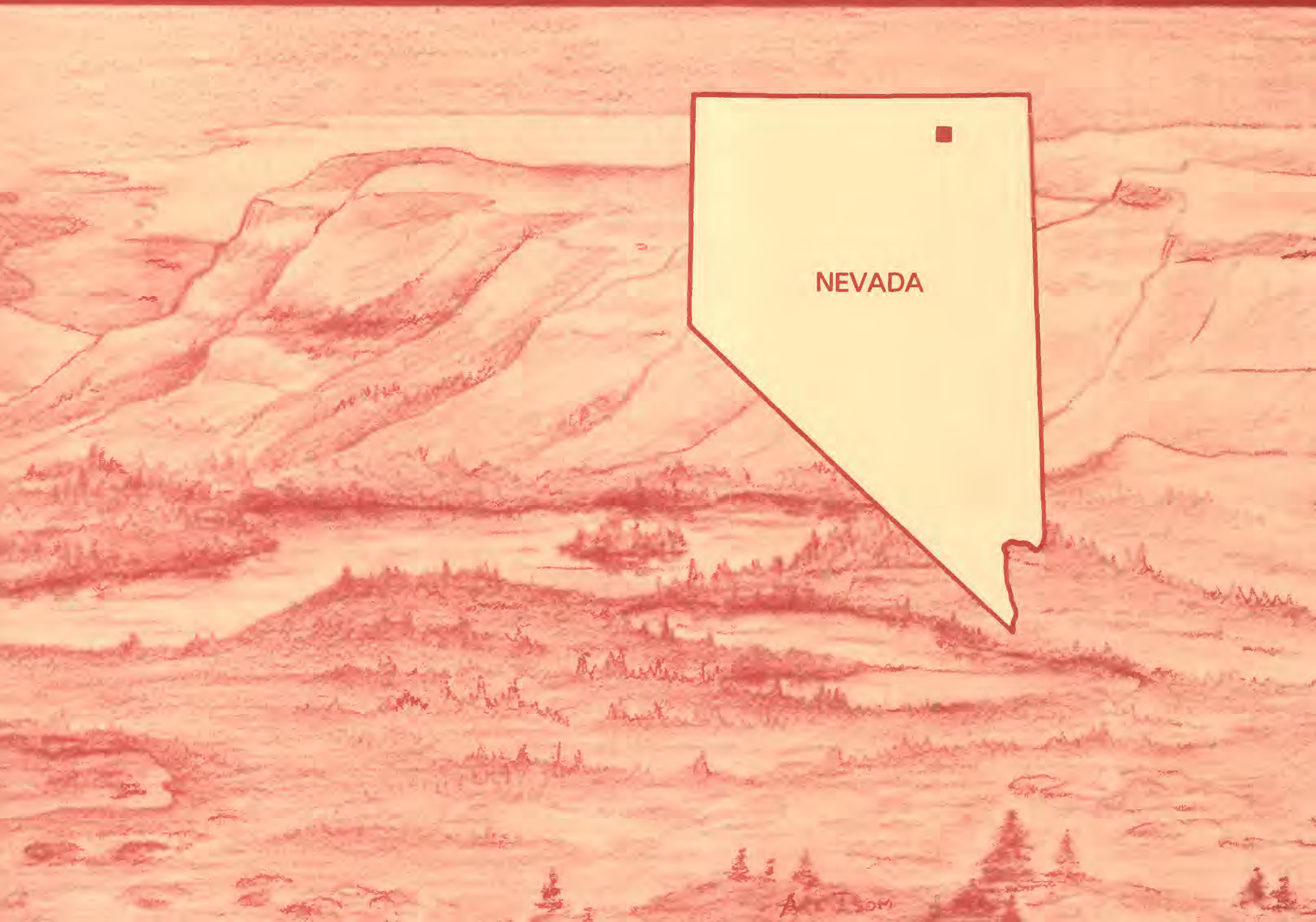
Mineral Resources of the Rough Hills Wilderness Study Area, Elko County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1725–D



Chapter D

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U.S. GEOLOGICAL SURVEY BULLETIN 1725

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
NORTHEASTERN NEVADA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1987

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center
Box 25425
Denver, CO 80225

Library of Congress Cataloging in Publication Data

Mineral resources of the Rough Hills Wilderness Study Area, Elko County, Nevada.

(Mineral resources of wilderness study areas—northeastern Nevada ; ch. D) (U.S. Geological Survey bulletin ; 1725–D)
Bibliography: p.
Supt. of Docs. No.: I 19.3:1725–D
1. Mines and mineral resources—Nevada—Rough Hills Wilderness (Nev.) I. Wallace, Alan R. II. Series. III. Series: U.S. Geological Survey bulletin ; 1725–D.
QE75.B9 no. 1725–D 557.3 s [553'.09793'16] 87–600324
[TN24.N3]

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 the Rough Hills Wilderness Study Area (NV–010–151), Elko County, Nevada.

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NORTHEASTERN NEVADA

Mineral Resources of the Rough Hills Wilderness Study Area, Elko County, Nevada

By Alan R. Wallace, Robert J. Turner, V.J.S. Grauch, *and* Joseph L. Plesha
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SUMMARY

The Rough Hills Wilderness Study Area (NV–010–151), hereafter referred to as the study area, comprises approximately 6,685 acres about 60 mi (miles) north of Elko in northern Elko County, Nev. Field work was conducted by the U.S. Geological Survey (USGS) and U.S. Bureau of Mines (USBM) to assess the mineral resource potential and the known mineral resources of the study area. The Charleston, Island Mountain, and Alder mining districts, are short distances to the east, west, and northwest, respectively. However, other than minor, unrecorded production of placer gold from the Prunty Prospect near the northeast corner (fig. 1), the study area has no history of mining. The wilderness study area has a low mineral resource potential for undiscovered metasomatic gold, silver, tungsten, molybdenum, and copper, disseminated gold and silver, placer gold, barite, tin, sand and gravel, uranium and thorium, and oil and gas.

Most of the Rough Hills Wilderness Study Area is underlain by the Jarbidge Rhyolite, a volcanic rock that was erupted approximately 15 m.y. ago (million years ago; see geologic time chart in appendix of this report). Mesozoic sedimentary rocks and older Tertiary volcanic rocks underlie the Jarbidge Rhyolite, and upper Tertiary sedimentary rocks overlie the rhyolite. All of the rocks in the area are faulted to some degree.

Despite scattered geochemical anomalies in the wilderness study area, the geologic, geochemical, and geophysical evidence indicate that the wilderness study area has low mineral resource potential for undiscovered gold, silver, tungsten, copper, and molybdenum. One small gold placer prospect (Prunty) is in the northeast corner of the study area. Slightly anomalous arsenic and mercury values were obtained from faulted sedimentary rocks at the southwest corner of the study area, but the geologic and geochemical evidence indicates that the extent of mineralized rocks is extremely limited and that the resource potential for associated gold and silver is low. The resource potential for oil and gas, sand and gravel, uranium and thorium, barite, and tin is low.

INTRODUCTION

The Rough Hills Wilderness Study Area covers approximately 6,685 acres in northern Elko County, Nevada (fig. 2). It is approximately 12 mi east of Wild Horse and 60 mi north of Elko, Nev. The area is accessible on the west and south sides and, in part, on the east side by dirt roads. Its appellation is appropriate, as the terrain is rugged and ranges in elevation from approximately 6,000 ft (feet) along the Bruneau River to 7,923 ft along the ridgecrest on the west side of the study area. Scattered juniper trees and abundant sagebrush cover the hillsides, and willows and aspen grow along the small streams.

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study area and is the product of several separate studies by the USBM (U.S. Bureau of Mines) and the USGS (U.S. Geological Survey). Identified resources are classified according to the system of the USBM and USGS (1980) which is shown in the appendix of this report. Mineral resource potential, the likelihood of occurrence of undiscovered metals and nonmetals, industrial rocks and minerals, and of energy sources (coal, oil, gas, oil shale, and geothermal sources), is classified according to the system of Goudarzi (1984), shown in the appendix of the report.

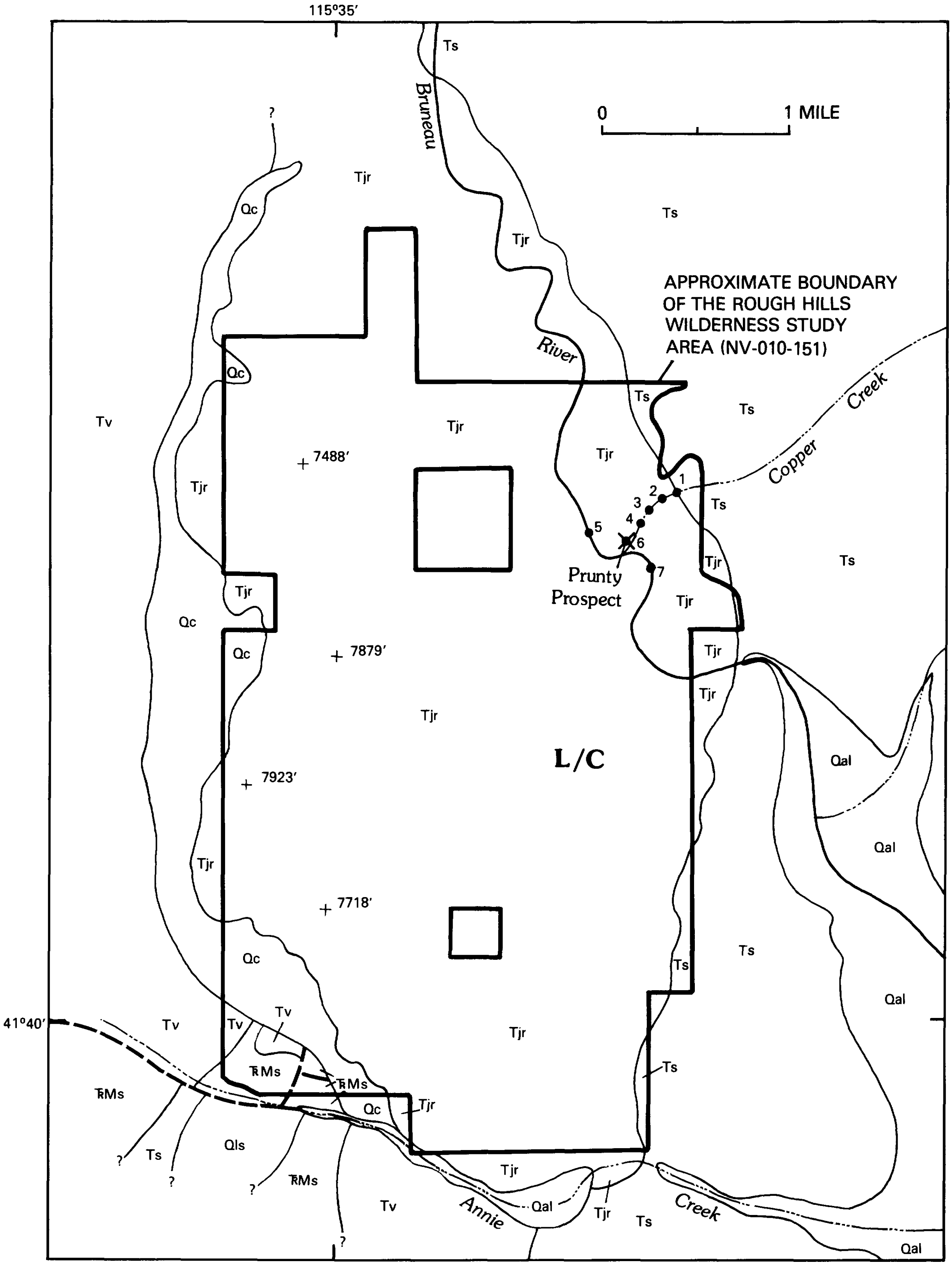
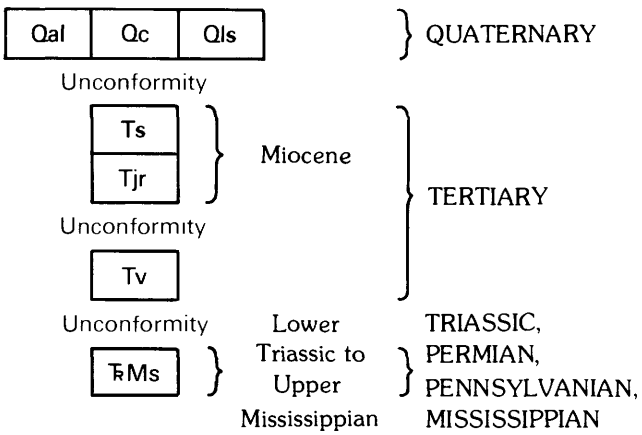


Figure 1 (above and facing page). Summary map showing mineral resource potential and generalized geology of the Rough Hills Wilderness Study Area.

EXPLANATION

L/C **Geologic terrane having low mineral resource potential for disseminated gold and silver; placer gold; contact metasomatic gold, silver, copper, tungsten, and molybdenum; barite; tin; sand and gravel; uranium and thorium, and oil and gas**—Applies to entire study area

CORRELATION OF MAP UNITS



LIST OF MAP UNITS

Qal **Alluvium (Quaternary)**

Qc **Colluvium (Quaternary)**

Qls **Landslide deposits (Quaternary)**

Ts **Sedimentary rocks, undivided (Tertiary)**

Tjr **Jarbidge Rhyolite (Miocene)**

Tv **Volcanic rocks, undivided (Tertiary)**

ŦMs **Sedimentary rocks, undivided (Lower Triassic through Mississippian)**

——— Contact—Queried where uncertain

——— **Fault, approximately located**

•7 **USBM sample locality**

Investigations by the U.S. Bureau of Mines

The USBM examined U.S. Bureau of Land Management, USBM, state, county, and other records for the locations of patented and unpatented mining claims, mineral leases, and oil and gas leases in and near the study area. Field studies concentrated on the examination of known and unrecorded mines, prospects, and mineralized areas inside or near the study area. Eighteen placer samples were collected from the Prunty placer prospect and from sand and gravel deposits along Copper Creek and the Bruneau River. Detailed information is available from the U.S. Bureau of Mines, Western Field Operations Center, E. 360 Third Avenue, Spokane, WA 99202.

Investigations by the U.S. Geological Survey

Geologic mapping and sampling of the study area were done by the USGS. Mapping was carried out during one week in the summer of 1986, during which time the field work was supported by helicopter access to the area. Mapping was done on 1:24,000 topographic maps and aerial photographs, and rock samples were collected at the same time for chemical analysis. Stream-sediment sampling was done during the summer of 1985 under the supervision of R.J. Turner. Geophysical data were compiled by V.J S. Grauch and J.L. Plesha.

APPRAISAL OF IDENTIFIED RESOURCES

By Staff
U.S. Bureau of Mines

Mining and Mineral Exploration History

The study area has no history of mining other than minor, unrecorded production of placer gold from the Prunty prospect at the confluence of Copper Creek and the Bruneau River (fig. 1). Local residents reportedly recovered about 2 oz (troy ounces) of gold during the depression years of the 1930's, and in 1981 other local residents did exploration work at the prospect (Frank Prunty, 1985, personal commun.). Although no records were found to indicate that the deposit has ever been claimed, there are nine pits and trenches, and an area of about 5,000 ft^2 has been sluiced to bedrock.

The Charleston mining district is adjacent to the eastern boundary of the study area (Quade and Tingley, 1984). Two other mining districts, the Island Mountain to the west and the Alder to the northwest, extend to within approximately 1 mi and 5 mi, respectively, of the study area. The first discoveries were made in the districts in the 1860's and 1870's. Since then, each district has

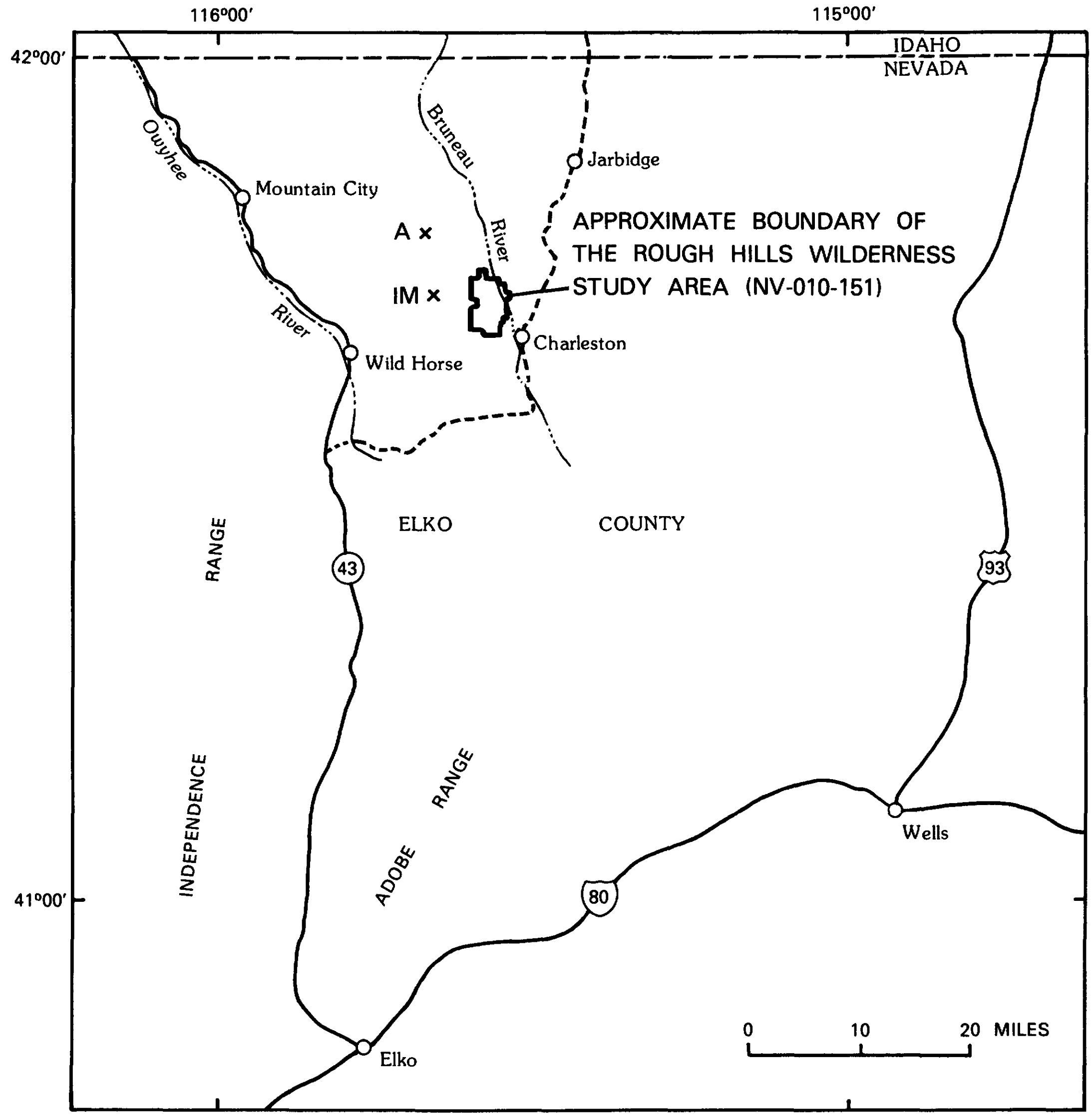


Figure 2. Index map showing location of the Rough Hills Wilderness Study Area in Elko County, Nevada. Dashed lines are dirt roads. A, Alder mining district; IM, Island Mountain mining district.

produced gold from placer deposits; gold, silver, copper, lead, antimony, tungsten, and minor zinc from quartz veins within pre-Tertiary sedimentary rocks cut by intrusives; and tungsten from tactite deposits (Smith, 1976). Some of the vein deposits contain fairly high gold and silver values, but none of the deposits are large. Bismuth, uranium, and molybdenum minerals also occur in some of the deposits; however, there was no production of these metals reported.

In recent years, there has been continued or renewed mining interest in the region. Several small mines in the three districts are producing or being explored for gold and silver in vein deposits, and some barite has been produced from a stratiform deposit in the Charleston district (unpub. data, Bureau of Land Management). Exploration for disseminated gold deposits has occurred in the districts and at the isolated Golden Empire prospect, 1.5 mi southwest of the study area.

Identified Resources

No identified resources were delineated within the study area. Sand and gravel at the Prunty prospect and along Copper Creek and the Bruneau River were examined for placer gold and other heavy minerals (fig. 1). Sample locations are on figure 1 and sample data are presented in table 1.

The Prunty placer prospect contains a perched deposit of gold-bearing gravel that covers about an acre and

Table 1. Descriptions and analytical results of placer samples.

Sample loc. (fig. 1)	Name or location	Sample type	Workings and production	Sample data
1	Copper Creek	Sand from plant roots	None	One pan sample; no gold.
2	Copper Creek	Pebbly gravel on bedrock.	None	One pan sample; $0.02 gold/yd^3 1/.
3	Copper Creek	Sandy gravel on bedrock.	None.	One pan sample; $0.10 gold/yd^3.
4	Copper Creek	Sandy gravel on bedrock.	None.	One pan sample; no gold.
5	Bruneau River	Gravel on bedrock.	None.	One pan sample; no gold.
6	Prunty Prospect	Stream gravel a few inches to about 8 ft thick, covering about an acre, is perched 5-25 ft above the present stream level. The gravel is derived primarily from quartzite and rhyolitic volcanic rocks. Fine placer gold is concentrated just above or in fractures in the rhyolitic bedrock. Scattered stream gravel, 0 to about 2 ft thick extends upslope for about 125 ft above the workings.	In the northeastern portion of the prospect, there are four pits as much as 15 ft across and 6 ft deep. In the southwestern portion, there are three pits and two trenches as much as 40 ft long and 5 ft deep. The trenches connect with an area about 100 ft long and 50 ft wide that has been sluiced to bedrock. It is estimated that about 450 yd^3 of gravel was processed from the workings. Local residents reported that about 2 oz of gold was recovered from the prospect during the 1930's.	A total of 12 placer samples were taken: On the slope above workings, one pan and three channel samples of scattered stream gravels from at or bedrock showed no significant gold. At or near the northeastern workings, two channel samples from a pit (not to bedrock) and two pan samples from bedrock showed nil to $0.05 gold/yd^3. At the southwest workings, a pan sample from a fracture in bedrock in the sluiced area showed $12.88 gold/yd^3. In an adjoining trench, a channel sample from the surface to 2.25 ft showed $0.57 gold/yd^3, another from 2.25 to 2.50 ft (to bedrock) showed $3.06 gold/yd^3, and a pan sample from a fracture in bedrock showed $0.54 gold/yd^3. The average grade of the three samples from the trench is about $0.85 gold/yd^3
7	Bruneau River	Slope wash and river gravel.	None.	One pan sample; $0.09 gold/yd^3.

1/Assuming gold values at $425/oz.

averages about 4 ft thick. This implies about 6,500 yd^3 (cubic yards) of gravel; however significant values (greater than $0.10 gold/yd^3, at a gold price of $425/oz) were found only in samples taken in the southwestern portion of the occurrence. There the gravel averages less than $1.00 gold/yd^3, and only about 3,000 yd^3 are present. This grade and volume of gravel is insufficient to be minable by large-volume commercial methods. These mining methods require gold values of several dollars per cubic yard and volumes of several thousand cubic yards of gravel treated per day. However, the occurrence may have value for recreational mining by hobbyists.

The source of the placer gold at the Prunty prospect is uncertain because placer gold was found in trace amounts along both Copper Creek and the Bruneau River. It is suspected, however, that most of the gold at the prospect was transported there via Copper Creek from the Charleston mining district. Apparently, the physical conditions necessary to significantly concentrate the gold occurred only at the confluence of the creek with the Bruneau River.

Other than placer gold, no mineral deposits similar to those that occur in the three nearby mining districts, or at the Golden Empire prospect, are known within the study area.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Alan R. Wallace, Robert L. Turner, V.J.S. Grauch, and Joseph L. Plesha
U.S. Geological Survey

Geology

The geology of northeastern Nevada, in which the study area is located, is dominated by complexly deformed pre-Tertiary sedimentary rocks that are unconformably overlain by Tertiary sedimentary, volcanic, and volcaniclastic rocks. Regionally, these units are cut by steep normal faults, creating a series of northerly trending horsts and grabens.

Upper Mississippian through Lower Triassic sedimentary rocks (unit ₮Ms, fig. 1) are exposed in the extreme southwestern corner of the study area, as well as to the south and west of the area. The sedimentary units are likely equivalents to the Lower Triassic Thaynes Formation (Hope and Coats, 1976) and to the Lower Permian to Upper Mississippian limestone, which includes Poorman Peak and Hammond Canyon Formations of Coash (1967). The lithologies included in this map unit are bluish-black orthoquartzite, blue-gray fossiliferous limestone, tan phyllite, conglomerate and sandstone containing subrounded clasts of black to white quartzite, and gray phyllitic chert.

Volcanic rocks of inferred Oligocene age (Hope and Coats, 1976) are exposed in the southwestern and western parts of the area. The rocks include yellowish tuffaceous sedimentary rocks, air-fall tuffs, and ash-flow tuffs. The latter contain abundant small plagioclase and pyroxene phenocrysts in a fine-grained, purplish-gray groundmass. The tuffs contain locally abundant pumice fragments and xenoliths of andesite and latite. The Tertiary volcanic rocks (unit Tv, fig. 1) dip steeply to the northwest and overlie the pre-Tertiary sedimentary rocks in the southern part of the area.

Most of the study area is underlain by the Jarbidge Rhyolite (unit Tjr, fig. 1), which was erupted approximately 15.4 m.y. ago (Coats and others, 1977). This unit includes complexly intercalated rhyolitic domes, ash flow tuffs, flows, and volcaniclastic sedimentary rocks. The rhyolite is massive to convoluted; flow units dip both to the east and west, and they overlap and are cut by domes. The rock typically contains large (0.3 inch) phenocrysts of quartz and potassium feldspar in a fine-grained reddish to light-pink groundmass. The phenocrysts are subhedral to ovoid or rounded, and they comprise approximately 5–40 percent of the rocks. Small pyroxene phenocrysts are rare. The volcanic rocks are generally unaltered, although vapor-phase alteration is present in the upper parts of many flows.

Upper Tertiary tuffaceous sedimentary rocks (unit Ts, fig. 1) cover the Jarbidge Rhyolite along the eastern margin of the study area. These poorly exposed units are composed primarily of tan to yellowish tuffaceous sedimentary rocks with thin lenses of conglomerate.

Colluvial deposits containing poorly sorted fragments of the Jarbidge Rhyolite cover the steep slopes on the western and southern edges of the study area. Hummocky landslide deposits cover slopes south of the study area. Small alluvial deposits are present along some of the streams in the study area; larger deposits are found along the floodplain of the Bruneau River east of the area and along Annie Creek just south of the study area (fig. 1).

Only a few minor faults were identified in the massive to convoluted Jarbidge Rhyolite, which underlies the majority of the study area. North- and east-trending, steeply dipping joints are locally abundant, and weathering along the closely spaced joint surfaces has created an erratic surface texture in the rhyolite.

The pre-Tertiary sedimentary rocks were moderately folded and weakly metamorphosed, probably during Jurassic and Cretaceous deformation (Stewart, 1980). Slaty cleavage is visible in the phyllites. Several faults, defined by zones of breccia and secondary iron oxides, cut the sedimentary rocks; they cut the Oligocene volcanic rocks as well, but their possible extension into the Jarbidge Rhyolite is concealed by colluvium.

Geochemistry

Twenty-nine stream sediment, twenty-five heavy mineral concentrate, and five rock samples were collected for this study. Five additional rock samples were collected for chemical analysis during geologic mapping.

Minus-80-mesh stream sediment and heavy mineral concentrate samples were selected as the primary sample media as they represent a composite of the rock and soil exposed upstream from the sample sites. The samples were collected from the active alluvium in the stream channels. Each sample was composited from several localities over a channel length of no greater than 50 ft. Analytical data and a description of the sampling and analytical techniques are given in a future publication.

Geochemical Results

Analytical data from the minus-80-mesh stream sediment samples show weakly anomalous but low-level values for zinc, arsenic, and silver at scattered sites throughout the study area. Six samples from drainages on the east side of the study area contained from 120 to 190 ppm (parts per million) zinc; no other element was consistently associated with the zinc. Ten ppm arsenic was detected in two samples at the southwestern corner of the area, and in two samples in the northern half of the area. Two samples at the northwestern and southeastern corners of the wilderness study area contained 0.5 ppm silver.

The analytical data for the nonmagnetic fraction of the heavy mineral concentrate samples have anomalous values for barium (>10,000 ppm), as well as slightly anomalous values for tin (100–200 ppm), molybdenum (one sample; 20 ppm), and silver (two samples; 20 and 100 ppm). Two of the samples with more than 10,000 ppm barium are from streams that drain areas underlain only by the Jarbidge Rhyolite. The other samples with highly anomalous barium are from streams that drain both the rhyolite and older rocks, or streams that drain only pre-Tertiary sedimentary rocks southwest of the study area. The other samples containing slightly anomalous silver, molybdenum, and tin are scattered throughout and near the study area.

Analytical data for rock samples showed one sample with slightly anomalous mercury (0.12 ppm) and arsenic

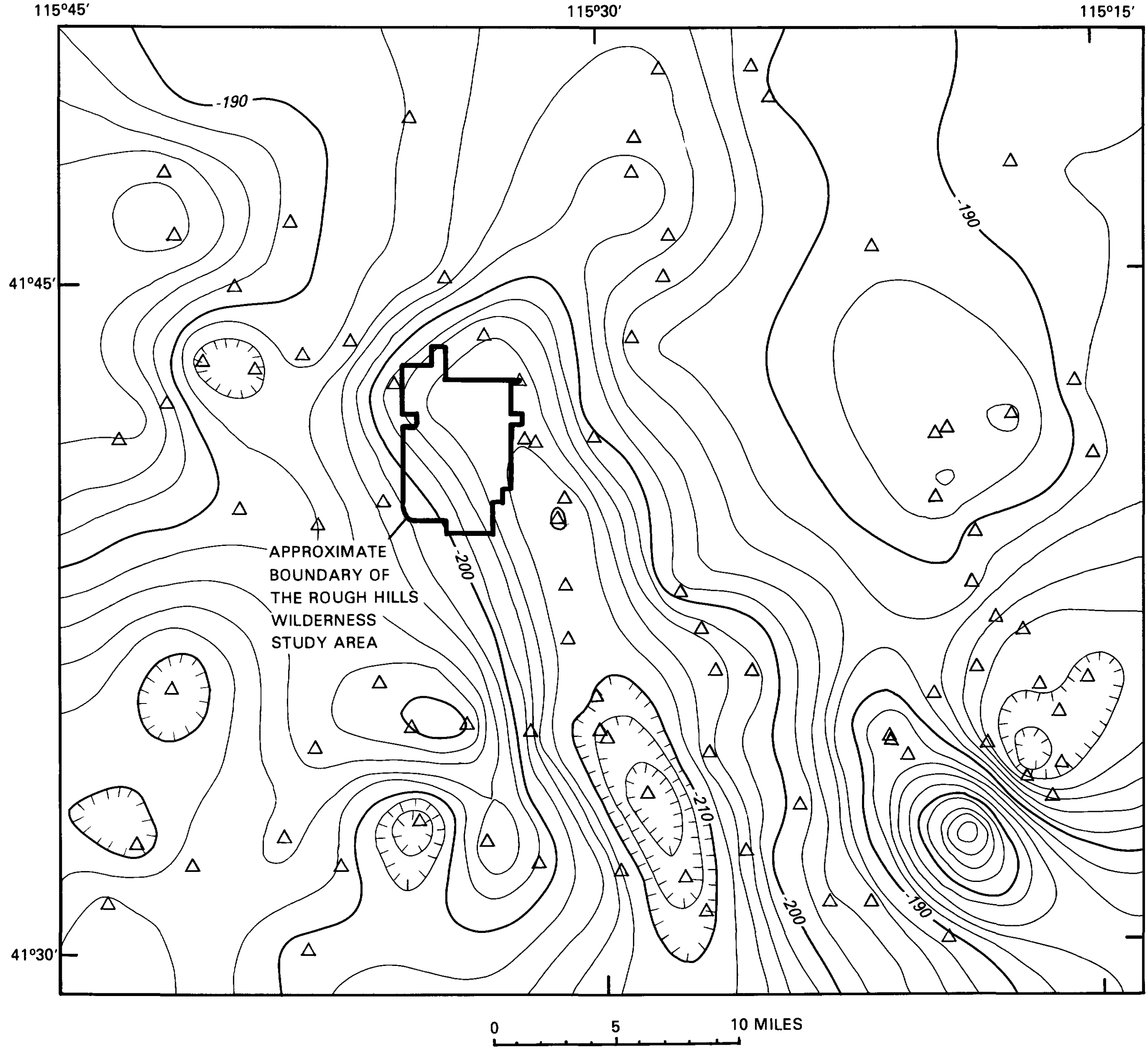


Figure 3. Complete Bouguer anomaly map. Reduction density=2.67 g/cm^3. Study area is outlined by the heavy solid line; density boundaries inferred from the horizontal gradient method by heavy dashed lines. Gravity stations are indicated by triangles. Hachures indicate areas of gravity lows. Contour interval is 5 milligals.

(70 ppm) and a second sample with slightly anomalous lead (50 ppm). The sample with arsenic and mercury was collected from pre-Tertiary sedimentary rocks in the southwest corner of the study area, an area from which two stream-sediment samples contained slightly anomalous arsenic. A rock sample collected from an altered fault zone in the pre-Tertiary rocks contained 14 ppm arsenic but no other anomalous elements. Although mercury and arsenic are typically associated with epithermal gold deposits, the values encountered here are relatively low.

Geophysics

Gravity and aeromagnetic data were interpreted for the study area. The gravity data were compiled using data available from the Department of Defense data bank (NOAA National Geophysical Data Center) and Erwin (1980). The complete Bouguer gravity anomaly map (fig. 3) generally represents deviations in rock density from 2.67 g/cm^3 (grams per cubic centimeter). The aeromagnetic data were obtained from a survey flown east-west with

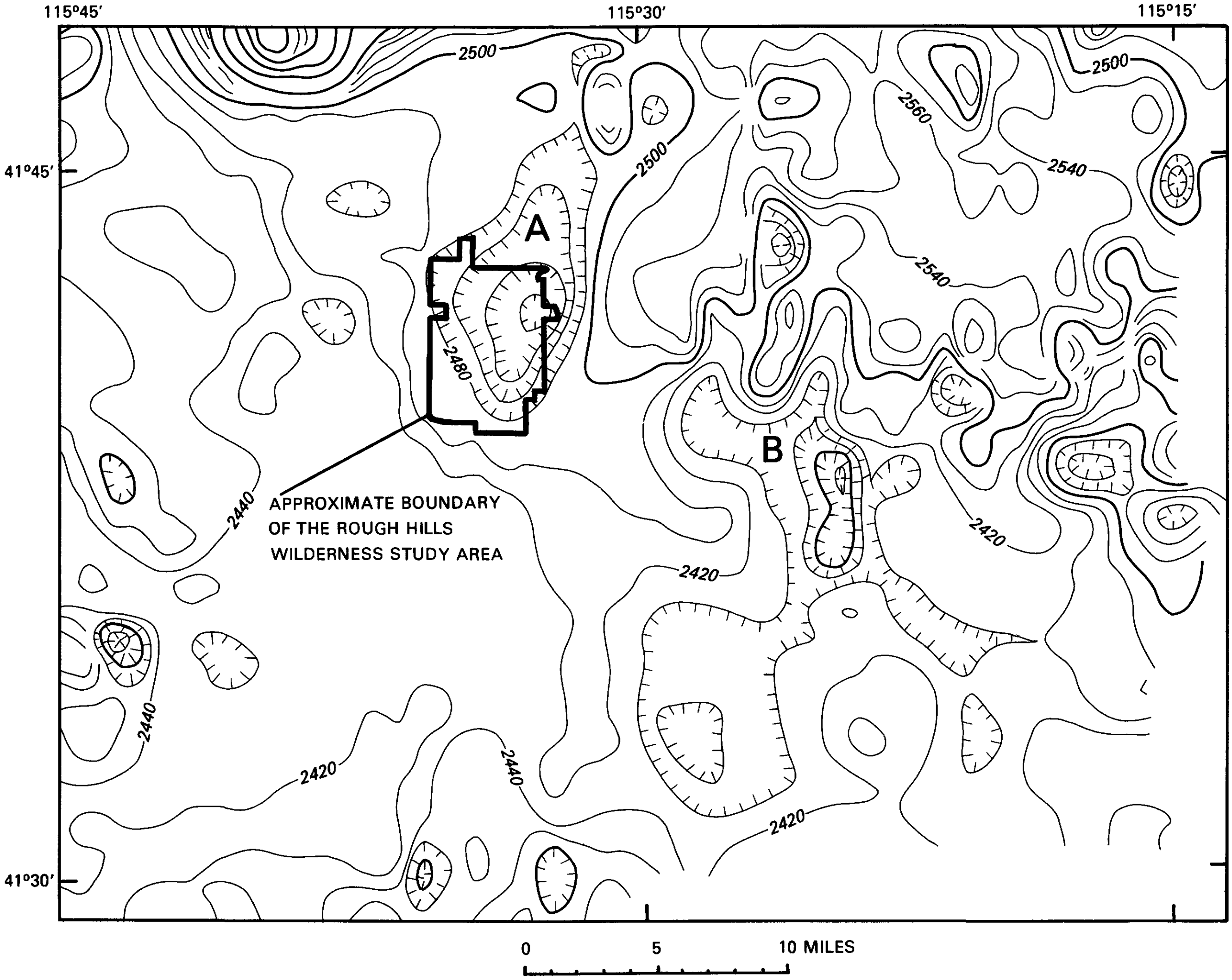


Figure 4. Total-field aeromagnetic map from a survey flown east-west with 1-mi spacing at 9,000-ft elevation. Letters are referred to in text. Hachures indicate areas of aeromagnetic lows. Contour interval is 20 nanoteslas.

1 mi spacing at 9,000 ft above sea level (U.S. Geological Survey, 1968a and b). The total-field aeromagnetic anomaly map (fig. 4) represents changes in the magnetic field caused by differences in the magnetic properties of rocks and variations in height of the magnetic sensor above the rocks. The lack of detailed gravity and aeromagnetic data make only regional interpretations possible.

Within the Basin and Range province, mountain ranges typically are associated with gravity highs and adjacent valleys are associated with gravity lows, as a result of the contrast between relatively high-density rocks (bedrock) of the mountains and lower-density rocks (alluvial fill) of the valleys. The study area is at the northern end of a large gravity low (fig. 3) that generally correlates with a valley. Density boundaries producing the low were inferred (fig. 3) by applying the horizontal gradient method to the gravity data (Cordell, 1979). These boundaries cut across topography and match faults exposed just east of the study area (Stewart and Carlson, 1978), suggesting that the low is produced by a structurally controlled graben. The graben terminates just north of the wilderness study area.

The wilderness study area is on a large aeromagnetic low (marked A on fig. 4), corresponding to exposures of Jarbidge Rhyolite, which is surrounded by essentially nonmagnetic sedimentary rocks. This implies that the Jarbidge Rhyolite has a large, reversely polarized remanent magnetization (greater than the induced component). This conclusion is further supported by the association of a large aeromagnetic low (B) with exposures of the Jarbidge Rhyolite southeast of the study area.

Aerial gamma-ray spectroscopy data were compiled and processed at a scale of 1:1,000,000. The resulting map indicates that the wilderness study area has no uranium or thorium anomalies (J. Duval, USGS, written commun., 1985).

In summary, the reconnaissance scale of the geophysical data identifies regional geologic features but does not identify features that might indicate specific mineral resources.

Mineral Resource Potential

Mineral deposits known to occur in the vicinity of the study area include contact metasomatic deposits of gold, silver, tungsten, copper, and molybdenum; vein deposits of gold and silver; bedded barite deposits; placer deposits of gold; and sand and gravel deposits. In addition, disseminated deposits of gold and silver in pre-Tertiary sedimentary rocks constitute a major source of gold and silver in northern Nevada.

The contact metasomatic deposits, as well as some of the vein deposits northwest of the study area, are genetically related to a Cretaceous granodiorite that was emplaced in Paleozoic sedimentary rocks, especially limestone (Granger and others, 1957; Lowe and others, 1985). Contact metasomatism converted the limestone to a garnet-magnetite hornfels with gold, silver, tungsten, copper, and molybdenum minerals. Although limestone is exposed in the southwestern part of the study area, it is not altered nor does it contain anomalous amounts of metals. In addition, no intrusive rock is present nor do the geophysical data indicate a buried pluton. Therefore, the potential for resources of gold, silver, tungsten, molybdenum, and copper in deposits related to contact metasomatism is low, with certainty level C. The absence of veins and a pluton also make the potential for gold-silver resources in intrusive-related vein deposits low, at certainty level C. The potential for these types of resources beneath the thick cover of Tertiary volcanic and sedimentary rocks is unknown due to the lack of exposure and reconnaissance nature of the geophysical data.

The Paleozoic and Mesozoic sedimentary rocks in the southwestern corner of the study area are faulted and weakly altered, but discrete veins are not evident. One sample of brecciated and altered rock contained slightly anomalous amounts of arsenic (70 ppm) and mercury (0.12 ppm), and two stream-sediment samples contained anomalous arsenic (15 and 25 ppm). Gold and silver were not detected due to their high analytical detection limits; the slightly anomalous arsenic and mercury, which commonly occur with gold and silver in epithermal mineral deposits, suggest that gold and (or) silver may be present. However, the extremely limited extent of the faults and related breccia and altered rocks indicates that the area influenced by hydrothermal activity was very small. Therefore, the pre-Tertiary sedimentary rocks in the southwestern part of the area have a low potential, at certainty level C, for deposits of gold and silver.

Heavy-mineral concentrates from streams that drain the Jarbidge Rhyolite contain detectable amounts of tin, which may be present in small grains of cassiterite. The sample-preparation procedure for heavy-mineral concentrates increases the relative concentration of tin-bearing minerals in the fraction to be analyzed, and tin concentrations below 500 ppm are not considered to be anomalous in rhyolitic terranes (du Bray and others, 1982). Rock and stream-sediment samples do not contain anomalous amounts of tin. The Jarbidge Rhyolite typically contains trace amounts of tin and other metals (Coats and others, 1977), but they are not present in significant amounts in the study area. Therefore, the study area has a low potential, at certainty level C, for tin.

Sedimentary barite deposits are present in Ordovician sedimentary rocks 6 mi west and 2 mi east of the study area. Similar deposits are common in northern Nevada, and they are typically associated with Ordovician and Devonian eugeosynclinal sedimentary rocks, especially bedded cherts (Papke, 1984). The pre-Tertiary sedimentary rocks exposed in the southwestern corner of the study area are of Triassic age and do not contain rocks typical of a eugeosynclinal depositional environment. Furthermore, barite was not observed in these rocks, nor did stream-sediment or rock samples from this area contain anomalous barium. Rocks exposed in the two drainages in the Jarbidge Rhyolite, from which heavy-mineral concentrate samples with anomalous barium were collected, did not contain visible barite or evidence of mineralization. The anomalous barium values may reflect local surficial formation of barite. Therefore, the study area has a low potential, at certainty level C, for barite resources.

Gold was mined from placer deposits 5 mi to the northwest and 2 mi to the east from Quaternary and Tertiary alluvial deposits. In addition, a small amount of placer gold was mined from the Prunty prospect within the study area, and alluvium in both the Bruneau River and Copper Creek contain traces of placer gold. The gold was probably derived from the nearby Charleston mining district. However, only small amounts of alluvium are present at these sites and elsewhere in the study area. Stream-sediment and heavy-mineral samples from other streams in the study area do not indicate the presence of gold in alluvial deposits. Although a small amount of placer gold was mined within the study area, the mineral resource potential for undiscovered placer gold resources is low at certainty level C.

Only small amounts of sand and gravel are present in alluvial deposits along the Bruneau River and Annie Creek. Therefore, the study area has a low potential, at certainty level C, for undiscovered sand and gravel resources.

The study area lacks the host rocks and structures favorable for the occurrence of oil and gas. Sandberg (1983) rated the potential for oil and gas resources in the study area as low. The mineral resource potential for oil and gas is low, with certainty level C. The aerialradiometric studies showed no anomalies for uranium or thorium. The mineral resource potential for uranium or thorium resources is also low, at confidence level C.

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APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

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

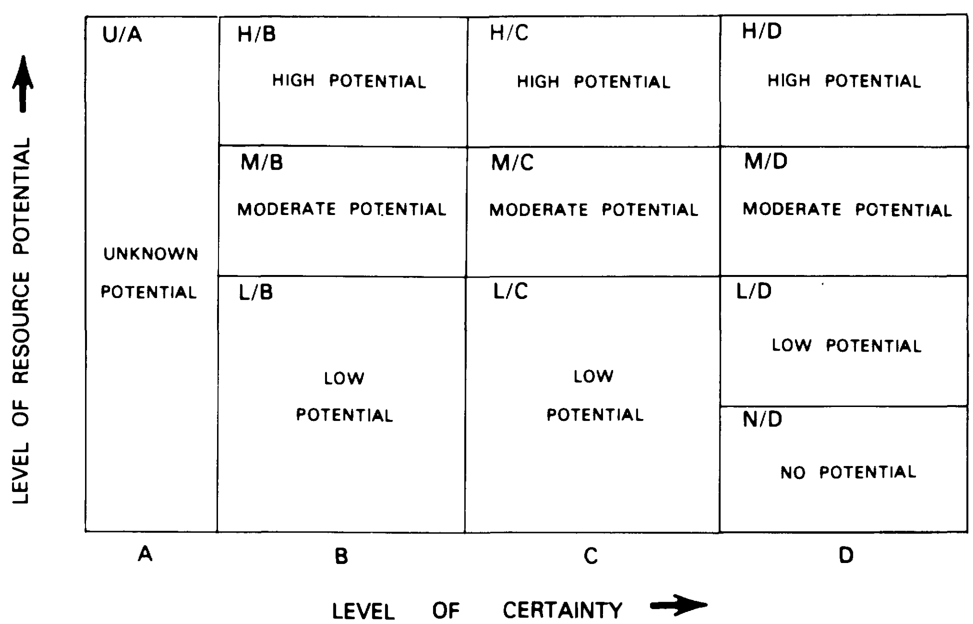
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application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

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

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

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

Levels of Certainty



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

Abstracted with minor modifications from:

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RESOURCE / RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	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 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 in this report

EON	ERA	PERIOD		EPOCH	BOUNDARY AGE IN MILLION YEARS
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 m.y. also called Precambrian, a time term without specific rank.

[2] Informal time term without specific rank.

*U.S. GOVERNMENT PRINTING OFFICE: 1987-0-773-047/66003

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