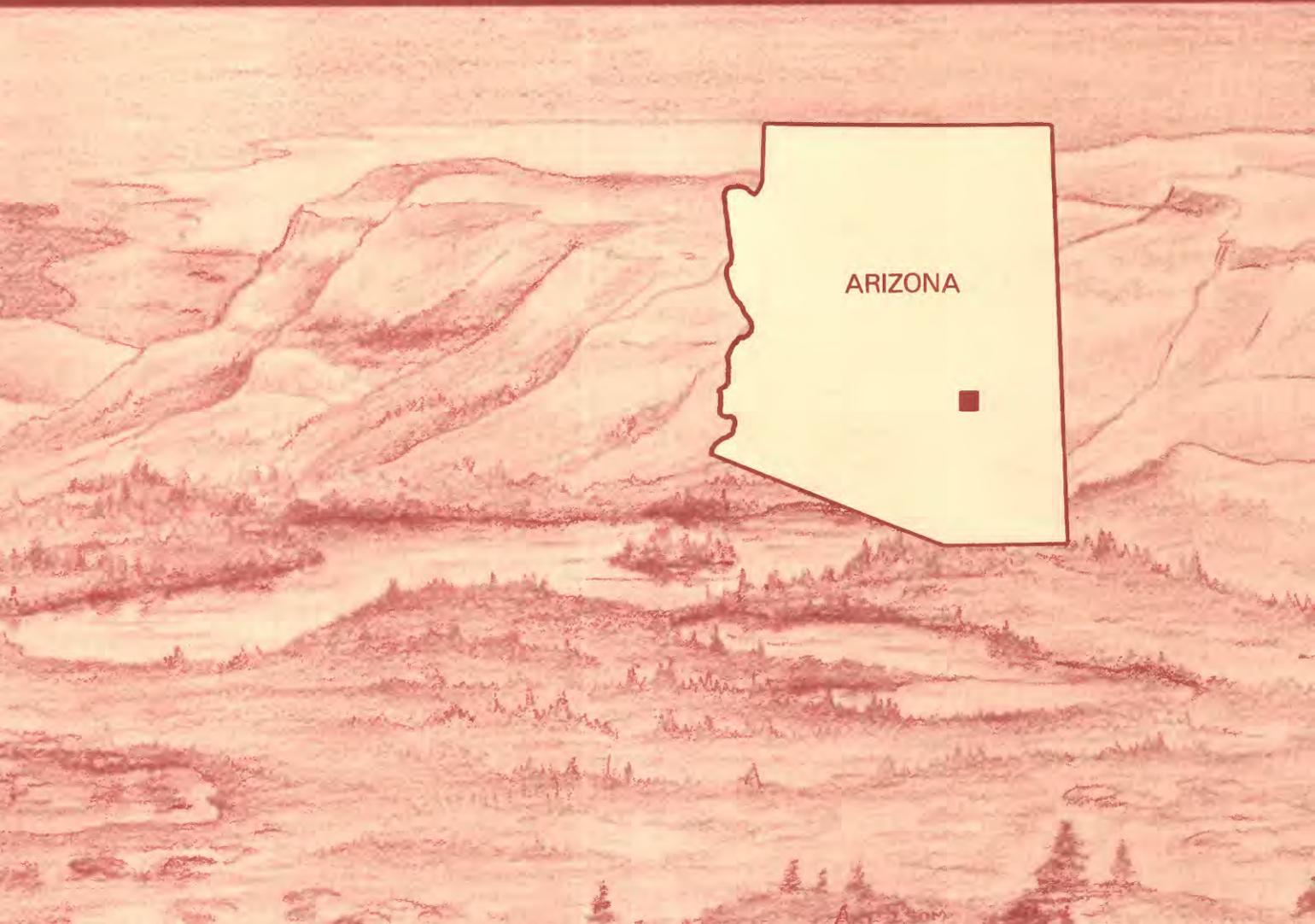


Mineral Resources of the Needles Eye Wilderness Study Area, Gila County, Arizona



U.S. GEOLOGICAL SURVEY BULLETIN 1703-B



DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

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

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

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

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

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

Levels of Certainty

 LEVEL OF RESOURCE POTENTIAL	U/A	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
	UNKNOWN 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			
	A	B	C	D
	LEVEL OF CERTAINTY 			

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

Abstracted with minor modifications from:

- Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: *Economic Geology*, v. 78, no. 6, p. 1268-1270.
- Taylor, R. B., Stoneman, R. J., and Marsh, S. P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: *U.S. Geological Survey Bulletin* 1638, p. 40-42.
- Goudarzi, G. H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: *U.S. Geological Survey Open-File Report* 84-0787, p. 7, 8.

Chapter B

Mineral Resources of the Needles Eye Wilderness Study Area, Gila County, Arizona

By FRANK S. SIMONS, PAUL K. THEOBALD,
RONALD R. TIDBALL, JAMES A. ERDMAN,
THELMA F. HARMS, and ANDREW GRISCOM
U.S. Geological Survey

GEORGE S. RYAN
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1703

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
SOUTHEASTERN ARIZONA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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



UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1987

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 Needles Eye Wilderness Study Area, Gila
County, Arizona.

(Mineral resources of wilderness study areas—Southeastern Arizona; ch.
B) (U.S. Geological Survey bulletin ; 1703-B)

Bibliography: p.

Supt. of Docs. no.: I 19.3:1703-B

1. Mines and mineral resources—Arizona—Needles Eye Wilderness. 2.
Geology—Arizona—Needles Eye Wilderness. 3. Needles Eye
Wilderness (Ariz.)

I. Simons, Frank S. (Frank Stanton) 1917- . II. Series. III. Series: U.S.
Geological Survey bulletin ; 1703-B.

QE75.B9 no. 1703-B
[TN24.A6]

557.3 s
[553'.09791'55]

86-600254

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 Needles Eye (AZ-040-001A) Wilderness Study Area, Gila County, Arizona.

RESOURCE / RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES		UNDISCOVERED RESOURCES		
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical	Speculative
			(or)		
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 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.

CONTENTS

Summary	1
Introduction	1
Investigations by the U.S. Bureau of Mines	3
Investigations by the U.S. Geological Survey	3
Appraisal of identified resources	3
Assessment of potential for undiscovered resources	4
Geology	4
Geophysics	4
Geochemistry	4
Mineral and energy resources	6
References cited	6

PLATE

1. Mineral resource potential map of the Needles Eye study area **In pocket**

FIGURES

1. Summary map showing mineral resource potential of the Needles Eye study area **2**
2. Index map showing the Needles Eye study area **3**

TABLE

1. Elements contained in anomalous amounts in heavy-mineral concentrates **5**

Mineral Resources of the Needles Eye Wilderness Study Area, Gila County, Arizona

By Frank S. Simons, Paul K. Theobald,
Ronald R. Tidball, James A. Erdman,
Thelma F. Harms, and Andrew Griscom
U.S. Geological Survey and
George S. Ryan
U.S. Bureau of Mines

SUMMARY

At the request of the U.S. Bureau of Land Management, 9,201 acres of the Needles Eye Wilderness Study Area (AZ-040-001A) were studied. In this report the studied area is called the "wilderness study area" or simply "study area." The Needles Eye Wilderness Study Area is in southern Gila County in southeastern Arizona, about 18 mi (miles) southeast of Globe. The area studied lies along the northern side of the Gila River just below Coolidge Dam and contains 9,201 acres (about 14 square miles) (fig. 1). A mineral survey of the area was done in 1983-84. No mining and only a little prospecting have been done in the area. No mineral reserves or resources were identified. None of the geophysical anomalies on the aeromagnetic or gravity maps of the area has been identified as providing evidence for mineral resource potential. The southwestern part of the study area has a moderate mineral resource potential for metals in vein or replacement deposits in and adjacent to a Tertiary (66-1.7 m.y. or million years; see geologic time chart on the last page of this report) quartz monzonite laccolith; the rest of the study area has a low mineral resource potential for metals, nonmetals, and fuels.

The Needles Eye, for which the wilderness study area is named, is a deep, narrow gorge cut by the Gila River through resistant Precambrian (3,400-570 m.y.) and Cambrian (570 to about 500 m.y.) quartzite about 8 river miles below the dam. The area is underlain by Precambrian granite; a conformable sequence of Precambrian and Paleozoic (about 570 to about 240 m.y.) sedimentary rocks; Cretaceous (138-66 m.y.), Tertiary(?), and Quaternary (less than 1.7 m.y.) volcanic and sedimentary rocks; and Tertiary quartz monzonite. The Precambrian and Paleozoic sedimentary rocks in general dip southwestward and form three northwesterly trending high ridges in which the rocks have been repeated along northwest-trending faults.

No mining has been done in the area, and only one prospect was found. No mineral reserves or identified resources were found in the study area (fig. 1). No oil and gas leases or lease applications are in or adjoining the study area. The potential for energy resources, oil, gas, and geothermal, is low.

One geochemically anomalous area considered to have moderate mineral resource potential was identified by analysis of stream-sediment samples and heavy-mineral concentrates (fig. 1, area 3). Samples anomalous in lead, together with lesser arsenic, barium, boron, cadmium, copper, silver, tin, vanadium, and zinc, suggest metal mineralization associated with a Tertiary intrusion. The rest of the area has a low mineral resource potential, although within it are two areas with slightly anomalous values whose outlines are shown on figure 1 (areas 1 and 2). Area 1 is mostly in Precambrian granite and is anomalous in a variety of elements that suggest weak mineralization associated with the granite. Area 2 is anomalous mainly in barium and may contain barite-rich veins in the fault system along Mescal Creek.

INTRODUCTION

The Needles Eye Wilderness Study Area (AZ-040-001A) is in Gila County, southeastern Arizona, about 18 mi southeast of Globe and 9 mi northeast of Christmas (fig. 2). The area trends northeast and comprises 9,201 acres (about 14 square miles). It is bounded on the southeast by the Gila River and the San Carlos Indian Reservation, to the northwest by public land, and on the north by the reservation. The Needles Eye, from which the area takes its name, is a deep narrow gorge cut by the Gila River through Precambrian and Cambrian quartzites about 4.5 mi (8 river miles) below Coolidge Dam.

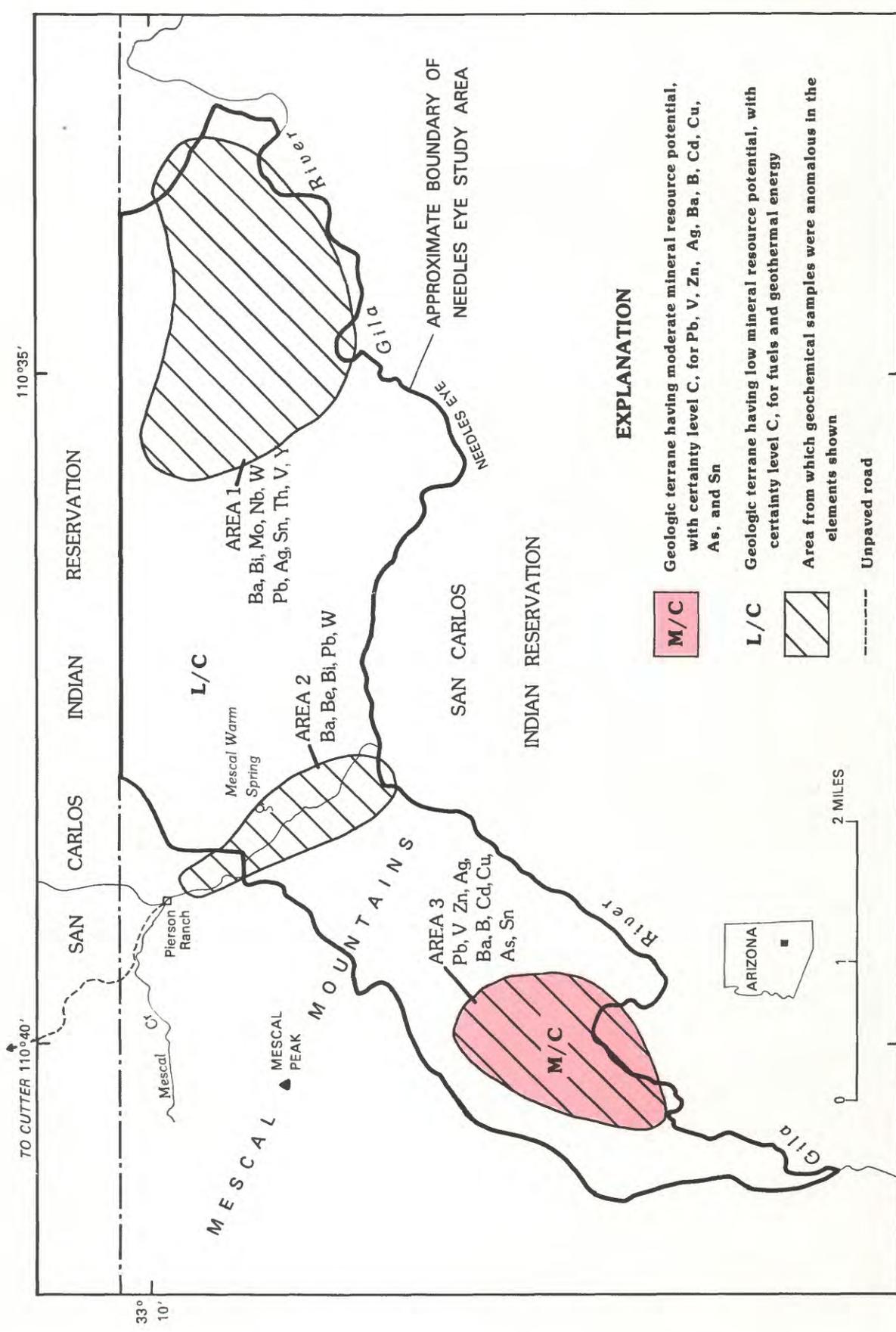


Figure 1. Mineral resource potential map of the Needles Eye study area, Gila County, Arizona



Figure 2. Index map showing the location of the Needles Eye study area, Gila County, Arizona

The eastern end of the study area may be reached by an unpaved road down the Gila River below Coolidge Dam to Hawk Canyon; the middle of the study area is accessible from Cutter on U.S. Highway 70 via an unimproved road as far as Pierson ranch on Mescal Creek just northwest of Mescal Warm Spring; and the southwestern end of the study area may be reached by an unpaved road that extends from Arizona Highway 77 about 2 mi north of Christmas. A high-voltage electrical transmission line from Coolidge Dam crosses the study area in a southwesterly direction; maintenance of the line is by helicopter, and the roads built during its construction are no longer passable.

The study area ranges in altitude from 2,100 ft (feet) where the Gila River leaves the area to 4,500 ft on the crest of the Mescal Mountains. The most conspicuous geographic feature is the canyon of the Gila River. The canyon consists of three narrow segments, more than 1,000 ft deep, where the river cuts through resistant sedimentary rocks of Precambrian and Paleozoic age, and separated by more open intervals where the canyon walls are less resistant granitic rocks of Precambrian and Tertiary age. The Mescal Mountains trend northwest across the middle of the area; their southwestern flank is a spectacular dip slope eroded on a thick section of resistant Paleozoic limestone.

Investigations by the U.S. Bureau of Mines

The U.S. Bureau of Mines investigations were done in 1983 by G. S. Ryan, and included a review of published material, a check of recordation files of the U.S. Bureau of Land Management for recent mining claims and of Gila County courthouse records in Globe for earlier claims, an aerial reconnaissance, and foot traverses (Ryan, 1985).

Investigations by the U.S. Geological Survey

The Needles Eye Wilderness Study Area was mapped geologically by Willden (1964) as part of the Christmas 1:62,500-scale quadrangle. Reconnaissance of the area by helicopter indicated that the previous geologic mapping was of high quality, and therefore only 3 days of geologic field work was done by F. S. Simons for this study, consisting of a few short traverses, numerous spot checks, and collection of 17 rock samples. The geochemical study is based on 27 stream-sediment samples and 27 heavy-mineral concentrates of stream sediments collected by P. K. Theobald, R. R. Tidball, and T. F. Harms, and 25 plant samples collected by J. A. Erdman. Spectrographic and chemical analyses were done by T. F. Harms, L. A. Bradley, J. M. Motooka, and N. M. Conklin. Interpretation of gravity and aeromagnetic geophysical data was by Andrew Griscom.

APPRAISAL OF IDENTIFIED RESOURCES

By George S. Ryan, U.S. Bureau of Mines

No mining and only a little prospecting has been done in the study area, and there are no identified reserves or resources (see resource/reserve classification chart on p. IV of this report). Phillips Uranium Co. leased claims in sec. 30 and NW¼ sec. 31, T. 3 S., R. 17 E., near the western edge of the study area, from a claimant. After drilling on contiguous claims 3 mi west of the study area, the company abandoned all claims in 1982. The Arizona geothermal resources map (Witcher and others, 1982) indicates no geothermal areas within 20 mi of the study area. No oil and gas leases or lease applications are within or adjoining the study area.

The one prospect pit found and sampled is near the northwestern boundary southeast of Mescal peak in NW¼ sec. 30, T. 3 S., R. 17 E. (pl. 1). The pit is in Mescal Formation, is 2x4x1 ft deep, and contains hematite veinlets 0.5–1 in. (inch) thick. Fire assays of rock samples from the pit indicated a trace of gold and silver, and spectrographic analyses showed only high iron, calcium, and silica.

A vertical altered zone in limestone was found in the eastern wall of a drainage 1,200 ft north of the Gila River in NE¼ sec. 29, T. 3 S., R. 17 E. (pl. 1). The altered zone is 9–10 ft wide and contains abundant hematite and minor malachite. Material has slumped from the zone, and it appears to have been excavated, but there is no dump. Assays of samples show no anomalous values of any element.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Frank S. Simons, Paul K. Theobald, Ronald R. Tidball, James A. Erdman, Thelma F. Harms, and Andrew Griscom, U.S. Geological Survey

Geology

The study area is underlain by granitic rocks of Precambrian, possibly Middle or Early Proterozoic, age; sedimentary rocks of Middle Proterozoic age; diabase of Middle Proterozoic age that intrudes Proterozoic granitic and sedimentary rocks; sedimentary rocks of Paleozoic (Cambrian to Pennsylvanian) age; volcanic and sedimentary rocks of Cretaceous age; quartz monzonite porphyry of Tertiary age that intrudes Mississippian and Pennsylvanian limestone; dacitic volcanic rocks of Tertiary age; conglomerate and basalt of Quaternary and Tertiary age; and tufa and alluvium of Quaternary age (pl. 1).

Sedimentary rocks of Precambrian and Paleozoic ages strike northwest and dip mainly southwest. They form three northwesterly trending ridges that have steep northeastern slopes and gentler southwestern slopes. The ridges are separated by northwesterly striking faults along which the northeastern side has moved relatively downward. The northeastern ridge, northeast of Dick Spring Canyon, and the southwestern ridge (Mescal Mountains), southwest of Mescal Creek, have a complete section of layered rocks, whereas on the middle ridge only rocks of Devonian and younger age are exposed. In the eastern part of the study area, older rocks are widely overlain by essentially flat-lying conglomerate and basalt flows that together constitute the Gila Conglomerate of Quaternary and Tertiary age.

Samples of 17 rocks were collected and analyzed by the six-step, optical emission, semiquantitative spectrographic method of Grimes and Marranzino (1968) for minor elements that might be useful in evaluating the mineral resource potential of the study area (analyses by M. J. Malcolm and P. H. Briggs, U.S. Geological Survey). Sample localities are shown on plate 1. These samples included six samples of Precambrian granite, two of Precambrian diabase, two of chert of the Mescal Formation, one of dolomite of the Martin Formation, one of Tertiary quartz monzonite porphyry, one of biotite

latite (unit Tv, pl. 1), two of olivine basalt, and two of calcareous tufa (unit Qt) from Mescal Warm Spring. None of the rocks contained anomalous amounts of the metallic or rare-earth elements.

Geophysics

Gravity data (Andrew Griscom and Craig Erdman, unpub. data, station spacing 1–4 mi) for the Needles Eye Wilderness Study Area were reduced to isostatic residual gravity values in order to nearly eliminate isostatic effects of high topography and thus accentuate the effects of rock units of the upper crust with different densities. Aeromagnetic data (Andrew Griscom and Craig Erdman, unpub. data, flight-line spacing 0.5 mi, nominal flight altitude of 1,000 ft above the ground) allow the differentiation between rock units having different magnetic properties.

These geophysical data indicate that the study area is relatively characterless geophysically except for some small magnetic anomalies that can be attributed to volcanic rocks or possibly to Precambrian diabase. None of the geophysical anomalies has been identified as providing evidence for any mineral deposits or occurrences in this area.

Geochemistry

Three types of samples, stream sediments, heavy-mineral concentrates, and plants, were collected at each locality. Twenty-seven stream-sediment samples, 27 heavy-mineral concentrates of stream sediments, and 25 mesquite samples were collected (pl. 1). Because this is a small data set, samples from within the study area are compared with several hundred additional samples collected in the same way, during the same field season, in adjoining areas in order to better characterize the geochemical nature of the study area. Details of the sample collection, preparation, and analysis, together with the analytical data, were reported by Harms and others (1985).

Three localities of samples having anomalous values have been identified in the study area. One is judged to have a moderate mineral resource potential, and two are thought to be of low potential.

Stream-sediment samples were obtained within minor stream channels and therefore reflect source materials within the 1–2 square miles of drainage basin above the sample site. Samples were sieved to pass a 30-mesh screen (about a 0.5-mm opening). These samples consist of weathered material mechanically transported to the sample site. A concentrate of the heavy minerals contained in stream sediment was prepared by panning, separation of the heavy fraction in bromoform (specific

gravity 2.8), and removal of iron and magnesium oxides and silicates by electromagnetic separation. The concentrate contains heavy and resistant minerals, some of which may be associated with ore deposits. Pulverized splits of the stream-sediment samples and heavy-mineral concentrates were analyzed for 31 elements by six-step, optical emission, semiquantitative spectrography (Grimes and Marranzino, 1968).

In general, the concentration of elements in stream-sediment samples is normal for the geologic terranes from which they were derived, and the range for most of the elements is small. Maximum values for lead (70 ppm) and tin (30 ppm) are from sample locality 1 (pl. 1). These values are not exceptionally high but are clearly anomalous. The maximum value for copper (100 ppm) was from locality 10 and is marginally anomalous. The barium content of stream sediment at locality 23 was only 30 ppm, which is about an order of magnitude lower than normal for samples from its source terrane, and the manganese content, 150 ppm, is also abnormally low. Hydrothermal alteration resulting in leaching of these two elements is a possible explanation; thus the sample is considered to be anomalous.

In the heavy-mineral concentrates, anomalously high values were obtained for 18 of the elements determined (table 1). The localities of samples yielding anomalous values cluster in three areas of distinct geologic character (pl. 1): area 1, in the eastern part of the study area, underlain largely by Precambrian granitic rocks; area 2, a narrow band of sites along Mescal Creek, in a fault-controlled valley; and area 3, in the southwestern part of the study area, underlain mainly by Tertiary quartz monzonite porphyry. Samples from area 1 contain anomalous amounts of barium, bismuth, copper, lead, molybdenum, niobium, silver, thorium, tin, tungsten, vanadium, and yttrium; those from area 2 contain anomalous quantities of barium, beryllium, bismuth, lead, and tungsten; and those from area 3 have anomalous amounts of arsenic, barium, boron, cadmium, copper, lead, silver, vanadium, and zinc.

Samples of the leaves of honey mesquite (*Prosopis juliflora*) were collected to provide information on soluble metals in the drainage basin and at depth. Uptake of minor elements by mesquite roots can take place as much as 50 ft laterally from the plant and 165 ft below the ground surface (Simpson, 1977). The mesquite samples were ashed, then digested in nitric and hydrochloric acids, and 30 elements were determined in the solutions by inductively coupled plasma spectroscopy.

Ash of mesquite leaves from the study area contained distinctly higher concentrations of calcium, strontium, and zinc, and slightly higher levels of boron, copper, and magnesium, than did samples from adjoining areas. Data on the 25 samples from the study area were combined with data on 210 similar samples from adjoining areas, and the enlarged data

Table 1. Elements contained in anomalous amounts in heavy-mineral concentrates, Needles Eye study area, Gila County, Arizona

[Area numbers and sample localities are shown on pl. 1. Semiquantitative spectrographic analyses. Amounts (in parentheses) in parts per million unless otherwise shown; pct, percent; L, detected but below lower limit of analytical determination; >, greater than; Do., ditto]

Area No.	Sample No.	Anomalous elements		
1	*10	Barium (>1 pct).		
	11	Do.		
	12	Barium (>1 pct), silver (1), niobium (150).		
	13	Barium (>1 pct), lead (300), vanadium (100), molybdenum (15), bismuth (20 L), thorium (L), tungsten (100 L).		
	14	None.		
	15	Barium (>1 pct), yttrium (2,000), tungsten (300), molybdenum (150).		
	16	Barium (>1 pct), bismuth (20 L).		
	17	Niobium (300), tin (50).		
	18	None.		
	19	None.		
	2	3	Barium (>1 pct), lead (500).	
		4	None.	
		5	Barium (>1 pct), bismuth (150), tungsten (100), beryllium (50).	
		6	Barium (>1 pct), beryllium (50).	
		7	Barium (>1 pct).	
		3	+1	Zinc (1 pct), lead (700), silver (1), vanadium (150), copper (150), cadmium (200), barium (>1 pct).
			23	Vanadium (300), arsenic (500 L), lead (2,000), zinc (2,000).
	24		Silver (500), lead (100), zinc (500).	
	25		Lead (5,000), barium (>1 pct), vanadium (500), silver (1).	
26	Boron (1,000), lead (300), vanadium (300).			

*Stream-sediment sample contained 100 ppm copper.

+Stream-sediment sample contained 70 ppm lead and 30 ppm tin.

set was examined statistically. The results suggest that copper, zinc, magnesium, and to a lesser extent, nickel, constitute a group of elements that is consistent with sulfide mineralization. Among samples from the study area, samples 8, 11, 16, 18, and 20 are highly anomalous, and samples 1, 2, 3, 9, 10, 14, 15, and 26 are anomalous. The suggestion that mesquite does respond to sulfide mineralization is supported by one mesquite sample, taken downstream from a small

copper-sulfide prospect, that is highly anomalous in copper, zinc, and magnesium. A group of samples that may indicate barium mineralization is characterized by anomalous boron and barium, with lesser amounts of zinc and calcium. The results from the mesquite samples indicate that elements are broadly dispersed in ground water that probably moved through mineralized source areas.

Mineral and Energy Resources

No mines and only one small prospect and one minor altered zone were seen in the study area. A moderately strong multielement geochemical anomaly was identified near the southwestern end of the study area (pl. 1, area 3), and two other weakly anomalous areas also were identified (pl. 1, areas 1 and 2). Panned-concentrate samples from area 3 contained highly anomalous amounts of lead, accompanied by vanadium, zinc, silver, and barium, and locally by boron, cadmium, copper, arsenic, and tin. The association of lead and vanadium suggest the presence of a lead vanadate mineral in the source area. This assemblage of elements, the local very high levels of some of them, and the distribution of anomalous samples in and around a Tertiary quartz monzonite porphyry laccolith (area 3) indicate a moderate mineral resource potential, with certainty level of C (Goudarzi, 1984; see inside front cover), for base and precious metals in veins and replacement deposits in the laccolith and in limestone adjacent to it. Samples from area 1 were anomalous in barium, molybdenum, niobium, tungsten, and bismuth, and a few samples were anomalous in lead, silver, tin, thorium, vanadium, or yttrium. This element assemblage and the low level of the anomaly suggest minor late-stage mineralization associated with Precambrian granite. Area 2 is characterized by a low-level barium and beryllium anomaly, together with local anomalous amounts of lead, bismuth, and tungsten. The area lies astride a fault zone along Mescal Creek, and most likely the anomaly reflects hydrothermal activity and possibly barite veins along the zone; however, a sample of brecciated granite from the fault zone near Mescal Warm Spring contained no anomalous amount of any element. The rest of the study area has a low resource potential for base and precious metals.

Some mineral production has come from nearby mining districts, in particular a substantial production of copper, silver, lead, zinc, and gold from the Banner (Christmas) mining district 5 mi southwest of the study area (Ross, 1925, p. 52-60; Eastlick, 1968). The host rocks of mineral deposits in the Banner district are also present in the study area, but the intrusive rocks of early Tertiary age with which the deposits are associated occur only at the southwestern end of the study area (area 3, pl. 1).

The Dripping Spring Quartzite, which occurs in two northwesterly trending belts within the study area, con-

tains uranium deposits northwest and west of the study area (Granger and Raup, 1959, fig. 51). A large area of this formation, west of and within the study area, was claimed by Phillips Uranium Co., and claims 3 mi or so west of the study area were explored and drilled. Exploration was unsuccessful, and all the claims were relinquished in 1982 (John Greenslade, Manager, Phillips Uranium Co., to G. S. Ryan, oral commun., 1984). The potential for uranium deposits in the Dripping Spring Quartzite within the study area therefore appears to be low, with certainty level C.

No structures favorable for the accumulation of oil and gas occur in the study area, no oil and gas leases or lease applications exist in or near the area, and the resource potential for oil and gas is low. Although one warm spring (temperature <80°F in November 1984) occurs in Mescal Creek, no geothermal source is likely in the study area (Witcher and others, 1982).

REFERENCES CITED

- Creasey, S. C., 1967, General geology of the Mammoth quadrangle, Pinal County, Arizona: U.S. Geological Survey Bulletin 1218, 94 p.
- Creasey, S. C., and Kistler, R. W., 1962, Ages of some copper-bearing porphyries and other igneous rocks in southeastern Arizona, *in* Short papers in geology, hydrology, and topography: U.S. Geological Survey Professional Paper 450-D, p. D1-D5.
- Eastlick, J. T., 1968, Geology of the Christmas mine and vicinity, Banner mining district, Arizona, *in* Ridge, J. D., ed., Ore deposits of the United States, 1933-1967 (Graton-Sales Volume), v. 2: New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, p. 1191-1210.
- Goudarzi, G. H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84-787, 42 p.
- Granger, H. C., and Raup, R. B., 1959, Uranium deposits in the Dripping Spring Quartzite, Gila County, Arizona: U.S. Geological Survey Bulletin 1046-P, p. 415-486.
- Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.
- Harms, T. F., Bradley, L. A., Tidball, R. R., Motooka, J. M., and Conklin, N. M., 1985, Analytical results and sample locality maps of stream sediments, heavy-mineral concentrates, and plant samples from Black Rock, Fishhooks, and Needles Eye Wilderness Study Areas, Graham and Gila Counties, Arizona: U.S. Geological Survey Open-File Report 85-462, 52 p., 3 plates.
- Ross, C. P., 1925, Ore deposits of the Saddle Mountain and Banner mining districts, Arizona: U.S. Geological Survey Bulletin 771, 72 p.
- Ryan, G. S., 1985, Mineral investigation of the Needles Eye Wilderness Study Area, Gila County, Arizona: U.S. Bureau of Mines Open File Report MLA 9-85, 8 p.
- Shride, A. F., 1967, Younger Precambrian geology in southeastern Arizona: U.S. Geological Survey Professional Paper 566, 89 p.

Simpson, B. B., ed., 1977, Mesquite—its biology in two desert ecosystems: Stroudsburg, Penn., Dowden, Hutchinson and Ross, Inc., 250 p.

Willden, Ronald, 1964, Geology of the Christmas quadrangle, Gila and Pinal Counties, Arizona: U.S. Geological Survey Bulletin 1161-E, 64 p.

Witcher, J. C., Stone, Claudia, and Rahman, W. R., Sr., 1982, Geothermal resources of Arizona [map]: U.S. National Oceanic and Atmospheric Administration, National Geophysical and Solar-Terrestrial Data Center, scale 1:500,000.

GEOLOGIC TIME CHART
 Terms and boundary ages used by the U. S. Geological Survey, 1986

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

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

² Informal time term without specific rank.

