# Mineral Resources of the Providence Mountains Wilderness Study Area, San Bernardino County, California

## U.S. GEOLOGICAL SURVEY BULLETIN 1712–D

Chapter D

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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 Providence Mountains Wilderness Study Area (CDCA-263), California Desert Conservation Area, San Bernardino County, California.

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CENTRAL CALIFORNIA DESERT CONSERVATION AREA

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## SUMMARY

### Abstract

The Providence Mountains Wilderness Study Area (CDCA-263) lies within the eastern Mojave Desert about 35 mi southeast of Baker, Calif., and the part on which mineral surveys were requested encompasses about 63,300 acres in the northern Providence Mountains and the Colton Hills and is contiguous with the Providence Mountains State Recreation Area. Geological, geochemical; geophysical, and mineral surveys of the study area were conducted by the U.S. Geological Survey and U.S. Bureau of Mines between 1982 and 1985 to appraise the identified mineral resources (known) and to assess the mineral resource potential (undiscovered) of the area.

The study area includes parts of the Trojan mining district. More than 700 workings and mineralized outcrops were examined during this study, including 467 workings within the study area; in this report they are grouped into 162 properties. Twelve mines in and near the study area produced at least 6,425 tons of ore containing about 300 oz of gold, 92,000 oz of silver, 25,000 lb of copper, 72,000 lb of lead, and 2,300 lb of zinc. The Vulcan mine-Burro prospect on the south boundary of the study area produced 2.6 million long tons of iron. Eight properties within and on the boundary of the study area contain a total of about 310,000 tons of indicated and (or) inferred subeconomic gold and (or) silver resources. Two properties contain a total of 340,000 long tons of indicated or inferred subeconomic iron resources ranging from 50 to 60 percent iron, and the Vulcan mine-Burro prospect contains a subeconomic iron resource of about 3 million long tons. The study area also contains large deposits of subeconomic limestone, dolomite, quartzite, sand and gravel, and stone resources.

Much of the central part and the southeast corner of the study area have high or moderate mineral resource potential for gold, silver, copper, lead, zinc, and tungsten in quartz vein and carbonate-replacement deposits. Smaller regions in the south-central and southeastern parts of the study area show high or moderate potential for iron resources associated with skarn deposits. An unknown potential is present in the north-central part of the study area for molybdenum resources and for gold and silver resources in low-grade bulk-tonnage deposits. An unknown potential for oil and gas resources occurs along the western edge of the study area. The entire study area has a low potential for undiscovered resources of gold in alluvium, uranium, geothermal energy, limestone, dolomite, and quartzite for industrial use and voluminous deposits of sand, gravel, and dimension stone. Much of the rock underlying the rugged terrain adjoining the Providence Mountains State Recreation Area on the west has no or low potential for mineral resources, as does the mesa area in the northern Colton Hills. In this report, any reference to the Providence Mountains Wilderness Study Area refers only to that part of the wilderness study area for which mineral surveys were requested.

## Character and Setting

The Providence Mountains Wilderness Study Area comprises most of the Providence Mountains north of Foshay Pass, east of Kelso and the Union Pacific Railroad, and south of roads traversing Macedonia and Wild Horse Canyons, and includes much of the Colton Hills west of Black Canyon Road (fig. 1). Bordering the southeastern part of the study area is the Providence Mountains State Recreation Area. The study area includes rugged, sparsely forested mountains exceeding 7,000 ft in elevation, 500- to 1,000-ft-high mesas north of the Colton Hills, and lowland hills and plains at about 3,400 ft elevation in the Colton Hills and at 2,200 ft elevation near Kelso.

The study area is underlain by diverse rock types that represent a long and complex geologic history. Outcrops of Proterozoic (see geologic time chart in

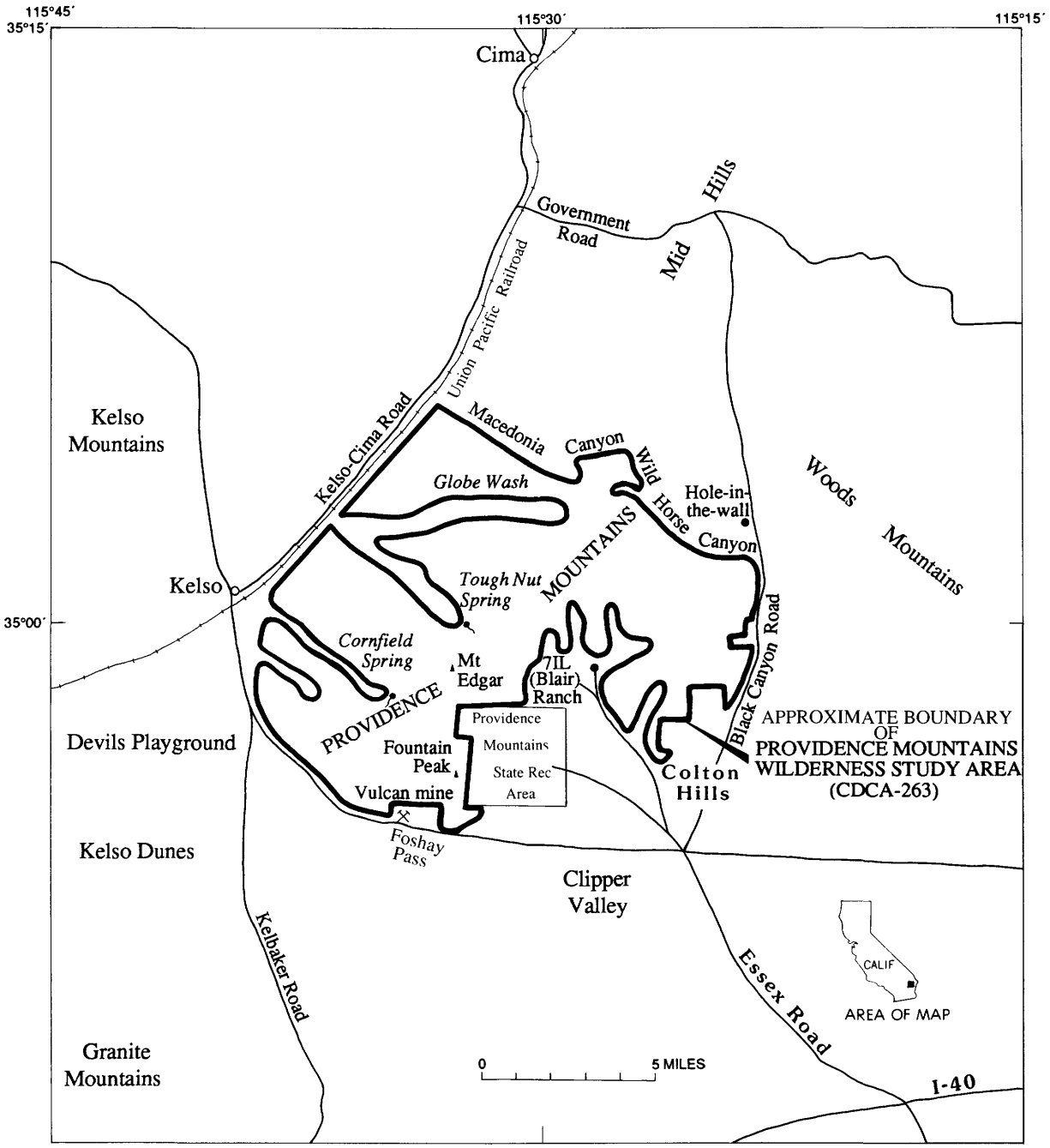


**Figure 1.** Location of the Providence Mountains Wilderness Study Area, San Bernardino County, California.

appendix for explanation of rock ages) gneiss and granite are widespread in the northern part of the study area. A thick sequence of Paleozoic sandstone, limestone, and dolomite is found at the higher elevations in the Providence Mountains. Jurassic and Cretaceous granitoid rocks of varying composition are widespread in the Colton Hills, in the northern and western parts of the study area, and in the Foshay Pass area. Tertiary volcanic rocks underlie prominent mesas south of Wild Horse Canyon. High-angle faults cut all of these units and have in many places controlled mineralization.

### Identified Resources

Eight properties within or bordering the study area contain a total of about 310,000 tons of indicated and (or) inferred subeconomic gold and (or) silver resources with associated copper, lead, and zinc. These deposits range in size from 10,000 to 110,000 tons. Also within or on the border are three occurrences of gold, ranging from 500 to 3,700 tons, and one occurrence each of silver-lead, 1,300 tons; silica, 9,900 tons; and dolomite, approximately 12 million tons. Two properties contain a total of about 340,000 long tons of indicated and inferred subeconomic iron resources ranging from 50 to 60 percent iron. Near but outside the study area are two mines with indicated or inferred subeconomic silver and (or) gold resources totaling about 43,000 tons and an inferred subeconomic iron resource totaling about 3 million long tons. Voluminous subeconomic deposits of limestone, dolomite, sand and gravel, and stone within the study area are not likely to be developed in the near future due to their relatively low bulk values and the high transportation costs to currently distant markets. Minor petrified wood and fossil localities may be subject to occasional recreational use, but are not considered an identified resource.

### Mineral Resource Potential

A belt along the east side of the Providence Mountains, parallel to the East Providence fault, defines an area of high potential for silver, gold, copper, lead, zinc, and tungsten in quartz vein and carbonate-replacement deposits (fig. 2). Many of the past producing mines from the Trojan mining district are within this belt or adjacent to it (within 1 mi) outside the study area boundaries. This belt is bordered to the west, south, and northeast by areas of moderate potential for most of these resources in the same deposit types. A small region in the southwestern part of the study area, adjacent to the Rex mine, also has high potential for gold and silver in quartz veins. The north half of the Colton Hills has moderate potential for these resources in the same type of vein deposits.

A high resource potential for iron in skarn deposits exists north of the Vulcan mine, near the south boundary of the study area. An adjacent area and one area on the northwest side of the Colton Hills have a moderate potential for iron in skarns. An unknown potential for molybdenum in a porphyry system is associated with felsic intrusions, breccia, and intense quartz-sericite alteration in upper Globe Wash. Intensely altered and silicified rocks along the ridge northeast of Summit Spring delineates a tract having unknown potential for low-grade bulk-tonnage gold and silver. The entire study area has a low resource potential for gold in placer deposits, uranium, and geothermal energy, and unknown potential for oil and gas along the western boundary.

Industrial limestone, dolomite, quartzite, and dimension stone locally occur in the study area, but the materials are highly faulted and generally impure; therefore the study area has low mineral resource potential for these commodities. The likelihood of developing these potential resources and potential sand and gravel resources is also low, due to rugged terrain and long distances to current markets.

Although nearly half of the study area contains areas of moderate or high mineral resource potential, much of the region encompassing the high peaks west of the Providence Mountains State Recreation Area and all of the northern Colton Hills underlying the prominent mesas has low or no resource potential for a variety of minerals, as shown on Figure 2 and Plate 1.

## INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management and is a joint effort by the U.S. Geological Survey and the U.S. Bureau of Mines. An introduction to the wilderness review process, mineral survey methods, and agency responsibilities were provided by Beikman and others (1983). 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). 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. Mineral assessment methodology and terminology as they apply to these surveys were discussed by Goudarzi (1984). See the appendixes for the definition of levels of mineral resource potential, certainty of assessment, and classification of identified resources.

The Providence Mountains Wilderness Study Area (CDCA-263) encompasses approximately 63,300 acres in the northern Providence Mountains and Colton Hills, San Bernardino County, Calif. The study area boundaries are approximately defined on the south by a dirt road through Foshay Pass, on the west by Union Pacific Railroad tracks, on the north by roads through Macedonia Canyon and Wild Horse Canyon, and on the east by Black Canyon Road and the Providence Mountains State Recreation Area (fig. 1). Paved and improved dirt roads provide access to the study area and a few unimproved dirt roads provide access within the study area. Elevations range from 7,048 ft on Mt.

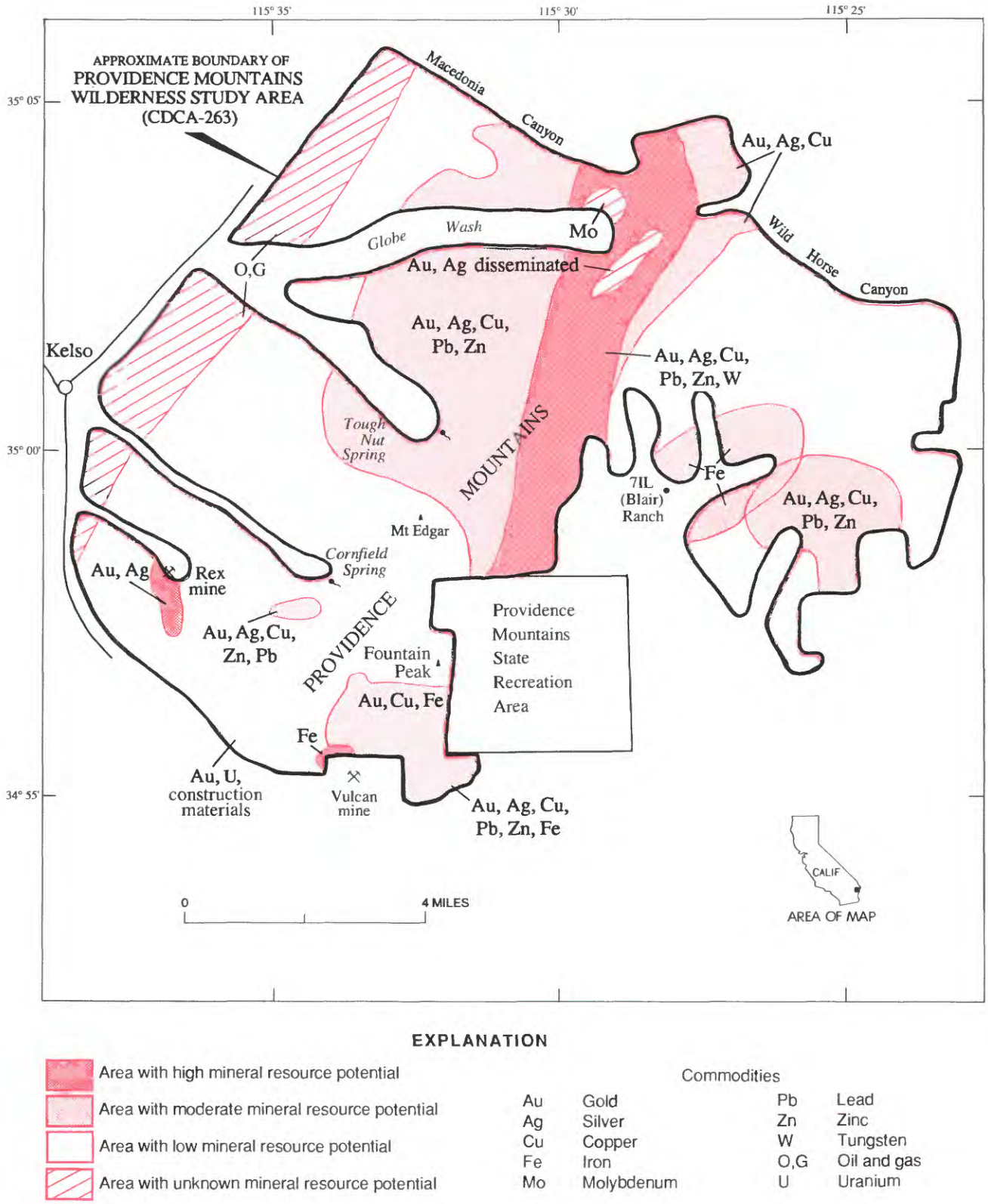


**Figure 2.** Generalized mineral resource potential for the Providence Mountains Wilderness Study Area, San Bernardino County, California.

Edgar in the Providence Mountains to 2,200 ft on the west in Kelso Valley and to 3,200 ft on the east in upper Clipper Valley. Most of the Providence Mountains within the study area are extremely rugged and parts of the northern Colton Hills have nearly vertical cliffs bounding flat-topped mesas.

A report by Hazzard (1954) represents the only comprehensive study of the stratigraphy and structure of the northern Providence Mountains. Stewart (1970) and Stone and others (1983) correlated the Paleozoic sedimentary rocks of the Providence Mountains with equivalent sequences in the Mojave Desert and Death Valley regions. Miller and others (1982) presented an overview of the late Mesozoic plutonism to the southwest and Beckerman and others (1982) described an extensive tract of plutons to the north.

A detailed account of the early mining history of the Providence Mountains is given in Vredenburgh and others (1981). Description of some of the more significant mining activity is included in various reports of the California State Mineralogist and the California Journal of Mines and Geology (Tucker and Sampson, 1930, 1931, 1943; Lamey, 1948; Eric, 1948; Wright and others, 1953; Goodwin, 1957). Hewett (1956) described a few of the mines along the north border of the study area. Miller and others (1985) discussed the mineral resources and geologic setting of the southern Providence Mountains, immediately south of the study area.

The U.S. Bureau of Mines (USBM) studied mines and prospects within and adjacent to the study area, investigated the mining and production history, and assessed the identified (known) mineral resources. This involved searching the literature, obtaining information from claim owners and from U.S. Bureau of Land Management (BLM) claim records, examining the workings, and analyzing the 1,259 samples collected in the field (Moyle and others, 1986; additional information and copies of this report are available from the U.S. Bureau of Mines Western Field Operations Center, E. 360 Third Avenue, Spokane, WA 99202). Identified resources are classified according to the system of the U.S. Bureau of Mines and U.S. Geological Survey (1980). The U.S. Geological Survey (USGS) carried out and integrated geological, geochemical, and geophysical investigations to assess the mineral resource potential (undiscovered resources) of the study area. Rock units, structure, and altered areas were mapped and described, and some igneous rocks and alteration products were isotopically dated. Folger and others (1986) presented the analytical results from a geochemical drainage-basin reconnaissance survey of the northern Providence Mountains, and of rock-chip samples from some of the major mines and prospects within the study area. Isostatic residual gravity and localized electrical geophysical surveys were also conducted. Aeromagnetic data were extracted from two regional studies (U.S. Geological Survey, 1981, 1983). Mineral resource potential is classified according to the system of Goudarzi (1984).

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American Copper and Nickel Co., Wheat Ridge, Colo.; U.S. Minerals Exploration Co., Arvada, Colo.; Sampson Engineering, Weaco Resources, Ltd., and Bolero Mines, Inc., of Vancouver, British Columbia, provided exploration data that helped the USBM appraise several properties. Frank and Barbara Kirnig, Donald Sterner, and George Warren provided helpful data pertaining to their mining claims.

## APPRAISAL OF IDENTIFIED RESOURCES

By Phillip R. Moyle, Jerry E. Olson, and
Richard S. Gaps
U.S. Bureau of Mines

### Mining and Exploration History

Exploration and mining in the region began in 1863, and more than 1,200 mining claims have been located since 1900. In 1982, nearly 300 mining claims in and contiguous to the study area remained actively held. Oil and gas leases and lease applications were filed on approximately 18,000 acres within the study area. The leases cover the basins around the study area and generally exclude the higher elevations except for a few square miles south of Cornfield Spring. San Bernardino County mining claim records were incomplete prior to 1900, but thereafter were relatively complete and show peaks in activity from 1900 to 1910, 1930 to 1940, about 1960, and about 1980. Since the earliest documented production in 1871, at least 14 mines within and adjacent to the study area have produced one or more of the following commodities: gold, silver, copper, lead, zinc, tungsten, and iron. (Recorded production by mine is listed in table 1.) From 1871 to 1980, mineral production records exist for 45 of the years. The mines within and adjacent to the study area have a total recorded production of 298 oz gold; 91,662 oz silver; 25,398 lb copper; 72,214 lb lead; and 2,312 lb zinc. Because of incomplete data, the reported figures are probably far less than actual production.

A detailed account of the early mining history of the Providence Mountains is recorded in Vredenburgh and others (1981). Mining began with the discovery of silver and the organization of the Rock Spring mining district immediately north of the study area. The town of Providence was founded in late 1863 in Macedonia Canyon and by November 1864 the Macedonia mining district was established. The

Macedonia mine (later known as the Caster-Pollux and the Columbia mine) (fig. 3, No. 23) was apparently discovered during this time. When Indian raids began in 1866, the district was abandoned. During a resurgence of mining in 1871 and 1872, 15 tons of ore (unknown type, valued at $650 per ton at that time) were shipped from the Macedonia mine (Moyle and others, 1986).

The Trojan mining district was organized in April 1880 after high-grade silver ore was discovered at the

**Table 1.** Recorded production from nonferrous metallic lode deposits within and adjacent to the Providence Mountains Wilderness Study Area

[*, outside study area; **, partly within study area; NR, not reported. Underlined name is mine of record]

| Map No. (fig. 3) | Property name | Year of production | Tons produced | Gold produced (oz) | Silver produced (oz) | Copper produced (lb) | Lead produced (lb) | Zinc produced (lb) | Reference |
|---|---|---|---|---|---|---|---|---|---|
| 10 | Silver Buddy mine | 1965 | 10 | NR | 22 | 1 | 142 | NR | U.S. Bureau of Mines statistical files. |
| 18* | Blue Rock Nos. 1-6 mine (Confidence Copper mine) | 1918 | 200 | NR | 2,435 | 10,626 | NR | NR | Hewett, 1956, p. 143. |
| 22* | Francis mine | 1917-1918 | 200-307 | NR | 2,377 | 10,626 | NR | NR | U.S. Bureau of Mines statistical files; Tucker and Sampson, 1930, p. 213, 1931, p. 272. |
| 23* | Castor-Pollux mine (Macedonia mine) | 1871-1872 | 15 | NR | NR | NR | NR | NR | Vredenburgh and others, 1981, p. 89. |
| | (Columbia mine) | 1926-1938 | 142 | 89.11 | 2,167 | 2,726 | 100 | NR | U.S. Bureau of Mines statistical files. |
| 38* | SS Nos. 20-22, 27-29 mine, south (Star[?] mine) | 1898-1901 | NR | 16.93 | NR | NR | NR | NR | U.S. Bureau of Mines statistical files. |
| 64<br>69 | Frisco No. 3 mine or Double H Nos. 1 and 2 mine | 1930-1931 | 106 | 44.11 | 54 | 329 | NR | NR | U.S. Bureau of Mines statistical files. |
| 72 | Providence mine | 1918 | 12 | NR | 445 | 166 | 2,465 | NR | U.S. Bureau of Mines statistical files. |
| 96* | Jo Je mine | 1937-1942 | 185 | 72 | 392 | NR | NR | NR | U.S. Bureau of Mines statistical files. |
| 122** | Rex mine | 1934-1951 | 126+ | 12 | 9 | NR | NR | NR | U.S. Bureau of Mines statistical files; Wright and others, 1953. |
| 144 | Silver King mine (Perseverance mine) | 1918-1920 | 20 | 6.98 | 1,489 | 11 | 232 | NR | U.S. Bureau of Mines statistical files. |
| 146* | Bonanza King mine | 1901-1960 | 5,302+ | 56.57 | 82,272 | 913 | 69,275 | 2,312 | U.S. Bureau of Mines statistical files. |
| 150<br>153 | Grande 1-7 mine or Max Dor 1 and 2 mine | 1980 | 100 | NR | NR | NR | NR | NR | Vredenburgh, 1982, p. 37. |

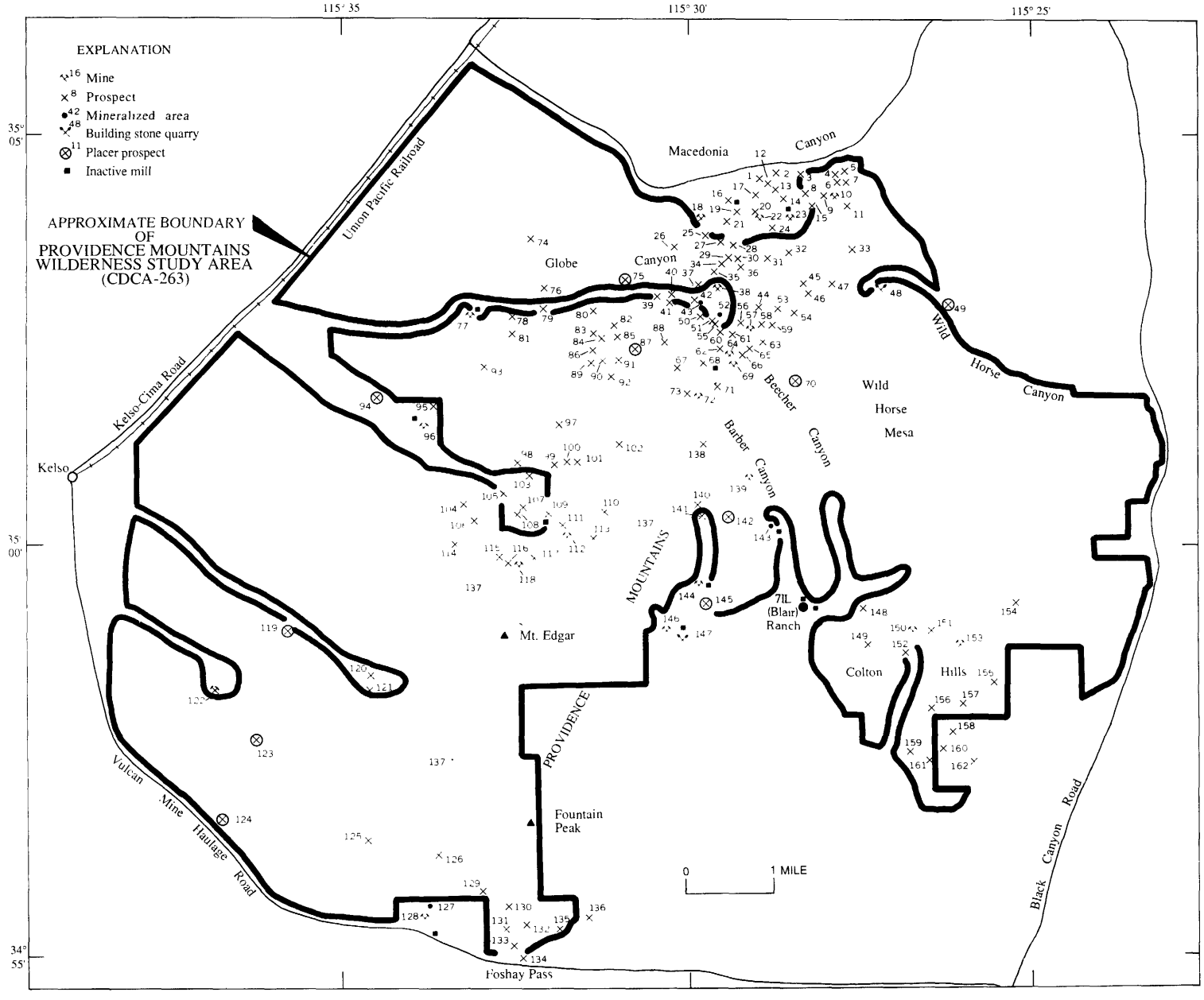


**Figure 3.** Location of mines, prospects, mineralized outcrops, and land status in the Providence Mountains Wilderness Study Area, San Bernardino County, California. Numbers refer to tables 1, 2, and 5.

Bonanza King mine (fig. 3, No. 146) (Dudley and Fickewirth, 1941). The Trojan district subsequently evolved into three smaller mining districts: the Gold Belt district on the west side of the Providence Mountains, the Providence Mountain/Brightwood district on the north side, and the Trojan/Providence district on the east side (Crossman, 1890, p. 223; Hill, 1912; Clark, 1970; and Wong, 1983). Many claim notices for this area also refer to a Kelso mining district.

The Bonanza King mine was producing silver and lead by 1883. Development consisted of approximately 20,000 ft of underground workings to a depth of 800 ft (Wright and others, 1953, p. 72-73), and it is by far the largest underground mine in the Providence Mountains. DeGroot (1890, p. 532) reported that production yielded $60,000/month from ore averaging $100/ton for a total production in the 1880's of $1.8 million (The Mining World, 1906, p. 225). Production ended when the original 10-stamp mill burned to the ground in July 1885.

After closure of the Bonanza King mine, exploration and mining in the 1890's spread southward to the mountains south of Foshay Pass. Exploration was renewed in the northern Providence Mountains about 1900 and resulted in the discovery of several gold and silver deposits and of iron deposits in Foshay Pass and the southwestern part of the study area. The Bonanza King mine reopened for a short time in 1901 and intermittently thereafter.

Mining in the Providence Mountains increased during World War I, but production up to World War II from the Castor-Pollux (Columbia mine, Macedonia mine), Globe, Frisco No. 3, Double H 1 and 2, Jo Je, and Rex mines (fig. 3, Nos. 23, 57, 64, 69, 96, and 122) was sporadic. The Vulcan mine (fig. 3, No. 128), operated by Kaiser Steel Corp. from 1942 through 1947, produced 2.6 million tons of blast-furnace-grade iron ore from a large open pit in Foshay Pass, 0.25 mi south of the study area. After World War II, only minor mineral production was reported from the Silver Buddy, Rex, Bonanza King, Grande 1-7, and Max Dor 1 and 2 mines (fig. 3, Nos. 10, 122, 146, 150, and 153). Within what is now the Providence Mountains State Recreation Area on the southeast side of the study area, several mines and prospects (Bell McGilroy, Mitchell, Mexican, and others) were worked primarily from the 1940's to the early 1960's (Wright and others, 1953; U.S. Bureau of Mines, statistical files).

In the early 1960's, U.S. Steel Corp. explored for a hypothetical eastward extension of the "Vulcan" iron body in Foshay Pass; exploration extended as far east as the 71L (Blair) Ranch. Several other exploration and preliminary development programs were initiated in the Providence Mountains after 1960, especially following the increase in precious-metal prices in 1974.

Since 1969, the area between Summit Spring and Macedonia Canyon has been the focus of molybdenum and gold exploration programs by Geodata, Inc., Rioamax, American Copper and Nickel Co., and, currently, U.S. Mineral Exploration Co. Piute Canyon Mines, Inc., of Bishop, Calif., and Raines Resources of Canada have located claim groups within the Summit Spring and Globe Wash area.

Since the late 1970's, an intensive exploration and preliminary development program for gold and silver by Weaco Resources, Ltd., and Bolero Mines, Inc., of Canada, has centered on the Bonanza King mine. Production Exploration Resources of Tonopah, Nev., has been exploring the nearby Silver King mine. Brownstone Mining Co., in 1979, experimented on tailings from the Bonanza King and Silver King mines with a pilot agitation-vat cyanide-leach plant located at the original Bonanza King mill north of the 7IL (Blair) Ranch. The metallurgical and recovery results are proprietary.

## Mines, Prospects, Claims, and Mineralized Outcrops

Lode mines, prospects, and claims, except for those in the Colton Hills area, are found in a belt that trends north to northeast from Foshay Pass to Macedonia Canyon and roughly parallels the trend of the East Providence fault (pl. 1). Precious- (gold and silver) and base- (copper, lead, zinc) metal assemblages are predominant in this belt. The deposits and occurrences are generally structurally controlled, but some metasomatic replacements occur in carbonate rocks. These metallic deposits and occurrences may be grouped into the six geographic areas discussed below according to host rock, mineral or metal assemblage, and type of occurrence. Additionally, placer gold occurrences, iron, molybdenum, and industrial minerals are described in the following sections. Pertinent data on the mines, prospects, and mineralized outcrops are summarized in table 5 (in appendix).

### Gold, Silver, Copper, Lead, and Zinc

Twenty-four properties (fig. 3, Nos. 1-24), including four past producers of gold, silver, copper, and lead, are on northeast- to east-northeast-trending, generally southeast-dipping quartz veins, shear zones, and faults that cut the Mid Hills Adamellite of Beckerman and others (1982) and Proterozoic gneiss in the Macedonia Canyon area. In this area, 7 shafts, 1 adit, 6 trenches, and 20 pits are within or on the border of the study area; and 17 shafts, 11 adits, 6 trenches, and 58 pits are adjacent to the study area. Mineralized zones commonly exhibit evidence of several episodes of brecciation and cementation; gneissic wallrock is generally intensely altered and replaced with silica. Pyrite, chalcopyrite, galena, sphalerite, and their oxidation products are present in quartz veins and silicified zones. Fluorite was observed in veins and wallrock at several properties and traces of wolframite, scheelite, and huebnerite were detected in petrographic and microprobe analyses of samples from the Blue Rock Nos. 1-6 mine (Confidence Copper mine) (fig. 3, No. 18). The properties in the Macedonia Canyon area are generally distinguished from those to the south in the Globe Canyon and Summit Spring area by their higher silver-to-gold ratios, a greater abundance of base metals, and their proximity to the Mid Hills Adamellite. The majority of these properties lie near the East Providence fault zone, which suggests a genetic link.

Thirty-nine mines and prospects (fig. 3, Nos. 25, 27-38, 42-48, 50, 51, 53-66, 68-69, and 71), including four past producers of gold, silver, and copper (table

1), are in the Globe Wash-Summit Spring area, within 1 mi of the East Providence fault zone. In this area, 29 shafts, 43 adits, 4 trenches, and at least 63 pits are within or on the border of the study area; and 3 shafts, 2 adits, 1 trench, 3 pits, and 2 isolated outcrops are within a corridor excluded from the study area. Mineralized zones generally are comprised of northeast- to east-trending quartz veins, shear zones, faults, and brecciated felsic intrusions in deeply weathered, intensely hydrothermally altered Proterozoic gneiss. The mineralized properties in the Globe Wash-Summit Spring area differ from those to the north by higher gold-to-silver ratios, the general lack of significant concentrations of base metals, and proximity to small masses of leucocratic granite. Gold values are especially high along the northeast-trending ridge from Summit Spring to the Globe mine (No. 57). At least one company was exploring for large-tonnage, low-grade gold deposits in the Globe Wash-Summit Spring area in 1984.

Common metallic minerals in the Globe Wash-Summit Spring area are pyrite, limonite pseudomorphs of pyrite, and some galena and secondary copper minerals. Mineralized structures are generally exposed for 100 ft or less, but some can be traced for as much as 1,500 ft. Propylitic alteration is widespread in the gneissic rocks, becoming more pervasive and intense near mineralized zones. Sericitic alteration of wall rock is common along quartz veins. Felsic intrusions occur as massive dikes or sills and as irregularly shaped, silica-cemented (collapse?) breccias but are invariably altered to quartz and sericite. One concentric, pipe-like intrusive body is exposed 1 mi northwest of Summit Spring in upper Globe Wash.

The surface expression of the north-northeast-trending East Providence fault zone in the Globe Wash-Summit Spring area is less distinct than in areas where it cuts carbonate rocks. Here the fault zone is wide, intensely deformed, and generally manifested as a topographic depression from Summit Spring to about 1 mi to the north near the SS Nos. 20-22, 27-29 mine, south (Star? mine) (fig. 3, No. 38). Rocks along both sides of the fault zone, especially in the hanging wall on the east, are intensely altered and commonly brecciated and silicified, as is the ridgeline north of Summit Spring. As in the Macedonia Canyon area, the East Providence fault zone obliquely cuts the gneissic foliation and earlier normal faults, and probably acted as the primary conduit for mineralizing solutions.

In the Tough Nut Spring area (fig. 3, Nos. 95-117), 16 of 23 nonferrous metal mines and prospects contain significant concentrations of gold, silver, copper, lead, and (or) zinc; the Jo Je mine (fig. 3, No. 96) has produced gold and silver. In this area, 8 shafts, 19 adits, 2 trenches, and at least 45 pits are within or on the boundary of the study area; 7 shafts, 5 adits, 3 trenches, and 16 pits are within a corridor excluded from the study area. Mineralized structures are northeast- to east-trending quartz veins, shears, and faults in Proterozoic gneiss, the Jurassic Ivanpah Granite of Beckerman and others (1982), the Cretaceous Mid Hills Adamellite, and Paleozoic carbonate rocks in close proximity to the Ivanpah Granite. Mineralized zones in gneiss are generally intensely chloritized and iron oxide stained. Fracture-filling specularite veinlets are common. Galena, limonite after pyrite, and secondary copper minerals are the most common metallic minerals observed in igneous rocks in this area. A north-northeast-trending set of felsic dikes, probably related to the Mid Hills Adamellite, intruded both the Proterozoic and Jurassic rocks in this area and may be related to the mineralizing events. In general, silver and gold are widespread in this area and the silver-to-gold ratio is approximately 10:1. Lead is more common than zinc, and copper content is erratic. Anomalous concentrations of molybdenum were detected in several occurrences associated with the Mid Hills Adamellite.

Five carbonate-hosted deposits, which contain high-grade silver- and gold-bearing replacement pods and lenses along faults and shear zones, are clustered around the Tough Nut mine (fig. 3, No. 112). Minerals consist predominantly of silver sulfosalts and lead and copper carbonates. The mineralized zones at the Tough Nut mine are geologically very similar to those at the Silver King and Bonanza King mines (fig. 3, Nos. 144 and 146).

The base- (copper, lead, zinc) and precious- (gold, silver) metal prospects in the Foshay Pass area (fig. 3, Nos. 126, 129-133) are found in carbonate rocks commonly within a few hundred feet of their irregular contacts with the Tertiary Fountain Peak Rhyolite of Hazzard (1954). In this area, 5 shafts, 11 adits, 7 trenches, and 5 pits are within the study area; and, in addition to the Vulcan mine-Burro prospect iron-skarn (fig. 3, No. 128) developments, 7 trenches, 1 pit, and a network of exploration and drill roads are adjacent to the study area. Mineralized zones are generally associated with north-northwest-trending, vertical or southwest-dipping faults or shear zones roughly parallel to the intrusive contact. Carbonate rocks near these zones are commonly silicified, but may be friable and bleached; yellow or white calcite veinlets are common. Malachite and azurite are present as blebs in limestone or as encrustations in fractured and altered zones throughout most of the workings. Minor chalcopyrite, galena, smithsonite, possible bornite, and traces of cinnabar and iodyrite (AgI) were observed in petrographic and microprobe analysis.

In the southern part of the East Providence fault zone between the Providence mine (fig. 3, No. 72), 0.5 mi south of Summit Spring, and the Bonanza King mine (No. 146), 3.5 mi to the south, the fault zone juxtaposes carbonate rocks against sheared Proterozoic gneiss. In this area, 2 shafts, 2 adits, and 3 pits are within the study area, and 6 shafts, 16 adits, 1 tunnel, 17 trenches, and 23 pits are adjacent to the study area. Three carbonate-hosted deposits along this segment of the fault, the Providence, Silver King (fig. 3, No. 144), and the Bonanza King mines, are past producers of gold, silver, copper, lead, and zinc (table 1). These deposits are found as replacements or cavity fillings in deformed, mostly finely brecciated carbonate rocks; the breccia zones apparently were mineralized as or before they were healed with pyrite (later altered to iron oxides) and calcite and (or) silica. Mineralized zones are subparallel to the East Providence fault at the Providence mine, along cross breaks (tension fractures) at the Bonanza King mine, and along splinter faults at the Silver King mine.

Although minor amounts of sulfide minerals--galena, sphalerite, and pyrite--are visible, most of the metallic minerals are carbonates such as cerussite and smithsonite, oxides such as hematite, and sulfosalts, such as cerargyrite or bromyrite. Minor gold-bearing occurrences east of the fault (for example, fig. 3, No. 138), are found in sheared and altered gneissic rocks and are mineralogically distinct from the carbonate-hosted deposits.

In the northern Colton Hills, 9 of 15 mines and prospects contain anomalous concentrations of gold, silver, lead, copper, iron, and barium. In this area, 13 shafts, 8 adits, 13 trenches, and 42 pits are within the study area, and 2 shafts, 2 adits, and 7 pits are adjacent to the study area. All of the workings are on veins, shears, or fault zones in Jurassic granitic rock. Three deposits show significant mineralization: (1) the Grande 1-7 mine (fig. 3, No. 150) is developed on a northwest-trending, northeast-dipping, 400-ft-long silicified shear zone with significant gold and silver concentrations; (2) the adjacent Max Dor 1 and 2 mine (fig. 3, No. 153) contains about 2,600 ft of quartz veins, which strike east and dip to the north, and a 300-ft fault that trends northwest and dips northeast; (3) the Gold Star prospects (fig. 3, Nos. 154 and 155) to the east have randomly oriented, mineralized veins and shears within a northeast-trending, intensely altered zone 60 to 400 ft wide and as long as 1.5 mi.

Of 23 remaining precious- and base-metal properties within and adjacent to the study area, most (fig. 3, Nos. 26, 39-41, 67, 73, 74, 76, 77, 79-86, 88, and 93) are situated in the west Globe Wash-Summit Wash area. Two lie in excluded corridors in the southwestern part of the study area (Nos. 120 and 122) and two lie in the Barber Canyon area (Nos. 138 and 139). The Okaw mine (No. 77) is a probable past producer and the Rex mine (No. 122) a known past producer of gold and silver. Mineralized zones at the Okaw mine are generally prominent, northeast-trending quartz veins in relatively fresh granitic rock, in places cut by felsic dikes. All rocks exhibit sericitic alteration and galena, limonite after pyrite, minor chalcopyrite, and sphalerite; secondary copper minerals were observed in the veins. The ore minerals at the Rex mine are in an intensely oxidized zone of massive to brecciated quartz and Jurassic granitic rock. The iron oxide zone appears to lie along the northern projection of the Hidden Hill fault (Miller and others, 1985). A prominent, gouge-filled silicified shear zone cuts Proterozoic gneiss at the Good Hope mine (No. 139). Most of the prospects developed on structures in Proterozoic gneiss in the lower Summit Wash area carry anomalous, but not currently economically significant, concentrations of precious and base metals.

## Placer Gold

Trace amounts of gold are present in the alluvium of several washes that drain the Providence Mountains. San Bernardino County and the BLM records indicate nearly 50 historic and actively held placer mining claims within and adjacent to the study area (Moyle and others, 1986). Of 39 alluvial samples from washes within and adjacent to the study area, 19 contained detectable gold. The gold is commonly very fine grained, bright, and subrounded to subangular. Only 6 samples contained gold exceeding $\$0.01/yd^3$; the highest contained $\$0.15/yd^3$ (at a gold price of \$400/oz). Generally, the placer gold is in alluvium derived from known mineralized areas such as those in Beecher Canyon, Globe Canyon, and the Summit Spring area (fig. 3, Nos. 70, 75, and 87).

Seven placer samples from the Cornfield Spring-Foshay Pass area contained gold. Although gold in two samples may have come from the Rex mine (fig. 3, No. 122), five are from washes that drain areas without known gold deposits. The source of the gold could be the Fountain Peak Rhyolite contact zone or the northwest-trending Hidden Hill fault. The latter was identified by Miller and others (1985) as related to gold and silver occurrences in the southern Providence Mountains.

## Iron

Three significant iron deposits, the Black Jack and Cornfield Springs Consolidated mines and the Vulcan mine-Burro prospect (fig. 3, Nos. 118, 121, and 128) and four iron prospects (Nos. 125, 134, 148, and 149) occur within and adjacent to the study area. Prospects 135 and 136 also were probably developed in search of iron. The iron deposits are found primarily in carbonate units near Jurassic granitic rocks (Miller and others, 1985).

The Vulcan mine open pit was developed on a magnetite-bearing, magnesium-silicate skarn along a fault-controlled contact between a syenite to quartz monzonite intrusion on the south and magnesium-rich carbonate rocks on the north. It is estimated that 3 million long tons of inferred subeconomic iron resources remain at the Vulcan mine-Burro prospect. The Black Jack and Cornfield Spring Consolidated iron mines also are in carbonate rocks, but they are 100 to 400 ft structurally above a contact with plutonic or gneissic rocks and are predominantly composed of specularite. The Black Jack mine contains 230,000 long tons of indicated subeconomic iron resources and the Cornfield Springs Consolidated mine contains 110,000 long tons of inferred subeconomic iron resources. Grades range from 50 to 60 percent iron.

## Molybdenum

In upper Globe Wash, massive felsic dikes or sills and irregularly shaped, silica-cemented (collapse?) breccias are altered to quartz and sericite. Widespread propylitic alteration in Proterozoic gneiss becomes more pervasive and intense near mineralized zones. Sericitic alteration of wall rock is common along quartz veins. The SS No. 17 prospect south (fig. 3, No. 42) contains visible grains of molybdenite (select sample yielded 0.025 percent molybdenum) along with large pyrite crystals and native sulfur after pyrite, in massive, white radial and ring quartz dikes surrounding a felsic intrusive breccia. Several companies have explored this area since 1970 on the basis of evidence suggesting a molybdenum stockwork deposit at depth. The highest molybdenum

**Table 2.** Identified mineral resources and occurrences in the Providence Mountains Wilderness Study Area

[*, outside study area; **, partly outside study area]

| Map No. (fig. 3) | Property name | Quantity (tons) | Resource classification[1/] | Weighted average oz/ton | Weighted average percent | Commodity |
|---|---|---|---|---|---|---|
| | | | Precious and base metals | | | |
| 10 | Silver Buddy mine | 1,300 | Occurrence | 3.3 | -- | Silver |
| | | | | -- | 1.24 | Lead |
| 23* | Castor-Pollux mine (Columbia mine, Macedonia mine) | 5,600 | Indicated subeconomic resources | 0.05 | -- | Gold |
| | | | | 9.1 | -- | Silver |
| | | 18,000 | Inferred subeconomic resources | 0.05 | -- | Gold |
| | | | | 9.1 | -- | Silver |
| 31 | Prospect | 35,000 | Inferred subeconomic resources | 0.04 | -- | Gold |
| | | | | 0.6 | -- | Silver |
| 32 | Dixie No. 2 prospect | 17,000 | Inferred subeconomic resources | 0.01 | -- | Gold |
| | | | | 1.0 | -- | Silver |
| 34 | SS No. 28 prospect, north | 10,000 | Inferred subeconomic resources | 0.02 | -- | Gold |
| | | | | 0.9 | -- | Silver |
| 35 | SS No. 29 prospect, north | 3,000 | Indicated subeconomic resources | 0.05 | -- | Gold |
| | | | | 1.7 | -- | Silver |
| | | 12,000 | Inferred subeconomic resources | 0.05 | -- | Gold |
| | | | | 1.7 | -- | Silver |
| 44 | Hoot Owl prospect | 500 | Occurrence | 0.32 | -- | Gold |
| 57 | Globe mine | 30,000 | Indicated subeconomic resources | 0.05 | -- | Gold |
| | | | | 1.0 | -- | Silver |
| | | 80,000 | Inferred subeconomic resources | 0.05 | -- | Gold |
| | | | | 1.0 | -- | Silver |
| 64 | Frisco No. 3 mine | 2,000 | Indicated subeconomic resources | 0.006 | -- | Gold |
| | | | | 0.2 | -- | Silver |
| | | 38,000 | Inferred subeconomic resources | 0.022 | -- | Gold |
| | | | | 0.7 | -- | Silver |
| 69 | Double H Nos. 1 and 2 mine | 45,000 | Inferred subeconomic resources | 0.02 | -- | Gold |
| | | | | 2.5 | -- | Silver |
| 99 | Green Scorpion prospect | 3,300 | Occurrence | 0.086 | -- | Gold |
| 122** | Rex mine | 3,700 | Occurrence | 0.22 | -- | Gold |
| 139 | Good Hope mine | 4,400 | Indicated subeconomic resources | 0.070 | -- | Gold |
| | | 32,000 | Inferred subeconomic resources | 0.031 | -- | Gold |
| 146* | Bonanza King mine | 19,000[2/] | Inferred subeconomic resources | 4.1 | -- | Silver |
| | | | Ferrous and industrial mineral deposits | | | |
| 78 | Prospect | 9,900 | Occurrence | -- | 99.15 | Silica |
| 118 | Black Jack mine | 230,000[3/] | Indicated subeconomic resources | -- | 55-60 | Iron |
| 121** | Cornfield Springs Consolidated mine | 110,000[3/] | Inferred subeconomic resources | -- | 50 | Iron |
| 127** | Dolomite outcrop | 12 million | Occurrence | -- | 19.1 | Magnesium compounds |
| 128* | Vulcan mine-Burro prospect | 3.0 million[3/] | Inferred subeconomic resources | -- | 50 | Iron |

[1/] see appendix for resource/reserve classification
[2/] From dumps
[3/] Long tons

concentrations were detected in chip samples collected near the SS Nos. 20-22, 27-29 mine, south (Star? mine), the center of the area of molybdenum exploration.

### Industrial Minerals

Limestone and dolomite units of possible economic significance in the Providence Mountains were reported by Gray and Bowen (1980, p. 154). The favorable units strike northeast, dip 30°-40° southeast, and lie within a 10,000-ft-thick Paleozoic section (Hazzard, 1954) of predominantly carbonate rocks in the south-central part of the study area. The Paleozoic section is intensely faulted and individual lithologic units cannot be traced for long distances. Favorable limestone units include members of the Cambrian Chambless Limestone (a unit within the Carrara Formation as designated by Stewart, 1970), Devonian Sultan Limestone, and Mississippian Monte Cristo Limestone (Hazzard, 1954, table 1). Limestone in sufficient quantity may also be present in marine parts of the Triassic Moenkopi Formation (Gray and Bowen, 1980, p. 154). Favorable dolomitic rocks include parts of the Cambrian Bonanza King Formation, Cambrian Nopah Formation (Cornfield Springs Formation of Hazzard and Mason, 1936), and Devonian Sultan Limestone (Hazzard, 1954, table 1). On the basis of limited sampling (Moyle and others, 1986) and supporting literature, the limestone and dolomite units described above are suitable for at least intermediate-grade industrial applications, which is currently the main market of raw carbonate products.

Ver Planck (1966) suggested that quartzite-bearing units in the Providence Mountains may contain silica resources suitable for industrial applications. Late Proterozoic quartzite is exposed at the base of the Paleozoic section on the west side of the study area near Tough Nut Spring. Lithologic, petrographic, and chemical data (Moyle and others, 1986) suggest that, due to the amount of impurities, the exposure is of doubtful economic importance.

One small silica prospect (fig. 3, No. 78) is on three segments (52, 72, and 180 ft long) of a northwest-trending, undulating, 6- to 10-ft-thick quartz vein. The vein crops out discontinuously over a strike length of 440 ft and is inferred to contain approximately 9,900 tons of quartz. One grab sample contained 99.15 percent silica, 0.30 percent iron, and 0.05 percent alumina. No gold or silver was detected. The silica grade meets the standards for industrial silica applications; however, the small size of the deposit and the long distance to market areas indicate the occurrence has little economic significance.

Two quarries in the Providence Mountains have produced building or decorative stone. One is a very small quarry (fig. 3, No. 48) in the welded, rhyolitic tuff of Hole-in-the-Wall of McCurry (1980). There is no record of production, but a maximum of 10 to 20 tons of stone was probably removed. The second quarry (No. 147), also in tuff of Hole-in-the-Wall and adjacent to the Bonanza King mine, was developed in the early 1880's as a source of dimension stone for buildings in the town of Providence. There is no record of production, but several hundred tons of roughly equidimensional rubble were probably quarried prior to 1890 to build the town. Stone from this or a nearby site was also used to construct foundations for the original Bonanza King and Silver King mills. Stone from both quarries is marginally suitable as wall or fireplace veneer.

Voluminous deposits of sand and gravel are present within the study area. Most of these deposits are in the Quaternary alluvium at lower elevations. Large deposits of limestone and dolomite in the study area may be suitable for common aggregate uses; however, the major consumption areas are distant. Because of the high-bulk, low-unit value of the commodity and the high transportation costs, development of these deposits is unlikely in the foreseeable future other than for small local uses.

### Recreational Minerals

Small amounts of petrified wood, originally Sequoia landsdorffia (Strong, 1966), are found below the volcanic ash beds near Barber Canyon and Whiskey and Domingo Springs at the mouth of Beecher Canyon (fig. 3, No. 143). A small open cut was dug by collectors in the ash beds east of Whiskey Spring (Howard Blair, oral commun., 1982). The petrified wood is found as rubble as much as 6 in. in diameter. It is agatized, nonfractured, and ranges from light tan to nearly black. Cut specimens show a distinct wood grain pattern in light-brown tones. The specimens are classified as excellent for jewelry due to the grain pattern and the competency of the rock. The petrified wood is likely to attract collectors, but the quantity is insufficient to support a commercial operation.

Hazzard (1954, table 1) described numerous invertebrate fossil localities within the Providence Mountains study area; the fossil assemblages include trilobites, ammonites, fusulinid foraminifera, algal stromatolites, algae, brachiopods, coral, bryozoans, and crinoids. Many of the sites are visited frequently by students, professional paleontologists, and amateur and commercial collectors (Vredenburgh, 1982, p. 8). The Latham Shale, about 0.5 mi south of Summit Spring, is apparently the most popular and accessible trilobite locality in the Providence Mountains. Large-scale commercial operations probably would not occur at any of the known fossil localities; however, recreational and minor commercial collecting are expected to continue.

## Appraisal of Resources

Eight properties within or bordering the study area contain a total of about 310,000 tons of indicated and (or) inferred gold and (or) silver resources with associated copper, lead, and zinc. Theses deposits range in size from 10,000 to 110,000 tons. Also within or bordering the study area are three occurrences of gold, ranging from 500 to 3,700 tons, and one occurrence each of silver and lead. The tonnage and grade of identified resources and occurrences in and

near the study area are listed in table 2. Resource and reserve classifications are in the appendix (U.S. Bureau of Mines and U.S. Geological Survey, 1980.

All of the identified gold and silver resources at mines in the study area are currently subeconomic at gold and silver prices of $400/troy oz and $10/troy oz, respectively. All of the deposits occur as 2- to 6-ft-thick veins and shear zones that dip moderately to steeply and would have to be mined by relatively high-cost open stope or shrinkage stope underground methods. Therefore, the production costs at individual mines would exceed the value of the recovered commodities, including any byproduct base metals.

The most promising scenario involves a consolidated mine plan for eight properties in the Macedonia Canyon-Globe Canyon area. Seven of the properties, including an unidentified prospect, the Dixie No. 2 prospect, SS No. 28 prospect, north, SS No. 29 prospect, north, and the Globe, Frisco No. 3, and the Double H Nos. 1 and 2 mines (fig. 3, Nos. 31, 32, 34, 35, 57, 64, and 69, respectively), contain cumulative indicated and inferred subeconomic gold and silver resources of approximately 270,000 tons (table 2). All are within approximately 1 mi of the confluence of the Globe Wash headwaters, a good location for an on-site mill. The addition of the Good Hope mine (fig. 3, No. 139) to this group, 2.5 mi away, would bring the cumulative gold and silver resources to approximately 310,000 tons. Other isolated deposits might be available as possible sources of additional mill feed, resulting in lower unit milling cost. Mining costs and on-site heap-leach milling costs would total approximately $70/ton (Moyle and others, 1986). Although the combined estimated value of the eight deposits (about $25/ton) is considerably lower than the estimated production cost for a consolidated plan ($70/ton), a threefold increase in precious-metal values and (or) the discovery of higher grades could permit a profitable operation.

Some of the deposits with subeconomic gold resources, such as the Good Hope mine (fig. 3, No. 139), or occurrences such as the Rex mine (No. 122) or the Green Scorpion prospect (No. 99), are relatively isolated from other promising deposits. Such geographic isolation may inhibit development due to lack of sufficient tonnage for an adequate mine life. For example, although the Good Hope mine contains about 36,000 tons of indicated and inferred subeconomic resources valued at about $15/ton, the estimated mining, milling, and recovery (heap leach) costs would be about $150 to $160/ton. Total mining and milling costs, if shipped to the custom mill at Ivanpah, Calif., would be about $160 to $170/ton.

The number of workings, the past production, and the character of identified deposits in the study area should continue to attract claim locations, prospecting, and at least moderate surface disturbance in the foreseeable future. The Summit Spring, Globe Wash, upper Beecher Canyon, and Macedonia Canyon areas are especially attractive to both small-scale prospecting and major exploration by private industry.

Exploration for large-tonnage, low-grade gold and silver deposits was conducted in the Summit Spring-Globe Canyon area during 1984. A large-tonnage deposit would be amenable to open-pit mining methods at a much lower cost (Moyle and others, 1986). Deposits as large as about 5 to 15 million tons of ore can be economically mined at grades as low as 0.02 oz/ton gold with 2 to 3 oz/ton silver (Ivosevic, 1984, p. 11-13).

The known placer gold occurrences in the study area are not classified as resources. However, small scattered high-grade concentrations may be present in alluvium derived from areas of lode gold deposits. Prospecting is expected to continue. There is sufficient spring water in some areas to support recreational placer gold mining.

Of the three iron deposits within or adjacent to the study area, the Black Jack and the Cornfield Springs Consolidated mines are probably too small for commercial development. The remaining iron resources at the Vulcan mine-Burro prospect are probably not amenable to surface mining and would, therefore, have an excessively high production cost. At 1984 market conditions, foreign competition forced closure of some large open-pit iron mines in the western states, such as the Eagle Mountain mine near Desert Center, Calif.

Analyses of subeconomic limestone and dolomite resources (Moyle and others, 1986) suggest that they are suitable for at least intermediate-grade industrial applications, which is the main market of raw carbonate products. Favorable characteristics of these deposits are their quality and quantity, the proximity of railroad facilities at Kelso, and the high demand and many processing plants in southern California (Bowen and others, 1973; Smith, 1984). Unfavorable characteristics are the rugged terrain, lack of local access roads (except to the dolomite in Foshay Pass), and the long distance to prospective market areas.

Only one of four samples of silica meets the standards for industrial applications; also, the small size of the occurrence and the transportation costs to ready markets indicate the occurrence has little economic significance. The high amount of impurities in samples from two other sites indicates these occurrences will probably not be considered as sources of industrial silica.

The large deposits of subeconomic limestone, dolomite, sand, and gravel resources within the study area probably will not be developed in the near future due to the relatively high-bulk, low-unit values and the high transportation costs to serve distant market areas. However, should resources closer to market areas be depleted, the size and grade of the Providence Mountains deposits and their proximity to the Kelso railhead could attract development. The most likely local demand of limestone and dolomite aggregate might be as railroad ballast or as riprap along roads susceptible to flash flood damage.

Although stone suitable as a decorative veneer or as dimension stone, has been quarried within the study area, the relatively high-bulk, low-unit value of the commodity and the high transportation costs to distant market areas are key factors controlling current or future development. These resources are classified as subeconomic, and quarrying of these deposits in the foreseeable future, other than for localized uses, is unlikely.

Minor petrified wood and fossil localities are subject to occasional recreational use; however, no large-scale commercial interest is expected, and these occurrences do not constitute an identified resource.

## ASSESSMENT OF MINERAL RESOURCE POTENTIAL

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### Geology

#### Geologic Setting

The Providence Mountains Wilderness Study Area lies in the northeastern part of the Mojave Desert, an area that contains widespread igneous and metamorphic rocks in mountain ranges generally separated by shallow alluvial basins and plains. The area near the Providence Mountains consists of a Proterozoic craton of gneiss and granite that is overlain by continental shelf deposits of Paleozoic and lower Mesozoic clastic and carbonate strata (Hazzard, 1954; Hewett, 1956). This area was also the site of voluminous late Mesozoic plutonism that can be defined by two petrologically distinct suites of granitoids of Late Jurassic and Cretaceous age (Miller and others, 1982). The Cordilleran thrust and fold belt developed north of the Providence Mountains at approximately the same time as late Mesozoic regional plutonism (Burchfiel and Davis, 1981). During late Tertiary time renewed magmatism produced widespread volcanic strata. Extensive faulting that accompanied the volcanism produced distinctive low-angle, fault-bounded, tilted blocks in much of the central Mojave Desert to the west (Dokka and Glazner, 1982) and in the Colorado River region to the east (Anderson, 1971; Mathis, 1982). However, the Providence Mountains do not show the tilted Tertiary strata typical of provinces underlain by shallow, low-angle, detachment faults.

#### Description of Rock Units

Early Proterozoic granitoid gneiss underlies much of the northern part of the study area (pl. 1). It is generally medium-grained biotite granite to granodiorite and in places contains garnet crystals 0.5 in. in diameter. The gneiss typically contains mafic segregations of biotite, epidote, and garnet and felsic segregations of quartz, feldspar, and garnet. The gneiss is lithologically variable on a scale of miles but no evidence for intrusion of the gneiss was observed. Lenses of mafic rocks, mostly biotite schist and amphibole schist, tens of feet wide, are interspersed throughout the gneiss. Leucocratic intrusions are rare except for large dikes and small plutons of leucocratic garnet syenogranite southwest of Macedonia Canyon. Biotite gneiss in the eastern Colton Hills is compositionally similar to the gneiss in the Providence Mountains and is cut by Jurassic granite.

Quartzite, siltstone, shale, and limestone overlying the gneiss range from latest Proterozoic to Middle Cambrian in age. The lower 1,200 ft are predominantly quartzite with lesser siltstone and dolomite; they were assigned to the Prospect Mountain Quartzite by Hazzard (1954), the Tapeats Sandstone by Hewett (1956), and the Johnnie Formation, Sterling Quartzite, Wood Canyon Formation, and Zabriskie Quartzite by Stewart (1970). Overlying the quartzitic rocks are shale, nodular limestone, and shaley limestone totaling about 900 ft. These rocks were subdivided by Hazzard (1954), but combined and called the Carrara Formation of Early and Middle Cambrian age by Stewart (1970).

Overlying these rocks is a 2,700-ft-thick section of predominantly dolomite with minor limestone and rare shale and quartzite. The unit consists of the Middle and Upper Cambrian Bonanza King Formation and the Upper Cambrian Nopah Formation.

A middle and upper Paleozoic limestone unit overlies the dolomitic rocks. This unit, about 4,850 ft thick, is comprised of three thick, cliff-forming limestone formations, the Devonian Sultan Limestone, the Mississippian Monte Cristo Limestone, and the Pennsylvanian and Permian Bird Spring Formation (Hazzard, 1954). Minor chert, sand, and shale are present in parts of these formations.

Locally overlying the upper Paleozoic limestone is a thick clastic and carbonate unit of early Mesozoic age. The lower part consists of red sandstone, nodular limestone, and shaley limestone and was assigned by Hazzard (1954) to the Triassic Moenkopi Formation. It is about 1,000 ft thick. Overlying conglomerate and volcanoclastic rocks, as much as 1,200 ft thick, may be Jurassic or Tertiary in age. The conglomerate contains clasts of volcanic rocks and limestone and is interbedded with siltstone. Volcanoclastic rocks are purple tuffs that appear to be related to the overlying Fountain Peak Rhyolite.

The Jurassic quartz monzonite of Goldstone (Miller and others, 1985) is a compositionally variable unit ranging from quartz syenite to quartz monzodiorite; much of the unit in the ridge northwest of Vulcan mine is monzogranite. The unit typically is subequigranular and coarse grained, contains purple potassium feldspar and mafic minerals of biotite, hornblende, and minor augite, and is altered to albite, chlorite, and epidote. Locally included in the quartz monzonite of Goldstone are mafic monzodiorite, gneissic rocks, and fine-grained felsic hypabyssal(?) granitoid.

In the northern Colton Hills, a suite of mafic granitoids overlaps partly in composition with the quartz monzonite of Goldstone. The mafic granitoids are compositionally and texturally variable, but are typically fine- to medium-grained, subequigranular biotite quartz monzonite or medium-grained, equigranular biotite-hornblende monzogranite. Rocks of this unit are mesocratic, contain little quartz, and have dark-gray or purple potassium feldspars. In exposures near Black Canyon Road and near the 7IL (Blair) Ranch (fig. 2), the granitoid has a strong penetrative foliation. Minor exposures of gabbro and diorite are present within this unit.

The mafic granitoids in the Colton Hills are cut by, and grade into, a suite of three Jurassic felsic plutons. Yellow-weathering, pink, coarse-grained, quartz-rich biotite granite is present near the Bonanza King mine. Light-gray, medium- to coarse-grained, porphyritic biotite monzogranite comprises most of the southern Colton Hills. This rock is foliated in the eastern exposures. In contrast to the two previously mentioned rocks, which contain pink to purple

potassium feldspar, the third felsic pluton is a leucocratic monzogranite that is quartz-rich and contains white feldspars and few or no mafic minerals. The leucocratic monzogranite cuts the foliated, porphyritic biotite monzogranite.

Monzogranite that crops out near Tough Nut Spring probably correlates with the Jurassic Ivanpah Granite of Beckerman and others (1982), which is present 12 mi to the north near Cima (fig. 1). It is melanocratic, medium- to coarse-grained, subequigranular to porphyritic biotite monzogranite and contains purple potassium feldspar. The unit cuts the Proterozoic gneiss and is intruded by the Cretaceous Mid Hills Adamellite of Beckerman and others (1982).

The Cretaceous Mid Hills Adamellite was mapped by Beckerman and others (1982) south to the Macedonia Canyon area (fig. 1), where it is white to light-gray, medium- to coarse-grained, hornblende-biotite monzogranite to granodiorite. Phenocrysts of potassium feldspar are usually absent in the Macedonia Canyon area, although they are widespread in the unit elsewhere (Beckerman and others, 1982). Identical adamellite as small plutons can be traced south in the Providence Mountains to Tough Nut Spring. Numerous biotite-hornblende dacite to rhyolite dikes cut the adamellite.

Cretaceous or older leucocratic granite is present as small intrusions and widespread dikes within the Proterozoic gneiss and, less commonly, in the Jurassic and earlier Cretaceous granitoids. The breccia and leucocratic granite unit includes tectonic breccia within the East Providence fault zone and probable intrusion breccias. Quartz and plagioclase are generally the only phenocrysts present in an aphanitic groundmass, and rarely are biotite phenocrysts found. Many of these intrusions are highly altered and (or) brecciated, including one mass that borders and grades into the Mid Hills Adamellite.

The Fountain Peak Rhyolite is a silicified, locally flow-banded, rhyolitic intrusive and extrusive body that contains rare biotite and plagioclase (Hazzard, 1954). Dikes extending from the body are reddish-brown biotite granitoids very similar to dikes of Jurassic age in the southern Providence Mountains (Miller and others, 1985), which suggests a Jurassic age for the body. However, Hazzard's (1954) assignment of the Fountain Peak to the Tertiary is also possible.

From bottom to top, Tertiary volcanic and sedimentary rocks in the Hole-in-the-Wall area include (1) conglomerate containing limestone boulders that overlies the Proterozoic gneiss, (2) the Peach Springs Tuff (Young and Brennan, 1974), a gray to pink, welded sanidine tuff about 19 Ma (Glazner and others, 1986), (3) local black aphyric vesicular basalt, (4) a 1,100-ft-thick, reddish-gray sanidine rhyolite ash-flow that is assigned to the tuff of Hole-in-the-Wall (McCurry, 1982) and dated at 16.9±0.4 Ma (J.K. Nakata, written commun., 1984), and (5) lacustrine sedimentary rocks consisting of thin-bedded dolomite and limestone and subordinate sandstone and conglomerate.

Landslide breccia of Tertiary or Quaternary age forms hills near Tough Nut Spring. These are typified by unsorted, crudely bedded, subangular clasts of limestone as large as several feet wide in a fine limestone breccia matrix. A landslide breccia near Hole-in-the-Wall is composed of tuff of Hole-in-the-Wall boulders and rubble and rests on the Mid Hills Adamellite.

Late Tertiary and Quaternary alluvium are found in active washes, paved terraces, and strongly cemented cliffy terraces. Clasts are lithologically heterogeneous and poorly sorted. Quaternary eolian sand extending east from Kelso Dunes (fig. 1) is unconsolidated to partly consolidated arkose.

## Structure

Ductile deformation during and (or) subsequent to emplacement of the Proterozoic granitoids produced gneissic foliation that strikes predominantly north to northeast and dips steeply east and west. The foliation is defined by preferred orientation of quartz, biotite, and hornblende, and by mineral segregations. It forms broad folds spaced about 2 mi apart that have nearly horizontal fold axes. Lineation is poorly defined in the gneiss. Jurassic granitoids in the eastern Colton Hills have a foliation that is north striking and gently west dipping. Progressive eastward development of this foliation in places has produced mylonitic fabrics.

Faults are difficult to distinguish from breccia zones of uncertain significance in much of the granitoid and gneissic rock in the study area. Most faults are known from areas underlain by Paleozoic and Tertiary strata.

Four sets of normal faults cut Paleozoic strata in the Providence Mountains. The oldest faults strike north-northwest, dip moderately to steeply east, and displace strata down to the east. Steep, approximately east-striking faults drop strata down to the north and cut the north-northwest-striking faults. Faults striking north-northeast cut the east-striking faults and range from steeply west dipping to vertical to moderately east dipping. Faults in this third set extend along the length of the range. The youngest set are low-angle normal faults that dip gently westward. The older three sets of faults predated or accompanied intrusion of rhyolite dikes that extend from the Fountain Peak Rhyolite. The relation of the low-angle normal faults to the rhyolite is not known.

Two major-displacement reverse faults bound the Paleozoic strata: the East Providence fault and the Hidden Hill fault zone of Miller and others (1985); these faults apparently crosscut the three older normal fault sets described above. The Hidden Hill fault has at least 1,000 ft of dip separation and the East Providence fault has 7,500 ft of displacement (Hazzard, 1954). Both faults are mineralized in and to the south of the study area (Miller and others, 1985) and form broad breccia zones in crystalline rocks. Faults striking east and east-northeast in Foshay Pass cut the Hidden Hill fault zone and the Fountain Peak Rhyolite. These fault intersections form major breccia and gouge zones in the quartz monzonite of Goldstone.

Faults cutting the Tertiary volcanic rocks in the northern Colton Hills and eastern Providence Mountains strike north to northeast and dip nearly vertical. They generally are of small separation, and blocks to the east are downthrown. Part of this fault

system closely parallels the East Providence fault, suggesting that the latter fault in part may have had similar downward movement to the east.

## Alteration

Hydrothermal alteration is widespread and locally intense in the study area. The altered rocks are found in three main environments: in intrusive rocks, in wall rocks near intrusions, and in and near fault zones.

Altered intrusive bodies show widespread partial alteration of biotite to chlorite and of plagioclase to sericite. Limonitic and albitic alteration is widespread in the quartz monzonite of Goldstone, and epidote veins and fracture coatings are abundant within this unit in Foshay Pass. Locally, quartz-magnetite veins cut the granitoid. Intense propylitic and albitic alteration is also developed in the Goldstone unit south of the study area (Miller and others, 1985).

Similar alteration is present in the Jurassic granitoids of the Colton Hills: the rocks are commonly albitized adjacent to fractures, epidote veins are common, and rare fracture zones contain hematite, limonite, epidote, pyrite, pyrolusite, and copper carbonate minerals. Near the 7IL (Blair) Ranch (fig. 1), albitized felsic dikes contain actinolite, diopside, and garnet; quartz-magnetite and epidote veins are common.

The Ivanpah Granite is intensely altered near its contact with Proterozoic gneiss. Limonite, sericite, and chlorite are widely developed and iron oxide minerals and boxwork after pyrite indicate sulfide introduction. The most intensely altered margins of the granite are cut by altered felsic dikes of probable Cretaceous age, suggesting that the dikes and possibly associated hydrothermal fluids followed the older intrusive contact.

The Mid Hills Adamellite contains widespread epidote in fractures and locally shows pronounced propylitic and argillic alteration. Dacite dikes cutting the unit are argillically altered and produced limonitic alteration in the adjacent granitoid. Leucocratic microgranite and intrusion breccia dikes related to the Mid Hills Adamellite commonly show pronounced silicification and propylitic, argillic, limonitic, and sausseritic alteration. In places this alteration appears to have been related to proximity to the East Providence fault zone.

The Fountain Peak Rhyolite has been widely silicified and feldspars have been altered to yellow clays. Quartz commonly lines vugs and spherules. Locally, biotite is replaced by hematite and pyrolusite is present on fracture surfaces.

Altered wall rocks are widespread adjacent to Mesozoic granitoids but rare next to the Fountain Peak Rhyolite. As described above, gneiss adjacent to the Ivanpah Granite is commonly sericitized and limonitized, but white dikes in the contact zone suggest that the alteration was associated with emplacement of Cretaceous dikes. Paleozoic carbonate strata intruded by the quartz monzonite of Goldstone were metamorphosed to white marble, and locally magnesian skarns and associated metallic minerals were formed.

Altered areas adjacent to the Mid Hills Adamellite include hematite- and limonite-bearing quartz veins. Widespread alteration in Proterozoic gneiss in the southern Mid Hills and northern Providence Mountains is probably related to the shallowly underlying Mid Hills Adamellite, as indicated by abundant felsic dikes and local intrusion breccia probably derived from the adamellite. Most of the gneiss shows replacement of biotite by chlorite, epidote in veins and fractures, and replacement of biotite by chlorite, epidote in veins and fractures, and replacement of metamorphic garnet by biotite. Locally, quartz veins with specular hematite are present west of Tough Nut Spring, and limonite with hematite and pyrite is present near the Good Hope mine. Endoskarn south of Globe Wash contains vesuvianite and garnet and is apparently related to hornblende diorite emplaced in the gneiss.

Altered fault zones are most pronounced along the East Providence fault zone. At the northern exposures of the fault (pl. 1), where it cuts Cretaceous granite, the zone is 40 to 400 ft wide and composed of brecciated and silicified granite containing widespread epidote along fractures. Southward, the fault passes into gneiss, where the zone of brecciation and alteration is as wide as 0.25 mi. Black and brown breccia that shows extensive development of limonite, hematite, chlorite, clay, and sericite is exposed in this segment of the fault zone, and silicified zones are present near its margins. Quartz veins and felsic dikes in the zone are less fractured than their country rock, suggesting that they were emplaced following some of the brecciation. Farther south where gneiss is juxtaposed with carbonate rocks, the fault zone is only 10 to 50 ft wide; altered gneiss is similar to that elsewhere in the zone, and limestone is generally dolomitized.

Widespread small breccia zones in Proterozoic gneiss show limonitic and propylitic alteration. The Hidden Hill fault zone shows limonitic and argillic alteration in brecciated granitoid; south of Foshay Pass it is also silicified and albitized (Miller and others, 1985). Limonitic and argillic alteration are also characteristic of faults in Foshay Pass (Miller and others, 1985). About 1 mi northeast of Foshay Pass, silicified faults are associated with chalcopyrite, bornite, hematite, and drusy quartz.

Although faults cutting the Tertiary volcanic rocks of the northern Colton Hills show little alteration, faults cutting the same rocks about 5 mi to the east control gold occurrences (Gottlieb and Friberg, 1984).

## Geochemistry

### Methods

The geochemical investigation of the Providence Mountains Wilderness Study Area consisted of collecting and analyzing 196 heavy-mineral-concentrate samples and 300 rock samples. The concentrate samples, each panned from 1.5 to 2 lb minus-80-mesh stream-sediment samples, were obtained using a common gold pan. In the laboratory, the samples were air dried, the lighter material was removed using bromoform, and the more magnetic

heavy-mineral fractions were removed using a magnetic separator. The resulting nonmagnetic heavy-mineral fractions were analyzed semiquantitatively for 31 elements using an optical emission spectrograph according to the method outlined by Grimes and Marranzino (1968). A complete tabulation of the analytical data and detailed discussion of the sampling and analytical methods are given in Folger and others (1986). A split of the nonmagnetic fraction was used for optical examination, mainly to detect various sulfide minerals or man-made contaminants.

The geochemical evaluation is based largely upon the distribution and variation of selected elements in the nonmagnetic fractions of the heavy-mineral concentrates. Distinct breaks in the frequency distributions for the data were used to identify threshold concentrations and anomalous geochemical populations. Thresholds for specific elements commonly enriched within the mineral deposit types known to exist in the study area are listed in table 3.

Rock samples were collected from the major mineral occurrences within and adjacent to the study area. Each rock sample was analyzed semiquantitatively for 31 elements using an optical emission spectrograph. Additionally, they were analyzed for gold, arsenic, cadmium, antimony, zinc, and bismuth by inductively coupled plasma using a modification of the method of O'Leary and Viets (1986). Cold-vapor atomic absorption was used to analyze for mercury (Vaughn and McCarthy, 1964) and a specific-ion electrode was used for fluorine (Hopkins, 1977). The resulting analytical data are included in Folger and others (1986).

## Interpretation of Geochemical Data

Maximum reported element concentrations for samples of veins or carbonate-replacement bodies from selected occurrences are listed in table 4. The data indicate that, except for the Vulcan mine iron-skarn, silver, copper, lead, and zinc are characteristically the predominant metals associated with both vein and carbonate-replacement mineralization. Observed ore-related minerals include galena, sphalerite, pyrite, chalcopyrite, bornite, stibnite, wolframite, barite, fluorite, and secondary oxides. The most anomalous gold values are associated with the quartz veins; analyzed carbonate replacement bodies never exceeded 1 part per million (ppm) gold. Molybdenum concentrations of at least 100 ppm were detected in mineralized veins at the Okaw mine and the Regulus-Vega-Spica prospect. A quartz vein from the Blue Rock 1-6 mine contains 2,000 ppm tungsten, and scheelite was visible in a hand sample.

Anomalous barium in concentrate samples is ubiquitous along the entire length of East Providence fault within the study area. Barium concentrations of greater than 10,000 ppm also extend about 3 mi west of the fault between Cornfield Spring and Tough Nut Spring. Many of the anomalous samples contain 20 to 80 percent barite. Barium anomalies seem to be much more widespread than recognized metalliferous mineralized areas within the northern Providence Mountains and are present throughout drainage basins underlain by both Paleozoic metasedimentary rocks and Mesozoic intrusions. Anomalous barium was not recognized in the Colton Hills, which are underlain by Jurassic plutons hosting mineralized quartz-vein systems. Therefore, the barite along the East Providence fault is believed to have been derived from background concentrations of the mineral within the Paleozoic carbonate units of the northern Providence Mountains.

Lead in concentrate samples is the best pathfinder element for areas with geochemical favorability for both the silver-gold vein and lead-silver-zinc replacement occurrences. Values of at

**Table 3.** Anomalous concentrations of selected elements in nonmagnetic heavy-mineral-concentrate samples

[Determined by semiquantitative emission spectrometry. <, element was detected but is present in too low concentrations to be measured by the analytical method used]

| Element | Lower limit of anomalous concentration (in parts per million) | Lower percentile of anomalous concentration | Maximum reported concentration (in parts per million) |
|---|---|---|---|
| silver | 1 | 87 | 500 |
| arsenic | <500 | 99 | 3,000 |
| gold | <20 | 99 | 50 |
| barium | 10,000 | 66 | >10,000 |
| bismuth | <50 | 95 | >2,000 |
| copper | 50 | 94 | 200 |
| molybdenum | 200 | 92 | 5,000 |
| lead | 2,000 | 79 | >50,000 |
| antimony | <200 | 99 | 3,000 |
| tungsten | 500 | 83 | 10,000 |
| zinc | <500 | 97 | 1,000 |

least 2,000 ppm extend from the Vulcan mine and Foshay Pass in a belt along the entire southeastern side of the northern Providence Mountains as far north as the Bonanza King mine. Much of this belt is centered along the southern part of the East Providence fault. Farther north, lead anomalies delineate the fault zone to the north and south of Summit Spring and in the Columbia mine area. From Summit Spring along the south side of Globe Wash, lead anomalies extend west to the tops of the alluvial fans and to the Okaw and Jo Je mines. High lead concentrations are also associated with the heavily prospected area around Tough Nut Spring. The north half of the Colton Hills, where Jurassic intrusions host veins bearing gold, silver, zinc, lead, and copper, shows scattered lead anomalies. Microscopic examination of all the concentrate samples showed only four to contain visible galena. However, at many of the known mineral occurrences within the study area, the ore-related minerals are strongly oxidized and it is

**Table 4.** Maximum reported concentrations for mineralized vein samples or replacement bodies

[All values in parts per million unless stated; L, less than given concentration; G, greater than given concentration]

| Location | Township | Range | Section | Quarter | Ag | As | Au | Bi | Cu | Hg |
|---|---|---|---|---|---|---|---|---|---|---|
| Silver King mine (Perseverance mine) | 11N | 14E | 32, 33 | SE, NW | 300 | 43 | 0.7 | 3 | 200 | 3.4 |
| Bonanza King mine | 10N | 14E | 3 | NW | 10 | 5L | 0.2 | 2L | 10 | 0.1 |
| C + K (Bell Gilroy) mine | 10N | 14E | 16 | NE | 1,000 | 386 | 0.1L | 2L | 10,000 | 4.9 |
| Mexican mine | 10N | 14E | 21 | NE | 7 | 7 | 0.1L | 2L | 200 | 0.1 |
| Burro 54 and 55 prospect | 10N | 14E | 28 | SW | 0.5L | 350 | 0.1L | 2L | 30 | 0.1L |
| Vulcan mine | 10N | 13E | 25 | SE | 0.5L | 100 | 0.1L | 2L | 1,500 | 0.1L |
| Rex mine | 10N | 13E | 9 | SE | 7 | 42 | 12. | 27 | 50 | 32 |
| Jo Je mine | 11N | 13E | 23 | NW | 100 | 7 | 18. | 23 | 15,000 | 0.2 |
| Okaw mine | 11N | 13E | 11, 12 | SE, SW | 70 | 5L | 0.5 | 15 | 700 | 0.3 |
| Tough Nut mine | 11N | 14E | 30 | SW | 700 | 74 | 0.1L | 2L | 300 | 3.4 |
| Fan 1-5 prospects | 11N | 14E | 19 | NE | 7 | 5 | 1.1 | 4 | 150 | 0.3 |
| Summit Springs prospects G3-G4 | 11N | 14E | 17 | NE, SE | 30 | 22 | 5.0 | 2L | 300 | 0.3 |
| Hill NW of Macedonia Canyon | 12N | 14E | 29 | SW | 70 | 5L | 0.1 | 2 | 7,000 | 0.3 |
| Regulus-Vega-Spica prospect | 12N | 14E | 34 | SE | 30 | 11 | 0.1 | 14 | 300 | 1.2 |
| Silver Buddy prospect | 11N | 14E | 2 | NW | 70 | 19 | 0.1 | 5 | 200 | 4.3 |
| Silver Buddy mine | 11N | 14E | 3 | NE | 300 | 10 | 0.1 | 1,150 | 300 | 0.2 |
| Castor-Pollux (Columbia) mine | 11N | 14E | 3 | NW | 700 | 419 | 44. | 3 | 700 | 1.0 |
| Blue Rock 1-6 (Confidence Copper) mine | 11N | 14E | 4 | NW | 300 | 15 | 1.0 | 5 | 10,000 | 4.4 |
| Star mine | 11N | 14E | 9 | NW | 100 | 65 | 2.1 | 127 | 300 | 0.3 |
| Outcrop NE of Star mine | 11N | 14E | 9 | NE | 100 | 5L | 0.2 | 3,780 | 30 | 0.2 |
| Blue Jay #1 prospect | 11N | 14E | 10 | NE | 30 | 30 | 0.9 | 4 | 100 | 0.1 |
| Globe mine | 11N | 14E | 9 | SE | 5 | 7 | 0.1 | 2L | 15 | 0.1 |
| Providence mine | 11N | 14E | 16 | SW | 100 | 25 | 2.0 | 16 | 70 | 0.7 |
| Gold Star North 1-44 prospect | 11N | 15E | 31 | SW | 15 | 115 | 1.9 | 16 | 150 | 0.4 |
| Outcrop south of Gold Star North | 10N | 15E | 4 | NW | 7 | 7 | 0.2 | 3 | 50 | 0.1 |
| Pink Falcon prospect | 10N | 15E | 8 | SE | 1.5 | 25 | 0.3 | 2L | 300 | 0.2 |
| Max Dor 1-2 mine | 10N | 15E | 8 | NW | 5 | 5L | 0.3 | 3 | 700 | 0.1L |
| Outcrop NE of Bearclaw Well | 11N | 14E | 36 | SW | 20 | 33 | 4.6 | 453 | 2,000 | 0.3 |
| Grande 1-7 mine | 10N | 15E | 7 | NE | 100 | 8 | 3.0 | 41 | 3,000 | 1.6 |

[1]Sample numbers are from Folger and others (1986).

possible that most of the high lead values reflect the presence of supergene lead carbonates and sulfates.

Gold was detected in only three concentrate samples, arsenic in one sample, and antimony in two samples. Even in watersheds containing known gold-bearing veins, gold was not detected. Silver was detected in 25 of the concentrate samples. Samples with anomalous concentrations of silver predominantly cluster north and south of Summit Spring and around the Columbia mine. Isolated samples with anomalous silver contents near known mineral occurrences are present in the Foshay Pass area, west of the Bonanza King mine, 0.5 mi north of the Mexican mine, near Tough Nut Spring, and near the Okaw mine, Jo Je mine, and one small prospect in the northwest corner of the study area (fig. 3, No. 74). No silver-bearing concentrate samples were found in the Colton Hills. Two samples from the southwestern part of the study area (011 and 057, Folger and others, 1986), over 1 mi from any known gold-silver occurrences, contain

| Mo | Pb | Sb | Zn | Other anomalous elements | Rock description | Geochemical sample[1] |
|---|---|---|---|---|---|---|
| 5 | 7,000 | 71 | 12,800 | Ba=5,000G | Carbonate replacement bodies | 132, 133,134 |
| 5L | 500 | 14 | 4,200 | --- | Carbonate replacement bodies | B&K |
| 30 | 20,000G | 600 | 526 | --- | Carbonate replacement bodies | 187 |
| 5L | 300 | 11 | 111 | --- | Carbonate replacement bodies | 144 |
| 15 | 30 | 3 | 13 | Ba=3,000 pct. | Altered granite | 192 |
| 5L | 10 | 2L | 25 | Fe=20 G; Co=500; Ni=1,000; V=500. | Fe skarn | 199 |
| 10 | 150 | 2L | 11 | Ba=3,000; Fe=20G pct | Quartz veins | 011 |
| 15 | 700 | 38 | 2L | --- | Quartz veins | 069, 070 |
| 500 | 15,000 | 7 | 91 | --- | Quartz veins | 026, 035 |
| 15 | 5,000 | 3 | 40,000G | --- | Carbonate replacement bodies | 400 |
| 5L | 150 | 10 | 292 | Ba=5,000 | Quartz veins, fault gouge | 023, 066 |
| 5 | 3,000 | 9 | 246 | --- | Quartz veins | 029, 072, 073 |
| 15 | 20,000G | 216 | 20 | --- | Quartz veins | 088 |
| 300 | 1,000 | 2L | 259 | --- | Quartz veins | 048 |
| 5L | 2,000 | 55 | 13,000 | --- | Fault gouge | G84MH11 |
| 7 | 20,000G | 20 | 655 | --- | Quartz veins | 107 |
| 30 | 20,000G | 13 | 25,900 | Mn=7,000 | Quartz veins | 102, 103 |
| 10 | 1,500 | 38 | 1,050 | Be=30; W=2,000; F=3.1 pct. | Quartz veins | 045 |
| 15 | 1,000 | 68 | 135 | --- | Quartz veins | 030, 032 |
| 20 | 1,000 | 2L | 10 | --- | Quartz veins | G84MH19 |
| 30 | 70 | 4 | 269 | Ba=5,000G | Quartz veins | 110 |
| 7 | 50 | 17 | 132 | --- | Quartz veins | 076 |
| 15 | 3,000 | 10 | 2,620 | Ba=5,000G | Quartz veins, fault gouge | 027, 028, 071 |
| 10 | 300 | 4 | 870 | Mn=5,000G; Fe=20G | Fault gouge | 165Y, F84CH35 |
| 70 | 7,000 | 6 | 32 | --- | Quartz veins | 165X |
| 7 | 7,000 | 2 | 157 | --- | Quartz veins | 166 |
| 5L | 200 | 2 | 354 | --- | Quartz veins | 177 |
| 5 | 5,000 | 44 | 176 | --- | Quartz veins | B84CH12 |
| 70 | 10,000 | 15 | 3,510 | --- | Quartz veins | 175, B84CH3 |

anomalous concentrations of silver. One of these samples also contains 2,000 ppm antimony and the other shows lead and zinc concentrations of 1,000 ppm. Both samples are from drainages mainly underlain by Paleozoic carbonate rocks and indicate geochemical favorability for additional carbonate-replacement bodies.

Molybdenum shows distribution patterns very similar to silver. Samples containing anomalous concentrations of molybdenum are widespread throughout the southern and southeastern parts of the northern Providence Mountains, around the Columbia mine, to the southwest of Summit Spring, and along the northwest edge of the study area. Copper, though present in sulfide and oxide minerals at many of the known mineral occurrences, shows very little geochemical contrast in concentrate samples; copper anomalies are weak and isolated. Zinc was detected in only seven concentrate samples, most of which drained the southern and southeastern parts of the northern Providence Mountains.

Samples containing anomalous concentrations of tungsten correlate with the Early Proterozoic gneiss underlying the northwestern part of the study area, but the exact source of the tungsten is still questionable. Scheelite is abundant at the Confidence Copper mine, where it is hosted by the Cretaceous Mid Hills Adamellite but is fairly close to contacts with the gneiss. The gneiss also contains numerous small masses and dikes of Cretaceous breccia and leucocratic granite, which may be feasible sources for the tungsten.

## Geophysics

### Aeromagnetic Data

Aeromagnetic data covering the study area were extracted from two regional surveys (U.S. Geological Survey, 1981, 1983). Flightlines for these surveys were oriented east-west, spaced approximately 0.5 mi apart, and flown at a nominal elevation of 1,000 ft above the ground surface. After a slight datum shift to bring the two surveys into concordance, the combined data over the study area were reduced to the pole (Baranov and Naudy, 1964) using an assumed direction for geomagnetic field and magnetization of $60^{\circ}$ inclination and $14^{\circ}$ declination. Reduction to the pole removes asymmetries in the magnetic anomalies by mathematically replacing the obliquely dipping field and magnetization vectors of the study area with vertically downward directed vectors such as would be found at the magnetic North Pole.

The highest magnetic anomaly values in the study area (approximately 3,500 gammas) coincide with the Vulcan mine. This positive anomaly continues about 2 mi eastward from its peak, which overlies the large pit at the Vulcan iron mine (fig. 3, No. 128), probably indicating an unexposed extension of the ore body to the east. A second high of somewhat lower amplitude (about 2,000 gammas) but similar appearance lies 1 mi northeast of the 7IL (Blair) Ranch. A small, local high gravity anomaly covers the same area. Iron minerals appear in veins in nearby outcrops in the Colton Hills and endoskarn is found locally in mafic granitoids (fig. 3, No. 149). However, the Jurassic igneous granitoid rocks themselves have a high magnetic susceptibility, so it is not known what proportion of this anomaly is caused by concentrations of iron. Two smaller positive anomalies, 2 to 3 mi to the northeast over exposures of the Tertiary tuff of Hole-in-the-Wall, suggest the presence of similar Jurassic igneous rocks and (or) small iron bodies under the tuff.

Other mafic (Proterozoic or Jurassic) rocks may cause an elongate north-trending positive anomaly in the southwest corner of the study area, because a small outcrop of Jurassic igneous rock is mapped under the northern part of the high. The westward gradient on this anomaly could mark a structural boundary, perhaps the edge of a pediment on the west side of the range; a gravity gradient lies in approximately the same location as the magnetic gradient.

Many of the Proterozoic units exposed in the study area coincide with positive aeromagnetic anomalies. Highs of modest amplitude (several hundred gammas) coincide with exposures of Proterozoic rocks in the southeast corner of the study area, and other moderate highs overlie most exposures of Proterozoic units in the northern and western parts of the Providence Mountains. Moderate highs over alluvium in the northern part of the study area could indicate the presence of buried Proterozoic rocks.

Broad aeromagnetic lows along the northwest edge of the study area are probably caused both by nonmagnetic sedimentary deposits under the valley and by nonmagnetic igneous rocks of the Cretaceous Mid Hills Adamellite in the subsurface. This second possibility is supported by low values over exposures of Mid Hills Adamellite on the west side of the Providence Mountains. These lows are adjacent to and merge with lows over the valley to the west.

Negative aeromagnetic anomalies over the Tertiary tuff of Hole-in-the-Wall are correlated with topographic highs, implying that this unit is in part reversely magnetized. The amplitude and smoothness of these lows requires only a modest magnetization for the tuff. Low values also coincide with much of the exposure of the Fountain Peak Rhyolite. For this unit, the absence of correlation of anomalies with topography suggests that these volcanic rocks are not very magnetic.

An east-trending negative anomaly over Macedonia Canyon may be associated with altered rocks and may help to define the extent of alteration, although the presence of Cretaceous granitic rocks, which are commonly not very magnetic, could partly be responsible for the low values. The eastern part of this low lies across the major north-striking East Providence fault zone. A linear belt of negative aeromagnetic anomalies lies over and adjacent to this fault along most of its length and along its extension into the southern Providence Mountains (Miller and others, 1985). In places the low values coincide with the nonmagnetic Paleozoic sedimentary section, but in areas underlain by generally magnetic Proterozoic or Jurassic rocks, the lows probably reflect alteration caused by fluids circulating along this fault.

## Gravity Data

An isostatic residual gravity map of the study area and the surrounding region was prepared from 265 new gravity observations collected by the U.S. Geological Survey (1981, 1983) and 96 existing gravity observations. The coverage is adequate for defining major structural boundaries and distinguishing geologic units of regional extent provided that density contrast between units exists. Isostatic residual gravity values range from a high of -6 milligals (mGal) to a low of nearly -40 mGal. The highest values overlie exposures of Jurassic mafic granitoid rocks, whereas the lowest values cover areas underlain by the felsic Cretaceous Mid Hills Adamellite. Local negative anomalies in the northeastern part of the study area coincide with exposures of Tertiary volcanic tuff.

The dominant gravity feature is a gradient sloping from high values in the southeast corner of the study area to low values in the northwest and north. As seen on regional gravity maps (Roberts and others, 1981), this gradient separates high gravity values associated with a belt of dense Jurassic igneous rocks on the south from a broad area of low values centered over less dense Cretaceous igneous rocks to the north and west. The presence of the gradient across the western and northern parts of the study area, where Proterozoic and Paleozoic rocks are exposed, suggests that additional low-density Cretaceous igneous rocks lie under much of the Providence Mountains area.

The high gravity values in the southeastern part of the study area are associated with outcrops of Jurassic mafic granitoids of the Colton Hills. High values extend into the alluvium southwest of the Colton Hills where similar Jurassic igneous rocks are inferred to exist at depth. A local high to the east of the 7IL (Blair) Ranch, based upon only two gravity observations, coincides with an aeromagnetic high and could reflect a buried iron deposit or a denser phase of the Jurassic mafic granitoids.

On the northwest side of the Providence Mountains, relatively lower gravity values overlie exposures of the Mid Hills Adamellite. Low values immediately to the northwest over alluvium may also be caused by these rocks and equivalent felsic components. Along the west and northwest sides of the range, steep regional gradients overlie alluvium about 1 to 2 mi from the range front. These gradients may indicate a structural edge to the pediment surface and suggest that the low gravity values over alluvium are also partly caused by thicker sedimentary deposits.

Gravity lows also coincide with exposures of the Tertiary tuff of Hole-in-the-Wall, especially near the northernmost part of the study area. The gravity observations showing the lowest values were collected on tops of mesas and at high points in the topography; this probably means that the assumed Bouguer reduction density of 2.67 g/cm$^3$ is inappropriate for these volcanic materials. A Bouguer density of 2.2 g/cm$^3$ would account for a large proportion of the low values, indicating that subsurface thicknesses of the volcanic units probably do not exceed 1,000 ft. However, much greater thickness of low density volcanic and volcanoclastic rocks is required to explain a large, circular gravity low centered over a presumed caldera 5 mi to the east of the study area in the Woods Mountains (McCurry, 1982).

## Electrical Geophysical Data

Electrical studies were limited to the southeastern part of the study area and consisted of induced polarization (IP) and telluric surveys. The focus of these surveys was the characterization of the East Providence fault zone and related structures.

Three IP lines were run using a 500 ft dipole (or "a") spacing, and 1 to 6 dipole spacings between the transmitter and the receivers (or Hertz "N" values of 1 to 6), with measurement frequencies of 1.0 and 0.1 Hertz. The south line ran from near Winding Star cave to the east for 4,500 ft. The East Providence fault was clearly expressed in this line by an abrupt resistivity change from high resistivities of 2,500 ohm-meters (ohm-m) in the Permian limestones on the west to resistivities of an order of magnitude lower to the east. The contact appeared nearly vertical from the IP data. The eastern, low-resistivity part of the line crossed over Quaternary alluvium, which is inferred to be shallow and probably overlying Proterozoic gneiss. Resistivities of several hundred ohm-m are very low for gneiss, suggesting that it has been altered. Polarization values increased with depth below this part of the line, attaining a maximum of 18 milliradians (mrad). These moderate polarization values indicate that some sulfide or clay minerals are present at depth.

The middle IP line ran east-southeast across the Bonanza King mine area. As on the Winding Star line, carbonate rocks cropping out west of the East Providence fault appear as high-resistivity units with low polarizability and the fault again shows an abrupt contrast in resistivity. Immediately east of the fault, the line followed the contact between alluvium and Proterozoic gneiss for about 1,000 ft, and for another 500 ft ran along the contact with the tuff of Hole-in-the-Wall. The rest of the eastern part of the line was on alluvium. The gneiss has resistivities in the 200 to 400 ohm-m range and slightly elevated polarizability over a background of 11 mrad. The tuff of Hole-in-the-Wall has lower resistivity, about 150 ohm-m, and lower polarizability. This suggests that the tuff is more porous than the gneiss, as might be expected, and contains a smaller percentage of polarizable minerals such as clays and sulfides.

The north IP line ran eastward through Barber Well, about 1 mi north of the Silver King mine. The west half of the line lies on Proterozoic gneiss east of the main East Providence fault. A splay of the fault crosses the line about midway and appears as a distinct resistivity contrast. On the west side, over gneiss, apparent resistivities are about 400 ohm-m and polarizability exceeds 10 mrad only near the fault. This increase in polarizability near the fault suggests that alteration and any associated mineralization was fault-related. The eastern part of the line ran over alluvium probably underlain by Tertiary volcanic rocks or felsic granitoids. Apparent resistivities along this part of the line were in the 100 to 200 ohm-m range, but polarizability was noticably higher at the larger N

values on this part of the line, reaching 20 mrad and indicating some clays or sulfides at depth.

A 5-mi telluric profile was run from Winding Star cave, east-northeast across Clipper Valley to the north end of the Colton Hills. Five-hundred-meter dipoles were used, and telluric voltages were measured at 25 Hz. These data show the same abrupt resistivity contrast across the East Providence fault as seen on the south IP line. The telluric data show that the low resistivities are within a zone east of the fault about 3,000 ft wide and may reflect alteration in the underlying rocks. Resistivities in the central part of the valley, outside the study area, are about four times greater than within the broad low-resistivity zone. Farther east, on the northern edge of the Colton Hills, resistivities decrease slightly to 200-300 ohm-m above mafic Jurassic granitoids. These low values are consistent with the observed alteration of the Jurassic granitoids and indicate that the alteration has been pervasive and extends to depths probably exceeding 3,000 ft.

## Mineral and Energy Resources

Geological, geochemical, and geophysical data and investigation of mines and prospects indicate that the Providence Mountains Wilderness Study Area contains areas of high and moderate mineral resource potential for gold, silver, copper, iron, lead, zinc, and tungsten; unknown potential for molybdenum, low-grade bulk-tonnage silver and gold, and oil and gas; and low potential for gold in alluvium, uranium, geothermal energy, limestone, dolomite, quartzite, stone, gravel, and sand.

### Silver, Gold, Copper, Lead, Zinc, and Tungsten

Precious- and base-metal veins and polymetallic replacement bodies with substantial concentrations of silver and (or) gold are widespread in the Mojave block of the Basin and Range province (Wilkins, 1984). These mineral deposit types are common in the Providence Mountains Wilderness Study Area, especially along the East Providence fault. An extensive belt (pl. 1, area A1) with a high mineral resource potential (certainty level D) for gold, silver, copper, lead, zinc, and tungsten in both vein and replacement occurrences stretches from the northeast corner of the Providence Mountains south to the Bonanza King mine area (pl. 1). See the appendixes for definition of levels of mineral resource potential and certainty of assessment. This belt, especially along the East Providence fault zone, contains brecciated, silicified, and sericitically and propylitically altered rocks and contains the highest density of mines and prospects within the study area. Heavy-mineral-concentrate samples over the entire belt are enriched in silver, lead, and molybdenum. Negative aeromagnetic anomalies that roughly coincide with the entire belt may reflect widespread hydrothermal alteration associated with vein and replacement deposits as mineralizing fluids destroyed magnetic minerals in the host rocks. Extensive alteration to depths of at least 3,000 ft, believed to be associated with silver, gold, copper, lead, zinc, and tungsten mineralization, is also indicated by IP data.

Mining records and geochemical data indicate a crude zoning within this belt of high resource potential. The northeast corner of the area (Plate 1, area A1a) and the region immediately to the west (outside the study area boundary), which include the Silver Buddy, Columbia, Francis, and Confidence Copper mines, have a high resource potential for silver, copper, lead, and zinc, certainty level D. The presence of wolframite, scheelite, and huebnerite at the Confidence mine, in addition to past production, indicates high resource potential for tungsten in area A1a, certainty level D. Samples with consistently anomalous concentrations of gold were recognized only at the Columbia mine and therefore area A1a has moderate resource potential for gold, certainty level D. Much of the north half of the belt (area A1b) is characterized by high potential, certainty level D, for gold, as well as silver, copper, lead, and zinc. This region includes the Globe, Frisco No. 3, and Double H 1 and 2 mines. Quartz veins and silicified shear zones are the dominant deposit types within areas A1a and A1b. (Two smaller areas (A12, A13) within area A1b contain resource potential for other commodities in different deposit types and are discussed later.) The southern half of the belt (A1c) is characterized by abundant carbonate rocks along the west side of the East Providence fault and thus includes carbonate replacement as well as vein occurrences. This region includes the Providence mine, and the Silver King and Bonanza King mines lie just east of the area, outside the study area. Area A1c has high potential, certainty level D, for silver, copper, lead, and zinc, whereas gold is less significant and the area has moderate resource potential for gold, certainty level D.

A relatively small area extending south from the Rex mine (area A2) represents the only other area with high potential, certainty level D, for gold and silver. At the Rex mine, quartz veins within a shear zone in Jurassic quartz monzonite contain very high gold concentrations and slightly anomalous silver. Copper, lead, and zinc are not above background concentrations within the veins, and thus area A2 has a high potential for only gold and silver resources. This area coincides with a local aeromagnetic high probably caused by mafic Jurassic granitoid rocks or Proterozoic units. At the Rex mine, near the north edge of the aeromagnetic anomaly, specular hematite is extremely abundant within the fault zone; the zone also contains the silver- and gold-bearing quartz and may be contributing to the aeromagnetic anomaly.

Three parts of the study area (A3, A4, A5) have a moderate potential, certainty level D, for gold and silver, along with low potential for copper, lead, and zinc, certainty level D. All three of these tracts contain anomalous silver, lead, and molybdenum in concentrate samples. The region around the Tough Nut mine (area A3) contains numerous small prospects in addition to the mine. Veins, usually associated with fault zones, are hosted by intensely altered early Proterozoic gneiss and the Jurassic Ivanpah Granite. Cambrian carbonate rocks in area A3 host mineralized replacement bodies. A small area extending from the Jo Je mine east to near the study area boundary (area A4) is underlain by the Mid Hills Adamellite and

contains mineralized quartz veins in a fault zone at the Jo Je mine. The third of these areas is associated with the Okaw mine (area A5). This locality is underlain by both Jurassic and Cretaceous intrusive rocks cut by dacite and leucocratic granite dikes. Known deposits are hosted by quartz veins and silicified shear zones, and surrounding wall rocks are sericitically altered.

Three other areas also have a moderate mineral resource potential, certainty level C, for gold and silver or gold and copper, and a low potential for lead and zinc and (or) copper and (or) silver, certainty level C. The largest of these areas (area A6) covers most of the north half of the Providence Mountains within the study area except for four of the previously discussed localities (areas A1, A3, A4, and A5). Area A6 most likely contains vein deposits hosted by the Proterozoic gneiss and Cretaceous granite, although the southern part of area A6 may also contain small carbonate-replacement bodies. Concentrate samples from area A6 show anomalous concentrations of silver, lead, and molybdenum, and propylitic and sericitic alteration of intrusive bodies is widespread. However, the lack of mines and the relatively few prospects suggest at best only a moderate resource potential.

The north half of the Colton Hills (area A7) shows a similar moderate resource potential, certainty level C, for gold and silver, and low potential for copper, lead, and zinc, certainty level C. This area is mainly underlain by Jurassic mafic granitoids cut by a series of dacite dikes and breccia zones and contains the Grande 1-7 and Max Dor 1 and 2 mines. Because only a few drainage concentrate samples contain anomalous concentrations of lead, mineralized veins appear to be less widespread in this area than in areas of high resource potential.

The last of these three areas (A8) with a moderate resource potential, certainty level C, lies along the north side of Foshay Pass. It contains a number of small prospects mainly within silicified shear zones in limestone. Although the area lacks geochemically anomalous concentrate samples, favorable structures for mineralizing fluid transport, observed mineralization, the presence of prospects, and the close similarity with mineralized zones proximate to the south (Miller and others, 1985), indicate moderate potential for gold and copper and low potential for silver, lead, and zinc.

Moderate potential for gold and silver resources, certainty level B, exists about 1.5 mi southeast of the Rex mine (area A9) where a heavy-mineral concentrate sample from a drainage predominantly in Paleozoic limestone is enriched in silver, gold, and especially antimony. Approximately 1 mi northeast of this region, a small area (area A10), also draining carbonate rocks, had minor prospecting activity; a heavy-mineral concentrate sample updrainage from known workings contains anomalous concentrations of silver and lead. Area A10 has low potential, certainty level C, for silver, copper, and lead resources, on the basis of the geochemical anomalies and past mining activity. Similarly, low potential, certainty level C, for gold, silver, and copper resources exists between area A8 and the study area boundary to the southwest. This area (area A11) is characterized by geochemical anomalies, limestone and highly altered Jurassic quartz monzonite, and abundant faults. Geologic and geochemical similarities between this area (A11) and the nearby area A8, which contains numerous small workings, suggests that area A11 may also contain mineralized quartz veins and replacement bodies, but that they are less numerous.

Low concentrations of gold in alluvium were detected in many of the washes, particularly downstream from the more significant lode gold occurrences. Although occasional high-grade pockets of placer gold may exist, the placer accumulations generally lack proven economic significance. The scattering of drainages with recovered gold have low resource potential, certainty level C, for placer gold across the study area.

One part of the study area (area A12) has an unknown potential for disseminated gold and silver resources. This region is located on the ridge to the northeast and southwest of Summit Spring within potential resource area A1b, and is characterized by widespread quartz veining. Area A12 lies just to the east of the East Providence fault, within Proterozoic gneiss, is extensively brecciated and silicified, and has been explored by at least one company for low-grade, high-tonnage, gold and silver accumulations. Detailed mapping of the associated alteration and rock-chip sampling for gold and silver analyses is necessary before a high, moderate, or low resource classification can be applied to the area.

There is also unknown potential for a molybdenum porphyry system (area A13) about 1 mi northwest of Summit Spring in upper Globe Wash. Brecciated, porphyritic, leucocratic Cretaceous granite intruding Proterozoic gneiss to the west of the East Providence fault zone shows extensive propylitic and argillic alteration, with local sericitic alteration and pyritization common near silicified breccia zones. One prospect pit in area A13 (fig. 3, No. 42) contains molybdenite rosettes in white quartz veins of both ring and radial geometry; the veins have anomalous fluorine, lead, and zinc concentrations. This area also has attracted mining company interests since 1970. Whereas alteration patterns within area A13 are consistent with a buried porphyry system, molybdenum resources at depth can only be evaluated through an extensive drilling program.

## Iron

Five areas within the study area have potential for iron resources. One of these (area B1) has a high resource potential, certainty level D, and is associated with the Vulcan iron-skarn deposit in Foshay Pass, which lies along the contact between Paleozoic carbonate rocks and Jurassic quartz monzonite. Although the Vulcan mine lies outside of the study area boundary, two small extensions of the magnetite-rich ore body may underlie the study area. These probable extensions of the ore body are delineated by the highly anomalous center of the aeromagnetic high extending along the main granite-carbonate contact.

Two areas (B2, B3) have a moderate potential for iron resources. Largely based on an eastward extension of the Vulcan mine area magnetic anomaly, a moderate potential, certainty level D, for additional

iron resources is delineated across most of the southern tip of the study area (area B2). This area is extensively faulted, bringing Jurassic quartz monzonite in contact with both Paleozoic carbonate units and the younger Fountain Peak Rhyolite. This contact throughout area B2 is characterized by small outcrops of magnetite. Moderate resource potential for iron, certainty level C, is centered around the 7IL (Blair) Ranch in the northwestern Colton Hills (area B3). The area is delineated by a magnetic high that is associated with a somewhat less pronounced gravity high. It includes two small prospects (fig. 3, Nos. 148 and 149) with magnetite skarn lenses and minor iron and copper sulfide minerals.

A large zone in the southwestern part of the study area (area B4) and a region south of Wild Horse Canyon in the Colton Hills (area B5) have low potential, certainty level B, for iron resources. Area B4 is largely underlain by Paleozoic carbonate rocks and has widespread outcrops of specular-hematite pods and lenses. Mafic Jurassic intrusive bodies might underlie Area B4 at depth, providing a feasible fluid source for the iron-rich replacement bodies. However, magnetite is not present in quantities great enough to show as aeromagnetic anomalies. Area B5 is characterized by a weak extension of the aeromagnetic anomaly that coincides with area B3. This part of the anomaly overlies exposures of the Tertiary tuff of Hole-in-the-Wall, south of Wild Horse Canyon. This may indicate the presence of Jurassic igneous rocks and (or) related magnetite-bearing skarn zones at shallow depths below the tuff.

Nonmetallic Resources

The Providence Mountains Wilderness Study Area has a low resource potential, certainty level C, for industrial limestone, in the limestone unit (pl. 1), dolomite, in the dolomite unit, quartzite, in the clastic rock unit, sand and gravel, in alluvial deposits, and dimension stone aggregate, in the tuff of Hole-in-the Wall. Impurities in the rock and highly faulted character indicate low resource potential. Rugged terrain, long distances to prospective markets, and larger deposits in adjacent areas with better access will limit development of any such materials within the study area.

No known uranium occurrences exist within the study area. Scintillometer surveys by U.S. Bureau of Mines and U.S. Geological Survey field crews indicated only slight background variations due to lithologic changes and no significant anomalies. Thorium enrichments in the concentrate samples generally reflect the presence of background amounts of thorite; no uranium minerals were identified in any of the samples. Rare allanite-bearing pegmatite dikes do, however, occur in the Proterozoic gneiss and scintillometer surveys did not cover the inaccessible cliffs of Paleozoic strata. Therefore, a low resource potential, certainty level C, exists for uranium minerals in pegmatites throughout the study area.

A north-northwest-trending regional belt of high heat flow traverses the Mojave Desert from southern Death Valley to Blythe (Lachenbruch and Sass, 1981). This belt is well defined immediately west of the Providence Mountains Wilderness Study Area and may include it. Parts of this belt have been explored for geothermal resources (Marsh and others, 1982) but no lease applications have been filed for the Providence Mountains area. Hot springs, gas vents, and silicious sinter are not present in the study area. On the basis of this information, there is low potential, certainty level C, for geothermal resources.

An unknown potential exists for oil and gas within the western part of the study area (area C1). The Providence Mountains are located along the southern extrapolation of the Cordilleran overthrust belt, a major oil- and gas-producing zone characterized by Paleozoic and Mesozoic sedimentary source and reservoir rocks and by structural traps. The overthrust belt extends from southern Nevada through Utah to Montana and northward, but southern parts have had little production. The study area shows no characteristics of the overthrust belt, but typical structural characteristics of the belt have been established to the north of the study area in the Clark Mountain Range and New York Mountains (Burchfiel and Davis, 1971, 1977, 1981) where thrust faults affect metamorphosed Paleozoic strata. A proposed extension of the overthrust belt (Howard and others, 1980) to the south of the Providence Mountains consists of nappes of highly metamorphosed sedimentary and igneous rock. It thus appears that many thrust-belt rocks in the region are metamorphosed, overmatured, and have no recognizable hydrocarbon potential. However, the highly metamorphosed Paleozoic sequences are all associated with Cretaceous intrusions whereas those within the study area are intruded by Jurassic plutons.

Miller and others (1982) pointed out that Paleozoic strata intruded by Jurassic plutons in parts of the Mojave region are less metamorphosed than those intruded by Cretaceous plutons, and shaly units in the Cambrian strata within the study area could possibly act as source rocks for hydrocarbons. Data on the thermal maturity of these rocks are lacking. The absence of porous sandstone and carbonate rocks also is not supportive of hydrocarbon accumulation. Furthermore, deep structures of the Providence Mountains area are unknown, making it impossible to evaluate possible source rocks, migration paths, and structural traps. Gravity data suggest that most of the study area is underlain at depth by granite, indicating no potential for oil and gas resources in pre-Cenozoic rocks.

Another possible hydrocarbon target is the Cenozoic basinal sediments along the west side of the northern Providence Mountains; the sediments possibly acted as a reservoir for hydrocarbons derived from within the basin or from older source rocks. In the nearest analogous basin 15 mi north of the study area in Ivanpah Valley, oil and gas exploration has focused on reservoirs in Tertiary basin-fill and lacustrine sediments. Minor hydrocarbon shows from test wells generally were found at depths greater than 1,600 ft but from some as shallow as 380 ft. Oil and gas leases, as of 1982, covered more than 18,000 acres of the Providence Mountains Wilderness Study Area, mainly in the basin along the west side. The low gravity anomaly values along the west and northwest margins of the study area would indicate sedimentary deposits greater than 1,000 ft thick if the low anomalies could be attributed to low densities in the sedimentary section alone. Unfortunately, the probable presence of

low-density granite in the basement under the valley compromises estimates of sedimentary thickness based on gravity observations. Given this reservation, area C1 along the west margin of the study area outlines a region that may contain basin sediments greater than about 400 ft thick that possess an unknown potential for oil and natural gas. Source rock, thermal history, and stratigraphic or structural traps cannot be evaluated with existing data.

### Recommendations for Further Work

The upper part of Globe Wash southeast to the Summit Spring area has received the most intensive exploration activity within the study area during the last ten years. Whereas this area contains abundant veins containing gold, silver, lead, zinc, copper, and tungsten that are similar to those found within other parts of the northern Providence Mountains, it also contains many indicators for disseminated gold-silver and molybdenum porphyry systems. Detailed mapping, geochemical sampling, and more extensive drilling is needed to fully evaluate the potential for these two additional types of mineral occurrences.

Further study of the Tertiary volcanic rocks is also warranted. A few concentrate samples from drainages solely within the tuff of Hole-in-the-Wall contained fluorite, sphalerite, or elevated lead values. These anomalous findings require further field study before it can be conclusively stated that the rhyolite tuff does or does not host any metallic resources. McCurry (1982) hypothesized a caldera ring around Wild Horse Mesa that could indicate a favorable geologic environment for gold mineral occurrences. Therefore, further mapping and sampling of the faults are needed. In addition, high-density rock-chip sampling of the widely altered Fountain Peak Rhyolite would provide a more certain resource assessment of possible disseminated gold-silver systems.

A complete analysis of hydrocarbon resources requires determining (1) thermal history of Paleozoic strata, (2) deep structure of the Providence Mountains and adjacent Kelso Valley, and (3) age, thermal history, and lithology of basinal sediments.

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# APPENDIXES

# DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

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.

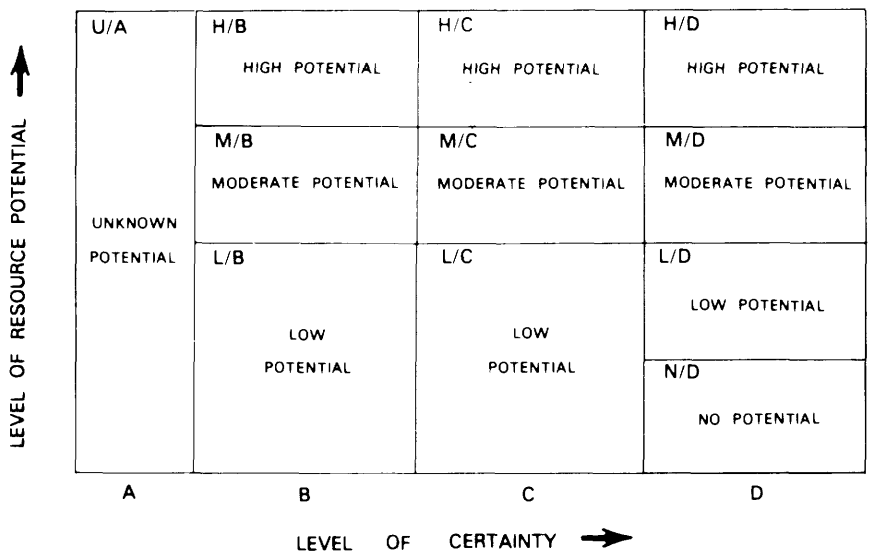
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate reasonable likelihood of resource accumulation, and (or) where an application 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:


Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268–1270.

Taylor, R. B., Stoneman, R. J., and Marsh, S. P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40–42.

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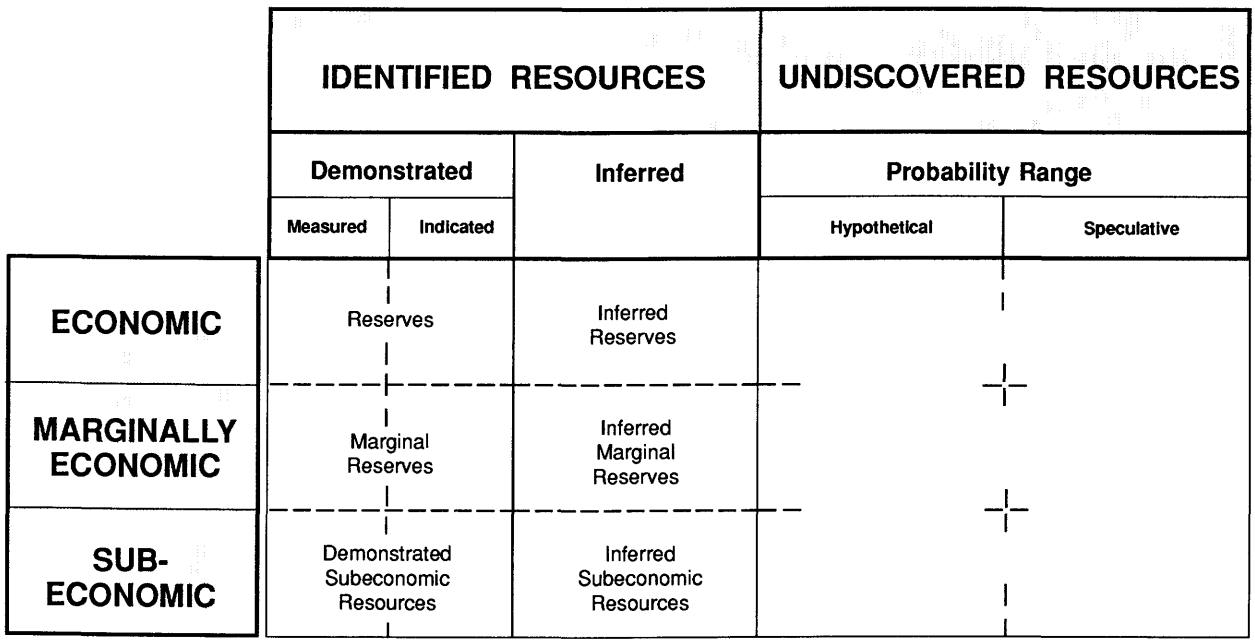
# RESOURCE/RESERVE CLASSIFICATION




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<br>Early | 96<br>138 |
| | | Jurassic | | Late<br>Middle<br>Early | 205 |
| | | Triassic | | Late<br>Middle<br>Early | ~240 |
| | Paleozoic | Permian | | Late<br>Early | 290 |
| | | Carboniferous Periods | Pennsylvanian | Late<br>Middle<br>Early | ~330 |
| | | | Mississippian | Late<br>Early | 360 |
| | | Devonian | | Late<br>Middle<br>Early | 410 |
| | | Silurian | | Late<br>Middle<br>Early | 435 |
| | | Ordovician | | Late<br>Middle<br>Early | 500 |
| | | Cambrian | | Late<br>Middle<br>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 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California

[Underlined names refer to properties with identified mineral resources or those which merit additional investigation for resources; those not underlined have little apparent significance or are insufficiently exposed to permit evaluation. #, actively held mining claim(s); *, outside study area; **, partly outside study area; ≥, greater than or equal to; ≤, less than or equal to; <, less than; pct, percent]

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 1* | Prospect | Granitic rock near contact with gneiss hosts 1.0- to 4.0-ft-thick quartz veins in faults and shears that strike N. 55° E. to east and dip northwest or southeast. Quartz is white to gray, iron oxide stained, and contains pyrite and minor secondary copper minerals. | Four pits and a 20-ft trench. | Of a total of one select and four chip samples, select sample contains trace gold and three contain 0.2 to 0.8 oz/ton silver. Two contain 0.130 and 0.184 pct copper, 0.0042 and 0.010 pct lead, and 0.0017 and 0.0010 pct zinc. Analytical values and nature of other properties nearby indicate that the mineralized zones should be studied in detail to determine if vein-type silver resources are present. |
| 2* | Prospect | A quartz vein strikes N. 78° E. and dips 60° SE. and a quartz breccia zone strikes N. 80° W. and dips 53° SW. in or near an east-trending contact zone of Proterozoic granite gneiss with intrusive granitic rock. Quartz contains pyrite, minor iron oxides, and sulfide boxwork. | Three pits | Of two chip samples, one contains 0.1 oz/ton silver; no gold was detected. |
| 3#** | Regulus-Vega-Spica prospect (Silver Fox shaft) | Workings are on northeast-trending, southeast- or northwest-dipping shear or fault zones and quartz veins. Proterozoic host rock deeply weathered, lenticular to banded gneiss near a contact with granitic rock. Most structures strongly sheared, moderately to intensely silicified, iron oxide stained, and contain disseminated pyrite, limonite after pyrite, and some galena. Vein quartz is gray to white and contains pyrite, chalcopyrite, galena, sphalerite, malachite, chrysocolla, and azurite. This 400- to 500-ft-wide zone of sheared, altered, and mineralized rock may represent northern projection of the East Providence fault. | A caved, 40-ft vertical shaft (Silver Fox), a 10-ft vertical shaft, an inclined shaft, a 20-ft trench, and 11 pits. | Of 13 chip, 1 random chip, 3 grab, and 5 select samples taken on the property, the 4 grab and select samples taken from dumps and stockpile of Silver Fox shaft contain from trace to 0.07 oz/ton gold and 0.4 to 2.6 oz/ton silver. No other gold values detected. Three select samples from quartz vein contain 1.4, 5.5, and 24.0 oz/ton silver; however, two chip samples across structure contain less than 1 oz/ton silver. Of 13 samples analyzed for copper, 12 contain 0.0008 to 0.89 pct and one contains 4.7 pct. Twelve of 13 samples contain 0.0027 to 4.4 pct lead and 0.0054 to 0.65 pct zinc. Significant but erratic analytical values indicate that further investigation is necessary to determine if vein-type silver, gold, copper, or lead resources are present. |
| 4 | White Rock prospect | A white to gray, pyrite- and iron-oxide-bearing, 0.5- to 5.0-ft-thick quartz vein approximately 2,000 ft long and oriented N. 20°-55° E., 32°-40° NW. in granitic rock. Vein crosses a contact where it fills local shears in granite gneiss. | Three pits | Six chip samples taken: no gold detected; silver ranges from 0.1 to 1.0 oz/ton in five samples; one sample contains 0.0062 pct copper, 0.044 pct lead, and 0.0013 pct zinc. Sample values indicate property merits additional investigation. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 5 | Prospect | A pyrite-, iron-oxide-, and secondary copper-mineral-bearing quartz vein occupies a fault approximately 550 ft long, striking N. 50°-60° E., and dipping vertical to 80° NW. Fault occurs in granitic rock 700 ft north of contact with granite gneiss. | Two shafts | Five samples: no gold detected; four contain 0.1 to 0.3 oz/ton silver; copper ranges from 0.0019 to 0.086 pct. |
| 6 | Prospect | Variably oriented, coarse-grained, felsic dikes, approximately 4 in. thick, in deeply weathered granitic rock. | One pit | One sample contains no gold or silver, 0.0069 pct copper, 0.0055 pct lead, and 0.0067 pct zinc. |
| 7# | Red Silver prospect | A 2-ft-thick quartz vein strikes N. 40°-70° E. and dips 65° NW. for at least 550 ft in granitic rock. Vein is white to gray, has massive to comb quartz structure, and contains 1 pct pyrite and galena, minor secondary copper minerals, and abundant iron oxide boxworks. | One 50-ft trench and two pits. | Of two chip and one select sample, one contains 0.01 oz/ ton gold, silver ranges from 0.7 to 3.5 oz/ton, copper ranges from 0.0021 to 0.103 pct, lead ranges from 0.073 to 0.67 pct, and zinc ranges from 0.0004 to 0.0024 pct. Size and persistence of structure and analytical values indicate the property merits additional investigation for vein-type silver resources with byproduc lead and copper. |
| 8** | Prospect | Two quartz veins and a quartz-bearing shear zone occur in deeply weathered Precambrian granite gneiss. One vein strikes east and dips 60° N. and the other strikes N. 30° E. and dips 40° SE.; shear zone strikes east and dips 30° S. Quartz is massive, white, and contains pyrite, galena, secondary copper minerals, iron oxides, and minor boxwork structures. | One 40-ft inclined shaft and two pits. | One chip and three select samples were taken. No gold was detected. A chip and a select sample from east-striking vein contain 2.2 and 1.8 oz/ton silver, 0.039 and 0.024 p copper, 1.32 and 0.76 pct lead, 0.12 and 0.093 pct zinc, and 0.0044 and 0.0030 pct molybdenum. A select sample from the N. 30° vein contains 24.8 oz/ton silver, 0.044 pct copper, 0.091 pct lead, 0.33 pct zinc, and 0.0023 pct molybdenum. Analytical values an nature of other properties nearby indicate vein-type resources of silver, lead, and zinc may be present. |
| 9 | Prospect | A northeast-trending, southeast-dipping, 20-ft-thick fault zone in granite gneiss. Zone consists of gray to brown banded clay. | Two pits | One sample contains no detectable gold, 0.2 oz/ton silver, 0.0046 pct copper, 0.0084 pct lead, and 0.014 pct zinc. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 10# | Silver Buddy mine | Granite gneiss hosts northeast-trending, northwest-dipping quartz veins, pods, and shear zones. Quartz is white to gray, iron oxide stained, and has visible limonite after pyrite, disseminated galena, minor sphalerite, and secondary copper minerals. Boxworks common and comb structures rare. Main vein crops out discontinously for 220 ft along strike and continuously 90 ft downdip, ranges in thickness from 0.1 to 2.5 ft, and may be continuous with a 240-ft shear zone. | One 90-ft adit with a raise and 55 ft of drifts, five bulldozed open cuts totalling 650 ft, two trenches, and two pits. From 10 tons (USBM statistical files) produced in 1965, 22 oz of silver, 1 lb of copper, and 142 lb of lead were recovered. | A mineral occurrence of 1,300 tons at 3.3 oz/ton silver and 1.24 pct lead. Of one select and nine chip samples taken, six chip samples on main vein contain 0.6 to 6.9 oz/ton silver, 0.011 to 0.077 pct copper, 0.36 to 2.04 pct lead, and 0.0021 to 0.081 pct zinc; a select sample from the stockpile contains 0.592 oz/ton silver, 1.65 pct lead, and less than 1 pct copper and zinc. Two chip samples from other quartz outcrops contain 1.1 and 3.6 oz/ton silver. A shear zone sample contains no silver and only minor copper, lead, and zinc. Exposed vein is of limited extent but minor past production and sporadically high sample values indicate this property may have additional silver, lead, and copper resources. |
| 11# | Silver Buddy prospect, south | Quartz veins, a shear zone, and a fault are in granite gneiss. Main vein crops out for 1,000 ft, strikes N. 50°-72° E., dips 43°-50° NW., and contains pyrite and galena. A N. 87° E.-striking, 40° SE.-dipping quartz vein of short outcrop length bears visible galena and is offset 7 ft by north-trending, westerly dipping normal fault. An east-trending, 65° S.-dipping shear zone has blebs of galena. An epidote- and specularite-rich skarn zone also in granite gneiss. | Two inclined shafts and five pits. | Seven samples taken on property. Of three chip samples on the main vein, no gold or silver were detected and one sample analyzed contains 0.0075 pct copper, 0.51 pct lead, and 0.026 pct zinc. A select sample contains no gold, 0.5 oz/ton silver, 0.125 pct copper, 1.78 pct lead, and 0.53 pct zinc. A sample from small quartz vein contains 0.1 oz/ton gold, 2.4 oz/ton silver, 0.057 pct copper, 2.86 pct lead, and 0.64 pct zinc. A shear zone sample contains a trace gold, 4.4 oz/ton silver, 0.023 pct copper, 0.291 pct lead, and 1.03 pct zinc. A sample from the skarn zone had 0.034 pct copper and no detectable gold, silver, molybdenum, tin, or tungsten. Sporadic but significant analytical values suggest the property merits additional investigation for silver and gold resources with byproduct lead, zinc, and copper. |
| 12* | Prospect | A 1-ft-thick fault zone trends N. 25° E. and dips 30° NW. in Proterozoic gneiss and schist. Several other fault and shear zones with various attitudes present. | One adit 110 ft long. | One chip sample contains a trace gold and no silver. |
| 13#* | Sadr prospect | Quartz veins and gouge zone are 3.5 ft thick, strike N. 60° W. and dip 60° SW. in Proterozoic gneiss. Quartz and argillized gneiss contain 1 to 2 pct pyrite and iron oxides. | One inclined shaft caved at 10 ft. | One chip and two select samples taken; a select sample from dump contains a trace gold, 0.2 oz/ton silver, 0.0039 pct copper, 0.033 pct lead, 0.011 pct zinc, and 0.028 pct molybdenum; a select sample from stockpile contains no gold and 0.9 oz/ton silver; chip sample contains no gold, 0.4 oz/ton silver, 0.051 pct copper, 0.299 pct lead, and 0.026 pct zinc. Analytical values and similar nearby deposits indicate that further studies for vein-type silver, lead, and gold resources are warranted. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 14* | Fremont-Easy Street prospect | Several outcrops of north- to northwest-trending, mostly northeast-dipping quartz veins and silicified shear zones are in Proterozoic gneiss. Quartz is gray to white and contains from none to abundant pyrite (none observed in higher grade samples) and minor manganese oxides. | Two 10-ft shafts and eight pits. | Of one grab and five chip samples, four contain from 0.01 to 0.45 oz/ton gold and all contain silver ranging from 0.02 to 2.5 oz/ton. One sample analyzed for base metals contains 0.020 pct copper, 0.51 pct lead, and 0.017 pct zinc. Erratic but significant assay values indicate this property should be studied in detail to determine whether or not vein-type gold, silver, and lead resources are present. |
| 15** | Prospect | White to gray-green quartz crops out in granite gneiss. One outcrop is apparently barren and the other contains galena, iron oxides, and boxwork. No structural controls evident. | Two pits | One grab sample contains no gold or silver and one select sample contains 0.01 oz/ton gold, 1.5 oz/ton silver, 0.021 pct copper, 2.59 pct lead, and 0.028 pct zinc. Analytical values and nearby deposits indicate further studies for vein-type silver, gold, and lead resources are warranted. |
| 16* | Prospect | A N. 70°-75° E.-striking, 72°-75° S.-dipping shear zone with boxwork structures in intensely silicified granitic rock. Zone exposed over 200 ft along strike and may be continuous with zone at Denib mine (no. 17). | One 36-ft adit and a 55-ft open cut. | Two chip samples contain no detectable gold and 0.1 to 0.2 oz/ton silver. |
| 17* | Denib mine | A sulfide-bearing shear zone as much as 20 ft thick, strikes N. 63°-80° E., and dips 70°-77° SE. in deeply weathered, banded gneiss and schist. Zone is argillized and contains quartz stringers and as much as 20 pct disseminated pyrite. Secondary, northeast-trending, northwest-dipping shear zones contain pervasive pyrite. | Two adits: lower is a 108-ft crosscut, upper has 151 ft of crosscuts and 190 ft of drifts with stopes. Stopes and a retort indicate probable minor production. | Eight chip and two grab samples taken. Of two grab samples, one contains a trace gold, 1.3 oz/ton silver, 0.063 pct copper, 0.59 pct lead, and 1.04 pct zinc and the other contains no gold, 0.2 oz/ton silver, and was not analyzed for other elements. Of eight chip samples, one contains a trace gold, six contain 0.1 to 0.2 oz/ton silver, and six contain from 0.0046 to 0.058 pct copper, 0.0063 to 0.214 pct lead, and 0.011 to 0.188 pct zinc. Size of zone, stoping in workings, and spotty but significant analytical values indicate that further investigation may reveal silver, gold, lead, and zinc resources at depth. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 18* | Blue Rock Nos. 1-6 mine (Confidence Copper mine) | Quartz veins striking N. 75° W. and dipping southwest in Mesozoic granitic rocks exhibiting sericitic alteraion, are intersected by veins striking N. 75° E. and dipping 65° S.E. Main vein crops out for at least 400 ft along strike, is 3 to 5 ft thick and developed to a depth of 100 ft. Quartz is massive to brecciated, white to gray, iron oxide stained, and has some comb structures. Pyrite, limonite after pyrite, chalcopyrite, and wolfamite observed. Microprobe examination detected oxides of bismuth, anitmony, and lead as well as minerals magnetite, barite, scheelite, and huebnerite with cross cutting seams of stolzite or raspite ($PbWO_4$). | One shallow vertical shaft, two inclined shafts (one inclined 65° S. for 100 ft), one combination adit and open cut, two 80-ft bulldozer cuts, one 40-ft open cut, a 20-ft trench, and five pits. Small shipments of tungsten ore made in 1918 (Cloudman and others, 1919, p. 849). Tucker (1921, p. 340) noted the presence of $8/ton ($20/oz) gold. | Four chip, one random chip, one grab, and one select sample taken. Select sample contains 0.04 oz/ton gold, 34.2 oz/ton silver, 1.17 pct copper, and 1.2 pct tungsten. No other gold detected. Of remaining samples, silver ranges from 0.1 to 3.3 oz/ton, copper from 0.0058 to 0.53 pct, tungsten from 0.0028 to 1.0 pct, lead from 0.0049 to 0.52 pct, zinc from 0.0047 to 0.112 pct, and molybdenum from none to 0.0053 pct. Two samples contain 0.0006 and 0.0008 pct tin and four analyzed for fluorine contain 0.11 to 1.0 pct. Past production and analytical values of deposit, and nature and size of similar deposits nearby suggest that further studies for tungsten-, silver-, gold-, and copper-bearing resources at depth are warranted. Deposits may be about 5,000 to 15,000 tons but further investigation is needed. |
| 19* | Prospect | A N. 55° E.-striking, vertical-dipping gray-green andesite dike and a N. 30° W.-striking, 85° SW.-dipping, graphic-textured dike composed of coarse quartz and potassium feldspar intrude, shear zones in Mesozoic granite. | Three pits | One chip sample contains no detectable gold or silver. |
| 20* | Prospect | Lenticular to banded gneiss with iron-oxide-stained quartz contains minor pyrite. | One pit | One grab sample contains no gold and 0.5 oz/ton silver. Sample analysis suggests further studies needed. |
| 21* | Prospect | A prominent, N. 60° W.-striking, 45° NE.-dipping alteration zone containing abundant quartz and pyrite and a barren, N. 45° E.-striking, 60° SE.-dipping dike in country rock. Quartz zone cannot be traced but may be related to many veins on Confidence Copper and Francis mine properties. | One caved shaft and one pit | One select sample contains no detectable gold, 0.3 oz/ton silver, 0.0053 pct copper, 0.0210 pct lead, no detectable zinc, and 0.0064 pct molybdenum. No gold or silver detected in one chip sample taken on dike. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 22* | Francis mine | Cuyamaca vein is 5 to 10 ft thick, strikes N. 60°-70° E. and dips 65° to 85° NW. in sheared, bleached, Proterozoic granite gneiss vertically proximal to Mesozoic granitic rocks. White to translucent gray, iron-oxide-stained quartz contains pyrite, limonite after pyrite, galena, chalcopyrite, sphalerite, fluorite, possible scheelite and (or) wolframite. Vein crops out for 1,700 ft and may continue another 800 ft along strike. | Workings include six shafts from 40 to 140 ft deep, three adits from approximately 30 to 120 ft long, and three pits. Production was at least 200 tons (USBM statistical files) containing 2,377 oz silver (average 11.9 oz/ton) and 10,626 lb copper (average 2.7 pct). Tucker (1918b) reported 500 tons produced. | Six chip, two random chip, five grab, and two select samples taken on property. Three samples contain a trace gold. Copper, lead, and zinc values were slight to moderate, never exceeding 1 pct for 13 samples analyzed. Thirteen samples contain from 0.1 to 5.8 oz/ton silver with 7 ranging from 1.0 to 5.8 oz/ton. Two of 12 samples contain 0.0022 pct molybdenum, 6 of 11 samples contain 0.0006 to 0.0008 pct tungsten and 9 of 11 samples contain 0.0005 to 0.0038 pct tin. Fluorine ranges from 0.1 to 1.0 pct in five samples analyzed. Tucker and Sampson (1930) noted the overall ore grades range from 2 to 25 oz/ton silver, 2 to 12 pct copper, 1 to 6 pct lead, and 4 to 20 pct zinc. Past production, persistence of veins, and consistently significant silver values and presence of copper, lead, and zinc in samples indicate property merits further investigation; individual pods may be about 5,000 to 10,000 tons. |
| 23* | Castor-Pollux mine (Columbia mine, Macedonia mine) | Main workings are on two or more east-northeast-trending, moderately southeast-dipping quartz veins and shear zones in Proterozoic lenticular to banded gneiss above a granitic contact. Pyrite, chalcopyrite, galena, sphalerite, calcite, and occasional fluorite associated with quartz and silicified zones. A grab sample from dump contained as much as 30 pct sulfides. One vein exposed for 500 ft along strike. | Four shafts (one is 320 to 350 ft deep), three adits, one trench, and three pits. In four years, from 1926-1938, a total of 142 tons (USBM statistical files) of ore containing 89.11 oz gold, 2,167 oz silver, 2,626 lb copper, and 100 lb lead were produced. | An estimated 5,600 tons of indicated and 18,000 tons of inferred subeconomic resources, averaging 0.05 oz/ton gold and 9.1 oz/ton silver, are contained in exposed quartz vein. Of 17 chip and random chip, 5 grab, and 2 select samples taken on property, gold ranges from trace to 0.11 oz/ton in 13 samples and silver ranges from 0.1 to 25.2 oz/ton in 24 samples. Copper, lead, and zinc are present in moderate amounts, but less than 1 pct in all samples. Additional resources of gold and silver with byproduct copper, lead, and zinc may be contained in main vein system, which was inaccessible. |
| 24* | Monte Video prospect | Variably oriented, white to gray, iron-oxide-stained quartz veins in localized shear zones in weathered, friable lenticular to banded gneiss. Quartz contains minor pyrite and boxworks; fluorite observed in quartz porphyry in one adit. | Two adits (8 ft and 70 ft) and 14 pits. | Seven chip and two select samples: one sample contains a trace gold; six contain 0.1 to 0.2 oz/ton silver; four samples contain 0.0006 to 0.0026 pct copper, none to 0.014 pct lead, and none to 0.0054 pct zinc. One of three samples analyzed contains 0.0016 pct molybdenum; two samples contain 0.0010 and 0.0020 pct tungsten, and none and 0.0005 pct tin; one sample analyzed for fluorine contains 0.40 pct. Analytical values are low but presence of gold and silver indicate further studies are warranted. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 25 | Prospect | Approximately N. 60° E.-striking, variably dipping, bleached, iron-oxide-stained, silicified shear zone and fault gouge 1 to 6 ft thick in gneiss; minor iron sulfides noted in crosscutting quartz vein 6 in. thick at workface. May be related to a breccia pipe a few hundred feet west of portal. | One adit, 160 ft long | Of six chip samples, three contain 0.1 to 0.2 oz/ton silver, two contain 0.0017 and 0.0041 pct lead, and six contain 0.0055 to 0.027 pct copper and 0.012 to 0.075 pct zinc. Higher values from vein at working face. |
| 26 | Prospect | About a 1-ft-thick zone of gouge and minor quartz along a fault striking N. 60° E. and dipping 84° SE. in sericitically altered gneiss. | One adit, 21 ft long | One random chip sample contains 0.0043 pct copper, 0.0074 pct lead, and 0.0083 pct zinc; no gold, silver, or molybdenum detected. |
| 27 | Fanny No. 2 prospect | Two silicified fault or shear zones strike N. 70° E. and dip 52° SE. to vertical in gneiss; zones are silicified, iron oxide stained, and contain massive to brecciated quartz with sericite. | One adit, 6 ft long, and one pit. | Of two chip samples, one contains 0.02 oz/ton gold and two contain 0.1 and 0.5 oz/ton silver; one sample had 0.0029 pct copper, nil lead, 0.0021 pct zinc, 0.02 pct molybdenum, and 0.0006 pct tungsten. Gold and silver analyses indicate that property merits further investigation for resources. |
| 28 | Prospect | A 4-ft-thick shear or fault zone containing a quartz vein strikes N. 70° E. and dips 78° SE. in altered gneiss; quartz is translucent gray with minor limonite after pyrite and gneiss is sheared, bleached, altered to sericite and chlorite and contains abundant boxwork. | One inclined shaft 26 ft deep. | One grab sample from dump contains 0.02 oz/ton gold, 0.4 oz/ton silver, 0.015 pct copper, 0.0094 pct lead, and 0.0095 pct zinc. Mineralization and alteration indicate further studies for vein-type gold resources are warranted. |
| 29 | Rex Nos. 1 and 2 prospect | Northeast-trending, vertical- to southeast-dipping silicified zones in granite gneiss 3 to 9 ft thick. Gneiss fractured and foliated; silicified zones formed by quartz vein swarms and by silica replacement of altered gneiss. One zone crops out for 100 ft. | One 20-ft-long adit, one 15-ft-long trench, and two pits. | Three chip samples contain 0.1 to 0.2 oz/ton silver, 0.0073 to 0.021 pct copper, 0.0021 to 0.028 pct lead, and 0.0040 to 0.043 pct zinc. |

**Table 5.** *Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 30 | Prospect | Workings expose 3- to 6-ft-thick, fine- to medium-grained, quartz latite dikes (?) in two northeast-trending, southeast-dipping and one northwest-trending, northeast-dipping shear zones in granite gneiss. Zones are silicified, iron oxide stained, and contain quartz veinlets, sericite, and abundant pyrite with minor galena. Extent of system of veins and dikes is unknown. | One short adit, one shallow shaft, and three pits. | Of two chip and two select samples, gold detected in two samples, trace and 0.05 oz/ton. Silver ranges from 0.3 to 2.0 oz/ton, copper from 0.0053 to 0.095 pct, lead from 0.0036 to 0.020 pct and zinc from 0.0032 to 0.094 pct. Intensity and type of alteration and gold and silver values indicate that property merits additional study. |
| 31 | Prospect | Two quartz-bearing fault zones in granite gneiss. Main zone strikes N. 60° W., dips 55°-80° NE., averages 6.4 ft thick, and is inferred for 350 ft along strike. Quartz is white to gray, iron oxide stained, and contains sulfide stringers, limonite after pyrite, and secondary copper minerals. Fault gouge is grayish-green and silicified and gneiss near zone is bleached. A second quartz vein, which crops out 300 ft south of the main zone, strikes north, dips 30° E., and is 5.5 ft thick. | One flooded adit of unknown length and three pits. | Deposit contains an inferred subeconomic resource of approximately 35,000 tons at an average grade of 0.04 oz/ton gold and 0.6 oz/ton silver. Of one chip sample from north-striking vein and a select and five chip samples from main vein, all but a select sample from dump contain gold and all contain silver. Five samples contain 0.0046 to 0.0270 pct copper, 0.0440 to 0.27 pct lead, 0.0007 to 0.0400 pct zinc, and 0.0033 to 0.0420 pct molybdenum. Alteration, size of exposed deposit, and analytical values indicate additional vein-type gold and silver resources may be present. |
| 32 | Dixie No. 2 prospect | Two shear or fault zones in granite gneiss. Main shear zone consists of gray quartz and fault gouge trending east and dipping 60°-85° S., crops out for 350 ft along strike, and averages 3.4 ft thick. Quartz and pyrite are abundant along with minor galena and sphalerite, and traces of argentite, chalcocite, and barite. Gneiss near vein is bleached and exhibits sericitic alteration. A localized, north-trending shear zone is 400 ft north of main zone. | A 56-ft adit, a 10-ft shaft, and five pits on main shear zone; one pit on shear zone. | Main shear zone contains an inferred subeconomic resource of approximately 17,000 tons at an average grade of 0.01 oz/ton gold and 1.0 oz/ton silver. Eight of nine samples from main shear zone contain 0.0019 to 0.011 pct copper, 0.012 to 0.059 pct lead, and 0.0031 to 0.0071 pct molybdenum. Three samples contain 0.021 to 0.35 pct zinc. No gold or silver detected in localized shear zones. Sample analyses and the extent of vein indicate that additional gold and silver resources may be associated with deposit. |
| 33 | Prospect | A 2-ft-thick quartz-rich structure (shear?) strikes N. 75° W. and dips 40° SW. in buff to brown medium-grained granite gneiss; extent of structure is unknown. | One shaft and two pits | One chip sample taken contains 0.21 oz/ton gold and 1.0 oz/ton silver. Although extent of structure is unknown, sample analysis and proximity of significant deposits to west indicate property merits further investigation. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 34 | SS No. 28 prospect, north | A 2- to 10-ft-thick zone of quartz, quartz sericite, and gouge strikes N. 45° E. and dips 74°-90° NW. in a fine- to medium-grained, silicified, intensely sericitized, felsic igneous dike or plug that has intruded granite gneiss. Zone averages 3.2 ft thick, crops out for 270 ft along strike, has a 96-ft vertical exposure, and horsetails to north. Quartz-sericite zone also contains minor potassium feldspar, 3 to 5 pct euhedral pyrite, and 1 to 3 pct jarosite after pyrite. | An 80-ft adit with a 5-ft winze and a 16-ft raise to surface. | Deposit contains an inferred subeconomic resource of approximately 10,000 tons at an average grade of 0.02 oz/ton gold and 0.9 oz/ton silver. Six of nine chip samples contain gold, which ranges from trace to 0.07 oz/ton, and seven samples contain silver, which ranges from 0.1 to 3.5 oz/ton. Copper values range from 0.0055 to 0.114 pct, lead ranges from 0.0021 to 0.042 pct, and zinc ranges from 0.0020 to 0.022 pct. Sample analyses and the geologic environment indicate that additional resources of vein-type gold and silver may be present. |
| 35# | SS No. 29 prospect, north | A northeast-trending, northwest-dipping, 1- to 5-ft-thick zone of gray to buff quartz and intensely bleached, silicified gneiss with some gouge and disseminated sulfides cuts gneiss for 190 ft. Country rock is very friable and altered, and may be intruded by and interfingered with intensely altered felsic volcanic rock. | Two adits, 115 ft and 52 ft long, one open cut and one pit. | Deposit contains an indicated subeconomic resource of 3,000 tons and an inferred subeconomic resource of 12,000 tons both at an average grade of 0.05 oz/ton gold and 1.7 oz/ton silver. One select, one random chip, and 14 chip samples were taken. Ten contain detectable gold, values range from 0.01 to 0.21 oz/ton, and all contain silver, values range from 0.2 to 3.5 oz/ton; copper values range from 0.019 to 0.28 pct, except one at 1.39 pct copper, and lead values range from 0.0021 to 0.48 pct; 10 samples contain from 0.0023 to 0.0044 pct molybdenum and 3 of 11 samples analyzed for tungsten contain from 0.0006 to 0.0220 pct. Significant sample analyses, prominence of vein, and proximity of other notable properties suggest presence of additional gold and silver resources. Persistent anomalous molybdenum values indicate further studies are warranted. |
| 36 | Prospect | Two silicified zones: first, a felsic dike, strikes N. 32° E. and dips 65° SE., and other strikes N. 20° E. and dips 80° SE. in gneiss. Dike is gray to brown, medium grained, quartz rich, and contains iron oxides and boxwork structures. | Two pits | A chip sample from silicified dike contains 0.03 oz/ton gold and 1.8 oz/ton silver, and a dump grab from silicified zone in gneiss contains 0.5 oz/ton silver. Copper values were 0.033 and 0.0092 pct, lead values 0.236 and 0.062 pct, and zinc values 0.019 and 0.0020 pct, respectively. Although no resource is identified, assay values indicate the property merits further investigation for gold and silver resources. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 37# | SS Nos. 17-19 prospect, north | Two east-trending mineralized structures and several small shear zones cut altered silicified gneiss and are related to mineralized felsic volcanic rocks that exhibit seritic alteration. A 2.0- to 3.5-ft-thick quartz vein crops out for 200 ft and dips steeply to north. A 4- to 10-ft-thick, 110-ft-long massive stratiform body is composed predominantly of a yellow, red, brown, and black iron oxide replacement and is interfingered with quartz veinlets and silicified gneiss. Underlain by altered, punky gneiss and overlain by felsic rock exhibiting quartz-sericite alteration. Halotrichite ($FeAl_2[SO_4]_4 \cdot 22H_2O$) has weathered from massive, oxidized, iron body. | Four adits, a caved shaft, two pits, and a trench; one adit is flooded, one is 20 ft long, one is 26 ft long with a winze, and one has 70 ft of crosscut and 40 ft of raise to two inclined shafts. Three holes were drilled on property. | Of 16 chip, 3 random chip, and a select sample, 6 contain detectable gold, from a trace to 0.03 oz/ton, and 13 contain silver, from 0.039 to 1.4 oz/ton. Copper ranges from 0.0054 to 0.055 pct, lead from 0.0027 to 0.33 pct, and zinc from 0.0010 to 1.16 pct; six of seven samples contain from 0.0036 to 0.031 pct molybdenum, and one sample from the stratiform body contains 25 pct iron. Higher gold and silver values from quartz vein while higher molybdenum values are associated with stratiform body. Significant sample values for gold, silver, zinc, and molybdenum, and similar deposits with resources in area, indicate property merits additional investigation. |
| 38 | SS Nos. 20-22, 27-29 mine, south (Star[?] mine) | Three prominent, subparallel quartz veins and several smaller veins strike N. 50°-70° E., dip northwest or southeast and cut gneissic and schistose rocks altered to potassium feldspar, quartz, albitized plagioclase, sericite, chlorite, and calcite. Vein systems occupy probable drag-induced faults and fissures caused by movements of East Providence fault on east side of property. Large veins crop out for 250 to 1,350 ft and are 0.6 to 8.0 ft thick. Quartz is white to gray, massive to brecciated, iron oxide stained and contains boxworks, limonite after pyrite, calcite, and rare galena. | Three adits, ranging from 8 to 175 ft with a 20-ft drift, three inclined shafts 10 to 40 ft deep, a flooded shaft, a caved shaft, two trenches, and 16 pits. Production from Star mine was 7.26 oz gold and in 1898 and 9.67 oz gold in 1901 (USBM statistical files). Wright and others (1953) noted a small shipment in 1914-1915. | Thirty chip, 5 random chip, 6 grab, and 1 select sample taken. Of 16 with detectable gold, 5 contain a trace and 11 contain 0.01 to 0.06 oz/ton. Twenty-five samples with detectable silver are in range of 0.052 to 3.2 oz/ton; 7 were $\geq$1 oz/ton. Of those analyzed, copper ranges from 0.0010 to 0.239 pct, lead ranges from 0.0021 to 0.67 pct, and zinc ranges from 0.0004 to 1.2 pct; only one exceeds 1 pct zinc. Molybdenum ranges from 0.0017 to 0.032 pct and 5 of 26 analyzed for tungsten contain 0.0006 to 0.0028 pct. Significant analytical values for gold, silver, copper, lead, and zinc, size and number of veins, alteration, and rock type indicate this system should be studied in detail. In addition, alteration, proximity to felsic intrusive dikes and plugs, and anomalous analytical values of molybdenum describe an environment similar to high-potassium, calc-alkaline molybdenum deposits of stock, plutonic, or Climax type. |
| 39#** | SS No. 40 prospect | A poorly exposed shear zone in quartz-rich gneiss exposed in a 6-ft-deep pit. Zone is 8 ft thick, strikes N. 70° W. and dips 70° NE. Quartz stringers .5 to 1 in. thick extend into country rock from shear zone. A 2-ft-thick quartz vein and a 3-ft-thick zone of iron-oxide-stained schist exposed. | One caved adit and two pits. | A chip sample across the 8-ft shear contains a trace gold and 0.04 oz/ton silver. Quartz vein contains 0.5 oz/ton silver and no gold. Iron-stained schist contains 0.006 oz/ton silver and no gold. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 40#* | SS No. 36 prospect | A light-pink, quartz-rich intrusive rock is partially altered to a soft punky material. | One pit | A 3-ft chip sample contains 0.003 oz/ton silver. |
| 41# | SS No. 38 prospect | An adit trending S. 20° W. in weathered, well-fractured biotite schist was probably intended to crosscut a 30- by 40- by 5-ft-thick massive white quartz outcrop 200 ft to southwest. | One 20-ft adit | One grab sample from quartz pod contains 0.035 oz/ton silver; no gold detected. |
| 42#* | SS No. 17 prospect, south | A prominent outcrop, approximately 100 ft in diameter, contains three distinct composition and alteration zones. A 30- by 40-ft outcrop on south consists of a network of massive, white, ring and radial quartz veins with minor molybdenite rosettes, fresh pyrite, boxwork structures, and cubic molds after pyrite containing residual sulfur. A lenticular 100- by 30-ft zone consists of subequal amounts of quartz and muscovite; grain size ranges from 1/32 to 1/4 in. Largest zone consists predominantly of quartz veins and breccia with approximately 25 pct sericite. Proton magnetometer surveys in area show this outcrop to be near center of a 200-300 gamma low indicating leaching of magnetite from rock. Outcrop may be breccia pipe. | One prospect pit on outcrop | Five samples taken. Two random chip samples, one each of quartz-muscovite and quartz breccia with sericite, contain 0.0077 and 0.0050 pct molybdenum, 0.0010 and 0.0013 pct zinc, and 0.072 and 0.062 pct fluorine. A select sample from a radial vein contains 0.002 oz/ton gold, 0.0620 pct lead, 0.0250 pct molybdenum, 0.0006 pct tungsten and 0.024 pct fluorine, and a select sample from a ring vein contains 0.002 oz/ton gold, 0.0007 pct zinc, 0.0062 pct molybdenum and 0.010 pct fluorine. A select sample of quartz with molybdenite rosettes contains 0.0570 pct molybdenum. Sample values for molybdenum and fluorine, alteration, and geologic setting indicate property merits additional investigation to determine if molybdenum resources of stock, plutonic, or Climax type are present at depth. |
| 43#** | SS No. 18 prospect, south | A prominent, intensely silicified, altered outcrop as much as 17 ft thick strikes N. 75° E. and dips 65° NW. in gneiss. It appears to be intruded by a felsic dike containing quartz veins with some intergrown potassium feldspar; sericite and iron oxides were observed. Structure crops out for about 100 ft. | None | Three chip samples across outcrop; copper ranges from 0.0034 to 0.0170 pct, zinc ranges from 0.0043 to 0.0050 pct, and molybdenum ranges from 0.0011 to 0.0022 pct. |
| 44# | Hoot Owl prospect | A north-striking, vertical-dipping, gray to white quartz vein as much as 2 ft thick (averages 1.2 ft) is exposed for 85 ft in fault gouge as much as 5 ft thick. Country rock is medium-grained granitic gneiss. No visible metallic minerals except minor disseminated pyrite. Vein is terminated on north end by east-trending, north-dipping faults. | A 115-ft-long adit includes a 10-ft raise and a 16-ft-winze. Part of adit was recently excavated to an open cut. | Vein contains an occurrence of about 500 tons at an average (weighted) value of 0.32 oz/ton gold. One grab sample and four chip samples taken. Three samples of vein contain from 0.068 to 0.224 oz/ton gold and one contains 2.12 oz/ton gold. No gold detected in crosscutting faults. Based on high gold values, strength of structure, and presence of other gold deposits nearby, this zone should be studied in detail to determine if resources are present. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 45 | Prospect | A N. 60° E.-striking, nearly vertical structure in granite gneiss bears comb quartz as much as 6 in. thick with calcite filling. Disseminated pyrite in quartz and in gouge. | One partially caved shaft and one trench. | Two grab samples contain 0.004 and 0.03 oz/ton gold, 0.274 and 3.1 oz/ton silver, 0.0022 and 0.0097 pct copper, and 0.021 to 0.16 pct zinc. One contains 0.016 lead and 0.0025 pct molybdenum. Gold and silver sample analyses indicate further study is warranted. |
| 46 | Triple 10 Nos. 1-3 prospect | Massive to brecciated quartz veins 1 to 14 in. thick in sheared gneiss exhibiting chlorite and sericite alteration. One vein system strikes N. 55°-60° E., dips 50°-65° SE., crops out discontinuously for 500 ft, and contains pyrite, limonite after pyrite, and abundant galena. A collapsed working 800 ft (along strike) from southwestern outcrop may be on same vein. An east-striking, 75° N.-dipping shear zone also developed. | One 20-ft adit, one caved adit or shaft and two inclined shafts, 20 and 25 ft deep. | Three chip and two select samples taken. Of four samples taken on quartz vein, two select samples contain 0.01 and 0.366 oz/ton gold, 2.5 and 8.4 oz/ton silver, 0.09 and 0.14 pct copper, 4.5 and 7.6 pct lead, and 0.28 and 0.88 pct zinc, two chip samples contain 0.006 and 0.032 oz/ton gold, 0.18 and 0.91 pct lead with one chip containing 0.9 oz/ton silver. Chip samples on shear zone contain no detectable values. Sporadic moderate to high assay values of gold, silver, and lead indicate that property merits further investigation. |
| 47 | Blue Jay No. 1 prospect | East-trending shear zones in granite gneiss contain calcite veins with pyrite-filled fractures, massive gray to white quartz, and quartz breccia with silica cement; probable argentite at one isolated outcrop. | Two adits, 145 and 37 ft long, two flooded shafts, one 40 ft to water line, one 8 ft to water line, two pits, and a cabin. | Of 15 chip, grab, and select samples, 2 contain detectable gold at 0.01 oz/ton. Silver was detected in 11 samples, 9 contain 0.02 to 0.31 oz/ton, and 1 select sample contains 21.1 oz/ton silver, 0.009 pct copper, 0.44 pct lead, and 0.03 pct zinc. Although sample analyses are generally low, the presence of detectable gold, one very significant silver value, and significant deposits of a similar nature to the northwest indicate property merits additional investigation. |
| 48 | Decorative stone quarry | Relatively flat-lying, punky to silicified, buff to gray, interbedded tuffs and rhyolitic lava flows underlie the property. Desired stone is apparently silicified tuff which splits into slabs 2 to 5 in. thick and about 12 in. in diameter. | One small quarry site and a network of exploration jeep trails. Possible production of less than 20 tons of decorative stone based on the size of the quarry. | No samples taken. Large tonnage available marginally suitable as wall facade decorative stone. Deposit is classed as subeconomic except for local use due to cost to ship to distant markets. |
| 49* | Doddle Bug-Wildcat-Wild Horse placer prospects | Fluvial sediments from washes in and entering Wild Horse Canyon are composed predominantly of gneissic, granitic, and volcanic silt, sand, and gravel (<1 in. in diameter) with 1-2 pct black sands. Claims were located about 1960 in secs. 2 and 11, T. 11 N., R. 14 E. and in sec. 18, T. 11 N., R. 15 E. S.B.M. | None | No gold observed in two 0.38 $ft^3$ reconnaissance samples. One sample contained trace garnet and trace of native copper. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 50 | Prospect | A shaft was driven N. 50° E. to intersect a quartz vein that crops out to the east and 10 ft higher in elevation. Vein is 6 ft thick, strikes N. 50° W. and dips 78° NE. in a quartz-mica schist with quartz veinlets. | One 25-ft-deep inclined shaft. | One chip sample across outcrop contains 0.01 oz/ton silver; no gold detected. |
| 51** | Frisco No. 1 prospect | Relatively unaltered to intensely altered, sulfide-bearing schist with no major structure observed. Altered schist contains magnetite, calcite, sericite, pyrite, and fine-grained chalcopyrite. A 35-ft-thick rhyolite porphyry dike and sulfide ore, that contain 0.15 and 0.73 oz/ton gold, respectively, are reported (Tucker and Sampson, 1930, p. 235). | One caved adit was approximately 400 ft long with a 50-ft raise to the surface and a 30-ft winze (Tucker and Sampson, 1930, p. 235). | Two grab samples from approximately 1,000 $yd^3$ dump contain none and 0.0006 oz/ton gold, 0.012 and 0.029 oz/ton silver, 0.015 and 0.040 pct copper, and 0.0037 and 0.0081 pct molybdenum. One contains 0.0049 pct zinc. Analytical results were low; however, the presence of other gold deposits nearby, and reported grades, indicate that the property merits additional investigation. |
| 52#** | SS No. 7 prospect | A gray to white, iron-oxide-stained, 1- to 3-ft-thick quartz vein that strikes N. 20° E., dips steeply southeast, and crops out for 50 ft. | None | One random chip contains 0.0017 oz/ton gold, 0.15 oz/ton silver, 0.0720 pct lead, and 0.0020 pct molybdenum. Gold sample analysis and similar significant deposits nearby indicate that further studies are warranted. |
| 53 | Prospect | Localized, variably oriented, narrow quartz veins 1-2 in. thick in Proterozoic gneiss. Veins are vuggy and iron oxide stained. One vertical vein strikes N. 80° E.; one strikes N. 60° W., dips 54° SW.; and one strikes N. 20° E., dips 27° SE. | One 25-ft adit and two small pits. Workings are spatially related but apparently not structurally related. | Of three chip samples, one contains 0.077 oz/ton gold and two contain 0.3 oz/ton silver. One high gold value and the geologic environment indicate that the vein system merits further study. |
| 54 | Prospect | A northwest-trending, steeply north-dipping fault zone is as much as 5 ft thick, exposed for 115 ft, and has a 2- to 10-in. calcite vein in clay gouge; contains abundant pyrite in pods with spotty galena. A crosscut intersects three quartz-calcite veins and a 50-ft-wide zone of brecciated gneiss rock with disseminated pyrite. Two, localized, north-trending, steeply east-dipping quartz veins and an east-trending, north-dipping shear zone are exposed on the surface. Veins and shear zones are in friable to punky, iron-oxide-stained, banded granite gneiss. | One tunnel with one portal caved includes 115 ft of drift and 135 ft of crosscut; one open cut, 10 ft diameter. | Of 11 chip samples underground, 8 contain detectable gold ranging from 0.006 to 0.138 oz/ton, 8 contain detectable silver ranging from 0.4 to 12.3 oz/ton, 3 contain 0.1 pct copper, 7 contain 0.02 to 0.61 pct lead, and 8 contain 0.01 to 0.65 pct zinc. Six samples taken on the 115-ft calcite vein averages 0.04 oz/ton gold and 4.7 oz/ton silver. No gold or silver were detected in three samples from veins and shear zones at surface. Exposed deposit is too small for resource calculation; however, sporadic, moderately high assay values indicate property merits additional study for gold and silver resources in veins. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 55** | Prospect | Localized, 1- to 6-ft-thick, northeast- to northwest-trending, easterly dipping, iron-oxide-stained, sulfide-bearing quartz veins in fractured gneiss show sericitic and chloritic alteration. Quartz is white, massive to brecciated, and contains pyrite, limonite after pyrite, galena, and possibly chalcopyrite. | Three adits, 22 ft, 25 ft, and 128 ft long. | Of six chip and two grab samples, four contain from a trace to 0.08 oz/ton gold, six contain from 0.006 to 1.13 oz/ton silver, and from 0.0018 to 0.02 pct copper, and five contain from 0.0089 to 0.97 pct lead. Three samples analyzed for zinc contain 0.0029 to 0.033 pct and, of two samples analyzed for molybdenum, one contains 0.024 pct. Sample analyses and size of vein system indicate further studies may reveal vein-type gold, silver, and possibly lead resources at depth. |
| 56 | Prospect | An iron-oxide-stained quartz vein, 0.3 to 0.5 ft thick, strikes N. 25° E. and dips 20° SE. in silicified granite gneiss. | One adit, 10 ft long | One chip sample contains 0.0015 oz/ton gold, 0.296 oz/ton silver, 0.12 pct lead, 0.0034 pct molybdenum, and 0.042 pct bismuth. Significant nearby properties and sample value suggest prospect merits additional investigation. |
| 57 | Globe mine | Roughly tabular, pinch and swell quartz veins and a zone of sheared and brecciated gneiss and quartz trend east and dip 30°-60° N. Zone is exposed for 240 ft along strike, 275 ft downdip and is about 5.0 ft thick. Nearby outcrops suggest a possible strike length of 1,500 ft. Quartz is white to dark bluish gray and contains pyrite, limonite after pyrite, galena, chalcopyrite, specularite, and probable sphalerite. Chlorite and epidote are common alteration minerals and hexahydrite encrustations have weathered out on ribs in shear zones. Felsic volcanic rock exhibiting sericitic and chloritic alteration contains disseminated pyrite in two locations in haulageway. | A 275-ft-long inclined shaft with 400 ft of drifts and 100 ft of stopes is connected by 700-ft haulageway to partially collapsed adit and shaft; three inclined shafts, a caved shaft, a 30-ft adit, and five pits. Tucker and Sampson (1930, 1931) reported very high-grade ore shipments. | Indicated subeconomic resources of 30,000 tons and inferred subeconomic resources of 80,000 tons at average grade of 0.05 oz/ton gold and 1.0 oz/ton silver. Seventy chip, 3 random chip, and 2 select samples taken. Fifty-one contain detectable gold, values ranging from a trace to 1.05 oz/ton; 12 contain $\geq$ 0.1 oz/ton gold. Fifty contain detectable silver, values range from 0.053 to 65.9 oz/ton; 16 exceed 1.0 oz/ton silver. Thirty-eight contain 0.0008 to 0.0100 pct copper, 42 contain 0.0014 to 0.34 pct lead, 74 contain 0.0035 to 0.13 pct zinc, and 59 of 62 samples analyzed contain 0.0018 to 0.0330 pct molybdenum. Of 21 analyzed for tin and tungsten, 20 contain 0.02 to 0.04 pct tin and 9 contain 0.0006 to 0.0014 pct tungsten. Geologic setting, metal values, and similar deposits nearby suggest additional gold, silver, and possible molybdenum resources may be present at depth. |
| 58 | Prospect | A massive, 5- to 8-in.-thick, iron-oxide-stained quartz vein strikes N. 3°-20° E. and dips 40°-80° NW. in silicified gneiss. Two outcrops of vein are 140 ft apart. Vein is apparently terminated at both ends by east-trending, north-dipping shear zones. | One 30-ft-long open cut, one 10-ft adit with a 30-ft-long open cut and one adit, 40 ft long. | Two quartz vein chip samples contain 0.192 and 0.078 oz/ton gold and one contains 0.1 oz/ton silver. One random chip on a 20-ft-wide shear zone contains 0.010 oz/ton gold and 0.2 oz/ton silver. Sample analyses and nearby past producer suggest prospect merits further investigation for gold resources at depth. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 59 | Prospect | An east-striking, 40°-50° N.-dipping quartz-bearing shear zone and a quartz vein in a fault gouge zone 4.5 ft thick, striking N. 80° W. and dipping 55° SW.; both are in altered, Proterozoic gneiss. | Two shallow pits | One select grab on quartz-bearing shear contains 0.074 oz/ton gold and 0.8 oz/ton silver. One chip sample from quartz vein contains 0.01 oz/ton gold and 0.01 pct lead and zinc. No copper detected. Based on gold and silver assay values and similar deposits in area, property merits additional investigation. |
| 60 | Prospect | A north-northwest trending, steeply northeast-dipping, pinch and swell quartz vein as much as 12 ft thick is poorly exposed in granite gneiss country rock that is silicified and sericitically altered. Some pyrite and considerable manganese oxides observed. Some secondary copper minerals on fractures. | One adit, 15 ft long, one caved shaft, and one trench. | Four of five chip and grab samples contain detectable gold and all contain detectable silver; gold assays range from 0.002 to 0.01 oz/ton and silver assays range from 0.09 to 3.4 oz/ton. One sample contains 1.3 pct copper with the rest ranging from 0.0012 to 0.04 pct; minor lead and zinc also detected. Two samples contain 0.0011 and 0.0056 pct molybdenum. Sample analyses for gold and silver, prominance of vein, and similar nearby deposits indicate property merits additional investigation for small, high-grade, vein-type gold and silver resources. |
| 61 | Prospect | Small quartz lenses in iron-oxide-stained, fractured banded gneiss. | One pit | One grab sample contains 0.006 oz/ton gold, 0.14 oz/ton silver, 0.0031 pct zinc, and 0.0021 pct molybdenum. Presence of anomalous gold and nearby past producers indicate additional studies are warranted. |
| 62 | Clamento No. 3 prospect | West-northwest-striking, variably dipping white to gray quartz veins in argillically to sericitically altered, punky to silicified gneiss along a northern projection of East Providence fault zone. Quartz is 1 ft thick, iron oxide stained, and in some places contains secondary copper minerals. | One inclined shaft, 30 ft deep, one adit 7 ft long, and three pits. | Three chip and three grab samples taken. All samples contain detectable gold and silver; silver ranges from 0.012 to 0.872 oz/ton and gold ranges from 0.0006 to 0.085 oz/ton. Two gold assays were greater than 0.01 oz/ton; at 0.085 and 0.077 oz/ton. One sample contains 1.9 pct lead and one contains 1.9 pct copper. Other sample values range from none to 0.031 pct copper, none to 0.058 pct lead, and 0.0030 to 0.079 pct zinc. Four samples contain from 0.0008 to 0.0048 pct molybdenum. Consistent gold values and nearby past producers suggest additional exploration for gold and silver resources with byproduct copper and lead resources is warranted. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 63 | Prospect | Generally northwest-trending, northeast-dipping, white to translucent gray, iron-oxide-stained, 1- to 6-ft-thick quartz veins associated with shear zones in gneiss. Quartz massive to brecciated with a few voids formed by dissolved pyrite. | Two short adits, one 20-ft-deep inclined shaft and three pits. | Four of nine chip samples contain measurable gold, from 0.002 to 0.085 oz/ton. Eight of nine samples contain measurable silver, from 0.05 to 2.7 oz/ton. Only one silver assay was above 1 oz/ton. Low levels of copper (< 0.03 pct), lead (< 0.17 pct) and zinc (< 0.05 pct) were detected in some samples. Molybdenum ranges from 0.003 to 0.0075 pct in five samples. Sample analyses and nearby gold and silver deposits indicate property merits additional study. |
| 64 | Frisco No. 3 mine | Two quartz veins have the following strikes and dips: the Horn Silver, N. 10°-30° W., 25°-42° NE., and the Silver Bell, N. 50°-70° W., 45°-75° NE. Veins in locally intensely altered, silicified gneiss. Quartz is white to gray, iron oxide stained and massive to brecciated with rare comb structures. Altered rock composed of quartz, potassium feldspar, sericite, jarosite, and iron oxides. Horn Silver vein is exposed for 55 ft and as much as 20 ft thick. Silver Bell vein is exposed for 500 ft and is 1 to 5.5 ft thick. | Five adits (5, 15, 35, 84, and 235 ft long), two shallow inclined shafts, a caved inclined shaft, two pits, and several open cuts. Production from 1 ton of ore was 2.11 oz gold and 54 oz silver in 1930 (USBM statistical files). | Silver Bell vein contains indicated subeconomic resource of 2,000 tons at 0.006 oz/ton gold and 0.2 oz/ ton silver and inferred subeconomic resource of 38,000 tons averaging 0.022 oz/ton gold and 0.7 oz/ton silver. One grab, 4 random chip, and 25 chip samples taken. Fifteen of 20 samples from Silver Bell vein contain 0.001 to 0.07 oz/ton gold and 0.04 to 6.0 oz/ton silver. Seven of 9 samples on Hornsilver vein contain 0.020 to 0.196 oz/ton gold and 0.3 to 11.8 oz/ton silver. Generally low levels (< 0.01 pct) of copper, lead, zinc, and molybdenum were detected in samples from two vein systems although lead ranges from 0.12 to 0.28 pct in eight samples and one contains 1.2 pct. Size, grade, and alteration indicate property merits further investigation for additional gold and silver resources with possible byproduct lead. |
| 65 | Prospect | A west-northwest-trending, northeast-dipping fault zone contains gray to white, massive to brecciated quartz veins and iron-oxide-stained fault gouge and breccia. Country rock is silicified Proterozoic gneiss. Main structure is 2 to 5 ft thick and crops out for approximately 80 ft. | Two shafts, 16 and 17 ft, and one adit, 8 ft long. | Of four chip samples, two have 0.006 and 0.038 oz/ton gold and 0.4 oz/ton silver. Three contain 0.01 to 0.2 pct lead, and four contain 0.01 to 0.04 pct zinc; no copper detected. Higher values in central part of outcrop. Sample analyses, size of vein, and nearby deposits indicate property merits further study for gold and possibly silver resources at depth. |
| 66 | Prospect | A 2-ft-thick shear zone strikes N. 22° E., dips 65° SE., contains quartz veins, and occurs in Proterozoic granite gneiss. Zone is highly fractured with iron oxide filling and purplish-brown alteration products in fractures and joints. | One pit | One chip sample has 1.29 oz/ton gold, 6.9 oz/ton silver, 0.17 pct lead, and 0.03 pct zinc. High gold and silver assay value indicates further study warranted. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 67 | SS Nos. 51, 52, 60, and 61 prospect | A discontinuous, northeast-trending, vertical to northwest-dipping, white, 1- to 5-ft-thick quartz vein, and a pegmatite dike in gneiss. Quartz and enclosing shear zone contain pyrite, limonite after pyrite, galena, and calcite. System is exposed for about 120 ft. | One flooded shaft, two adits, 140 ft and 65 ft long, and six pits. | Eleven chip samples contain 0.01 to 0.03 pct copper and 0.01 to 2.8 pct lead; only one sample exceeds 0.5 pct lead. No gold or silver detected. Extent of workings and high lead assay value indicate further study needed. |
| 68 | Prospect | Minor amounts of iron-oxide-stained, vuggy quartz in 4- to 12-ft-thick, variably oriented, bleached, silicified gouge and shear zones in altered gneiss. Main structure strikes N. 15°-20° W. with a near vertical dip. | Two adits, 8 and 15 ft long, one 20-ft trench and one pit. | Of five chip samples, three contain from 0.001 to 0.05 oz/ton gold. Silver values range from 0.04 to 0.9 oz/ton. Gold and silver analyses indicate additional study needed. |
| 69 | Double H Nos. 1 and 2 mine | A quartz vein and a silicified, altered shear zone strike N. 50°-60° W., dip 45°-75° NE., and crop out for approximately 1,000 ft in gneissic rock. Vein averages 1.4 ft thick, is white to gray, and contains pyrite, galena, and sphalerite. | Two pits, a 50-ft-long open cut, two adits (45 ft and 90 ft long), one caved adit, and one inclined shaft at least 40 ft deep. Production from 105 tons of ore was 42 oz gold and 329 lb copper in 1931 (USBM statistical files). | An inferred subeconomic resource of 45,000 tons at average grade of 0.02 oz/ton gold and 2.5 oz/ton silver with byproduct lead and zinc. Past production, size of deposit, and sample analyses suggest further investigation may reveal additional vein-type gold and silver and byproduct copper, lead, and zinc resources at depth. Eight chip and three select samples; nine contain gold ranging from 0.006 to 0.268 oz/ton and averages 0.063 oz/ton; silver ranges from 0.5 to 44.4 oz/ton and averages 8.2 oz/ton, only four exceed 5 oz/ton silver. Lead and zinc range from 0.01 to 1.2 pct and 0.02 to 0.3 pct and averages 0.2 and 0.07 pct, respectively. Past production, size of deposit, and sample values suggest further investigation may reveal additional vein-type gold and silver resources and by-product copper, lead, and zinc. |
| 70 | Santa Anita-Beecher Canyon placer prospects | Fluvial sediments from head and mouth of Beecher Canyon are composed predominantly of gneissic sand and pebbles with slight to moderate quantities of volcanic rock. Two samples had notable comb quartz fragments. One claim was located in 1916 at mouth of canyon, and two claims were located in 1961 at head of canyon. | None | Of four 0.38 $ft^3$ reconnaissance pan samples of typical sediments and one select 0.38 $ft^3$ pan sample of surficial concentrations of black sands, three samples contained gold. Two reconnasisance samples at head of canyon contained 0.022 and 0.023 mg of bright, subrounded gold and traces of pyrite, scheelite, and zircon. Select sample at mouth of canyon contained 0.169 mg of bright, subangular to subrounded gold and a trace of garnet. Value of three samples is estimated to range from \$0.02 to \$0.15/$yd^3$ at a gold price of \$400/oz. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 71 | Orro Platta prospect | Quartz veining 1 to 4 ft thick along predominantly northwest-trending, northeast-dipping fault zones. Country rock is Proterozoic gneiss with argillic (?) alteration and scattered iron oxide staining. Quartz vein exposed in workings for 450 ft along its northwest trend, but continuity of structure is uncertain between workings. | One shaft, 18 ft deep, three adits, two 10 ft long and one 50 ft long, and one pit. | Of seven chip samples from quartz veins and gouge, six have no gold and one has 0.186 oz/ton gold and 11.7 oz/ton silver. Three samples have 0.2 to 0.5 oz/ton silver and one has 1.1 oz/ton silver. One sample contains 0.05 pct copper, six contain 0.01 to 0.08 pct lead, one contains 0.52 pct lead, and zinc values range from 0.01 to 0.08 pct. Sporadic but significant sample values, and past producers in vicinity, indicate vein system should be studied in detail to determine if gold, silver, and possibly lead resources are present. |
| 72 | Providence mine | Two north-northeast-trending faults bound a 30-ft-thick zone of silver-bearing limestone breccia, near a contact with gneiss. East Providence fault gouge averages 5.5 ft thick and contains gold. Deposit is exposed for 80 to 130 ft but fault contact and limestone breccia continues at least 3 mi south. | A 224-ft adit, two adits, and two shafts, one collapsed at collar. Leech (1890, p. 105) reported 4.1 oz gold produced in 1889 and USBM statistical files report 12 tons containing 445 oz silver, 166 lb copper, and 2,465 lb lead produced in 1918. | Of 15 chip and 2 random chip samples, 3 contain 0.01 to 0.11 oz/ton gold and 4 contain 0.3 to 1.0 oz/ton silver. Four samples contain 0.01 to 0.06 pct lead. Past production, similarity of this deposit to Silver King mine (no. 149), and sample analyses indicate property merits further investigation for additional silver, gold, lead, and copper resources at depth or laterally along brecciated limestone. |
| 73 | SS Nos. 63, 64 prospect | Workings on two sets of structures in Proterozoic gneiss and Paleozoic limestone and local exposures of granitic rock. One set strikes N. 50°-65° E. with dips ranging from 50° NW. to 45° SE. and the other set strikes N. 20°-30° W. and dips 45°-50° NE. Structures range from 0.5 to 9.0 ft thick. | Three adits, 5 ft, 32 ft, and one caved; four inclined shafts 11 ft, 25 ft, at least 50 ft, and 50 ft with 50 ft of drift. | Of nine chip samples, four contain 0.2 to 0.5 oz/ton silver; none contains gold. Extent of workings, nearby deposits, and sample analyses indicate property merits additional investigation; silver resources may be associated with shear zones in carbonate rocks. |
| 74 | Prospect | Localized, variably oriented quartz veins and silicified zones 2 to 6 ft thick in light-green, coarse, crystalline rock intruded by rhyodacite dikes and (or) sills. Crystalline rock exhibits sericitic alteration. Veins strike north, northeast, and east and dip north or east. | One adit, 15 ft long, and three pits. | Of four chip samples, one contains a trace gold, two contain 0.1 to 0.2 oz/ton silver, two contain 0.003 to 0.0069 pct copper and four contain from 0.0038 to 0.0054 pct molybdenum. |
| 75 | Terry placer prospect | Fluvial sediments from Globe Canyon are composed of gneissic pea gravel and 2 pct black sands. Wash commonly has only a thin veneer of alluvium over bedrock. Claim located in 1980. | One pit to bedrock. An attempted sluicing operation apparently failed. | One 0.38 $ft^3$ reconnaissance pan sample contained four bright, subangular to subrounded, chunky fragments of gold for a total of 0.020 mg. Value is estimated at \$0.02/$yd^3$ at a gold price of \$400/oz. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 76 | Prospect | Multiple, white, iron-oxide-stained quartz veins totaling 0.7 ft thick in a fault gouge zone striking N. 70° E. and dipping 65° NW. in gneiss exhibiting sericite and chlorite alteration. Quartz contains fresh galena, limonite after pyrite, secondary copper minerals, and manganese oxide crusts. | One inclined shaft 10 ft deep. | One chip sample contains 0.017 oz/ton gold and 0.36 oz/ton silver, 0.041 pct copper, 0.84 pct lead, 0.0045 pct zinc, and 0.0077 pct molybdenum. Sample analysis indicates further investigation for gold and possibly silver and lead warranted. |
| 77# | Okaw mine | Country rock is quartz monzonite intruded by rhyolitic dikes. Both monzonite and dikes exhibit sericitic alteration. Northeast-striking quartz veins, 0.6 to 3.7 ft thick, dip steeply to south and contain galena, limonite after pyrite, and minor amounts of chalcopyrite, sphalerite, and secondary copper minerals. Veins and shears are exposed for at least 400 ft. | Five shafts, all inaccessible, 3 adits, 24, 30, and 105 ft long, and 8 pits. Building foundations appear to be from a mill. No known production. | Of 16 chip, 3 select, and 2 grab samples, 17 contain measurable gold and silver. Eleven samples have gold values between 0.01 and 0.29 oz/ton and 7 samples have silver values between 1.0 and 6.1 oz/ton. All samples contain detectable lead; 8 contain from 1.2 to 7.8 pct. Copper values range from 0.0009 to 0.83 pct and molybdenum values range from 0.0018 to 0.027 pct in 15 samples analyzed. Number and sizes of veins and high analytical values for gold, silver, lead, and copper indicate further exploration warranted. |
| 78 | Prospect | Three segments (52 ft, 72 ft, and 180 ft) of a northwest-trending, variably dipping, 6- to 10-ft-thick, white quartz vein crop out for a strike length of 440 ft in granitic rock. | One pit | One grab sample contains 99.15 pct $SiO_2$, 0.30 pct iron, and 0.05 pct $Al_2O_3$. No gold or silver detected. Inferred size of occurrence is 9,900 tons. Silica grade meets specifications for some industrial applications; however, small deposit size and great distance to market suggest little, if any, economic significance in the foreseeable future. |
| 79** | Prospect | An altered zone in quartz monzonite is exposed in two pits 50 ft apart. Zone of alteration is 8 ft thick as exposed in face of one pit. A part of zone about 3 ft thick is leached and bleached to punky white clay and contains quartz ribs 2 in. to 4 in. thick. | Two pits | A sample from 3-ft section contains trace gold and 0.06 oz/ton silver. Additional investigation is merited. |
| 80 | Prospect | A contact of quartz monzonite and gneiss is exposed for 10 ft. Contact strikes N. 80° E. and dips south at 40°. Fractured and silicified zone 6 ft thick in quartz monzonite at adit portal. Zone contains minor pyrite and copper carbonate. | One 10-ft adit | A 3-ft chip sample contains 0.01 oz/ton gold and 0.17 oz/ton silver. Gold value indicates prospect should be investigated in more detail. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 81 | Prospect | Shaft symbol on provisional (1983) U.S. Geological Survey Hayden 7.5-minute quadrangle. Granitic terrain; may be an extension of Prospect (No. 78). Prospect not found during field studies. | One shaft (?) | Property not examined. |
| 82 | Prospect | Lenses and stringers of specular hematite in pinkish, medium-grained, quartz-rich intrusive rock, probably quartz monzonite. A pit in weathered gneiss is located S. 80° E., 100 ft from center of bulldozer cut. Stringers of hematite as much as 1 in. thick can be traced 400 ft south from bulldozer cut and 100 ft to north. Maximum thickness of lenses exposed in a cut is 2 ft. Ore mineral is massive, specular hematite with minor amount of pyrite. | One 50-ft-long bulldozer cut and one pit. | A grab sample from a 4-ton stockpile contains 41.5 pct iron and 0.05 oz/ton silver. |
| 83 | Del No. 2 prospect, north extension | A fractured, iron-oxide-stained, 5-ft-thick zone strikes N. 85° W. and dips 45° NE. along an irregular contact zone between gneiss and granitic rock. | Open cut 10 ft deep | One chip sample contains no detectable gold or silver. |
| 84 | Prospect | An iron-oxide-stained 25-ft-thick contact zone between gneiss and a rhyolite dike. | One 3-ft adit and a 32-ft trench. | One chip sample contains 0.009 oz/ton silver. |
| 85 | Prospect | A 2-ft-thick, N. 80° W.-striking, vertical, silicified, iron-oxide-stained zone along a dike in foliated schist. | One pit | One chip sample contains 0.3 oz/ton silver; no gold detected. |
| 86 | Del No. 2 prospect | A 600-ft-long, relatively flat-lying, weak skarn zone along a contact between a fine-grained gray rock (limestone?) and granitic rocks. | One 62-ft adit, three shallow shafts, and four pits. | One chip and one select sample contains 0.009 and 0.006 oz/ton silver. No gold was detected. |
| 87 | Firefly-White Eagle-Star placer prospects | Fluvial sediments from Summit Wash are composed of poorly sorted gneissic sands, gravels, and cobbles. Wash is narrow and moderately scoured at upper elevations and rapidly widens and thickens at confluence with Globe Wash. Claims located 1913-1938. | None | Of three 0.38 $ft^3$ reconnaissance pan samples, one contained 10 bright, subrounded to subangular pitted, chunky fragments of gold, for a total of 0.110 mg, and traces of garnet and hematite. Value is estimated at \$0.10/$yd^3$ at a gold price of \$400/oz. Two samples contained traces of scheelite. |
| 88 | SS No. 49 prospect | A 5-ft-thick, vuggy, iron-oxide-stained, pyrite-bearing quartz zone trends N. 40° W. in green to white, fine-grained intrusive rock. | Open cut 8 ft long | One chip sample contains 0.0014 pct molybdenum and 0.0018 pct tungsten; no gold or silver was detected. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 89 | Del No. 2 prospect, south extension | A 2-ft-thick breccia zone strikes N. 30° E. and dips 80° NW. along a contact zone between gneiss and granitic rock. Zone contains 1/4- to 1/2-in.-thick quartz veinlets, minor secondary copper minerals, and some garnet and epidote. | One pit | One chip sample contains 0.01 oz/ton silver; no gold detected. |
| 90 | Prospect | Pits are in a N. 30° W.-striking, 64° NE.-dipping, fracture zone in a light-gray, fine-grained rhyolitic rock. Zone is observed for 25 ft along strike and is 3.5 ft thick. | Two shallow pits | One chip sample contains 0.007 oz/ton gold. Sample analysis indicates the prospect warrants further study. |
| 91 | Prospect | A thin, irregular, altered contact zone between weathered gneiss and a light-colored, quartz-rich intrusive rock. 1.5-ft-thick, iron-oxide-stained contact zone trends N. 45° E., dips vertical and is altered to clay. | Two pits | One chip sample contains no detectable gold or silver. |
| 92 | Prospect | Light-gray to tan, fine-grained, silicified rock, probably rhyolite, is iron oxide stained, contains as much as 5 pct fine, crystalline pyrite, and knife-edge to 1/4-in.-thick veinlets and blebs of specular hematite A nearby pit is in brecciated, silicified limestone cemented with massive white calcite. Breccia contains irregular stringers of specular hematite. | One 24-ft-deep inaccessible shaft and one pit. | A grab sample of rhyolite contains 0.006 oz/ton gold and 0.006 oz/ton silver. A grab sample of limestone contains 0.55 oz/ton gold and 0.06 oz/ton silver. Although the geologic environment is not well understood at this prospect, the gold sample analyses suggest prospect merits additional investigation. |
| 93 | Silver Queen I-XXXIII prospect | Several quartz veins generally trend northeast, dip steeply southeast, and crop out in granitic country rock. Veins are 0.5 to 1.0 ft thick and contain galena, pyrite, and chalcopyrite. Minor amounts of secondary copper minerals and iron oxides are also present. Veins pinch and swell and can be traced 200 ft. One vein, exposed in pit, is cut off by fault or shear zone just below surface. | Three shallow shafts, three trenches, and one pit. | A total of five samples were taken, four of which were from quartz veins. Two of four quartz vein samples contain 0.19 and 0.37 oz/ton gold, 2.2 and 4.7 oz/ton silver, and 4.2 and 1.8 pct lead. Exposed veins are too narrow and discontinuous to make a resource estimate, but high values of gold, silver, and lead warrant further exploration. |
| 94* | First Chance placer prospect | Fluvial sediments consist of 90 pct pea gravel and coarse sands and 10 pct silt and clay; composition is predominantly granitic and contained 1-3 pct black sands. The First Chance claims were located in secs. 9, 16, and 23, T. 11 N., R. 13 E., S.B.M., in 1954 and 1957. | None | One 0.38 $ft^3$ reconnaissance pan sample contained two particles of bright, subangular to angular gold for a total of 0.001 mg. Material is valued at less than \$0.01/$yd^3$ at a gold value of \$400/oz. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 95** | Prospect | Three- to 7-ft-thick silicified and altered zones trend north, dip steeply east, and crop out discontinuously for approximately 400 ft in gneiss and quartz monzonite. Numerous quartz veinlets merge into massive gray quartz with minor amounts of specular hematite. | One 38-ft adit and three pits. | Four samples contain no gold or silver and only minor amounts of copper, lead, and zinc. |
| 96#* | Jo Je mine | Two subparallel quartz veins 500 ft apart trend west-northwest and dip south in granitic rock. Veins are 1 to 3 ft thick, crop out for 700 to 900 ft, and contain white to gray, massive to brecciated, iron-oxide-stained quartz with limonite after pyrite and rare galena. An andesite dike lies adjacent to south vein. Northwest-trending, northeast-dipping normal faults cut north vein. | Workings consist of six shafts, 15 to 90 ft deep, two trenches and nine pits. Main shaft may have 300 ft of drifts on two levels. USBM statistical files indicate 185 tons of crude ore contained 72 oz gold and 392 oz silver (grades averaged 0.39 oz/ton gold and 2.1 oz/ton silver) from a small cyanide mill. | Of 1 select and 15 chip samples, 8 contain gold ranging from 0.012 to 0.163 oz/ton and averaging 0.052 oz/ton, and 6 contain silver ranging from 0.3 to 2.1 oz/ton and averaging 0.9 oz/ton. Copper values range from 0.0091 to 0.06 pct, lead values range from 0.03 to 0.53 pct, and zinc values range from 0.0013 to 0.01 pct. Production history and sporadic but significant gold and silver values indicate this property may have additional high-grade, vein-type resources at depth. |
| 97 | Morning Star prospect | A quartz vein 3 in. thick in granitic rock and contains pyrite and limonite pseudomorphs after pyrite. | One adit (caved) | One grab sample contains 0.0009 oz/ton gold and 0.02 oz/ton silver, 0.0046 pct zinc and 0.0056 pct molybdenum; no copper or lead detected. Presence of gold suggests further exploration is warranted. |
| 98 | Prospect | A 0.5-ft-thick quartz vein with stringers of remnant sulfides strikes N. 30° E. and dips 32° SE. in granitic country rock. Chloritic alteration along the contacts and stringers of hematite within the country rock. | One pit | One chip sample contains 0.01 oz/ton gold, 0.0020 pct copper, 0.0400 pct lead, and 0.0044 pct molybdenum. Alteration and sample analysis indicate prospect merits additional investigation for gold resources. |
| 99 | Green Scorpion prospect | A fault zone trends northeast and dips northwest in metaigneous rock and contains a quartz vein, quartz breccia, and soft gouge. Vein contains relict sulfides, secondary copper minerals, and iron and manganese oxide staining. Extensively silicified, carbonatized, and sericitized porphyritic dikes of andesite to rhyodacite composition are exposed in workings and cut by mineralized fault. Fault zone is exposed discontinuously for 185 ft along strike and averages 2.3 ft thick. | One 55-ft-long adit and one pit. | Deposit contains 3,300 tons with weighted average grade of 0.086 oz/ton gold. Four chip and one select sample were taken. Gold assay values range from 0.0005 to 0.16 oz/ton, and average 0.1 oz/ton, and silver assay values range from 0.04 to 0.3 oz/ton. Copper content ranges from 0.012 to 0.17 pct, two samples contain 0.0047 and 0.0062 pct molybdenum, and one sample contains 0.0039 pct zinc. Several high gold assay values indicate property merits additional investigation. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 100 | Independence prospect | Coarse-grained granite gneiss is brecciated locally, with sericitic and kaolinitic alteration and some iron oxide staining. | One bulldozer cut and one pit. | One smaple contains 0.0170 pct zinc and 0.0048 pct molybdenum; no gold, silver, copper, or lead detected. |
| 101 | Greek prospect | Two intersecting shears in porphyritic rhyolite exhibiting sericitic alteration. Gouge along structures is iron oxide stained and 2 in. thick. | Two pits. | One sample contains 0.5 oz/ton silver and 0.0054 pct molybdenum; no copper, lead or zinc detected. Silver sample analysis and nature of nearby deposits indicate further study is warranted. |
| 102 | Fan 1-5 prospect | Granitic intrusive rock and granite gneiss is intruded by dikes of andesitic to dacitic composition. Several fault or shear zones containing quartz veins, breccias, and gouge trend northwest and northeast and dip northerly. Minor occurrences of secondary copper minerals and primary sulfides are within the 1- to 5.5-ft-thick veins. Bleached country rock exhibits chloritic alteration. One vein is exposed for 200 ft and shear zone is exposed for 400 ft along northwest strike. | Five adits (125, 75, 60, 38, and 37 ft long) and 10 pits. One adit has flooded winze (depth unknown) and another has 25-ft stope to surface. | A total of 26 chip samples taken. Of 16 that contain detectable gold, 8 contain from 0.021 to 1.059 oz/ton and 8 contain from 0.0003 to 0.007 oz/ton gold. Of 19 that contain detectable silver, 4 contain from 1.1 to 33.6 oz/ton and remainder range from 0.003 to 0.936 oz/ton silver. Three of 9 samples with detectable lead contain from 0.29 to 2.6 pct; remainder range from 0.0170 to 0.055 pct lead. Six contain low levels of copper (<0.02 pct), 10 contain low levels of zinc (<0.083 pct), and 8 contain low levels of molybdenum (0.0006 to 0.0022 pct). Few, sporadic, high-grade samples, size of structures, and geologic setting indicate further sampling and exploration for gold and silver resources and byproduct lead are warranted. |
| 103** | Prospect | Granite gneiss contains specular hematite along fractures striking N. 15° W. and dipping 85° NE. | | One select sample: no gold or silver detected. |
| 104 | Pink Jack' prospect | Granite gneiss is intruded by west-northwest-trending, south-dipping pegmatite and andesite dikes. Country rock adjacent to dikes exhibits intense alteration; shearing along country rock and dike contacts. Sulfide textures and boxwork structures common along with iron oxides; minor secondary copper minerals in pegmatite dikes. Mineralized zones are 1 to 6.5 ft thick. | | Fifteen ship samples taken. Thirteen contain detectable gold ranging from 0.0006 to 0.56 oz/ton. Nine contain greater than 0.03 oz/ton gold, and have a weighted average of 0.157 oz/ton. All samples analyzed contain values ranging from 0.0009 to 0.093 oz/ton silver, 0.0006 to 0.266 pct copper, 0.0031 to 0.089 pct lead, and 0.0023 to 0.021 pct zinc. Significant gold assay values and proximity to other properties with high gold values indicate further exploration warranted. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 105** | Prospect | Numerous, localized shear and silicified zones, 0.3 to 2.2 ft thick, some containing quartz veins, in granitic to gneissic country rock. General trend of structures is east to east-northeast with variable dips. Metallic minerals in veins include galena, chalcopyrite, pyrite, and secondary copper minerals. | Two adits, 25 and 17 ft long; one shaft, 10 ft deep; three pits. | One of five chip samples contains 0.25 oz/ton gold and 1.5 oz/ton silver along with 0.66 pct copper, 11.9 pct lead, and 0.0045 pct zinc. Four remaining samples contain 0.003, 0.004, 0.037, and 0.048 oz/ton gold with silver ranging from 0.020 to 0.41 oz/ton, copper ranging from 0.0087 to 0.0170 pct, lead ranging from 0.077 to 0.239 pct, and zinc ranging from 0.0023 to 0.0075 pct. High gold, silver, and lead values, presence of anomalous copper, and similar properties in area indicate that property merits additional investigation. |
| 106 | Prospect | Quartz veins, in or near west-northwest-trending, northeast-dipping fault (?) contact between quartzite and gneiss are iron oxide stained and commonly contain limonite pseudomorphs after pyrite. Veins are 1 to 3.5 ft thick. | Two pits and one 10-ft incline. | Of three chip samples, two contain 0.002 oz/ton gold. Three contain from 0.002 to 0.122 oz/ton silver, 0.0011 to 0.0067 pct copper, 0.0045 to 0.0074 pct lead, and 0.0086 to 0.062 pct zinc. Gold sample analyses indicate further study warranted. |
| 107* | Prospect | At incline, two parallel quartz veins 3.0 ft thick, striking N. 75° W. and dipping 60° SW. can be traced for about 50 ft in granitic country rock. Veins contain chalcopyrite, chrysocolla, and limonite after pyrite. Both veins are truncated by fault just below ground surface. Country rock shows chloritic alteration near veins. At adit, two two 4-ft-thick shear zones intersect in gneissic country rock. | One 15-ft-deep incline and one 6-ft-long adit. | One chip sample taken across two veins contains 0.240 oz/ton gold and 0.245 oz/ton silver, 0.379 pct copper, 1.2 pct lead, and 0.060 pct zinc. A second chip sample contains 0.0026 oz/ton gold, 0.032 oz/ton silver, 0.0018 pct copper, 0.050 pct lead, and 0.0095 pct zinc. Sample analyses of gold, silver, lead, and possibly copper suggest further investigation needed. |
| 108* | L'Chacana prospect | A 1- to 4.5-ft-thick quartz vein crops out along north-trending ridge of granite gneiss country rock for about 800 ft. Vein contains minor amounts of secondary copper minerals. About 150 ft to east a stockpile (?) of quartz vein material contained some galena and secondary copper minerals. End of shaft dump contains pegmatite with a brecciated matrix displaying disseminated pyrite and sericitic and argillic alteration. A shallow intrusive contact is indicated. | One 100-ft-deep inclined shaft, one caved adit, two pits, and one trench. | Of 10 chip and 4 grab samples taken, 1 grab sample contains 0.046 oz/ton gold and 0.577 oz/ton silver, 5.8 pct lead, 0.171 pct copper, and 0.289 pct zinc. Another grab sample contains 0.0178 oz/ton gold, 0.0467 oz/ton silver, 0.0007 pct copper, and 0.0023 pct lead. Of seven chip samples on main vein, six contain from 0.0026 to 0.007 oz/ton gold along with minor silver, copper, lead, and zinc. Geologic environment and sample analyses suggest property should be studied in detail to determine if vein or disseminated gold resources and byproduct lead, silver, zinc, and possibly copper are present at depth. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 109** | Prospect | Two subparallel shear zones strike N. 25° to 40° E., dip 42° to 85° NW. and form a zone 2 to 3 ft thick in granite gneiss. | One 16-ft adit | One chip sample contains 0.0003 pct copper and 0.0016 pct lead; no gold or silver detected. |
| 110 | Prospect | Granite gneiss near a contact with quartzite contains numerous northwest-trending shear zones, a N. 70° E.-striking, 50° SE.-dipping quartz vein, and a northwest-trending porphyritic andesite dike. Secondary copper minerals along fracture surfaces in shear zones and 0.7-ft-thick quartz vein contains numerous iron-oxide-filled, boxwork structures. | Eight pits and one trench | Of seven chip and one grab sample, seven contain 0.0008 to 0.042 oz/ton gold, six contain 0.006 to 0.068 oz/ton silver, and minor copper, lead, and zinc were detected. Contact environment and gold sample analysis indicate further studies warranted. |
| 111 | Prospect | Fault gouge zones between gneissic rock to the northwest and metasediments to the southeast. The fault zone trends north-northeast and is 18 ft wide. | Two adits, 25 and 48 ft long | Three of four chip samples contain 0.1 to 0.3 oz/ton silver; copper ranges from 0.0004 to 0.0012 pct, lead was constant at 0.0023 pct and zinc ranges from 0.0047 to 0.0072 pct. |
| 112# | Tough Nut mine | Upper workings in carbonate rocks and one lower working in shale and quartzite. Mineralized zones are irregular, 1- to 6-ft-thick replacement pods and lenses predominantly in carbonates. Main zone is along an east-trending, south-dipping fault that offsets shale and quartzite. Gangue is calcite with possible barite. Minor pyrite and pyrrhotite in lower working. Possible lead sulfates or carbonates in mineralized zones. Mineral assemblage is very similar to those at Silver King (Perserverance) and Bonanza King mines ( Nos. 144 and 146). | Lower working is 360-ft adit with two drifts. Upper workings consist of three adits totaling 46 ft, four inclined shafts with stopes totaling at least 300 ft, and nine prospect pits. No production recorded; however, some production indicated by: (1) stopes, (2) high grade samples, (3) old millsite, and (4) similarity of geology to nearby past producers to east. | Of 30 chip, 4 random chip, and 2 grab samples taken, most of the 26 samples from workings in carbonate rock contain detectable gold and silver. Values range from 0.0012 to 2.01 oz/ton gold and 0.012 to 67.2 oz/ton silver. Three samples have more than 0.1 oz/ton gold and five samples have more than 1.0 oz/ton silver. Lead ranges from 0.003 to 2.9 pct; zinc ranges from 0.0005 to 0.49 pct; and copper ranges from 0.001 to 0.035 pct. Exposed mineralized structures are largely mined out; however, probable past production, sporadic but high assay values, and similarity of geology to significant past producers to east suggest property merits further investigation for gold, silver, lead, and possibly, zinc resources at depth. |
| 113 | Lopez No. 1 prospect | The 4- to 10-ft-thick mineralized zones along north-trending faults within and at contacts between limestone, shale, and quartzite at base of Paleozoic sedimentary assemblage (Hazzard, 1954). Chrysocolla, malachite, and azurite in zones along with iron oxides, quartz, and coarse crystalline calcite. Main zone is exposed for about 75 ft. | One 45-ft adit and two pits. | Of one grab and five chip samples, four contain 0.004 to 0.012 oz/ton gold and three contain 0.018 to 0.092 oz/ton silver. Two samples contain 1.18 and 4.7 pct copper, mostly in form of secondary copper minerals. Minor lead also detected. Gold and copper sample analyses indicate further study warranted. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 114 | Prospect | One north-northwest-trending massive pod and numerous veinlets of specular hematite in, and are associated with, pegmatite dikes in gneissic to granitic country rock. Zone is discontinuously exposed for 550 ft and is 2.6 to 4.6 ft thick. | One 12-ft-deep shaft and one pit. | In four chip samples, gold ranges from 0.0026 to 0.0035 oz/ton, silver ranges from 0.0058 to 0.044 oz/ton and iron (Fe) ranges from 3.8 to 7.1 pct. Size of structure and gold sample analyses indicate property merits further investigation. |
| 115 | Lopez No. 3 prospect | Interbedded limestone and shale are intruded by porphyritic andesite near base of Paleozoic sedimentary assemblage (Hazzard, 1954). Discordant and concordant shear zones and breccias contain some pyrite and considerable amounts of iron oxides and minor copper oxide staining. One sulfide-rich zone is 0.3 to 1.2 ft thick, strikes east-northeast, and dips 30°-40° SE. | Two adits and an inclined shaft totaling 168 ft. | Gold assays in six of eight chip samples range from 0.006 to 0.11 oz/ton; six silver assays range from 0.23 to 1.8 oz/ton; four lead values are from 1 to 9.7 pct and one zinc value is 2.62 pct. Gold, silver, lead, and zinc assay values indicate property merits additional investigation. |
| 116# | Iris Fin prospect | Actual location of this claim is uncertain. One sample taken along shale and limestone contact. | One pit | One chip sample contains 0.2 oz/ton silver, 0.0099 pct copper, 0.015 pct zinc, and 0.0016 pct molybdenum. |
| 117 | Prospect | A 1-ft-thick gouge zone containing chlorite strikes N. 60° E. and dips 65° SE. in shale or phyllite. An iron-oxide-stained breccia pod in limestone; breccia is vuggy and yellow, red, brown, and black. | One 12-ft-long adit and one trench. | Two samples contain no gold or silver. |
| 118# | Black Jack mine | Deposit consists of a fault-bound, north-trending, steeply west-dipping lens or block of specular hematite with minor magnetite in limestone and shale metasediments of Paleozoic (Hazzard, 1954) age. It lies approximately 3/4 mi east of and 400 ft in elevation above metasediment contact with Proterozoic gneissic rocks underlain at shallow depths by granitic rock. Deposit crops out for 300 ft along strike, is 60 to 80 ft thick, and is as much as 145 ft deep. | One 45-ft-long adit, one 115-ft-deep shaft, two pits, and six diamond drill holes. Patented claim. | Deposit estimated to contain indicated subeconomic resource of 230,000 long tons at a grade of 55 to 60 pct iron. Four chip samples across large outcrops contain 52 to 60 pct iron, 0.02 to 0.05 pct phosphorus, 0.08 to 0.22 pct sulfur, and 3 to 24.1 pct $SiO_2$. In previous analyses by industry, iron ranges from 56 to 58 pct. There is no indication that resources beyond those calculated are present; deposit appears to be bounded by faults. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 119 | Kelso Placer prospect, north | Fluvial and alluvial fan deposits consist of poorly sorted gravels and cobbles (40-60 pct), sands 40-50 pct, and silts or clays (<10 pct) of predominantly carbonate rock and minor quartzite. Claim activity consists of Edna in 1905, Gold Creek group in 1975, and Kelso Placers in 1979. | None | Of seven 0.38 $ft^3$ reconnaissance pan samples, three contained detectable gold. One contained three particles of subangular, flat gold weighing 0.002 mg; two particles were bright and one was dull. One sample contained four particles of bright, subangular to subrounded, chunky gold weighing 0.020 mg and a third sample contained 0.068 mg of bright, subrounded gold. Traces of garnet, zircon, and scheelite were noted in some samples; one contained a trace of hematite. Values are estimated at \$0.06/$yd^3$, \$0.02/$yd^3$, and less than \$0.01/$yd^3$ at a gold price of \$400/oz. |
| 120#** | Lone Tree prospect | Two shear zones, about 3 ft thick and oriented N. 25° W., 70° NE. and N. 63° E., 48° SE., intersect in buff, medium-grained, meta-igneous rock. Northeast zone contains some quartz and northwest zone contains minor malachite. | A 13-ft adit with 16 ft of drift and a 13-ft crosscut (included in a patented claim group No. 121). | A 3-ft chip sample across intersect contains 0.08 pct copper; no gold and silver detected. |
| 121#** | Cornfield Springs Consolidated mine | Pods, lenses, and stringers of massive specular hematite replace quartzite and limestone metasediments of early Paleozoic age less than 100 ft above contact with metaigneous rocks of unknown age. replacement bodies are generally concordant with bedding, which strikes N. 65° E. and dips 35° SE. Iron deposit crops out discontinuously for almost 400 ft, is as much as 20 ft thick (230 ft thick at depth), and may have been cut at depth of 175 ft by workings not now accessible. | One 25-ft inclined shaft, two inclined adits, not accessible (reported to be 65 ft and 635 ft long by Mineral Survey No. 4692), and three pits. One 60-ft-deep shaft is apparently caved (patented claims). | Inferred subeconomic resources of 110,000 long tons contain at least 50 pct iron. One chip sample contains 26 pct iron and two random chip samples average 50 pct iron. Contact environment, literature description, and form of deposit suggest several hundred thousand tons of additional iron resources may be present. |
| 122** | Rex mine | A N. 25° W.-trending, steeply southwest-dipping fault cuts Jurassic age, metamorphosed granitic and subvolcanic rocks. Several localized, north-trending shear zones are also present. Fault exposed for 170 ft and contains a brecciated, pinch and swell, quartz vein exposed for 140 ft and averaging 2.5 ft thick. Gold is restricted to quartz vein. Fault zone is largely composed of earthy to specular hematite and is inferred to be northern extension of Hidden Hill fault, which partly controls Vulcan mine-Burro prospect (No. 128). | Main working consists of 182 ft of drifts and crosscuts, two portals, two connecting 20 ft deep shafts, and possible inaccessible lower levels. Other workings include a a 10-ft-deep shaft, three trenches, and four pits. Cumulative production (USBM statistical files) for 1939 and 1951 was 126 crude tons containing 17 oz gold and 9 oz silver; small shipments reported (Wright and others, 1953) for 1934 and 1948. | Exposed vein deposit is estimated to contain an occurrence of 3,700 tons at an average grade of 0.22 oz/ton gold. Of 16 chip and 3 select samples, 9 contain detectable gold and three contain detectable silver. Gold ranges from 0.016 to 0.564 oz/ton, with 4 samples exceeding 0.1 oz/ton, and silver ranges from 0.006 to 0.7 oz/ton. None of the gold-bearing samples contain detectable silver. Less than 0.01 pct each of copper, lead, and zinc were detected in two samples analyzed. Major fault control, size of mineralized structure, and sample analyses suggest additional vein-type gold resources may be present at depth. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 123 | Kelso placer prospect, south | Fluvial sediments predominantly limestone in composition. Material is poorly sorted, consisting generally of 60 pct cobbles and gravel and 40 pct sand. Claim activity consists of Saturn, Uranus, and Milky Way Claims in 1950, Providence Placer Group in 1973, and Kelso Placers in 1979. | None | Of four 0.38 $ft^3$ reconnaissance pan samples, three contained gold. One contained a dull, chunky, subangular to subrounded particle of gold with a weight of 0.001 mg; one sample contained three bright to tarnished, subangular, chunky flakes of gold with a weight of 0.006 mg; and one sample contained 0.006 mg of bright, subangular gold. Two samples contained traces of zircon and scheelite. Sediment values estimated to be less than \$0.01/$yd^3$ at gold value of \$400/oz. |
| 124 | Bonanza 1-8 placer prospects | Fluvial sediments consist of poorly sorted sand and pea gravel (70-80 pct) with minor cobbles and fines; composition varies from predominantly syenite to limestone and some rhyolite. Heavy black sands and magnetic fraction are due to Vulcan mine-Burro prospect (No. 128). Bonanza placers were located in 1979. | None | Of five 0.38 $ft^3$ reconnaissance pan samples, two contained two dull, chunky, subangular to subrounded gold flakes, each with weights of 0.003 and 0.004 mg. Traces of garnet, zircon, scheelite, and hematite were also observed. Sediment values estimated to be less than \$0.01/$yd^3$ at gold price of \$400/oz. |
| 125 | Iron Mountain prospect | Northeast-trending, brecciated shear zones in interbedded shale and limestone. A skarn-type mineral assemblage consists of magnetite, specular hematite, garnet, epidote, pyrite, chalcopyrite, secondary copper minerals, and quartz. Zones are localized, partially controlled by bedding, and very low in the Palezoic assemblage, close to Jurassic intrusive rocks. | Two adits, 10 and 37 ft long. | Of four chip and select samples, two contain 0.4 and 3.2 pct copper. No gold, silver, lead, or zinc detected. |
| 126 | Prospect | Fault gouge, 1 to 5 ft thick, exposed along length of adit on north-northeast-trending contact between limestone and rhyolite. Sheared to brecciated rocks are iron oxide stained and contain malachite and chrysocolla. | One adit at least 150 ft long, and three pits. | Of four samples in adit, one contains 0.016 oz/ton gold and two contain 0.2 and 0.4 oz/ton silver. A select sample from stockpile contains 5.2 oz/ton silver and 0.74 pct copper. A grab sample contains 1.0 oz/ton silver and 0.23 pct copper. Contact environment and gold, silver, and copper values indicate prospect merits additional study. |
| 127* | Dolomite outcrop | A north-northeast-trending ridge 2,000 ft long and 1,000 ft wide at base, and is part of lower dolomite member of Cambrian Bonanza King Formation (Hazzard, 1954). | None | Eight random chip samples: MgO ranges from 5.4 to 21.4 pct. Exclusive of one low sample, occurrence averages 19.1 pct MgO; however, several samples contain high $SiO_2$ and $Fe_2O_3$. The deposit is considered an occurrence with an inferred size of 12 million tons. Areal extent of this and other dolomite units in Paleozoic assemblage in Providence Mountains is very large. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 132 | Burro No.31 prospect | Northwest-trending, vertical to northeast-dipping fault ones 1.0 to 7.0 ft thick in limestone. Two short (≤50 ft) fault zones are silicified and contain quartz, calcite, iron and manganese oxides, malachite, possibly smithsonite, minor magnetite, and chalcopyrite. A 20-ft-wide, prominent, fault-bound zone is internally sheared, faulted, bleached, and has localized silicification and iron oxide staining. Fault-bound talcose zones also contained in main fault zone. | Two adits (68 and 250 ft long) and one pit. | Of nine chip samples, one contains a trace gold and six contain 0.1 to 0.2 oz silver/ton. Eight samples analyzed for copper, lead, and zinc contain minor to moderate values (<1 pct) except for one that contains 2.70 pct copper. Fault control, rhyolite contact, and gold and copper sample analyses indicate property merits additional study. |
| 133 | Sunrise prospect | Localized, 2- to 3-ft-thick shear zones in limestone approximately 1/2 mi south of contact with rhyolite plug. One zone strikes north, dips 78° E., and contains subequal amounts of quartz and and carbonate veining with minor iron oxide, magnetite, and traces of malachite and chalcopyrite. Another fault trends northwest, dips steeply southwest, and contains iron and manganese oxides in fractures, and minor encrusted malachite. | One adit, 60 ft long, one caved adit, approximately 30 ft long, and one shaft of unknown depth. | One select contains 0.062 oz/ton gold, 18.3 pct copper, and 0.01 pct lead. One chip sample contains 0.2 oz/ton silver, 0.125 pct copper, 0.0045 pct lead, and 0.25 pct zinc. Gold and copper analytical values and proximity to rhyolite plug indicate further study warranted. |
| 134** | Prospect | North- to northwest-trending, southwest-dipping shear zones 4 to 70 ft thick are locally exposed in and near a contact zone between Paleozoic carbonates and a Jurassic granitic intrusion. One zone contained a 1.6-ft-thick magnetite vein of unknown length; hanging wall is limestone and footwall is intrusive rock. | Two bulldozer cuts, each 100 ft, and one pit. | Of two chip samples across shear zones, one contains 0.1 oz/ton silver; copper values were ≤ 0.002 pct and zinc values were ≤ 0.007 pct. A chip sample across magnetite contains 61.1 pct $Fe_2O_3$, 14.7 pct $SiO_2$, 10.9 pct MgO, 6.2 pct CaO, 1.6 pct MnO, 1.3 pct $Al_2O_3$, 0.15 pct $P_2O_5$, and 0.12 pct sulfur. Small but high-grade outcrops of magnetite along contact zone for 1 1/4 mi east of the Vu mine-Burro prospect (No. 128) are consistent with the geologic environment attributed to that mine. Further exploration is warranted. |
| 135** | East Burro prospect | Three workings in a very irregular, northeast-trending contact zone between silicified rhyolite on north and weathered, granitic intrusion on south. Zone is intensely bleached, contains fragments of limestone, and exhibits chloritic alteration. Remainder of workings in weathered, friable to sheared granitic rock without apparent structure. | Eight bulldozer cuts, each approximately 50 ft long. | Two grab samples contain 0.0011 to 0.057 pct copper; one contains 0.08 oz/ton silver. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 128#* | Vulcan mine-Burro prospect | A magnesium silicate skarn-type iron deposit along northwest-trending fault contact between dolomitic carbonate rocks on north and quartz monzonite on south. Main ore body was 700 ft long, 325 ft wide, and composed of magnetite, subordinate specular and earthy hematite, and minor limonite and pyrite. Serpentine is major gangue mineral. Smaller deposit east of the mine. | Main open pit is 1,000 ft long by 500 ft wide by 100 to 250 ft deep. Other workings are smaller open pit, north-trending adit, and numerous pits, trenches, and drill roads. Property consists of five patented mining claims, a patented millsite, and 12 unpatented claims. Wright and others (1953) show production of 2.643 million long tons of 50 pct iron from 1942 to 1947. Minor production from dumps and stockpiles in 1950's (patented claims). | Permission to enter property was denied by Kaiser Steel. Based on published data (Lamey, 1948), deposit is estimated to contain 3.0 million long tons of inferred, subeconomic resources averaging 50 pct iron. Aeromagnetic surveys and fault contact suggest additional resources may be present to east. |
| 129 | Rector Not prospect | A fault strikes N. 30° W. and dips 55° NE. in limestone near a contact between silicified malachite-, chalcopyrite-, and galena-bearing limestone and iron-oxide-stained rhyolite. | One adit, 30 ft long, two open cuts, 100 ft long, and one dump (no portal found). | Of two select samples, one contains 0.014 oz/ton gold and both contain silver, 0.2 and 0.6 oz/ton. One sample contains 9.4 pct copper, 0.07 pct lead, and 0.01 pct zinc. Gold and copper analytical values and similar types of minerals and alteration along the fault contact in Foshay Pass area indicate property merits additional investigation. |
| 130 | Copper King-Queen of the Night prospect | A fault zone approximately 4 ft thick strikes N. 5°-20° W. and dips 65° NE. in light-gray, iron-oxide-stained limestone. The 80-ft-long exposure is subparallel with and less than 100 ft from a contact with rhyolite. Fault zone is probably several hundred feet long. Limestone is silicified and contains blebs of malachite and azurite and veinlets of calcite. Microprobe examination showed fine-grained inclusions of cinnabar and iodyrite (AgI) in malachite. | One shaft 20 ft deep, one adit 6 ft long, and three bulldozer cuts, each about 100 ft long. | Two chip samples contain 0.15 and 0.48 pct copper; no gold or silver was detected. |
| 131 | Tip Top prospect | Fault zones 1.0 to 3.5 ft thick and strike N. 45° W. to N. 10° E. and dip 80° NE. to 85° NW. in fractured, gray, iron-oxide-stained limestone south of rhyolite contact. Rocks contain minor to abundant malachite with chalcopyrite and possible bornite. | Three shafts, 20 to 70 ft deep, and two adits, 8 and 10 ft long. | Of two chip, two select, and one grab sample, two contain silver, 0.4 and 0.6 oz/ton; no gold detected. Chip samples contain 0.08 and 0.84 pct copper, grab sample contains 1.72 pct copper and select samples contain 13.3 and 25 pct copper. High-grade copper, presence of of silver, and proximity to rhyolite contact indicate further study warranted. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 136* | Burro 54 and 55 prospect | A deeply weathered, intensely iron-oxide-altered granitic intrusion near a contact with rhyolite intrusion. | One bulldozer cut 110 ft long. | One grab sample contains 0.0022 pct copper; no gold or silver detected. |
| 137a | Limestone outcrop | Hazzard (1954) described several northeast-striking, southeast-dipping, thick sections of limestone cropping out for as much as 7 mi as follows: (1) Bullion Dolomite Member (250-350 ft thick) and part of the Yellowpine Limestone Member (75-125 ft thick) of the Mississippian Monte Cristo Limestone, (2) Crystal Pass (250-300 ft thick) and upper part of Valentine (350-400 ft thick) Members of the Devonian Sultan Limestone, (3) Lower Cambrian Chambless Limestone (170-220 ft thick), and (4) marine derived parts of the Triassic Moenkopi Formation (500 ft thick). | None | Of eight grab samples of limestone, two contain 85.7 and 89.4 pct $CaCO_3$ and six contain from 91.6 to 95.5 pct. Four samples contain greater than 1 pct $SiO_2$. Sample analyses suggest this limestone is suitable for cement or intermediate-grade industrial applications; it will probably not be of economic significance until depletion of limestone resources closer to metropolitan markets. |
| 137b | Dolomite outcrop | Light- to dark-gray, subcrystalline dolomite in the Cornfield Springs Formation. Unit strikes northeast and dips 30°-40° SE. Hazzard (1954) described dolomitic formations cropping out for approximately 7 miles along strike as follows: (1) Cambrian Bonanza King Formation (1,875 - 2,230 ft thick); (2) lower part of the Cambrian Cornfield Springs Formation (650 ft thick); and (3) the Ironside Member of the Devonian Sultan Limestone (50-75 ft thick). | None | Two grab samples of dolomite contain 19.3-19.5 pct MgO, 0.23-0.28 pct $Fe_2O_3$, 0.46-0.51 pct $Al_2O_3$, and 0.012-0.022 pct $SiO_2$. Sample analyses suggest this dolomite is suitable for at least intermediate-grade industrial applications; it will probably not be of economic significance until depletion of dolomite resources closer to metropolitan markets. |
| 137c | Quartzite outcrop | The Prospect Mountain Quartzite section is from 50 to several hundred ft thick, crops out for approximately 3 mi, strikes east-northeast and dips 20°-40° SE. (Ver Planck, 1966). Outcrops are buff, orange, or red and may be banded due to cross bedding. | None | One sample of quartzite contains 94.0 pct $SiO_2$; however, $Fe_2O_3$ is 2.3 pct and $Al_2O_3$ is 2.5 pct. Deposit is of doubtful economic significance for industrial grade $SiO_2$. |
| 138 | Prospect | Two 1-in.-thick quartz veins trend north in lenticular to banded gneiss east of the East Providence fault. Quartz is white to clear or light pink with occasional vugs and boxworks. | One caved inclined shaft approximately 50 ft long. | Of two select samples of quartz, one contains 0.01 oz/ton gold, 0.2 oz/ton silver, 0.0093 pct copper, 0.0021 pct lead, and 0.0037 pct zinc. Gold sample value and proximity to East Providence fault suggest prospect merits additional investigation. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 139# | Good Hope mine | A quartz-filled, brecciated shear zone strikes east for 690 ft, dips steeply to north and averages 2.7 ft thick. Zone truncated on east by north-striking fault and on west it disappears beneath a volcanic cap. Country rock is Proterozoic metamorphic rocks with Tertiary volcanic caps on ridge tops. | Two adits, 140 and 40 ft long, connected by a raise, and three pits. | Deposit contains an indicated subeconomic resource of 4,400 tons averaging 0.070 oz/ton gold and an inferred subeconomic resource of 32,000 tons at an average grade of 0.031 oz/ton gold. Of 16 chip samples, 13 contain a trace to 0.256 oz/ton gold and 1 contains 0.2 oz/ton silver. No copper or lead detected. Size and grade of deposit indicate additional gold resources may be present at depth. |
| 140 | Prospect | Workings in limestone-gneiss contact zone 4 to 20 ft wide along north-trending East Providence fault. Limestone is brecciated and healed with calcite. Limonite staining and minor secondary copper minerals were observed in gouge zone in gneiss. | One pit and one 38-ft-long adit. | Of five chip samples, two contain 0.1 oz/ton silver and one contains 0.01 pct copper. |
| 141#** | Red Rock prospect | The north-trending, east-dipping East Providence fault is exposed for approximately 2,000 ft along a contact between limestone on west and gneiss on east. Limestone is brown to gray and commonly brecciated throughout a 2- to 5-ft-thick zone that is calcite-hematite healed. | One partially caved vertical shaft, two adits, 4 and 10 ft long, two pits, and one exploratory drill hole. | Of one select and six chip samples, only select sample contains trace gold. One sample contains 0.1 oz/ton silver. Copper values range from none to 0.0010 pct, lead values from none to 0.01 pct, and zinc from 0.0008 to 0.0033 pct. Although the assay values are low, past producers to north and south on same structure indicate property merits additional investigation for resources of silver, lead, and gold. |
| 142 | Sunny Boy Extension placer prospect | Fluvial sediments from Barber Canyon washes; upper tributaries are well scoured in steep, narrow canyons. Predominantly gneissic with minor volcanic sediments are 95 pct sand and pea gravel with 1-5 pct gravel at 1 to 2 in., and 1-2 pct silt and clay; black sands range from 3 to 10 pct. Sunny Boy Extension was located in NW1/4 sec. 28, T. 11 N., R. 14 E., S.B.M., in 1955. | None | No gold observed in two 0.38 $ft^3$ reconnaissance pan samples; both contained traces of garnet. |
| 143 | Petrified wood outcrop | Agatized Sequoia landsdorffia as float and at base of volcanic ash beds near Barber Canyon and at the mouth of Beecher Canyon. It is non-fractured rubble to 6 in. diameter and ranges from light tan to nearly black with a distinct wood grain pattern visible in cut specimens. | One small cut in ash beds east of Whiskey Spring. | About 2 to 3 $yd^3$ of petrified wood float was observed in Barber Canyon. It is classed as excellent for jewelry. Price is estimated at $0.10 to $0.25/lb wholesale delivered or $1.00/lb retail for raw product. Quantities and quality appear to be suitable for recreational use but would not support a long-term commercial operation. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 144#* | Silver King mine (Perseverance mine) | Mineralized pods and lenses in fissures and calcite and quartz cemented breccia zones 1.5 to 10 ft thick near fault intersections with the north-trending, east-dipping East Providence fault. Some significant metal values locally along 1,200 ft of main fault and 750 ft of west-trending splinter fault. Minerals include argentite, argentiferous galena, cerussite, silver chlorides and bromides, malachite, anglesite, and willemite. | Workings consist of 4 shafts, 7 adits, 11 trenches, and 14 pits. Adits are 10 to 30 ft long; one shaft is 50 ft deep with a 25-ft drift, and one is 162 ft deep with 1,350 ft of drifts and crosscuts. From 1918-1920, mine production (USBM statistical files) was 20 tons containing 6.98 oz gold, 1,489 oz silver, 11 lb copper, and 232 lb lead. Tucker (1920) estimated $250,000 production in 1880's. | Of 41 chip, 4 random chip, and 2 grab samples, 14 contain detectable gold and 27 contain detectable silver. Six contain a trace and 8 contain 0.01 to 0.04 oz/ton gold. Thirteen contain 0.1 to 0.9 oz/ton and 14 range from 1.9 to 7.7 oz/ton silver. Copper ranges from 0.0005 to 0.0098 pct in 26 of 27 samples analyzed, lead ranges from 0.0021 to 0.266 pct in 21 of 22 samples analyzed, and zinc ranges from 0.0051 to 0.36 pct in 22 samples analyzed. Production history and assay values suggest additional silver, gold, lead, and copper resources may be present at depth. Mineralized zones, based on surface exposure, are expected to contain about 5,000 to 10,000 tons of ore. expected to be about 5,000 to 10,000 tons. |
| 145** | Silver Queen-Golden Horse placer prospects | Predominantly coarse sands and gravels of gneissic composition from a north-trending dry wash that passes through 3 mi of sheared and altered rocks along hanging wall of the East Providence fault. The Silver Queen and Golden Horse claims were located in 1955 and 1961, respectively, in W1/2 sec. 33, T. 11 N., R. 14 E., S.B.M. | None | One 0.38 $ft^3$ reconnaissance pan sample from active channel contained three gold particles with a total weight of 0.008 mg. Gold was dull, chunky, and subrounded to subangular. Value of material is estimated to be less than $0.01/$yd^3$ at a gold value of $400/oz. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 146#* | Bonanza King mine | 4- to 20-ft-thick replacement bodies in in brecciated carbonate rocks along en echelon cross-breaks (tension fractures) between the north-northeast- trending, east-dipping East Providence fault and a westerly dipping or vertical boundary fault on west. Bounding faults diverge with depth; having a 100 ft span at surface and a 500 ft span on the 5th level of main working. Mineralized zones are recognized by calcite and red iron oxide in fractures and contain one or more of the following: argentite, cerargyrite, bromyrite, galena, cerussite, sphalerite, smithsonite, malachite, and pyrite. | Workings consist of one large multilevel development, one tunnel, seven adits, (three caved), six trenches, and seven pits. Three larger adits total 560 ft of drifts and crosscuts. Large working consists of an 800-ft-deep shaft (500 ft vertical and 300 ft inclined) that serviced eight levels; an intermediate level and five main levels are accessible and total more than 7,400 ft. Overall main working is developed by about 20,000 ft of drifts, crosscuts, stopes, and manways (Wright and others, 1953). Production from 1883-1887 was valued at $1.8 million, primarily from silver (Mining World, Feb. 6, 1906, p. 225-226), and more than 5,302 tons produced from 1901-1960 contained 56.57 oz gold, 82,272 oz silver, 913 lb copper, 69,275 lb lead, and 2,312 lb zinc (USBM statistical files) (patented claims). | On-site dumps and tailings contain 19,000 tons of inferred subeconomic resources averaging 4.1 oz/ton silver. Seventy-three chip, 18 random chip, 3 grab, and 1 select sample taken. Of 32 samples with gold, 14 contain a trace, 17 contain 0.0002 to 0.23 oz/ton and 1 contains 1.28 oz/ton. Thirty-seven samples contain 0.04 to 0.9 oz/ton silver, 23 contain 1.0 to 8.6 oz/ton silver, 8 contain 12.8 to 56.6 oz/ton silver, and 1 contains 75.5 oz/ton silver. Copper, lead, and zinc are ubiquitous; copper values were generally 0.001 to 0.01 pct while lead and zinc values were an order of magnitude higher. Five lead values and four zinc values in the range of 1-5 pct. Production data, mapping and sampling data, and drill intercepts indicate property merits further investigation for additional silver, gold, lead, copper, and zinc resources at depth. |
| 147* | Dimension stone quarry | Orange, buff, and gray welded tuff beds crop out on small hill adjacent to East Providence fault. | One quarry. Possible production of several hundred tons of dimension stone used to construct buildings of Providence townsite. | No samples. Large tonnage available of stone primarily suitable as a dimension stone. Quarried stone must usually be split or cut, which would increase the cost and, therefore, decrease profitability. Deposit is not considered to be economically significant except for local use. |
| 148 | BC prospect | Weathered, Proterozoic, metamorphosed, intrusive rocks with iron staining, abundant epidote, and rare magnetite veinlets. One minor shear zone strikes N. 20° E., is vertical and contains minor magnetite. Area coincides with a significant aeromagnetic anomaly and was part of a regional area (Vulcan mine-Burro prospect, No. 128) explored by U.S. Steel in the early 1960's. Magnetite skarn pod at Adams-Ikes Hope prospect (No. 149) may be related to this deposit. | Two dozer cuts, two pits, and a slant drill hole of unknown depth; workings spread over about 1/2 $mi^2$. | Of one chip and one select sample, no gold or silver were detected and only minor copper and lead were detected in one sample. Based on exploration history, aeromagnetic anomaly, and presence of a nearby, small iron body (Adams-Ikes Hope prospect), this prospect should be studied in detail to determine whether or not resources are present. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 149# | Adams-Ikes Hope prospect | Lower workings on shear zones oriented N. 50° W., vertical and N. 75° E., 85° SE. in metamorphosed rocks; one is intruded by a vuggy, clear, 8-in.-thick quartz vein containing pyrite, chalcopyrite, iron oxides, and secondary copper minerals. Upper workings are on a N. 10° E.-trending skarn lens of pyrite and magnetite with epidote and garnet. Lens is approximately 50 ft wide and is traceable by float for as much as 200 ft downslope. | One 15-ft shaft and two pits are on quartz and alteration zones; one 20-ft adit and one pit on magnetite zone. | Of three chip samples of vein and shear zones, one contains 0.036 oz/ton gold, two contain 0.3 and 2.1 oz/ton silver, copper ranges from 0.03 to 0.18 pct, and lead ranges from 0.01 to 2.7 pct. Two samples from magnetite lens contain 25.7 and 38. pct iron, 6.8 and 3.6 pct $Al_2O_3$, and 34.3 and 20.5 pct $SiO_2$. One contains 21.8 pct sulfur. Gold, silver, and lead sample analyses indicate property merits additional investigation. Magnetite body indicates need for detailed studies of BC prospect (No. 148). |
| 150# | Grande 1-7 mine | One prominent vein system trends northwest, dips northeast, and crops out for at least 400 ft. Structure is exposed for 140 ft vertically, averages 2.7 ft thick, and contains veins, pods, and blebs of quartz in a gray-green gouge. Nearby, three veins and shear zones cut granitic rock; one contains red jasper with galena and minor secondary copper minerals. | A 90-ft adit with an 8-ft winze, two 15-ft adits, and five pits. Vredenburgh (1982) reported 100 tons of unknown type ore produced in 1980 from this or Max Dor 1 and 2 mine. | One select and nine chip samples. Gold detected in four of seven samples from main vein, 0.010, 0.216, 2.144, and 2.182 oz/ton, and in two of three samples from nearby structures, 0.042 and 0.130 oz/ton. Jasper contains 2.6 oz/ton silver and three samples from main structure contain 0.5, 3.2, and 9.4 oz/ton silver. Nine samples contain 0.03 to 0.92 pct and one contains 8.50 pct lead. Copper in four samples ranges from 0.02 to 0.26 pct. Erratic but high gold and silver values and persistence of structure indicate further studies may reveal additional vein-type, gold and silver resources at depth. |
| 151 | Raindrop prospect | Localized, 0.5-ft-thick, white quartz veins are oriented N. 60° E., 72° NW. and N. 28° W., 24° NE. in granitic rock; quartz contains abundant limonite pseudomorphs after pyrite. | Three trenches, 40 to 100 ft long. | Two samples contain 0.01 and 0.09 pct lead; no gold or silver detected. |
| 152# | Why Not Nos. 1-5 prospect | At least eight quartz vein segments 0.5 to 4.4 ft thick, most trending northwest, occupy local shears or faults in Jurassic granitic rock. Longest vein is traced for 350 ft and may be 900 ft long. Quartz is commonly white, vuggy, and brecciated and contains pyrite, limonite, minor galena, and traces of secondary copper minerals. | Two adits, 8 and 35 ft long, two shafts, 10 and 15 ft deep, three trenches and eight pits. | Of nine chip, one random, and two select samples, seven contain detectable gold and four contain silver. Gold ranges from 0.012 to 0.118 oz/ton and averages 0.057 oz/ton; 3 contain from 0.2 to 0.5 oz/ton silver and 1 contains 1.8 oz/ton silver; lead detected in 11 samples ranges from 0.03 to 0.8 pct and copper ranges from 0.01 to 0.09 pct in seven samples. Gold and silver sample analyses and number and type of veins suggest further exploration is warranted. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 153# | Max Dor 1 and 2 mine | Two major structures: an east-trending, north-dipping quartz vein crops out discontinuously for 2,300 ft and a 300-ft spur, and a northwest-trending, northeast-dipping fault exposed for about 350 ft in granitic rocks. 0.6- to 6.5-ft-thick quartz vein is white to clear and contains pyrite, chalcopyrite, malachite, and azurite. Fault is 1 ft thick and composed of green gouge with quartz. | Three small pits, an open pit, four trenches, two dozer cuts, and a 47-ft shaft with 25 ft of crosscuts and drifts. Vredenburgh (1982) reported 100 tons of unknown type ore produced in 1980 from this or Grande 1-7 mine. | One select and 15 chip samples. Three of 13 samples from quartz veins contain 0.020 to 0.082 oz/ton gold and 3 samples from fault contain 0.012 to 0.590 oz/ton gold. One sample contains 0.3 oz/ton silver, 10 contain 0.01 to 0.12 pct copper and 10 contain from 0.01 to 2.38 pct lead. Based on significant values and prominent structures, this property merits further study for gold with byproduct silver and lead resources at depth. |
| 154# | Gold Star North 1-44 prospect | Variably-trending, generally easterly-dipping, localized, 0.1- to 2.8-ft-thick shear zones and narrow quartz veins are associated with a northeast-trending zone that may be several hundred feet wide of pervasively and intensively altered intrusive rock. This is north extension of Gold Star 1-10 prospect (No. 155). Quartz is white to clear and contains pyrite, limonite pseudomorphs after pyrite, siderite, specularite, chrysocolla, malachite, azurite, and possible chalocopyrite. | One 50-ft-deep inclined shaft, two adits, 20 and 60 ft long, and seven pits. | Of 16 samples, 4 contain from 0.010 to 0.324 oz/ton gold and 2 contain silver, 0.4 and 2.3 oz/ton. Of 10 analyzed for copper, 9 contain from 0.03 to 0.72 pct. Prominent, pervasively altered zone and sample analyses indicate additional investigation is warranted for vein-type gold and silver with byproduct copper resources at depth. |
| 155# | Gold Star 1-10 prospect | Localized, north-trending, east-dipping, 0.5- to 7.8-ft-thick quartz veins and shear zones along a 60- to 400-ft-wide zone of pervasively and intensively altered intrusive rock. This is south extension of Gold Star North 1-44 prospect (No. 154). Altered zone extends for approximately 1 mi along a north-northeast trend. | Four inclined shafts, 17 to 55 ft deep, including 55 ft of drifts, two trenches, and six pits. | Of 25 samples, 3 contain a trace to 0.072 oz/ton gold. Five analyzed for copper contain 0.0009 to 0.02 pct and four of five analyzed for lead range from 0.03 to 0.47 pct. Based on sporadic gold assays and south extension of Gold Star North 1-44 prospect, this property warrants further investigation for gold with byproduct lead and copper resources. |
| 156 | Prospect | A north-trending, 30°-50° W.-dipping, 4-in.- to 1-ft-thick quartz vein exposed for 90 ft in shear zone cutting metamorphosed igneous rock shear. Shear is composed of punky clay gouge and limonite, and quartz contains visible galena. | One 90-ft-long adit with at least a 40-ft partially caved crosscut, and one 40-ft trench. | Of four chip samples, two contain 3.2 and 4.3 oz/ton silver and two contain 0.2 and 0.3 oz/ton silver. Lead values range from 0.02 to 1.27 pct. No gold detected. Silver and lead sample values indicate prospect merits additional study. |
| 157 | Pink Falcon prospect | Several graphic-textured, generally northwest-trending, 1- to 3-ft-thick dikes with pink to purple feldspar, abundant white to clear quartz, and minor biotite are exposed for about 20 ft. Some quartz exhibits comb structures with hematitic jasper banding. Hornblende diorite country rock exhibits intense to sericite and chlorite alteration. | Three shafts, 10 to 20 ft deep. | Of one grab and three chip samples, two contain 0.01 and 0.02 pct copper; no gold, silver, or molybdenum detected. |

**Table 5.** Summary description of mines, prospects, and mineralized outcrops in Providence Mountains Wilderness Study Area, San Bernardino County, California—*Continued*

| Map No. (fig. 3) | Name | Summary | Workings and production | Sample and resource data |
|---|---|---|---|---|
| 158* | Prospect | Fault and shear zones strike north to northwest, dip moderately west, and are associated with quartz fillings in granite gneiss country rock. Main zone crops out discontinously for 320 ft and contains narrow (< 6 in.) quartz veins and lenses. Other than minor galena, no significant minerals were observed. | Two inclined shafts, 25 and 70 ft deep, one 30-ft adit, and six pits. | Six chip and one select sample contain no detectable gold or silver. One chip sample with visible galena contains 0.76 pct lead. |
| 159 | Lou-Al-Mark Nos. 1-3 prospect | A north-trending, vertical zone of fault gouge 1.3 ft thick with silicified hematite-limonite stringers in granitic country rock. Surface expression along drainage between pits is approximately 500 ft. | Two pits | One chip sample has 0.02 pct lead; no gold or silver were detected. |
| 160* | Prospect | Localized shear zones in granite gneiss strike N. 85° W. and dip 33° SW. One contains an aplite dike with abundant chrysocolla staining and the other contains 1- to 3-in.-thick veins with drusy and comb quartz structures. Sinuous cavities in quartz are filled with bladed barite to 1 in. long with interstital galena and chlorite. | Two pits and two small trenches. | Two samples taken: a grab sample contains 2.05 pct copper and 0.12 pct barium and a select sample contains 1.0 oz/ton silver, 0.01 pct copper, 8.8 pct lead, and 11.8 pct barium. Silver, lead, copper, and possibly barium sample values indicate prospect merits further study. |
| 161 | Silver Duchess prospect | A 2-ft-thick quartz vein, bordered by fault gouge in granitic rock, strikes N. 17° W. and dips 82° N. with pyrite and iron oxide in fractures. | Two pits and one collapsed shaft or adit. | One chip and one select sample; no gold or silver detected. |
| 162* | Prospect | An argillized alaskite dike 8 ft thick trends N. 10°-20° W. in pegmatite granite; only locally exposed. | One pit | One random chip; no gold, silver, or copper detected. |

# Mineral Resources of Wilderness Study Areas: Central California Desert Conservation Area

This volume was published as chapters A—D

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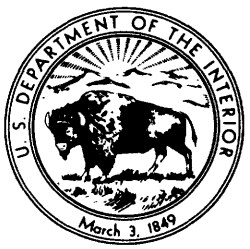

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[Letters designate the separately published chapters]

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