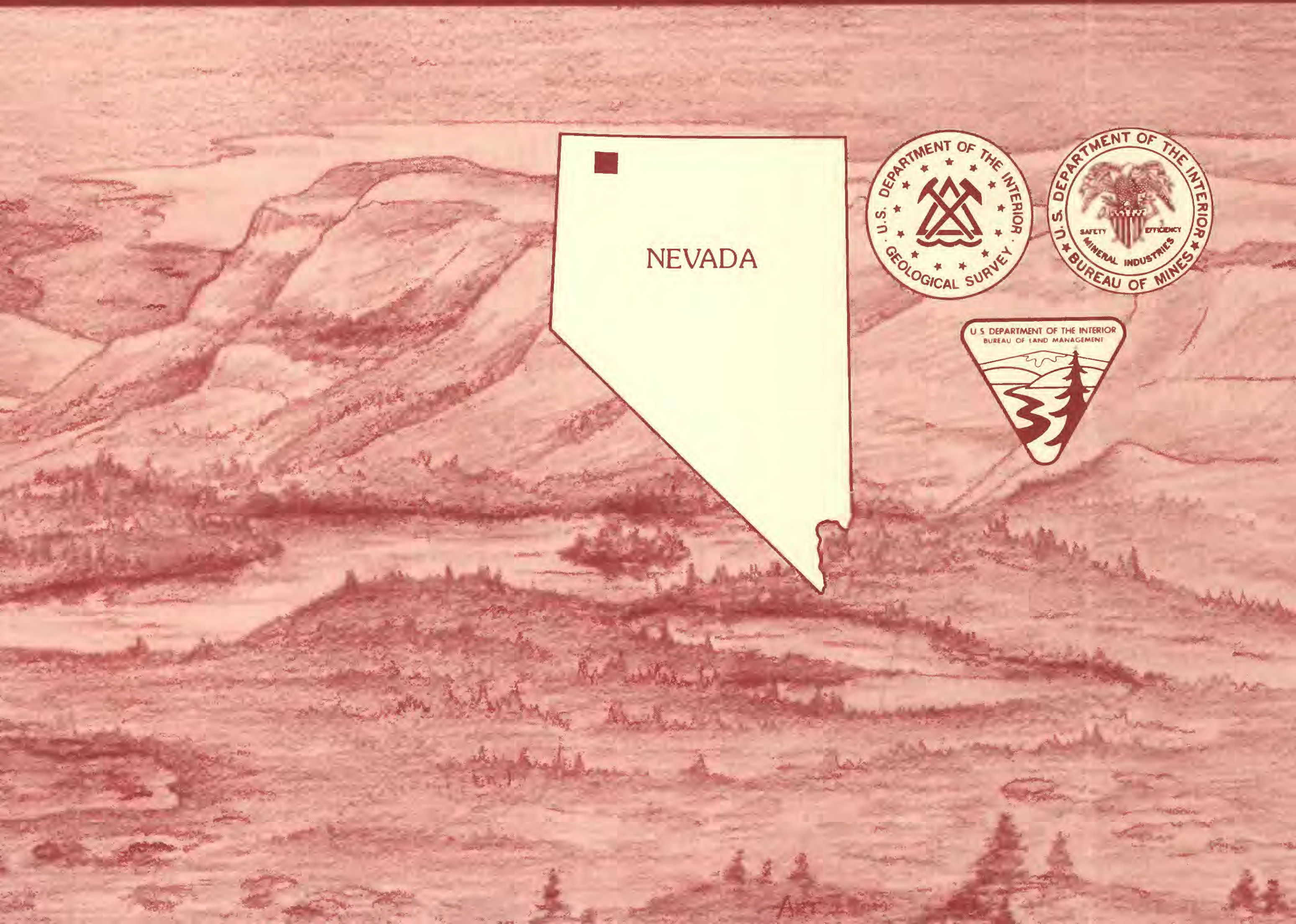
Mineral Resources of the High Rock Lake Wilderness Study Area, Humboldt County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1707–A



Chapter A

Mineral Resources of the High Rock Lake Wilderness Study Area, Humboldt County, Nevada

By DONALD C. NOBLE, DONALD PLOUFF, and JOEL R. BERGQUIST
U.S. Geological Survey

TERRY R. NEUMANN and TERRY J. CLOSE
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 : 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 High Rock Lake Wilderness
Study Area, Humboldt County, Nevada.

U.S. Geological Survey Bulletin 1707-A
Bibliography
Supt. of Docs. No.: I 19.3:1707-A
1. Mines and mineral resources—Nevada—High Rock
Lake Wilderness. 2. High Rock Lake Wilderness (Nev.)
I. Noble, Donald C. II. Series: U.S. Geological Survey
Bulletin 1707-A
QE75.B9 No. 1707-A 557.3s 87-600157
[TN24.N3] [557.93'54]

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 High Rock Lake Wilderness Study Area (NV-020-007), Humboldt County, Nevada.

CONTENTS

FIGURES

Mineral Resources of the High Rock Lake Wilderness Study Area, Humboldt County, Nevada

By Donald C. Noble, Donald Plouff, *and* Joel R. Bergquist
U.S. Geological Survey

Terry R. Neumann *and* Terry J. Close
U.S. Bureau of Mines

SUMMARY

Abstract

The part of the High Rock Lake Wilderness Study Area (NV-020-007) requested for mineral surveys encompasses 14,000 acres in the northern part of the Calico Mountains. Field work for this report was carried out in 1984 and 1985. The study area is underlain predominantly by slightly tilted volcanic rocks (rhyolitic ash-flow tuffs). No resources were identified within the study area. A low potential exists throughout the study area for undiscovered volcanic-hosted resources of mercury, uranium, and disseminated gold. The northern part of the study area has low potential for undiscovered geothermal energy resources. In this report, references to the study area refer only to that part of the High Rock Lake Wilderness Study Area requested by the U.S. Bureau of Land Management for mineral surveys.

Character and Setting

The High Rock Lake Wilderness Study Area is located in the northern part of the Calico Mountains about 45 mi north of Gerlach, Nev. (fig. 1). A major active normal fault system bounds the west margin of the range. The study area is underlain by slightly tilted Miocene (see appendix for geologic time scale) rhyolitic volcanic rocks. Rocks in the northwestern part of the study area locally exhibit weak hydrothermal alteration.

Identified Resources and Mineral Resource Potential

There are no identified mineral resources in the High Rock Lake Wilderness Study Area. The study area has a low potential for undiscovered volcanic-hosted resources of mercury, uranium, and disseminated gold (fig. 2). There is low potential for undiscovered geothermal resources in the northern part of the study area.

INTRODUCTION

Area Description

The High Rock Lake Wilderness Study Area (NV-020-007) covers 14,000 acres in the northern part of the Calico Mountains in western Humboldt County, Nev., about 45 mi north of Gerlach, Nev. (fig. 1). The study area includes parts of the Mud Meadow, High Rock Lake, and Wagner Springs 7.5-minute quadrangles. The terrain is relatively gentle in much of the study area, although steep cliffs are present in Box Canyon, Fly Canyon, and along the east side of High Rock Lake. The climate is arid to semiarid, and vegetation is sparse with greasewood, sagebrush, and cheatgrass the dominant species.

The best access to the study area is from Gerlach via the Soldier Meadow County Road (HU 217) (fig. 1). The study area can also be reached from the southwest by an unimproved dirt road through Smokey Canyon.

Previous Investigations

Willden (1964) published a geologic map of Humboldt County that differentiates Cenozoic and pre-Cenozoic rocks, but provides little detail of the Cenozoic stratigraphy. Unpublished reconnaissance geologic mapping of the Cenozoic rocks of the western part of Humboldt County by D.C. Noble, incorporated into the Geologic map of Nevada (Stewart and Carlson,

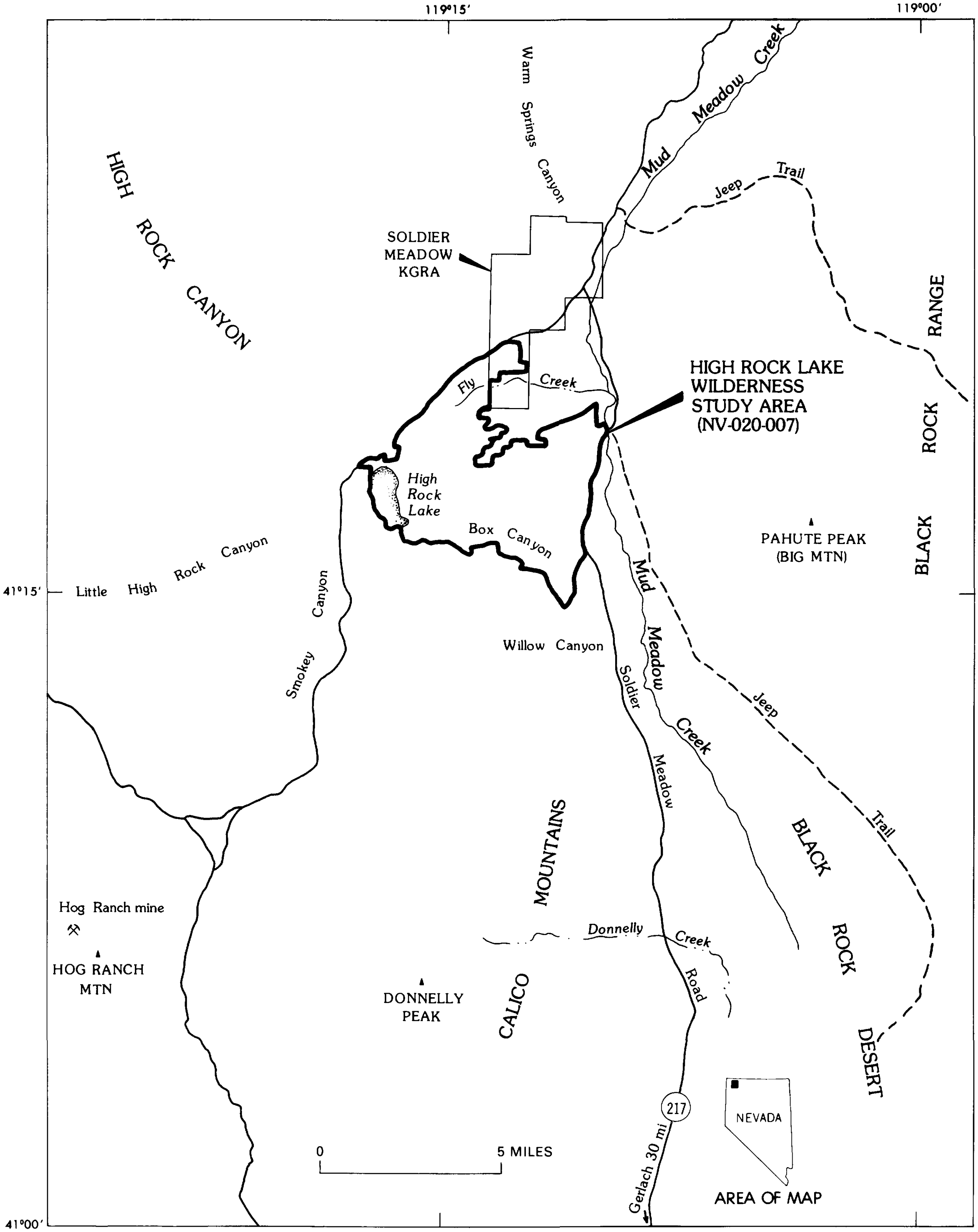


Figure 1. Index map showing location of High Rock Lake Wilderness Study Area, Humboldt County, Nevada. Known geothermal resource area (KGRA) boundaries from Muffler (1979).

1978), was the foundation for the geologic mapping completed in 1985 for this study.

Present Investigations

This mineral resource study is the result of a cooperative effort by the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) to evaluate the mineral resources and mineral resource potential of the High Rock Lake Wilderness Study Area. Mineral assessment methodology and terminology are discussed by Goudarzi (1984). Studies by the USGS are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, and the presence of geochemical and geophysical anomalies. The USBM evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, and mineralized areas.

U.S. Bureau of Mines personnel conducted a mineral survey of the High Rock Lake Wilderness Study Area. All available data on geology, mining, and mineral resources of this area, including federal and county mining claim records, were reviewed prior to field work. Mapping and sampling of mines, prospects, and mineralized zones were carried out in the summer of 1984.

The geochemical evaluation of the study area was based on data from the evaluation of study areas in the Winnemucca district by Barringer Resources, Inc. (1982), and on fire-assay and optical emission-spectrographic analyses of samples by the U.S. Bureau of Mines (Neumann and Close, 1985).

APPRAISAL OF IDENTIFIED RESOURCES

By Terry R. Neumann and Terry J. Close
U.S. Bureau of Mines

No identified mineral resources were delineated in the High Rock Lake Wilderness Study Area, and no mineral properties or mineralized zones are located within the study area. A belt of opalized rocks that extends about 2 mi south-southeast from the mouth of Willow Canyon (fig. 1) outside the study area has been prospected for gemstone opal. The opal occurs within vesicles in basalt, and must be extracted by hand. Almost all the opal is common variety, but milk opal, hyalite, moss opal, and precious fire opal are present locally. The opal dehydrates within several weeks of extraction, and thus is not gem quality. Moreover, basalt flows that host the opal are present in only a very small area in the southeastern part of the study area (fig. 2).

Finely bedded tuffaceous volcaniclastic sedimentary rocks exposed 8 mi south of the study area near Donnelly Creek (fig. 1) contain about 50 percent clinoptilolite, a zeolite mineral (Neumann and Close, 1985). However, the rock unit that contains the zeolite is not exposed in the study area.

Although geochemical sampling of stream sediments conducted by Barringer Resources, Inc. (1982), disclosed localized low-level anomalies of mercury, fire-assay and optical-emission spectrographic analyses of rock-chip samples from the study area failed to reveal anomalous concentrations of metals.

The Soldier Meadow Known Geothermal Resource Area (KGRA) adjoins and includes a small section of the northern part of the study area (fig. 1). No hot springs are present in the study area, although several hot springs are found in Soldier Meadow, 1 mi north of the study area. Surface temperatures of these springs are about 129 °F, and subsurface temperatures are about 239 °F (White and Williams, 1975; Brook and others, 1979).

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Donald C. Noble, Donald Plouff, and
Joel R. Bergquist, U.S. Geological Survey

Geology

The High Rock Lake Wilderness Study Area is underlain by volcanic rocks mostly of middle Miocene age and alluvium, colluvium, and other surficial deposits of Quaternary age. The principal rocks exposed are densely welded comenditic (peralkaline rhyolite) ash-flow tuffs of the Soldier Meadow Tuff (Noble and others, 1970), which cap an eastward-tilted mesa that comprises most of the study area. These tuffs were erupted from vents located several miles north of Soldier Meadow (Korringa, 1973; Greene and Plouff, 1981; Park and others, 1983) and perhaps directly north and (or) northwest of the study area. Near the mouth of Box Canyon, the Soldier Meadow Tuff overlies basalt and rhyolitic ash-flow and air-fall tuffs of the tuff of Trough Mountain and the Summit Lake Tuff (Noble and others, 1970; Korringa, 1973) (fig. 2). East of High Rock Lake and in the upper part of Box Canyon, the Soldier Meadow Tuff overlies peralkaline rhyolite (comendite) flows that probably are younger than the Summit Lake Tuff. Bedded and reworked tuffs, largely of rhyolitic composition, contain vertebrate fossils and overlie the Soldier Meadow Tuff north of High Rock Lake and in Fly Canyon. With the exception of the basalts, which could be late Oligocene to middle Miocene in age, all the volcanic rocks within the study area are middle Miocene (15 to 16 million years before present (Ma)) (Noble and others, 1970, 1987; Hart and Carlson, 1985).

A major north-trending normal fault with an offset of greater than 1,000 ft is located a few hundred yards east of High Rock Lake. Related faults to the east offset the Soldier Meadow Tuff. A system of normal faults, down dropped on the east side, bound the Calico Mountains on the east. A few landslides are present in the upper and middle parts of Box Canyon.

Lacustrine deposits related to late Quaternary Lake Lahontan are exposed in the eastern part of the study area, and lacustrine deposits related to High Rock Lake are exposed on the west side of the area.

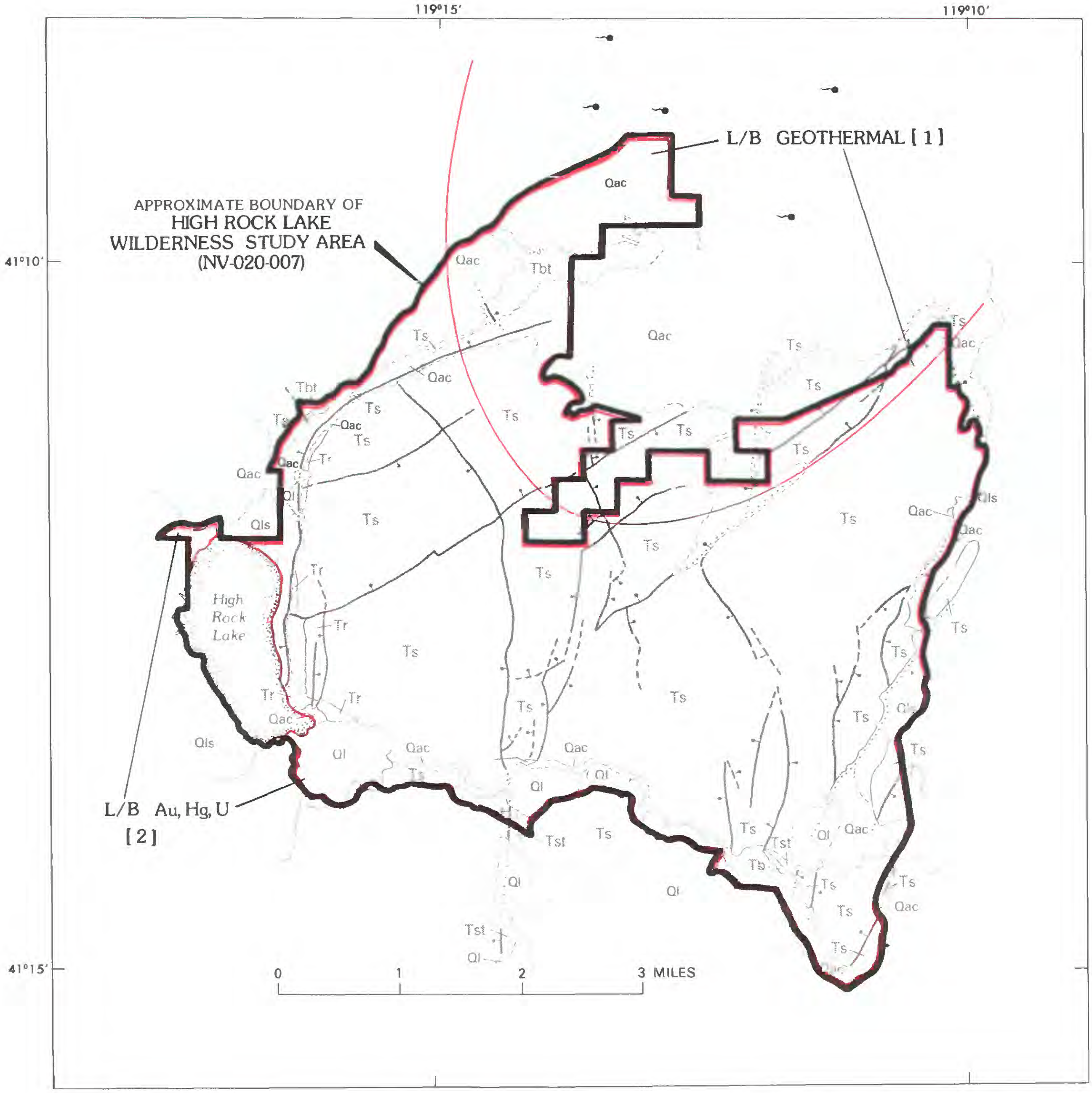


Figure 2. Mineral resource potential and generalized geology of the High Rock Lake Wilderness Study Area, Humboldt County, Nevada. Geologic mapping by D.C. Noble (unpub. data, 1985).

EXPLANATION

Area with low mineral resource potential—See appendix for definition of levels of mineral resource potential and certainty of assessment

Commodities

Au	Gold
Hg	Mercury
U	Uranium
	Geothermal

Types of deposits

1	Geothermal energy
2	Volcanic-hosted hydrothermal deposits

Geologic map units

Qac	Alluvium and colluvium (Quaternary)
Ql	Landslide deposits (Quaternary)
Qls	Lake sediments (Quaternary)
Tbt	Bedded tuff (Middle Miocene)
Ts	Soldier Meadow Tuff (Middle Miocene)
Tr	Rhyolite (Middle Miocene)
Tst	Summit Lake Tuff and tuff of Trough Mountain (Middle Miocene)
Tb	Basalt (Middle Miocene to Upper Oligocene)

Contact—Dashed where approximately located; dotted where concealed

Fault—Dashed where approximately located or inferred; dotted where concealed; bar and ball on downthrown side

Hot spring

Figure 2. Continued.

No evidence of hydrothermal alteration was observed within the study area except for local opalization of the Soldier Meadow Tuff adjacent to a normal fault about 0.5 mi north-northeast of High Rock Lake.

Geochemical Studies

A geochemical-geostatistical study of the High Rock Lake Wilderness Study Area was contracted with Barringer Resources, Inc., of Golden, Colo. by the U.S. Bureau of Land Management. Twenty-three stream-sediment samples were collected within the study area and analyzed for 33 major and minor elements using induction coupled argon plasma emission (ICP), fluorimetric analysis, colorimetric methods, and atomic absorption spectroscopy (Barringer Resources, Inc., 1982).

Stream sediments derived largely from the Soldier Meadow Tuff contain relatively high concentrations of fluorine (averaging about 700 ppm) and mercury (averaging about 15 ppb) (Barringer Resources, Inc., 1982). However, these values probably reflect the high background concentrations of fluorine and mercury that are characteristic of the Soldier Meadow Tuff (Korringa, 1973; Stuart and others, 1983). Concentrations in the samples of uranium, gold, silver, and other elements diagnostic of precious- or base-metal mineralization are within background values.

U.S. Bureau of Mines personnel collected 28 rock-chip samples from unclaimed areas in and near the study area (Neumann and Close, 1985). Most of the samples were taken along faults in Cenozoic volcanic rocks. The samples were analyzed for gold and silver by fire-assay methods and for 29 other elements by semiquantitative optical emission spectrography. None of the samples contain anomalous concentrations of ore-related or pathfinder elements.

Geophysical Studies

J.S. Duval (written commun., 1985) determined concentrations of potassium, equivalent uranium, and equivalent thorium by examining unpublished composite-color maps of gamma-ray spectrometric data. The maps were prepared at a scale of 1:1,000,000 from radiometric data acquired in regional surveys contracted by the U.S. Department of Energy as part of the National Uranium Resource Evaluation (NURE) Program. East-west flightlines were flown at altitudes of about 400 ft above mean terrain with a three-mile spacing (Geodata International, Inc., 1979). The study area has moderate radioactivity with values of 1.5 to 2.5 weight percent potassium, 2.5 to 4.0 ppm equivalent uranium, and 6 to 12 ppm equivalent thorium based on criteria discussed by Duval (1983). There are no identified radioelement anomalies in or near the study area.

An aeromagnetic survey of the region was flown to provide detailed magnetic data for evaluation of the resource potential of the study area (U.S. Geological Survey, 1985). North-south flightlines at intervals of 0.5 mi were flown at altitudes of about 1,000 ft above the mean terrain. The aeromagnetic map has rather uniformly spaced, east-trending, magnetic-intensity contours over most of the study area. The volcanic rocks near the surface throughout the study area apparently have low magnetization because the pattern of the magnetic contours is not correlated with prominent topographic scarps that occur within and along the boundary of the study area. The magnetic patterns may reflect the fact that peralkaline rhyolites commonly have low magnetic susceptibilities and low intensities of thermoremanent magnetization. The most prominent feature of the aeromagnetic map is a 1-mi-wide belt of east-trending magnetic contours near the center of the study area that curves northward before reaching High Rock Lake. The change of magnetic amplitude across the belt is a fairly constant 100 to 120 nanoteslas (nT). The belt may reflect the south and west edges of a large magnetic body concealed less than 1 mi beneath the surface, or it may reflect a step along the edge of a body concealed at a greater depth. The gradient along this belt forms part of a 600-nT magnetic high that is 7 by 14 mi and centered in the Black Rock Range about 4 mi east of Mud Meadow Lake (fig. 1) (Nevada Bureau of Mines and Geology, 1974). The broad magnetic high centered in the Black Rock Range and extending into the study area may indicate an underlying pluton with moderate to high magnetization.

Donald Plouff and C.F. Erdman established two gravity stations in the study area and three stations along the northwest edge of the study area to supplement gravity data from the National Geophysical Data Center (1984). The preliminary Bouguer gravity anomaly map by Plouff (unpub. data) shows a 5- by 8-mi gravity high with an amplitude of 8 to 15 milligals (mGal), centered about 4 mi east of Mud Meadow Lake. This gravity high nearly coincides with the central part of the broad magnetic high.

A small north-south-elongated, 3- by 5-mi gravity high is centered south of Mud Meadow Lake and overlies the east boundary of the study area. This local high may be part of the broad gravity high centered east of the study area (U.S. Geological Survey, 1972), because the two are separated by a narrow gravity low of less than 2 mGal. The gradient along the west edge of the local gravity high curves northeast to merge with the west edge of the broad gravity high near the northern part of Mud Meadow Lake.

North- to northwest-elongated gravity and magnetic lows reflect thickened sediments beneath and to the south of High Rock Lake. A gravity low centered on Fly Creek with an amplitude of 4 to 7 mGal and a width of about 4 mi probably indicates a thick sequence of sediments centered between Fly Creek and the hot springs outside the northwest corner of the study area (fig. 2). For example, assuming that the sediments are 0.4 g/cm^3 less dense than surrounding volcanic rocks and that the sedimentary basin has the shape of a 4-mi-diameter vertical cylinder, the sediments must be about 1,250 ft thick to produce a gravity low with an amplitude of 6 mGal. The maximum thickness of the sediments would be greater if the depression had a more realistic bowl shape.

CONCLUSIONS

The evaluation of mineral resource potential is based on a variety of data that include geologic, geochemical, and geophysical features, a survey of mines and prospects, and the mineral resources present in the surrounding regions.

Economically viable volcanic-hosted gold deposits of late Cenozoic age are present in northwestern Nevada, for example, the Hog Ranch mine, located about 15 mi southwest of the study area (fig. 1) in the northern part of the Leadville district. Scattered gold and (or) silver anomalies have been recognized in similar volcanic rocks of essentially the same age as the Soldier Meadow and Summit Lake Tuffs (D.C. Noble and E.H. McKee, unpub. data, 1985). Although no anomalous concentrations of gold or silver were recognized within the study area, on the basis of geologic setting, the study area has low potential, certainty level B, for disseminated gold in hydrothermal deposits.

Mercury deposits are known in northwestern Nevada (Williams and Compton, 1953; Willden, 1964; Bonham, 1969). The slightly elevated concentrations of mercury within the study area probably are related to a high background level typical of the Soldier Meadow Tuff and not to mineral deposits. The study area has low potential, certainty level B, for mercury in hydrothermal deposits.

The Soldier Meadow Tuff contains higher concentrations of uranium than do most rhyolites (Korringa, 1973; Stuart and others, 1983), and peralkaline rhyolites are known to be associated with potentially economic uranium mineralization elsewhere in northwestern Nevada (Wallace and others, 1980; Wallace and Roper, 1981). However, the aerial gamma-ray spectrometric survey, discussed above, disclosed no anomalous equivalent uranium concentrations, and geological surveys revealed no surface manifestations of uranium resources. The study area has a low potential, certainty level B, for uranium in volcanic-hosted deposits.

Opal is locally mined from basalt for gemstones in the Calico Mountains south of the study area (Neumann and Close, 1985). Similar basalt is exposed only in a very small area in the southeastern part of the study area. Because of the rapid dehydration of opal found in the basalt, the study area is not considered to have potential for undiscovered resources of gemstone opal. The opal may, however, be of interest to hobbyists.

The Soldier Meadow Known Geothermal Resource Area (KGRA) includes the northern part of the study area (fig. 1). The subsurface reservoir temperature of this area has been estimated to be about 239 $^{\circ}$F (White and Williams, 1975; Brook and others, 1979). No deep drilling has been done. Geothermal waters of such temperature have potential for industrial processing applications. The northeastern part of the High Rock Lake Wilderness Study Area has low potential, certainty level B, for geothermal energy.

REFERENCES CITED

Barringer Resources, Inc., 1982, Geochemical and geostatistical evaluation wilderness study areas, Winnemucca District, northwest Nevada, prepared for United States Bureau of Land Management: Golden, Colo., 5 v., 24 pl., scale 1:250,000.

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.

Brook, C.A., Mariner, R.H., Mabey, D.R., Swanson, J.R., Guffanti, Marianne, and Muffler, L.J.P., 1979, Hydrothermal convection systems with reservoir temperatures $\geq 90^{\circ}$ C., in Muffler, L.J.P., ed., Assessment of Geothermal Resources of the United States--1978: U.S. Geological

Survey Circular 790, p. 18-85.
Duval, J.S., 1983, Composite color images of aerial gamma-ray spectrometric data: Geophysics, v. 48, no. 6, p. 722-735.
Geodata International, Inc., 1979, Aerial radiometric and magnetic survey, Vya national topographic map, Nevada: U.S. Department of Energy Open-File Report GJBX-136 (79), v. 2.
Goudarzi, G.H., 1984, Guide to preparation of mineral reports on public lands: U.S. Geological Survey Open-File Report 84-787, 42 p.
Greene, R.C., and Plouff, Donald, 1981, Location of a caldera source for the Soldier Meadow Tuff, northwestern Nevada, indicated by gravity and aeromagnetic data: Geological Society of America Bulletin, v. 92, no. 1, p. 39-56.
Hart, W.K., and Carlson, R.W., 1985, Distribution and geochronology of Steens Mountain-type basalts from the northwestern Great Basin: Isochron/West, no. 43, p. 5-10.
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.
Muffler, L.J.P., ed., 1979, Assessment of geothermal resources of the United States--1978: U.S. Geological Survey Circular 790, map 1, scale 1:2,500,000.
National Geophysical Data Center, 1984, DMA gravity file of the United States: Boulder, Colo., National Oceanic and Atmospheric Administration, 2 magnetic tapes.
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 MLA 38-85, 14 p.
Nevada Bureau of Mines and Geology, 1974, Aeromagnetic map of Nevada—Vya sheet: Nevada Bureau of Mines and Geology Map 48, 1 pl., scale 1:250,000.
Noble, D.C., McKee, E.H., Smith, J.G., and Korringa, M.K., 1970, Stratigraphy and geochronology of Miocene rocks in northwestern Nevada: U.S. Geological Survey Professional Paper 700-D, p. D23-D32.
Noble, D.C., Plouff, Donald, Bergquist, J.R., and Barton, H.N., 1987, Mineral resources of the Pahute Peak Wilderness Study Area, Humboldt County, Nevada: U.S. Geological Survey Bulletin 1726-C in press.
Park, S.L., Erwin, J.W., Noble, D.C., and McKee, E.H., 1983, Paleomagnetic stratigraphy, geochemistry, and source areas of Miocene ash-flow tuffs and lavas of the Badger Mountain area, northwestern Nevada [abs.]: Geological Society of America Abstracts with Programs, v. 15, p. 281.
Stewart, J.H., and Carlson, J.E., 1978, Geologic map of Nevada: U.S. Geological Survey in cooperation with the Nevada Bureau of Mines and Geology, scale 1:500,000.
Stuart, E.J., Bornhorst, T.J., Rose, W.I., Jr., and Noble, D.C., 1983, Distribution and mobility of uranium and thorium in the Soldier Meadow Tuff, northwestern Nevada: Economic Geology, v. 78, p. 353-358.
U.S. Geological Survey, 1972, Aeromagnetic map of the Vya and part of the McDermitt 1° by 2° quadrangles, Nevada: U.S. Geological Survey Open-File Report, scale 1:250,000.
U.S. Geological Survey, 1985, Aeromagnetic map of the High Rock Lake area, northwestern Nevada: U.S. Geological Survey Open-File Report 85-751, scale 1:62,500.
Wallace, A.B., Drexler, J.W., Grant, N.K., and Noble, D.C., 1980, Icelandite and aenigmatite-bearing pantellerite from the McDermitt Caldera complex, Nevada-Oregon: Geology, v. 8, p. 380-384.
Wallace, A.B., and Roper, M.W., 1981, Geology and uranium deposits along the northeastern margin, McDermitt Caldera complex, Oregon: in Goodell, P.C., and Waters, A.C., eds., Uranium in volcanic and volcaniclastic rocks: American Association of Petroleum Geologists, Studies in Geology No. 13, p. 73-79.
White, D.E., and Williams, D.L., eds., 1975, Assessment of geothermal resources of the United States: U.S. Geological Survey Circular 726, 155 p.
Willden, Ronald, 1964, Geology and mineral deposits of Humboldt County, Nevada: Nevada Bureau of Mines Bulletin 59, 154 p.
Williams, Howel, and Compton, R.R., 1953, Quicksilver deposits of Steens Mountain and Pueblo Mountains, southeast Oregon: U.S. Geological Survey Bulletin 995-B, p. 19-77.

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.

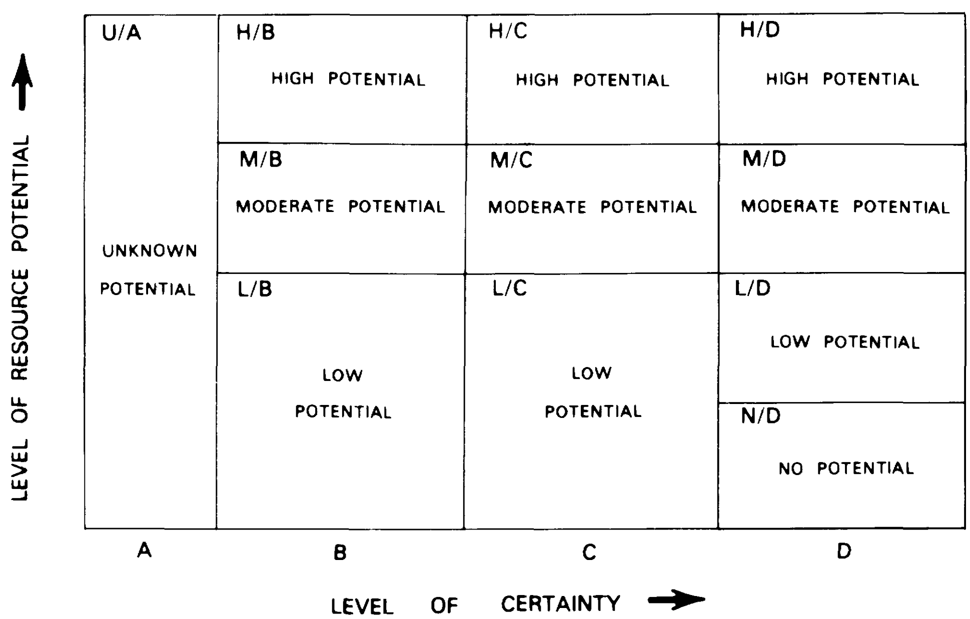
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application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

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.

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 785-048/48051

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