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MINERAL RESOURCE POTENTIAL OF THE EAGLE MOUNTAINS WILDERNESS STUDY AREA (CDCA-334), 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 Eagle Mountains Wilderness Study Area (CDCA-334), California Desert Conservation Area, Riverside County, California.

SUMMARY

Geologic, geochemical, and geophysical investigations and a survey of mines and prospects indicate that those parts of the Eagle Mountains Wilderness Study Area (chiefly in the northwest half) that are intruded by propylitically altered mafic dikes or intermediate, hornblende porphyry 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. High stream-sediment concentrations of molybdenum 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 throughout 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, geochemical, and geophysical 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 known 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 indirect techniques (aeromagnetic and stream-sediment geochemical surveys). 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 resources (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 Eagle Mountains Wilderness Study Area consists of about 78 mi^2 in the southeastern and east-central part of the Eagle Mountains, Riverside County, Calif. (fig. 1). The western boundary of the wilderness study area abuts Joshua Tree National Monument, the northern boundary skirts the most productive part of the Eagle Mountains mining district, and parts of the southern and eastern boundaries follow the Colorado River aqueduct. Principal access to the interior of the wilderness study area is provided by jeep trails in Big Wash and an unnamed, major north-draining wash in the western part of the study area.

The Eagle Mountains lie just north of Interstate Highway 10 between its intersection with the Cottonwood Spring-Pinto Basin Road and Desert Center,

[1]Resource--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.

approximately 170 mi east-southeast of Los Angeles. The range, covering an area of about 250 mi^2, rises abruptly from Pinto Basin to the north and from Chuckwalla Valley to the east and south. Bajadas exist along the eastern and northwestern flanks of the range. To the west, the Eagle Mountains merge with the Cottonwood Mountains at Cottonwood Pass. The highest peak in the Eagle Mountains, at 5,350 ft, is situated in the south-central part of the range north of Chiriaco Summit. At the base of the range, the desert floor ranges in elevation from about 1,100 to 2,000 ft. The Eagle Mountains are transected by linear features that consist of segments of drainages aligned along the traces of east-west trending faults. Big Wash, which drains east in the southeastern part of the range, is the largest of these fault-controlled drainages.

The Eagle 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, Orocopia, Chuckwalla, and Little Chuckwalla Mountains.

GEOLOGY

Rocks of the Eagle 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 Eagle Mountains also crop out in other parts of the crystalline basement complex of the Chuckwalla, Orocopia, 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 interfingers with pelitic and feldspathic granofels units. Dolomite occurs locally in the section. 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.

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 Eagle

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. All of these units are exposed in the Eagle Mountains.

Swarms of felsic, intermediate, and mafic dikes crosscut plutons of both batholithic suites in the Eagle, Chuckwalla, 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 development 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 out extensively in mountain ranges south of the Eagle 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 southern Chuckwalla and central Orocopia Mountains.

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 Eagle Mountains on the north and south and faults within the range.

The chief economic mineral occurrences in the Eagle Mountains were the recently abandoned iron deposits in the Eagle Mountain mine area of the northeastern part of the range. These iron deposits have usually been interpreted as skarns developed by metasomatic replacement of dolomite during intrusion by plutonic rocks of the older batholithic suite (Harder, 1912; Hadley, 1945; Dubois and Brummett, 1968), although stratigraphic relations are consistent with the iron having been derived from the sedimentary rocks rather than the plutonic rocks (Powell, 1981). Whatever the origin, the combination of appropriate host rocks and Jurassic intrusive rocks plunges southward beneath the wilderness study area. If present at all, any iron deposits in the study area would lie beneath thousands of feet of overburden.

Gold, silver, tungsten, molybdenum, copper, and lead minerals in the Eagle 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, 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 either propylitically altered mafic dikes or relatively unaltered hornblende porphyry dikes (fig. 2). Mafic or intermediate dikes occur in the immediate vicinity of most mines and prospects both in Precambrian and Mesozoic crystalline rocks of the range. Mineralization at least in part postdates emplacement of the dikes, although the length of time between emplacement of the dikes and mineralization has not been established. Similar relations are observed nearby to the south in the Chuckwalla Mountains (Powell and others, 1984).

Within the Eagle Mountains, altered mafic dikes occur in small swarms that strike approximately west-northwest or north-northwest. The mafic dikes vary in dip from vertical to subhorizontal. Hornblende porphyry dikes strike northeast and are steeply dipping.

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 hornblende porphyry dikes are roughly andesitic in composition and are characterized by 1- to 5-mm prismatic hornblende phenocrysts in a dark-gray aphanitic matrix. The intermediate hornblende porphyry dikes are relatively unaltered. At one locality in the north-central part of the range, the two lithologic varieties appear to grade into one another in a single dike. Locally, the altered mafic dikes are pervasively foliated parallel to their contacts.

The mafic dikes are usually nonresistant, whereas the intermediate hornblende porphyry dikes tend to be resistant. Both are typically 2 to 15 ft thick and both exhibit continuity of up to thousands of feet along strike, but poor exposure and faulting generally make the altered mafic dikes difficult to map.

Among the hypotheses that can be proposed to explain the spatial association between the mafic and intermediate dikes and the presence of mineralization is: In the final stages of or after their emplacement and cooling, the mafic and intermediate dikes 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 Eagle 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 at least 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 or intermediate dikes and evidence for mineral concentrations forms a basis for evaluating mineral resource potential.

GEOCHEMISTRY

Sediment in dry stream courses was sampled at 78 sites in and near the study area. Samples were composites, taken across what appeared to be the most recently active stream channel at each site. Two fractions were prepared from each sample: a minus-80-mesh (less than 0.18 mm) sieved fraction of bulk sediment and a nonmagnetic heavy-mineral fraction of panned concentrate. Sample fractions were analyzed using a semiquantitative emission spectrographic method (Grimes and Marranzino, 1968): concentrations of 29 elements were determined in the nonmagnetic heavy-mineral fractions and 31 elements in the sieved bulk-sediment fraction. Visual examination under a binocular microscope was made on unground splits of 46 nonmagnetic concentrates to determine the identity and relative proportions of minerals present in the samples. Confirmatory tests, mainly by X-ray diffraction, were made to aid identification.

The principal heavy minerals present in the nonmagnetic concentrates are, in order of average abundance, zircon, sphene, and apatite. Other minerals present, generally only as traces, include anatase in 25 samples, fluorite in 17, rutile in 30, and scheelite in 19. Except for pyrite in 5 samples, no sulfide minerals were seen. Traces of limonite were seen in 18 samples. Cassiterite, monazite, and allanite were not identified.

Anomalously high concentrations of metallic elements, which may occur in sulfides or in the observed limonite, were detected in several samples. Lead was detected in all nonmagnetic heavy-mineral fractions. Fifteen samples containing 300 parts per million (ppm) or more of lead appear to form a discrete population that is considered anomalous (fig. 3). Metallic lead contamination is present in samples from two additional localities. Anomalous bismuth was detected in 16 heavy-mineral fractions and silver in 4 (fig. 3). Molybdenum was detected in 27 heavy-mineral fractions: in 12 of these, molybdenum may occur as a minor constituent of scheelite; in the remaining 15 samples (contoured in fig. 4), in which the ratio of tungsten to molybdenum is 15 or less, molybdenum may be derived from molybdenite. One concentration of cobalt, two of copper, and one of vanadium were detected at levels that lie above the normal range of concentrations for these elements.

Anomalously high concentrations of tungsten were detected in 48 heavy-mineral fractions in amounts ranging from less than 100 ppm to 5,000 ppm (contoured in fig. 4). Scheelite was identified in the unground splits of most of these samples, including all samples that contained 150 ppm or more.

Tin was detected in the heavy-mineral fractions of 57 samples in amounts ranging from less than 20 ppm to 2,000 ppm, and in one sieved bulk-sediment fraction at 100 ppm and in three at 15 ppm; whereas niobium was detected in 74 heavy-mineral fractions in amounts ranging from less than 50 ppm to 300 ppm. In heavy-mineral fractions of most of the samples, tin occurs in amounts that are one-half or less of the amounts of niobium present: consequently, tin and niobium are believed to occur for the most part as minor constituents of titanium-bearing minerals such as sphene, rutile, and anatase. In 11 occurrences shown as anomalous in figure 3, the amounts of tin present equal or exceed the amounts of niobium. The 6 occurrences containing 300 ppm or more tin are the most significant because they correspond to samples containing only small amounts of titanium-bearing minerals and low analytical values for titanium. Although the mineral has not been identified, it appears likely that these 6 samples contain small amounts of cassiterite. Three sieved-sediment fractions that each contain 15 ppm tin are from localities that also yielded anomalously high tin concentrations in the heavy-mineral fractions. A sample from another locality with 100 ppm tin in the bulk-sediment fraction contained only 30 ppm in the heavy-mineral fraction but is shown as anomalous in figure 3.

Thorium, lanthanum, and yttrium were detected in elevated concentrations in several samples. Lanthanum and yttrium were detected in both fractions of all samples, whereas thorium was detected in 6 sieved-sediment fractions and 66 nonmagnetic heavy-mineral fractions. One or more of these three elements are likely to occur in some of the more common minerals identified in heavy-mineral fractions from the Eagle Mountains, including apatite, fluorite, sphene, and zircon. Thorite was identified in one of these samples. Monazite or allanite, as possible sources for the relatively large amounts of thorium, lanthanum, and yttrium, were not identified. Although thorium is widely distributed in nonmagnetic heavy-mineral fractions from throughout the study area, samples containing the greatest amounts are largely confined to drainages that tap Mesozoic granitic rocks. Samples from drainages in the Joshua Tree terrane contain lesser amounts of thorium or are barren, whereas those from the San Gabriel terrane contain at the most only very small amounts of thorium.

The geochemical data from stream sediments indicate that the most favorable areas within the wilderness study area for the occurrence of metallic sulfide minerals as well as for tungsten and tin minerals are confined largely to the granite gneiss of the Joshua Tree terrane where it is intruded by altered mafic or hornblende porphyry dikes (fig. 2). The Mesozoic granitic rocks appear to be more favorable for the occurrence of thorium minerals. A similar geochemical signature crosscuts additional Precambrian and Mesozoic units to the south of the study area in the nearby Chuckwalla Mountains where mafic dikes are more extensively exposed (Powell and others, 1984).

GEOPHYSICS

Aeromagnetic data were obtained from surveys flown by Fairchild Aerial Surveys, Inc. for a division of U.S. Steel Corp. in 1954 and by High Life-QEB in 1981 (U.S. Geological Survey, 1983). The U.S. Steel surveys were flown at one time with an average spacing of 0.25 mi but in a piece-meal fashion; the two pieces that cover the study area were flown at 3,750- and 3,000-ft barometric altitudes, and were oriented roughly east-west and north-south, respectively. Only a very small portion of the 1981 High Life-QEB survey overlaps the wilderness study area on the south. This survey was flown east-west at 0.5-mile spacing 1,000 ft above ground. Gravity data available from the U.S. Department of Defense master gravity file (NOAA National Geophysical Data Center) are too sparse in the Eagle Mountains to aid in resource assessment.

The U.S. Steel surveys were analytically draped 1,000 ft above ground and constant datums removed so that they could be merged with the High Life-QEB survey into one larger, coherent data set (fig. 5). In level surveys, the plane flies closer to the tops of mountains than to the bottoms of valleys so that small magnetic sources on mountaintops are enhanced and those in valleys may be lost. By analytically draping the data, anomalies on mountaintops will look similar to those in valleys (if the sources are similar). Draped data, however, deepen the lows due to valleys when compared to level data (Grauch and Campbell, 1984).

The high relief of the study area lends itself to identification of geologic units magnetically. High-relief topography composed of uniformly magnetized rocks causes positive anomalies that, although shifted due to the polarity of the Earth's field, approximately mirror the topographic shapes (considering induced magnetization only). Therefore, coherent magnetic units are indicated where there is a correspondence between topographic and aeromagnetic highs. Rocks that lack magnetization, because of primary composition or later destruction by alteration, can be determined by general lack of aeromagnetic character over rugged areas or by aeromagnetic lows that correspond to topographic highs.

Of the geologic units mapped in the area, Jurassic gabbroic and dioritic intrusive rocks show the strongest magnetic signature (fig. 5), owing to their mafic composition and their occurrence in relatively large bodies. Large positive aeromagnetic anomalies (A, fig. 5) that occur over several individual outcrops in the extreme northwestern corner of the study area and continue just outside the boundary show that these outcrops are part of one large coherent body. A major aeromagnetic high (B, fig. 5) that is located just south of the southeast corner of the study area corresponds to exposed gabbro but also extends out into the valley, suggesting the presence of a large body of gabbro under alluvium in the valley. Another large aeromagnetic anomaly (C, fig 5) near the northeastern border of the area suggests that the exposed gabbro is only a small part of a much larger body below the surface.

Exposed gabbro unexpectedly lacks aeromagnetic signature in a few places because (1) the subsurface extent of the intrusion is too small, and (or) (2) the magnetization of part or all of the rock has been destroyed by alteration. Alteration is the more likely explanation for the lack of signature over the massive outcrop of gabbro in the north-central part of the area (D, fig. 5), which is south of the Rainbows End mine. Alteration may also be the cause of the broad aeromagnetic low (E, fig. 5) partially covering syenite-mangerite-jotunite of the Precambrian San Gabriel terrane and gabbro in the east-central part of the study area.

The granite gneiss of the Joshua Tree terrane is exposed extensively in the Eagle Mountains. Its aeromagnetic signature suggests that the gneiss is somewhat magnetic because of its correlation to topography in many places. In the Eagle Mountains, the large aeromagnetic high (F, fig. 5) near the center of the western border of the study area generally correlates with a mountain made up of the granite gneiss. However, farther down the mountain into the valley where a granodioritic subunit of the Jurassic and (or) Cretaceous granitic rocks crops out, the correlation ceases, suggesting that this anomaly is a combination of effects from the granite gneiss and the granodiorite.

There are also large areas of broad aeromagnetic lows (G, H, fig. 5) over high-relief topography of granite gneiss, indicative of loss of magnetization or a primary compositional difference in the gneiss itself. The latter reasoning is unlikely because of general homogeneity in the mapped unit. These lows flank the major aeromagnetic high at F (fig. 5) on the north and south. On the north, the low (G, fig. 5) crosses a ridge in the vicinity of altered mafic and (or) hornblende porphyry dikes and continues down into the valleys on either side of the ridge. Aeromagnetic lows in the valleys are to be expected even with magnetic rocks so that a lack of magnetization cannot be conclusively attributed to valley rocks.

The southern low (H, fig. 5) covers a broad area that extends across the northwestern side of the large anomaly attributed to gabbro (B, fig. 5). It extends eastward into the Big Wash, where it is again indistinguishable from normal valley effects, but may also extend farther east, joining the low (E, fig. 5) over the gabbro and San Gabriel terrane discussed earlier.

A sharp aeromagnetic low (I, fig. 5) follows a mapped fault along the west side of the large granite gneiss aeromagnetic high. This negative anomaly may be due to alteration along the fault, valley effects, or a combination of both.

The mafic and intermediate dikes associated spatially with geologic and geochemical evidence for mineralization are generally too thin to be detected in the aeromagnetic data. However, the lack (or loss) of magnetization over broad areas as suggested in the preceding paragraphs may be related to alteration in and around the dikes. Indeed, there is a spatial correlation between aeromagnetic lows (D, G, H, J, fig. 5) that are or may be caused by a loss of magnetization and anomalous geochemical values and the presence of mafic or intermediate dikes (compare fig. 5 with figs. 2, 3, 4, and 6). The large broad low at E (fig. 5) is the only exception.

MINING DISTRICTS AND MINERALIZATION

Field examination of known mineral deposits and mineralized areas in and near the Eagle Mountains Wilderness Study Area were conducted by Bureau of Mines personnel during December 1981 and in February and September 1982 (McColly, 1983). This study included reconnaissance of all mines, mining claims, prospects, and mineralized areas inside or within a mile of the study area boundary (fig. 6; table 1 on accompanying map).

During the investigation, 33 samples were taken. All were fire-assayed for gold and silver, which have lower detection limits of 0.005 oz/ton and 0.02 oz/ton, respectively. Additional analyses by appropriate methods were made when minerals containing other metals were seen or suspected. Selected samples were analyzed spectrographically for 42 elements to ensure that anomalous contents of other, unanticipated elements were not overlooked.

The results of all analyses are available for public inspection at the U.S. Bureau of Mines, Intermountain Field Operations Center, Denver Federal Center, Denver, CO 80225.

Mining activity

Although early mining and prospecting in the Eagle Mountains chiefly yielded gold, by far the greatest resource has been iron. Both placer and lode gold deposits, mostly small, were being developed by the late 1800's, although some of the gold and iron deposits may have been discovered as early as 1865 (Vredenburg and others, 1981). Roads and scattered mine workings give evidence that these activities took place in the study area; however, nearly all workings found appeared to be old and abandoned.

U.S. Bureau of Land Management records show three mining claims filed within the study area, but no leases or permits for oil, gas, or other minerals have been issued for lands either in or near the area. Although courthouse records indicate a dozen or so other claims were located within the study area, few of these can be located in the field from their descriptions or matched to existing workings. None of the three claims filed with the Bureau of Land Management for 1981--the Shooting Star No. 1, the Little Storm-Jade Mountain, or the Independence No. 2--was active when visited, or appeared to have been worked recently.

Mining districts and mineralized areas

All mines and prospects in the Eagle Mountains are included in the Eagle Mountain mining district, though nearly all of the district mineral production came from properties in the north end of the range outside the study area.

Iron, gold, lead, silver, copper, jade, and roofing granules have been produced in the district. Of these, only gold is known to occur within the study area; however, the deposit mined for roofing granules on the Little Storm-Jade Mountain claim may extend inside the area for a short distance. The material is not exposed, and no attempt has been made to test or develop this possible extension.

Southern Eagle Mountains area

Most of the gold prospects found within the Eagle Mountains Wilderness Study Area are in the southern part of the Eagle Mountains, and all but two are south of Big Wash. Samples were taken in unsurveyed secs. 19 and 20, T. 5 S., R. 14 E., near Hayfield Summit Spring to test a reported anomalous area, but no gold was detected in assays.

Golden Eagle mine. About 1 mi inside the south boundary of the study area, several small and shallow workings at the Golden Eagle mine (no. 1, fig. 6) explore northeast-striking shear zones in monzogranite. The shear zones are exposed for a distance of about 600 ft. Workings include an inclined shaft and an adit, both caved, near the base of a hill at the east end of the exposure; a 50-ft adit with a stope to the surface at the west end, near the hilltop; and several short adits, trenches, open cuts, pits, and dumps along the exposed shear zones.

An ounce of gold from the Golden Eagle mine reported in 1941 is the only recorded production from the study area. Of 6 samples taken, 3 had detectable gold and two of these were taken at the edges of the stope. The highest gold value obtained was from a 1.0 ft chip sample containing 0.236 oz gold per ton. No resources are identified, but low-tonnage, low-grade gold resources may be present in the subsurface.

Shooting Star No. 1. The Shooting Star No. 1 prospect (no. 2, fig. 6) is located in the south-central part of the study area. The highest gold assay obtained during this study, 1.034 oz gold per ton, was taken on this prospect from a narrow, 1- to 4-in wide, north-striking, vertically dipping vein in granite. Other samples with gold from this property ranged in value from 0.026 to 0.926 oz gold per ton. Gold apparently is confined to the vein, as adjoining wallrock samples assayed below the detection limit for gold. The vein is exposed to a depth of about 25 ft in a vertical shaft, and for about 50 ft along the surface. Exposures of similar structures 150 to 250 ft northeast, may be offset or parallel structures.

A sample taken from a stockpile containing hand-sorted vein material, probably from the shaft, assayed 0.042 oz gold per ton, indicating that values from the vein are quite variable. The gold assay values available are too few, too widely spaced, and too erratic to calculate any meaningful resource tonnage for the property. Owing to the narrowness of the vein, only a few tons of gold-bearing material can be inferred; there is no evidence that the vein widens either at depth or along strike.

Lucky Dollar prospect. A shear zone in coarse-grained monzogranite strikes S. 25° E. and dips 33° NE. at the Lucky Dollar prospect (no. 3, fig. 6), 1/2 mi southeast of the Golden Eagle mine. The main working is a 179-ft adit that explores this zone for 154 ft, then doubles back on a bearing of N. 2° W. for 25 ft along a set of intersecting fractures. A small pit exposes the surface intersection of the shear zone approximately 40 ft above the adit portal. Neither alteration nor mineralization is apparent along either the shear zone or fracture set, and there is no evidence of production. A hand-picked dump sample assayed below the detection limit for gold. No resource is indicated.

Orofino(?) prospects. The Orofino(?) prospects (no. 4, fig. 6) lie just north of Big Wash in the SW 1/4 sec. 36, T. 4 S., R. 13 E. A highly fractured and iron-oxide stained contact zone between quartzite and a felsic dike is explored by a 40- to 50-ft deep inclined shaft. About 1,200 ft east, a 10x10x5-ft pit (Orofino No. 3 claim) exposes a highly altered, sheared, and brecciated zone in schist. Assay values of 0.012 and 0.006 oz gold per ton were obtained from the shaft and pit, respectively. No resource is indicated at either site, and no production is recorded.

Unnamed prospect. A shaft, estimated to be about 20 ft deep, was found at an unnamed prospect (no. 5, fig. 6) in unsurveyed sec. 2, T. 5 S., R. 13 E.. The shaft follows a quartz vein in the gneissic country rock. A hand-picked dump sample assayed below the detection limits for gold, and neither production nor resources are indicated.

Storm Jade mine area

Storm Jade mine (no. 6, fig. 6) (Storm Sulphide, Green Giant-Long Green, Little Storm-Jade Mountain). The south half of the Little Storm-Jade Mountain claim extends into the study area, the north half and the five Storm Sulphide claims that comprise the rest of the group lie outside. The claims trend in a northwest-southeast direction along a contact zone between limestone and mafic dikes. Alteration along the contact has produced irregular bodies containing mixtures of epidote, garnet, and probably californite, a massive light-green variety of vesuvianite. The mixture results in a dense, green rock which, during the 1950's was mined and crushed for use as roofing granules that sold for $20.00 per ton (Evans, J. R., 1960, unpublished report, California Division of Mines and Geology). Most of the material sold was mined from the Storm Sulphide No. 11 claim, but some production from the north end of the Little Storm-Jade Mountain claim is indicated. Similar material may be present at the south end of the claim and within the study area, although none is exposed.

During the early 1960's, nephrite jade was discovered on the Storm Sulphide No. 2 claim (Evans, J. R., 1960, unpublished report, California Division of Mines and Geology). The amount recovered is unknown, but probably was only a few hundred pounds as the mine workings are not extensive. They consist of a 75-ft-long adit connected to the surface by a short shaft; a 15-ft-long adit; and a few other shallow workings (Evans, J. R., 1960, unpublished report, California Division of Mines and Geology).

Independence prospects (no. 7, fig. 6). A vertical shaft, estimated to be about 70 ft deep, and a shallow open cut explore S. 58° E.-striking, near-vertical shear zones in granite on the Independence No. 1 prospect, in secs. 9 and 16, T. 4 S., R. 14 E., just north of the study area boundary. Independence No. 2 prospect is within the study area. Gold was found in shear zones and small veins on the Independence No. 1 prospect, but the only workings found lie outside the study area, and there is no evidence that the mineralized structures extend south of the boundary into the Independence No. 2 prospect.

Joshua Tree National Monument area

Two unnamed gold prospects in the Joshua Tree National Monument near the western boundary of the study area were found and sampled, one in sec. 13, T. 5 S., R. 12 E. (no. 8, fig. 6), the other in sec 36, T. 3 S., R. 12 E. (no. 9, fig. 6)

A 20 ft shaft in sec. 13 explores a N. 20° E. striking, 65° E. dipping shear zone in granite.

At the prospect in sec. 36, a 30-ft-long open cut exposes a mineralized zone along a contact between an hornblende porphyry dike and granite gneiss. Gold was present in two samples, but none of the mineralized structures appears to project into the study area.

Eagle Mountain Mine area

Metal-production reported from the Eagle Mountain mining district totalled 215 million long tons of iron, 7,257 oz of gold, 14,768 oz of silver, 1.48 million lbs of lead, and 114,424 lbs of copper (U.S. Bureau of Land Management, 1982). More than 99.9 percent of this mineral value has come from Kaiser Steel Corporation's Eagle Mountain mine (U.S. Bureau of Land Management, 1982), which closed in 1982. Nearly all of the remainder was produced from the Black Eagle, Iron Chief, and Rainbows End mines, and a few other nearby properties. All are north of the wilderness study area boundary (fig. 6).

The gold and base-metal deposits occur either as replacements along carbonate rock-granite contacts or in fissure veins in either granite or metamorphic rocks (Clark, 1970, p. 157-158).

Eagle Mountain mine. The iron deposits at the Eagle Mountain mine (no. 10, fig. 6) were first claimed in early 1890's, acquired by the Southern Pacific Railroad in 1908, and purchased by Kaiser Steel Corporation in 1944 (Dubois and Brummett, 1968, p. 1595). Mining began in 1948, and production continued until October 1982, when mining and processing activities ended. In late 1982, the Kaiser Steel Corporation announced the permanent closing of the property (Pay Dirt, 1983).

Iron ore occurs as bedded replacement deposits of magnetite and hematite in two main zones, 150 ft and 60 ft thick, respectively, in the north limb of a northwest-bearing anticline composed of Precambrian and (or) Paleozoic metasedimentary rocks (Dubois and Brummett, 1968, p. 1593). Huseman (1953, p. 82) stated that the anticline top and its south limb are completely missing except for a small part of the top on the south orebody. Both the south orebody and the north-limb beds dipping northward are exposed in the main pit at the mine. As the pit lies about 3 mi northeast of the study area boundary, it is apparent that no extensions of the known iron deposits occur in the study area.

Black Eagle mine. Now owned by Kaiser Steel Corporation, the Black Eagle mine (no. 11, fig. 6) was the chief producer of silver and lead in the district, operating intermittently from the time it was located in 1898 until shut down in December 1940 (Evans, J. R., 1960, unpublished report, California Division of Mines and Geology). Tucker and Sampson (1945, p. 147) estimated that the mine produced $200,000 in metal values, chiefly in lead and silver, but also some copper. Ore was mined from a 4- to 10-ft-wide quartz vein along a quartzite-diorite contact. There is no known extension of the mineralized vein into the study area.

Iron Chief mine. Located in the 1890's, the Iron Chief mine (no. 12, fig. 6) had various owners and periods of production until acquired by Kaiser Steel Corporation (Evans, J. R., unpublished report, California Division of Mines and Geology, 1960). Evans, citing Tucker and Sampson (1929), reported a total production of $150,000 in metal values from the Iron Chief mine, mostly gold, though some copper may also have been recovered. Ore was produced from a 6-ft-wide contact zone between carbonate rock and quartz monzonite (Evans, J. R., 1960, unpublished report, California Division of Mines and Geology). The N. 70° W.-trending ore zone does not project into the study area.

Rainbows End mine (Annie Laurie, Nancy). The amount of metal produced from the Rainbows End mine (no. 13, fig. 6) is unknown, but some copper, gold, and silver production was likely. Most of the mine workings are on a patented claim now owned by Kaiser Steel Corporation. Eight surrounding unpatented claims are also owned by Kaiser, and the group lies a short distance north of the study area boundary. Samples containing copper, gold, and silver were taken from the surface exposure of the main vein and from the dump. The vein strikes north on a granite-diorite contact, and dips 70°-75° W. Two shafts and several small prospects explore the vein, but much of the surrounding area has been disturbed by drill-site construction, making detailed observations difficult. No information was available concerning the results of the drilling program. A 2,000-ft southward projection of the vein would extend into the study area; however, the vein could be followed only a short distance south before it disappeared under alluvium.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Assessment criteria

Gold, silver, tungsten, molybdenum, bismuth, lead, and copper have been mobilized and concentrated in parts of the Eagle Mountains. Of these metallic elements, gold historically has been the resource most sought after in the Eagle Mountains--although iron has been the principal resource--with incidental extraction of silver, copper, and lead.

Data gathered during this reconnaissance study permit neither specification of the processes or absolute timing of mineralization in the Eagle Mountains, nor substantiation of the presence of undiscovered resources. However, from the geologic, geochemical, and geophysical 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, tungsten, and molybdenum resources in the region:

(1) the presence of quartz veins and zones of fracturing and faulting where accompanied by the presence of altered mafic or hornblende porphyry 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;

(4) troughs of anomalously low values on the aeromagnetic map.

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 or intermediate dikes and that are characterized by a low aeromagnetic signature relative to surrounding areas to have potential for these resources. Although areas with potential generally are indicated by a combination of geological, geochemical, and geophysical 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 or intermediate dikes are not exposed have yielded no geochemical or geologic evidence for mineralization, we have not assigned them a potential (figs. 4, 6).

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 or tungsten vein deposits that are known in the Eagle Mountains, the nearby Chuckwalla Mountains, and elsewhere in the Transverse Ranges are generally small in volume and 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 northwestern Mojave Desert about 150 mi northwest of the study area in a geologic setting that is similar in some respects to that of the Eagle and 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 75 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 Eagle 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 Eagle Mountains. Recorded production from these mines totals 7,257 oz. Gold-bearing rock is present at these mines and numerous other "mines" and prospects both within and outside the boundaries of the wilderness 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 where a third or more of assays on systematically collected 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. 6). In areas 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 Eagle Mountains as a byproduct of gold mining. Total production recorded for the vicinity of the study area is 14,768 oz, none of which came from the wilderness study area. 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

Although small amounts of tungsten are reported to have been produced in some mines in the nearby Chuckwalla Mountains (Bateman and Irwin, 1954), no production or claims have been recorded for the Eagle Mountains.

We assign a high potential for undiscovered tungsten resources in vein deposits to areas that are characterized by high tungsten concentrations (greater than 700 ppm) in the nonmagnetic heavy-mineral fraction of stream-sediment samples (fig. 4). 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 or intermediate dikes, and thus are areas in which we have recognized no evidence of a potential.

The lack of tungsten production from the Eagle Mountains together with comparison of the stream-sediment tungsten concentrations with those of the Chuckwalla Mountains (Powell and others, 1984), are consistent with the presence of small, low-grade vein deposits. However, by analogy with the vein scheelite deposits in the Atolia district of the Mojave Desert, it is 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 Eagle Mountains indicate that undiscovered occurrences of molybdenum-bearing minerals are likely in parts of the wilderness study area.

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 fractions of stream-sediment samples (fig. 4). 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 or intermediate dikes, and thus we have recognized no evidence of a potential.

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 geochemical 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 and intermediate dikes rather than 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 Eagle Mountains.

Copper and lead

Copper and lead were produced at some mines in the Eagle Mountains as a byproduct of gold and silver mining. In addition, copper was detected in one vein sample that was collected north of the study area. 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 (fig. 4).

Tin and thorium

Tin and thorium concentrations in some panned concentrates from stream-sediment samples in the Eagle 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 Eagle 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 Eagle Mountains have not been analyzed. Thorite has been observed in one panned concentrate from the Eagle Mountains. Comparison of geochemical data for stream-sediment samples from the Eagle Mountains with those for samples from the nearby Chuckwalla 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 throughout the study area.

Iron

Iron has been mined extensively in the Eagle Mountains to the north of the wilderness study area, but there is no evidence that significant iron mineralization has occurred within the wilderness study area. The geologic conditions thought to have led to the deposition of iron to the north are not found in the study area: no dolomite is exposed in the study area and the stratigraphic level at which it is found north of the study area projects thousands of feet beneath the study area. The aeromagnetic highs in the study area are not likely to be caused by the presence of magnetite ore bodies.

Sand, gravel, and stone

Sand, gravel, and crystalline rocks suitable for construction purposes are abundant in the wilderness study area, but similar or better grade material is abundant and accessible in the region outside the study area. Material suitable for use as roofing granules may occur at a locality in the northern part of the study area, within the southern half of the Little Storm-Jade Mountain claim. None is exposed, however, and the bulk of this resource lies outside the study area at the sites from which it was originally produced.

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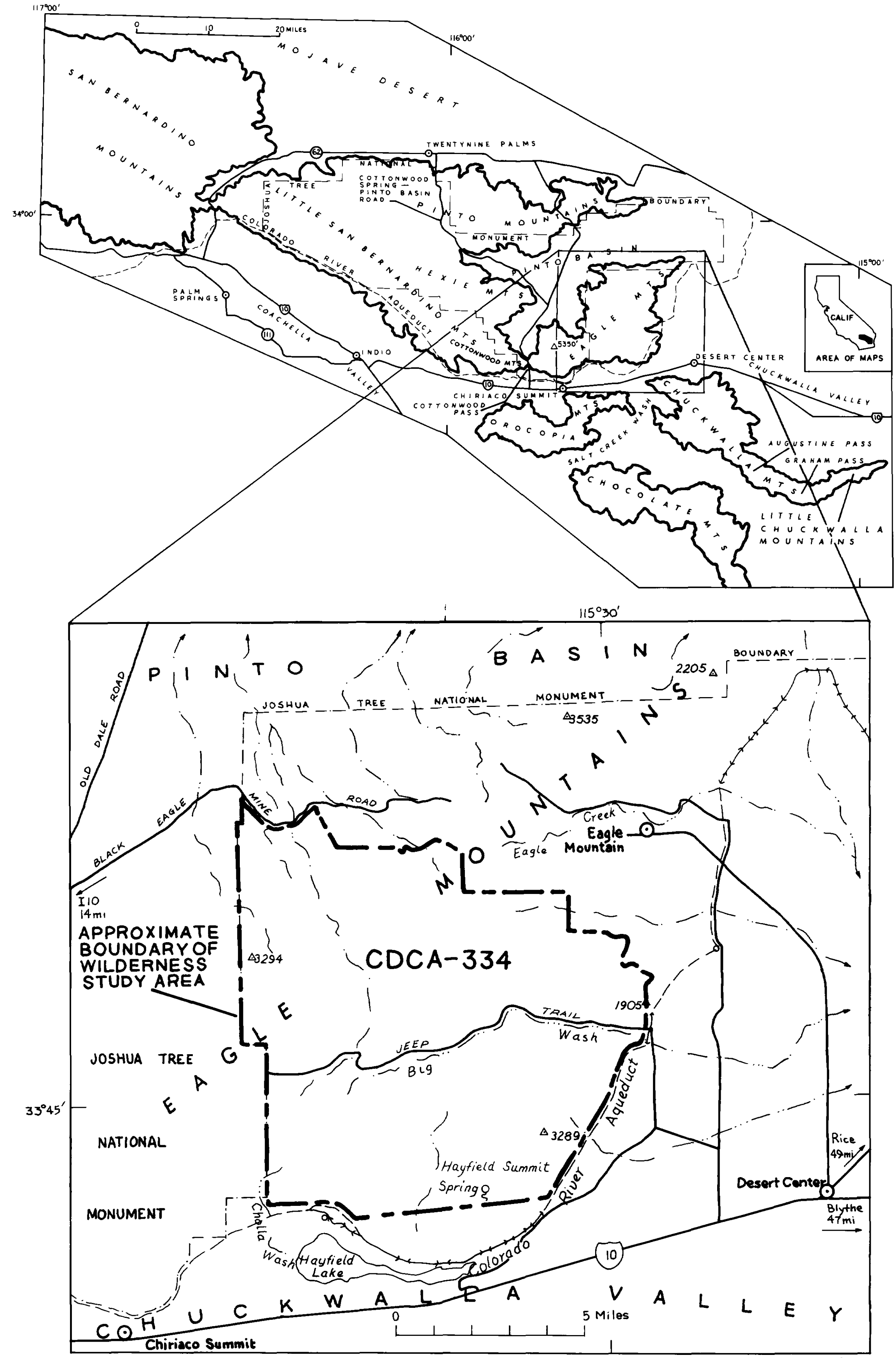
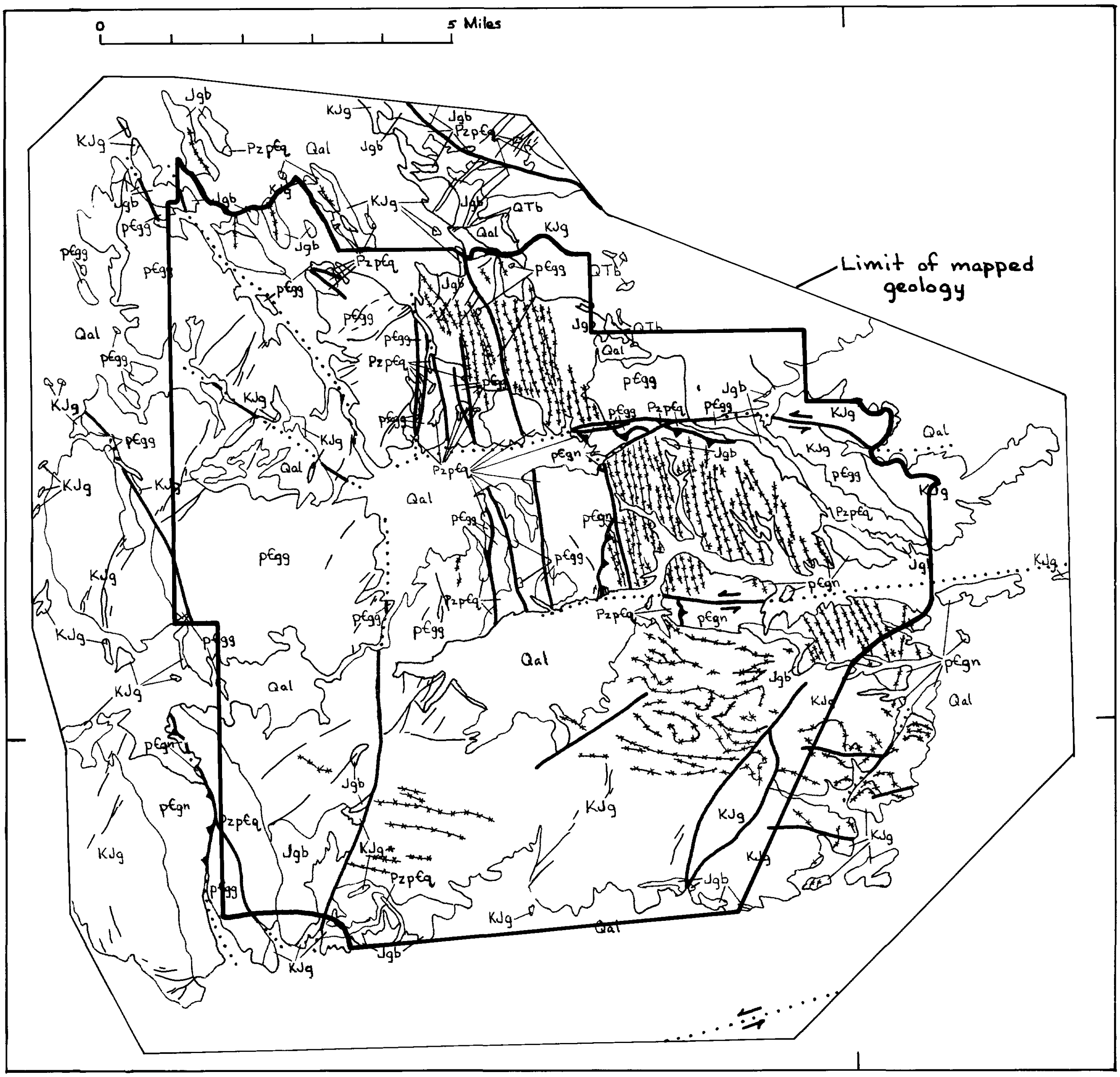


Figure 1.--Index maps showing location of the Eagle Mountains Wilderness Study Area (CDCA-334), California Desert Conservation Area, Riverside County, Calif.



EXPLANATION

Qal	Alluvium (Quaternary)
QTb	Basalt (Quaternary and (or) Tertiary)
KJg	Granitic rocks (Cretaceous and (or) Jurassic)
Jgb	Gabbro and diorite (Jurassic)
Pz p€q	Quartzite, granofels, schist, and dolomite of Joshua Tree terrane (Paleozoic and (or) Precambrian)
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 AND INTERMEDIATE, HORNBLENDE PORPHYRY DIKES (Tertiary, Cretaceous, and (or) Jurassic)

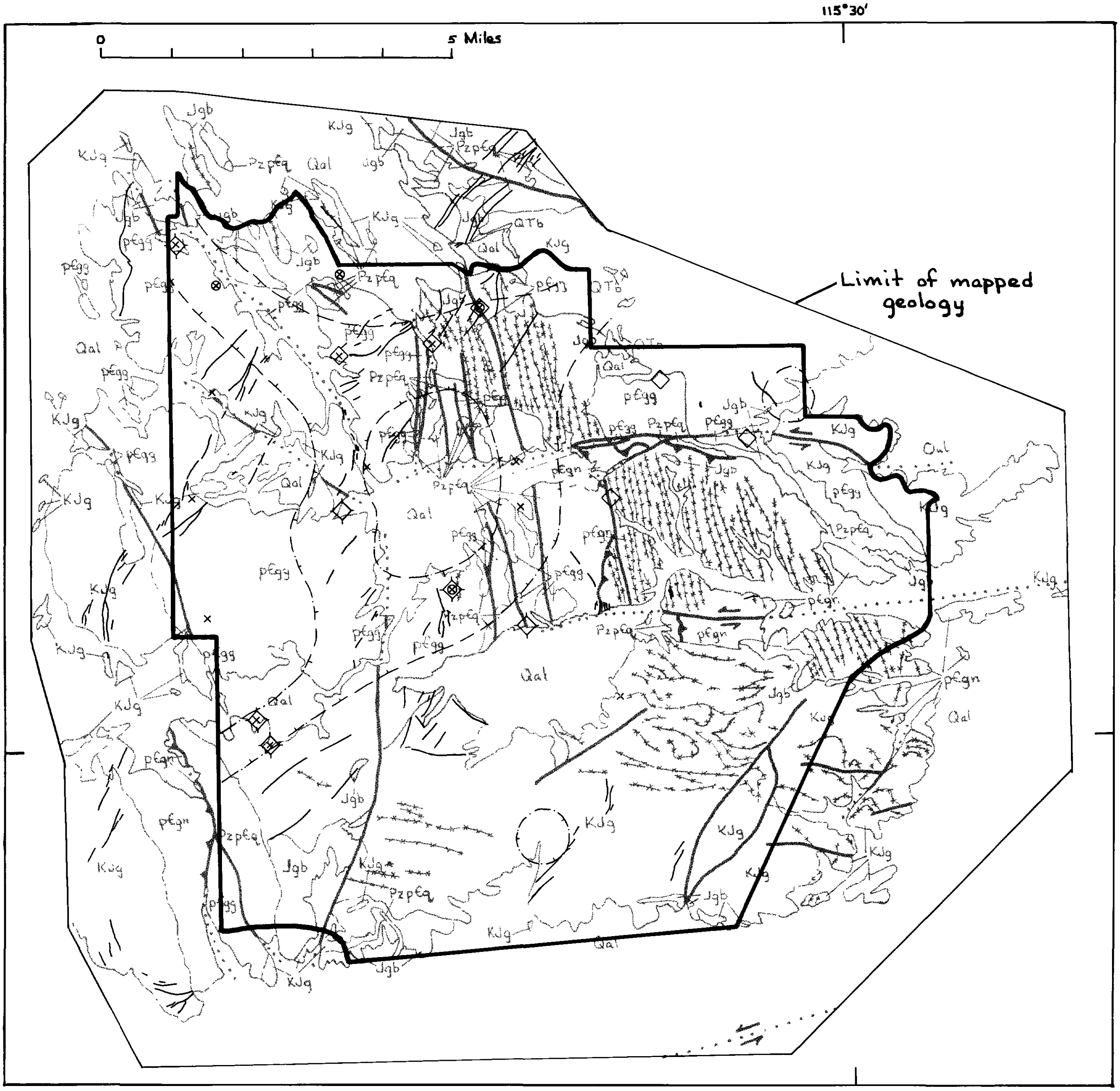
CONTACT

HIGH-ANGLE FAULT OR FRACTURE--Dotted where concealed; arrows indicate relative movement

RED CLOUD THRUST FAULT--Dotted where concealed; sawteeth on upper plate

APPROXIMATE BOUNDARY OF WILDERNESS STUDY AREA

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



EXPLANATION

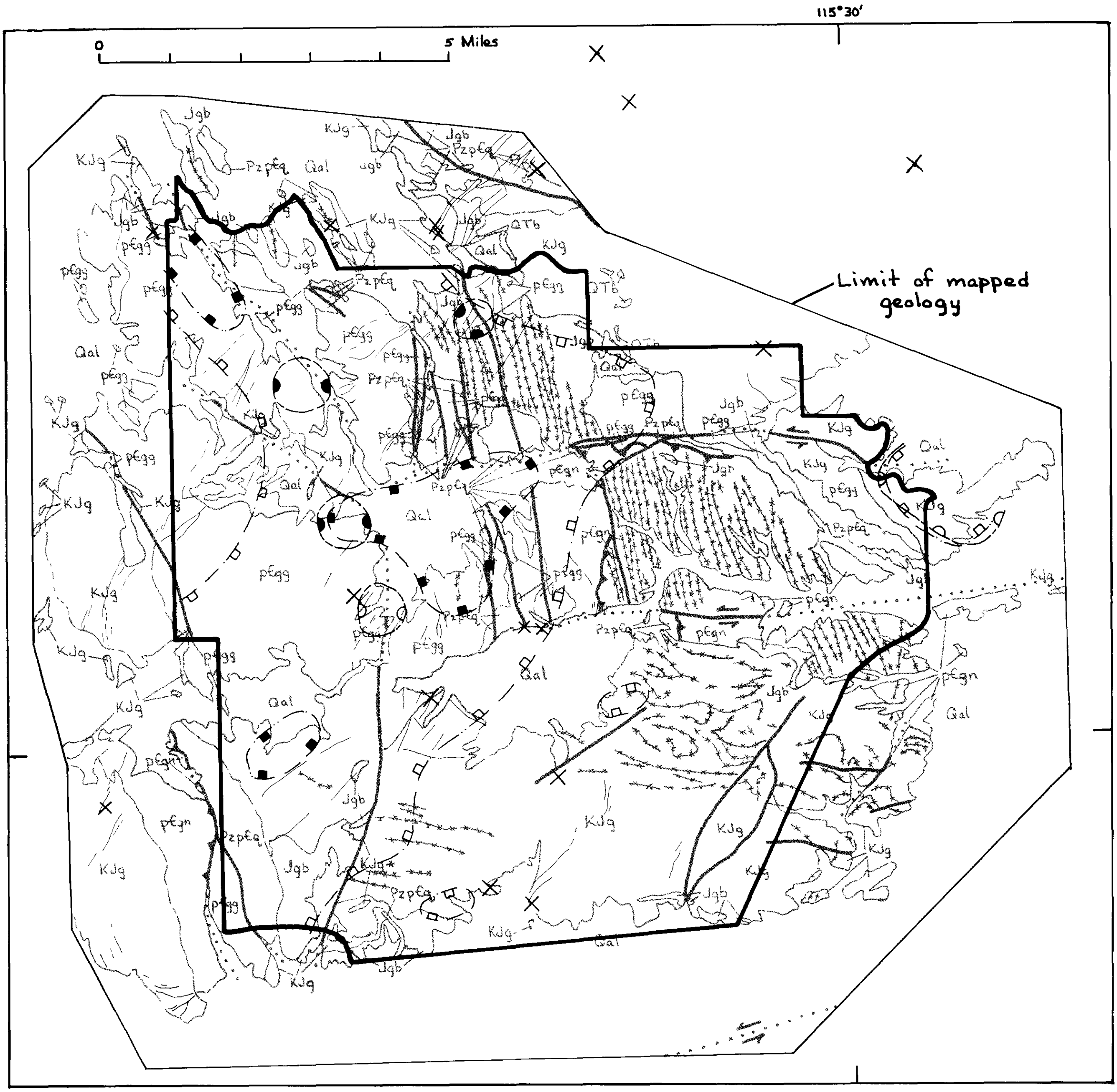
AREAS OF ANOMALOUS LEAD CONCENTRATIONS (300 ppm or greater) in nonmagnetic heavy-mineral fraction of stream-sediment samples, barbs point toward higher concentrations

× SITE OF ANOMALOUS BISMUTH CONCENTRATION (about 20 ppm or greater) in nonmagnetic heavy-mineral fraction of stream-sediment sample

○ SITE OF ANOMALOUS SILVER CONCENTRATION (2 ppm or greater) in nonmagnetic heavy-mineral fraction of stream-sediment sample

◇ SITE OF ANOMALOUS TIN CONCENTRATION (100 ppm or greater) in nonmagnetic heavy-mineral fraction of stream-sediment sample--barbs indicate a tin concentration of 300 ppm or greater. (One site included with 100 ppm tin in minus-80-mesh bulk-sediment sample.)

Figure 3.--Areas of elevated lead, bismuth, silver, and tin concentrations in stream-sediment samples from the Eagle Mountains Wilderness Study Area, Calif. For explanation of geologic units and symbols, see figure 2.



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

MINE OR PROSPECT

Figure 4.--Areas having potential for undiscovered tungsten and molybdenum resources, Eagle Mountains Wilderness Study Area, Calif. For explanation of geologic units and symbols, see figure 2.

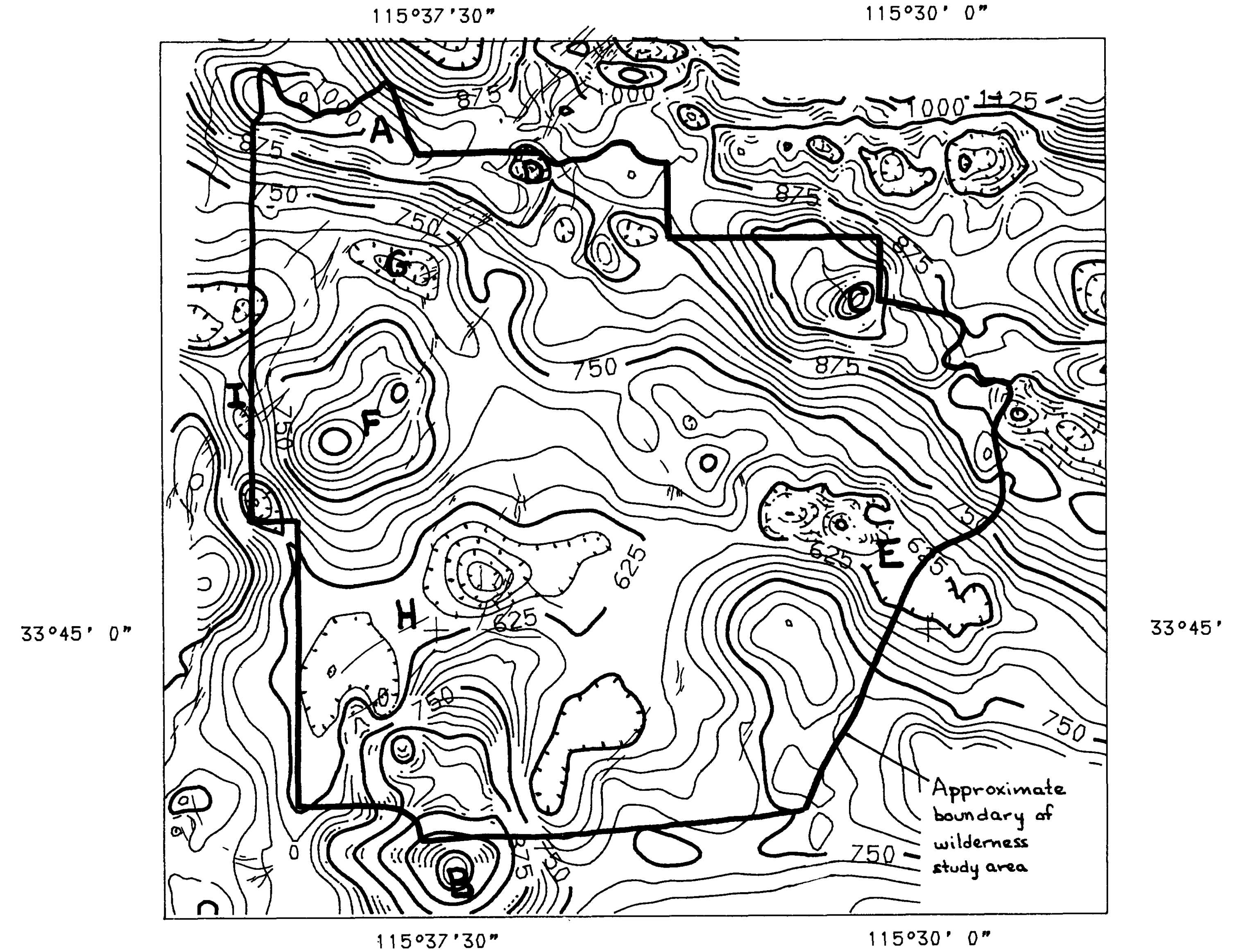
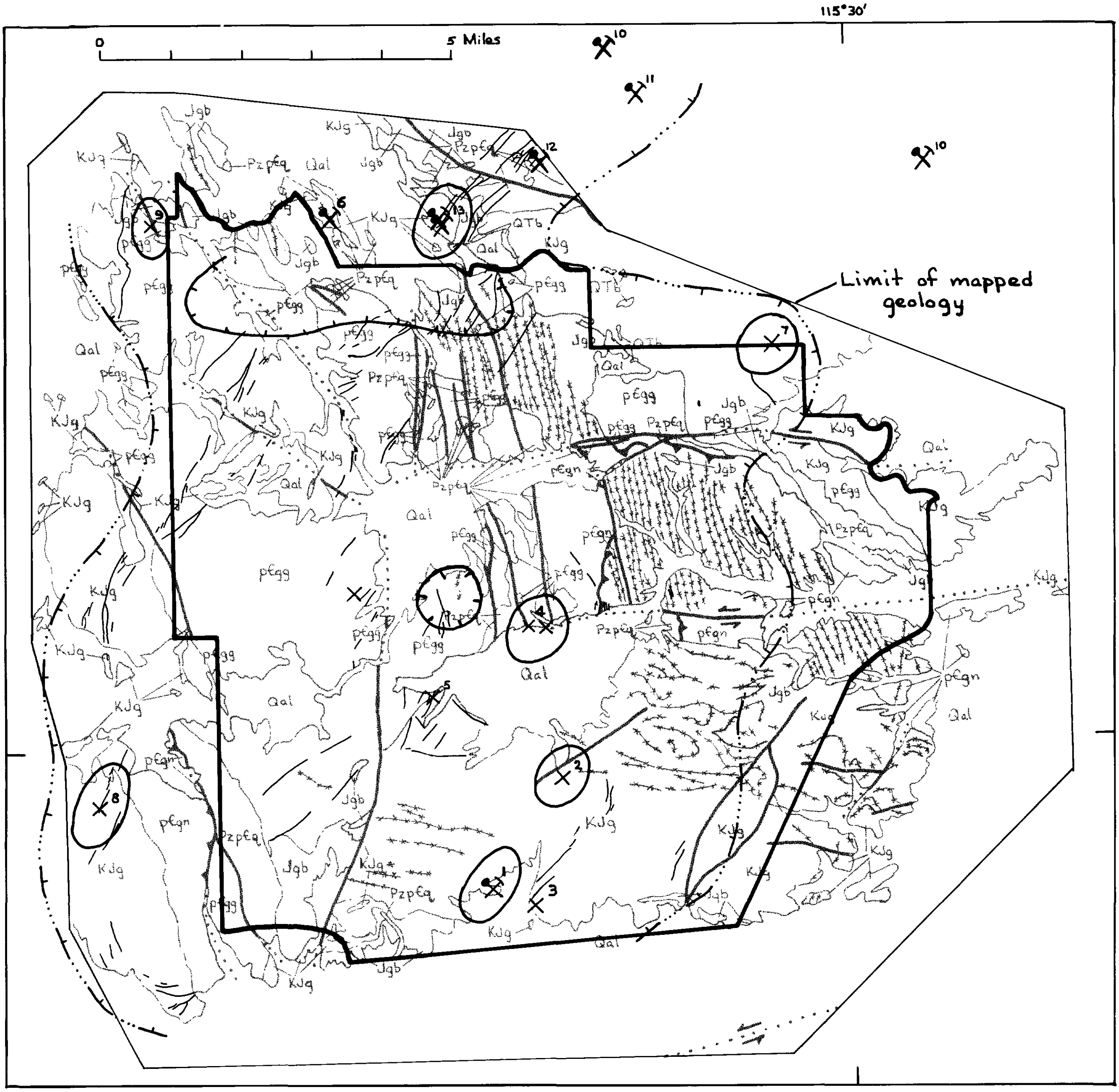


Figure 5.--Residual total intensity aeromagnetic contour map over the Eagle Mountains Wilderness Study Area, Calif. (from Grauch, 1984). Contour interval = 25 gammas, geomagnetic reference field removed. Data were compiled from three different surveys that were continued to 1,000 feet above ground and then merged. Hachured contours represent closed lows. Letters indicate features referred to in text. Mafic and intermediate dikes are superimposed on aeromagnetic contours.



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)

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

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. 4)

AREA WITH POTENTIAL FOR UNDISCOVERED TIN AND THORIUM RESOURCES--Low potential throughout the wilderness study area (compare fig. 3)

MINE, PROSPECT

1 Golden Eagle mine
2 Shooting Star No. 1 prospect
3 Lucky Dollar prospect
4 Orofino(?) prospects
5 Unnamed prospect referred to in text
6 Storm Jade mine
7 Independence prospects Nos. 1, 2
8-9 Unnamed prospects referred to in text
10 Eagle Mountain mine (open pits)
11 Black Eagle mine
12 Iron Chief mine
13 Rainbows End mine

Figure 6.--Areas having potential for undiscovered gold, silver, copper, lead, tin, and thorium resources, and location of mines and prospects, Eagle Mountains Wilderness Study Area, Calif. For explanation of geologic units, see figure 2.