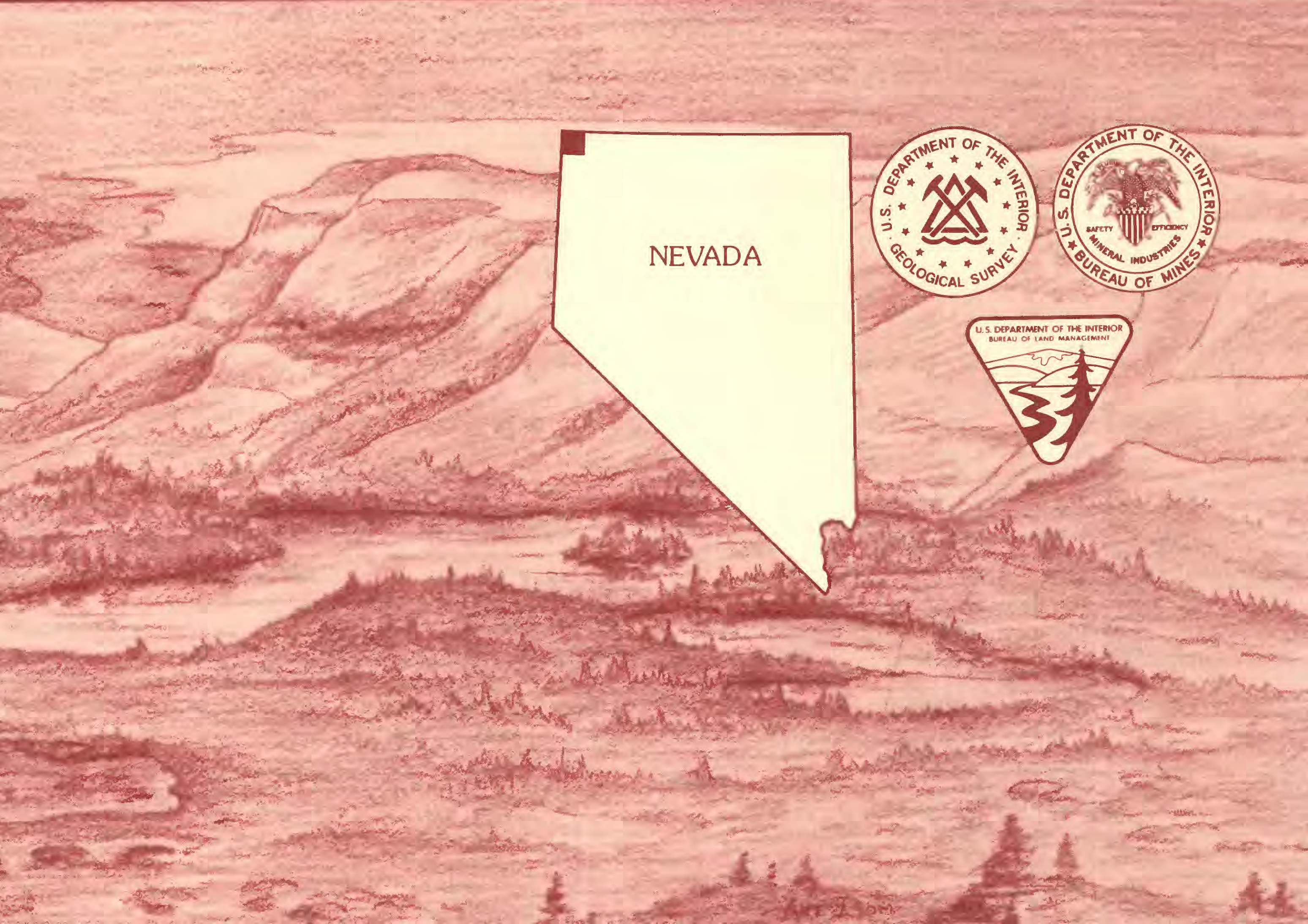
Mineral Resources of the High Rock Canyon Wilderness Study Area, Washoe County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1707–D



Chapter D

Mineral Resources of the High Rock Canyon Wilderness Study Area, Washoe County, Nevada

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

CARL W. PONADER
Stanford University

DOUGLAS F. SCOTT
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

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1988

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 High Rock Canyon Wilderness Study Area, Washoe County, Nevada.

Mineral resources of wilderness study areas—northwestern Nevada, U.S. Geological Survey Bulletin 1707-D
Bibliography.
Supt. of Docs. No.: I 19.3:1707-D
1. Mines and mineral resources—Nevada—High Rock Canyon Wilderness. 2. High Rock Canyon Wilderness (Nev.) I. Turrin, Brent D. II. Series. III. Series: U.S. Geological Survey Bulletin 1707-D.

QE75.B9 No. 1707-D 557.3s 87-600484
[TN24.N3] [553'.09793'55]

STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of part of the High Rock Canyon Wilderness Study Area (CA-020-913B), Washoe County, Nevada.

CONTENTS

FIGURES

Mineral Resources of the High Rock Canyon Wilderness Study Area, Washoe County, Nevada

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

Carl W. Ponader
Stanford University

Douglas F. Scott
U.S. Bureau of Mines

SUMMARY

Abstract

The High Rock Canyon Wilderness Study Area (CA-020-913B), located 40 mi north of Gerlach, Nev., and 25 mi south-southeast of Vya, Nev., encompasses approximately 33,300 acres. The U.S. Bureau of Land Management requested mineral surveys on 11,980 acres of the High Rock Canyon Wilderness Study Area. In this report, references to the "High Rock Canyon Wilderness Study Area" or "study area" refer only to the lands on which the U.S. Bureau of Land Management requested surveys.

Geologic, geochemical, geophysical, and mineral surveys of the wilderness study area were conducted by the U.S. Geological Survey and U.S. Bureau of Mines between 1985 and 1986 to evaluate the identified (known) mineral resources and to assess the mineral resource potential (undiscovered). There are no identified mineral resources in the study area. However, these studies indicate that parts of the study area have a high potential for zeolite mineral resources in altered tuffaceous sediments, a moderate resource potential for gold, silver, and mercury in epithermal-type precious-metal deposits, and a low potential for uranium, lithium, geothermal energy, oil, and gas resources. There is a low resource potential for zeolite in the southern part of the area. Presently, there are no mining districts, mines, current claims, gas or geothermal leases, or mineral resource production in the study area.

Character and Setting

The High Rock Canyon Wilderness Study Area (CA-020-913B) is situated in the transition zone between the Basin and Range and Columbia Plateau physiographic provinces. The Basin and Range Province is an extensive semi-arid to arid tract of subparallel, north-trending en echelon mountain ranges and intervening valleys. The Columbia Plateau Province is a high dissected plateau composed mostly of Tertiary volcanic rocks. The 11,980-acre study area, located in the Calico Mountains, eastern Washoe County, Nev., 40 mi north of Gerlach and 25 mi south-southeast of Vya, comprises a 1- to 2-mile-wide strip along the southwestern rim of High Rock Canyon (fig. 1). Elevations range from 5,000 ft at the canyon bottom to over 6,000 ft on the canyon rim. The canyon walls are steep and subparallel to the regional tectonic structure. The area is underlain by a sequence of Tertiary rhyolitic to dacitic ash-flow tuffs and flows (see Geologic time chart in appendixes for age definitions). Two major sets of faults that trend northwest and northeast occur within the study area.

Identified Resources

There are no identified resources within or adjacent to the study area. However, altered tuffs in the Yellow Rock Canyon area (fig. 2) contain as much as 80 percent

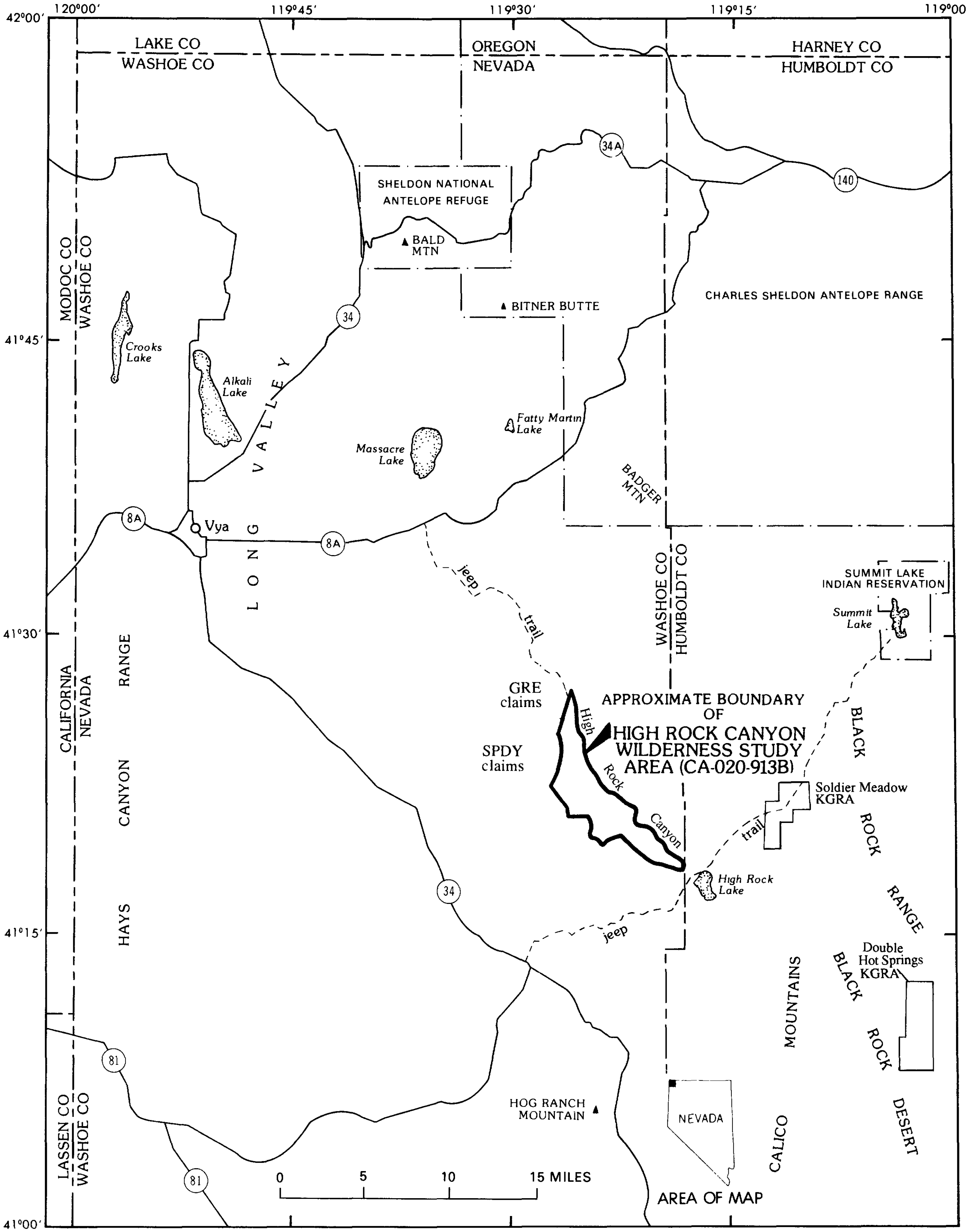


Figure 1. Index map showing location of High Rock Canyon Wilderness Study Area, Washoe County, Nevada.

clinoptilolite (zeolite). These clinoptilolite deposits are not currently classified as a resource by the U.S. Bureau of Mines.

Four mining districts are located near the study area; the Leadville silver district, approximately 20 mi south of the study area; the Lone Pine mercury-gold district, approximately 35 mi north-northeast of High Rock Canyon; and the Leonard Creek and Varyville gold mining districts, approximately 30 mi northeast of the study area. In addition, small perlite, diatomite, and uranium prospects are found 10 to 20 mi southwest of the study area.

Mineral Resource Potential

The Calico Mountains are part of a regional area that is characterized by extensive exposures of Tertiary volcanic rocks that are locally hydrothermally altered and silicified. In this region, hydrothermally altered rocks may host deposits of precious metals (gold and silver) and industrial minerals. In the Yellow Rock Canyon vicinity of the study area there is a high mineral resource potential for zeolite, in the form of clinoptilolite, and a moderate resource potential for epithermal-type gold, silver, and mercury deposits (fig. 2). There is also a moderate resource potential for epithermal-type gold, silver, and mercury deposits and a low resource potential for zeolite near the southern tip of the study area. In addition, there is a low resource potential for uranium, lithium, geothermal, oil, and gas resources throughout the entire study area.

INTRODUCTION

The High Rock Canyon Wilderness Study Area, (CA-020-913B) comprises approximately 11,980 acres in the Calico Mountains, eastern Washoe County, Nev. A mineral resource survey of the study area was conducted in the spring of 1985. This mineral survey was requested by the U.S. Bureau of Land Management (BLM) and is a joint effort by the U.S. Geological Survey (USGS) and U.S. Bureau of Mines (USBM).

Identified resources and known mineralized areas are evaluated by the USBM by collecting data on current and past mining activities and through field examination of known mines, prospects, claims, and mineralized areas. Identified resources are classified according to the system described by U.S. Bureau of Mines and U.S. Geological Survey (1980).

Studies by the USGS are designed to provide a reasonable scientific basis to assess the potential for undiscovered mineral resources within the wilderness study area. Field mapping of geologic units and structures, geochemical sampling, and geophysical studies were performed to provide the necessary data to evaluate, with respect to known ore-deposit models, the mineral resource potential of the study area. Mineral assessment methodology and terminology as they apply to these surveys are given in Goudarzi (1984). See appendixes for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

The climate is semiarid to arid, dominated by continental tropical air masses in summer and continental polar air masses in winter, typical of a middle-latitude desert climate (Sthraler, 1969, and Houghton and others, 1975). Annual temperatures range from less than -4 °F in winter to more than 100 °F during the summer. Daily summer temperature changes frequently exceed 50 °F. Precipitation ranges from 5 to 15 in. annually, mostly as snow and winter rain. During summer, relative humidity averages about 20 percent but may fall to 10 percent.

Several varieties of sagebrushes and grasses cover most of the area. Willow, cottonwood, and aspen occur along drainages.

Wildlife in the area includes pronghorn antelope, deer, coyote, bobcat, mountain lion, and a variety of smaller mammals. Feral horses and burros are also abundant. The avian population varies seasonally in numbers and species.

Most parts of the study area are accessible via unimproved roads from Nevada State Highway 34. The study area can also be accessed from the north via Nevada State Road 8A. These roads pass through High Rock Canyon along the northeast boundary of the study area, following the historic Lassen-Applegate Trail of the mid-1800's. An unimproved road borders the southwest part of the study area. However, these roads are subject to periodic washouts and in places may only be passable to high-clearance four-wheel-drive vehicles.

APPRAISAL OF IDENTIFIED RESOURCES

By Douglas F. Scott
U.S. Bureau of Mines

Methods and Scope of Investigation

U. S. Bureau of Mines personnel gathered data concerning mines, claims, prospects, and mineralized areas from BLM records, published literature, USBM files and production records, and county mining records. Field work was conducted during June and July 1985 and consisted of ground and helicopter reconnaissance and an examination of all known claims and prospects in or near the study area.

Twenty-six lode samples and seven placer samples were collected within or adjacent to the study area and analyzed for gold, silver, and numerous metallic elements. In addition, samples were measured for radioactivity and fluorescence. Quantitative concentrations of gold and silver were determined by fire assay; concentrations for other elements were determined by atomic absorption or inductively coupled plasma analysis. In addition, at least one sample from each prospect, claim, or mineralized area was analyzed for 40 elements by semiquantitative spectrographic methods (including antimony, barium, cadmium, cobalt, chromium, copper, gold, iron, lead, lithium, magnesium, manganese,

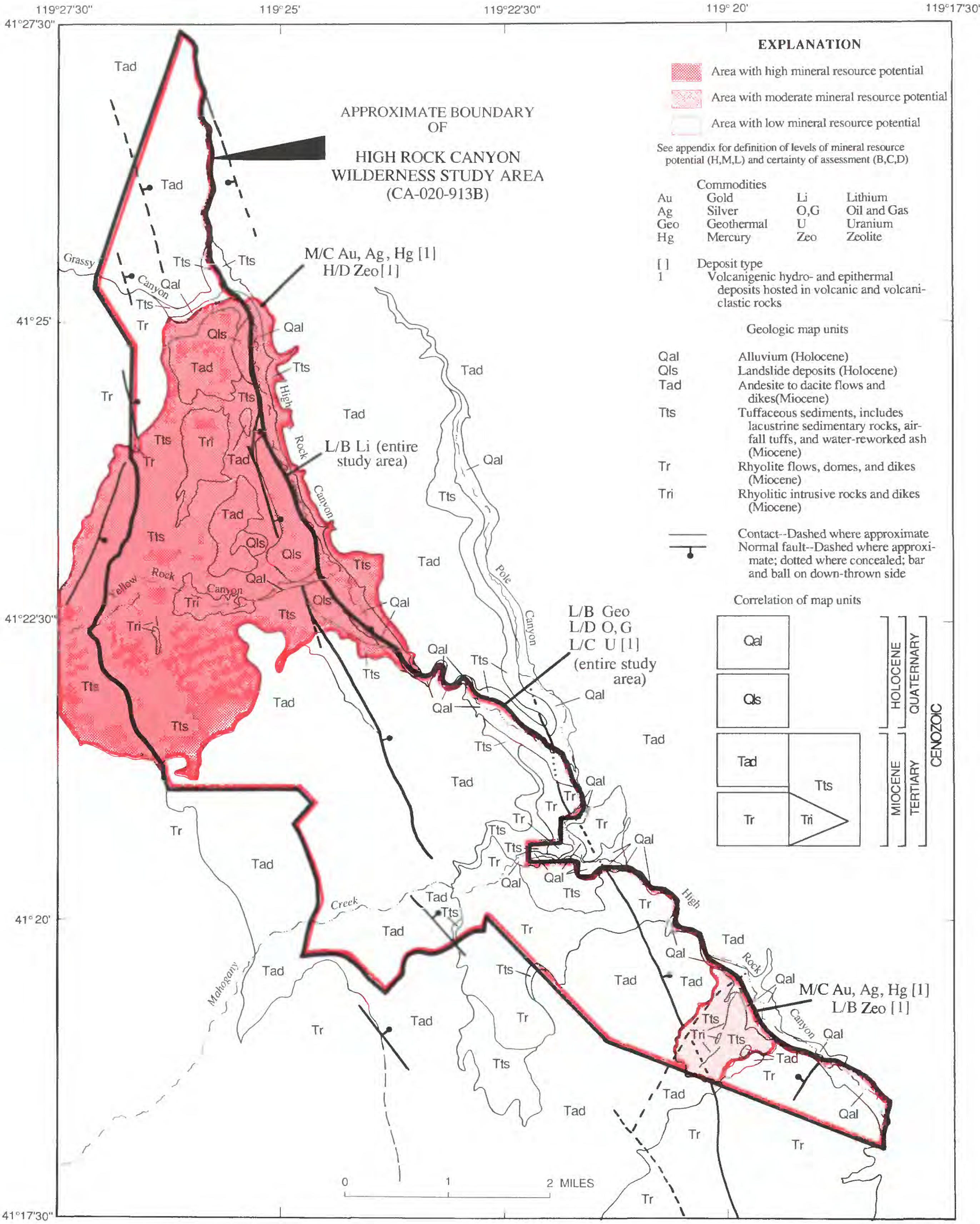


Figure 2. Mineral resource potential and generalized geologic map of High Rock Canyon Wilderness Study Area, Washoe County, Nevada.

molybdenum, nickel, platinum, silver, tin, titanium, vanadium, and zinc). Samples of altered tuffaceous sediments were examined microscopically and by X-ray diffraction for clay and zeolite minerals. The results of these analyses are summarized in Scott (1987). Additional information concerning the study area and copies of the Mineral Land Assessment report are available from the U.S. Bureau of Mines, Western Field Operations Center, E. 360 Third Avenue, Spokane, WA 99202.

History of Mining and Mineral Exploration

No mining districts, current claims, oil, gas, or geothermal leases or production are known in the area.

In 1911, six placer claims were located in High Rock Canyon (adjacent to east edge of area) from the confluence of Mahogany Creek and extending north for about 1 mi. Seven placer samples collected from these abandoned placer claims contained gold values ranging from zero to $0.06 per cubic yard (gold valued at $400/troy ounce).

One prospect trench in the southeast part of the study area is about 50 ft long, 12 ft wide, and 6 ft deep. The trench is along a fault zone that strikes N. 65° E. and dips vertically in ash-flow tuff. The zone is filled with green, fractured, and opalized breccia, averages 35 ft thick, and crops out discontinuously for at least 200 ft. Six samples were taken. Three chip samples of opalized breccia contained no detectable gold, silver, arsenic, or mercury, and one sample of opal contained no gold, silver, or mercury and 72.0 ppm arsenic. Two random samples of ash-flow tuff contained 50.0 and 56.0 percent zeolite (clinoptilolite).

Zeolites occur in varying concentrations in ash-flow tuff in Yellow Rock Canyon and lower Mahogany Creek. Within the study area, seven samples of ash-flow tuff contained from 50 to 65 percent clinoptilolite. Two samples of discolored ash-flow tuff, adjacent to the area, contained 65.0 and 80.0 percent clinoptilolite. The basal part of the ash-flow tuff was not exposed; therefore, thickness of the tuff is unknown. In the study area, ash-flow tuff outcrops are several hundred feet thick and occur discontinuously in an area of about 6 square miles. Several hundred million tons of ash-flow tuff occur in the area, and zeolites were found at several locations. Reconnaissance samples of ash-flow tuff were random and less than 50 ft in length.

Near Grassy Canyon, a 3.5-ft-thick fracture in basalt is filled with brown cryptocrystalline quartz and fractured and dark-colored opal. The samples contained no detectable gold or silver.

About 4 mi west from the area are 28 opal claims known as the SPDY claims. Fractures in ash-flow tuff are filled with massive white-to-green opal. The opal is fractured and massive and not of gem quality.

Major mining companies were exploring (1984) for disseminated gold-silver-mercury deposits north, south, and west of the area. Forty-four gold-silver-mercury claims (GRE claims) were maintained by Tenneco in 1984. Mercury occurs in cinnabar in massive opal and opalized breccia. Concentrations of mercury from two samples were 120.0 and 330.0 ppm. Concentrations of gold and silver were low; however, similarities between geologic features in the study area and those associated with known disseminated gold, silver, and mercury deposits indicate company interest may continue near and into the northwest part of the area.

Identified Resources

No mineral resources were identified in or adjacent to the High Rock Canyon study area.

Massive opal, opalized breccia, ash-flow tuff, and mercury in opal exist in several known disseminated gold, silver, and mercury deposits. These geologic conditions occur in and near the north, south, and west parts of the area. Bureau of Mines samples adjacent to the northwest part of the area indicated as much as 120.00 and 330.0 ppm mercury in opal and opalized breccia. Although no resources were identified, continued mining company exploration near the area, especially in or near the north, south, and west parts of the area, is expected.

Zeolite resources were not estimated because of

(1) low concentrations of sampled zeolite,
(2) unknown areal extent of zeolite-bearing tuff,
(3) unknown thickness of zeolite-bearing tuff,
(4) incomplete identification of zeolite-bearing tuff outcrops,
(5) current low market demand for zeolite,
(6) difficulty in field identification of zeolite-bearing tuffs, and
(7) absence of proximal mills.

Further exploration may define the extent and concentration of zeolites in tuff; however, because adequate deposits of higher and more consistent grade are proximal to existing mills and because market demands for zeolites are low, interest by mining companies should be minor now and in the foreseeable future.

Opal in the study area is massive, dark colored, and fractured and therefore not of gem quality. Future interest by gem collectors for opal should be minor.

Placer-gold exploration is not expected due to very low concentrations of gold in the alluvium sampled.

Sand and gravel occur in small amounts sporadically in the area. Because sand and gravel outside the area are adequate for present market demands, sand and gravel in the area do not constitute a resource.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

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

Carl W. Ponader
Stanford University

Geology

The High Rock Canyon Wilderness Study Area is underlain by Tertiary volcanic flows and volcaniclastic sediments (fig. 2). Although the basal contact of the Tertiary section is not exposed, local relief indicates that the volcanic section is more than 1,000 ft thick. The major fault trends within the study area, northwest and northeast, are typical of this part of the Basin and Range Province.

The oldest geologic unit exposed in the study area has been called the Canon Rhyolite of Merriam (1910) by Bonham (1969). This unit, composed of rhyolite flows, domes, and subordinate intercalated pyroclastic deposits, is Miocene in age. Potassium-argon (K-Ar) ages of 15 Ma (million years ago) are reported in Noble and others (1970) and Harvey and others (1986). Commonly, the unit is light purplish gray to reddish brown, microcrystalline to fine-grained rock containing fractured phenocrysts of alkali feldspar, quartz, and rare euhedral to subhedral biotite and alkali amphibole. Flow banding, flow foliations, and ramp structures are common features of the Canon Rhyolite. The rocks are peralkaline in composition, as are most rhyolitic tuffs and lavas of middle Miocene age in the region (Noble and others, 1968; Noble and others, 1970; Korringa, 1973; Bonham, 1969; and Harvey and others, 1986).

Interbedded with and unconformably overlying the Canon Rhyolite is a sequence of ash-flow tuffs, tuffaceous sediments, and dacitic to andesitic flow rocks informally referred to as the High Rock sequence by Bonham (1969). This unit has been subdivided into two subunits within the study area: a gray-green tuffaceous sedimentary unit that consists primarily of air-fall tuff, and a unit consisting of dacitic to andesitic flow rocks. Dacite-andesite flows are interbedded with the tuffaceous sedimentary rocks. Locally, the High Rock sequence contains welded air-fall tuff, ash-flow tuff, and water-worked tuffaceous sediments.

Two known mining districts near the study area have similar geologic environments. The Leadville District, approximately 20 mi south of the study area, is the largest producer of lead and silver in Washoe County. Production started in 1910 and continued intermittently until 1928 (Bonham, 1969). The Hog Ranch mine, located near the Leadville District began production in October 1986. Estimated reserves of approximately 5 million tons of heap-leachable gold ore have been reported (Anonymous, 1986).

The Lone Pine District is approximately 35 mi north-northeast of High Rock Canyon. Gold and silver prospecting occurred there between 1897 and 1909, although no gold or silver production was reported. However, mercury was discovered in 1929, and a small amount was produced. The district has been idle since 1955 (Tuchek and others, 1984).

Small perlite, diatomite, and uranium prospects are present 10 to 20 mi southwest of the study area. For a complete discussion of the surrounding mining districts in Washoe County and Humboldt County, see Bonham (1969) and Willden (1964), respectively.

Geochemistry

As part of a reconnaissance geochemical survey of the High Rock Canyon Wilderness Study Area, 69 stream-sediment samples were collected, of which 24 are from within the study area. The minus-80-mesh-size fraction of stream-sediment and heavy-mineral-concentrate samples were collected from alluvium in stream channels. A complete description of the sampling and analytical techniques is given in Adrian and others (1987).

Geochemical samples were analyzed for 31 elements by six-step semiquantitative emission-spectrographic methods (Myers and others, 1961 and Grimes and Marranzino, 1968). Additional analyses were by atomic-absorption spectroscopy and inductively coupled argon-plasma atomic-emission spectroscopy. These analytical data are used to identify drainages that have anomalously high concentrations of metallic elements. Geochemical concentrations are considered anomalous if they are greater than one standard deviation above mean background values.

Some of the stream-sediment samples from the Yellow Rock Canyon drainage are anomalous in arsenic, antimony, mercury, and cadmium. In addition, some of the heavy-mineral concentrates from the study area show anomalous concentrations of arsenic, antimony, and mercury; one sample contained detectable gold. Geochemical anomalies of arsenic, antimony, mercury, and cadmium are often associated with volcanic-hosted epithermal-type gold-silver deposits (Berger, 1986) and may suggest mineral resource potential.

Geophysics

Geophysical data used in the evaluation of the mineral resource potential consist of aerial gamma-ray spectroscopy, aeromagnetic, and gravity surveys.

Gamma-ray Spectroscopy

Radiometric data for the area were compiled by Geodata International Incorporated (1979) for the Department of Energy National Uranium Resource Evaluation (NURE) program. The gamma-ray flux survey consists of three east-west flightlines on 3-mi centers at an altitude of 300 to 700 ft above mean ground level. Gamma-ray fluxes from the radioactive isotopes of uranium, thorium, and potassium were recorded for the gamma-ray flux survey.

Gamma-ray flux levels for potassium, uranium, and thorium in the study area are about the same as in the surrounding terrain. The gamma-ray flux levels for uranium and thorium are slightly higher along the northern flight line, which was flown over late Miocene sedimentary rocks, approximately 2 mi south of the northern boundary of the study area. Uranium anomalies have been reported from fractured pieces of petrified wood found in these sediments (Garside, 1973). Uranium minerals in Tertiary sedimentary rocks often occur as encrustations or disseminated flakes along bedding planes or iron-stained fractures (Garside, 1973). These radiometric data do not indicate significant uranium or thorium occurrences.

Aeromagnetic Survey

An aeromagnetic survey was conducted as part of the mineral resource evaluation of the study area (U.S. Geological Survey, 1985). North-south flight lines, spaced at 0.5-mi centers, were flown at an altitude of about 1,000 ft above mean ground level.

Five roughly circular magnetic lows 1 to 2 mi in diameter are scattered throughout and along the southeast boundary of the study area. An inverse correlation between magnetic anomalies and topography indicates that source rocks for the magnetic lows are reversely magnetized and are at or near the surface. For example, magnetic lows overlie hilltops and magnetic highs commonly overlie canyons. However, one conspicuous magnetic low overlies an area of rhyolitic intrusives exposed in the Yellow Rock Canyon area. This magnetic low probably defines a Tertiary intrusive complex.

Gravity Survey

The wilderness study area is located along the southwestern flank of a conspicuous gravity low centered approximately 3 to 4 mi northeast of the study area (fig. 3). The gravity low is the southernmost part of a regional gravity low approximately 12 by 30 mi in size. Plouff (1984) interpreted this gravity low as a buried caldera. Presumably, the gravity low is present because of the accumulation of relatively low-density tuffaceous sedimentary rocks within the caldera depression.

Mineral Resource Potential

The mineral resource potential for the High Rock Wilderness Study Area is classified using the system of Taylor and Steven (1983), Taylor and others (1984); and Goudarzi (1984). See appendixes for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

A large volume of altered (zeolitized) tuff occurs in the Yellow Rock Canyon area. These altered tuffs contain as much as 80 percent zeolite (clinoptilolite). The basal part of the ash-flow tuff was not exposed; therefore, thickness of the tuff is unknown. In the study area, however, the zeolite-bearing ash-flow tuff outcrops are as much as 400 ft thick and occur discontinuously in an area of about 6 mi^2. This indicates that several hundred million tons of ash-flow tuff occur in the Yellow Rock Canyon area. On the basis of these data, surface relief, and aerial extent of the zeolite-bearing material in the Yellow Rock Canyon area, there is a high resource potential, certainty level D, for approximately 13 million to 1.3 billion yd^3 of zeolite-bearing material (clinoptilolite) at a grade of approximately 50 to 80 percent clinoptilolite in the study area. An exchange capability of 1.2 milliequivalents/gram has been reported for zeolite occurrences in the High Rock Lake Wilderness Study Area (NV-020-007), approximately 5 mi east-southeast of this study area (Neumann and Close, 1985).

The study area has a moderate resource potential for mercury, gold, and silver in epithermal-type deposits, certainty level C. Zeolite-bearing rocks and the anomalous concentrations of mercury, arsenic, antimony, and molybdenum found in the Yellow Rock Canyon area indicate that hydrothermal systems have been active in the past. Moreover, an epithermal-type gold deposit at the Hog Ranch mine, located approximately 15 mi south of the study area, indicates that hydrothermal mineralization has occurred in the region. Ring-fracture structures along the postulated caldera of Plouff (1984) could have provided conduits for hydrothermal fluids.

At McDermitt, Nev., about 60 mi to the east-northeast, a caldera is the site of uranium and extensive mercury deposits (Rytuba, 1975). In addition, lithium occurrences are also found in zones of zeolitization at McDermitt, Nev. (Rytuba and Glanzman, 1979). This evidence suggests a low resource potential for lithium, certainty level B, for the High Rock Canyon study area. There is also a moderate resource potential for epithermal-type gold, silver, and mercury deposits, certainty level C, and a low resource potential for zeolite, certainty level B, near the southern tip of the study area.

The High Rock Canyon study area has a low resource potential for uranium, certainty level C, as suggested by the geochemical and radiometric data. Only four uranium prospects have been reported from northern Washoe County (Garside, 1973).

Oil and gas resource potential for the study area is low, certainty level D. Because of the extensive Miocene volcanic activity, the area is too thermally mature to have formed any hydrocarbon reserves (Sandberg, 1983).

There are no known geothermal production leases or hot springs within the study area. However, the Soldier Meadow KGRA (Known Geothermal Resource Area) and the Double Hot Springs KGRA are within 5 and 18 mi, respectively. Given the lack of field evidence for the

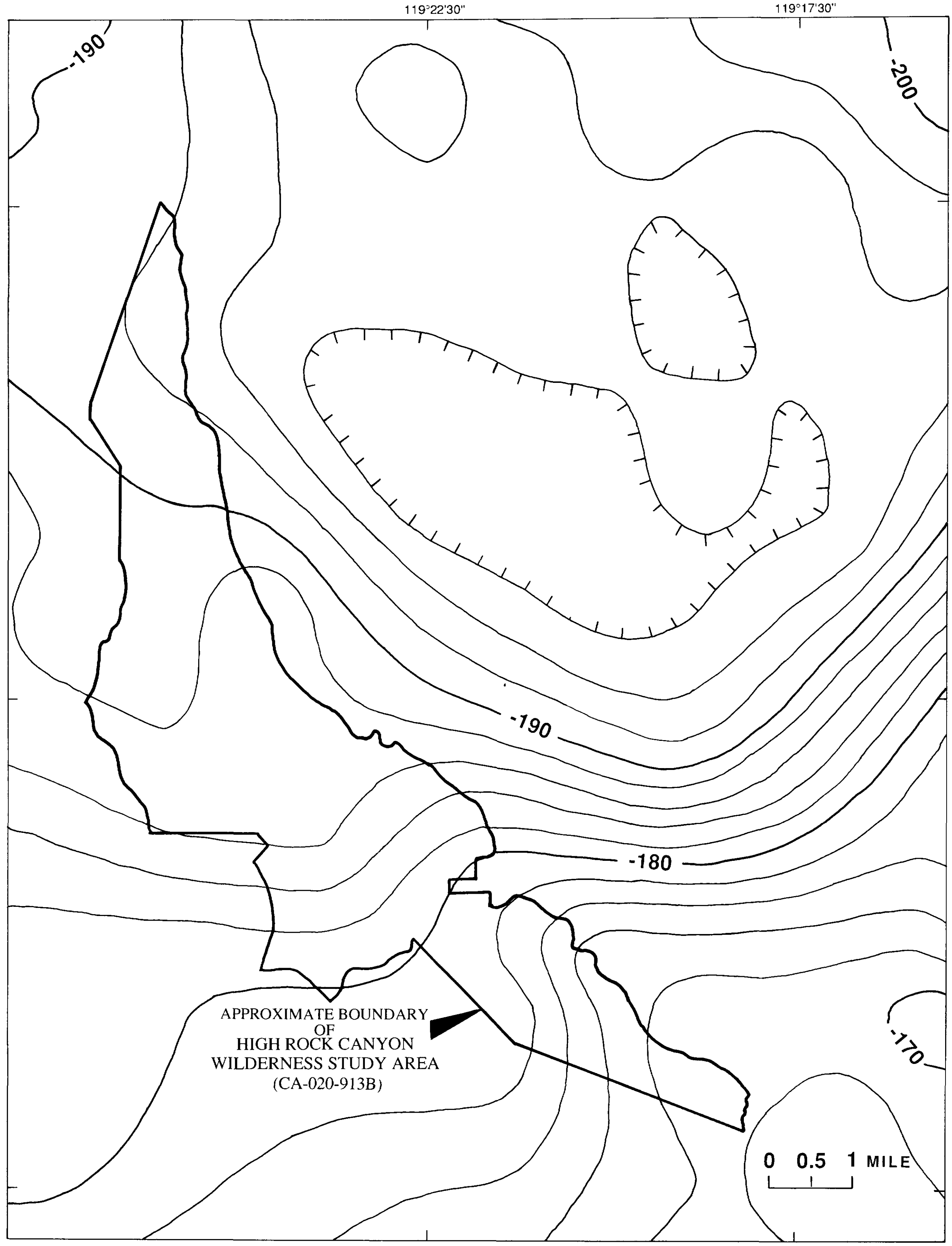


Figure 3. Gravity-contour map of High Rock Canyon Wilderness Study Area, Washoe County, Nevada. Values in gammas; contour interval 2 gammas; hachured in direction of gravity low.

necessary hydrologic conditions to form hot springs within the High Rock Canyon study area, the geothermal resource potential for the study area is low, certainty level B.

REFERENCES CITED

Adrian, B.M., Tunner, R.L., Malcolm, M.J., Fey, D.L., Crock, J.G., and Delaney, T.A., 1987, Analytical results and sample locality map of stream-sediment, heavy-mineral-concentrate and rock samples from the Rough Hills Wilderness Study Area, Elko County, Nevada, (NV-010-151): U.S. Geological Survey Open-File Report 87-431, 12 p.

Anonymous, 1986, Hog Ranch gold discovery first in northern Washoe County: Nevada Mining Association Bulletin, February-March, p. 20-21.

Berger, B.R., 1986, Descriptive model of hot-spring Au-Ag *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, 379 p.

Bonham, H.F., 1969, Geology and mineral deposits of Washoe and Storey Counties, Nevada, with a section on industrial minerals by K. G. Papke: Nevada Bureau of Mines and Geology Bulletin 70, 140 p.

Garside, L.J., 1973, Radioactive mineral occurrences in Nevada: Nevada Bureau of Mines and Geology Bulletin 81, 121 p.

Geodata International, Inc., 1979, Aerial radiometric and magnetic survey national topographic map, Vya, Nevada: U.S. Department of Energy Open-File Report GJBX-136 (79), v. 2, 73 p.,scale 1:125,000.

Goudarzi, G.H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84-0787, 51 p.

Harvey, S.D., Noble, D.C., and McKee, E.H., 1986, Hog Ranch gold property, northwestern Nevada: age and genetic relation of hydrothermal mineralization to coeval peralkaline silicic and associated basaltic magmatism: Isochron/West, no. 47, p. 9-11.

Houghton, J.G., Sakamoto, C.M., and Gifford, R.O., 1975, Nevada's weather and climate: Nevada Bureau of Mines and Geology Special Publication 2, 78 p.

Korringa, M.K., 1973, Linear vent area of the Soldier Meadow Tuff, an ash-flow sheet in northwestern Nevada: Geological Society of America Bulletin, v. 84, p. 3849-3866.

Merriam, J.C., 1910, Tertiary mammal beds of Virgin Valley and Thousand Creek, in northwestern Nevada; Part I, Geologic history: Berkeley, University of California, Department of Geology Bulletin, v. 6, no. 2, p. 21-53.

Neumann, T.R., and Close, T.J., 1985, Mineral resources of the High Rock Lake Wilderness Study Area (BLM No. NV-020-007), Humboldt County, Nevada: U.S. Bureau of Mines Open-File Report 38-85, 13 p.

Noble, D.C., Chipman, D.W., and Giles, D.L., 1968, Peralkaline silicic volcanic rocks in northwestern Nevada: Science, v. 160, p. 1337-1338.

Noble, D.C., McKee, E.H., Smith, J.R., and Korringa, M.K., 1970, Stratigraphy and geochronology of Miocene volcanic rocks in northwestern Nevada, *in* U.S. Geological Survey Research 1970: U. S. Geological Survey Professional Paper 700-D, p. D23-D32.

Plouff, Donald, 1984, Interpretation of aeromagnetic and gravity data, Charles Sheldon Wilderness Study Area, Nevada and Oregon: U.S. Geological Survey Bulletin 1538-B, p. 35-50, pl. 2, scale 1:125,000.

Rytuba, J.J., 1976, Geology and ore deposits of the McDermitt caldera, Nevada-Oregon: U.S. Geological Survey Open-File Report 76-535, 9 p.

Rytuba, J.J., and Glanzman, R.K., 1979, Relation of mercury, uranium, and lithium deposits to the McDermitt caldera complex, Nevada-Oregon: Nevada Bureau of Mines and Geology Report 33, p. 109-117.

Sandberg, C.A., 1983, Petroleum potential of wilderness lands in Nevada: U.S. Geological Survey Circular 902-H, p. H1-H11.

Scott, D.F., 1987, Mineral resources of the High Rock Canyon Wilderness Study Area, Washoe County, Nevada: U.S. Bureau of Mines Mineral Land Assessment Open-File Report 14-87, 18 p.

Sthraler, A.,1969, Physical geography: New York, John Wiley and Sons, Inc., p.219-238. [Condensed by Wladimir Koppen, from Die Klimate der Erde: Grundriss der Klimakunde, Berlin, Walter de Gruyter Co., 369 p.]

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, 42 p.

Tuchek, E.T., Johnson, F.J., and Conyac, M.D., 1984, Economic appraisal of the Charles Sheldon Wilderness Study Area, *in* Mineral resources of the Charles Sheldon Wilderness Study Area, Humboldt and Washoe Counties, Nevada, and Lake and Harney Counties, Oregon : U.S. Geological Survey Bulletin 1538-D, p. D89-D139.

U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, 5 p.

U.S. Geological Survey, 1985, Aeromagnetic map of the High Rock Lake area, northwestern Nevada: U.S. Geological Survey Open-File Report 85-751, 1 sheet, scale 1:62500.

Willden, Ronald, 1964, Geology and mineral deposits of Humboldt County, Nevada: Nevada Bureau of Mines and Geology Bulletin 59, 154 p.

APPENDIXES

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 permissive. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

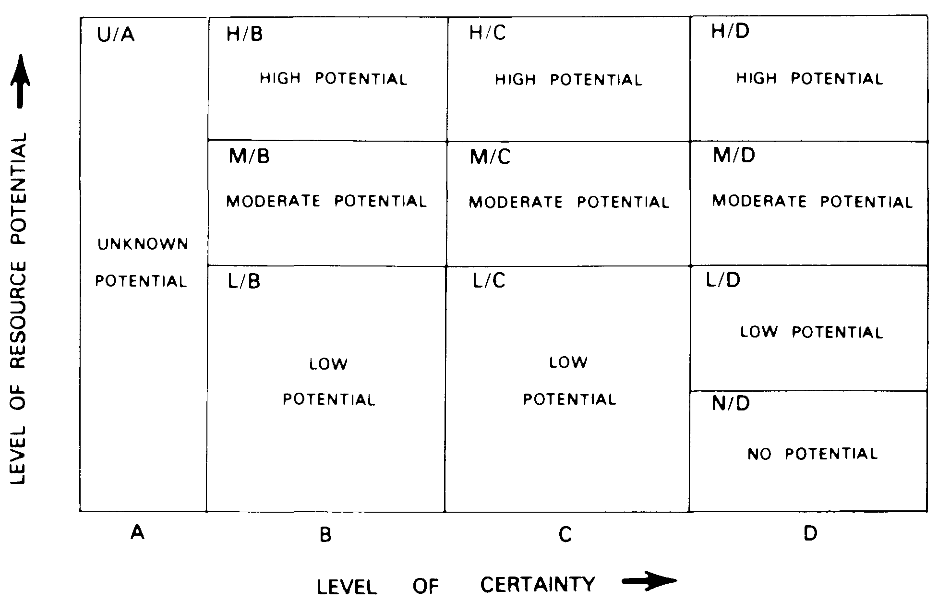
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate reasonable likelihood of resource accumulation, and (or) where an application 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 occurence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data supports 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:

Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268–1270.

Taylor, R. B., Stoneman, R. J., and Marsh, S. P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40–42.

Goudarzi, G. H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–0787, p. 7, 8.

RESOURCE/RESERVE CLASSIFICATION

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

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from 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 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.

GPO 585-045/78036

U.S. DEPARTMENT OF THE INTERIOR

March 3, 1849