Mineral Resources of the Eagletail Mountains Wilderness Study Area, La Paz, Maricopa, and Yuma Counties, Arizona

U.S. GEOLOGICAL SURVEY BULLETIN 1702-G

Chapter G

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U.S. GEOLOGICAL SURVEY BULLETIN 1702

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
SOUTHWESTERN AND SOUTH-CENTRAL ARIZONA

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, Jr., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1989

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center, Box 25425
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Mineral resources of the Eagletail Mountains Wilderness Study Area, La Paz,
Maricopa, and Yuma counties, Arizona / by Robert J. Miller . . . [et al.]
p. cm. — (U.S. Geological Survey bulletin ; 1702-G)
Bibliography: p.
Supt. of Docs. no. : I 19.3:1702-G
1. Mines and mineral resources—Arizona—Eagletail Mountains Wilderness.
2. Eagletail Mountains Wilderness (Ariz.) I. Miller, Robert J. (Robert Jennings),
1949- . II. Series.
QE75.B9 no. 1702-G 557.3 s—dc20 89-600093
[TN24.A6] [553'.09791'7] CIP

STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of part of the Eagletail Mountains Wilderness Study Area (AZ–020–128), La Paz, Maricopa, and Yuma Counties, Arizona.

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Mineral Resources of the Eagletail Mountains Wilderness Study Area, La Paz, Maricopa, and Yuma Counties, Arizona

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SUMMARY

Abstract

The Eagletail Mountains Wilderness Study Area (AZ–020–128) encompasses most of the Eagletail Mountains and parts of adjoining alluvium-filled valleys. At the request of the U.S. Bureau of Land Management, mineral surveys were conducted on 78,020 acres of the wilderness study area. In this report, references to the wilderness study area refer only to that area for which mineral surveys were requested. The U.S. Bureau of Mines and the U.S. Geological Survey carried out fieldwork during 1986 and 1988 to appraise the mineral resources (known) and assess the mineral resource potential (undiscovered) of the study area.

No mineral resources were identified within the study area. Several areas have potential for undiscovered resources. One area having moderate potential for silver and lead and low potential for gold, barium, copper, manganese, molybdenum, and zinc resources extends along the length of Cemetery Ridge, which crosses the southwest boundary of the study area. An area northeast of Cemetery Ridge and extending along the south boundary of the study area has low potential for gold, silver, lead, zinc, copper, barium, manganese, and molybdenum resources. One area having moderate and an adjacent area having low potential for gold, silver, lead, zinc, and copper resources lie immediately west of and extend into the northwest corner of the study area. An area including the Double Eagle mine in the southeast corner of the study area has moderate potential for silver and low potential for gold, copper, lead, and zinc. An area along the northeast side of the Eagletail Mountains has moderate potential for gold and silver and low potential for lead, zinc, copper, and molybdenum resources. A minor amount of green tuff has been quarried along the northern boundary of the study area for use as ornamental stone. Two areas within the study area have low potential for further resources of this tuff. The northernmost of the two areas also has low potential for silver. One area southwest of Courthouse Rock near the center of the study area has low potential for perlite. An area along the southwest margin of the study area and an area along the east boundary of the study area are underlain by a thick accumulation of basin-fill sediments. These two areas have low potential for geothermal resources. The entire study area has low potential for oil and gas resources. Sand and gravel is abundant in the study area, but it has no unique properties and adequate resources are available closer to markets.

Manuscript approved for publication, March 2, 1989.

Character and Setting

The Eagletail Mountains Wilderness Study Area comprises 78,020 acres in southwest Arizona, between Phoenix and Quartzite and about 4 mi south of Interstate 10 (fig. 1). The study area includes most of the Eagletail Mountains as well as parts of the surrounding pediments and alluvium-filled valleys. Topography is extremely rugged in the main part of the Eagletail Mountains but subdued to nearly flat in the valleys and on pediments that underlie much of the study area. Elevations range from 3,043 ft on Eagletail Peak to approximately 1,300 ft in the lower parts of adjoining valleys. The pediments are underlain predominantly by crystalline rocks of Proterozoic and (or) Mesozoic age (see appendixes for geologic time chart). Upper Oligocene(?)- to Miocene-age basaltic to rhyolitic lava flows and tuffs overlie the crystalline rocks and constitute the topographically high part of the range. Faulting occurred during and following volcanism and is primarily responsible for the northwest trend of the range.

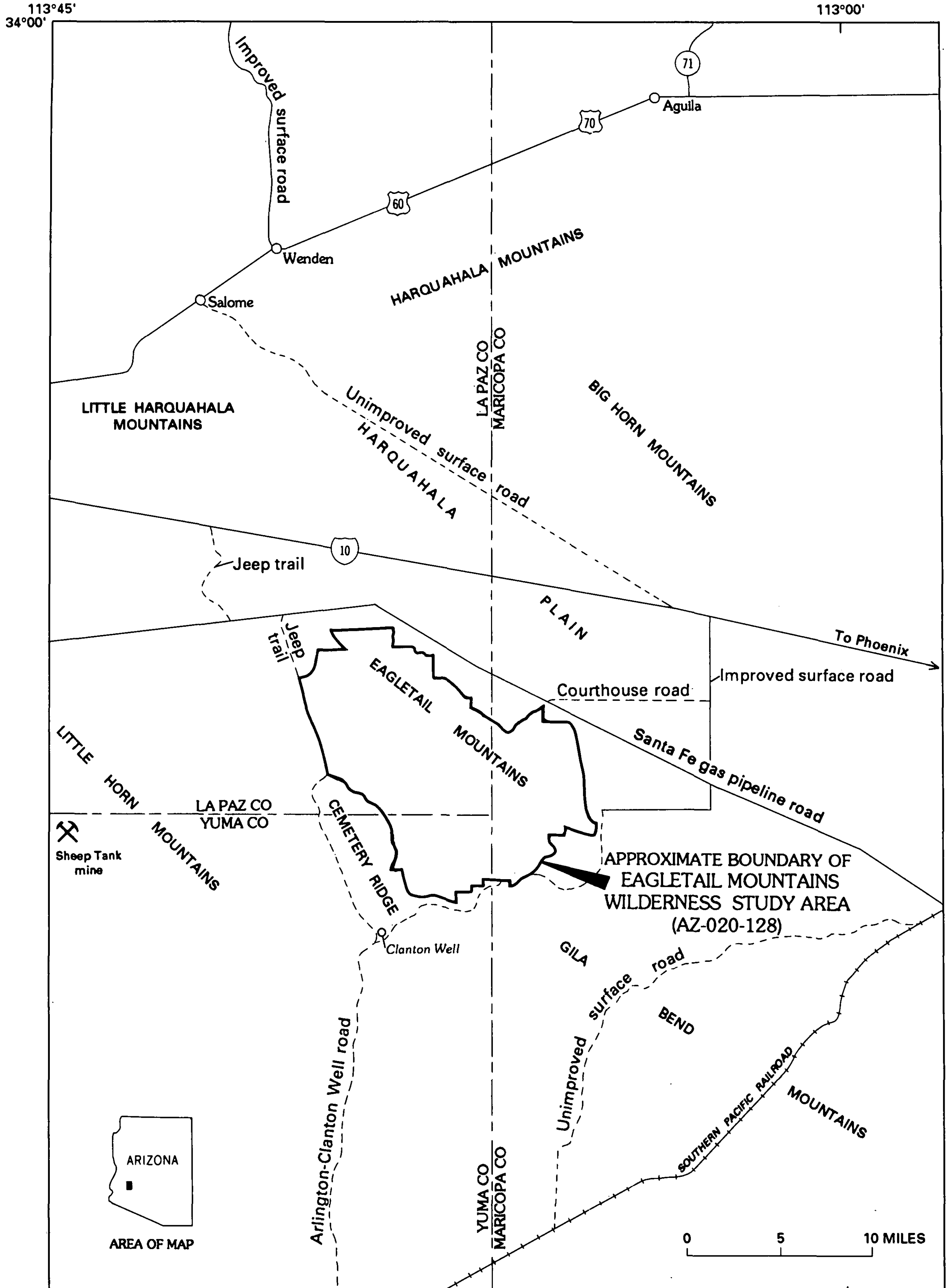


Figure 1. Index map showing location of the Eagletail Mountains Wilderness Study Area, La Paz, Maricopa, and Yuma Counties, Arizona.

Identified Resources

No mineral or energy resources were identified in the study area. Prospecting in and near the study area has been sporadic since the 1860's, but the only known production is a small quantity of manganese from prospects near Cemetery Ridge, south of the study area. The Double Eagle mine, one-third mile southeast of the study area, has no known production. Tuff, probably for use as ornamental stone, was quarried near the northwestern boundary of the study area. The amount of tuff removed, if any, is not known but was apparently quite small. Although sand and gravel are present in the study area, other deposits are more accessible and closer to existing markets.

Mineral Resource Potential

Anomalous concentrations of silver, lead, zinc, copper, molybdenum, and manganese were detected in rock or stream-sediment samples from Cemetery Ridge, south of the study area boundary. Lithologies and structures exposed on Cemetery Ridge may extend beneath a thin cover of alluvium in one area near Nottbusch Butte (pl. 1). An area including Nottbusch Butte and part of Cemetery Ridge has moderate potential for silver and lead and low potential for gold, barium, copper, manganese, molybdenum, and zinc resources in small fault-controlled epithermal vein deposits. An area northeast of Cemetery Ridge and extending along the south boundary of the study area has low resource potential for gold, silver, lead, zinc, copper, barium, manganese, and molybdenum in epithermal vein deposits. This area is covered by alluvium.

Geochemical and geologic data suggest the presence of a volcanic-hosted vein system of small areal extent immediately outside the northwest boundary of the study area. The periphery of that epithermal system may extend into the study area. One area of moderate potential and a surrounding area of low potential for gold, silver, lead, zinc, and copper resources reflect the possible extension of that epithermal system into the northwest corner of the study area.

The Double Eagle mine and vicinity are within an area having moderate potential for silver and low potential for gold, copper, lead, and zinc.

An area west of Courthouse Rock in the northeastern part of the study area has moderate potential for gold and silver and low potential for lead, zinc, copper, and molybdenum in epithermal vein deposits. Prospects in crystalline rocks of this area contain traces or minor amounts of gold and silver.

Two areas in the northern part of the study area have low potential for tuff for use as ornamental stone. The northernmost of these areas also has low potential for silver. These areas include three small quarries.

One area within the central part of the Eagletail Mountains has low resource potential for perlite resources. This area is underlain by rhyolite glass that is locally altered to perlite.

The potential for undiscovered geothermal resources is low in two areas within the study area. These areas, along the southwest and east boundaries of the study area, are underlain by thick accumulations of Quaternary sedimentary and (or) Tertiary volcanic rocks. Wells drilled near Centennial Wash northwest of the study area encountered 97-°F water that may be suitable for low-temperature geothermal applications. The crystalline and volcanic rocks that make up the Eagletail Mountains and Cemetery Ridge are not favorable source and reservoir rocks for oil and gas, hence the potential for oil and gas resources is low in the study area.

Mineral resource potential, geology, and mines and prospects of the Eagletail Mountains Wilderness Study Area are shown on plate 1. The mineral resource potential and geology of the study area are shown in figure 2.

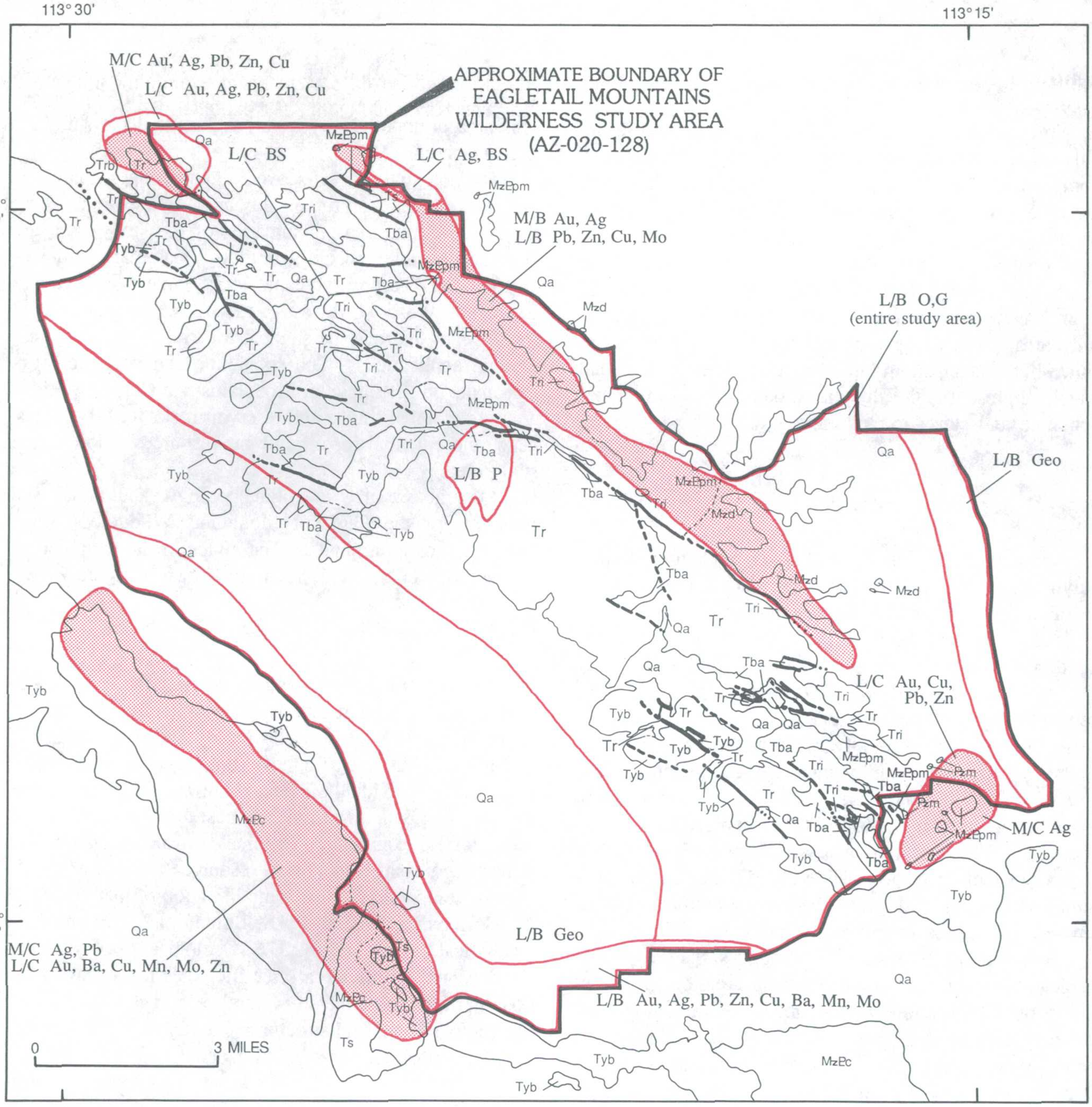
INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management and is the result of a cooperative effort by the U.S. Geological Survey and U.S. Bureau of Mines. The U.S. Bureau of Mines evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas. Identified resources are classified according to a system that is a modification of that described by McKelvey (1972) and U.S. Bureau of Mines and U.S. Geological Survey (1980). U.S. Geological Survey studies are designed to provide a scientific basis for assessing the potential for undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. Goudarzi (1984) discussed mineral assessment methodology and terminology as they apply to these surveys. See "appendixes" for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

Area Description

The Eagletail Mountains Wilderness Study Area covers 78,020 acres in southwest Arizona about 60 mi west of Phoenix and 4 mi south of Interstate 10 (fig. 1). The terrain is extremely rugged along the bedrock scarp that forms the northeast side of the Eagletail Mountains.

Access to the northeast side of the study area is provided by several jeep trails originating from the Santa Fe gas pipeline road. In addition, two dirt roads service



EXPLANATION

Area having moderate mineral resource potential (M)

Area having low mineral resource potential (L)

Levels of certainty of assessment

B Data only suggest level of potential
C Data give good indication of level of potential

Commodities

Au	Gold	Cu	Copper	P	Perlite
Ag	Silver	Mo	Molybdenum	B	Barium
Pb	Lead	Mn	Manganese	Geo	Geothermal energy
Zn	Zinc	BS	Building stone	O,G	Oil and gas

—— - - Contact—Dashed where approximately located

—— - - ·· Fault—Dashed where approximately located; dotted where inferred

Geologic map units

Qa	Alluvium (Quaternary and (or) Tertiary)
Tyb	Younger basalt (Miocene)
Tr	Rhyolite flows, flow breccias, and minor amounts of tuff (Miocene)
Tri	Rhyolite intrusive rocks (Miocene)
Trb	Rhyolite autobreccia (Miocene)
Tba	Basalt and (or) andesite flows and flow breccias (Miocene and (or) Oligocene)
Ts	Sedimentary rocks (Miocene and (or) Oligocene)
Mzd	Hornblende-biotite diorite and monzodiorite (Mesozoic?)
Pzm	Sedimentary rocks (Paleozoic)—Includes Martin, Supai, and Kaibab Formations. Metamorphosed and attenuated
MzPpm	Porphyritic monzonite to granite (Mesozoic and (or) Proterozoic)
MzPc	Crystalline rocks (Mesozoic and (or) Proterozoic)

Figure 2. Map showing mineral resource potential and generalized geology of the Eagletail Mountains Wilderness Study Area, La Paz, Maricopa, and Yuma Counties, Arizona.

wildlife watering tanks in the Eagletail Mountains, and one road from Clanton Well services two tanks north of Nottbusch Butte. Part of the southeast and west boundary of the study area parallels the Arlington-Clanton Well road, and an unnamed road that runs north from Clanton Well along part of the west boundary intersects the pipeline road.

Vegetation in the Eagletail Mountains is transitional between the Creosote-white bursage series and the Palo verde-cacti series of the Sonoran Desert biome (Turner and Brown, 1982). Creosotebush is found throughout the area. Saguaro and hedgehog cacti and paloverde have slightly higher water requirements and grow on the bajadas and mountain sides. Whitethorn acacia, ocotillo, and jojoba are common in the area.

Previous and Present Investigations

E.D. Wilson mapped the area during a reconnaissance study in the 1950's as part of the compilation of the Maricopa County geologic map (Wilson and others, 1957). That mapping provided the basis for the geology of the study area depicted on the geologic map of Arizona (Wilson and others, 1969). A reconnaissance study of the geology of the southern part of the Eagletail Mountains by Krokosz (1981) did not add significant detail to existing information. Shafiqullah and others (1980) reported potassium-argon dates of three samples of volcanic rock and one sample of diorite from the Eagletail Mountains as part of a regional synthesis of Cenozoic events in southwestern Arizona.

The U.S. Geological Survey conducted field studies in the study area during the spring of 1986 and 1987. These studies included geologic mapping and sampling of stream sediments and rocks for geochemical analysis. Available gravity, airborne magnetometer, and gamma-ray survey data were compiled and evaluated.

Investigations by the U.S. Bureau of Mines included a search of mining records and field examination and sampling of all mines and prospects within or near the study area. Sample data were discussed by Lane (1986) and complete analytical data for all samples are available for public inspection at the U.S. Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO 80225.

APPRAISAL OF IDENTIFIED RESOURCES

By Michael E. Lane
U.S. Bureau of Mines

U.S. Bureau of Mines personnel reviewed literature concerning mining and geology of the region. In addition, Bureau of Land Management records were reviewed for mining claim information, unpatented and patented claim locations, and oil and gas leases and lease applications. About 20 worker-days were spent examining mines and prospects inside and within approximately 1 mi of the study area boundary (pl. 1). Surface and underground surveys were made by compass and tape methods. Mines and prospects were mapped and sampled. In all, 69 grab, select, and chip samples were collected; 9 samples were from within the study area. All but 4 samples were fire assayed for gold and silver; selected samples were analyzed by semiquantitative emission spectrographic methods for 40 elements. Some samples contain visible copper and manganese minerals and were analyzed by atomic-absorption methods for these elements.

Mining History

The study area includes part of the Eagletail mining district, where prospecting began in the 1860's and has been sporadic since. The only reported production from this district is 40 tons of 22-percent manganese ore from an unspecified location, probably near Cemetery Ridge (Keith, 1978, p. 34–36). Decorative stone (tuff) was quarried adjacent to the northern boundary of the study area. Approximate locations of mining claims in and near the study area are shown on plate 1; no workings were found at the claims in the study area.

Energy Resources

Oil and gas leases cover most of the study area and it has low potential for hydrocarbons (Ryder, 1983, p. C19–20).

On the east, the study area bounds an "...area of significant lateral extent favorable for discovery and development of local resources of low-temperature (less than 194 °F) geothermal water..." (Sammel, 1979, map 1). To the northwest, several thermal wells were drilled in the alluvium of Centennial Wash (pl. 1). The deepest hole was 2,011 ft. These wells encountered shallow, low-temperature (95 to 104 °F) geothermal waters (Arizona Bureau of Geology and Mineral Technology, 1982).

Appraisal of Sites Examined

Six mineralized areas, one inside and five outside the study area, are examined and sampled (table 1; Lane, 1986). These areas were grouped by geographic location for discussion. Mineralization near Granite Mountain (table 1, No. 6) consists of minor amounts of silver and copper in faults cutting diorite, but the amount and extent of mineralization are small and no resources are identified. The other five areas sampled are within 1 mi of the study area: one near the north boundary of the study area, two near the southeast boundary, and two on Cemetery Ridge.

Table 1. Mines and prospects in and near the Eagletail Mountains Wilderness Study Area, La Paz, Maricopa, and Yuma Counties, Arizona

[Au, gold; Ag, silver; Cu, copper; Mn, manganese; st, short ton]

Map No. (pl. 1)	Name	Summary	Workings	Sample data
1	Unnamed prospect	Faults, fractures, and breccia in diorite, diabase, latite, and tuff; locally weathered and sheared; copper, manganese, iron (specularite) minerals; mineral occurrences scarce.	Three inaccessible shafts, 10 pits.	Two samples; one contains 0.43 percent and one contains 0.37 percent Cu.
2	Unnamed prospect	Faults in tuff	None	Four samples contain between 1.35 and 20 percent Mn.
3	Double Eagle mine	Limestone overlying phyllite; limestone and phyllite dump material; brecciated limestone in pit.	Two inaccessible shafts, one pit.	Minor Cu, 0.43 percent and 1.15 percent in two samples; one sample contains 0.01 oz/st gold; two samples contain silver, 1.8 oz/st and 0.1 oz/st.
4	Unnamed prospect	Faults and diabase dikes in granite; granite often altered, sheared, brecciated, and containing specularite, quartz veins and pods, and copper minerals; minor copper occurrences.	Three inaccessible shafts, 25 pits, 1 adit, 1 trench.	Eight samples contain between 0.092 and 10 percent Cu.
5	Unnamed prospect	Small hill composed of phyllite near Double Eagle mine; numerous quartz veinlets and pods.	Three small pits	One sample contains a trace of gold; two samples contain 0.1 oz/st silver.
6	Victory claim	Faults in diorite(?); specularite	One shaft, one adit, two pits.	One sample contains 0.1 oz/st silver; two samples contain Cu, 0.274 and 0.79 percent.
7	Unnamed prospect	Tuff quarried possibly for decorative stone; operation small and apparently unsuccessful; dipping steeply toward southwest.	Three small quarries	No metal concentrations.

These five areas had detectable but not anomalous concentrations of gold, silver, copper, and manganese. Samples collected in these five areas were in short, narrow faults, fractures, and breccia zones in crystalline basement rocks and limestone. Some samples were of quartz veins or pods within faults (Lane, 1986). At these five sites, no resources are identified. In a follow-up study of acreage added after the initial U.S. Bureau of Mines study, four samples were taken near Courthouse Rock. Minor, noneconomic concentrations of gold were measured in two samples, (6 and 21 parts per billion, ppb). No other elements were found in economically significant concentrations.

Three quarries in green tuff, less than 0.25 mi north of the study area, were sampled (table 1, No. 7). The tuff dips steeply southwest and may underlie the northern part of the study area. Anomalous concentrations of metallic elements were not detected in samples of the tuff. The tuff was probably quarried for use as decorative stone (Lane, 1986).

Conclusions

No mineral resources were identified in the study area; mineral occurrences are widely scattered, sparse, discontinuous, and low in metal content. Decorative stone (tuff) was quarried adjacent to the northern boundary of the study area. This tuff dips steeply toward the study area. If the tuff extends into the study area, it would be too deep to mine by surface methods; the likelihood for its development is low.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Robert J. Miller, Floyd Gray, Jerry R. Hassemer, William F. Hanna, James A. Pitkin, *and* Michelle I. Hornberger
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Geology

The Eagletail Mountains are a structurally controlled northwest-trending ridge of Proterozoic and (or) Mesozoic crystalline rocks unconformably overlain and intruded by middle Tertiary silicic volcanic and hypabyssal rocks and overlain by minor amounts of sedimentary rocks. Proterozoic and (or) Mesozoic megaporphyritic quartz monzonite to granite and associated mafic rocks form much of the northeast side of the range. The megaporphyritic quartz monzonite underlies much of the pediment area near Courthouse Rock (pl. 1). Potassium feldspar megacrysts in the unit range from 0.5 to 3 in. in size and typically make up 10–30 percent of the rock. This unit is mesoscopically similar to the granitic rocks of the Sore Fingers crystalline complex of Richard (1982) in the Little Harquahala Mountains north of the study area. Shafiqullah and others (1980) and Rehrig and Reynolds (1980) reported an Early Cretaceous minimum age for the granitic rocks of the Sore Fingers crystalline complex. Intrusions of diorite and pendants of schist, orthogneiss, and hornblendite are distributed sporadically in the quartz monzonite. Weakly foliated to unfoliated aplite and fine-grained leucocratic granite dikes and pods also predate the quartz monzonite. Hornblende-biotite diorite underlies most of Granite Mountain on the northeast side of the study area. This diorite appears to intrude the quartz monzonite. A potassium-argon age of 52 Ma (million years before present) was obtained on biotite from the diorite (Shafiqullah and others, 1980); however, the presence of a pervasive foliation suggests that this is probably a minimum age for the intrusion of the body.

Cemetery Ridge is underlain by an assemblage of weakly to unfoliated fine-grained granite, hornblende pegmatite, diorite, and small bodies of hornblendite. The age of these crystalline rocks is not known. The megaporphyritic quartz monzonite exposed in the Eagletail Mountains does not occur near Cemetery Ridge.

Crystalline basement exposures northeast of the Eagletail Mountains are intruded by a northwest-trending swarm of dikes of diverse compositions. Most dikes are rhyolitic, rhyodacitic, and basaltic and probably represent feeders for the middle Tertiary volcanic rocks. Aphyric rhyolite and chloritized mafic dikes are also present and may be pre-Tertiary in age.

Metamorphosed Paleozoic sedimentary rocks are exposed at the southeastern end of the range at the Double Eagle mine and in two small hills surrounded by pediment gravels. Massive dolomitic marble form the most prominent exposures, and thinly bedded phyllitic shale and minor marble are exposed nearby. These lithologies represent an extremely attenuated, overturned section of the Martin, Supai, and Kaibab Formations, respectively (Stephen Reynolds, oral commun., 1988). Metasedimentary and metavolcanic rocks are also exposed in pediment hills southeast of the study area and are locally intruded by granite.

Cobble conglomerates and minor weakly indurated arkosic sandstone were locally deposited on crystalline rocks prior to inception of volcanism. A silicic tuff, altered to a distinctive green color, overlies and may be interbedded locally with the conglomerate. The overlying Tertiary volcanic rocks consist of basaltic andesite at the base, followed upward by a thick sequence of intermediate and silicic flows, and tuffs of early Miocene age. A potassium-argon age of 23.7±0.7 Ma has been obtained from an ash-flow tuff near the base of the volcanic sequence (Shafiqullah and others, 1980). Rhyolitic domes, flows, and tuffs unconformably overlie the other volcanic rocks. A shallow-dipping rhyolite flow near the center of the range yields an age of 19.0±0.4 Ma (R.J. Miller, 1988, unpub. data). A nearly flat-lying unit of basalt and andesite caps the sequence.

The present range front roughly coincides with a high-angle normal fault that brings pre-Tertiary basement rocks against Tertiary volcanic rocks. This fault predates the later phase of volcanism and provided a path for several rhyolite intrusions. The older part of the volcanic sequence strikes parallel to the range and is rotated to a present dip of 30° to 70° SW. The major part of this rotation occurred between approximately 20 and 22 million years ago, which is consistent with the timing of similar events in the Kofa National Wildlife Refuge area reported by Sherrod and others (1988). Large amounts of vertical rotation are generally attributed to movement along low-angle detachment faults. The Eagletail Mountains may lie in the upper plate of a regional detachment fault; however, the presence of such a structure has not been documented in or near the study area. Low-angle faults separating volcanic units from underlying crystalline rocks were mapped in the central part of the Eagletail Mountains and near Nottbusch Butte. These faults are not considered to be of regional extent, however.

Geochemistry

A reconnaissance geochemical survey of the Eagletail Mountains Wilderness Study Area was conducted in 1986. This survey included nearby areas of known mineralization.

Samples were collected in and near the Eagletail Mountains Wilderness Study Area; these included 178 sieved stream-sediment samples, 160 nonmagnetic heavy-mineral concentrate samples and 30 panned heavy-mineral-concentrate samples. An additional 46 rock samples and 1 water sample were also collected. Complete analytical data and descriptions of analytical procedures were provided by J.R. Hassemer (unpub. data, 1988). Data from the National Uranium Resource Evaluation (NURE) program (Bennett, 1981) were also used in the geochemical evaluation. Samples collected during that study were mostly located outside the study area, but they provide regional geochemical information, especially for uranium and thorium.

Analytical Methods

In both the U.S. Geological Survey and the NURE studies, stream-sediment material was passed through 100-mesh stainless-steel screens. The fine fraction was retained for analysis. The nonmagnetic heavy-mineral-concentrate samples were produced from a sediment sample by hand panning followed by heavy-liquid immersion and electromagnetic separation. At 30 sites, a separate sample was collected and hand panned but was not concentrated further. Rock samples were crushed, pulverized, and then analyzed.

All sediment and rock samples were analyzed for 31 elements by a semiquantitative six-step, direct-current arc, optical-emission spectrographic method (Myers and others, 1961; Grimes and Marranzino, 1968). Rock samples were also analyzed for arsenic, antimony, bismuth, and cadmium by an inductively coupled plasma–emission spectroscopic method (Crock and others, 1987). The minus-100-mesh stream sediments were analyzed for uranium and thorium by a neutron-activation method (Millard and Keaton, 1982). Panned heavy-mineral concentrates were analyzed for gold and platinum by atomic-absorption spectroscopy (J.R. Hassemer, unpub. method based on modifications of Thompson and others, 1968, and Swider, 1968).

Results

The level at which the concentration of an element was considered anomalous was determined by inspection of histograms, percentiles, and enrichment relative to crustal abundance. Antimony, arsenic, barium, beryllium, bismuth, cadmium, chromium, cobalt, copper, gold, iron, lead, manganese, molybdenum, nickel, silver, tin, thorium, tungsten, and zinc were detected in anomalous concentrations in some samples.

On the basis of data from rock samples collected from a few mines and prospects in and near the study area, silver, arsenic, copper, lead, and zinc are characteristic of the deposits that may be found in the study area.

Antimony was detected in only a few rock samples from the Double Eagle mine area and from prospects near Cemetery Ridge. Except for samples collected near the Double Eagle mine, most rock samples from mines and prospects contain barium and manganese. However, nonmagnetic-concentrate samples collected near the Double Eagle mine and prospects 1 mi east of the Double Eagle mine contain anomalous concentrations of barium. Therefore, barium and manganese(?) may occur on the outer fringes of deposits in the Double Eagle mine area.

Data from the stream-sediment samples indicate that anomalous concentrations of zinc are ubiquitous in the study area, but only at threshold levels of 100–200 parts per million (ppm). Arsenic, also at low levels (10 ppm), is common in the stream-sediment samples collected in the study area. Where pre-Tertiary rocks crop out in the stream drainages, one or more (but not all) of the metals including silver, molybdenum, lead, copper, and manganese generally occur at low levels.

Sediment samples collected from small drainages northwest of the study area boundary contain anomalous concentrations of beryllium, arsenic, silver, copper, lead, molybdenum, and zinc. That area is underlain by rhyolite autobreccia possibly related to near-vent dome-forming processes and is a possible exploration target for base- and precious-metal (gold, silver, copper, lead, and zinc) deposits.

In the central part of the Eagletail Mountains, west and northwest of Courthouse Rock, molybdenum is detected at or slightly above threshold-levels in some of the sieved-sediment and panned-concentrate samples. The significance, if any, of this weak anomaly is not known.

Weak anomalies of threshold-level tin in sieved sediments occur near Eagletail Peak. However, only trace amounts of cassiterite (a tin mineral) were observed in many of the nonmagnetic concentrates throughout the wilderness study area. The single sample tested (and confirmed to contain cassiterite) by X-ray-diffraction analysis (S.J. Sutley, oral commun., 1987) was from an area where tin concentrations are below threshold levels.

Uranium was not detected in anomalous concentrations in any of the sieved stream-sediment samples; none of the values exceed 10 ppm uranium. The NURE results are similar in that no concentrations exceed 6 ppm; NURE water samples do not exceed concentrations of 5 ppm uranium (Bennett, 1981). The one water sample collected in this survey, from a tank at Clanton Well, contains only 3 parts per billion (ppb) uranium; thus, there is no geochemical indication of a uranium-bearing mineral deposit in the wilderness study area.

Scattered, weak anomalies of thorium in the nonmagnetic samples as well as the occasional grain of scheelite (a tungsten mineral) or fluorite are also considered of little significance. Thorium values in samples collected during the NURE program in and near the wilderness study area do not exceed 35 ppm.

Geophysics

Gravity and Aeromagnetic Studies

The Eagletail Mountains Wilderness Study Area is covered by regional gravity (Aiken, 1976; Lysonski and others, 1980a, b; Aiken and others 1981) and magnetic (LKB Resources, Inc., 1980) surveys having sufficient resolution to define features of several square kilometers or more in area. Contours of complete (terrain-corrected) Bouguer gravity anomalies are defined by about 30 observation points within the study area and another 60 points immediately surrounding the study area. Contours of magnetic anomalies are defined by measurements made along seven east-west flightlines and two north-south tielines. The flightlines and tielines were spaced, on average, about 3 mi and 12 mi apart, respectively, and were flown at a nominal altitude of 360 ft above ground.

The aeromagnetic data were reprocessed to incorporate a more accurate geomagnetic reference field, identify errors in flightline locations, and smooth the effects of these location errors. The resulting map, generally consistent with but slightly more detailed than those previously produced (Sauck and Sumner, 1970; LKB Resources, 1980), was generated using a Fourier filtering algorithm (Hildenbrand, 1983) which passes anomaly wavelengths greater than 6 mi.

The Bouguer gravity anomaly map (fig. 3) shows that the central and northwestern part of the study area is dominated by a large-amplitude gravity low bounded by steep gradients and that the eastern part of the study area is dominated by an equally prominent gravity high. The low tends to conform to much of a large tract of felsic volcanic rocks and alluvium, whereas the high is associated with a diversity of Proterozoic and (or) Mesozoic intermediate to mafic plutonic rocks and overlying felsic volcanic rocks. Basaltic andesite in the study area is too thin, too vesicular, or both, to generate detectable highs. Salient lows northeast and northwest of the study area are associated with low-density basin fill of substantial thickness beneath Harquahala Plain; to the northeast, basin fill is about 1.5 mi thick (Oppenheimer and Sumner, 1980).

The magnetic anomaly map (fig. 4) is characterized by a northwest-trending band of magnetic lows traversing the south-central part of the study area and by prominent highs at or near the north-central, southeast, and southwest margins of the study area. Interpretation of this map requires caution because the large flightline spacing in relation to altitude leads to aliasing, a spectral phenomenon produced

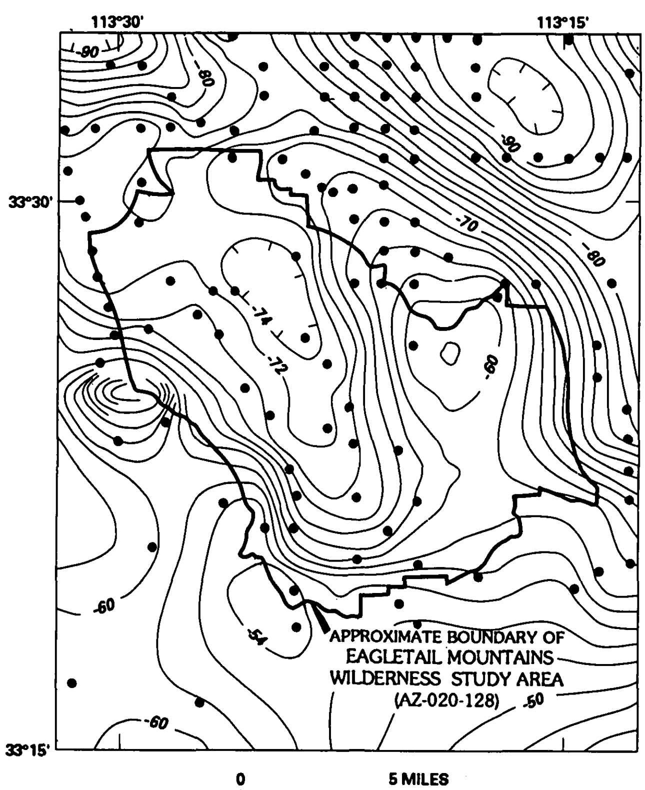

Figure 3. Bouguer gravity anomaly map of the Eagletail Mountains Wilderness Study Area, La Paz, Maricopa, and Yuma Counties, Arizona. Contour interval 2 milligals; hachured in direction of low values. Dots represent gravity stations.

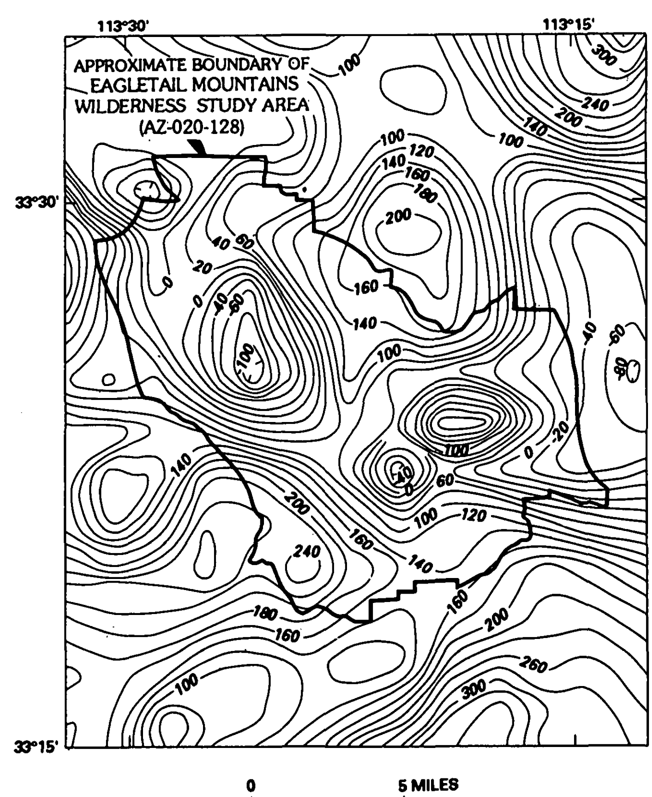

Figure 4. Aeromagnetic anomaly map of the Eagletail Mountains Wilderness Study Area, La Paz, Maricopa, and Yuma Counties, Arizona. Contour interval 20 nanoteslas; hachured in direction of low values.

by undersampling to the extent that anomalies may be incorrectly contoured across flightlines. An excellent example of this phenomenon is shown by the elliptical high near the east border of the study area. Both of the closest east-west flightlines completely missed this feature. Fortuitously, a single north-south tieline intersected the feature. On the basis of the gravity data, this anomaly is inferred to be caused by Proterozoic and (or) Mesozoic and Mesozoic(?) basement rocks, rather than by volcanic rocks, such as those which generate the small circular low immediately southwest of the elliptical anomaly. The band of lows is inferred to be caused by thin, strongly magnetized basalt flows. The broad neighboring highs appear to be the more magnetic components of the crystalline terrane, which includes plutonic rocks ranging from granite to hornblendite.

The most significant geophysical features in this study area are outlined in figure 5; the hachured line separates the relatively low-density, mostly felsic volcanic rock terrane from a terrane underlain at shallow depths by higher density diorite and related crystalline rocks. Iterative gravity modeling along profiles indicates that if the average density

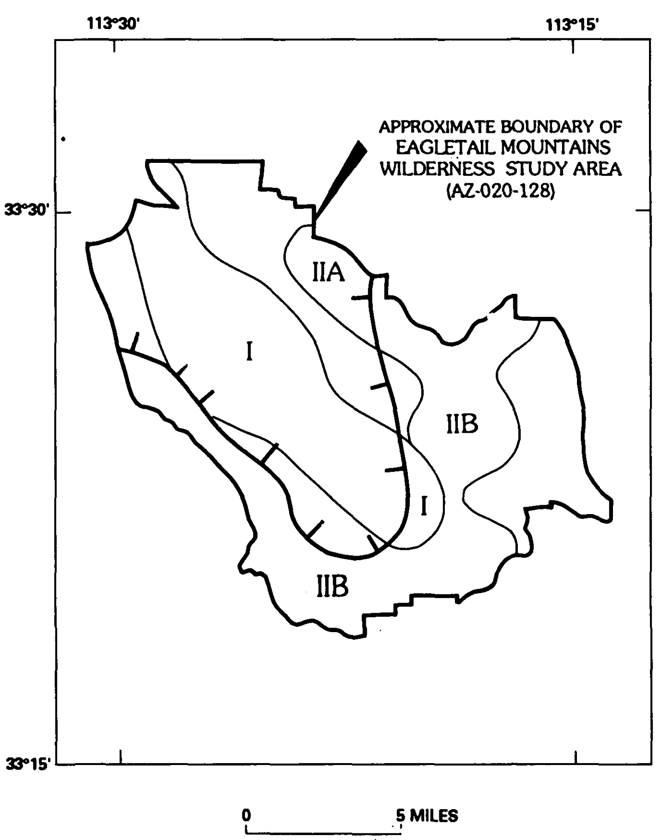

Figure 5. Regions of geophysical significance in the Eagletail Mountains Wilderness Study Area, La Paz, Maricopa, and Yuma Counties, Arizona. Hachured line approximately separates low-density volcanic rock terrane (I) from higher density diorite and related rocks (IIA, IIB). See text for detailed discussion.

contrast between volcanic and basement rocks is about 0.35 grams per cubic centimeter (g/cm^3), which is expected from the lithologies mapped, the volcanic pile reaches a thickness of at least 0.7 mi in the study area. The steep gradients at the margins of the gravity features suggest that much of the boundary that separates these two terranes may be controlled by steeply dipping faults.

Region I, shown on figure 5, which is mostly confined to the terrane northwest of the hachured line, is underlain in part by basalt of varying thickness with a strong reversed magnetization. It is not known whether basalt mapped southeast and south of the region has a similar magnetic property because flightlines did not cross these exposures. If the basalt possesses a maximum total magnetization of about 10 A/m (amperes/meter) and a ratio of remanent to induced magnetization of about 20, as some other basalts in central Arizona do, two local lows in this region could be produced: one low by a 15- to 30-ft thickness of basalt and one broader low by a 60-ft thickness of basalt.

Region II is divided into part A, northwest of the hachured line, and part B, on the other side of the line. Part IIA is underlain by dioritic and monzonitic rocks that have moderately strong normal magnetization but which, on the basis of gravity anomaly data, are not as thick as rocks in adjacent areas. Felsic subvolcanic rocks that crop out nearby may laterally intrude this diorite and quartz monzonite at depth. It is not possible to accurately estimate at what depth this intrusion might occur; however, in plan view, it would be mostly confined within the study area to part IIA.

Part IIB, which within the study area forms an arcuate trace, is underlain by dioritic, monzonitic, and related rocks that are both fairly dense and moderately to strongly magnetic. This terrane, like most other basement terranes in central Arizona, is characterized by normally polarized magnetization. The local high-amplitude high, detected by a north-south tieline, has a wavelength that suggests the felsic volcanic rock cover is no more than about 1,500 ft thick above the causative source rock.

Aerial Gamma-Ray Spectrometry

Aerial gamma-ray spectrometry is a geophysical technique that measures the near-surface (0- to 1.50-ft depth) distribution of the natural radioelements potassium (K), uranium (eU), and thorium (eTh). Because this distribution is controlled by geologic processes, aerial gamma-ray measurements can be used in geologic mapping, in mineral exploration, and in understanding geologic processes. Calibration of aerial systems at sites of known radioelement concentrations permits survey results to be reported in percent for K and in parts per million for eU and eTh. The "e" (for equivalent) prefix denotes the potential for disequilibrium in the uranium and thorium decay series.

The spectrometric data discussed in this report were obtained by the NURE Program of the U.S. Department of Energy (DOE). Data acquisition was keyed to 1° by 2° topographic quadrangles and flightline spacing was usually at 3- and 6-mi intervals. Spectrometric data described in this report were derived from the NURE report for the Phoenix 1° by 2° quadrangle (LKB Resources, Inc., 1979). The wide spacing meant that the data were suitable for contour and other maps only at scales of 1:500,000 and smaller. All NURE flight altitudes were 400 ft above ground level. (An aerial gamma-ray system at 400 ft above ground level effectively detects terrestrial gamma radiation from an 800-ft-wide swath along the flightline).

Examination of radioelement maps that include the Eagletail Mountains Wilderness Study Area indicates that it is characterized by radioelement concentrations of 1.5 to 3 percent K, 3 to 4 ppm eU, and 5 to 15 ppm eTh. These concentrations are controlled by the location of the NURE flightlines relative to the wilderness study area. The concentrations are reasonable for the Proterozoic and (or) Mesozoic crystalline rocks, Tertiary volcanic rocks, and Quaternary sedimentary rocks that occur in the study area.

Mineral Resource Assessment

Gold, Silver, Copper, Lead, Zinc, Manganese, Molybdenum, and Barium

Geochemical and geologic data suggest that the gold and silver mineralization in the region was primarily deposited by epithermal systems. The occurrences in the study area are divided into two types. The most widespread type involves small fault-controlled vein deposits hosted by Proterozoic and (or) Mesozoic crystalline rocks. The second type occurs within, and is hosted by, a thick sequence of middle Tertiary volcanic rocks. The age of both types of mineralization is probably middle Tertiary and may be contemporaneous with local volcanism.

Along the northeast slope of the Eagletail Mountains, epithermal vein deposits typically contain specularite and quartz. These veins are localized along faults and shears generally having a northwest strike. The northwest direction parallels the trend of a middle Tertiary dike swarm as well as high-angle normal faulting that controls the topographic expression of the range.

Immediately northwest of the study area, stream-sediment samples contain anomalous concentrations of arsenic, lead, zinc, barium, and minor concentrations of molybdenum and silver. Rhyolite autobreccia near this geochemical anomaly is generally unaltered but extensively cut by manganiferous calcite veinlets. A sample from argillic alteration of tuff along a fault in the same area contains a trace of gold, and samples from jasperoid veins contain elevated levels of arsenic and antimony (800 and 500 ppm, respectively). Gold mineralization at the Sheep Tank mine, 20 mi west of the study area, occurs in volcanic rocks of the same age and similar structural setting (Cousins, 1984). At the Sheep Tank mine, low-angle faults or breccia zones controlled the gold deposition. Low-angle faults are not exposed near the geochemical anomaly in the northwest corner of the study area. One area, defined by geochemical data, has moderate potential (certainty level C) for gold, silver, lead, zinc, and copper resources. An area having low resource potential for the same elements (certainty level C) is defined by the extent of autobrecciated rhyolite.

The Double Eagle mine area, at the southeast end of the Eagletail Mountains, is a pediment surface covered by alluvium. Mineralization at the Double Eagle mine occurs in open-space fracture-filling veinlets containing galena, sphalerite, and fluorite. Mines and prospect pits near the Double Eagle mine are typically located along fault shears in Proterozoic and (or) Mesozoic intermediate plutonic rocks. Mineralization consists of specular hematite veinlets and quartz veins containing specular hematite and minor amounts of copper minerals. The area including the Double Eagle mine and nearby prospects has moderate potential (certainty level C) for silver. This area also has low potential (certainty level C) for gold, copper, lead, and zinc.

One area along the northeast flank of the Eagletail Mountains includes scattered geochemical anomalies of silver, lead, molybdenum, barium, and minor gold. Samples collected from prospect pits along specularite, quartz, and rare fluorite-bearing shears in crystalline rocks contain minor or trace amounts of these elements. This area has moderate potential (certainty level B) for gold and silver and low potential (certainty level B) for lead, zinc, copper, and molybdenum in small epithermal vein deposits.

Cemetery Ridge, located along the southwestern boundary of the study area, is underlain by crystalline rocks that are extensively brecciated and cut by Tertiary dikes. This area has moderate potential for silver and lead and low potential for gold, barium, copper, manganese, molybdenum, and zinc (both certainty level C). Deposits in this area are likely to consist of fault-controlled epithermal veins similar to the Yellow Breast mine, 3 1/2 mi southwest of the study area. Manganese also fills veins and breccia in Tertiary volcanic rocks near Cemetery Ridge. An area northeast of Cemetery Ridge and extending along the south boundary of the study area has low potential (certainty level B) for gold, silver, lead, zinc, copper, barium, manganese, and molybdenum. In this area, alluvium may conceal possible mineralization.

Perlite

An area near the center of the Eagletail Mountains Wilderness Study Area has low potential (certainty level B) for perlite. The perlite occurs at the base of thick, shallow-dipping rhyolite flows. The flows are part of the post-rotational sequence of volcanic eruptions, 19 to 20 million years in age, in the range and overlie air-fall tuff. Perlite formed when the glassy base of the flows was locally hydrated.

Ornamental and Building Stone

A lithic-rich rhyolitic tuff has been quarried at three locations near the north-central boundary of the study area. This tuff has a distinctive green color and was apparently quarried for use as ornamental stone. The amount of production (if any) from these operations is not known but must be very small. Two areas within the study area have low potential (certainty level C) for further resources of this tuff. One of those areas also has low potential for silver (certainty level C).

Energy Resources

Wells drilled in Centennial Wash north of the study area have encountered warm water that is possibly suitable for low-temperature geothermal uses (Sammel, 1979). Geophysical data indicate a substantial increase in the thickness of alluvium and valley-fill sedimentary rocks near the east boundary of the study area. The southwestern part of the study area is also underlain by a thick sequence of sedimentary and (or) volcanic rocks. These areas may have an environment similar to that of Centennial Wash and, therefore, have low potential (certainty level B) for low-temperature geothermal resources.

The crystalline and volcanic rocks that compose the Eagletail Mountains and Cemetery Ridge are not favorable source rocks for oil and gas, hence the study area has low potential (certainty level C) for oil and gas resources.

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APPENDIXES

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

LEVELS OF RESOURCE POTENTIAL

H **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.

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

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

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

U **UNKNOWN** mineral resource potential is assigned to areas where information is inadequate to assign a low, moderate, or high level of resource potential.

LEVELS OF CERTAINTY

A Available information is not adequate for determination of the level of mineral resource potential.
B Available information only 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.

LEVEL OF RESOURCE POTENTIAL ↑

A	B	C	D
U/A UNKNOWN POTENTIAL	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
	M/B MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/D MODERATE POTENTIAL
	L/B LOW POTENTIAL	L/C LOW POTENTIAL	L/D LOW POTENTIAL
			N/D NO POTENTIAL

LEVEL OF CERTAINTY →

Abstracted with minor modifications from:

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

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

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RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from McKelvey, V.E., 1972, Mineral resource estimates and public policy: American Scientist, v. 60, p. 32-40; and U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, p. 5.

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 MILLION YEARS (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	[1]~570
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.