Mineral Resources of the Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley Wilderness Study Areas, San Diego County, California
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 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 presents the results of mineral surveys for part of the Sawtooth Mountains (CA-060-024B) Wilderness Study Area, San Diego County, California and for the Carrizo Gorge/Eastern McCain Valley (CA-060-025A) Wilderness Study Area, San Diego County, California.
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MINERAL RESOURCES OF WILDERNESS STUDY AREAS: SOUTHERN CALIFORNIA AND CALIFORNIA DESERT CONSERVATION AREA

Mineral Resources of the Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley Wilderness Study Areas, San Diego County, California

By Victoria R. Todd, James E. Kilburn, David E. Detra, Andrew Griscom, Daniel H. Knepper, Jr., and Fred A. Kruse
U.S. Geological Survey

Eric Gather and David A. Lipton
U.S. Bureau of Mines

SUMMARY

Abstract

This report presents the results of mineral surveys of part of the Sawtooth Mountains (CA-060-024B) Wilderness Study Area and all of the Carrizo Gorge/Eastern McCain Valley (CA-060-025A) Wilderness Study Area. In this report, the areas studied are referred to as "the wilderness study areas", or simply "the study areas." The Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley study areas encompass approximately 24,696 and 14,573 acres, respectively, in eastern San Diego County, California. Field work for this report was carried out during 1983 and 1984. No mineral resources or resource potential have been identified in the Sawtooth Mountains Wilderness Study Area. The study area contains extensive sand and gravel occurrences, but these occurrences are not considered resources because similar ones are present closer to population centers such as San Diego and El Centro. The Carrizo Gorge/Eastern McCain Valley Wilderness Study Area has moderate potential for resources of undiscovered gem-grade minerals (kunzite, aquamarine) in pegmatite dikes in the vicinity of Mount Tule in the western part of the study area. No oil, gas, coal, or geothermal resources were identified in either of the study areas.

Character and Setting

The Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley Wilderness Study Areas have been combined into a single report because they are geographically close and have similar geologic settings. The Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley Wilderness Study Areas occupy approximately 24,696 and 14,573 acres, respectively, in eastern San Diego County, Calif. They are located about 40 and 50 mi east of San Diego, respectively (fig. 1). The study areas lie within a transitional physiographic zone between the Peninsular Range province, the mountainous spine of Alta and Baja California to the west, and the Colorado Desert to the east. This zone is characterized by rugged topography and has a semiarid to arid climate. Conifer forests occupy the higher mountain ridges, and chapparal-desert plant communities are found at lower elevations. Topographic relief in the study areas ranges from about 3,800 to 4,100 ft.

The Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley Wilderness Study Areas are underlain by Cretaceous (63 to 138 million years before present (Ma); see appendix for geologic time scale) plutonic rocks of the Peninsular Ranges batholith that form much of the crystalline bedrock of the Peninsular Ranges. The batholith is composed of a variety of deformed Early Cretaceous plutons that were intruded by relatively undeformed younger Cretaceous plutons. These plutons intruded metamorphosed Paleozoic (240 to 570 Ma) and Mesozoic (63 to 240 Ma) sedimentary and volcanic rocks, remnants of which are exposed as steeply dipping tabular bodies, or screens, between the plutons. Patches of Cenozoic (63 Ma to present) alluvial deposits unconformably overlie the uplifted and deeply eroded batholith in both study areas. Faults of various ages cut the batholithic rocks. In the Sawtooth Mountains Wilderness Study Area, some faults cut Quaternary alluvium.

Small gold deposits are found in metasedimentary rocks in the Deer Park and Laguna Mountains mining districts, about 4 mi west of the Sawtooth Mountains Wilderness Study Area. There is no record of mining activity in similar metasedimentary rocks within the study area, and no gold or other mineral...
Figure 1. Index map showing location of Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley Wilderness Study Areas, San Diego County, California.
resources were found during this study. The Carrizo Gorge/Eastern McCain Valley Wilderness Study Area contains no mines, and no mineral resources were identified during this study. Two gem-producing mines are located in pegmatite dikes adjacent to the west boundary of the study area, and similar pegmatite dikes occur within the study area in the vicinity of Mount Tule.

Mineral Resources and Mineral Resource Potential of the Sawtooth Mountains Wilderness Study Area

No mineral resources or resource potential have been identified in the Sawtooth Mountains Wilderness Study Area although evidence of minor mineralization is present. Two prospects in the western part of the study area revealed pegmatite and quartz veins in pelitic schist (fig. 2), a geologic environment similar to that of gold-bearing mineralized zones about 4 mi west of the study area. Samples from the two prospects in the study area contained no significant metal concentrations. A reconnaissance geochemical survey of stream sediments revealed widespread tungsten and tin anomalies as well as localized silver, barium, copper, bismuth, and lead anomalies. These geochemical anomalies are probably related to the abundances of particular rock types within the study area and do not indicate resources. The above data, and the absence of mining activity in the area, indicate that there is no potential for undiscovered mineral resources. Sand and gravel occurrences exist but are not considered resources at this time because of the high cost of transporting these materials to population centers. No potential for undiscovered oil and gas or other energy resources was identified in the study area.

Mineral Resources and Mineral Resource Potential of the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area

No mineral resources have been identified; however, available data suggest that the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area has moderate potential for gem-grade minerals in pegmatite dikes near Mount Tule (fig. 3). Two active mines adjacent to the west boundary of the study area near Mount Tule have produced significant quantities of gem-grade aquamarine and kunzite from pegmatite dikes that cut a large screen consisting of gabbro, tonalite, and metasedimentary rocks. Many lithologically similar dikes are present within the study area in the Mount Tule area and detailed exploration of them might disclose gem-bearing pockets. Scattered exposures of manganiferous rocks in the study area are too small to be considered resources. A reconnaissance geochemical survey of stream sediments disclosed widespread tungsten and tin anomalies as well as locally high concentrations of boron, bismuth, molybdenum, and barium. In most cases, these anomalies are related to the abundances of specific rock types within the study area and do not indicate the existence of mineral resources. No mineral or sand and gravel resources were identified in the study area. No potential for undiscovered oil and gas or other energy resources was determined in the study area.

INTRODUCTION

Area Descriptions

This report presents the results of mineral surveys of part of the Sawtooth Mountains (CA-060-024B) Wilderness Study Area and all of the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area. In this report, the areas studied are referred to as "the wilderness study areas," or simply "the study areas." The Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley Wilderness Study Areas are located about 40 and 50 mi east, respectively, of San Diego, Calif., where they comprise approximately 24,696 and 14,573 acres, respectively (fig. 1). In this region, a subdued upland surface that forms the crest of the Peninsular Ranges is succeeded to the east by rugged desert mountain ranges and alluviated valleys. The climate is semi-arid to arid; vegetation varies from pinyon-juniper-mountain mahogany woodlands at higher elevations, through a mixed chaparral-sage-desert flora at intermediate elevations, to a true desert community that includes agave and cactus with isolated palm groves at the heads of canyons.

The Sawtooth Mountains Wilderness Study Area includes part of the deeply incised eastern escarpment of the Laguna Mountains; elevations range from about 5,900 ft at the edge of the escarpment to about 1,800 ft in the desert valley below. Sunrise Highway provides access to the western part of the study area and the northern part can be reached by unimproved dirt roads that lead up several large canyons. McCain Valley Road originates at California Highway 80 in Boulevard and provides access to the southern part of the area.

The Carrizo Gorge/Eastern McCain Valley Wilderness Study Area is located in the In-ko-pah Mountains and includes part of the McCain Valley National Cooperative Land and Wildlife Management Area on the west. The southern boundary of the study area lies less than 1 mi north of Interstate 8. The study area encompasses part of the western wall of a spectacular gorge cut by northward-flowing Carrizo Creek. Elevations range from 4,647 ft on Mount Tule to about 800 ft in lower Carrizo Canyon; peaks named Grunt, Gasp, and Groan suggest the ruggedness of the terrain in and near the study area. The western part of the area can be reached from McCain Valley Road by an unimproved dirt road to Sacote Spring (fig. 3). Access to the northern part of the area is from County Road S-2, while the eastern part is accessible from Dubber Spur, a siding on the presently defunct San Diego and Arizona Eastern Railroad.

Previous and Present Investigations

This mineral resource study is a joint effort by the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM). The history and philosophy of such joint mineral surveys of U.S. Bureau of Land
Figure 2. Map showing generalized geology of the Sawtooth Mountains Wilderness Study Area, San Diego County, California. Area contains no mineral or energy resource potential.
EXPLANATION

- Stream-sediment sample site
- Unnamed prospect—See table 1 for description
- Surficial deposits (Quaternary and Tertiary)
- Late-tectonic to posttectonic tonalite (Cretaceous)
- Tonalite of Las Bancas (Cretaceous?—I-type pluton
- Gneissic and migmatic granitic rocks (Cretaceous?)—S-type pluton
- Prebatholithic metasedimentary rocks (Jurassic and Triassic)
- Contact
- High-angle fault—Dashed where approximately located or inferred; dotted where concealed; U on upthrown side; D on downthrown side
- Low-angle fault—Teeth on upper plate
- Shear zone

Figure 2. Continued.

Management (BLM) study areas are discussed by Beikman and others (1983). Mineral assessment methodology and terminology are discussed by Goudarzi (1984). Studies by the USGS are designed to provide a reasonable scientific basis for estimating the possibilities for the existence of undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, and presence of geochemical and geophysical anomalies. The USBM evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, and mineralized areas.

Published geologic maps of the Agua Caliente Springs (Todd, 1977), Monument Peak (Todd, 1978), and Mount Laguna (Todd, 1979) quadrangles describe the geology of most of the Sawtooth Mountains Wilderness Study Area. The northern part of the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area was mapped by Hoggatt (1978), and a study by Minch and Abbott (1973) provided information on the post-batholithic geologic history south of the study area. The U.S. Geological Survey carried out field investigations in the study areas during 1983 and 1984. The work included new mapping, whole rock and stream sediment sampling for geochemical analysis and radiometric dating, and aeromagnetic and gravity surveys. A total of 98 panned heavy-mineral concentrates from stream sediment samples from both study areas were analyzed. The analytical data are given in Detra and Kilburn (1985a, b).

The U.S. Bureau of Mines conducted a library search for information on mines and prospects in and adjacent to the study areas. These data were supplemented by information from claim owners and from San Diego County and U.S. Bureau of Land Management mining claim and lease records. Field studies by U.S. Bureau of Mines personnel were carried out in 1983. The study areas were searched on foot and by helicopter for evidence of mining activity or mineralized zones. During this time, 13 lode samples were collected from the two study areas for chemical analysis by fire assay, atomic absorption, inductively coupled plasma spectrographic, colorimetric, and X-ray fluorescence methods. In addition, approximately 40 elements were analyzed by semiquantitative spectrographic method. Analytical results are given in Cather (1984) and Lipton (1985).

Acknowledgments

The authors acknowledge Fred Stevens and Loren Beebe who supplied production data pertinent to their mining claims adjacent to the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area. We also thank personnel of the El Centro and Riverside district offices of the Bureau of Land Management for advice on access to the study areas and for generously making their records available to us. The Anza-Borrego Desert State Park gave permission for helicopter landings in the state park adjacent to the study areas.

Regional Geologic Setting

The Sawtooth Mountains and Carrizo Gorge/Eastern McCain Valley Wilderness Study Areas lie within the Cretaceous Peninsular Ranges batholith of southern California, U.S.A., and Baja California, Mexico, and have similar geologic settings. In San Diego County, the batholith is overlapped by Upper Cretaceous to lower Pleistocene (?) sedimentary rocks. Batholithic rocks in San Diego County have been divided into an older intrusive sequence that was contemporaneous with regional deformation and a younger sequence that largely postdated regional deformation (Todd and Shaw, 1979). Uranium-lead zircon ages from rocks that are considered to belong to the older sequence range from 120 to 105 Ma, whereas ages of the younger plutons range from 100 to 95 Ma (Silver and others, 1979; Clinkenbeard and others, 1986). The older, deformed intrusive sequence was further subdivided into western I-type and eastern S-type granitic rocks (Todd and Shaw, 1979; 1985). This contrast in plutonic rock types is thought to reflect profound west-to-east differences in the source rocks of the batholith: western I-type plutons crystallized from partial melts of igneous source materials and eastern S-type plutons from partial melts of metasedimentary materials. The I- and S-type granitic rock classification is used in this report because it permits a large number of plutons to be divided into two groups, each including genetically related plutons. In San Diego County, these groups appear to be related to the presence or absence of mineral deposits, for example, S-type plutons are locally associated with gold in syntectonic quartz veins (Donnelly, 1934), while I-type granitic plutons show little mineralization.
Prebatholithic rocks that form the western wall of the Peninsular Ranges batholith are composed of metamorphosed volcanic and volcanioclastic rocks of Late Jurassic and Early Cretaceous age (Silver and others, 1963; Fife and others, 1967; Gastil and others, 1975; Schoellhamer and others, 1981). Inclusions of metavolcanic rocks in the batholith in the western part of San Diego County are undated, but are generally correlated with the Upper Jurassic and Lower Cretaceous wallrocks. Wallrock inclusions in eastern San Diego County are composed of metasedimentary rocks that contain minor metavolcanic layers. Possibly related metasedimentary rocks outside the study area have yielded Middle Jurassic, probable Triassic, and Early Ordovician fossils (Gastil and others, 1981; Miller and Dockum, 1983). Although some of the prebatholithic metasedimentary rocks in eastern San Diego County may have been coeval with the western metavolcanic rocks, it is likely that Paleozoic and older Mesozoic strata are present.

Intrusion of the plutons, which largely post-dates deformation, was followed by uplift, erosion, sedimentation, and volcanism. Sedimentary and volcanic rocks include the Lusardi Formation, a locally derived continental fanglomerate of Late Cretaceous age, which overlies the eroded batholith in San Diego County (Kennedy and Peterson, 1975), the Eocene Poway Group (Kennedy and Peterson, 1975), and Miocene andesite and basalt (Minch and Abbott, 1973). These volcanic rocks were uplifted by predominantly normal displacements on late Tertiary and Quaternary faults of the Elsinore fault zone, which forms the east margin of the Laguna and In-ko-pah Mountains of the Peninsular Ranges, and these rocks now occupy a position near the crest of the range. Faults of this system are still active, and have displaced batholithic contacts laterally as much as 2 mi (Todd, 1977; 1978; 1979).

### TABLE 1. Prospects in the Sawtooth Mountains Wilderness Study Area

<table>
<thead>
<tr>
<th>Map No. (fig. 2)</th>
<th>Name</th>
<th>Summary</th>
<th>Workings</th>
<th>Sample data and resource estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unnamed prospect</td>
<td>A limonite-stained quartz vein in schist. Vein averages 1.0 ft thick, strikes N. 30° E. and dips steeply. It can be traced about 25 ft along strike.</td>
<td>One shallow prospect pit</td>
<td>One sample of vein contained no significant metal values.</td>
</tr>
<tr>
<td>2</td>
<td>Unnamed prospect</td>
<td>A pegmatite dike and accompanying quartz vein are concordant with foliation of biotite schist and strike N. 15° E. and dip 70° SE. Strike length could not be determined due to poor exposure. Pegmatite is about 1.7 ft thick and quartz vein averages 1.0 ft thick and is locally vuggy and limonite-stained. A 4-ft diameter mass of silicified limonite-stained quartzite is within 50 ft of decline.</td>
<td>One 40-ft decline</td>
<td>Three samples collected: a sample from 200-lb stockpile of pegmatite contained 0.03 oz/ton gold; two samples of pegmatite and vein quartz contained no significant metal values.</td>
</tr>
</tbody>
</table>

**APPRAISAL OF IDENTIFIED RESOURCES OF THE SAWTOOTH MOUNTAINS WILDERNESS STUDY AREA**

By Eric Gather  
U.S. Bureau of Mines

No resources were identified in the Sawtooth Mountains Wilderness Study Area, and no record of mining activity was encountered during the literature search. Two unnamed prospects in the western part of the study area (fig. 2) are in a geologic environment similar to that of mines in the nearby Julian, Deer Park, and Laguna Mountains mining districts, which have yielded gold. Lode gold mines in the Julian district, located 9 mi northwest of the study area, were operated principally from 1870 to the early 1900's, and on a small scale during the 1930's; the mines yielded about $5 million in gold (Weber, 1963). Mineralized zones in the district are primarily in a large inclusion of Triassic and Jurassic(? metasedimentary rocks that extends to the southeast. These rocks host small gold deposits in the Deer Park and adjacent Laguna Mountains districts about 4 mi west of the study area. The gold in all three districts is found in discontinuous quartz veins that are generally concordant with schistosity.

Four samples were taken at the two unnamed prospects in the study area. A sample of pegmatite from a 200-lb stockpile contained 0.03 oz/ton (troy ounce per ton) gold (table 1). The three remaining samples were from pegmatite and quartz veins and contained no significant metal values (Cather, 1984).

Sand and gravel occurrences in the study area are extensive, but these commodities are more accessible closer to population centers such as San Diego and El Centro. No oil, gas, coal, or geothermal resources were identified in the study area.

**ASSESSMENT OF MINERAL RESOURCE POTENTIAL OF THE SAWTOOTH MOUNTAINS WILDERNESS STUDY AREA**

By Victoria R. Todd, James E. Kilburn, David E. Detra, Andrew Griscom, Daniel H. Knepper, Jr., and Fred A. Kruse  
U.S. Geological Survey

**Geology**

The western half of the Sawtooth Mountains Wilderness Study Area is underlain by Early Cretaceous I- and S-type plutons that were emplaced during regional deformation. I-type plutons consist of pyroxene tonalite and gabbro, while S-type plutons consist of tonalite and granodiorite. Large inclusions of prebatholithic rocks and numerous small inclusions were caught up in, and between, these plutons. All contacts dip steeply to the east. The pervasive north-
northwest fabric of the batholith in the west half of
the study area is manifested by the parallel alignment
of elongated and flattened plutons, wallrocks, mineral
foliation, and the axial planes of isoclinal folds.
Lineations and fold axes in both plutons and wallrocks
are coaxial and plunge steeply down the dip of
foliation. The S-type plutons and wallrocks were
folded together into a large south-pointing fold prior
to intrusion of the I-type pyroxene tonalite.
Moderately deformed pyroxene tonalite apparently
intruded the hinge area of the fold and was drawn up
north-northwestward along the fold limbs.
The east half of the study area is underlain by
part of a large leucocratic pluton that intruded the I- and S-type plutons; it yields uranium-
lead zircon ages of 95, 97, and 98 Ma in the southern
part of San Diego County (L.T. Silver, personal
comm., 1979; Clinkenbeard and others, 1988). This
pluton is moderately deformed along the west margin
but is essentially massive in its interior. Swarms of
large leucocratic and pegmatite dikes emanate from
this pluton and extend for many miles into the older
plutonic terrane.

The prebatholithic rocks within and between the
plutons consist of calcicarbonate-bearing, feldspathic
metasiltite, pelitic schist, minor amphibolite, and
scarce marble. The metasedimentary rocks are thin-
bedded and contain turbidite structures, suggesting
deposition in a deep-water marine marginal basin.
Limestone, metamorphosed to marble, is scarce and is
found as small lenses. Skarns are present locally
where small limestone bodies are intruded by granitic
dikes. These prebatholithic rocks are undated but are
presumed on regional evidence to be Triassic and
Jurassic(?). It is interesting that the only barium anomalies
are found near the junction of the Tierra Blanca and
Carlsbad, which may have provided natural
conduits for migrating hydrothermal solutions. The widespread tin and tungsten
anomalies in conjunction with scattered copper, lead,
bismuth, and silver concentrations are not surprising.
Geochemical anomalies in the study area were
limited to widespread tungsten and tin anomalies in
addition to localized silver, barium, copper, bismuth,
and lead concentrations. Most concentrates contain
scheelite and barite but lack other ore-forming sulfide
and oxide minerals. The widespread tin and tungsten
anomalies in conjunction with scattered copper, lead,
bismuth, and silver concentrations are not surprising.

The geologic environment within the study area is
similar to that of the large northwest-trending
mineralized belt that lies immediately west of the
study area (described in an earlier section) in which
small skarns are present locally at contacts between
metasedimentary rocks and granitic bodies. This belt
probably originated in these screens. The scattered tungsten-bearing skarns in which tin, silver,
bismuth, copper, and lead may be common constitu-
ts. Although no skarn deposits were seen within the
study area, undetected small skarn deposits may be
present in the series of wallrock screens that underlie
steep, brushy slopes along the west side of the study
area. The prominent tungsten, copper, and lead
anomalies probably originated in these screens. The
scattered tungsten anomalies located in the eastern
part of the study area, specifically in Canebrake Wash
and the Inner Pasture, may be associated with small
metasedimentary inclusions within the granitic rocks.
Most of the tin probably is derived from an accessory
mineral or minerals disseminated throughout the large
leucocratic tonalite pluton. Skarns may also have
made some contribution to the tin anomalies. Barite,
probably derived from minor veins and replacement
bodies in the surrounding granitic and metamorphic
rocks, was detected in minor amounts in most of the
concentrates. Due to the pervasive character of the
barite, it is interesting that the only barium anomalies
are found near the junction of the Tierra Blanca and
Sawtooth Mountains in the northeastern part of the
study area. The barium anomalies coincide with the
Elsinore fault zone, which may have provided natural
conduits for migrating hydrothermal solutions. However, evidence associating the barite and
anomalous barium to specific mineralized systems of
economic interest is lacking in the study area.
Geophysical Studies

Three aeromagnetic and gamma-ray spectrometer profiles (High Life Helicopters, Inc., and QEB, Inc., 1980) cross the study area with a flightline spacing of approximately 3 mi. The data were collected along east-west traverses by helicopter at a height of 400 ft above ground. The magnetic data collected near the study area are nearly featureless because none of the rocks are particularly magnetic. A major magnetic boundary between magnetic I-type plutonic rocks to the west and nonmagnetic S-type rocks to the east is located 1 to 2 mi west of the study area and there strikes approximately N. 45° W. The radioactivity data for the study area indicate no significant amounts of uranium or thorium.

The limonite mineral group has unique spectral reflectance characteristics that can be detected on Landsat images using a color-ratio compositing technique described by Rowan and others (1974). This technique was applied in the Sawtooth Mountains Wilderness Study Area. The extensive lowland areas along lower Storm Canyon, the Potrero, Inner Pasture, and Canebrake Wash (fig. 2) are densely vegetated and thus could not be evaluated for anomalous concentrations of limonite using Landsat data. Elsewhere in the study area, only a few isolated patches of limonitic materials were observed. These limonitic areas are small and are not clustered into patterns suggestive of possible hydrothermal alteration. The only significant occurrence of anomalous limonite near the study area is in the Tierra Blanca Mountains 1.5 mi northeast of the study area boundary.

Gravity data for the Sawtooth Mountains Wilderness Study Area (Oliver and others, 1980; Roberts and others, 1981; Andrew Griscom, unpub. data, 1986) are sparse and do not provide significant information contributing to a mineral resource appraisal of the study area.

Conclusions

Geologic, geochemical, and geophysical investigations in the Sawtooth Mountains Wilderness Study Area indicate that the area lacks significant mineralization. No mineral resources are identified. Although the geologic setting of the study area is similar to those of the nearby Deer Park and Laguna Mountains mining districts, there is no mineral resource potential for gold or other metals in the study area. This is probably because the host rock for gold-bearing quartz veins, pelitic schist, forms only a minor part of the bedrock in the study area.

Sand and gravel deposits in and near the study area are large, but similar deposits are present closer to population centers. There is no potential for oil, gas, or coal resources in the study area because such commodities would not be expected to occur in crystalline rocks. Hot springs are present at Agua Caliente Springs in the frontal fault zone of the Tierra Blanca Mountains outside the study area, but this locality is not considered a geothermal resource. There are no geothermal resources within the study area.

APPRAISAL OF MINERAL RESOURCES OF THE CARRIZO GORGE/EASTERN McCAIN VALLEY WILDERNESS STUDY AREA

By David A. Lipton
U.S. Bureau of Mines

The Carrizo Gorge/Eastern McCain Valley Wilderness Study Area contains no mines, and no mineral resources were identified in the area. Chemical analyses of nine lode samples from eight properties in and adjacent to the study area by the U.S. Bureau of Mines revealed no anomalous mineral concentrations (table 2) (Lipton, 1985). Two gem-producing mines are adjacent to the west boundary of the study area in the vicinity of Mount Tule (fig. 3). High-grade gem pockets containing kunzite and aquamarine in pegmatite dikes are currently being developed at the Pack Rat and Beebe Hole mines. The Beebe Hole mine has produced gem-quality kunzite valued at approximately $500,000 during the last 10 yr, and aquamarine valued at several thousand dollars in the last few years (Fred Stevens, oral commun., 1984). Additional gem-bearing pockets are likely to exist at these claims, but remaining resources cannot be calculated because of the scattered nature of the deposits.

Pegmatite dikes at these claims dip away from and do not extend into the study area. However, more than two dozen similar pegmatite dikes are present in the area from Mount Tule to Carrizo Gorge and a few dikes are found in the Rockhouse Canyon area. The pegmatite dikes within the study area in the vicinity of Mount Tule contain several of the characteristic minerals used by prospectors to find pockets within the dikes, such as line rock, schorl, and abundant sheets of mica. Detailed exploration of the pegmatite dikes near Mount Tule might disclose gem-bearing pockets. The Rockhouse Canyon area lacks many of the minerals characteristic of gem-bearing pockets.

Small exposures of manganiferous rocks are scattered within the central part of the study area. However, these occurrences are not extensive enough to be considered resources. Occurrences of sand and gravel were not identified. There are no leases for oil and gas or geothermal energy.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL OF THE CARRIZO GORGE/EASTERN McCAIN VALLEY WILDERNESS STUDY AREA

By Victoria R. Todd, James E. Kilburn, David E. Detra, Andrew Griscom, Daniel H. Knepper, Jr., and Fred A. Kruse
U.S. Geological Survey

Geology

The Carrizo Gorge/Eastern McCain Valley Wilderness Study Area is underlain by deformed Early Cretaceous I- and S-type plutonic rocks and preba- lithic metasedimentary rocks (fig. 3). These rocks were intruded by a largely undeformed granitic pluton in part dated at 95 Ma by the uranium-lead method.
Map No. differs from the Sawtooth Mountains Wilderness Study Area in that the older rocks form a large screen that is surrounded by the undeformed granitic pluton. This complex of Mount Tule, underlies Mount Tule in the southwestern part of the study area. A steep-walled gabbro-pyroxene dike is present in the southeast part of the study area. A single outcrop of Miocene volcanic rocks, the Alverson Andesite (Dibblee, 1954), is present in the study area.

Numerous screens and inclusions of prebatholithic rocks are present within the Mount Tule rocks. Contact relations outside the study area indicate that pyroxene tonalite of the Mount Tule complex intruded the S-type plutonic rocks, which consist of a mixture of S-type gneissic granodiorite, partly melted pelite schist, and paragneiss. Underformed garnetiferous two-mica granite in the southern part of the study area has given rise to numerous large leucocratic and pegmatite dikes that extend for miles across the older plutons in the study area.

Upper amphibolite-grade metasedimentary rocks are caught up in both older and younger plutonic rocks in the study area and locally form extensive migmatite zones within the plutonic rocks. These metasedimentary rocks are generally more quartz-rich and, east of the study area, contain more marble than those in the Sawtooth Mountains Wilderness Study Area. Skarns are developed locally where I-type granites are caught up in both older and younger plutonic rocks. These deposits are associated with an incursion of the Gulf of California. These deposits are unconformably overlain by Pleistocene and Holocene alluvial fan deposits in Carrizo Canyon to the north.
Figure 3. Map showing mineral resource potential and generalized geology of the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area, San Diego County, California.
Geochemical Studies

A reconnaissance geochemical survey of stream sediments was conducted in the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area in 1984. Sampling and analytical methods are described in an earlier section on geochemical investigations in the Sawtooth Mountains Wilderness Study Area. A complete listing of the analytical results can be found in Detra and Kilburn (1985b).

Spectrographic analysis revealed widespread tungsten and tin anomalies as well as locally high concentrations of boron, bismuth, molybdenum, and barium. Mineralogically, the study area is characterized by widespread scheelite and barite and an absence of ore-forming sulfide and oxide minerals. The study area contains numerous pegmatite dikes and skarns that contain the above elements as common constituents. The most prominent tungsten anomalies are present with the only boron and bismuth anomalies in drainages along the east flank of Mount Tule in the southern part of the study area. Locally, minor tin anomalies accompany the boron and tungsten. Molybdenum anomalies are chiefly confined to Carrizo, Rockhouse, and Bow Willow Canyons in the north half of the study area and are also associated with the widespread tin anomalies. Unfortunately, no parent mineral was determined for the tin anomalies, which appear to be a regional trait. Most of the tin anomalies probably come from an accessory mineral, or minerals, in the undeformed leucocratic granitic pluton. Various minerals in skarns and pegmatites may have contributed in some measure to the tin anomalies. Scheelite was identified by optical methods as a minor mineral component in about 80 percent of the concentrates and tourmaline was found coincident with the Mount Tule boron anomalies.

The anomalous barium concentrations found in Rockhouse and Bow Willow Canyons probably represent minor barite veins and (or) replacement bodies in the surrounding metasedimentary and granitic rocks. Barite, identified by optical methods, is present in the majority of the samples but associated ore-related minerals were not located in the study area. Barite formation may be related to circulation of hydrothermal solutions in faults of the Elsinore fault zone.

Geophysical Studies

Four aeromagnetic and gamma-ray spectrometer profiles (High Life Helicopter, Inc., and QEB, Inc., 1980) cross the study area with a flightline spacing of approximately 3 mi. The data were collected along east-west traverses by helicopter at a height of 400 ft above ground. The magnetic data are nearly featureless because none of the rocks within the study area are particularly magnetic. The radioactivity data for these profiles show no anomalous amounts of uranium or thorium within the study area.

The limonite mineral group has unique spectral reflectance characteristics that can be detected on Landsat images using a color-ratio compositing technique described by Rowan and others (1974). This technique was used to look for areas of limonite in the Carrizo Gorge/Eastern McCain Valley Wilderness...
Study Area. The spectral response to Landsat data of the study area is dominated by vegetation. Consequently, the presence of anomalous concentrations of limonite that might possibly be associated with hydrothermal alteration could not be evaluated in most of the study area. In the eastern part of the study area, between Carrizo Gorge and the less dissected uplands to the west, the data indicate scattered occurrences of limonitic materials at the surface, but these occurrences are small and are not clustered into patterns that suggest hydrothermal alteration.

Gravity data available for the study area (Oliver and others, 1980; Roberts and others, 1981; Andrew Griscom, unpub. data, 1986) represent only about 10 stations and do not contribute significantly to the mineral resource appraisal of the area.

Conclusions

Geologic studies, geochemical sampling, examination of prospects, and the absence of producing mines in the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area indicate that the area lacks significant mineralization. Gem-bearing pegmatite dikes have been mined for aquamarine and kunzite at two claims outside, and adjacent to, the west boundary of the study area. The host rock of the gem-bearing dikes is a large, predominantly metasedimentary screen near Mount Tule. Although the pegmatite dikes at these claims do not extend into the study area, similar pegmatite dikes are present within the area in the vicinity of Mount Tule. Available data suggest that the Carrizo Gorge/Eastern McCain Valley Wilderness Study Area has moderate potential (certainty level C) for gem-grade minerals in pegmatite dikes in the vicinity of Mount Tule. See appendix for definition of levels of mineral resource potential and certainty of assessment. No other mineral resources are indicated and there is no potential for sand and gravel resources. There is no potential for resources of oil and gas or geothermal energy in the study area because such commodities would not be expected to occur in crystalline rocks.

REFERENCES CITED


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

Definitions of Mineral Resource Potential

LOW mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

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 likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH 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 high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign low, moderate, or high levels of resource potential.

NO mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

Levels of Certainty

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A. Available information is not adequate for determination of the level of mineral resource potential.
B. Available information suggests the level of mineral resource potential.
C. Available information gives a good indication of the level of mineral resource potential.
D. Available information clearly defines the level of mineral resource potential.

Abstracted with minor modifications from:


### GEOLOGIC TIME CHART

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

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\(^1\)Rocks older than 570 Ma also called Precambrian, a time term without specific rank.  
\(^2\)Informal time term without specific rank.