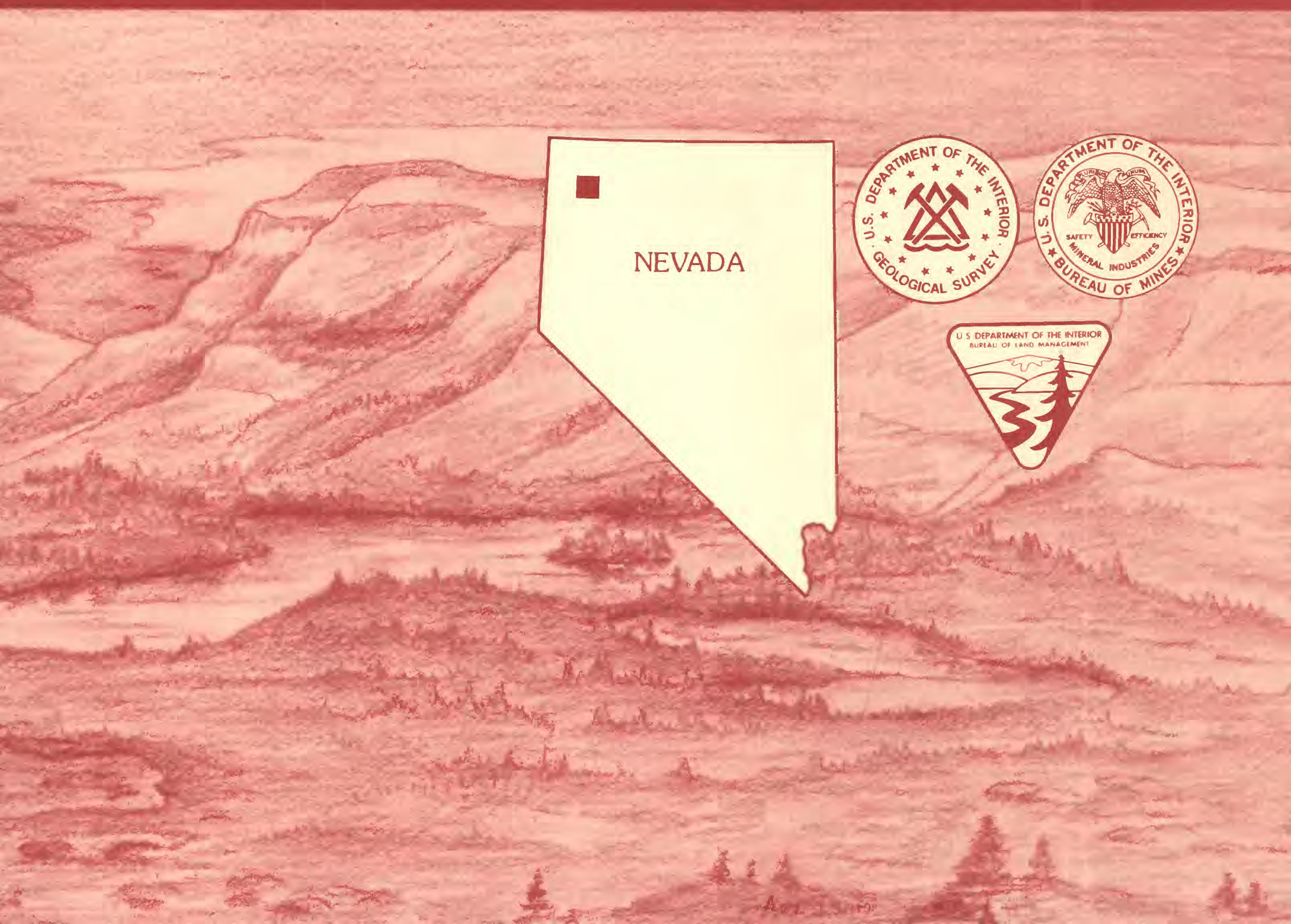
Mineral Resources of the Mount Limbo Wilderness Study Area, Pershing County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1726–A



Chapter A

Mineral Resources of the Mount Limbo Wilderness Study Area, Pershing County, Nevada

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
HUMBOLDT AND PERSHING COUNTIES, NEVADA

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 Area

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 of 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 Mount Limbo Wilderness Study Area (NV-020-201), Pershing County, Nevada.

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Mineral Resources of the Mount Limbo Wilderness Study Area, Pershing County, Nevada

By William J. Keith, Robert L. Turner, *and* Donald Plouff
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SUMMARY

Abstract

At the request of the Bureau of Land Management, 12,900 acres of the Mount Limbo Wilderness Study Area (NV-020-201) were studied. In this report, the area studied is referred to as "the wilderness study area," or simply "the study area." The study area is located at the southern end of the Selenite Range in Pershing County, Nev. Geological, geochemical, geophysical, and mineral surveys were conducted by the U.S. Geological Survey and the U.S. Bureau of Mines from 1983 to 1986 to assess the mineral resource potential of the study area. No resources were identified in the area; however, the results of these surveys indicate the existence of a zone with moderate potential for the southern end of the study area. Elsewhere within the study area, the potential for gold and silver resources is low. Potential for geothermal resources is low in the entire study area. The granitic and volcanic rocks found in the study area are unfavorable for the accumulation of oil and gas.

Character and Setting

The study area is located at the southern end of the Selenite Range, approximately 20 mi southeast of Gerlach, Nev. (fig. 1). The topography is typical of the Basin and Range geomorphic province, with north-south trending fault-bounded valleys and ranges. It is an area of high relief, ranging from 4,000 ft at the valley floor to 8,237 ft at the summit of Kumiva Peak. The study area comprises a granodiorite pluton of Cretaceous age (63 to 138 million years before present, or Ma) (see Geologic Time Chart, last page of report) bounded on the east and west by high-angle normal faults. Small felsic to mafic, aplitic to pegmatitic dikes intrude the pluton. Alluviated valleys flank the study area.

Identified Resources

Four prospects are located in the study area, but it contains no mines or active claims. Past interest centered on locally mineralized quartz veins, but they contained no identified mineral resources. Small tufa (calcareous sinter) deposits in the southwest part of the study area contain low concentrations of gold and silver and may be significant. Stone, sand, and gravel are present in the study area but are distant from anticipated markets.

Mineral Resource Potential

The southernmost part of the study area has moderate resource potential for gold and silver (fig. 2). Stream-sediment samples from this part of the study area contain anomalous concentrations of a suite of elements (arsenic, antimony, bismuth, cadmium, and

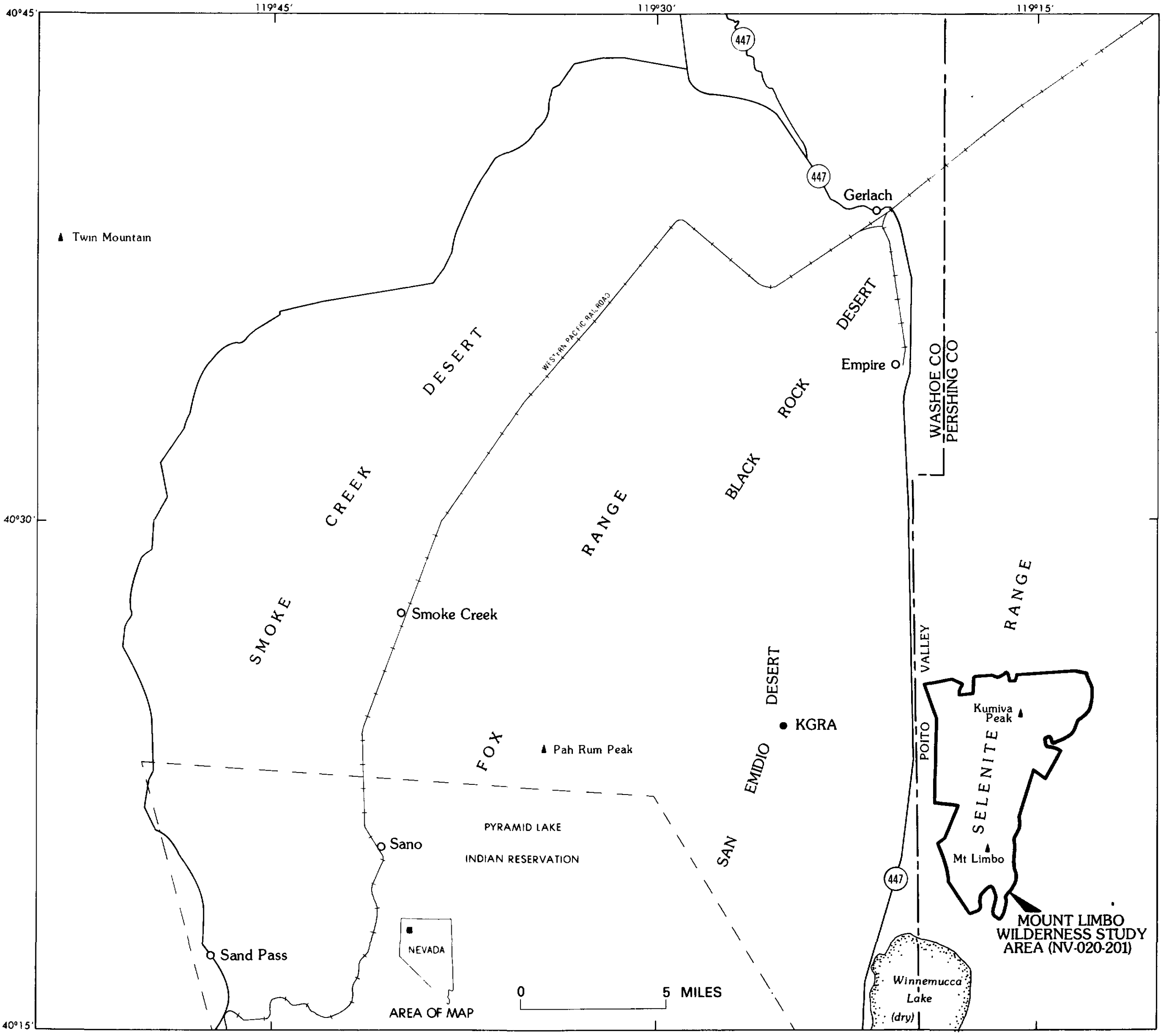

Figure 1. Index map showing the location of the Mount Limbo Wilderness Study Area, Pershing County, Nevada.

silver) that typically occur in gold and silver vein deposits. The presence of faults and veins in this area also facilitates this type of mineralization. Most of the observed alteration consists of thin (several inches thick) argillic selveges around veins and oxidation halos adjacent to minor faults and fractures.

In the rest of the study area the rarity of veins and absence of extensive alteration indicate low potential for gold and silver resources.

The potential for geothermal resources in the study area is low, although a known geothermal resource area (KGRA), with water temperatures as high as 95°C, is located in the San Emidio desert (fig. 1, KGRA) 4 mi west of the study area.

The granitic and volcanic rocks found in the study area are not favorable host rocks for the accumulation of hydrocarbons.

INTRODUCTION

Area Description

At the request of the Bureau of Land Management, 12,900 acres of the Mount Limbo Wilderness Study Area (NV-020-201) were studied. In this report, the area studied is referred to as "the wilderness study area," or simply "the study area." The study area consists of rugged, sparsely vegetated terrain bordering the northeast edge of Winnemucca Dry Lake in western Pershing County, Nev. (fig. 1). It is located in the southernmost part of the Selenite Range and is flanked by broad (2 mi wide on the west, 10 mi wide on the east) alluviated valleys. The area is accessible by gravel roads on all sides, but the interior is accessible only by helicopter, horseback, or on foot. Altitudes range from 4,000 ft at the southern tip of the study area to 8,237 ft at Kumiva Peak near the north end.

Previous and Present Investigations

A geologic map of the study area prepared by the U.S. Geological Survey in 1984 (fig. 2) at a scale of 1:62,500 provided a basis for the interpretation of geochemical, geophysical and mining claim data. Supplemental geologic data for the north end of the study area was taken from a Master's thesis by R.A. Crewdson (1974).

Studies by Smith and others (1971), Johnson (1977), and the U.S. Bureau of Land Management (1983) also provided geologic data for this report.

Geochemical data were obtained from a geochemical-geostatistical study done for the U.S. Bureau of Land Management by Barringer Resources, Inc. (1982) and from analyses of stream-sediment and rock-chip samples collected by the U.S. Geological Survey in 1984 (Day and others, 1986).

Earlier geophysical data, which consisted of a regional gamma-ray survey (Geodata International, Inc., 1978) and aeromagnetic maps (U.S. Geological Survey, 1972), were supplemented in 1984 by a gravity study and a regional gravity compilation conducted by the U.S. Geological Survey (unpub. data).

The U.S. Bureau of Mines studied the known prospects and claims within and adjacent to the study area as a means of developing a model that would predict the grade and tonnage of mineral resources that might occur in the study area (Rumsey, 1986).

Acknowledgments

The U.S. Geological Survey and the U.S. Bureau of Mines received assistance from the following: V. Dunn, U.S. Bureau of Land Management geologist, provided information on locations of mineralized areas; Helen Thrasher, owner, and Harold Playford, lessee of the Thrasher mine, provided local history and directions; R. Baker, C. Erdman, K. Greene, J. Lewis, and N. Logue assisted in the fieldwork.

APPRAISAL OF IDENTIFIED RESOURCES

By Clayton M. Rumsey,
U.S. Bureau of Mines

Methods

From 1984 to 1986, the U.S. Bureau of Mines (USBM) conducted a library search and examined U.S. Bureau of Land Management (BLM), USBM, and Pershing County claim and production records in order to determine the level of mining and prospecting activity in the study area. The field study included inspections of all prospects and mineralized localities within the study area. The Thrasher and Stormy Day mines, and three nearby prospects, were examined to determine whether mineralized zones might extend into the study area. In addition, ground and air reconnaissance was done in areas of obvious rock alteration. Sixteen prospects and mineralized sites in and near the study area were examined and 69 samples were collected, including chip samples collected across mineralized zones and grab samples from stockpiles of mineralized rock. All samples were assayed for gold and silver by the combined fire assay-inductively coupled plasma method. The presence and concentration of other elements were determined by atomic-absorption analysis. Selected samples from sites with anomalous radioactivity were analyzed for uranium. Gold and silver concentrations are reported in parts per million (ppm); the content of other elements is reported in ppm or percent. Detection limits were as follows: gold, 0.007 ppm; silver, 0.3 ppm; uranium, 0.5 ppm; and lead, 30 ppm. Conversion factors are 1 ppm = 0.0292 oz/ton, and 10,000 ppm = 1 percent.

Mining History

In 1941 tungsten was discovered in the southern part of the Hooker mining district, which extends to within 1 mile of the north end of the study area. Between 1944 and 1957, the Stormy Day mine produced 19,523 tons of ore containing 1.66 percent tungsten trioxide. The neighboring Thrasher mine produced an unknown amount of tungsten ore (Johnson,

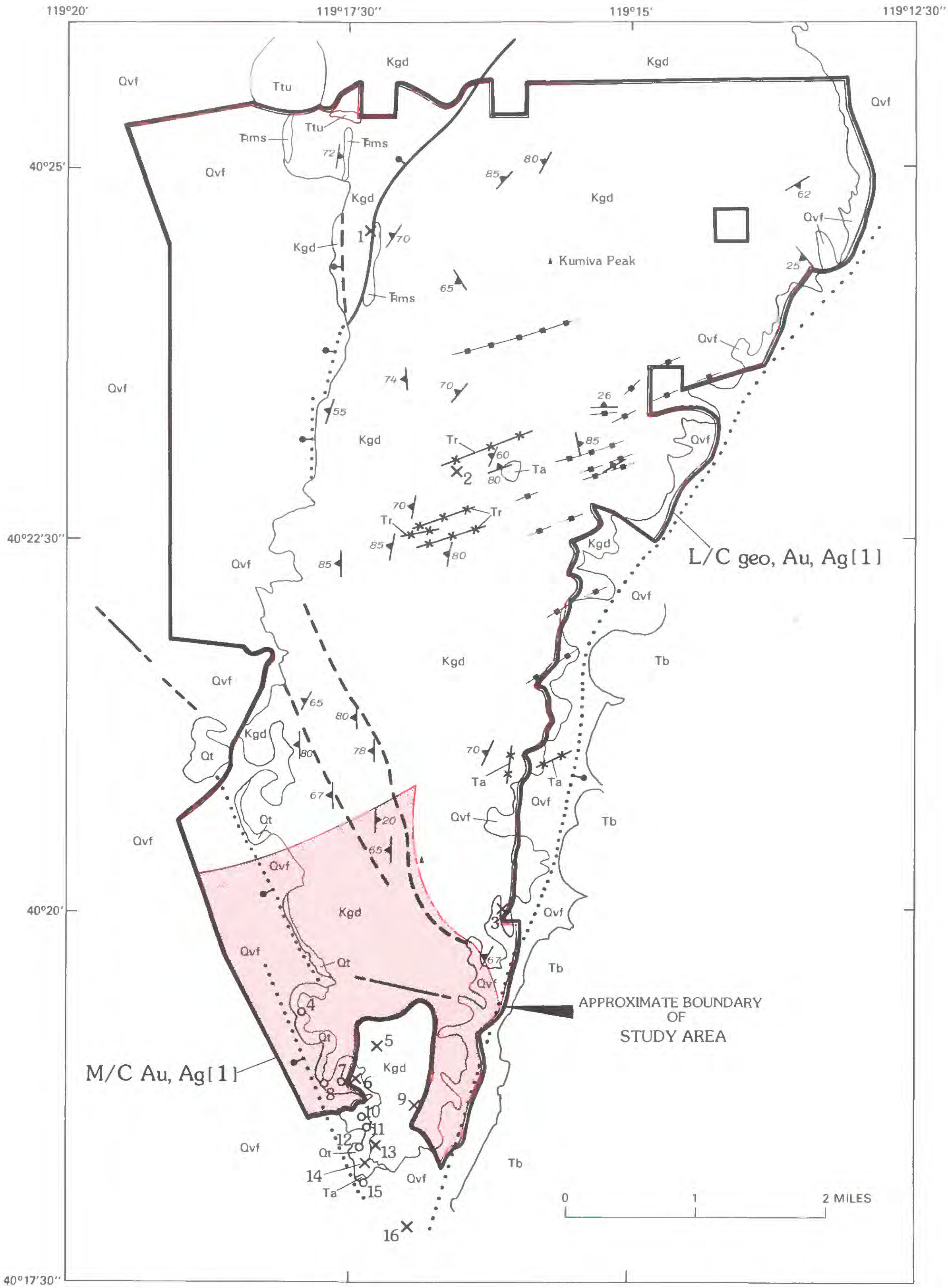

Figure 2. Geologic map of the Mount Limbo Wilderness Study Area showing prospects, mineralized areas, and areas of mineral resource potential.

EXPLANATION

AREA WITH MODERATE MINERAL RESOURCE POTENTIAL--Certainty level C (M/C). See Appendix 1 and figure 3 for definition of mineral resource potential and certainty of assessment

AREA WITH LOW MINERAL AND GEOTHERMAL RESOURCE POTENTIAL--Certainty level C (L/C)

COMMODITIES

Au	Gold
Ag	Silver
geo	Geothermal

[ ] TYPES OF DEPOSITS AND OCCURRENCES

1 Epithermal precious metal deposits

CORRELATION OF MAP UNITS

Qvf	Holocene	QUATERNARY
Qt	Pleistocene	QUATERNARY
Tr		TERTIARY
Tb		TERTIARY
Ta		TERTIARY
Ttu		TERTIARY
Unconformity		
Kgd		CRETACEOUS
Unconformity		
T̄ms		TRIASSIC

GEOLOGIC MAP UNITS

Qvf	VALLEY FILL (HOLOCENE)
Qt	TUFA (PLEISTOCENE)
Tr	RHYOLITE DIKES (TERTIARY)
Tb	BASALT (TERTIARY)
Ta	ANDESITE DIKES AND PLUG (TERTIARY)
Ttu	UNDIFFERENTIATED TUFF (TERTIARY)-Tuff of latitic to dacitic composition (Crewdson, 1974)
Kgd	GRANODIORITE (CRETACEOUS)
T̄ms	METASILTSTONE (TRIASSIC)-Metamorphosed calcareous siltstone (Crewdson, 1974)

MAP SYMBOLS

CONTACT

FAULT-Dashed where approximately located, dotted where hidden. Bar and ball on downthrown side

72 STRIKE AND DIP OF FOLIATION IN PLUTONIC ROCKS-Number indicates dip angle

DIKES-Composition indicated by symbol

PROMINENT JOINTS

×2 PROSPECT-Number refers to table 1

o11 SINTER OR TUFA DEPOSITS SAMPLED-Number refers to table 1

Figure 2. Continued.

1977, p. 58). Both mines are now inactive. There is no record of mining or production within the study area, and the study area contained no active claims at the time of the study (1984).

Sites Studied

The 16 prospects and mineralized sites examined (fig. 2) consist of calcareous sinter or tufa deposits and quartz veins in granodiorite (table 1). Quartz veins at prospects in the study area are small and have low mineral concentrations. Although a relatively high concentration of silver (580 ppm) was obtained from a sample collected at one prospect (fig. 2, no. 9), silver concentrations in other samples are relatively low. Sinter or tufa deposits near Winnemucca Lake contain low, yet anomalous, concentrations of gold, silver, and uranium (table 1).

Conclusions

Although precious-metal resources may occur at depth, none were identified at the surface in the study area. Although there are sites of anomalous uranium, the conditions are not favorable for uranium deposits and no resources are indicated.

Tungsten deposits at the Thrasher and Stormy Day mines (fig. 2) do not extend into the study area. Stone, sand, and gravel, although present, are not considered resources because they are too far from anticipated markets.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By William J. Keith, Robert L. Turner, and Donald Plouff
U.S. Geological Survey

Geological Studies

The Selenite Range (fig. 1) is a north-trending mountain range in the Basin and Range physiographic province. The wilderness study area, at the southern tip of the range, contains a fault-bounded granodioritic body (fig. 2, unit Kgd) of Cretaceous age (Smith and others, 1971) that was intruded by mafic, felsic, and aplitic to pegmatitic dikes. Much of the faulting in the study area is of the high-angle basin-range type. Alteration consists largely of oxidized fringes on the faults and dikes and argillic fringes on some of the veins.

The granodiorite pluton consists of plagioclase, potassium feldspar, quartz, hornblende, biotite, and sphene, and has a texture that ranges from generally equigranular in the southern part of the study area to porphyritic in the north. A north-trending plane of foliation is less intense to the north. The northern part of the pluton appears to be younger than the southern part, and younger phases of the pluton locally intrude the older. Inclusions, consisting of hornblende, biotite, plagioclase, and quartz, that occur throughout the pluton, probably are segregations in the pluton rather than xenoliths.

Mafic dikes found in the study area have a wide range of compositions and fill joints and faults in the pluton. The smaller dikes (1- to 24-in. wide), containing fine-grained granular hornblende, biotite, plagioclase, and quartz, occur throughout the pluton but are more numerous in the southern part. One dike composed almost entirely of hornblende was observed on the east side of the study area. Andesite dikes (fig. 2, unit Ta), ranging from 1 to 15 ft in width, occur sporadically throughout the pluton. These dikes are aphanitic to porphyritic with sparse phenocrysts (xenocrysts?) of plagioclase and (or) hornblende.

Felsic dikes occur throughout the study area as pegmatites of predominantly potassium feldspar and (or) quartz and as aplites. Locally (north-central ridge crest), 1- to 3-ft-wide dikes of aphanitic rhyolite (fig. 2, Tr) trend approximately N. 70 E.

Dendritic and cellular tufa (fig. 2, unit Qt), reportedly of algal origin (Morrison, 1964), drape parts of the granodiorite. Cavities in the tufa typically are filled with detrital biotite, hornblende, and lesser amounts of other detrital minerals making chemical analysis of the unit quite variable. The tufa is confined to the area below the 4,400-ft contour (approximate upper level of Pleistocene Lake Lahontan, Morrison, 1964). Some of the authors of this report believe that the tufa (calcareous sinter) deposits along the southwest slopes of the study area are of thermal-spring origin, and others believe that they precipitated from chemically saturated lake water.

Geochemical Studies

Geochemical studies of the study area were conducted at two levels: a regional reconnaissance survey (Barringer Research Inc., 1982) with an average sample density of one sample per square mile, and a more detailed study (Day and others, 1986) of an area shown by the Barringer study to contain relatively high concentrations of arsenic.

In the Barringer study, 54 stream-sediment samples were collected from sites along the range front. Analytical results of this survey show relatively high concentrations of arsenic, cadmium, copper, fluorine, strontium, uranium, and zinc. The distribution of these elements may reflect enrichment or depletion in older and younger parts of a pluton (Hildreth, 1981).

Twenty-nine sites were sampled (both stream-sediment and rock samples) along a 4-mile zone in the southern part of the study area. Analyses of the nonmagnetic part of heavy-mineral concentrates in the stream-sediment samples show anomalous concentrations of lead, scandium, and thorium (Day and others, 1986). Sphene, which contains minor amounts of thorium, was identified in all but two samples and is the probable source of the thorium. The occurrence of anomalous lead and scandium, each at a single site, is not significant. Chemical analyses of rock samples show concentrations of antimony, arsenic, bismuth, cadmium, and silver that are greater than the normal range in fresh granodiorite from the area (Day and others, 1986). This suite of elements is characteristic of precious-metal deposits (Boyle, 1984).

Geophysical Studies

Concentrations of potassium and equivalent thorium and uranium were estimated for the study area by examining composite-color maps of gamma-ray spectrometric data (J.S. Duval, written commun., 1985). The data were obtained from radiometric profiles compiled by Geodata International, Inc. (1978). Based on criteria discussed by Duval (1983), the study area has moderate radioactivity with values of 1.5 to 2.5 percent potassium, 6 to 12 ppm equivalent thorium, and 2.0 to 3.5 ppm equivalent uranium. There is no indication of anomalous concentrations of radioelements.

In 1984, the U.S. Geological Survey established 47 gravity stations in and near the study area to compile a regional gravity map (D. Plouff, unpub. data). Although lacking coverage along the crest of the Selenite Range, the Bouguer gravity-anomaly map shows a gravity high over the range that exceeds 10 milliGals relative to the surrounding valleys. The thickness of Quaternary sediments east and west of the range are believed to be insufficient to entirely account for the magnitude of the gravity high. Prominent gravity gradients along the east and west flanks of the range suggest that block-faulting occurred along inferred major faults (fig. 2) that separate the crystalline core of the range from the surrounding, less dense basement rocks.

An aeromagnetic map of the region shows a distinct magnetic high located over the Selenite Range (U.S. Geological Survey, 1972). The shape of the anomaly closely conforms to topography; hence, it reflects moderate magnetization of the granodiorite. The aeromagnetic survey was flown at a constant barometric elevation of 9,000 ft above sea level. Consequently, the level of magnetic intensity is about 100 nanoteslas lower along a flightline near Mount Limbo (7,312 ft) than along a flightline near Kumiva Peak (8,237 ft). The shape of the magnetic high is similar to that of the gravity high, but the magnetic gradient along the west flank of the range is more linear and extends farther south than the gravity gradient, and the magnetic gradient along the east flank is less pronounced. The small scale of the aeromagnetic map (1:250,000), the wide spacing of flightlines (2 mi), and strong topographic effects limit interpretation to defining the margin of the granodiorite of Mount Limbo.

MINERAL AND ENERGY RESOURCES

Anomalous concentrations of arsenic, antimony, bismuth, cadmium, and silver, coupled with permissive host rock and the presence of faults and veins in an area in the southern part of the Mount Limbo Wilderness Study Area (fig. 2), indicate that the mineral resource potential for gold and silver at depth is moderate with a C certainty level. See fig. 3 and appendix 1 for definitions of levels of mineral resource potential and certainty of assessment. No estimate of depth to or size of the body of mineralized rock can be made from the available data.

The rest of the study area has a low mineral resource potential (certainty level C) for gold and silver. Plutonic rock commonly is the host for base- and precious-metal deposits, but the lack of hydrothermal alteration and the sporadic, isolated distribution of the geochemical anomalies indicate that the probability of the occurrence of a vein or disseminated type of mineral deposit in this area is low.

Geothermal energy resource potential is low (certainty level C) throughout the study area. A known geothermal resource area four mi west of the study area in the San Emidio Desert (fig. 1, KGRA) has water temperatures as high as 95°C (Muffler, 1978), but there is no evidence that a hydrothermal system extends into the study area.

The predominant rock type in the study area is granodiorite, which is an unfavorable host for petroleum and natural gas accumulation.

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Table 1.--Descriptions of prospects and sinter or tufa sites in the Mt. Limbo Wilderness Study Area
[Asterisk indicates locations outside the study area]

Map No.	Name	Summary	Workings and production	Sample and resource data
1	Pinto prospect (silver-uranium)	A 5-ft-thick limonite-stained quartz vein and float "occur" along a range-front fault that parallels a contact between granodiorite and volcanic rocks. The fault strikes N. 10° E., dips 65° NW., and can be traced for 6 mi.	One prospect pit.	Eight samples: one chip sample collected across the quartz vein contained 3.532 ppm silver; one grab sample of quartz from the prospect pit contained no gold or silver; one of six other grab samples from along the fault contained 1.041 ppm silver and two each had 0.97 ppm U_3O_8.
2	Unnamed prospect (silver-uranium)	A 6-ft-thick, iron-oxide-stained smoky quartz vein with an attitude of N. 45° W., 35° NE. is exposed for 7 ft in granodiorite.	One prospect pit.	One chip sample contained 9.19 ppm silver and 4.0 ppm U_3O_8.
3	Unnamed prospect (uranium)	Iron-oxide-stained contact between granodiorite and rhyolite trends generally easterly.	Two 150- by 2-ft-deep trenches, and a prospect pit.	Three chip and two grab samples: chip samples of granodiorite contained 2.8 to 5.1 ppm U_3O_8; a grab sample of concentrated black sand had 544 ppm U_3O_8; and a grab sample from a dump contained 3.5 ppm U_3O_8.
4	Sinter or tufa site (uranium)	About 80 percent of the granodiorite in a 500- by 2,200-ft area is coated with calcareous sinter or tufa that is 0.5 to 4 ft thick.	None.	Three chip samples and one grab sample of sinter or tufa contained between 1.8 and 2.8 ppm U_3O_8.
5*	Unnamed prospect (uranium)	Altered rhyolite tuff and granodiorite "occur" along a contact that strikes N. 85° E. and dips 45° N.	A 90-ft trench	Five chip samples taken along the contact contained from 2.8 to 7.0 ppm U_3O_8.
6*	Unnamed prospect (silver-uranium-gold)	A 0.5-ft-thick, iron-oxide-stained quartz vein "occurs" in altered granodiorite	Two 30-ft trenches	Three chip samples contained 1.047 to 1.209 ppm silver and 2.7 to 4.0 ppm U_3O_8; one had 0.04 ppm gold.
7	Sinter or tufa site (silver-uranium)	About 60 percent of a 170- by 85-ft area of granodiorite is coated with calcium carbonate 1 ft thick.	None.	Four chip samples contained from 1.00 to 1.142 ppm silver; three contained 3.4 to 3.7 ppm U_3O_8.
8	Sinter or tufa site (gold-uranium)	Calcareous sinter or tufa at a former thermal spring coats about 25 percent of underlying granodiorite to a thickness of 1.5 ft, 50 to 300 ft from the spring.	None.	Four chip samples contained from 1.5 to 6.4 ppm U_3O_8; one had 0.008 ppm gold.
9*	Unnamed prospect (silver-lead-uranium)	A 1,600-ft-wide zone of leached and iron-oxide-stained quartz veins trends northeasterly in granodiorite.	About an acre of the ridge top was bulldozed.	Three chip and two grab samples: one chip sample from a small vein contained 0.01 ppm gold, 580 ppm silver, 2.19 percent lead, and 59 ppm U_3O_8. The other chip samples contained 0.8 and 2.966 ppm silver, and 33 and 50 ppm lead. One grab sample contained 3.22 ppm silver, 0.019 ppm lead, and 2.2 ppm U_3O_8.
10*	Sinter or tufa site (silver-uranium-gold)	Calcareous sinter or tufa, at least 0.5 ft thick, overlies granodiorite 520 ft from former thermal springs.	None.	Three chip samples contained from 0.989 to 1.191 ppm silver and 3.4 to 5.1 ppm U_3O_8; two had 0.024 and 0.058 ppm gold.
11*	Sinter or tufa site (silver-gold)	Calcium carbonate sinter or tufa of undetermined thickness coats granodiorite over a 50-ft diameter area.	None.	Three chip samples contained from 1.042 to 1.217 ppm silver; two had 0.018 and 0.124 ppm gold.
12*	Sinter or tufa site (silver-uranium)	Calcium carbonate sinter or tufa 0.1 to more than 10-ft-thick coats about 80 percent of the granodiorite within a 1-acre area that includes former thermal springs.	None	Four chip samples contained from 2.4 to 3.8 ppm U_3O_8; three had 0.997 to 1.106 ppm silver.
13*	Unnamed prospect (silver-uranium)	Two 1-ft-thick aplite dikes enclose 0.3-ft-thick veins of iron-oxide-stained quartz. The dikes are 5 ft apart, exposed for 50 ft, trend northward, and dip 10° eastward in granodiorite.	None	Two chip samples contained 1.175 and 1.336 ppm silver, and 5.9 and 6.5 ppm U_3O_8.
14*	Limbo group (uranium-silver-gold)	A 4-ft-thick, iron-oxide-stained quartz vein which strikes N. 30° W. and dips 60° NE., is exposed for 200 ft in granodiorite.	One 18-ft adit.	Ten samples of the quartz vein contained from 3.2 to 153 ppm U_3O_8. Two samples had 0.007 and 0.013 ppm gold, and nine contained from 1.149 to 5.023 ppm silver.
15*	Sinter or tufa site (uranium)	Calcium carbonate sinter or tufa 1 to 5 ft thick near a former thermal spring coats basalt on a mound that is 100 ft wide and 50 ft high.	None	Two chip samples contained 1.3 and 4.1 ppm U_3O_8.
16*	Unnamed prospect (uranium)	Three 2-ft-thick, aplite dikes within 400 lateral feet strike between due north and N. 30° W. and dip vertically in altered granodiorite.	Minor trenches and topsoil bulldozed from a 40 by 100 ft area.	Five samples: four had from 1.8 to 7.5 ppm U_3O_8.

APPENDIX 1. Definition of levels of mineral resource potential and certainty of assessment

Mineral resource potential is defined as the likelihood of the presence of mineral resources in a defined area; it is not a measure of the amount of resources or their profitability.

Mineral resources are concentrations of naturally occurring solid, liquid, or gaseous materials in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Low mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment where the existence of resources is unlikely. This level of potential embraces areas of dispersed mineralized rock as well as areas having few or no indications of mineralization. Assignment of low potential requires specific positive knowledge; it is not used as a catchall for areas where adequate data are lacking.

Moderate mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable chance for resource accumulation, and where an application of genetic and (or) occurrence models indicates favorable ground.

High mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resources, where interpretations of data indicate a high likelihood for resource accumulation, where data support occurrence and (or) genetic models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential requires positive knowledge that resource-forming processes have been active in at least part of the area; it does not require that occurrences or deposits be identified.

Unknown mineral resource potential is assigned to areas where the level of knowledge is so inadequate that classification of the area as high, moderate, or low would be misleading. The phrase "no mineral resource potential" applies only to a specific resource type in a well-defined area. This phrase is not used if there is the slightest possibility of resource occurrence; it is not appropriate as the summary rating for any area.

Expression of the certainty of the mineral resource assessment incorporates a consideration of (1) the adequacy of the geologic, geochemical, geophysical, and resource data base available at the time of the assessment, (2) the adequacy of the occurrence or the genetic model used as the basis for a specific evaluation, and (3) an evaluation of the likelihood that the expected mineral endowment of the area is, or could be, economically extractable.

Levels of certainty of assessment are denoted by letters, A-D (fig. 3).

A. The available data are not adequate to determine the level of mineral resource potential. Level A is used with an assignment of unknown mineral resource potential.

B. The available data are adequate to suggest the geologic environment and the level of mineral resource potential, but either evidence is insufficient to establish precisely the likelihood of resource occurrence, or occurrence and (or) genetic models are not known well enough for predictive resource assessment.

C. The available data give a good indication of the geologic environment and the level of mineral resource potential, but additional evidence is needed to establish precisely the likelihood of resource occurrence, the activity of resource-forming processes, or available occurrence and (or) genetic models are minimal for predictive applications.

D. The available data clearly define the geologic environment and the level of mineral resource potential, and indicate the activity of resource—forming processes. Key evidence to interpret the presence or absence of specified types of resources is available, and occurrence and (or) genetic models are adequate for predictive resource assessment.

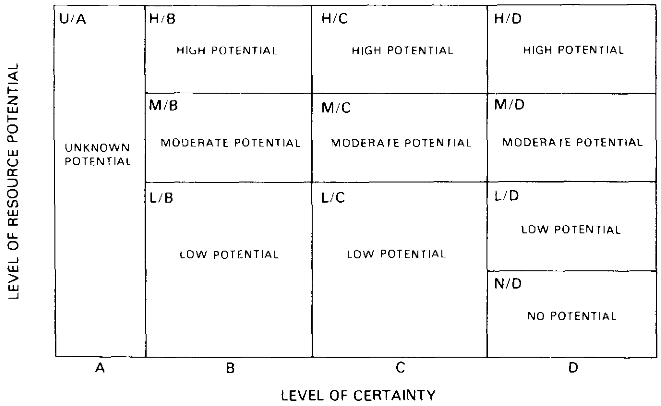

Figure 3. Major elements of mineral resource potential/certainty classification.

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	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	~570[1]
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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