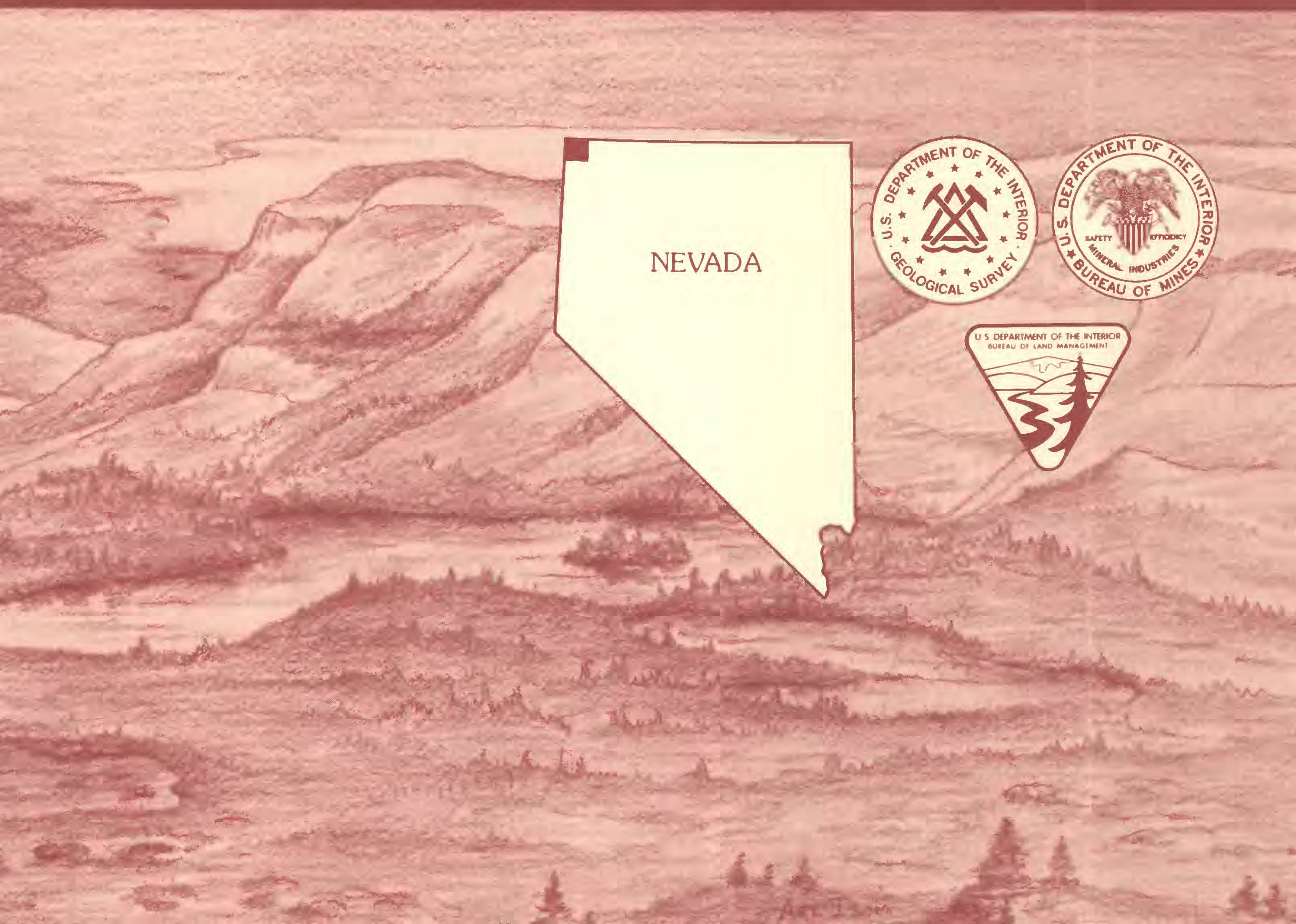
Mineral Resources of the East Fork High Rock Canyon Wilderness Study Area, Washoe and Humboldt Counties, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1707–B



Chapter B

Mineral Resources of the East Fork High Rock Canyon Wilderness Study Area, Washoe and Humboldt Counties, Nevada

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U.S. GEOLOGICAL SURVEY BULLETIN 1707

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
NORTHWESTERN NEVADA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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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 of certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of part of the East Fork High Rock Canyon Wilderness Study Area (CA 020-914/NV-020-006A), Washoe and Humboldt Counties, Nevada.

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Mineral Resources of the East Fork High Rock Canyon Wilderness Study Area, Washoe and Humboldt Counties, Nevada

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SUMMARY

Abstract

The part of the East Fork High Rock Canyon Wilderness Study Area (CA-020-914/NV-020-006A) included in this study encompasses 33,460 acres in the northwestern part of Nevada. Throughout this report, "wilderness study area" and "study area" refer to the 33,460 acres for which mineral surveys were requested. The U.S. Geological Survey and the U.S. Bureau of Mines conducted geological, geophysical, and geochemical surveys to assess the mineral resources (known) and the mineral resource potential (undiscovered) of the study area. Fieldwork for this report was carried out in 1985 and 1986. No mines, significant prospects, or mining claims are located inside the study area, and no identified resources were found. The wilderness study area has moderate mineral resource potential for gold, silver, and mercury and for zeolite minerals. A low potential also exists for geothermal energy resources, and potential for oil and gas is unknown.

Character and Setting

The East Fork High Rock Canyon Wildernesss Study Area is located approximately 25 mi east-southeast of Vya, in the northwestern part of Nevada (fig. 1). Rolling hills and gentle slopes are typical of most of the study area. The western part of the study area is deeply incised by canyons and the eastern part includes several small buttes.

The Soldier Meadow Tuff, a rhyolitic tuff, is the oldest exposed unit in the study area. Canyons and streamcuts reveal air-fall tuff and lacustrine sediments overlying the Soldier Meadow tuff. The air-fall tuffs and sediments were intruded by rhyolite domes. In the central, relatively flat part of the study area, the tuffs and sedimentary rocks are overlain by several thin, dark andesite to dacite flows. Geophysical evidence indicates that the study area may be located over the ring fracture of a caldera system.

Identified Resources

No identified mineral or energy resources exist in the study area and the area does not lie in any established mining district. No known mines or mining claims are located within the study area. The only known prospect is in barren rock.

Mineral Resource Potential

Two areas in the northern and western part of the study area have moderate mineral resource potential for gold, silver, and mercury in epithermal deposits. Evidence for this potential is provided by geochemical anomalies and areas of slightly altered rock. Part of the ring fracture system of a caldera may pass through the area; such fractures, if they exist, could have provided conduits for hydrothermal mineralizing fluids.

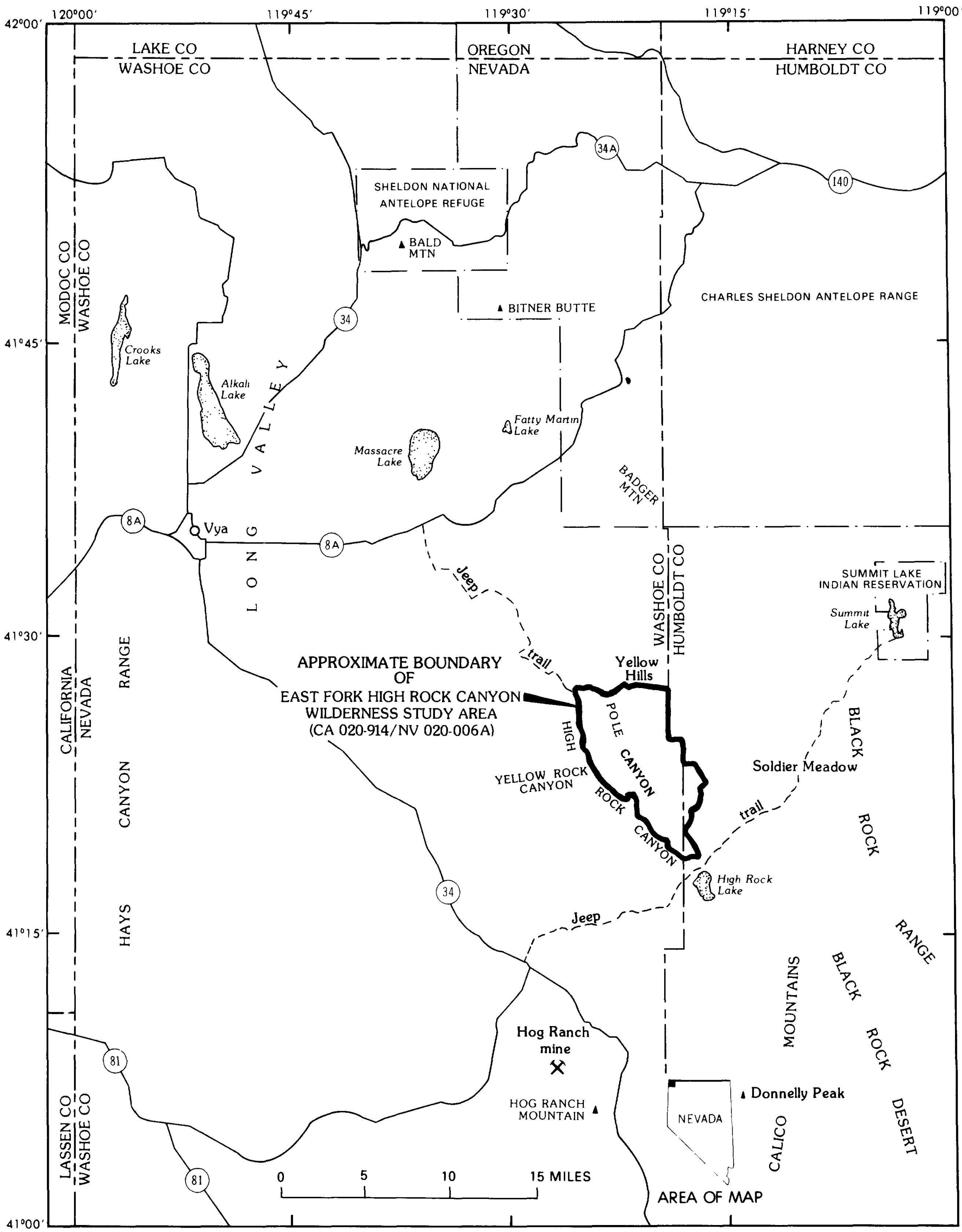

Figure 1. Index map showing location of the East Fork High Rock Canyon Wilderness Study Area, Washoe and Humboldt Counties, Nevada.

One area along the west boundary of the study area has moderate resource potential for zeolite minerals. Evidence for this potential is provided by the occurrence of these minerals west of the study area in altered tuffaceous rocks (Turrin and others, 1987) that extend into the study area.

Due to the presence of hot springs 5 mi to the east, the study area has a low potential for geothermal energy resources. No evidence of recent geothermal activity in the study area has been found. Potential for oil and gas resources is unknown.

INTRODUCTION

This mineral resource study is a joint effort by the U.S. Geological Survey and the U.S. Bureau of Mines. Mineral assessment methodology and terminology are discussed in Goudarzi (1984). Identified resources are classified according to the the system described by the U.S. Bureau of Mines and the U.S. Geological Survey (1980). See the appendix for the definition of levels of mineral resource potential, certainty of assessment, and classification of identified resources. Studies by the U.S. Geological Survey are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geological units and structures, possible environments of mineral deposition, presence of geophysical and geochemical anomalies, and applicable ore-deposit models. The U.S. Bureau of Mines evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas.

Area Description

The U.S. Bureau of Land Management requested that 33,460 acres of the East Fork High Rock Canyon Wilderness Study Area (CA-020-914/NV-020-006A) be evaluated for mineral resource potential. The study area is about 47 mi southeast of the northwestern corner of Nevada and approximately 25 mi east-southeast of Vya (fig. 1). A small, sloping plateau deeply incised on the west side by the precipitous High Rock and Pole Canyons is the dominant topographic feature of the area. In places the canyons have sheer cliffs 500 ft high and a total depth approaching 800 ft. In the eastern part of the study area, erosion has sculpted numerous small buttes. High Rock Lake, a year-round lake, is located 1 mi south of the wilderness study area and provides a haven for migratory waterfowl. Antelope, wild horses, and coyotes are the larger mammalian residents of the study area. The climate is arid to semiarid, with an average of less than 10 in. of precipitation a year (Sthraler, 1969). The vegetation is sparse, consisting of sagebrush, various range grasses, and a solitary juniper tree.

Access to the study area from the southwest is provided by approximately 13 mi of unimproved jeep trails from Nevada Route 34. The study area can also be reached from the north by Nevada Route 8A via approximately 17 mi of jeep trails. Jeep trails pass through High Rock Canyon along the historic Lassen-Applegate Trail of the mid to late 1800's.

Previous and Present Investigations

Bonham (1969) provided a good description of the geology of the High Rock area. Willden (1964) wrote a geological overview of neighboring Humboldt County. Korringa (1973), Korringa and Noble (1970), and Noble and others (1970, 1973) studied the Soldier Meadow Tuff, which crops out in the eastern part of the study area.

Previous reconnaissance studies of the geology and mineral resources of wilderness study areas in the region were carried out by Barringer Resources, Inc. (1982). The uranium resource potential for the region was evaluated as part of the U.S. Department of Energy National Uranium Resource Evaluation (NURE) program (Geodata International, 1979).

The U.S. Geological Survey carried out field investigations in the study area during the summers of 1985 and 1986. This work included geologic mapping and geochemical sampling. Eighty-six rock samples and 43 stream-sediment samples were collected and analyzed. Rock samples were collected from areas of altered bedrock and from each lithologic unit in order to obtain information on trace-element signatures associated with potentially mineralized areas and to provide data on background trace-element concentrations.

The U.S. Bureau of Mines conducted a library search for information on mines and prospects within the study area. Additional data were obtained from records of Washoe and Humboldt Counties, the U.S. Bureau of Land Management, and the U.S. Bureau of Mines. Field studies by U.S. Bureau of Mines personnel were carried out in 1985 (Schmauch, 1986). Forty-five rock samples were collected from areas of possible mineral concentrations within and immediately outside the study area. Samples were analyzed by fire-assay, atomic-absorption, and inductively coupled argon-plasma spectrophotometric methods. Complete analytical data are on file at the U.S. Bureau of Mines, Western Field Operations Center, E. 360 Third Ave., Spokane, WA 99202.

Acknowledgments

James T. Bateson provided able assistance with the geologic mapping. Joseph McFarlan, geologist, and the staff of the Cedarville, Calif., District Office of the U.S. Bureau of Land Management provided logistical support, information, and the use of the Bureau's facilities at Stevens Camp. Dr. D.C. Noble, professor at the University of Nevada, Reno, led an informative field trip for U.S. Bureau of Land Management and U.S. Geological Survey geologists to the study area and the surrounding region.

APPRAISAL OF IDENTIFIED RESOURCES

By Steven W. Schmauch
U.S. Bureau of Mines

No identified mineral resources exist in the East Fork High Rock Canyon Wilderness Study Area. The study area does not lie in an established mining district and no records of historical or active claims exist. The closest mining district, the Leadville district, is located about 30 mi south of the study area.

The Hog Ranch Mountain gold mine, currently being brought into production, is located approximately 17 mi south-southwest of the study area. This epithermal deposit consists of an estimated 5 million tons of low-grade, heap-leachable ore in silicified rhyolite host rocks (Harvey and others, 1986).

Approximately six miles north of the study area, 46 gold-silver-mercury claims (the GRE claims) were main-

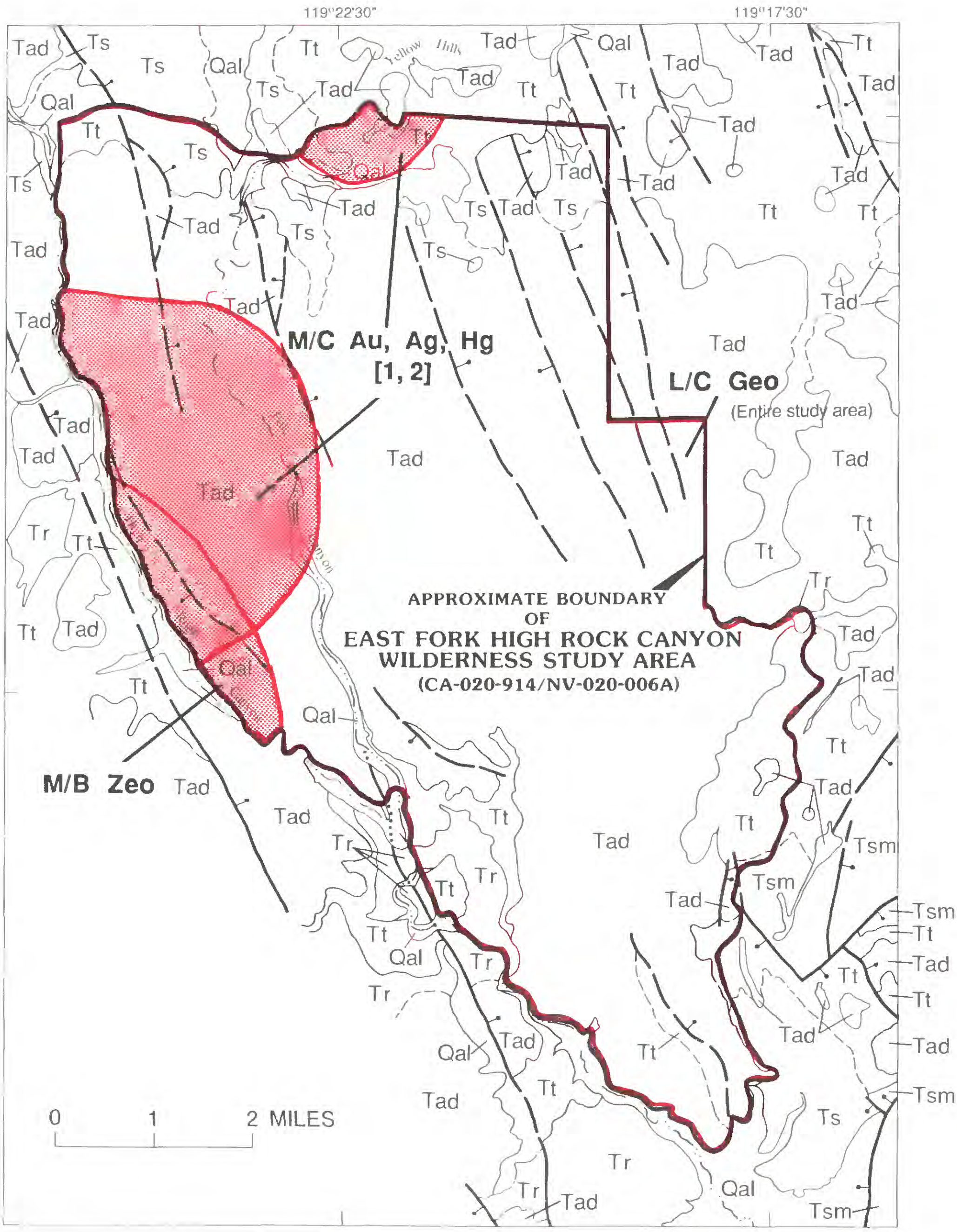

Figure 2. Mineral resource potential and geology of the East Fork High Rock Canyon Wilderness Study Area, Washoe and Humboldt Counties.

tained in 1984 by Tenneco. At this site mercury occurs in cinnabar in massive opal and opalized rhyolite breccia. Concentrations of mercury in two samples from these claim areas are 120 ppm and 330 ppm; concentrations of gold and silver are low (Scott, 1987).

The study area was examined for site-specific indications of possible hydrothermal-epithermal precious-metal deposits. Diagnostic features of this type of deposit, including large areas of intense silicification, quartz fissure veins, silicic or argillic wallrock alteration, or fractured, favorable host rocks, were not observed. Slightly altered tuffs, possible indicators of former hydrothermal activity, occur in Yellow Rock Canyon and the Yellow Hills.

EXPLANATION

Area with moderate mineral resource potential

Area with low mineral resource potential

See appendix for definition of levels of mineral resource potential and certainty of assessment

Commodities

Au	Gold
Ag	Silver
Hg	Mercury
Zeo	Zeolites
Geo	Geothermal

[ ] Deposit types

1 Epithermal or hot-spring deposits of gold and silver in volcanic and volcaniclastic rocks

2 Epithermal mercury deposits in volcanic and volcaniclastic rocks

Geologic map units

Qal	Alluvium (Quaternary)
Ts	Lacustrine sedimentary rocks (Tertiary)
Tad	Andesite to dacite flows and dikes (Tertiary)
Tr	Rhyolite flows, domes, and dikes (Tertiary)
Tt	Air-fall tuff (Tertiary)
Tsm	Soldier Meadow Tuff (Tertiary)

Contact—Dashed where approximate

Normal fault—Dashed where approximate, dotted where concealed; bar and ball on downthrown side

Intermittent stream

Figure 2. Continued.

A part of a zeolite-bearing altered tuff is exposed in a canyon wall near Yellow Rock Canyon. West of High Rock Canyon, larger areas of this unit are exposed at the surface (Scott, 1987).

Small accumulations of sand and gravel in the study area have no unique commercial characteristics and larger supplies are more readily available closer to market areas.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Jay A. Ach, Donald V. Plouff, *and* Robert L. Turner
U.S. Geological Survey

Geology

Pre-Miocene basement rocks are not exposed within or near the East Fork High Rock Canyon Wilderness Study Area but are inferred to be Mesozoic granites or metamorphic rocks. Cretaceous granites are exposed 13 mi east of High Rock Lake in the Black Rock Range, and granites of similar age intrude Triassic and (or) Jurassic metamorphosed sedimentary rocks in the southern Calico Mountains 15 mi south of High Rock Lake.

The oldest unit exposed in the study area is the middle Miocene Soldier Meadow Tuff (fig. 2). Reported radiometric ages for this unit are between 14.7±0.5 Ma (million years) and 15.6±1.7 Ma (Noble and others, 1970; Marvin and others, 1970; Noble and others, 1973). This unit is composed of lava flows and ash flows of peralkaline rhyolite (comendite). The tuff is light gray to light tan and contains less than 25 percent total phenocrysts of smokey quartz, sanidine (commonly chatoyant), and minor sodic amphibole, iron-rich clinopyroxene, and vapor-phase arfvedsonite. Korringa and Noble (1970) indicate that the Soldier Meadow Tuff was erupted from a linear series of vents at the west edge of Soldier Meadow, a few miles east of the study area. Gravity data presented in this paper indicate that these vents may lie along a caldera ring fracture.

A light-bluish-gray to light-gray, pumiceous, nonwelded air-fall tuff conformably overlies the Soldier Meadow Tuff. This unit is composed of approximately 80 percent uncollapsed pumice fragments in a matrix of ash. Sparse sanidine, quartz, and plagioclase phenocrysts are present in the pumice fragments and the matrix. Small clasts of Soldier Meadow Tuff are common in this unit; in a few localities these clasts reach a diameter of 4 to 5 ft. Parts of this unit may be water-lain, and in places the upper part has been reworked by water. The unit has been altered to light mustard yellow in Yellow Rock Canyon, east of the study area; a small amount of altered rock of this type is exposed within the study area near the junction of Yellow Rock and High Rock Canyons. A thin rhyolite obsidian that overlies the pumiceous tuff gives a potassium-argon age of 15.3±0.5 Ma (Noble and others, 1973).

The pumiceous air-fall tuff has been intruded by a light-gray to light-purplish-gray rhyolite. Similar rhyolites nearby give a potassium-argon age of 15.1±0.5 Ma (Noble and others, 1973). Sparse sanidine, aegirine, and soda-amphibole are the phenocryst phases in this unit. Small zones of vapor-phase alteration are common. Whole-rock geochemistry (J.A. Ach, unpub. data, 1986) indicates that this rhyolite is metaluminous/peraluminous in composition, but on the basis of vapor-phase mineralogy, Noble and others (1973) consider this rhyolite to be peralkaline (a comendite). Sodium loss upon cooling is common in peralkaline rhyolites (Noble, 1970); for this rock, the loss of only 0.15 percent sodium upon cooling would resolve the apparent conflict between chemistry and mineralogy.

Tuffaceous lacustrine sedimentary rocks crop out at both the north and south ends of the study area and probably overlie the pumiceous tuff. These rocks are white to light gray and fine to very fine grained. In the southern part of the area, they contain middle Miocene vertebrate fossils (Carl Swisher, oral comm., 1986), and a thin layer of tuff overlying the sediments gives potassium-argon ages of 14 Ma (Carl Swisher, oral commun., 1986). The sedimentary rocks in the northern part of the area have similar lithologies and probably are middle Miocene as well.

Several dark, 5- to 25-ft-thick lava flows form the flat surface in the central part of the study area and cap the buttes in the eastern part. These flows weather to a rusty brown, but are bluish to purplish black on freshly broken surfaces. Upper surfaces of the flows are vesiculated. These flows are extremely phenocryst poor, with only rare sanidine and clinopyroxene observed. Whole-rock chemical analyses (Ach, unpub. data, 1986) indicate that these flows are high-potassium andesites and dacites (banakites). No radiometric ages have been reported for this unit; it probably is also middle Miocene in age.

Quaternary deposits consist of alluvium in the canyon bottoms, talus on canyon slopes, and local landslide deposits along the canyon sides.

North-northwest-trending basin-and-range faults occur along High Rock and Pole Canyons and in the northern part of the study area. Vertical offsets along these faults are typically between 25 and 200 ft.

Geophysical Studies

Geophysical surveys of the study area have used aerial gamma-ray, aeromagnetic, and gravity techniques.

Radiometric data were compiled by Geodata International, Inc. (1979), for the U.S. Department of Energy National Uranium Resource Evaluation (NURE). Three east-west flightlines totalling about 12 mi in length and separated by about 3 mi recorded gamma-ray flux from radioactive isotopes of uranium, thorium, and potassium. Flight altitudes above the ground level varied from 300 to 400 ft over most of the study area but exceeded 1,000 ft over High Rock Canyon. The flux level of potassium is about the same as in surrounding areas along the profiles. However, the flux levels of uranium and thorium isotopes are fairly constant and low compared with adjacent areas, except in alluvium-covered valleys. The uniformly low values for uranium and thorium may reflect rock alteration.

An aeromagnetic drape survey 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 spaced at intervals of 0.5 mi were flown at altitudes of about 1,000 ft above the mean ground surface. Twelve elongate magnetic lows that have long dimensions ranging from 0.5 to 2.0 mi are scattered throughout the study area. Magnetic lows overlie hilltops and magnetic highs commonly overlie canyons. This inverse correlation of magnetic anomalies with topography indicates that the source rocks for the magnetic lows are reversely magnetized and are at or near the ground surface. This effect is further exaggerated because flight altitudes tended to decrease closer to the reversely magnetized rocks over hillcrests and to increase more than 1,000 ft above canyons.

The reversely magnetized source rocks consist mostly of high-potassium andesite to dacite flows that are prevalent at the surface. Some of the intense magnetic lows may indicate andesite/dacite vent areas. The rhyolite exposed to the southeast of the confluence of Pole and High Rock Canyons is not correlated with a magnetic anomaly, indicating the rhyolite is weakly magnetized. A conspicuous magnetic high, about 2.5 mi in diameter, overlies the Yellow Hills along the north edge of the study area, indicating rocks of normal magnetization at or beneath the surface in that area.

Gravity studies were based on data from 18 U.S. Geological Survey gravity stations in the study area and an additional 27 stations within 3 mi of the boundary. The stations were established during 1984 and 1985. These data were supplemented by published gravity data from 7 stations (National Geophysical Data Center, 1984).

The gravity minimum of a large gravity low covers a 3- by 6-mi area in the northeast corner of the study area (fig. 3). Bouguer gravity anomaly values increase 22 milligals (mGal) southward from the gravity minimum and 8 mGal southwestward from the minimum to the edge of the larger 12- by 30-mi gravity low. The northern part of this large gravity low was interpreted by Greene and Plouff (1981) as a caldera filled with and concealed beneath younger flat-lying sediments and volcanic rocks. The entire large gravity low is here interpreted to represent either a large single caldera or two or more smaller, nested calderas. The gravity low presumably results from the density contrast between the less dense tuffaceous sedimentary rocks filling the caldera and the denser country rocks outside the caldera rim.

Assuming that tuffaceous sedimentary rocks are 0.3 g/cm^3 (grams per cubic centimeter) less dense than rocks outside the caldera, 5,740 ft of intracaldera sedimentary rocks

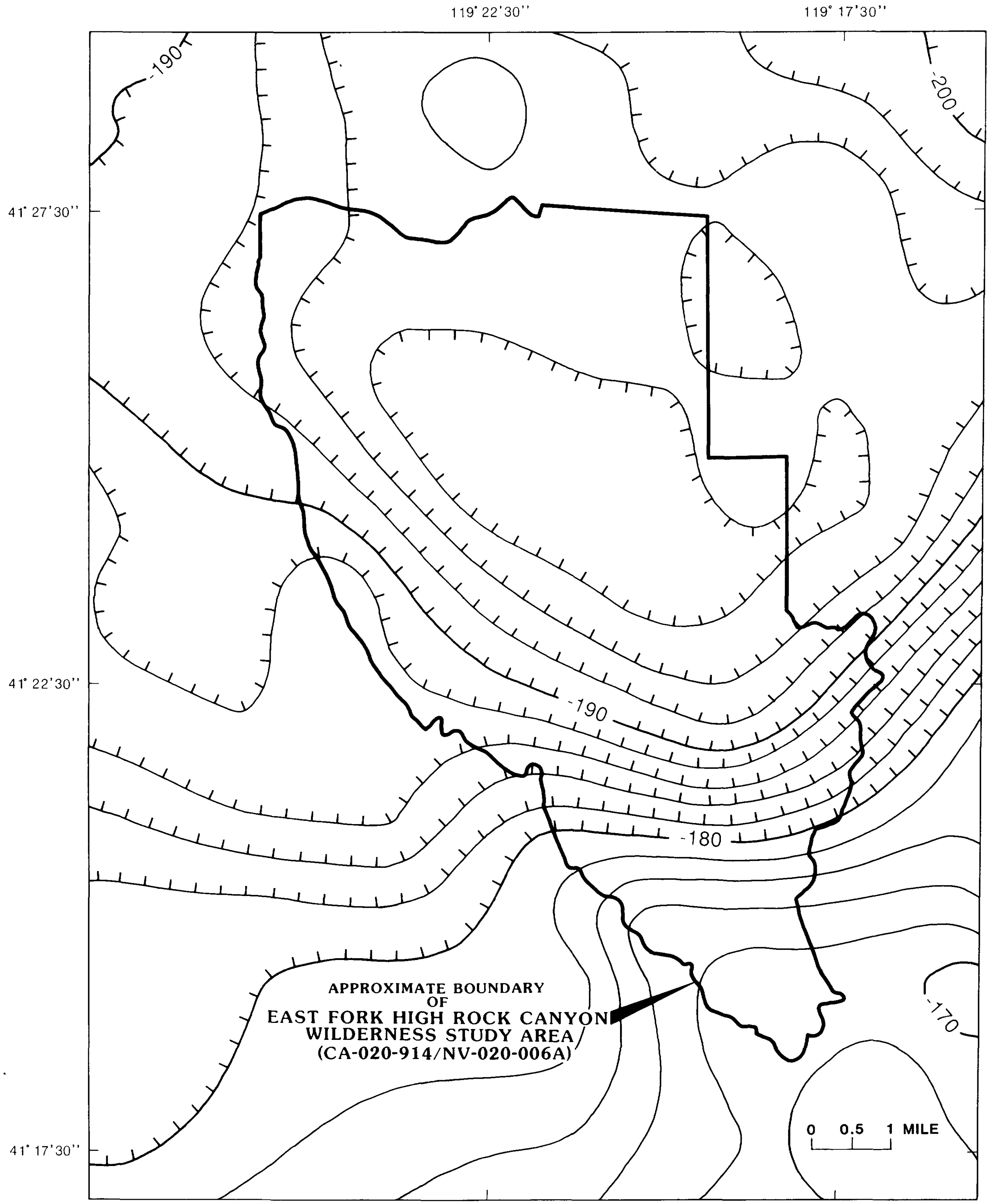

Figure 3. Gravity map of the East Fork High Rock Canyon Wilderness Study Area, Washoe and Humboldt Counties, Nevada. Values in milligals; contour interval 2 milligals; hachured in direction of gravity low.

are needed to account for the 22-mGal amplitude of the gravity low (Nettleton, 1940, p. 112). The observed gravity gradient of 7.5 mGal/mi in the southern part of the study area exceeds a gradient of 6.4 mGal/mi calculated for a model of a vertical caldera wall that extends to the surface (Nettleton, 1940, p. 112). Since the proposed caldera is not exposed at the surface, three possibilities could explain this higher-than-expected gradient: (1) the south wall may dip somewhat southward from vertical; (2) the density contrast between the underlying former magma reservoir and surrounding basement rocks may contribute to the amplitude of the anomaly; or (3) the rocks beneath a gravity high to the south (Keith and others, 1987) are denser than Tertiary volcanic rocks in the basement on other sides of the caldera. The gravity increase to the southwest is only 8 mGal, compared to the 22-mGal increase to the south. This smaller increase could be due to less relief on the caldera margin (calculated at 2,100 ft) or deeper burial of the caldera margin in this area.

Geochemical Studies

A reconnaissance geochemical investigation of the study area was made using samples of stream sediment, the nonmagnetic fraction of heavy-mineral concentrates from stream sediments, and rock. The stream-sediment and concentrate samples contain material derived from major rock units of the drainage basins within the study area. Sampled drainage basins range in area from less than one to several square miles.

Forty-three stream-sediment samples, 43 heavy-mineral-concentrate samples, and 86 rock samples were analyzed for 31 elements by six-step semiquantitative emission-spectrographic methods (Myers and others, 1961; Grimes and Marranzino, 1968), with additional analyses by atomic-absorption spectroscopy and inductively coupled argon plasma-atomic emission spectroscopy. These analyses identify drainages that have anomalously high concentrations of metallic and metal-related elements. For this study, anomalous geochemical values were determined by inspection of histograms of the data from both the study area and the surrounding region and by comparing the data to the average abundances in silicic volcanic rocks. For most elements, a value was considered anomalous if it exceeded the mean value for the element by two standard deviations.

In the northwestern and northern parts of the study area, stream-sediment, heavy-mineral-concentrate, and rock samples all have anomalously high concentrations of arsenic. Samples of altered rock and chalcedony in this area show high concentrations of arsenic but only slight, if any, anomalies in their concentrations of mercury, antimony, molybdenum, cadmium, and zinc.

Data from Barringer Resources, Inc. (1982), indicates that stream sediments in the eastern part of the study area have anomalously high concentrations of barium. No other geochemical anomalies and no visibly altered rocks were observed in this part of the study area, making a hydrothermal origin for these anomalies unlikely. These anomalies may reflect high levels of barium in the andesite to dacite flows (J.A. Ach, unpub. data, 1986).

Previous regional uranium surveys, which included aerial gamma-ray emission studies (Geodata International, Inc., 1979), found no indications of uranium or thorium concentrations near the study area. Available stream-sediment data (Barringer Resources, Inc., 1982) show only very slight, scattered anomalies of uranium and (or) thorium, supporting these previous conclusions.

Mineral and Energy Resources

The investigations by the U.S. Geological Survey and the U.S. Bureau of Mines indicate that the East Fork High Rock Canyon Wilderness Study Area has two areas of moderate resource potential for gold and silver in epithermal or hydrothermal deposits and mercury in epithermal deposits, certainty level C. The resource potential for zeolites is moderate with a B certainty level. The resource potential for geothermal energy is low, with a C certainty level. The resource potential for petroleum and natural gas is unknown (certainty level A), but their occurrence within the study area is very unlikely.

The potential for gold, silver, and mercury in the parts of the study area near Yellow Rock Canyon and in the Yellow Hills (fig. 2) is indicated by arsenic anomalies and scattered lesser anomalies of mercury, molybdenum, cadmium, antimony, and zinc. In the areas where these anomalies are present, the pumiceous air-fall tuff is altered to a mustard-yellow color or has partially silicified zones containing chalcedony veins. Together, the geochemical anomalies and the alteration suggest probable former hydrothermal activity in these areas.

Anomalously high values for arsenic, antimony, molybdenum, and mercury are often associated with epithermal hot-spring type gold-silver mineralization (Bonham and Giles, 1983; Bonham and Tingley, 1984), epithermal silver-gold mineralization of the low-sulfur type (Bonham, 1984; Bonham and Tingley, 1984), or epithermal mercury mineralization (Rytuba and Glanzman, 1979), all of which occur in silicic volcanic and volcaniclastic host rocks. Important mineral deposits of these types are usually associated with the complex structures and features found in volcanic eruptive centers. These structures and features include strongly persistent fracture systems, especially caldera-related ring fractures and grabens, and volcanic domes and plugs in complexly faulted areas (Berger, 1982). Although few mineral deposits are directly caldera related (McKee, 1979; Raul Madrid, oral commun., 1987), caldera ring fractures, as considered possible in this study area, may form a permissive environment for epithermal deposits. Examples of epithermal deposits located within caldera systems are the Round Mountain, Nev., gold deposit (Bonham and Tingley, 1984), the Creede, Colo., silver-gold base-metal deposits (Barton, 1982), and the mercury, uranium, and lithium deposits found at McDermitt, Ore. (Rytuba, 1976).

Accumulations of zeolites are found in the mustard-yellow altered part of the pumiceous air-fall tuff in Yellow Rock Canyon (Turrin and others, in press), where five samples analyzed by the U.S. Bureau of Mines contain 55 to 80 percent clinoptilolite, a zeolite mineral (Scott, 1987; Turrin and others, in press). A similarly altered part of this tuff extends into the study area. Therefore the mineral resource potential for zeolites in this part of the study area is considered moderate with a certainty level B.

Small sand and gravel deposits suitable for construction use are present in the study area but are too small to a constitute resource. No undiscovered sand and gravel resources are expected beyond known deposits.

For this study, the resource potential for petroleum and natural gas is considered unknown, certainty level A. Geologic data indicate a low probability for the occurrence of petroleum and natural gas in the Cenozoic rocks of the wilderness study area. Evidence for hydrocarbon potential is negligible; the volcanic rocks and the limited lacustrine sedimentary strata immediately underlying the study area might possibly include suitable reservoir rocks, but lack hydrocarbon source beds. The nature of the basement rocks is conjectural, however. Sandberg (1983) considers the area to have "zero petroleum potential" because widespread Miocene volcanism and geothermal heating rendered the area too thermally mature for the formation of hydrocarbons.

Geothermal energy resource potential for the study area is low with a C certainty level. No evidence of recent geothermal activity in the study area has been found, but several hot springs exist 5 mi east of the study area in the Soldier Meadow Known Geothermal Resource Area. Previous regional geothermal surveys have not indicated any geothermal potential for the area (Muffler, 1979; Reed, 1983).

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APPENDIXES

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

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.

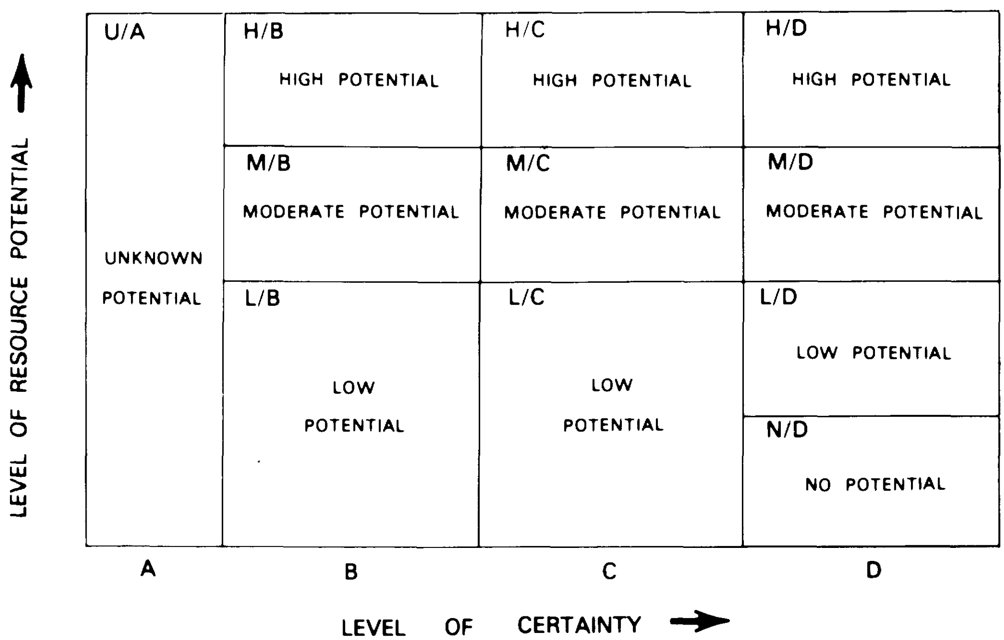
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate reasonable likelihood of resource accumulation, and (or) where an application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

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RESOURCE/RESERVE CLASSIFICATION

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

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

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err and others—MINERAL RESOURCES, EAST FORK HIGH ROCK CANYON WILDERNESS STUDY AREA, NEVADA—U.S. Geological Survey Bulletin 1707-B