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MINERAL RESOURCE POTENTIAL OF THE CHUCKWALLA MOUNTAINS WILDERNESS STUDY AREA (CDCA-348), RIVERSIDE COUNTY, CALIFORNIA

SUMMARY REPORT

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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 Chuckwalla Mountains Wilderness Study Area (CDCA-348) California Desert Conservation Area, Riverside County, California.

SUMMARY

Geologic and geochemical investigations and a survey of mines and prospects indicate that those parts of the Chuckwalla Mountains Wilderness Study Area (chiefly in the Red Cloud Canyon and Corn Springs Wash vicinities) that are intruded by propylitically altered mafic dikes with spatially associated quartz veins and shear zones have moderate or high potential for the presence of undiscovered low- to medium-grade gold, silver, and tungsten resources in vein deposits. High stream-sediment concentrations of molybdenum strongly suggest that parts of those areas intruded by the dikes also contain molybdenum-bearing minerals and thus have moderate or high potential for the presence of undiscovered molybdenum resources. However, there has been no recorded production of molybdenum in the region and any resources that may be present in the study area are likely to be significant only if the mineralized quartz veins and shear zones are manifestations of an extensive subsurface quartz-vein stockwork system. All areas with moderate or high potential for gold, silver, tungsten, or molybdenum resources also have low potential for the presence of undiscovered copper and lead resources. Low potential for the presence of undiscovered tin and thorium resources exists in the north part of the wilderness study area. Sand, gravel, and stone suitable for construction materials are found in the study area, but similar or better quality materials

are abundant and accessible outside the area. No new mineral occurrence was located during this study.

INTRODUCTION

Scope and procedure

This report summarizes the results of geologic and geochemical surveys by the U.S. Geological Survey and an investigation of mines, prospects, and mineralized areas by the U.S. Bureau of Mines. These surveys provide mineral-resource data for land-use decisions regarding the study area and, if compatible with such decisions, provide a basis from which to plan followup mineral resource investigations. Our objectives in this summary pamphlet are (1) to appraise identified resources[1] in the study area and (2) to assess the potential for undiscovered resources.

To accomplish the first objective, we have examined known mineral occurrences and reviewed production history of mines in and around the study area. To accomplish the second objective, we have sought evidence for mineral concentrations by direct observation (geologic mapping) and by a stream-sediment geochemical survey. From these surveys and the examination of mines and prospects, we have identified geologic environments in the study area that are favorable for the concentration of mineral resources and have judged the likelihood or potential for undiscovered mineral resources. Based on the strength of the evidence for mineralization, the potential is rated as low, moderate, or high. Where a specific model can be inferred for the occurrence of mineral concentrations in the study area, the approximate scale of resource (see footnote 1) likely to be present in any undiscovered mineral deposit is evaluated by appropriate analogy with similar known deposits elsewhere in the region.

Geographic setting

The Chuckwalla Mountains Wilderness Study Area consists of about 90 mi^2 in the northern Chuckwalla Mountains, Riverside County, Calif. (fig. 1). The area is split into two parts by a corridor along Corn Springs Wash; embayments into each part exclude areas with numerous mines and prospects and the roads leading to them. These roads provide ready access to the wilderness study area.

The Chuckwalla Mountains lie just south of Interstate Highway 10 at Desert Center, which is approximately 180 mi east-southeast of Los Angeles. The range covers an area of about 57,312 acres (215 mi^2), mostly north of an

[1]Resources--a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible (U.S. Bureau of Mines and U.S. Geological Survey, 1980). Defined in this broad fashion, a resource may include material (reserves) that can be developed profitably under current market conditions or it may contain only material (marginal reserves, subeconomic resources) that requires more favorable market conditions or more advanced technological capability to be developed profitably.

unnamed east-draining wash that is followed by DuPont Road. South of that wash, the range is narrow and trends southeast to Graham Pass where it merges with the east-west trending Little Chuckwalla Mountains.

The Chuckwalla Mountains rise abruptly from the desert floor and reach 4,504 ft at Black Butte and 4,216 ft at Pilot Mountain in the south-central part of the wilderness study area. The northern part of the Chuckwalla Mountains is flanked by bajadas on all sides. At the base of the range on its northeast flank, the desert floor ranges in elevation from about 900 to 1,600 ft, whereas on the southwest flank of the range, the desert floor ranges from about 1,400 to 2,600 ft. The Chuckwalla Mountains are nearly transected by three major east-draining washes--Corn Springs Wash, Ship Creek, and the unnamed wash that is followed by Dupont Road.

The Chuckwalla Mountains are part of the eastern Transverse Ranges province as defined by Jahns (1954) and extended by Powell (1981). The eastern ranges of the province also include the San Bernardino, Little San Bernardino, Pinto, Hexie, Cottonwood, Eagle, Orocopia, and Little Chuckwalla Mountains.

GEOLOGY

Crystalline rocks of the Chuckwalla Mountains Wilderness Study Area constitute parts of a Mesozoic batholith and Precambrian and Precambrian and (or) Paleozoic country rock into which the batholith has intruded (fig. 2). The batholithic and prebatholithic units exposed in the Chuckwalla Mountains also crop out in other parts of the crystalline basement complex of Orocopia, Eagle, Cottonwood, Hexie, Little San Bernardino, and Pinto Mountains. Stratigraphic and structural relations for the prebatholithic units rely on geologic mapping in all of these ranges (Powell, 1981, 1982).

The Precambrian and Precambrian and (or) Paleozoic rocks comprise two lithologically distinct prebatholithic terranes. These terranes have been called the Joshua Tree and San Gabriel terranes by Powell (1981, 1982) after regions of southern California in which their lithologic units were initially characterized. The two terranes are superposed along a prebatholithic low-angle fault system of regional extent, the Red Cloud thrust.

The structurally lower Joshua Tree terrane consists of Precambrian granite capped by a metamorphosed paleosol and overlain nonconformably by orthoquartzite that, in the Eagle and Pinto Mountains, interfingers with pelitic and feldspathic granofels and, locally, dolomite. A northeast-trending pattern of metamorphic isograds indicates a low-pressure, high-temperature metamorphic gradient that culminated at about 3.5 kb and 600°C. Near the Red Cloud thrust, the rocks of the Joshua Tree terrane are pervasively deformed to granite gneiss, lineated quartzite, and schist. The granite gneiss is extensively exposed in the Chuckwalla Mountains, whereas minor exposures of the metamorphosed paleosol and quartzite occur only in the southwest corner of the range.

Precambrian units of the San Gabriel terrane comprise a three-part deep-crustal section. At the highest level, metasedimentary gneiss of uppermost amphibolite-grade is intruded by granodioritic augen gneiss. Both of these units are intruded by retrograded granulite gneiss at an intermediate level, and the granulitic rocks in turn are intruded by syenite-mangerite-jotunite at the lowest level exposed in the eastern Transverse Ranges province.

The Red Cloud thrust system is inferred to have developed in four sequential structural events, all of which are recognized in the Chuckwalla Mountains (Powell, 1981, 1982): (1) early thrusting that probably moved parallel to east-northeast mineral lineations recorded in both plates; (2) regional folding of the initial thrust surface around north-northeast trending axes; (3) later thrusting with some component of westward movement that broke across a fold in the older thrust surface to produce a stacking of crystalline thrust plates of the two terranes; (4) continued or renewed folding of both thrust faults with eventual overturning toward the southwest. The thrusting resulted in westward-vergent allochthonous emplacement of the San Gabriel terrane over the Joshua Tree terrane and occurred sometime between 1,195 m.y. and 165 m.y. ago.

Mesozoic plutonic rocks in the region comprise two batholithic suites, both of which intrude the Joshua Tree and San Gabriel terranes and the Red Cloud thrust system. The older suite is Jurassic and consists of gabbro-diorite intruded by quartz-poor porphyritic monzogranite and quartz monzonite. The younger suite, Jurassic and (or) Cretaceous includes granodiorite intruded by quartz-rich porphyritic monzogranite, intruded in turn by quartz-rich, nonporphyritic monzogranite. Most of these units are exposed in the Chuckwalla Mountains.

Swarms of felsic, intermediate, and mafic dikes crosscut plutons of both batholithic suites in the Chuckwalla, Eagle, and Pinto Mountains. Throughout these ranges, dikes strike approximately west-northwest, north-northwest, or northeast. These three directions coincide with orientations of a regional fracture set that crosscuts batholithic and prebatholithic units. Emplacement of the dikes and developmemt of the fracture set are both manifestations of regional dilation and they may overlap in time.

Upper Oligocene and (or) lower Miocene volcanic and sedimentary rocks crop our extensively in mountain ranges south of the Chuckwalla Mountains (Crowe, 1978; Crowe and others, 1979). The volcanic rocks are chiefly basalt and andesite; the sedimentary rocks are chiefly terrestrial conglomerate and sandstone. The northern limit of these rocks lies in the Chuckwalla Mountains just south of the wilderness study area.

The mountain ranges between the San Bernardino and Little Chuckwalla Mountains are delineated by several Cenozoic east-west left-lateral strike-slip faults that have a cumulative displacement of about 30 mi (Powell, 1981, 1982). This fault system includes faults bounding the northern block of the Chuckwalla Mountains on the north and south and faults within the northern part of the range.

Gold, silver, tungsten, molybdenum, copper, and lead minerals observed in the Chuckwalla Mountains occur in quartz veins and shear zones. At some localities, these veins and zones have envelopes of bleached and limonite-stained rock. In and near the study area, these minerals include scheelite, molybdenite, galena, pyrite, fluorite, hematite, limonite, copper carbonate minerals, and dendritic manganese oxide. Moreover, gold and silver were detected in assays of samples from the quartz veins and shear zones. The mineralized quartz veins and shear zones are spatially associated with propylitically altered mafic dikes (fig. 2). Mafic dikes occur in the immediate vicinity of most mines and prospects both in Precambrian and Mesozoic crystalline rocks of the range. Mineralized quartz veins crosscut the mafic dikes and, locally, the mafic dikes are mineralized. Thus, mineralization at least in part postdates emplacement of the mafic dikes although the length of time between emplacement of the dikes and mineralization has not been established. Similar relations are observed nearby to the north in the Eagle Mountains (Powell and others, 1984).

Within the Chuckwalla Mountains, the mafic dikes are usually fine-grained, greenish-gray altered dioritic rock characterized by the presence of a propylitic alteration assemblage of actinolite, chlorite, and epidote. The dikes are usually nonresistant to erosion and 2 to 10 ft thick, although locally dikes are as thick as 40 ft. They commonly exhibit continuity of several thousand feet along strike, but poor exposure and faulting generally make the dikes difficult to map. The dikes vary in dip from vertical to subhorizontal, but in the northwest-trending sets moderate to steep northeastward dips predominate. Locally, the dikes are pervasively foliated parallel to their contacts.

Among the hypotheses that can be proposed to explain the spatial association between the propylitically altered mafic dikes and the presence of mineralization is: In the final stages of or after their emplacement and cooling, the mafic dikes may have served as catalysts for metallic-mineral deposition from mineralizing fluids emanating from an unknown source. The source of the fluids and the metals could be related to that of the mafic dikes, to younger felsic dikes in the Chuckwalla Mountains, or to Oligocene and (or) Miocene volcanism and plutonism that occurred south of the study area. Alternatively, hydrothermal fluids from one of these sources may have leached and concentrated precious and base metals from the mafic dikes themselves as they were propylitically altered. The mineralizing fluids may have moved through all of the regional fracture system, but left deposits only in the vicinity of mafic dikes; or the mineralizing fluids may have moved through fractures only in the vicinity of the dikes.

The data gathered during our investigations do not conclusively demonstrate the origin, processes of deposition, or absolute timing of mineralization in the study area. However, the empirical association between mafic dikes and evidence for mineral concentrations forms a basis for evaluating mineral resource potential.

GEOCHEMISTRY

In March 1982, the U.S. Geological Survey conducted a reconnaissance geochemical survey of the Chuckwalla Mountains Wilderness Study Area and vicinity. The purpose of the survey was to determine abundances and variations of trace-element contents in stream sediments that may indicate local concentrations of ore-forming and pathfinder (ore-associated) elements. The survey consisted of the collection and analysis of 196 heavy-mineral panned concentrates from stream sediment, about the same number of bulk stream-sediment samples for sieving, and a few rock samples from altered or mineralized zones and from various lithologic units present in the area. Each sample collected was analyzed by emission spectrographic methods for 31 elements (Grimes and Marranzino, 1968). The rock samples were also analyzed for gold, mercury, zinc, arsenic, antimony, cadmium, and bismuth by atomic absorption (AA) methods.

The results of the stream-sediment survey are the chief geochemical basis for the mineral resource appraisal of the study area. The rationale is that as a result of weathering and erosion a variety of metallic elements will be enriched in the modern alluvium of drainage basins if the drainage basin contains mineral deposits. In contrast, stream-alluvium from drainage basins without mineral deposits is expected to show background element concentrations that are normal for sediment derived from rock-types exposed in the area. Exceptions to these assumptions include elevated element contents related to unusual rock compositions or to dispersed element enrichments in subeconomic mineral concentrations. Thus, each anomaly, evaluated in its geologic context, can be used for assessment of mineral resource potential, but should be tested further by detailed follow-up studies in order to determine the presence or absence of economically important mineral deposits.

A three-phase approach was used to evaluate and interpret the stream-sediment data: (1) establishing if ore-forming and pathfinder elements are enriched above background amounts; (2) determining the dispersion patterns of any anomalous elemental concentrations; and (3) relating the dispersion patterns to geologic environment in order to ascertain their causes and possible relation to ore-grade commodities. Minerals present in the samples were identified to aid in the evaluation of the geochemical anomalies. From the mineral associations, elemental suites, and geologic environment, it is possible to infer the types of mineral deposits that may be present in the study area.

Geochemical analyses of stream-sediment samples from the Chuckwalla Mountains have shown that the nonmagnetic heavy mineral fraction of drainage-basin alluvium locally contains anomalously high concentrations of tungsten, molybdenum, lead, beryllium, bismuth, and scattered silver. The most elevated concentrations occur along a north to northwest-trending zone on the southwest flank of the study area (fig. 3). Locally, this zone is also enriched in niobium, tin, and thorium. Scheelite and fluorite have been identified microscopically in splits of analyzed samples from the zone. In this report, the contoured concentration data for only tungsten and molybdenum (fig. 3) and silver (fig. 4) are shown to indicate areas in which mineralization has occurred. The same areas are indicated by the other metallic elements (K. C. Watts, unpublished data, 1984).

The zone of anomalously high metal concentrations in and around Red Cloud Canyon is characterized by propylitically altered mafic dikes, quartz veins, and high-angle faults and fractures. Dilation along faults and fractures in Red Cloud Canyon may have facilitated the migration of mineralizing fluids that supplied the enriched elements. Furthermore, the mafic dikes may have provided chemical controls for mineral deposition (for example, relative to the units they intrude, the dikes are rich in calcium, which is required for the precipitation of scheelite from tungsten-rich solutions).

A west- to northwest-trending zone of weaker tungsten, molybdenum, and lead anomalies occurs along and mainly south of Corn Springs Wash. As in the area of Red Cloud Canyon, scheelite and fluorite have been identified microscopically in sample splits. The Corn Springs Wash zone is also spatially related to mafic dike swarms and fractures. The element dispersion pattern parallel to Corn Springs Wash is connected to the Red Cloud Canyon zone of anomalies by northeast-trending linear patterns of anomalous molybdenum, lead, beryllium, and fluorite that may be related to fractures along which mineralizing fluids may have moved.

Anomalously high concentrations of the lithophile elements tin, niobium, and thorium occur in the alluvium of streams that drain the north flank of the Chuckwalla Mountains. The drainage basins of these streams are underlain by Jurassic and (or) Cretaceous granitic rocks that contain abundant sphene, apatite, and zircon. These accessory minerals, which commonly are enriched in tin, niobium, and thorium in granitic rocks, are probably the source of the anomalous concentrations of lithophile elements, although we have not analyzed separates of these minerals from the Chuckwalla Mountains. Enrichments of tin, niobium, and thorium in the accessory minerals would suggest that the granitic rocks were capable of concentrating these elements in mineral deposits, but the principal ore minerals of tin and thorium--cassiterite and monazite, respectively--have not been observed in the stream sediments. Molybdenum, probably in either molybdenite or an accessory mineral in the Mesozoic granitic rocks, is concentrated in some of the same areas as the lithophile elements.

A small number of silver and gold anomalies were detected in the stream alluvium. Silver anomalies were found near known gold-silver deposits in the southwest part of the study area in and around Red Cloud Canyon. Gold anomalies were found in only two samples, both of which were collected near Chuckwalla Spring outside of the wilderness study area. Some altered and mineralized rock samples from outcrops in the study area also contain gold.

The dispersion patterns of tungsten, molybdenum, and fluorine (as indicated by the presence of fluorite) along the Red Cloud Canyon zone of anomalies suggest an analogy with patterns of mineralization commonly observed around granite-molybdenite (Climax-type) systems in the western United States (Wallace and others, 1978, p. 357, 363, and 364; Sharp 1978, p. 373-376; Mutschler and others, 1981, p. 879-880; Theobald, 1982, p. 43). If the mineralization in Red Cloud Canyon is associated with Climax-type molybdenum deposits, analogy between the dispersion patterns suggests that such deposits are likely to be present in the subsurface in association with quartz-vein stockworks in or near altered felsic igneous cupolas. However, despite a range of at least 2,000 ft in the exposure level of batholithic rocks in the Chuckwalla Mountains and nearby mountain ranges, exposed cupolas, stockworks, or Climax-type deposits have not been discovered. Consequently, other models for the origin of the metal anomalies in the Chuckwalla Mountains should also be considered.

MINING DISTRICTS AND MINERALIZATION

Method of investigation

In 1981 and 1982, the U.S. Bureau of Mines conducted a field investigation of the Chuckwalla Mountains Wilderness Study Area during which mines, prospects, and mineralized areas were examined inside and within approximately 1 mi of the study area (fig. 5). Accessible mines were mapped and surveyed with compass and tape. A total of 712 samples were collected and fire-assayed for gold and silver, for which the lower detection limits are 0.005 oz/ton and 0.2 oz/ton, respectively. In addition, selected samples were analyzed spectrographically for up to 42 elements. The analytical results for most samples are available for public inspection at the U.S. Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver, Colorado 80225.

Mining activity

The Chuckwalla Mountains have been extensively mined in and near the study area. Prospects and mines investigated range in size from small pits to well-developed mines such as the Red Cloud, Great Western, and Granite mines. Several of the larger mines have produced gold, silver, and lead. Production records list all mines in the study area as being in the Chuckwalla mining district. In 1982, sporadic prospecting was being conducted throughout the study area and Emerau Mining Corporation was beginning excavation on a gold-bearing quartz vein just outside the study area near the Red Cloud mine.

Many mining claims in and near the study area have been filed with the U.S. Bureau of Land Management (1981 records), including 7 patented claims. Permission was granted to investigate and sample on all of the patented claims, but information gathered from one claim, the Bryan mine, is confidential and is not included in this report at the request of the owner.

In addition, several oil and gas leases and lease applications are on file with the Bureau of Land Management for areas in Chuckwalla Valley. Some of these areas extend slightly into the study area.

The Bureau of Mines appreciates information supplied by Danny Figueroa concerning the Red Cloud mine area.

Mineralized areas

Cap Hunter mine area

The Cap Hunter mine and mineralized area are in SW. 1/4 sec. 34, T. 7 S., R. 16 E., about 1 mi south of the study area. Mineralization in the mine area has occurred in quartz veins, fault zones, and in augen gneiss country rock. The veins, commonly within fault zones, strike approximately N. 60° W. and dip about 45° SW. Remnants of sulfide minerals, including galena, occur locally in the veins.

Several of twenty-six samples taken contained detectable gold and silver in concentrations up to 1.01 oz/ton and 3.1 oz/ton, respectively.

Until 1954, the Cap Hunter mine produced 2 oz of gold, 45 oz of silver, 2,264 lb of lead, and 54 lb of copper from 44 tons of ore. There has been no reported production since (U.S. Bureau of Mines records).

Aztec mine area

The Aztec mine area is in sections 18, 19 and 20, T. 7 S., R. 17 E. (unsurveyed) on the southeast boundary of the study area. The mine area contains many workings, most of which are pits or trenches. Some of the workings are in or within 1/4 mi of the study area. The workings in the mine area explore fault zones, quartz veins, or altered zones in gneissic country rock, most of which strike between N. 25°-80° E. or N. 50°-80° W.

The highest gold and silver values, in samples from a structure within the study area, were 1.108 oz/ton and 2.8 oz/ton, respectively. In addition, one sample contained 15.5 weight percent lead. Sampling of structures outside the study area yielded gold contents of up to 0.198 oz/ton and silver contents of up to 0.2 oz/ton.

There has been no reported production from the Aztec mine area.

Beal mine area

Workings in the Beal mine area are in the SE. 1/4 sec. 13, T. 7 S., R. 15 E. and the NW. 1/4 sec. 18, T. 7 S., R. 16 E., about 1 mi west of Black Butte and 2 mi northwest of Gulliday Well. The area is along the south boundary and a few hundred feet outside the study area. The workings consist of lower and upper adits and small pits that expose a shear zone and a tightly folded quartz vein up to 10 ft wide. The shear zone strikes slightly west of north in the lower adit, and a 2-ft wide quartz vein in the upper adit strikes northeast and dips 52° NW. The projection of the shear zone and quartz vein along strike extends into the study area within a few hundred feet.

Fourteen samples were taken in the area. No detectable gold and only 0.2 oz of silver per ton were found in the samples.

There has been no reported production from the Beal mine area.

Area I

Area I is in the southwestern part of the study area, about 3 mi west of the Beal mine. It encompasses sections 14, 15, 21, and 22 and parts of sections 13, 16, 20, 23, 26, 27, 28, and 29, T. 7 S., R. 15 E. Area I contains several adits and pits, a few of which are inside the study area, that follow quartz veins, fault zones, and altered zones in gneissic country rock. Molybdenite occurs in a quartz vein in at least one adit with unknown name in the SW. 1/4 sec. 14. The largest working, the Liberation(?) mine, is about 1/4 mi outside the study area and has surface, 30-ft, and 60-ft levels. The Liberation(?) mine explores a fault or shear zone generally striking N. 40° E. and dipping about 60° NW. The shear zone varies in width from 3 to 60 in. Although it cannot be traced into the study area, the projection of the structure on strike intersects the study area within a mile.

Of the 20 samples taken at the Liberation(?) mine, 7 contained detectable gold in concentrations up to 0.314 oz/ton in a 30-in chip sample. The highest silver value was 2.4 oz/ton in a 16-in chip sample. The highest gold value (2.008 oz/ton) in area I was in a dump sample taken near the Liberation(?) mine. Of the samples taken in the rest of area I, only one sample contained detectable gold.

There has been no reported production from area I.

Area II

Area II is near the southwest corner of the study area just northwest of area I. It is about 1 mi east of the Gas Line Road and about 1/2 mi southwest of the Model mine, NW. 1/4 sec. 2, T. 7 S., R. 14 E. Most of the mining in this area is just outside the study area, but two workings are on the boundary.

Mineral concentrations within area II occur mostly in quartz veins, fault or shear zones, and alteration zones in gneissic country rock. Although no consistency of strike or dip is apparent, about twice as many structures strike between north and west as strike between north and east. Widths of sampled structures ranged from 6 in to 66 in. Although none of the structures could be traced into the study area, one structure where two samples were taken, if projected about 3/4 mi, intersects the study area. Other structures sampled are approximately parallel to the boundary of the study area and miss it entirely if projected.

Of 45 samples taken in area II, 12 samples contained detectable gold, 5 of which are from structures that may intersect the study area. Two sample localities may be inside the study area depending on the exact location of the boundary. The highest gold value was 0.736 oz/ton and the highest silver value was 1.7 oz/ton. Seven samples contained detectable silver. Ten samples contained detectable tungsten; the highest value obtained was 87 parts per million (ppm).

Production recorded for the Echo Valley mine, located within 1/4 mi of the study area, consists of 2 oz of gold, 8 oz of silver, and 500 lb of lead from one ton of ore (U.S. Bureau of Mines records).

Red Cloud Canyon area

The Red Cloud Canyon area lies along Red Cloud Canyon in the southwestern part of the study area, about 1 mi northeast of area II. The Red Cloud Canyon area, approximately one-third of which is in the study area, encompasses parts of sections 29, 30, 31, 32, and 33, T. 6 S., R. 15 E. The Red Cloud and Great Western mines are the two largest workings in this area. Although mostly inaccessible now, these mines had several levels and were more than 300 ft deep. In general, mineralized structures in the Red Cloud Canyon area include quartz veins, fault zones, and shear zones. The larger structures strike primarily north to northwest. Smaller structures strike approximately east or northeast.

Two major structures were sampled in the Red Cloud Canyon area. One is a combined quartz vein and shear zone that strikes generally N. 45° W. Three patented claims that encompass the Red Cloud and Great Western mines are located along this structure, which extends well into the study area. The mines are along the boundary and, depending on its exact location, may be in the wilderness study area. The other major structure is a prominent quartz vein up to several feet wide that strikes slightly west of north and is exposed for several hundred yards. Several workings along the quartz vein, which contains scheelite, include pits, trenches, shallow shafts, and short adits. To the south, the vein is covered by alluvium.

A total of 130 samples were taken in the Red Cloud Canyon area. Of these, 38 contained detectable gold and 22 contained detectable silver. Some samples contained minor copper, manganese, and tungsten. The highest gold value was 0.7 oz/ton and the highest silver value was 6.3 oz/ton. Both these samples were taken within 1 mi of the study area.

Red Cloud mine production records from the U.S. Bureau of Mines indicate that between 1899 and 1901, 140.29 oz of gold were recovered; between 1932 and 1940, 1329.25 oz of gold and 425 oz of silver were recovered. There are no figures on the production from the Great Western mine. Bureau of Mines records show that in 1911, 338.62 oz of gold and 38 oz of silver were recovered from 1,100 tons of ore from the Eureka mine in the study area, SE. 1/4 sec. 6, T. 7 S., R. 15 E.

Lost Pony mine area

The Lost Pony mine area is mostly in unsurveyed sec. 19, T. 6 S., R. 15 E. In addition, one adit in the Lost Pony mine area is in unsurveyed sec. 29, T. 6 S., R. 15 E. The mine area is on the west side of the study area about 2 mi south of a microwave relay station. Most of the workings are within 1 mi of the study area and one adit is in the study area.

Mineralization in the Lost Pony mine area is predominantly in fault or shear zones and quartz veins, locally in combination. The country rock is gneiss and granite. The fault and shear zones range in width from 10 to 67 in and the quartz veins range in width from 11 to 38 in. Most of the structures strike between N. 45° W. and west or between N. 75° E. and east. Although they could not be traced into the study area, projection of the veins on strike reaches the study area in 1 to 2 mi. Visible mineral concentrations are minor in most of the structures.

Of the 22 samples taken in the Lost Pony mine area, 7 contained detectable gold in concentrations up to 0.446 oz/ton and 7 contained between 0.2 and 6.6 oz silver per ton. Silver is not always associated with gold. All samples containing gold, except one, were taken at the Lost Pony mine.

There has been no reported production from the Lost Pony mine area.

Area III

Area III, along the boundary in the northwestern corner of the study area, contains two groups of workings.

A southwestern group of workings, in sec. 1, T. 6 S., R. 14 E., consist of several trenches, pits, and a short adit. The workings explore two quartz veins up to 1.5 ft wide in gneiss. The veins strike N. 53° W. and N. 45° W., and dip 53° SW. and 58° SW., respectively. The workings along the N. 45° W.-striking vein include a series of pits extending over a distance of one-half mile. Locally, the vein is not exposed and in most of the pits the vein is not visible.

A northeastern group of workings within area III lies in the SE. 1/4 sec. 36, T. 5 S., R. 14 E. The workings consist of a few pits and trenches that explore quartz veinlets within a shear zone in gneiss for a distance of a few hundred feet. The shear zone strikes between N. 25° W. and N. 18° W. and dips from 65° to 76° SW. Small amounts of galena, sphalerite, and pyrite were found at some sample localities.

Six of fourteen samples taken in the southwestern group of workings contained detectable gold at values between 0.028 and 0.372 oz/ton. The 4 samples taken from the northeastern group contained gold at values between 0.020 and 0.434 oz/ton. Silver values of 0.2 and 0.4 oz per ton were found in two samples.

No production has been reported from area III.

Granite mine area

The Granite mine area lies along the northwest boundary of the study area. The area contains extensive workings that comprise the Granite and Gold Crown (San Diego) mines in the SW. 1/4 NW. 1/4 sec. 4, T. 6 S., R. 14 E., and a few short adits and several pits located from 1 to 5 mi from the Granite mine. The Granite mine may be partially in the wilderness study area.

The Granite mine is the largest in vicinity of the study area and consists of a shaft and an adit that provide access to approximately 1,200 ft of workings on four levels to a depth of about 100 ft. The workings follow two mineralized faults in granite. At the south end of the Granite mine, a shaft has been sunk on a fault which strikes about N. 10° W. and dips 45°-75° SW. The shaft is open to a depth of 80 ft where it is filled by rubble. At the north end of the mine, the main level connects with a 340-ft crosscut adit which was driven along a fault that strikes N. 75° E. and dips 40°-60° N.

The N. 10° W.-striking fault zone consists of sheared granite, zones of clay gouge up to 6 ft wide, and sporadic quartz veins, pods, and stringers. The quartz veins, pods, and stringers are generally less than 1 ft wide but in some parts of the mine reached 3.5 ft in width. Hematite and limonite are present as stains and as pseudomorphs after pyrite. Stains of manganese oxides and copper carbonates are also present.

The N. 75° E.-striking fault zone at the north end of the mine consists of sheared granite and clay gouge up to 5 ft wide. Numerous thin mafic dikes have been intruded into and along the fault zone. Hematite and limonite stains are present. The dikes and veins within the Granite mine have been sheared and fractured by further movement along the faults.

At a few localities within the Granite mine, radioactivity is above background. Samples taken at these locales contained small amounts of thorium and uranium, the highest being 35 ppm and 15 ppm, respectively.

Approximately S. 10° E. from the shaft of the Granite mine, a few short adits and several pits are aligned over a distance of about 850 ft. These workings explore faults and quartz veins that strike between N. 25° W. and N. 25° E. The majority of these workings are part of the adjoining Gold Crown (San Diego) mine (Saul and others, 1968).

South of this line of workings, the major portion of the Gold Crown (San Diego) mine consists of an upper and lower adit that contain approximately 450 ft of workings in the study area. The Gold Crown workings cut several faults that are generally less than 1 ft wide but locally are up to 5 ft wide. The faults zones include sheared granite, clay gouge, and in some areas quartz veins and (or) thin mafic dikes. Hematite and limonite occur as stains and as pseudomorphs after pyrite. Stains of manganese oxides and small amounts of copper carbonate are present.

About 1/2 mi west of the Granite mine, a 50-ft adit has been driven along a fault striking N. 9° W. and dipping 67° SW. in granite. The adit is on the wilderness study area boundary and the fault may extend into the study area. The fault consists of sheared granite with quartz stringers. Hematite and limonite are present as stains and as pseudomorphs after pyrite, along with some stains of manganese oxides. One pit about 1 mi southeast of the Granite mine explores sheared granite with a quartz veinlet and contains stains of iron and manganese oxides.

Of 120 samples taken in this area, 65 were from the Granite mine and 26 of these contained detectable gold and 21 contained detectable silver. The highest gold content was 0.946 oz/ton and the highest silver content was 3.4 oz/ton. Of 22 samples taken at the Gold Crown mine, 9 contained detectable gold in concentrations up to 0.388 oz/ton. One of the three samples taken at the adit 1/2 mi west of the Granite mine contained a gold value of 0.013 oz/ton. One sample from the pit 1 mi southeast of the Granite mine yielded a gold value of 0.028 oz/ton.

There has been no reported production for the Granite mine area.

Area IV

Area IV is about 2 mi south of the Granite mine and about 1 mi east of the microwave relay station. The area encompasses most of sections 8, 9, 10, 17, and 16, T. 6 S., R. 15 E. within the study area. The largest working in the area is the Gold King mine which consists of two adits and a nearby trench in a canyon just east of the microwave relay station.

Workings in the area expose many fault or shear zones that locally contain quartz veins. The strikes of the structures are predominantly north to northwest. Dips vary greatly to the east and southwest. Widths of the structures investigated range between 8 and 56 in. The country rock in area IV is mostly monzogranite and gabbro-diorite crosscut by mafic dikes. Several of the structures that were sampled showed copper and manganese staining.

Forty-seven samples were taken in area IV. Of these, 10 contained detectable gold and 9 contained detectable silver. The highest gold and silver values were 1.398 and 2.4 oz/ton, respectively. Both values are from the same sample, which also contained the highest copper value, 0.61 weight percent.

There has been no reported production from area IV.

Area V

Area V is about 2 mi west of Aztec Well and about 3 mi southeast of the microwave relay station. The area is southeast of and adjacent to area IV. Area V encompasses part of sections 15, 16, 21, and 22, T. 6 S., R. 15 E. About 1/2 of area V is within the study area. Area V is bisected by the corridor between the northern and southern parts of the wilderness study area. Most of the workings are within 1/4 mi of the study area.

The workings in area V expose fault or shear zones that contain many small quartz veins, the majority of which strike about N. 45° W. and dip to the southwest. The country rock is monzogranite, which is locally altered. Mafic dikes are common. Visible minerals consist of copper minerals and scheelite. The adit on the Lucky Strike patented claim follows a combined shear zone and quartz vein.

A total of 43 samples were taken in area V; 13 contained detectable gold in concentrations up to 1.220 oz/ton. Only 4 samples contained detectable silver in concentrations up to 1.2 oz/ton. Three samples taken at the Lucky Strike mine contained detectable gold and one sample contained 1.2 oz of silver per ton. In addition to gold and silver, several samples contained minor amounts of tungsten, lead, and copper.

There has been no reported production from workings in area V.

Area VI

Area VI is in the NE. 1/4 sec. 11, T. 6 S., R. 15 E., about 3 mi east of the Granite mine and about 3 mi north of Aztec Well. Area VI is about 1/2 mi inside the study area. Only one adit and one trench were found in area VI.

Of 4 samples taken along a fault none contained detectable gold or silver. A quartz vein about 3-4 in wide associated with the fault contains no visible base- or precious-metal minerals.

There has been no known production from area VI.

Irish Wash area

The Irish Wash area is about 1 mi south of Aztec Well and about 3 mi southwest of Corn Spring. The area covers most of sections 25, 26, and 36, T. 6 S., R. 15 E. Most of the Irish Wash area is within 1/2 mi of the wilderness study area. Some of the prospects investigated are along the study area boundary and may be in the study area, depending on the exact location of the boundary.

Most of the workings investigated in the Irish Wash area exposed quartz veins and fault or shear zones in monzogranitic and gneissic country rock. Commonly, quartz veins are contained within the fault and shear zones. The structures strike predominantly north to N. 56° W. and range in width from 10 to 40 in. The structure could not be traced into the study area.

Of 85 samples taken in the Irish Wash area, 40 samples contained detectable gold. The highest gold value was 0.442 oz/ton. In addition, 8 samples contained detectable silver. The highest silver value was 4.3 oz/ton.

Two mines in the area have recorded production (U.S. Bureau of Mines). The Triangle (Pilot) mine is reported to have yielded 11.81 oz of gold and 2 oz of silver from 8 tons of ore in 1929. The C.O.D. mine is reported to have yielded 5 oz of gold and 1 oz of silver from 10 tons of ore in 1939 and 1940.

Area VII

Area VII is west of and adjacent to Corn Springs. The area encompasses parts of sections 17, 19, 20, 29, and 30, T. 6 S., R. 16 E. There are two major mines, the Bryan mine and a mine with unknown name, and several prospects in the area. Information on the patented Bryan mine is confidential. The mine of unknown name consists of several inclined shafts and an adit following quartz veins. The majority of the prospects in area VII are within 1 mi of the study area, but only one prospect investigated is in the wilderness study area.

The workings follow quartz veins and fault or shear zones that strike predominantly north to northeast in granodioritic country rock. The quartz veins are typically iron-stained and commonly contain copper minerals. Locally, mafic dikes are found in the vicinity of the veins and structures.

Of the 61 samples taken in area VII, 11 contained detectable gold and 5 contained detectable silver. The highest gold and silver values were 1.247 oz/ton and 0.5 oz/ton, respectively.

There has been no known production from area VII.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Assessment criteria

Gold, silver, tungsten, molybdenum, bismuth, lead, and copper have been mobilized and concentrated throughout much of the Chuckwalla Mountains. Of these metallic elements, gold has been the principal resource sought and produced historically, with incidental extraction of silver and lead. Tungsten has been extensively sought (Bateman and Irwin, 1954) and small amounts may have been produced, although no production has been recorded.

Data gathered during this study permit neither specification of the processes or absolute timing of mineralization in the Chuckwalla Mountains, nor substantiation of the presence of undiscovered resources. However, from the geologic and geochemical surveys and the examination of mines and prospects, we have established the following empirical criteria for assessing potential for the presence of undiscovered gold, silver, molybdenum, and tungsten resources in the region:

(1) the presence of quartz veins and zones of fracturing and faulting where accompanied by the presence of propylitically altered mafic dikes;

(2) elevated concentrations of tungsten, molybdenum, silver, gold, or bismuth in stream-sediment samples;

(3) the presence of mines and prospects and gold or silver detected in assays of samples of quartz veins and bleached or limonite-stained rock.

Areas in which there is evidence of potential for gold, silver, tungsten, or molybdenum resources are usually indicated by more than one criterion. We judge all areas that contain mafic dikes to have potential for these resources. Although areas with potential generally are indicated by a combination of geological and geochemical criteria, our assignment of a specific level of low, moderate, or high potential for the presence of a particular metallic mineral resource is based on the strength of the geochemical evidence for that resource. Because areas in which mafic dikes are not exposed have yielded no geochemical or geologic evidence for mineralization, we have not assigned them a potential (figs. 3, 4).

Known deposits in the region

Vein deposits of gold and (or) tungsten (in scheelite) are common in the Transverse Ranges and Mojave Desert provinces of southern California. Gold and tungsten vein deposits that are known in the Chuckwalla Mountains and elsewhere in the Transverse Ranges are generally small in volume and typically of low to medium grade, although high-grade pockets have been found (see Bateman and Irwin, 1954; Clark, 1970). However, the largest production of both gold (Rand district) and tungsten (Atolia district) in southern California came from vein deposits in the Rand Mountains in the northern Mojave Desert about 170 mi northwest of the study area in a geologic setting that is similar in some respects to that of the Chuckwalla Mountains (see Hulin, 1925; Powell, 1981). Other important historical production of gold in the region has come from veins in Mesozoic plutonic and pre-middle Mesozoic country rocks in the Cargo Muchacho and Tumco districts of the Cargo Muchacho Mountains about 60 mi southeast of the study area (Henshaw, 1942; Clark, 1970; Morton, 1977). Newly discovered large, low-grade deposits of gold in veins and disseminated in gneiss are currently being developed in the Chocolate and Cargo Muchacho Mountains, southeast of the Chuckwalla Mountains. Scheelite also occurs in quartz veins in the Chocolate and Cargo Muchacho Mountains (Bateman and Irwin, 1954; Clark, 1970).

Molybdenite occasionally has been reported to occur in veins in the Transverse Ranges province, but it is rarely cited as a resource. However a northwest-trending belt of stockwork and porphyry molybdenum deposits have been documented or inferred in Mesozoic plutonic rocks about 100 mi northeast of the Eagle Mountains (see Eidel and others, 1968; Lockard and others, 1980; Light and others, 1983).

Gold and silver

Small amounts of gold have been produced from mines in the Chuckwalla Mountains outside the wilderness study area. Recorded gold production from these mines totals 1829 oz. Gold-bearing rock is present at these mines and numerous other mines and prospects both within and outside the boundaries of the study area. Although additional resources are thought to exist at these mines, the distribution and grade of ore in the quartz veins and zones of bleached and limonite-stained rock are highly variable, and the ore-bearing veins and zones themselves tend to be thin and discontinuous. Consequently, quantitative assessment of grade and tonnage would require drilling and detailed geologic and geochemical studies beyond the scope of this investigation.

In areas--such as parts of Red Cloud Canyon, Irish Wash, and the northwestern corner of the Chuckwalla Mountains--where a third or more of assays on systematically collected vein samples show gold, or where silver is detected in the nonmagnetic heavy-mineral fraction of stream-sediment samples, we assign a high potential for the presence of undiscovered gold resources in quartz veins or shear zones (fig. 4). In areas--such as parts of the vicinity of Corn Springs Wash--where less than a third of assays on vein samples show gold, we assign a moderate potential. In areas--such as along the southwest margin of the Chuckwalla Mountains Wilderness Study Area including Red Cloud Canyon and along a belt from the northwest to southeast corners of the wilderness study area including most of Corn Springs Wash--characterized by the presence of mafic dikes, but where gold is rare in assayed vein samples or where field observations did not indicate a need for assay data, we assign a low to moderate potential.

Although any undiscovered gold deposits in the study area are likely to be similar in size and grade to those already known, the presence of much larger deposits in the subsurface, such as those in the Rand, Cargo Muchacho, and Chocolate Mountains, cannot be ruled out.

Small amounts of silver have been produced from mines in the Chuckwalla Mountains as a byproduct of gold mining. Total silver production recorded for the study area and immediate vicinity is 519 oz. Silver was detected in assays of fewer samples than was gold. Potential for the presence of undiscovered silver resources parallels, and is incidental to, the potential for gold resources.

Tungsten

Small amounts of tungsten are reported to have been produced in the range (Bateman and Irwin, 1954) and a few extant claims are for tungsten. In addition, tungsten was detected in assays of samples collected at mines and prospects throughout the study area, although it is sporadic in its occurrence, and, generally, assayed concentrations are low.

We assign a high potential for undiscovered tungsten resources in vein deposits to areas--such as parts of Red Cloud Canyon and the south margin of the wilderness study area--that characterized by high tungsten concentrations (greater than 700 ppm) in the nonmagnetic heavy-mineral fraction of stream-sediment samples (fig. 3). In areas--such as parts of the southwest margin of the wilderness study area and parts of Corn Springs Wash--where stream-sediment tungsten concentrations fall in the range from 100 ppm to 700 ppm, we assign a moderate potential. Areas where stream-sediment tungsten concentrations are 100 ppm or less are also characterized by the absence of mafic dikes, and thus are areas in which we have recognized no evidence of a potential.

The lack of significant tungsten production from the Chuckwalla Mountains, together with the relatively low tungsten concentrations detected in vein samples, are consistent with the presence of widespread small, low-grade vein deposits. However, by analogy with the vein scheelite deposits in the Atolia district of the Mojave Desert, it is the possible that larger and higher-grade subsurface deposits are present.

Molybdenum

There are no identified molybdenum deposits in the wilderness study area. However, the high concentrations of molybdenum detected in stream sediment samples from the Chuckwalla Mountains indicate that undiscovered occurrences of molybdenum-bearing minerals are likely in parts of the wilderness study area, especially along the southwest margin of the wilderness study area including Red Cloud Canyon and along Corn Springs Wash.

We assign a high potential for the presence of undiscovered molybdenum resources to areas that are characterized by high concentrations of molybdenum (greater than 70 ppm) in the nonmagnetic heavy-mineral fraction of stream-sediment samples (fig. 3). Where stream-sediment molybdenum concentrations fall in the range from 10 ppm to 70 ppm, we assign a moderate potential. Areas where stream-sediment molybdenum concentrations are 10 ppm or less are also characterized by the absence of mafic dikes, and thus are areas in which we have recognized no evidence of a potential. If tungsten is inferred to be a pathfinder for subsurface molybdenum deposits, as it is in many of the world's large molybdenum deposits, then areas with high potential for the presence of tungsten resources may also be considered to have high potential for the presence of molybdenum resources.

Evidence for molybdenum mineralization in the study area occurs in and around the same vein system as evidence for tungsten, gold, and silver mineralization. Furthermore, although the association of molybdenum, tungsten, and fluorine is consistent with derivation from a felsic igneous source, at the present level of exposure, the mineralized vein system is spatially associated with swarms of mafic dikes rather than with swarms of more abundant felsic dikes. By analogy with many of the world's large molybdenum deposits, potential molybdenum resources in the study area are likely to occur in deposits large enough to be significant only if the host quartz veins and shear zones are manifestations of an extensive subsurface quartz-vein stockwork system. Because the stream-sediment geochemical results are consistent with, but do not demonstrate, the presence of an extensive stockwork system, more detailed mineralogical and geochemical studies are needed to evaluate the likely form and content of potential molybdenum resources in the Chuckwalla Mountains.

Copper and lead

Small amounts of lead were produced at some mines in the Chuckwalla Mountains as a byproduct of gold mining. In addition, copper and lead were detected in assays of samples collected at mines and prospects throughout the study area. These elements are distributed sporadically and, generally, their assayed concentrations are low. In and around the wilderness study area, evidence for copper and lead mineralization tends to be found in areas characterized by gold, silver, tungsten, and molybdenum mineralization. Consequently, we assign a low potential for the presence of undiscovered copper and lead resources in small vein deposits to all areas with potential for gold, silver, tungsten, or molybdenum resources.

Tin and thorium

Tin and thorium concentrations in some panned concentrates from stream-sediment samples in the Chuckwalla Mountains are anomalously high--typically by one or two orders of magnitude--compared with values detected in panned concentrates from other areas of the Transverse Ranges (see, for example, Obi and others, 1984). However, the principal ore minerals of tin and thorium--cassiterite and monazite, respectively--have not been observed microscopically in panned concentrates from the Chuckwalla Mountains, nor have bedrock sources for these elements been ascertained. Sphene or allanite, either of which could be of plutonic or pneumatolytic origin, are possible sources for both tin and thorium, although these minerals from the Chuckwalla Mountains have not been analyzed. Comparison of geochemical data for stream-sediment samples from the Chuckwalla Mountains with those for samples from the nearby Eagle Mountains (Powell and others, 1984)--where identical rocks are exposed--shows that elevated concentrations of tin are derived from areas underlain both by the Precambrian granite gneiss of the Joshua Tree terrane and Mesozoic granitic rocks. This observation is consistent with deposition of tin in a crosscutting mineralizing system. Therefore, we assign a low potential for the presence of undiscovered tin and thorium resources in small vein deposits to the north part of the wilderness study area; in the south part, we have found no evidence of a potential for tin or thorium resources.

Oil and gas

The alluvial basin flanking the northern half of the study area is largely leased and under application for leases for oil and gas. Locally, these leases extend into the crystalline rocks that underlie the study area. We have found no evidence of a potential for oil or gas resources in or under the igneous and metamorphic rocks of the wilderness study area.

Sand, gravel, and stone

Sand, gravel, and crystalline rocks suitable for construction purposes are abundant in the study area, but similar or better grade material is abundant and accessible in the region outside the study area.

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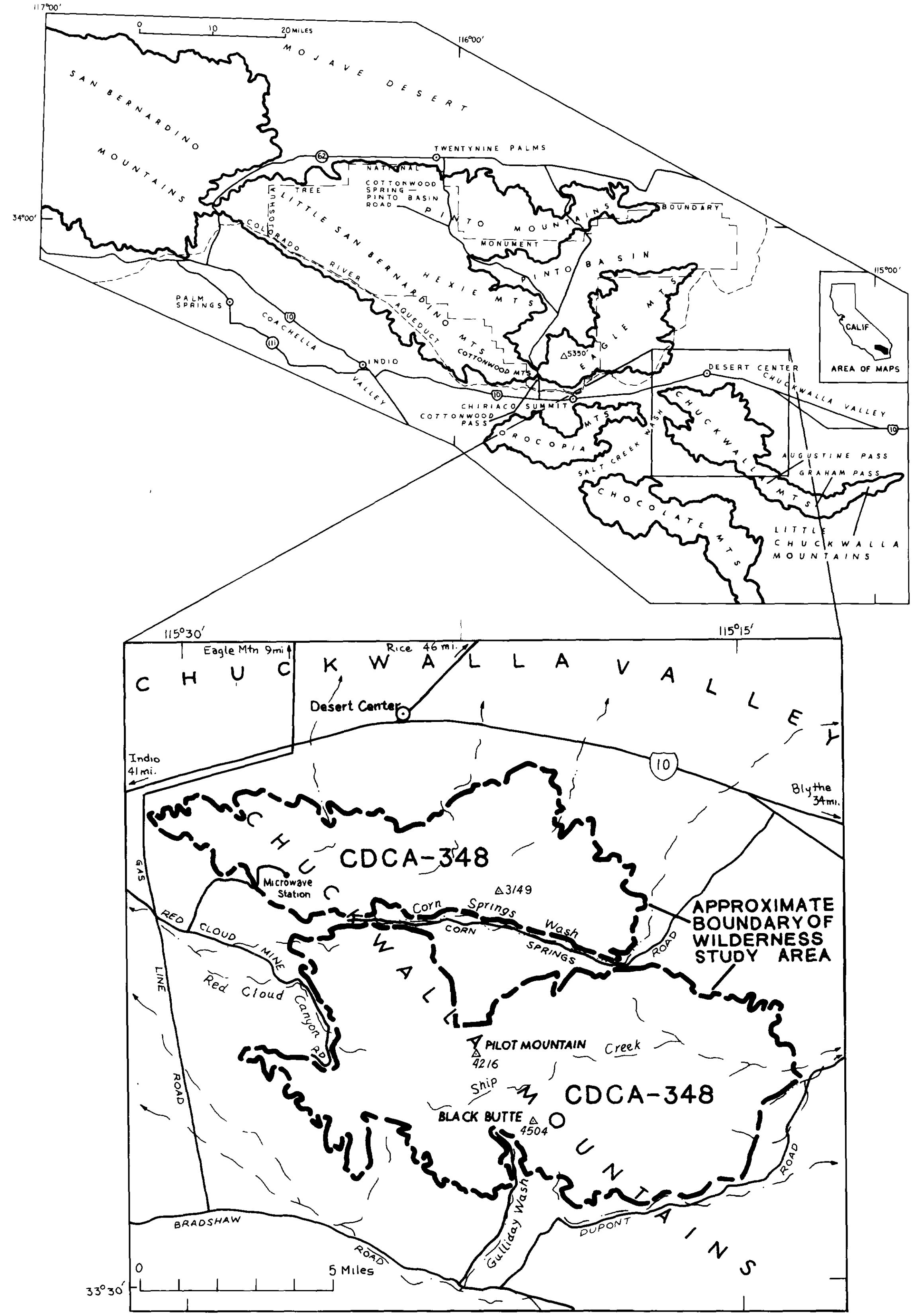
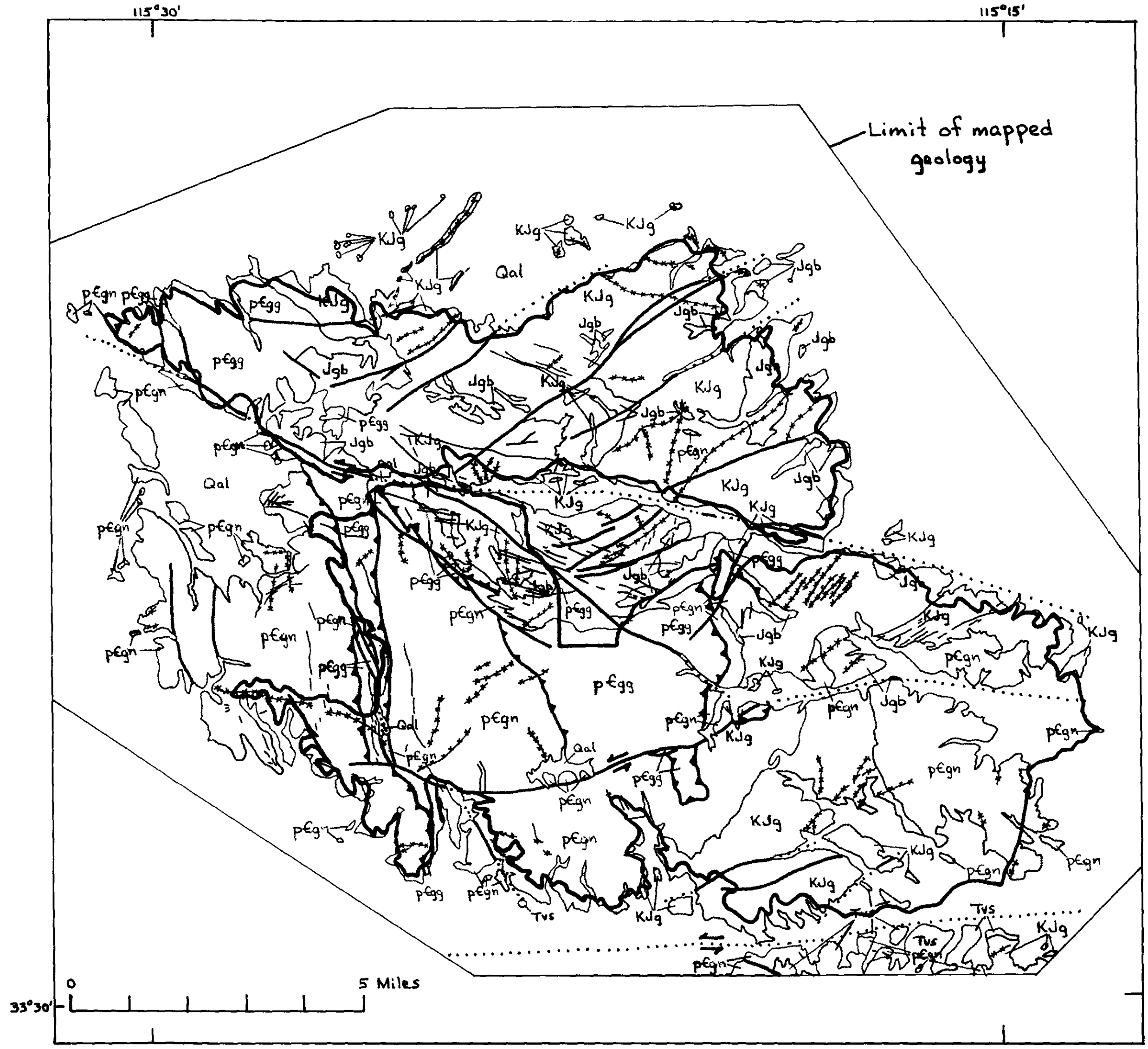


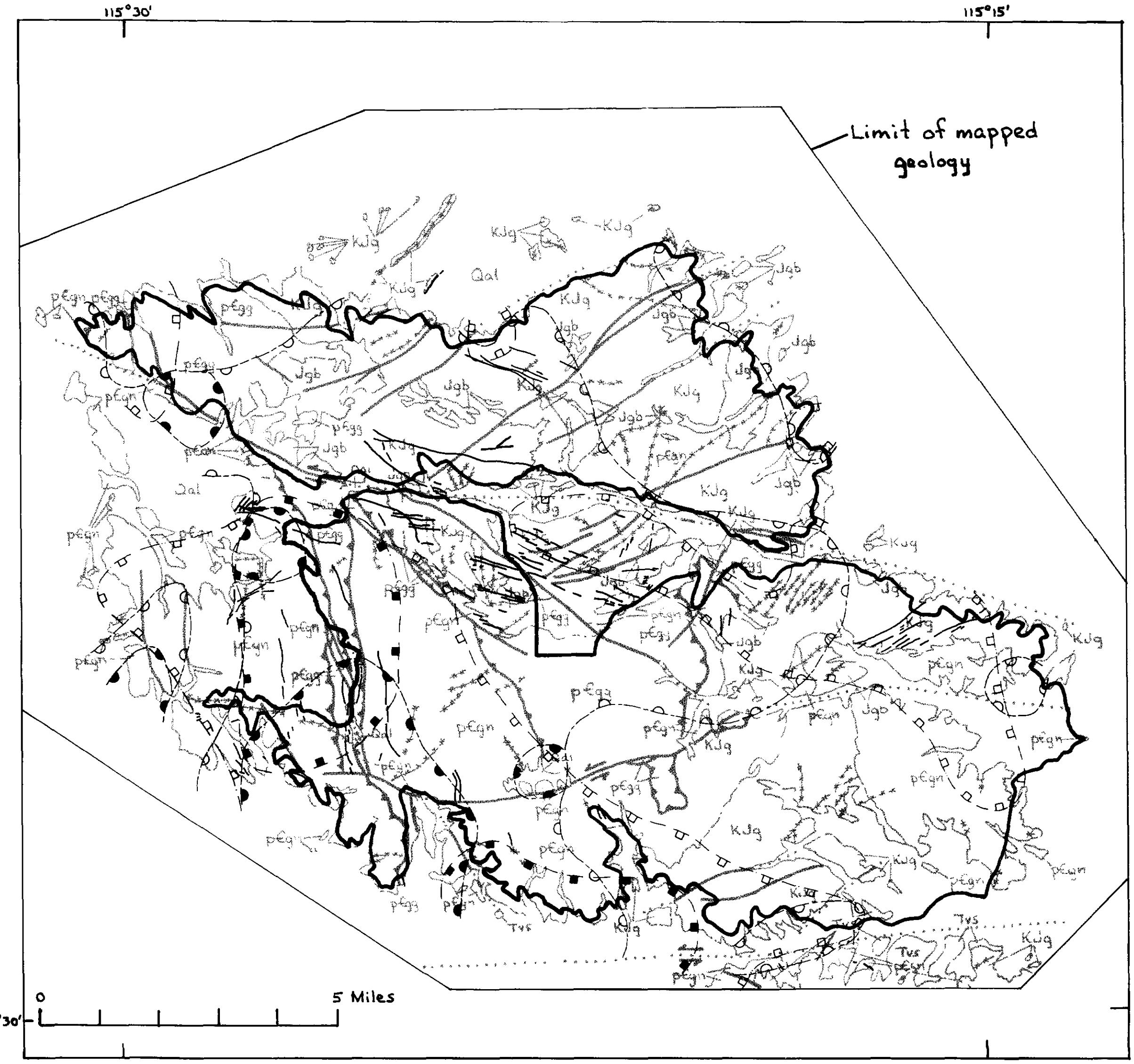
Figure 1.--Index maps showing location of the Chuckwalla Mountains Wilderness Study Area (CDCA-348), California Desert Conservation Area, Riverside County, Calif.



EXPLANATION

Qal	Alluvium (Quaternary)
Tvs	Volcanic and sedimentary rocks (Tertiary)
KJg	Granitic rocks (Cretaceous and (or) Jurassic)
Jgb	Gabbro and diorite (Jurassic)
p€gn	Gneiss and plutonic rocks of San Gabriel terrane (Precambrian)--Metasedimentary gneiss, orthogneiss, and syenite-mangerite-jotunite
p€gg	Granite gneiss of Joshua Tree terrane (Precambrian)
	FELSIC DIKES (Tertiary, Cretaceous, and (or) Jurassic)
	MAFIC DIKES (Tertiary, Cretaceous, and (or) Jurassic)
	CONTACT
	HIGH-ANGLE FAULT OR FRACTURE--Dotted where covered; arrows indicate relative movement
	RED CLOUD THRUST FAULT--Sawteeth on upper plate
	APPROXIMATE BOUNDARY OF WILDERNESS STUDY AREA

Figure 2.--Geologic map of the Chuckwalla Mountains Wilderness Study Area, Calif.



EXPLANATION

AREAS WITH POTENTIAL FOR UNDISCOVERED TUNGSTEN AND MOLYBDENUM RESOURCES --Delineated on basis of elemental concentrations in nonmagnetic heavy-mineral fractions of stream-sediment samples. Resources probably occur in vein deposits

TUNGSTEN

High potential (concentration greater than 700 ppm)--Teeth on side of higher concentration

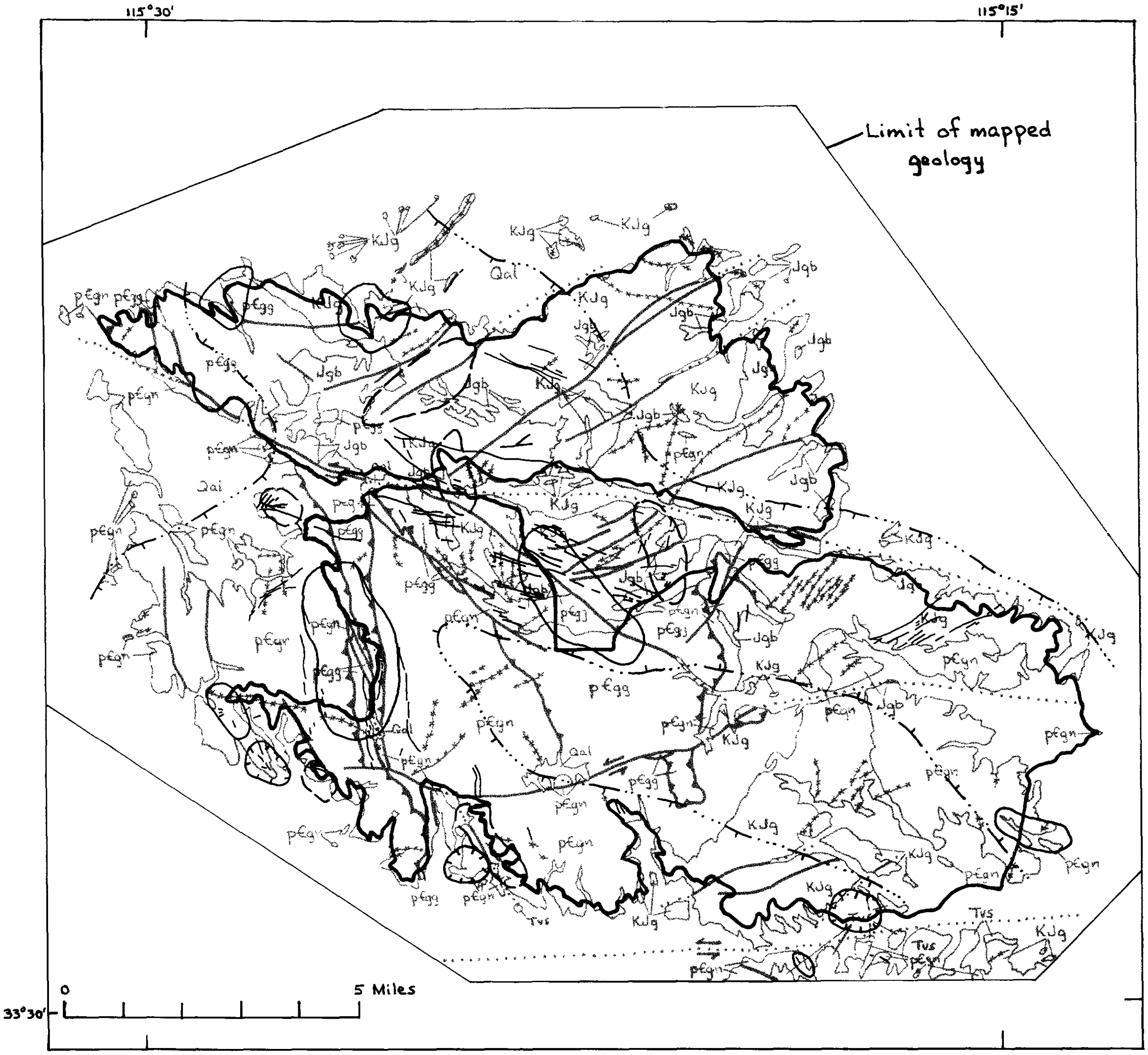
Moderate potential (concentration greater than 100 ppm)--Teeth on side of higher concentration

MOLYBDENUM

High potential (concentration greater than 70 ppm)--Teeth on side of higher concentration

Moderate potential (concentration greater than 10 ppm)--Teeth on side of higher concentration

Figure 3.--Areas having potential for undiscovered tungsten and molybdenum resources, Chuckwalla Mountains Wilderness Study Area, Calif. For explanation of geologic units and symbols, see figure 2.



EXPLANATION

AREAS WITH POTENTIAL FOR UNDISCOVERED GOLD AND SILVER RESOURCES

High potential--Delineated on basis of assay values (smooth line) or silver concentrations in nonmagnetic heavy-mineral fractions of stream-sediment samples (hachured line)

Moderate potential--Delineated on basis of assay values

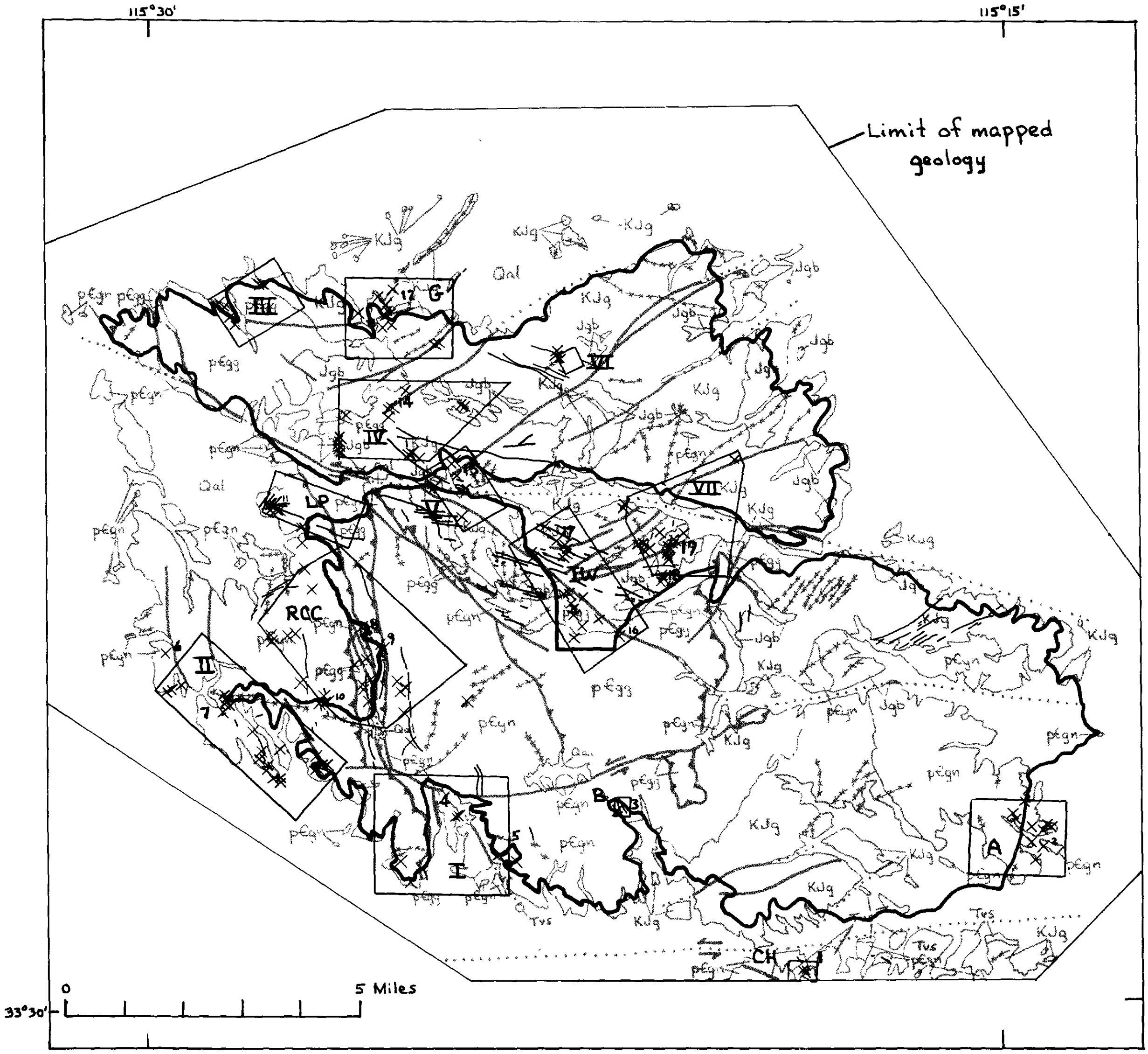
Low to moderate potential--Delineated on basis of proximity to mafic dikes and a lack of geochemical evidence for moderate or high potential; barbs on side of higher concentration

AREAS WITH POTENTIAL FOR UNDISCOVERED COPPER AND LEAD RESOURCES--Low potential in all areas that have moderate or high potential for gold, silver, tungsten, or molybdenum resources (also see fig. 3)

AREA WITH POTENTIAL FOR UNDISCOVERED TIN AND THORIUM RESOURCES--Low potential in the north part of the wilderness study area

X MINE OR PROSPECT--Numbered mines identified in figure 5

Figure 4.--Areas having potential for undiscovered gold, silver, copper, lead, tin, and thorium resources, Chuckwalla Mountains Wilderness Study Area, Calif. For explanation of geologic units and symbols, see figure 2.



EXPLANATION

MINERALIZED AREAS

A	Aztec mine	IW	Irish Wash
B	Beal mine	LP	Lost Pony mine
CH	Cap Hunter mine	RCC	Red Cloud Canyon
G	Granite mine	I-VII	Numbered areas referred to in text

× MINES AND PROSPECTS--Numbers indicate mines referred to in text

1	Cap Hunter mine	11	Lost Pony mine
2	Aztec mine	12	Granite mine
3	Beal mine	13	Gold Crown (San Diego) mine
4	Mine with unknown name	14	Gold King mine
5	Liberation(?) mine	15	Lucky strike mine
6	Model mine	16	Triangle (Pilot) mine
7	Echo Valley mine	17	C.O.D. mine
8	Red Cloud mine	18	Bryan mine
9	Great Western mine	19	Mine with unknown name
10	Eureka mine		

Figure 5.--Mines, prospects, and mineralized areas in the Chuckwalla Mountain Wilderness Study Area, Calif. For explanation of geologic units and symbols, see figure 2.