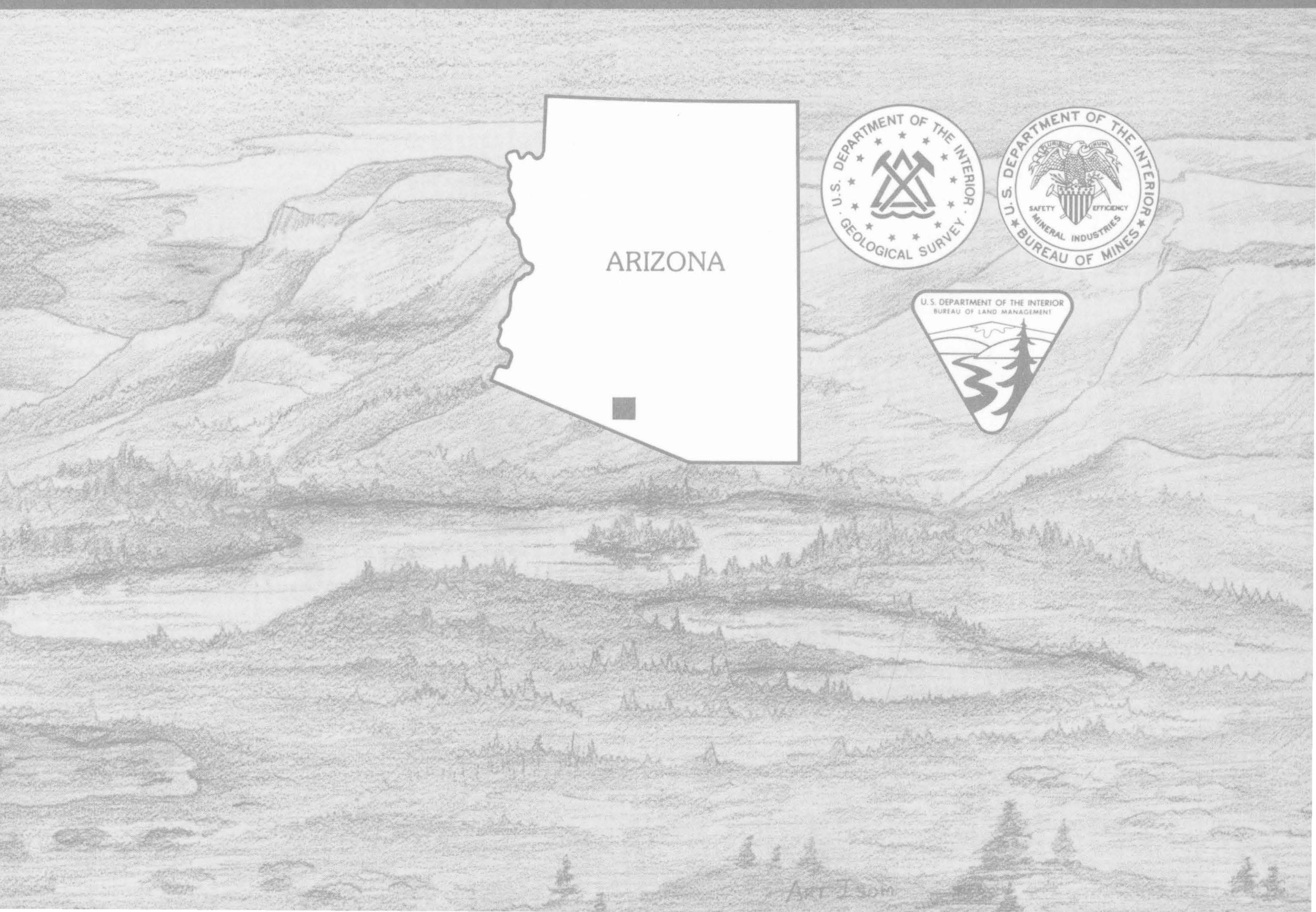
Mineral Resources of the Table Top Mountain Wilderness Study Area, Maricopa and Pinal Counties, Arizona

U.S. GEOLOGICAL SURVEY BULLETIN 1702-A



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Chapter A

Mineral Resources of the Table Top Mountain Wilderness Study Area, Maricopa and Pinal Counties, Arizona

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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
DONALD PAUL HODEL, 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 Table Top Mountain Wilderness Study Area (AZ-020-172), Maricopa and Pinal Counties, Arizona.

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Mineral Resources of the Table Top Mountain Wilderness Study Area, Maricopa and Pinal Counties, Arizona

By Jocelyn A. Peterson, Gary A. Nowlan, William F. Hanna, *and* James A. Pitkin
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U.S. Bureau of Mines

SUMMARY

Abstract

The part of the Table Top Mountain Wilderness Study Area (AZ-020-172) requested for mineral surveys by the U.S. Bureau of Land Management encompasses 34,400 acres in south-central Arizona. Field work was carried out by the U.S. Bureau of Mines in the spring of 1985 to appraise the known mineral resources and by the U.S. Geological Survey in the winter and spring of 1986 to assess the mineral resource potential (undiscovered) of the study area. Samples from three prospects within the study area contain minor gold, silver, copper, lead, and zinc, but resources of these elements were not identified at these localities. Common variety sand and gravel deposits in the area are inferred subeconomic resources but are not likely to be developed. Areas of exposed Pinal Schist have low mineral resource potential for copper, gold, and silver in veins similar to those on the IC claims and for copper, lead, molybdenum, barite, and (or) tungsten in epithermal veins. The Oracle Granite has low potential for resources of quartz, feldspar, mica, lanthanum (a rare-earth element), uranium, thorium, and beryllium in pegmatites and low potential for resources of uranium, thorium, and lanthanum in accessory monazite. The entire study area has low potential for copper resources in porphyry copper deposits, but they would be more likely beneath the pediment of the southeastern part of the study area. There is a low potential for resources of the evaporite minerals gypsum or anhydrite and halite, uranium in intermontane basins, placer tin, and oil and gas as suggested by geology, geochemistry, or leasing activity. The extreme northwest corner of the study area has a low potential for geothermal energy resources.

Publication authorized by the Director, U.S. Geological Survey, March 17, 1988.

Character and Setting

The Table Top Mountain Wilderness Study Area (AZ-020-172) is in south-central Arizona about 35 mi east-southeast of Gila Bend, Ariz. (fig. 1) and 50 mi northeast of Ajo, Ariz. The area lies within the Sonora Desert section of the Basin and Range physiographic province, a region characterized by typically large mountain chains separated by deep, alluvial-filled valleys. The study area is underlain primarily by schist and quartz monzonite (fig. 2) of Proterozoic age (see geologic time chart in appendixes). Several peaks are covered by Tertiary basalt and clastic sedimentary rocks; Table Top includes a thin layer of middle Proterozoic sedimentary rocks. Major stream beds, pediments, and intermontane valleys have a cover of alluvium.

Identified Resources and Mineral Resource Potential

The Table Top Mountain Wilderness Study Areas is not within any organized mining district, but there are several placer and lode claims within and along the western and northern parts of the area (McDonnell, 1986). No production has been recorded from these claims and they were inactive at the time of the field examination by the U.S. Bureau of Mines (USBM). There are also claims in the southeastern part of the study area. Of the three prospects sampled, all have low-level geochemical anomalies for copper, lead, zinc, gold, and (or) silver. There are no identified mineral resources in the study area.

The Pinal Schist has low potential for resources of copper, gold, and silver in quartz veins similar to those on the IC claims and for resources of copper, lead, molybdenum, barite, and (or) tungsten in epithermal veins (hereafter called polymetallic epithermal veins) (fig 2). The Oracle Granite has low resource potential for quartz, feldspar, mica, uranium, thorium, lanthanum (a rare-earth element), and beryllium in pegmatites and a low potential for uranium, thorium, and rare-earth elements in accessory monazite. The study area has low potential for copper resources in porphyry copper deposits, although the pediment in the southeast corner seems to be more favorable. Low potential for resources of several commodities is suggested by the geology, geochemistry, or leasing activity. These include gypsum or anydrite and halite resources in evaporite deposits, uranium resources in the alluviated valleys, placer tin resources, and oil and gas resources. The extreme northwest corner of the study area has low potential for geothermal energy resources.

INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management (BLM) and is a joint effort by the U.S. Geological Survey (USGS) and the USBM. An introduction to the wilderness review process, mineral survey methods, and agency responsibilities was provided by Beikman and others (1983). 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, claims, and mineralized areas. Identified resources are classified according to the system described by U.S. Bureau of Mines and U.S. Geological Survey (1980). 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,

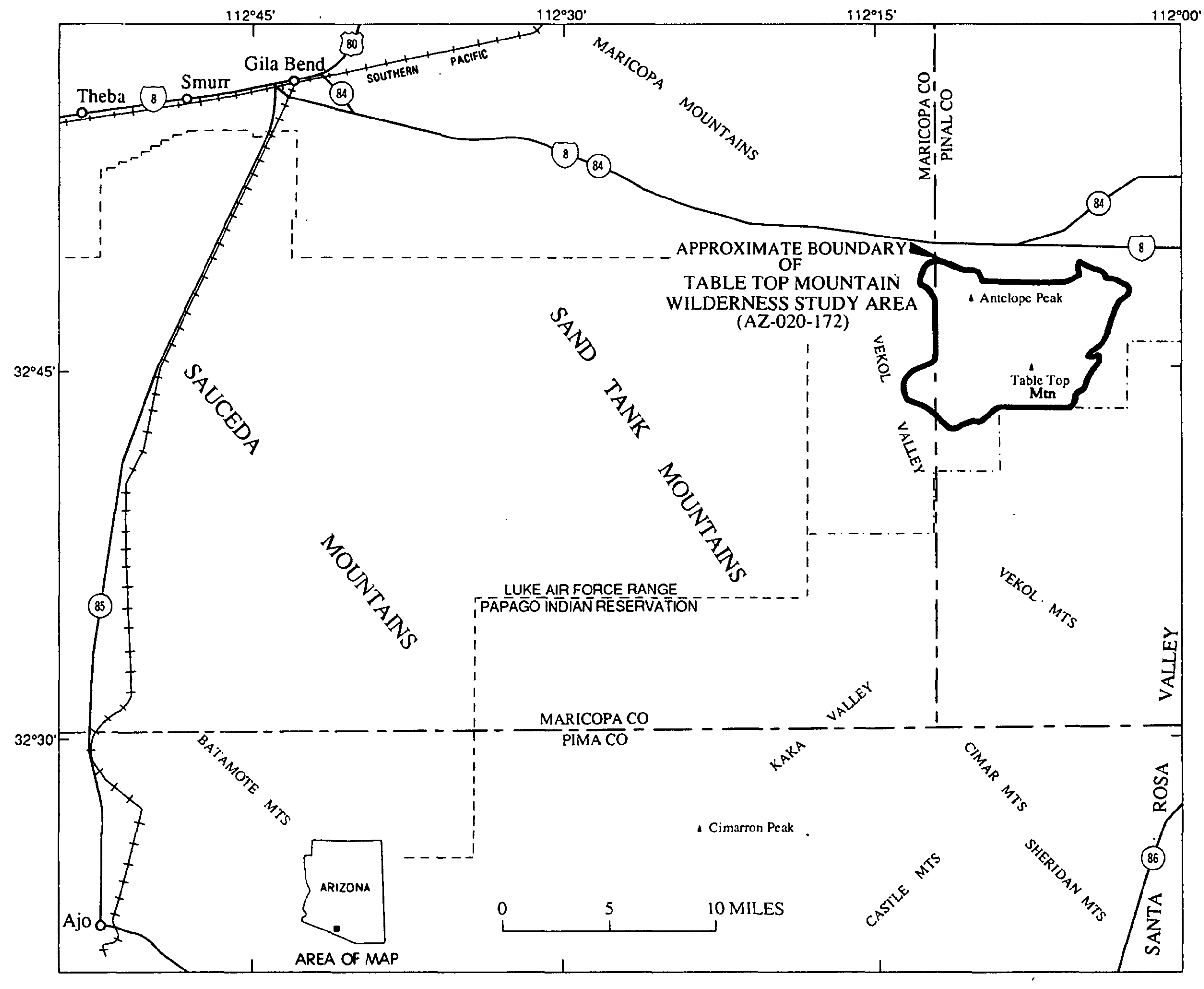

Figure 1. Index map showing location of the Table Top Mountain Wilderness Study Area, Maricopa and Pinal Counties, Arizona.

possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. Mineral assessment methodology and terminology as they apply to these surveys were discussed by Goudarzi (1984). See appendix for the definition of levels of mineral resource potential, certainty of assessment, and classification of identified resources.

The Table Top Mountain Wilderness Study Area in south-central Arizona (AZ-020-172) encompasses 39,823 acres, of which the BLM requested mineral surveys on 34,400 acres. The area is centered on the rugged Table Top Mountains where elevations range from 4,737 ft at the summit of Table Top to 1,600 ft in the valleys peripheral to the mountains. The area can be reached by several dirt roads leading south from Interstate Highway 8 into Vekol Valley and into the unnamed valley along the north boundary of the study area. Much of the interior is inaccessible to vehicles. The arid climate supports typical southern Arizona desert fauna and flora.

The study area is located about 35 mi east-southeast of Gila Bend, Ariz. (fig. 1), and 50 mi northeast of Ajo, Ariz., within the Sonora Desert section of the Basin and Range physiographic province, an area usually characterized by elongate mountain ranges separated by broad valleys.

The USBM study began with a review of the literature related to mining in the Table Top Mountains vicinity. BLM mining claim information and land status plats were examined as were mineral information and production data compiled by the USBM. Subsequent field work was undertaken to examine mines, prospects, and known mineral occurrences inside and within 2 mi of the study area. Three prospects within the study area were surveyed, mapped, and sampled.

The USGS mapped the geology of the study area in 1986. The work helped to revise previous mapping by Dockter and Keith (1978) and reconnaissance mapping by R.M. Tosdal done as part of a regional study (Peterson and others, 1987b). Rock and stream-sediment samples were collected for geochemical analyses. Geophysical studies were based on interpretations of available published data. M.I. Hornberger assisted with the field work by the USGS.

APPRAISAL OF IDENTIFIED RESOURCES

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

Mining History

The Table Top Mountain Wilderness Study Area is not within an organized mining district and has no recorded mineral production. The study area is 10-15 mi north of the Vekol mining district, where gold, silver, copper, lead, and zinc have been produced. Mineral deposits in the Vekol district formed along faults as replacements in Paleozoic limestone, dolomite, and shale (Denton and Haury, 1946; Arizona Department of Mineral Resources file data), structures and rocks that do not extend into the study area.

Several unpatented placer and lode claims are within and along the west and north edges of the study area (McDonnell, 1986); the placer claims cover most of Vekol Valley to the west. No active mining operations were noted within the study area during the USBM field investigation, but results of past mining or prospecting were examined on the IC, Silver King, and Silver Queen claims and on an area in the southeastern part of the study area (fig. 2).

American Rockwool, Inc., Casa Grande, Ariz., was mining basalt about 0.5 mi north of the study area (fig. 2) for use in manufacturing insulation. The rock was crushed and mixed with steel slag and coke in a furnace, melted at about 3,600 °F and blown and spun into fibers. The loose fibers were used as blowing wool insulation or combined with resin to form insulation batts. Robert Corsentino (Plant Superintendent, American Rockwool, Inc., oral commun., 1985) said that the company has about a 10-yr reserve of the basalt at its quarry. He also indicated that the company empirically tested the basalt and that a detailed investigation of basalt in the surrounding area had not been made. As of March 10, 1986, the plant had stopped production and the company had no future start-up plans.

Two sand and gravel pits are near the study area, one 0.5 mi to the north (fig. 2) and the other 2.5 mi to the northwest. Several smaller borrow pits are scattered near the north boundary along Interstate Highway 8. The material was used primarily in constructing interchanges and overpasses for the highway; some may also have been used in local building projects.

Mineral Appraisal

Three of the prospected localities within the Table Top Mountain Wilderness Study Area were sampled: the IC and Silver King claims and an unnamed shaft in the southeastern part of the study area (fig. 2). Samples collected at these prospects included chip, select, and grab samples, which were analyzed for gold and silver by fire assay and inductively coupled plasma-atomic emission spectrometry, and for copper, lead, and zinc by atomic-absorption spectrophotometry. Samples were also analyzed for 40 elements by semiquantitative optical-emission spectrography. Analytical data are summarized by McDonnell (1986). Copper occurrences reported by Krason and others (1982) based on Stipp and others (1967) were searched for but not found. They may have been accidentally mislocated and were intended to represent the IC, Silver King, and Silver Queen claims, which were not shown by them. A sample of the basalt mined by American Rockwool, Inc., was also collected.

At the IC claims, quartz veins as thick as 3 ft and fault zones as wide as 6 ft contain visible chrysocolla exposed in pits, trenches, and shafts in the Pinal Schist. Bulldozer cuts disrupt much of the surface, making the extent of the veins and faults difficult to determine; additional mineralized rock may have been removed or covered. Samples from the mineralized area contain minor gold, silver, copper, and zinc, but resource estimates could not be calculated from the scattered field and analytical data.

A decomposed iron-oxide-stained quartz monzonite of the Oracle Granite is exposed in an 18-ft-deep shaft in the southeast corner of the study area (fig. 2). The iron-oxide stain is dispersed throughout the quartz monzonite and is probably due to the weathering of mafic minerals. No mineralized rock was apparent, but gold, copper, and zinc were detected in a chip sample from the quartz monzonite. The quartz monzonite exposed here is similar to quartz monzonite exposed on the Silver King and Silver Queen claims in the northern part of the study area, where occurrences of gold and silver in quartz-calcite veinlets have been reported by claimant Charles Irwin (oral and written commun., 1986). Prospecting on the claims has

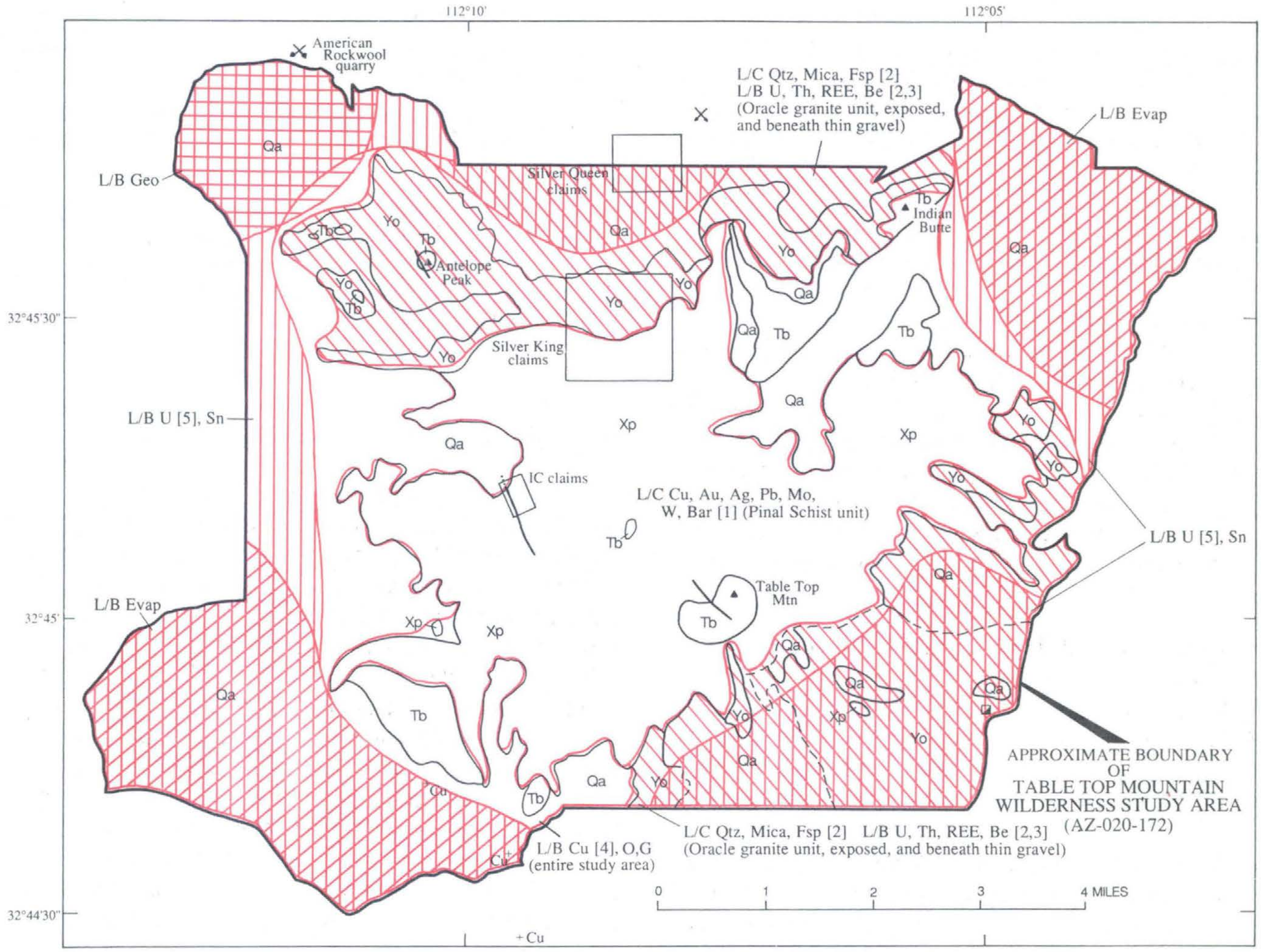

Figure 2. Mineral resource potential and generalized geology of the Table Top Mountain Wilderness Study Area, Maricopa and Pinal Counties, Arizona.

been limited to surface sampling. The USBM sampled quartz-calcite veinlets that crop out on the Silver King claims but detected no gold and only minor silver, lead, and zinc; the veinlets are not well exposed on the Silver Queen claims. More detailed geologic, geochemical, and geophysical surveys, and possible exploratory drilling, would be needed to determine the economic significance of veins and faults in the study area.

A sample of the basalt mined by American Rockwool, Inc., was collected and analyzed for whole-rock composition and metal content. Because American Rockwool, Inc., made no formal analysis of the basalt, we attempted to determine why this particular basalt is useful in manufacturing insulation on the basis of the whole-rock analysis. Mineralogical and chemical studies of the basalt, however, did not reveal any special characteristic to indicate why this basalt is more suitable than others for making insulation.

Sand and gravel occur in drainages and low-lying parts of the study area and are an inferred subeconomic resource. Nearby material was used in constructing Interstate Highway 8 and probably for other local building projects. Transportation costs and a low unit value restrict the market to local use, and sufficient material outside the study area will satisfy this demand.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Jocelyn A. Peterson, Gary A. Nowlan, William F. Hanna, *and* James A. Pitkin
U.S. Geological Survey

Geology

The Table Top Mountain Wilderness Study Area is underlain primarily by Proterozoic igneous and metamorphic rocks, but several peaks are capped by Tertiary conglomerate and basalt (Peterson and others, 1987b). The lower Proterozoic Pinal Schist covers most of the central part of the study area (fig. 2). It is a fine-grained, strongly foliated muscovite-quartz schist that in places is chloritic. Metamorphic segregations of quartz are locally abundant and seldom absent. In the north half of the area the schist is intruded by a few small very dark green pods that are presumed to be altered diabase. The schist contains localized concentrations of secondary copper minerals, commonly in veinlets associated with small local faults or larger faults as at the IC claims.

The middle Proterozoic Oracle Granite, which intrudes the Pinal Schist, crops out extensively on the edges of the

EXPLANATION

Geologic terrane having low mineral resource potential--See appendixes for definition of levels of mineral resource potential (L) and certainty of assessment (B,C)

- L/B U,Sn
- L/B Evap
- L/B Geo
- L/C Qtz, Mica, Fsp; L/B U, Th, REE, Be--Oracle Granite unit, exposed, and beneath thin gravel
- L/C Cu, Au, Ag, Pb, Mo, W, Bar--Pinal Schist unit

Commodities

Ag	Silver	U	Uranium
Au	Gold	Bar	Barite
Cu	Copper	Evap	Evaporites
Mo	Molybdenum	Fsp	Feldspar
Pb	Lead	Geo	Geothermal
REE	Rare-earth element lanthanum	Mica	Mica
Sn	Tin	O,G	Oil and gas
Th	Thorium	Qtz	Quartz
Be	Beryllium	W	Tungsten

[ ] Deposit types

1	Veins
2	Pegmatites
3	Disseminated monazite
4	Porphyry copper
5	Caliche

Geologic map units

Qa	Alluvium, talus, and gravel (Quaternary)
Tb	Basalt and conglomerate (Tertiary)
Yo	Oracle Granite (Middle Proterozoic)
Xp	Pinal Schist (Early Proterozoic)

Contact—Dashed where approximately located

Fault—Dotted where concealed

Shaft

Quarry

+Cu Copper occurrence

Figure 2. Continued.

Table Top Mountains and on adjacent pediment surfaces, particularly pediments in the southeastern part of the study area. The unit is compositionally a quartz monzonite to rare granodiorite, but "granite" has been retained in the formal name of the unit. It is typically coarse grained, sometimes to the extent of forming small pegmatites of quartz-monzonitic composition. Elsewhere, there are larger pegmatites consisting mostly of quartz with some muscovite, although feldspar-dominant pegmatites are also present. Aplite is found locally.

On Table Top below the Tertiary rocks is a thin layer of the middle Proterozoic Pioneer Formation of the Apache Group, the only formation of the group present in the study area. It consists of a fine-grained red sandstone with distinctive (and diagnostic) light-colored spherical areas throughout that are less than 0.5 in. in diameter and typically even smaller.

Paleozoic and Mesozoic rocks are absent in the area. Unconformably resting on the Proterozoic rocks in the northern part of the area are scattered outcrops of a basaltic andesite, perhaps the same basaltic rocks as those at the American Rockwool, Inc., quarry. A Tertiary conglomerate crops out mostly beneath outcrops of basalt. Because it is poorly consolidated, it was readily eroded elsewhere. The subrounded to subangular clasts are derived from the Pinal Schist, Oracle Granite, Apache Group (including those formations of the group not present in the study area), and a variety of volcanic rocks that are not exposed in the area. Olivine basalt caps several of the peaks in the area and forms the somewhat flat top of Table Top. The unit is made up of several flows.

Three unconsolidated Quaternary units are present in the area. Flanking some of the peaks are poorly sorted, semiconsolidated to unconsolidated, locally derived terrace gravels. More immediate to some of the mountains are talus slopes, which obscure underlying geology. Pediment surfaces are covered by alluvium, and major drainages contain alluvium.

There are no major structures in the area. Minor faults were seen in the units of Proterozoic and Tertiary age on the west side of the area. The Pinal Schist has a strong schistosity that lacks a regional trend because of the intense small-scale folding that the unit has undergone.

Evidence of alteration is scarce. The prospect in the Oracle Granite in the southeastern part of the area (shaft, fig. 2) has highly oxidized and slightly chloritized quartz monzonite. Chloritic areas are common throughout the Pinal Schist, sometimes associated with the copper oxides, but development of chlorite rather than muscovite could be the result of original compositional differences in the rocks from which the schist was derived.

Geochemistry

For the reconnaissance geochemical survey of the Table Top Mountain Wilderness Study Area, stream-sediment samples were collected at 72 sites and 11 samples of mineralized or altered rock were collected at seven sites. Stream-sediment and panned-concentrate samples derived from stream sediments, the sample media used for this study, represent a composite of material eroded from the drainage basin of the stream sampled. Three samples were collected at each site. One was dried and sieved through a 30-mesh stainless-steel sieve. A 30-mesh sieve was used rather than the more conventional 80-mesh to lessen possible dilution by wind-blown material in this desert environment. The minus-30-mesh stream-sediment sample was analyzed for 31 elements by emission spectrographic methods and for antimony, arsenic, bismuth, cadmium, and zinc by other methods (see Adrian and others, 1987). The other two samples each consisted of 20 lb of stream sediment that were panned until about 3 oz or less remained. One of these raw panned-concentrate samples was further concentrated by heavy liquids and magnetic separations to produce a nonmagnetic heavy-mineral concentrate (called concentrate hereafter), which was then analyzed for the same 31 elements by semiquantitative spectrographic methods. The other raw panned-concentrate sample was analyzed for gold by atomic absorption without further treatment. Anomalous element concentrations present in the study area, the lower and upper limits of determination, the range of concentrations, the 50th percentile value, and the threshold (highest background) concentrations are listed in table 1. Threshold values were established by visually examining the data and comparing them with stream-sediment and concentrate sample data used as part of a mineral-resource assessment of the Ajo and Lukeville 1 by 2 quadrangles (Theobald and Barton, 1983, 1987). Analytical results, sample preparation and analytical methods, and references for the analytical methods are given in Adrian and others (1987).

Geochemical data for the Table Top Mountain Wilderness Study Area suggest epithermal vein deposits and pegmatites. Probable pegmatite areas are underlain by the Oracle Granite and are characterized by anomalous beryllium, scandium, niobium, tin, lanthanum, and thorium. Areas that may contain epithermal vein deposits, on the other hand, are underlain mostly by the Pinal Schist. These areas are characterized by three suites of geochemically anomalous elements: barium, bismuth, molybdenum, and tungsten; lead; and copper, gold, molybdenum, and tungsten.

Concentrate samples from area A (fig. 3) show a close association of anomalous concentrations of barium, bismuth, molybdenum, and tungsten. Some concentrate samples from the area also contain anomalous concentrations of copper and lead. One raw panned-concentrate sample contains an anomalous amount of gold. One stream-sediment sample from area A contains an anomalous concentration of boron. Area A encompasses the IC claims (McDonnell, 1986) where chrysocolla is visible in quartz veins and fault zones. Mineralized rock samples from outcrops and dump material at the claims contain as much as 6.3 parts per million (ppm) gold, 12.5 ppm silver, 200 ppm arsenic, 1,000 ppm bismuth, 3,000 ppm boron, and greater than 2 percent copper (McDonnell, 1986, fig. 4; Adrian and others, 1987, table 6). Geochemical data from area A fit some of the geochemical criteria for polymetallic epithermal vein deposits of the region but the known mineralization more closely resembles that of gold-silver quartz veins (Peterson and others, 1987a, p. 7-8).

Several concentrate samples from area B (fig. 3) contain anomalous concentrations of lead. Also, one concentrate sample and the stream-sediment sample from the same site contain anomalous concentrations of barium and copper, respectively. Although area B is not as geochemically favorable for epithermal vein deposits as area A because of the fewer number of elements present in anomalous amounts, local outcrops of quartz veins and chrysocolla indicate some mineralization has taken place.

Concentrate samples from area C (fig. 3) contain anomalous amounts of molybdenum and tungsten. One raw panned-concentrate sample contains an anomalous amount of gold. One minus-30-mesh stream-sediment sample contains an anomalous concentration of copper. Area C is somewhat favorable for polymetallic epithermal vein deposits or gold-silver quartz veins.

Concentrate samples from area D (fig. 3) contain anomalous amounts of beryllium and scandium; this is an area underlain by the Oracle Granite where prominent quartz veins and pegmatites are located. Scandium is, in some cases, associated with pegmatites and is found in mafic minerals in other cases (Rankama and Sahama, 1950, p. 512). The presence of both pegmatites and anomalous beryllium and scandium concentrations in area D indicate a pegmatite association. Beryl, the most common beryllium mineral, is not present in concentrate samples because it has a low specific gravity. Thus, the beryllium is a constituent of some other mineral that is associated with the quartz monzonite or pegmatites. Anomalous amounts of scandium in concentrate samples from area E (fig. 3) probably reflect the presence of the known pegmatites in

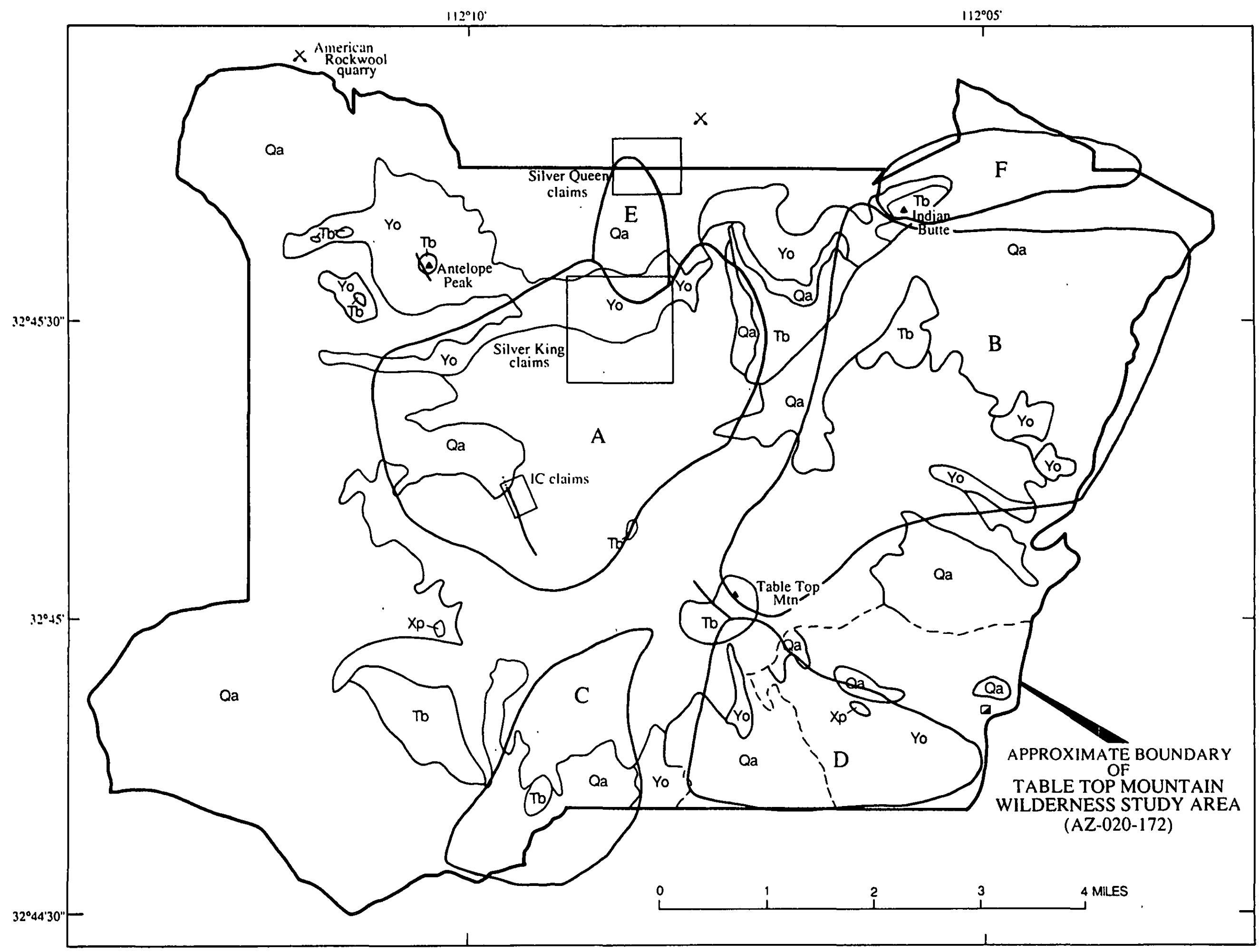

Figure 3. Geochemical anomaly map (alphabetically labeled areas) of the Table Top Mountain Wilderness Study Area, Maricopa and Pinal Counties, Arizona. See text for discussion of alphabetically labeled areas. See figure 2 for explanation of geologic map units.

the area. Concentrate samples from area F contain anomalous concentrations of niobium, tin, and thorium; this association of elements (Peterson and others, 1987a) suggests that pegmatites may be present in area F (fig. 3), although none were noted during geologic mapping.

Four concentrate samples from the area have at least 500 ppm lanthanum. The samples were collected in areas of Oracle granite.

Tin is anomalous in concentrate samples from several scattered sites; all of these sites are on streams that have drainage basins entirely on pediments. Therefore, the anomalous tin values may reflect incipient placer tin deposits.

Geophysics

Gravity and Magnetic Data

The area of the Table Top Mountain Wilderness Study Area is included in regional gravity (D.P. Klein, written commun., 1987; Lysonski and others, 1981; Defense Mapping Agency Aerospace Center, 1974, 1975) and detailed magnetic (U.S. Geological Survey, 1980; D.P. Klein, written commun., 1987) surveys having sufficient resolution to define anomalies of several square miles or larger. Contours of complete (largely terrain corrected) Bouguer gravity anomalies are defined by about 25 observations within and near the study area. Contours of total-intensity magnetic anomalies are defined by measurements made along nine east-west traverses spaced about 1 mi apart at a nominal altitude of 4,000 ft above sea level.

The Bouguer gravity anomaly map is characterized by large-amplitude lows near the northwest and southwest corners of the study area and by a small-amplitude low near the southeast corner. All of these lows are associated with low-density basin sediments and minor associated basalt that is relatively vesicular, thin, or both. The sediment thickness beneath the large amplitude lows is about 1,500 to 3,000 ft; thickness beneath the small-amplitude low is 600 to 1,500 ft in the deepest parts of the basin (Oppenheimer and Sumner, 1980), on the basis of gravity modeling and well-hole data. The northeast and west-central parts of the study area are characterized by highs separated by a saddle. This zone is largely associated with moder-

Table 1. Statistics for anomalous elements from drainage samples collected in and near the Table Top Mountain Wilderness Study Area, Maricopa and Pinal Counties, Arizona

[Results based on 72 samples. Concentrations determined by emission spectrographic methods except gold determined by atomic absorption. All values reported in parts per million except iron, which is in percent. N, not detected; L, detected but below limit of determinations; G, greater than upper limit of detrmination]

Element	Lower Limit of determination	Upper Limit of determination	Minimum concentration	Maximum concentration	50th percentile	Threshold concentration
			Minus-30-mesh stream sediments			
Boron	10	2,000	10	100	20	70
Copper	5	20,000	7	50	7	30
Iron	0.05	20	1.5	15	3	10
			Nonmagnetic heavy-mineral concentrate			
Barium	50	10,000	200	G	500	3,000
Beryllium	2	2,000	N	20	2	7
Bismuth	20	2,000	N	1,500	50	700
Copper	10	50,000	N	100	10	70
Lead	20	50,000	N	5,000	30	200
Molybdenum	10	5,000	N	100	N	15
Niobium	50	5,000	N	100	N	50
Scandium	10	200	N	G	30	150
Strontium	200	10,000	L	2,000	2000	1,000
Thorium	200	5,000	N	1,000	N	200
Tin	20	2,000	N	100	N	20
Tungsten	100	20,000	N	5,000	N	500
Gold-a	0.05[1]	--[2]	N	0.19	N	N

[1]Based on 10-g sample.
[2]Upper limit is open ended.

ately dense components of the Pinal Schist locally intruded by Oracle Granite.

The magnetic anomaly map is dominated by short-wavelength, large-amplitude anomalies, some of which are affected by topography. Most of the anomalies overlap two or more magnetic lithologic units; therefore, anomaly sources cannot be unambiguously identified by visual examination of the data. The strongest clue to the most likely anomaly sources is provided by measuring remanent and induced magnetization (average magnetic dipole moment per unit volume), which yields the total magnetization capable of generating an anomaly. One measurement each of total magnetization for the Oracle Granite, Pinal Schist, and olivine basalt was made. Samples of the olivine basalt and Pinal Schist have total magnetizations, respectively, about 17.5 and 2.5 times stronger than that of the Oracle Granite, which itself is weakly to moderately magnetic. Thus, on this basis, the large-amplitude magnetic anomalies are most likely caused by basalt.

The lapping of magnetic anomalies over more than one magnetic unit is inferred to be caused largely by abnormal directions of average total magnetization. For example, most basalt crops out beneath steep anomaly flanks rather than beneath anomaly maxima. This offset of anomaly maxima with respect to source is caused largely by reversed to abnormally directed remanent magnetization, which is stronger in all three of the measured samples than induced magnetization. Specifically, anomalies A, B, C, D, and E (fig. 4) are singlet or doublet high and low anomalies probably caused largely by basalt, which is partly buried and which in other places is more highly elevated than surrounding terrain and, thus, was close to the magnetometer sensor during the aerial survey. An elongate pair of east-trending anomalies, F and G (fig. 4), have a buried source; the inferred source is basalt, possibly as feeder dikes, based on the short wavelength and high amplitude of these features. Other small-amplitude anomalies, such as H, I, J, K, and L (fig. 4), may be associated with the moderately magnetic Pinal Schist or Oracle Granite.

Aerial Gamma-ray Spectrometry

Aerial gamma-ray spectrometry measures the near-surface (less than 2 ft) distribution of potassium (K), uranium (eU), and thorium (eTh). The e (for equivalent) prefix denotes the potential for disequilibrium in the uranium and thorium decay series. Because the distribution of these elements is controlled by geologic processes, aerial gamma-ray measurements can be used in geologic mapping, mineral exploration, and understanding of geologic processes.

The spectrometry data used for this report were obtained between 1974 and 1981 for the National Uranium Resource Evaluation (NURE) program of the U.S. Department of Energy (1979). Flightline spacing was usually at 3- to 6-mi intervals, which yields data suitable for producing contour and other maps at scales of 1:500,000 and smaller. All NURE flight altitudes were 400 ft above ground level. At this altitude terrestrial gamma radiation can be detected along a swath 800 ft wide along the flightline. Data for the region around the study area are presented on contour maps and color composite image maps (Duval, 1983) at scales of 1:500,000 and 1:1,000,000. Spectrometric data described below were derived from the NURE report for the Ajo 1° by 2° quadrangle (U.S. Department of Energy, 1979).

The Table Top Mountain Wilderness Study Area is characterized by radioelement concentrations of 1-2 percent K, 3-5 ppm eU, and 7-14 ppm eTh. These concentrations are determined from three NURE flightlines that partially outline the study area on the north, south, and east and provide sparse control for defining radioelement distribution for the area. The concentrations detected are within normal ranges for the Proterozoic crystalline rocks, Tertiary sedimentary and volcanic rocks, and Quaternary materials that are present in the study area. The sparse flightline coverage of the study area, however, precluded deriving direct information on mineral resource potential from the aerial gamma-ray data.

Mineral and Energy Resources

The Table Top Mountain Wilderness Study Area lies within a part of Arizona that has major porphyry copper and other types of deposits. There are small known copper-bearing veins and pegmatites inside the area. Other types of deposits found nearby have a remote chance of being present in the subsurface rocks. There is also permissive evidence for some types of deposits that are not currently known within the region.

Proterozoic Copper-gold-silver Veins or Polymetallic Epithermal Veins

The area underlain by Pinal Schist has a low mineral resource potential, with a certainty level of C, for copper, gold, and silver resources in small quartz veins and for barite, molybdenum, lead, copper, and (or) tungsten resources in polymetallic epithermal veins, because of their scattered distribution and small size. Small copper-gold-silver quartz veins are present on the IC claims and elsewhere within exposures of the Pinal Schist but have had no recorded production. In appearance they resemble other gold-silver quartz veins in the region (Peterson and others, 1987a), but they are thought to have originated in the Proterozoic as the region was metamorphosed (R.M. Tosdal, written commun., 1985). The veins are characterized by spotty chrysocolla and limonite pseudomorphs of sulfide minerals and a gangue of white quartz. These veins also contain small amounts of gold and silver (McDonnell, 1986). Host rocks are weakly sericitized and chloritized locally near the veins. Most of the veins are small, narrow, localized occurrences, commonly emplaced along small faults with an undetermined but probably small offset. Geochemical data discussed above suggest that the Pinal Schist may contain polymetallic epithermal veins as well.

In a regional survey (Barton and others, 1982), three of 13 concentrate samples collected from the study area contain tungsten at detectable levels (100 ppm, 1,500 ppm, and 3,000 ppm). The source of the tungsten is not known. The only nearby tungsten occurrence is in the Gunsight Hills about 50 mi to the southwest, where scheelite and quartz fragments litter the pediment surface over a Tertiary granitic pluton (Wilson, 1941). If there is a pluton genetically associated with tungsten in the study area, it is not exposed. Tungsten has already been evaluated as a possible constituent of polymetallic epithermal veins in the

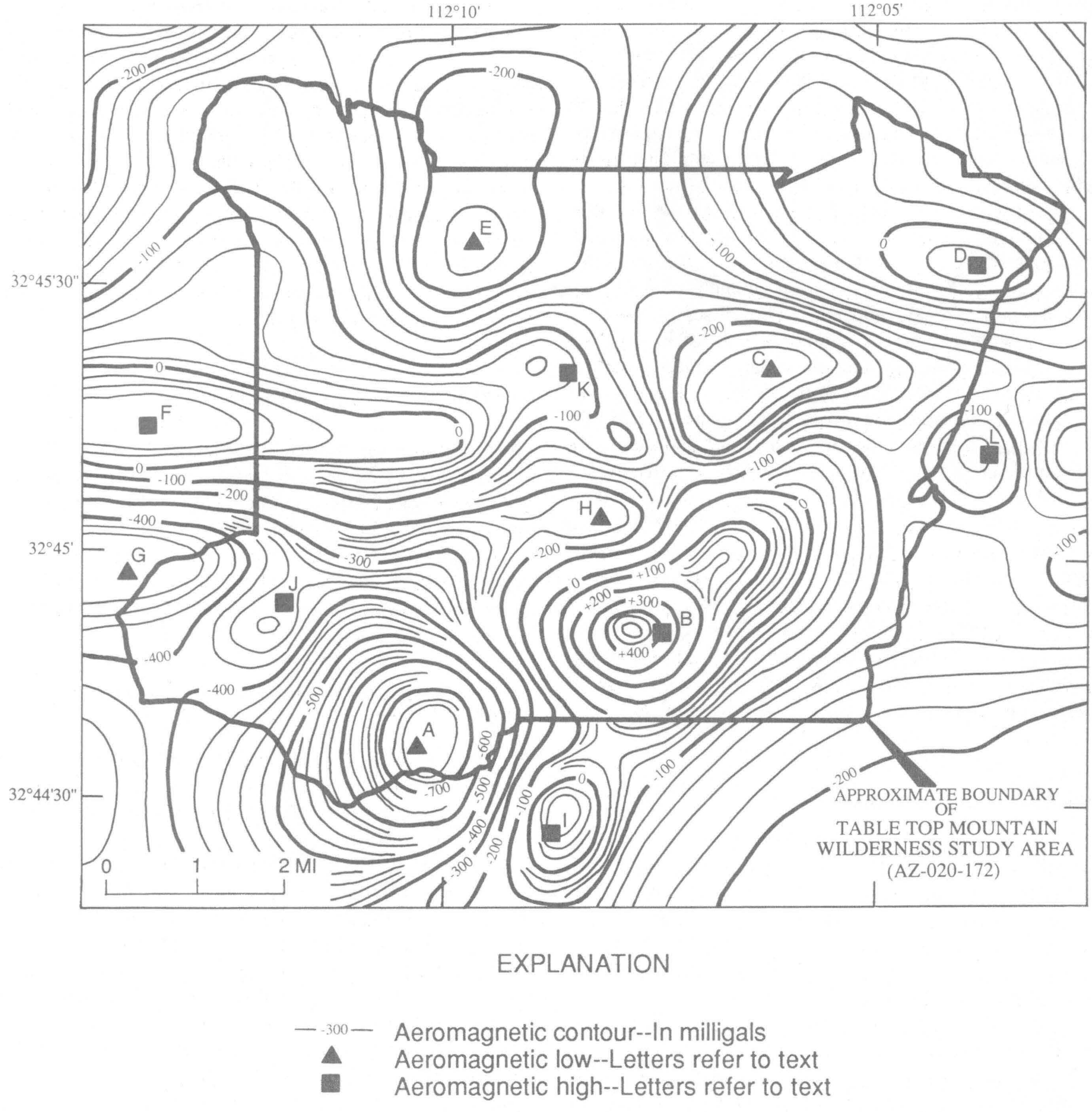

Figure 4. Aeromagnetic anomaly map of the Table Top Mountain Wilderness Study Area and vicinity, Maricopa and Pinal Counties, Arizona.

Pinal Schist, but it could also form distinct veins containing only tungsten as a commodity.

Pegmatites

The area underlain by the Oracle Granite has a low potential, certainty level C, for resources of quartz, mica, and feldspar in pegmatites, and a low potential, certainty level B, for resources of lanthanum (a rare-earth element), uranium, thorium, and beryllium in pegmatites. Two types of pegmatites are present in the study area. Both are simple pegmatites; the complex zoned pegmatites that commonly contain rare minerals were not seen. The first type is compositionally the same as the Oracle Granite, but its crystals are much larger than those of the host rock. These pegmatites usually form veins several feet long and a few inches wide. Their contacts with the host rock are sharp. These pegmatites have not been prospected. The second type of pegmatite is more prominent because it is typically made up mostly of white quartz, or less commonly feldspar, with some very coarse muscovite. These pegmatites are at least one foot to several feet wide; the larger ones can be traced along strike for several tens of feet. Although these could be mistaken for quartz veins, the presence of muscovite and the geochemical data for areas underlain by the Oracle Granite indicate that they are more likely pegmatites. A pegmatite on the Silver King claims is associated with narrow, black calcite veinlets.

Pegmatites can be host to several commodities including quartz, feldspar, mica, gem quality minerals, rare-earth elements (including lanthanum), uranium, and thorium. The Table Top Mountains lie south of the major productive pegmatite belt of Arizona, but there has been one productive pegmatite southwest of the area at the San Antonio mine (Keith, 1974), where quartz was mined for use as silica flux in the New Cornelia Smelter at Ajo. Quartz from pegmatites within the study area may be suitable for such uses. Geochemical data for the area (Adrian and others, 1987; Barton and others, 1982) suggest that the pegmatites could also contain some rare-earth elements or uranium and thorium, and possibly beryllium, though the minerals that would commonly host these elements were not seen during the field investigations.

Monazite-bearing Rocks

The parts of the study area underlain by the Oracle Granite have a low potential, certainty level B, for resources of uranium, thorium, and lanthanum in monazite, an accessory mineral in the Oracle Granite and possibly in associated pegmatites (see previous section). Monazite is a rare-earth- and thorium-bearing mineral that can be present in granitic rocks, certain schists, and pegmatites. It can also accumulate in detrital material as placer deposits. Geochemical and mineralogical data from a regional study (Barton and others, 1982) indicate the presence of lanthanum; three of their 13 concentrate samples have greater than 2,000 ppm lanthanum, and monazite was identified in some samples. Two of the same samples also contain 300 and 1,000 ppm thorium. Uranium was not measured. Four concentrate samples from the current study have at least 500 ppm lanthanum.

Porphyry Copper

The entire study area has low potential for copper resources in porphyry copper deposits, certainty level B. Porphyry copper and related skarn deposits are widespread throughout Arizona and several occur within 50 mi of the study area. These deposits can be hosted by a variety of rocks but are usually associated with Laramide (Late Cretaceous and early Tertiary) calcalkalic intrusions. They typically contain large tonnages and low grades with disseminated, vein, or stockwork copper-sulfide minerals and have a characteristic alteration pattern (Titley, 1982; Lowell and Guilbert, 1970).

In the Vekol Hills deposit about 15 mi south of the study area, the Pinal Schist and quartz monzonite (presumably the Oracle Granite) form a basement complex, which underlies the Apache Group and associated Proterozoic diabase. A Paleozoic sedimentary sequence nearby in the Vekol Mountains hosts skarn deposits. Late Cretaceous or early Tertiary porphyritic stocks, dikes, and sills intrude all the pre-Mesozoic units (Steele, 1978). Most of the ore is hosted by the pre-Mesozoic rocks with only minor mineralization in the porphyritic rocks. The sulfide minerals pyrite, chalcopyrite, and molybdenite are disseminated within the host rocks and fill fractures. There is little supergene enrichment.

The study area is geologically similar to the setting for the Vekol Hills deposit except for the lack of Paleozoic sedimentary rocks. The place most likely to have a porphyry copper deposit is in the prospected area (shaft, fig. 2) where the weakly altered Oracle Granite might suggest a buried pluton and possibly a porphyry copper deposit. Porphyritic intrusions are not known to be present, which is why there is only a low rating and a low degree of certainty for such resources. However, intrusions could be present; it has been suggested that pegmatites west of the study area are genetically associated with younger plutons (Peterson and others, 1987a). If pegmatites in the study area are also associated with younger plutons, these plutons have not yet been exposed.

Geothermal Energy

No geothermal waters or leasing activity are known within the study area. Witcher and others (1982) showed no thermal springs or wells in or near the study area; they did not define the area as favorable for the discovery of geothermal resources. Krason and others (1982), however, suggested the possibility of favorability for geothermal resources in the northwest corner of the study area based on a small-scale map published in Jones (1979). Therefore, the northwest corner of the study area has low potential, certainty level B, for geothermal resources.

Other Commodities

The periphery of the Table Top Mountains, and consequently of the study area, is flanked by pediment surfaces that become deep basins to the northeast and southwest. These pediments have a low potential for resources of gypsum, anhydrite, or halite in evaporite deposits, certainty level B. The part of the basin about 7 mi northeast of the area has been designated as favorable for the presence of continental evaporite deposits because it lies within a structural area termed the Gila Low, which is known to contain two evaporite deposits (Peterson and others, 1987a). Within the study area, evaporites are not likely because the basin is very shallow, However, in the Sauceda Mountains about 30 mi west of the study area, a celestite deposit of evaporite origin is exposed on the edge of the pediment (Moore, 1935) and similarly shallow evaporite deposits could possibly exist in the Table Top area buried beneath the pediment surface.

Uranium in the basins surrounding the Table Top Mountains is unlikely but possible. These areas have a low potential, certainty level B, for uranium. Uranium can form in sedimentary basins in several ways: in calcrete (Carlisle, 1978), in tuffaceous lake-bed sediments (Davis and Hetland, 1956), and precipitated in caliche where the uranium is transient throughout the rainy season (Bell, 1956). The basin margins around Table Top Mountains are too shallow for the development of calcrete, and a lack of exposed tuffaceous rocks makes lake-bed accumulations improbable. Thus, the most likely means of accumulating uranium in the study area is in caliche deposits. These accumulations are typically small and of low grade. For any such uranium deposits to develop, a suitable source area is required. Peterson and others (1987a) have designated the area north of the study area as being suitable as a uranium source region, and the study area itself may also be a source area.

Several scattered tin anomalies in the concentrate samples collected on the pediments suggest that there may be small amounts of placer tin present around the edges of the area. These areas have low potential, certainty level B, for tin. A source for this tin is not known.

There have been no reported oil or gas discoveries, but scattered parcels of Federal land are leased for oil and gas in and around the Table Top Mountains (McDonnell, 1986). Ryder (1983) included the study area in a zone of "low to zero" potential and further indicated that in this zone hydrocarbons could accumulate only in the sediment-filled basins, which are generally too shallow in the study area. Also, the study area consists mostly of intrusive, metamorphic, and volcanic rocks, which are not conducive to hydrocarbon accumulation. Any hydrocarbons in nearby sedimentary rocks would likely have migrated or been destroyed through tectonic and magmatic activity. Therefore, we concur with Ryder's conclusions and assign a low potential, certainty level B, for oil and gas resources to the entire study area.

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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.

A	B	C	D
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

LEVEL OF RESOURCE 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.

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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 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 Early	96 138
		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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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.

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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.)

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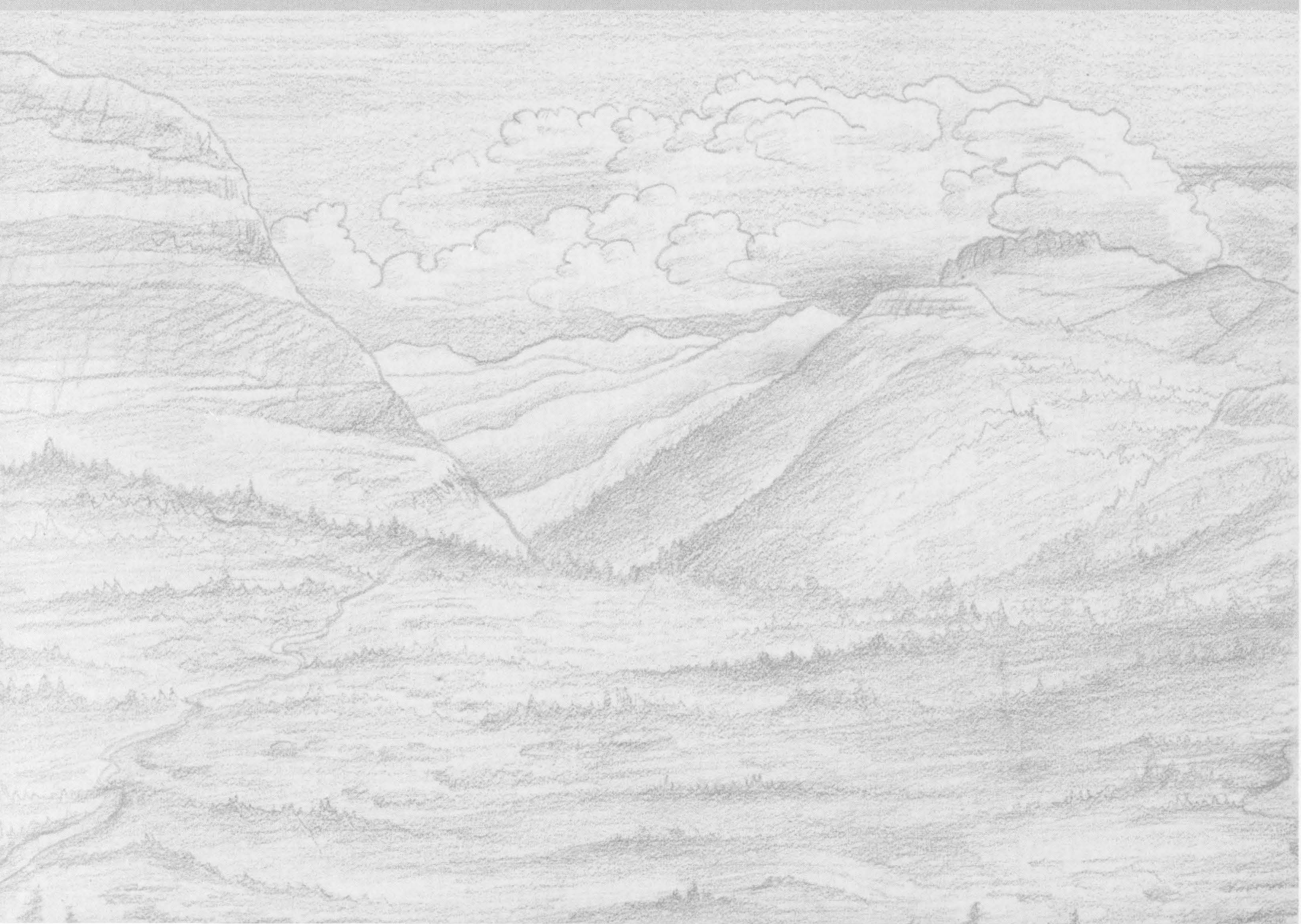

Peterson and others—MINERAL RESOURCES, TABLE TOP MOUNTAIN WILDERNESS STUDY AREA, ARIZONA—U.S. Geological Survey Bulletin 1702-A