Mineral Resources of the Cinder Cones Wilderness Study Area, San Bernardino County, California

U.S. GEOLOGICAL SURVEY BULLETIN 1712–B

Chapter B

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
CENTRAL CALIFORNIA DESERT CONSERVATION AREA

DEPARTMENT OF THE INTERIOR
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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-576, 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 the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report represents the results of a mineral survey of part of the Cinder Cones Wilderness Study Area (CDCA-239), California Desert Conservation Area, San Bernardino County, California.

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SUMMARY

Abstract

At the request of the Bureau of Land Management, 44,299 acres of the Cinder Cones Wilderness Study Area (CDCA-239) were studied by the U.S. Geological Survey and the U.S. Bureau of Mines. In this report, the area studied is referred to as "the wilderness study area", or simply "the study area." The study area is located in the Ivanpah upland near Baker, Calif. Fieldwork for this report was carried out between 1983 and 1985. Two small young cinder cones in the wilderness study area contain an estimated 30 million tons of cinders; however, there are sufficient cinders outside the study area to satisfy demand in the foreseeable future. There are no mines in the wilderness study area, and of several prospects for metallic minerals examined, none contain identified resources. Mineralized areas in mines and prospects surrounding the study area are associated with quartz veins in Cretaceous (see geologic time chart on last page of report) granitic intrusions and with Proterozoic(?) or Paleozoic rocks near such intrusions. Quartz veins are rare in Cretaceous granites within the study area, and the limited exposures of Proterozoic(?)-Cretaceous rock contacts are not strongly altered or mineralized, thus the mineral resource potential for gold, silver, lead, and zinc is low. Areas underlain by Cretaceous granite, Tertiary volcanic and sedimentary rocks, and Quaternary alluvium and volcanic rocks have a low mineral resource potential for gold, silver, lead, zinc, oil, gas, and geothermal energy.

Character and Setting

The Cinder Cones Wilderness Study Area is in northeastern San Bernardino County, Calif. and includes part of a north-trending assemblage of Tertiary and Quaternary basaltic volcanoes. The volcanic rocks and underlying granitic rocks form an inconspicuous highland called the Ivanpah upland (Hewett, 1956) between the Old Dad Mountains to the south and the Shadow Mountains to the north (fig. 1). Older lava flows form an east-sloping mesa within the eastern third of the study area, which has about 1,000 ft of relief on the west side, and 150 ft on the east side. Younger lavas and cinder cones lie outside the study area to the south, southeast, and southwest of the mesa. At least 20 central volcanic vents are located in the study area, all but two of which are deeply eroded and weathered. West of the mesa is a low dome about 5 mi in diameter with a total topographic relief of about 1,000 ft, which formed by erosion of granitic and Tertiary sedimentary rocks. A smaller dome, partially exhumed from beneath sedimentary rocks, is located at the south edge of the study area.

Rocks of the study area are dominantly granitic intrusive rocks, basaltic flows and tephra, and sedimentary rocks of various ages. Gneiss crops out in small areas, and a variety of dikes unrelated to the basaltic volcanism cut the granitic rocks. Apparently the basaltic flows are not deformed and retain their original depositional attitudes. The volcanic rocks overlie Tertiary sedimentary rocks, which are locally deformed, and the Proterozoic(?) and Mesozoic crystalline rock basement.

Mining activity near the study area has occurred intermittently since about 1897 (Hewett, 1956, p. 165), but there are no mines within the study area. Gold and silver were produced from the Paymaster mine, about 3 mi south of the study area in the Old Dad mining district (Clark, 1970, p. 161), and from the Telegraph mine (fig. 1), about 1.5 mi north of the study area (Hewett, 1956, p. 120; Wright and others, 1953, p. 82). Since 1954, cinders have been produced from the Cima and Aiken mines (fig. 1) near the southeast boundary of the study area (Tognoni, 1983, p. 1).

Identified Resources

Two young cinder cones within the study area contain about 30 million tons of volcanic cinders similar to those mined at two sites adjacent to the southeast border of the study area. Those mines contain adequate resources to supply the local market demand for the foreseeable future; moreover, many other cinder cones in the region have cinders of

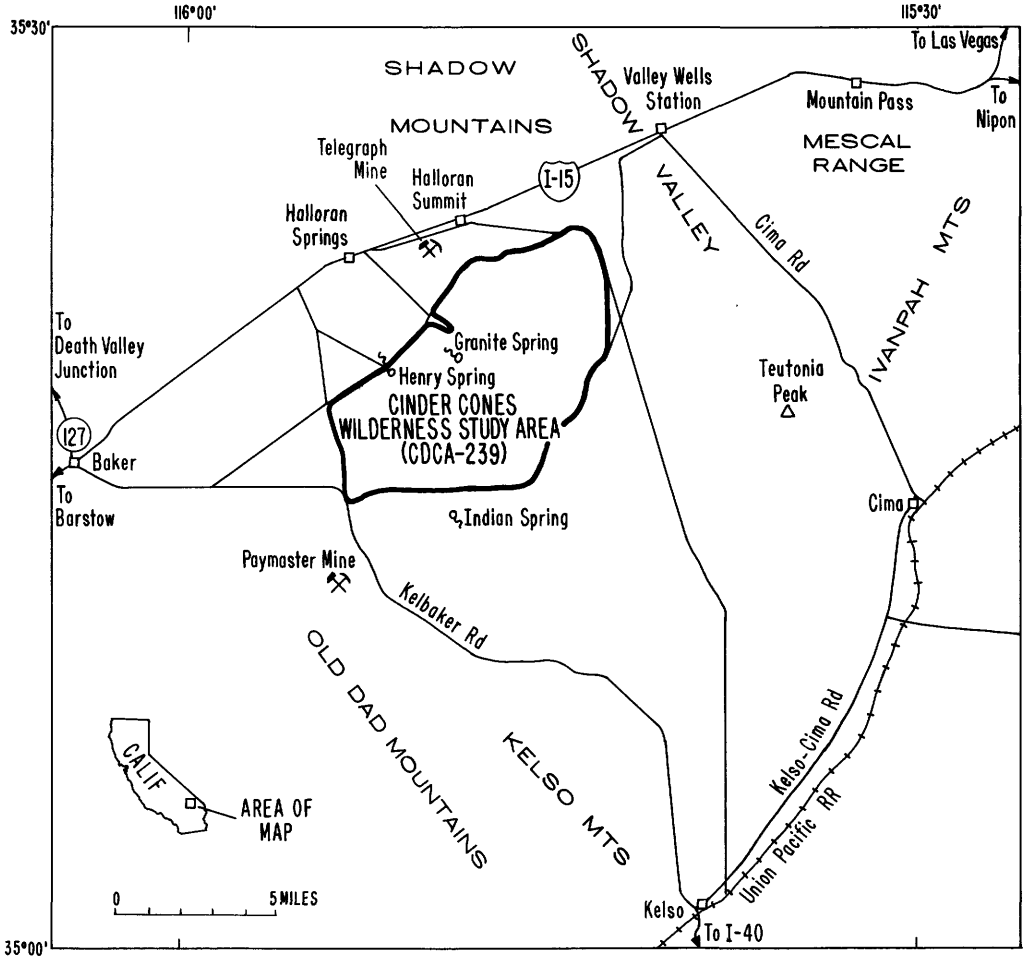

Figure 1. Index map showing location of the Cinder Cones Wilderness Study Area, San Bernardino, County, California.

commercial quality. Concentrations of gold and silver were found at two prospects in the study area, but no gold or silver resources were identified because of the limited extent of mineralized rock.

Mineral Resource Potential

Geologic mapping and aeromagnetic anomalies indicate that contacts between Proterozoic(?) rocks and Cretaceous granitic rocks are concealed beneath alluvium in the southwestern and extreme northern parts of the study area. These concealed contacts are believed to have low mineral resource potential for gold, silver, lead, and zinc because exposed contacts between these rock types in the study area are apparently unmineralized. A few isolated rock and stream-sediment samples from the study area contain anomalous single-element concentrations. The geochemistry of these samples is unlike that of nearby mining areas, so the remainder of the study area is thought to have low potential for gold and silver resources.

U.S. Bureau of Mines (Rumsey and McMahan, 1985) records of proprietary assay results indicate the presence of significant concentrations of gold in cinders. However, published analyses of cinders from these and other sources do not indicate gold anomalies in the volcanic rocks. Thorium anomalies in samples from the study area are associated with monazite and thorite crystals; these minerals are common minor accessories in granitic rocks and are not a thorium resource.

Geologic and geophysical data indicate that relatively thin sections of Tertiary sedimentary and volcanic rocks are underlain by granitic and metamorphic rocks to depths of at least 2.5 mi; therefore, the study area has low potential for oil, gas, and geothermal energy resources.

INTRODUCTION

Area Description

The Cinder Cones Wilderness Study Area (CDCA-239) encompasses 44,299 acres in the northeastern Mojave Desert. The area is 14 mi north-northeast of Baker, Calif., and 80 mi southwest of Las Vegas, Nev. (fig. 1). All of the study area has low relief; the only inaccessible places are west- and east-facing cliffs with vertical relief of no more than 200 ft. The lowest elevation in the study area is 2,000 ft and the highest is 4,955 ft.

The region is arid and experiences moderately large seasonal changes in temperature and precipitation. Temperatures range from 10°F in winter to more than 100°F in the summer. Average annual precipitation ranges from about 4 to 6 in. (Troxell and Hofman, 1954).

The density, diversity, and cover of vegetation within the wilderness study area are substantially greater than in lower-lying areas of the Mojave Desert. The dominant plant communities (Vasek and Barbour, 1977; Curry, 1983) are Creosote Bush Scrub and Yucca-Ephedra Scrub. Common representatives in the study area of the former community are Larrea (creosote), Ambrosia, Krameria, Lycium, Coleogyne, Ephedra, Hymenoclea, and various species of Opuntia (including barrel, hedgehog, jumping cholla, pencil cholla, silver cholla, staghorn cholla, and beavertail cactus), perennial and annual grasses, Eriogonum, Thamnosoma, Cassia, four-wing saltbush, Haplopappus, and Dalea. Plants representing the Yucca-Ephedra community include Yucca brevifolia and Y. schidigera, Salvia, and Encelia. Some washes contain desert willow and catclaw, and most areas of granitic alluvium have well-developed lichen and algal crusts. Wildlife observed during fieldwork include desert tortoises, coyotes, bobcats, rattlesnakes, vultures, several kinds of hawks, eagles, owls, ravens, quail, and numerous small birds, lizards, rodents, small mammals, and insects, in addition to feral burros.

Lava flows in the study area have a noteworthy abundance of petroglyphs scribed on outcrop surfaces.

Access to the western, eastern, and northern parts of the study area is provided by unimproved roads that form part of the study area's boundary (fig. 1). Access to the southern and southeastern parts is provided by unmaintained roads, most of which are unsuitable for 4-wheel drive vehicles. A passable trail terminates at Indian Spring, 1 mi south of the study area boundary.

Previous and Present Investigations

Early geologic mapping by Hewett (1956), which included all of the study area, defined the major rock units of the area and greatly aided this study. Geologic maps of part of the Old Dad Mountains include a narrow strip of the southern end of the study area (Barca, 1966) and a strip along the eastern side of the study area (Evans, 1971). Detailed studies of the geomorphology and ages of the Tertiary and Quaternary basaltic flows and cinder cones were published by Dohrenwend and others (1984). Other geologic maps and detailed petrologic studies describe the volcanic rocks adjacent to the study area and present geochemical data on gold contents of cinders from three volcanic cones (Katz, 1981; Breslin, 1982).

The U.S. Geological Survey (USGS) conducted field investigations in 1984 and 1985. The work included field checking of existing maps, new mapping of the entire wilderness study area at a scale of 1:24,000, geochemical sampling, and gravity surveys. Earlier aeromagnetic (U.S. Geological Survey, 1983) and gravity (Snyder and others, 1982) surveys are reviewed in this report. During 1983, the U.S. Bureau of Mines (USBM) conducted a mineral survey of the Cinder Cones Wilderness Study Area as part of a joint study with the USGS. The USBM investigation included a library search for information on mines and prospects in and around the study area. These data were supplemented by information from claim owners. Field investigations conducted in 1983 examined and sampled known prospects and mineralized sites. Unrecorded mineralized sites were looked for in reconnaissance surveys.

APPRAISAL OF IDENTIFIED RESOURCES

By Clayton M. Rumsey and Arel B. McMahan, U.S. Bureau of Mines

Introduction

Twenty-six rock samples were collected at prospects and mineralized sites in the study area. Additionally, 25 rock samples and 58 alluvial samples were collected throughout the study area to verify the presence or absence of reported gold concentrations. Chip samples were collected across mineralized zones or other exposures where possible, and grab samples were collected from dumps, stockpiles, and float. All samples were assayed for gold and silver using a combined fire assay-inductively coupled plasma method (Rumsey and McMahan, 1985) at detection limits of 0.007 and 0.3 parts per million (ppm), respectively. Semiquantitative spectrographic analyses for 40 elements were performed on selected samples to determine if anomalous concentrations of other metals were present. Thin sections of seven rock samples were examined with a petrographic microscope to determine rock type, alteration suites, and mineral assemblages. Samples of alluvium were either 5-lb grab samples of surficial sand and gravel or 20-lb channel samples of sediment. Material larger than 0.25 in. was screened and visually examined for heavy minerals, and the remaining portion was concentrated on a Wilfley table. Precious metals in the concentrate were recovered by amalgamation.

History and Production

Mining claims on record in the study area in 1981 included 61 placer and 3 lode claims, none of which are currently active. No oil and gas or mineral leases are known to exist within the study area. In 1982, the nearest mining activity was at the Telegraph mine (fig. 1), about 1.5 mi north of the study area in the Halloran Spring mining district (Clark, 1970, p. 158), and at the Cima and Aiken cinder mines within 2 mi of the southeast boundary of the study area. Mines and prospects examined for this study are shown in figure 2 and are summarized in table 1.

There has been no recorded mineral production from the study area. In prehistoric times, Native Americans mined turquoise from deposits 10 mi north of the study area, and probably transported it on a nearby foot trail that later was named the Mojave trail by white settlers (Ver Planck, 1961, p.4). Historical mining began around 1897 (Hewett, 1956, p. 165). The earliest known production of metallic ore nearby began around 1900 at the Paymaster mine (fig. 1), about 3 mi southwest of the study area in the Old Dad mining district (Clark, 1970, p. 161). From 1932 to 1944, this mine produced 316 oz gold and 117 oz silver from quartz veins in granite gneiss (Hewett, 1956, p. 120-122). The Telegraph mine, discovered in 1930, produced 2,560 oz gold, 5,423 oz silver, and 500 lb copper between 1932 and 1948 from quartz veins in Cretaceous granitic rocks (Hewett, 1956, p. 120; Wright and others, 1953, p. 82).

The Cima and Aiken cinder mines are located in the Cima mining district (Tognoni, 1983, p. vi) where ten placer claims were located in 1947 (Tognoni, 1983, p.8). Production from the Cima cinder mine and from what is now the Aiken cinder mine began in 1954 (Tognoni, 1983, p. 1), and by 1961 total production reached at least 1.4 million tons (Tognoni, 1983, p. 26).

Mineral Deposits

Cinder cones in the region are closely associated with basalt flows, most of which issued from the same vents. Of the 20 central volcanic vents inside the study area, 2 cones in the southern part (fig. 2, locality 6) are young enough to have preserved large amounts of slightly weathered cinders suitable for commercial use. All of the other vent deposits are substantially older so that most of the cinders have been removed by erosion and remaining deposits are weathered or composed dominantly of lava. The two relatively young cinder cones contain about 30 million tons of volcanic cinders similar to those at the Cima and Aiken deposits. The two mines outside the study area have adequate resources to supply local markets for the foreseeable future. Also, many other cinder cones in the region have commercial-quality cinders.

Proprietary assay results obtained by USBM from the owners of the Aiken and Cima cinder mines (Rumsey and McMahan, 1985) indicate the presence of significant concentrations of gold in cinders and possibly in basalt and Cretaceous granite. However, neutron-activation analyses of cinders and blocks from three cones adjacent to and outside of the study area (Breslin, 1982, p.98) revealed gold concentrations of less than 0.001 to 0.004 ppm, which are typical of basaltic volcanic rocks (Crockett, 1974). Breslin's results were confirmed by the USBM sample program (Rumsey and McMahan, 1985). Alluvial samples collected throughout the study area contain only trace amounts of gold.

The levels of gold and silver concentration and local alteration of rocks and veins at two prospects (fig. 2 and table 1, nos. 2 and 4) in the study area indicate the presence of mineralization similar to that in Cretaceous granitic rock at the Telegraph mine and in Proterozoic(?) gneiss at the Paymaster mine. Because of the limited extent of mineralized rock, no gold or silver resources were identified at either of the two prospects within the study area.

Trace amounts of gold in 51 alluvial samples collected throughout the study area suggest that gold remained when the parent rock was eroded away, or that the trace amounts characterize the parent Proterozoic(?) gneiss and (or) Cretaceous granite. However, no gold was found in the panned-concentrate samples analyzed by the USGS, except at the Paymaster mine. Assays show that granitic rocks in the study area contain trace amounts of gold. In all cases, the gold detected in alluvium and granitic rocks is present in amounts too small to be considered a resource.

Stone, sand, and gravel deposits within the study area are too far from anticipated markets to be considered resources. No evidence of oil, gas, uranium, or geothermal energy was found in the study area.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Howard G. Wilshire, James G. Frisken, Robert C. Jachens, and Douglas V. Prose, U.S. Geological Survey

Geology

The Cinder Cones Wilderness Study Area is underlain mainly by Cretaceous granitic rocks that are partly covered by a veneer of Tertiary and Quaternary sedimentary and volcanic rocks (fig. 2). Proterozoic(?) gneiss, into which the Cretaceous granitic rocks were intruded, crops out most extensively on the western side of the study area. The Cretaceous rocks are cut by northwest-trending dikes of fine-grained porphyritic and nonporphyritic hornblende biotite andesite or dacite 1 to 15 ft wide. Intrusive contacts between Proterozoic(?) rocks and Cretaceous granitic rocks, and between Cretaceous granitic rocks and andesite or dacite dikes, are locally well exposed. Where exposed, these contacts are apparently unaltered.

The Tertiary sedimentary rocks are composed of detritus from nearby Cretaceous granitic rocks with lesser amounts (generally less than 5 percent) from more distant Proterozoic gneiss, dike rocks, and quartz veins in the granitic rocks. The moderately to well-bedded, poorly consolidated sedimentary rocks composed of boulders, gravel, sand, and silt are preserved mainly beneath mesa-capping basalts. At the north end of the study area, these rocks dip 25° to 40° to the southeast and are in angular discordance with the overlying basalt flows. To the south, the sedimentary rocks appear to be less tilted. Because the oldest known basalt flow on the mesa is dated at 4.8 million years before present (Ma) (Turrin and others, 1985), the sedimentary rocks are at least Pliocene (2-5 Ma) age. The maximum thickness of Tertiary sedimentary rocks is approximately 1,000 ft, assuming that the section at the north end of the study area is not repeated by faulting. The maximum paleotopographic relief on the bedrock surface beneath the Tertiary sedimentary rocks is at least 450 ft.

Late Tertiary and early Quaternary basalt flows and cinder cones overlie the sedimentary and crystalline rocks. Basalt dikes are common in eroded cinder cones, but have not been observed in Cretaceous granitic rocks. The basalts were erupted between about 8 and 0.015 Ma (Turrin and others, 1985). Younger Quaternary detritus consists of small alluvial fans adjacent to bedrock outcrops and more extensive unconsolidated alluvium and colluvium on gentle slopes.

Geochemical Studies

A reconnaissance geochemical study of the study area was undertaken in 1984 by the U.S. Geological Survey. Rock samples and the nonmagnetic fraction of heavy-mineral concentrates panned from stream sediments collected in active streams were analyzed. These two sample media were selected because they are reliable indicators of base- and precious-metal anomalies in the arid desert environment of southeastern California. Twenty-three rock samples of stream cobbles, outcrops, and mine dumps collected from sixteen sites adjacent to and within the study area are mineralized or altered, and were collected to characterize the geochemistry of local ore deposits and of mineralized and altered rocks. Thirty-two concentrates were prepared from sediment collected from 32 washes inside and south of the study area representing drainage basins ranging in size from 0.5 to 5 mi^2. Two concentrates represent mineralization associated with the Paymaster mine, and one is from a very small drainage west of the Telegraph mine. The other concentrates represent areas without known mineralized areas.

Nonmagnetic concentrates usually exclude clays, organic material, and common rock-forming minerals (some of which contain metal anomalies unrelated to ore-forming processes) and concentrate many minerals that are commonly related to mineralization and alteration, thereby increasing the chances of detecting relatively weak geochemical anomalies that may be missed by using untreated stream sediments. Also, microscopic examination of concentrates allows identification of the minerals and man-made contaminants that cause the geochemical anomalies.

The rock and nonmagnetic concentrates were pulverized, then analyzed for 31 elements by a semiquantitative emission spectrographic method (Grimes and Marranzino, 1968; Motooka and Grimes, 1976) and for gold by atomic-absorption methods (Thompson and others, 1968). The rocks were also analyzed for arsenic, antimony, cadmium, bismuth, and zinc by atomic absorption (Viets, 1978), which provides lower detection levels for these elements than does spectrography.

All the known and potential mineral deposits adjacent to the study area and potential mineral deposits within it can probably be accounted for by Hewett's (1956) model of Laramide ore deposits. Hewett considered the Cretaceous intrusive rocks to be the dominant element in the mineralizing process and pointed out that metallic-mineral deposits were concentrated in late-stage dikes, fracture zones, and quartz veins emplaced near the contact between the plutons and Proterozoic (?) crystalline and Paleozoic sedimentary country rocks. The characteristic anomalous geochemical suite of these mesothermal vein systems consists of antimony, arsenic, bismuth, copper, gold, lead, molybdenum, silver, tin, tungsten, and vanadium. In some regions, such vein systems may be underlain by porphyry copper-molybdenum mineralization (Cox and Singer, 1986).

Most important in this area are precious-metal, multiple-element, multiple-media, and adjacent-site anomalies. Most rock and panned-concentrate samples collected for this study do not contain geochemical anomalies. Many samples have a restricted suite of anomalous elements or are anomalous in only a single element. No gold concentrations at the lower detection limit of 0.05 ppm were found in concentrates. Samples from westward-draining washes in the southern part of the study area contain low-level lanthanum, lead, molybdenum, thorium, and vanadium anomalies, but possess no concentrations of

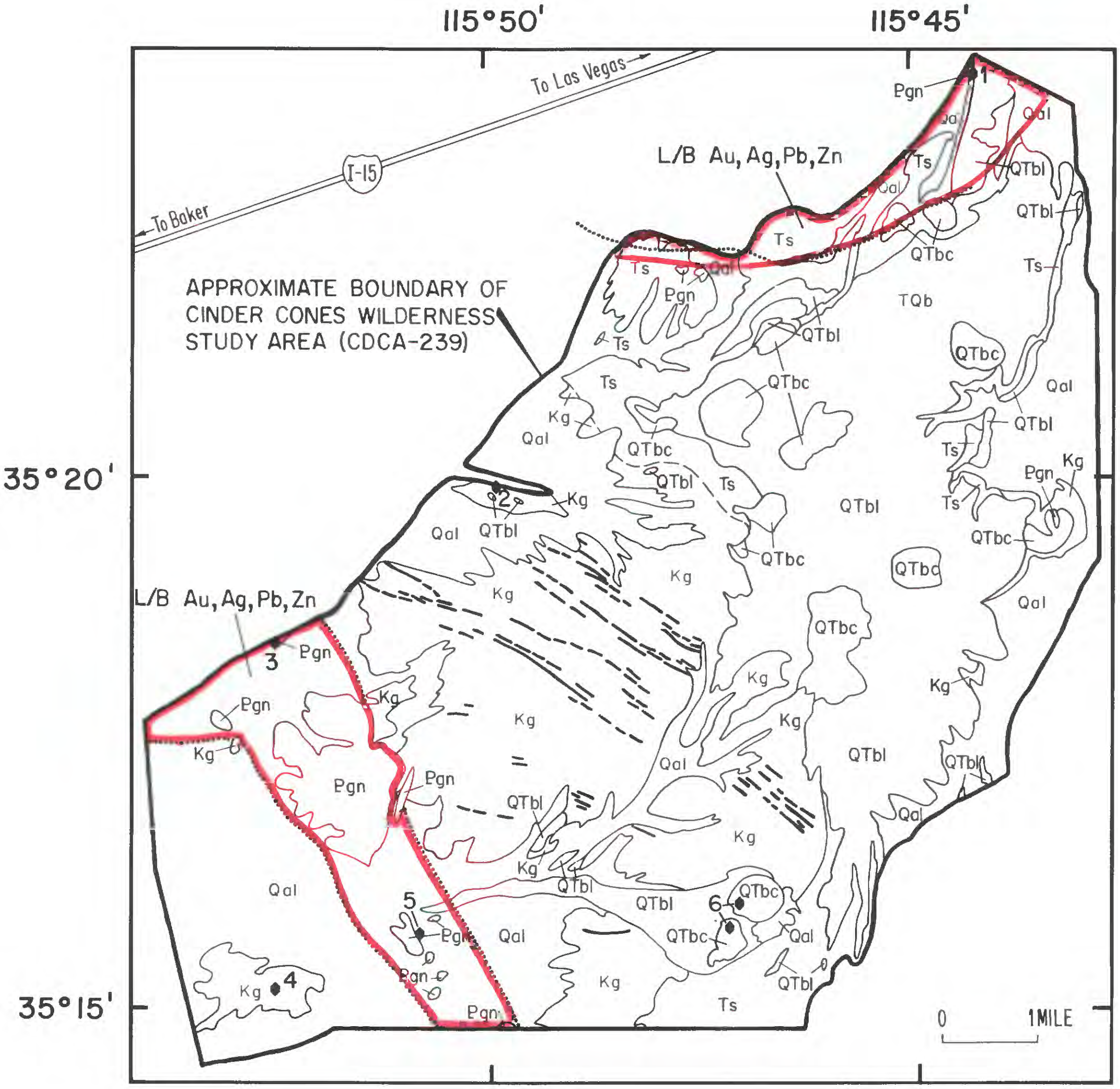

Figure 2. Map showing the geology and mineral resource potential of the Cinder Cones Wilderness Study Area, San Bernardino County, Californina.

EXPLANATION

Area with low mineral resource potential, certainly level B (L/B). See appendix 1 and figure 3 for definition of levels of mineral resource potential and certainty of assessment

COMMODITIES

Au Gold
Ag Silver
Pb Lead
Zn Zinc

CORRELATION OF MAP UNITS

Qal	Holocene and Pleistocene	QUATERNARY
QTbl, QTbc		QUATERNARY / TERTIARY
Ts		TERTIARY
Kg		CRETACEOUS
Pgn		PROTEROZOIC(?)

GEOLOGIC MAP UNITS

Qal Alluvium and colluvium (Holocene and Pleistocene)
QTbl Basalt lava (Quaternary and Tertiary)
QTbc Basalt cinders, agglutinate, maar beds (Quaternary and Tertiary)
Ts Sedimentary rocks (Tertiary)
Kg Granitic rocks (Cretaceous)
Pgn Gneiss (Proterozoic?)

MAP SYMBOLS

Contact--Dashed where approximately located
Concealed contact--Located by aeromagnetic data
Tertiary dike rocks--Dashed where approximately located
4 Prospect--Number refers to table 1

Figure 2. Continued.

precious metals. The anomalies may be related to contact zones between remnants of the Proterozoic(?) rocks and Cretaceous granitic rocks and probably do not indicate the presence of a mineral resource.

Mineralized rocks from mines and prospects located within 4 mi of the study area mostly contain anomalous amounts of antimony, arsenic, bismuth, copper, gold, silver, and zinc; some of the samples contain low concentrations of molybdenum, tungsten, or manganese. The Telegraph mine produced gold and silver from quartz veins trending N. 30° E. and dipping 40° NW. At least 20 such veins occur in intrusive rocks southwest of the Telegraph mine. A composite sample of quartz-vein material collected from outcrops about 1 mi west of the Telegraph mine contains 44 ppm gold and 7 ppm silver, demonstrating that the ore deposits of the Telegraph mine extend along strike to the southwest. A concentrate sample from a very small drainage about 1 mi west of the Telegraph mine contains anomalous vanadium (500 ppm). Rock samples collected from mines about 3 mi northeast of the Telegraph mine posess relatively lower or no concentrations of gold, but are rich in silver, copper, lead, and zinc.

Two concentrate samples collected adjacent to the Paymaster mine are anomalous in bismuth, copper, gold, lead, and silver. Other mines near the Paymaster mine have produced precious or base metals from quartz veins in the Prospect Mountain Quartzite, a formation that is not known to be present in the study area.

One concentrate sample from a previous geochemical study (Van Trump and Miesch, 1976), reportedly collected 2 mi northeast of Granite Spring, contained 90 ppm bismuth, 130 ppm copper, 8 ppm gold, and 150 ppm lead; a concentrate collected for this study 2 mi below this site revealed no anomalous concentrations. At a site along the north side of the study area, another concentrate collected during previous studies (Van Trump and Miesch, 1976) reportedly contained 40 ppm bismuth, and a stream-sediment sample contained 50 ppm molybdenum. These previously determined anomalies in the northeast corner of the study area are presumably derived from underlying Tertiary sedimentary rocks. However, the nine concentrate samples that were taken from the same area during our study are not anomalous. In that part of the area, the Tertiary sedimentary rocks are composed mostly of detritus derived from Cretaceous granitic rocks and contain less than 5 percent fragments of Proterozoic (?) metamorphic rocks and Tertiary andesite or dacite dike rocks. No fragments of Paleozoic rocks were seen in the Tertiary sedimentary rocks in the northern part of the study area. Pebbles of pre-Tertiary crystalline rocks were found at seven of our nine sample sites, which indicates that these washes drain at least limited exposures of pre-Tertiary rocks and (or) Tertiary sedimentary rocks derived from pre-Tertiary rocks. The lack of geochemical anomalies in our concentrate samples suggests that the existence of an extensive mineralized area covered by sedimentary rocks and basalt is unlikely.

Anomalous concentrations of lanthanum, thorium, and yttrium are present in most of the concentrates and seven samples have thorium concentrations of 5,000 ppm or more. Thorite and monazite crystals were identified in some of the concentrates and the anomalies are probably derived from these accessory minerals in the crystalline rocks. It is unlikely that a minable resource occurs within the study area. Rare-earth minerals, including monazite, are mined at the Mountain Pass mine 11 mi northeast of the study area, but that deposit is Proterozoic (?) in age and is related to carbonatite and syenite-shonkinite intrusions, which are not known to occur within the study area. Barite and fluorite are also associated with the deposit at Mountain Pass, and these minerals were not seen in concentrates.

Geophysical Studies

An aeromagnetic survey of the study area was flown in 1981 and compiled under contract to the USGS. Total-field magnetic data were obtained from east-trending flight lines spaced approximately 0.5 mi apart and flown at a height of 1,000 ft above average terrain. Because of the topography of the study area, actual terrain clearance varied from about 400 to 1,600 ft. Corrections applied to the data compensate for diurnal variations of the Earth's magnetic field, and the International Geomagnetic Reference Field (updated to December 1981) was subtracted to yield a residual magnetic map (U.S. Geological Survey, 1983).

Comparison of anomalies depicted on the aeromagnetic map with the exposed rock types indicates that, within the study area, rock magnetization correlates well with the major rock units defined by geologic mapping. Tertiary sedimentary rocks and Quaternary alluvium are effectively nonmagnetic and cause no magnetic anomalies. Tertiary and Quaternary basaltic rocks are strongly magnetic and yield high-amplitude, short-wavelength magnetic anomalies, especially over volcanic vent deposits. A broad magnetic low over the Cretaceous granitic rocks (DeWitt and others, 1984; Hewett, 1956) exposed in the central part of the study area and a low over similar rocks exposed in the southwest corner indicate that these rocks are much less magnetic than either the basaltic rocks or the Proterozoic (?) gneiss with which they are in contact. One exception is the Cretaceous granitic rocks in which the Telegraph mine is located; this rock-type has a very high proportion of mafic inclusions that probably cause the magnetic anomaly. No similar rocks are exposed in the study area.

Gravity data near the study area were obtained from Snyder and others (1982) and supplemented by nine measurements made in 1985. The observed gravity data, based on the International Gravity Standardization Net datum (Morelli, 1974), were reduced to free-air gravity anomalies by using standard formulas (Telford and others, 1976). Bouguer, curvature, and terrain corrections (out to a distance of 103.6 mi from each station) at a standard reduction density of 2.67 g/cm^3 were added to the free-air anomaly at each station to determine complete Bouguer gravity anomalies.

The Bouguer gravity field over the study area and surrounding regions reflects shallow density contrasts and deep-crustal density distributions that correlate with the topography in a manner consistent with the concept of isostasy (Oliver, 1980). To isolate that part of the gravity field that arises from near-surface density distributions, an isostatic residual-gravity map was constructed from the Bouguer gravity data by removing a regional gravity field computed from a model of the crustal-mantle interface, assuming Airy-type isostatic compensation (Jachens and Griscom, 1985).

The density of some of the major rock units was determined by measuring hand samples collected from surface exposures near the study area. Thirty-eight samples of the Cretaceous granitic rocks averaged 2.60 ± 0.02 g/cm^3, and six samples of the Proterozoic (?) crystalline rocks averaged 2.69 ± 0.04 g/cm^3. Although the number of samples of Proterozoic (?) crystalline rock is small, their average density agrees well with that of 35 other samples of similar rocks from the eastern Mojave Desert (2.69 ± 0.11 g/cm^3). Only three samples of basalt were measured and they yielded an average density of 2.64 ± 0.05 g/cm^3.

The aeromagnetic data were used as the primary means for locating the buried Proterozoic(?) gneiss-Cretaceous granitic rocks contacts (fig. 2). The locations of the contacts were inferred from the magnetic data using an automated technique for locating steeply dipping contrasts in magnetic properties (Blakely and Simpson, 1986). The two inferred-contact segments in the western part of the study area are well defined and agree closely with the mapped contact where it is exposed. The easternmost of these two segments is also reflected in the gravity data by a gradient that separates residual-gravity values of about -12 milligal (mGal) over Proterozoic (?) rocks to the west from values less than -25 mGal over Cretaceous granitic rocks to the east. Gravity modeling based on a density contrast of 0.09 g/cm^3 between Proterozoic (?) gneiss and Cretaceous granitic rocks suggests that the contact is nearly vertical and extends to a depth of nearly 2.5 mi.

The inferred-contact segment that lies near the north boundary of the study area separates magnetic rocks to the north from less magnetic rocks to the south. Numerous outcrops of Proterozoic(?) gneiss (not shown on fig. 2) are present north of the west half of this contact segment and three small exposures bracket it in the study area. Cretaceous granitic rocks also crop out north of the inferred contact. Thus, the area of magnetic rocks north of the contact is not underlain completely by Proterozoic (?) gneiss, but probably is a mixture of Cretaceous granitic rocks and remnants of the magnetic Proterozoic (?) rocks that formed the roof of the intrusive rocks. The less magnetic rocks to the south probably are Cretaceous granitic rocks with or without a cap of Tertiary sedimentary rocks largely derived from Cretaceous granitic rocks. This interpretation is supported by the gravity data, which show low residual gravity values north and south of the contact.

Conclusions

Geologic, geophysical, and geochemical studies of the Cinder Cones Wilderness Study Area have not revealed resources of base- and precious-metals. A review of mine production and mineral occurrences in areas surrounding the study area indicate that conditions conducive to base and precious metal mineralization are met only locally within the study area. Proterozoic (?) and Paleozoic rock surrounding Cretaceous granitic intrusions and quartz veins in the intrusions are the main hosts of base- and precious-metal deposits surrounding the study area. Quartz veins are rare within the study area, and quartz-vein detritus is uncommon in Tertiary and Quaternary alluvium. Local exposures of Proterozoic (?)-Cretaceous rock contacts in the study area are not apparently mineralized; concealed parts of the contact zones are revealed by aeromagnetic studies. These zones have low potential for precious- and base-metal resources, certainty level B (see appendix 1 and figure 3 for a definition of mineral resource potential and levels of certainty). Gold and silver concentrations at two prospects in the study area are associated with locally altered granitic rock, but no gold or silver resources were identified at either locality. Paleozoic metasedimentary rocks, which host mineral deposits to the south of the study area, are not present within the study area.

No hot springs or other indications of geothermal activity are associated with the Tertiary and Quaternary volcanic rocks, and most of the study area, including the area occupied by the volcanic rocks, is underlain by Cretaceous granitic rocks and smaller areas by Proterozoic (?) metamorphic rocks. Geophysical modeling indicates that Cretaceous granitic rocks are at least 2.5 mi thick beneath the wilderness study area. Hence, the potential for oil, gas, and geothermal energy resources is low, certainty level C.

Large quantities of sand and gravel are present in the northern and south-central parts of the study area, but much larger deposits occur outside the study area.

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TABLE 1--Mines and prospects in and adjacent to the Cinder Cones Wilderness Study Area
[Asterisk indicates location outside of the study area]

Map No.	Name	Summary	Workings and production	Sample and resource data
1	Unnamed prospect	1.5-ft-thick dike strikes N. 30° E., 35° SE. in Proterozoic(?) gneiss; dike has 4 in. of gouge along hanging wall, 2 in. along footwall.	A 20-ft-long adit.	One sample collected across dike and gouge contains no gold or silver.
2	Raw Silver Cone prospect	Two clayey,brecciated, iron-stained shear zones exposed for 200 ft in Cretaceous granite; host rock locally altered and leached; malachite coats 10 percent of fractures; one zone is 2 ft thick and strikes N. 45° W., dips 43° NE.;other zone is 3 ft thick, strikes N. 79° W., and dips 45° SE.; 5 zones of pink to white altered, massive clay-like material are as much as 90 ft across.	5 trenches totalling 239 ft and 2 adits totalling 101 ft; one caved adit and two prospect pits.	12 samples collected from veins and altered zones; 3 samples contain only traces of gold; 5 have 0.05-0.32 oz/ton gold; 3 have only traces of silver; 5 have 0.4-1.8 oz/ton silver; 1 select sample from 50-lb stockpile contains 41.3 oz/ton silver; 2 samples contain only traces of copper. Mineralized rock of limited extent. No resources are apparent.
3	Holladay Gold prospect	Northeast-trending contact zone between Cretaceous granite and Proterozoic schist traced for 145 ft; rock along the contact altered and silicified (5 ft thick zone of alteration).	Three 5-ft-square by 3-ft-deep prospect pits.	3 chip samples collected across Proterozoic(?) schist, silicified schist, and gneiss contained no gold or silver.
4	Little Dove prospect	3 brecciated quartz-filled shear zones contain gold and silver in foliated granite; shear zones discontinuously exposed for 130 ft; quartz is vuggy and iron-stained, locally contains limonite and pyrite; zones are about 1 ft thick, strike N. 80° E., N. 70° W., and N. 30° W.; all dip 50° N.	One 7-ft-square by 25-ft-deep shaft; 1 8-ft-square by 23-ft-deep shaft inclined 50° N. Three 5-ft-square by 3-ft-deep pits.	6 chip samples contain trace amounts to 0.15 oz/ton gold; 1 select grab sample contains 0.86 oz/ton gold and 1.2 oz/ton silver; 4 chip samples contain 0.4 oz/ton silver. Mineralized rock of limited extent; no resources apparent
5	Bronco prospect	A 4-in.-thick quartz-filled shear zone is exposed for 30 ft in a 5-ft-thick zone of bleached, silicified foliated granite.	One 50-ft by 100-ft bulldozed area.	One chip sample collected across the shear zone contains no gold or silver.
6	Cinder occurrences	Two cinder cones consist of red and black, coarse- to moderately cellular well-bedded cinders that range in grain size from <0.13 to 6 in. angular block.	None.	Cinder prospect contains 30 million tons of volcanic cinders.
*	Aiken and Cima cinder mines	Cinder cones at 2 mines consist of well-bedded, coarse to moderately cellular red to black cinders that range in size from <0.13 to 6 in. angular blocks.	Cima cinder mine has 8 cones with excavation pits in 6; recorded production is 130,000 tons; total production much greater (Rumsey and McMahan, 1985). Aikin cinder mine has pits in 2 cones; total production to 1983 was 1.28 million tons (Rumsey and McMahan, 1985).	About 8 million tons of cinders remained at Aikin cinder mine in 1983; cinder resources at the Cima cinder mine are unknown but probably substantial. Both mines will supply market demand for the forseeable future.

APPENDIX 1. Definition of levels of mineral resource potential and certainty of assessment

Mineral resource potential is defined as the likelihood of the presence of mineral resources in a defined area; it is not a measure of the amount of resources or their profitability.

Mineral resources are concentrations of naturally occurring solid, liquid, or gaseous materials in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Low mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment where the existence of resources is unlikely. This level of potential embraces areas of dispersed mineralized rock as well as areas having few or no indications of mineralization. Assignment of low potential requires specific positive knowledge; it is not used as a catchall for areas where adequate data are lacking.

Moderate mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable chance for resource accumulation, and where an application of genetic and (or) occurrence models indicates favorable ground.

High mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resources, where interpretations of data indicate a high likelihood for resource accumulation, where data support occurrence and (or) genetic models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential requires positive knowledge that resource-forming processes have been active in at least part of the area; it does not require that occurrences or deposits be identified.

Unknown mineral resource potential is assigned to areas where the level of knowledge is so inadequate that classification of the area as high, moderate, or low would be misleading. The phrase "no mineral resource potential" applies only to a specific resource type in a well-defined area. This phrase is not used if there is the slightest possibility of resource occurrence; it is not appropriate as the summary rating for any area.

Expression of the certainty of the mineral resource assessment incorporates a consideration of (1) the adequacy of the geologic, geochemical, geophysical, and resource data base available at the time of the assessment, (2) the adequacy of the occurrence or the genetic model used as the basis for a specific evaluation, and (3) an evaluation of the likelihood that the expected mineral endowment of the area is, or could be, economically extractable.

Levels of certainty of assessment are denoted by letters, A-D (fig. 3).

A. The available data are not adequate to determine the level of mineral resource potential. Level A is used with an assignment of unknown mineral resource potential.

B. The available data are adequate to suggest the geologic environment and the level of mineral resource potential, but either evidence is insufficient to establish precisely the likelihood of resource occurrence, or occurrence and (or) genetic models are not known well enough for predictive resource assessment.

C. The available data give a good indication of the geologic environment and the level of mineral resource potential, but additional evidence is needed to establish precisely the likelihood of resource occurrence, the activity of resource-forming processes, or available occurrence and (or) genetic models are minimal for predictive applications.

D. The available data clearly define the geologic environment and the level of mineral resource potential, and indicate the activity of resource—forming processes. Key evidence to interpret the presence or absence of specified types of resources is available, and occurrence and (or) genetic models are adequate for predictive resource assessment.

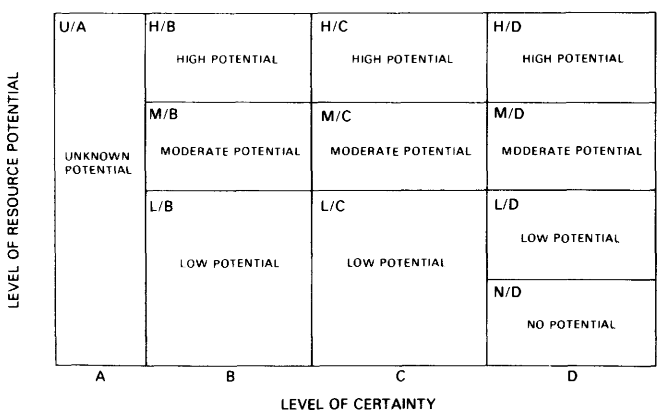

Figure 3. Major elements of mineral resource potential/certainty classification.

GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey in this report

EON	ERA	PERIOD		EPOCH	AGE ESTIMATES OF BOUNDARIES (in Ma)
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				(3800?)
pre-Archean[2]					4550

[1]Rocks older than 570 Ma also called Precambrian, a time term without specific rank.

[2]Informal time term without specific rank.

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