MINERAL RESOURCE POTENTIAL OF THE COXCOMB MOUNTAINS
WILDERNESS STUDY AREA (CDCA-328),
SAN BERNARDINO AND RIVERSIDE COUNTIES, CALIFORNIA

SUMMARY REPORT

By

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STUDIES RELATED TO WILDERNESS
Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine their mineral resource potential. 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 Coxcomb Mountains Wilderness Study Area (CDCA-328), California Desert Conservation Area, Riverside and San Bernardino Counties, California.

SUMMARY

Geologic, geochemical, geophysical, and mineral surveys within the Coxcomb Mountains Wilderness Study Area in southeastern California define several areas with low to moderate potential for base and precious metals. Inferred subeconomic resources of gold at the Moser mine (area Ha) are estimated at 150,000 tons averaging 1.7 ppm Au. The remainder of the study area has low potential for other mineral and energy resources including radioactive minerals and geothermal resources. Oil, gas, and coal resources are not present within the wilderness study area.

INTRODUCTION

The Coxcomb Mountains Wilderness Study Area (CDCA-328) is located in the Mojave Desert of southeastern California approximately 154 mi east of Los Angeles, Calif., and 148 mi southwest of Las Vegas, Nev. The wilderness study area encompasses approximately 46,000 acres bounded by the Joshua Tree National Monument on the west, State Highway 62 on the north, and service roads for the Colorado River Aqueduct on the east and south. This area includes the eastern Pinto Mountains and much of the Coxcomb Mountains except for the area within the Joshua Tree National Monument (fig. 1). Elevations within the wilderness study area vary from 1,200 ft along the southwest boundary to 3,290 ft along the crest of the Coxcomb Mountains. The climate is arid with an average rainfall of approximately 3 in. per year.

The U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) have completed mineral surveys of the Coxcomb Mountains Wilderness Study Area to assess the mineral resource potential. The USGS conducted geologic, geochemical, and geophysical investigations to determine the controls and extent of known mineralization as a guide to undiscovered mineralized areas. The USBM described and sampled the known mines and mineral prospects.

GEOLOGY, GEOCHEMISTRY, AND GEOPHYSICS
PERTAINING TO MINERAL RESOURCE ASSESSMENT

Geology

Previous geologic studies in and adjacent to the Coxcomb Mountains Wilderness Study Area by Miller (1944), Hope (1968), Greene (1968), and Calzia (1982) indicate that the wilderness study area is underlain by metagneous and metasedimentary rocks of Jurassic and (or) older age intruded by granitic rocks of Late Jurassic to Late Cretaceous age. The metamorphic and granitic rocks are overlain by volcanic and sedimentary deposits of Tertiary and Quaternary age. Metagneous rocks are mapped in the northern half of the wilderness study area. These rocks include porphyritic quartz monzonite in the central Pinto Mountains that grades eastward to quartz monzodiorite in the eastern Pinto and southern Sheep Hole Mountains and to biotite amphibole monzogranite. Metagneous rocks of andesitic composition are found in the western and southern Pinto Mountains. Metasomatic rocks of andesitic composition are found in the western and southern Pinto Mountains outside of the wilderness study area. These metasomatic rocks may be older than the quartz monzodiorite, but the contact relations between these rocks are not known.

Metasedimentary rocks are mapped in and adjacent to the wilderness study area. These rocks, the McCoy Mountains Formation of Miller (1944), include metasiltstone and fine-grained metasedimentary rocks with lenses of pebble conglomerate and metagraywacke. Metasedimentary rocks in the southern Coxcomb Mountains were folded at least twice and are metamorphosed to the greenschist facies. The relative age of the metasomatic rocks in the Pinto, Sheep Hole, and McCoy Mountains is unknown. The metasomatic and metasedimentary rocks are intruded by the Coxcomb Granodiorite of Miller (1944). Calzia (1982) has subdivided the Coxcomb Granodiorite into four facies that include (oldest to youngest): biotite-horn-
Cretaceous in age. This age assignment is based on K-Ar dates from the monzogranite and biotite-hornblende granodiorite facies (Calzia, 1983) and new Pb/U isotopic data from the southernmost granodiorite facies (E. DeWitt, written commun., 1983).

Olivine basalt flows and volcanioclastic deposits of Tertiary (?) and Quaternary age are interbedded with tilted fanglomelate deposits in the Joshua Tree National Monument west of the Coxcomb Mountains. The fanglomerate deposits are overlain by alluvial and eolian deposits of Quaternary age. Playa deposits and a single outcrop of the Bishop ash are interbedded with the alluvial deposits.

The rocks within the Coxcomb Mountains Wilderness Study Area are broken into large blocks by northwest-, northeast-, and east-trending faults. The northwest-trending faults generally are the oldest and are cut by northeast-trending faults in the Coxcomb and eastern Pinto Mountains. Northwest-trending faults terminate within an east-trending valley in the eastern Pinto Mountains. This valley is aligned with a large east-trending fault mapped by Hope (1966) west of the wilderness study area and is probably fault controlled. A large east-trending topographic low in the central Coxcomb Mountains is probably located along a fault. Here the north-west-trending faults cross the east-west structure with no apparent offset. Most of the mineralization in the wilderness study area is located along faults and joints that trend N. 10°-30° W. and N. 70° W. to east-west.

Geochronology

A reconnaissance geochemical study of the Coxcomb Mountains Wilderness Study Area identified several areas of anomalous base- (Cu, Pb, Zn, Mo) and (or) precious- (Au, Ag) metal mineralization. Anomalous concentrations of various elements within these areas are defined by Kilburn and others (1983). The sample media consisted of rocks, stream sediments, and heavy-mineral concentrates from stream sediments. A total of 114 stream-sediment and 82 concentrate samples were gathered from active alluvium in selected drainages throughout the study area. Twenty rock samples were collected from outcrop areas of observed alteration and from mine dumps and adits to determine mineral suites and trace-element signatures of mineralized systems.

The samples were processed in the sample-preparation laboratories prior to analysis. All processed samples were analyzed by a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968) for 31 elements.

Spectrographic analysis of the nonmagnetic fraction of the heavy-mineral concentrates provided the most useful data in evaluating the mineral potential of the wilderness study area. This medium, which contains the sulfide minerals and their oxidation products, showed a greater contrast in metal mineralization. Anomalous concentrations of various elements within these areas are defined by Kilburn and others (1983). The sample media consisted of rocks, stream sediments, and heavy-mineral concentrates from stream sediments. A total of 114 stream-sediment and 82 concentrate samples were gathered from active alluvium in selected drainages throughout the study area. Twenty rock samples were collected from outcrop areas of observed alteration and from mine dumps and adits to determine mineral suites and trace-element signatures of mineralized systems.

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by private companies to measure geothermal gradients in alluvial valleys north and east of the wilderness study area. These mines and mineral deposits are critical to an understanding of the mineral potential of the wilderness study area. The mines and mineralization are briefly described in this section. An assessment of the resource potential of the wilderness study area based on these deposits is described in the last section. Oil, gas, and coal resources are not indicated within the wilderness study area.

Mines and mining districts

Moser mine

The Moser mine is located on the eastern flank of the Coconino Mountains within the wilderness study area. The main workings consist of more than 1,000 ft of drifts and stopes, numerous pits, and several short adits located along a northwestern-trending fault that cuts the McCoy Mountains Formation of Miller (1944) and the biotite-hornblende granodiorite unit. Minerals noted at the main working include quartz, SiO2, pyrite, FeS2, arsenopyrite, FeAsS, Cu-silicates, CuS, and chalcopyrite, CuFeS2, and psilomelane, MnO·H2O. Twenty-five samples collected by the USBM and USGS in fault zones within and adjacent to the mines indicate anomalous concentrations of Ag, Cu, Pb, Zn, and As. Precious-metal concentrations range from nil to as much as 100 ppm Au and nil to 50 ppm Ag.

Iron mines

The Iron Age and Snowflake mines are located in the northeastern Pinto Mountains just west of the wilderness study area. Little is known about these large iron ore bodies. They are associated with the metamorphic assemblage actinolite+chlorite+serpentine in quartz monzonite. Relict textures in the quartz monzonite, primarily orthoclase pheno- crys and rounded quartz grains, as well as the metamorphic assemblage suggest that the iron ore is associated with skarn deposits. No carbonate deposits, however, are known near the mines. High-angle reverse faults further confuse the geologic setting of these mines.

The ore mineral at the Iron Age and Snowflake mines is hematite (Fe2O3) replacing magnetite (FeO·Fe2O3). Wright and others (1953, p. 95) report that assays of 20 samples from the Iron Age mine range from 67.27 percent iron, 3.32 percent silice, 0.932 percent sulfur, and 0.6 percent phosphorous. Production at the Iron Age and Snowflake mines exceeded 1.3 million tons from 1964 to 1969.

Last Chance mine

The Last Chance mine is located in the Coconino Mountains just within the Joshua Tree National Monument. This mine consists of a single drift along a northwest-trending fault that cuts metaigneous (the biotite-amphibole monzonite) unit and igneous (the biotite-muscovite monzonite) unit) rocks. An iron-stained quartz vein is located along a north-trending fault that cuts the northwest-trending fault. A shaft follows the quartz vein until the shaft and drift intersect at depth.

The ore minerals at the Last Chance mine are unknown but probably contain gold and (or) silver. A semiquantitative analysis of the quartz vein indicates no anomalous concentrations of precious and base metals. The waste pile at the adit consists of quartz, hematite, limonite (FeO(OH)·nH2O), and calcite (probably secondary).

Erwin mine

The Erwin mine is located south of the wilderness study area along the southeast flank of the Coconino Mountains. This mine consists of a single trench dug along a northwest-trending fault that juxtaposes the McCoy Mountains Formation and the biotite-hornblende granodiorite unit. Mineralization includes quartz, Cu-silicates, siderite, hematite, white mica (sericite), and secondary calcite. Spectrographic analyses of rock samples indicate anomalous concentrations of Cu, Ag, and Mo.

Eagle Mountain mine

The Eagle Mountain mine is located 6 mi southwest of the Coconino Mountains Wilderness Study Area. The mine, opened in 1948 by Kaiser Steel, consists of two deep open pits in metasedimentary rocks of post-Precambrian and pro-Jurassic age. The district longsin in a series of lenses and dolomite beds that are interbedded with quartzite. The metasediments are intruded by porphyritic quartz monzonite and are folded into a large east-west anticline that extends completely across the Eagle Mountains. The ore zone is exposed for more than 5 mi and continues eastward for approximately 3 mi beneath the valley between the Coconino and Eagle Mountains.

The primary ore minerals, magnetite and pyrite, form many replacement lenses and stringers after actinolite- tremolite granofels within the ore zone. Primary ores consist of 42.5 percent Fe, 0.1 percent P, and 1.7 percent S (Dubois and Brummert, 1968, p. 1604). Secondary ore minerals include hematite (martite) after magnetite and limonite-hematite-goethite (FePO4) mixture after pyrite.

The secondary ores are of greatest interest at the Eagle Mountain mine because oxidation during formation of the secondary ores removed most of the sulfur from the primary ore allowing the production of a low-sulfur product by magnetic and gravity concentration methods. The mine produces 8 million tons of approximately 35 percent Fe per year with reserves of 350 million tons (Leszykowiski and Causey, 1982, p. 5). Production to date exceeds 100 million tons (Scott and Wilson, 1980, p. 140). The Eagle Mountain mine is scheduled to close in 1985 because of a declining market and increased cost.

Dale mining district

The Dale mining district, located about 2 to 3 mi west of the wilderness study area, includes the Virginia Dale and the Monte Negro mining districts. The Monte Negro district was first prospected in 1884 and continues to be active in the present. Most mines within the Dale mining district are located along quartz veins within diorite, quartz diorite, and andesite of Jurassic and older age. The ores include gold, silver, lead, copper, and iron as well as lesser amounts of manganese and uranium. Larry Vredenburgh (written commun., 1981) reported that approximately 185,000 troy oz of gold was recovered from the most productive mines in the district.

An aeromagnetic low extends southeastward through the Dale mining district into the wilderness study area and across the Pinto Mountains into the Pinto Basin. The aeromagnetic low may be caused by alteration of magnetite to hematite and (or) pyrite during gold mineralization. The Zulu Queen and Outlaw mines, located within the aeromagnetic low on the southern flank of the Pinto Mountains, contain gold-bearing quartz veins in northwest-trending fault zones that cut igneous rocks similar to rocks in the Dale mining district. The close spatial relation between the mines and the aeromagnetic low as well as the geologic similarity of mines within the aeromagnetic low suggest that gold mineralization may extend southeastward from the Dale mining district into the wilderness study area.

Other mineralization

Base- and precious-metal mineralization

In addition to the Moser and Erwin mines, numerous prospect pits are located near the contact between the McCoy Mountains Formation and the biotite-hornblende granodiorite unit. The mineral assemblage and geochemical suite noted in these workings suggest that base- and precious-metal mineralization associated with skarns developed in metallimestone beds near the contact with the granodiorite. The mineral assemblage within the wilderness study area includes scheelite (CaWO4), apatite (Ca5(PO4)3F), garnet (ZnAl2O4), monazite (Ce, La, Y, Th) PO4, and garnet. South of the wilderness study area, the mineral assemblage includes quartz, Cu-silicates, hematite, siderite, white mica (sericite), chlorite, secondary calcite, and locally dolomites(?) Spectro-
graphic analyses of heavy-mineral concentrates collected south of the Moser mine and within the wilderness study area disclose anomalous values of W, Mo, Pb, and Bi. Analyses of stream-sediment, heavy-mineral concentrate, and rock samples south of the wilderness study area indicate anomalous concentrations of Mo, Zn, and Pb with varying amounts of Cu, W, and Ag.

Barium
Several barite (BaSO4) veins in quartz monzodiorite were sampled by the USBM in the Boler group of mines along the northwest boundary of the wilderness study area. These veins are 1.2 ft thick and contain 47.9 percent BaO with minor amounts of gold and silver. Other barite veins are located at the Hot Hell #2 claim north of the Boler group. The mineralized veins within this claim contain 27.3 percent BaO, as high as 0.12 ppm Au and 20.0 ppm Ag, and magnetite nodules.

Uranium and thorium
Geologic studies in the Coxcomb Mountains were initiated as part of the National Uranium Resource Evaluation (NURE) program to evaluate the uranium (U) and thorium (Th) potential of igneous rocks in this range. Table 1 lists the variation in U and Th concentrations determined from 96 samples collected within the Coxcomb Mountains. These values show an increase of U and Th content with fractionation of the igneous rocks but do not indicate anomalous concentrations of these elements.

Chew and Antrim (1982) described several environments favorable for uranium mineralization in the McCoy Mountains Formation. These environments include an ancient braided-stream system as well as faulting and slump features. Slump features in the McCoy Mountains Formation are well developed along the southern front of the Coxcomb Mountains south of the wilderness study area and may be favorable environments for uranium mineralization.

The USBM identified a single radioactive anomaly in metasomogenic rocks (syenite?) in the eastern Pinto Mountains. This anomaly contains 25 ppm U3O8 and 397 ppm ThO2. Larry Vredenburg (written commun., 1981) reported a uranium and potassium anomaly at the Iron Age mine and several uranium and thorium anomalies within the Dale mining district.

Geothermal resources
In 1981, the Geothermal Division of Phillips Petroleum drilled several shallow wells on a one-township spacing to measure geothermal gradients on public lands within the Coxcomb Mountains and adjacent Sheep Hole-Cadiz Wilderness Study Areas. A second phase of drilling within the Coxcomb Mountains Wilderness Study Area was completed before September 1982. Although data from these wells are confidential to Phillips Petroleum, they probably were drilled to evaluate a north-trending zone of high but variable heat flow that extends through the wilderness study areas. Heat flow measured in 100-m (328 ft) thermal-gradients wells completed by the USGS in the same area varies from 1.29 to 3.44 HFU (J. H. Sass, written commun., 1980).

The geothermal potential of this zone of high heat flow cannot be evaluated because the USGS wells are approximately 18 mi apart, and because the local hydrologic system is complex. Mohorich (1980, p. 183) reported that the energy per unit volume of water from low-temperature geothermal systems is low and the fluids generally could not be transported economically more than a few miles. Locally, low-temperature geothermal systems may be suited for direct applications to space heating, agriculture, and industry.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL
Geologic, geothermal, geophysical, and mineral surveys within the Coxcomb Mountains Wilderness Study Area define several areas with low to moderate resource potential for base and precious metals. Resource-potential terms are defined by R. B. Taylor and T. A. Steven (written commun., 1983). Briefly, an area of high mineral resource potential exists where all conditions of a genetic model of ore accumulation are met. This includes not only known mining districts but other areas where geologic, geophysical, analytical, and other data demonstrate or indicate an excellent possibility that mineralized rock exists.

Areas of moderate mineral resource potential include areas where the requirements of a genetic model have been satisfied, or can reasonably be interpreted to have been satisfied, but where evidence for mineralization is less obvious or has not yet been found. Areas classified with a low mineral resource potential lack evidence to support a favorable genetic model, lack indications of potential mineralization, or have an unfavorable combination of geologic factors including lack of source or mechanism of accumulation.

Area I is defined by the aeromagnetic low that extends from the Dale mining district through the northwest corner of the wilderness study area. Evidence of gold mineralization (quartz veins and bleached rocks) and alteration of magnetite to hematite and (or) pyrite spatially associated with this low in the Dale mining district were not found within the wilderness study area. The area defined by the aeromagnetic low within the wilderness study area therefore has low potential for precious-metal resources.

Area II is located along the contact between the McCoy Mountains Formation and the biotite-hornblende granodiorite unit and includes skarn deposits. This area is considered to have moderate potential for hypothermal base-metal resources and inferred subeconomic precious-metal resources as indicated by the anomalous concentrations of Mo, Pb, Zn, Cu, As, Au, and Ag in rock samples, and by the mining activity at the Moser mine. Inferred subeconomic gold resources at the mine are estimated at 150,000 tons averaging 1.7 ppm Au.

Area III is located in the central Coxcomb Mountains south of the Moser mine. Analyses of heavy-mineral concentrates indicate anomalous concentrations of W, Mo, Pb, and Bi. The associated mineral assemblage (scheelite, apatite, galena, monazite, and garnet) suggests contact metasomatic activity. These geochemical and mineral data indicate that area III has low potential for tungsten, molybdenum, and lead resources in skarn deposits.

Area IV is located south of the wilderness study area and includes the Erwin mine. This area contains anomalous concentrations of Mo, Zn, and Pb with varying amounts of Cu, W, and Ag. These geochemical anomalies indicate that area IV has low potential for base and precious metals.

The remainder of the Coxcomb Mountains Wilderness Study Area has low potential for mineral resources including radioactive minerals and geothermal resources. This assessment is based on the following evidence: 1) the general absence of base, precious, and radioactive mineralization in geologic environments known to be favorable for these resources; 2) generally low concentrations of metallic and radioactive elements determined by chemical analyses of stream-sediment, heavy-mineral concentrate, and rock samples; 3) the general lack of aeromagnetic and gravity anomalies associated with mineralized areas; and 4) the absence of reported production from mines and prospects within the wilderness study area.

REFERENCES


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**Table 1. Uranium and thorium content (ppm) of rocks in the Coxcomb Mountains, Calif.**

<table>
<thead>
<tr>
<th>Coxcomb Granodiorite</th>
<th>McCoy Mountains Formation</th>
<th>Biotite-amphibole monzogranite</th>
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<tbody>
<tr>
<td>Kgp</td>
<td>Kgd</td>
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<table>
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<th>U₂O₈</th>
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Kgp = Porphyritic biotite granodiorite
Kgd = Biotite-hornblende granodiorite
KgdN = Porphyritic biotite granodiorite to monzogranite
Kg = Biotite-muscovite monzogranite
Figure 1.—Index map showing location of the Coxcomb Mountains Wilderness Study Area (CDCA-328).
Figure 2.—Mineral resource potential and locations of mines and prospects in and near the Coxcomb Mountains Wilderness Study Area (CDCA-328).