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MINERAL RESOURCES AND RESOURCE POTENTIAL OF THE SOUTH PROVIDENCE MOUNTAINS WILDERNESS STUDY AREA, SAN BERNARDINO COUNTY, CALIFORNIA

SUMMARY REPORT

By

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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 their mineral values. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the South Providence Mountains Wilderness Study Area (CDCA-262), California Desert Conservation Area, San Bernardino County, California.

SUMMARY

Geologic, geochemical, and geophysical evidence, together with a review of historical and recent mining and prospecting activities, suggests that much of the South Providence Mountains Wilderness Study Area has a wide range of potential for the occurrence of several types of undiscovered mineral resources. Eight mines and prospects in the study area have potential for gold, silver, lead, or copper resources. A high, moderate, or low potential for hydrothermal gold-copper mineral resources is ascribed to much of the study area. This mineralization is associated with plutonism and extensive alteration of the host granitoids. Several observations suggest that the exposed rocks may be distal to a gold-rich copper porphyry system, and much of the study area is given a low mineral resource potential for such a system. A high potential for epithermal volcanogenic gold resources is indicated for one small area of altered metavolcanic, plutonic, and hypabyssal rocks, and a moderate potential for epithermal gold resources is indicated for three other small areas. A low potential for placer gold resources is indicated for all alluvium in the area with particularly strong support for two small areas. Radioactive-mineral resources are possible in one area of granite, which is ascribed a low resource potential. A low potential for hydrocarbon resources is indicated for basinal sediments in a small part of the study area and an unknown potential exists for hydrocarbon deposits in Paleozoic strata. For other possible resources such as building stone and aggregate and geothermal resources there is unknown potential or no recognized potential.

Mines in and immediately adjacent to the study area contain an estimated 200,000 tons of indicated and inferred marginal gold reserves and an additional 11,000 tons of marginally economic gold-bearing dump reserves. Thirteen mines have potential for additional resources. If a mine adjacent to the study area containing identified gold reserves were developed, a mill at that mine could process ore from possible resources in the study area, thus increasing the likelihood for development in the study area.

INTRODUCTION

The South Providence Mountains Wilderness Study Area is in San Bernardino County, southeastern California, in the southern part of the north-trending Providence Mountains. The study area includes most of the rugged mountain terrain south of Foshay Pass, a low area separating the northern and southern parts of the Providence Mountains (fig. 1). The study area, which comprises about 24,500 acres, lies about 8 mi southeast of the town of Kelso and 4 mi north and northwest of Interstate Highway 40. The study area was examined in a cooperative survey to evaluate known resources and the potential for undiscovered resources. The U.S. Bureau of Mines (USBM) studied the identified mineral resources of mines and prospects and the U.S. Geological Survey (USGS) conducted geologic, geochemical, and geophysical surveys to determine the extent of alteration associated with the mines and prospects and to determine whether additional mineralization may occur in the study area.

The study area largely occupies rocky, steep, mountainous terrain covered by abundant desert vegetation, including sparsely forested mountain peaks; piedmont areas south and west of the Providence Mountains are also included. Elevations range from 2,900 ft at the northwest corner of the area to 6,612 ft on the crest of the range; much of the range is in excess of 4,500 ft. Boundaries of the study area are in many places graded roads or jeep tracks; however, roads providing access to the area are few. The only road crossing the area passes from Arrowweed Spring to Quail Spring Wash (fig.

1). Bulldozer tracks established for prospecting occur west of Hidden Hill and south of Goldstone Spring. Two older jeep tracks in partial decay cross the piedmont east to the mountain front at secs. 4 and 20 and 21, T. 9 N., R. 13 E.

Geologic setting

Rocks exposed in the South Providence Mountains Wilderness Study Area are principally Mesozoic granitic rocks of variable composition, age, and degree of alteration. These crystalline rocks are grouped as mixed gneiss containing rocks probably of both Proterozoic and Mesozoic age, Jurassic hypabyssal to metavolcanic rocks, Jurassic plutonic rocks of highly variable lithology, and Cretaceous granitic rocks. Unconformably overlying the crystalline rocks are Miocene volcanic and sedimentary strata exposed south of the study area at Van Winkle Mountain. Fringing the mountainous areas are wide piedmonts covered with Pliocene to Quaternary alluvium; much of the piedmont area is occupied by very thin deposits as evidenced by widely distributed small pediment exposures of underlying crystalline rock. Faults in the study area are generally north trending and of uncertain age. Alteration of several types is extensive throughout virtually the entire study area.

Mining activity

Although the mines and mining districts of the southern Providence Mountains have been discussed by various authors, this joint evaluation is the first comprehensive study of the mining activity of this area. One of the earliest discussions of mining in the Arrowhead district was by DeGroot (1890), and the Bighorn mine was briefly examined by Tucker (1920). Bonham and Cooksley (1959) and Bonham (1959) conducted reconnaissance studies of the southern Providence Mountains which were followed by a review by Vredenburgh (1982).

County claim records indicate that at least 350 lode and placer mining claims have been located in the southern Providence Mountains to date. Of these, approximately 300 occur within the study area, mostly within the Arrowhead mining district (Vredenburgh, 1982). Although none of the claims are patented, three groups have been surveyed (nos. 1, 13, and 23, table 5 and fig. 4). Seventy-four claims, including the Hidden Hill and Bighorn mines, were actively held in 1982.

The first recorded mining activity occurred in 1882. Gold exploration spurred by declining silver prices (Vredenburgh and others, 1981) resulted in the discovery of the Hidden Hill and the Bighorn mines. Mining and prospecting activity peaked during the early 1900's, resulting in numerous smaller discoveries. By 1914, both the Hidden Hill and Bighorn mines had closed; however, the Bighorn mine reopened in 1918 and produced about $100,000 worth of gold, silver, lead, and copper by 1920 when the mine closed again.

Gold placer mining has occurred sporadically in and near the study area since the early 1900's. Of the approximately 100 placer claims filed since 1900, only two claim groups, the Valcerie adjacent to the study area and the Crucerro in the study area, were active in 1982. No production record exists for placer prospects in the southern Providence Mountains; total placer production is estimated to be less than 25 tr oz gold.

Mining activity flourished during the 1930's and again in the 1960's, primarily in areas of previous mining. Interest in this area was supported by concomitant interest in the Providence Mountains to the north and the Gold Reef district to the southeast (Vredenburgh and others, 1981). The study area and vicinity was being assessed by several minerals-exploration companies in 1982.

Mining production from the southern Providence Mountains consists primarily of precious metals with lesser copper and lead and small amounts of iron and fluorospar. Few production records exist for the various mines. The six recorded producers are the Bighorn, Buena Vista, Coarse Gold, Hidden Hill, Pilot, and Providence mines. Total production is approximately 8,627 oz of gold, 1,374 oz of silver, 19,889 lb of copper, 21,348 lb of lead, and less than 100 tons each of iron and fluorospar, valued in total at almost $4,000,000 at current prices.[1] Major production of iron from the Vulcan mine, just north of the study area, is not included in these figures.

Approximately 8,300 acres are currently (1982) under lease for oil and gas exploration.

[1]Gold $400 per ounce, silver $10 per ounce, lead $0.15 per lb, copper $0.76 per lb, iron $36 per ton.

GEOLOGY PERTAINING TO MINERAL RESOURCE ASSESSMENT

Although regions near the southern Providence Mountains have been the subject of geologic study (Hazzard, 1954; Hewett, 1956; Kupfer and Bassett, 1962; McCurry, 1982; Beckerman and others, 1982), few studies of the southern Providence Mountains are published. Parts of the area were described by Sabine (1971) and Stein and Warrick (1979), and reconnaissance studies were reported by Bonham (1959) and Bonham and Cooksley (1959).

Lithologic description

Mixed gneiss and granite. The oldest units are gneissic granite (MzEg) found at Van Winkle Mountain and mixed gneiss (JEm) occurring primarily in low areas along the eastern and northwestern parts of the study area. The gneiss in Van Winkle Mountain is light-weathering quartz-rich fine- to medium-grained granodiorite interlayered with coarse pegmatite and mafic gneiss. Mixed gneiss exposed in the southern Providence Mountains is generally quartz rich, foliated, and pervasively intruded by several Jurassic granitic units.

Paleozoic strata. Tan to light-gray marble derived from Paleozoic strata (Pz m) is exposed just north of the study area in and around Foshay Pass. Impure marble, mapped as part of the Triassic Moenkopi Formation by Hazzard (1954), is included in the unit. The metamorphosed Paleozoic and Triassic strata lack ornamental value due to impurities and calc-silicate inclusions. Small lenses and faulted slices of marble of probable Paleozoic strata occur near zones of mineralization in the southern Providence Mountains.

Jurassic metavolcanic rocks. Hypabyssal and metavolcanic rocks (Jh) in the Hidden Hills are intensely altered and compositionally variable. Rock types of this unit are: medium-grained hypabyssal granitoid containing dark-gray feldspars and clotted mafics; medium- to fine-grained medium-gray quartz-poor feldspar-rich hypabyssal granitoids, and foliated extremely fine grained intermediate to silicic metavolcanic rock. Most rocks are dark, altered, and difficult to distinguish; as a result intrusive relations with other Jurassic rocks are ambiguous. White-weathered albitized metavolcanic rocks (Jam) along the east flank of the Hidden Hills are quartz rich.

Jurassic plutonic rocks. The Jurassic rocks underlie the majority of the study area and have undergone a complex history of intrusion, faulting, diking, and alteration. These rocks are similar to those described in the surrounding region (Miller and others, 1982; Allen and others, 1983).

Mafic plutonic rocks, generally monzodiorite (Jmd), are the oldest post-Precambrian intrusive rocks. These rocks are typically medium grained, dark, and nonresistant and range from monzodiorite to diorite. Intruding the monzodiorite unit is an areally restricted unit composed of mafic-enriched porphyritic biotite quartz monzonite to diorite (Jb).

The syenogranite of Quail Spring (Jqs) is medium- to coarse-grained hornblende-biotite syenogranite to quartz monzonite and quartz monzodiorite (igneous rock terminology follows Streckeisen, 1976). The syenogranite of Quail Spring has variable lithology, probably partly due to the extensive alteration throughout the Horse Hills. Textures vary from medium to coarse grained, and quartz content is also variable. Field criterion for the unit is generally abundant (20-25 percent) quartz. The Quail Spring unit intrudes the monzodiorite unit (Jmd) and intrudes and grades into quartz monzonite of Goldstone.

Composing most of the higher parts of the southern Providence Mountains are the quartz syenite of Winston Basin (Jwb), the quartz monzonite of Goldstone (Jg), and transitional lithologies (Jm). These units are similar in their low quartz content, purplish phenocrysts of potassium feldspar, and coarse grain size. The quartz syenite of Winston Basin is markedly porphyritic, in contrast to the equigranular to subequigranular quartz monzonite of Goldstone. The Winston Basin unit varies from quartz syenite to quartz monzonite. The quartz monzonite of Goldstone was described by Hazzard (1954) as syenite, but our modal data show that the composition ranges from quartz syenite to quartz monzodiorite. Near Hidden Hill and southeast of Foshay Pass the Goldstone unit is highly variable in texture and grades into hypabyssal rocks which are included in the unit. Locally, the Goldstone unit intrudes the Winston Basin, but in most areas transitional mixed granite (Jm) intervenes. The transitional rocks typically have a groundmass identical to the equigranular Goldstone unit but contain sparse potassium feldspar phenocrysts. The Goldstone unit intrudes the monzodiorite (Jmd) and biotite quartz monzonite (Jb) units.

The above described groups of plutonic and metavolcanic rocks are assigned to the Jurassic on the basis of lithologic similarity to dated Jurassic granitoids and metavolcanic rocks elsewhere in the region (Miller and others, 1982) and a K-Ar date of 157.0 ± 3.9 m.y. (M. A. Pernokas, unpub. data, 1983) on biotite obtained from the quartz monzonite of Goldstone.

Jurassic dikes. Sheeted dikes (Jsd) forming a complex zone of altered fine-grained rocks extend along the west margin of the range from Winston Basin nearly to Arrowweed Spring. The dikes generally belong to three types: (1) dark-green to black dacite porphyry which is in places glassy or flow banded; (2) flinty light-green aphanitic rock, sometimes containing round quartz phenocrysts; and (3) light-bluish-gray fine-grained quartzo-feldspathic dikes. The latter type is most common. The dike zone extends southward toward Cretaceous plutonic rocks in the vicinity of Arrowweed Spring, where the zone becomes diffuse. The dikes are cut by the pluton and occur farther to the south in the western Horse Hills. Sparse dikes occur throughout the remainder of the range and generally are one of two types: green altered intermediate-composition dikes or more common pink to light-gray felsic aplitic dikes. These dikes do not appear to be consistently separable on the basis of either relative age or orientation.

Cretaceous plutonic rocks. Cretaceous plutonic rocks are two variants of the granite of Arrowweed (Ka and Kaa). The typical Arrowweed, termed the White Fang Quartz Monzonite by Stein and Warrick (1979) and first described by Sabine (1971), is porphyritic and coarse grained and ranges from biotite monzogranite to granodiorite. Phenocrystic potassium feldspar and rounded quartz are distinctive. Common aplite dikes and rare pegmatite dikes occur in the unit. A related aplitic phase (Kaa) ranges from monzogranite to granodiorite. Its phenocryst assemblage includes all the main phases of the coarse Arrowweed, but is set in a fine-grained aplitic matrix of the same phases. Textures of the aplitic Arrowweed suggest that it may represent a quenched version of the coarser rock, but intrusive relations are ambiguous. A Cretaceous age is indicated for the Arrowweed unit by a K-Ar date of 74.5 ± 1.9 m.y. on biotite (J. K. Nakata, unpub. data, 1984).

Tertiary rocks. The Fountain Peak Rhyolite (Tfp) of Hazzard (1954) occurs in the northern Providence Mountains. It is aphanitic to glassy, in many places flow-banded, rhyodacite(?) with rare yellowish altered feldspars. It was considered by Hazzard to be a Tertiary intrusion, but the possibility that it is wholly or in part Mesozoic cannot be discounted. It may be in part extrusive, as suggested by Hazzard.

The Tertiary volcanic section at Van Winkle Mountain, from bottom to top, is: (1) a heterogeneous volcanic unit (Tv) of waterlain tuff, tuff breccia, ash-flow tuff, sandstone, and conglomerate; (2) glassy flow-banded rhyodacite (Trf); (3) well-bedded airfall and ash-flow tuff (Tva); and (4) black olivine basalt flows (Tb). This sequence is Miocene as established by K-Ar dating of the same units in the Bristol Mountains 10 mi to the west (D. M. Miller, unpub. data, 1983).

Pliocene and Quaternary deposits. Unconsolidated and partly consolidated sand and gravel of Quaternary age occur as alluvial fans, dissected fans, and as broad piedmonts. Highly dissected gravelly deposits (QToa) south of the Horse Hills and in the northwest corner of the study area contain clasts of local rock types and are Pliocene to Pleistocene. Pleistocene alluvium (Qoa) typically has a pronounced pavement consisting of darkly varnished rocks and red soils. Holocene alluvium (Qa) occupies active and inactive washes and piedmont areas.

Structure

The southern Providence Mountains contain at least three sets of faults and zones of extensive fracturing. Faults include: (1) one major fault and a group of subsidiary faults that dip moderately westward—the Hidden Hill fault system, (2) high-angle faults that extend northward near both the east and west fronts of the range (including the Bighorn fault zone), and (3) a complex zone of high-angle faults of east and northeast strikes in the Foshay Pass area. A zone of brecciation in Granite Pass may mark another fault zone.

The Hidden Hill fault system is excellently exposed west of Hidden Hill where it is characterized by one or more resistant silicified zones. At Hidden Hill and northward, the main fault has west and southwest dips of 40 to 50 degrees, contrasting with all other faults in the area. The fault system strikes northward along the steep eastern front of the mountains, passing over the crest about 2 mi south of Foshay Pass. Within Foshay Pass, its trace is difficult to follow in the highly fractured and altered rocks of that area. North of the pass a fault described by Hazzard (1954) passes through the Vulcan mine and has a moderate southwestward dip; it is inferred to represent the northward continuation of the Hidden Hill fault system. Dip separation on the fault is probably of reverse sense, in which case it is greater than about 1,500 ft, based on the lack of repetition of lithologic units. Parallel smaller zones of breccia close by the main fault occur at several points.

High-angle north-striking faults occur near each side of the range. The faults on the east side of the range belong to the Bighorn fault zone, along which the Bighorn mine and many other prospects lie. Sense of separation on these faults is unknown, although their position along the margins of the range is reminiscent of range-bounding normal faults of the Basin and Range province. Breccia zones along the Bighorn fault zone and faults on the western side of the range are nonresistant and weather to yellow brown and reddish brown.

Cutting the Bighorn and Hidden Hill fault zones are small east-striking high-angle faults showing right-lateral separation on the order of tens of feet. These faults are characterized by small brown-weathered breccia zones and generally lack visible mineralization. A larger fault of similar orientation, but apparently of left-lateral separation, occurs west of Foshay Pass in the conspicuous east-west physiographic low separating the northern and southern Providence Mountains. Also present in the pass, and apparently the only unbroken fault there, is a northeast-striking high-angle fault that forms a conspicuous topographic lineament. Alteration and brecciation along this fault are similar to those associated with the east-striking set.

Granite Pass contains a nearly straight northwest-striking and steeply to moderately northeast-dipping breccia zone separating Jurassic and Cretaceous plutonic rocks. The breccia zone contains fractured granitoid rocks that are altered by silica, chlorite, and calcite. Aplite dikes on both sides of the zone are fractured, but not cut; they cannot be demonstrated to cross the zone. A combination of brecciation along intrusive contacts and subsequent minor faulting may explain the relations in Granite Pass.

Alteration

Alteration in all Jurassic granitoids. Background alteration, present virtually throughout the Jurassic crystalline rocks in the study area, includes albitization and sericitization of feldspars and widespread development of chlorite and epidote. Plagioclase feldspars in general exhibit sericitization as fine disseminated flakes within their cores, but sericite does not appear in the matrix. Chlorite is commonly found as an alteration product of biotite. Blackish iron oxides and widespread epidote form minor coatings of minerals along joints and fractures. Albitic alteration of both feldspars creates white fractured zones. This is a regional phenomenon developed so far as known only in the Jurassic group of plutonic rocks (Miller and others, 1982; Allen and others, 1983) and therefore likely developed in conjunction with plutonism. Sericitic and propylitic alteration may have been later, but probably was pre-Late Cretaceous because Cretaceous granitoids are not affected.

Pronounced alteration. Alteration associated with the Hidden Hill fault produced massive propylitically altered black to dark-green highly silicified breccia. Chlorite, silica, and iron oxides apparently are the primary constituents of this alteration type. Silicification varies in intensity along the fault: in the Hidden Hill area the fault is highly silicified, containing white to yellow fine-grained siliceous material; northward, little silica is present until the area where the fault crosses the main mountain ridge, where black and dark-brown siliceous breccia occurs. Near the Vulcan mine the rocks in the fault zone are variably silicified and replaced by magnetite typical of the iron-rich skarn forming this deposit.

Alteration products associated with the Bighorn fault zone and with faults in the Foshay Pass area typically weather yellowish to reddish brown and are nonresistant. Extensive limonite is associated with these faults. Argillic alteration is pronounced in these and other east-striking faults.

Albitization that intensely modified host rock occurs locally in the Jurassic rocks, particularly where associated with fault and breccia zones. It is especially well developed in the Bighorn fault zone, where rocks locally are bleached white; albite is the only feldspar, and mafic minerals are absent. Widespread bleaching and albitization occur in highly diked rocks in the Horse Hills, Quail Spring Basin, and in the northeast corner of the study area. In the Horse Hills albitization is accompanied by silicification quartz-magnetite veining. These areas also have widely varying textures indicating hypabyssal intrusive environment and highly variable quartz content.

Remote sensing. Alteration in the South Providence Mountains Wilderness Study Area was studied (G. L. Raines, written commun., 1983) using the Landsat color-ratio technique and subsequent analysis as previously described (Raines, 1983). Alteration identified by these techniques, and by subsequent analysis of samples, and examined in the field showed propylitic and (or) argillic alteration, with associated anomalous trace-element geochemical suites compatible with those identified through our stream-sediment geochemical studies.

Possible sources for mineralization

Several geologic settings commonly favorable elsewhere for the occurrence of significant mineral deposits occur in the South Providence Mountains Wilderness Study Area. Nonetheless, large deposits of precious or base metals and energy minerals have not been found. A large deposit north of the study area and several small deposits east of the area suggest that some of these same geologic settings within the study area may be favorable. Sites favorable for mineralization might be expected in the following geologic environments: (1) Mesozoic granitoid plutons; (2) aplite, pegmatite, and other dikes in the Mesozoic granitoid rocks; (3) zones of fracturing and brecciation; (4) areas of wallrock metasomatism where Mesozoic granitic rocks may have intruded Paleozoic strata; (5) altered volcanic rocks; (6) placer deposits in alluvium adjacent to the range; (7) possible radioactive materials deposits associated with highly albitized Jurassic granite or Cretaceous granite; and (8) possible oil- or gas-bearing Paleozoic strata at depth or Tertiary basins containing hydrocarbons.

1. Widespread alteration in epizonal Jurassic intrusive rocks suggests that mineralization, if present, may occur in areas of local enrichment, such as wallrock contacts or fault zones, or metals may be dispersed. Alteration is best developed in the syenogranite of Quail Spring, and least well developed in the quartz syenite of Winston Basin. None of the plutonic units shows visible development of dispersed metals. Cretaceous granitic rocks may have been mesozonal (Miller and others, 1982) and are generally unaltered although pyrite is rarely developed along fractures.
2. Hydrothermal dike swarms and late-stage magmatic fluids forming pegmatite dikes may be enriched in metals. Extensive aphanitic to fine-grained felsic sheeted dikes (Jsd) occur along the length of the western side of the range, where they are restricted to Jurassic plutonic rocks. Alteration, both in wallrock and dike rock, is well developed in these areas, indicating favorable sites for mineralization at depth, but no mineralization was noted. Pegmatite dikes are extremely rare in Jurassic rocks, but occur widely, but sparsely, in the Cretaceous granite of Arrowweed. No evidence for alteration or mineralization of these dikes was observed.
3. Zones of intense fracturing are widely distributed along the east and west margins of the range, along the Hidden Hill fault system, and in the Foshay Pass area; these zones are potential sites for hydrothermal alteration and mineralization. Intense alteration and mineralization are noted along some of these fractured zones, suggesting that the zones acted as conduits for mineralizing fluids. Prospects and mines occur along nearly the entire length of the Bighorn fault zone, suggesting that parts of the fault zone located in the study area may be mineralized. The Hidden Hill fault is heavily prospected at its south end (at Hidden Hill) and cuts a major iron deposit at the Vulcan mine just north of the study area. The fault's highly altered character and the known mineralization associated with it outside the study area, coupled with prospects along it within the study area, suggest that it may be mineralized within the study area. Intense fracturing and faulting along the western side of the range and in Foshay Pass, and associated intense alteration of the rocks, provide evidence for hydrothermal activity in these areas. Mineralization was observed in many fault and breccia zones.
4. Wallrock metasomatism by granitic bodies, producing skarn deposits, might potentially occur in the study area because Paleozoic carbonate strata occur close-by to the north. The Vulcan mine, a major iron-rich magnesian skarn deposit, occurs just north of the study area at the faulted contact of Jurassic granitoid and Paleozoic carbonate strata. The only observed carbonate rocks in the southern Providence Mountains occur: (1) adjacent to the study area at its northeast corner; (2) as a 10-ft-wide faulted inclusion north of the Bighorn mine; and (3) as a small faulted inclusion on the south side of Foshay Pass adjacent to the Hidden Hill fault. Therefore, major skarn deposits in the study area seem unlikely, but subsurface occurrences of favorable lithologies remain a possibility.
5. Highly to moderately altered metavolcanic rocks at Hidden Hill may represent a favorable host for base- and (or) precious-metal deposits. Previous mining activity there suggests that mineralization occurred in that environment. Remobilization of these rocks by Jurassic plutonism may have caused volcanogenic gold mineralization.
6. Alluvium adjacent to the Providence Mountains has been prospected for placer deposits, but no activity is known to be current.
7. Uranium, rare-earth, and thorium mineralization in the Bristol Mountains, about 10 mi southwest of the study area, was considered by Otton and others (1980) to possibly be related to albitized Jurassic granitoids. Similar host rock and alteration in the southern Providence Mountains indicate a possibility for similar mineralization in the study area. Scintillometer traverses through areas of highly albitized rock in

Quail Spring Wash failed to show anomalous occurrences of radioactive materials; unaltered rocks were typically less than 150 counts per second (cps), and albitized rocks locally were as much as 220 cps. Cretaceous granitoids in the nearby Granite Mountains show anomalous uranium, suggesting that similar granitoids in the study area may be enriched in uranium.

8. The overthrust belt, a known site for oil and gas deposits, extends southward to the Providence Mountains area (Burchfiel and Davis, 1981) and possibly beyond (Howard and others, 1980). Unmetamorphosed Paleozoic strata in the northern Providence Mountains that contain possible source and reservoir rocks are close to the study area. Paleozoic strata have not been identified in the study area, but may be present at depth because the separation on faults in Foshay Pass is unknown. In addition, nearby Tertiary basinal deposits have been prospected for hydrocarbon deposits; possible Tertiary basin deposits occur in the northwestern part of the study area.

GEOCHEMISTRY PERTAINING TO MINERAL RESOURCE ASSESSMENT

The geochemical investigation of the South Providence Mountains Wilderness Study Area, consisted principally of collecting and analyzing 74 stream-sediment, 73 heavy-mineral-concentrate, and 152 rock samples and evaluating the resulting data. Each sample was semiquantitatively analyzed for 31 elements using an optical emission spectrograph according to the method outlined by Grimes and Marranzino (1968). In addition, sediment and rock samples were analyzed for gold, arsenic, bismuth, cadium, antimony, and zinc by atomic-absorption spectrometry and for mercury by instrumental analysis. A complete tabulation of the data and detailed discussion of the sampling and analytical methods are given in Detra and others (1984).

The geochemical evaluation is based largely on the distribution and variation of selected elements in the stream-sediment samples and 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; tables 1 and 2 list these threshold concentrations for specific elements of interest. R-mode factor analysis was used to derive the most characteristic mineralization signatures.

For the stream-sediment data base, areas interpreted as having highest potential for undiscovered resources were defined by a gold-silver-copper-bismuth-arsenic-mercury suite of trace elements. Anomalous concentrate samples were found to have a distinctive gold-silver-copper-lead-strontium (± barium, bismuth, molybdenum) signature. As expected, sediment and concentrate samples, anomalous with regard to the above element suites, defined both the Bighorn and Hidden Hill mining areas (locations 14 and 23, fig. 4). Ore from quartz veins at the Bighorn mine (see table 5, no. 14 for ore description) pulverized to minus 100 mesh contained anomalous manganese, silver, bismuth, copper, gold, and mercury. At Hidden Hill (table 5, no. 23) mineralized quartz veins carried anomalous silver, bismuth, copper, gold, and mercury.

Rock samples from the major mineral occurrences in these two districts and from other minor prospects in the southern Providence Mountains lack any consistently anomalous lead and (or) zinc concentrations. However, a suite of mineralized samples of quartz veins, breccia, and host granitoid rock from a number of small prospects near the northeast corner of the study area contrasts sharply with other gold-copper mineral occurrences. Consistently high cadmium, barium, lead, and zinc concentrations, in addition to anomalous amounts of the more common gold-copper associations, may represent an occurrence structurally higher in the regional mineralizing sequence than elsewhere in the southern Providence Mountains or may be related to altered carbonate Paleozoic rocks.

The concentrate data do not point to any new areas of resource favorability. A bismuth-molybdenum-tungsten-thorium enrichment in concentrates from the southwestern part of the study area is possibly related to high background for highly differentiated felsic Cretaceous plutonic rocks. A cobalt-copper-nickel anomaly near Goldstone Spring is reflective of locally abundant mafic dikes and magnesian skarn retrograded to serpentine. Anomalous barium concentrations of more than 5,000 ppm throughout the northeastern part of the study area could be related to hydrothermal activity along the extensive fault networks there. A trend of nickel enrichment from Quail Spring southeast to Hidden Hill most likely reflects outcroppings of mafic plutonic rocks.

Lead concentrations for concentrate samples are exceptionally high throughout the study area, excluding southern Winston Basin, the region north of the Bighorn mine, and the Quail Spring Wash area. Over one-third of the samples contain at least 200 ppm lead, which is far above background for concentrate samples collected from other plutonic complexes similar to the southern Providence Mountains. This is especially unexpected as (1) most of the mineral occurrences in the study area only have minor galena and (2) the observed extensive alteration would normally be expected to cause depleted lead concentrations in the affected plutonic rocks. The significance of these anomalous lead concentrations is presently unknown.

Widespread alteration and diking have been mapped throughout the Horse Hills, but no known prospects occur in this area. Stream-sediment geochemistry indicates a weak molybdenum-copper anomaly along the eastern side of the Horse Hills. However, iron-stained quartz from this area contained 10,000 ppm copper and 2,000 ppm molybdenum, as well as some anomalous mercury and gold. Small but highly mineralized zones apparently cause the molybdenum-copper anomaly.

Scattered sediment samples with anomalous mercury concentrations occur at and near the limits of the Bighorn mine area. These may indicate geochemical favorability for undiscovered gold-quartz-magnetite-chalcopyrite veins similar to those at the Bighorn mine, but in the surrounding area. Anomalous boron, gold, cadmium, mercury, and barium in sediments from a number of washes in the Goldstone Spring region could indicate more widespread gold mineralization than is presently recognized; no tourmaline is recognized as the source for the boron. Nearby, sediment concentrates in Winston Basin locally contain anomalous gold, mercury, antimony, bismuth, and copper. Brecciated quartz syenite nearby contained 0.15 ppm gold.

Stream-sediment and heavy-mineral-concentrate sampling at the chosen site density apparently failed to locate small but highly mineralized areas. One-half mile downstream from the above-described rock and sediment anomaly, just beyond a junction with a slightly larger drainage, another stream-sediment sample showed no geochemically anomalous concentrations. Similarly, a sample of albitized quartz syenite from a fault zone near the headwaters of a small wash contained 1,000 ppm bismuth, 10,000 ppm copper, and 0.15 ppm gold; one mile down the drainage no trace-element enrichments were found in either sediment or concentrate samples. These examples emphasize that, due to either the limited mobility of many of the ore elements in this environment or the limited size of many of the copper-gold occurrences, detailed mapping of alteration patterns with associated lithogeochemical study may be the most useful exploration tool.

Samples of ore, host rock, skarn, and fault breccia at Goldstone Spring yielded anomalous abundances of several rare-earth elements and nickel. Other elements enriched in these rocks are consistent with the mafic dikes and serpentine skarn compositions. The skarn is in many locations brecciated in the Hidden Hill fault zone.

GEOPHYSICS PERTAINING TO MINERAL RESOURCE ASSESSMENT

Aeromagnetic data

The South Providence Mountains Wilderness Study Area is included in an aeromagnetic survey of the Needles 1° by 2° quadrangle (U.S. Geological Survey, 1981). The survey was flown in an east-west direction at a constant nominal elevation of 1,000 ft above the surface of the ground. Flight lines were spaced approximately 0.5 mi apart with north-south tie lines every 10 mi. Because it is not possible to maintain a constant elevation above ground level when flying over rugged terrain, some apparently anomalous magnetic data result from the changing distance to magnetic sources as the plane skims peaks and flies high over narrow valleys. Most such anomalies have small dimensions and are easily identified when the locations of anomalies are compared with topography.

The portion of the aeromagnetic survey which emcompasses the study area (fig. 2) was reduced to the pole (Baranov and Naudy, 1964; Hildenbrand, 1983) using an assumed direction of magnetization with inclination of 60° and declination of 14°. Reduction to the pole removes asymmetries in the magnetic anomalies by mathematically replacing the obliquely dipping magnetization and field vectors of the study area with vertically downward directed vectors such as would be found at the magnetic North Pole.

A broad aeromagnetic high coincides with the central part of the mountain range that is underlain by Jurassic igneous rocks, and several sharper anomalies superimposed on this broad high coincide with individual topographically high features. This relation suggests that these sharp aeromagnetic highs are produced by rocks exposed at the surface. Some of the exposed rocks have magnetic susceptibilities as high as 2.0×10^{-3} cgs units.

A north-northwest-trending belt of anomalously low aeromagnetic values lies along the east boundary of the study area. This belt of lows (indicated by L1 on fig. 2) cuts across geologic units and parallels the fault zones along the eastern front of the Providence Mountains. The lows are probably caused by alteration that has destroyed magnetic minerals (principally magnetite) in the rocks. Similar magnetic lows are commonly found over areas of alteration and mineralization, and many of the important gold-silver mines and prospects in the study area fall within these lows. The parallelism of the Bighorn fault zone and the magnetic low belt suggests that the fault zone has controlled the locus of alteration. The coincidence of mines and prospects with the magnetic low suggests that other areas of mineralization presently hidden by alluvium may also occur along this trend.

Another magnetic low (L2) of lesser amplitude in the southwest corner of the study area coincides with exposures of Jurassic granitic rocks and approximately coincides with an area of diking and intense albitic alteration and anomalous geochemical concentrations. This magnetic low may also outline an area of alteration and possible mineralization.

A large broad low (L3) along the west edge of the study area coincides with an area of exposed Cretaceous granitic rocks. Other Cretaceous granitic rocks in the Needles 1° by 2° quadrangle generally have a lower color index and a lesser magnetization than the darker Jurassic igneous rocks. Thus the magnetic low L3 probably records the inherent absence of magnetic minerals in these granitic rocks rather than alteration.

A small elongate north-south-trending low (L4) in the northern part of the study area lies close to another geochemically anomalous area in Jurassic igneous rocks and may again mark a zone of alteration. A second small low (L5) over Winston Basin may also indicate alteration, but it is of such a small size that it might be a topography-related anomaly.

A northwest-trending aeromagnetic high (H1) coincides with areas covered by alluvium on the western side of the study area. This anomaly extends from an area of exposed Jurassic igneous rocks in the Providence Mountains toward a magnetic high just east of the Kelso Dunes, which is also underlain by Jurassic igneous rocks. Thus the northwest-trending high and a smaller high (H2) over alluvium at the south end of the study area probably indicate the presence of Jurassic igneous rocks under the alluvium.

A very large magnetic high (H3) over the Vulcan mine about 1 mi north of the study area does not seem to have any counterparts within the study area. Although vein fillings of iron ore have been observed within the study area, all of the sharper magnetic highs within the area seem to be associated with topographic features underlain by Jurassic granite. Veins filled by iron ore may contribute to these magnetic highs, but the highs are of such modest amplitude when compared to the high over the Vulcan mine that the volumes of possible iron ore would be quite small. Also, the magnetization values of the igneous rocks alone seem adequate to account for these magnetic highs.

Gravity data

Bouguer gravity values within the study area range from a high of -92 mGal in the southwest corner of the area to a low of almost -110 mGal near the northwest corner (fig. 3). Coverage within the most mountainous parts of the area is limited by the difficulty of access. Nonetheless, even where the density of observations is high, the gravity field seems to vary smoothly over the study area, suggesting that no major near-surface density contrasts occur within the area. Most density measurements on a suite of igneous rocks collected from the study area fell into the range 2.60-2.73 g/cm^3, confirming this interpretation of the gravity data.

The steepest gradient (G) within the study area occurs west of the western range front of the Providence Mountains in the northwestern part of the study area. This gradient may overlie a buried fault with an abruptly increased thickness of alluvium on the west side. The alluvium appears thickest under the northwest corner of the study area where the lowest gravity values occur. These values, compared with values over nearby Jurassic granitic bedrock exposures, give a gravity relief of approximately 7 mGal which implies depths to crystalline basement of roughly 1,400 ft for an assumed density contrast of 0.4 g/cm^3 between alluvium and Jurassic bedrock. Alluvium thicknesses immediately to the east and south of the study area are judged to be small since the gravity values remain high in these areas. On the basis of negligible gravity gradients, the Bighorn and related faults near the east margin of the range apparently offset alluvium little or not at all.

Electrical geophysics

Electrical methods used in and adjacent to the South Providence Mountains Wilderness Study Area consisted of audio-magnetotelluric (AMT) soundings as well as induced polarization (IP) and telluric traverses. All of this work was done on the east margin of the study area in order to better define structures associated with the Bighorn fault system and to help assess the potential for mineralization along that structure.

Based on abrupt changes in resistivities, a fault is interpreted along the east margin of the study area east of the Bighorn mine and Hidden Hill mining district; it apparently downdrops rocks a few tens of feet on the east. Resistivities associated with intrusive rocks are moderate to high; 100 to several thousand ohm-meters. AMT soundings show that these units increase in resistivity with depth, suggesting that alteration and mineralization is not pervasive at depth or that it is confined to narrow zones. IP data obtained between Hidden Hill and the Bighorn mine show low polarizability, but higher than background values associated with extensions of the mineralized areas. Polarizability increases with depth, an effect which may be associated with near-surface oxidation of sulfides.

Northeast of Hidden Hill, Clipper Valley appears to have very little alluvial fill. However, east of the Bighorn mine electrical data indicate low resistivities that would be consistent with fill on the order of 1,200 ft thick. Because this is inconsistent with the gravity data, basement resistivities are inferred to be anomalously low. This is in accord with an AMT sounding near the Blind Hills further east which shows Precambrian rocks of about 100 ohm-meters. Because these resistivities are quite low for basement rocks, the possibility exists that mineralization in the Bighorn fault area resulted from a mineralizing system centered below Clipper Valley.

MINING DISTRICTS AND MINERALIZED AREAS

Methods of study

Mining claim records and activities (both current and historic) within and surrounding the study area were checked through the San Bernardino County courthouse, the U.S. Bureau of Mines production records and Mineral Industry Location System (MILS), records of the U.S. Bureau of Land Management California State, District, and Area offices, and published and unpublished records of the California Division of Mines and Geology. Attempts were made to contact all known claimants and owners of all mining properties in or near the study area for permission to examine their mines or prospects and to obtain any pertinent scientific or historic information.

During field examination of the study area in 1982, mine and prospect sites were examined and 529 rock and 42 placer samples were collected. A total of 349 chip samples were taken from mineralized structures; the remaining 180 grab samples were collected from country rock and from dumps. All rock samples were crushed, pulverized, homogenized, split, and assayed for gold and silver. Other elements of interest were determined by either inductively coupled plasma, atomic-absorption, colorimetric, or x-ray fluorescent methods as appropriate. At least one sample from each locality was analyzed for 42 elements[1] by semiquantitative spectrography. Elements found to be in anomalous concentrations were then analyzed by utilizing one of the quantitative methods listed above. Reconnaissance pan samples of alluvium were collected from all major stream drainages and known placer claims in the study area. The placer samples (approximately 0.008 yd^3 each) were panned to a rough concentrate (approximately 2 lbs) where possible and subsequently processed on a laboratory-size Wilfley table. Resulting heavy-mineral fractions were examined for precious metals, scheelite, cinnabar, cassiterite, monazite, and native copper and tested for the presence of radioactive and fluorescent minerals. The detailed results are on file at the U.S. Bureau of Mines Western Field Operations Center (WOFC), Spokane, Wash.

Placer deposits

All known placer prospects (table 3), major creek beds, and arroyos draining the study area were sampled and evaluated. Black sand was found throughout the area. Observed trace minerals included zircon, scheelite, native copper, magnetite, hematite, and gold; no radioactive minerals were detected, although aerial radiometric surveys of the area showed slightly anomalous thorium in black sands east and west of Foshay Pass (J. Otton, oral commun., 1984). Gold particles ranging from 100 mesh to 400 mesh are generally bright and occasionally chunky but usually angular to rounded. Examining the samples revealed: (1) relative gold content of streambeds and creek and arroyo beds; (2) gold values ranging from nil to \$1.827 per yd^3 [2]; (3) 29 percent of the samples from placer claims contained detectable gold; (4) gold occurs in greater concentration in drainages along the east than the west edge of the study area; (5) the gold and tungsten content of samples generally increases with presence of black sand; (6) gold and tungsten generally occur in the same samples; (7) samples containing tungsten but no gold generally contain no zircon; and (8) gold content and individual grain size increases proportionately with the number of quartz veins exposed in a given drainage.

Lode deposits

Most mines and prospects (tables 4 and 5) are associated with either the Hidden Hill or the Bighorn fault zones. Numerous small prospects occur at or near other faults, dikes, and limestone contacts in and adjacent to the study area. Gold is the principal mineral resource of economic interest, although silver, copper, and lead have been produced sporadically from chalcopyrite- or galena-bearing quartz veins.

Veins are generally oxidized to depths of 60 to 100 ft below the present surface and contain a variety of sulfide minerals at depth, including marcasite, pyrite, arsenopyrite, pyrrhotite, galena, sphalerite, and chalcopyrite. Locally, particularly in Winston Basin, veins contain sulfides in surface exposures. Other vein minerals include magnetite, specularite, orpiment, realgar, manganese oxide, malachite, azurite, and chrysocolla. Vein gangue minerals include quartz (clear, milky, or blue), calcite, ankerite, magnetite, fluorite (green and purple), epidote, chlorite, and specularite. The most common gangue mineral, quartz, may be massive, sacchroidal, crystalline, vuggy, or contain comb structure. All other gangue minerals may occur as admixtures, pockets, cavity filling, contact occurrences, breccia cement, or crosscutting veins in quartz veins.

Some veins are offset across faults; others contain quartz- and (or) fluorite-cemented vein quartz breccias, implying multiple pulse hydrothermal activity and post-depositional cataclastic deformation. Veins generally trend northwest to north-northeast and dip steeply east or west; however, veins along the Hidden Hill fault dip 35-55° west. Except in the Hidden Hill area where age relations are uncertain, ore-mineral deposition is considered to be Jurassic or early Cretaceous because Jurassic intrusive rocks contain veins and crosscutting Cretaceous intrusive rocks do not.

The number and distribution of known workings and mineralized zones are insufficient to determine distinct mineralogic and alteration zonation. However, gold and copper appear to correlate in both the Hidden Hill and Bighorn mine areas.

Oil and gas

No oil or gas had been discovered in the study area by 1982. However, U.S. Bureau of Land Management (BLM) records indicate that all of secs. 2, 8, 14, 20, 26, 32, and 34, T. 9 N., R. 13 E., and all of secs. 4, 8, 20, 28, 32, and 34, T. 9 N., R. 14 E., San Bernardino Base and Meridian, were under oil and gas lease as of August 1982 (fig. 4).

Resource estimate

Two mines (table 5, nos. 14, 23) adjacent to the east boundary of the South Providence Mountains Wilderness Study Area together contain an estimated 195,000 tons of identified currently marginal gold-bearing resources. One mine (table 5, no. 36) inside the study area contains 40 tons of marginally economic gold-bearing dump reserves. Four mines (table 5, nos. 10, 13, 14, and 23) outside and immediately adjacent to the study area contain approximately 11,000 combined) tons of marginally economic gold-bearing dump resources. Thirteen mines and prospects within or immediately adjacent to the study area have potential for additional vein-type gold resources (especially near Hidden Hill and Bighorn mines, based on past production). Two mines (Bighorn and Buena Vista) have potential for additional resources of vein-type lead and zinc. Other locations along the Hidden Hill fault may have potential for vein-type deposits and resources. Five areas (table 5, nos. 3, 18, 23, 24, and 31) display potential for disseminated gold resources, and the Golden Nugget group (table 5, no. 24) has potential for porphyry copper and molybdenum resources.

Factors favorable for mineral development include (1) rail transportation is less than 25 mi from most mines, (2) many prospects have road access, (3) climate allows year-round production, and (4) some prospects contain favorable byproduct minerals.

Factors unfavorable for mineral development include (1) limited availability of water for mining and milling, (2) pinch and swell nature of veins in vein deposits, and (3) the currently depressed market value for some potential metal products.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Favorability of geologic formations and structures, direct evidence for mineralization, and indirect evidence such as geochemical and geophysical anomalies are integrated in this section to arrive at assessments of mineral resource

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[1] Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, columbium, copper, gallium, gold, hafnium, indium, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, nickel, phosphorus, platinum, rhenium, scandium, silicon, silver, sodium, strontium, tantalum, tellurium, thallium, tin, titanium, vanadium, yttrium, zinc, and zirconium.

[2] All gold values computed at a gold price of \$400 per ounce.

potential (fig. 5).

The likelihood of occurrence of undiscovered mineral resources is classified according to high, moderate, and low potential. **High mineral resource potential** exists in an area where the geologic environment is favorable for the occurrence of undiscovered resources, where data indicate probable resource accumulation, where mineral concentration has taken place, and where genetic models conforming with collected data would suggest the presence of resources. **Moderate mineral resource potential** exists in areas where most of the geologic environment is favorable for the occurrence of undiscovered resources, where data indicate a reasonable chance for resource accumulation, and where genetic models indicate that the area is favorable. **Low mineral resource potential** exists in areas (a) where most of the geologic environment is unfavorable for the occurrence of undiscovered resources, or (b) where the geologic environment is permissive for the occurrence of undiscovered resources, but either available data indicates that resource accumulation is unlikely or the requirements of genetic models cannot be supported. **No mineral resource potential** exists in areas where all data indicate that favorable models and geologic environments are not present. In cases where data are available to specify with moderate, but not total, certainty that no potential exists, there is **no recognized potential. Unknown mineral resource potential** is assigned to areas where the level of knowledge is inadequate to classify by the above scheme.

Parts of the South Providence Mountains Wilderness Study Area have the following potentials for undiscovered mineral resources: (1) a high, moderate, or low potential for gold-copper hydrothermal mineral resources is indicated for much of the area; (2) a high or moderate potential for epithermal gold mineral resources is indicated for four small areas; (3) a moderate potential for placer gold resources is indicated for two small areas and a low potential is indicated for remaining alluvium; (4) a low potential for gold-rich copper porphyry-type mineral resources is indicated for much of the area and molybdenum stockwork mineralization may be a subset of this system; (5) a low potential for radioactive material resources is indicated for one area of granite; and (6) dependent on models for deep-seated structures, a low potential for hydrocarbon resources may exist in the study area.

Gold-copper hydrothermal system

Most of the study area bears geochemically anomalous gold and copper concentrations that typically are associated with high concentrations of silver and bismuth. Highest concentrations of these elements occur along the eastern side of the study area, coincident with highly altered host rock, mineralized structures, and districts with historic mining productivity. In other parts of the study area geochemical studies and alteration of host rock are similar, suggesting that the hydrothermal system responsible for mineralization affected to some degree the entire study area. The hydrothermal system apparently was related to multiple intrusion of epizonal Jurassic granitoids and dikes, and later faults acted as major fluid conduits to locally enrich mineralization. Because of the widespread alteration and mineralization in plutonic rocks, a hydrothermal mineralizing system, associated with remobilization by Jurassic plutonism, is inferred.

The gold-copper hydrothermal system is classified according to three categories of potential for undiscovered mineral resources, each defined by specific criteria (table 6). Variants of geochemical signatures, such as lead and zinc in the northeast, molybdenum in the Horse Hills, and nickel at Goldstone Spring, are addressed in appropriate discussions below. These variants appear not to represent significantly different hydrothermal systems and therefore are classified within the gold-copper system.

High potential (GC-1). The gold-copper mineralization is evidenced by mines and prospects along the Bighorn fault zone (mostly within $1/2$ mi of the study area) and is supported by gold-copper-silver-bismuth associations from geochemical studies of stream sediments. Individual ore bodies apparently are mostly lensoid and small, but widely distributed. Their association with fault and breccia zones, propylitic, argillic, and albitic alteration, and Jurassic host rocks indicates the probable extension of equally favorable sites for mineralization in parts of the zone in the study area. Areas (labeled GC-1, fig. 5) of the fault zone having these characteristics, and also anomalous geochemical concentrations, coincide with an aeromagnetic low which apparently records the destruction of magnetite by alteration in the zone. It is inferred that the extent of the zone is typified by similar alteration and mineralization, and thus it is considered to have a high potential for undiscovered gold and copper resources. On the basis of the proven mining record, good geochemical concentrations, and structural extrapolations of favorable ore-deposition sites, the designation of a high mineral resource potential for this area is made with confidence.

At the Adams Corral property adjacent to the northeast corner of the study area (fig. 4; table 5, no. 3), a possibility for lead and zinc mineralization in association with gold and copper is indicated by the deposits. Our data are few and therefore the potential for lead and (or) zinc mineral resources is unknown.

Moderate potential (GC-2). Areas adjacent to area GC-1 are characterized by anomalous geochemical concentrations, favorable alteration, and local occurrences of sulfides and favorable structures. These areas, classified as GC-2a and GC-2b (fig. 5), have a moderate mineral resource potential because they share many characteristics with area GC-1. Less apparent alteration and lower geochemical concentrations than in area GC-1 make resource accumulation less likely. Local variations, superimposed on the main pattern of geochemically anomalous gold and copper, are evident in GC-2 areas, and the areas are divided by these variations. Area GC-2a, near Foshay Pass, contains local skarn associations similar to those at the major magnetite deposit at the Vulcan mine and also locally abundant mafic dikes that may be enriched in nickel. In addition to potential for gold-copper mineral resources, the locally anomalous concentrations of iron, nickel, cobalt, and vanadium may indicate potential for small iron-rich skarn-related resources. Because of inadequate data, the potential for these resources is unknown. Geophysical data rule out a major iron deposit of the size and type of Vulcan mine. Area GC-2b, in the Horse Hills area, is characterized by extensive diking and altered siliceous granitoids. Locally anomalous concentrations of molybdenum are found in addition to gold and copper, possibly indicating potential for molybdenum stockwork resources; the potential is unknown with the presently sparse data base.

Low potential (GC-3). On the basis of widespread alteration and slightly to moderately anomalous geochemical concentrations, the remaining exposed and shallowly buried Jurassic granitoids are considered to have a low potential for gold-copper mineral resources related to those in the Bighorn and Hidden Hill areas. Locations of Jurassic rocks overlain by thin deposits of late Cenozoic alluvium are inferred from the aeromagnetic studies.

No recognized potential. Appropriate alteration, brecciation, and geochemical suites are lacking in Cretaceous granitoids; they, together with areas of thick alluvial deposits, have no recognized potential for hydrothermal gold-copper mineralization.

Gold-rich copper porphyry system

Several characteristics of the alteration, mineralization, and geologic environment of the southern Providence Mountains match typical characteristics of gold-rich copper porphyry systems as outlined by Sillitoe (1979). Sillitoe considered the following criteria to be representative of gold-rich copper porphyries: (1) feldspar-stable alteration, (2) chalcopyrite±bornite ore-mineral assemblages, (3) generally low molybdenum content, and (4) abundant (3 to 10 wt percent) magnetite plus replacement quartz; other common characteristics inferred from data presented by Sillitoe (1979) are (5) low quartz content of host plutonic rock, and (6) host rock intruding andesitic to rhyolitic rocks. Of these criteria, all but number (4) is met by the data as presently known. In particular, the quartz-gold-chalcopyrite-magnetite assemblage in albitized host rock is provocative. Deficiencies with this model in the study area are: (1) magnetite, although abundant, does not approach 5 wt percent except in quartz-magnetite veins in the Horse Hills, and aeromagnetic response precludes significant magnetite accumulations near the surface; (2) the most extensive mineralization coincides with reduced magnetic response; (3) the extensive fractures and widespread quartz typical of many porphyry systems are lacking; (4) zonations of alteration types and of geochemically anomalous elements do not clearly define a porphyry system; (5) no ore-grade or near ore-grade mineralization is exposed at the surface; and (6) there is no direct evidence for widely occurring gold, although geochemical analysis shows that some sediments and a few rocks distal to the major fault systems carry gold in abundances above the normal crustal levels. Accordingly, a low mineral resource potential for widespread low-grade gold and (or) copper is indicated. Three subsets of this system are present: (1) Cretaceous plutonic rocks have none of these characteristics and therefore have no recognized potential; (2) exposed Jurassic granitoids satisfy the criteria and therefore have a low potential; and (3) unexposed Jurassic granitoids inferred from aeromagnetic signatures occur under Cenozoic deposits in the northwestern and southwestern parts of the study area. Similar mineralization characteristics are inferred for these areas and therefore they have a low potential. The sum of all areas identified for gold-copper hydrothermal systems (GC-1, GC-2a, GC-2b; GC-3; fig. 5), therefore, is the extent of the area having a low potential for a gold-rich copper porphyry system.

The possibility for molybdenum resources in the Horse Hills area is suggested by local geochemically anomalous molybdenum concentrations and nearby fluorine occurrences, in addition to the granitoid host rock and other criteria summarized above for the gold-rich copper porphyry system. The data are permissive of a disseminated molybdenum (stockwork) model, but do not specifically require it, so an unknown potential for disseminated molybdenum mineral resources in the southwestern part of the study area is indicated.

Epithermal gold

Altered metavolcanic and felsic hypabyssal rocks in the Hidden Hill area that are associated with a granitic intrusive system suggest conditions for undiscovered epithermal gold resources. Favorable indicators for this model are: (1) intermediate to silicic volcanic rocks, (2) extensive propylitic, argillic, and silicic alteration, (3) multiphase intrusives, (4) existing precious-metal mines and prospects, (5) geochemically anomalous concentrations of gold and silver, (6) areas of intense fracturing, and (7) exposures of subvolcanic plutonic rocks in the most highly mineralized area (Hidden Hill). However, lack of advanced argillic alteration indicates some departure from the epithermal gold model. A high mineral resource potential for epithermal gold is indicated (area G-1, fig. 5) by satisfaction of a genetic model, favorable geologic environment, and evidence of mineral accumulation and concentration.

Three other areas (areas G-2, fig. 5) with geochemically anomalous concentrations of gold share the favorable indicators noted for the Hidden Hill area above, but have no associated volcanic rocks. The area in the northeast extreme of the study area has faulted and metamorphosed limestone pods, and the area near Winston Basin contains rhyolite dikes. A moderate resource potential for epithermal or disseminated gold is indicated by partial satisfaction of a genetic model, favorable geologic environment, and evidence of mineral accumulation and concentration.

Placer gold

Known bedrock gold sources on the east side of the study area, alluvium in drainages emanating from these sources, and detectable, but low, concentrations in these drainages indicate possible undiscovered gold placer resources. At gold prices of $400 per oz, two of the drainages show a value of slightly greater than 20 percent of currently profitable resources. These areas (labeled P, fig. 5) are designated as having a low potential for placer gold resources and are particularly significant because they occur downstream from gold mineralization and they contain relatively thick gravel accumulations compared to other drainages. They lack proven resource accumulation. Other areas of alluvium within the study area also have low potential for placer gold resources.

Nonmetallic resources

No nonmetallic mineral activities have been recorded within the study area. No significant occurrences of decorative stone or sources of riprap are found. Significant deposits of common borrow occur in the study area, but even larger deposits exist in adjacent valleys which have better access. Limestone occurrences are negligible. Accordingly, there is no recognized potential for nonmetallic mineral resources.

Radioactive minerals

Otton and others (1980) described uranium, rare-earth, and thorium mineralization in the Bristol Mountains, 15 mi southwest of the study area, in a similar geologic setting. Albitized Jurassic granitoids there host mineralized veins. We observed no strongly anomalous readings during scintillometer surveys of the study area, although albitized Jurassic granitoids are consistently more radioactive than unaltered rocks. We also failed to verify a uranium anomaly in Quail Spring Wash reported by the U.S. Bureau of Land Management. Aerial radiometric surveys of the area conducted in 1977 and 1978 (J. K. Otton, oral commun., 1983) showed thorium enrichment in alluvium, probably resulting from concentrations of heavy minerals from thorium-rich granite. No significant enrichment of uranium in the area is shown by the aerial data. Accordingly, there is no recognized potential for undiscovered radioactive mineral resources in Jurassic granitoids. Cretaceous granitoids in the Granite Mountains west of Granite Pass (fig. 1) show strongly anomalous uranium, based on aerial surveys. Because the granite of Arrowweed in the study area is identical to granitoids in the Granite Mountains and because stream-sediment surveys found slight enrichments of uranium and thorium (with high uranium/thorium ratios) adjacent to outcrops of the Arrowweed, a low potential for undiscovered radioactive mineral resources is indicated for the outcrop area of the granite of Arrowweed (labeled RM, fig. 5).

Geothermal resources

A north-northwest-trending regional belt of high heat flow (80 to 100 mw/m^3) traversing the Mojave Desert from southern Death Valley to Blythe, Calif., is indicated by preliminary interpretation of USGS heat-flow data (A. H. Lachenbruch, oral commun., 1983). This belt, defined by widely spaced data points (about 20-mi spacing), occurs immediately west of the South Providence Mountains Wilderness Study Area and possibly includes the study area. It also includes areas of youthful volcanism. Parts of this belt have been explored for geothermal resources (Marsh and others, 198?), but no lease applications have been filed for the Providence Mountains area. Hot springs, gas vents, siliceous sinter, and travertine are not present in the study area. On the basis of these data, the geothermal resources for the study area have an unknown potential.

Oil and gas resources

Assigning oil and gas resource potential depends largely on establishing the favorability of geologic environment; particularly: (1) presence of source rock, (2) amount of reservoir rock, (3) structural or stratigraphic traps, and (4) thermal maturity of source rocks. These factors are unknown for the South Providence Mountains Wilderness Study Area because appropriate sedimentary rocks do not crop out in the area. As a result, potential for undiscovered hydrocarbons is based on possible deep structure and is therefore model dependent.

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 ranges from southern Nevada and 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 about 25 mi north of the study area in the Clark Mountain Range and New York Mountains (Burchfiel and Davis, 1971, 1977, 1981), where the thrusts affect highly metamorphosed Paleozoic strata. A proposed extension of the overthrust belt (Howard and others, 1980) south of the Providence Mountains consists of highly metamorphosed sedimentary and igneous rock occurring as nappes. It thus appears that many thrust-belt rocks in the general region of the study area are overmature and have no recognized hydrocarbon potential. Unmetamorphosed thrust-belt strata also occur in the region (Burchfiel and Davis, 1981), so the resource potential is unknown for the South Providence Mountains Wilderness Study Area.

Sedimentary strata, largely Paleozoic, in the northern Providence Mountains are largely unmetamorphosed (Hazzard, 1954) and, if present at depth in the southern Providence Mountains, could represent potential for hydrocarbon resources. Granitic rocks surrounding the highly metamorphosed Paleozoic strata north and southeast of the Providence Mountains are largely Cretaceous (Beckerman and others, 1982; Miller and others, 1982). In contrast, the Paleozoic strata in the Providence Mountains are intruded by and only slightly metamorphosed by Jurassic granitoids. The general observation that Paleozoic strata are less metamorphosed where intruded by Jurassic granitoids than by Cretaceous granitoids seems to hold southward in the Mojave Desert (Miller and others, 1982). If Paleozoic strata occur at depth in the study area, they might therefore be expected to be unmetamorphosed. Available geophysical data do not require any major changes of rock type in the subsurface, but deep occurrences of sedimentary rocks cannot be ruled out. Although the Paleozoic strata in the northern Providence Mountains are largely limestone and dolomite, shaly units in Cambrian strata could possibly act as source rock. Reservoir rock and structural traps within the Paleozoic strata must remain hypothetical because porous sandstone and carbonate rocks are minor to absent, and fractured rock and structures that might be present beneath the study area are unknown. In addition, data on the thermal maturity of the possible source rocks are lacking. The potential for hydrocarbon resources accordingly is unknown.

Another possible model is that young (probably Tertiary) basinal sediments in the Kelso area acted as a reservoir for hydrocarbons derived from either Paleozoic or Tertiary source rocks. In the nearest analogous basin, oil and gas exploration 20 mi north of the study area in the Ivanpah Valley has focused on reservoirs in Tertiary basin-fill and lacustrine sediments. Minor hydrocarbon shows from these test wells generally were found at depths greater than 1,600 ft, but from some as shallow as 380 ft. The thickest basin sediments in the study area occur in the northwest corner, where they are estimated from gravity data to be about 1,400 ft thick. These sediments are of unknown character. Lack of production from the better-known Ivanpah Valley, coupled with the uncertain character of the Kelso basin sediments in the study area and their unknown thermal maturity, make the potential for oil and gas resources in this basin low to unknown. Area H outlines the region of basin sediments greater than about 400 ft thick (fig. 5). The area is based on interpretation of gravity data, which is imprecise due to sparse data; the position of the boundary for the area could shift as much as $\frac{1}{2}$ mi with more detailed data.

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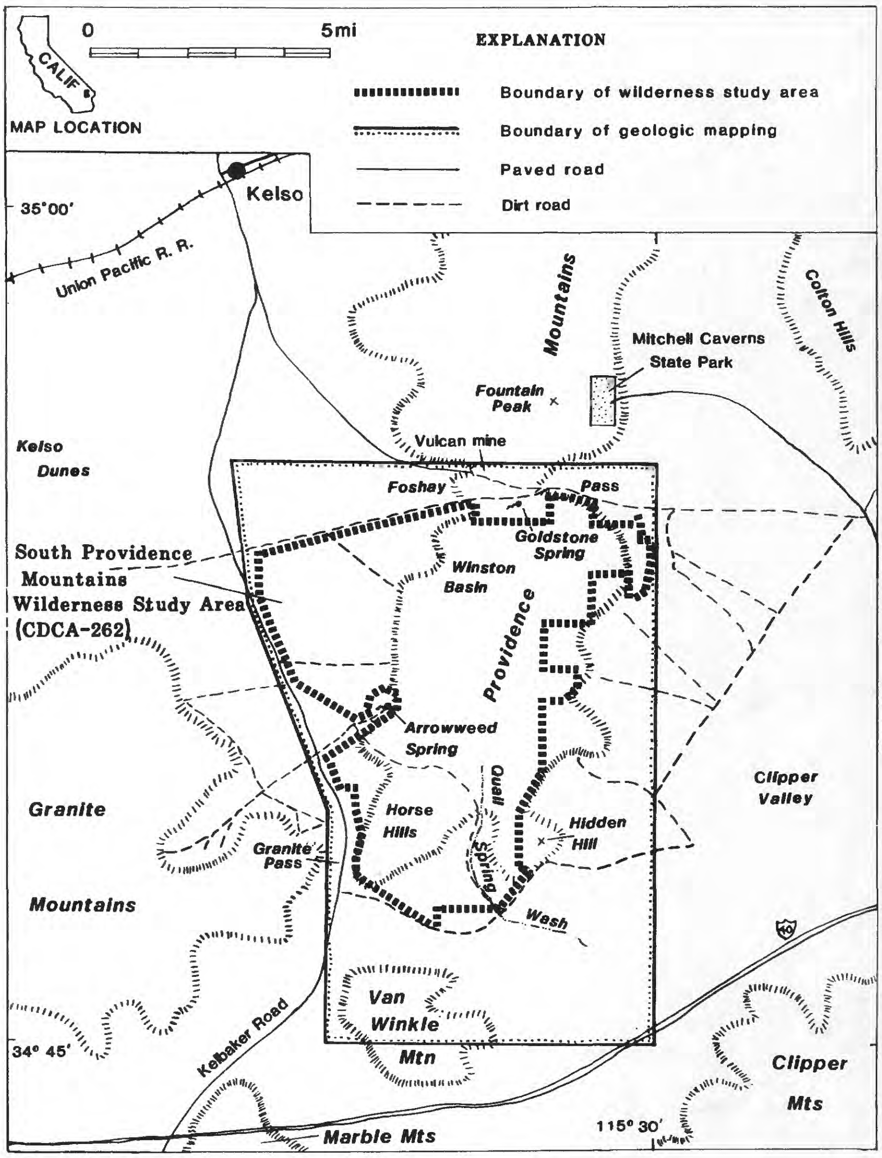

Figure 1. Index map showing location of South Providence Mountains Wilderness Study Area, Calif.

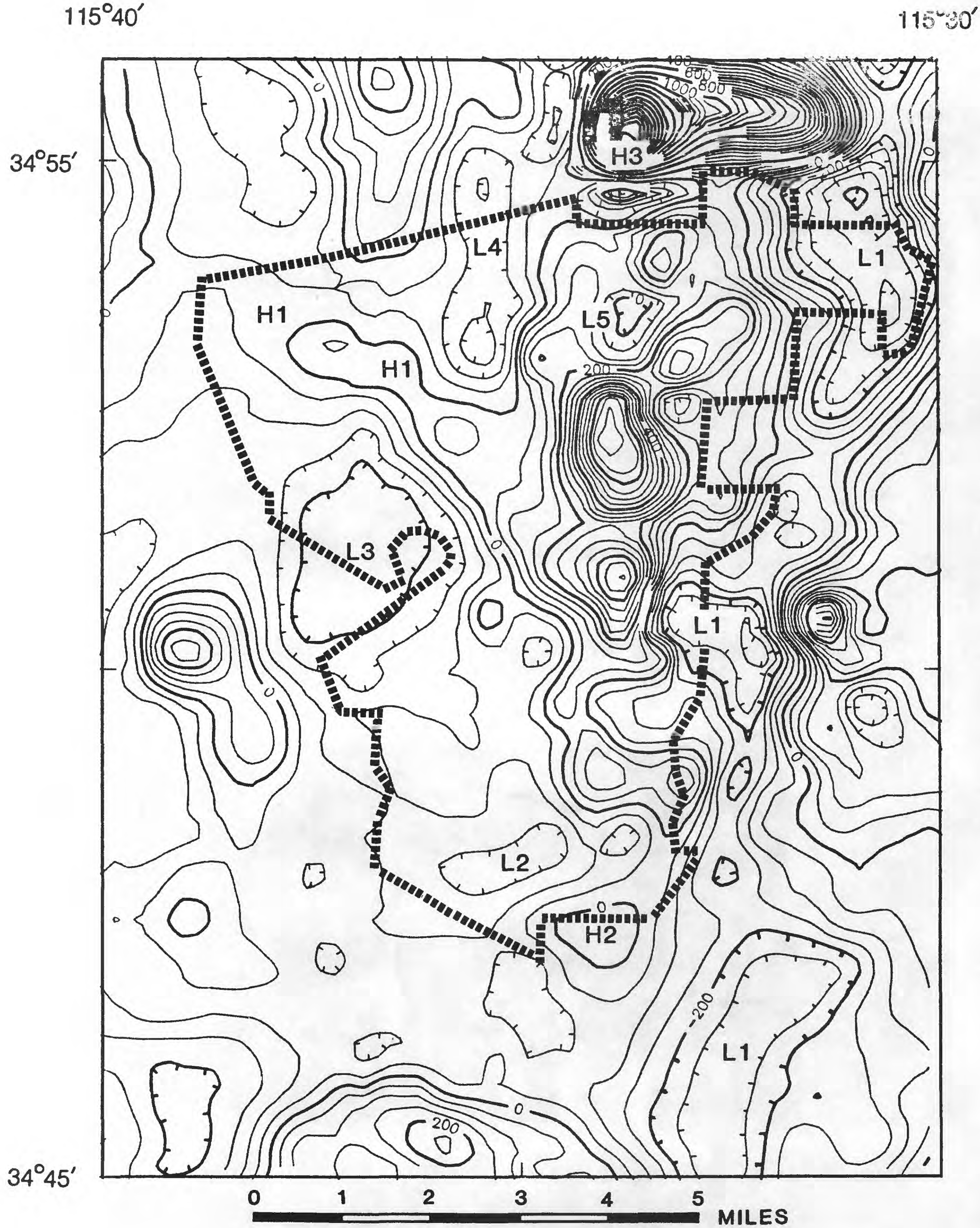

Figure 2. Aeromagnetic anomaly map reduced to the pole for the South Providence Mountains Wilderness Study Area (outlined). Contour interval is 50 gammas. Hachures on low side of contours. H, high; L, low; numbers refer to discussion in text.

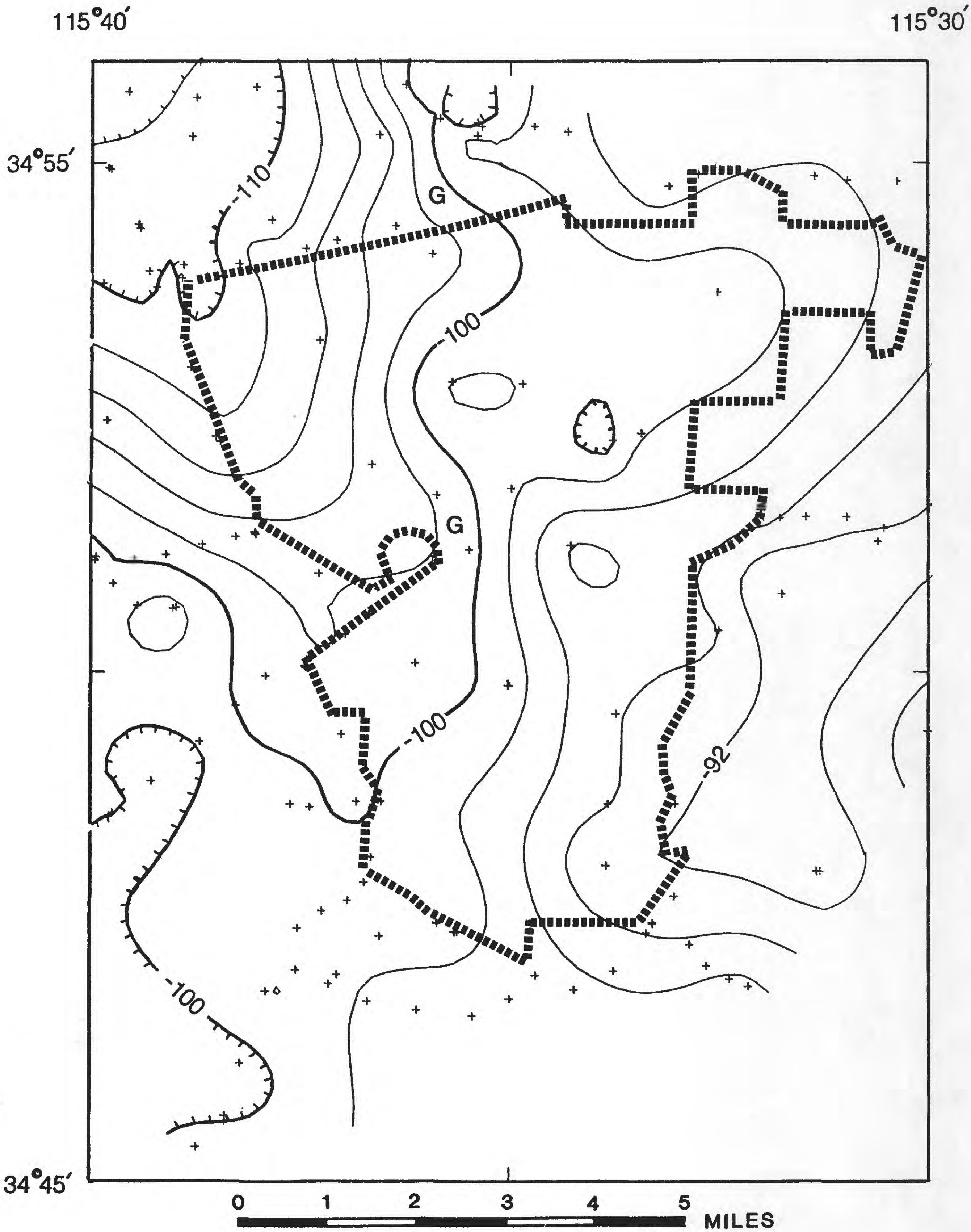

Figure 3. Complete Bouguer gravity map of the South Providence Mountains Wilderness Study Area (outlined). Contour interval is 2 mGal. Hachures on low side of contours. Plus mark (+) shows location of gravity observation. G, steep gradient.

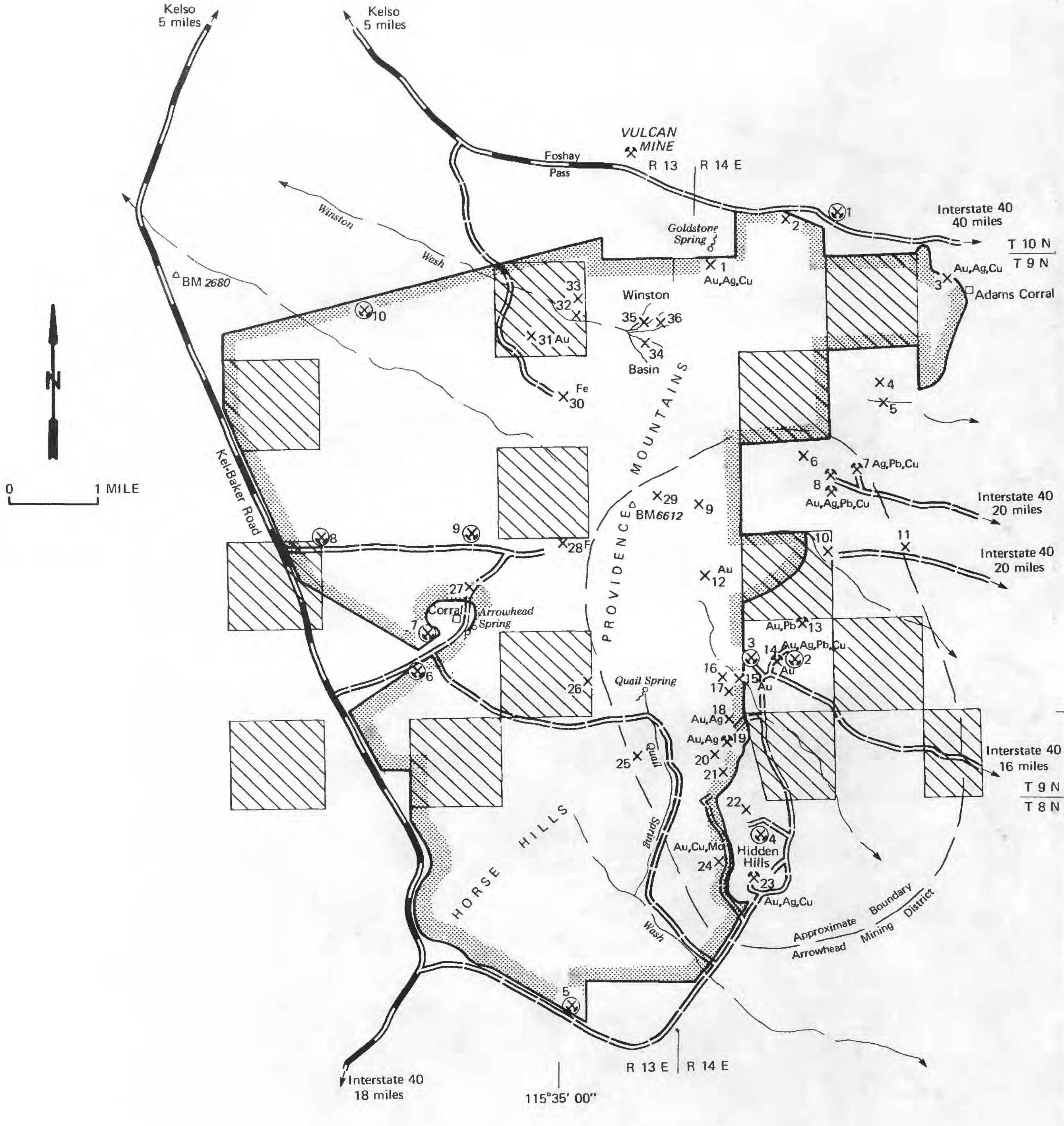

Figure 4. Locations of mines and prospects and oil and gas leases in the South Providence Mountains Wilderness Study Area.

⚒, × Lode Prospect and Mine Names

1. Goldstone Group
2. Foshay Pass Barite
3. Adams-Anna Ore
4. Sample
5. Unknown
6. Warm Springs Gold
7. Providence Mine
8. Pilot Mine
9. Hayman
10. Midas Touch
11. Unknown
12. Echo
13. Buena Vista Mine
14. Bighorn Mine
15. Wild Ass
16. Santa Anna
17. Lady Luck
18. Unknown
19. Golden Gift Mine
20. Unknown
21. Wild Cat
22. Long Chance
23. Hidden Hill Mine
24. Golden Nugget
25. Gold Cross
26. Midnight Group
27. Sunview
28. Philadelphia Fluorspar
29. Lauri
30. Iron King
31. Unknown
32. Pennsylvania
33. Blue Danube
34. Texas
35. Center
36. Crystal

Placer Prospect Names

1. Due Group
2. Unknown
3. Valcerie Group
4. Copper Charlie
5. Lucky Bird No. 1 and 2
6. Edith Group
7. Virginia Group
8. Unknown
9. Green Beauty
10. Crucerro Group

EXPLANATION

Wilderness Study Area Boundary

Secondary highway

Dirt road

×

Lode prospect

⚒

Lode mine

Placer prospect

Current oil and gas lease

△BM*6612*

Bench mark and elevation

Commodity symbols indicate potential for commodities

Au Gold

Ag Silver

Cu Copper

Pb Lead

Mo Molybdenum

F Fluorspar

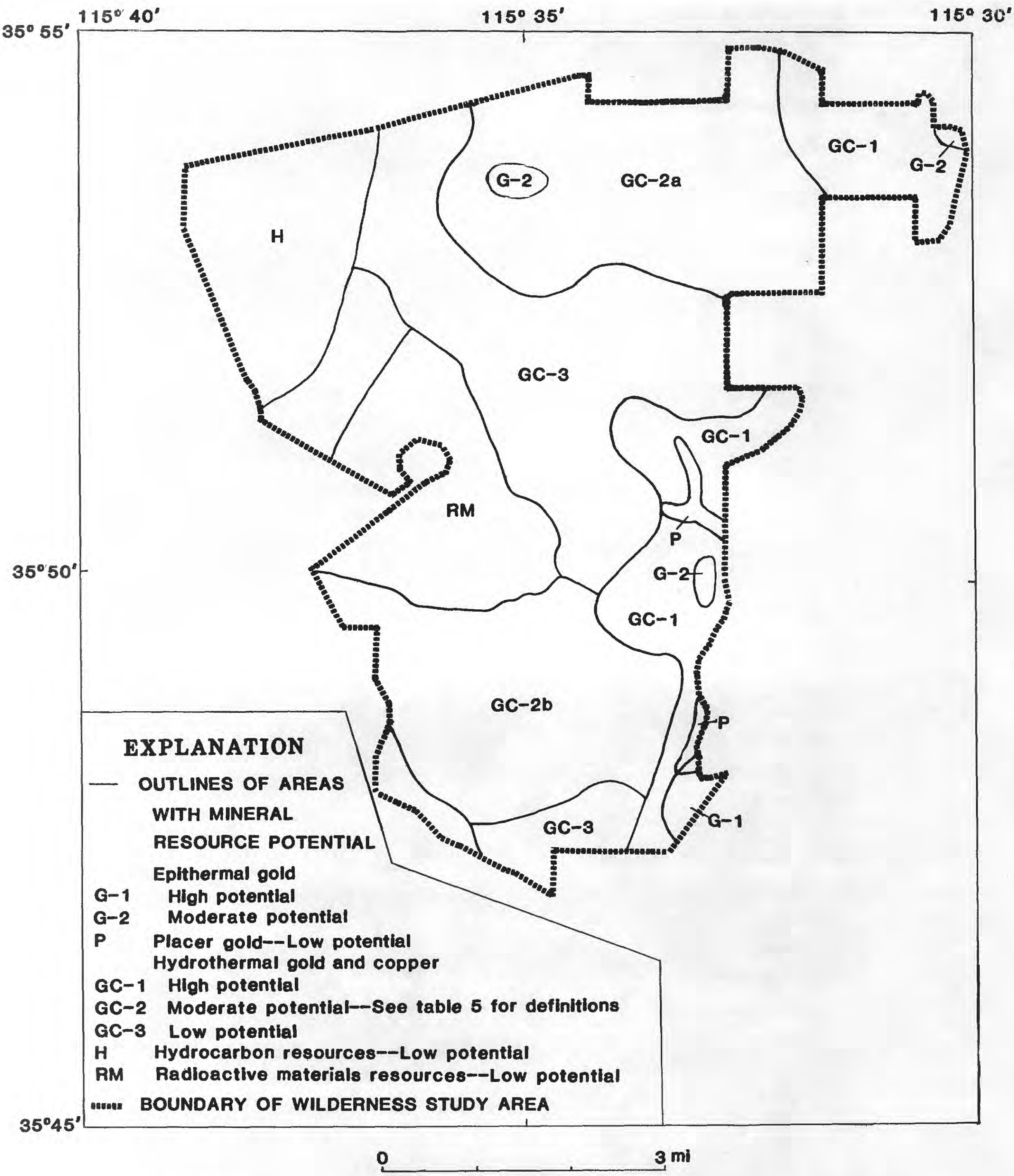

Figure 5. Locations of areas with mineral resource potential, South Providence Mountains Wilderness Study Area.

Table 1.--Anomalous concentrations of selected elements in stream sediments
[L, detectable, but less than concentration given;
spec, optical emission spectrographic analysis;
AA, atomic-absorption spectrometry; Inst, instrumental analysis]

Element	Method of analysis	Lower limit of anomalous concentration (ppm)	Lower percentile of anomalous concentration	Maximum reported concentration (ppm)
Ag	spec	0.5L	91	5
As	AA	5	91	10
Au	AA	0.5L	91	3
Bi	AA	2L	91	46
Cu	spec	100	88	1000
Hg	Inst	0.04	85	2

Table 2.--Anomalous concentrations of selected elements in nonmagnetic heavy-mineral-concentrate samples as determined by semiquantitative emission spectrometry
[L, detectable, but less than concentration given;
G, greater than given concentration]

Element	Lower limit of anomalous concentration (ppm)	Lower percentile of anomalous concentration	Maximum reported concentration (ppm)
Ag	5	78	1000
Au	20L	93	500G
Ba	5000	60	10000G
Bi	50	84	100
Cu	100	74	5000
Mo	10L	88	300
Pb	150	62	20000G
Sr	1000	92	5000G

Table 3.--Summary of placer prospects in and adjacent to the South Providence Mountains Wilderness Study Area
[*, outside the study area]

Map No.	Name	Summary	Workings and production	Sample data
1	Due Group*	Claim area is covered by multiple alluvial fans	One pit	One pan sample; contained no detectable gold.
2	Unknown*	Pit dug in bottom of narrow stream channel 300 ft east of the main Bighorn mine shaft. Quartz syenite bedrock is exposed in pit floor.	One 5-ft by 6-ft by 4-ft-deep pit	Four samples from a 4-in. by 4-in. channel 32 in. long cut in pit face from surface into bedrock. Upper two samples (20 in. total length) contained no gold. Two-in. layer of gravel immediately above bedrock contained 58 cents/yd^3 1/. First 10 in. of decomposed bedrock contained 54 cents/yd^3 1/.
3	Valcerie Group*	Creek contains multiple deposits of fluvial sand and gravel. Channel ranges from 6 to 50 ft wide. Sand and gravel ranges from 4 to 11 ft deep.	No workings	Four samples from a 4-in. by 4-in. channel, 45 in. deep from surface to 3 in. into bedrock; contained no detectable gold.
4	Copper Charlie*	Area is covered by alluvial fans cut by arroyos.	No workings	One pan sample from bed of active arroyo; contained 0.8 cents/yd^3 1/.
5	Lucky Bird No. 1 and 2	Area is covered by alluvial fans cut by arroyos.	No workings	One pan sample from bed of active arroyo; contained no detectable gold.
6	Edith Group	Area is covered by multiple alluvial fans cut by arroyos.	No workings	One pan sample from bed of active arroyo; contained no detectable gold.
7	Virginia Group	Area is covered by multiple alluvial fans cut by arroyos.	No workings	One pan sample from bed of active arroyo containing visible black sand; contained no detectable gold.
8	Unknown	Area is covered by multiple alluvial fans cut by arroyos.	One 6-ft by 8-ft by 4-ft-deep pit	One 4-in. by 4-in. vertical channel sample 4 ft long in pit face; contained no detectable gold.
9	Green Beauty	Gravel bars 1 in. to 6 ft thick, 4 to 6 ft wide, and 25 ft long in active arroyo.		One 4-in. by 4-in. vertical channel sample 4 ft long, composed of bar gravel; contained 0.2 cents/yd^3 1/.
10	Crucerro Group	Area is covered by multiple alluvial fans cut by numerous arroyos.	No workings	Eight pan samples collected from active part of each of eight major arroyos. Five samples contained no detectable gold; three samples contained 1.5 to 3.4 cents/yd^3 1/.

1/ Gold value calculated at $400 per oz.

Table 4.--Production from mines in and immediately adjacent to the South Providence Mountains Wilderness Study Area

Map No.	Name	Period of operation	Ore (tons)	Au (oz)	Ag (oz)	Pb (lb)	Cu (lb)
7	Providence	1918	12	---	455	2,465	166
8	Pilot (B & B)	1911	19	20.22	21	---	---
		1913	5	9.19	5	---	---
		1914	29	51.47	45	2,199	---
		1916	27	---	767	---	19,667
		1932	5	3.09	1	---	---
		1935	20	3.0	1	---	---
13	Buena Vista	unknown	10	---	---	6,000	---
14	Bighorn	1918-1920	800	4,838	---	---	---
		1933	2	3	3	---	---
		1938	5	1	---	---	---
		1940-1941	37	2	56	10,684	56
19	Golden Gift (Coarse Gold)	1935	24	16.5	20	---	---
23	Hidden Hill	pre-1907	?	1,602	---	---	---
		1913	0.15	650	---	---	---
		1918-1919	1,000	1,428	---	---	---
	Totals		1,995.15	8,627.47	1,374	21,348	19,889

Table 6.--Criteria used to define the potential for undiscovered gold-copper resources (areas GC-1, GC-2, and GC-3; see fig. 5)

Area	Subarea	Resource potential	Criteria
GC-1		High	a) Past gold production b) Presence of mines and prospects c) Anomalous metal concentrations in geochemical samples d) Observed extensive propylitic and argillic alteration e) Silicification in the proximity of Bighorn and Hidden Hill fault systems f) Observed sulfide mineralization g) Observed aeromagnetic low
GC-2		Moderate	a) Anomalous geochemical concentrations b) Local occurrence of sulfide minerals c) Moderately to extensively developed propylitic and argillic alteration d) Local occurrence of silicified rocks and fault breccia e) Observed aeromagnetic low
	GC-2a		a) Local occurrence of skarn mineralization b) Local anomalous concentrations of iron, nickel, cobalt, and vanadium
	GC-2b		a) Locally extensive diking b) Local occurrence of anomalous molybdenum concentrations c) Quartz-magnetite veins
GC-3		Low	a) Slightly to moderately anomalous metal concentrations in geochemical samples b) Altered granitic rocks

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountains Wilderness Study Area

[Underlined names refer to properties with mineral resources that have been identified or may be present; many of those not underlined are insufficiently exposed to permit evaluation]

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
1	Goldstone Group**	Veins of milky to colorless quartz, 2 in. to 8 in. thick, are in syenite and quartz monzonite. Bleaching due to argillic alteration is common near veins. Smaller quartz veinlets parallel main veins on either side. Veins contain various amounts of pyrite, chalcopyrite, specularite, malachite, azurite and limonite. Host rocks are cut locally by north-trending shear zones, as wide as 3 in., and by epidote and chlorite veinlets. Silification is common.	One bulldozer cut, 3 pits, a 25-ft- and a 35-ft-deep shaft, a caved decline, and two caved adits.	The prospect may have gold-silver-copper vein-type resources. Three chip and 8 grab samples collected. Two chip samples of syenite contained a trace of both gold and silver; a vein chip sample contained 0.13 oz/ton gold and 0.72 oz/ton silver. Four grab samples contained 0.1 to 9.1% copper. A chip and 3 grab samples contained 0.03 to 0.09% fluorine. Other anomalous metal values were reported: 2 chip and 6 grab samples contained 8 to 300 ppm lead; 3 chip and 6 grab samples contained 10 to 130 ppm zinc. Copper values in 3 chip and 3 grab samples ranged from 14 to 295 ppm. All samples contained molybdenum which ranged from 3 to 24 ppm. One grab sample contained 11 ppm tungsten.
2	Foshay Pass Barite**	Two small fractures cut syenite with occasional clay alteration and a trace of iron oxide staining. Fractures are each filled with 1/2 in. of clay; they strike N. 10° E. and dip vertically. Two veins of barite are reported in this vicinity.	No workings.	One chip sample across clay gouge zones contained no significant values.
3	Adams - Anna Ore**	Quartz veins, as thick as 18 in., striking N. 70° W. with vertical dips, generally cut an orange, bleached, and silicified limestone and quartz monzonite dikes. Vein quartz is colorless to white and contains trace of pyrite, limonite after pyrite, and chrysocolla. The limestone is intruded by quartz monzonite; both places are altered to clay with some sericite and silicified. Both rock types are cut by pre- and post-mineralization faults, fractures, shears, and breccia zones.	Six trenches, 6 shafts (as deep as 100 ft) and one 75-ft-long adit.	Prospect may have skarn, vein, and disseminated gold-silver-copper resources. Twenty-seven chip samples and one grab sample collected. Five vein chip sample contained trace to 0.23 oz/ton gold, and 0.071 to 1.4% copper; trace to 1.7 oz/ton silver; 3 had 0.10 to 1.8% lead, 3 had 0.1 to 1.8% zinc. Four host-rock samples had 0.1 to 0.61% lead, and 2 samples had 0.1 to 0.4% zinc. All remaining chip and grab samples contained lower, but anomalous metal values: 21 to 820 ppm lead, 20 to 750 ppm zinc, 2 to 900 ppm copper. In 22 samples molybdenum content ranged from 2 to 64 ppm.
4	Sample*	North- to northeast-trending, steeply dipping shear zones as thick as 24 in. cut quartz monzonite and 2 west-trending syenite dikes. Both rock types show slight argillic alteration, are locally bleached and silicified, have limonite on fractures, and some iron-oxide stain. In quartz monzonite, blotches of chlorite are locally replaced by pyrite, chalcopyrite, or malachite. Specularite is also present on some fractures. Malachite-stained clay gouge zones are as thick as 1.5 ft with inclusions of silicified country rock.	Two small pits and an 86-ft-long adit.	Three chip and 3 dump grab samples were collected. The grab samples contained trace to 0.01 oz/ton gold and trace silver; 2 grab samples contained 0.4 and 0.59% copper. Other anomalous values were reported: zinc values in the 6 samples ranged from 46 to 85 ppm; fluorine content ranged from 0.024 to 0.50%. Three grab samples contained 39 to 44 ppm molybdenum and 92 to 250 ppm copper.

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
5	Unknown*	Quartz veins and multiple shears cut mixed andesite and quartz monzonite. Veins of colorless quartz trend N. 30° W. to N. 20° E., and dip 30° to 70° E. White quartz veins trend east and dip steeply north and south. Both vein types show comb structure. Minor amounts of malachite, azurite, chrysocolla, limonite, and manganese oxides occur in clear quartz veins. Shear and gouge zones are 1- to 14-in. thick, trend N. 10° to 75° E., and dip 65° to 85° SE. Host rocks are bleached and silicified near veins and have a selvage of clay alteration. Some limonite and iron-oxide stain occurs locally.	Three cuts, one caved adit, a 20-ft-long and a 50-ft-long adit.	Seventeen samples were collected. Two grab samples of dump material contained trace and 0.03 oz/ton gold, 0.25 and 1 oz/ton silver, 0.82 and 1.6% copper and 0.075 and 0.934% fluorine. Of the 15 chip samples three were from veins and 5 from fault gouge zones. Metal values in these 8 samples ranged from trace to 0.14 oz/ton gold and trace silver; 3 contain 0.06 to 1.3% copper; 1 contained 0.23% lead, and 7 contained 0.1 to 0.17% fluorine. Of the remaining 7 chip samples of syenite host, all 7 contained trace gold and silver, one contained 0.2% lead; and 7 contained 0.011 to 0.074% fluorine. Other anomalous metal values were reported in vein and gouge samples: 200 and 400 ppm zinc in two samples and 200 to 950 ppm lead in 6 others.
6	Warm Springs Gold*	Veins trending N. 30° to 55° E. and dipping 70° to 90° E. and W. and northeast-trending shears as thick as 6 in. cut weathered syenite. Veins contain white to colorless quartz, are as much as 16-in. thick, display comb structure locally, and contain pyrite, chalcopyrite, malachite, azurite, limonite, and specularite. Chlorite occurs as discrete veinlets, adjacent to quartz veins generally along the footwall contact, or as a cavity filling in quartz-vein comb structure. Syenite is altered to clay and in places bleached and silicified near veins. Some sericite and iron oxide stain and limonite are also present.	Two cuts, a 30-ft-deep decline, and a 200-ft-long northwest-trending adit.	Fourteen chip samples and 1 grab sample; grab sample of dump contained 0.27 oz/ton gold and 1 oz/ton silver, 0.67% copper, and 0.04% fluorine. Nine chip samples collected from thin sulfide-rich veins contained trace to 0.65 oz/ton gold and trace to 1.75 oz/ton silver. Three samples contained 0.1 to 7% copper, and 0.029 to 0.14% fluorine. Other anomalous values were reported: all 5 host-rock chip samples contained trace gold and silver; 7 chip samples contained 100 to 500 ppm copper and 300 to 1,500 ppm fluorine.
7	Providence mine*	A north-trending 4-in.-thick shear and gouge zone offset by a 6-in. west-trending milky quartz vein is exposed at the collar of a shaft. Veins are lensoid. Host rock is orange, iron stained syenite with feldspars altered to clay.	Three shafts; a two-compartment shaft is reported to be 150-ft deep. Reported production in 1918 was 12 tons of ore containing 455 oz of silver, 2,456 lb of lead, and 166 lb of copper.	Mine may have vein-type silver-lead-copper resources. Four samples: the dump sample contained trace silver, 0.18% copper, and 0.24% fluorine. A chip sample of the shear zone contained 0.13% fluorine. The quartz vein contained trace gold and silver and 0.13% fluorine.

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
8	Pilot mine*	Colorless to white quartz vein, as thick as 6 in., intrudes quartz monzonite. The vein is lensoid and grades into a narrow (1-3 in.) gouge zone on both ends beyond the mine workings. The vein strikes N. 10° E. and dips vertically. Quartz monzonite is bleached, contains limonite, and is altered to clay, quartz, and sericite.	One 45-ft-deep shaft. Reported production from 1911 - 1935 is 105 tons of ore containing 86.97 oz gold, 840 oz silver, 2,199 lb lead, and 19,667 lb copper.	Mine may have vein-type gold-silver-lead-copper resources. Three samples collected. No significant metal values detected.
9	Hayman	A quartz vein occurs in syenite near the east side of a N. 20° E.-trending dacite dike. The vein averages about 1-ft thick. Smaller (1-3-in.-thick) parallel veins occur nearby. Dacite is clay altered and locally silicified. Syenite is silicified and contains specularite in places near the dike.	One pit.	Two chip samples; one of the dike and one of the quartz vein; the latter contained trace silver and 0.6% copper.
10	Midas Touch*	Veins (as thick as 14 in.) of colorless and milky quartz cut biotite quartz monzonite and often parallel dikes. Colorless quartz veins contain pyrite, arsenopyrite, marcasite, disseminated specularite, malachite, chrysocolla, limonite after pyrite, and a trace of selenite. Some quartz veins are blue black and brecciated, with transparent blue and white quartz cement. Calcite veins also are present. The biotite quartz monzonite is intruded by northwest- and northeast-trending quartz monzonite and andesite dikes, is propylitically altered, and is locally bleached and iron oxide stained; no limonite present.	Eleven pits, 7 shafts as much as 100-ft deep, and one 25-ft-long decline.	Dump contains approximately 200 tons of rock averaging 0.08 oz/ton gold. Twelve chip and 6 grab samples were collected. Two quartz-vein chip samples contained trace and 0.01 oz/ton gold and traces of silver. Of the 12 grab samples: 4 dump-rock samples contained trace to 0.2 oz/ton gold and traces of silver; 4 host-rock samples contained trace to 0.15 oz/ton gold and traces of silver; copper values of 3 samples ranged from 0.1 to 0.25%; 3 of 4 samples of small stockpiles contained trace to 1 oz/ton gold and trace silver; one sample contained 0.05% fluorine.
11	Unknown*	Pegmatite, mafic dikes, colorless quartz, and epidote veinlets intruded quartz monzonite and biotite quartz monzonite. Host rock contains a trace of pyrite, minor malachite, and chrysocolla.	Two pits, one 6-ft-long cut, and one 15-ft-deep shaft.	Four samples: 3 grab samples contained traces of silver, zinc, and niobium and 0.014 to 0.15% fluorine; one contained 1.8% copper. A 5-ft chip sample of the pit face contained 0.27% fluorine and 0.095% niobium.

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
12	Echo	Quartz, epidote, and magnetite veinlets cut syenite, and andesite, quartz monzonite, and diorite dikes. Colorless and milky quartz veinlets are as thick as 3 in. and trend N. 10° E. Syenite is unaltered; quartz monzonite and andesite are silicified. Diorite has chlorite, tourmaline, epidote, and clay alteration. A limonitic fracture zone, 12-ft-thick, strikes N. 48° E. and dips 80° E.	Two pits, a 70-ft-long trench, and one 50-ft-deep shaft.	This prospect may have vein-type gold-bearing resources. Four samples: two grab samples of quartz from dumps contained 0.12 and 0.15 oz/ton gold and traces of silver, zinc, and copper; 1 had 0.16% copper. A 10-ft-long chip sample of the 12-ft-thick limonitic fracture zone contained 0.35 oz/ton gold and trace silver.
13	Buena Vista mine*	A quartz vein occurs along the footwall of a fault-controlled, silicified andesite dike in syenite. The vein is 6-in. to 6-ft thick, colorless to white, and is either massive or a multitude of veinlets. Limonite and local areas of bleached host rock are associated with the vein. It trends N. 26° E., dips 56° W., and is paralled on the footwall by a shear and breccia zone 6-in. thick. Pyrite, chalcopyrite, and malachite occur in trace amounts in the vein; fluorite occurs both in the vein and nearby host rock. The syenite with intense silicification has clay alteration and some sericite near dike and vein.	One pit, a caved decline, a partially caved 150-ft-deep shaft with at least 2 caved levels, and a caved adit. Recorded pre-1940 production of 6,000 lb of lead.	Dumps contain approximately 1,000 tons of rock with an average gold content of 0.038 oz/ton. Mine may have vein-type gold-lead resources. Fifteen samples were collected. Five grab samples from dump material contained trace to 0.11 oz/ton gold and traces of silver; 2 had 0.1 and 0.65% copper. Of 10 chip samples from veins and wallrock, 5 contained traces of gold and 3 had traces of silver and 0.07 to 21% fluorine; 1 of these samples also contained 0.12% copper. Other anomalous metal values were reported: 8 samples contained 11 to 150 ppm zinc; 12 had 11 to 150 ppm copper and 9 contained 9 to 47 ppm molybdenum.
14	Bighorn mine*	Colorless to white quartz veins as thick as 4 ft cut andesite and quartz monzonite dikes and syenite. The veins trend N. 37° W. to N. 85° E., dip steeply west and east and contain pyrite, chalcopyrite, specularite and hematite. Some veins are brecciated and cemented with chlorite; shear and (or) gouge zones parallel some veins. Veins and veinlets of specularite and purple and green fluorite occur locally. In places, the syenite is silicified, bleached, and altered to clay and sericite. The andesite dike is cut by a syenite dike and both are cut by colorless quartz veinlets.	One 15-ft-long cut, 5 pits, 6 shafts as deep as 200 ft with 2 levels each, and 2 adits 120-ft and 60-ft long. Recorded production from 1918-1941 is 844 tons of ore which contained 4,844 oz gold, 59 oz silver, 10,684 lb lead, and 56 lb copper.	A 1920 California Division of Mines and Geology property examination (Tucker, 1920) indicated 6,000 tons of dump rock assaying $5/ton at $20.67/oz gold, and about 195,000 tons of reserves in place contained approximately 0.25 oz/ton gold and 1.5% copper. Under 1982 economic conditions, these are marginal reserves. The property may have additional vein-type gold-silver-lead-copper resources. Of 14 chip samples taken in 1982 of surface exposures of both host and vein material, 6 contained trace to 0.07 oz/ton gold and traces of silver and 3 had 0.1 to 0.941% copper. Ten grab samples were collected from dumps and small quartz stockpiles. Six contained gold and silver values ranging from trace to 0.1 oz/ton and trace to 0.25 oz/ton, respectively. Other anomalous metal values were reported: 4 samples contained 10 to 41 ppm lead; 11 had 6 to 290 ppm zinc; 18 contained 1 to 950 ppm copper; and 10 had 3 to 55 ppm molybdenum.

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
15	Wild Ass**	Quartz veins cut quartz monzonite and syenite. Veins are 4- to 12-in. thick, trend N. 10° to 20° E., dip 70° to 90° W., and are colorless to white quartz with limonite fracture coatings and a trace of pyrite. The quartz monzonite and syenite contain clay, epidote, and chlorite alteration. There is local silicification in host rock near quartz veins.	One 15-ft-deep shaft and a 48-ft-deep decline.	This prospect may have vein-type gold-bearing resources. Ten samples collected: 5 grab samples of dumps contained trace to 0.1 oz/ton gold and traces of silver; 2 samples contained 0.1 and 0.13% lead, and 0.029 and 0.095% fluorine. One chip sample of the vein contained 0.37 oz/ton gold and trace silver. Four chip samples of the host rock had 0.015, 0.01, 0.005, and trace gold. Other anomalous metal values were reported: 4 samples contained 91 to 180 ppm zinc; 9 contained 46 to 210 ppm copper and 7 to 100 ppm molybdenum.
16	Santa Anna	A 22-in.-thick milky quartz vein, composed of multiple veinlets separated by clay seams, parallels an andesite dike in syenite. Both andesite and syenite are clay altered and contain a trace of pyrite and malachite in quartz.	One 7-ft-deep decline.	One chip sample of vein material; it contained 0.1% copper, 0.03% fluorine, and 22 ppm molybdenum.
17	Lady Luck	Quartz veins and quartz monzonite dikes cut syenite and andesite host rock. Fractured veins (as thick as 3 ft) of massive white quartz strike N. 10° to 20° E., dip 20° to 50° N., and contain minor limonite and specularite. Host rock is generally clay-altered, silicified and contains sericite, especially near veins, and limonite on some fractures.	Six pits.	Four chip and 7 grab samples collected. One grab sample of syenite dump rock contained 0.36 oz/ton gold; six grab samples contained traces of gold and trace to 0.33 oz/ton silver. All 4 chip samples had traces of gold and silver, 1 had 0.32% copper, and fluorine content was from 0.02 to 0.15%. Two grab samples had 0.11 and 0.19% copper. Lead occurred in one sample (170 ppm); 6 samples contained zinc (48 to 330 ppm); 7 samples had 27 to 280 ppm, copper and 8 had 28 to 67 ppm molybdenum.
18	Unknown	A 3- to 7-ft-thick fault-controlled quartz vein is in syenite and quartz monzonite. The vein strikes north, dips 45° to 65° W., and is traceable for about 800 ft. It is composed of white quartz cut by colorless quartz veinlets; minor colorless quartz veins cut across the main vein and host rock at N. 58° E., and dip 26° W. The host rock is intensely fractured locally, displays pre- and post-vein faults, contains sericite, traces of limonite, and some pink feldspar veinlets, is silicified near the vein, and contains clay alteration elsewhere.	Five pits scattered for about 800 ft along vein.	This prospect may have vein and disseminated gold-silver resources. Nine samples collected. All 7 chip samples of quartz vein and syenite host contained trace to 0.06 oz/ton gold, trace to 0.05 oz/ton silver, and 0.02 to 0.07% fluorine. Two grab samples: one of white quartz contained traces of gold and silver; another of syenite contained 0.05 oz/ton gold and 0.03 oz/ton silver. Both grab samples contained 0.014 and 0.076% fluorine. Other anomalous metal values were reported: 2 samples contained 170 to 270 ppm lead; 5 samples contained 90 to 370 ppm zinc; copper and molybdenum content in all 7 samples was 60 to 850 ppm and 23 to 80 ppm, respectively.

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
19	Golden Gift (Coarse Gold) mine	A bifurcating vein of semitranslucent quartz with pyrite cuts andesite and syenite. Vein is as thick as 1 ft, strikes N. 20° E., and dips 37° NW. Parallel calcite veins cut syenite. The host rock is moderately fractured and bleached and contains clay alteration.	One 35-ft-deep decline. Recorded production in 1935 was 16.5 oz gold and 20 oz silver from 24 tons of ore.	Mine may have gold-silver vein-type resources. Six samples: 3 vein chip samples and one dump grab sample contained traces of gold and silver, 0.05 to 0.2% copper, and one had 0.019% fluorine. Two host-rock chip samples contained 0.034 to 0.098% fluorine. Five samples contained 9 to 42 ppm molybdenum.
20	Unknown	The only tabular quartz-rich structure, exposed in the pit, is a 25-ft-thick silicified zone at the andesite-quartz monzonite contact. This zone is composed of silicified andesite cut by colorless and milky quartz veinlets which contain pyrite. The andesite is cut by quartz monzonite dikes. Both are cut by subsequent fault and shear zones, some of which are silicified and bleached. Andesite has clay alteration with local admixtures of sericite and quartz. Quartz monzonite has weak clay alteration and is weakly bleached.	One pit and a 65-ft-long adit.	Six chip samples and 2 grab samples of dump material: dump samples contained traces of gold and silver and 0.12 to 0.25% fluorine. Four chip samples of andesite contained traces of gold and silver and 0.09 to 0.15% fluorine. A chip sample of quartz monzonite contained 0.14% fluorine. One chip sample from a silicified vein like structure contained traces of gold and silver. Two samples contained 220 and 450 ppm lead, and 7 contained 18 to 230 ppm zinc. All 8 samples contained 41 to 620 ppm copper and 44 to 170 ppm molybdenum.
21	Wild Cat	Colorless quartz, black chalcedony, barite, and magnetite veins cut syenite. The largest quartz vein is 1-ft thick, brecciated, cemented by limonite, strikes N. 20° E., and dips 70° W. Fractures in syenite contain traces of malachite, limonite, and manganese oxides. Syenite is intruded by a quartz monzonite dike which has clay and silicic alteration.	Four pits.	Four samples collected. Two select samples of stockpiles contained traces of gold and silver. One stockpile sample, analyzed for barium and manganese had 37% and 0.024%, respectively. A 2-ft chip sample of a vein-breccia zone contained a trace of silver and 11.6% barium. An adjacent 7 ft chip sample from the hanging wall dike contained a trace of silver, and 6.03% barium. The 4 samples also contained anomalous zinc (43 to 57 ppm), copper (130 to 490 ppm), and molybenum (16 to 78 ppm).
22	Long Chance*	A 1-ft-thick quartz vein is centered in a 15-ft-thick clay-rich zone in andesite. The vein is colorless quartz, with a few milky quartz breccia fragments, and is cut by milky quartz veinlets. The vein contains a trace of fluorite. Andesite is silicified and has traces of epidote and chlorite on fractures.	One pit and two bulldozer cuts, each 45-ft long.	Two chip samples (one vein and one host): each contained 0.01 oz/ton gold and trace silver; the vein sample had 0.11% copper.

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
23	Hidden Hill mine*	One major quartz vein and numerous smaller quartz veins, breccia zones, shears, faults, and gouge zones cut andesite. Near veins, andesite is silicified and altered to clay, with various amounts of chlorite and epidote. The principal quartz vein has a strike length of 325 ft, pinches and swells from 1- to 18-in. thick, and has an average thickness of 6 in. It strikes N. 30° E., dips 20° west, and contains both colorless and white quartz with local comb structure and vugs; some vugs are filled with limonite. Locally the vein footwall is bounded by a 1- to 6-in. clay or breccia layer. Pyrite and chalcopyrite occur in the main vein; orpiment, realgar, manganese oxides, limonite, and malachite occur in minor parallel, en echelon, and crosscutting quartz veins.	Property contains a small abandoned mill, two cuts, 13 pits, three shafts, and 1 adit with approximately 800 ft of workings on 4 levels. Recorded production for pre-1907 mining was 1,602 oz gold; between 1913 and 1919, 1,000 tons of ore yielded 2,078 oz gold.	Mine dump contains approximately 4,000 tons of rock averaging 0.08 oz/ton gold and 0.08 oz/ton silver. Mine has about 550 tons of subeconomic quartz-vein resources averaging 0.60 oz/ton gold. Assuming a 4-ft mining thickness is necessary, this would result in 4,000 tons of vein resources averaging 0.09 oz/ton gold. Mine may have additional gold resources within the vein. Of the 124 samples collected, 26 were grab samples of four types. A single mill-tailings sample contained 0.10 oz/ton gold, 0.35 oz/ton silver, and 0.45% copper. Eighteen dump samples contained trace to 0.17 oz/ton gold and trace silver; 7 had 0.1 to 0.22% copper. Four stockpile samples had from 0.03 to 0.12 oz/ton gold and traces of silver. Three samples of material backfilled into the main workings contained 0.02 to 0.37 oz/ton gold, traces of silver, and 0.076 to 0.17% copper. Of 97 chip samples collected, 28 were of vein quartz with trace to 6.5 oz/ton gold and trace to 1 oz/ton silver (2 of these samples had 3.5 and 11.7 oz/ton gold); two had 0.1 to 4.7% copper. Of 69 andesite chip samples, 22 contained trace to 0.1 oz/ton gold and traces of silver. Each of the 124 samples analyzed contained anomalous metal values: each had lead (150 to 2400 ppm); 77 contained zinc (9 to 630 ppm); 100 contained copper (16 ppm to 4.7%); and 105 contained molybdenum (7 to 540 ppm).

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
24	Golden Nugget**	Numerous quartz veins, fractures, faults, shear and breccia zones, metallic mineral pods, and local syenite and aplite dikes cut andesite and quartz monzonite. Fault and vein trends are northwest to northeast. Host rocks, especially local rhyolite bodies, are generally propylitically altered, although rocks near the Hidden Hill and the Big Horn faults are silicified, sericitic, and intensely bleached. Quartz veins, 1- to 6-in. thick, strike N. 15° W. to N. 15° E. and dip from 40° W. to 70° E., are colorless to white, and some are blue. Some veins contain comb structures or are brecciated and cemented with clay or chlorite. Many contain limonite or iron-oxide stain. Blue and green fluorite veins occur locally; fluorite and quartz fill faults, fractures, and some dike-host contacts. Pyrite, chalcopyrite, malachite, azurite, magnetite, limonite, and manganese oxide are also present.	Ten cuts, 14 pits, 13 adits as much as 250-ft long, 4 declines, and 2 shafts as deep as 40 ft.	The prospect may have vein-type gold, disseminated gold, and a porphyry copper/molybdenum resource. One hundred eleven samples collected: of the 43 grab samples, 23 host and dump samples contained trace to 0.06 oz/ton gold, 15 contained trace to 1.4 oz/ton silver, and 1 contained 0.27% copper; 4 quartz stockpile samples had trace to 0.76 oz/ton gold and trace silver and 4 had 0.1 to 1.4% copper. Of 68 chip samples, 17 host rock samples contained trace to 0.08 oz/ton gold and 23 contained traces of silver; of 22 vein samples, 17 contained trace to 2.83 oz/ton gold (only 1 sample had more than 1 oz/ton) and traces of silver. Seven chip samples contained 0.08 to 25% fluorine; 2 samples had 0.15% and 0.28% lead and 13 samples had 0.10 to 0.22% copper. Of the 111 samples, 15 contained lead (100 to 620 ppm), 25 contained zinc (26 to 600 ppm), 89 contained copper (20 to 990 ppm), and 56 contained molybdenum (6 to 270 ppm).
25	Gold Cross	Small quartz veinlets averaging one per ft cut medium-grained, fractured quartz monzonite. The quartz monzonite is locally altered to clay, and contains trace iron oxides in fractures.	One pit.	One 3-ft chip sample of quartz monzonite contained 18 ppm lead, 24 ppm zinc, and 19 ppm copper.
26	Midnight Group	Quartz monzonite cut by diorite and lamprophyre dikes; locally silicified and limonitic.	One pit.	Two grab samples of quartz monzonite contained 24 and 35 ppm zinc, 12 and 125 ppm copper, and 6 and 120 ppm molybdenum.
27	Sunview	Unaltered granite.	One 50-ft-long bulldozer cut.	One chip sample of granite contained 13 ppm lead, 34 ppm zinc, and 15 ppm copper
28	Philadelphia Fluorspar	Quartz monzonite, locally silicified, bleached and sericitized, cut by a 12- to 14-in.-thick vein of green and purple fluorite which strikes N. 33° E. and dips 75° NW. Vein is brecciated on east side.	One 8-ft-deep shaft and 500 ft of bulldozer cuts on four levels.	The property may have fluorspar resources. Five chip samples contained 23 to 30% fluorine. All samples contained lead (29 to 38 ppm), zinc (13 to 30 ppm), and copper (5 to 15 ppm).

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
29	Lauri	Quartz veins in syenite. Veins trend N. 12° W., dip 70° to 80° W., are as thick as 4 in., are fractured, and contain traces of pyrite. Syenite is cut by numerous fractures and northerly trending faults, is silicified and bleached within 10 to 50 ft of veins, and contains traces of sericite and limonite.	Five trenches, 3 pits, and 3 shafts 20-ft, 30-ft, and 35-ft deep.	Seven chip and 6 grab samples. Five chip samples (including all vein samples) contained trace to 0.30 oz/ton gold; all samples contained trace to 1.2 oz/ton silver, and 3 samples contained 0.28 to 7.3% copper. Other anomalous metal values were reported: all samples contained 9 to 43 ppm lead and 13 to 83 ppm zinc. Ten samples contained 63 to 620 ppm copper, and 12 samples contained 4 to 20 ppm molybdenum. Only 1 sample contained tin (8 ppm) and two contained tungsten (11 and 16 ppm).
30	Iron King	A 10- to 20-ft-wide zone of magnetite-rich, sheared syenite and a 2- to 6-ft-thick magnetite vein trending N. 30° E. cut a medium-gray mafic-rich syenite. Syenite is locally silicified, is altered to clay, epidote, and chlorite, and is intruded by a 4-ft-thick quartz monzonite dike. Pit exposes a zone of silicified quartz monzonite. Limonite occurs on fractures.	One 200-ft-long bulldozer cut, a 4-ft-deep pit and a 55-ft-long adit.	Prospect may have iron resources. Six chip and one grab sample collected. All 7 samples contained 2.7 to 81% iron and 0.08 to 0.51% titanium dioxide. Five chip samples and one grab sample contained 22 to 53 ppm lead, 15 to 135 ppm zinc, and 14 to 195 ppm copper. Two chip samples contained 2 and 6 ppm molybdenum. A single chip sample was analyzed for silicon dioxide (8.3%), chromium (43 ppm), and vanadium (320 ppm).
31	Unknown	Milky quartz veins, colorless quartz veinlets, gouge-filled shear zones, pegmatite and andesite dikes, and quartz monzonite cut orange rhyolite. Veins trend N. 20° W., dip 21° to 80° W., are 2- to 6-in. thick, contain specularite, and pyrite in center and along edge. Some show post-mineral faulting. Rhyolite is fractured and silicified and has local sericite. Limonite is present on most fractures.	Three pits and 2 adits (one caved); open adit is 78-ft long.	Prospect area may have a vein and a disseminated gold resource. Eight chip samples and one grab sample collected from quartz veins, gouge zones, and rhyolitic host rock. Eight samples contained gold values from trace to 0.77 oz/ton. All 9 samples contained 10 to 210 ppm lead, 10 to 37 ppm zinc, and 19 to 21 ppm copper. Five samples contained 6 to 9 ppm molybdenum.
32	Pennsylvania	Syenite with weak chlorite and clay alteration is cut by veinlets of calcite, chlorite, and epidote. No visible vein. Quartz on dump contains malachite, chrysocolla, pyrite, sphalerite, chalcopyrite and a trace of visible gold. Quartz is colorless, forms comb structures, and contains sulfide minerals at contact with host rock.	One 20-ft-long open cut and one caved decline.	Dump contains about 50 tons of rock. A select sample of quartz from the dump contained 0.85 oz/ton gold, 0.56 oz/ton silver, and 2.9% copper. One chip sample of syenite contained 120 ppm zinc, 110 ppm copper, and 40 ppm molybdenum; dump sample contained 130 ppm zinc and 49 ppm molybdenum.

Table 5.--Summary of mines and prospects in and adjacent to the South Providence Mountain Wilderness Study Area--Continued

Map no.	Name	Summary	Workings and production	Sample data and resource estimate
33	Blue Danube	Granite with three gouge zones and a breccia zone. Granite with chlorite and clay alteration contains orange clay gouge zones and a breccia zone 6-in. to 1-ft thick, exposed in the adit 105 ft from portal. Breccia strikes N. 31° W. and dips 85° W.	One adit 155-ft long.	Four chip samples across gouge and breccia zones contained traces of gold and silver. They also contained 46 to 210 ppm zinc and 0.064 to 0.18% fluorine. One sample contained anomalous copper (14 ppm) and molybdenum (6 ppm).
34	Texas	Colorless and milky quartz veins with traces of pyrite and marcasite cut andesite and rhyolite. The andesite is also cut by a north-trending 6-in.- to 5-ft-thick shear zone, and a 6- to 10-ft-thick rhyolite dike. The andesite is locally bleached and silicified but generally chloritic and altered to clay; dike is pale orange, bleached, and silicified. Some limonite is present. A second north-trending shear zone, which cuts the andesite and rhyolite, is 2- to 4-ft thick and generally parallels west side of dike.	One 150-ft-long adit.	Ten chip and 4 grab samples collected. Eight chip and 3 grab samples contained traces of gold. Thirteen samples had 7 to 250 ppm zinc; 2 had 195 to 240 ppm lead; 5 had 12 to 50 ppm copper; and 13 had 14 to 140 ppm molybdenum.
35	Center	Colorless and milky quartz, epidote, and specularite veinlets cut medium- to fine-grained quartz monzonite, which has numerous fractures and displays clay and quartz alteration. Veinlets contain malachite, pyrite, trace of chalcopyrite, and dark-gray quartz bands.	One pit.	Two chip samples and 1 grab sample collected; all contained trace to 0.015 oz/ton gold, traces of silver, and 0.12 to 0.80% copper. One chip sample contained 39 ppm zinc; all three contained 8 to 24 ppm molybdenum.
36	Crystal	A lensoidal, colorless to milky quartz vein averaging 6-in. thick cuts brown monzonite. The vein contains specularite, minor epidote, minor pyrite, and small clasts of host rock; it strikes N. 74° W., and dips vertically. Near the shaft, country rock is an unaltered, medium-grained quartz monzonite cut by aplite dikes.	One cut, 3 pits, and a 15-ft-deep shaft.	Three grab samples from the 40-ton dump averaged about 0.2 oz/ton gold. Of 3 chip samples, 2 contained traces of gold and silver. Grab samples of stockpiles contained trace to 0.22 oz/ton gold and trace to 0.43 oz/ton silver; 1 contained 26 ppm copper. Two grab and 2 chip samples contained 25 to 47 ppm zinc and 7 to 63 ppm molybdenum.

* Outside the wilderness study area
** Partly outside the wilderness study area