 45,000 acres of the Bristol/Granite Wilderness Study Area (CDCA-256) were studied by the U. S. Geological Survey and the U. S. Bureau of Mines. In this report, the area studied is referred to as "the wilderness study area", or simply "the study area".

The wilderness study area is located 25 mi southeast of Baker, California. Two iron deposits total about 110,000 tons at 47 percent iron but are not large enough to constitute resources. The potential for undiscovered iron resources is low. There is low resource potential for undiscovered tungsten, silver, gold, lead, zinc, limestone marble, perlite, and oil and gas. Sand and gravel resources are present but more accessible supplies are abundantly available outside of the study area.

Character and Setting

The Bristol/Granite Wilderness Study Area (CDCA-256) lies in the Mojave Desert, near Baker, Calif. The study area occupies approximately 45,000 acres and includes the rugged Granite Mountains and flanking lowlands on the north and west sides of the range (fig. 1). The Granite Mountains are composed of Mesozoic (63 to 240 million years before present (Ma); see Geologic Time Chart, appendix), plutonic, and metaplutonic rocks, with small pendants of calcareous Paleozoic (240 to 570 Ma) strata (fig. 2). Tertiary (2 to 63 Ma) igneous dikes, volcanic rocks, coarse sedimentary debris, and Quaternary (2 Ma to present) alluvium are present in the study area around the flanks of the range. There are no active mines in the study area.

Mineral Resource Potential

Skarns (formed where calcium-rich rocks have been metamorphosed) are favorable hosts for iron and tungsten deposits. Small deposits of magnetite-hematite contain about 110,000 tons of ore averaging 47 percent iron at the Iron Victory prospect and 10 tons at 43 percent iron at the Comanche mine (fig. 2). Neither deposit is considered large enough to constitute a resource. The potential for undiscovered iron resources in the study area is low. Stream-sediment samples contain tungsten, molybdenum, and the mineral scheelite (indicative of tungsten mineral occurrences in skarn rocks). The study area has a low potential for undiscovered tungsten resources.

An occurrence of silver at the Silver Lode mine adjacent to the wilderness study area is associated with sulfides and hydrothermally altered granite along fracture zones within a Cretaceous (about 75 Ma) pluton. Altered granite of the same pluton exposed within the study area adjacent to the Silver Lode mine has low potential for undiscovered hydrothermal silver and associated lead, zinc, and gold resources.

The study area has low mineral potential for undiscovered epithermal gold, limestone marble, perlite, and oil and gas resources. Sand and gravel are

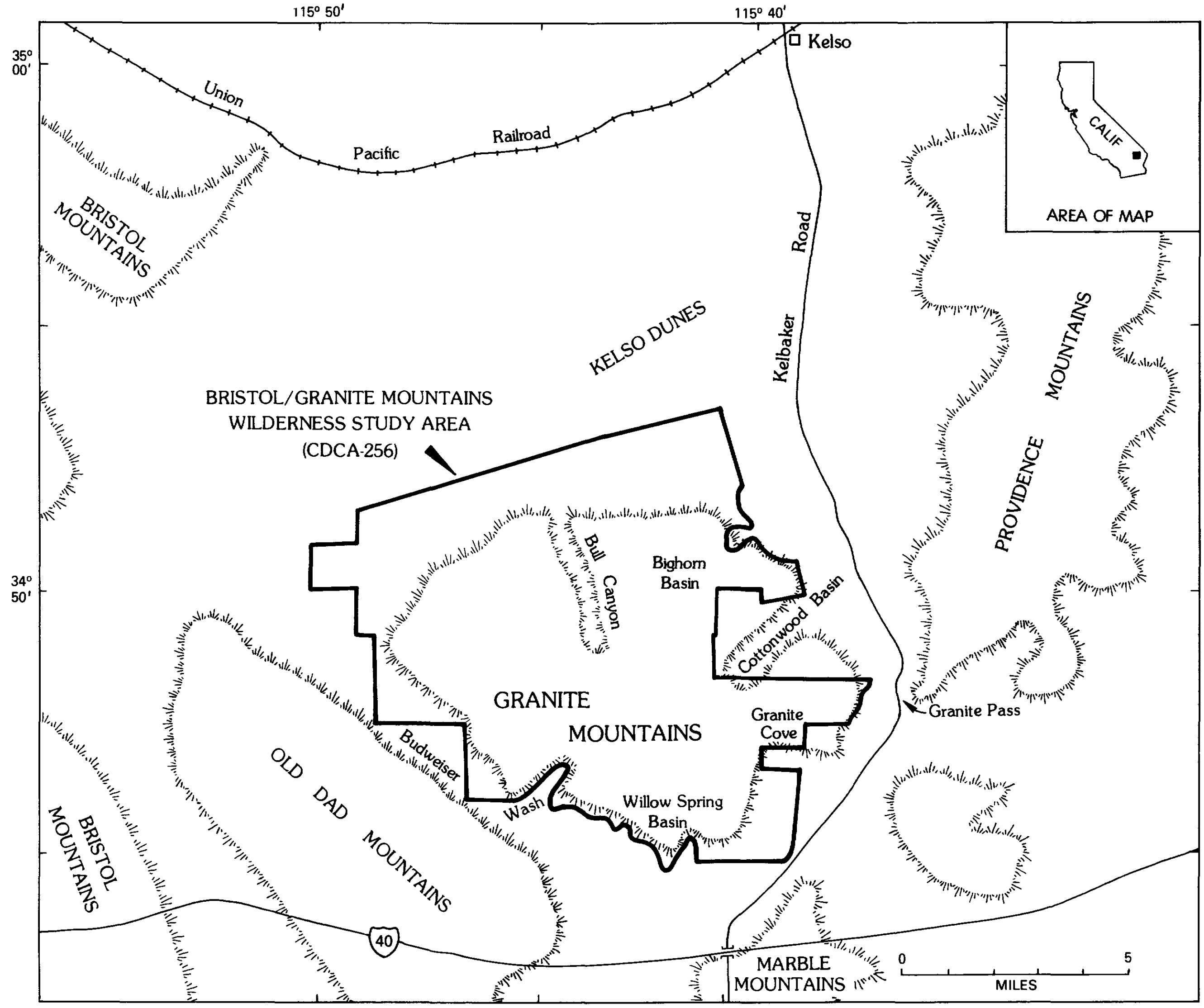

Figure 1. Index map showing the location of the Bristol/Granite Mountains Wilderness Study Area, San Bernardino County, California.

present, but more accessible supplies are abundantly available outside the study area.

INTRODUCTION

This mineral resource study is a joint effort of the U.S. Geological Survey and the U.S. Bureau of Mines. The history and philosophy of such joint mineral surveys of U.S. Bureau of Land Management Wilderness Study Areas were discussed by Beikman and others (1983). Mineral assessment methodology and terminology were discussed by Goudarzi (1984). See the appendix for the definition of levels of mineral resource potential and certainty of assessment. Studies by the U.S. Geological Survey are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. The U.S. Bureau of Mines evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas. Identified resources are classified according to the system described by U.S. Bureau of Mines and U.S. Geological Survey (1980).

Location and Physiography

The Bristol/Granite Mountains Wilderness Study Area (CDCA-256) is located in the Mojave Desert of southeastern California, about 10 mi south of Kelso and 25 mi southeast of the town of Baker (fig. 1). The Union Pacific railway passes 7 mi north of the study area, and Interstate Highway 40 passes 3 mi to the south. Access to the study area is provided by dirt roads leading west from the Kelbaker Road. The study area encompasses most of the rugged Granite Mountains; elevations range from 1,890 ft at the northwestern corner of the study area to 6,786 ft at the range crest. The mountain range contains numerous springs and water seeps. The higher elevations and north-facing slopes are vegetated by pinyon pine, juniper, and various shrubs and grasses. Lower elevations and south-facing slopes are more sparsely vegetated by yucca, cacti, creosote, and other shrubs.

Previous and Present Investigations

The U.S. Bureau of Mines conducted a literature search and studied claims records of mining activity in and adjacent to the wilderness study area. Field examination of mines, prospects, claims, and mineralized zones was carried out in 1982, and seventy-four rock samples were collected and examined in the laboratory (Sabine, 1984). Previous reports of mineral occurrences are contained in Wright and others (1953), and reports written for the Southern Pacific Company (Bonham, 1959; Bonham and Cooksley, 1959; Gamble, 1959a, b; Oesterling and Spurck, 1964).

The U.S. Geological Survey assessed the mineral resource potential of the study area by integrating and interpreting geologic, geochemical, and geophysical data from existing sources and new investigations. Mineral evaluations of adjacent wilderness study areas were reported in Yeend and others (1984) and Miller and others (1985). Field mapping done in 1984 and 1985 by K. Howard and T. Fitzgibbon provided most of the geologic information for the study area. Supplementary geologic mapping was provided by Charles Sabine, Lorie Cahn, and Helen Gibbons (all in Stein and Warrick, 1979), by B.E. John (written commun., 1980), Bonham (1959), Bonham and Cooksley (1959), Gamble (1959a, b), and Miller and others (1982). A stream-sediment sampling survey conducted in 1984 provided geochemical data (Detra and Kilburn, 1985). Areas of limonitic alteration were outlined by Raines (1983) as a result of his spectrographic study of Landsat images; some of the limonitic areas were field checked and sampled for geochemical analysis. In 1983-1984, new gravity data were collected to supplement existing gravity data, and aeromagnetic data (U.S. Geological Survey, 1981) provided a basis for further geophysical interpretations. An aerial gamma-ray survey (Geodata International Inc., 1979) also provided useful data.

Acknowledgments

The authors wish to acknowledge Michael Miller, Steven Munts, Jerry Olson, and Michael Sokaski of the U.S. Bureau of Mines Western Field Operations Center, and D.H. Sorg, B.E. John, J.K. Nakata, J.E. Wright, S.E. Shaw, T. Gage, and J.A. Pitkin of the U.S. Geological Survey for assistance in field work and laboratory investigations.

APPRAISAL OF IDENTIFIED RESOURCES

By Charles Sabine, U.S. Bureau of Mines

Methods and Scope of Investigation

Preliminary work for this report included compilation of available geologic and mineral resource literature, production records, and U. S. Bureau of Land Management and San Bernardino County claim records. In the spring of 1982, mines, prospects, and areas containing active and lapsed claims in the study area were examined and sampled (table 1).

Seventy-four samples were collected in the study area. Chip samples were taken from mineralized structures and altered zones. Grab samples were collected from mine and prospect dumps. Samples were prepared for analysis at the U. S. Bureau of Mines Western Field Operation Center and analyzed for gold, silver, and other elements by fire-assay and atomic-absorption methods by a contract laboratory. At least one sample from each locality was analyzed by semi-quantitative spectrography for 42 elements, including gold, arsenic, copper, iron, lead, molybdenum, platinum, silver, tin, and zinc. Limestone samples were analyzed at the U.S. Bureau of Mines Reno Research Center. Results were presented by Sabine (1984).

Mining History

There has been very little mining activity and no production in the study area during the past 120 years. The Comanche mine was first located in 1902 and was known as the El Companche in 1925 and the Comanche in the 1950's. It was known as the Christopher in 1965. There were no claims on the property when it was examined in 1982.

Claims were located in the vicinity of the Silver Lode mine as early as 1902 when the property was known as the Pine Ridge mine. The Silver Queen Nos. 1-4 claims were located in 1919, and the mine was known by that name thereafter. Most of the workings were developed during the 1930's. The Silver Lode Nos. 1 and 2 claims were filed in 1978, and the McCoy group of ten lode claims was filed in 1982.

Claims were located for iron in the vicinity of the Iron Victory prospect as early as 1912. The present claims were located in 1942 and patented January 26, 1956.

Reserves and Identified Resources

The Comanche mine and six prospects lie within the wilderness study area; the Silver Lode mine is adjacent to the study area (fig. 3). The Comanche mine is situated in a roof pendant consisting of magnesian marble. The marble contains 41 to 45 percent calcium oxide and 14 to 16 percent magnesium oxide. About 10 tons remain from a 110-ton pod of magnetite that contained 42.5 percent iron. Less than 50 tons remain from a mineralized fault breccia that averaged 2.5 percent copper and 0.3 oz/ton silver.

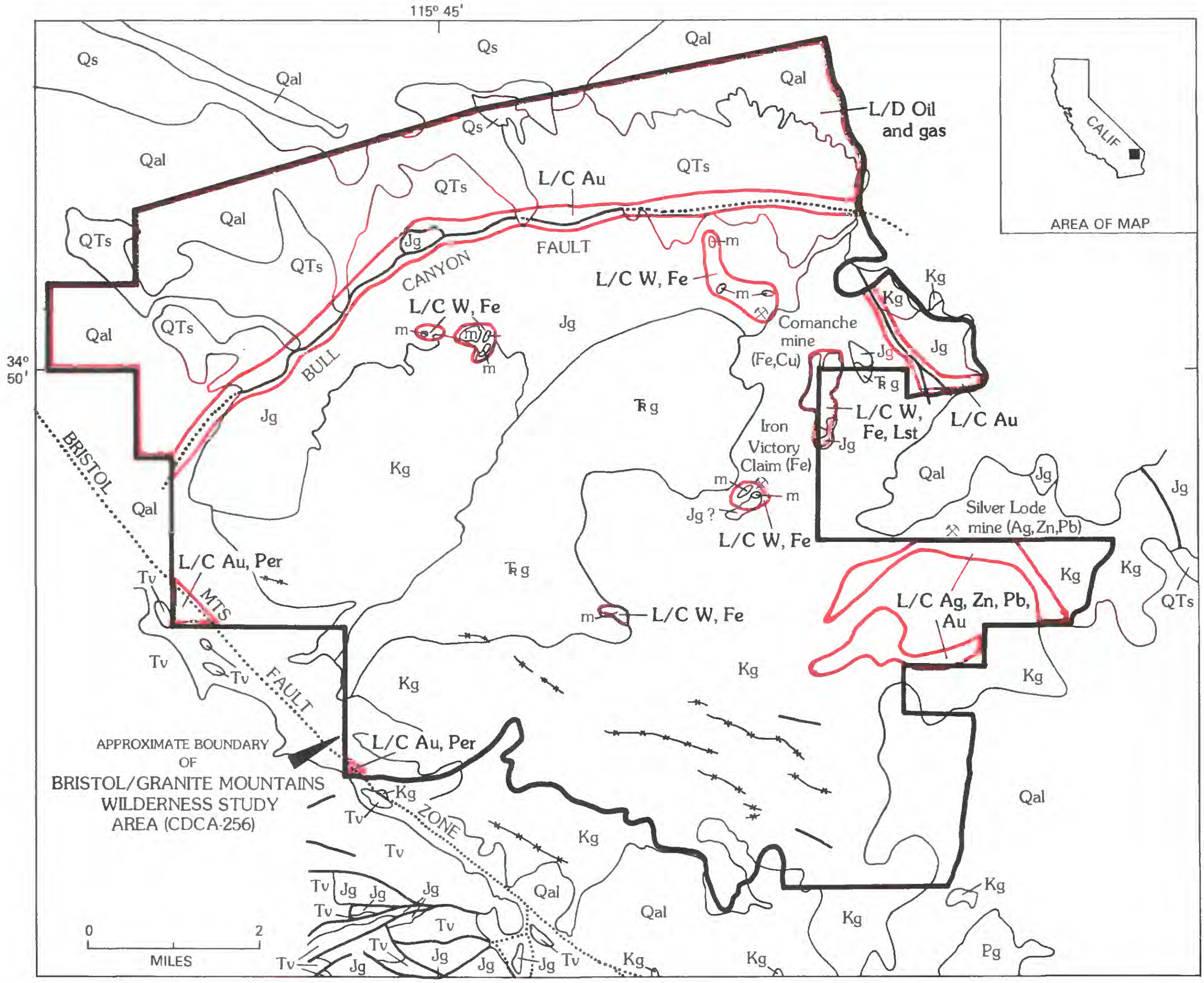

Figure 2. Mineral resource potential and generalized geology of the Bristol/Granite Mountains Wilderness Study Area, San Bernardino County, California.

The Iron Victory prospect explored lenses of magnetite and hematite that contain some chalcopyrite; they occur along a skarn zone in a marble roof pendant. About 110,000 tons of iron-rich rock, averaging 47.2 percent iron, are present. The largest lens contains about 30,000 tons of iron-rich rock. About 150,000 tons of magnesian marble, which averages 41.0 percent calcium oxide and 11.7 percent magnesium oxide, are also present in the roof pendant.

Silver, copper, lead, and zinc minerals are disseminated along altered joints and in quartz veins in granite at the Silver Lode mine (fig. 3). Analyzed samples contained as much as 0.12 oz/ton gold, 1.8 oz/ton silver, 1.1 percent lead, 3.8 percent zinc, and 0.3 percent copper (table 1). Mineralized zones in the workings are not considered to be resources, but they may indicate the presence of possible silver-lead-zinc resources at depth.

Magnesian marble examined at the Comanche mine, Iron Victory prospect, and elsewhere in the study area contains too much magnesium oxide for commercial use other than as agricultural soil supplements or crushed stone. Transportation costs to existing markets would exceed the value of the rock.

Sand and gravel are abundant within the study area. However, more accessible supplies of these materials are abundantly available outside the study area. According to Yeend and others (1984), the U.S. Bureau of Mines considers the windblown sand of much of the Kelso Dunes dune field adjacent to the north side of the study area to be a source of marginal reserves of glass and feldspar sand, with byproduct magnetite and gold. Very little of this dune field extends into the study area.

EXPLANATION

Area of low mineral resource potential with some evidence of resource forming processes. See appendix for definition of levels of mineral resource potential and certainty of assessment

COMMODITIES

W	Tungsten
Ag	Silver
Au	Gold
Fe	Iron
Zn	Zinc
Pb	Lead
Lst	Limestone
Per	Perlite
Oil and gas	

DESCRIPTION OF MAP UNITS

Qs	Windblown sand (Quaternary)
Qal	Alluvium (Quaternary)
QTs	Fanglomerate and sedimentary breccia (Quaternary? and Tertiary)
	Rhyolite dike (Miocene)
Tv	Volcanic rocks (Miocene)
Kg	Granite and granodiorite (Cretaceous)
Jg	Granitoid rocks (Jurassic and Jurassic?)
₨g	Granitoid gneiss (Triassic?)
m	Marble, calc hornfels, and skarn—Paleozoic and Triassic(?) protoliths
Ꝑg	Granitoid rocks (Proterozoic)
	Contact
	Fault—Dotted where concealed
	Mine or prospect having mineral occurrence

Figure 2. Continued.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Keith A. Howard, James E. Kilburn, Robert W. Simpson, Todd T. Fitzgibbon, David E. Detra, and Gary L. Raines
U.S. Geological Survey

Geology

Rock Units

The Bristol/Granite Mountains Wilderness Study Area contains rocks ranging in age from Paleozoic to Cenozoic (fig. 2). The Granite Mountains are largely underlain by Mesozoic plutonic rocks.

Several small pendants of metasedimentary rocks are part of the plutonic suite in the Granite Mountains. The metamorphosed strata are mainly marble, siliceous marble, dolomite marble, and calc-silicate hornfels. Some of the marble and siliceous marble can be lithologically correlated with the Bird Spring Formation (Pennsylvanian and Permian) and the Monte Cristo Limestone (Mississippian), which are exposed a few miles to the northeast in the Providence Mountains. The siliceous marble contains metamorphic wollastonite and phlogopite. Calc-silicate rock associated with the Paleozoic marble includes laminated calc-silicate hornfels that is tentatively correlated with Triassic strata exposed in the Little Piute Mountains (Miller and others, 1982). Skarns containing diopside, garnet, quartz, and epidote are associated with the calcareous rocks and are important for resource evaluation (fig. 3). Field relations suggest that the skarns formed mainly by intrusion of Jurassic diorite and felsic plutonic rocks. Triassic(?) and Cretaceous plutonic intrusions also may have contributed to skarn formation. Quartzite, schist, and metavolcanic rocks of unknown age occur as small bodies in the study area.

Plutonic rocks of the Granite Mountains can be divided into Triassic(?), Jurassic, and Cretaceous intrusive suites. The oldest of these suites consists of hornblende quartz diorite gneiss and hornblende quartz monzodiorite gneiss containing megacrysts of potassium feldspar 2-10 cm across. An inclusion of laminated calc-silicate hornfels within the augen gneiss suggests that it postdates Triassic(?) calc-silicate strata. The gneissic rocks also contain amphibolite inclusions and biotite-rich and diorite inclusions. A Triassic(?) age for the gneisses is suggested by cross-cutting Jurassic diorite and by the quartz-poor, potassium-feldspar-rich composition reminiscent of Triassic monzonite in the western Mojave Desert (Miller, 1977).

A wide variety of plutonic rocks belong to the Jurassic intrusive suite. Quartz monzonite characterized by medium-grained lavender potassium feldspar crops out along the east side of the Granite Mountains. The quartz monzonite is assigned a Jurassic age based on its close resemblance to Jurassic rocks in the eastern Mojave Desert as described by John (1981), D. Miller and others (1982, 1985), and Allen and others (1983). A heterogeneous unit of diorite and metadiorite gneiss has mutually intrusive relations with the quartz monzonite and intrudes the Triassic(?) augen gneiss. The diorite unit is heterogeneous in texture and composition, and much of it consists of fine-grained foliated metadiorite characterized by migmatitic wisps of leucocratic rock. The Jurassic quartz monzonite and diorite are intruded by several other plutonic rocks (here included in the Jurassic plutonic suite): fine-grained inclusion-spotted quartz monzonite, medium-grained quartz monzodiorite, and syenogranite present in varying degrees on the north, west, and northeast sides of the Granite Mountains.

The Triassic(?) and Jurassic intrusive suites and older rocks are metamorphosed, foliated, and locally intricately folded throughout most of the Granite

Mountains. The foliation strikes northeast to east, dips steeply, and is cut by small, east-striking mafic dikes of Late Jurassic or Cretaceous age. The cross-cutting mafic dikes have been slightly distorted and cut by dikes of undeformed Cretaceous plutonic rocks.

The Cretaceous intrusive suite consists of a granodiorite pluton, a zoned pluton, and many granite, aplite, and pegmatite dikes. The granodiorite pluton forms a sheet-like mass in the western part of the area that dips west at moderate angles. The larger zoned pluton occupies the southeastern part of the study area. A discontinuous border phase of granodiorite is intruded by porphyritic monzogranite that forms a broad annular zone around, and gradational to, a central zone of nonporphyritic monzogranite (Sabine, 1971). The zoned pluton yielded potassium-argon (K-Ar) dates of 70.9 to 74.5 Ma on biotite (R.F. Marvin, written commun., 1982; M.A. Pernokas, written commun., 1982; Miller and others, 1985) and U-Pb data on zircon that indicate a similar age (J.E. Wright, written commun., 1985).

Sabine (geologic map in Stein and Warrick, 1979) found that the Mesozoic plutonic rocks are cut by west-northwest-striking rhyolite dikes. A Miocene age for the dikes is likely, based on the prevalence of Miocene volcanic rocks in the region. Miocene volcanic flows and tuffs of basaltic to rhyolitic composition crop out along the southwest border of the wilderness study area, where they are in fault contact with the Cretaceous zoned pluton. Rhyolitic flow rocks adjacent to the study area there are partly perlitic.

Tertiary fanglomerate and sedimentary breccia flank the north side of the Granite Mountains. They are locally in fault contact with Jurassic rocks. Deposits of Tertiary or Quaternary fanglomerate overlie Jurassic rocks in the northeast part of the study area and southeast of Granite Pass. Quaternary alluvium laps around the Granite Mountains; it forms a thin veneer over partly exposed pediment on the south border of the study area. Windblown sand deposits are present on the north side of the study area.

Faults and Evidence of Alteration

Faults are present on the periphery of the Granite Mountains, but the interior of the range contains few faults, in contrast to the adjacent highly faulted Old Dad Mountains (fig.2). However, the interior does contain a system of altered fracture zones that transect the pluton in the eastern and southeastern part of the Granite Mountains and define a crudely orthogonal pattern along east-northeast- and north-northwest-striking joint systems. Individual zones are as long as 3 mi and as wide as 0.5 mi. Within fracture zones, the granite is sheared, argillized, chloritized, and sericitized to varying degrees. Copper, lead, and zinc sulfides are disseminated in fracture zones at the Silver Lode mine. Quartz veins fill fractures in some zones, most notably in the Granite Cove area, where gossans also are present. A reddish gossan zone covering about one third of an acre also crops out high in the southern Granite Mountains at the headwaters of Budweiser Wash. A quartz muscovite vein along one of the northwest-trending fracture zones, on the north side of Cottonwood Basin, was sampled in order to investigate the age of alteration. The muscovite yielded a K-Ar date of 68.0 ± 1.7 Ma (J.K. Nakata, written commun., 1985). This date is close to the K-Ar dates (70.9 to 74.5 Ma) on unaltered biotite in the pluton, and to the crystallization age inferred for the granite. These data indicate that the alteration closely followed crystallization of the granite; the alteration may have been deuteric or hydrothermal.

A normal fault at least 2 mi long on the northeast side of the wilderness study area north of Cottonwood basin dips 45-50° to the northeast. The fault zone is marked by sericitic breccia a few yards thick containing pyrite, and by rust-colored hematitic vein quartz. An adit more than 100 feet long was driven along the fault zone.

The trace of the Bull Canyon fault, a low-angle normal fault of late Tertiary age, skirts around the northern base of the Granite Mountains. The fault dips 20-40° north and northwest, outward from the range. A zone of red to tan breccia and gouge, locally over 300 ft thick, separates a chloritically altered footwall of Jurassic and Jurassic(?) plutonic rocks from chloritized and brecciated equivalents and Tertiary sedimentary breccia in the hanging wall. Striae measured at two localities trend in the northwest quadrant. The fault breccia, derived from local crystalline rocks, was previously interpreted as volcanic rock (Stein and Warrick, 1979). The breccia is locally calcareous and manganiferous but is more generally silicified. It contains brecciated white vein quartz, vuggy quartz, jasper, and limonitic boxwork. Outcrops of the altered breccia form a band 5 mi long in the northwest part of the study area (fig. 3). Prospect pits are present in the breccia, but direct evidence of mineral deposits was not observed.

West-to-northwest-striking rhyolite dikes in the southern Granite Mountains are bordered by discolored, brownish granite. At least one of the dikes follows an older quartz vein. Sabine (in Stein and Warick, 1979) mapped several faults with similar strikes in the same area.

A major northwest-trending fault, the Bristol Mountains fault zone (Gamble, 1959a, b), separates the Granite Mountains from the Old Dad Mountains to the southwest. It juxtaposes Tertiary volcanic rocks of the Old Dad Mountains against Cretaceous granodiorite of the Granite Mountains. Where exposed in pediment adjacent to the southwest corner of the wilderness study area, the fault zone is a few feet wide and consists of reddish brecciated vein quartz, black calcite, and gouge. The fault dips northeast 70-80°. In the northern Bristol Mountains, 9 mi northwest of the wilderness study area, it dips moderately (50°) to steeply northeast (Davis, 1973). In both places, Mesozoic plutonic rocks in the hanging wall overlie Tertiary supracrustal rocks in the footwall, indicating reverse separation.

Remote-Sensing Data on Alteration

A remote-sensing study outlined areas in which rocks are discolored by limonite or other iron oxides

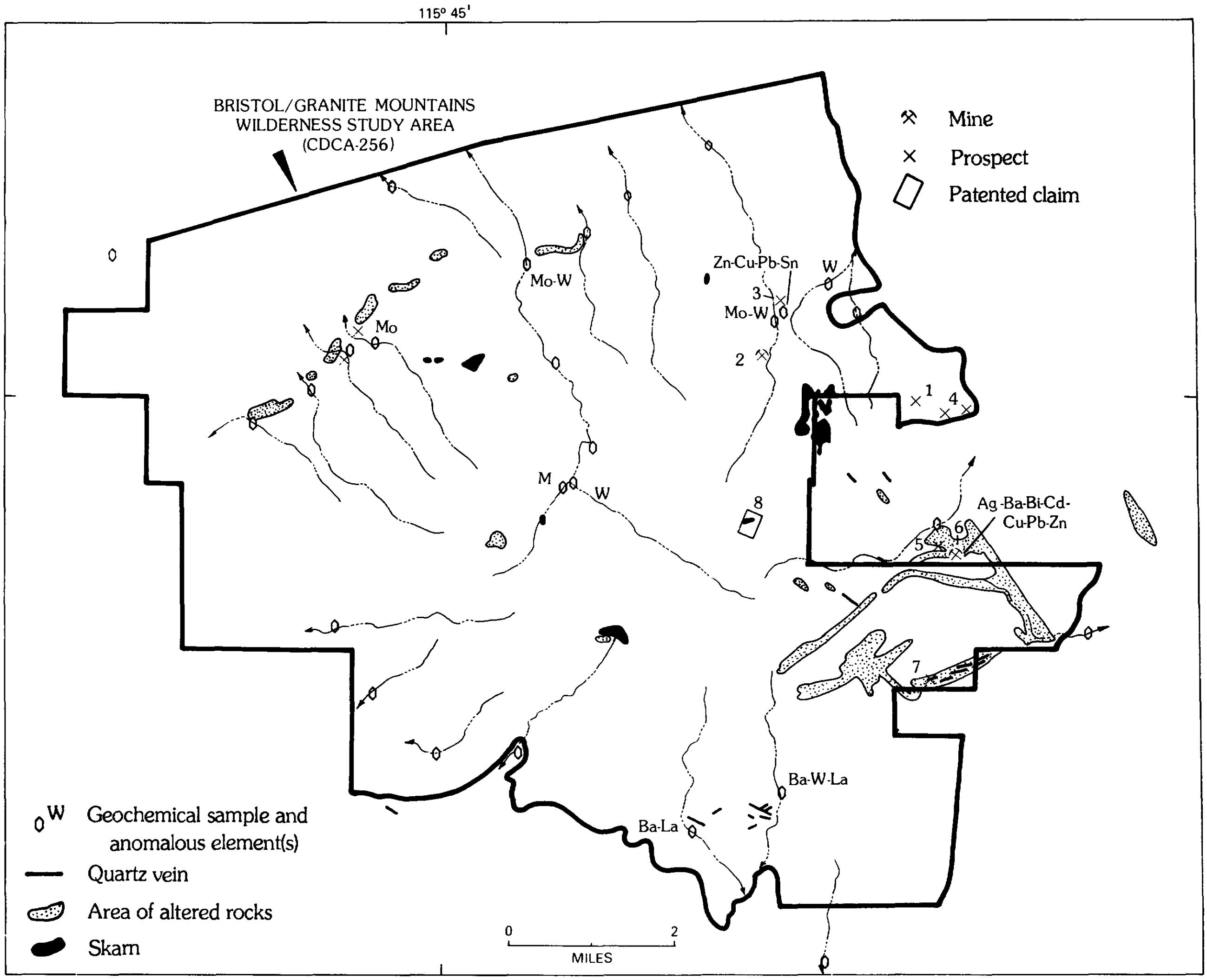

Figure 3. Map of the Bristol/Granite Mountains Wilderness Study Area showing mines and prospects, geochemical sample sites, quartz veins, and areas of altered rocks. Numbers refer to mines and prospects: 1, unknown; 2, Comanche mine; 3, unknown; 4, Golden Legend Nos. 1 and 2; 5, unknown; 6, Silver Lode mine; 7, unknown; 8, Iron Victory. Letters refer to anomalous elements: Ag, silver; Ba, barium; Bi, bismuth; Cd, cadmium; Cu, copper; La, lanthanum; Mo, molybdenum; Pb, lead; Sn, tin; W, tungsten, Zn, zinc.

(Raines, 1983). The discoloration can result from weathering of sulfide minerals or from other processes unrelated to alteration. Field reconnaissance determined that several discolored areas were not altered, but confirmed that skarn is present in lower Bighorn Basin, propylitically altered rocks occur along the Bull Canyon fault, and pegmatite occurs near the crest of the Granite Mountains (fig. 3).

Geochemistry

Reconnaissance geochemical sampling of stream sediments was conducted in the study area in 1984 for a geochemical survey. Twenty-eight samples were collected from drainages near range fronts that drain areas ranging from less than one to several square miles (see fig. 3). Samples were analyzed for 30 elements by a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968); analytical results are given in Detra and Kilburn (1985). Nonmagnetic heavy-mineral concentrates of stream sediments were particularly useful for assessing mineralization because they concentrate ore-forming sulfide and oxide minerals. Further geochemical data comes from analyses of altered rocks sampled from inactive mine workings (Detra and Kilburn, 1985; table 1) and limonitic areas (G. Raines, unpub. data).

Tungsten anomalies are present in Bull Canyon and in stream courses that drain the ridge between Bighorn and Cottonwood basins (fig. 3). This ridge is capped by a large pendant of calcareous metasedimentary rocks. The tungsten is probably derived from skarn deposits associated with such pendants. Samples collected from stream channels that provide drainage of the east and west flanks of the ridge revealed abundant scheelite and calc-silicate minerals (relatively rare manganoan diopside being a minor component). Anomalous molybdenum, a common constituent of tungsten-bearing skarns, locally occurs coincident with tungsten anomalies.

A sample of altered rock collected from Bighorn Basin for the remote-sensing survey contained anomalous concentrations of silver, gold, bismuth, cadmium, copper, mercury, and zinc. Gouge from a shear zone in an adit at or near prospect No. 3 (fig. 3) contained anomalous concentrations of copper, lead, tin, and zinc. The presence of pyrite in this sample may explain iron oxide stains found within the shear zone. Five miles east of Bighorn Basin, in the area of the Bull Canyon fault, propylitically altered rocks contained anomalous concentrations of arsenic, cadmium, copper, molybdenum, and antimony. These elements are sometimes associated with epithermal deposits of gold.

Evidence of hydrothermal activity also exists on the south side of Cottonwood basin at or near the site of the Silver Lode mine (fig. 3, No. 6), where quartz veins with disseminated pyrite and minor veinlets of galena are evident. A geochemical sample composited from mine tailings contained anomalous concentrations of silver, barium, bismuth, cadmium, copper, lead, and zinc. This trace-element signature correlates with the sulfide assemblage of galena, chalcopyrite, sphalerite, and pyrite identified in the concentrate. Laser-microprobe studies confirmed the presence of silver and bismuth in galena, and cadmium and copper were found to be integrants of sphalerite. Bornite and covellite were also reported at this locale by Gamble (1959b). Pegmatite samples collected about 4 mi east of the mine for the remote-sensing study contained a similar assemblage of elements.

Barium and lanthanum anomalies occur together in stream-sediment samples collected from Willow Spring basin near the southern edge of the wilderness study area (fig. 3). Barite was identified optically. Since most barite deposits in the region occur in veins and small stringers (Wright and others, 1953), it seems likely that the barium present in the concentrates in the study area has a similar origin. Geologic or geochemical evidence to indicate that the barite (barium) is associated with mineralized systems of economic interest has not been found. The rare-earth phosphate monazite, a common accessory mineral in granitic rocks, was identified in the optical study and probably is the source of the anomalous lanthanum.

Geophysical Studies

Aeromagnetic data for the study area were extracted from a regional survey of the Needles 1° x 2° quadrangle (U.S. Geological Survey, 1981), for which east-west flight lines were spaced approximately 0.5 mi apart and flown at a nominal elevation of 1,000 ft above the ground surface. The data obtained over the study area were reduced to the pole (Baranov and Naudy, 1964) to remove asymmetries in the magnetic anomalies and better define rock bodies with which the anomalies are associated. Some anomalies in the study area can be attributed to inconstant flight altitude above the rugged terrain.

Magnetic anomalies within the study area range from highs of about 300 gammas to lows of approximately -200 gammas. These anomalies are modest in amplitude by comparison with those occurring in adjacent mountain ranges. Two occurrences of magnetite noted by the U.S. Bureau of Mines, one a 20 ft by 30 ft pod at the Comanche mine and the other located in a skarn at the Iron Victory prospect, do not coincide with aeromagnetic anomalies, although the latter occurrence does lie near the southeast end of a moderate high over Triassic(?) gneissic rocks that are themselves moderately magnetic. Therefore, the magnetite bodies must be small; the aeromagnetic pattern does not suggest the presence of a large unseen subsurface accumulation.

A magnetic high over the mouth of Cottonwood basin in the eastern part of the study area is probably caused by Jurassic or Cretaceous igneous rocks exposed in the area. A series of magnetic lows located in the northern and northwestern parts of the study area lie over or are adjacent to the low-angle Bull Canyon fault. These low-intensity anomalies probably reflect topographic effects and natural variations in magnetite content of mostly unaltered plutonic rocks, although loss of magnetite in altered rocks may in part account for the lows. Changes in the patterns of magnetic anomalies across Budweiser Wash indicate that the northwest-trending Bristol Mountains fault zone is a major fault zone. Negative magnetic anomalies occurring along the trend of the fault zone, especially to the south of the Granite Mountains, could be caused by alteration; however, no evidence of mineralization was seen in adjacent parts of the study area that would account for it.

The regional isostatic gravity field appears in Roberts and others (1981). New gravity data collected in and near the study area by the U.S. Geological Survey in 1983 and 1984 were combined with existing data in order to prepare an isostatic residual-gravity map. The coverage is adequate for defining major structural boundaries and distinguishing geologic units of regional extent, provided that density contrasts exist.

Isostatic residual-gravity values range from a high of -10 mGal in the northern part of the study area over exposures of Jurassic gneiss to a low of -26 mGal in the south over Cretaceous granite. This relation is consistent with the distribution of gravity highs and lows over Jurassic and Cretaceous rocks in many of the neighboring ranges (for example, Miller and others, 1985). A linear, northwest-striking gradient along the southwest side of the study area indicates that the Bristol Mountain fault zone juxtaposes unlike rocks with less dense rocks on the southwest side. Gravity values over alluviated areas at the northwest and northeast edges of the wilderness study area suggest that sedimentary fills are less than 1,000 ft thick.

An aerial gamma-ray survey (Geodata International, Inc., 1979) detected uranium levels above the normal background level over parts of the Granite Mountains. However, the anomalies correlate closely with flight altitude above terrain and not closely with geologic units. Flight altitude often greatly exceeded nominal during the aerial traverses of this rugged area, so terrain corrections and resulting anomalies may be unreliable. The gamma-ray-survey data are not considered to indicate the presence of significant uranium or thorium concentrations in the wilderness study area.

Mineral and Energy Resources

Geologic, geochemical, and geophysical data indicate that the Bristol/Granite Mountains Wilderness Study Area has low resource potential for tungsten, silver, gold, lead, zinc, limestone marble, perlite, and oil and gas. See the appendix for definition of mineral resource potential and certainty of assessment (Goudarzi, 1984). Figure 2 outlines areas of low potential for mineral resources for which there are indications that mineralization processes occurred.

Skarn Iron and Tungsten

Skarns, formed by contact metasomatism of calcareous strata, are favorable hosts for iron and tungsten deposits. Iron deposits at the Iron Victory and Comanche mines are probably similar in origin to other iron deposits in the eastern Mojave Desert, including the much larger Vulcan mine iron deposit located 8 mi northeast of the study area (Miller and others, 1985). Most such deposits occur at intrusive contacts of Jurassic plutons with carbonate rocks. Based on the lack of sharp aeromagnetic highs and the limited extent of carbonate rocks, no large iron deposits are thought to exist in the study area. Small undiscovered bodies of iron would not constitute resources now or in the foreseeable future. The mineral resource potential for iron is therefore considered to be low in areas where skarns are present, with a C certainty level.

Based on the presence of the tungsten-bearing mineral scheelite and anomalous concentrations of tungsten and molybdenum in stream sediments downstream from skarns, tungsten appears to be associated with skarns in the area. There has been no known exploration for tungsten in the study area. No tungsten minerals were seen in outcrop. The resource potential for tungsten in the skarns of the study area and downstream placers is considered to be low, with a C certainty level. Studies of the tungsten minerals in outcrop could improve the certainty of this assessment.

Hydrothermal Silver

The altered fracture zones (fig. 3) in and near the zoned Cretaceous pluton occupying the southeastern part of the study area (fig. 2) provide evidence of hydrothermal or deuteric fluids that may represent a mineralizing system. This alteration probably closely followed the emplacement of the pluton at several miles depth, and was formed at a moderate to low temperature, as indicated by the presence of quartz and quartz-muscovite veins, chloritized granite, and sulfides of copper, zinc, lead, and iron at the Silver Lode mine. In the area of the Comanche mine, the presence of iron-staining and copper- and iron-sulfide minerals in fracture zones north of the pluton may be related to the same alteration event. Geochemically anomalous silver, barium, bismuth, cadmium, zinc, lead, and gold, and the presence of sulfides at the Silver Lode mine (just outside the study area) indicate that similar small occurrences of silver and associated zinc, lead, and gold may be present along adjacent zones of fractured and altered granite in the study area. Any such occurrences may be low-grade and even smaller than the occurrence at the Silver Lode mine. The mineral resource potential for hydrothermal silver and associated lead, zinc, and gold in two areas within the wilderness study area is considered to be low, with a C certainty level.

Epithermal Gold in Fault Breccias

Extensive iron-stained breccia along the Bull Canyon low-angle normal fault on the northwest flank of the Granite Mountains provides a potential environment for epithermal or low-grade hot-spring-type gold deposits. The presence of limonite boxworks, iron-staining, jasper, and quartz veinlets suggests that alteration produced silica deposits and sulfide minerals; reconnaissance geochemical sampling shows anomalous concentrations of arsenic, cadmium, copper, molybdenum, and antimony. There is no direct evidence of gold or other mineral resources. Accordingly, the mineral resource potential for epithermal gold in the breccia is considered to be low, with a C certainty level. A thorough geochemical survey of the breccia would improve the certainty of assessment.

The fault zone north of Cottonwood basin on the east side of the study area also contains iron-stained vein quartz, and it has been prospected. No evidence of significant mineral deposits was observed, and this area therefore has a low resource potential for epithermal gold, with a C certainty level.

Two other areas have some indicators of a geologic environment possibly suitable for gold mineralization. However, after examination of these areas, described below, it was concluded that gold is less likely to occur in these areas than in the two areas described above. At the southwest boundary of the study area, the Bristol Mountains fault zone is present beneath alluvium. Iron-stained vein quartz occurring along the fault zone indicates the possibility of epithermal mineralization. It is unlikely that gold resources exist along the fault zone because the fault zone is narrow and lacks known mineral deposits where it is exposed close to the study area, and because no important deposits are known to exist where the fault zone is extensively exposed 10 mi to the northwest in the Bristol Mountains. Accordingly, the mineral resource potential for gold in these areas is low, with a C certainty level.

Oil and Gas

There is no potential for oil and gas within the crystalline rocks of the Granite Mountains. Cenozoic basin sediments north and northwest of the Granite Mountains provide a possible environment for oil and gas if the sediments are thick enough, but gravity data suggest that these sediments are less than 1,000 ft thick. Oil and gas resources are unlikely to be present unless the sediments are much thicker. The potential for oil and gas resources in areas underlain by Cenozoic materials is low, with a D certainty level.

Limestone

Limestone marble, if highly calcareous, can constitute a resource. At the Comanche mine and the Iron Victory prospect, marble is magnesian according to analyses by the U. S. Bureau of Mines; much of the marble elsewhere in the study area is siliceous. Highly calcareous marble may occur locally along the east border of the study area southeast of the Comanche mine, where several acres of white calcareous marble, probably correlative with the unmetamorphosed Monte Cristo Limestone, are present a few hundred feet outside the east border (NW section 36, T.9N., R.12E.). Metamorphosed Monte Cristo Limestone is mined elsewhere in the Mojave Desert. However, the Monte Cristo Limestone was not recognized within the study area, and so the mineral resource potential for limestone marble within a small area in the eastern part of the study area is low with a C certainty level.

Perlite

Perlite is present in Tertiary volcanic rocks in the Old Dad Mountains adjacent to the southwest corner of the study area. The Tertiary volcanic rocks are undoubtedly present in small areas beneath alluvium in the study area southwest of the Bristol Mountains fault zone (fig. 2). Perlite was not observed within the wilderness study area, but could be present under a veneer of alluvium southwest of the Bristol Mountains fault zone; therefore, the potential for perlite resources is low with a C certainty level.

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APPENDIXES

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

LOW mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is permissive. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

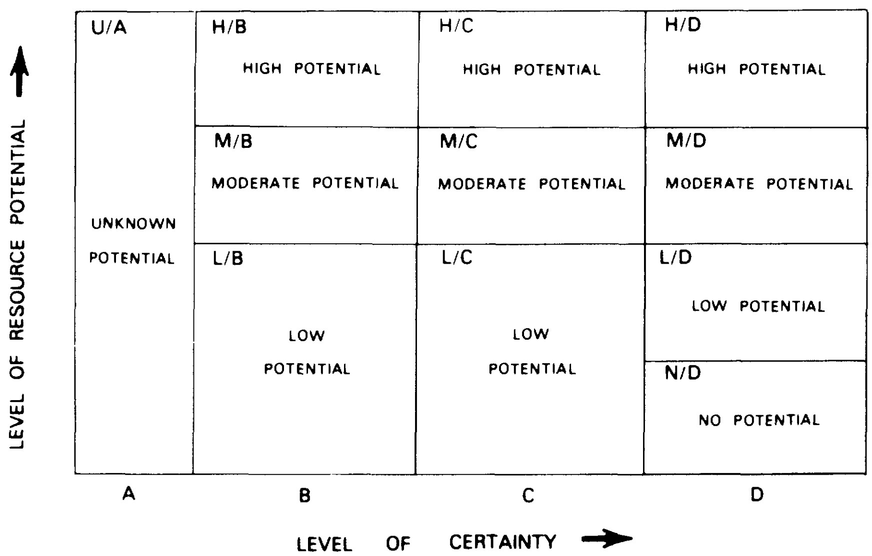
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data supports mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign low, moderate, or high levels of resource potential.

NO mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

Levels of Certainty



A. Available information is not adequate for determination of the level of mineral resource potential.
B. Available information suggests the level of mineral resource potential.
C. Available information gives a good indication of the level of mineral resource potential.
D. Available information clearly defines the level of mineral resource potential.

Abstracted with minor modifications from:

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RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, p. 5.

GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey in this report

EON	ERA	PERIOD		EPOCH	AGE ESTIMATES OF BOUNDARIES (in Ma)
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				(3800?)
pre-Archean[2]					4550

[1]Rocks older than 570 Ma also called Precambrian, a time term without specific rank.

[2]Informal time term without specific rank.

TABLE 1. *Mines and prospects in and adjacent to the Bristol/Granite Mountains Wilderness Study Area*

Map no.	Name	Geology	Workings	Sample data
1	Unknown	Milky quartz vein, 1 ft thick and 100 ft long, in granodiorite.	One 12- by 10-ft pit.	One sample--no significant values.
2	Comanche mine	Wedge-shaped pod of chalcopyrite-bearing magnetite 20 ft long, 3 ft thick, and 19 ft wide, replaced marble along the footwall of fault in upper adit. Pod originally contained about 110 tons, of which about 10 remain. Interstitial malachite and azurite occur in zone of fault breccia 40 ft long and 2 ft thick. Less than 50 tons of mineralized breccia remain. Deposit is in 400-ft-long roof pendant of marble in diorite and quartz monzonite.	Two adits, one pit. Upper adit: 70 ft of drift, one stope open to surface, winze to lower level (unmapped). Lower cross-cut adit: 205 ft long, no mineralized structures.	Two chip samples of magnetite contain 42.5% iron; a grab sample from the loading bin contains 10.7% iron, 0.86% copper, and .38 oz/ton silver. Four chip samples across the fault breccia average 2.5% copper (range 0.05-5.0) and 0.3 oz/ton silver range 0.21-0.68). Two chip samples of marble contain 40.8 and 44.8% CaO, and 15.6 and 13.8% MgO, respectively.
3	Unknown	Green malachite stain on diorite at portal. No other mineralized structures.	One adit, 104 ft long.	Three samples--no significant values.
4	Golden Legend Nos. 1 and 2	Milky quartz veins, as thick as 7 ft and as long as 40 ft, in quartz monzonite.	One pit.	Three samples--no significant values.
5	Unknown*	Disseminated chrysocolla and pyrite in altered quartz monzonite.	One pit.	One sample--0.115% copper, 0.16% zinc, 0.09% lead, and 0.1 oz/ton silver.
6	Silver Lode mine*	Sulfides and secondary minerals containing silver, lead, zinc, and copper disseminated along altered joints in granite and in the quartz veins. Altered zones and veins range from less than 1 in. to 1 ft thick; most are less than 6 in. thick.	Two adits, 200 and 85 ft long, three shafts, five pits, and one trench.	Twenty-seven samples were collected. Selected and grab samples contained as much as 0.12 oz/ton gold, 1.8 oz/ton silver, 0.30 copper, 1.1% lead, and 3.8% zinc. Chip samples averaged 0.005 oz/ton gold, 0.114 oz/ton silver, 0.02% copper, 0.13% lead, and 0.33% zinc
7	Unknown	East-northeast-trending zone of en-echelon quartz veins in altered granite is more than 2,000 ft long. Individual veins as thick as 3 ft and as long as 100 ft.	One pit.	Three samples--no significant values.
8	Iron Victory prospect (patented)	Lenses of magnetite and hematite with some chalcopyrite occur in a 400 x 150-ft skarn zone in a roof pendant of marble in diorite and granite.	One cut, one pit.	About 110,00 tons of iron-rich rock average 47.2% iron; the largest single body contains about 30,000 tons. About 150,000 tons of marble average 41.0% CaO and 11.7% MgO. Five samples of iron-rich rock and four of limestone were collected.

*Outside study area

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March 3, 1849