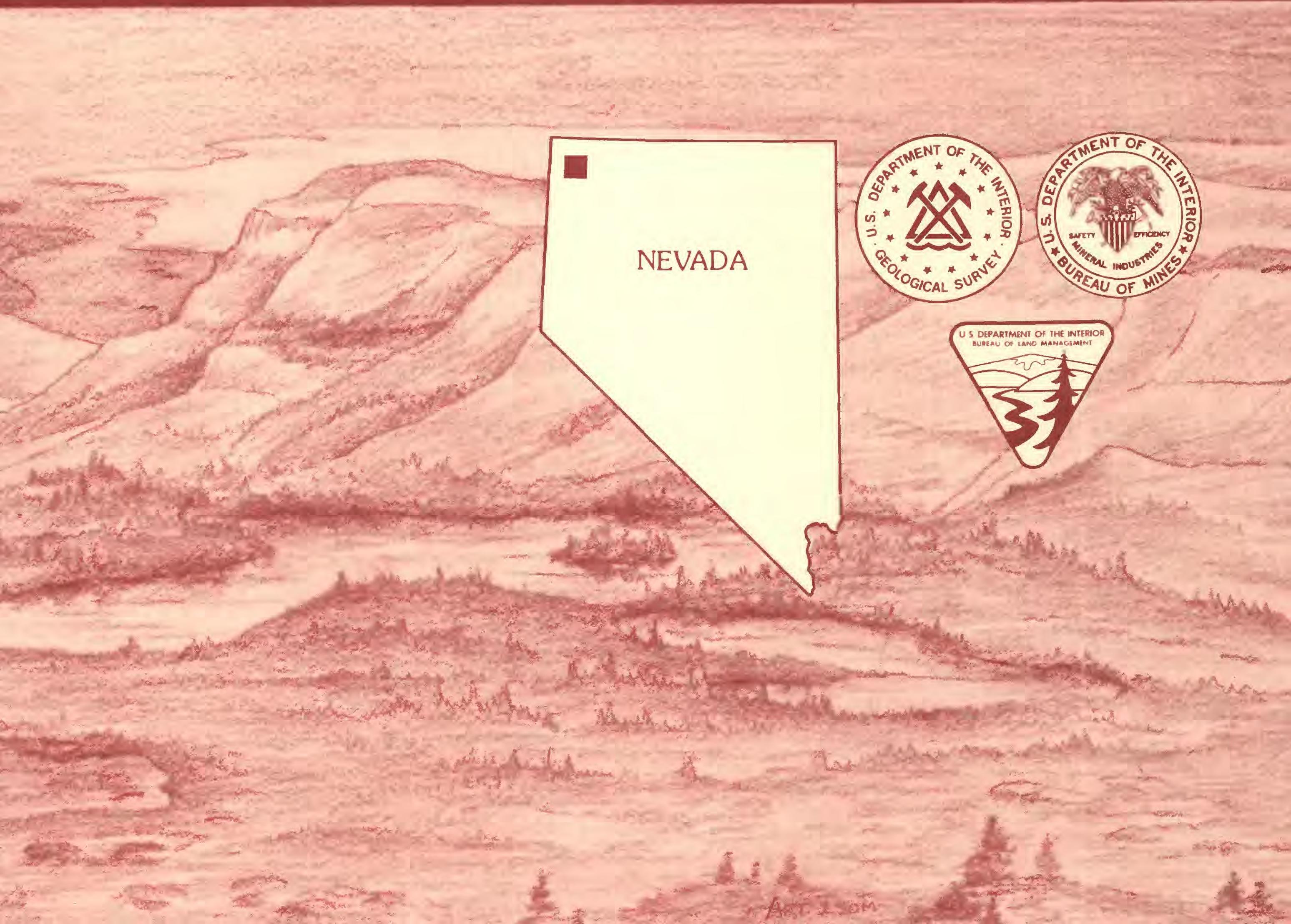
# Mineral Resources of the Massacre Rim Wilderness Study Area, Washoe County, Nevada

## U.S. GEOLOGICAL SURVEY BULLETIN 1707-E



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Chapter E

# Mineral Resources of the Massacre Rim Wilderness Study Area, Washoe County, Nevada

By JOEL R. BERGQUIST, DONALD PLOUFF, and ROBERT L. TURNER
U.S. Geological Survey

J. DOUGLAS CAUSEY
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1707

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
NORTHWESTERN 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 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 Massacre Rim Wilderness Study Area (CA-020-1013), Washoe County, Nevada.

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# Mineral Resources of the Massacre Rim Wilderness Study Area, Washoe County, Nevada

*By* Joel R. Bergquist, Donald Plouff, *and* Robert L. Turner
*U.S. Geological Survey*

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*U.S. Bureau of Mines*

## SUMMARY

### Abstract

The part of the Massacre Rim Wilderness Study Area (CA-020-1013) for which mineral surveys were requested by the U.S. Bureau of Land Management encompasses 23,260 acres northeast of Massacre Lake, about 15 miles northeast of Vya, Nev. Geological, geochemical, geophysical and mineral surveys were conducted by the U.S. Geological Survey and the U.S. Bureau of Mines in 1985 to assess the mineral resources (known) and mineral resource potential (undiscovered) of the study area. No identified metallic or nonmetallic resources occur within the study area. There is moderate mineral resource potential for gold, silver, and mercury in hydrothermal deposits in the eastern part of the study area. There is moderate mineral resource potential for uranium throughout the study area. There is no potential for oil and gas in the study area. The potential for geothermal resources is unknown. In this report, references to the "Massacre Rim Wilderness Study Area" or "study area" refer only to lands for which mineral surveys were requested by the U.S. Bureau of Land Management.

### Character and Setting

The Massacre Rim Wilderness Study Area is in northwest Nevada, about 22 mi east of the California border, 16 mi south of the Oregon border, and 16 mi northeast of Vya, Nev. (fig. 1). The regional setting is transitional between the Basin and Range and the Columbia Plateau physiographic provinces. This region is characterized by volcanic uplands of moderate relief and alluviated valleys. The study area is almost wholly within an upland area. Elevations range from 5,630 ft near Massacre Lake to 6,370 ft at Bitner Table (fig. 1). Access to the margins of the study area is provided by unpaved roads leading north from Nevada Highway 8A and by a jeep trail that leads south from Nevada Highway 34A.

The study area is underlain mostly by basalt flows of Miocene age (see appendixes for geologic time chart). The basalt mostly covers older Tertiary rhyolite and tuffaceous alluvial and lake deposits of Tertiary to Holocene age. In many places in the region the basalt has been eroded, exposing the underlying older rocks and tuffaceous sediments. Because the tuffaceous sediments which underlie the basalt flows are relatively incompetent, there has been extensive landsliding in the region.

No mines have been developed within the study area, and there are no known prospects or mineralized areas. The nearest prospecting was for gold, silver, and mercury in Bald Mountain Canyon in the Lone Pine mining district about 4 mi northwest of the study area.

### Identified Resources

No identified resources exist within the Massacre Rim Wilderness Study Area. Basalt from the study area could be used as road metal or for other industrial purposes, but it is not considered to be a resource because of the abundance of other suitable materials in the region.

### Mineral Resource Potential

The study area has moderate mineral resource potential for gold, silver, and mercury in hydrothermal deposits associated with a caldera on the east side. The entire study area has moderate resource potential for uranium in volcaniclastic deposits. There is no resource potential for oil and gas. The potential for geothermal energy is unknown.

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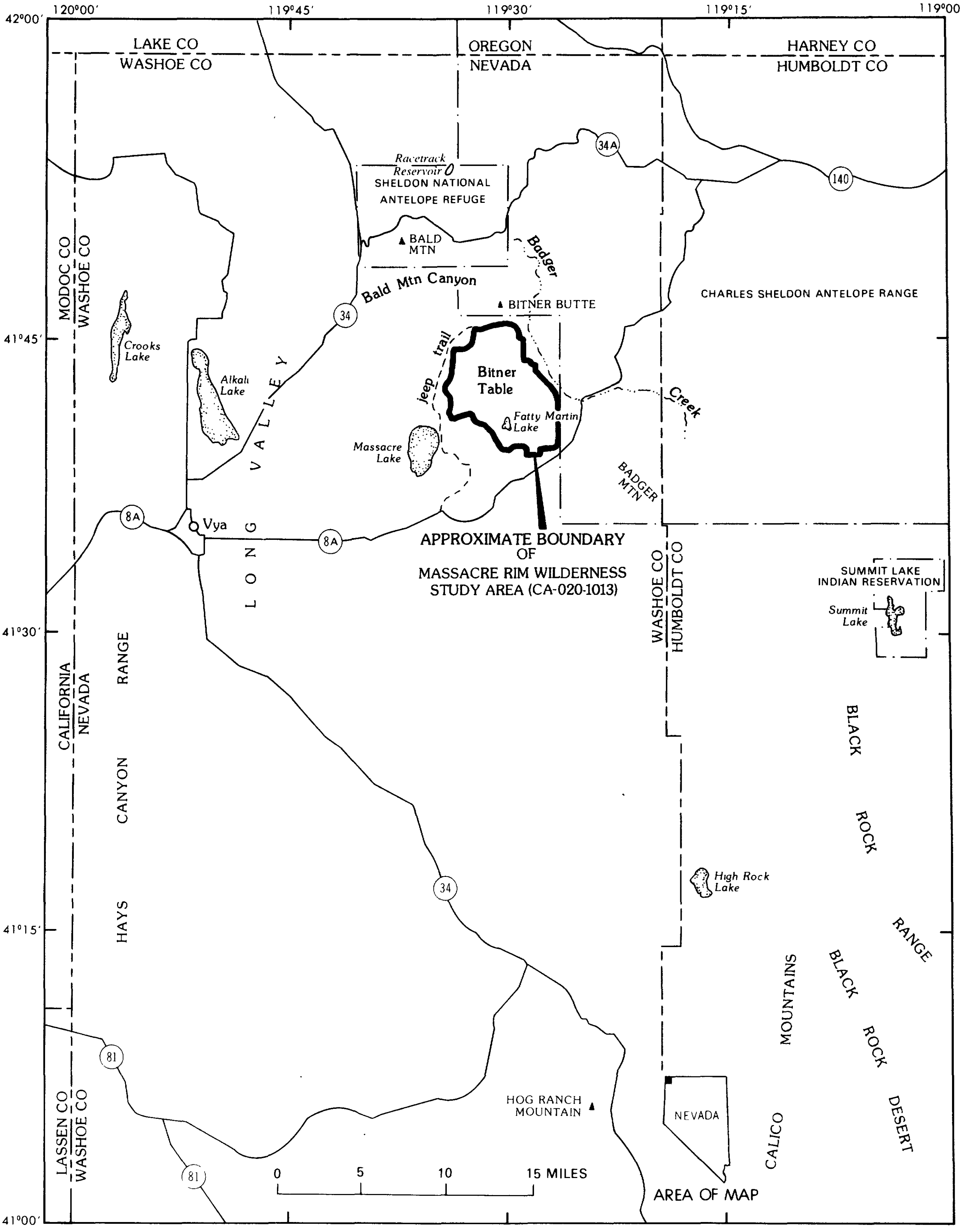



**Figure 1.** Index map showing location of Massacre Rim Wilderness Study Area, Washoe County, Nevada.

## INTRODUCTION

This mineral resource study is the result of a cooperative effort by the U.S. Geological Survey and the U.S. Bureau of Mines. Mineral assessment methodology and terminology are discussed in Goudarzi (1984). 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 the U.S. Geological Survey (1980). See appendixes for the definition of levels of mineral resource potential and certainty of assessment and for the classification of identified resources. Studies by the U.S. Geological Survey are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geological units and structures, possible environments of mineral deposition, presence of geophysical and geochemical anomalies, and applicable ore-deposit models. The U.S. Bureau of Mines 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.

### Area Description

The Bureau of Land Management requested mineral surveys of 23,260 acres within the Massacre Rim Wilderness Study Area (CA-020-1013). The study area is in northern Washoe County, Nev., although it is administered by the Bureau of Land Management office in Susanville, Calif. The Charles Sheldon Antelope Range borders the eastern side of the study area and is within one-tenth mile of the northern part of the study area (fig.1). The Sheldon National Antelope Refuge is about 3 mi north of the study area.

The study area is in the transition zone between the Basin and Range and the Columbia Plateau physiographic provinces. This region is typical northern Great Basin open plateau, having volcanic uplands and alluviated valleys. There are numerous perennial and ephemeral alkali lakes in the region. Massacre Lake, the largest in the area, is about 1 mi southwest of the study area and covers 6 to 8 mi$^2$. Fatty Martin Lake is within the southern part of the study area and covers about 0.3 mi$^2$. A few other small ephemeral lakes are wholly or partly in the study area. The western part of the Massacre Rim Wilderness Study Area consists mostly of Bitner Table, a relatively flat surface of basalt flows that have been faulted and dissected in part. The eastern part of the study area consists of a northwest-trending box canyon that drains through a 120-ft-deep notch into Badger Creek, which flows northwest along the eastern side of the study area.

The region has an arid to semiarid climate, with an average annual precipitation of about 4 to 8 in. (Houghton and others, 1975). The study area has a few intermittent streams. Antelope, coyotes, badgers, martens, skunks, and raccoons are the largest mammalian residents of the area. Vegetation is sparse and consists mostly of sagebrush, grasses, and scattered juniper trees.

### Previous Investigations

Bonham (1969) described the geology and mineral deposits of Washoe County, Nev. His report includes a geologic map of the region at a scale of 1:250,000, discussions of the geologic units found in the study area, and information on the nearby Lone Pine mining district. Bailey and Phoenix (1944), and Ross (1941) discussed the mercury occurrences in the Lone Pine mining district. Park (1983) mapped and described the geology of an area that includes the eastern part of the study area. The U.S. Geological Survey and U.S. Bureau of Mines (1984) made a four-part study of the Charles Sheldon Wilderness Study Area, which adjoins the Massacre Rim Wilderness Study Area. Greene's (1984) geologic map of that area, at a scale of 1:125,000, includes the eastern and northern parts of the present study area, and the text includes discussions of the geologic units and structure. Plouff (1984) interpreted aeromagnetic and gravity data for that area and reported evidence for a buried caldera that may underlie the eastern part of the Massacre Rim Wilderness Study Area. Cathrall and others (1984) did a geochemical evaluation of that area, and some of their samples were collected from the northern and eastern margins of the Massacre Rim Wilderness Study Area. Tuchek and others (1984) wrote an economic appraisal of the Charles Sheldon Wilderness Study Area and described the mineral commodities, mines, and prospects in areas north and east of the Massacre Rim Wilderness Study Area. Mineral resource appraisals of other nearby wilderness study areas were done by Ach and others (1987), Bergquist and others (1988), Keith and others (1987), Noble and others (1987a, b), and Turrin and others (1988). Larson and Beal (1978) described the geologic framework and uranium favorability of the region. Howell (1979) discussed the geology and mineral resources of the Vya, Nev., 1° by 2° quadrangle.

### Present Investigations

The U.S. Geological Survey conducted field investigations in the summer of 1985. This work consisted of geologic mapping, collecting gravity data, and geochemical sampling of bedrock and stream sediments. The rock samples were collected from representative and possibly mineralized parts of each lithologic unit found in the study area. The analyses of these samples provide data that can be used to help identify mineralization and potential resources.

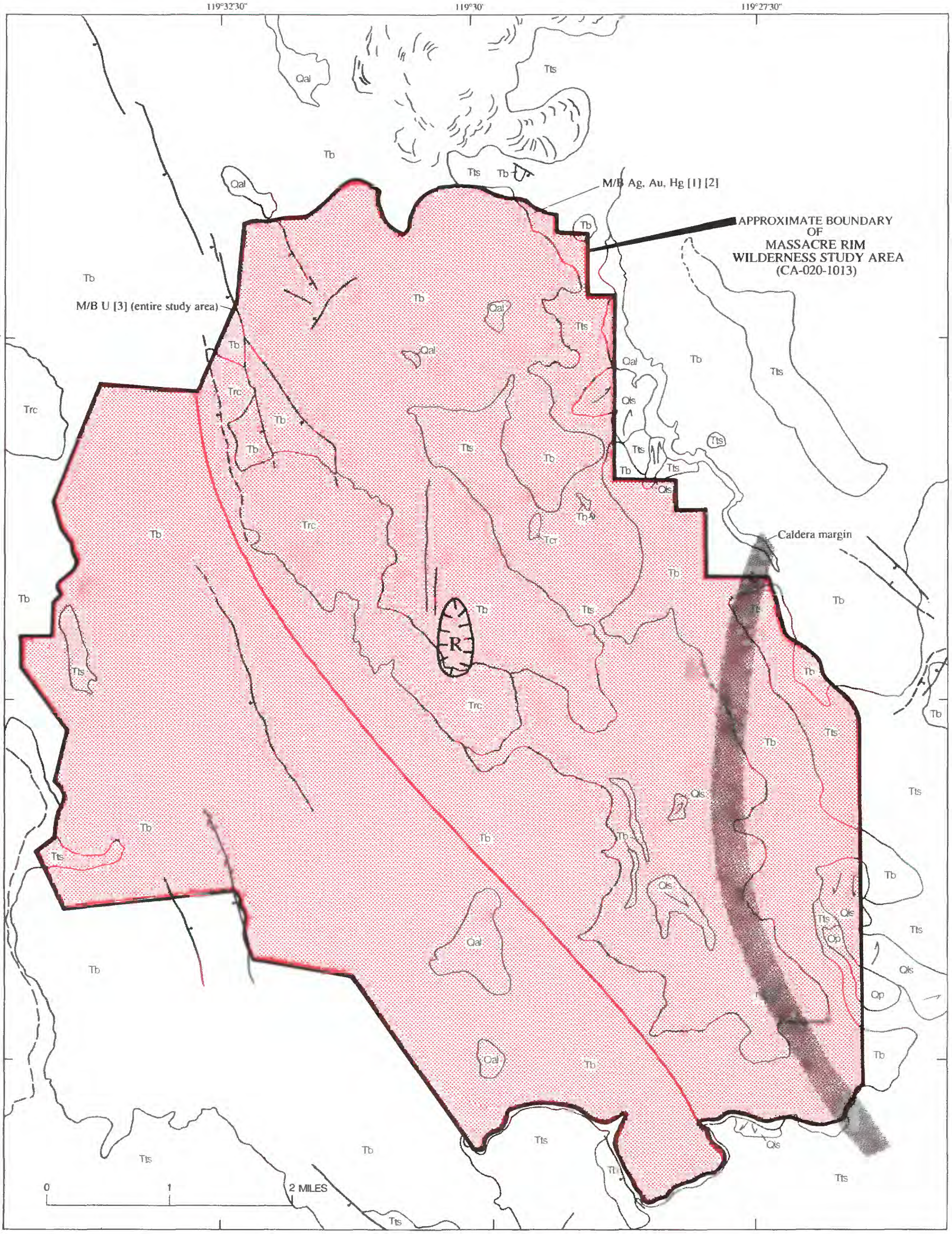



Figure 2. Mineral resource potential and generalized geology of Massacre Rim Wilderness Study Area, Washoe County, Nevada.

EXPLANATION

Area with moderate mineral resource potential (M); data only suggest certainty level (B)

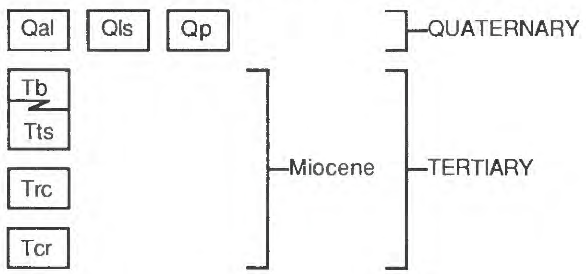
Commodities

| | |
|---|---|
| Au | Gold |
| Ag | Silver |
| Hg | Mercury |
| U | Uranium |

[ ] Types of deposits

| | |
|---|---|
| 1 | Hot-spring gold-silver |
| 2 | Hot-spring mercury |
| 3 | Volcanogenic uranium |

Correlation of map units




Description of geologic map units

**Qal** **Alluvium and colluvium (Quaternary)**--Stream deposits of clay, silt, sand, gravel, and boulders, and colluvium

**Qls** **Landslide deposits (Quaternary)**--Chaotic masses and blocks of basalt and tuffaceous sedimentary rocks; arrow shows direction of movement

**Qp** **Playa and lacustrine deposits (Quaternary)**--Clay, silt, sand, and alkali salts

**Tb** **Basalt of Catnip Creek of Greene (1984) (Miocene)**--Brownish-black- to black-weathering basalt flows; dark to medium gray on fresh surfaces; individual flows typically 10 to 20 ft thick; locally vesicular to scoriaceous

**Tts** **Tuffaceous sedimentary rocks (Miocene)**--Unconsolidated to weakly consolidated, weakly to distinctly bedded, mostly lacustrine deposits of volcanic ash, claystone, siltstone, volcaniclastic sandstone, and pumice-rich, air-fall, and water-laid tuffs. Rock colors are white, light shades of gray and brown, light pink, and reddish

**Trc** **Rhyolite of Catnip Mountain of Greene (1984) (Miocene)**--Light- to medium-gray rhyolite, locally streaked light reddish gray; locally pumiceous or glassy; minor amounts of obsidian; phenocrysts of quartz, alkali feldspar, and sodic amphibole in aphanitic groundmass

**Tcr** **Canon Rhyolite of Merriam (1910) (Miocene)**--Reddish-gray to maroon rhyolite, streaked and mottled medium to light gray; banded, lithophysal, and vesicular textures; phenocrysts of quartz, alkali feldspar, and biotite in aphanitic groundmass

Contact--Dashed where approximate

Fault--Dashed where approximate. Bar and ball on downthrown side

Flow ridges in basalt

Inferred margin of buried caldera

Area of anomalous radioactivity

**Figure 2.** Continued.

The U.S. Bureau of Mines reviewed information relating to current and past mining and prospecting activities in and near the study area. U.S. Bureau of Mines personnel examined (1) U.S. Bureau of Mines files, (2) the U.S. Bureau of Mines computerized Mineral Industry Location System (MILS), (3) U.S. Bureau of Land Management records of mining claims, land status, and land use, and (4) Washoe County records of mining claims. The field study in 1985 consisted of a reconnaissance for mines, prospects, claims, and mineralized areas. Complete results of studies by the U.S. Bureau of Mines were given by Causey (1987).

U.S. Bureau of Mines personnel collected four samples of rock and one of alluvium from areas of possible mineral concentrations within and adjacent to the study area. All samples were analyzed by semiquantitative spectrographic analyses for 40 elements to determine anomalous concentrations. The rock samples were assayed for gold and silver using a combined fire assay-inductively coupled plasma method. One rock sample was analyzed for mercury by X-ray fluorescence. One sample of tuff was analyzed by X-ray diffraction for the presence of zeolites. The sample of alluvium was concentrated and examined for gold, scheelite, ilmenite, garnet, zircon, and magnetite. Complete analytical data are on file at the U.S. Bureau of Mines, Western Field Operations Center, E. 360 Third Avenue, Spokane, WA 99202.

## Acknowledgments


Joseph McFarlan and other members of the Cedarville, Calif., District Office of the U.S. Bureau of Land Management provided help and the use of Stevens Camp. Don Coops permitted access to the study area through his ranch. Dr. Donald C. Noble of the University of Nevada, Reno, led an informative field trip through the region for Bureau of Land Management and U.S. Geological Survey personnel.


## APPRAISAL OF IDENTIFIED RESOURCES

*By* J. Douglas Causey
*U.S. Bureau of Mines*

### Mining History and Production

There are no identified resources in the Massacre Rim Wilderness Study Area, and no mines, prospects, claims, or indications of mineralized zones were found. The nearest prospecting activity is in Bald Mountain Canyon in the Lone Pine mining district, about 4 mi northwest of the study area. That area was first prospected for gold, but none was found in mineable amounts, and the district was inactive until the discovery of mercury as cinnabar in 1929 (Ross, 1941; Bailey and Phoenix, 1944; Bonham, 1969). A small amount of mercury was produced, but there is no known production of gold or silver from the district. Present prospecting in the area of Bald Mountain Canyon is for gold and associated silver in silicified and altered andesite and interbedded tuff.

## Mines, Prospects, Claims, and Mineralized Sites

No gold, silver, mercury, or zeolites were observed in samples of rock submitted for analysis. These samples consisted of basalt, pumiceous volcanic rocks, brecciated tuff, and tuff altered to montmorillonite. No anomalous concentrations of valuable minerals were detected in the sample of alluvium.

No industrial commodities were observed. Basalt from the study area could be used for stone products or crushed for use as road metal. It is not classified as an identified resource because basalt is abundant in the region, and other sources are closer to existing markets.

# ASSESSMENT OF MINERAL RESOURCE POTENTIAL

*By* Joel R. Bergquist, Donald Plouff, *and* Robert L. Turner
*U.S. Geological Survey*

## Geology

Rocks in the Massacre Rim Wilderness Study Area comprise a series of late Tertiary volcanic flows, intrusive rocks, and volcaniclastic sediments (fig. 2). Most of the area is covered by basalt flows that largely cover the older rocks and older sediments. The rocks of the area have been fractured by numerous steeply dipping normal faults, most of which trend northwest. The oldest rocks in the study area are mapped as equivalents of the Canon Rhyolite (Merriam, 1910) of Miocene age. They are exposed in a small area in the northeastern part of the study area. The rhyolite is predominantly reddish gray to maroon and is streaked and mottled medium to light gray. The rock is an aphanitic porphyry with phenocrysts of quartz, alkali feldspar, and biotite. Banded, lithophysal, and vesicular textures are present. Because the outcrops of Canon Rhyolite in the study area are found only in a small area near a valley bottom, little is known about the extent or thickness of this unit.

The younger rhyolite of Catnip Mountain (Greene, 1984) is found in the central and northwestern parts of the study area. This unit was previously included in the Canon Rhyolite (Bonham, 1969). This rhyolite is predominantly light to medium gray and locally streaked light reddish gray. Phenocrysts of quartz, alkali feldspar, and sodic amphibole are found in an aphanitic groundmass. Textures are banded (eutaxitic), lithophysal, and vesicular. The rhyolite varies locally from light gray and pumiceous to dark gray or black and glassy. Minor amounts of small black obsidian (volcanic glass) pebbles derived from this unit can be found in the colluvium.

Stratigraphically above the rhyolites is a sequence of tuffaceous sedimentary rocks that are interbedded with basalt flows near the top of the section. The section of sedimentary rocks comprises volcanic ash, claystone, siltstone, volcaniclastic sandstone and pumice-rich, air-fall, and water-laid tuffs. The rocks are typically unconsolidated to weakly consolidated and weakly to distinctly bedded. They occur in various colors, including white, light shades of gray, light brown, light pink, and red. The coarser clastic rocks are typically poorly sorted and contain angular to rounded fragments of volcanic rock, pumice, volcanic glass, and opalized wood in a clayey to silty matrix. The presence of opalized wood, gastropod shells, and bedding structures indicates that most of these beds were deposited in freshwater lakes.

The basalt of Catnip Creek of Miocene age (Greene, 1984, p. 29) overlies and is interbedded with the uppermost beds of the tuffaceous sedimentary rocks. Basalt forms most of the bedrock in the study area and vicinity. Some of the thin basalt flows that are interbedded with the tuffaceous sedimentary rocks show weathered, pillow-like structures which indicate that the lava flowed into lakes and was quenched. The numerous thin basalt flows (each 10 to 20 ft thick) have a minimum aggregate thickness of 300 ft based on measurements in fault scarps about 10 mi north of the study area at Racetrack Reservoir. Greene (1984) described a continuous sequence of 24 basalt flows on the east side of Racetrack Reservoir. Columnar jointing was observed in some of the flows exposed in the study area.

The basaltic lavas were erupted from numerous vents and fissures in the region, a few of which are found within the study area. Bitner Butte on the northern boundary of the study area is a prominent vent complex and is the source of the youngest basalt flows in the area. Basalt flows radiate outward from the summit of this 400-ft-high conical vent.

The basalt of Catnip Creek is typically dark to medium gray on fresh surfaces, is fine grained to aphanitic, and contains 25-60 percent plagioclase, 7-30 percent olivine, 12-50 percent clinopyroxene, 2-12 percent magnetite, and 1-10 percent voids between plagioclase crystals (Greene, 1984, p. 29). Microphenocrysts of olivine and plagioclase locally make up as much as a few percent of the basalt (Greene, 1984), but the rock is typically equigranular. The basalt weathers to brownish black or black. Tops and bottoms of flows are vesicular to scoriaceous, and the bottoms of flows locally include autobreccia.

Surficial deposits consist of alluvium and colluvium, landslide debris, and lacustrine (lake) and playa sediments. The alluvium consists of unsorted stream deposits of clay, silt, sand, gravel, and boulders. It includes fine-grained marsh sediments along Badger Creek. Landslides and glide blocks are common in the region because the tuffaceous sediments on which the basalt rests are loosely consolidated and easily eroded. This erosion results in instability due to oversteepening and ultimately in catastrophic failure of the overlying basalt. The landslides are characterized by chaotic, broken blocks of lava and tuffaceous sediments. In some places, large sections of basalt have slid as relatively coherent glide blocks over the underlying sediments.

Playa and lacustrine deposits are found in large and small basins throughout the region. The Massacre Lake basin southwest of the study area encompasses about 16 $mi^2$ of lake deposits. Fatty Martin Lake, which is wholly within the study area, encompasses about 0.3 $mi^2$. Other smaller areas of lacustrine and playa deposits are scattered over the study area.

The region is broken by conjugate sets of steep normal faults that trend northeast and northwest (the dominant direction). The faulting reflects post-Oligocene tectonic extension in the Basin and Range province and possibly differential settling of overlying rocks into depleted subsurface magma reservoirs. Vertical displacements on these faults are as much as a few hundred feet in the western part of the study area northeast of Massacre Lake.

## Geochemical Studies

A reconnaissance geochemical survey was conducted in the Massacre Rim Wilderness Study Area in the summer of 1985. Minus-80-mesh stream sediments and heavy-mineral concentrates derived from stream sediments were collected from 32 sites, and rocks were sampled at 8 sites. The bulk stream-sediment samples were collected from the active alluvium in stream channels; each one was composited from several localities along a channel length of about 50 ft. Stream sediments were collected because they represent a composite of the rock and soil exposed upstream from the sample site. The heavy-mineral concentrate includes the ore-forming and ore-related minerals and permits determination of some elements that are not easily detected in bulk stream sediments.

Rocks were collected from mineralized and unmineralized outcrops and from stream beds. Samples that appeared fresh and unaltered were collected to provide information on geochemical background values. Altered or mineralized samples were collected to determine the suite of elements associated with the 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 direct-current arc, semiquantitative, emission spectrographic analysis (Grimes and Marranzino, 1968; Crock and others, 1983). The rocks were also analyzed for arsenic, bismuth, cadmium, antimony, and zinc (O'Leary and Viets, 1986), for gold (Thompson and others, 1968), and for mercury (Koirtyohann and Khalil, 1976). Analytical data and a description of the sampling and analytical techniques are given in Adrian and others (1988).

For this study, anomalous geochemical values were determined by inspection of histograms of the data from both the study area and the surrounding region and by comparing the data to the average abundances in silicic volcanic rocks. For most elements, a value was considered anomalous if it exceeded the mean value for the element by two standard deviations.

The eastern part of the study area is delineated as weakly anomalous on the basis of geochemical data. This area contains stream sediments that are anomalous in cadmium (1.0-6.0 parts per million, ppm) and weakly anomalous in zinc (160-200 ppm). The heavy-mineral concentrates are anomalous in gold (0.10 ppm or less) and weakly anomalous in mercury (0.16-0.20 ppm) and zinc (200-320 ppm). However, the rocks sampled in the eastern part of the study area contained no anomalous ore-forming or ore-related elements. There is a postulated caldera ring fracture zone on the northeast side of the study area (Plouff, 1984). Anomalous mercury in heavy-mineral concentrates from this part of the study area may indicate hydrothermal activity along the ring fractures of the caldera. Anomalous elements in the northern part of the study area are found in or down stream from outcrops of peralkaline Miocene rhyolites.

The weakly anomalous mercury and zinc may reflect high background values found in basalt and peralkaline rhyolite. Some of the basalt in the region has background values of mercury that range from 0.10 to 1.0 ppm, and peralkaline rhyolite may contain background zinc of 200 ppm or more (James J. Rytuba, written commun., 1987). Numerous mercury prospects in rhyolite are found in Bald Mountain Canyon about 4 mi north-northwest of the study area. The weak mercury anomalies may indicate the extension of this mercury mineralization, possibly accompanied by gold mineralization, into the study area.

## Geophysical Studies

Geophysical evaluation of the mineral resources of the study area is based on interpretations of aerial gamma-ray, gravity, and aeromagnetic surveys.

Radiometric data were compiled by Geodata International, Inc. (1979) for the National Uranium Resource Evaluation (NURE) program of the Department of Energy.

Coverage of the study area includes one north-south flightline located about 1 mi west of the east edge of the study area and three east-west flightlines spaced at 3-mi intervals starting at the northern edge of the study area. Readings of gamma-ray flux from radioactive isotopes of uranium, thorium, and potassium were recorded. Flight altitudes over the study area ranged from 400 to 550 ft above the ground. The flux level for all three isotopes is at or below normal background level except for one location. Count rates exceeded three standard deviations above mean background level over a 0.5-mi east-west line segment centered near a jeep trail located at near the center of the study area (lat 41°43.2'N., long 119°30.3'W.). The source of the sharp anomaly, however, is uncertain without confirmation by a ground scintillometer survey.

Six gravity stations were established in the study area, another station was along the boundary of the study area, and 10 stations were within 3 mi of the boundary (Donald Plouff, unpub. data, 1985). These data were supplemented by gravity values from Plouff (1977) for 1 station in the study area, 2 stations along the boundary, and 13 stations within 3 mi of the boundary.

A gravity map of the area (Donald Plouff, unpub. data, 1985) shows that the eastern 2 mi of the study area overlies the west margin of a caldera described by Greene and Plouff (1981). The caldera is defined by a 12- by 30-mi gravity low having an amplitude of about 20 milligals (mGal). The gravity low presumably results from the density contrast between the less dense tuffaceous sedimentary rocks that fill the caldera and the denser country rocks outside the caldera rim. The caldera is concealed beneath flat-lying sediments and younger volcanic rocks. The density contrast between an underlying former magma reservoir and the surrounding basement rocks also may contribute to the amplitude of the anomaly.

A gravity high having an amplitude of 3 mGal and a diameter of about 3 mi is centered near the south corner of the west edge of the study area. The gravity high probably reflects a topographic or structural high of volcanic or pre-Cenozoic basement rocks between the caldera to the east and a smaller area of subsidence reflected by a 5-mGal, 6- by 8-mi gravity low to the west. The gravity high also may reflect an igneous plug that has intruded sedimentary rocks and less dense volcanic rocks. A small gravity high centered at the northern tip of the study area is located at the southwest end of a narrow gravity high that extends more that 10 mi to the northeast. A narrow, east-west-elongated gravity low between the two gravity highs overlies the location of the radioactivity anomaly and may reflect a narrow area of subsidence or possible brecciation.

An aeromagnetic map of the region (U.S. Geological Survey, 1972; Plouff, 1984, pl. 2) covers the study area. The flightlines were flown in an east-west direction at a spacing of about 2 mi and a constant barometric elevation of 9,000 ft. There is an excellent correlation between a broad magnetic low and the gravity low that defines the large caldera east of the study area. The most conspicuous anomaly in the study area is a magnetic high of low amplitude, which extends southward from Bitner Butte through the southeast corner of the study area. The magnetic high generally reflects topographically higher volcanic rocks having normal magnetization. A small magnetic low is centered about 1 mi southeast of the gravity high near the southwest corner of the study area. Therefore, the source of the gravity high may be rocks having low magnetization in the pre-Cenozoic basement. The magnetic low also reflects subsided sediments or rocks having inherently low or altered magnetization, which are located above the source of the gravity high.

## Mineral Resource Potential

The possible presence of concealed mineral deposits is suggested by anomalous concentrations of certain elements, associations of anomalous elements, and geophysical data. In conjunction with permissive rocks and favorable geologic structures, these data lead to the conclusion that the study area has moderate potential, certainty level B, for gold, silver, and mercury in the eastern part of the study area, and moderate potential for uranium, certainty level B, throughout the study area. Cathrall and others (1984, p. 78) identified the northeastern part of the study area as having unspecified mineral resource potential on the basis of geological and geophysical evidence.

The eastern part of the study area has mineral resource potential for hot-spring gold and silver deposits. Berger (1985, 1986) discusses the nature and characteristics of this type of deposit. The study area has a number of the enumerated characteristics of such deposits. The Tertiary rhyolites that are in part porphyritic are permissible host rocks. Rocks in the region are fractured by numerous, predominantly northwest-trending, high-angle normal faults that can act as conduits for mineralizing fluids. Geochemical sampling revealed anomalous gold (as much as 0.1 ppm) and weakly anomalous mercury (0.16 to 0.20 ppm). These two elements are part of a suite of elements that characterize such deposits. Gold concentrations of less than 0.50 ppm have also been found in unspecified rock types about 5 mi east of the study area (Cathrall and others, 1984). The gravity survey indicates that the eastern part of the study area overlies the west rim of a buried caldera described by Greene and Plouff (1981) and Plouff (1984). Intracaldera sediments would have low thermal conductivity and would act as a thermal insulator, thus refracting heat toward the edge of the caldera. Ring fractures along the edge of the postulated caldera may have provided channels for hydrothermal ore-bearing solutions to migrate upward toward the surface, and intracaldera sediments could be permeated with precipitates of those solutions. The

McDermitt caldera, about 55 mi east-northeast of the study area, for example, is the site of uranium deposits and extensive mercury deposits of this type (Rytuba, 1976). On the basis of geochemical and geophysical studies, geologic mapping, structural setting, and descriptive ore-deposit models, the eastern part of the study area is assigned a moderate mineral resource potential, certainty level B, for gold and silver in hot-spring type, precious-metal deposits.

The eastern part of the study area also has mineral resource potential for hot-spring type deposits of mercury. Rytuba (1986) provides descriptive and grade-tonnage models of this type of deposit. The study area has several characteristics of this type of deposit. The presence of Tertiary basalt flows that are found in the study area is typical of many areas having hot-spring mercury deposits. Rocks of the study area are fractured by high-angle normal faults, which can act as conduits for ore-bearing fluids, and there are rock types permissive for mercury deposits. Geochemical samples obtained from the northern part of the study area contain small amounts of both mercury and gold. The presence of anomalous gold and weakly anomalous mercury is significant because hot-spring mercury deposits in some places are found in association with hot-spring gold deposits (Rytuba and Glanzman, 1978, 1979; Rytuba, 1986). Cathrall and others (1984) reported mercury anomalies of from 0.20 to 0.60 ppm in rock samples collected a few miles east of the study area. These amounts are comparable to the magnitude of the mercury anomalies found within the study area. As with hot-spring gold deposits, ring fractures along the margin of the postulated caldera would provide conduits for warm-water mineralizing fluids. On the basis of the evidence, the eastern part of the study area is assigned a moderate mineral resource potential, certainty level B, for mercury in hot-spring deposits.

Mercury, as cinnabar, and minor amounts of gold are found in Bald Mountain Canyon about 4 mi northwest of the study area. The host rocks in that area are andesite flows and flow breccias with intercalated tuffs (Bonham, 1969). The mercury is found as cinnabar in veinlets and stringers and is disseminated along fractures in silicified and argillized andesite. No andesite is found at the surface in the study area, but it may occur beneath tuffaceous sediments and basalt. Even if mineralized andesite is present at depth in the study area, and if the mercury mineralization occurs in that unit as in Bald Mountain Canyon, the thickness of the overlying rocks in the study area would make discovery and exploitation of mercury difficult and expensive.

The entire study area has moderate mineral resource potential, certainty level B, for uranium in volcanogenic deposits. Potential for undiscovered uranium resources in volcaniclastic deposits is indicated by the geophysical gamma-ray flux anomaly. This anomaly is high, being 3 standard deviations above mean background level. It was recorded by an aerial survey, and the anomalous area could be more accurately delineated by a ground reconnaissance with a scintillometer. The study area has some of the characteristics of volcanogenic uranium deposits outlined by Bagby (1986). These are (1) peralkaline porphyritic rhyolite in shallow intrusives and dome flow rocks, (2) an associated nearby caldera, (3) fractured and faulted country rock, and (4) the presence of mercury in geochemical samples. At the McDermitt caldera complex, 55 mi north-northeast of the study area, Wallace and Roper (1981) reported uranium concentrations in a horizon within tuffaceous lake sediments. The study area has extensive tuffaceous lake sediments beneath the overlying basalt. Rytuba and Glanzman (1978) also reported that uranium is locally associated with mercury deposits at the McDermitt caldera. Other loci for uranium concentrations at the McDermitt caldera are along geologic contacts, unconformities, and reduction-oxidation boundaries (Wallace and Roper, 1981), as well as in ash-flow tuffs, moat-fill sediments, ring domes, and intrusive rocks (Rytuba, 1981). It is not known which, if any, of these conditions is the source of the radioactivity anomaly in the study area. The anomaly was detected over an area of basalt, but radioactive isotopes may be leaking upward through the fractured basalt from underlying concealed rocks and structures. Cathrall and others (1984) reported anomalous uranium (12 ppm) in samples of unspecified rock type from a tributary to Badger Creek about 5 mi east of the study area and from Bald Mountain Canyon (22 ppm) about 4 mi northwest of the area. Their studies of uranium in Virgin Valley, about 20 mi east of the study area, showed that the area contains large low-grade uranium resources in tuffaceous sediments. A more complete description of the uranium occurrences in Virgin Valley was reported by Lovering (1954). On the basis of the geophysical evidence, geologic character, structural setting, and proximity to other radioactivity anomalies, the study area is assigned a moderate mineral resource potential, certainty level B, for uranium in volcaniclastic deposits.

There is no evidence of current geothermal activity in the study area, and the potential for geothermal resources is unknown, certainty level A.

Sandberg (1983) reports that the Massacre Rim Wilderness Study Area has "zero potential" for petroleum. Geologic mapping shows a series of rhyolite intrusions overlain by tuffaceous sedimentary rocks that are in turn overlain by basalt. Only the sedimentary rocks could be reservoir rocks, but because of extensive erosion that in places exposes the entire section of sedimentary rocks in many parts of the study area, there are no sufficient traps for oil and gas. Also, heat associated with volcanism in the area probably would have driven off any pre-existing hydrocarbons. Therefore, based on available data, the study area has no potential for oil and gas, certainty level D.

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# APPENDIXES

## DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

### LEVELS OF RESOURCE POTENTIAL

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

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

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

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

U **UNKNOWN** mineral resource potential is assigned to areas where information is inadequate to assign a low, moderate, or high level of resource potential.

### LEVELS OF CERTAINTY

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

LEVEL OF RESOURCE POTENTIAL →

| A | B | C | D |
| --- | --- | --- | --- |
| U/A<br>UNKNOWN POTENTIAL | H/B<br>HIGH POTENTIAL | H/C<br>HIGH POTENTIAL | H/D<br>HIGH POTENTIAL |
| | M/B<br>MODERATE POTENTIAL | M/C<br>MODERATE POTENTIAL | M/D<br>MODERATE POTENTIAL |
| | L/B<br>LOW POTENTIAL | L/C<br>LOW POTENTIAL | L/D<br>LOW POTENTIAL |
| | | | N/D<br>NO POTENTIAL |

LEVEL OF CERTAINTY →

Abstracted with minor modifications from:

Taylor, R.B., and Steven, T.A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268-1270.
Taylor, R.B., Stoneman, R.J., and Marsh, S.P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40-42.
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## RESOURCE/RESERVE CLASSIFICATION

| | IDENTIFIED RESOURCES | | | UNDISCOVERED RESOURCES | |
|---|---|---|---|---|---|
| | Demonstrated | | Inferred | Probability Range | |
| | Measured | Indicated | | Hypothetical | Speculative |
| ECONOMIC | Reserves | | Inferred Reserves | | |
| MARGINALLY ECONOMIC | Marginal Reserves | | Inferred Marginal Reserves | | |
| SUB-ECONOMIC | Demonstrated Subeconomic Resources | | Inferred Subeconomic Resources | | |

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from McKelvey, V.E., 1972, Mineral resource estimates and public policy: American Scientist, v. 60, p. 32-40; and U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, p. 5.

## GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey in this report

| EON | ERA | PERIOD | | EPOCH | AGE ESTIMATES OF BOUNDARIES (in 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<br>Middle<br>Early | 205 |
| | | Triassic | | Late<br>Middle<br>Early | ~240 |
| | Paleozoic | Permian | | Late<br>Early | 290 |
| | | Carboniferous Periods | Pennsylvanian | Late<br>Middle<br>Early | ~330 |
| | | | Mississippian | Late<br>Early | 360 |
| | | Devonian | | Late<br>Middle<br>Early | 410 |
| | | Silurian | | Late<br>Middle<br>Early | 435 |
| | | Ordovician | | Late<br>Middle<br>Early | 500 |
| | | Cambrian | | Late<br>Middle<br>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.

# Mineral Resources of Wilderness Study Areas: Northwestern Nevada

This volume was published as chapters A—E

U.S. GEOLOGICAL SURVEY BULLETIN 1707

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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

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[Letters designate the separately published chapters]

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