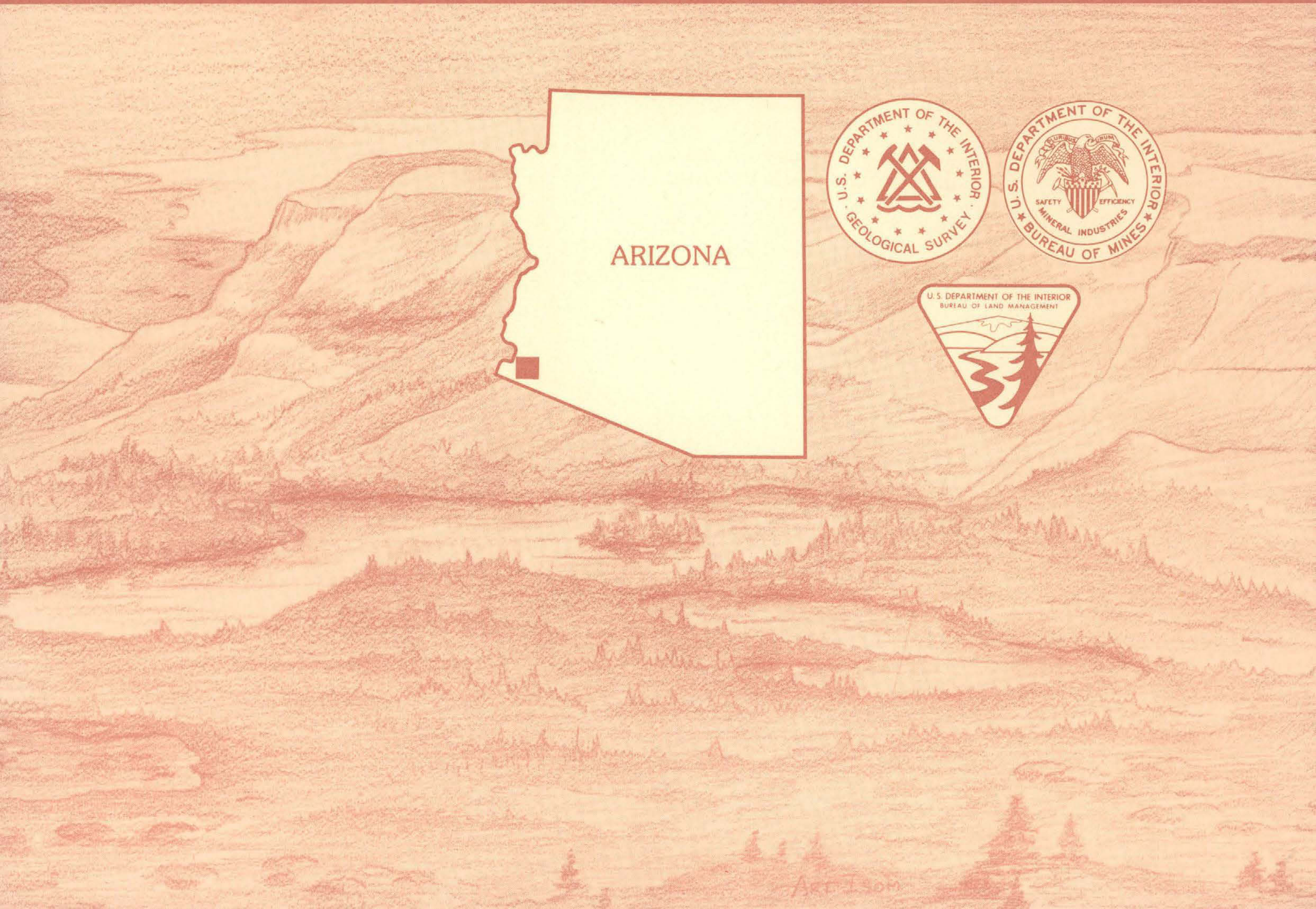
Mineral Resources of the Muggins Mountains Wilderness Study Area, Yuma County, Arizona

U.S. GEOLOGICAL SURVEY BULLETIN 1702–D



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Chapter D

Mineral Resources of the Muggins Mountains Wilderness Study Area, Yuma County, Arizona

By DAVID B. SMITH, RICHARD M. TOSDAL,
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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

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of part of the Muggins Mountains Wilderness Study Area (AZ–050–053A), Yuma County, Arizona.

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Mineral Resources of the Muggins Mountains Wilderness Study Area, Yuma County, Arizona

By David B. Smith, Richard M. Tosdal, James A. Pitkin, *and* M. Dean Kleinkopf
U.S. Geological Survey

Robert H. Wood, II
U.S. Bureau of Mines

SUMMARY

Abstract

At the request of the U.S. Bureau of Land Management, approximately 8,855 acres of the Muggins Mountains Wilderness Study Area (AZ–050–053A) in southwestern Yuma County, Arizona, was evaluated for mineral resources (known) and mineral resource potential (undiscovered). In this report, the area studied is referred to as "the study area"; any reference to the Muggins Mountains Wilderness Study Area refers only to that part of the wilderness study area for which a mineral survey was requested. Fieldwork for this report was conducted between 1983 and 1988.

Nearly half the study area is covered by unpatented mining claims, but no patented mining claims exist. There are no identified resources of metallic minerals in the study area.

The study area contains sand and gravel, and the potential for gold in placer deposits is moderate. A tract having moderate potential for uranium extends along the southeast boundary of the study area. The potential for geothermal energy resources and oil and gas resources is low in the study area.

Character and Setting

The Muggins Mountains Wilderness Study Area is located in southwestern Yuma County, Ariz., approximately 6 mi northwest of Wellton and 25 mi northeast of Yuma (fig.1). The relief with rugged hills, steep-walled arroyos, and broad sandy washes is about 1,470 ft.

The oldest rock exposed in the study area is Proterozoic augen gneiss (see "Appendixes" for geologic time chart). Paleozoic and lower Mesozoic metasedimentary rocks are exposed in a narrow east-trending mylonitic shear zone (fig. 2). The Proterozoic through lower Mesozoic rocks are intruded by monzogranite and diorite of Jurassic(?) age. The upper Oligocene(?) and lower Miocene Kinter Formation unconformably overlies the crystalline rocks. The Kinter Formation is divided into two informal members, a lower member consisting of fine-grained sandstone, siltstone, and tuff and an upper member consisting of coarse conglomerate, fanglomerate, and sandstone. Silicic volcanic flows, domes, tuff, and tuffaceous sedimentary rocks interfinger with the Kinter Formation at its margins.

Middle Tertiary volcanism, sedimentation, and extensional deformation were contemporaneous in the area. A tectonic breccia lies between the basement rocks and the volcanic flows. Latite dikes intrude the breccia, overlying conglomerate and volcanic rocks, and the underlying basement rocks. Continued extension during the Tertiary broke the area into northwest-striking, southwest-tilted blocks. Unconformably overlying all the older rocks and structures are gravel, sand, and silt deposited on the Gila River floodplain.

Identified Resources

The study area contains sand and gravel, but they have no unique qualities to make them more valuable than the vast quantities in nearby areas.

There are no identified resources of metallic minerals in the study area although about one-half of the area is covered by unpatented mining claims. Over one-third of the study area is under lease for oil and gas, but the area is untested.

The Muggins Mountains were first prospected in the 1860's for placer gold and silver. In the 1950's, U.S. Atomic Energy Commission investigators found several scattered uranium occurrences in the Tertiary sedimentary rocks in the southeastern part of the range, outside the study area.

Manuscript approved for publication April 3, 1989.

Mineral Resource Potential

The entire Muggins Mountains Wilderness Study Area has moderate potential for gold in placer deposits. This rating is based on gold anomalies in panned concentrates derived from stream sediments collected at five sampling sites within the study area and on the historical production of minor amounts of placer gold and silver from the Muggins mining district, which includes part of the study area.

One small drainage basin along the southeast boundary of the study area has moderate potential for uranium. This potential is based on anomalous concentrations of molybdenum and lead in nonmagnetic heavy-mineral concentrates derived from stream sediments and anomalous concentrations of lead in minus-80-mesh stream sediments. These geochemical anomalies are similar to those downstream from a known uranium occurrence 0.5 mi east of the study area.

The potential for oil and gas in the study area is low on the basis of unfavorable evidence for the presence of hydrocarbon source rocks. The study area has low potential for geothermal energy.

INTRODUCTION

This report presents an assessment of the identified resources and the mineral resource potential of 8,855 acres of the Muggins Mountains Wilderness Study Area (AZ–050–053A), Yuma County, Ariz. The term "study area" refers to that part of the total wilderness study area for which the U.S. Bureau of Land Management (BLM) requested a mineral survey. The study area is approximately 6 mi northwest of Wellton and 25 mi northeast of Yuma, Ariz. (fig. 1). The entire study area is located immediately south of the U.S. Army Yuma Proving Ground. Secondary roads from U.S. Highway 80 provide access to gravel and unimproved roads that, in turn, provide limited access to the study area.

The topographic relief in the study area is about 1,470 ft and elevations range from about 200 ft near the south and west boundaries to 1,666 ft at the summit of Klothos

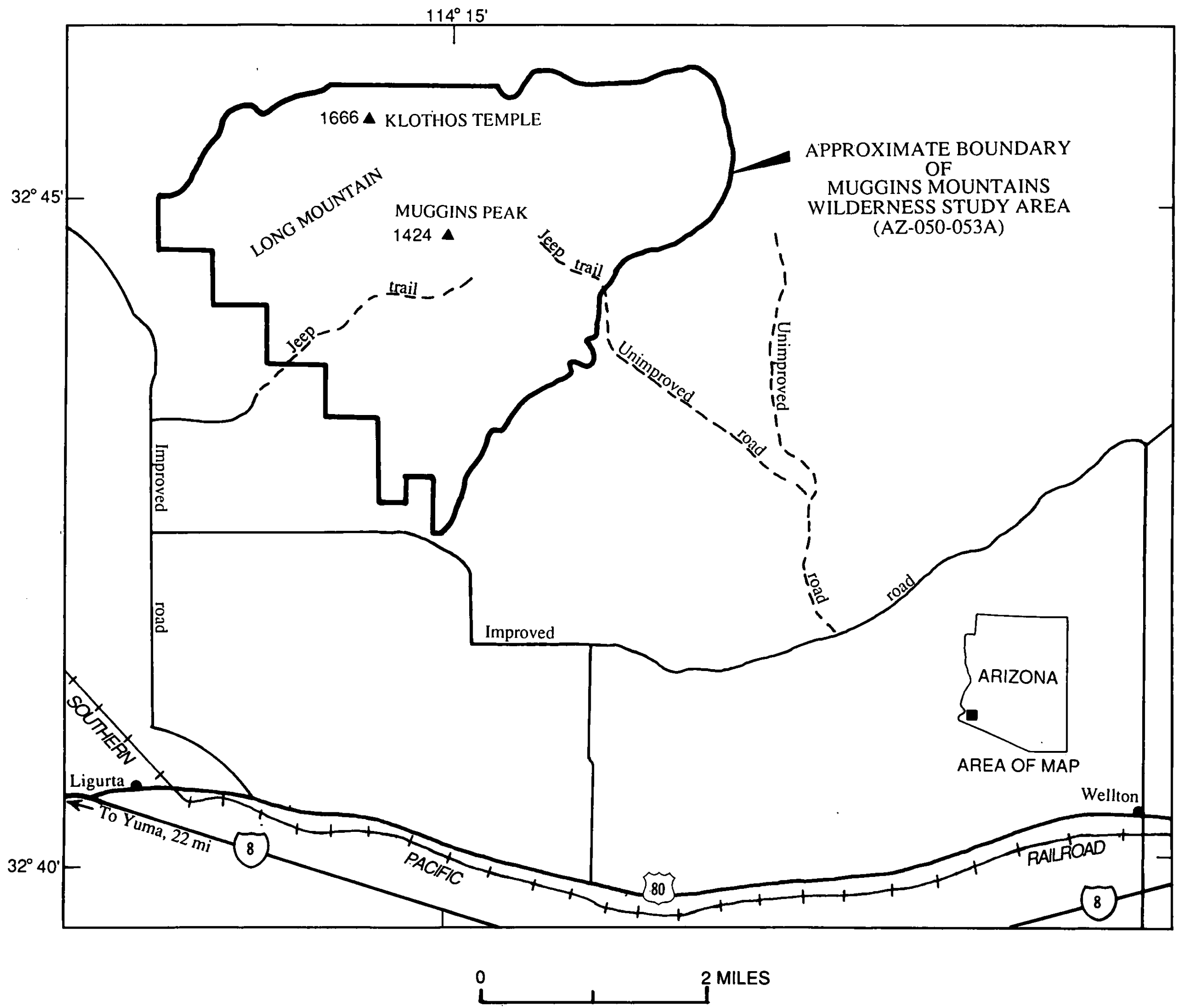


Figure 1. Index map showing location of Muggins Mountains Wilderness Study Area, Yuma County, Arizona.

Temple. Intermittent streams have dissected the area into an intricate pattern of rounded hills, flat mesas, and deep, steep-walled arroyos. Virtually all streams within the study area flow southward into the Gila River. The climate is arid with an average annual rainfall of approximately 3 in. at Yuma and 4–6 in. in the adjacent mountains (Hely and Peck, 1964).

This mineral resource study is a joint effort by the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM). The history and philosophy of such joint mineral surveys of BLM study areas are discussed by Beikman and others (1983). Mineral assessment methodology and terminology are discussed by Goudarzi (1984). Studies by the USGS are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, and presence of geochemical and geophysical anomalies. The USBM evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, and mineralized areas. Identified resources are classified according to a system that is a modification of that described by McKelvey (1972).

Acknowledgements

R.B. Vaughn assisted with the reconnaissance geochemical survey. B.M. Adrian, T.A. Roemer, K.A. Romine, and P.L. Hageman conducted chemical analyses on all samples collected by the USGS. M.J. Grubensky compiled the geologic map. We also thank BLM personnel in Yuma, Ariz., for their helpful discussions and cooperation during this project.

APPRAISAL OF IDENTIFIED RESOURCES AND KNOWN MINERALIZED AREAS

By Robert H. Wood, II
U.S. Bureau of Mines

The USBM surveys and studies mines, prospects, and mineralized areas to appraise identified mineral resources. Identified resources, as defined by the U.S. Bureau of Mines and the U.S. Geological Survey (1980), are those whose location, grade, quality, and quantity are known or can be estimated from specific geologic evidence. They include economic, marginally economic, and subeconomic components (see "Appendixes").

Personnel from USBM reviewed various sources of mineral information including published and unpublished literature. Mining claim and oil and gas lease information, current as of January 1987, was obtained from the BLM State Office in Phoenix, Ariz. Field study was concentrated on the examination of known mines, prospects, and mineralized areas inside and within 3 mi of the study area boundary; peripheral mineral occurrences were examined to determine whether they might extend into, or are similar to those within, the study area.

Thirty samples (5 rocks and 25 panned concentrates) were collected for analysis (Wood, 1988). Rock samples were collected at prospects. Panned-concentrate samples, consisting of a concentration of heavy minerals from a 16-in. gold pan heaped with minus-0.5-in. material, were collected from major drainages in and within 3 mi of the study area to obtain information regarding placer gold deposits. Analytical methods and results are discussed in Wood (1988). Complete analytical data are available for inspection at the U.S. Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO 80225.

Mining and Leasing Activity

The study area is in the Muggins Mountains, which include the Muggins mining district. The total recorded district production of placer gold and silver, until the area was withdrawn for military purposes in 1942, was 2,748 troy oz (ounce) of gold and about 500 troy oz of silver. Production data after 1981, when the study area was again opened to mining, are not available; however, there is evidence of recent placer mining in the study area. Gold placer deposits were mined in two areas: Vinegarroon Wash north of the study area and in washes draining southward from Muggins Peak, Klothos Temple, and Long Mountain inside the study area (fig. 2). Quartz veins in Proterozoic metamorphic and igneous rocks north of the study area were mined for gold, silver, and copper (Keith, 1978). This type of lode deposit has not been reported in the study area.

Uranium is the other element of economic interest in the Muggins mining district, although no uranium production has been reported. The nearest known uranium occurrence, the Red Knob prospect, is a stratabound occurrence about 0.5 mi east of the study area (Peirce and others, 1970).

According to BLM records as of October 1987, nearly half the study area was covered by unpatented mining claims (fig. 3); however, there are no patented mining claims in the study area. Over half the study area is covered by oil and gas leases (fig. 3) according to BLM records as of January 1987.

Gold

Placer gold was reported in washes and canyons draining southward from Muggins Peak, Klothos Temple, and Long Mountain. The gold occurs as particles as much as 0.15 in. across and was probably derived from gold-bearing quartz veins in the Proterozoic gneiss, schist, and granite that crop out in the northern Muggins Mountains (Keith, 1978; Wilson, 1933). Conglomerate and alluvium in the study area contain gneiss and granite clasts derived from the Proterozoic rocks.

Gold was detected in panned-concentrate samples from four drainages in the study area and two drainages southeast of the study area (fig. 3). Of the samples containing gold, the concentrations range from a trace to 0.230 troy oz/ton in the panned concentrate, equivalent to about \$0.75/yd^3 (cubic yard). Two of the samples, however, contain more gold; the values of samples 14 and 16 (fig. 3) were about \$26.25/yd^3 and \$33.90/yd^3, respectively (Wood, 1988). Gold yield was calculated using a pan factor of 150, a gold price of \$500/troy oz and was based on a screened (minus-0.5-in.) yd^3 of gravel, estimated to represent between 25 percent and 50 percent of the gravel in place.

The drainages containing gold in the study area are small. Samples with the highest gold concentrations were from the shallow (about 1 ft deep), narrow (no more that 12 ft wide) gravel deposits near the heads of the drainages (Wood, 1988). Low gold concentrations detected in the generally wider and thicker gravels deposited downstream may represent either partial gold depletion by past placer operations or dilution by barren sediment. In some areas, a thick alluvial cover prevented sampling at bedrock, where placer gold is commonly concentrated. The higher gold concentrations in gravels near the heads of the drainages might be profitable for small, 2- to 3-person placer operations; however, these small quantities of gravel could not support a commercial mining operation. On the basis of samples taken at each of the two locations where high gold values were indicated, we estimate that less than 20 troy oz of gold are contained in about 550 yd^3 of gravel at sample site 14 (fig. 3) and less than 5 troy oz of gold are contained in about 50 yd^3 of gravel at site 16 (fig. 3).

Uranium

There are no identified uranium resources in the study area. The Red Knob prospect, about 0.5 mi east of the study area, is the nearest known uranium occurrence (fig. 2). According to Smith and others (1984), this prospect occurs in the lower member of the Kinter Formation and is associated with a northwest-trending normal fault near an intrusive rhyolite dome. A 1.5-ft-thick silicified mudstone bed is exposed along a 15-ft-long trench at the portal of a collapsed and partly filled adit at least 35 ft long. Weeksite, a rare uranium silicate (Outerbridge and others, 1960), calcite, chalcedony, mimetite, and vanadinite occur in the silicified mudstone bed. Wood (1988) reported that rock samples contain as much as 1,150 parts per million (ppm) lead, 295 ppm vanadium, 41 ppm uranium, 25 ppm molybdenum, and 1.8 ppm (0.05 troy oz/ton) silver. These subeconomic concentrations are contained in samples from the silicified mudstone bed at the Red Knob prospect.

Only the upper member of the Kinter Formation is exposed in the study area. Geochemical studies by Smith and others (1984) indicate that a drainage basin inside the southeastern boundary of the study area may contain mineralized rock with a geochemical signature similar to that at the Red Knob prospect. Scintillometer readings taken along traverses in this drainage basin did not show values above background levels.

Sand and Gravel

The drainages and alluvial fans in the study area contain sand and gravel, which were being mined, possibly for use as local road surfacing material, near the southern tip of the study area during the USBM's field investigation (fig. 3). Sand and gravel in the study area have no unique qualities to make them more valuable than the vast quantities available in nearby areas.

Conclusions

Placer gold was found in four drainages in the study area. High gold concentrations identified at the heads of two of the drainages might be profitable for small, 2- to 3-person placer operations; however, the amount of gold in both drainages is probably less than 25 troy oz. This amount of gold would not support a commercial operation. Considerable additional work is needed to quantify the identified placer gold resource in the study area because the gold is irregularly distributed, partially buried by locally thick alluvium, and partly removed by past placer mining.

A low-grade uranium occurrence, containing by-product subeconomic concentrations of lead and vanadium, is associated with faulting in the lower member of the Kinter Formation about 0.5 mi east of the study area. This member underlies the study area but is not exposed. There are no identified resources of uranium in the study area.

The sand and gravel in drainages and alluvial fans in the study area have no unique qualities to make them more valuable than the vast quantities in nearby areas.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By David B. Smith, Richard M. Tosdal, James A. Pitkin, *and* M. Dean Kleinkopf
U.S. Geological Survey

Geologic Setting

The oldest rock in the Muggins Mountains is Proterozoic augen gneiss, which underlies the northwestern part of the range. Only a small part of this unit crops out in the study area (fig. 2). The augen gneiss in the northern part of the range is similar in age to other metaplutonic bodies in the region, which are of Proterozoic age, on the basis of U-Pb (uranium-lead) ages on zircon (L.T. Silver *in* Olmstead and others, 1973, and *in* Dillon, 1976). In the Muggins Mountains, the augen gneiss is inferred to be part of the widespread anorogenic granite suite of Middle Proterozoic age found throughout the southwest (Anderson, 1983; written commun., 1989).

Paleozoic and lower Mesozoic metasedimentary rocks crop out in a narrow east-trending ductile shear zone. There, chlorite phyllite and epidote quartzite are structurally overlain by chloritic calc-silicate rocks, white and blue marble, and orange dolomitic marble. These metasedimentary rocks are similar to other metamorphosed Paleozoic and lower Mesozoic sedimentary rocks in the lower Colorado River region (Hamilton, 1982; Leveille and Frost, 1985), and their protoliths are probably correlative with the Supai, Kaibab, and Moenkopi Formations. However, in the Muggins Mountains their normal stratigraphic sequence is apparently inverted.

Proterozoic through lower Mesozoic rocks are intruded by porphyritic monzogranite and less abundant diorite of Jurassic(?) age. These granitic rocks are the unmetamorphosed equivalents to the orthogneisses that host gold deposits at Picacho and Mesquite in southeastern California (Tosdal and others, 1985). In the Muggins Mountains, the contacts of the Jurassic(?) monzogranite are mylonite and mylonitic schist that formed in ductile shear zones. The upper shear zone includes the inverted Paleozoic and lower Mesozoic section, which implies that the shear zones may be the remnant of a major structure.

Sandstone, siltstone, conglomerate, and fanglomerate of the upper Oligocene(?) and lower Miocene Kinter Formation unconformably overlie the Jurassic(?) monzogranite unit. The Kinter Formation is divided into two informal members that are interbedded along their contact. The lower member consists of fine-grained sandstone, siltstone, and white vitric tuff beds. Early Miocene camel fossils are reported from these rocks and 22.5±0.7 Ma (million years before present) and 24.2±1.2 Ma potassium-argon (K-Ar) ages on biotite were determined for two tuffs outside the study area (Lance and Wood, 1958; Shafiqullah and others, 1980). The upper member of the Kinter Formation consists of conglomerate, fanglomerate, and minor sandstone that represent debris flows and alluvial fan deposits. Proterozoic augen gneiss is the dominant clast type, Jurassic(?) monzogranite is subordinate, and Tertiary volcanic clasts are minor. Silicic volcanic flows, domes, tuff, and tuffaceous sedimentary rocks are interbedded with the Kinter Formation.

Field relations indicate that middle Tertiary volcanism, sedimentation, and extensional deformation were contemporaneous in the range. A tectonic breccia along the western part of the range lies between the basement rocks and the volcanic flows. The breccia grades upward into conglomerate and sandstone at the base of the volcanic section. This type of breccia is common along detachment faults that fringe the Gila River trough in the northern Mohawk Mountains (Mueller and others, 1982) and in the Baker Peaks (Pridmore and Craig, 1982) 30 mi and 20 mi southeast and east of the Muggins Mountains, respectively. Latite dikes intrude the tectonic breccia, basement rocks, and overlying conglomerate and volcanic rocks. Evidence for a second episode of extensional tectonism in the range is provided by the rapid transition from the fine-grained lower member to the coarse-grained upper member of the Kinter Formation. The silicic volcanic rocks are interbedded with the upper member of the Kinter Formation. A final episode of extensional deformation broke the area into northwest-striking structural blocks that dip 10–30° SW.

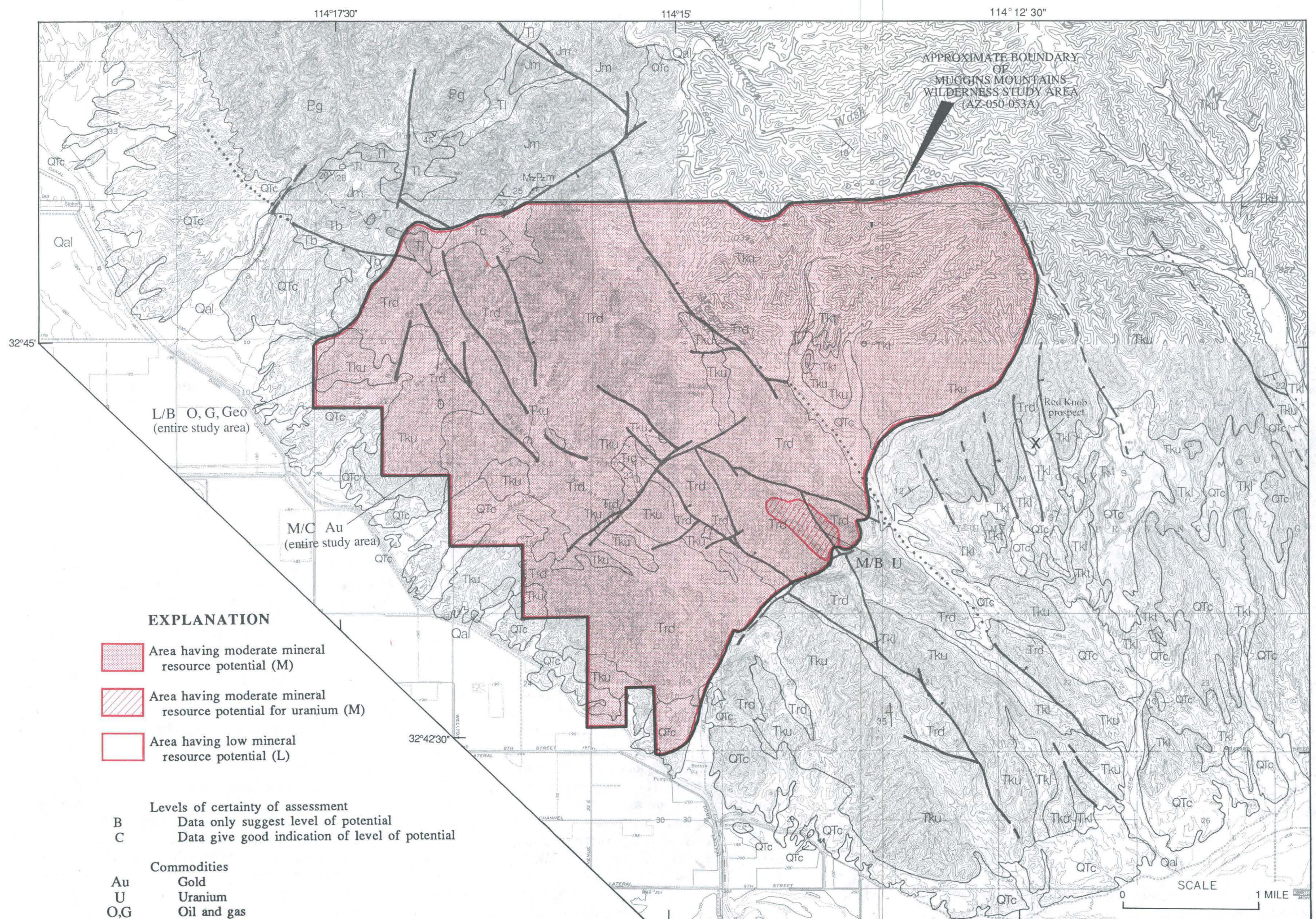
Quaternary gravel, sand, and silt unconformably overlie the older units. The youngest unit consists of unconsolidated silt and sand deposited on the Gila River floodplain.

Geochemistry

A reconnaissance geochemical survey was conducted in the Muggins Mountains Wilderness Study Area in 1983. The purpose of the survey was to evaluate the study area for evidence of mineralization; it was not designed to locate individual mineral deposits. The sample media and sample density were chosen to identify favorable geochemical provinces and mineralized districts; thus barren ground not favorable for mineral occurrences is eliminated and attention is drawn to the more promising areas (Levinson and others, 1987).

Minus-80-mesh stream sediments and heavy-mineral concentrates derived from stream sediments were selected as the primary sample media because they represent a composite of rock and soil exposed in the drainage basin upstream from the sample site. Chemical analysis of sediments provides information that helps identify those basins that contain unusually high concentrations of elements which may be related to mineral occurrences. In addition, studies show that heavy-mineral concentrates derived from stream sediments are a very useful sample medium in arid environments or in areas of rugged topography, where mechanical erosion is predominant relative to chemical erosion (Bugrov and Shalaby, 1975; Overstreet and Marsh, 1981; Zeegers and others, 1985). In this study, the nonmagnetic fraction of the heavy-mineral concentrates was analyzed. In areas where mineralization occurred, this fraction represents a concentration of ore-forming and ore-related minerals such as pyrite, galena, cassiterite, sphalerite, chalcopyrite, stibnite, free gold, barite, and scheelite. This selective concentration of ore-related minerals permits determination of some elements that are not easily detected in bulk stream-sediment samples.

Both stream sediments and heavy-mineral concentrates were collected at 48 sampling sites inside and within 3 mi of the study area boundary. Samples were collected from active alluvium in first-order (unbranched) and second-



EXPLANATION

(M)	Area having moderate mineral resource potential (M)
(M, uranium)	Area having moderate mineral resource potential for uranium (M)
(L)	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
- U — Uranium
- O,G — Oil and gas
- Geo — Geothermal

X — Prospect

DESCRIPTION OF MAP UNITS

Qal **Alluvium (Quaternary)**—Pale-brown, unconsolidated silt and fine sand. Forms floodplain deposits of Gila River and floors of active washes

QTc **Conglomerate and sandstone (Quaternary and Tertiary?)**—Unconsolidated to poorly consolidated conglomerate, sandstone, and minor amounts of siltstone

Tl **Latite (Miocene)**—Orange-weathered, banded gray biotite-latite dikes and plugs

Trd **Rhyolite, latite, and dacite (Miocene)**—Red-brown, brown, gray, and black rhyolite, rhyodacite, latite, and dacite flows, domes, and minor amounts of yellow and pink lithic-lapilli tuff, tuff breccia, and tuffaceous sandstone

Tc **Conglomerate and sandstone (Miocene)**—Brown conglomerate, sandstone, minor breccia, and less-abundant orange tuff breccia, tuffaceous sandstone, and white tuff

Tb **Breccia (Miocene)**—Angular fragments of monzogranite and diorite that grades from intact but completely shattered rocks to a crudely bedded sedimentary deposit with a sandy matrix

Kinter Formation (Miocene and Oligocene?)—Conglomerate, sandstone, siltstone, and minor amounts of tuff; divided into:

Tku **Upper member (lower Miocene and upper Oligocene)**—Poorly to moderately sorted and bedded conglomerate, fanglomerate, minor coarse-grained sandstone, and minor white tuff; grades into and interfingers with sandstones of the lower member, locally includes white biotite tuff marker beds (t); maximum thickness is 3 m

Tkl **Lower member (lower Miocene and upper Oligocene?)**—Well-bedded, well-sorted, tan, fine- to medium-grained sandstone, siltstone, and minor white tuff; locally includes white biotite vitric tuff marker beds (t); maximum thickness is 3 m

Jm **Monzogranite (Jurassic?)**—Gray, fine- to medium-grained biotite porphyritic monzogranite and minor amounts of diorite

MzPzm **Marble and phyllite (Mesozoic and Paleozoic)**—Chlorite phyllite and schist, epidote quartzite, quartzose marble, white, blue, gray marble, and orange dolomitic marble

Pg **Augen gneiss (Proterozoic)**—Coarsely porphyritic augen gneiss characterized by abundant pink potassium feldspar augen

- **Contact**—Dashed where approximately located
- **Fault**—Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side
- 40 **Strike and dip of beds**
- 28, 20 **Strike and dip of foliation**—Showing bearing and plunge of lineation

Figure 2. Mineral resource potential and generalized geology of Muggins Mountains Wilderness Study Area, Yuma County, Arizona. Polyconic projection. Geology by R.M. Tosdal, 1983 and 1987. Contour intervals 20 and 40 feet; intermediate intervals 5 and 10 feet.

Base from U.S. Geological Survey, 1:24,000, Dome, 1955; Ligurta, Wellton, 1965 (photorevised, 1982); 1:62,500, Red Bluff Mtn., 1955.

order (below the junction of two first-order) streams. Eight rock samples were also collected for chemical analysis. Samples of unaltered rock were analyzed to provide information on geochemical background values. Samples at mines, prospects, and altered areas were taken to determine suites of elements associated with mineralization and alteration. Analytical data and a description of the sampling and analytical techniques are given in Smith and others (1984). Additional data were obtained by analyzing the minus-80-mesh stream sediments for gold by a graphite-furnace atomic-absorption method (detection limit, 0.002 ppm).

Results

Only one anomalous area was delineated by the reconnaissance geochemical survey, and this area was delineated on the basis of only one sampling site. A small drainage basin along the southeast boundary of the study area contains anomalous amounts of lead (1,000 ppm) and molybdenum (300 ppm) in the nonmagnetic heavy-mineral concentrate and an anomalous amount of lead (100 ppm) in the minus-80-mesh stream sediment. This geochemical signature is similar to that of the drainage basin containing the Red Knob uranium prospect approximately 0.5 mi east of the study area (fig. 3). Nonmagnetic heavy-mineral concentrates collected from this drainage contain 1,500 ppm lead and 150 ppm molybdenum.

Low-level anomalies of tin (20–200 ppm) and tungsten (less than 100 to 1,000 ppm) are contained in nonmagnetic heavy-mineral concentrates from scattered sampling sites in the northern two-thirds of the study area. The origin of these anomalies is uncertain, but we believe they are derived from silicic volcanic rocks rather than mineralized rocks.

Geophysical Studies

Reconnaissance gravity and aeromagnetic anomaly maps (U.S. Geological Survey gravity files; LKB Resources, Inc., 1980) provide some information on regional geology. The data lack sufficient detail to delineate local structures and igneous intrusions that might be associated with mineral deposits.

The regional data on the Department of Energy's National Uranium Resource Evaluation (NURE) residual intensity magnetic anomaly map of the El Centro 1° by 2° sheet is based on 6-mi spaced traverses flown at an average of 400 ft above the terrain (LKB Resources, Inc., 1980). Only one east-west traverse crossed the study area. The magnetic intensity contours trend northeast to east across the study area with an average southeasterly gradient of about 10 gammas/mi. This gradient may be related to the Proterozoic augen gneiss mass northwest of the study area (fig. 2). The regional gravity contours trend northeast across the study area with a pronounced gradient to the southeast averaging about 4 milligals per mile (mGal/mi). This northeast-trending pattern coupled with the regional northeast- to east-trending magnetic anomaly patterns suggests that the central part of the study area may be underlain by northeast-trending lithologic boundaries or fracture zones, probably within the crystalline basement complex.

An aerial gamma-ray survey conducted in the region as part of the NURE program (U.S. Department of Energy, 1979) measured the near-surface distribution of the natural radioelements potassium, uranium, and thorium. The survey was flown on flightlines spaced 6 mi apart at 400 ft above ground level. An aerial gamma-ray system at this altitude effectively detects terrestrial gamma radiation from a swath 800 ft wide along the flightline. Results indicate that the Muggins Mountains Wilderness Study Area is characterized by radioelement concentrations of 2.5 to 3.5 percent potassium, 4 to 6 ppm equivalent uranium, and 12 to 14 ppm equivalent thorium. (The term "equivalent" denotes the assumption that uranium and thorium are in equilibrium with their daughter products.) These concentrations are controlled by the location of NURE flightlines relative to the study area; in this instance, one east-west NURE flightline crossed the study area. Despite the sparse control, the concentrations detected are reasonable background levels for the Proterozoic crystalline rocks, Tertiary volcanic rocks, and Tertiary(?) and Quaternary alluvium and colluvium of the study area.

Mineral Resource Potential of the Muggins Mountains Wilderness Study Area

This assessment of the mineral resource potential of the Muggins Mountains Wilderness Study Area draws upon different and diverse sets of geologic data. These include regional geology, geochemistry, geophysics, mineral occurrence maps, mining claim records, and the application of ore-deposit models to geologic terranes. These data were used to delineate favorable tracts within the study area and an estimate was then made of the level of resource potential and degree of certainty for each tract (fig. 2). Mineral resource potential refers to undiscovered mineral resources; the true test of an estimate of mineral resource potential is through active exploration.

Gold

Gold and minor amounts of silver have been produced from placer deposits in the Muggins Mountains Wilderness Study Area. Gold was detected in five panned-concentrate samples collected by the USBM in the south-central part of the study area south of the Muggins Peak and Long Mountain area and in two concentrate samples collected southeast of the study area (fig. 3). Using graphite-furnace atomic-absorption analysis of minus-80-mesh stream sediments, the USGS detected gold (0.006 and 0.004 ppm) in two samples southeast of the study area (fig. 3). No gold was detected by this method in samples collected within the study area.

Wilson (1933) and Keith (1978) reported placer gold production near Klothos Temple in the northwestern part of the study area and in the headwaters of Vinegarroon Wash, approximately 0.5 mi north of the study area, in addition to the area south of Muggins Peak and Long Mountain. This gold is deposited in ancient bars on terraces above and in stream channels where the bedrock consists of conglomerate intercalated with lavas (Keith, 1978). The source of the gold in the placer deposits is reported to be gold-bearing quartz veins in Proterozoic gneiss, schist, and granite exposed north of the study area (Wilson, 1933; Keith, 1978).

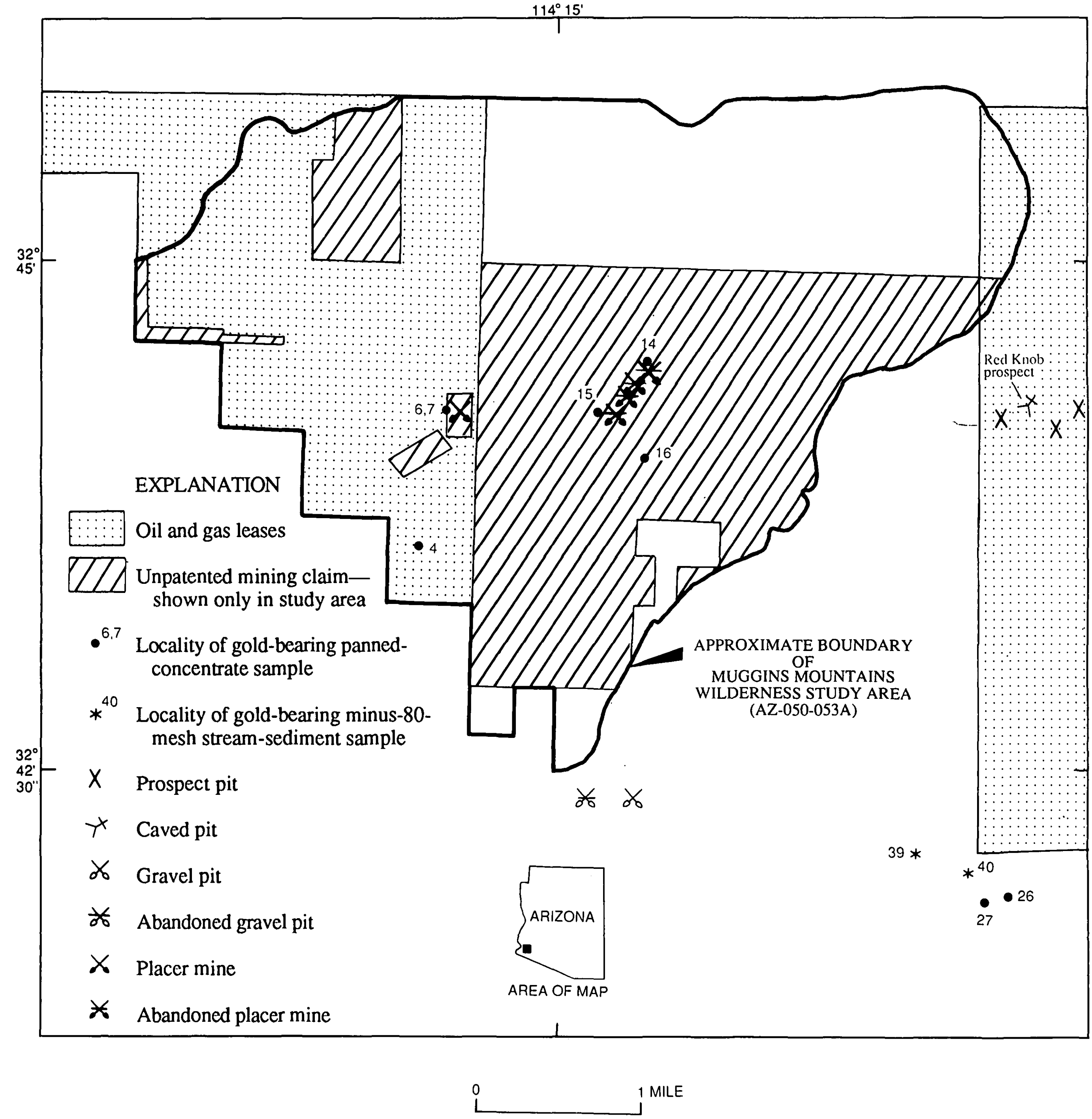


Figure 3. Mines, prospects, oil and gas leases, and anomalous geochemical sample localities in Muggins Mountains Wilderness Study Area, Yuma County, Arizona.

The entire study area has moderate potential with certainty level C for gold in placer deposits (see "Appendixes" for levels of mineral resource potential and certainty of assessment). This rating is based on the distribution of past placer mining activity and the distribution of gold in panned-concentrate samples over a large part of the study area. Geologic mapping and geochemical sampling for this report were not sufficiently detailed to delineate all alluvium that might contain placer gold.

Uranium

Exploration for uranium in the Muggins Mountains has been intermittent since the early 1950's. Uranium occurs in the Muggins Mountains as pods and disseminations in silicified mudstones adjacent to northwest-trending faults, in interlacing quartz stringers within dikes or sills, as disseminations in volcanic rocks and mudstone and sandstone beds, in association with copper carbonates and silicified wood fragments in mudstone beds, and in loosely consolidated conglomerates or talus deposits (Reyner and Ashwill, 1955). Many of these relations suggest that the source of the uranium is tuffaceous lake sediments from which connate water and dissolved uranium were squeezed out during compaction. The uranium precipitated in a reducing environment created by carbonaceous lacustrine sediments (Keith, 1978).

All the known uranium prospects in the Muggins Mountains are east of the study area. One such prospect, called the Red Knob claims by Reyner and Ashwill (1955), is about 0.5 mi east of the study area boundary in the lower member of the Kinter Formation near an intrusive rhyolite dome. Weeksite, mimetite, calcite, vanadinite, and chalcedony occur within a highly silicified mudstone bed, 1 to 3 ft thick, along the north side of a normal fault that trends northwest. Chemical analyses of rocks from this prospect show elevated concentrations of uranium (as much as 257 ppm), lead (as much as 2,000 ppm), molybdenum (as much as 500 ppm), vanadium (as much as 300 ppm), and zinc (as much as 700 ppm) (Smith and others, 1984; Wood, 1988). Nonmagnetic heavy-mineral concentrates derived from stream sediments collected downstream from the Red Knob prospect contain anomalous amounts of lead (1,500 ppm) and molybdenum (150 ppm). One small drainage basin along the southeastern boundary of the study area contains similar anomalies of lead (1,000 ppm) and molybdenum (300 ppm) in heavy-mineral concentrates and a small lead anomaly (100 ppm) in minus-80-mesh stream sediments. A normal fault strikes northwest along the center of the stream channel (fig. 2). On the basis of the lead and molybdenum anomalies and the presence of the fault, this drainage basin has moderate potential, certainty level B, for uranium resources (fig. 2). However, a scintillometer survey taken along traverses in this drainage basin by USBM personnel in 1987 did not detect readings above background levels.

Geothermal Energy

Wilson (1933) reported a group of thermal springs on the northern bank of the Gila River near the southeastern margin of the Muggins Mountains approximately 9 mi east of the study area. The temperature of the water was reportedly 140 °F. However, no hot springs or other indications of recent geothermal activity are known within the study area. The geothermal energy resource potential of the Muggins Mountains Wilderness Study Area is low, certainty level B (fig. 2).

Oil and Gas

The study area is located within the structural depression known as the Gila trough, which contains as much as 6,000 ft of lower to middle Tertiary sedimentary rocks. Ryder (1983) states that minor oil shows were reported from holes drilled in the Gila trough. He ranks the hydrocarbon potential of the trough as low, however, because the organic richness, reservoir quality, and thermal history of the sedimentary rocks are unfavorable for the generation and entrapment of significant volumes of hydrocarbons. Therefore, the Muggins Mountains Wilderness Study Area has low potential, certainty level B, 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	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
	M/B MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/D MODERATE POTENTIAL
UNKNOWN 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.

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mith; others—MINERAL RESOURCES, MUGGINS MOUNTAINS WILDERNESS STUDY AREA, YUMA COUNTY, ARIZONA—U.S. Geological Survey Bulletin 1702-D