Mineral Resources of the Owens Peak Wilderness Study Area, Tulare and Kern Counties, California

U.S. GEOLOGICAL SURVEY BULLETIN 1705–A

Chapter A

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS: SOUTH-CENTRAL CALIFORNIA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Area

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and 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 Owens Peak (CA-010-026) Wilderness Study Area, Tulare and Kern Counties, California.

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Mineral Resources of the Owens Peak Wilderness Study Area, Tulare and Kern Counties, California

By Michael F. Diggles, James G. Frisken, Andrew Griscom, *and* Herbert A. Pierce
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SUMMARY

Abstract

The part of the Owens Peak Wilderness Study Area (CA-010-026) designated as suitable for mineral surveys encompasses 14,430 acres in the southern Sierra Nevada. Field work was carried out in 1981 through 1985 to assess the mineral resource potential of the area.

The wilderness study area is underlain by granitic rocks that intruded metasedimentary rocks. Tungsten, occurring in the mineral scheelite, sometimes is present in skarns along the contacts between these two rock types.

There are four areas of mineral resource potential in the Owens Peak Wilderness Study Area (CA-010-026). The area of Burnt House Canyon has moderate mineral resource potential for tungsten and low mineral resource potential for copper and zinc. The area around Spanish Needle Creek has moderate mineral resource potential for tungsten and low mineral resource potential for lead. The canyon east of Lamont Meadow has low mineral resource potential for tungsten, copper, and barite. The area of lower Three Pines Canyon has low mineral resource potential for tungsten and copper.

In this report, any reference to the Owens Peak Wilderness Study Area, the "wilderness study area," and "study area" refers only to that part of the wilderness study area designated by the U.S. Bureau of Land Management as suitable for mineral surveys.

Character and Setting

There are two Owens Peak Wilderness Study Areas (CA-010-026 and CDCA-158) in the southern Sierra Nevada west of the range crest and north of Walker Pass (fig. 1). The mineral resources of the eastern wilderness study area, CDCA-158, are described by Diggles and others (1985). This report covers the western wilderness study area (CA-010-026); it is approximately 14,430 acres in area and is located 15 mi east of Isabella. The terrane is generally steep and rugged, with elevations ranging from about 4,500 ft in the valleys to 8,453 ft at the summit of Owens Peak.

Most of the area is underlain by plutonic rocks of the Sierra Nevada batholith. The majority of these rocks are leucocratic, nonfoliated Cretaceous (63 to 138 million years before present) granites and granodiorites. There is also an older set of more mafic granitic rocks of Jurassic age (240 to 570 million years before present) that are granodioritic to tonalitic in composition. The oldest intrusive rocks in the wilderness study area are probably Triassic (205 to 240 million years before present) and (or) Jurassic gabbros and diorites. The granitic rocks intrude Paleozoic(?) (240 to 570 million years before present) metamorphosed sedimentary rocks composed of quartz-mica schist, quartzite, and marble. There are zones of garnet-epidote-wollastonite calc-silicate hornfels near marble-granite intrusive contacts.

Identified Mineral Resources

In 1983, U.S. Bureau of Mines personnel conducted an appraisal of the mineral resources of the Owens Peak Wilderness Study Area (CA-010-026). This study was done in conjunction with the mineral appraisal of the Owens Peak (CDCA-158) and Little Lake Canyon (CDCA-157) Wilderness Study Areas. Ten mines, prospects, and mineralized areas were examined and sampled, one of which, the Golden Age

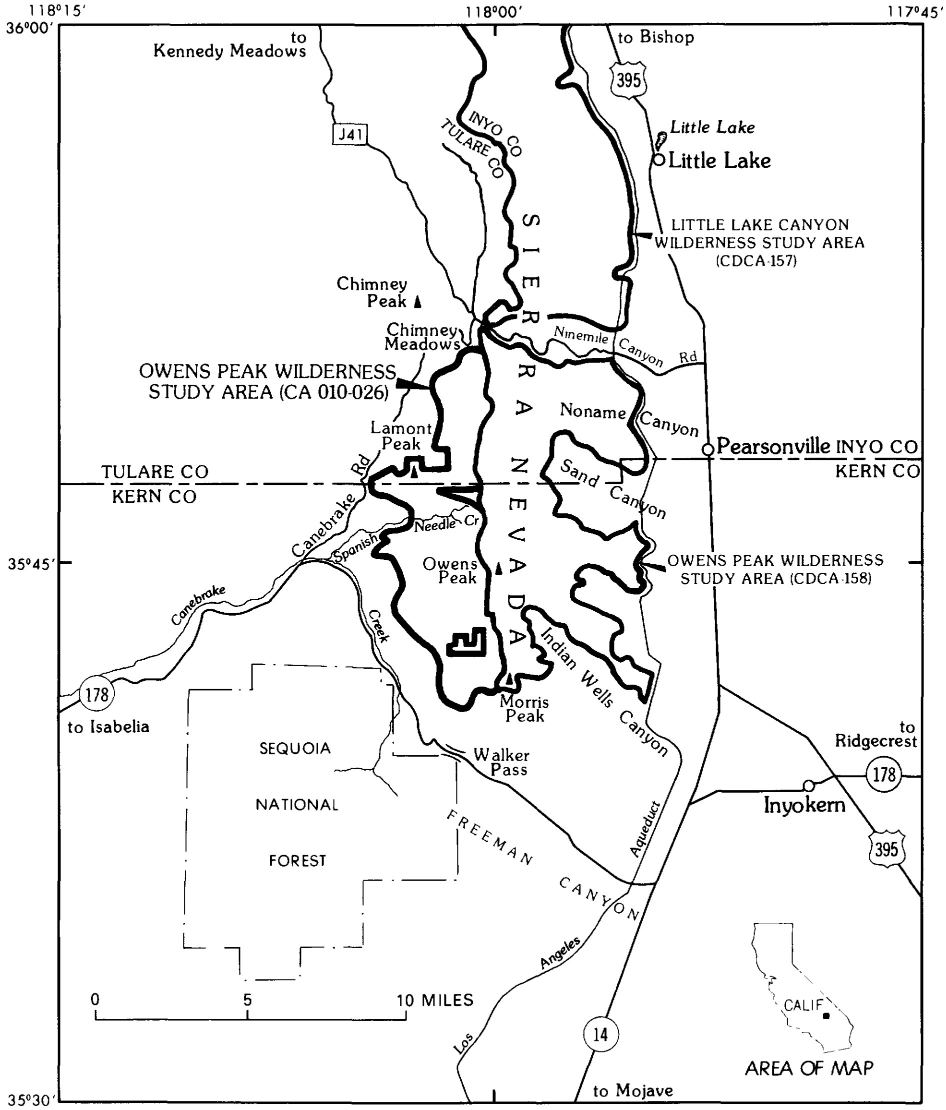

Figure 1. Index map showing location of Owens Peak (CA-010-026) Wilderness Study Area, Tulare and Kern Counties, California.

prospect, is in the Owens Peak Wilderness Study Area (CA-010-026) (fig. 2, no. 1; table 1).

Metallic and nonmetallic mineral resources were not identified in the wilderness study area. The Golden Age prospect, located in Burnt House Canyon, encompasses two different mineral occurrences. Small skarns containing minor quantities of tungsten have been exposed in exploratory trenches. Sand and gravel deposits are sparse and small, and energy minerals were not identified in the wilderness study area.

Mineral Resource Potential

There are four areas of mineral resource potential in the Owens Peak Wilderness Study Area (CA-010-026) (fig. 2). The area of Burnt House Canyon, where the Golden Age prospect is located, is underlain by gneissic diorite and biotite granodiorite with minor pods of metamorphic rocks, including calc-silicate hornfels. Geochemical analyses of heavy-mineral concentrates from stream sediment indicate that tungsten, zinc, and copper are present. Inspection of the concentrates showed the presence of pyrite, and illumination under short-wave ultraviolet light showed the presence of scheelite and willemite. There is a pegmatite dike in the area that contains abundant muscovite. Samples from this prospect contain anomalous amounts of tungsten. The area has moderate mineral resource potential for tungsten and low mineral resource potential for copper and zinc.

Spanish Needle Creek is underlain by quartz-mica schist containing local pods of calcareous metamorphic rocks. Heavy-mineral concentrate samples from the area contained anomalous concentrations of tungsten, as well as a minor lead anomaly. Visual inspection of samples with a short-wave ultraviolet lamp showed that scheelite is present. The area has moderate mineral resource potential for tungsten and a low mineral resource potential for lead.

The canyon east of Lamont Meadow and west of Sand Canyon is underlain by granodiorite containing minor pegmatite dikes and local pods of metamorphic rocks. Geochemical samples contained anomalous concentrations of barium and slightly anomalous concentrations of tungsten and copper. The area has low mineral resource potential for tungsten, copper, and barite.

The area of lower Three Pines Canyon is underlain by granodiorite that contains local bodies of calc-silicate hornfels in metamorphic rocks. Geochemical studies show slightly anomalous concentrations of tungsten and copper accompanied by low concentrations of the associated skarn-related elements bismuth and molybdenum. The area has low mineral resource potential for tungsten and copper.

INTRODUCTION

Location and Physiography

The Owens Peak Wilderness Study Area (CA-010-026) is located 15 mi east of Isabella, Calif. and 1 mi north of Walker Pass in the southern Sierra Nevada (fig. 1). The study area consists of about 14,430 acres and extends from Walker Pass northward to Chimney Meadow, and from the Sierra Nevada crest on the east to Canebrake Road on the west. Access to the area is by California Highway 178 from the south, county road J41 from the north, and spurs off of Highway 178 and Canebrake Road from the west. There is no road access from the east. The terrane is generally steep and rugged with elevations ranging from about 4,500 ft in the Canebrake Creek valley in the southwest to 8,453 ft at the summit of Owens Peak in the east. The vegetation is typically sagebrush and mountain mahogany on the lower slopes. Higher ground is covered by vegetation of the Transition Zone (Storer and Usinger, 1963): Jeffrey pine, incense cedar, black oak, ceanothus, and rare sugar pine on the north side of Lamont Peak. The middle elevations are in the Upper Sonoran Zone, where piñon and digger pine, live oak, ceanothus, manzanita, and chinquapin dominate.

Procedures and Sources of Data

The U.S. Geological Survey conducted field investigations of the Owens Peak Wilderness Study Area (CA-010-026) from 1982 to 1985. This work included detailed geologic mapping where necessary, field checking of existing maps, geochemical sampling, and inspecting outcrops for scheelite using ultraviolet lamps. Aeromagnetic data were collected in 1981. The general geology of the area west of the Sierra Nevada crest was described by Miller (1931, 1946) and Miller and Webb (1940). The Inyokern quadrangle, adjacent to the wilderness study area to the southeast, was mapped by Dibblee (1954). A detailed geologic map of the Owens Peak Wilderness Study Area (CA-010-026) was made by Diggles and Clemens (1986). The mineral resource potential of the Owens Peak (CDCA-158) and Little Lake Canyon (CDCA-157) Wilderness Study Areas, east and northeast of this study area, were described by Diggles and others (1985). The mineral resource potential of the Rockhouse Basin Wilderness Study Area, 15 mi west of the study area, was described by Taylor and others (1984) and summarized by Taylor (1984).

The U.S. Bureau of Mines gathered information about current and past mining activities in and near the wilderness study area and conducted field studies between March and July 1983. Data were taken from U.S. Bureau of Land Management mining-claim recordation indices, and land-status and use records, the U.S. Bureau of Mines Mineral Industry Location System, and Tulare and Kern County claim records. When possible, they contacted claim owners to obtain permission to examine their claims.

The U.S. Bureau of Mines conducted a search for all mines, prospects, claims, and mineralized zones within the study area. Mapping and sampling were done where warranted. In addition to the 15 rock samples and 53 panned-concentrate samples collected by the U.S. Geological Survey, the U.S. Bureau of Mines collected a total of 8 rock and 4 placer samples. U.S. Bureau of Mines' rock samples were assayed for gold and silver using a combined fire assay-ICP (Inductively Coupled Plasma) method, for tungsten by both colorimetric and x-ray fluorescence

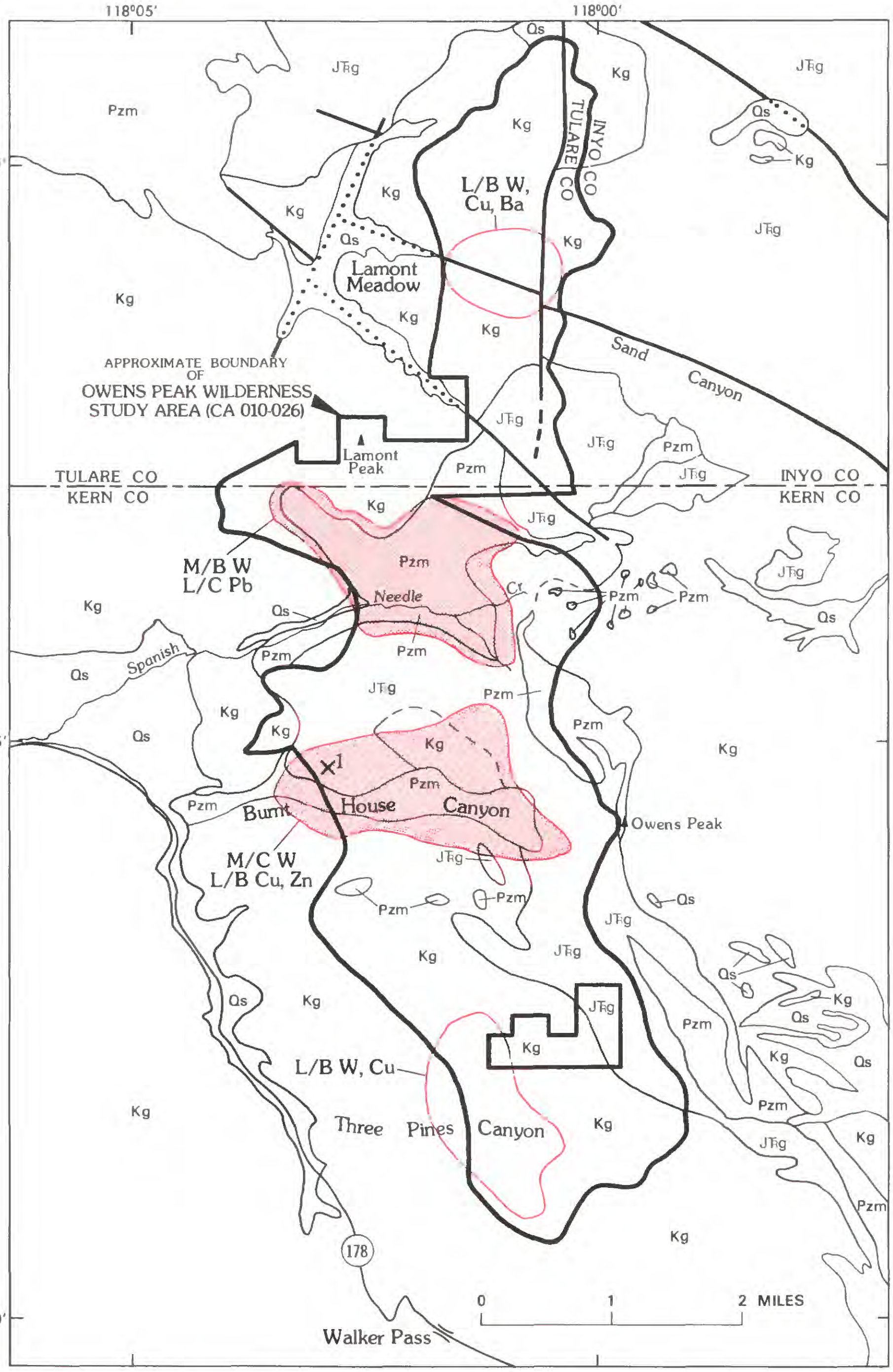

Figure 2. Generalized geologic map and areas of mineral resource potential in the Owens Peak (CA-010-026) Wilderness Study Area, California.

EXPLANATION

GEOLOGIC TERRANE HAVING MODERATE MINERAL RESOURCE POTENTIAL--Commodities as shown. See appendix 1 and figure 3 for definition of levels of mineral resource potential.

GEOLOGIC TERRANE HAVING LOW MINERAL RESOURCE POTENTIAL

COMMODITIES

Ba	Barite
Cu	Copper
Pb	Lead
W	Tungsten
Zn	Zinc

CORRELATION OF MAP UNITS

Qs	QUATERNARY
Kg	CRETACEOUS
JTRg	JURASSIC AND (OR) TRIASSIC
Pzm	PALEOZOIC (?)

DESCRIPTION OF MAP UNITS

Qs	Surficial deposits (Quaternary)
Kg	Granitic rocks (Cretaceous)
JTRg	Granitic rocks (Jurassic and (or) Triassic)
Pzm	Metamorphic rocks (Paleozoic ?)

MAP SYMBOLS

CONTACT--Dashed where approximately located

FAULT--Dashed where inferred, dotted where concealed

×1 PROSPECT--Number refers to Table 1

Figure 2. Continued.

methods, and for molybdenum and tellurium by atomic-absorption spectroscopy. All samples were analyzed by semiquantitative spectroscopy for 40 elements, including antimony, barium, cadmium, cobalt, chromium, copper, gold, iron, lead, lithium, magnesium, manganese, molybdenum, nickel, platinum, silver, tin, titanium, vanadium, and zinc.

The 4 placer samples collected from stream channels near mineral properties and concentrated in the field were examined by microscope, ultraviolet lamp, and magnetic separator for gold, scheelite, ilmenite, garnet, zircon, and magnetite. Complete results of the U.S. Bureau of Mines' work in the wilderness study area are given by Causey and Gaps (1985).

Acknowledgments

The authors greatly appreciate the cooperation of the local property owners. Gary D. Walker and Robert Waiwood of the U.S. Bureau of Land Management's Bakersfield office lent assistance. Diane E. Clemens, David A. Dellinger, James E. Conrad, L. Darlene Batatian, Karen E. Carter, Kimberley R. Greene, M. Alisa Mast, Julian C. Grey, A. Dean McCollaum, Soren E. Jensen, Jr., J. Donald Landells, Jackson Ruby, Wiley Cranney, J. Mitch Linne, Terry Close, Terry Neumann, Richard S. Gaps, and Edward McHugh helped to complete the field work.

APPRAISAL OF IDENTIFIED RESOURCES

By J.Douglas Causey, U.S. Bureau of Mines

Mining and Mineral Exploration History

Gold was discovered prior to 1880 in Indian Wells Canyon, 10 mi east of the wilderness study area, (Troxel and Morton, 1962), but no gold has been found in the wilderness study area.

Tungsten was found in the wilderness study area, but the only production has come from outside the study area in Indian Wells Canyon. Mining took place near the end of World War II and between 1951 and 1956. The interest in tungsten between 1951 and 1956 was high because the U.S. General Services Administration was purchasing tungsten concentrates for $63 per short ton unit of contained WO_3. The market price was about $56 in 1986 (Engineering and Mining Journal, 1986).

Since World War II, activity in the region has been limited to exploration and small-scale mining, mainly for tungsten in scheelite-bearing skarn deposits.

There were no producing mines in or adjacent to the wilderness study area in 1983.

Mines, Prospects, and Mineral Occurrences

Scheelite-bearing skarn is present at the Golden Age prospect (no. 1, fig. 2). No extensive areas containing scheelite are exposed on the prospect; mainly small isolated skarn bodies, no more than 40 ft in diameter, are present in the metamorphic rocks and along contacts with granodiorite. These bodies are related to calcareous zones in roof pendants in the Sierra Nevada batholith. Epidote-garnet-quartz skarns containing small amounts of scheelite, malachite, azurite, and chrysocolla occur at the Golden Age prospect.

Appraisal of Identified Resources

Metallic mineral resources were not identified in the Owens Peak Wilderness Study Area (CA-010-026). The Golden Age prospect encompasses two mineral occurrences with minor quantities of tungsten.

Sand and gravel resources were not found in the study area during this investigation. There is a possibility that rock types found in the wilderness study area could meet local demand for dimension stone, road metal, riprap, and other stone resources. However, similar material of equal or better quality is abundant closer to local markets.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Michael F. Diggles, James G. Frisken, Andrew Griscom, Herbert A. Pierce U.S. Geological Survey

Geology

The geology of the wilderness study area consists dominantly of granitic rocks of the Sierra Nevada batholith that represent at least three major periods of intrusive activity (Evernden and Kistler, 1970). Most of the wilderness study area is underlain by leucocratic, nonfoliated Cretaceous rocks of granitic to granodioritic composition. There is also an older set of granitic rocks of Jurassic age that are often more mafic in composition and stromatic to schlieric in texture. The oldest intrusive rocks in the area are presumably Triassic and (or) Jurassic in age. These rocks are mesocratic to melanocratic, gabbroic to dioritic, and schistose to gneissic. The granitic rocks intrude Paleozoic(?) quartz-biotite-muscovite schist, quartzite, and marble. There are zones of garnet-epidote-wollastonite calc-silicate hornfels near marble-granite contacts.

Paleozoic(?) Metamorphic Rocks

Metamorphic rocks in the area consist of quartz-mica schist, phyllite, quartzite, marble, calc-silicate hornfels, and metadacite. The most common rock type among the metamorphic units is quartz-mica schist. Skarns formed where plutonic rocks intruded calcareous rocks. These contact-metamorphic zones are important for their mineral resource potential. Garnet, epidote, wollastonite, and scheelite ($CaWO_4$) are present in these zones. The biotite-actinolite hornfels show relict compositional layering. Metavolcanic rocks consist of granoblastic, equigranular augite-tremolite-hornblende amphibolite and chlorite-actinolite greenschist. The metamorphic rocks define a large roof pendant that crops out from Indian Wells Canyon to Canebrake Creek. The pendant may correlate in part with the Jurassic or older Kernville Series of Miller, (1931) which is located 4 mi west of the wilderness study area.

Triassic and (or) Jurassic Granitic Rocks

The older of two general sets of plutonic rocks in the wilderness study area consists of Triassic and (or) Jurassic gabbro, diorite, tonalite, quartz diorite, and granodiorite. The gabbro is melanocratic, coarse grained, and seriate to porphyritic. It is present in small bodies that seldom exceed 0.7 mi^2 in area. The diorite is mesocratic to melanocratic, medium grained, seriate, and stromatic to schlieric. It is exposed from west of Owens Peak southeast into Indian Wells Canyon. The tonalite, quartz diorite, and granodiorite are mesocratic, medium grained, seriate to porphyritic, and stromatic to schlieric. These rocks are present in limited exposures in the northern part of the wilderness study area but dominantly crop out north and west of it. They are locally rich in mafic inclusions that have been assimilated to varying degrees.

Cretaceous Granite and Granodiorite

The younger of the two sets of plutonic rocks consists of Cretaceous granite, alaskite, and granodiorite. In general, the younger plutonic rocks are more leucocratic than the older ones and are nonfoliated. The granite is leucocratic, fine- to coarse-grained, and equigranular. It is exposed in a limited area near the eastern edge of the wilderness study area and extends eastward into the Owens Peak (CDCA-158) Wilderness Study Area at Indian Wells and Sand Canyons. Numerous small pods of medium- to coarse-grained alaskite, alkali-feldspar granite, and associated aplite and pegmatite bodies are present along the crest of the Sierra Nevada in and near the wilderness study area (Diggles, 1984). The granodiorite is leucocratic, medium to coarse grained, and seriate to porphyritic.

Quaternary Surficial Deposits

Quaternary surficial deposits include Holocene stream-channel deposits consisting of poorly sorted gravel, sand, and silt found in channels and flood plains, and older Quaternary stream-channel deposits on dissected terraces.

Structure

The metamorphic rocks in and near Burnt House Canyon have a strong foliation that trends generally northwest. These rocks underwent at least two periods of uplift following major intrusive events (Nokleberg and Kistler, 1980).

The dominant geomorphic and structural features in the wilderness study area are a series of en echelon faults that run west-northwest across the range and controlled the formation of the major canyons in the eastern and northern parts of the wilderness study area. This series of faults is best exposed in Ninemile Canyon, where shearing and offset, as well as potassic alteration (shown by potassium-feldspar alteration of plagioclase) can be seen along shear zones in roadcuts. Overprinting this fault system is the Sierra Nevada front fault zone along which the range was uplifted. Parts of the range-front faults can be seen in saddles from the base of the range to its crest.

Geochemistry

Methods and Background

In the spring of 1984, the U.S. Geological Survey conducted reconnaissance stream-sediment sampling of the western Owens Peak Wilderness Study Area (CA-010-026). The eastern Owens Peak Wilderness Study Area (CDCA-158) was sampled and mapped in 1982 (Diggles and others, 1985; Detra and others, 1985). Sampling from the two studies overlap. The 1984 reconnaissance of the Owens Peak Wilderness Study Area (CA-010-026) was designed to detect types of mineral occurrences found in the eastern wilderness study area. Nonmagnetic heavy-mineral concentrates were collected from 53 sampling sites. In addition, 15 mineralized or altered rock samples were collected. The data from this sampling program are presented by Adrian and others (1986). Areas thought to be mineralized were sampled in greater detail than other areas. The nonmagnetic fraction of the heavy-mineral concentrates was chosen as the primary geochemical sampling medium because this concentrate, prepared from panned, active stream sediment, tends to retain minerals related to hydrothermal mineralization and alteration. It also excludes clays, organic matter, and the common rock-forming minerals, some of which account for metal anomalies unrelated to mineralization. An example of the use of concentrates to locate tungsten mineralization is described by Theobald and Thompson (1959).

The nonmagnetic heavy-mineral concentrates were examined microscopically to determine if ore-related minerals or man-made contaminants were present and then were examined under short-wave ultraviolet lamp for scheelite and willemite. They were then pulverized and analyzed for 31 elements, including antimony, barium, cadmium, cobalt, chromium, copper, gold, iron, lead, magnesium, manganese, molybdenum, nickel, silver, thorium, tin, titanium, tungsten, vanadium, and zinc using a six-step semiquantitative emission-spectrographic method (Grimes and Marranzino, 1968). The concentrates were also analyzed for tungsten by atomic absorption (Welsch, 1983), and the remaining nonmagnetic concentrate of each sample was analyzed for gold by atomic-absorption spectroscopy. Mineralized samples were also collected and examined under ultra-violet light for the presence of scheelite. Eight rock samples were analyzed for gold by atomic-absorption spectroscopic analysis using methods of Thompson and others (1968) and Ward and others (1969). All 15 rocks were analyzed for 31 elements by spectrographic analysis.

Threshold values for rocks were chosen at 2 to 3 times crustal abundance values for similar nonmineralized rocks according to geochemistry-text tables (Rose and others, 1979), and for concentrates on the basis of past experience with this sample media and by comparison with thresholds used for the eastern Owens Peak (CDCA-158) Wilderness Study Area.

The geologic setting of the Owens Peak Wilderness Study Area (CA-010-026) is similar to that of the contiguous areas of the Owens Peak (CDCA-158) Wilderness Study Area (Diggles and others, 1985), which have a low mineral resource potential for tungsten, lead, and copper along the border between the two study areas from upper Sand Canyon to upper Ninemile Canyon, and low to moderate resource potential for gold and tungsten along the southwest side of upper Indian Wells Canyon. The mineral occurrences described by the U.S. Bureau of Mines for the two wilderness study areas indicate that the gold and tungsten zones are present in skarns and metamorphic roof pendants, and that the most important minerals are scheelite in skarns and gold associated with pyrite, galena, and sphalerite in contact-metamorphic zones. Geochemically, these occurrences are best characterized by anomalous concentrations of tungsten, lead, and bismuth in the panned-concentrate samples. Slightly anomalous levels of copper and molybdenum also commonly are present in both wilderness study areas and are associated with skarns.

Results and Interpretation

The geochemical interpretations are based primarily on data from the heavy-mineral concentrates. The elements occurring in anomalous values in the concentrate samples are shown below with their established threshold values (in parentheses) in parts per million (ppm): barium (2,000), bismuth (20), copper (50), lanthanum (500), lead (70), molybdenum (10), thorium (500), tin (30), tungsten (15), and yttrium (700). The distribution of these elements, when present in anomalous concentrations, is used to help determine the areas of mineral resource potential shown on figure 2. The highest tin concentration (150 ppm) is associated with a pegmatite that is possibly mineralized. Ten samples with tin values ranging from 30 to 100 ppm fall either in the region northeast of Lamont Meadows or east of the drainage divide in upper Indian Wells Canyon. Lower tin concentrations correlate well with yttrium and lanthanum concentrations and are therefore interpreted as being contained within accessory minerals of the granitoids. Most of the concentrate samples collected in or near the wilderness study area have tungsten concentrations in excess of 50 ppm, and samples from nine sites have concentrations greater than 500 ppm. Scheelite was identified in many of these samples. Anomalous lead concentrations as high as 1,000 ppm and bismuth concentrations as high as 300 ppm are, for the most part, associated with high tungsten concentration. The association of lead, bismuth, copper, and molybdenum with tungsten is indicative of tungsten-skarn mineralization, but the intensity of the anomalies may simply reflect the close proximity of the sampling sites to outcrops of mineralized rock. Copper-stained rocks are common in the Lamont Meadows area and willemite (Zn_2SiO_4) is present as fracture fillings at the Golden Age prospect. Wulfenite ($PbMoO_4$) and powellite ($CaMoO_4$) were identified in some heavy-mineral concentrates and their presence suggests molybdenum-bearing rocks may be present, but correlation among the presence of lead, molybdenum, and tungsten is not strong. The uncommon occurrence of zinc anomalies and widespread but low-level molybdenum, copper, and lead anomalies suggest that these metals, although present in the mineralized skarns, are probably not present in ore-grade concentrations. They may, however, have value as by-product metals.

Between Lamont Meadow and upper Sand Canyon, the concentrate samples have uniquely high barium concentrations, but are not strongly anomalous in the tungsten-skarn suite of elements. Surrounding sample sites to the north, south, and east are characterized by anomalous tungsten, lead, copper, tin, and molybdenum. In addition, most of these sites have disseminated pyrite in intrusive igneous and in metamorphic rocks. High barium values and pyrite occurrences are uncommon elsewhere in the wilderness study area. The barium is probably derived from barite present in small pods of metamorphic rocks exposed near the Sierra Nevada crest above the sampling site. One stream-cobble sample has 2,000 ppm barium and may indicate barite associated with mineralization upstream.

The most highly mineralized areas appear to be (1) the north end of the wilderness study area east and northeast of Lamont Meadow, (2) upper Spanish Needle Creek, (3) central Burnt House Canyon, and (4) the ridge area at the south end of the wilderness study area. Metamorphic roof-pendant rocks extending over the Sierra Nevada crest from the Owens Peak Wilderness Study Area (CDCA-158) have high concentrations of bismuth, lead, tin, and tungsten on the east side of the crest where gold and tungsten have previously been mined (Diggles and others, 1985).

The most anomalous sample from the wilderness study area, a locally derived concentrate, was collected near a pegmatite near the Golden Age prospect. No obvious mineralization was noted in the pegmatite, although iron staining was present. Skarn mineralization took place nearby. The concentrate contained 300 ppm tungsten, 200 ppm lead, 500 ppm copper, greater than 1 percent barium, and 2 percent pyrite. Willemite was also reported from this pegmatite and was noted in nearby skarn rocks, as was copper staining. A sheared gneissic diorite outcrop 0.6 mi east of the Golden Age prospect on a hillside north of the creek contained 150 ppm copper, 200 ppm bismuth, and 1,000 ppm manganese. Pyrite crystals in pegmatite were also seen nearby.

Gold was not seen in the concentrates or detected in the analyses, including the atomic-absorption analyses (detection limit 0.05 ppm) of the combined magnetic and nonmagnetic concentrates. The U.S. Bureau of Mines' analyses of rocks from the Golden Age claims detected anomalous concentrations of gold but did not lead to the identification of gold resources there. Eight rock samples analyzed for gold by the U.S. Geological Survey showed no gold values at a detection limit of 0.1 ppm.

One skarn sample from an outcrop along the road up lower Spanish Needle Creek contained 1,000 ppm chromium and 500 ppm nickel. No nickel-chromium anomalies were identified within the area studied.

Scattered occurrences of skarn and mineralized calc-silicate rocks near contacts with the batholith probably account for all of the anomalies in the portion of the area studied, but follow-up work would be required to describe each occurrence.

Geophysics

Aeromagnetic Data

An aeromagnetic survey of the Owens Peak Wilderness Study Area (CA-010-026) (U.S. Geological Survey, 1982) was flown in 1981 by a private contractor. The aeromagnetic data were collected along parallel east-west flight lines spaced 0.5 mi apart at a constant elevation of 9,000 ft. The contractor subtracted the earth's main field from the data, gridded the data set using a grid spacing of 200 meters, and machine-contoured the gridded data at a scale of 1:62,500 to produce the residual aeromagnetic map.

Variations in the earth's magnetic field on a residual map are generally caused by variations in the amounts of magnetic minerals present in different rock units, magnetite being the most common magnetic mineral in this area. Magnetic minerals may cause a high magnetic anomaly if they are concentrated or a low magnetic anomaly if they are absent. The resulting magnetic anomalies may act as a guide to mineral occurrences or deposits. Boundaries between more or less magnetic rock units are located approximately at the steepest gradient on the flanks of the magnetic anomaly because, at the latitudes of the study area, the inclination of the Earth's main magnetic field is relatively steep (61° below the horizontal). Comparison of the contoured aeromagnetic map with the geologic and topographic maps indicates that most of the magnetic anomalies are caused by topographic relief in magnetic terrane composed of Mesozoic plutonic rocks, in particular the mesocratic to melanocratic units. Relatively magnetic intrusive rocks are represented by diorite in Indian Wells Canyon, gabbro and quartz diorite in the eastern part of the wilderness study area, granodiorite at Lamont Peak, and granodiorite at Morris Peak. These rocks, described by Diggles and Clemens (1986), tend to have similar magnetic properties, as shown by their mutual geologic contacts not being expressed as magnetic gradients. Major hills or mountains composed of these rocks usually are associated with magnetic highs. The weakly magnetic rock units are the metamorphic and granitic rocks exposed in Sand Canyon and near Owens Peak. These rocks are associated with magnetic lows, and the contacts with more mafic rocks tend to be associated with magnetic gradients. The faults in the northern part of the wilderness study area appear as linear magnetic lows, but this is probably an effect of the low topographic expression of the faults. Limonitic alteration was mapped only in the southern part of the wilderness study area.

An unusual circular magnetic anomaly with an amplitude of about 200 gammas and a source width of about 0.7 mi is located at Owens Peak and has an associated magnetic low directly to the north. This feature is a topographic effect caused by the proximity of the rocks of Owens Peak itself, which was only 500 ft below the aircraft and is composed of a magnetic diorite also found in Indian Wells Canyon.

In general, the aeromagnetic data do not appear to provide any evidence for mineral resource potential in this area.

Electrical Data

Fourteen audiomagnetotelluric (AMT) soundings and two telluric traverses were carried out in and near the wilderness study area. The data collected show a north-northwest-trending, relatively low-resistivity trough on the west side of the wilderness study area, principally occurring within intrusive granitic rocks of the southern Sierra Nevada batholith. This trough encompasses the Golden Age prospect on the north side of Burnt House Canyon and correlates with a north-northwest-trending area of limonite alteration. Limonite minerals are secondary iron-bearing minerals that often form by weathering of minerals formed during hydrothermal alteration (Blanchard, 1968). This area of alteration corresponds with limonite minerals mapped from Landsat multispectral-scanner (MSS) data using a color-ratio compositing technique described by Rowan and others (1974) (D.H. Knepper, Jr, written commun, 1986). Two additional areas where MSS data show limonite anomalies are located in Three Pines Canyon and Spanish Needles Creek (D.H. Knepper, Jr., written commun, 1986).

It may be inferred from the electrical data that the low represents an area of general alteration in the granitic rocks. The two telluric traverses help to define the eastern boundary of the low-resistivity trough and correlate directly with the AMT data. The principal telluric line along Burnt House Canyon (line 2, H.A. Pierce, unpub. data, 1985) shows that the electrical boundary extends over a lateral distance of more than 0.6 mi. This suggests a rather diffuse boundary for the inferred alteration within the intrusive rocks. A map of apparent resistivities (at 27 Hertz) was produced for the 14 AMT sounding sites (H.A. Pierce, unpub. data, 1985). This map shows the extent and strike of the low-resistivity trough. The north and south ends of the trough are not well defined by these data. The trough presumably extends for some unknown distance beyond the survey area. A cross-section of the inverted soundings (8, 9, and 10, H.A. Pierce, unpub. data, 1985) show that this low extends 0.6 to 1.3 mi downward.

The presence of this low-resistivity trough adds certainty to the mineral resource assessment of the area around Burnt House Canyon by confirming the presence of alteration indicated by geochemical results.

CONCLUSIONS

The Owens Peak Wilderness Study Area (CA-010-026) is situated in the Sierra Nevada physiographic province, which contains the largest concentration of tungsten deposits in the United States (Newberry, 1982). The mineral-deposit model that is most appropriate to apply in this study area is the tungsten-skarn felsic-plutonic-rock model (Einaudi and others, 1981; Cox, 1983; Cox and Singer, 1986).

There are four areas that have mineral resource potential in the Owens Peak Wilderness Study Area (CA-010-026). The area of Burnt House Canyon is underlain by gneissic diorite and biotite granodiorite with minor pods of metamorphic rocks, including calc-silicate hornfels. The Golden Age prospect is located in this canyon and is described in table 1. Samples from this prospect have anomalous concentrations of tungsten. The results of the geochemical analyses indicate that tungsten is present in concentrations greater than 1,000 ppm. Minor zinc and copper were also detected. Alteration and skarn mineralization are indicated by anomalous concentrations of tungsten, lead, bismuth, copper, and molybdenum, and are confirmed by the results of AMT soundings and the presence of a limonite anomaly on MSS maps. Visual inspection of the concentrates showed scheelite (W), willemite (Zn), and pyrite. There is a pegmatite dike in the area that contains abundant muscovite. The area has moderate mineral resource potential for tungsten with a certainty level of C, and low mineral resource potential for copper and zinc with a certainty level of B.

The Spanish Needle Creek area is underlain by several hundred acres of quartz-mica schist containing local pods of calcareous metamorphic rocks. Geochemical sampling of the area showed anomalous concentrations of tungsten, as well as minor lead concentrations. Alteration of rocks in the drainage is indicated by a limonite anomaly on MSS maps. Inspection of concentrate samples under ultra-violet light showed that scheelite is present. The area has moderate mineral resource potential for tungsten with a certainty level of B, and low mineral resource potential for lead with a certainty level of C.

The canyon east of Lamont Meadow and west of Sand Canyon is underlain by granodiorite containing minor pegmatite dikes and local pods of metamorphic rocks. Geochemical samples contained slightly anomalous concentrations of tungsten and copper. There are also anomalous concentrations of barium, and copper staining was seen in float. The area has low mineral resource potential for tungsten, copper, and barite with a certainty level of B.

The area of lower Three Pines Canyon is underlain by biotite-porphyritic granodiorite with local areas of calc-silicate hornfels in metamorphic rocks. Geochemical results show slightly anomalous concentrations of tungsten and copper accompanied by low concentrations of the associated skarn-related elements bismuth and molybdenum. Alteration of the rocks in this area is indicated by the presence of a limonite anomaly on MSS maps. The area has low mineral resource potential for tungsten and copper with a certainty level of B.

The lack of significant limonite anomalies and the mineral assemblages observed in hand specimens indicate that mineralization in the wilderness study area is probably limited to small skarn bodies and pegmatites.

The wilderness study area has no geothermal energy potential (Higgins, 1981) and the geology is not conducive to petroleum or natural gas resource potential.

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TABLE 1. - Prospect in Owens Peak Wilderness Study Area (CA-010-026)

Map no.	Name	Summary	Workings and production	Sample and resource data
1	Golden Age Prospect	Two types of deposits, skarn and pegmatite, crop out of Golden Age and Golden Age Nos. 1-5 claims. Two outcrops of skarn are located about 300 ft apart; one is about 1 ft by 10 ft and the other about 40 ft by 80 ft. The skarn generally consists of garnet, epidote, and quartz. Small amounts of scheelite are present locally; one outcrop contains secondary copper minerals. Much of the surrounding rock is hornfels; a diorite-gabbro dike is also exposed. A muscovite-rich feldspar-quartz pegmatite pod, less than 100 ft in diameter, is about 300 ft south of the skarn deposits. The muscovite is irregularly distributed with flakes as much as 1 in. in diameter. Some of the quartz and feldspar are intergrown.	Three trenches (50, 30, and 30 ft long) and three small pits.	Eight samples were taken. Five samples taken from epidote, garnet, and quartz-bearing skarn. One contained 0.0015 oz/ton gold, two contained 0.0137 and 0.0225 oz/ton silver, one contained 0.076 percent copper, and two contained 0.06 and 0.17 percent tungsten trioxide. Two samples of diorite or gabbro contained 0.0019 and 0.0022 oz/ton gold. A sample of pegmatite contained 0.0025 oz/ton gold. Muscovite is estimated to comprise about 10 percent of the pegmatite.

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

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

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

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

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

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

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

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

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

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

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

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

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

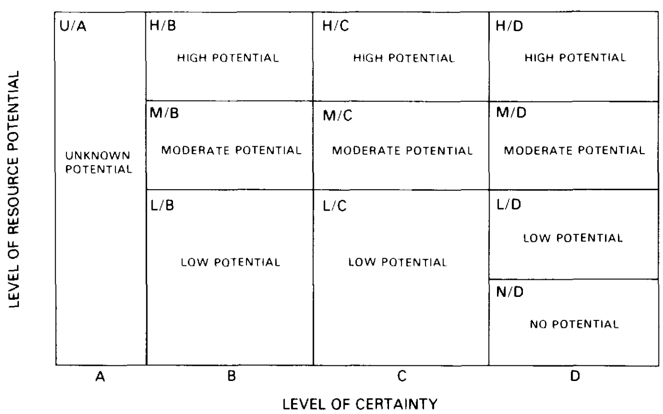

Figure 3. Major elements of mineral resource potential/certainty classification.

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