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Mineral Resources of the Kingston Range Wilderness Study Area, San Bernardino County, California

U.S. GEOLOGICAL SURVEY BULLETIN 1709–D

Chapter D

Mineral Resources of the Kingston Range Wilderness Study Area, San Bernardino County, California

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U.S. GEOLOGICAL SURVEY BULLETIN 1709

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
NORTHEASTERN CALIFORNIA DESERT CONSERVATION AREA, 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 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 a part of the Kingston Range Wilderness Study Area (CDCA-222), California Desert Conservation Area, San Bernardino County, California.

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Mineral Resources of the Kingston Range Wilderness Study Area, San Bernardino County, California

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SUMMARY

Abstract

The Kingston Range Wilderness Study Area (CDCA-222) covers 255,058 acres in the southern Death Valley region of southeastern Calif. The U.S. Bureau of Land Management designated 38,713 acres of this large area (fig. 1) as suitable for the study of mineral resources. An appraisal of identified resources and assessment of the mineral resource potential of the smaller area, hereafter designated the study area, are described in this report. Geologic, geochemical, geophysical, and mineral surveys indicate that the study area has high and moderate resource potential for talc and iron-skarn deposits, high and low resource potential for polymetallic lead-silver deposits, high resource potential for polymetallic copper-iron-silver deposits, and low resource potential for bedded-iron deposits. Oil and gas and geothermal resources are not present in the study area.

Character and Setting

The Kingston Range is located approximately 15 mi east of Tecopa, Calif. near the California-Nevada state line (fig. 1). Furnace Creek Road, a paved and partially improved dirt road from Tecopa, traverses the Kingston Range parallel to the northern boundary of the study area. Topographic relief, expressed by deep canyons and high peaks, is about 5,000 ft.

The Kingston Range consists of a thick section of sedimentary rocks of Proterozoic and Cambrian age (see Geologic Time Chart, last page of this report) that unconformably overlies gneiss, schist, and granite of Proterozoic age. The sedimentary rocks include the Crystal Spring Formation, Beck Spring Dolomite, and Kingston Peak Formation of the Proterozoic Pahrump Group unconformably overlain by the Late Proterozoic Noonday Dolomite and undivided clastic deposits of Late Proterozoic and Cambrian age. These rocks are intruded by Tertiary granite porphyry and are unconformably overlain by fanglomerate and alluvial deposits of Tertiary and Quaternary age.

Mineral Resources

Thirty-six mines, prospects, and mineral occurrences are known in and adjacent to the study area (appendix 2). Areas with high, moderate, or low resource potential for talc, iron, and polymetallic deposits are shown on figure 2. Talc and iron-skarn deposits are found in the dolomite member of the Crystal Spring Formation. Talc occurs in alteration zones caused by contact metamorphism of the dolomite during intrusion of the diabase. An alteration zone within the study area contains 430,000 tons of identified talc resources. This alteration zone has high resource potential for talc.

Iron-skarn deposits in the study area consist of discontinuous lenses of magnetite and hematite. The Beck mine contains 7.2 million long tons of ore averaging 45 to 56.4 percent iron. The dolomite member of the Crystal Spring Formation has high resource potential for iron in iron-skarn deposits.

Talc, iron-skarn, and bedded-iron deposits occur in the Kingston Peak Formation along the east side of the study area. Several talc (including the Horse Thief talc prospect) and iron-skarn prospects occur in large megabreccia clasts of dolomite that were deposited in the Kingston Peak Formation. The geology of the talc and iron-skarn prospects in the megabreccia clasts is similar to deposits in the dolomite member of the Crystal Spring Formation. The dolomite megabreccia clasts in the Kingston Peak Formation have moderate resource potential for talc and iron in contact metamorphic alteration zones and iron-skarn deposits, respectively. The Horse Thief talc prospect contains 200,000 tons of identified resources. Other talc and

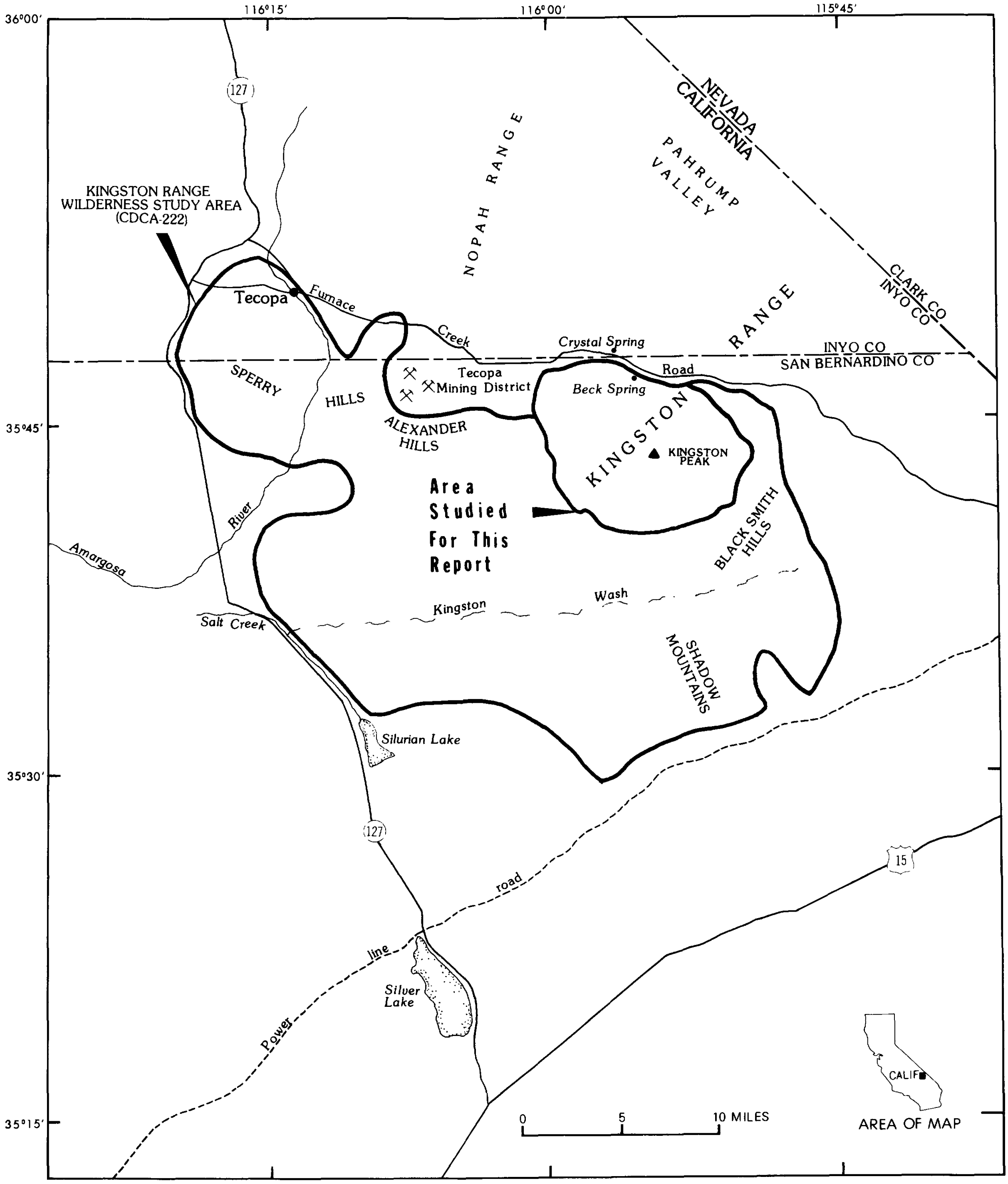

Figure 1. Index map showing location of the Kingston Range Wilderness Study Area, San Bernardino County, California.

iron-skarn prospects in the dolomite clasts are small and contain low total tonnage.

Bedded-iron deposits occur in thin, laterally discontinuous beds of siltstone and shale in the Kingston Peak Formation. These deposits contain hematite and hematite pseudomorphs after pyrite and magnetite. The Kingston Peak Formation has low resource potential for iron in bedded-iron formations.

Polymetallic deposits occur in fault zones near the base of the Noonday Dolomite, in dolomite megabreccia clasts in the Kingston Peak Formation, and in quartz veins in the granite porphyry. Polymetallic deposits in the Noonday Dolomite include galena, chalcopyrite, and calcite and are characterized by anomalous concentrations of copper, lead, silver, and zinc. Several small mines and prospects have produced several hundred tons of lead-silver ore since the early 1900's. The Noonday Dolomite has high resource potential for lead and silver resources in polymetallic deposits.

A large aeromagnetic anomaly is generated over dolomite megabreccia clasts in the Kingston Peak Formation in the southeast corner of the study area. Several of these megabreccia clasts contain copper-iron-silver deposits. Rock samples from one deposit contain trace amounts of gold and 90 ppm uranium. The area defined by the aeromagnetic anomaly has high resource potential for copper, iron, and silver resources in polymetallic deposits.

Quartz veins in the granite porphyry include pyrite ± hematite and are characterized by anomalous concentrations of antimony, arsenic, lead, mercury, silver, and zinc. A trace of gold was detected in one vein. Molybdenum, tungsten, and uranium anomalies are located near intrusive contacts with the Kingston Peak Formation and in brecciated fault zones in the granite porphyry. A few quartz veins have vugs and vesicles filled with amethyst crystals. Based on the lack of ore-bearing minerals associated with the geochemical anomalies, the quartz veins in the granite porphyry have low potential for lead and silver resources.

INTRODUCTION

Location and Physiography

The Kingston Range Wilderness Study Area (CDCA-222) is located in the southern Death Valley region of southeastern California. At the request of the U.S. Bureau of Land Management, 38,713 acres of the study area were designated as suitable for the study of mineral resources. A paved and improved dirt road from Tecopa, Calif. traverses the Kingston Range and parallels the northern boundary of the study area. The topography of the study area is shown on parts of the Tecopa, Horse Thief Spring, Silurian Hills, and Kingston Peak 15-minute quadrangles. Elevations vary from 2,400 ft along the west side of the study area to 7,320 ft at Kingston Peak. Most of this relief is expressed as deep canyons with steep walls. Vegetation includes creosote bush and joshua trees at the lower elevations, Nolina woodland, bitterbrush, and sagebrush at intermediate elevations, and pinyon-juniper woodland and white fir-pinyon forest at elevations above 6,000 ft (Stone and Sumida, 1983). The climate of the study area is from arid to subhumid. Freezing temperatures and snowfall often occur during the winter months. High temperatures (often in excess of 110 °F), low relative humidity, and sudden thunderstorms are characteristic of the weather during the summer months. Mean annual precipitation is about 7 in.

Previous Work

The geology and mineral resources of the Kingston Range were first described by Hewett (1956). Wright (1968) described the talc deposits of the Kingston Range as part of a study of talc in the southern Death Valley region. Hewett (1948) and Graff (1985) described the iron deposits in the Crystal Spring and Kingston Peak Formations, respectively. Hall (1984) studied the lead-silver deposits in the Kingston and southern Nopah Ranges.

Methods

The U.S. Geological Survey conducted geologic, geochemical, and geophysical studies in 1984 and 1985 to assess the mineral resource potential of the study area. This work identified the extent of and geologic controls on known mineralized areas as a guide to undiscovered mineralized areas. Geologic studies included field checking existing geologic maps and new geologic mapping at 1:24,000 scale.

A reconnaissance geochemical survey was designed to locate anomalous concentrations of elements that may be related to base- and precious-metal (copper, lead, zinc, silver, and gold) mineralization. Geochemical samples included rock samples collected from mines, prospects, areas with altered and unaltered rocks, and stream-sediment samples collected from the most recently active dry stream channels. A total of 63 rock and 61 stream-sediment samples were collected for the geochemical survey.

All of the rock samples and nonmagnetic heavy-mineral concentrates separated from the stream-sediment samples were pulverized and analyzed for 31 elements by semiquantitative emission-spectrographic methods described by Grimes and Marranzino (1968). The concentration of antimony, arsenic, bismuth, cadmium, gold, mercury, and zinc in rocks was determined by atomic-absorption spectroscopy. Analytical methods for antimony, arsenic, bismuth, cadmium, and zinc are described by Viets (1968). Analytical methods for gold and mercury are described by Thompson and others (1968), by McNerney and others (1972) and Vaughn and McCarthy (1964), respectively. The uranium in rocks was determined by the fluorometric methods described by Centanni and others (1956).

Geophysical studies conducted in the study area include aeromagnetic and gravity surveys. An aeromagnetic survey of the northern Mojave Desert and southern Death Valley regions was flown in 1981 and compiled under contract to the U.S. Geological Survey (U.S. Geological Survey, 1983). Total-field magnetic data were collected along east-west flight lines spaced approximately 0.5 mi apart and flown at a height of 1,000 ft above average terrain. Actual terrain clearance varied from 200 ft over mountain peaks to more than 2,500 ft over steep-walled canyons. Corrections were applied to the magnetic data to compensate for diurnal variations of the Earth's magnetic field. The International Geomagnetic Reference Field (updated to December 1981) was subtracted from the corrected magnetic data to yield a residual magnetic-anomaly map.

Published gravity data obtained in the vicinity of the study area (Snyder and others, 1982) were supplemented by 26 new gravity stations (Morin, 1986). The observed gravity values, based on the International Gravity Standardization Net datum (Morelli, 1974), were reduced to free-air gravity anomalies by using standard formulas (Telford and others, 1976). Bouguer, curvature, and terrain corrections at a standard reduction density of 2.67 g/cm^3 were added to the free-air anomaly at each station to determine complete Bouguer gravity anomalies.

The U.S. Bureau of Mines conducted library research and field studies to appraise the known mines, prospects, and mineral occurrences in and adjacent to the study area. Mining and mineral-lease records were obtained from the U.S. Bureau of Mines, U.S. Bureau of Land Management, and San Bernardino County files. Mine maps and production and reserve data were provided by several mining companies.

Twenty-one mines and prospects in and adjacent to the study area were mapped and sampled by permission of the property owners. Thirty-one rock samples and one alluvial sample were collected during this study. Rock samples include chip samples collected in a continuous line across a mineralized zone, and grab samples collected unsystematically from mine dumps, stockpiles, and talus deposits. Only chip samples were used for grade-and-tonnage estimates.

Rock samples were crushed, split, and checked for the presence of radioactive and fluorescent minerals. At least one sample from each mine, prospect, and mineral occurrence was analyzed by semiquantitative emission spectrography. The concentration of gold and silver was determined either by fire assay or by fire assay combined with inductively coupled plasma-atomic emission spectrometry. Talc grade was determined by petrographic techniques and chemical analyses.

Acknowledgments

The U.S. Geological Survey appreciates the cooperation of B.W. Troxel, M.R. McMackin, L.A. Wright, and B.C. Burchfiel for providing unpublished geologic maps of the Kingston Range. Junior Huffman and Eddie Feltz of Tecopa provided trailer space, power, water, and a temporary heliport at the Beck mine. John Kame guided Calzia on a tour of Kame's mines and prospects, and pointed out select samples for assay.

The U.S. Bureau of Mines wishes to thank Standard Slag Company, Huntington Tile, Inc., Cyprus Industrial Minerals Company, and Pfizer, Inc. (Minerals, Pigments, and Metals Division) for resource, production, and geologic data from their mines adjacent to the study area.

APPRAISAL OF IDENTIFIED RESOURCES

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

Mining History and Current Activity

Approximately 174 mineral claims were located in and adjacent to the study area (fig. 2; plate) from 1905 to 1980. Iron was discovered in the Kingston Range by Charles Beck of Goodsprings, Nev. in 1905. Claims at the Beck mine were patented in 1912 and explored by drilling in 1924. No production occurred during this time because of the isolated location of the mine. Standard Slag Company eventually bought the mine, built a road through the mountain range, and produced 2.1 million long tons of iron ore by open-pit methods from 1971 to 1982. Iron mining has continued at a slower pace since 1982.

Prospecting for lead, silver, and zinc in the Kingston Range progressively increased from 1900 to 1919, when the Tonopah and Tidewater Railroad was constructed through Tecopa. The Chambers, Blackwater, Jupiter, and Blue Dick mines (plate 1, Nos. 16, 17, 18, and 22) were discovered during this period. Some ore was shipped from these mines, but most lead-silver mines in the Kingston Range were unprofitable because of the isolated location of the range and the high cost of transporting ore (Hewett, 1956; Neraas, 1983).

The Kingston Range is part of one of the largest talc belts in the United States (Wright, 1968). The Tecopa (Smith), Vulcan, and Excelsior mines (plate 1, Nos. 2, 6, and 9) were discovered in the 1930's as the demand for talc in the manufacture of ceramic tile, paint, and electrical insulators increased. New talc mines were opened as demand increased. These included the Rogers and Crystal Spring mines (plate 1, Nos. 1 and 5) in the 1940's and the Omega, Pioneer, and Apex mines (plate 1, Nos. 4, 10, and 11) in the 1950's. Underground-mining methods changed to open-pit methods in the 1960's and 1970's with changing market conditions.

Several mines in the Kingston Range were active during this study. Production was recorded at the Rogers, Omega, Crystal Spring, Pioneer, Apex, and Beck mines (plate 1, Nos. 1, 4, 5, 10, 11, and 14) between 1983 and 1985. Exploration and minor development work were completed at the Momi mine and the Horse Thief and Kame By-Pass prospects (plate 1, Nos. 19, 13, and 27, respectively) during this time. All of the mines and prospects depend on the Furnace Creek Road for access to and transportation of ore from the Kingston Range.

Mineral Deposits

Talc, iron, and precious-metal deposits associated with iron ore are located within and

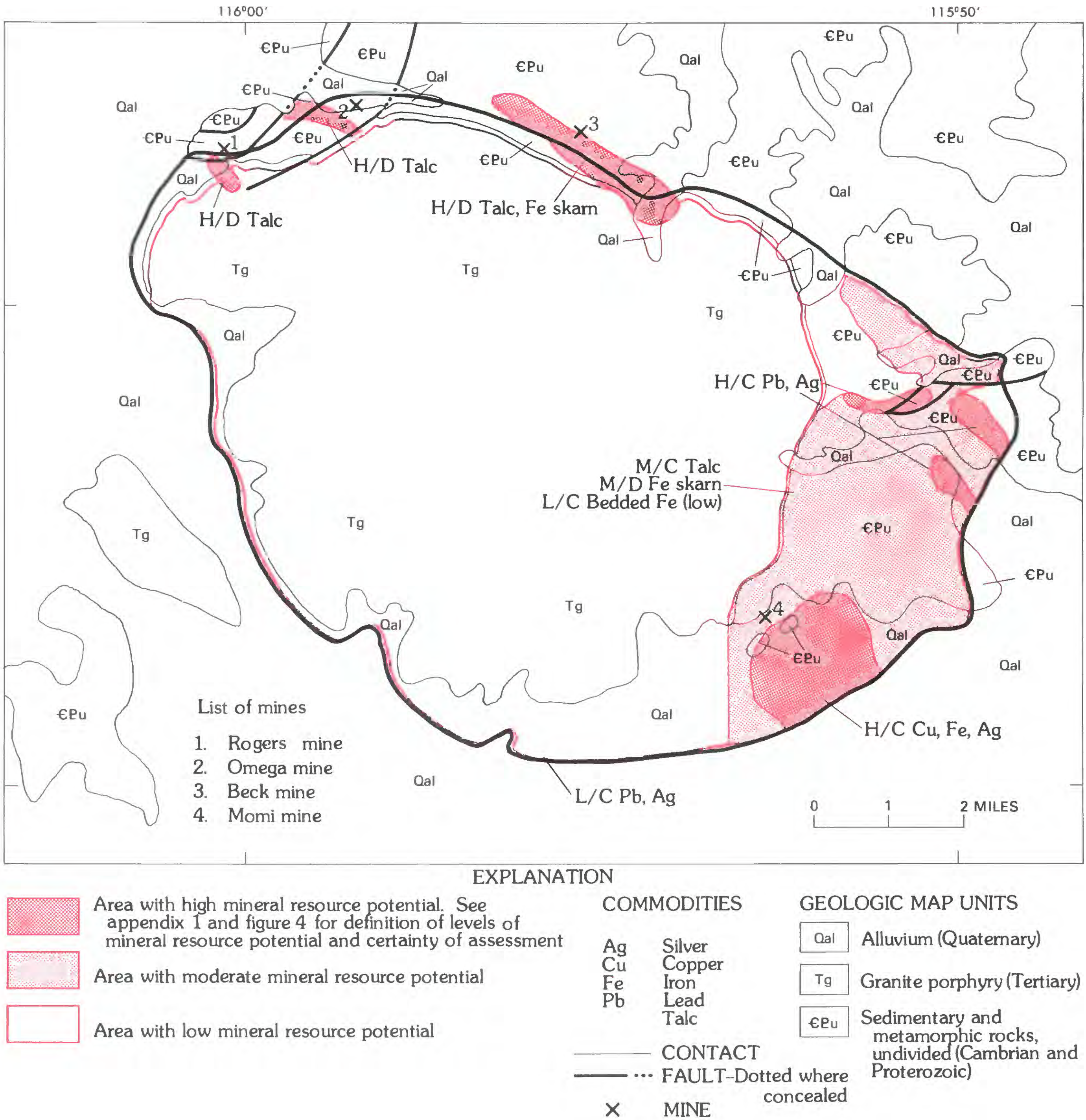

Figure 2. Map showing mineral resource potential of part of the Kingston Range Wilderness Study Area.

immediately adjacent to the study area. Talc deposits are found along the northern boundary and in the southeast corner of the study area. The Crystal Spring mine and talc mines several miles northeast of the study area (Snow White, Excelsior, Pioneer, and Apex mines) were not examined by the U.S. Bureau of Mines, but are included in this report.

Talc occurs as lenses 10 to 50 ft thick in an alteration zone 6.5 mi long located along the northern boundary of the study area. Talc mines located within this zone include the Rogers, Tecopa (Smith), American Olean, Omega, Vulcan, Sam Flake, and Booth mines (plate 1, Nos. 1, 2, 3, 4, 6, 7, and 8). Combined identified resources total approximately 1.7 million tons of talc, of which 430,000 tons are within the study area. Most of the talc is considered reserves because the Rogers and Omega mines were active during this study and the talc grade is similar at all seven mines.

The Horse Thief prospect is located in dolomite in the southeast corner of the study area (plate 1, No. 13). The talc zone is approximately 1,670 ft long and 10 to 20 ft thick. The Horse Thief prospect contains an identified resource of 200,000 tons of talc to an average depth of 70 ft. Additional resources may exist at depths below 70 ft.

Iron deposits are found at three localities. Iron at the Beck mine (plate 1, No. 14) occurs in discontinuous lenses of magnetite and hematite in dolomite (Hewett, 1948). The iron-rich lenses are 150 ft wide and 1,000-1,500 ft long. Total identified resources are 7.2 million long tons of ore averaging 45 to 56.4 percent iron. The measured resources are classified as reserves by the mine owners.

Thin lenses of hematite in dolomite are found at the Western Iron prospect (plate 1, No. 21). This prospect contains a small amount of low-grade iron-bearing material.

Iron at the Momi prospect (plate 1, No. 29) occurs as magnetite and hematite replacement bodies in dolomite. This prospect contains less than 50 long tons of iron-bearing material averaging 48 percent iron.

Several base- and precious-metal occurrences associated with iron are found in the study area. Copper-iron-silver deposits in the southeast corner of the study area include the Momi mine as well as the U Sun Up prospect and the Momi Iron-Copper Extension (plate 1, Nos. 19, 31, and 32). All of these deposits are in dolomite. The Momi mine contains 40,000 tons of identified resources averaging 24.6 percent iron and 5.6 percent copper. A sample from a stockpile at the mine contains 0.3 oz/ton silver.

The U Sun Up prospect and Momi Iron-Copper Extension have no identified resources. A grab sample from a small stockpile at the U Sun Up prospect contained 55 percent iron and 0.17 percent copper. A sample of hydrothermally-altered dolomite from the Momi Iron-Copper Extension contained no significant geochemical anomalies.

The Kame By-Pass, Villa de Oro, and Rex gold-silver-iron prospects are located northeast of the study area. Limonite and vuggy quartz occur in brecciated dolomite at the Kame By-Pass (plate 1, No. 27). The north-trending breccia zone is vertical and is about 4 ft thick. This prospect contains approximately 600 tons of identified resources averaging 1.0 oz/ton silver and 0.02 oz/ton gold. A select sample collected from a stockpile contained 1.6 oz/ton silver and 0.03 oz/ton gold.

The Villa de Oro and Rex prospects (plate 1, Nos. 25 and 26) are located in faulted, iron-stained dolomite. These prospects have no identified resources. Chip samples collected from the dolomite contain trace amounts of gold.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By James P. Calzia, James G. Frisken, and
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U.S. Geological Survey

Geology

The Kingston Range is located within the southwestern Basin and Range geomorphic province, which is characterized by fault-controlled north- to northeast-trending ranges separated by parallel valleys or basins. The Tertiary geologic history of this province is characterized by active faulting and extensive volcanism (Eaton, 1982). These tectonic and magmatic processes formed the steep mountains, deep basins, and many of the mineral deposits characteristic of the Basin and Range province.

The Kingston Range consists of a thick section of sedimentary rocks of Proterozoic to Cambrian age that unconformably overlies metamorphic and igneous rocks of Proterozoic age. The metamorphic, igneous, and sedimentary rocks are intruded by granite of Tertiary age and are overlain by unconsolidated fanglomerate and alluvial deposits of Tertiary and Quaternary age.

The oldest rocks in the Kingston Range include gneiss, foliated greenschist, and pink granite. These metamorphic and igneous rocks are similar to others found in the southern Death Valley region (Wright, 1968). The metamorphic and granitic rocks yield U-Pb ages of approximately 1,800 and 1,400 million years before present (Ma), respectively (Lanphere and others, 1964).

The sedimentary rocks consist of the Proterozoic Pahrump Group, the Late Proterozoic Noonday Dolomite, and undivided Late Proterozoic and Cambrian clastic rocks. Wright and others (1974) reported that the Pahrump Group was deposited in a fault-controlled, deeply subsiding sedimentary basin that they named the Amargosa aulacogen.

The Pahrump Group (Hewett, 1940) is divided into three formations with type localities in the Kingston Range. These formations are (oldest first) the Crystal Spring Formation, the Beck Spring Dolomite, and the Kingston Peak Formation. The Crystal Spring Formation is approximately 2,700 ft thick at its type locality east of Crystal Spring. This formation is divided into three members: (1) a lower member of purple mudstone, feldspathic to arkosic sandstone, and metaquartzite conglomerate; (2) a middle member, hereafter referred to as the dolomite member, of quartzite, dolomite, stromatolitic limestone, and chert; and (3) an upper member of dolomite, siltstone, and arkose. The dolomite member is the host rock of all the talc and most of the iron deposits in the study area.

Green diabase was emplaced as sills in the Crystal Spring Formation. Diabase sills elsewhere in the southern Death Valley region yield a whole-rock Rb-Sr date of 1,100 Ma (Wasserburg and others, 1964) and are correlated with diabase sills (1,200 Ma) in Arizona (Wrucke and Shride, 1972).

The Beck Spring Dolomite conformably overlies the Crystal Spring Formation. The Beck Spring Dolomite is 1,750 ft thick at its type locality north of Beck Spring and consists of laminated, oolitic, and cherty dolomite with stromatolitic and algal mounds. The Beck Spring Dolomite is not mineralized within the study area.

The Kingston Peak Formation conformably overlies the Beck Spring Dolomite. The thickness of the Kingston Peak Formation ranges from 1,160 ft at its type locality north of Beck Spring to more than 8,800 ft in the southeast corner of the study area. The thicker sections were deposited in the deeper parts of the Amargosa aulacogen. The Kingston Peak Formation is divided into three members: (1) a lower member of siltstone and diamictite (massive, poorly sorted clastic material of glacial (Miller, 1985) or glacial-marine (Graff, 1985) origin; (2) a middle member (hereafter referred to as the megabreccia member) of large angular clasts of dolomite, gneiss, and diabase as much as 1 mi long; and (3) an upper member of cyclic deposits of conglomerate, sandstone, and siltstone. Graff (1985) described bedded-iron deposits in the upper member of the Kingston Peak Formation.

Within the study area, the Noonday Dolomite overlies the Kingston Peak Formation and overlies progressively older rocks farther north in the Kingston Range. The Noonday Dolomite consists of pink stromatolitic dolomite that is about 500 ft thick. Dolomite located along the contact between the Noonday Dolomite and the Kingston Peak Formation is fractured, brecciated, and has a well-developed linear fabric. This contact locally may be a flat fault, although Wright and others (1974) believe this contact is an unconformity of regional extent. All of the lead-silver mines within and adjacent to the study area are located along this contact.

The Noonday Dolomite is conformably overlain by more than 5,000 ft of undivided Late Proterozoic and Cambrian deposits. These deposits include (in stratigraphic order) the Johnnie Formation, the Stirling Quartzite, the Wood Canyon Formation, the Zabriskie Quartzite, and the Carrera Formation. The undivided Late Proterozoic and Cambrian deposits are not mineralized within the study area.

The metamorphic, igneous, and sedimentary rocks are intruded by granite porphyry and dikes of Tertiary age. The granite porphyry is divided into a margin facies of brown biotite-hornblende granite porphyry with feldspar phenocrysts, and an interior facies of white granite with euhedral quartz phenocrysts. Biotite from the margin facies yields a K-Ar date of 12.8 Ma (Armstrong, 1970). The interior facies is finer grained than the margin facies and includes altered mafic minerals and miarolitic cavities. Petrographic and textural data suggest that the interior facies was saturated with volatiles and may represent the top of a magma chamber.

Andesite(?), rhyolite porphyry, and aplite dikes intrude the metamorphic, igneous, and sedimentary rocks as well as the granite porphyry. Andesite sills, similar in composition to the andesite(?) dikes, yield K-Ar dates of 12.5 and 11.1 Ma from biotite and plagioclase, respectively (Jon Spencer, written communication, 1983). Field relations indicate that the rhyolite-porphyry dikes are older than the aplite dikes. The age of the rhyolite porphyry and the aplite dikes relative to the andesite(?) dikes is not known.

Tertiary fanglomerate deposits dip 20° to 30° east and include rounded to subangular boulders of the granite porphyry and the older rocks. The fanglomerate deposits are unconformably overlain by horizontal fanglomerate deposits, and by Quaternary alluvial, eolian, and stream-sediment deposits.

The Tertiary geologic history of the Kingston Range is characterized by granitic magmatism synchronous with severe crustal extension. Crustal extension is manifest by low-angle normal faults and steep strike-slip faults. Bedding in the Proterozoic and Cambrian rocks defines a large eroded dome cored by the granite porphyry. Petrographic and field relations suggest that the dome formed as the granite porphyry was emplaced.

The granite porphyry is both older and younger than low-angle normal faults that flatten with depth. A low-angle normal fault older than the granitic porphyry crops out along the road between Beck and Crystal Springs. This fault, named the Kingston Range thrust by Hewett (1956) and the Kingston Range detachment fault by Burchfiel and others (1985), juxtaposes Proterozoic and Cambrian rocks over gneiss, cuts talc deposits and the dolomite host rocks of the iron-skarn deposits, and was folded during intrusion of the granite porphyry. Regional tectonic relations described by Hewett (1956) and Burchfiel and others (1985) indicate that this low-angle normal fault is Tertiary in age.

A wide zone of steep faults cuts the granite porphyry along the western boundary of the study area. Slickensides indicate both strike-slip and dip-slip motion on these faults. Faults that cut the granite porphyry are locally filled with dikes and(or) quartz veins.

Geochemistry

Geochemical analyses of rock samples collected from the Noonday Dolomite and the granite porphyry and nonmagnetic, heavy-mineral concentrates obtained from stream-sediment samples are characterized by anomalous concentrations of antimony, arsenic, barium, bismuth, cadium, copper, lead, manganese, mercury, silver, and zinc. Trace amounts of gold were detected in rock samples from the Momi mine. Two rock samples from the granite porphyry and from quartz veins in the granite porphyry contain anomalous concentrations of molybdenum, tungsten, and uranium.

Anomalous concentrations of thorium, lanthanum, and yttrium were found in heavy-mineral-concentrate samples collected from streams that drain the granite porphyry. Thorite and monazite were tentatively identified in a few of these samples. These minerals are probably disseminated throughout the granite porphyry and are not concentrated in veins or placers within the study area.

Geophysics

Aeromagnetic data indicate that the Tertiary granite porphyry is more magnetic than the Proterozoic gneiss, schist, and granite. The Proterozoic and Cambrian sedimentary rocks are nonmagnetic. The different magnetic characteristics of the rocks define a roughly circular aeromagnetic anomaly approximately 10 mi in diameter and 450 nanoteslas in amplitude that lies over the granite porphyry and reaches its maximum amplitude over alluvial deposits southwest of the study area (fig. 3). This anomaly is characterized by numerous aeromagnetic highs and lows that reflect the varying magnetic character of the underlying rocks. Geophysical modeling of this anomaly along a north-south profile suggests that the granite porphyry generally forms a steep contact with the older rocks and extends beneath the Kingston Peak Formation and alluvial deposits in the southern third of the study area.

Gravity data define an elongate gravity low 15 mi long by 10 mi wide over the granite porphyry. Gravity values near the center of the gravity low are -25 milligals relative to gravity values near zero over the more dense Proterozoic and Cambrian sedimentary rocks. Modeling of the gravity data along a northeast-trending profile over the center of the gravity low indicates that the granite porphyry extends to a depth of about 4 mi with steep walls and a relatively flat floor.

Mineral Resource Potential

Talc, iron (including iron-skarn and bedded-iron deposits), and polymetallic deposits are located within the study area. Each deposit is assigned high, moderate, or low mineral resource potential at various certainty levels as defined in appendix 1. Oil and gas and geothermal resources are not present within the study area.

Talc occurs within alteration zones in the dolomite member of the Crystal Spring Formation (Wright, 1968). The alteration zone, a result of contact metamorphism of the dolomite during intrusion of the diabase, consists of discontinuous lenses of green tremolite-rich rock nearest the diabase, white talc schist, and brown silicate-carbonate rock. The green tremolite-rich rocks contain diopside and calcite, the talc schist includes talc ± tremolite, and tremolite + calcite is common to all three rock types. Commercial talc from the talc schist is enriched in magnesium and deficient in aluminum, iron, and alkali elements relative to talc from other rocks in the alteration zone (table 1).

The alteration zone along the north boundary of the study area has high resource potential for talc at certainty level D. This alteration zone contains approximately 1.7 million long tons of talc, of which 430,000 tons are within the study area. The Rogers and the Omega mines (plate 1, Nos. 1 and 4) are actively mining talc from this alteration zone within the study area.

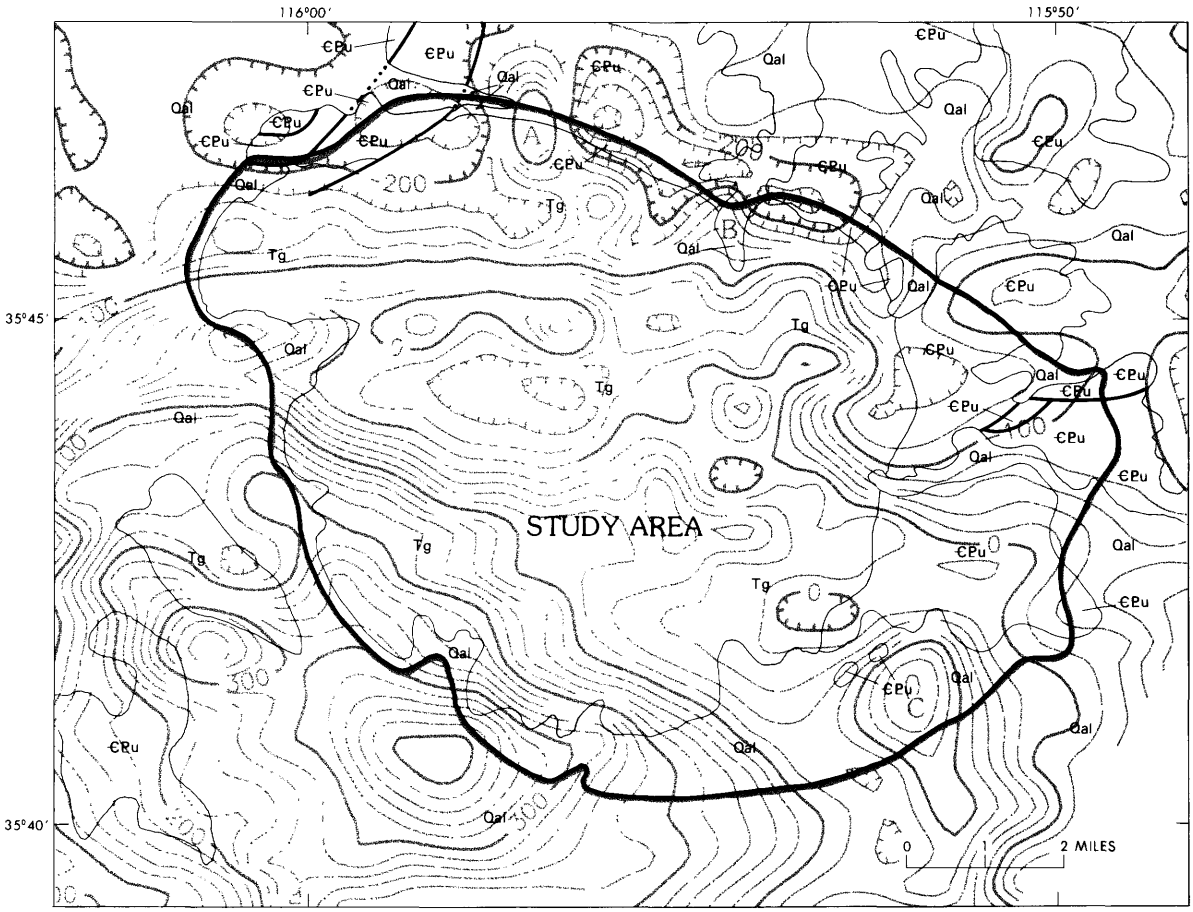
Iron deposits within the study area consist of iron skarn and bedded-iron deposits. Iron-skarn deposits (Cox and Singer, 1986) occur in limestone or dolomite at or near intrusive contacts. The intrusive rock may be diabase or granite. Ore and gangue minerals include magnetite ± pyrite ± chalcopyrite associated with an alteration assemblage of diopside + calcium-rich garnet. Iron-skarn deposits are characterized by strong magnetic anomalies and include anomalous concentrations of iron, cobalt, copper, gold, and possibly tin.

The best example of an iron-skarn deposit in the Kingston Range is the Beck mine (plate 1, No. 14). This active open-pit mine is located on two discontinuous lenses of magnetite and hematite mixed with pyrite ± chalcopyrite. The western lens strikes west-northwest, dips 70° N., and is conformable to bedding in the dolomite member of the Crystal Spring Formation. The eastern lens occurs in diabase along a steep, west-to-northwest-trending fault zone. Hewett (1948) reported that the dolomite is altered to wollastonite + tremolite and(or) diopside + garnet, serpentine (antigorite), and ankerite. Chemical analyses of iron ore from the Beck mine are listed in table 2.

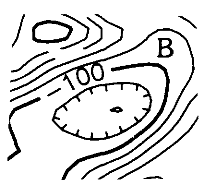
Hewett (1948) concluded that the iron deposits at Beck mine are related to the granite porphyry, although the evidence was not convincing. Hewett's evidence, obtained from drill-hole data, includes magnetite lenses that separate and replace layers of diabase and a reddish andesite porphyry dike that cuts the iron deposit and the diabase. This evidence indicates that the Beck deposit postdates the diabase and predates the andesite prophyry dike and suggests that the iron deposit may represent a late exhalative phase of either the diabase or the granite porphyry.

The alteration assemblages associated with the iron-skarn deposit (wollastonite + tremolite and(or) diopside + garnet) are stable at higher temperatures, given low total pressure ($P_{total} = P_{load} + P_{fluid} = 0.5$ kbar; Wright, 1968) and geologically reasonable mole fractions of CO_2, than the diopside + calcite, talc ± tremolite, and tremolite + calcite assemblages associated with the talc deposits (Winkler, 1974, fig. 9-2). This temperature relation, combined with the presence of pyrite ± chalcopyrite mixed with magnetite and the absence of sulfide minerals associated with the talc deposits, indicates that the iron-skarn deposit formed at higher temperatures in a sulfur-rich system than did the talc deposits. The widespread association of talc deposits and diabase in the southern Death Valley region, the unique association of an iron-skarn deposit and diabase in the Kingston Range, and the geochemical association of iron with copper, lead, silver, and zinc in the study area suggest that the Beck iron-skarn deposit postdates the diabase and talc deposits and is related to the granite porphyry.

The iron deposit at the Beck mine generates a sharp aeromagnetic anomaly (fig. 3, anomaly A) relative to the large circular aeromagnetic anomaly over the granite porphyry. A sharp, northward deflection of west- to northwest-trending aeromagnetic contours (fig. 3, anomaly B) suggests



EXPLANATION



Contours of residual magnetic field intensity in nanoteslas (nT)—Hachures indicate direction of decreasing intensity. Letters indicate magnetic anomaly described in text

——— Contact

——··· Fault--Dotted where concealed

GEOLOGIC MAP UNITS

Qal	Alluvium (Quaternary)
Tg	Granite porphyry (Tertiary)
€Pu	Sedimentary and metamorphic rocks, undivided (Cambrian and Proterozoic)

Figure 3. Aeromagnetic map of the Kingston Range, California.

that another magnetic body is buried beneath alluvial deposits two miles southeast of Beck Spring. Outcrops of the dolomite member of the Crystal Spring Formation trend into this area and most likely underlie the alluvial deposits. Hewett (1948) reported a small iron prospect in this area, but this prospect was buried during subsequent mining operations. The combination of geophysical and geologic data (sharp aeromagetic anomalies, known and reported iron deposits, and the lateral continuity of the host rocks) indicates that the dolomite member of the Crystal Spring Formation has high resource potential for iron in iron-skarn deposits at certainty level D.

Large megabreccia clasts of dolomite, as much as 1 mi long, were deposited in the Kingston Peak Formation along the eastern boundary of the study area. These dolomite clasts were eroded from outcrops of the dolomite member of the Crystal Sring Formation and the Beck Spring Dolomite north of the Kingston Range (Troxel and others, 1977). Several dolomite clasts contain talc and magnetite prospects (the Horse Thief talc and the Momi iron prospects, plate 1, Nos. 13 and 29) that are geologically the same as talc and iron-skarn deposits near Beck Spring. Deposits in the dolomite clasts are limited by the clast size and generally are small with low total tonnage. The megabreccia clasts of dolomite in the Kingston Peak Formation have moderate resource potential for talc and iron-skarn deposits at certainty level C.

Bedded-iron deposits include all stratigraphic units of layered, bedded, or laminated rocks that contain 15 percent or more iron (Gross, 1970). The iron minerals are commonly interbedded with quartz, chert, or carbonate minerals. The iron-rich interbeds conform with the banded structure of adjacent sedimentary, volcanic, or metasedimentary rocks.

Gross (1970) classified bedded-iron deposits in eight categories on the basis of lithologic features and associated sedimentary rocks. The two best known categories are Lake Superior- and Algoma-type deposits. Lake Superior-type deposits consist of interbedded chert- or quartz-rich layers with iron minerals and prominent granular or oolitic textures. These deposits, extensively developed in Late Precambrian rocks, are associated with dolomite, quartzite, black carbonaceous shales, slate, chert breccia, and volcanic rocks. Algoma (Keewatin)-type deposits consist of laminated chert- or quartz-rich beds with iron oxides, carbonate minerals, and sulfides. Oolitic textures are absent or inconspicuous. These deposits, found in early Precambrian, Paleozoic, and Mesozoic rocks, are associated with volcanic rocks, including tuffs and pyroclastic rocks, and with heterogeneous assemblages of graywacke, fine-grained clastic rocks, and iron-rich chert.

Bedded-iron deposits in the Kingston Peak Formation range from 30 to 300 ft thick and consist of graded, repetitious cycles of boulder conglomerate or sedimentary breccia, diamictite, coarse sand, silt, and dark red fine-grained laminated silt (Graff, 1985). The laminated silt, host rock of the bedded-iron deposits, consists of quartz, carbonate and lithic clasts, and pumice fragments in an iron-rich matrix of quartz, chlorite, hematite, and magnetite.

The Kingston Peak Formation has low resource potential for iron in bedded-iron deposits at certainty level C. These iron deposits are classified Algoma-type deposits because they occur in laminated quartz-rich beds and they lack oolitic textures. The iron deposits have low resource potential because of the high silica and alumina content of the iron-rich matrix (table 2). Iron, derived from hydrothermal leaching of mafic volcanic rocks or from volcanoclastic fragments, was deposited as detrital grains in a low-energy environment. Postdepositional diagenesis and(or) low-grade metamorphism remobilized, concentrated, and recrystallized iron as hematite, magnetite, and hematite pseudomorphs after magnetite and pyrite.

Polymetallic deposits consist of replacement and vein deposits. Polymetallic replacement deposits occur as lenses, pipes, and veins in limestone or dolomite near intrusive contacts with porphyritic plutons (Cox and Singer, 1986). Ore minerals, located along faults, preexisting solution channels, or caverns, are zoned outward from sphalerite ± chalcopyrite, galena ± sphalerite, and sphalerite + manganese-carbonate. Copper- and silver-sulfides occur in the two inner zones. Gold is rare. Pyrite, marcasite, and barite are widespread gangue minerals. The carbonate host rocks are dolomitized, silicified to form jasperoid, and oxidized to ochreous masses containing cerussite, anglesite, and hemimorphite.

Polymetallic vein deposits occur in faults, fractures, and breccia zones near equigranular diorite to granite hypabyssal intrusions and(or) dike swarms in sedimentary and metamorphic rocks (Cox and Singer, 1986). Polymetallic replacement deposits may form where high permeability zones intersect carbonate rocks. The veins include quartz + calcite ± dolomite ± ankerite ± barite ± fluorite ± iron- and manganese-carbonate minerals. Ore and gangue minerals include gold with pyrite + sphalerite ± galena ± chalcopyrite ± copper- and silver-sulfides ± hematite.

Anomalous concentrations of arsenic, barium, copper, lead, manganese, silver, and zinc are associated with polymetallic replacement and vein deposits. These geochemical anomalies are zoned outward from a copper- and gold-rich central zone to a wide lead-zinc-silver intermediate zone and a manganese-rich peripherial zone. Anomalous iron content is common to all zones.

The Noonday Dolomite has high resource potential for lead-silver resources in polymetallic replacement deposits at certainty level C. These deposits, including the Silver Rule, Chambers, Blackwater, and Jupiter mines (plate 1, Nos. 15, 16, 17, and 18), occur along fault zones and fractures near the base of the Noonday Dolomite. The faults and fractures are filled with fault gouge, quartz, and(or) calcite veins. Ore and gangue minerals include argentiferous galena, chalcopyrite, pyrite, calcite, dolomite, and barite. The host rock is bleached and locally oxidized to form small limonite gossens. Galena is altered by weathering to cerussite and anglesite. Recent assays indicate that the ore contains 2 to 12 oz/ton silver and 0.1 to 0.5 ppm gold. The iron content of these polymetallic deposits increases eastward from approximately one percent at the Chambers mine to 20 percent at the Jupiter mine. Molybdenum and uranium were detected in rock samples collected from the Chambers and Jupiter mine, respectively.

A large aeromagnetic anomaly located at the southeast corner of the study area (fig. 3, anomaly C) is generated either by a buried iron-rich mineral deposit or by more magnetic rocks within the granite porphyry. The anomaly is located over alluvial deposits and isolated outcrops of the Kingston Peak Formation. The Momi mine, U Sun Up prospect, and Momi Iron-Copper Extension (plate 1, nos. 19, 31, and 32), all located within the area of the aeromagnetic anomaly, occur in dolomite megabreccia clasts in the Kingston Peak Formation. Ore and gangue minerals at the Momi mine include galena, chalcopyrite, chrysocolla, magnetite, and quartz. Rock samples collected from this mine and these prospects yield the same geochemical anomalies as the polymetallic deposits in the Noonday Dolomite and the quartz veins in the granite porphyry. Samples from the Momi mine contain 0.1 to 0.2 ppm gold, 8 to 12.5 ppm silver, 5.6 percent copper, and 90 ppm uranium. Samples from the Momi mine and the Momi Iron-Copper Extension contain 25 and 55 percent iron, respectively. The geochemical data suggest that the aeromagnetic anomaly is generated by a copper- and iron-rich polymetallic deposit that is buried beneath the alluvial deposits. If this is the case, then the area defined by the aeromagnetic anomaly has high mineral resource potential for copper, iron, and silver in polymetallic deposits at certainty level C.

Quartz veins fill fault zones and joints in the granite porphyry. These veins vary in texture from massive to porous and include pyrite, minor hematite, and rare amethyst crystals. Chemical analyses indicate that the quartz veins contain anomalous concentrations of base-metals (copper, lead, and zinc) and elements (arsenic, antimony, cadmium, and mercury) associated with gold and silver mineralization. Ore-bearing minerals were not found during this study. The veins contain less than 0.1 ppm silver and 10 to 15 ppm uranium. Anomalous concentrations of molybdenum and tungsten occur in veins that cut the contact between the granite porphyry and the Pahrump Group. The lack of ore-bearing minerals associated with the geochemical anomalies suggests that base-metals, gold, and silver were not concentrated to form an ore deposit during crystallization of the quartz veins. These data indicate that the quartz veins have low mineral resource potential for lead and silver at certainty level C.

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TABLE 1--Chemical analyses of talc deposits (in weight percent), Kingston Range, California (Wright, 1968)[--No data]

	Commercial talc			Noncommercial talc
	Tecopa mine	Crystal Spring mine	Excelsior mine	Tecopa mine
SiO_2	56.88	54.37	55.70	60.9
MgO	31.29	27.10	30.73	9.88
Al_2O_3	0.45	2.73	1.49	8.85
CaO	4.92	5.36	7.16	5.23
FeO(total)	0.63	0.23	0.33	1.91
K_2O	--	--	1.6	4.66
Na_2O	--	--	1.7	1.46
Volatiles[1]	5.33	11.96	3.59	7.58

[1]Includes H_2O^+, H_2O^-, and CO_2.

TABLE 2--Chemical analyses of iron deposits (in weight percent), Kingston Range, California (modified from Butner, 1944; and Graff, 1985)[--No data]

	Beck mine		Bedded-iron deposits	
	West Pit	East Pit	Hematite	Iron-rich siltstone[1]
FeO (total)	56.6	56.1	93.85	56.88
SiO_2	6.24	7.56	4.80	28.10
CaO	4.91	2.66	0.41	0.57
MgO	2.61	3.63	0.34	3.64
MnO	0.02	0.12	0.61	--
P_2O_5	0.15	0.03	--	--
S	0.18	0.63	--	--

[1] Includes 10.32% Al_2O_3 and 1.95% TiO_2.

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. 4).

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.

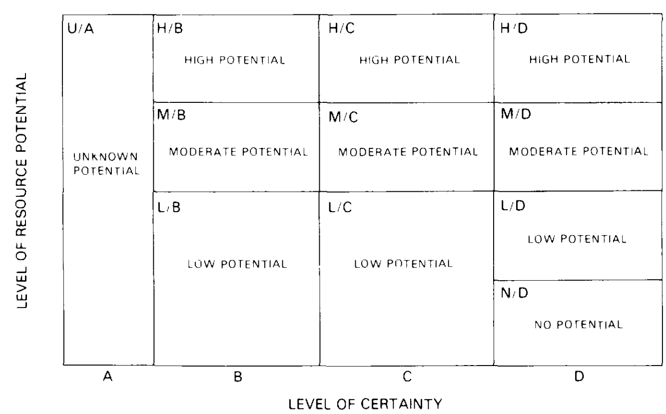

Figure 4. Major element of mineral resource potential/certainty classification.

APPENDIX 2. MINES, PROSPECTS, AND MINERAL OCCURRENCES IN AND ADJACENT TO PART OF THE KINGSTON RANGE WILDERNESS STUDY AREA, CALIFORNIA

Map no.	Name (pseudonym)	Geology	Workings and developments	Production and grade	Reference(s)
			Talc Mines		
1	Rogers mine	Two northwest-trending alteration zones that dip northeast. Northern zone consists of laminated talc and silicate rock 6-12 ft thick. Southern zone consists of approximately 5 ft of talc covered by alluvial deposits. Each zone approximately 1700 ft long.	Southeast end of northern zone penetrated by 400-ft adit that trends N. 45° E. Adit connected to surface by raise that trends 40° NE and follows dip of alteration zone. Other developments include a 60-ft adit that trends southeast, a shallow shaft, and several trenches and cuts. An open pit, 1,000 ft long by 50-100 ft wide, is located upslope from the two adits.	Several hundred tons of talc shipped from northern zone from 1940 to 1942[1].	Wright, 1968; Stone and Sumida, 1983.
2	Tecopa (Smith) mine	Discontinuous talc zones that dip 65° NW pinch and swell to maximum thickness of 25 ft. Most of the talc ore is foliated and friable, although some ore is blocky. Talc zones located at or within 40 ft of contact between diabase and the dolomite member of the Crystal Spring Formation. Talc zones terminated by rhyolite-porphyry dikes.	Mine workings separated into two groups of patented claims. Workings on the western group include a 50-ft shaft and a 130-ft adit completed before 1942. The shaft is inclined 60° WSW parallel to the strike of the talc body. A 500-ft drift trends southwest at the base of the shaft. Mine workings on the eastern group of claims are located along an alteration zone 800 ft long by 8 ft wide. Talc was mined at three levels from adits and drifts completed after 1942.	Produced 40,000 tons of talc from 1935 to 1954[1].	Wright and others, 1953; Wright, 1968.
3	American Olean mine (Annex, Sam Flake extension)	Discontinuous talc beds that extend from the Tecopa (Smith) Mine to the Omega Mine.	One open pit 200 ft long by 250 ft wide.	Production unknown.	McMahan and Rumsey, 1986.
4	Omega mine	Talc located in northwest-trending alteration zone that dips northeast. Alteration zone is 3,000 ft long and 50-100 ft thick. Pods and lenses of talc ore in the alteration zone are several hundred feet long by 30 ft wide. Ore consists of blocky to friable talc ± tremolite with low percentage of limey material.	Prior to 1960, the mine included several open cuts up to 200 ft long by 40 ft wide by 30 ft deep. A 600-ft drift that trends southeast from the base of the alteration zone in 8 ft of ore was developed after 1960. Open-pit mines greater than 2,000 ft long have opened and locally caved this drift.	Produced 11,500 tons of ore by 1959. Mining continued through 1985[1].	Wright, 1968.

APPENDIX 2. MINES, PROSPECTS, AND MINERAL OCCURRENCES IN AND ADJACENT TO PART OF THE KINGSTON RANGE WILDERNESS STUDY AREA, CALIFORNIA (continued)

Map no.	Name (pseudonym)	Geology	Workings and developments	Production and grade	Reference(s)
			Talc Mines		
5	Crystal Spring mine	Discontinuous talc zones that trend east and dip 60° N. Widest and most continuous zone can be traced laterally for approximately 200 ft and varies from a few inches to 20 ft thick. Talc zones are cut to the east and west by north-trending faults.	Mine includes four claims with two east-trending adits and drifts, a 20-30 ft deep shaft, and several cuts.	Produced several hundred tons of talc by 1959 and is currently in operation[1].	Wright, 1968.
6	Vulcan mine	Talc-bearing alteration zone trends N. 55° W. and dips steeply to northeast. Ore consists of discontinuous bodies of white talc schist up to 40 ft thick.	The mine was developed underground from 1939 to 1942 and by open pit from 1952 to 1960. Currently the pit measures 420 ft long, 15-60 ft wide, and 30 ft deep. The current owners proposed an open-pit mining plan to continue operations in the Vulcan mine and adjacent Sam Flake claims. They planned to mine to a depth of 75 ft and recover an estimated 20,000 tons of talc.	Produced 9,000 tons of talc from 1938 to 1960[1].	Wright, 1968.
7	Sam Flake claims	Four talc zones, 10 to 20 ft thick, separated by 10 to 15 ft of dolomite.	One bulldozer trench 100 ft long, 20 ft wide, and 10-20 ft deep, and several smaller cuts.	Production unknown	McMahan and Rumsey, 1986.
8	Booth (Kingston #8) mine	Northwest-trending lenses of talc that dip northeast. Talc lenses are approximately 100-200 ft long and 25 ft thick. Several lenses of talc schist mixed with siliceous dolomite to west.	Two adits 50 to 170 ft long, several pits, and one open cut.	Production unknown.	Wright, 1968; McMahan and Rumsey, 1986.
9	Excelsior mine	Talc schist approximately 600 ft long and 15 ft thick. Talc is cut by northwest-trending faults.	Mine includes 12 patented claims and has operated since 1936. Mine developments include a 700 ft adit that trends north. An inclined winze connects the adit with two drifts located at the 90 ft level and at the bottom of the winze. The drifts are 220 and 350 ft long in talc schist.	The Excelsior, Pioneer, and Apex mines produced 47,000 tons of talc from 1936-1959. The Excelsior mine was closed in the 1960's.	Wright, 1968.
10	Pioneer mine	Talc schist that trends north and dips 35°-50° E. Talc schist is 6-12 ft thick and is cut by numerous northwest-trending faults,	This mine, opened in 1951, includes one 400 ft adit that trends south-southeast, and several cuts.	See Excelsior mine production data.	Wright, 1968.
11	Apex mine	Talc-bearing alteration zone that dips 30° E. and is 45 ft thick. Ore consists of talc ± tremolite, 10-15 ft thick, in dolomite member of Crystal Spring Formation.	Mine opened in 1957 and currently in operation. This mine includes two drifts connected by crosscuts through the alteration zone and an open bulldozer cut.	Combined production of the Apex and Pioneer mines averaged 4,000 ton of talc per year since 1980.	Wright, 1968; Stone and Sumida, 1983.
12	Snow White (Kingston #1) mine	A zone of talc schist more than 100 ft long and 5-20 ft thick. The ore zone strikes west-northwest dips north, and is cut by northeast-tending faults.	One claim that was prospected since the late 1940's. Development work in the late 1950's included a short adit, bulldozer trench, and several shallow pits.	No production reported.	Wright, 1968.

APPENDIX 2. MINES, PROSPECTS, AND MINERAL RESOURCES IN AND ADJACENT TO PART OS THE KINGSTON RANGE WILDERNESS STUDY AREA, CALIFORNIA (continued)

Map no.	Name (pseudonym)	Geology	Workings and developments	Production and grade	Reference(s)
			Talc Mines		
13	Horse Thief (Johnson) prospect	Talc located in megabreccia clasts of diabase and Crystal Spring Formation deposited in the Kingston Peak Formation. Talc is located in an alteration zone within the dolomite member of the Crystal Spring Formation. The northwest-tending alteration zone pinches and swells from 0-100 ft thick and is 1,300-1,700 ft long. Ore consists of white to pale green talc ± tremolite approximately 10-20 ft thick.	Two adits, a 20 ft shaft, and several pits.	No production reported. Talc contains approximately 18 percent CaO.	Wright, 1968; McMahan and Rumsey, 1986.
			Iron Mine		
14	Beck (Iron Gossan) mine	Discontinuous lenses of magnetite and hematite after magnetite in the dolomite member of the Crystal Spring Formation. The iron lenses are 1,000-1,500 feet long and 150 ft wide. Total outcrop length is approximately 4,000 ft. The ore dips 70-80° N. and is conformable to bedding in the dolomite. Drilling data suggest that the iron lenses do not extend to more than 650 ft below the outcrop.	Beck mine was first patented in 1912 and was explored extensively by drilling in 1924. Iron ore was mined in the 1970's and 1980's from two large open pit mines, named the West and East Pit. The open pit mines cover approximately 140 acres.	Produced 2.1 x 10^6 long tons averaging 57 percent Fe from 1971-1982. The mine is currently active and is producing ore for use in portland cement. Estimated resources total 7.2 million long tons averaging 45 to 56.4 percent Fe.	Hewett, 1948; Stone and Sumida, 1983.
			Lead - Silver Mines [2]		
15	Silver Rule (John Chambers, Union Pacific) mine	Irregular lenses of galena and cerussite in the Noonday Dolomite. Lenses form at the intersection of faults that trend N. 70° W. and dip 70° N. with cross-fractures that trend N. 20° W. and dip 70° SW. Ore zone is 3-13 ft wide.	Two tunnels on 12 claims. The lower tunnel is 860 ft long; the upper tunnel is 1,210 ft long. Claims were located in the early 1900's and developed as late as 1950 with most mining activity from 1910 to 1916.	Total ore produced from the Silver Rule and Chambers mines is approximately 600 tons with an average grade of 10-40 percent Pb, 3-10 percent Zn, 5-10 oz/ton Ag, minor Cu, and trace Au. The 1910 production was about 140 tons of ore averaging 48 percent Pb, 2 oz/ton Ag, and trace of Au. The 1950 production was several tons of ore averaging 8.5 percent Pb, 6 percent Zn, 2.3 oz/ton Ag, and trace of Au.	Sampson, 1937; Hewett, 1956; Stone and Sumida, 1983.

APPENDIX 2. MINES, PROSPECTS, AND MINERAL OCCURRENCES IN AND ADJACENT TO PART OF THE KINGSTON RANGE WILDERNESS STUDY AREA, CALIFORNIA (continued)

Map no.	Name (pseudonym)	Geology	Workings and developments	Production and grade	References
			Lead - silver mines		
16	Chambers (Crystal Spring) mine	Polymetallic replacement deposit located along a northwest-trending breccia zone that dips 65-75° N. in Noonday Dolomite. Breccia zone is approximately parallel to bedding in the dolomite. Ore consist of fine-grained galena with secondary anglesite, pyromorphite, auricalcite, and calamine.	Three tunnels located at different elevations. The lower two tunnels trend west and are connected by a winze. The upper tunnel trends southwest and is approximately 100 ft long in barren dolomite.	Same as Silver Rule.	Hewett, 1956; Wright and others, 1953.
17	Blackwater mine	Northwest-trending polymetallic veins that dip 60°-70° N. in Noonday Dolomite. Veins are cut by northeast-trending flat faults. Veins include galena and cerussite in a large open cut, and copper-sulfides and lead ore in adits near the open cut.	Mine opened in 1914; includes a large open cut approximately 25 ft deep, and two northwest-trending adits.	Several carloads of ore shipped from prospect pits. Ore assayed 20 percent Pb and 12 oz/ton Ag. Ore from the two adits averages 15-30 percent Cu, and approximately the same grade lead and silver as ore from the open cut. Recent assay of ore from the two adit yields 12.24 oz/ton Ag and 0.002 oz/ton Au.	Hewitt, 1959
18	Jupiter (Blue Dick, Sunrise, Midnight, Beck) mine	Polymetallic replacement deposit in Noonday Dolomite. Veins include galena with secondary anglesite and iron-oxide minerals.	Development includes several shallow cuts and adits on either side of the ridge and a southwest-trending adit that extends 450 ft into Noonday Dolomite.	Approximately 86 tons of ore, averaging 32-55 percent Pb, 6 percent Zn, 6-12 oz/ton Ag, and traces of gold were shipped in 1914 from the cuts and adits. No ore was found in the southwest-trending adit.	Hewett, 1956; Stone and Sumida, 1983; Hall, 1984.
19	Momi (Iron Cap, Big Cherokee) mine	Veins of lead-silver, copper, and iron minerals located along a fault within a megabreccia clast of dolomite in the Kingston Peak Formation. Fault trends north and dips 70° W. Ore zone includes galena, chalcopyrite, chrysocolla, and iron-oxide minerals.	Single inclined shaft approximately 40 ft deep. A 20 ft adit is located south of the inclined shaft.	A complex ore, averaging 4.6 percent Pb 1.77 percent Cu, and 18.64 oz/ton Ag, was shipped from this mine in 1939. The deposit contains an estimated 40,000 tons of resources averaging 24.6 percent Fe and 5.6 percent Cu. A sample from a stockpile contained 0.3 oz/ton Ag. Recent assays of ore yield 0.005 oz/ton Au and 90 ppm U.	Stone and Sumida, 1983; McMahan and Ramsey, 1986.

APPENDIX 2. MINES, PROSPECTS, AND MINERAL OCCURRENCES IN AND ADJACENT TO PART OF THE KINGSTON RANGE WILDERNESS STUDY AREA, CALIFORNIA (continued)

Map no.	Name (pseudonym)	Geology	Workings and developments	Production and grade	Reference(s)
			Prospects and mineral occurrences		
20	Unnamed prospect	Fault contact between Crystal Spring Formation and rhyolite porphyry dike.	Single shaft 30 ft deep.	No production reported. Sample of fault breccia contains 100 ppm U, 0.01 oz/ton Au, and anomalous concentrations of copper, lead, zinc, and silver.	McMahan and Ramsey, 1986
21	Western Iron prospect	Thin lenses of hematite in brecciated Crystal Spring Formation.	One patented claim with several shallow cuts and adits.	No production reported. Iron is lower grade than iron at Beck mine.	Stone and Sumida, 1983.
22	Kame Piute Claims (Blue Dick, Geranimo group)	Polymetallic veins along fault zones in the Noonday dolomite. Northeast-trending vein dips steeply to south and is 200 ft long and 0.5 ft wide. Vein consists of galena, pyrite, and copper sulfide minerals.	Seven claims that include several adits 20-40 ft long connected by a shaft, bulldozer cuts, and a 96 ft well that produces 34 gal/min water.	Blue Dick produced $7,000 of Ag in 1919 at $0.57/oz Ag. Veins reportedly contains 22-68 percent Pb, trace of Zn and 200-300 oz/ton Ag. Recent analyses of select (high grade) samples average 0.3 to 1.4 oz/ton Ag.	John Kame (oral commun., 1985).
23	Kame Claims no. 8,9, and 10 (Kame no. 8 is the Silver Knob; Kame no. 10 is the Peacock claim)	Polymetallic veins along steep, northwest-trending fault zones in Noonday Dolomite. Veins include galena and copper sulfide minerals.	Kame no. 8 includes two north-northeast-trending adits 68 and 92 ft long; Kame no. 9 is undeveloped; and Kame no. 10 includes an open cut and a 60 ft adit.	Produced 125 tons of ore from Kame no. 8, 9, 10 in 1981-1982. Ore grade varies with claims but reportedly ranges from 10-60 oz/ton silver and 0.5-10 oz/ton Au. Select samples from Kame no. 10 yield 1.5-1.8 oz/ton Ag.	John Kame (oral commun., 1985).
24	Amethyst	Porous quartz veins with amethyst crystals in granite porphyry. Euhedral terminated crystals are up to 0.25 in. in diameter and 0.25 to 0.5 in. long.	No development	Gem quality material collected by rockhounds	Henry, 1952
25	Villa de Oro prospect	Iron-stained dolomite 20 ft long, 15 ft wide, and 6 ft thick adjacent to the granite porphyry.	Claim monuments.	No production reported. Chip sample across iron-stained dolomite contains a trace of gold.	McMahan and Rumsey, 1986.
26	Rex prospect	Limonite-stained fault zone in dolomite. Northeast-tending fault dips 45° NW. and is approximately 4 ft wide.	Claim monuments.	No production reported. Chip sample across the dolomite contains a trace of gold.	McMahan and Rumsey, 1986.
27	Kame By-Pass (A No. 1, Blue Bell, Virginia) claim	Polymetallic veins within north-trending fault zone in Noonday Dolomite. Fault zone dips 50°-70° W. and is several feet wide. Veins include iron-stained copper minerals and rare galena.	Two short adits into an open chamber 25 ft long and 20 ft deep. Several small prospects are located on the hillside south of the adits.	No production reported. Veins reportedly contain 29 percent Cu, 2-4 oz/ton Ag, and less than 0.3 oz/ton Au. A sample across the shear zone contained 1.0 oz/ton Ag and 0.02 oz/ton Au. A select sample from the stockpile contained 1.6 oz/ton Ag and 0.03 oz/ton Au. Recent assays yield 1.3 oz/ton Ag from veins within the open chamber and 0.01 oz/ton Au from the prospects south of the adits.	McMahan and Rumsey, 1985; John Kame (oral commun., 1985).

APPENDIX 2. MINES, PROSPECTS, AND MINERAL OCCURRENCES IN AND ADJACENT TO PART OF THE KINGSTON RANGE WILDERNESS STUDY AREA, CALIFORNIA (concluded)

Map no.	Name (pseudonym)	Geology	Workings and developments	Production and grade	Reference(s)
		Prospects and mineral occurrences			
28	Unnamed prospect	Silicified iron-stained shale exposed in a stream cut. The shale is horizontal and is 40-100 ft thick.	No development.	A chip sample of the shale at stream level contained a trace of gold.	McMahan and Rumsey, 1986.
29	Momi prospect	Magnetite and hematite lenses in megabreccia clast of dolomite in Kingston Peak Formation. Dolomite clast is 15 ft long, 10 ft wide, and 3 ft thick. Iron-stained quartzite in the Kingston Peak Formation occurs 100 ft east of the magnetite lens.	Claim monuments.	Prospect contains less than 50 tons of mineral averaging 40 percent Fe. A chip sample of the quartzite contained no significant mineral values.	McMahan and Rumsey, 1985.
30	Unnamed prospect	Bedded iron formation in upper member of the Kingston Peak Formation. Iron formation consists of hematite and hematite pseudomorphs after magnetite in brown to red laminated siltstone with sandy interbeds. Site includes seven hematite-rich beds each 30 to 80 ft thick.	No development.	No production reported. Siltstone consist of 10-25 percent hematite. Iron-rich sedimentary matrix of iron formation contains 37-57 percent iron.	Graff, 1985.
31	U Sun Up prospect	Pods of limonite with copper-carbonate in a megaclast of brecciated dolomite in the Kingston Peak Formation. The mineralized breccia zone trends northeast, dips slightly southeast, and is 15 ft thick.	Inclined shaft approximately 15 ft deep.	Grab sample from a stockpile contained 55 percent Fe and 0.17 percent Cu.	McMahan and Rumsey, 1986.
32	Momi Iron-Copper Extension	Hydrothermally altered megabreccia clast of dolomite deposited in the Kingston Peak Formation. The dolomite clasts is 200 ft long and 15-20 ft wide.	Claim monuments.	No production reported. A sample of dolomite contained no significant mineral values.	MaMahan and Rumsey, 1986.
33	Unnamed prospect	Northwest-trending vein in the granite porphyry. Vein includes quartz, pyrite, and hematite.	A 10-12 ft pit and small bulldozer cut.	Vein contains 0.002 oz/ton Au. 0.5 ppm Hg, 15 ppm Bi, and anomalous concentrations of copper, lead, zinc, and silver	G. L. Raines (written commun., 1985).
34	Unnamed prospect	Bedded iron formation in upper member of the Kingston Peak Formation. Iron formation includes hematite and magnetite pseudomorphs in interbedded iron-rich siltstone and sandstone.	No development	Iron-rich sedimentary matrix contains 33 percent Fe.	Graff, 1985.
35	Unnamed prospect	Iron-stained and bleached alteration zone in granite porphyry. The alteration zone trends northeast for approximately 2,000 ft.	No development	Channel sample across the alteration zone contains 0.02 oz/ton Ag.	McMahan and Rumsey, 1986.
36	Unnamed prospect	Altered granite near northeast-trending vertical fault. Disseminated sulfides are reported near Porcupine Tanks.	No development	Anomalous concentrations of barium, bismuth, cadmium and lead.	G. L. Raines (written commun., 1985).

1 Production and resource data furnished by owners or based on field examination were combined with data for other talc deposits to conceal proprietary company data.
2 Precious metal concentrations are reported as oz (troy)/short ton.

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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DEPARTMENT OF INTERIOR
DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

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[Letters designate the chapters]

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