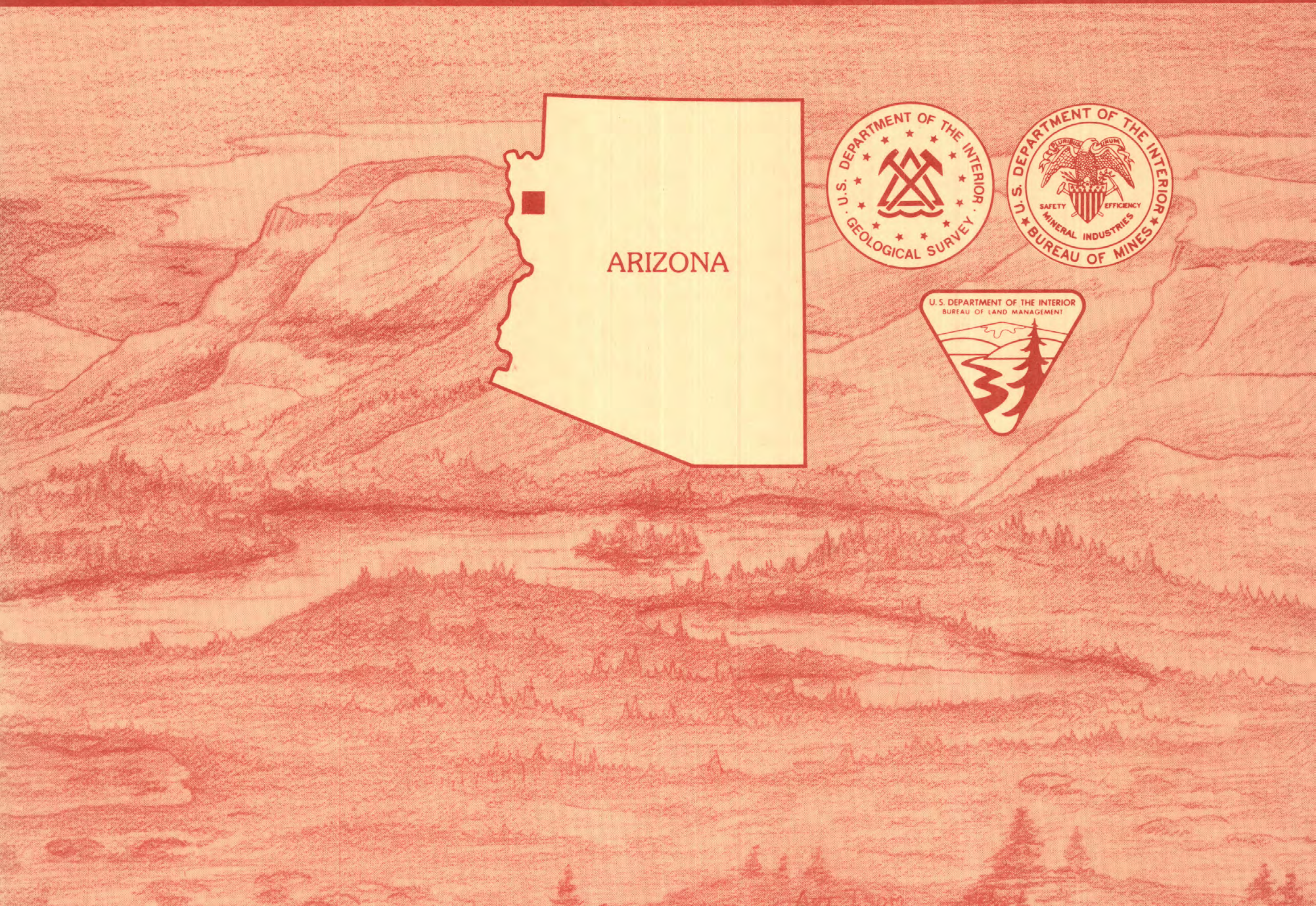
Mineral Resources of the Mount Tipton Wilderness Study Area, Mohave County, Arizona

U.S. GEOLOGICAL SURVEY BULLETIN 1737–B



AVAILABILITY OF BOOKS AND MAPS OF THE U.S. GEOLOGICAL SURVEY

Instructions on ordering publications of the U.S. Geological Survey, along with prices of the last offerings, are given in the current-year issues of the monthly catalog "New Publications of the U.S. Geological Survey." Prices of available U.S. Geological Survey publications released prior to the current year are listed in the most recent annual "Price and Availability List." Publications that are listed in various U.S. Geological Survey catalogs (**see back inside cover**) but not listed in the most recent annual "Price and Availability List" are no longer available.

Prices of reports released to the open files are given in the listing "U.S. Geological Survey Open-File Reports," updated monthly, which is for sale in microfiche from the U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225. Reports released through the NTIS may be obtained by writing to the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161; please include NTIS report number with inquiry.

Order U.S. Geological Survey publications **by mail** or **over the counter** from the offices given below.

BY MAIL

Books

Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Circulars, publications of general interest (such as leaflets, pamphlets, booklets), single copies of Earthquakes & Volcanoes, Preliminary Determination of Epicenters, and some miscellaneous reports, including some of the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from

U.S. Geological Survey, Books and Open-File Reports
Federal Center, Box 25425
Denver, CO 80225

Subscriptions to periodicals (Earthquakes & Volcanoes and Preliminary Determination of Epicenters) can be obtained ONLY from the

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

(Check or money order must be payable to Superintendent of Documents.)

Maps

For maps, address mail orders to

U.S. Geological Survey, Map Distribution
Federal Center, Box 25286
Denver, CO 80225

Residents of Alaska may order maps from

Alaska Distribution Section, U.S. Geological Survey,
New Federal Building - Box 12
101 Twelfth Ave., Fairbanks, AK 99701

OVER THE COUNTER

Books

Books of the U.S. Geological Survey are available over the counter at the following Geological Survey Public Inquiries Offices, all of which are authorized agents of the Superintendent of Documents:

- **WASHINGTON, D.C.**--Main Interior Bldg., 2600 corridor, 18th and C Sts., NW.
- **DENVER, Colorado**--Federal Bldg., Rm. 169, 1961 Stout St.
- **LOS ANGELES, California**--Federal Bldg., Rm. 7638, 300 N. Los Angeles St.
- **MENLO PARK, California**--Bldg. 3 (Stop 533), Rm. 3128, 345 Middlefield Rd.
- **RESTON, Virginia**--503 National Center, Rm. 1C402, 12201 Sunrise Valley Dr.
- **SALT LAKE CITY, Utah**--Federal Bldg., Rm. 8105, 125 South State St.
- **SAN FRANCISCO, California**--Customhouse, Rm. 504, 555 Battery St.
- **SPOKANE, Washington**--U.S. Courthouse, Rm. 678, West 920 Riverside Ave..
- **ANCHORAGE, Alaska**--Rm. 101, 4230 University Dr.
- **ANCHORAGE, Alaska**--Federal Bldg, Rm. E-146, 701 C St.

Maps

Maps may be purchased over the counter at the U.S. Geological Survey offices where books are sold (all addresses in above list) and at the following Geological Survey offices:

- **ROLLA, Missouri**--1400 Independence Rd.
- **DENVER, Colorado**--Map Distribution, Bldg. 810, Federal Center
- **FAIRBANKS, Alaska**--New Federal Bldg., 101 Twelfth Ave.

Chapter B

Mineral Resources of the Mount Tipton Wilderness Study Area, Mohave County, Arizona

By ROBERT C. GREENE, ROBERT L. TURNER,
ROBERT C. JACHENS, and WILLIAM A. LAWSON
U.S. Geological Survey

CARL L. ALMQUIST
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1737

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
BLACK MOUNTAINS REGION, 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 Mount Tipton Wilderness Study Area, Mohave
County, Arizona / by Robert C. Greene . . . [et al.].
p. cm. — (Mineral resources of wilderness study areas—Black
Mountains region, Arizona ; ch. B)(U.S. Geological Survey bulletin ; 1737–B)
Includes bibliographical references.
Supt. of Docs. no. : I 19.3:1737–B
1. Mines and mineral resources—Arizona—Mount Tipton Wilderness.
2. Mount Tipton Wilderness (Ariz.) I. Greene. Robert C. II. Series. III. Series:
U.S. Geological Survey bulletin ; 1737–B.
QE75.B9 no. 1737–B 557.3 s—dc20 89-600219
[TN24.A6] [553'.09791'59] 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 the Mount Tipton Wilderness Study Area (AZ-020-012/042), Mohave County, Ariz.

CONTENTS

FIGURES

TABLE

Mineral Resources of the Mount Tipton Wilderness Study Area, Mohave County, Arizona

By Robert C. Greene, Robert L. Turner, Robert C. Jachens, *and* William A. Lawson
U.S. Geological Survey

Carl L. Almquist
U.S. Bureau of Mines

SUMMARY

Abstract

The Mount Tipton Wilderness Study Area (AZ–020–012/042) comprises 33,950 acres in Mohave County, Ariz. At the request of the U.S. Bureau of Land Management, this area was evaluated for identified mineral resources (known) and mineral resource potential (undiscovered). This work was carried out by the U.S. Bureau of Mines and the U.S. Geological Survey in 1984–87. In this report, the area studied is referred to as the "wilderness study area" or simply "the study area." There are no identified mineral resources in the study area. The southernmost part of the study area is adjacent to the Wallapai (Chloride) mining district and has low mineral resource potential for gold, silver, copper, lead, zinc, and molybdenum in hydrothermal veins. This area also has a low mineral resource potential for tungsten in vein deposits and for uranium in vein deposits or pegmatites. In the central part of the wilderness study area, one small area has low mineral resource potential for uranium in vein deposits or pegmatites and another small area has low resource potential for thorium in vein deposits. The entire study area has low resource potential for geothermal energy but no potential for oil or gas resources.

Character and Setting

The Mount Tipton Wilderness Study Area (fig. 1) lies in westernmost Arizona between Hoover Dam and Kingman. It is in the Cerbat Mountains, part of the Basin and Range province of western North America. Granitic gneiss and hornblende gneiss of Precambrian age (see "Appendixes" for geologic time chart) underlie most of the study area. Welded tuff, mud-flow deposits, and andesite of Tertiary age underlie small areas near the southwest and north borders of the study area.

Manuscript approved for publication May 10, 1989.

Identified Mineral Resources and Mineral Resource Potential

There are no identified mineral resources in the wilderness study area.

The southernmost part of the study area is immediately adjacent to the Wallapai (Chloride) mining district and has low mineral resource potential for gold, silver, copper, lead, zinc, and molybdenum in hydrothermal veins (fig. 2). This area also has a low mineral resource potential for tungsten vein deposits and for uranium in vein deposits or pegmatites. In the central part of the wilderness study area, one small area has low mineral resource potential for uranium in vein deposits or pegmatites and another small area has low resource potential for thorium in vein deposits. The entire study area has low resource potential for geothermal energy but no potential for resources of oil and gas.

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 the U.S. Bureau of Mines. An introduction to the wilderness review process, mineral survey methods, and agency responsibilities was provided by Beikman and others (1983). The U.S. Bureau of Mines evaluates identified resources at individual mines and mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas.

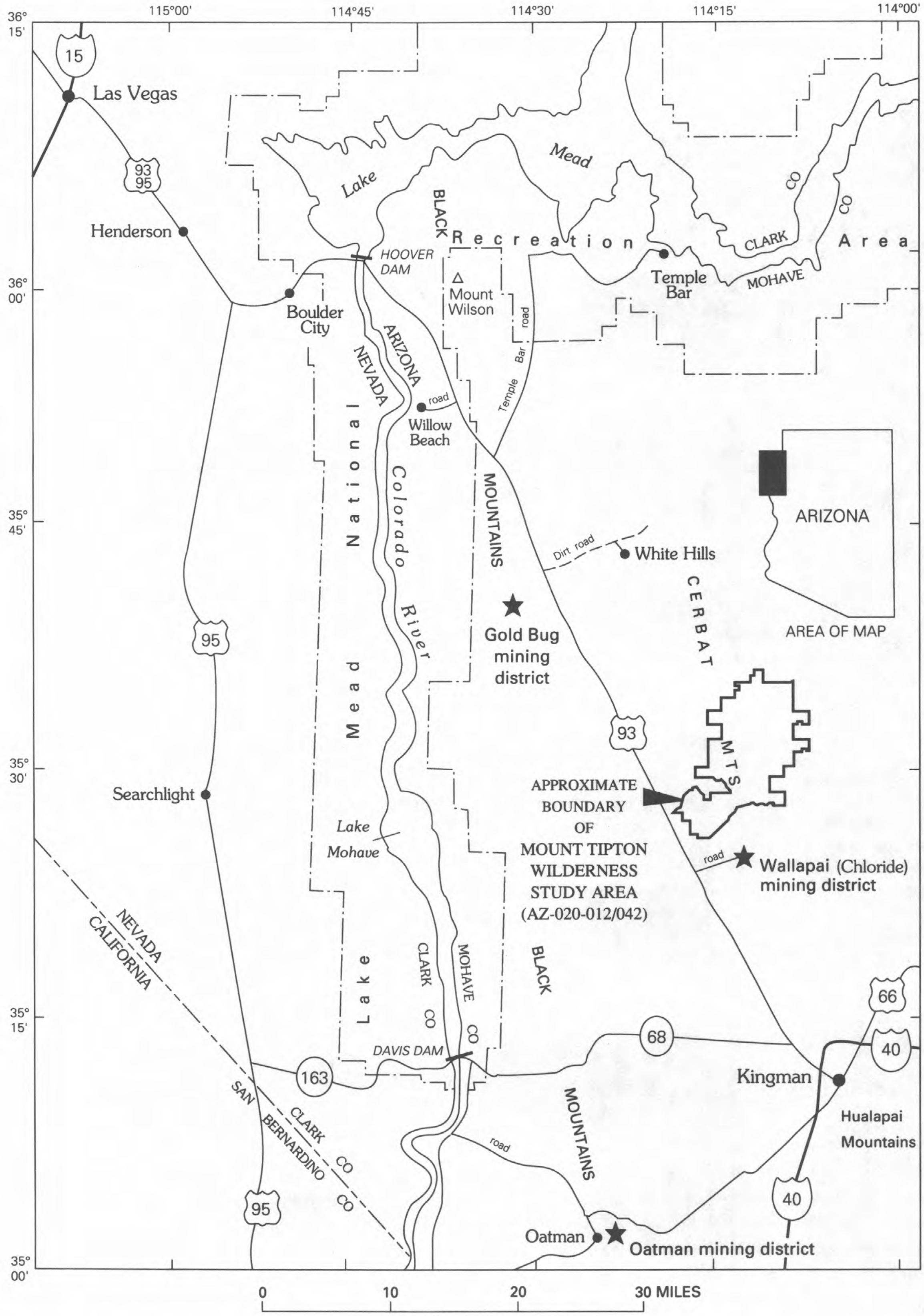


Figure 1. Map showing location of Mount Tipton Wilderness Study Area, Mohave County, Arizona.

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.

Setting

The Mount Tipton Wilderness Study Area (AZ–020–012/042) comprises 33,950 acres in Mohave County, Ariz., east of the Colorado River and directly east of U.S. Highway 93, the highway connecting Hoover Dam and Kingman (fig. 1). Mount Tipton, 7,148 ft high, is in the central part of the Cerbat Mountains, a north-trending range that is 32 mi long. Valleys on either side of the range lie at an altitude of about 3,000 ft; farther to the west the Black Mountains form a low ridge, then the land drops abruptly to the Lake Mohave section of the Colorado River, where the surface altitude is less than 600 ft.

Previous Work and Present Study

Previous geologic mapping in the Mount Tipton area consists of reconnaissance work that appears on the geologic maps of Arizona (Wilson and others, 1969; Reynolds, 1988). Mineral surveys can be found in Schrader (1909) and in a resources report by the U.S. Bureau of Land Management (1983). The Wallapai (Chloride) mining district, which lies immediately south of the wilderness study area, is discussed by Dings (1951).

Reconnaissance geologic mapping for the present report was carried out by W.A. Lawson in the central and southern parts on the Mount Tipton and Chloride 7.5-minute quadrangles and by R.C. Greene mostly in the western part of the Grasshopper Junction 7.5-minute quadrangle. Geochemical sampling and interpretation of results are mostly by R.L. Turner, and interpretation of geophysics is by R.C. Jachens. Appraisal of identified resources is by C.L. Almquist of the U.S. Bureau of Mines. Final assembly and interpretation is by R.C. Greene.

Aerial photographs were lent by the U.S. Bureau of Land Management office in Kingman, Ariz. William Hamilton of Quail Spring Ranch kindly provided trailer parking space and access to the wilderness study area as well as information about the locations of prospects.

APPRAISAL OF IDENTIFIED RESOURCES

By Carl L. Almquist
U.S. Bureau of Mines

Introduction

In 1987, the U.S. Bureau of Mines conducted a mineral investigation of the Mount Tipton Wilderness Study Area. No leasable, locatable, or salable mineral resources were identified. This investigation included a review of literature, unpublished U.S. Bureau of Mines and U.S. Bureau of Land Management files, and mining claim and land status records; mining claim holders were contacted; prospects in the study area and adjacent areas were examined and sampled; and sample analyses were evaluated. Two U.S. Bureau of Mines geologists spent three days in the study area. They collected nine chip, grab, and select samples, which were analyzed by Chemex Labs, Inc., Sparks, Nev. Copper, lead, zinc, silver, molybdenum, arsenic, and antimony were determined by inductively coupled plasma–atomic emission analysis. Gold was determined by fire assay and neutron activation analyses. The results of these analyses are listed in table 1 of this report.

Mining and Mineral Exploration History

Minerals-related activity in the study area has included prospecting, locating mining claims, and oil and gas leasing; there is no recorded production of any mineral commodities. A block of lode and placer mining claims extends into the northwest corner of the study area, and one mining claim lies on the south boundary (Almquist, 1988, fig. 2). Recorded production for the adjacent Wallapai (Chloride) mining district from 1901 to 1981 is 666.1 million lb copper, 53.2 million lb molybdenum, 80.1 million lb lead, 126.5 million lb zinc, 11.5 million troy oz silver, and 0.151 million troy oz gold (Keith and others, 1983, p. 52–53).

Mines, Prospects, Mining Claims, and Leases

No previously unknown mines, prospects, or mineralized areas were found during reconnaissance of mining claims in the study area. Four outcrop samples were collected at sites on the block of mining claims where assays obtained by the claim holders show that significant concentrations of base and precious metals are present. The U.S. Bureau of Mines samples, however, contain insignificant concentrations of gold, silver, copper, lead, zinc, molybdenum, arsenic, and antimony (table 1, Nos. 6–9). An effort to develop a natural spring as a water source was the only surface

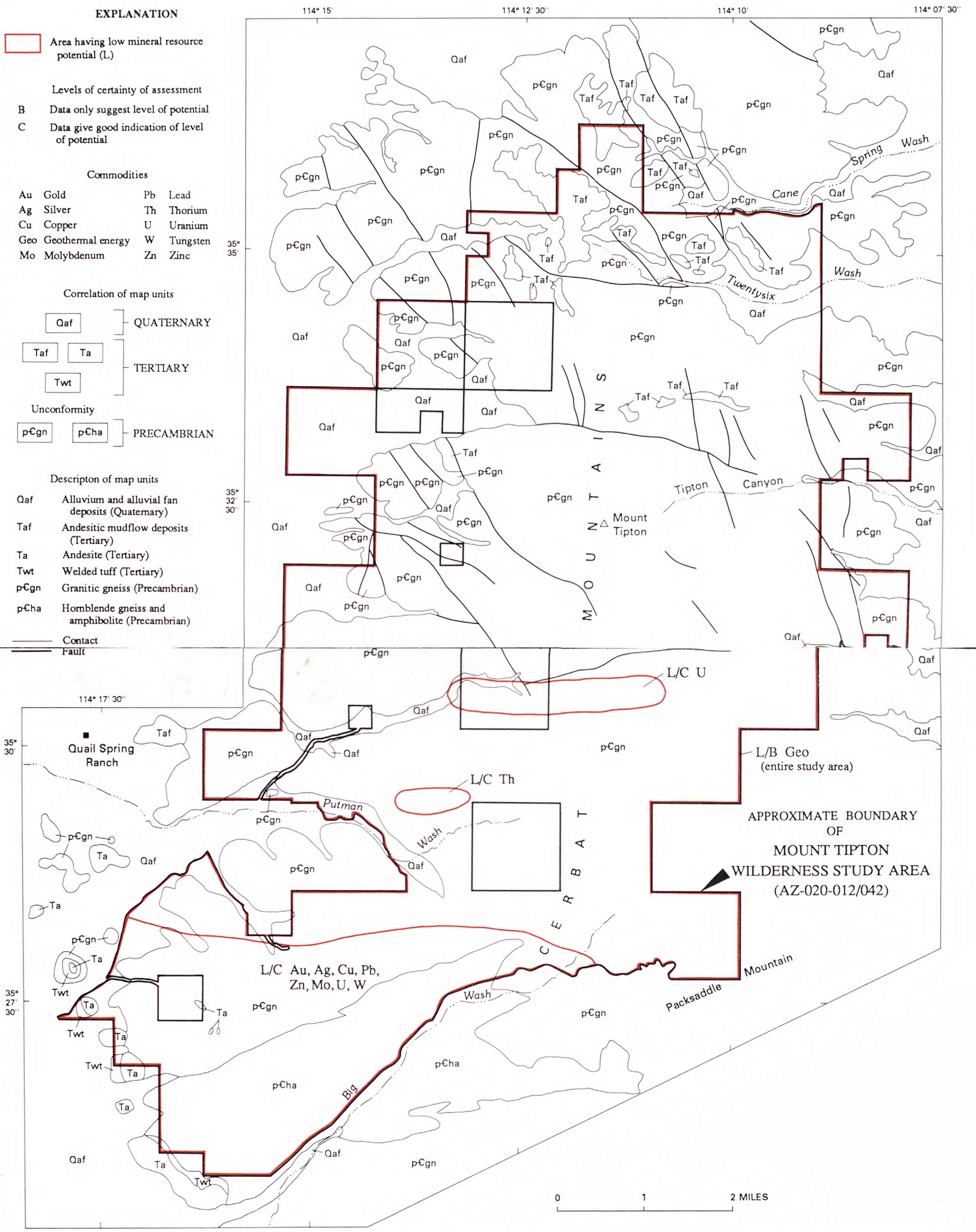


Figure 2. Mineral resource potential and generalized geology of Mount Tipton Wilderness Study Area, Mohave County, Arizona. Study area includes several blocks of privately owned land. Geology by W.A. Lawson and R.C. Greene, 1984–1987.

Table 1. Analytical data for samples collected by the U.S. Bureau of Mines during the mineral investigation of the Mount Tipton Wilderness Study Area, Mohave County, Arizona

[Au analyses are by fire assay and neutron activation; Ag, Cu, Pb, Zn, Mo, As, and Sb analyses are by inductively coupled plasma–atomic emission spectrography. All analyses by Chemex Labs, Sparks, Nevada. na, not applicable; >, greater than; <, less than; ppb, parts per billion; ppm, parts per million. Sample sites shown in Almquist (1988, fig. 2)]

Sample			Analytical data								Remarks
No.	Type	Length (ft)	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	Mo ppm	As ppm	Sb ppm	
1	Grab	na	<1	1.5	48	16	7	1	7	8.0	Prospect pit; pegmatitic quartz mass in Precambrian gneiss.
2	Chip	5.3	<5	.1	1	5	2	1	6	1.8	Prospect trench; pegmatitic quartz mass in Precambrian gneiss and schist.
3	Chip	1.0	9	4.8	100	15	17	1	380	20.0	Prospect pit; 1.0-ft-thick quartz vein striking N. 70° W., dipping 65° NE in Precambrian schist.
4	Grab	na	16	.6	66	6	84	2	510	17.6	Inclined shaft; quartz vein striking N. 10° W., dipping 60° NE in Precambrian gneiss; limonite.
5	Select	na	54	>100.0	9,400	670	336	1	1,700	>1,000	Inclined shaft; quartz vein fragments in sorted pile on dump; chalcopyrite, azurite, malachite, limonite.
6	Chip	4.0	4	.1	5	2	6	1	6	.3	Outcrop of Precambrian gneiss.
7	Chip	5.5	2	.1	4	1	7	2	4	.2	Outcrop of Precambrian gneiss.
8	Chip	6.0	12	.1	4	2	34	1	5	.2	Outcrop of Precambrian gneiss.
9	Chip	1.5	4	.1	4	1	5	4	4	.1	1.5-ft-thick quartz vein in outcrop of Precambrian gneiss.

disturbance observed on the block of claims. Scintillometer readings in the claim areas did not exceed the background level of 50 counts per second (CPS) by more than 75 percent.

At a site about 0.5 mi outside the south boundary of the study area, quartz veins in iron-stained gneiss contain concentrations of copper, lead, zinc, silver, and gold (table 1, Nos. 3–5). At the surface, the veins are poorly exposed, irregular, and about 1 ft thick; none are traceable into the study area. Workings at this site consist of two inclined shafts and several pits. An additional prospect pit (table 1, No. 1) just inside the south boundary of the study area and a prospect trench (table 1, No. 2) 0.5 mi outside the study area show no significant element concentrations.

In 1979, 20 shallow (40 ft deep or less) exploratory holes were drilled along the south boundary of the study area in an unsuccessful effort to locate uranium concentrations in Precambrian crystalline rocks (Robert A. Laverty, former claim holder, oral commun., 1987). Scintillometer readings did not exceed the background level of 50 CPS by more than 75 percent, and no mineralized zones were observed near the drilling sites.

Industrial mineral commodities in the study area have no apparent superior qualities and represent only a small fraction of abundant supplies available from established sources located elsewhere, which make those in the study area uncommercial.

Ryder (1983, p. C19) rated the study area as having zero potential for the occurrence of petroleum, on the basis of the sole presence of igneous and metamorphic rocks. Nevertheless, approximately 11,500 acres were under lease for oil and gas at the time of the U.S. Bureau of Mines investigation (Almquist, 1988, fig. 3).

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Robert C. Greene, Robert L. Turner, Robert C. Jachens, *and* William A. Lawson
U.S. Geological Survey

Geology

The Cerbat Mountains are part of the Basin and Range province of western North America, a region characterized by fault-block mountains and intervening alluvium-filled valleys. The Mount Tipton Wilderness Study Area (fig. 2) is underlain principally by granitic gneiss of Precambrian age; hornblende gneiss and amphibolite are predominant in the southern part of the area. The Precambrian rocks are locally overlain by welded tuff, andesite, and andesitic mud-flow deposits, all of Tertiary age.

The hornblende gneiss and amphibolite (map unit p€ha) are dark-gray to black rocks, mostly fine to medium grained, and form prominent outcrops on ridges and spurs. The hornblende gneiss consists of about 50 percent plagioclase and 50 percent hornblende with minor opaque and accessory minerals and alteration products. This mostly medium grained rock has a prominent irregular foliation; hornblende and plagioclase are each dominant in alternate lenticular layers. The hornblende gneiss grades by an increase in hornblende content into amphibolite, a fine-grained rock having weak foliation and prominent lineation consisting of the same minerals but whose hornblende content approaches 100 percent. Granitic gneiss is locally interlayered with the hornblende gneiss, and quartz-feldspar pegmatite is also abundant.

Granitic gneiss (map unit p€gn) is the predominant rock type underlying Mount Tipton and other parts of the Cerbat Mountains. It is a medium- to coarse-grained rock having the colors of the individual minerals: pinkish to yellowish gray (feldspar), light gray (quartz), and dark gray (biotite). Outcrops, locally forming cliffs and spires, are abundant; the mostly light yellowish gray surfaces are undergoing granular disintegration. The rocks have characteristically weak foliation shown by aligned biotite grains and clots or by quartz-rich lenses. The gneiss is composed mostly of plagioclase, microcline, and quartz. Quartz content is commonly 20 to 40 percent, and the feldspars may be in any relative proportion. Biotite content is 1 to 3 percent, and trace amounts of opaque and accessory minerals make up the rest of the most commonly occurring gneiss. Less common gneisses contain minor hornblende or sillimanite with garnet. Hornblende-rich gneiss as described above is locally interlayered, as are pegmatite and aplite (not separately mapped).

Welded tuff (map unit Twt) is present locally near the ends of spurs and in small detached areas in the southwestern part of the study area. The tuff is of varied texture and color; it is pinkish to brownish gray and has prominent fragmental texture. It is of andesitic to dacitic composition and contains phenocrysts of plagioclase, augite, biotite, and (locally) sanidine, each 1 percent or less. The groundmass is composed mostly of fragments of andesite or dacite which in turn contain microphenocrysts of plagioclase and augite; flattened devitrified pumice and shards are common, especially toward the top of the unit.

Andesite (map unit Ta) is present locally in the southwestern part of the study area, generally overlying welded tuff but in places resting directly on gneiss. The andesite is dark to medium gray and has aphanitic to micrograined groundmass with abundant microphenocrysts of plagioclase (25 to 35 percent) and augite (5 to 10 percent).

Andesitic mudflow deposits (map unit Taf) principally cap peaks and ridges in the northern part of the study area. Abundant bold outcrops commonly form vertical cliffs. Flows of andesite resembling that described above are locally present at or near the base of the mudflow unit, suggesting that the two units are of the same age. The matrix of the mudflow deposits consists of very light brownish gray and unsorted andesite fragments; angular clasts of andesite of various colors and textures range from 0.1 to 1 in. in diameter, and some subangular to subrounded fragments of the same materials are as large as 6 ft. Clasts of gneiss are locally present near the base. Some layers consist entirely of material no larger than very coarse sand, but most layers contain unsorted matrix-supported clasts of pebble to boulder size. Some layers seen in cliffs have larger clasts concentrated near their base or near their top; the latter situation suggests that the clasts were rafted during mudflow movement.

Quaternary surficial deposits (map unit Qaf) surround the Cerbat Mountains. They consist principally of alluvial fan deposits and of alluvium in active stream channels.

The general structure of the Cerbat Mountains is that of a large horst or uplifted block bounded by concealed faults lying in the valleys to the east and west. Several northwest-trending minor faults are present in the north part of the study area. The internal structure of the Precambrian rocks is complex and has not yet been studied. The Cerbat Mountains block is more or less truncated on both the north and south ends by sags in the horst; volcanic rocks of Tertiary age are exposed in these sags (Reynolds, 1988).

The sources of the volcanic rocks in the study area have not been identified. However, the position of the thick andesitic mudflow deposits (fig. 2) indicates a source high on Mount Tipton itself. Additional mapping in adjacent areas is needed to find a source for the andesite and welded tuff low on the southwest flank of the mountains.

Geochemistry

A reconnaissance geochemical survey was conducted in the Mount Tipton Wilderness Study Area to evaluate it for indications of mineralization. Reconnaissance surveys are not designed to find individual deposits, rather they allow large areas to be subdivided into geochemical provinces or mineralized districts. Rocks and minus-80-mesh stream sediments were selected as the sample media for this study. Stream sediments from 43 sites were collected, and heavy-mineral concentrates were prepared from each; rock samples from 26 sites were also collected.

The stream-sediment samples were collected from active alluvium in the stream channels. Each sample was composited from several localities along a channel length of approximately 50 ft. The stream sediments were seived through an 80-mesh screen and pulverized to a fine powder before analysis. To prepare a heavy-mineral concentrate, stream sediment was seived through a 10-mesh screen and then panned until most of the quartz, feldspar, clays, and organic matter were removed. The remaining minerals of low density were removed with a heavy liquid (bromoform, specific gravity 2.8). The sample was then separated into magnetic, slightly magnetic, and nonmagnetic fractions by use of an electromagnet. The nonmagnetic fraction of the concentrates was ground to a fine powder and analyzed.

Stream sediments represent a composite of the rock and soil exposed upstream from the sample site. The heavy-mineral concentrate is representative of the heavy-mineral components of the rocks exposed in the drainage basin and could include ore-forming and ore-related minerals if mineralization has occurred within the drainage basin. Elements that are not easily detected in bulk stream sediments may appear in analyses of these concentrates.

Rock samples were taken from mineralized, altered, and unaltered outcrops and from stream float. Samples of fresh, unaltered rock provide information on geochemical background concentrations. Altered or mineralized samples were collected to determine the suite of elements associated with observed alteration or mineralization. The rocks were crushed and pulverized to a fine powder before analysis.

The heavy-mineral concentrates, stream sediments, and rocks were analyzed for 31 elements by semiquantitative, direct-current arc emission spectrography (Grimes and Marranzino, 1968; Crock and others, 1983). The rocks were also analyzed for arsenic, antimony, bismuth, cadmium, and zinc by atomic absorption (O'Leary and Viets, 1986) and for gold (Thompson and others, 1968) and mercury (Koirtyohann and Khalil, 1976). Analytical data for the Mount Tipton Wilderenss Study Area and a description of the sampling and analytical techniques were supplied by J.H. Bullock, Jr. (written commun., 1988).

Geochemical Results

The analyses of the samples collected in the Mount Tipton Wilderness Study Area show a few elevated or anomalous concentrations. Most of the samples having anomalous concentrations are from the southernmost part of the study area; others are from widely scattered sites.

Anomalous concentrations in the nonmagnetic fraction of the heavy-mineral concentrates include bismuth (100 to 1,000 parts per million, ppm), molybdenum (as much as 300 ppm), silver (as much as 20 ppm), tin (as much as 1,500 ppm), and tungsten (1,000 to 20,000 ppm). Three samples having anomalous tungsten and bismuth content are from the hornblende gneiss and amphibolite unit in the southernmost part of the study area. Other samples from widely scattered sites in the more common granitic gneiss have anomalous single-element concentrations of bismuth, molybdenum, silver, or tin. Some of these may be associated with the northwest-trending faults in the north half of the study area.

The Wallapai (Chloride) mining district to the south includes some of the same rocks as those that underlie the study area. According to Schrader (1909), the suite of elements associated with the mineralization in this mining district includes silver, lead, gold, and copper. This suite of elements does not appear in anomalous concentrations in the Mount Tipton Wilderness Study Area; thus the geochemical data obtained during this study do not support the extension of mineralization similar to that in the Wallapai district into the study area.

Three samples from mineralized quartz veins in the southernmost part of the study area contain anomalous silver (maximum 2 ppm) and copper (maximum 2,000 ppm); two contain vanadium (maximum 30 ppm), and one contains 10 ppm each of cobalt and nickel. Numerous prospect pits in this area attest to the presence of mineralization.

Geophysics

Three types of geophysical data (magnetic, radiometric, and gravity), from regional surveys in western Arizona, were compiled and examined to help assess of the mineral resource potential of the Mount Tipton Wilderness Study Area. Detailed aeromagnetic and radiometric data are available along profiles spaced about 1 mi apart. The sparse distribution of the gravity stations makes the data adequate for addressing the regional structural and tectonic setting of the study area but does not permit detailed statements about mineral resource potential at the deposit scale.

Aeromagnetic Data

An aeromagnetic survey of the Kingman 1° by 2° quadrangle, California, Nevada, and Arizona, was flown in 1977 and compiled by Western Geophysical Company of America (1979) under contract to the U.S. Department of Energy as part of the National Uranium Resource Evaluation (NURE) program. These data were subsequently merged with aeromagnetic surveys over adjacent areas by Mariano and Grauch (1988). Total-field magnetic data over the wilderness study area and surrounding parts of Arizona were collected along east-west flightlines spaced approximately 1 mi apart at a nominal height of 400 ft above the ground surface. Corrections were applied to the data to yield a residual magnetic field that primarily reflects the distribution of magnetization in the underlying rocks.

The magnetic field over the Precambrian rocks of the Cerbat Mountains is characterized by elongate highs and lows that crudely define a northeast-trending magnetic grain similar to that produced by the basement rocks beneath the Colorado Plateau, adjacent to the east. Within the wilderness study area, one linear magnetic high more than 300 nanoteslas in amplitude and roughly 3 mi wide lies over the hornblende gneiss and amphibolite body (map unit p-Cha) that crops out in the southern part of the study area. This high indicates that concealed extensions of this body continue beneath the alluvium of the adjacent valley southwest of the study area boundary for more than 5 mi and also continue eastward along the south edge of the study area. A second major magnetic high within the study area, centered about 1 mi south of Mount Tipton, trends west and then north, straddling the west boundary of the study area. This high, 2 to 3 mi wide with an amplitude comparable to that of the first anomaly discussed above, lies over granitic gneiss (map unit p-Єgn). It is atypical of the magnetic field over most exposures of granitic gneiss within the study area and suggests the presence of a phase of granitic gneiss that is more magnetic, and probably more mafic, than normal.

The Wallapai (Chloride) mining district (Dings, 1951) shows a magnetic feature that probably is indirectly related to the mineralization in the area. A broad, deep magnetic low over the Precambrian rocks is spatially well correlated with the district and includes more than 90 percent of the mines and prospects shown by Dings (1951). Only the mines of the Stockton Camp, located along the southeast edge of the district, are outside the low. The spatial dimensions of the low and its location with respect to adjacent magnetic highs make it unlikely that this anomaly is a polarization effect of nearby magnetic bodies. Rather, it probably is caused by a magnetization that is significantly lower in the Precambrian rocks of the Wallapai mining district than in the surrounding Precambrian rocks. The lower magnetization may have resulted from alteration of the magnetic minerals by the mineralizing fluids that were the source of the deposits in the mining district.

Whatever the cause of the broad magnetic low, its close spatial correlation with the deposits of the Wallapai mining district indicates that it should be considered as a potential guide in assessing the mineral resource potential of the area surrounding the district. Because the low terminates 1 to 2 mi south of the south boundary of the study area, this guide suggests that Wallapai district mineralization does not continue north into the study area.

Radiometric Data

Radiometric data for the study area were collected at the same time and from the same aircraft as the magnetic data. Recordings were made of gamma-ray flux indicative of radioactive isotopes of potassium, thorium, and uranium. Only one anomaly indicative of thorium and having a count rate greater than one standard deviation above the mean was detected within the study area (Western Geophysical Company of America, Aero Service Division, 1979). The anomaly is about 1 mi wide and is centered at 35°29.5′ N. and 114°12.9′ W., just north of Putman Wash (fig. 2). A strong anomaly indicative of uranium was detected along a 3 mi-long east-west flightline segment extending west from the southwest end of Packsaddle Mountain. The anomalous segment lies mostly south of the study area but is within 0.3 mi of the study area boundary. Minor anomalies indicative of uranium within the study area are scattered along a flightline located at 35°30.3′ N., near the center of figure 2.

Gravity Data

Gravity data for the Mount Tipton Wilderness Study Area and vicinity include those shown by Mariano and others (1986) and an additional eight measurements made during 1987. Gravity data are sparse for the study area (3- to 5-mi spacing) but are more numerous in the surrounding areas.

Gravity values and total gravity relief in the study area are typical of those present over Precambrian rock exposed throughout the Cerbat Mountains. The total relief of about 15 milligals can be accounted for by density variations of about 0.2 grams per cubic centimeter (g/cm^3) in the country rock, which extends to depths of 5,000 to 6,000 ft. Density contrasts of 0.2 g/cm^3 or larger are characteristic of density differences between mafic and felsic Precambrian rocks in the region. Thus the sparse gravity data do not suggest any unusual density contrasts within the study area.

Mineral and Energy Resource Potential

The southernmost part of the study area (fig. 2) has low mineral resource potential, certainty level C, for gold, silver, copper, lead, zinc, and molybdenum in polymetallic veins such as those described by Cox (1986, model 22c). These commodities have had substantial production in the Wallapai (Chloride) mining district, in part from veins in hornblende gneiss similar to that exposed in the study area. The area of low mineral resource potential includes the outcrop area of the hornblende gneiss unit (p-Єha) and its extension as indicated by an aeromagnetic high. Mineral resource potential is suggested by anomalous concentrations of silver, copper, vanadium, cobalt, and nickel in quartz veins and by anomalous silver concentrations in heavy-mineral concentrates.

This area also has low mineral resource potential, certainty level C, for vein deposits of tungsten, as described by Cox and Bagby (1986, model 15a); this potential is suggested by the presence of anomalous concentrations of tungsten and bismuth in heavy-mineral concentrates. Furthermore, this area has low resource potential, certainty level C, for uranium in vein deposits or pegmatites. This potential is suggested by the uranium anomaly shown by the airborne radiometric survey and by the presence of anomalous vanadium, a common associate of uranium.

Two other small areas within the study area (fig. 2) have low mineral resource potential, certainty level C, for uranium and thorium, respectively, as suggested by the airborne radiometric anomalies.

There are no known warm springs in the Cerbat Mountains and no volcanic or intrusive rocks of Quaternary age. However, data points from the map of Muffler (1979) suggest that the area has a heat flow of about 100 milliwatts per square meter, which is quite high. Basin-and-range faults, which are present in the area, can act as conduits for low-temperature water-circulation systems. Therefore the entire study area has low potential, certainty level B, for geothermal energy resources.

The study area is underlain by high-grade metamorphic rocks and some young volcanic and continental sedimentary rocks. Because these are not good source rocks, the study area has no potential, certainity level D, for oil and gas resources (Ryder, 1983).

REFERENCES CITED

Almquist, C.L., 1988, Mineral investigation of the Mount Tipton Wilderness Study Area (AZ–020–012/042) and proposed additions, Mohave County, Arizona: U.S. Bureau of Mines Open-File Report MLA 9–88, 12 p.

Beikman, H.M., Hinkle, M.E., Frieders, Twila, Marcus, S.M., and Edward, J.R., 1983, Mineral surveys by the Geological Survey and the Bureau of Mines of Bureau of Land Management Wilderness Study Areas: U.S. Geological Survey Circular 901, 28 p.

Cox, D.P., 1986, Descriptive model of polymetallic veins, *in* Cox, D.P., and Singer, D.A., eds., Mineral deposits models: U.S. Geological Survey Bulletin 1693, p. 125.

Cox, D.P., and Bagby, W.C., 1986, Descriptive model of W veins, *in* Cox D.P., and Singer, D.A., eds., Mineral deposits models: U.S. Geological Survey Bulletin 1693, p. 64.

Crock, J.G., Lichte, F.E., and Briggs, P.H., 1983, Determination of elements in National Bureau of Standards geological reference material SRM 278 obsidian and SRM 668 basalt by induction coupled argon plasma–atomic emission spectrometry: Geostandards Newsletter, no. 7, p. 335–340.

Dings, M.G., 1951, The Wallapai mining district, Cerbat Mountains, Mohave County, Arizona: U.S. Geological Survey Bulletin 978–E, p. 123–163.

Goudarzi, G.H., 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–787, 51 p.

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.

Keith, S.B., Gest, D.E., DeWitt, E.H., Toll, N.W., and Everson, B.A., 1983, Metallic mineral districts and production in Arizona: Arizona Bureau of Geology and Mineral Technology Bulletin 194, 58 p.

Koirtyohann, S.R., and Khalil, Moheb, 1976, Variables in determination of mercury by cold vapor atomic absorption: Analytical Chemistry, v. 48, p. 136–139.

Mariano, John, and Grauch, V.J.S., 1988, Aeromagnetic maps of the Colorado River region including the Kingman, Needles, Salton Sea, and El Centro 1° x 2° quadrangles, California, Arizona, and Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF–2023; 5 sheets, scale 1:250,000; 1 sheet, scale 1:750,000.

Mariano, John, Helferty, M.G., and Gage, T.B., 1986, Bouguer and isostatic residual gravity maps of the Colorado River region, including the Kingman, Needles, Salton Sea, and El Centro quadrangles: U.S. Geological Survey Open-File Report 86–347; 6 sheets, scale 1:250,000; 1 sheet, scale 1:750,000.

McKelvey, V.E., 1972, Mineral resource estimates and public policy: American Scientist, v. 60, p. 32–40.

Muffler, L.J.P., ed., 1979, Assessment of geothermal resources of the United States—1978: U.S. Circular 790, 163 p., 3 maps, scales 1:2,500,000, 1:5,000,000, 1:1,000,000.

O'Leary, R.M., and Viets, J.G., 1986, Determination of antimony, arsenic, bismuth, cadmium, copper, lead, molybdenum, silver and zinc in geologic materials by atomic absorption spectrometry using a hydrochloric acid–hydrogen peroxide digestion: Atomic Spectroscopy, v. 7, p. 4–8.

Reynolds, S.J., 1988, Geologic map of Arizona: Arizona Geological Survey Map 26, scale 1:1,000,000.

Ryder, R.T., 1983, Petroleum potential of wilderness lands in Arizona, *in* Miller, B.M., ed., Petroleum potential of wilderness lands in the western United States: U.S. Geological Survey Circular 902–C, 22 p.

Schrader, F.C., 1909, Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona: U.S. Geological Survey Bulletin 397, 226 p..

Thompson, C.E., Nakagawa, H.M., and Van Sickle, G.H., 1968, Rapid analysis for gold in geologic materials, *in* Geological Survey Research 1968: U.S. Geological Survey Professional Paper 600–B, p. B130–B132.

U.S. Bureau of Land Management, 1983, Mount Tipton G–E–M resources area: Technical Report, AZ–04, 31 p.

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, 5 p.

Western Geophysical Company of America, Aero Service Division, 1979, Airborne gamma-ray spectrometer and magnetometer survey, Las Vegas quadrangle (Arizona, California, Nevada), Williams quadrangle (Arizona), Prescott quadrangle (Arizona), and Kingman quadrangle (Arizona, California, Nevada), final report: U.S. Department of Energy Open-File Report GJBX 59(79), v. 2, variously paged.

Wilson, E.D., Moore, R.T., and Cooper, J.R., 1969, Geologic map of Arizona: Arizona Bureau of Mines and U.S. Geological Survey, scale 1:500,000.

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 →

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td rowspan="4">U/A
UNKNOWN POTENTIAL</td><td>H/B
HIGH POTENTIAL</td><td>H/C
HIGH POTENTIAL</td><td>H/D
HIGH POTENTIAL</td></tr>
<tr><td>M/B
MODERATE POTENTIAL</td><td>M/C
MODERATE POTENTIAL</td><td>M/D
MODERATE POTENTIAL</td></tr>
<tr><td rowspan="2">L/B
LOW POTENTIAL</td><td rowspan="2">L/C
LOW POTENTIAL</td><td>L/D
LOW POTENTIAL</td></tr>
<tr><td>N/D
NO POTENTIAL</td></tr>
</table>

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.

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.

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.

SELECTED SERIES OF U.S. GEOLOGICAL SURVEY PUBLICATIONS

Periodicals

Earthquakes & Volcanoes (issued bimonthly).
Preliminary Determination of Epicenters (issued monthly).

Technical Books and Reports

Professional Papers are mainly comprehensive scientific reports of wide and lasting interest and importance to professional scientists and engineers. Included are reports on the results of resource studies and of topographic, hydrologic, and geologic investigations. They also include collections of related papers addressing different aspects of a single scientific topic.

Bulletins contain significant data and interpretations that are of lasting scientific interest but are generally more limited in scope or geographic coverage than Professional Papers. They include the results of resource studies and of geologic and topographic investigations; as well as collections of short papers related to a specific topic.

Water-Supply Papers are comprehensive reports that present significant interpretive results of hydrologic investigations of wide interest to professional geologists, hydrologists, and engineers. The series covers investigations in all phases of hydrology, including hydrogeology, availability of water, quality of water, and use of water.

Circulars present administrative information or important scientific information of wide popular interest in a format designed for distribution at no cost to the public. Information is usually of short-term interest.

Water-Resources Investigations Reports are papers of an interpretive nature made available to the public outside the formal USGS publications series. Copies are reproduced on request unlike formal USGS publications, and they are also available for public inspection at depositories indicated in USGS catalogs.

Open-File Reports include unpublished manuscript reports, maps, and other material that are made available for public consultation at depositories. They are a nonpermanent form of publication that may be cited in other publications as sources of information.

Maps

Geologic Quadrangle Maps are multicolor geologic maps on topographic bases in 7 1/2- or 15-minute quadrangle formats (scales mainly 1:24,000 or 1:62,500) showing bedrock, surficial, or engineering geology. Maps generally include brief texts; some maps include structure and columnar sections only.

Geophysical Investigations Maps are on topographic or planimetric bases at various scales; they show results of surveys using geophysical techniques, such as gravity, magnetic, seismic, or radioactivity, which reflect subsurface structures that are of economic or geologic significance. Many maps include correlations with the geology.

Miscellaneous Investigations Series Maps are on planimetric or topographic bases of regular and irregular areas at various scales; they present a wide variety of format and subject matter. The series also includes 7 1/2-minute quadrangle photogeologic maps on planimetric bases which show geology as interpreted from aerial photographs. Series also includes maps of Mars and the Moon.

Coal Investigations Maps are geologic maps on topographic or planimetric bases at various scales showing bedrock or surficial geology, stratigraphy, and structural relations in certain coal-resource areas.

Oil and Gas Investigations Charts show stratigraphic information for certain oil and gas fields and other areas having petroleum potential.

Miscellaneous Field Studies Maps are multicolor or black-and-white maps on topographic or planimetric bases on quadrangle or irregular areas at various scales. Pre-1971 maps show bedrock geology in relation to specific mining or mineral-deposit problems; post-1971 maps are primarily black-and-white maps on various subjects such as environmental studies or wilderness mineral investigations.

Hydrologic Investigations Atlases are multicolored or black-and-white maps on topographic or planimetric bases presenting a wide range of geohydrologic data of both regular and irregular areas; principal scale is 1:24,000 and regional studies are at 1:250,000 scale or smaller.

Catalogs

Permanent catalogs, as well as some others, giving comprehensive listings of U.S. Geological Survey publications are available under the conditions indicated below from the U.S. Geological Survey, Books and Open-File Reports Section, Federal Center, Box 25425, Denver, CO 80225. (See latest Price and Availability List.)

"Publications of the Geological Survey, 1879- 1961" may be purchased by mail and over the counter in paperback book form and as a set of microfiche.

"Publications of the Geological Survey, 1962- 1970" may be purchased by mail and over the counter in paperback book form and as a set of microfiche.

"Publications of the U.S. Geological Survey, 1971- 1981" may be purchased by mail and over the counter in paperback book form (two volumes, publications listing and index) and as a set of microfiche.

Supplements for 1982, 1983, 1984, 1985, 1986, and for subsequent years since the last permanent catalog may be purchased by mail and over the counter in paperback book form.

State catalogs, "List of U.S. Geological Survey Geologic and Water-Supply Reports and Maps For (State)," may be purchased by mail and over the counter in paperback booklet form only.

"Price and Availability List of U.S. Geological Survey Publications," issued annually, is available free of charge in paperback booklet form only.

Selected copies of a monthly catalog "New Publications of the U.S. Geological Survey" available free of charge by mail or may be obtained over the counter in paperback booklet form only. Those wishing a free subscription to the monthly catalog "New Publications of the U.S. Geological Survey" should write to the U.S. Geological Survey, 582 National Center, Reston, VA 22092.

Note.--Prices of Government publications listed in older catalogs, announcements, and publications may be incorrect. Therefore, the prices charged may differ from the prices in catalogs, announcements, and publications.

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

Greene and others—MINERAL RESOURCES OF THE MOUNT TIPTON WILDERNESS STUDY AREA, ARIZONA—U.S. Geological Survey Bulletin 1737–B