

Mineral Resources of the Fort Piute Wilderness Study Area, San Bernardino County, California

U.S. GEOLOGICAL SURVEY BULLETIN 1713-C



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MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
EASTERN CALIFORNIA DESERT CONSERVATION AREA, CALIFORNIA

DEPARTMENT OF THE INTERIOR
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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 a part of the Fort Piute Wilderness Study Area (CDCA-267), California Desert Conservation Area, San Bernardino County, California.

CONTENTS

Summary

- Abstract C1
- Character and setting 1
- Identified resources 1
- Mineral resource potential 3

Introduction 3

- Area description 3
- Previous and present investigations 3
- Acknowledgments 3

Appraisal of identified resources 5

- History and production 5
- Mineral deposits 5

Assessment of mineral resource potential 6

- Geology 6
 - Rock units 6
 - Structure 6
 - Summary of geologic relations between the Piute Range and Castle Mountains 7
- Geochemical studies 7
- Geophysical studies 8

Potential for undiscovered mineral resources 8

- Metals 9
- Placer gold 9
- Energy resources 9

References cited 9

Appendix 1. Definition of levels of mineral resource potential and certainty of assessment and geologic time scale 11

PLATE

In pocket

1. Mineral resource potential map of the Fort Piute Wilderness Study Area, San Bernardino County, California

FIGURES

1. Index map showing location of the Fort Piute Wilderness Study Area, San Bernardino County, California C2
2. Map showing mineral resource potential of the Fort Piute Wilderness Study Area, San Bernardino County, California 4

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SUMMARY

Abstract

The Fort Piute Wilderness Study Area (CDCA-267) is in northeastern San Bernardino County, California, near the boundary between California and Nevada. Mineral surveys were requested for 31,371 acres of the Fort Piute Wilderness Study Area. In this report the area studied is referred to as "the study area". Examination of mines and prospects in the area was accomplished by the U.S. Bureau of Mines in 1981 and 1982. Field investigations of the area were carried out by the U.S. Geological Survey in 1983 and 1985. No mines or prospects, few mining claims, and no identified resources are located within the wilderness study area. Moderate and low potential for gold resources appears limited to outcrops of gneiss and granite exposed along the eastern side of the Piute Range. Available information indicates that there is no potential for energy resources, including oil and gas, uranium, or geothermal, in the study area.

Character and Setting

The Fort Piute Wilderness Study Area in San Bernardino County, Calif., comprises the part of the Piute Range and adjacent alluvial apron that lie south of the California-Nevada state line (fig. 1). The Piute Range trends north and has a steep eastern escarpment, which rises as much as 2,000 ft above

Piute Valley. The west flank of the range slopes gradually to 1,000 ft above Lanfair Valley. Deep canyons that are oriented transverse to the north trend of the range provide hiking routes across the north and south ends of the study area. In the late nineteenth century, Fort Piute (now in ruins) occupied a site beside perennial Piute Spring in the southern transverse canyon.

Most rocks of the Piute Range were formed in the Miocene epoch (see Appendix 1 for geologic time chart) of the Tertiary period. These rocks are andesitic to rhyolitic lava flows with sedimentary interbeds. Minor amounts of silicic tuff and andesitic to rhyolitic intrusive rocks also are present. Basal Miocene volcanic and sedimentary rocks dip moderately to the west, and overlying lava flows are dominantly horizontal, except on the east flank of the Piute Range, where the overlying flows are exposed in blocks bounded by high-angle normal faults. In these blocks the Miocene rocks have moderate eastward dips. The volcanic and sedimentary rocks overlie a complex that comprises Proterozoic gneiss and granite; the complex is intruded by granitic plutons of Mesozoic (Jurassic? or Cretaceous?) age. The gneiss and granite are exposed locally along the east flank of the Piute Range. The Proterozoic to Miocene rocks are overlain by Quaternary stream and lake deposits.

Identified Resources

No identified metallic resources are located within the Fort Piute Wilderness Study Area, although

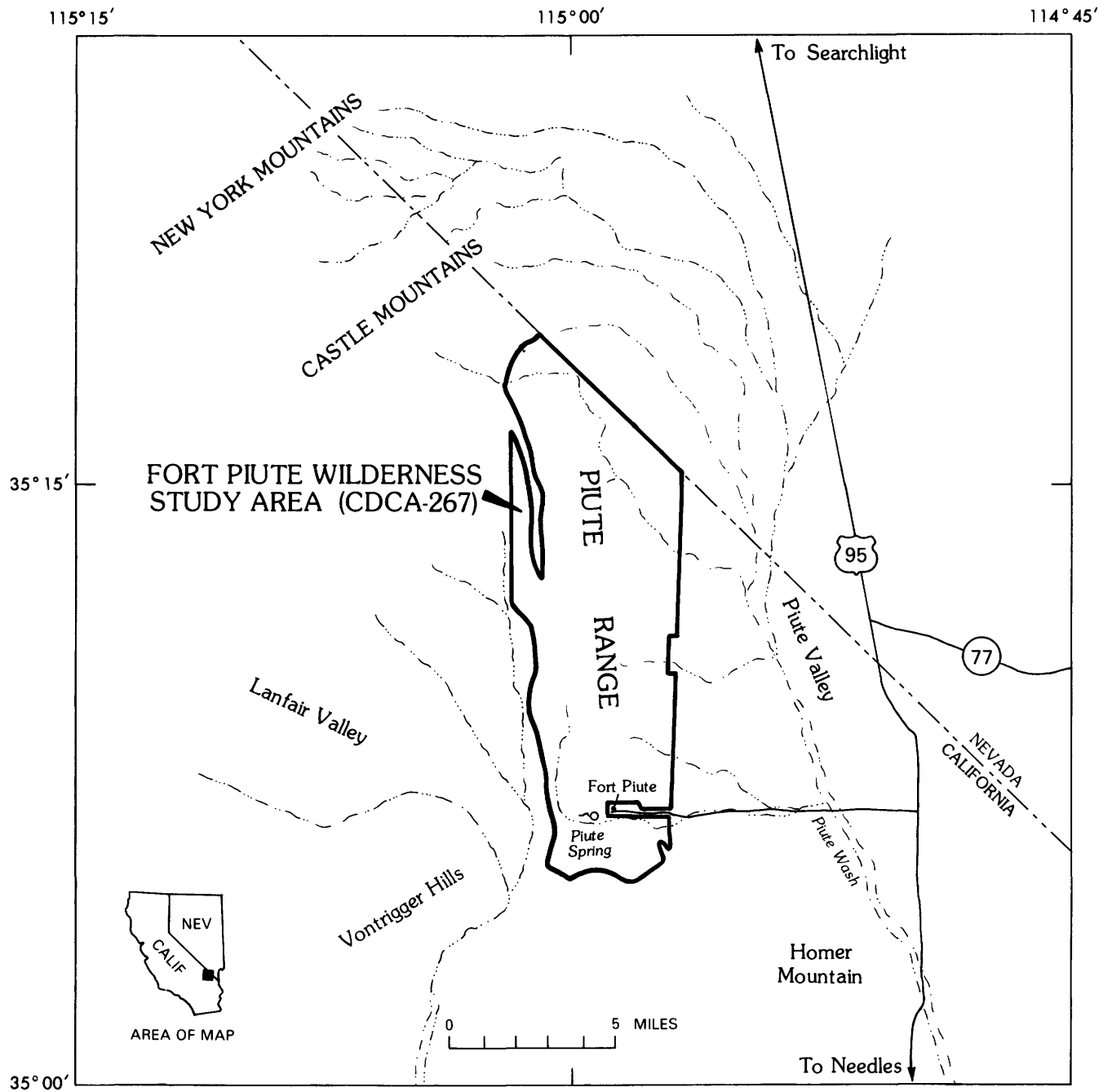


Figure 1. Index map showing location of the Fort Piute Wilderness Study Area, San Bernardino County, California.

identified resources such as gold, silver, copper, and kaolinite are found in mining districts outside the wilderness study area boundary. Only eight placer mining claims have been recorded within the study area, and field reconnaissance revealed no evidence of current or historic mining activity.

Mineral Resource Potential

Geologic and geochemical data indicate that areas on the east side of the Fort Piute Wilderness Study Area (fig. 2) have moderate potential for undiscovered resources of gold where the contact between Proterozoic gneiss and Mesozoic granite is exposed. This assessment is based on the presence of anomalous gold in stream-sediments and stream-sediment concentrates at several locations in parts of the central and southeastern parts of the study area, where aeromagnetic anomalies caused by Proterozoic and Mesozoic rocks also are present. The magnetic anomalies are present continuously to the southwest and project into the mineralized Exchequer mining district, where gold and copper were mined from small dikes and veinlets associated with contact zones between Proterozoic gneiss and intrusive Mesozoic granite. Similar contact relations are exposed in the central part of the study area.

Additional areas of exposed Proterozoic gneiss in the northern part of the Fort Piute Wilderness Study Area have low potential for gold. This assessment is based on anomalous concentrations of arsenic and antimony in rock samples. The aeromagnetic anomaly pattern characteristic of the Exchequer mining district is not found in the northern part of the study area. Also, no Mesozoic rocks are exposed at this end of the study area, and no mineralized zones or distinctive minerals were noted in the outcrops of Proterozoic gneiss and intrusive Proterozoic granite. Thus, Proterozoic rocks in the northern part of the study area do not warrant the level of resource potential given rocks of the central part, where all the geologic, geophysical and geochemical factors are present.

Rare-earth minerals, including monazite, are mined at the Mountain Pass mine (not shown on figures) approximately 30 mi northwest of the Fort Piute Wilderness Study Area. This deposit is related to intrusive carbonatite and syenite-shonkinite rocks of Proterozoic age, none of which are exposed in or within 20 mi of the study area, and thus, there is no potential for rare-earth resources in the study area. In addition, there is no indication from any of the data collected in these studies that the Fort Piute Wilderness Study Area is likely to have potential for resources of oil, gas, geothermal energy, or uranium.

INTRODUCTION

Area Description

This study of part of the Fort Piute Wilderness Study Area (CDCA-267) encompasses 31,371 acres of the northeastern Mojave Desert near the Colorado River. The area is 25 mi north of Needles, Calif., and

15 mi south of Searchlight, Nev. About one quarter of the study area has low relief and lies east of the Piute Range. The range itself is rugged, with elevations that vary from 2,800 to 4,800 ft above sea level within a horizontal distance of 2 mi in the central part of the study area. The region is arid: annual rainfall ranges from 2.2 to 6.9 in. Temperatures range from as low as 10° F during winter months to more than 100° F during summer months.

Vegetation is sparse on east-facing slopes and includes creosote, ambrosia, indigo bush, several varieties of brittle bush (*Encelia*), buckwheat (*Eriogonum*), and many varieties of cacti and small yucca. On west-facing slopes and on the west side of the range, palo verde, catclaw acacia, Joshua tree, and tall grasses also occur. Numerous annual wildflowers, such as paintbrush, buttercup, desert sunflower, desert lavender, desert aster, and desert mariposa, are present everywhere. Along streams or near springs the exotic species tamarisk (salt cedar), is found along with native willow and mesquite. Wildlife observed during this study includes mountain sheep, desert tortoise, cougar, coyote, rattlesnakes, chuckawalla and smaller lizards, and many vultures, hawks, small birds, and rodents.

The north and south ends of the study area are accessible by minimally maintained trails and tracks: a trail at the south end is reached by the Old Government Road, and those at the north end by a partly maintained road (formerly a railroad grade) between Searchlight, Nev., and Barnwell, Calif. On the east side of the study area these routes intersect a maintained powerline road that parallels the approximate Fort Piute Wilderness Study Area boundary. Access to other areas requires cross-country hiking from the powerline road across alluvial fans or from the ends of the various trails.

Previous and Present Investigations

The generalized structure and geology of the Piute Range was described by Hewett (1956) and is represented on a reconnaissance geologic map by Binger and Bonham (1973). Detailed geologic maps of nearby areas were produced by Medall (1964, Castle Mountains, Calif.), Balkwill (1964, northern New York Mountains and Castle Peaks, Calif.), Turner and others (1983), and Turner (1985a and b, northeastern Castle Mountains, Calif. and Nev.).

The U.S. Geological Survey conducted field investigations in the Fort Piute Wilderness Study Area from 1983 to 1985. Work included mapping at 1:24,000 scale, sampling of mapped units for petrographic characterization, geochemical sampling to evaluate the potential for undiscovered mineral resources, and aeromagnetic and gravity surveys. The U.S. Bureau of Mines conducted a mineral resource study of the Fort Piute Wilderness Study Area in 1981-82 to evaluate identified resources.

Acknowledgments

Jay Noller helped complete mapping of the Fort Piute Wilderness Study Area, compiled all mapping,

and reviewed early versions of this report. Robert E. Reynolds of the San Bernardino County Museum provided background information about the geology of the Piute Range and guided us to outcrops of Pliocene lake deposits.

APPRAISAL OF IDENTIFIED RESOURCES

By John R. McDonnell, Jr., U.S. Bureau of Mines

The U.S. Bureau of Mines conducted a mineral survey of the Fort Piute Wilderness Study Area, San Bernardino County, Calif., during 1981-82. The investigation included a review of available published and unpublished material related to the mineral resources and mining activity of the Piute Range and vicinity. Mining claim locations were obtained from San Bernardino County and U.S. Bureau of Land Management records. Production data were collected from U.S. Bureau of Mines files and other sources.

The U.S. Bureau of Mines conducted a field examination of the wilderness study area in 1982. This examination consisted of aerial and ground reconnaissance of the Piute Range for mining activity or evidence of mineralization. No mining activity or mineralized occurrences were found and no samples were collected. Detailed results of the study are available in McDonnell (1983).

History and Production

Bureau of Land Management records (November 1, 1982) and field observations indicate that about eighty placer claims are located along the southwest boundary of the study area; eight of these claims are within the study area boundary. A field check of the placer claims revealed no discernible mine workings. Recurrent lode mining activity has occurred in several nearby areas. Claim locations are available in McDonnell (1983).

The Signal mining district, including Signal Hill and Homer Mountain, is about 5 mi south of the study area (fig. 2). Ore mined from the district contained gold, silver, copper, lead, tungsten, and vanadium (Cloudman and others, 1919; Wright and others, 1953). Exploration along the main vein of the Leiser Ray mine (fig. 2) began prior to 1891. During World War I, the mine produced 13,600 lb of copper, 960 lb of lead, and 400 oz of silver (Hewett, 1956). An unpublished report for the California Desert Geology-Energy-Minerals resource area studies (U.S. Bureau of Land Management, 1981) mentioned reports of geochemical anomalies of niobium, cerium, chromium, cobalt, and vanadium, and concluded that there is "some potential for a copper-porphyry deposit in this (Signal Hill) area."

The Exchequer mining district, which includes the Vontrigger Hills, is 7-8 mi southwest of the study area. From 1926 to 1929, the Vontrigger claims produced 3,729 tons of ore that average 5.03 percent copper (Wright and others, 1953). Through 1982, the California mine (on part of the Vontrigger claims) produced about 450,000 lb of copper, 4,000 oz of silver

and 350 oz of gold. A gamma-ray survey conducted during the National Uranium Resource Evaluation determined the California mine area to be anomalously high in thorium (U.S. Bureau of Land Management, 1981; Luning and others, 1982).

The Hart mining district, located in the Castle Mountains, is about 5 mi northwest of the study area (fig. 2). Gold mining in the district began in the early 1900's. During the 1940's, the Oro Belle mine, located at the southwest end of the Castle Mountains, produced 3,000 to 4,000 tons of ore averaging 0.34 oz/ton of gold. Kaolinite mining began in the early 1920's in the southwest end of the Castle Mountains (Wright and others, 1953) and intermittent clay production ceased in 1981. At the time of this report, there was no evidence of mining activity in the district.

Mineral Deposits

The Fort Piute Wilderness Study Area includes no mining districts, and no mineralized areas are known within the Tertiary volcanic rocks exposed in the study area. There are no known mineral deposits within the study area, although the oldest rocks in the Piute Range are Proterozoic gneiss and intrusive Mesozoic granite that resemble ore-bearing rocks of the Exchequer and Signal mining districts. In the Signal and Exchequer mining districts, gold is found in quartz veins (Tischler, 1960a) and seems to be concentrated in and near the contacts between gneiss and granitic intrusive bodies (Hewett, 1956). Copper minerals occur discontinuously within brecciated zones in the gneiss. These ores may have been deposited in an inferred Late Cretaceous interval of mineralization recognized by Hewett (1956) in these districts.

Rocks like those of the Hart mining district are not exposed in the Fort Piute Wilderness Study Area. Mined deposits of the Hart mining district occur in volcanic rocks of Miocene age (Hewett, 1956; Tischler, 1960a and b), which are coeval with the dominant rock types exposed in the study area. This episode of mineralization probably is related to Miocene rhyolite plugs that intruded layered rhyolitic flows, breccia, and tuff of the Castle Mountains (Medall, 1964).

Calzia and others (1979) stated that the Piute Valley, north and east of the study area (fig. 1), contained "prospectively valuable" accumulations of oil and gas resources. This classification was based on geologic and seismic data that suggest that the Idaho-Wyoming overthrust belt extends into southeastern California. Oil leases in Piute and Lanfair Valley are held by several companies, but company representatives disclosed no immediate plans for exploration.

Calzia and others (1979) concluded that the north end of Piute Valley outside the study area boundary (fig. 1) contained prospectively valuable geothermal resources. This assessment was based on one site north of the study area that had a water temperature 51.8° F above ambient values for the region. No evidence of potential geothermal resources inside the study area has been reported.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Jane E. Nielson, James G. Frisken, and Robert C. Jachens, U.S. Geological Survey

Geology

Rock units

The Piute Range comprises a sequence of Miocene sedimentary and volcanic rocks as much as 2,000 ft thick. The volcanic rocks are dark-colored (black, gray, and red) lava flows, breccia, and tuff that range in composition from andesite to rhyolite. They are interbedded with discontinuous sedimentary units that probably were deposited on alluvial fans and in stream channels. The Miocene sequence nonconformably overlies a complex of Proterozoic gneisses intruded by Mesozoic granitic plutons. Outcrops of gneiss and (or) granite in the study area are found at the mouths of canyons along the eastern range front and in several downstream areas between the range front and the southeast study area boundary (pl. 1). Remnants of Pliocene(?) to Holocene fan and playa deposits overlie both the Miocene and underlying rocks at the southwest and southeast margins of the range. Most of the terrain of low relief within the study area is covered by Quaternary alluvial fans that nearly surround the range.

The Proterozoic crystalline rocks consist of biotite-rich augen gneiss and foliated leucocratic granitic dikes. The augen gneiss is characterized by large (as much as 2 in.) potassium feldspar porphyroclasts. This unit and similar gneiss exposed in the New York Mountains (fig. 1) give uranium-lead isotopic ages of 1,660–1,720 Ma (million years Before Present) (Wooden and others, 1986). Numerous ductile shear zones in the augen gneiss grade into mylonitic zones that locally are cut by the foliated leucocratic granite dikes. The deformed Proterozoic rocks are intruded by a suite of undeformed granitic plutonic rocks that includes leucogranite, hornblende-biotite granite, biotite quartz monzonite, and granodiorite. The assemblage probably is part of the regionally extensive suite of Mesozoic granitic to dioritic plutons collectively called the Teutonia batholith (Beckerman and others, 1982). Contacts between the Proterozoic and probable Mesozoic rocks are exposed only in outcrops of the south-central Piute Range (pl. 1).

The Miocene rocks of the Piute Range comprise two main assemblages, here designated the basal and overlying sequences. The contact between basal Miocene and underlying gneiss and granite is an irregular nonconformity, with as much as 400 ft of relief locally. The character of the basal Miocene rocks changes from south to north along the eastern front of the Piute Range. In the southeastern study area the basal Tertiary sequence comprises arkosic sandstone and conglomerate, whereas in the northeastern study area the basal Tertiary rocks are an assemblage of interfingering arkosic sandstone and conglomerate, andesite flows and breccia, and a distinctive welded ash-flow tuff, the Peach Springs Tuff of Young and Brennan (1974). The Peach Springs Tuff is overlain by andesitic flow breccia, reworked

tuff, and air-fall tuff. In the northeastern part of the study area, the arkosic units are derived solely from foliated Proterozoic gneiss, whereas clasts in arkosic units of the southeastern study area are derived from both Proterozoic and Mesozoic granitic rocks.

The overlying sequence comprises two assemblages of dark-red, gray, or black volcanic rocks and interbedded gravels, separated by a laterally continuous white ash-fall tuff bed. The volcanic deposits are andesite, basaltic andesite, and rhyolite flows, and flow breccia, tuff and tuff breccia, and uncommon basalt flows. The lava flows and breccia units commonly grade laterally into lenticular river-gravel deposits that contain pebbles and cobbles of both Miocene volcanic rocks and pre-Tertiary lithologies. Pre-Tertiary cobbles include Paleozoic limestone and garnet-bearing gneiss not found in the Piute Range, but which are exposed in the New York Mountains to the northwest (fig. 1). Abundant phyrlic and aphyric andesitic dikes are found throughout the Miocene sequence in the Fort Piute Wilderness Study Area. Three rhyolitic bodies and one andesite plug intrude the lower part of the Miocene sequence in the southern half of the Piute Range.

Calcareous siltstone, sandstone, and conglomerate of late Tertiary and early Quaternary age overlie Mesozoic granitic rocks and abut Miocene lava and tuff near Fort Piute.

Structure

All dips measured in volcanic rocks of the study area are 45° or less. The basal sequence is tilted up to 45° to the west by a family of Tertiary high-angle normal faults with northerly strikes. These faults form the boundaries of tilted blocks that are progressively dropped down to the east. Cross faults with easterly strikes offset the Proterozoic and basal Miocene rocks at the northeastern range front (pl. 1). East-trending faults are not exposed in the overlying sequence, and apparently predate deposition of the younger Miocene units. Northeast of the study area boundary these fault zones are silicified and stained with limonite.

Rocks of the overlying sequence of the Piute Range predominantly have dips of 15° or less. However, at the south and north ends of the study area these units are cut by normal faults that trend north and northwest, dropping the rocks down to the west, and causing eastward tilts up to 35°. The north-trending faults are offset by north-northeast-trending transverse faults in the vicinity of Fort Piute canyon (pl. 1).

The pattern and trend of the regional drainage suggest that it predated major uplift of the Piute Range. Piute Wash (fig. 1), the local major watercourse, drains south and east into the Colorado River. The courses of subordinate washes trend subparallel or perpendicular to Piute Wash, whereas the courses of most streams that drain the northern Castle Mountains are deflected northeast around the end of the Piute Range, then turn south to follow the regional slope (fig. 1). Two streams have cut deeply incised canyons across the north and south ends of the range.

Summary of geologic relations between the Piute Range and Castle Mountains

The assessment of mineral resource potential for the Fort Piute Wilderness Study Area depends in part on whether or not the mineralized rocks of the Castle Mountains underlie the Piute Range, as speculated by Hewett (1956), Tischler (1960a), and Turner (1985b). The Castle Mountains is a faulted asymmetrical anticline, which exposes Proterozoic(?) gneiss of high metamorphic grade in the core (pl. 1). The gneiss is overlain by Miocene volcanic and sedimentary rocks that define the northwest- and southeast-dipping limbs of the anticline (Turner, 1985b; pl. 1). Turner (1985b) observed that volcanic rocks of the Piute Range overlie rhyolite tuffs and flows of the Castle Mountains and that a thick sequence of Piute Range rocks are downfaulted against the southeast limb of the Castle Mountains anticline. Turner (1985b) concluded that flows of the Piute Range are younger than rocks of the northern Castle Mountains, and that the Castle Mountains rocks underlie the Piute Range, but are unexposed because they are displaced by faults. If these speculations are correct, mineralized rocks like those that contain gold deposits in the Hart mining district (fig. 2) might underlie the Miocene rocks of the Fort Piute Wilderness Study Area.

Stratigraphic relations and radiometric dating indicate that rocks of the Castle Mountains are not older than basal volcanic rocks in the Piute Range. The basal unit in the Castle Mountains has been dated at 18 Ma (Turner and others, 1983), which is equivalent to the probable age of Peach Springs Tuff (Glazner and others, 1986) that crops out at the base of the Piute Range. The youngest age determined on a flow in the Castle Mountains is 14.4 Ma, whereas the youngest age from the Piute Range is about 8 Ma (J.K. Nakata, written commun., 1985). Thus, Miocene rocks of the Castle Mountains are coeval with those of the Piute Range.

Dark andesitic flows of the uppermost Piute Range volcanic sequence overlie older light-pink or white rhyolite flows and ash-flow tuffs of the southern Castle Mountains on the southeast limb of the anticline, east of the Hart mining district (Medall, 1964). Here, the Castle Mountains rhyolite sequence is only 150 ft thick, compared to a thickness of 1,300 ft at the Hart mining district on the northwest limb (Medall, 1964). This attenuated sequence of Castle Mountains rocks dips toward the Piute Range and is truncated by faults, as observed by Turner (1985b). However, rocks similar to the distinctive light-colored rhyolites of the Castle Mountains are not exposed in the basal sequence of the Piute Range. These relations suggest that the Castle Mountains section pinches out or interfingers with rocks of the Piute Range near the west boundary of the study area. However, because streams that drain south from the Castle Mountains merge into washes that traverse the Piute Range (fig. 1), mineralized rocks from the Castle Mountains are found in late Tertiary and Quaternary alluvial deposits of the Piute Range.

Dacite and rhyolite intrusive bodies occur in both the Castle Mountains and the Piute Range. Rhyolite plugs located in the Castle Mountains may have been conduits for mineralizing solutions that promoted ore

deposition. Intrusions in the Piute Range are unlike those in the Castle Mountains in appearance, mineralogy, and bulk composition. Hydrothermal alteration and silicification of host rocks characteristically found at the margins of plugs in the Castle Mountains are not evident in the Piute Range.

Geochemical Studies

A reconnaissance geochemical study of the Fort Piute Wilderness Study Area was undertaken in 1984 by the U.S. Geological Survey. The sampling program was chosen to seek base- and precious-metal anomalies characteristic of mineralized districts near the study area, and thus would not necessarily reveal magnetic-mineral or nonmetallic-mineral resources.

Two types of sample were chosen for most of the geochemical analyses because these media have been found to reliably reveal base- and precious-metal anomalies in the arid desert environment of southeastern California. Rock samples from 23 sites in and adjacent to the study area and samples of stream cobbles, outcrops, and mine dumps in areas outside the study area were collected and analyzed to characterize the geochemistry of both mineralized rocks within the study area and to compare them with nearby ore deposits. The nonmagnetic fraction of heavy-mineral concentrates was panned from active streams at 31 sites, including two from the south side of the Hart mining district and one from the Leiser Ray mine in the Signal mining district. The nonmagnetic fraction of stream sediments tends to concentrate minerals related to mineralization and alteration.

The rock and nonmagnetic concentrates were pulverized and analyzed by a semiquantitative emission spectrographic method (Grimes and Marranzino, 1968; Motooka and Grimes, 1976) for 31 elements, including silver (Ag), arsenic (As), gold (Au), barium (Ba), bismuth (Bi), copper (Cu), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), antimony (Sb), tin (Sn), vanadium (V), tungsten (W), and zinc (Zn). In addition, the rocks were analyzed by atomic-absorption methods for Au (Thompson and others, 1968), As, Bi, Sb, and Zn (Viets, 1978), and mercury (Hg) (McNerney and others, 1972; Vaughn and McCarthy, 1964). The distribution of all geochemical sample sites and the numbers of anomalous sample sites are shown on plate 1.

Relatively few samples collected in the study area have anomalous values for the elements sought, and only rare samples are anomalous for more than two elements. Anomalous values are defined relative to threshold values that vary according to sample and rock types. Threshold values for rocks were based on average concentrations of the elements sought, compared with values both in unaltered unmineralized rocks and in mineralized rocks collected at mining sites near the study area. Threshold values for concentrates were based on experience of the most common values for the sample medium in the region. Any detectable level of Au, As, or Sb is considered anomalous in stream-sediment concentrates.

In the southern part of the study area, three stream-sediment concentrates collected near Fort

Piute (site 70, pl. 1) and at sites 69 and 71 all contained highly anomalous amounts of Pb (150-10,000 ppm—threshold 100 ppm). Fragments of metallic Pb (bullets?) were identified in a sample from site 70, which contained 10,000 ppm Pb. Rock samples collected from outcrops in Fort Piute canyon (site 70) contain 7 ppm Sb (threshold 3 ppm) and 150 ppm Pb (threshold 70 ppm). No evidence of mineral deposition was observed in Fort Piute canyon, and most stream-sediment samples showed lower than threshold values for Pb, so that human contamination most likely accounts for the Pb anomalies.

Cobbles of light-colored rhyolite and andesite were collected in the stream bed of Fort Piute canyon. Both cobbles contain disseminated pyrite and anomalous concentrations of As and Sb. However, these rock types are not known to crop out in the Piute Range and probably are detritus derived from the Castle Mountains.

Small quantities of lead-rich ore, containing 15 ppm Ag (threshold 1 ppm), 81 ppm As (threshold 10 ppm), 7000 ppm Cu (threshold 100 ppm), 10,000 ppm Pb, and 25 ppm Sb, were found at site 69, which is outside the study area boundary. The ore came from an unknown source (probably not inside the study area), and apparently was processed at an abandoned ranch located at site 69.

At site 252, approximately 3 mi north of Fort Piute canyon, a sample of granite from outcrop had a slightly anomalous concentration of Sb (5 ppm), and a stream-sediment concentrate collected downstream from the outcrops contained a flake of gold. One mi to the north (site 448), a stream-sediment concentrate contained no anomalies, but cobbles of limonitic, brecciated quartz and granitic rocks with disseminated epidote and pyrite all were found in the sediment sample. The cobble of brecciated quartz contained 8 ppm Au (threshold 0.1 ppm) and 15 ppm Ag. Farther north (site 247), a cobble consisting of gossan contained anomalous amounts of As (200 ppm) and Sb (40 ppm). Two miles northeast (site 73), another cobble from stream sediments contained anomalous concentrations of As (36 ppm) and Sb (8 ppm). These anomalies could indicate the presence of covered mineral deposits similar to those of the Signal or Exchequer districts. In particular, the presence of gold at sites 252 and 448 suggests the potential for undiscovered gold deposits in the study area.

Geophysical Studies

An aeromagnetic survey of the Fort Piute Wilderness Study Area was conducted in 1981. Total-field magnetic data were collected along easterly flightlines spaced approximately 0.5 mi apart and at a height of 1,000 ft above the terrain. Because of the rugged topography in the Piute Range, actual terrain clearance varied from about 400 ft to about 1,800 ft. Corrections were applied to the data to compensate for diurnal variations of the Earth's magnetic field, and the International Geomagnetic Reference Field (updated to 1981) was subtracted to yield a residual magnetic map (U.S. Geological Survey, 1983).

Measurements of magnetism in hand samples from the Fort Piute Wilderness Study Area indicate

that the Miocene volcanic rocks are the most magnetic rocks in the area, and that some of the Mesozoic granitic rocks also are magnetic. Although a hand sample of Proterozoic gneiss was found to be nonmagnetic, magnetic highs over the Vontrigger Hills southwest of the study area show that some rocks of inferred Proterozoic age also are magnetic. Most positive magnetic anomalies in this region are present over outcrops of Proterozoic, Proterozoic(?), and Mesozoic rocks.

Regional magnetic anomalies suggest a direct relation between the Proterozoic and Mesozoic rocks of the Exchequer mining district and those beneath the Miocene deposits in the southern part of the study area. A linear positive magnetic anomaly extends nearly 20 mi N. 50° E. from the southwest end of the Exchequer mining district and passes through the southern 40 percent of the study area. The trend and appearance of this anomaly are distinct from the magnetic signature of volcanic rocks in the study area. Along much of its length the source of the anomaly lies beneath alluvium or volcanic deposits. At both the northeast and southwest ends, the anomaly is present where Proterozoic crystalline rocks are exposed and where Mesozoic granite crops out immediately southeast of the linear anomaly trend. The correlation of the magnetic anomalies with gneiss and granite suggests that a belt of Proterozoic gneiss and intrusive granitic rocks with magnetic signature like that of the Exchequer mining district passes beneath the southern part of the Fort Piute Wilderness Study Area.

Magnetic anomalies over the Signal and Hart mining districts do not extend into the study area. The Signal district is characterized by east-oriented anomalies caused by the Proterozoic and Mesozoic granite that are exposed in Signal Hill and Homer Mountain. A large, elliptical anomaly extends northeast from the Hart mining district, passing north of the study area. This anomaly probably is related to Proterozoic(?) gneiss that is exposed in the core of the Castle Mountains anticline.

POTENTIAL FOR UNDISCOVERED MINERAL RESOURCES

Two ore-deposit models (Cox and Singer, 1986) probably account for all of the known mineral deposits in the adjacent mining districts; these models also define potential for undiscovered resources of the Fort Piute Wilderness Study Area.

(1) Mineralization of Mesozoic (Late Cretaceous?) age, found in the Exchequer and Signal mining districts, is present in mesothermal late-stage mineralized dikes, fracture zones, and quartz veins emplaced near the intrusive contact between Proterozoic gneiss and granitic plutons of the Teutonia batholith. The characteristic geochemical suite comprises Au, Ag, Cu, Pb, Zn, Mo, As, Sb, Bi, and sometimes W, Sn, and V.

(2) Altered and mineralized Miocene rocks in the Hart mining district of the Castle Mountains include kaolinized tuff and silicified breccia zones in rhyolite, which contain native gold. Breccia and quartz-vein material from Hart district mines contained anomalous

concentrations of Au, Ag, Mn, Hg, As, and Sb. This suite of elements is characteristic of epithermal deposits. At Stray Cow Well in the eastern Castle Mountains immediately north of the study area, stream cobbles of silicic extrusive rocks like those in the vicinity of Hart contain quartz veins, and outcrop samples of silicic rocks contain small amounts of Ag, As, and Sb.

Metals

Aeromagnetic, geochemical, and geologic data all indicate moderate potential for resources of gold (certainty level C) in parts of the south-central study area. See Appendix 1 for definitions of levels of mineral resource potential and certainty. Magnetic anomalies caused by pre-Tertiary rocks extend southwest from this part of the study area into the adjacent Exchequer mining district, where mineral deposits are found in veins and shear zones associated with contacts between Proterozoic and Mesozoic crystalline rocks (Hewett, 1956). Geologic mapping in the study area shows that similar contacts between foliated Proterozoic rocks and unfoliated Mesozoic granite are exposed in the south-central part. No mineralized zones are evident in the limited exposures of these pre-Tertiary rocks, but anomalous concentrations of Au (accompanied variously by Ag, As, or Sb) have been found in two stream-sediment samples collected downstream from outcrops of gneiss or granite.

Gneiss outcrops of the northern part of the study area have low resource potential for gold (certainty level C). Rock samples from Proterozoic gneiss in the northern part of the study area have low anomalous concentrations of As and Sb at two sites where some (Proterozoic?) granitic cobbles in stream sediments contained alteration minerals. The mineral potential is rated lower for these outcrops than for the south-central part of the area because the magnetic anomaly characteristic of the Exchequer mining district does not extend into this part of the study area, and geologic mapping shows that no contact zones are exposed here. Other outcrops of Proterozoic gneiss and granite occur between those rated of low or moderate potential. These outcrops lie north of the magnetic anomaly and are not in contact with Mesozoic granite, and rock and sediment samples collected nearby have no geochemical anomalies. Thus, no resource potential is assessed for these outcrops.

The results of this study indicate that there is no potential in the study area for resources of gold, kaolinite, or perlite related to Miocene rocks or mineralization. Geologic mapping indicates that Miocene rocks of the Castle Mountains, which contain resources of gold, kaolinite, and perlite, do not extend beneath the Piute Range. The characteristic suite of anomalous elements in mineralized rocks of the Castle Mountains is absent in stream-sediment concentrates and in Miocene volcanic rocks of the Piute Range.

Placer Gold

Anomalously high concentrations of gold were

found in one stream-sediment concentrate (site 252) and in a cobble from another stream-sediment sample (site 448) in the south-central part of the study area. These values indicate that resources of placer gold may exist in the study area. The sampling program undertaken does not provide an estimate of average gold concentrations in sand and gravel, and thus the data are inadequate to determine whether or not the gold values are characteristic of this part of the study area; thus the potential for placer gold is unknown.

Energy Resources

The U.S. Geological Survey (Calzia and others, 1979) has classified the north end of the Piute Range as prospectively valuable for geothermal resources, based on one drill hole site (north of the study area boundary) that has water with a temperature slightly higher than ambient for the region. Deposits of tufa found along north-trending faults in gneiss and granite 1 mi east of the study area boundary indicate that hot springs activity occurred perhaps as recently as 10,000 years ago. However, there is no known evidence of geothermal activity in the volcanic rocks of the Piute Range, and no recent geothermal activity is evident within the study area. Thus the study area is judged to have no potential for resources of geothermal energy.

No oil and gas occurrences are known within the study area. The U.S. Geological Survey (Calzia and others, 1979) has classified the Piute Valley, north and east of the Fort Piute Wilderness Study Area, as prospectively valuable for oil and gas resources, but the classification does not include the study area. Scott (1982) found that pre-Tertiary rocks throughout southeastern California, including those in the study area, generally have low or no resource potential for oil and gas because of regional Mesozoic tectonism and metamorphism. Tertiary rocks of the study area are dominantly volcanic flows and minor sedimentary deposits that are poor in organic material. Information available indicates that volcanic, metamorphic, and igneous rocks exposed in and projected to underlie the study area are unlikely to be host rocks for oil and gas. Therefore, the study area is judged to have no potential for oil and gas resources.

A gamma-ray survey conducted during the National Uranium Resource Evaluation program (Western Geophysical Company of America, 1979) found no anomalous areas of potential uranium or thorium resources within the boundaries of the study area. Thus, the area is judged to have no potential for uranium or thorium resources.

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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

| | | | | |
|---|----------------------|--------------------|--------------------|--------------------|
| <div>↑</div> <div>LEVEL OF RESOURCE POTENTIAL</div> | U/A | H/B | H/C | H/D |
| | | HIGH POTENTIAL | HIGH POTENTIAL | HIGH POTENTIAL |
| | UNKNOWN POTENTIAL | M/B | M/C | M/D |
| | | MODERATE POTENTIAL | MODERATE POTENTIAL | MODERATE POTENTIAL |
| | | L/B | L/C | L/D |
| | | | LOW POTENTIAL | LOW POTENTIAL |
| | | | N/D | |
| | | | NO POTENTIAL | |
| | A | B | C | D |
| | LEVEL OF CERTAINTY → | | | |

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

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GEOLOGIC TIME CHART

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

| EON | ERA | PERIOD | | EPOCH | AGE ESTIMATES OF BOUNDARIES (in Ma) | |
|----------------------------|------------------------|--------------------------|-------------------------|-------------------------|---|------|
| Phanerozoic | Cenozoic | Quaternary | | Holocene | 0.010 | |
| | | | | Pleistocene | | 1.7 |
| | | Tertiary | Neogene Subperiod | Pliocene | 5 | |
| | | | | Miocene | 24 | |
| | | | Paleogene Subperiod | Oligocene | 38 | |
| | | | | Eocene | 55 | |
| | | | | Paleocene | 66 | |
| | | | | Mesozoic | Cretaceous | |
| | Jurassic | Late Middle Early | 138 | | | |
| | | 205 | | | | |
| | Triassic | | Late Middle Early | | ~240 | |
| | 290 | | | | | |
| | 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 ?) ----- | | | | | 4550 |
| pre - Archean ² | | | | | | |

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

²Informal time term without specific rank.

