Mineral Resources of the Indian Pass and Picacho Peak Wilderness Study Areas, Imperial County, California

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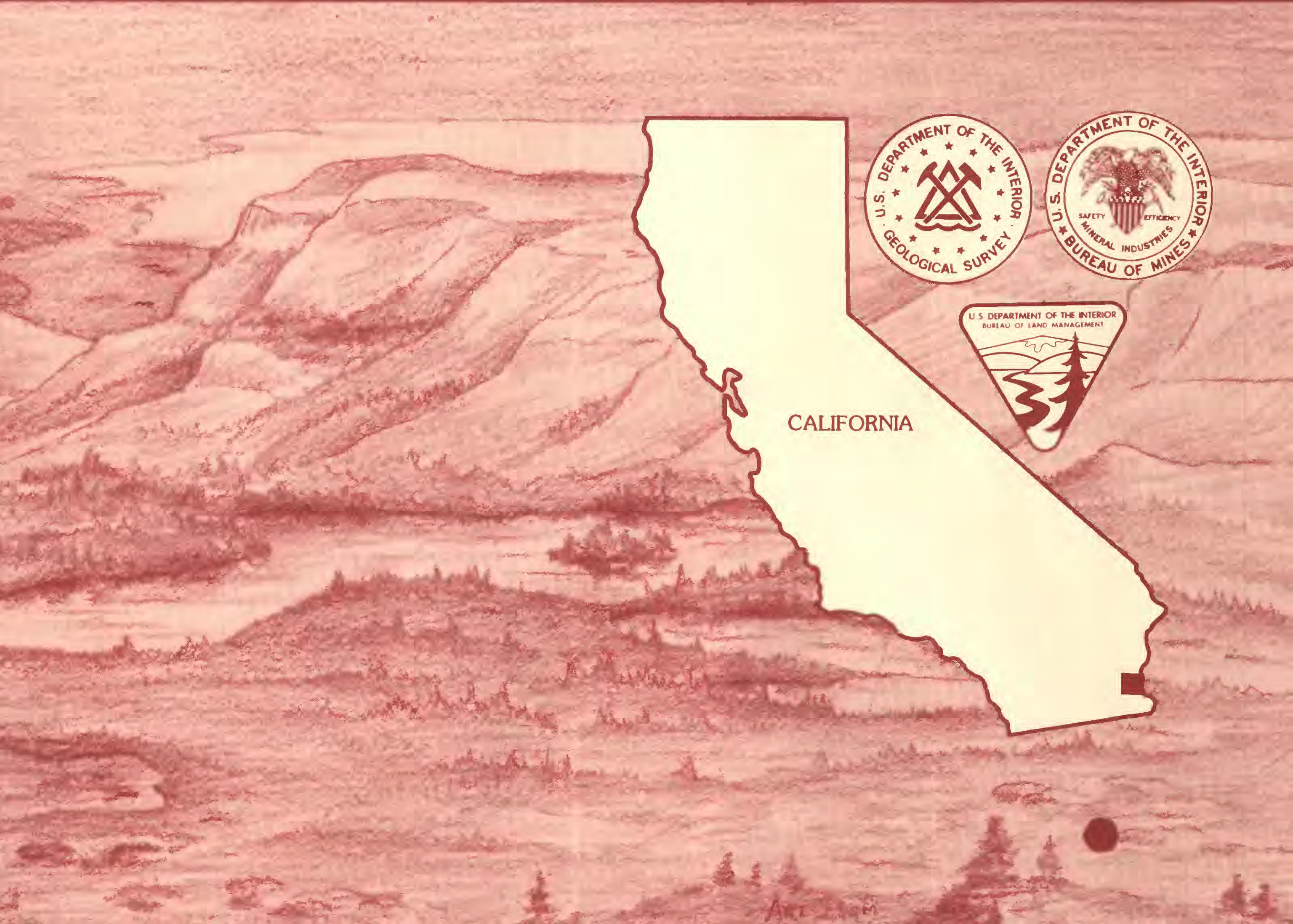

Chapter A

Mineral Resources of the Indian Pass and Picacho Peak Wilderness Study Areas, Imperial County, California

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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

U.S. GEOLOGICAL SURVEY
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 Indian Pass (CDCA-355) Wilderness Study Area and part of the Picacho Peak (CDCA-355A) Wilderness Study Area, Imperial County, California.

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Mineral Resources of the Indian Pass and Picacho Peak Wilderness Study Areas, Imperial County, California

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SUMMARY

Abstract

At the request of the Bureau of Land Management, the U.S. Geological Survey and U.S. Bureau of Mines studied the Indian Pass (CDCA-355) Wilderness Study Area and the Picacho Peak (CDCA-355A) Wilderness Study Area in eastern Imperial County, Calif. Mineral surveys were conducted on 33,640 acres of the Indian Pass Wilderness Study Area and 5,450 acres of the Picacho Peak Wilderness Study Area. Field work for this report was carried out between 1982 and 1985.

Within the collective area of the two study areas, there were 344 active mining claims in 1982. The prospects visited and sampled within and adjacent to the Indian Pass Wilderness Study Area have no identified resources. However, a tract having high resource potential for gold was delineated in the southwestern part of the Indian Pass Wilderness Study Area. This tract has been the site of much exploration activity for gold since 1983. Other tracts located within the Indian Pass Wilderness Study Area have moderate resource potential for gold and silver, moderate potential for tungsten, and low potential for gold, lead, zinc, and copper.

The prospects sampled within and adjacent to the Picacho Peak Wilderness Study Area have no identified resources. Tracts having high resource potential for gold were delineated in the north-central part of the Picacho Peak Wilderness Study Area. Other tracts within the Picacho Peak Wilderness Study Area have low potential for undiscovered gold, lead, zinc, and copper resources.

Character and Setting

The Indian Pass and Picacho Peak Wilderness Study Areas occupy the southeast end of the Chocolate Mountains approximately 25 mi north-northwest of Yuma, Ariz., in easternmost Imperial County, Calif. (fig. 1). The relief is about 1,800 ft with rugged hills, steep-walled arroyos, and broad sandy washes.

The study areas are underlain by rocks ranging in age from Proterozoic(?) and Mesozoic to Quaternary (see appendix 1 for geologic time chart). The structurally lowest rocks in the study areas are Proterozoic(?) and Mesozoic gneiss and Jurassic(?) supracrustal and granitic rocks that have been superposed over the late Mesozoic Orocopia Schist along the Late Cretaceous Chocolate Mountains thrust. Weakly to moderately metamorphosed Jurassic(?) supracrustal and granitic rocks are also juxtaposed against the gneiss and Orocopia Schist along younger normal faults. At Peter Kane Mountain, the Orocopia Schist was intruded and thermally remetamorphosed by a pluton at about 21-26 million years before the present (Ma). Block faulting in Oligocene time was followed by silicic volcanism, which continued into early Miocene time. Regional extension followed soon after the cessation of volcanism. Conglomerate marks the erosion of the volcanic field. Latest Tertiary(?) and Quaternary conglomerate, sandstone, and siltstone unconformably overlie the older rocks and structures.

California's earliest mineral production (worked in 1779-81 by Spanish miners) was from placer gold deposits in the region just south of the study areas. Lode gold deposits at the Picacho mine, approximately 5 mi east-southeast of the Picacho Peak Wilderness Study Area, and the Cargo Muchacho district, about 10 mi south of the study areas (fig. 1), were discovered in the late 19th century.

Identified Resources

The 37 prospects visited and sampled during this study contained no identified resources. However, our sampling and the recent drilling program by Gold Fields Mining Corporation provide strong evidence that gold resources exist in the Indian Pass and Picacho Peak Wilderness Study Areas. There has been no mineral production from the study areas.

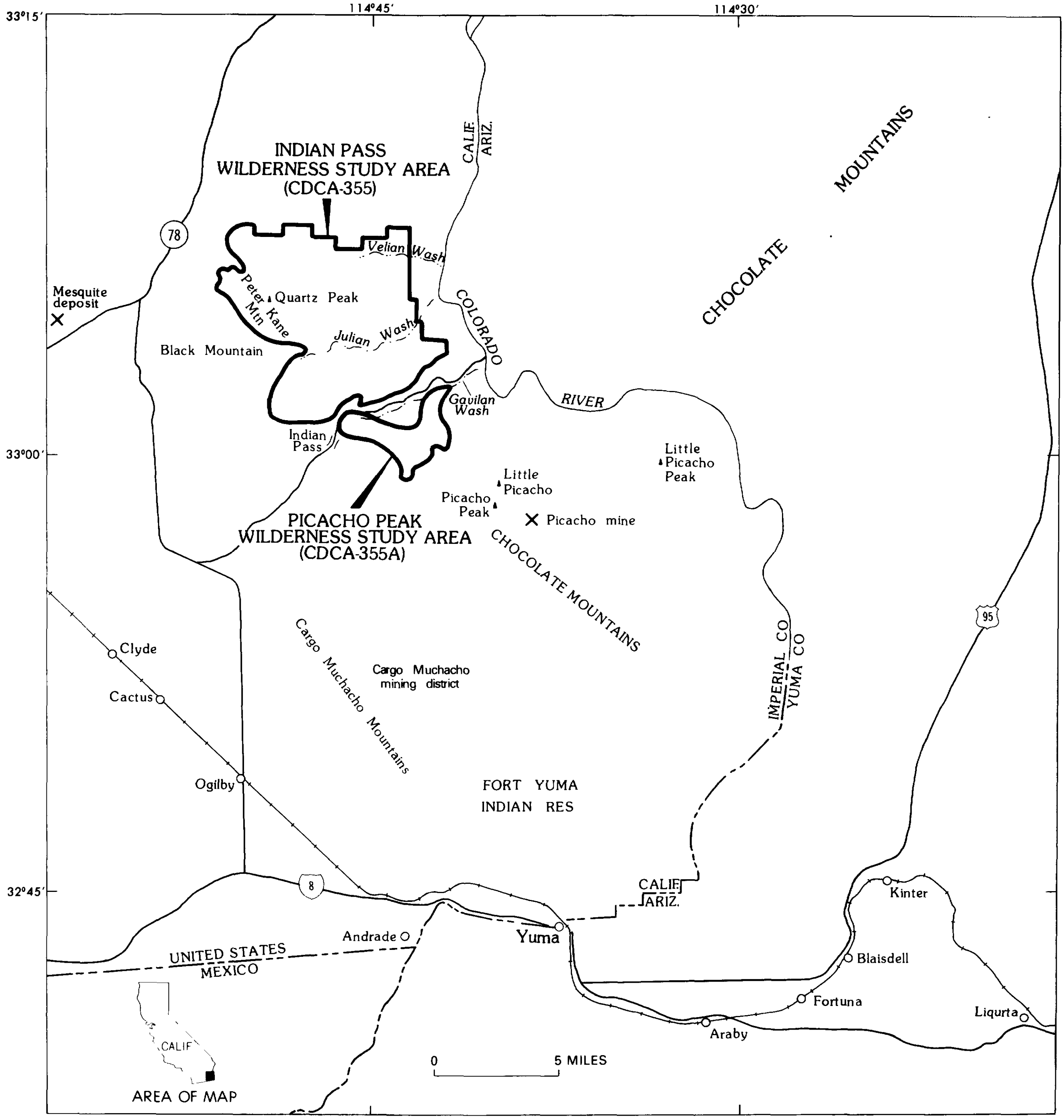

Figure 1. Index map showing location of Indian Pass and Picacho Peak Wilderness Study Areas, Imperial County, California.

Mineral Resource Potential

The Indian Pass and Picacho Peak Wilderness Study Areas each have tracts having high mineral resource potential for gold. The Indian Pass Wilderness Study Area also has localities with moderate resource potential for gold and silver, moderate potential for tungsten resources, and low potential for gold, lead, zinc, and copper resources. The Picacho Peak Wilderness Study Area has localities with low potential for gold, lead, zinc, and copper resources.

The region around the study areas has intermittently produced significant quantities of gold since the mid-1800's and is currently being explored for additional gold resources. Within a 10-mi radius of the study areas, the Picacho mine is currently producing gold, the Mesquite deposit produced its first gold in early 1986, and the Cargo Muchacho district (fig. 1) is the site of an announced gold discovery (Epler, 1985).

Tracts within both study areas have high resource potential for gold. These tracts are underlain by gneiss of the upper plate of the Chocolate Mountains thrust in a narrow east-trending belt near the north boundary of the Picacho Peak Wilderness Study Area and in the southwest corner of the Indian Pass Wilderness Study Area (pl. 1; fig. 2). This gneiss is lithologically similar to the host gneiss at the Mesquite deposit and in the Cargo Muchacho district. In 1985, Gold Fields Mining Corp. conducted a helicopter-supported drilling program in the gneiss both inside and adjacent to the Indian Pass Wilderness Study Area. They reported drilling intercepts with mineralized rock containing ore-grade gold recoverable by the heap-leaching process (S.N. Watowich, written commun., 1985). The mineralized horizons range from 20 to 55 ft thick and contain 0.016 to 0.062 oz/ton (0.55 to 2.1 parts per million (ppm)) gold. These results were confirmed through reanalysis of sample splits by the U.S. Geological Survey laboratories in Denver, Colo.

Two tracts of land within the Indian Pass Wilderness Study Area have moderate resource potential for gold and silver in epithermal deposits (fig. 2). These tracts were delineated primarily on the basis of anomalous concentrations of pathfinder elements such as arsenic, antimony, and mercury in rocks and (or) heavy-mineral concentrates from stream sediments.

The area around Peter Kane Mountain in the Indian Pass Wilderness Study Area (fig. 2) has moderate resource potential for tungsten in skarn deposits at the contact of an intrusive granite with rare marble horizons in the Orocopia Schist. This area was identified by anomalous concentrations of tungsten and bismuth in heavy-mineral concentrates derived from stream sediments and by high concentrations of tungsten, bismuth, copper, silver, tin, lead, and zinc in rocks. However, it is doubtful that the volume of carbonate host rock is sufficient for the accumulation of exploitable quantities of tungsten.

Both the Indian Pass and Picacho Peak Wilderness Study Areas have low resource potential for copper in hydrothermal veins and for gold, lead, zinc, and copper in volcanogenic massive sulfide deposits.

INTRODUCTION

This report presents an assessment of the identified resources and the mineral resource potential of the Indian Pass (CDCA-355) and Picacho Peak (CDCA-355A) Wilderness Study Areas, Imperial County, Calif. (fig. 1). The Indian Pass and Picacho Peak study areas comprise approximately 33,640 acres and 5,450 acres, respectively. They are located in easternmost Imperial County at the southeast end of the Chocolate Mountains and lie about 25 mi north-northwest of Yuma, Ariz. Access to the study areas from Yuma is by Interstate Highway 8 west for 13 mi to the Ogilby Road, north on this road for 12 mi to the Indian Pass graded dirt road, then east for 7 mi to Indian Pass and Gavilan Wash. Access to more remote parts of the areas is by unimproved dirt roads, many of which can be traveled only by four-wheel-drive vehicles. Large parts of the areas are inaccessible except by foot.

The topographic relief in the study areas is about 1,800 ft, with a maximum elevation of 2,177 ft at Quartz Peak on Peter Kane Mountain. Intermittent streams have dissected the land into an intricate pattern of rugged hills, steep-walled arroyos, and broad sandy washes. The climate is arid and the average annual rainfall at Yuma is approximately 3 in. (Hely and Peck, 1964). The sparse vegetation in the area is of the Lower Sonoran Life Zone—creosote, ironwood, ocotillo, palo verde, and brittle bush.

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

ACKNOWLEDGMENTS

R.B. Vaughn, Kim Gullickson, and Christine Ye assisted with the reconnaissance geochemical survey. B.M. Adrian, T.A. Roemer, and Marianne Walter conducted chemical analyses on all samples collected by the USGS. G.B. Haxel mapped parts of the areas. Craig Erdman helped reduce the geophysical data.

Gold Fields Mining Corp. in Yuma, Ariz., kindly furnished samples from its surface exploration and drilling program for geochemical analysis.

We also thank BLM personnel in El Centro, Calif., for their helpful discussions and cooperation during this project.

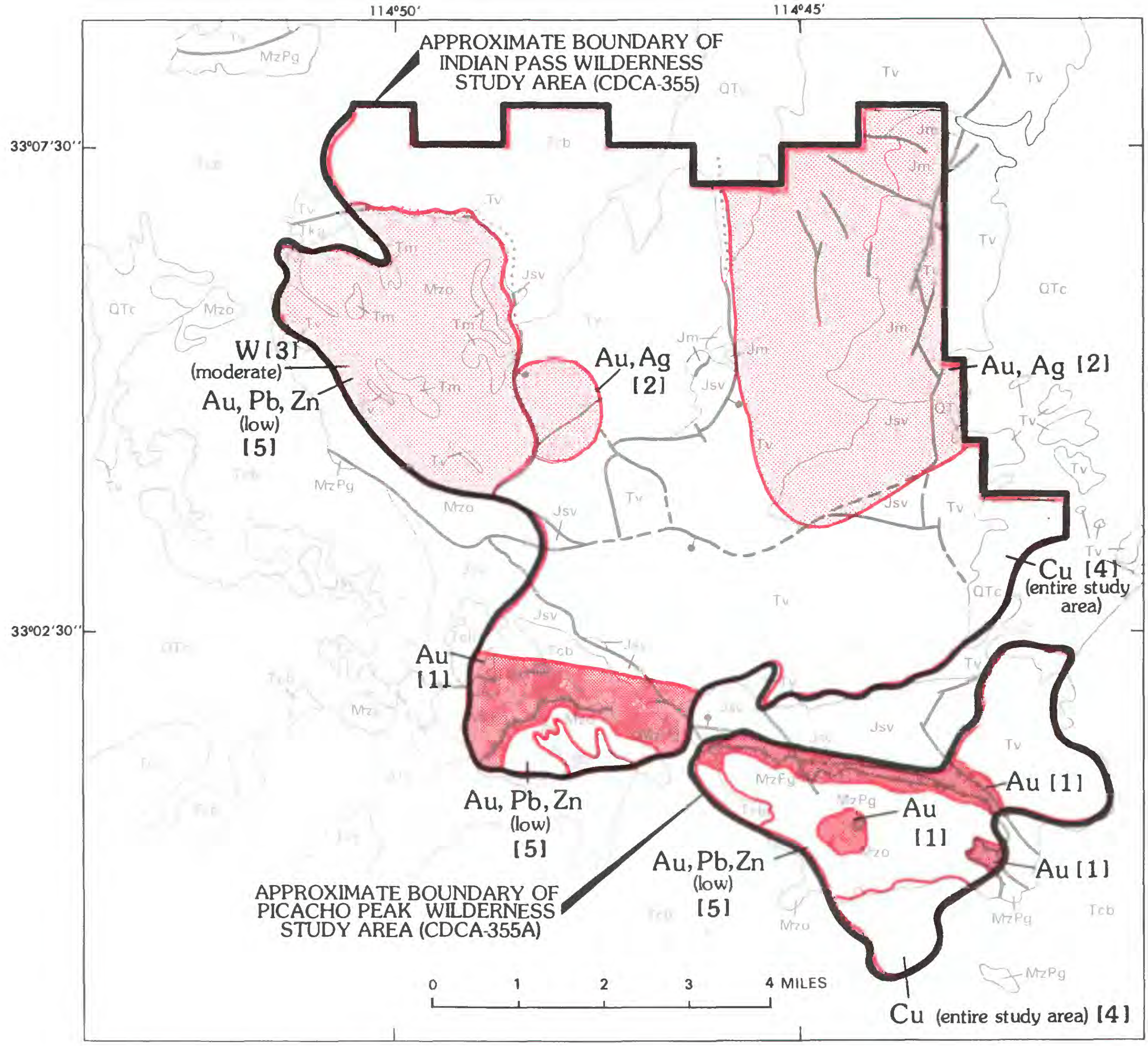

Figure 2. Mineral resource potential and generalized geology of the Indian Pass and Picacho Peak Wilderness Study Areas, Imperial County, California.

APPRAISAL OF IDENTIFIED RESOURCES AND KNOWN MINERALIZED AREAS

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

In 1983 and 1984, all available literature and unpublished material pertaining to mining activity, mineral production, and geology in the Indian Pass and Picacho Peak Wilderness Study Areas were reviewed. U.S. Bureau of Land Management (BLM) records and Imperial County records were searched for mining claims located in and adjacent (within 1 mi) to the study areas. Claim owners were contacted and, when possible, interviewed. Mines, prospects, and mineralized zones in and adjacent to the study areas were sampled and mapped as warranted.

During the investigation 169 rock samples were taken by USBM personnel. Samples were analyzed chemically at the USBM Reno Research Center, Reno, Nev. Analytical methods are described in McMahan and Rumsey (1984) and Rumsey and McMahan (1984, 1986). Detailed analyses are available from the U.S. Bureau of Mines, Western Field Operations Center, East 360 Third Avenue, Spokane, Wash., 99202.

Mining History

No mines were in operation within or adjacent to the study areas in 1983 and 1984. The nearest mines with records of significant production are the Picacho gold mine and nearby gold placers 5 mi to the southeast; several gold mines in the Cargo Muchacho district, 10 mi to the south; and manganese mines 5 mi north of the Indian Pass Wilderness Study Area. Placer gold near the current Picacho mine was discovered and worked by Spanish settlers in 1780. Deposits in the Cargo Muchacho district have been worked since 1823 (Morton, 1977), and the Picacho lode gold deposit was mined by 1880. Chemgold, Inc., a wholly owned subsidiary of Glamis Gold, Ltd., has been producing gold in its heap-leaching operation at the Picacho mine since 1983.

Claims owned by the Gold Fields Mining Corp. include the mineralized zone along the Chocolate Mountains thrust (pl. 1) both inside and outside the study areas near Indian Pass. Surface exploration and drilling of the zone has proceeded since 1983; helicopter-supported drilling was used to complete 12 holes inside the Indian Pass Wilderness Study Area in 1985.

Mining claim records of the BLM indicate that 832 other mining claims were current in 1982; 256 lode and 88 placer claims were in the study areas, and 488 lode and placer claims were nearby. Lode claims were located mainly on copper carbonate-stained exposures of the Winterhaven Formation and on quartz pods and lenses within the Orocopia Schist. The only mineral production reported adjacent to the study areas was from claims near the north boundary of the Picacho Peak Wilderness Study Area (pl. 1, Nos. 26 and 27). Ten tons of hand-sorted copper carbonate were shipped from these claims in 1968 and 1969. The shipments contained 0.07 oz/ton gold, 7.58 oz/ton silver, and 15.86 percent copper.

Mines, Prospects, and Mineralized Outcrops

Twenty-three mines, prospects, and mineral occurrences inside the study areas and 14 outside were examined for this study (pl. 1 and table 1). The prospects at these localities are associated with surficial occurrences of copper carbonate and silicate and have been scraped, pitted, and trenched by bulldozers. These occurrences represent local remobilization of copper from mafic minerals in the rock and do not constitute an identified resource.

EXPLANATION

Area with high mineral resource potential

Area with moderate mineral resource potential

Area with low mineral resource potential

See appendix 1 for definition of levels of mineral resource potential

Commodities

Au	Gold
Ag	Silver
Cu	Copper
Pb	Lead
W	Tungsten
Zn	Zinc

[ ] Deposit types

1. Gneiss-hosted disseminated gold
2. Epithermal gold and silver in veins, breccia pipes, pods, or dikes in volcanic and hypabyssal rocks
3. Skarn tungsten deposits in carbonate rocks near contact with felsic intrusive rocks
4. Hydrothermal copper veins in diverse host rocks
5. Volcanogenic massive sulfide and gold in metavolcanic rocks of submarine precursors

Geologic map units

Qtc	Conglomerate and sandstone (Quaternary and (or) Tertiary)
Tcb	Conglomerate and basalt (Pliocene? to middle Miocene)
Tv	Volcanic, hypabyssal, and sedimentary rocks (Lower Miocene? and Oligocene)
Tm	Monzogranite (Oligocene)
TKg	Granite porphyry (Tertiary and (or) Cretaceous)
Mzo	Orocopia Schist (Upper Mesozoic)
Jm	Monzogranite and diorite (Jurassic?)
Jsv	Sedimentary and volcanic rocks (Jurassic?)
MzPg	Gneiss (Mesozoic and (or) Proterozoic)

Contact

Fault--Dashed where approximate; dotted where concealed; bar and ball on downthrown side

Thrust fault--Sawteeth on upper plate

Figure 2. Continued.

Mineralized Zone along the Chocolate Mountains Thrust Fault

Gold, silver, and copper are found along the Chocolate Mountains thrust in hydrothermally altered gneiss in the upper plate and the Orocopia Schist in the lower plate. The mineralized zone is silicified and moderately to intensely iron oxide stained, and it locally contains secondary copper minerals. The fault contact and mineralized zone crop out in a west-northwest-trending belt across the southwest corner of Indian Pass Wilderness Study Area and the northern part of Picacho Peak Wilderness Study Area (pl. 1). Gold in the mineralized zone was not recognized prior to 1983, at which time mining company geologists found significant gold values in upper plate gneiss. Until then the only prospect workings in the thrust zone consisted of a few bulldozer pits and trenches that exposed minor secondary copper occurrences in rocks of both the upper and lower plates.

Sampling was concentrated within 20 ft of the fault contact where the gneiss and schist are most intensely mineralized. Seventy samples were taken at 51 sites. Nineteen of these sites are in or just outside the Indian Pass Wilderness Study Area; 32 sites are along the mineralized zone in and near the Picacho Peak Wilderness Study Area. Sample descriptions and localities are given by McMahan and Rumsey (1984) and Rumsey and McMahan (1984). Most samples are of mineralized gneiss from the upper thrust plate. Samples from 36 sites contain 0.0003 to 0.26 oz/ton (0.010 to 8.3 ppm) gold and 0.004 to 0.21 oz/ton (0.13 to 7.2 ppm) silver. Traces of gold were detected in samples from nine sites, while neither gold nor silver was detected in samples from six sites. Samples at five sites contain 0.001 to 0.014 percent copper. The average grade of gold in these samples (0.004 oz/ton) is too low to support an estimate of gold resources. Additional exploration may reveal localities with higher gold and silver concentrations and the mineralized zone may contain higher gold and silver values farther away from the oxidized, and possibly leached, outcrops.

Recent exploratory rotary drilling, both inside and outside the study areas, by Gold Fields Mining Corp., has shown that the mineralized zone in altered upper plate gneiss continues downdip under Tertiary sedimentary and volcanic cover and that the thrust fault decreases in dip to the northeast. This suggests that mineralized gneiss may be only thinly covered in the southwestern part of the Indian Pass Wilderness Study Area and for 2 mi along the fault in the northern part of the Picacho Peak Wilderness Study Area. While Gold Fields Mining Corp. has not blocked out resources in the zone, it reports at least 10 drilling intercepts of mineralized rock 20 to 55 ft thick that contain 0.016 to 0.062 oz/ton (0.55 to 2.1 ppm) gold (S.N. Watowich, written commun., 1985). A large-tonnage, low-grade gold deposit, if found along the thrust zone, would likely be amenable to low-cost methods of production including open-pit mining and heap-leach gold recovery.

The mineralized gneiss in the two study areas has a geologic and structural setting similar to that at the Picacho and Mesquite mines. Recent published production figures for the Picacho mine indicate that at a mining rate of about 800,000 tons/year, cost of production is about $4.8/ton of ore ($160/oz of gold); reserves are 10 million tons at a grade of 0.03 oz/ton (1.0 ppm) gold (American Gold News, 1984). At the Mesquite mine, which first produced gold in early 1986, costs of production are estimated at about $9.2/ton of ore ($200/oz of gold) for a mining rate of 2.8 to 3.0 million tons/year; reserves are 66 million tons at a grade of 0.046 oz/ton (1.6 ppm) gold (The Northern Miner, 1985).

Conclusions

An identified resource is a resource whose location, grade, quality, and quantity are known or can be estimated from specific geologic knowledge (U.S. Bureau of Mines and U.S. Geological Survey, 1980). On the basis of this definition, no resources were identified in either the Indian Pass or Picacho Peak Wilderness Study Areas. However, the recent drilling program by Gold Fields Mining Corp. provides strong evidence that gold resources exist in the Indian Pass and Picacho Peak study areas.

The pods, lenses, and stringers of secondary copper minerals, on which most of the past lode claims are located, are economically insignificant. Large quantities of stone and sand and gravel in the study areas are suitable for dimension and crushed stone and for aggregate, but high transportation costs and remote location from major markets prevent development of these resources in the foreseeable future.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By David B. Smith, Byron R. Berger, Richard M. Tosdal, David R. Sherrod, Gary L. Raines, Andrew Griscom, and Maryann G. Helferty
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Geologic Setting

Quartzofeldspathic gneiss and amphibolitic gneiss of Proterozoic(?) and Mesozoic age that are thrust over the oceanic Orocopia Schist represent the lowest two structural domains in the study area (pl. 1). At least two, if not more, ages of gneiss are present. Weakly to moderately metamorphosed Jurassic(?) supracrustal rocks, consisting of metamorphosed Jurassic(?) rhyolitic volcanic rocks and the Jurassic(?) Winterhaven Formation of Haxel and others (1985), are juxtaposed against the gneiss package and the Orocopia Schist along normal faults of both latest Cretaceous and middle Tertiary age (Haxel and others, 1985; Tosdal and Sherrod, 1985; Drobeck and others, 1986). Both the supracrustal rocks and gneiss are intruded by Jurassic(?) dioritic and monzogranitic stocks and dikes. Equivalents to these Jurassic(?) volcanic and plutonic rocks are also recognized in the gneiss package along the southwest margin of the Indian Pass Wilderness Study Area.

The late Mesozoic Orocopia Schist is composed of metamorphosed oceanic sedimentary rocks derived from a continental source and subordinate basalt and chert (Haxel and Dillon, 1978; Haxel and others, 1985). Graywacke and semipelite are the dominant protoliths. Mukasa and others (1984) report a Middle Jurassic (pre-163 Ma) minimum age for the protolith.

Metamorphism of the Orocopia Schist in the study areas and of its correlative bodies elsewhere in southern California is due to tectonic burial in excess of 32 mi beneath an overriding crystalline thrust sheet (Graham and Powell, 1984). In southeastern California, this tectonic contact is known as the Chocolate Mountains thrust (Haxel and Dillon, 1978). In the study areas, only gneissic rocks are superposed over the Orocopia Schist. However, field relations to the east and west indicate that the Jurassic(?) granitoids and supracrustal rocks are also part of the upper plate of the thrust sheet (Dillon, 1976; Haxel and others, 1985).

A granite porphyry equivalent to the informally named granite of Marcus Wash of Haxel and others (1985) is exposed in a few scattered outcrops in the study areas. This granite intrudes the Orocopia Schist, the upper plate gneiss, and the Winterhaven Formation. Metamorphism of the Jurassic(?) supracrustal rocks and the localized remetamorphism of the Orocopia Schist accompanied intrusion of the granite along a latest Mesozoic low-angle normal fault (Haxel and others, 1985). Frost and Martin (1982) reported a Paleocene (60 Ma) potassium-argon minimum age for this granite and preceding deformation.

In early Oligocene time, after a period of magmatic quiescence and regional erosion, the area underwent high-angle faulting. In the vicinity of the Picacho mine, this early phase of middle Tertiary deformation was accompanied by low-angle normal or detachment faults (Drobeck and others, 1986). Talus breccias and mudflow deposits accumulated at the base of the fault scarps; algal limestone, fine-grained tuffaceous sandstone, and siltstone accumulated in basins. Eruption of basaltic andesite and pyroxene dacite at about 30 Ma marked the beginning of active silicic volcanism. Normal fault movements synchronous with volcanic activity exerted important control over the areal distribution of some volcanic rocks (Crowe, 1978). Regionally, the silicic volcanism continued into early Miocene time and formed an extensive volcanic field (Dillon, 1976; Crowe, 1978; Crowe and others, 1979).

At Peter Kane Mountain, a porphyritic biotite granite intruded and thermally remetamorphosed the Orocopia Schist (Haxel, 1977). The granite is equivalent to a series of stocks exposed discontinuously along the entire length of the Chocolate Mountains, with hornblende, biotite, and sanidine potassium-argon ages between 21 and 26 Ma (Armstrong and Suppe, 1973; Miller and Morton, 1977; Crowe and others, 1979).

After cessation of volcanism in the early Miocene, curviplanar normal faults broke the rocks into several arcuate blocks. Related but subsidiary normal faults further subdivided the larger blocks. Preexisting structural anisotropies such as the planar fabric of the gneiss, the trace of the Chocolate Mountains thrust, and folds in the crystalline rocks were important in localizing the curviplanar master faults. All these normal faults probably formed during middle Tertiary regional extension, which affected much of southwestern Arizona and parts of southeastern California (Tosdal and Sherrod, 1985; Frost and Martin, 1982).

Early Miocene(?) conglomerate records the erosion of the Oligocene volcanic field. The paucity of crystalline basement clasts in the conglomerate indicates that, in contrast to areas to the west (Dillon, 1976), the study areas were almost completely covered by volcanic rocks in early Miocene time.

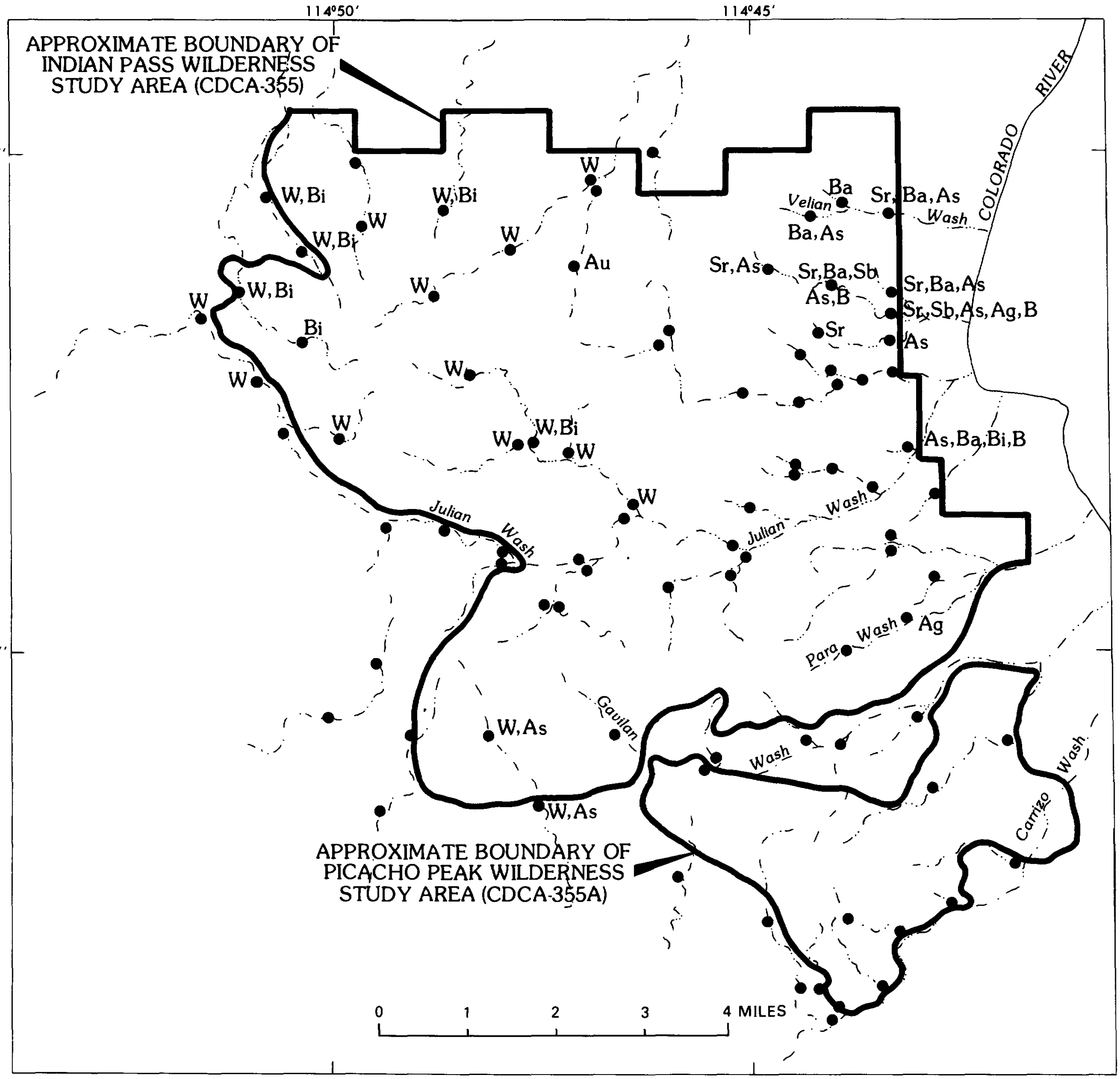
Middle Miocene to Pliocene(?) conglomerate unconformably overlies all older rocks and structures. Clasts are mostly of crystalline rocks. Interbedded with the conglomerate is the (informally named) basalt of Black Mountain (Crowe, 1978; Haxel, 1977). Latest Tertiary(?) and Quaternary conglomerate, sandstone, and siltstone unconformably overlie the older rocks and structures.

Geochemistry

A reconnaissance geochemical survey was begun in the Indian Pass and Picacho Peak Wilderness Study Areas in 1982. Minus-80-mesh stream sediments and heavy-mineral concentrates derived from stream sediments were selected as the primary sample media because they represent a composite of rock and soil exposed in the drainage basin upstream from the sample site. Chemical analysis of sediments provides information that helps identify those basins that contain unusually high concentrations of elements, which may be related to mineral occurrences. Stream sediments and heavy-mineral concentrates were collected from active alluvium in first-order (unbranched) and second-order (below the junction of two first-order) streams as shown on figure 3. Rock samples for geochemical analysis were also collected both in and near the study areas. Samples that appeared unaltered were taken to provide information on geochemical background values. Samples at mines, prospects, and altered areas were taken to determine suites of elements associated with mineralization and alteration. Analytical data and a description of the sampling and analytical techniques are given in Adrian and others (1984).

Summary of Results

Analysis of the nonmagnetic fraction of heavy-mineral concentrates was the most useful in evaluating the study areas on a reconnaissance basis. Concentrates generally contain minerals that result from ore-forming processes, not ordinary rock-forming ones. Minerals concentrated in this type of sample include sulfide and oxide minerals such as pyrite (FeS_2), galena (PbS), cassiterite (SnO_2), sphalerite (ZnS), chalcopyrite ($CuFeS_2$), stibnite (Sb_2S_3), and cinnabar (HgS). Other minerals concentrated in this sample medium are native gold, barite ($BaSO_4$), and scheelite ($CaWO_4$). This selective concentration of ore-related minerals permits determination of some



EXPLANATION

● Geochemical sample site

Element

Ag	Silver	B	Boron	Sb	Antimony
As	Arsenic	Ba	Barium	Sr	Strontium
Au	Gold	Bi	Bismuth	W	Tungsten

Figure 3. Distribution of tungsten, bismuth, gold, silver, arsenic, antimony, barium, strontium, and boron anomalies in nonmagnetic heavy-mineral concentrates derived from stream sediments collected in the Indian Pass and Picacho Peak Wilderness Study Areas, Imperial County, California.

elements that are not easily detected in bulk stream-sediment samples.

Threshold values (lowest anomalous value, table 2) were determined by inspection of frequency distribution histograms for each element. A plot of anomalies for selected elements in this sample medium (fig. 3) shows three areas within the Indian Pass Wilderness Study Area with distinctive multielement geochemical signatures. The area around Peter Kane Mountain in the northwest quadrant of the study area has high concentrations of tungsten (as much as 2,000 ppm) and bismuth (as much as 1,000 ppm). Scheelite was found during microscopic examination of samples containing anomalous tungsten. The area north of Julian Wash, in the northeast quadrant of the Indian Pass Wilderness Study Area, is characterized by high concentrations of arsenic (500-10,000 ppm), barium (greater than 10,000 ppm), antimony (200-300 ppm), strontium (5,000-10,000 ppm), and (or) boron (1,000-greater than 5,000 ppm). The southwest corner of the Indian Pass Wilderness Study Area has high values of tungsten (as much as 1,000 ppm) and arsenic (as much as 500 ppm) in nonmagnetic heavy-mineral concentrates.

Chemical analysis of minus-80-mesh stream sediments produced few geochemical anomalies. Samples from the area north of Julian Wash show anomalous concentrations of arsenic (40-85 ppm compared to a background of 5-20 ppm). Apparently dilution by common rock-forming minerals was so great that other elements related to possible mineralization were not present in anomalous amounts in this sample medium.

Lithogeochemical studies using rock samples in the study areas focused on those areas determined to be geochemically anomalous from analysis of heavy-mineral concentrates and on the area underlain by quartzofeldspathic gneiss exposed as the upper plate of the Chocolate Mountains thrust (pl. 1). Because the geologic setting of these samples is known, geochemical results can yield relatively specific interpretations for resource analysis.

Mineralized rocks collected on Peter Kane Mountain contained high concentrations of copper, lead, zinc, tungsten, bismuth, silver, and tin (table 3). This area is underlain by the late Mesozoic Orocopia Schist intruded by granite of Oligocene age (pl. 1). Altered and mineralized rocks were localized at or near the intrusive contact. At the surface, the mineralized rock contains secondary copper and iron minerals where the granite intrudes metabasite horizons of the Orocopia Schist, and contains scheelite where it intrudes rare marble within the Orocopia Schist. Fluids associated with the intruding granite apparently leached copper from mafic minerals in the Orocopia Schist and then precipitated it locally as carbonate or silicate minerals. Scheelite was precipitated where similar fluids, presumably carrying magmatic tungsten, encountered calcium-rich marble horizons.

Rocks collected from the northeast quadrant of the Indian Pass Wilderness Study Area contain high concentrations of arsenic (as much as 18 percent), antimony, boron, mercury, and strontium (table 3). Scattered anomalous concentrations of gold, silver, copper, and fluorine were also detected. This part of the study area is underlain by metasedimentary and metavolcanic rocks of Jurassic(?) age, biotite monzogranite of Jurassic(?) age, and Tertiary volcanic and hypabyssal rocks composed of flows, domes, and tuffs of intermediate to silicic composition. All these rock types are cut by north-striking normal faults. The geochemical anomalies in both rocks and heavy-mineral concentrates are probably related to silica-clay alteration associated with some of these faults. There may have been some hot-spring activity in this area related either to the waning stages of the Tertiary volcanic episode or to displacements along normal faults during Miocene regional extension.

Quartzofeldspathic gneiss of the upper plate of the Chocolate Mountains thrust is exposed in a relatively narrow east-trending belt near the north boundary of the Picacho Peak Wilderness Study Area and in the southwest corner of the Indian Pass Wilderness Study Area (pl. 1). The gneiss in the Indian Pass Wilderness Study Area is lithologically similar or related to the gneiss that is the host rock for gold mineralization at the Mesquite deposit and in the Cargo Muchacho Mountains.

Gold Fields Mining Corp. began surface exploration of fractured, oxidized gneiss near Indian Pass in 1983. The company conducted a helicopter-supported drilling program in 1985 in the southwestern part of the Indian Pass Wilderness Study Area. Gold Fields Mining Corp. furnished the USGS with 326 samples from their surface sampling program and 127 samples of cuttings from three drill holes for geochemical analysis. USGS personnel also collected and analyzed samples of fractured, oxidized gneiss from this area. Analyses for selected mineralized samples are shown in table 3.

The surface samples from the southwestern part of the Indian Pass Wilderness Study Area show scattered high gold concentrations. Forty-three percent of the surface samples contain greater than 0.05 ppm gold (the lower limit of determination). The mean for the samples containing detectable gold is 0.12 ppm with a maximum of 4.6 ppm. Other elements present in anomalous concentrations are arsenic, tungsten, mercury, antimony, and tellurium.

Sixty-one percent of the samples from the drill holes contain gold equal to or greater than 0.05 ppm. The mean for these samples is 0.13 ppm with a maximum of 3.9 ppm. More importantly, two of the three holes studied by the USGS intersect mineralized zones 20-50 ft thick with gold concentrations averaging from 1.4-1.9 ppm (0.04-0.06 oz/ton).

Rock samples analyzed from brecciated Tertiary volcanic rocks just east of Peter Kane Mountain (pl. 1) show high mercury values (as much as 5 ppm). The major fault that separates the Orocopia Schist from the volcanic rocks (pl. 1) may have acted as a pathway for meteoric water to descend, become heated, and rise to the surface along fractures as mercury-bearing hot springs.

Remote Sensing

Color-ratio-composite images of Landsat data were used to map the generalized distribution of limonitic (hydrous iron oxide) material as a guide to hydrothermal alteration, which, in turn, acts as a guide to mineralized systems. All areas defined as limonitic in and near the Indian Pass and Picacho Peak Wilderness Study Areas were visited and selectively sampled to determine (1) if the limonite was associated with hydrothermal alteration; (2) the assemblage of alteration minerals where present; and (3) the assemblage of trace elements associated with the alteration.

A zone of limonitic hydrothermal alteration extends from the central part of the Picacho Peak Wilderness Study Area through the central and southwestern parts of the Indian Pass Wilderness Study Area (fig. 4). Rocks in this zone are classified as propylitically altered on the basis of weak or incipient alteration characterized by replacement of mafic minerals by chlorite, epidote, carbonate, quartz, and minor sericite, montmorillonite, and pyrite. A limonitic area associated with apparently unaltered volcanic rocks was mapped in the northeastern part of the Indian Pass Wilderness Study Area (fig. 4).

Geophysical Studies

Gravity data used for this report were taken from Snyder and others (1982) and Helferty and Erdman (1985). Reduction routines (Jachens and Roberts, 1981) applied to the data produced an isostatic residual gravity map that primarily represents the effects of lateral density variations in upper crustal rocks. The isostatic residual gravity data were interpolated to a rectangular grid with a spacing of 0.93 mi and machine contoured at a contour interval of 2 milligal (mGal).

In a general way, the gravity field of the study areas slopes down to the northeast from high values of -12 mGal in the southwest to low values of -30 mGal in the northeast. The cause of this gradient is not clear, but low values of -30 mGal elsewhere in this region appear to be associated with Mesozoic granitic rocks. It is therefore possible that a belt of such rocks trends approximately east-west across the north half of the Indian Pass Wilderness Study Area. The gravity lows are also caused in part by increased thicknesses of younger low-density alluvium and other sediments, but the effects of this unconsolidated material on the gravity field are believed to be less important than the effects of the proposed granitic rocks. The source rocks causing the higher gravity values in the southwest corner of the study area, although concealed beneath Tertiary and Quaternary cover, are most likely Proterozoic crystalline rocks. A local gravity ridge in the eastern part of the Indian Pass Wilderness Study Area may be caused by Jurassic(?) monzogranite and diorite of somewhat higher density than the surrounding Mesozoic rocks.

Aeromagnetic data used for this report were collected by a private contractor in December 1981. The survey consisted of east-west flightlines spaced 0.5 mi apart at an elevation of 1,000 ft. To contour the survey results, the data were interpolated to a rectangular grid with a spacing of 0.12 mi and machine-contoured at a contour interval of 20 gammas.

The most prominent feature of the aeromagnetic data is a northwest-striking high along the south and west boundaries of the Indian Pass Wilderness Study Area. This anomaly is caused by the presence of a large mass of Miocene basalt. More deep-seated sources cause a belt of magnetic highs, 1.5 mi wide, striking N. 60° W. across the northern part of the Indian Pass Wilderness Study Area. These highs are most probably caused by a belt of Tertiary intrusive rocks, some of which are exposed. Much lower levels of magnetization are present in the Picacho Peak Wilderness Study Area and in the southwest corner of the Indian Pass Wilderness Study Area where Mesozoic schists and Proterozoic(?) and Mesozoic gneisses crop out.

Mineral Resource Potential of the Indian Pass Wilderness Study Area

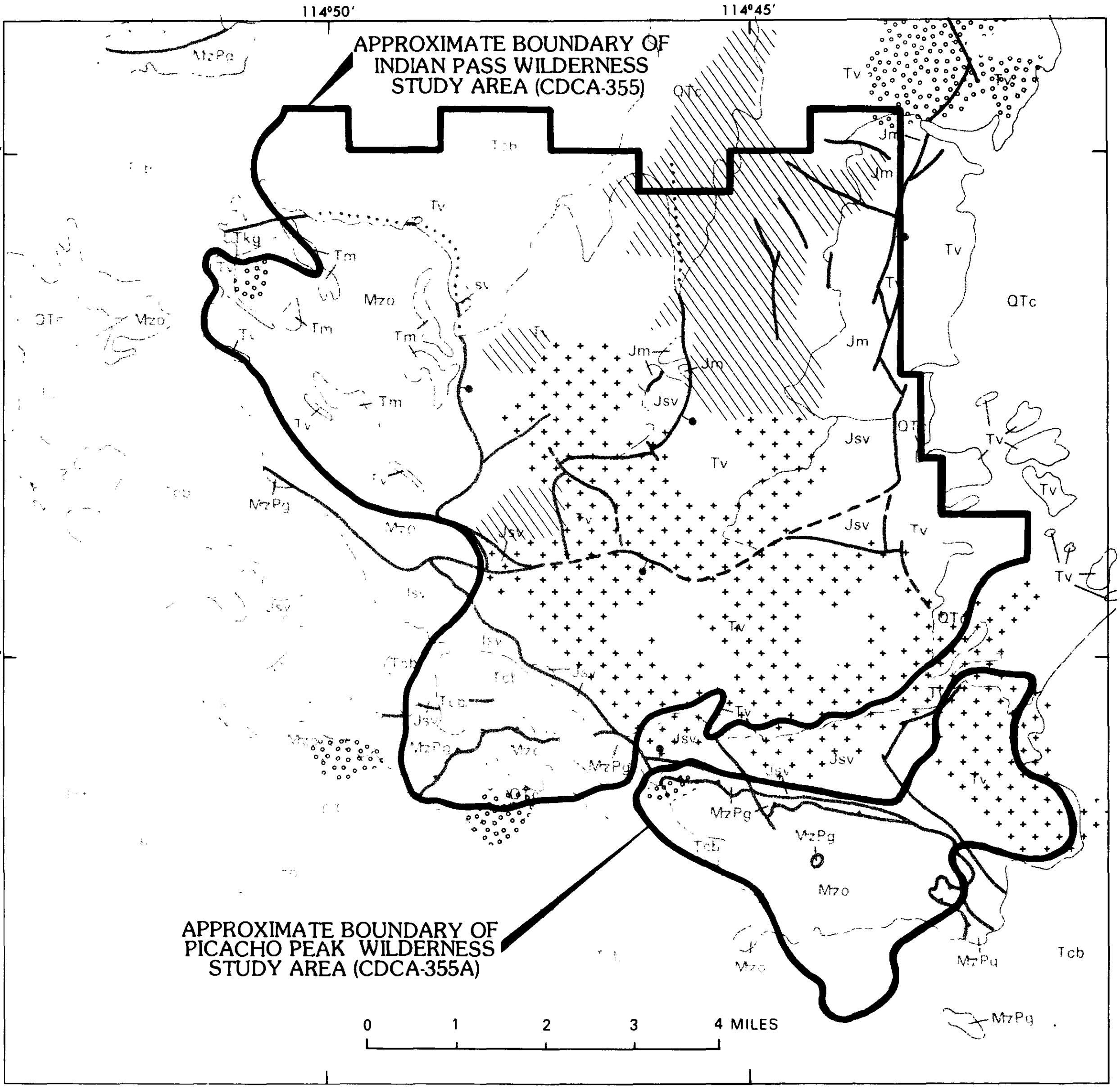
This assessment of the mineral resource potential of the Indian Pass and Picacho Peak Wilderness Study Areas draws upon many different and diverse sets of geologic data. These include regional geology, geochemistry, geophysics, mineral occurrence maps, mining claim records, present exploration activity, and the application of ore deposit models to geologic terranes. These data were used to delineate favorable tracts within the study areas (pl. 1) and an estimate was then made of the level of resource potential and degree of certainty for each tract for certain ore-deposit types. The mineral resource potential refers to undiscovered mineral resources; the true test of an estimate of mineral resource potential is through active exploration. Ore-deposit descriptive models used in the assessment are those compiled by Erickson (1982), Cox (1983a, b), and Eckstrand (1984). Additionally, models based on mineral occurrences in the study areas and models based on new types of gold deposits recently recognized in southeastern California and southwestern Arizona were used.

The assessment that follows is presented by deposit type. Characteristics of known deposits are briefly summarized and each tract is evaluated according to several assessment criteria.

Gneiss-Hosted Disseminated Gold

Recent exploration in southeastern California and southwestern Arizona has resulted in the recognition of a new type of gold deposit. An example of this type is the Mesquite deposit. The gold in this type of deposit is generally hosted by gneiss or schist and is localized in intensely brecciated and oxidized zones. Geochemically, gold itself is the best indicator for this deposit type. Scattered anomalous concentrations of arsenic, antimony, mercury, tungsten, and tellurium may be present. The age of mineralization may range from the Mesozoic into the Tertiary. The present state of understanding of this deposit type is insufficient to unequivocally characterize the environment of deposition.

The southwest corner of the Indian Pass Wilderness Study Area is judged to have high resource



EXPLANATION

Limonite associated with propylitic alteration

Limonite in unaltered volcanic rocks

Limonite associated with both propylitic alteration and unaltered volcanic rocks

Figure 4. Anomalous limonitic areas interpreted from Landsat color-ratio-composite images for the Indian Pass and Picacho Peak Wilderness Study Areas, Imperial County, California. See fig. 2 for map unit symbols used in this figure.

potential (certainty level D) for gold in gneiss-hosted deposits (fig. 2; pl. 1). This tract is underlain by quartzofeldspathic gneiss of the upper plate of the Chocolate Mountains thrust. Exploration drilling by Gold Fields Mining Corp. intercepted gold-bearing horizons 20-50 ft thick averaging from 1.4-1.9 ppm gold (0.04-0.06 oz per ton). See appendix 1 for definition of levels of mineral resource potential and certainty of assessment.

Epithermal Gold and Silver

This type of deposit is found in volcanic and hypabyssal rocks of intermediate to silicic composition. The deposits are generally Tertiary, but may be of any age. Native gold, electrum, and tetrahedrite are found in vuggy quartz veins, breccia pipes, pods, or dikes whose orientation is controlled by the distribution of a pervasive, extensive fracture system. The veins are usually flanked by altered zones which also may contain ore-grade mineralization. A typical geochemical signature includes anomalous concentrations of gold, silver, arsenic, antimony, thallium, and tellurium.

Favorable Tertiary host rocks are exposed over much of the Indian Pass Wilderness Study Area. Two tracts, the northeastern part of the study area north of Julian Wash and a small area immediately east of Peter Kane Mountain, are judged to have moderate potential (certainty level C) for undiscovered gold and silver resources in epithermal precious-metal deposits primarily on the basis of stream-sediment and rock geochemistry (fig. 2; pl. 1). The northeastern tract contains anomalous arsenic and antimony in heavy-mineral concentrates, arsenic in minus-80-mesh sediments, and arsenic, antimony, boron, mercury, fluorine, and gold in rocks. The tract east of Peter Kane Mountain contains anomalous mercury in brecciated, silicic volcanic rocks.

Skarn Tungsten

This type of deposit consists of scheelite ($CaWO_4$), which occurs in the thermal aureole at the contact between felsic intrusive rocks and calcareous sedimentary rocks. Most of these deposits are Mesozoic in age. The geochemical signature generally includes tungsten, molybdenum, zinc, copper, tin, bismuth, and beryllium.

Favorable host areas are found where rare marble layers in the Orocopia Schist are intruded by granite at Peter Kane Mountain in the western part of the Indian Pass Wilderness Study Area. Strong tungsten and bismuth anomalies are present in heavy-mineral concentrates collected from streams draining Peter Kane Mountain. The concentrates contain visible scheelite, and scheelite was found in a prospect pit in hornfelsed marble on the west side of Peter Kane Mountain. Rocks collected near the intrusive contact contain anomalous concentrations of tungsten, bismuth, copper, beryllium, and tin. The entire outcrop area of the Orocopia Schist on Peter Kane Mountain is judged to have moderate potential (certainty level C) for tungsten resources in skarn deposits (fig. 2; pl. 1). The volume of marble is probably insufficient for the accumulation of exploitable quantities of scheelite.

Vein Copper

This type of deposit is found in many different host rocks depending on the particular geologic setting. In some cases ore deposition is controlled by distribution of faults and fractures. Structurally controlled ore shoots may be found within the veins, especially where the veins change attitude. Chalcopyrite, bornite, chalcocite, tetrahedrite, and native gold may be present in simple, anastomosing, and reticulate veins, vein breccia, and local stockworks. Anomalous concentrations of copper, arsenic, gold, silver, and antimony are found in both the vein and altered wall rock. The age of such deposits ranges from Precambrian to Tertiary.

In the Indian Pass Wilderness Study Area, veins containing secondary copper minerals are found in Jurassic(?) metasedimentary and metavolcanic rocks, in Tertiary volcanic rocks, and near the contact of the Orocopia Schist with intrusive granite on Peter Kane Mountain. The source for copper in these occurrences is probably mafic minerals in the host rock itself. Copper is leached from these minerals by hydrothermal fluids, transported for short distances, and precipitated. The entire area within the boundary of the Indian Pass Wilderness Study Area is judged to have low potential (certainty level C) for resources of vein copper (pl. 1).

Volcanogenic Massive Sulfide and Gold

This type of deposit consists of copper, lead, zinc, and possibly gold in mafic or felsic metavolcanic rocks of submarine origin. The deposits are found in areas of local extensional tectonic activity, and range in age from Precambrian to Tertiary. The geochemical signature commonly includes gold, arsenic, boron, and antimony. Platinum-group metals may be present in mafic volcanic terranes.

The Orocopia Schist contains layers of quartzite, siliceous marble, and metabasite derived from chert, limestone, and basalt, respectively (Haxel, 1977). This oceanic rock assemblage comprises a permissive geologic setting for volcanogenic massive-sulfide deposits, possibly containing gold. The Orocopia Schist also contains the mineral fuchsite (chromium-rich muscovite) that is a known alteration product in such deposits. Geology and geochemistry provided no direct evidence for the existence of such a deposit in the Indian Pass Wilderness Study Area, however. The entire outcrop area of the Orocopia Schist has low potential (certainty level B) for gold, lead, zinc, and copper resources in volcanogenic massive sulfide deposits (pl. 1).

Mineral Resource Potential of the Picacho Peak Wilderness Study Area

As in the previous section, the assessment that follows is organized by deposit type. Characteristics of known deposits are given in the previous section and are not repeated here.

Gneiss-Hosted Disseminated Gold

The part of the Picacho Peak Wilderness Study Area underlain by quartzofeldspathic gneiss of the upper plate of the Chocolate Mountains thrust is judged to have high resource potential (certainty level C) for gold in gneiss-hosted disseminated deposits (fig. 2; pl. 1). Scattered anomalous concentrations of gold are present in rocks collected along the thrust. The geologic setting is the same as the southwestern part of the Indian Pass Wilderness Study Area where drilling by Gold Fields Mining Corp. intercepted gold-bearing horizons 20-50 ft thick averaging form 1.4-1.9 ppm gold (0.04-0.06 oz/ton).

Vein Copper

Occurrences of secondary copper minerals are found in the Picacho Peak Wilderness Study Area in Jurassic(?) metasedimentary and metavolcanic rocks, in Tertiary volcanic rocks, and in the Orocopia Schist. As in the Indian Pass Wilderness Study Area, the source of the copper is probably mafic minerals in the host rocks. The entire area within the boundary of the Picacho Peak Wilderness Study Area is judged to have low potential (certainty level C) for copper in hydrothermal veins (pl. 1).

Volcanogenic Massive Sulfide and Gold

The oceanic rock assemblage of the Orocopia Schist comprises a permissive geologic setting for this type of deposit. No direct geological or geochemical evidence for such a deposit was found in the Picacho Peak Wilderness Study Area, however. The entire outcrop area of the Orocopia Schist has low potential (certainty level B) for gold, lead, zinc, and copper resources in volcanogenic massive sulfide deposits (pl. 1).

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Table 1. Mines, prospects, and mineralized outcrops in and adjacent to the Indian Pass and Picacho Peak Wilderness Study Areas

[*, outside study area; **, partially outside study area]

Map No. (pl. 1)	Name	Workings	Resource data
*1	Thedford prospect	Claim discovery monument	A silicified zone and quartz-rich dikes in schist. A chip sample collected across 9 ft of silicified schist contains 0.10 oz/ton silver and 0.31 percent copper. A chip sample collected across 3 ft of a quartz-rich dike contains 0.10 oz/ton silver.
*2	Burslem prospect	One caved adit	A 7-ft-thick shear zone is exposed for 100 ft in granite. A sample across shear zone contains 0.62 percent copper.
3	Burslem prospect	Claim discovery monument	A chip sample across a 2-ft-thick, north-striking, vertical shear zone contains 0.10 oz/ton silver and 0.78 percent copper. Shear zone is exposed for 100 ft in altered granite.
4	Burslem prospect	Four pits 3 ft deep, 8 to 32 ft wide, and 16 to 48 ft long.	Five chip samples were taken from pods and lenses of manganiferous gouge that is found along 340 ft of a granite and schist contact. They contain 0.0045, 0.092, 0.334, 0.336, and 0.68 percent copper. Two contain a trace gold, and one contains 0.0009 oz/ton gold. Four contain 0.10, 0.20, 0.90, and 1.10 oz/ton silver; 0.0030, 0.022, 0.023, and 0.60 percent lead; and 0.012, 0.025, 0.71, and 0.84 percent zinc. One contains 2.39 percent manganese.
5	Thedford prospect	A 10- by 8-ft pit with a 6-ft highwall.	A 2-ft-thick quartz lens in schist. A chip sample contains 0.55 percent copper.
*6	Cinder pit (name unknown)	A 120- by 40-ft pit with a 20-ft highwall.	About 1,800 cubic yards (yd^3) of cinders were mined from the pit in this basalt-covered area. Cinders are red, fractured, and diameter averages 1 in. About 5,000 yd^3 of cinders remain.
7	Miller prospect	None	Area underlain by siliceous schist. No significant mineral values are contained in a chip sample collected across 10 ft.
8	Quartz outcrop	None	Quartz vein striking N. 40° E. and dipping 45° NW. exposed for 40 ft in schist. A chip sample collected across 3 ft contains 0.20 oz/ton silver.
9	Shear zone	None	A 0.3-ft-thick shear zone strikes N. 70° E., is vertical, and is exposed for 4 ft in andesite. One sample contains 0.20 oz/ton silver.
10	Prospect (name unknown)	A 4- by 5- by 7-ft-deep shaft.	A 0.2-ft-thick shear zone that strikes N. 65° W. and dips 65° SW. is in schist. A sample from the shear zone at collar of shaft contains 0.10 oz/ton silver.
11	Pomeroy Dot prospect	Three pits 60 ft apart; maximum diameter is 15 ft.	An 18-ft-thick stratum of bleached, porous schist is enclosed in unaltered schist. Three chip samples, one from each pit, contain 0.10, 0.20, and 0.30 oz/ton silver.

Table 1. Mines, prospects, and mineralized outcrops in and adjacent to the Indian Pass and Picacho Peak Wilderness Study areas--Continued

Map No. (pl. 1)	Name	Workings	Resource data
12	Pomeroy prospect	None	A 0.1-ft-thick, malachite-stained quartz vein that strikes N. 70° W. and dips 45° SW. in silicified, malachite-stained schist. A chip sample of vein contains 0.50 oz/ton silver and 0.49 percent copper. A chip sample across 3 ft of schist contains 0.20 oz/ton silver and 0.0061 percent copper.
*13	Prospect (name unknown)	A 30- by 50-ft bulldozed area.	An isolated, copper-enriched, 3-ft-diameter by 0.5-ft-thick pod in basalt was broken and scattered by bulldozer. A sample contains a trace gold, 0.50 oz/ton silver, and 5.4 percent copper.
*14	Singer Mucho Labor prospect	Bulldozer trenches	A 0.5-ft-thick quartz vein strikes N., dips 5° W. in schist and is exposed for 7 ft. A chip sample of the vein contains 0.04 oz/ton gold and 0.40 oz/ton silver.
*15	Dumortierite occurrence	None	Boulders and cobbles of dumortierite in washes. It appeared to be of semiprecious gemstone quality.
*16	Prospect (name unknown)	A bulldozed 20-ft-diameter area.	A 5-ft-thick quartz vein that trends N. 15° E. and dips 60° NW. is in chloritic rock. A sample contains 0.30 oz/ton silver.
*17	H.R.J. Research prospect	A 4- by 6- by 4-ft pit	Copper carbonate- and iron oxide-stained quartz is in argillite and schistose rock. A sample contains 0.10 oz/ton silver and 0.007 percent copper.
*18	H.R.J. Research 51 prospect	A 10- by 8- by 40-ft bulldozer cut.	A quartz lens in schistose rock. A chip sample collected across 1 ft contains 0.10 oz/ton silver.
*19	Prospect (name unknown)	An 8- by 10- by 50-ft bulldozer cut and a 200-ft-diameter pit.	A sample from the cut contains 0.20 oz/ton silver and 0.014 percent copper. A chip sample collected across 3.5 ft from altered schist and dolomite stained with azurite and malachite contains 0.29 oz/ton silver and 0.042 percent copper.
*20	Butler prospect	A 100- by 150-ft pit, an east-trending bulldozer cut, and bulldozer trails.	A 4-in.-thick quartz vein in schist, and a fault-gouge zone in dolomite and schist. A sample of porous, siliceous, schistose rock from the pit contains 0.40 oz/ton silver. A sample of gouge and another of quartz contain no significant mineral values.
21	Gavilan prospect	Bulldozer trails	Slightly iron oxide-stained schistose rock. A chip sample collected across 6 ft from a bulldozer trail contains no significant mineral values.
22	Gavilan prospect	A 1- by 7-ft cut with a 7-ft highwall.	A chip sample collected across 4 ft of iron oxide-stained schist contains no significant mineral values.
23	Gavilan prospect	A shallow east-trending cut along a bulldozer trail.	A sample of altered and bleached mica-schist contains no significant mineral values.

Table 1. Mines, prospects, and mineralized outcrops in and adjacent to the Indian Pass and Picacho Peak Wilderness Study areas--Continued

Map No. (pl. 1)	Name	Workings	Resource data
*24	Harp prospect	Two bulldozer cuts, 20 and 50 ft long and 8 ft deep and scraping of surface by bulldozer in an area of about 2 acres.	Copper carbonate-stained rocks of the Winterhaven Formation cut by bulldozers. A sample contains 0.0007 percent copper.
*25	Wallace prospect	One bulldozer pit	Copper carbonate minerals found in a quartz lens in volcanic and sedimentary rocks of the Winterhaven Formation. A chip sample collected across 5.2 ft of quartz lens contains 0.2 oz/ton silver.
*26	Wallace prospect	One caved shaft, numerous bulldozer cuts, and an estimated 40 acres scraped by bulldozer.	Copper carbonate minerals in the Winterhaven Formation. Copper is associated with calcite and dolomite and fills solution channels in both volcanic and sedimentary rocks of formation. Two samples from a quartz lens near the contact of volcanic and sedimentary rocks each contain 0.099 oz/ton silver. Spectrographic analysis indicates minor copper.
*27	Wallace-Spencer mine	Numerous bulldozer cuts ranging from a few inches to 6 ft deep in a 40- to 50-acre area.	Copper carbonate minerals in the Winterhaven Formation volcanic and sedimentary rocks. The copper minerals fill solution cavities and replace dolomite and calcite encrustations. Pods, lenses, and stringers of copper carbonate from less than 1 in. to 3 in. thick are scattered sparsely in as much as a 20-ft thickness of weathered rocks. The mine produced 10 tons of hand-sorted ore shipped in 1968 and 1969. A sample of copper carbonate selected from a bulldozer pit contains 31 percent copper and 0.15 oz/ton gold.
*28	Wallace prospect	Numerous bulldozer cuts, pits, and scrapings in a 20-acre area.	Copper carbonate minerals found in solution cavities associated with calcite in sedimentary rocks of the Winterhaven Formation. A sample across 6 ft of the wall of a bulldozer pit contains no significant mineral values.
29	Quartz-schist outcrop	None	Quartz lenses as much as 3.2 by 25 ft in schist below Chocolate Mountains thrust contact. A sample across a 3.2-ft-thick lens contains 0.099 oz/ton silver.
30	Quartz-schist outcrop	None	Quartz lenses in iron oxide-stained schist of Chocolate Mountains thrust lower plate. A petrographic analysis determined that rock is altered biotite-muscovite schist. A sample of iron oxide-stained schist contains 0.2 oz/ton silver.
31	Zimmer prospect	Numerous bulldozer pits and scrapings.	Quartz lenses found in copper carbonate-stained schist. A composite sample across three quartz lenses contains 0.0099 oz/ton gold.
32	Zimmer prospect	One bulldozer pit 15 ft wide, 40 ft long, and 8 ft deep.	Schist overlain by volcanic tuff. Two samples of schist contain no significant mineral values.

Table 1. Mines, prospects, and mineralized outcrops in and adjacent to the Indian Pass and Picacho Peak Wilderness Study areas--Continued

Map No. (pl. 1)	Name	Workings	Resource data
33	Wallace prospect	One 4-ft by 6-ft by 12-ft deep shaft.	Quartz lenses in hydrothermally altered schist of Chocolate Mountains thrust lower plate. Fault contact of the lower and upper plates strikes N. 45° W. and dips 20° NE. A sample collected across 2 ft of a quartz lens contains 0.5 oz/ton silver. A sample of silicified schist contains a trace of gold.
**34	Zimmer prospect	Numerous bulldozer cuts in a 90-acre area.	Copper carbonate staining of blue-gray volcanic rocks and schist. A sample collected across 6 ft of copper carbonate-stained material contains no significant mineral values.
35	Quartz-schist outcrop	None	Quartz lenses and pods in schist underlying Chocolate Mountains thrust. A 2- by 60-ft lens contains no significant mineral values.
36	Quartz-schist outcrop	None	Quartz lenses and pods in altered schist below Chocolate Mountains thrust. A chip sample across a 6-in.-thick quartz lens and enclosing schist contains 0.2 oz/ton silver. Spectrographic analysis shows minor copper.
37	Dumortierite occurrence	None	Dumortierite boulders as much as 12 in. in diameter and cobbles 3 in. in diameter found sparsely in Quaternary and older alluvium. A sample of a cobble was found suitable for lapidary uses; occurrence is of interest only to mineral collectors.

Table 2. Summary of analyses for 12 elements in 89 samples of nonmagnetic heavy-mineral concentrates

[All concentrations in parts per million. N, not detected at the lower limit of determination shown in parentheses; <, detected at concentration below lower limit of determination; >, detected at concentration above upper limit of determination]

Element	Background samples: Range of values	Background samples: Percent of samples	Anomalous samples: Range of values	Anomalous samples: Percent of samples
Antimony	N(200)	98	200-300	2
Arsenic	N(500)	88	<500-10,000	12
Barium	10-10,000	94	>10,000	6
Bismuth	N(20)	92	<20-1,000	8
Boron	N(20)-700	97	1,000->2,000	3
Gold	N(20)	98	20-100	2
Lead	N(20)-100	72	150-10,000	28
Molybdenum	N(10)	83	<10-150	17
Silver	N(1)	96	1-70	4
Strontium	N(200)-3,000	94	5,000-10,000	6
Tin	N(20)-70	86	100-1,000	14
Tungsten	N(100)	81	<100-2,000	19

Table 3. Analyses of selected rock samples

[All values in parts per million unless indicated otherwise. N, not detected at the lower limit of determination shown in parentheses; <, detected at concentration below lower limit of determination]

Peter Kane Mountain, near contact of the Orocopia Schist and monzogranite

Sample No.	Ag	Au	Bi	Cu	Mo	Pb	Sn	W	Zn
811	15	N(0.05)	1,900	2 pct.	10	2,000	N(10)	13	130
826	100	N(0.05)	1,000	2 pct.	100	2 pct.	50	5	2 pct.
942	7	0.05	84	1,000	N(5)	500	500	2,000	430

Northeastern quadrant, north of Julian Wash

Sample No.	Ag	As	Au	B	Cu	F	Hg	Sb	Sr
006	N(0.5)	18 pct.	N(0.05)	20	10	<100	0.18	65	N(100)
007	N(0.5)	14 pct.	N(0.05)	300	10	<100	0.16	20	N(100)
854	N(0.5)	80	0.90	100	50	250	<0.02	9	700
866	N(0.5)	10	0.05	10	N(5)	180	<0.02	4	500
919	N(0.5)	1,700	N(0.05)	200	30	1,900	0.26	640	5,000
920	N(0.5)	700	N(0.05)	2,000	15	800	0.18	26	500
983	10	N(5)	0.30	20	1.5 pct.	<100	N(0.02)	N(2)	N(100)
985	N(0.5)	210	0.05	<10	50	200	0.16	12	3,000
986	N(0.5)	1,300	0.05	200	50	500	0.44	38	1,500

Gavilan Wash near Indian Pass, brecciated gneiss

Sample No.	Ag	Au	As	Hg	W
962	1.0	2.2	165	0.04	58
967	0.55	0.5	5	0.62	45
394	N(0.5)	0.55	100	N(0.02)	2.0
393	<0.5	N(0.05)	250	N(0.02)	110
167	N(0.5)	<0.05	20	0.16	6.5

Southwestern part of Indian Pass Wilderness Study Area; drill hole samples (cuttings)

Sample No.	Ag	Au	As	Hg	W
10	0.7	1.0	60	0.04	26
140	1.0	1.3	110	N(0.02)	4.5
145	1.0	3.0	80	N(0.02)	9.0
205	N(0.05)	N(0.05)	10	N(0.02)	16
65	<0.5	0.1	60	0.18	17

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

Definitions of Mineral Resource Potential

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

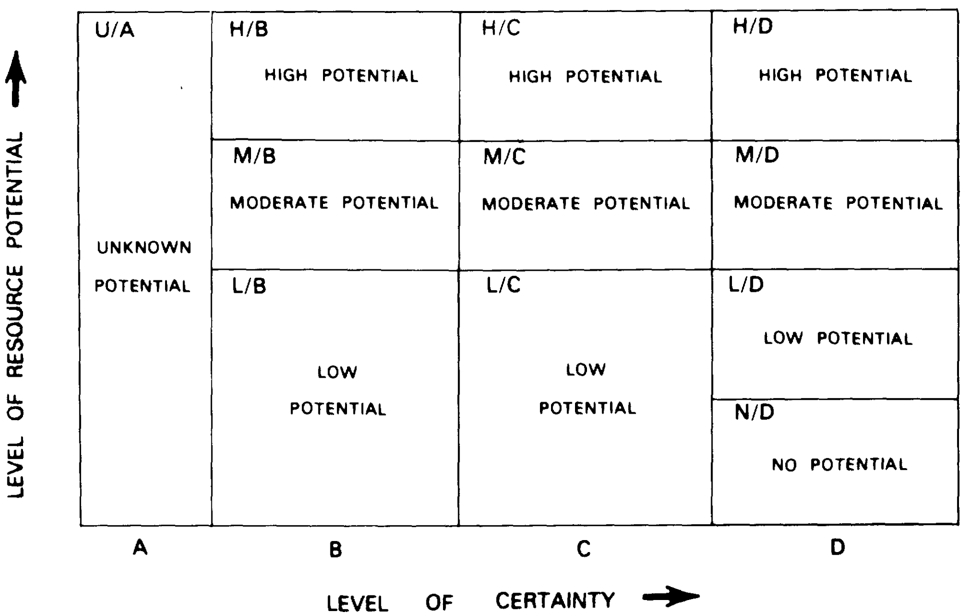
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

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

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

Levels of Certainty



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:

Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268–1270.

Taylor, R. B., Stoneman, R. J., and Marsh, S. P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40–42.

Goudarzi, G. H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–0787, p. 7, 8.

GEOLOGIC TIME CHART

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

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

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

[2]Informal time term without specific rank.

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