Mineral Resources of the Jacumba (In-ko-pah) Wilderness Study Area, Imperial County, California

U.S. GEOLOGICAL SURVEY BULLETIN 1711–D

Chapter D

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
SOUTHERN CALIFORNIA AND CALIFORNIA DESERT CONSERVATION AREA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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Dallas L. Peck, Director

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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 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 a mineral survey of part of the Jacumba (In-ko-pah) (CDCA-368) Wilderness Study Area, Imperial County, California.

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SUMMARY

Abstract

This report presents the results of a mineral survey of part of the Jacumba (In-ko-pah) Wilderness Study Area (CDCA-368) that was designated by the Bureau of Land Management as suitable for mineral surveys. In this report, the area studied is referred to as the "wilderness study area", or simply "the study area." The study area encompasses approximately 28,443 acres in southwestern Imperial County, Calif. Field work for this report was carried out between 1983 and 1985. Numerous mines, prospects, and claims are present in the study area, but none are being actively mined or prospected. Three sites inside the study area have identified limestone resources that total about 1.8 million tons. Four areas in the northwestern, northern, and eastern parts of the study area have high potential for undiscovered limestone resources. Two north-trending belts in the western and eastern parts of the study area have low resource potential for tungsten.

Character and Setting

The Jacumba (In-ko-pah) Wilderness Study Area is located between the Peninsular Ranges province on the west and the Yuha Desert on the east (fig. 1). The United States-Mexico border forms the south boundary of the study area. Much of the area is characterized by rugged topography. Maximum relief in the study area is about 3,400 ft. A semiarid climate and chapparal vegetation are found at the higher elevations, whereas an arid climate and desert plant communities are characteristic of lower areas.

The study area is underlain by Cretaceous (66 to 138 million years before present (Ma); see appendix for geologic time chart) plutonic rocks of the Peninsular Ranges batholith (informal name). The batholith is composed of a variety of plutons that intruded metamorphosed Paleozoic and Mesozoic sedimentary and volcanic rocks. Neogene (24 to 1.7 Ma) marine and alluvial deposits unconformably overlie the uplifted and deeply eroded batholithic rocks in the study area, and faults of the Elsinore fault zone cut both the batholithic rocks and the sedimentary deposits. Evidence of mining or prospecting activity was found at 26 sites in, or just outside of, the Jacumba (In-ko-pah) Wilderness Study Area. In 1983, 106 claims were held in 13 claim groups. At that time, none of the claims or sites was being actively mined or prospected.

Identified Mineral Resources and Resource Potential

Geologic and geochemical studies, and an evaluation of known mineral occurrences indicate locally high potential for undiscovered limestone resources in three areas in the northern part of the study area and in one area in the eastern part. In addition, a northwest-trending belt in the western part of the study area and four irregular areas that define a north-trending belt in the eastern part have low potential for tungsten resources (fig. 2).

Metasedimentary strata of Paleozoic and Mesozoic(?) age that are present as steeply dipping tabular bodies, or screens, within granitic plutons in the study area locally contain abundant limestone (metamorphosed to marble). Known deposits in the study area contain identified resources of about 1.8

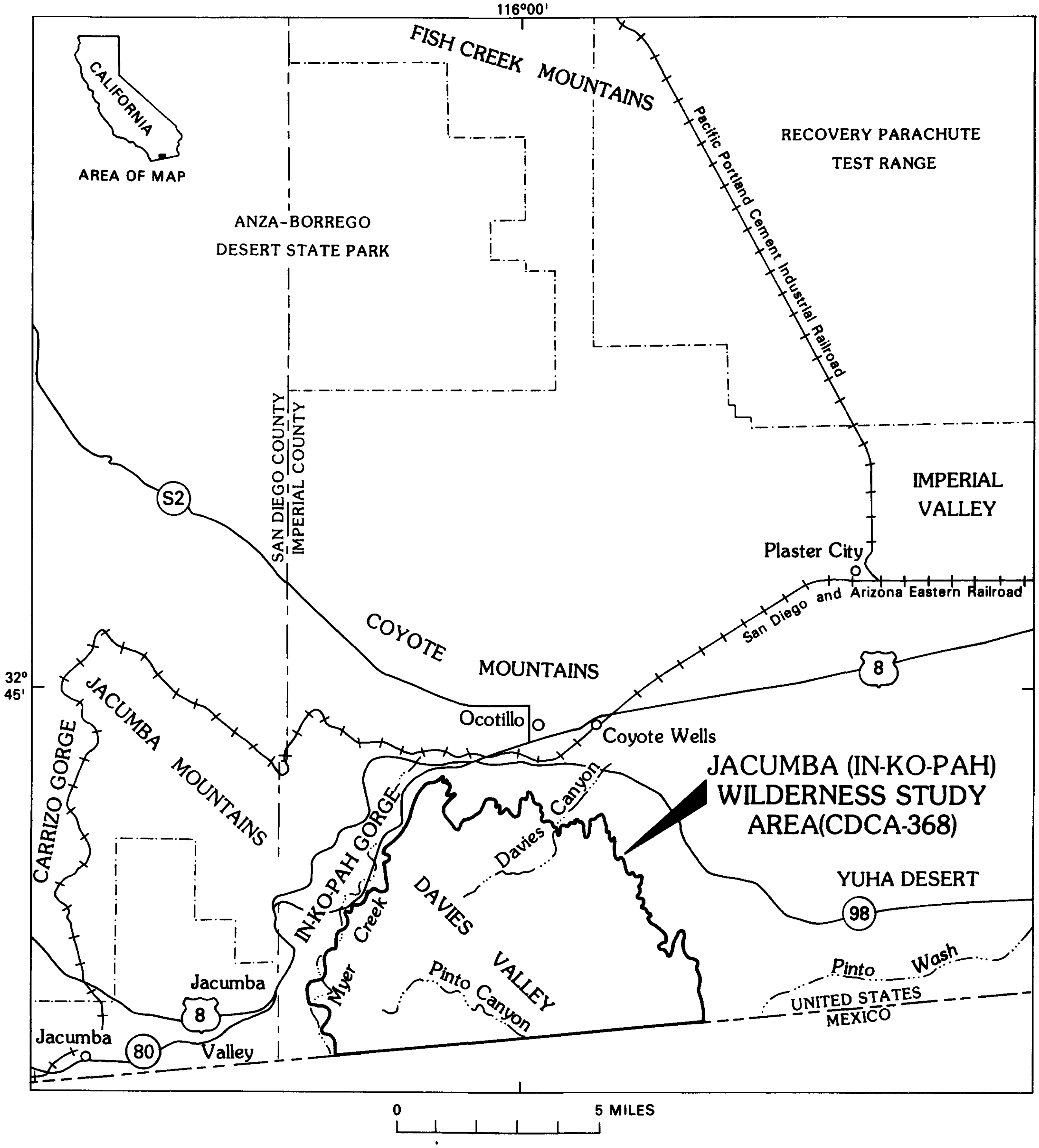

Figure 1. Index map showing location of the Jacumba (In-ko-pah) Wilderness Study Area, Imperial County, California.

million tons of limestone, although economic conditions are unfavorable for the development of these small deposits at the present time. Abundant deposits of high-quality limestone are present in the Coyote Mountains to the north.

Tungsten-bearing skarn deposits are present between marble-bearing metasedimentary screens and surrounding plutons. These small, irregular, and sporadically mineralized skarn deposits are probably the source of widespread anomalous concentrations of tungsten, molybdenum, and tin, and localized gold, silver, bismuth, and zinc anomalies in stream sediments in the study area. Rock samples from several skarn deposits contain significant amounts of tungsten. Although known tungsten occurrences inside the study area are too small or low grade to be considered resources, undiscovered resources may exist. Thus, areas of skarn deposits and metasedimentary screens in the study area have low resource potential for tungsten. No potential for geothermal energy, uranium, or oil and gas resources was identified in the study area.

INTRODUCTION

Area Description

The Jacumba (In-ko-pah) Wilderness Study Area (CDCA-368) occupies 28,443 acres in the southwest corner of Imperial County, Calif. (fig. 1). The study area is located in the southeastern part of the Jacumba Mountains, which forms the eastern faulted escarpment of the Peninsular Ranges immediately north of the international border with Mexico. The Jacumba Mountains rise above the Yuha Desert, which is the western part of the Imperial Valley, a broad alluvial valley that lies partly below sea level. The study area is roughly bisected by north-northwest-trending Davies Valley (fig. 1), which was eroded along a major fault zone that separates high-standing batholithic rocks on the west from low hills that expose metasedimentary rocks and Neogene volcanic and sedimentary rocks on the east. Other north-trending faults cross the eastern and western parts of the study area, and part of the Elsinore fault zone bounds the study area on the east (fig. 2). These faults have produced a rough stair-step topography in which fault-bounded blocks are progressively lower to the east. Elevations range from about 4,000 ft in the western part of the area to about 600 ft near the eastern front of the range. The climate of the region is arid, with rainfall ranging between 3 and 4 in. per year (Morton, 1977) and summer temperatures often exceeding 100 to 110 ^{O}F at lower elevations.

Access to the area is chiefly from California Highway 98, which extends south from Interstate 8 to Calexico. Several dirt roads maintained by the Bureau of Land Management lead southwest from California Highway 98 into the eastern part of the area. On the west side of the study area, a jeep trail leads from Jacumba Valley to the PK mine (fig. 2, No. 26).

Previous and Present Investigations

This mineral resource study is a joint effort by the U.S. Geological Survey and the U.S. Bureau of Mines. The history and philosophy of such joint mineral surveys of U.S. Bureau of Land Management Wilderness Study Areas were discussed by Beikman and others (1983). Mineral assessment methodology and terminology were discussed by Goudarzi (1984). See appendix for the definition of levels of mineral resource potential and certainty of assessment. Studies by the U.S. Geological Survey are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. The U.S. Bureau of Mines 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, claims, and mineralized areas. Identified resources are classified according to the system described by U.S. Bureau of Mines and U.S. Geological Survey (1980).

The Jacumba (In-ko-pah) Wilderness Study Area includes parts of the In-ko-pah Gorge and Coyote Wells 7.5-minute quadrangles. Published geologic maps by Brooks and Roberts (1954) and Morton (1977) describe the geology of the region. Unpublished mapping by T.W. Dibblee, Jr. (written commun., 1943) covers part of the Jacumba Mountains. The U.S. Geological Survey carried out field investigations in the study area between 1984 and 1985. The work included geologic mapping and whole-rock and stream-sediment sampling for geochemical analyses and radiometric dating. A total of 52 panned heavy-mineral concentrates from stream sediment samples were analyzed; the analytical data are given in Detra and Kilburn (1985).

The U.S. Bureau of Mines conducted a library search for information on mines and prospects in and adjacent to the study area. Mines and prospects in and near the study area were described by Sampson and Tucker (1942) and Morton (1977). These data were supplemented by information from U.S. Bureau of Land Management mining claim and land status records. Claim owners were contacted when possible. Field studies by U.S. Bureau of Mines personnel were carried out in the fall of 1983. Rock samples collected from outcrops, prospects, and mines were analyzed for a variety of elements by fire-assay, atomic absorption, colorimetric, X-ray fluorescence, plasma spectrographic, and semiquantitative spectrographic methods. Detailed sample data are presented in McHugh (1985).

Acknowledgments

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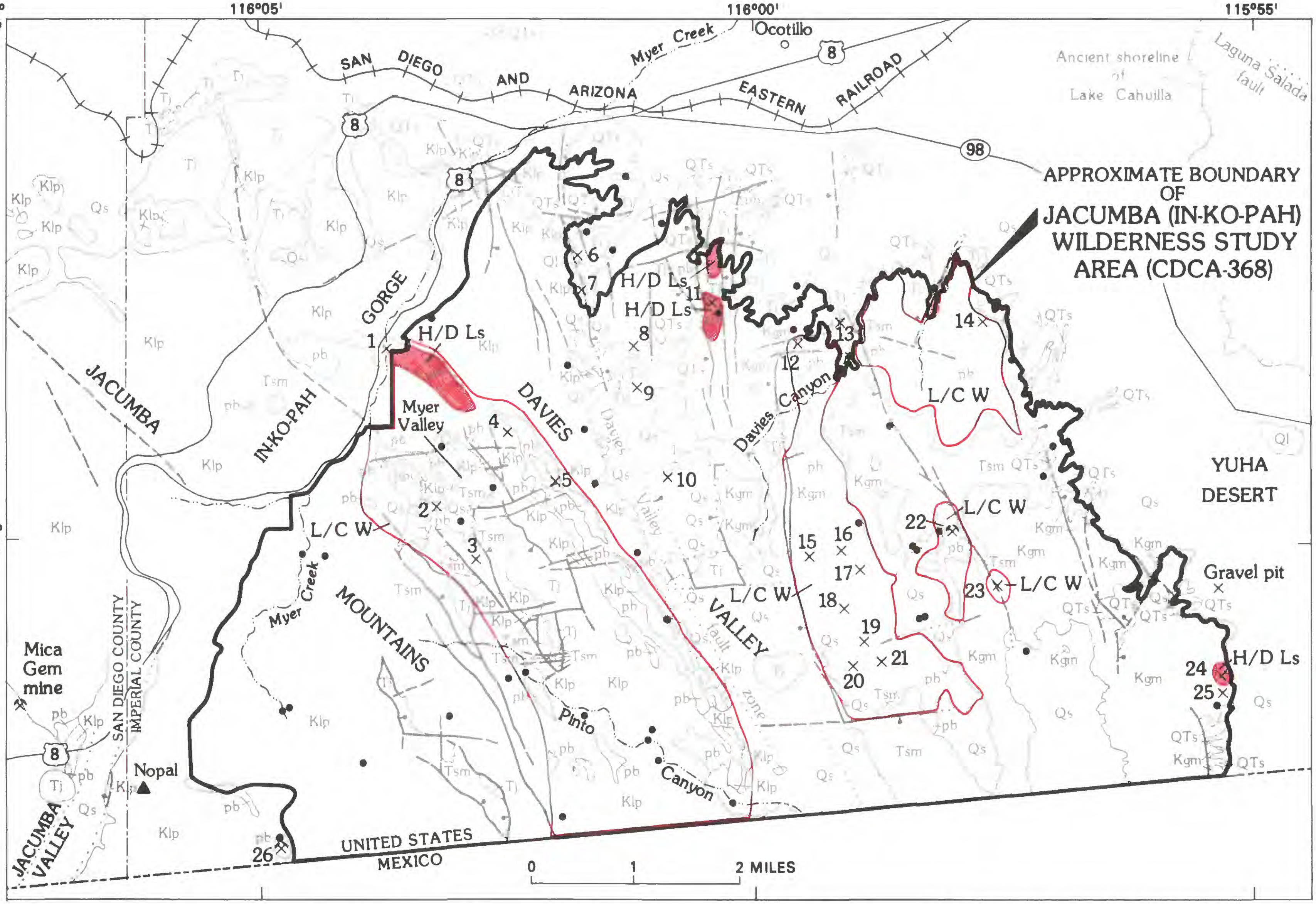

Figure 2. Mineral resource potential and simplified geology of the Jacumba (In-ko-pah) Wilderness Study Area, Imperial County, California.

Management El Centro Resource Area office for providing information concerning access and mining activity in the Jacumba (In-ko-pah) Wilderness Study Area. We also thank personnel of the Riverside district office of the Bureau of Land Management for generously making their records available to us.

APPRAISAL OF IDENTIFIED RESOURCES

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History and Production

Evidence of mining or prospecting activity was found at 26 sites in, or less than 1 mi outside of, the Jacumba (In-ko-pah) Wilderness Study Area (fig. 2) (McHugh, 1985). In 1983, 106 claims were held in 13 claim groups. None of the claims or sites was being actively mined or prospected when visited during this study. Descriptions of mines, prospects, and deposits are listed in table 1.

The Mountain Spring limestone deposit (fig. 2, No. 1) in In-Ko-Pah Gorge was first worked before 1927 (Logan, 1947, p. 241), and a few hundred tons were mined in 1940 and 1959 from a pit just outside the study area (Morton, 1977, p. 66). Other limestone deposits inside the study area have been intermittently prospected since 1954; none have recorded production.

The PK mine (fig. 2, No. 26), just west of the study area, and the Roark mine (fig. 2, No. 22) and other prospects inside the study area were developed for tungsten during government subsidy programs between 1951 and 1958. Originally prospected for gold (Morton, 1977, p. 96), the PK mine produced 596 short ton units of tungsten trioxide (11,920 lb WO_3) during 1954 and 1955. The Roark mine may have produced a small amount of tungsten. Coarse muscovite in pegmatite dikes and a scheelite-bearing skarn zone at the Mica Gem mine, 1.6 mi west of the study area, were prospected between 1936 and 1940 (Weber, 1963, p. 193, 277).

Diatomite at the White Christmas deposit (fig. 2, No. 6) was first claimed in 1941; no production is known. Pyroclastic basalt from the Weaver deposit (fig. 2, No. 13) was mined during the 1950's for use as roofing granules and decorative gravel (Morton, 1977, p. 84). Both deposits were developed just outside the study area.

Sand and gravel have been mined intermittently from fanglomerate and stream gravel deposits just outside the north and east boundaries of the study area. Gravel was being quarried from a pit just east of the study area in 1983.

Mineral Deposits

Two principal deposit types were examined by the U.S. Bureau of Mines: (1) limestone (metamorphosed to marble) in screens consisting of metasedimentary rocks surrounded by plutonic rocks and (2) bodies of tungsten-bearing skarn associated with contacts between limestone-bearing screens and

EXPLANATION

Area with high mineral resource potential

Area with low mineral resource potential

Mine with recorded past production—See table 1 for description

See appendix for definitions of mineral resource potential and levels of certainty

Commodities

Ls Limestone
W Tungsten

Geologic map units

Ql Lacustrine deposits of Lake Cahuilla (Quaternary)
Qs Surficial deposits (Quaternary)
QTs Sedimentary rocks (Quaternary and Tertiary)
Tj Jacumba Volcanics of Minch and Abbott (1973) (Tertiary)
Tsm Split Mountain Formation of Woodard (1974) (Tertiary)
Klp Tonalite of La Posta (Cretaceous)
Kgm Tonalite of Granite Mountain (Cretaceous)
pb Prebatholithic metasedimentary rocks (Mesozoic and Paleozoic?)

Contact

Fault—Dashed where approximate; dotted where concealed. Bar and ball on downthrown side

Geochemical sample site

X3 Prospect

Mines, prospects, and deposits—See table 1 for descriptions. Underline indicates identified resource.

1 Mountain Spring limestone deposit—Identified resource extends into study area
2 Myer Valley prospect
3 Unnamed prospect
4 Chain prospect
5 Unnamed prospect
6 White Christmas deposit (Bronko claims)
7 Stone quarry
8 Unnamed
9 Unnamed prospect
10 Easy Pickins prospect
11 White Hope limestone deposit
12 Red Schist prospect
13 Weaver deposit
14 Hematite prospect
15 Unnamed prospect
16 Unnamed prospect
17 Unnamed prospect
18 Unnamed prospect
19 Unnamed prospect
20 Golden Alter prospect
21 Unnamed prospect
22 Roark mine (Graphite claim)
23 North star prospect
24 Cal-White limestone deposit
25 Unnamed prospect
26 PK mine (Elliott mine)

Figure 2. Continued.

plutonic rocks. Resources were identified on the basis of geologic evidence and sample data.

Limestone resources were identified at three sites in the study area. The Mountain Spring and White Hope limestone deposits are in the northern part of the study area (fig. 2, Nos. 1 and 11), and the Cal-White deposit is in the southeastern part (fig. 2, No. 24). The limestone is present as irregular lenses that dip moderately to steeply. The thickness of the lenses probably varies where concealed, and overburden increases rapidly with depth as a result of the steep dips. Resource projections are limited because of these factors. Geochemical analyses of samples from the deposits (table 1) suggest that the limestone is generally suitable for portland cement and agricultural uses.

Limestone was opencut mined at the Mountain Spring deposit just outside the study area. The main lens contains about 210,000 tons of limestone and extends inside the study area. At the White Hope deposit, two lenses of limestone are aligned parallel to foliation in enclosing gneissic tonalite. One lens contains approximately 175,000 tons of limestone. The second lens is not well exposed, but is estimated to contain 170,000 tons of limestone. At the Cal-White limestone deposit, lenses of limestone are intercalated with metasedimentary rocks and gneissic tonalite. This deposit contains an estimated 1.4 million tons of limestone resources.

Two prospects and an inactive mine in the east half of the study area (fig. 2, Nos. 18, 22, and 23) may have tungsten resources associated with skarn deposits. The diopside-tremolite-garnet skarn is in thinly laminated limestone and biotite schist along contacts with tonalite. Irregular quartz-tourmaline pegmatite dikes transect both the host rocks and the skarn. The calcium tungstate mineral scheelite ($CaWO_4$) is disseminated in the skarn zones as blebs and in stringers. Although the scheelite-bearing zones are too sparsely mineralized or too small to constitute resources, additional sampling in unexposed parts of the zones might reveal tungsten resources.

Two scheelite-bearing skarn zones are exposed at the unnamed prospect 1 mi east of Davies Valley (fig. 2, No. 18). A limestone lens at the Roark mine (Graphite claim, fig. 2, No. 22) is poorly exposed but is at least 25 ft thick; a weakly silicated zone in the bed contains disseminated scheelite (Morton, 1977, p. 96). Segments of six skarn zones are exposed in workings and outcrops at the North Star prospect (fig. 2, No. 23). One chip sample from a 3.2-ft-thick skarn zone contained 0.02 oz/ton gold and 1.66 percent tungsten trioxide (WO_3); an 8-ft-thick shear zone in schist is enriched in manganese oxides. Samples from other workings and outcrops suggested only minor mineralization.

The PK mine (Elliott mine), located immediately outside the study area about 1,000 ft north of the international border (fig. 2, No. 26), is in a small roof pendant in tonalite that contains an irregular tungsten-bearing skarn body. Resource estimates based upon sampling of mineralized skarn at the 3,990, 4,000, and 4,040 ft levels of the mine and upon an assumed downdip width of the skarn body of 60 ft indicate 30,000 tons of low-grade ore with an average grade of 0.19 percent WO_3. One 9,000-ton segment of the deposit also contains 0.06 oz/ton gold. At the estimated average 1985 price of \$68/t WO_3 (metric ton unit of WO_3, which contains 7.93 kg W) or \$3.89/lb W (U.S. Bureau of Mines, 1986, p. 168), the value of tungsten ore in the deposit is \$11.71/ton. The average grade of the deposit is low, and the roof pendant that contains the deposit is small. Underlying tonalite is exposed in the lower workings, ruling out downward extension of the mineralized zone. No associated tungsten occurrences are exposed in the study area.

The White Christmas diatomite deposit (Bronko claims) is located about 3 mi southwest of Ocotillo, just outside the study area (fig. 2, No. 6). Diatomite beds as much as 12 ft thick are present in Quaternary lake sediments in two erosional remnants. Two diatomite samples collected by the Bureau of Mines contained abundant sand, silt, and broken diatom tests, which limits use of the material for most filter applications. Loomis (1965, p. 4) estimated 3,000 to 5,000 tons of material averaging 79 to 80 percent SiO_2 in the diatomite deposits, and possibly 30,000 to 50,000 tons of similar material covered by unconsolidated sand near the deposit. No identified diatomite resources are inside the study area.

Appraisal of Mineral Deposits

The Cal-White, Mountain Spring, and White Hope limestone deposits contain indicated limestone resources of about 1.4 million, 210,000, and 175,000 tons, respectively. The White Hope and Cal-White deposits are at the range front along the edge of the study area, making access relatively simple. The Mountain Spring deposit is in In-Ko-Pah Gorge along Interstate 8, where access might require construction of an interchange. Large, partially developed deposits of high-quality limestone are present 6 mi north of Ocotillo in the Coyote Mountains, where Bowen and others (1973) describe three deposits, each with more than 20 million tons of limestone resources. These deposits would probably be developed before the smaller deposits in the study area.

Known tungsten occurrences inside the study area are too small or low grade to be considered resources. The character of the known mineralized skarn bodies suggests that other such occurrences, if present, would be small, irregular, and only sporadically mineralized. Low prices have resulted in periodic, temporary closing of domestic tungsten mines in recent years. Tungsten is a strategic and critical commodity, and net reliance on imports in 1985 was about 68 percent. Although U.S. demand for tungsten is expected to increase at an average annual rate of 16 percent through 1990 (U.S. Bureau of Mines, 1986), development of such small deposits as might be expected to occur in the study area is not probable in the foreseeable future.

Diatomite deposits do not extend into the study area, and no large-scale development of the White Christmas deposit is expected. Very large deposits of relatively pure diatomite in other parts of California and in Nevada dominate domestic markets and provide exports to foreign markets.

Sand and gravel in alluvial fan deposits are mainly outside the study area along the east side of the range. In the northern part of the area, fan deposits mantle bedrock both inside and outside the study area. Development of sand and gravel deposits inside the study area is unlikely because similar deposits are available closer to major population centers.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Victoria R. Todd, James E. Kilburn, David E. Detra, Andrew Griscom and Fred A. Kruse
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Geology

The southern part of the Jacumba Mountains is underlain by relatively undeformed plutons that are considered to belong to a late-tectonic to posttectonic intrusive sequence in the Peninsular Ranges batholith (Todd and Shaw, 1979). Similar plutons to the west in San Diego County have uranium-lead zircon ages that range from 95 to 100 Ma (Silver and others, 1979; Clinkenbeard and others, 1986). Thus, the plutons in the southern Jacumba Mountains are tentatively considered to be middle Cretaceous in age. Two plutons of this intrusive sequence crop out in the Jacumba (In-ko-pah) Wilderness Study Area. Strongly foliated late-tectonic tonalite forms most of the crystalline bedrock east of Davies Valley, whereas weakly foliated to massive posttectonic tonalite underlies much of the block west of Davies Valley (fig. 2). Both plutons range in composition from hornblende-biotite tonalite to biotite granodiorite; the western pluton also includes leucocratic muscovite-biotite granodiorite. Pegmatite dikes are abundant in both western and eastern tonalite plutons.

Screens and inclusions of wallrocks in the study area consist of high-grade metasedimentary rocks of unknown age including metaquartzite, semipelitic schist, and marble, the last containing the limestone deposits mentioned in an earlier section of this report. These rocks may include two units—deep-water arkosic and graywacke sandstones and shale (turbidites) with scarce interbedded carbonate rocks that crop out in San Diego County to the west (the Julian Schist) and a continental shelf sequence of quartz-rich sandstone, shale, and abundant carbonate that is present in the eastern part of the batholith. The Julian Schist is presumed to be Triassic and (or) Jurassic in age (Donnelly, 1934), while the eastern prebatholithic rocks are at least in part Paleozoic (Miller and Dockum, 1983). Therefore, the prebatholithic rocks in the study area are tentatively considered to be Paleozoic and Mesozoic(?) in age.

The wallrock screens contain concordant fine- to medium-grained granitic dikes that emanate from the surrounding plutons. Pegmatite dikes commonly were emplaced into contact zones between screens and tonalite plutons. Skarns developed locally where limestone was intruded by tonalite and (or) by granitic dikes. Retrograde alteration and oxidation of high-grade skarn minerals such as garnet and diopside led to local concentrations of epidote, clinozoisite, tremolite-actinolite, chlorite, hematite, limonite, and calcite. Skarn minerals form irregular scattered lenses as much as 300 ft across that commonly are associated with isoclinally folded metasedimentary rocks. Scheelite occurs locally in skarn as disseminated blebs, stringers, and pods locally as much as 2 ft long but typically less than a few inches long.

The eroded crystalline basement of the southern Jacumba Mountains is overlain on the north and east by Miocene through Pleistocene sedimentary and volcanic deposits; remnants of Miocene deposits overlie the crystalline rocks on both sides of Davies Valley (fig. 2). These deposits are remnants of a thick (locally 20,000 ft) sequence of terrestrial and marine sediments and intercalated volcanic rocks deposited in, and marginal to, the Salton Trough. The Salton Trough is a complex rift valley that has been tectonically active since Miocene time (Gibson and others, 1984).

The Miocene Split Mountain Formation of Woodard (1974) crops out mainly east of Davies Valley (fig. 2). Patches of this formation are also preserved beneath the Jacumba Volcanics of Minch and Abbott (1973) in fault blocks west of Davies Valley. The Split Mountain Formation formed as a thickening wedge of coalescing alluvial fans during the early phase of uplift of the Peninsular ranges (Gibson and others, 1984). The formation underlies andesitic pyroclastic rocks in the northeast part of the study area. These volcanic rocks locally form a very thin, extensively faulted veneer over the Split Mountain Formation and possibly also over Quaternary sediments. The volcanic rocks may have been partly or wholly displaced by posteruptive gravitational gliding or large-scale landsliding during uplift of the Peninsular Ranges.

The Salton Trough was flooded by marine waters in early Pliocene time (Bell-Countryman, 1984). As the basin continued to subside, a shoaling series of alluvial fan, shoreline, and deep-water marine deposits was rapidly deposited conformably on the Split Mountain Formation and volcanic rocks. Gradationally overlying these predominantly marine deposits is a sequence of Pliocene and Pleistocene brackish-water to lacustrine sediments with marine interbeds, the Palm Spring Formation. The Imperial and Palm Spring Formations crop out east of the study area in the down-faulted Yuha Desert block, and in the badlands that lie north of the study area between the Coyote Mountains and the northern Jacumba Mountains. An undated sequence of alluvial fan sands and gravels overlies the Jacumba Volcanics in the northern part of the study area; these sediments may correlate with the Pliocene and younger Imperial and Palm Spring Formations, or may consist of Miocene strata.

The southern Jacumba Mountains probably began to rise as an uplifted fault block sometime during Pliocene time and then continued to be elevated during Quaternary time by north- and north-northwest-trending high-angle faults in Davies Valley and along the east flank of the range. A mosaic of north- and east-trending dip-slip faults in the northeastern part of the study area has produced a triangular graben composed chiefly of Miocene rocks; this graben is bounded on the west by a fault, or faults, under the alluvium of Davies Valley (fig. 2). The Laguna Salada fault, which lies about 1 mi east of the southern Jacumba Mountains, cuts Quaternary alluvium suggesting that the range-bounding faults may still be active. All of the above faults are part of the active Elsinore fault zone, which has undergone chiefly dip-slip motion south of 33° N. lat (Todd and Hoggatt, 1979).

The most recent geologic feature adjacent to the southern Jacumba Mountains is the high shoreline of ancient Lake Cahuilla, which lies less than 1 mi east of the range. The lake originated by periodic flooding and overflow of the ancestral Colorado River into the Salton Trough (Morton, 1977). Although it probably existed as recently as several hundred years ago, the lake has probably formed and dried up repeatedly since at least late Pleistocene time. Fine-grained lake sediments in the northern part of the study area (the White Christmas diatomite deposit) (fig. 2, No. 6) and patchy lacustrine sediments east of the study area suggest that the earliest lakes may have extended westward into the valleys of the southern Jacumba Mountains (Morton, 1977).

Geochemical Studies

A reconnaissance geochemical survey of stream sediments was conducted in the study area in 1984 by the U.S. Geological Survey. Heavy-mineral concentrates were derived from fifty-two samples collected from streams that drain areas ranging from a fraction to several square miles within the study area. Each sample was sieved through a minus-80-mesh screen to remove the coarsest material and divided into light and heavy fractions using a bromoform mineral separation technique. The heavy fraction was further separated using a magnetic separator. All samples were analyzed for 30 elements by a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). A complete listing of the analytical results can be found in Detra and Kilburn (1985). In addition, concentrates were examined optically for mineral identification.

Spectrographic analysis of the concentrates revealed widespread anomalous concentrations of tungsten and tin as well as numerous anomalous concentrations of barium, lead, and molybdenum. In addition, isolated local anomalous concentrations of gold, silver, bismuth, zinc, and strontium were noted. Mineralogically, the concentrates are characterized by abundant barite and scheelite coupled with an apparent absence of ore-forming sulfide and oxide minerals. Optical studies also identified gold at one sample site. Contaminating lead shot observed in the samples coincides with five of the nine anomalous lead concentrations.

The ubiquitous scheelite and accompanying tungsten anomalies are undoubtedly mineralogical and chemical manifestations of the numerous skarn deposits that are present in the study area. Anomalous concentrations of one or more of the elements molybdenum, tin, gold, silver, bismuth, and zinc, often constituents of tungsten-bearing skarns, are associated with the tungsten anomalies throughout the eastern part of the study area and in the western part near the PK (Elliott) mine. A skarn-related multiple-element anomaly is found in a minor drainage below the PK mine (Elliott mine) in the southwest corner of the study area. The anomalous trace-element suite here included tungsten, tin, molybdenum, bismuth, gold, and silver. The sample contained a substantial amount of scheelite (50 percent) and several gold flakes. The PK mine, initially a gold prospect but later mined for tungsten, is situated within an irregular skarn body near the contact between a metasedimentary roof pendant and enclosing tonalite (Morton, 1977).

The tin anomalies appear to be a regional geochemical signature of the late-tectonic to posttectonic intrusive sequence. Although no mineralogic or lithologic host was determined, it is possible that much of the tin may be derived from an accessory mineral or minerals disseminated throughout these granitic rocks. Additionally, skarns may have contributed in some measure to the tin anomalies.

The source of the barium and barite anomalies is uncertain. Although barite was identified as a minor component in most of the concentrates, the majority of barium anomalies are restricted to the region east of Davies Valley. This may represent structural control by the numerous faults that bound the valley and the eastern range front and (or) lithological control by the Miocene sedimentary rocks that occur mainly east of Davies Valley. Anomalous concentrations of strontium and barium are present jointly near the northeast boundary of the study area; the strontium may be a constituent of barite, having replaced barium in a solid solution series.

Most, and perhaps all, of the anomalous lead concentrations can be attributed to contamination rather than natural sources. Evidence includes lead shot fragments found in over half the anomalous samples and the failure to identify a lead-related mineral in any of the concentrates.

Geophysical Studies

Three aeromagnetic and gamma-ray spectrometer profiles (High Life Helicopters, Inc., and QEB, Inc., 1980) cross the study area. The data were collected along east-west and north-south 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, except for some weakly magnetic volcanic rocks. The radioactivity data for these profiles show no anomalous amounts of uranium or thorium within the study area.

Gravity data available for the study area (Oliver and others, 1980; Roberts and others, 1981) consist only of about 15 stations and do not contribute significantly to the mineral resource appraisal of the 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 map areas of limonite in the Jacumba (In-ko-pah) Wilderness Study Area. Limonite occurrences in exposed bedrock are considered anomalous and may indicate the presence of hydrothermal alteration. The largest limonite occurrence is in the southeast corner of the study area and covers roughly 1 mi^2. This and several other limonite anomalies in the area seem to be associated with faulted parts of the tonalite of Granite Mountain (fig. 2). These areas are favorable for the occurrence of hydrothermally altered rocks. Scattered limonite occurrences within the study area coincide closely with the eastern of two zones of low tungsten resource potential (fig. 2) and, to a lesser extent, with the western zone. However, these occurrences are small and their areal extent does not indicate a large hydrothermal system if indeed they are associated with hydrothermally altered rocks. Other limonite occurrences are associated with volcanic rocks that also may be hydrothermally altered.

Conclusions

Geologic studies, geochemical sampling, examination of prospects and mines, and a review of the history of mine production in and near the Jacumba (In-ko-pah) Wilderness Study Area indicate that the study area contains two main types of mineral occurrences, both associated with pre-Cenozoic crystalline rocks. Metasedimentary strata of Paleozoic(?) age that are present as screens within tonalite plutons locally contain abundant limestone. Limestone resources were identified at three sites within the study area. The study area has a high potential, certainty level D, in four areas for additional low- to moderate-tonnage limestone resources in and near these deposits (fig. 2). See appendix for definition of levels of mineral resource potential and certainty of assessment.

The second type of mineral occurrence in the study area consists of relatively abundant skarn deposits. Rock samples from four localities in the study area contain significant amounts of tungsten and minor amounts of gold. Samples from the PK mine (Elliott mine) outside the study area contain tungsten, gold, and silver. Widespread occurrences of the tungsten mineral scheelite in stream-sediment concentrates in the study area probably originated in skarn deposits. Local anomalous concentrations of molybdenum, tin, gold, silver, bismuth, and zinc also probably are derived from tungsten-bearing skarns. No deposits of ore minerals containing these elements were found in the study area.

The parts of the study area that are underlain by known skarn deposits and (or) metasedimentary screens have low resource potential, certainty level C, for tungsten in skarns of metasomatic origin (fig. 2). Known tungsten occurrences inside the study area are too small or low-grade to be considered resources, but the widespread development of skarns in the study area indicates that other skarn bodies may be present at depth. Geologic evidence suggests that such occurrences will be small, irregular, and only sporadically mineralized. No potential for other mineral resources or for geothermal energy, uranium, or oil and gas resources was determined in the study area.

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APPENDIXES

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 permissive. 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 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 occurence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data supports 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

LEVEL OF RESOURCE POTENTIAL →

<table>
<tr><td rowspan="4">U/A
UNKNOWN POTENTIAL</td><td>H/B
HIGH POTENTIAL</td><td>H/C
HIGH POTENTIAL</td><td>H/D
HIGH POTENTIAL</td></tr>
<tr><td>M/B
MODERATE POTENTIAL</td><td>M/C
MODERATE POTENTIAL</td><td>M/D
MODERATE POTENTIAL</td></tr>
<tr><td rowspan="2">L/B
LOW POTENTIAL</td><td rowspan="2">L/C
LOW POTENTIAL</td><td>L/D
LOW POTENTIAL</td></tr>
<tr><td>N/D
NO POTENTIAL</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td></tr>
</table>

LEVEL OF CERTAINTY →

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:

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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
Phanerozoic	Cenozoic	Quaternary		Pleistocene	1.7
Phanerozoic	Cenozoic	Tertiary	Neogene Subperiod	Pliocene	5
Phanerozoic	Cenozoic	Tertiary	Neogene Subperiod	Miocene	24
Phanerozoic	Cenozoic	Tertiary	Paleogene Subperiod	Oligocene	38
Phanerozoic	Cenozoic	Tertiary	Paleogene Subperiod	Eocene	55
Phanerozoic	Cenozoic	Tertiary	Paleogene Subperiod	Paleocene	66
Phanerozoic	Mesozoic	Cretaceous		Late	96
Phanerozoic	Mesozoic	Cretaceous		Early	138
Phanerozoic	Mesozoic	Jurassic		Late Middle Early	205
Phanerozoic	Mesozoic	Triassic		Late Middle Early	~240
Phanerozoic	Paleozoic	Permian		Late Early	290
Phanerozoic	Paleozoic	Carboniferous Periods	Pennsylvanian	Late Middle Early	~330
Phanerozoic	Paleozoic	Carboniferous Periods	Mississippian	Late Early	360
Phanerozoic	Paleozoic	Devonian		Late Middle Early	410
Phanerozoic	Paleozoic	Silurian		Late Middle Early	435
Phanerozoic	Paleozoic	Ordovician		Late Middle Early	500
Phanerozoic	Paleozoic	Cambrian		Late Middle Early	~570[1]
Proterozoic	Late Proterozoic				900
Proterozoic	Middle Proterozoic				1600
Proterozoic	Early Proterozoic				2500
Archean	Late Archean				3000
Archean	Middle Archean				3400
Archean	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.

TABLE 1. *Mines, prospects, and deposits in and adjacent to the Jacumba (In-kò-pah) Wilderness Study Area*

[*, outside study area]

Map No. (fig. 2)	Name	Summary	Workings and production	Sample and resource data
1*	Mountain Spring limestone deposit	Coarsely crystalline, white to gray limestone in a 200-ft-wide, 2,500-ft-long steeply dipping tabular body, or screen composed of metasedimentary rocks in tonalite. Screen also contains biotite schist and narrow pegmatite dikes along bedding. Limestone forms 1,600-ft-long lens as much as 30 ft thick that strikes N. 65° W. and dips 45° SW. Limestone contains small inclusions of schist and some disseminated graphite. Irregular pods of garnet-epidote-quartz skarn along margins of limestone lens; pods are as much as 5 ft thick and 15 ft long.	An open cut in limestone about 70 ft across and 35 ft high. Three small prospect pits in skarn zones. A few hundred tons of limestone mined in 1940 and 1959 (Morton, 1977; p. 66).	Two samples of limestone bed averaged 0.60 pct Al_2O_3, 51.8 pct CaO, 0.14 pct Fe_2O_3, 1.6 pct Mgo, less than 0.03 pct P_2O_5, and 9.6 pct SiO_2. One of two from skarn zones contained 0.08 pct WO_3. Lens contains 210,000-ton indicated, subeconomic limestone resource.
2	Myer Valley prospect	Banded epidote-diopside-garnet skarn along contacts between small marble and schist screens and tonalite. Screens are as much as 240 ft long and 80 ft wide. Pegmatite dikes and sills common.	Three small prospect pits and several bulldozer cuts.	Four samples of skarn contained no significant mineral values.
3	Unnamed prospect	Irregular veins of coarsely crystalline white calcite in deeply weathered tonalite. Veins are as thick as 25 in. and strike N. 55° E., dipping steeply northwest.	One 4-ft-deep, 5-ft-square pit along road.	Veins are too impure and highly fractured to be calcite resource; one sample contained no significant mineral values.
4	Chain prospect	Quartz-garnet-diopside skarn is in biotite schist and marble near contacts with tonalite. Skarn in irregular, scattered lenses as much as 300 ft across.	Four shallow pits in skarn zones in area 1,000 ft across.	One of four samples of skarn contained 0.01 pct WO_3; remainder contained no significant mineral values.
5	Unnamed prospect	A garnet-quartz-diopside skarn zone lies along bedding in marble. Zone exposed 40 ft downdip and as thick as 4 ft; parts heavily limonite-stained. Ultraviolet light disclosed no scheelite.	A 37-ft-long inclined shaft was driven S. 56° W. and down at 37°.	Three samples from skarn zone contained no significant mineral values.
6*	White Christmas deposit (Bronko claims)	Diatomite beds as much as 12 ft thick in Quaternary(?) lake sediments. Diatomite mixed with volcanic ash and with sand- and silt-sized grains of quartz, feldspar, and biotite. Diatomite beds rest on older alluvium, including fanglomerate and montmorillonite clay, and overlain by unconsolidated sand. Beds flat-lying and exposed in two erosional remnants. Northern exposure 150 ft long and as much as 60 ft wide; southern exposure is 200 ft long and as much as 50 ft wide.	The diatomite beds are exposed along stream-cut channels, and in several pits and trenches.	Samples of diatomite were collected by T. Loomis in 1965 for patent application: 7 ft channel sample from southern exposure contained 83.62 pct SiO_2. Clay in Quaternary alluvium also sampled by Loomis (1965, p. 5) but found to be unsuitable for drilling mud or sealing reservoirs because of poor gelling properties and excessive sand content. Two diatomite samples collected by U.S. Bureau of Mines in 1983 revealed high content of sand, silt, and broken tests, which limits use of material for most filter applications.
7*	Stone quarry	Intrusive rock of tonalite composition has mantle of decomposed rock from 0 to 5 ft thick.	One opencut, several vats for treatment of decomposed material. Apparently only material sufficient for testing was removed.	Claimants proposed to screen and wash micaceous, decomposed intrusive rock to remove coarse particles and sell biotite-chlorite-silt fines for use in drywall and paint industries. Expense of treatment would greatly exceed value of product (Loomis, 1965, p. 4). No samples were taken.

TABLE 1. *Mines, prospects, and deposits in and adjacent to the Jacumba (In-ko-pah) Wilderness Study Area*—Continued

Map No. (fig. 2)	Name	Summary	Workings and production	Sample and resource data
8	Unnamed	Fracture zone in volcanic mudflow debris strikes N. 15° E. and dips 60° NW.	None (prospect shown on In-ko-pah Gorge 1:24,000 sheet not found. Fracture zone at location was sampled).	One chip sample contained no significant mineral values.
9	Unnamed prospect	Fragments of chalcedony and common opal in andesite tuff breccia.	One pit and one 3-ft-wide, 10-ft-long, 1.5-ft-deep trench.	One chip sample contained no significant mineral values.
10	Easy Pickins prospect	Area of unconsolidated Quaternary alluvium, mainly sandy gravel, listed as gold prospect by Morton (1977, p. 51).	One 15-ft-deep shaft, caved	No minerals of economic value were found; no samples were collected.
11	White Hope limestone deposit	Two parallel beds of coarse-grained white gray limestone strike N. 10°- 35° W. and dip 35°-55° SW. along foliation in gneissic tonalite. One bed 8 to 21 ft thick, averaging about 14 ft, and exposed along strike for about 1,500 ft. Second bed 300 to 400 ft to the east, about 20 ft thick, and exposed for 1,000 ft along strike. Limestone contains sparsely disseminated graphite. Granitic sills intrude limestone in places and follow segments of beds.	One small opencut	Four samples collected from western exposure averaged 0.30 pct Al_2O_3, 54.5 pct CaO, 0.10 pct Fe_2O_3, 0.76 pct MgO, less than 0.02 pct P_2O_5, and 2.8 pct SiO_2. Western bed contains 175,000-ton indicated limestone resource; eastern bed inferred to contain 170,000-ton inferred limestone resource.
12	Red Schist prospect	Intensely sheared and folded biotite schist pervasively hematite-stained. Schist bounded on south and west by tonalite and overlain by andesitic volcanic rocks and alluvium on north and east. Schist contains bands of marble and veins of quartz. Pegmatite dikes to 10 in. thick contain coarse garnet, apatite, and sphene crystals.	None found	Seven chip samples of schist, pegmatite dikes, and quartz veins contained no minerals of economic significance. One stream sediment sample contained 0.00046 oz/yd^3 gold in minus-20-mesh flakes.
13*	Weaver deposit	Vesicular, deeply weathered, dark-gray basalt exposed at the mouth of a dry wash.	A small production of roofing granules during the 1950's (Morton, 1977, p 84). Several bulldozer cuts, and opencut about 130 ft square and 12 ft deep	Although possible source of decorative gravel, degree of weathering and proximity of more suitable material 8 mi north in the Coyote Mountains (Morton, 1977, p. 83) make development of deposit unlikely.
14	Hematite prospect	A 2-ft-thick, hematitic quartz vein extends for 22 ft along shear zone in chloritic schist; it strikes N. 58° W. and dips 14° SW. Isolated quartz lenses contain blebs of chalcopyrite. An 8-ft-thick bed of montmorillonite-rich clay underlies fanglomerate in area.	Two prospect pits: one on quartz vein, one on weathered pegmatite dike.	Two chip samples of quartz and one of weathered pegmatite contained no significant mineral values. A sample of clay bed had 13.3 pct Al_2O_3, 4.8 pct CaO, 4.3 pct Fe_2O_3, 2.4 pct K_2O, 3.4 pct MgO, 1.1 pct Na_2O, 0.038 pct P_2O_5, and 60.5 pct SiO_2.
15	Unnamed prospect	Quartz-garnet-actinolite skarn zones follow bedding in interlayered quartzite and biotite schist. Strike about N. 15° W., dip 30°-60° NE (Morton, 1977, p. 97).	Two small prospect pits	One grab sample of actinolite-rich skarn contained 0.19 pct WO_3. A chip sample of one skarn zone (2.6 ft thick) contained 0.01 pct WO_3.

TABLE 1. *Mines, prospects, and deposits in and adjacent to the Jacumba (In-ko-pah) Wilderness Study Area*–Continued

Map No. (fig. 2)	Name	Summary	Workings and production	Sample and resource data
16	Unnamed prospect	An 18-in.-thick marble bed in biotite schist contains weakly developed quartz-diopside-garnet skarn zone. Ultraviolet light disclosed no scheelite.	A 44-ft-long incline (25°) (20 ft underground) was driven S. 61° W. A 10-ft-deep vertical shaft 800 ft southwest of incline (Morton, 1977, p. 96) has apparently been filled.	Two chip samples of skarn from incline and grab sample of limonitic schist from site of vertical shaft contained no significant mineral values.
17	Unnamed prospect	A limonitic pegmatite dike in biotite-muscovite schist strikes N. 20° W. and dips 35° SW.	One caved adit about 15 ft long.	One sample of pegmatite contained no significant mineral values.
18	Unnamed prospect	Fine- to medium-grained diopside-tremolite-garnet skarn in zones along contacts where tonalite intrudes thinly laminated limestone and biotite schist. Irregular quartz-tourmaline pegmatite dikes transect schist and skarn. Scheelite disseminated in skarn zones and in blebs as much as 0.5 in. across and in stringers as much as 0.25 in. thick and 3 in. long. Scheelite-bearing skarn zone at southern working exposed for about 65 ft in northerly direction and averages about 4 ft wide. Scheelite found in one apparently isolated, 2-ft-long pod at northern working.	Southern working consists of 61-ft-long, curved trench as much as 8 ft deep, at crest of isolated knob. Northern working, about 1,100 ft N. 18° W. from trench is 25-ft-long incline driven S. 80° W.	Four chip samples of skarn and quartz-rich pegmatite contained less than 0.01 pct WO_3. Scheelite-bearing skarn in samples from north and south workings, selected by use of ultraviolet light, contained 0.43 and 1.46 pct WO_3, respectively. No samples contained detectable gold or silver.
19	Unnamed prospect	Hematitic biotite schist has narrow dikes of biotite tonalite along foliation.	One 5-ft-diameter, 2-ft-deep pit.	One chip sample from zone contained no significant mineral values.
20	Golden Alter prospect	Two quartz veins strike N. 30° to 65° W. in gneissic tonalite and biotite schist; dip 65° NE to vertical. One vein exposed intermittently for 1,800 ft and averages 3.4 ft thick; other 50 ft long and 1.4 ft thick. Both stained in places by iron and manganese oxides.	Eight pits and two shafts, 14 and 15 ft deep, on quartz veins. One pit in tonalite. Jeep trails and bulldozer cuts lead to most workings.	Five chip samples from quartz veins contained no significnt mineral values. A select sample from manganese-rich pod had 11 pct manganese and 0.051 pct zinc
21	Unnamed prospect	Narrow stringers of siliceous hematite along biotite schist-pegmatite contact. Strike is N. 80° E., dip is 45° NW.	One 6-ft-deep, 3-ft-square pit.	One chip sample from hematitic contact zone contained 0.026 ppm gold.
22	Roark mine (Graphite claim)	A limestone lens at main shaft poorly exposed but at least 25 ft thick; it strikes N. 60° W. and dips 55° SW; a weakly silicated zone in lens contains disseminated scheelite (Morton, 1977, p. 96). A 5- to 10-ft-thick felsic dike forms footwall of bed and schist forms hanging wall. Tonalite crops out nearby, and biotite-tourmaline pegmatite dikes transect both metasedimentary and intrusive rocks. Scheelite sparsely disseminated in quartz-garnet skarn zone in interlayered limestone and biotite schist 600 ft southeast of shaft.	A 30-ft-deep vertical shaft has 80 ft of horizontal workings at 30-ft level (Morton, 1977, p. 96). Two prospect pits southeast of shaft.	A chip sample of quartz-garnet skarn in prospect pit contained 0.07 pct WO_3. Chip sample of pegmatite from other pit contained no significant mineral values. A grab sample from near shaft, of gray, medium-grained limestone with some diopside-quartz skarn contained 0.29 pct WO_3.

TABLE 1. *Mines, prospects, and deposits in and adjacent to the Jacumba (In-ko-pah) Wilderness Study Area*–Continued

Map No. (fig. 2)	Name	Summary	Workings and production	Sample and resource data
23	North Star prospect	Interlayered limestone and biotite schist near contact with underlying tonalite have been altered to tremolite hornfels and, in places, to garnet-quartz-diopside-calcite skarn. Subparallel foliation and banding in metasedimentary rocks strike N. 20 to 55° W. and dip 20 to 75° SW. Skarn zones are irregular and controlled by host rock composition and proximity to intrusive rocks. Segments of six skarn zones exposed in workings and outcrops are 0.7 to 7 ft thick and as long as 60 ft. Pegmatite dikes as thick as 6 ft transect both metasedimentary and intrusive rocks. An 8-ft-thick sheared zone in schist is enriched in manganese oxides.	One 52-ft-long adit mainly in biotite schist and pegmatite dikes crosscuts manganese-bearing sheared zone. Ten prospect pits are in alluvium, marble, schist, or tonalite. Skarn zones exposed in three pits.	Twelve samples collected from workings and outcrops. Four samples from adit and nearby pits contained no significant mineral values. One chip sample from 3.2-ft-thick skarn zone in pit above, and 600 ft north of, adit contained 0.02 oz/ton gold and 1.66 pct WO_3. Two of three chip samples from skarn zone in pits 1,300 ft west of adit contained 0.01 pct WO_3; third had no no significant mineral values. No mineral values were detected in four other samples from skarn zones, schist, and pegmatite northwest of adit.
24	Cal-White limestone deposit (Cal-White, Little White, Kimberly, and Ray claims)	Bedded, white to gray, medium to coarsely crystalline limestone intercalated with schistose metasedimentary rocks and gneissic tonalite. Limestone occurs in lenses of variable orientation, apparently having been thinned in places by folding. Graphite is disseminated in minor amounts through parts of limestone. A distinct H_2S odor is released from freshly broken rock. Chlorite and coarse hornblende hornfels bands sporadically included in limestone bodies near margins. One irregular body essentially continuous for 1,550 ft and ranges from 6 to 50 ft thick. Other lenses 100 to 300 ft long and 16 to 30 ft thick.	A 14-ft-high, 30-ft-wide opencut and two shallow trenches in limestone where road ends at foot of range.	Twelve samples taken across apparent bedding in three limestone exposures contained 0.12 to 1.7 pct Al_2O_3, 43.4 to 55.9 pct CaO, 0.12 to 1.7 pct Fe_2O_3, 0.8 to 10.6 pct MgO, less than 0.02 to 0.27 pct P_2O_5, and 1.0 to 14.6 pct SiO_2. Three exposures contain about 1.4 million tons of indicated subeconomic limestone resources.
25	Unnamed prospect	Chloritic, limonite-stained tonalite contains veinlets of calcite.	Sloughed pit(?)	One chip sample from across limonitic zone contained no significant mineral values.
26*	PK mine (Elliott mine)	An irregular, tungsten-bearing skarn body in small roof pendant in tonalite. Roof pendant 350 ft long and 300 ft wide and exposed along the crest of ridge. Pendant consists of biotite schist with thin beds of interlayered limestone. Pegmatite dikes as much as 20 ft thick transect both tonalite and rocks of roof pendant. Skarn consists of pyroxene (diopside), garnet (mainly adradite), and scheelite. Retrograde alteration and oxidation of skarn resulted in formation of epidote, clinozoisite, tremolite, and hematite. Scheelite both finely disseminated and in blebs to 1 in. across, concentrated in zone 200 ft long and about 30 ft wide.	Scheelite-bearing skarn exposed in four adits with 108, 164, 169, and 253 ft of workings. Stopes in three adits open to surface. A fifth adit is 79 ft long entirely in tonalite. At least four opencuts in roof pendant; largest is 40 ft in diameter and 25 ft deep. During 1954 and 1955, 1,950 tons of ore yielded 11,920 lb WO_3 (596 short ton units).	Of 23 chip samples from skarn zone, 15 contained 0.01 to 0.91 pct WO_3, and 11 contained a trace to 0.22 oz/ton gold. Two select samples of scheelite-bearing skarn contained 0.75 pct and 1.84 pct WO_3. One of three samples of tonalite contained 0.02 oz/ton gold and 0.1 oz/ton silver. Scheelite-bearing zone contains 30,000 tons of indicated subeconomic resources with average grade of 0.19 pct WO_3, including 9,000 ton block that contains 0.06 oz/ton gold.

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