DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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U.S. GEOLOGICAL SURVEY AND THE U.S. BUREAU OF MINES
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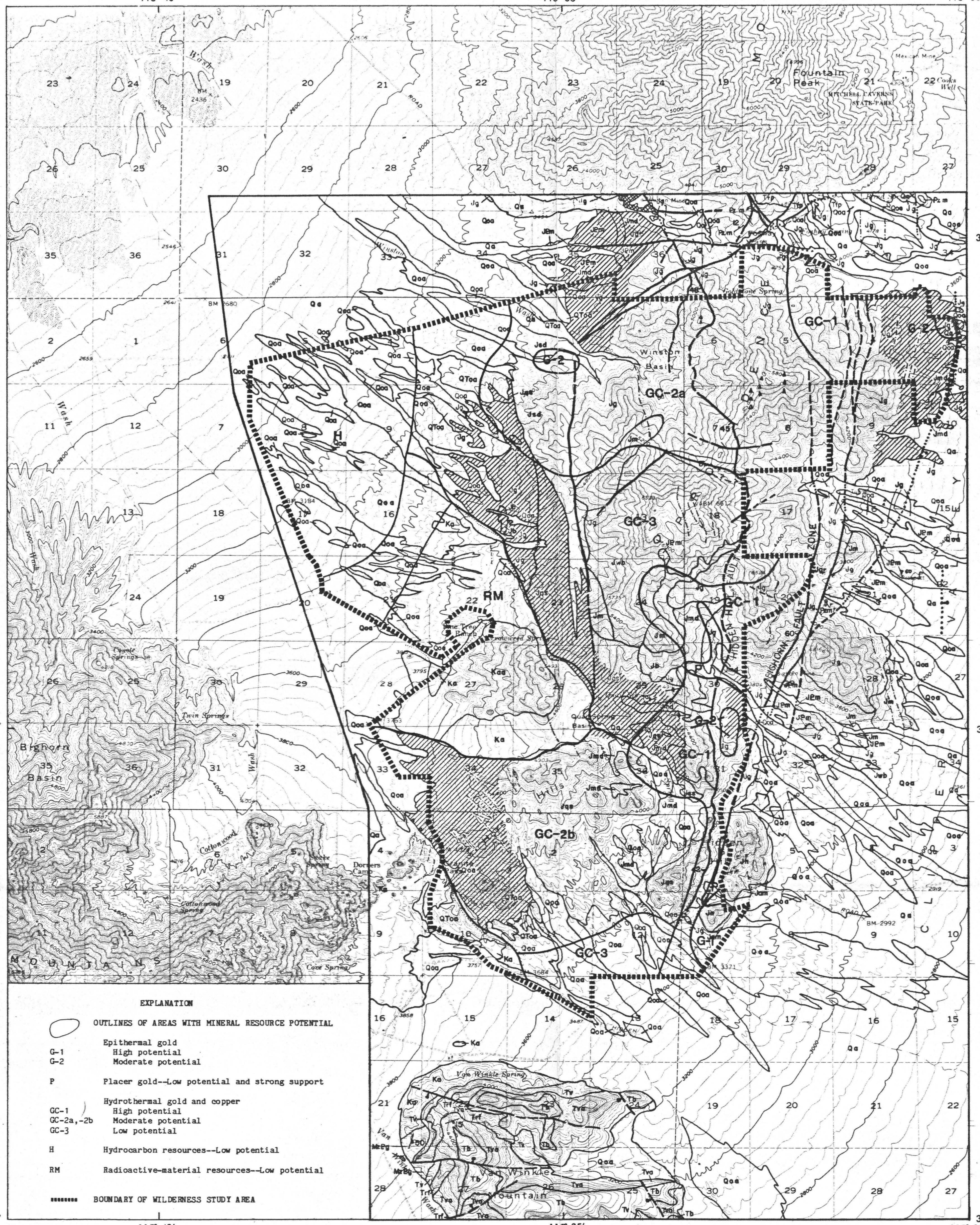


EXPLANATION

OUTLINES OF AREAS WITH MINERAL RESOURCE POTENTIAL

	Epithermal gold
G-1	High potential
G-2	Moderate potential
P	Placer gold--Low potential and strong support
	Hydrothermal gold and copper
GC-1	High potential
GC-2a, -2b	Moderate potential
GC-3	Low potential
H	Hydrocarbon resources--Low potential
RM	Radioactive-material resources--Low potential

BOUNDARY OF WILDERNESS STUDY AREA

Base from U.S. Geological Survey
Flynn, 1956

SCALE 1:62 500

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped by D.M. Miller, 1982, assisted by R.H. Husk; D. M. Miller and L.L. Glick, 1983, assisted by L.K. Fox

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

By

David M. Miller, Linda L. Glick, Richard Goldfarb, Robert W. Simpson, Donald B. Hoover, David E. Detra, and John C. Dohrenwend

U.S. Geological Survey

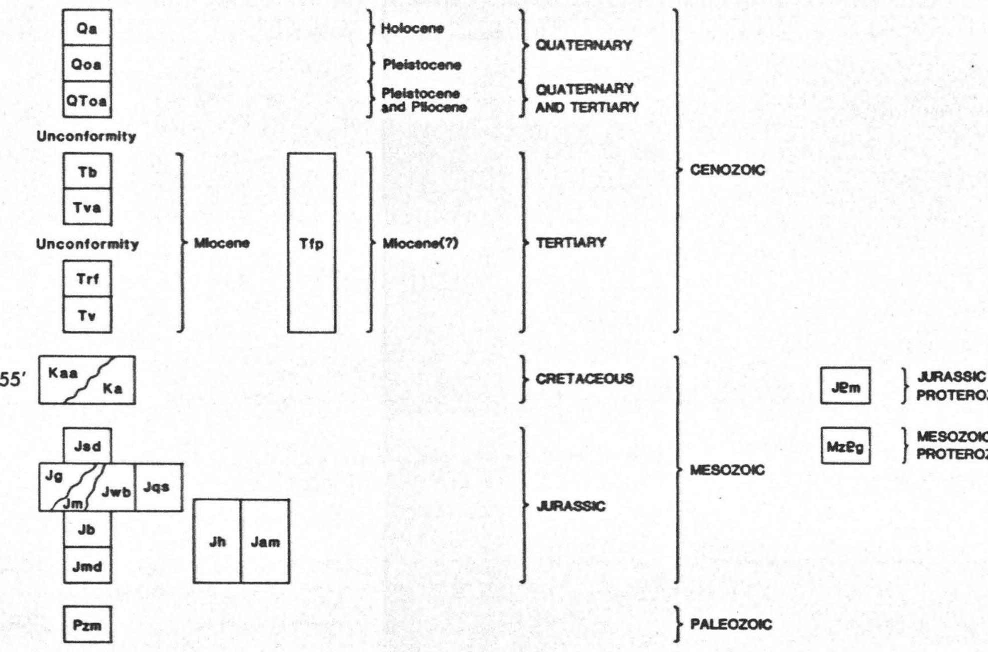
and

Steven R. Munts

U.S. Bureau of Mines

1984

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qa ALLUVIUM (HOLOCENE)--Unconsolidated alluvium consisting of poorly sorted sand, silt, and gravel

Qoa OLDER ALLUVIUM (PLEISTOCENE)--Partially consolidated alluvium and colluvium forming terraces with desert pavements consisting of varnished clasts. Typically with prominent red soils

QToa OLDEST ALLUVIUM (PLEISTOCENE AND PLIOCENE)--Partially consolidated alluvium typically capping high resistant terraces

Tb BASALT (MIOCENE)--Black olivine-pyroxene basalt flows. Ranges from nonvesicular to highly vesicular. Forms mesa tops on Van Winkle Mountain

Tva AIRFALL AND ASH-FLOW TUFF (MIOCENE)--White to buff bedded ash-flow tuff, airfall tuff, and tuff breccia. Unconformably overlies flow-banded rhyodacite

Trf FLOW-BANDED RHYODACITE (MIOCENE)--Gray siliceous prominently flow-banded rhyodacite or rhyolite flow containing rare plagioclase and biotite phenocrysts

Tv VOLCANIC AND SEDIMENTARY ROCKS (MIOCENE)--Tuff breccia, ash-flow tuff, water-laid tuffaceous sandstone and conglomerate, and lacustrine deposits. Nonconformably overlies Mesozoic and older plutonic rocks

Tfp FOUNTAIN PEAK RHYOLITE OF HAZZARD (1954) (MIOCENE?)--Siliceous, generally aphyric rhyodacite. May represent intrusive dome and (or) extrusive flows. Volcaniclastic rocks of probable Jurassic age locally included

GRANITE OF ARROWWEED (CRETACEOUS)--

Kaa Aplitic monzogranite to granodiorite (terminology from Streckeisen, 1976)--Light-gray and resistant, with phenocrysts of potassium feldspar, quartz, plagioclase, and biotite set in fine-grained matrix of same minerals

Ka Porphyritic biotite granodiorite to monzogranite--Light-gray and coarse-grained; potassium feldspar phenocrysts 0.5 to 2 in. long

Jsd SHEETED DIKES (JURASSIC)--Dikes consisting of dark dacite porphyry, flinty light-green aphanitic rock, and light-bluish-gray fine-grained quartzofeldspathic rock. Dikes form a complex sheeted intrusive zone trending about N. 20° W. along western side of range

Jg QUARTZ MONZONITE OF GOLDSTONE (JURASSIC)--Medium- to coarse-grained melanocratic subequigranular granitoid plutonic rocks ranging from quartz monzodiorite to quartz monzonite and quartz syenite. Mafic phases are biotite, hornblende, and augite; magnetite, sphene, and zircon are common accessories. Extensive albitization of the unit occurs in western Horse Hills and southeast of Foshay Pass. Potassium feldspar phenocrysts less than 5 percent

Jm MIXED GRANITE (JURASSIC)--Rocks transitional between the quartz monzonite of Goldstone and the quartz syenite of Winston Basin, consisting of two types: 1) Interlayered (on 1- to 8-ft scale) lithologies typical of the two rock units, and 2) rocks with groundmass identical to the Goldstone unit but containing sparse (5 to 15 percent) potassium feldspar phenocrysts. Unit occurs between plutons of the quartz monzonite of Goldstone and the quartz syenite of Winston Basin

Jwb QUARTZ SYENITE OF WINSTON BASIN (JURASSIC)--Markedly porphyritic coarse-grained melanocratic augite-hornblende-biotite quartz syenite to quartz monzonite. Magnetite, sphene, and zircon are common accessories. Phenocrysts (1 to 1.5 in. across) are anhedral purple to pink potassium feldspar

Jqs SYENOGRANITE OF QUAIL SPRING (JURASSIC)--Melanocratic medium- to coarse-grained hornblende-biotite syenogranite to quartz monzonite and quartz monzodiorite. Extensive albitic alteration in most areas bleached the rock. Compositionally and texturally variable

Jb PORPHYRITIC BIOTITE QUARTZ MONZONITE (JURASSIC)--Dark-gray mafic medium-coarse-grained porphyritic hornblende-biotite quartz monzonite to diorite. Biotite phenocrysts are 0.3 to 0.4 in. wide

Jmd HORNBLENDE-BIOTITE MONZODIORITE (JURASSIC)--Dark-gray to black medium-grained biotite-hornblende monzodiorite to diorite. Mafic minerals typically show preferred orientation. Hornblende abundant; occurs as intergranular and poikilitic prisms. Unit is nonresistant and forms slopes and valleys

Jh HYPABYSSAL AND METAVOLCANIC ROCKS (JURASSIC)--Dark-weathering highly propylitically altered medium- to fine-grained quartz-poor hypabyssal rocks and dark-colored foliated fine-grained intermediate to silicic metavolcanic rocks. Forms dark hills at Hidden Hill. Hypabyssal rocks north and west of Hidden Hill show little propylitic alteration, but otherwise are similar to those at Hidden Hill and grade into quartz monzonite of Goldstone

Jam ALBITIZED METAVOLCANIC ROCKS (JURASSIC)--White albitized fine- to medium-grained metarhyolite. May include thin beds of meta-arkose

JEm MIXED GNEISS (JURASSIC AND PROTEROZOIC?)--Granitic gneiss and mafic gneiss pervasively intruded parallel to foliation by Jurassic granitoids

MzEg GNEISS AND GRANITE (MESOZOIC AND PROTEROZOIC?)--Leucocratic fine- to medium-grained granodiorite interlayered with pegmatite, granite gneiss, and mafic gneiss

Pz m METASEDIMENTARY ROCKS (PALEOZOIC)--Tan to light-gray marble and calc-silicate rocks. Contact metamorphosed adjacent to Jurassic plutonic rocks. Locally includes Triassic metasedimentary strata

CONTACT--Dotted where concealed; queried where uncertain

44
FAULT--Showing dip; bar and ball on downthrown side; dashed where location uncertain; dotted where concealed

BRECCIA ZONE--Possibly representing a fault

10
BEDDING--Showing strike and dip

FOLIATION--Showing strike and dip

43
Inclined

Vertical

DIKE

MINE DUMP

AREA OF EXTENSIVE FELSIC DIKES

BOUNDARY OF GEOLOGIC MAPPING

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 activites, 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 and hypabyssal rocks. Three areas display a moderate potential for epithermal gold resources. A low potential for placer gold resources is indicated for all alluvium with particularly strong support for two small areas. A low potential for radioactive mineral resources is indicated for one area of granite. 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 an unknown potential or no potential recognized.

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. 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.

GEOLOGY

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. Propylitic, argillic, albitic, and sericitic alteration is extensive throughout virtually the entire study area.

GEOCHEMISTRY

Based on stream-sediment geochemical data, areas interpreted as having highest resource potential 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 existing mining districts. The concentrate data do not point to any new areas of resource favorability, but stream-sediment and heavy-mineral-concentrate sampling at the chosen site density apparently failed to locate small but highly mineralized areas.

GEOPHYSICS

A north-northwest-trending belt of anomalously low aeromagnetic values along the east boundary of the study area cuts across geologic units and parallels fault zones along the eastern front of the range. The lows, which are probably caused by alteration that has destroyed magnetic minerals, coincide spatially with many of the important gold-silver mines and prospects in the study area, suggesting that other areas of mineralization presently hidden by alluvium may also occur along this trend.

Bouguer gravity values seem 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, in the northwestern part of the study area, may overlie a buried fault with an abruptly increased thickness of alluvium on the west side. Gravity values there suggest that alluvium is roughly 1,400 ft thick.

Resistivities associated with intrusive rocks are moderate to high. Audiomagnetotelluric soundings show that these rock units increase in resistivity with depth, suggesting that alteration and mineralization is not pervasive at depth or that it is confined to narrow zones.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Favorability of geologic formations and structures, direct evidence for mineralization, and indirect evidence such as geochemical and geophysical anomalies, as discussed in the accompanying pamphlet, are integrated to arrive at assessments of potential for undiscovered resources. Outlined on the accompanying map are areas for which potentials for undiscovered mineral resources are defined.

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 faults later acted as major fluid conduits to locally enrich mineralization. Because of the widespread alteration and mineralization in plutonic rocks, a hydrothermal system, associated with remobilization by Jurassic plutonism, is inferred.

High potential (GC-1). The gold-copper mineralization is evidenced by mines and prospects along the Bighorn fault zone (mostly within ½ 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) 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 fault zone is typified by similar alteration and mineralization, and thus it is considered to have high a potential for undiscovered gold and copper resources.

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, have a moderate potential for undiscovered gold and copper resources on the basis of analogies with known mineralization in 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. Geophysical data rule out a major iron deposit of the size and type of Vulcan mine. Area GC-2b, in the Horse Hills, is characterized by extensive diking and altered siliceous granitoids. Locally anomalous concentrations of molybdenum there are found in addition to gold and copper.

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 undiscovered gold and copper resources related to those in the Bighorn and Hidden Hill areas.

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 undiscovered hydrothermal gold and copper resources.

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). Because several criteria for porphyry systems are not met, a low potential for widespread undiscovered low-grade gold and (or) copper resources is indicated. Three environments relative to this system model are present: (1) Cretaceous plutonic rocks have none of these characteristics and therefore have no potential recognized; (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 the areas have a low potential. The sum of all areas identified for gold-copper hydrothermal systems (GC-1, GC-2a, -2b, GC-3), therefore, is the extent of the area having a low potential for a gold-rich copper porphyry system.

The possibility for disseminated molybdenum in the Horse Hills area is suggested by geochemically anomalous molybdenum and fluorine. The data are permissive of a disseminated molybdenum (stockwork) model, but do not specifically require it, so the potential for undiscovered molybdenum resources is unknown.

Epithermal gold

Altered metavolcanic and felsic hypabyssal rocks in the Hidden Hill area that are associated with a granitic intrusive system suggest conditions for epithermal gold resources. Many favorable indicators for this model are present, closely matching the model in one case (area G-1), which has a high potential for undiscovered disseminated epithermal gold resources, and less closely matching in three other areas (G-2), which have a moderate potential for undiscovered disseminated gold resources.

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 placer gold 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) are designated as having a low potential for undiscovered placer gold resources. They lack proven resource accumulation. Other alluviated areas within the study area also have low potential for undiscovered placer resources, but have less support for that designation.

Radioactive minerals

Although albitized Jurassic granitoids in the study area are similar to granitoids hosting mineralized veins in some ranges nearby, no strongly anomalous scintillometer or aerial radiometric readings were observed for the study area. Accordingly, there is no recognized potential for undiscovered radioactive mineral resources in Jurassic granitoids. Cretaceous granitoids in the Granite Mountains west of Granite Pass 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 the Arrowweed, a low potential for undiscovered radioactive mineral resources is indicated for the outcrop area of the granite of Arrowweed (labeled RM).

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, the potential for undiscovered hydrocarbons is based on possible deep structure and is therefore model dependent.

Available geophysical data do not require any major changes of rock type in the subsurface. However, deeper occurrences of sedimentary rocks cannot be ruled out. Although the Paleozoic strata in the northern Providence Mountains are largely limestone and dolomite, significant organic-rich 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. 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. The unknown 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, outlining the region of basin sediments greater than about 400 ft thick, is based on interpretation of gravity data.

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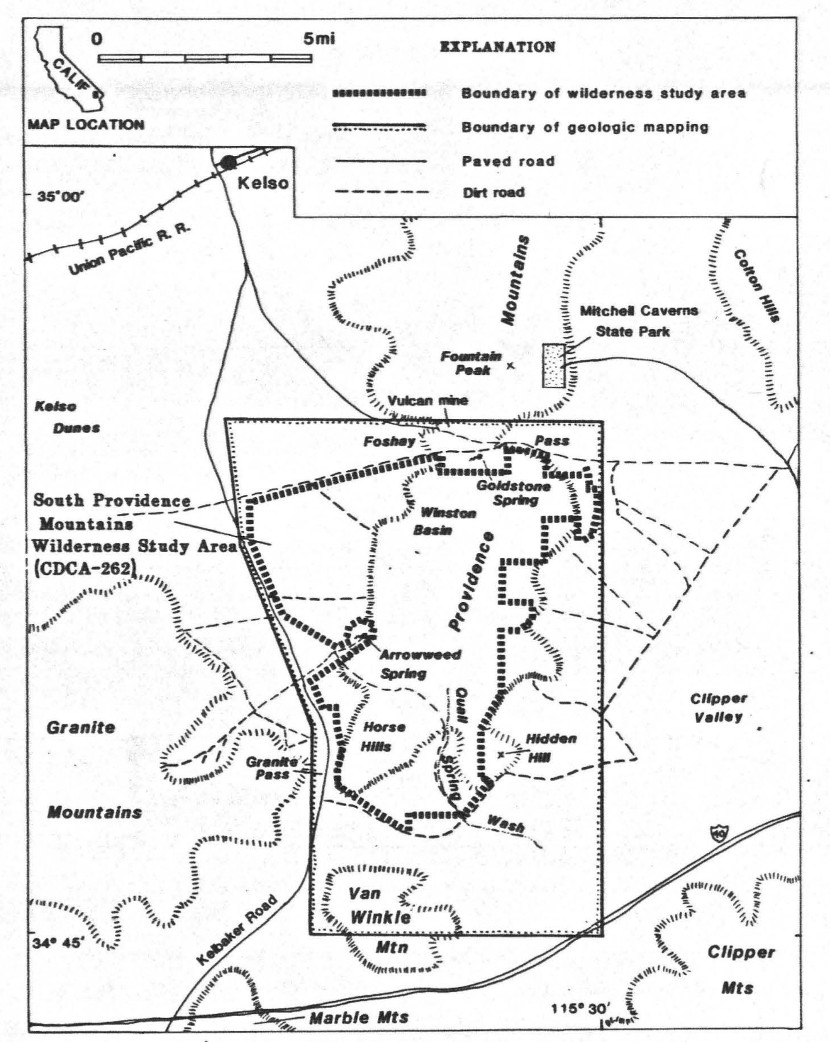

Location map of South Providence Mountains Wilderness Study Area.

Explanatory pamphlet accompanies map