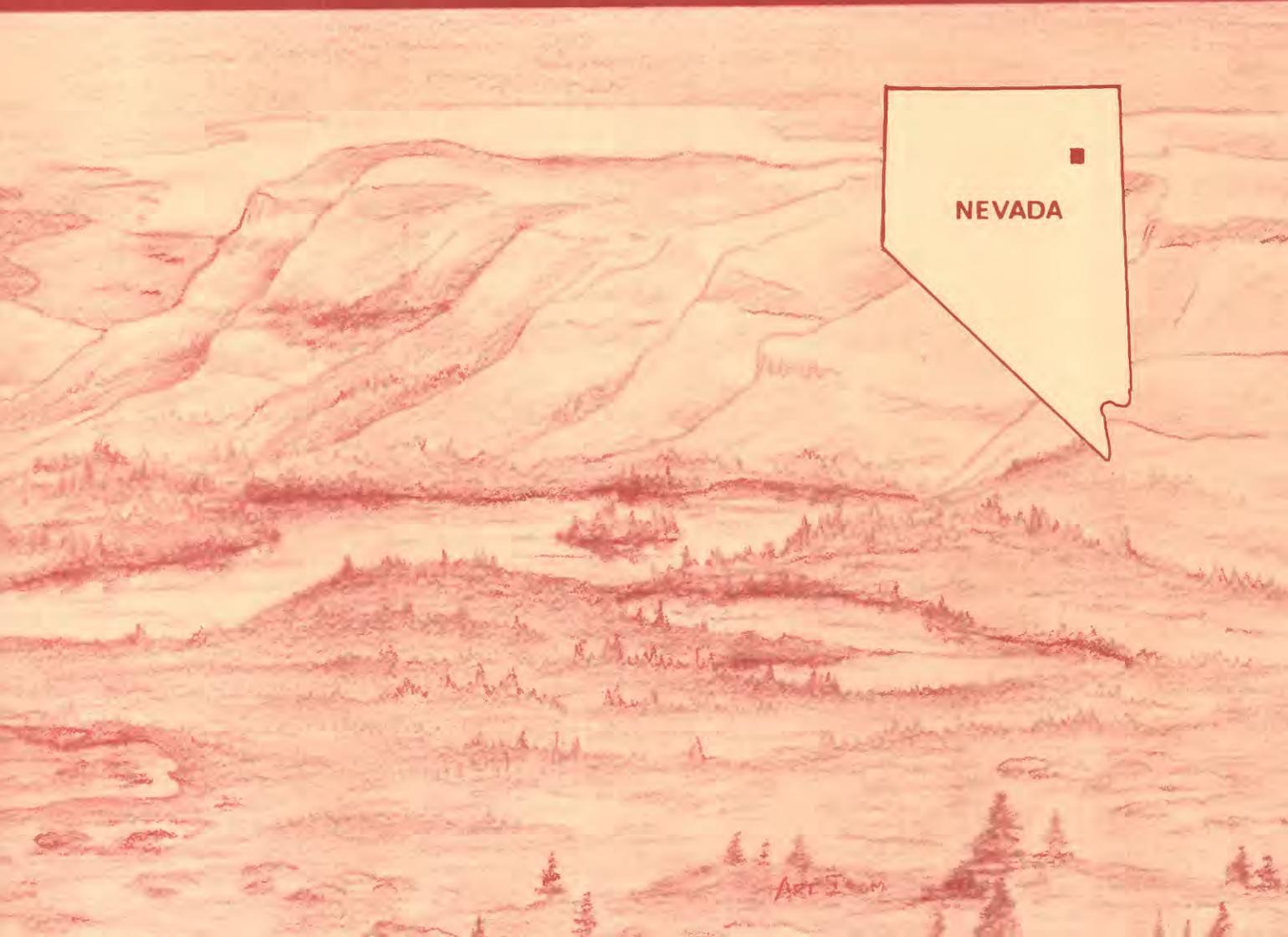


Mineral Resources of the Goshute Canyon Wilderness Study Area, Elko and White Pine Counties, Nevada



U.S. GEOLOGICAL SURVEY BULLETIN 1725-E



Chapter E

Mineral Resources of the Goshute Canyon Wilderness Study Area, Elko and White Pine Counties, Nevada

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
NORTHEASTERN NEVADA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary



U. S. GEOLOGICAL SURVEY
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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 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 a part of the Goshute Canyon (NV-040-015) Wilderness Study Area, Elko and White Pine Counties, Nevada.

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PLATE

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1. Map showing mineral resource potential and geology of the Goshute Canyon Wilderness Study Area

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Mineral Resources of the Goshute Canyon Wilderness Study Area, Elko and White Pine Counties, Nevada

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Howard W. Oliver
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ABSTRACT

The U.S. Geological Survey and the U.S. Bureau of Mines conducted investigations to appraise the identified resources (known) and assess the mineral resource potential (undiscovered) of 22,225 acres of the Goshute Canyon (NV-040-015) Wilderness Study Area, Elko and White Pine Counties, Nev. (fig. 1). There are no identified resources in the study area. The study area has moderate mineral resource potential for gold, silver, antimony, copper, lead, zinc, and tungsten in and near jasperoid replacement bodies (fig. 2). The rest of the study area has low mineral resource potential for the same metals. The study area has low energy resource potential for coal, oil and gas, uranium, and geothermal energy.

SUMMARY

The Goshute Canyon Wilderness Study Area is in the central Cherry Creek Range about 50 mi (miles) north of Ely, Nev., which is the nearest population center (fig. 1). Graded gravel and dirt roads lead to the study area from the small communities of Cherry Creek on the south and Currie on the north (fig. 1). The central Cherry Creek Range is an 18-mi-long by 6-mi-wide tilted fault-block range flanked by Steptoe and Butte Valleys on the east and west sides, respectively. Elevations within the study area range between 5,940 and 10,275 ft (feet) (1,810 and 3,132 m (meters)).

The central Cherry Creek Range is underlain by a west-dipping section of carbonate rocks and lesser amounts of shale and quartzite of Cambrian through Pennsylvanian age (see geologic time chart in Appendix). Notable geologic structures in the area include: (1) a thrust-fault system in the

southwestern part of the area along which the Mississippian Chainman Shale overlies older Mississippian Joana Limestone or Devonian Guilmette Limestone; (2) a northwest-trending oblique-slip fault system that crosses the range along the southern margin of the area; (3) a series of arcuate faults in the eastern part of the area that moved large blocks of Paleozoic rocks downward toward Steptoe Valley; and (4) a major normal fault system along the east side of the range.

No significant mining activity has occurred within the Goshute Canyon Wilderness Study Area; however, about 100 claims have been located, mainly at five prospects. A few precious (gold and silver)- and base (copper, lead, and zinc)-metal anomalies occur and are restricted to jasperoid replacement bodies and associated rocks at and near the prospects. Metal concentrations of as much as 1 ppm (parts per million) gold, 10 ppm silver, 100 ppm antimony, 100 ppm copper, 70 ppm lead, 7,000 ppm zinc, and 200 ppm tungsten were found in jasperoid replacement bodies and associated rocks within the study area. Numerous thin dikes and sills of probable Tertiary age intrude the Paleozoic section throughout the area, but they contain no significant metal anomalies. These dikes and sills suggest that plutonic rocks occur beneath the central Cherry Creek Range, which may have been the source of metal-bearing hydrothermal fluids in the jasperoids. There is moderate resource potential for undiscovered resources of gold, silver, antimony, copper, lead, zinc, and tungsten in and near jasperoid replacement bodies in the study area. The mineral resource potential for these metals in the rest of the area is low.

Lenticular beds of bituminous coal occur within the Scotty Wash Quartzite on the west side of the Cherry Creek

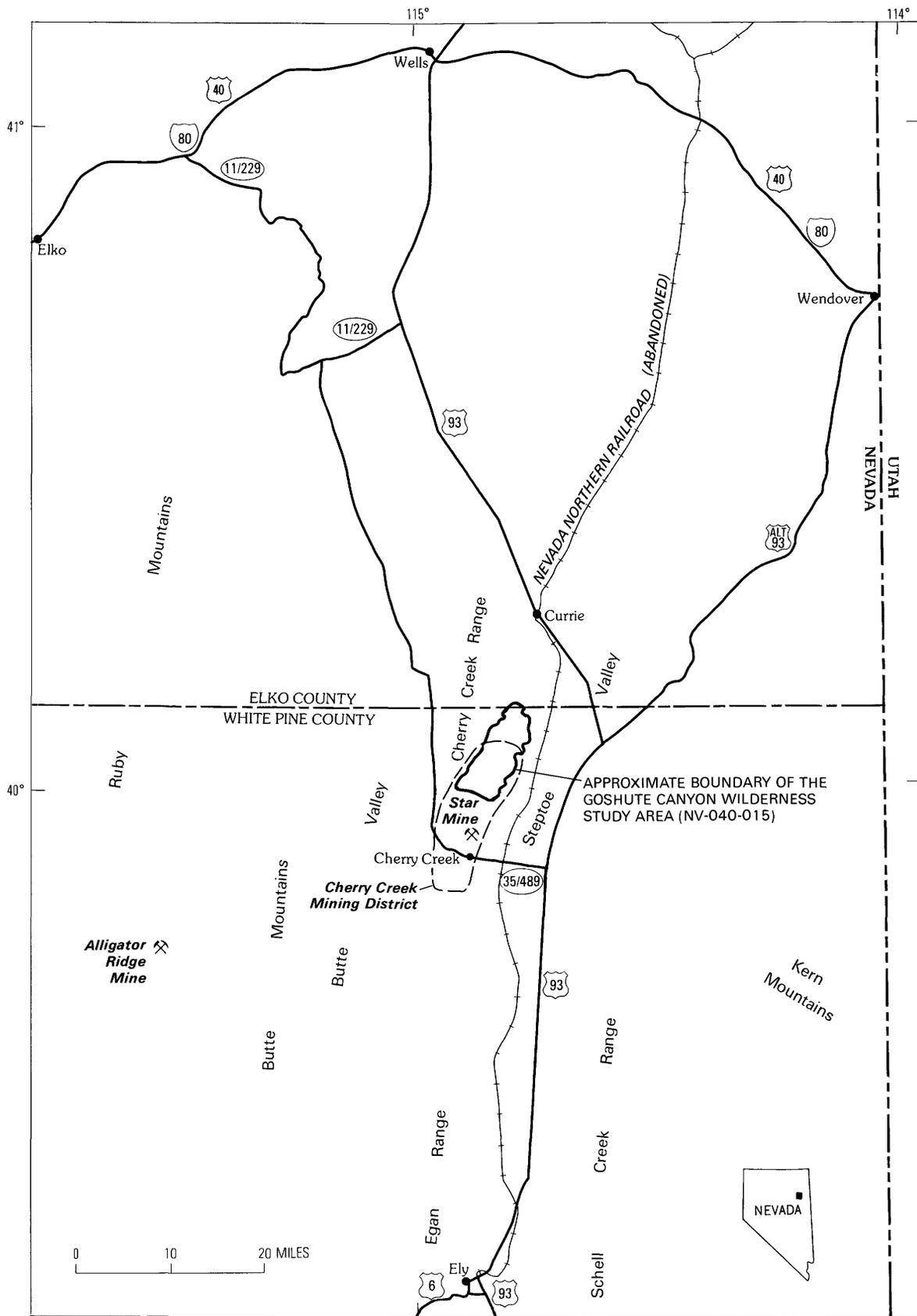
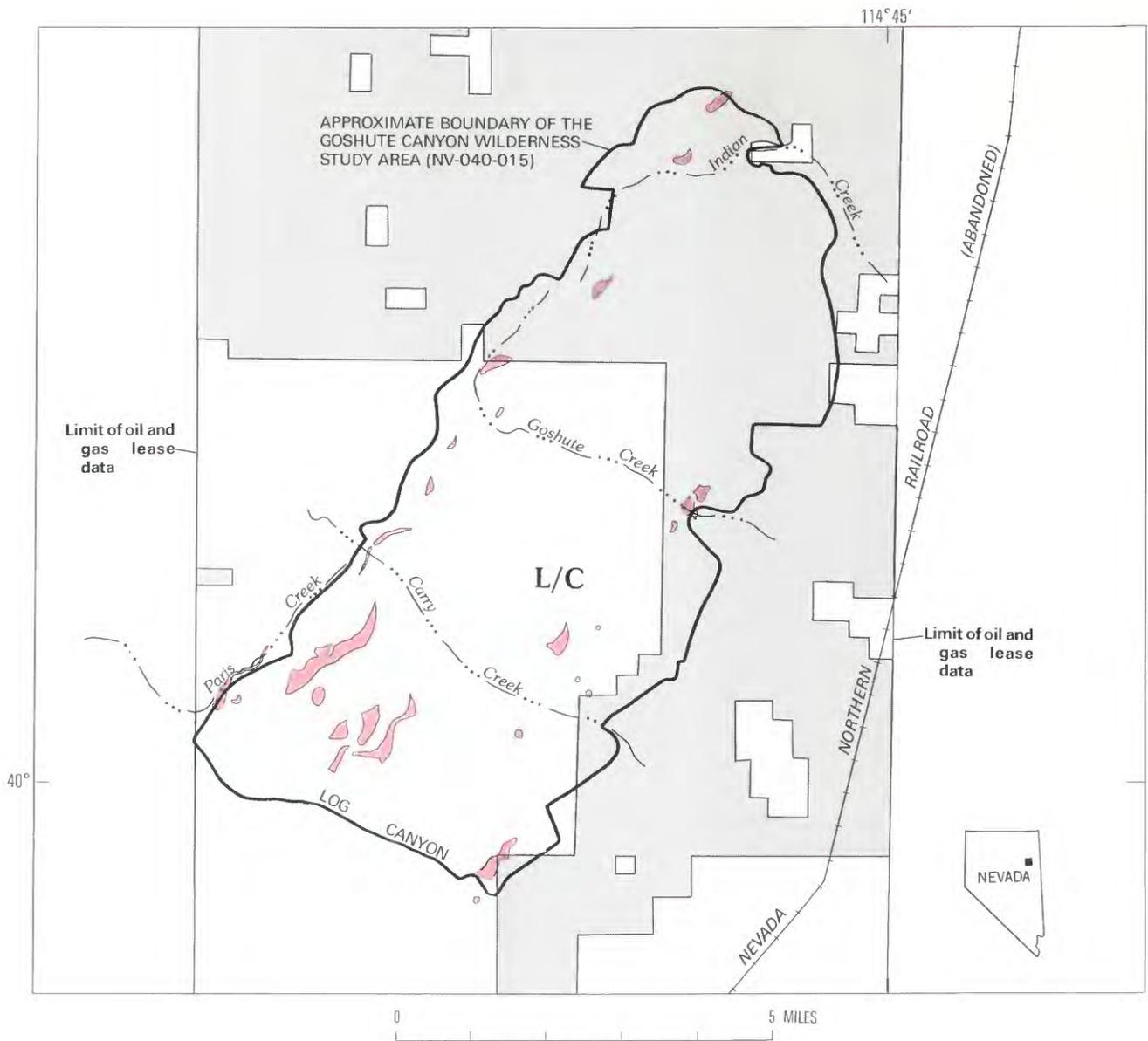


Figure 1. Index map showing location of the Goshute Canyon Wilderness Study Area, Elko and White Pine Counties, Nevada.



EXPLANATION

M/C	Geologic terrane having moderate mineral resource potential for antimony, copper, gold, lead, silver, tungsten, and zinc, with certainty level C
L/C	Geologic terrane having low mineral resource potential for antimony, copper, gold, lead, silver, tungsten, and zinc (except as noted above), and low energy resource potential for coal, oil and gas, uranium, and geothermal energy, all with certainty level C—Applies to entire study area
	Area of oil and gas leases
LEVEL OF CERTAINTY	
C	Data indicate geologic environment, indicate resource potential, but do not establish activity of resource-forming processes

Figure 2. Map showing mineral-resource potential of the Goshute Canyon Wilderness Study Area, Elko and White Pine Counties, Nevada.

Range just outside the study area, but the formation does not occur within the study area. The Chainman Shale, which

crocks out along the western margin of the study area, is a principal source rock for petroleum in several oil fields in

eastern Nevada. However, organic geochemical data obtained from samples of Chainman Shale in the central Cherry Creek Range indicate that rock temperatures have been high enough to mature the organic matter in the Chainman and to exceed the oil and gas generation stage. Significant near surface uranium anomalies and geothermal activity were not detected in the study area. Energy resource potential for coal, oil and gas, uranium, and geothermal energy is low within the study area.

INTRODUCTION

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

The USGS and the USBM studied mineral resources and the mineral- and energy-resource potential of 22,225 acres of the 30,585-acre Goshute Canyon Wilderness Study Area (NV-040-015) in Elko and White Pine Counties, Nev. (fig. 1), at the request of the BLM (U.S. Bureau of Land Management). In this report, the area studied is referred to as the "wilderness study area" or the "study area." Field studies of the area were conducted during the summer of 1983 and spring and summer of 1986 by USGS geologists, geochemists, and geophysicists, and during the summer of 1985 by USBM geologists.

The study area is in the central Cherry Creek Range about 50 mi north of Ely and 68 mi south of Wells. Graded gravel and dirt roads from the small communities of Cherry Creek on the south and Currie on the north provide access to the study area. Nevada Route 35/489 leads west from U.S. Highway 93 to Cherry Creek (fig. 1). The Cherry Creek Range, like other ranges in the Basin and Range physiographic province, rises steeply from sagebrush-covered playa-lake valleys. The range itself is moderately forested with piñon pine and juniper trees. Some groves of aspen, mountain mahogany, white fir, limber pine, and lodgepole pine occur in moist areas at higher elevations, and belts of cottonwood trees occur along streams at lower elevations. Elevations within the study area range from about 5,940 to 10,275 ft (1,810 to

3,132 m). Base map elevations and topographic contours are in meters (pl. 1). Access to the study area is by a few rough jeep trails and on foot.

Personnel of the USBM made a literature search in which mining, mineral-lease, and mining-claim information were compiled. Field work by USBM personnel consisted of examination of prospects and mines in and around the study area. Accessible mine workings were mapped, and mineralized areas and mine dumps were sampled. Detailed descriptions of analytical procedures and results are in Johnson (1986). Copies are available from the U.S. Bureau of Mines, Western Field Operations Center, E. 360 Third Avenue, Spokane, WA 99202.

Personnel of the USGS collected stream-sediment and heavy-mineral concentrate samples from 22 drainages in and around the study area which represent the rocks within the drainage basin upstream from each sample locality. The stream-sediment samples and the nonmagnetic fraction of panned heavy-mineral concentrate were analyzed. Detailed descriptions of analytical procedures and results are in Tucker and others (1984).

Existing 1:250,000-scale geologic mapping of White Pine County (Hose and others, 1976) was examined, and a photogeologic study of the area was conducted prior to field work by USGS personnel. Geologic mapping techniques appropriate to preparation of a 1:24,000-scale geologic map (pl. 1) were employed. Outcrops were examined for signs of mineralized rock. During mapping, 67 samples of selected rock units were collected for petrographic examination and for analysis for specific elements.

The mineral-resource potential of the Goshute Canyon Wilderness Study Area described here is based on data from many sources. Among these are the study of geology and mineral deposits of White Pine County (Hose and others, 1976), a reconnaissance study of mineral resources in the study area (Great Basin Geology-Energy-Minerals Joint Venture, 1983), geophysical studies of the Elko and Ely 1° × 2° quadrangles (Saltus, in press; Hildenbrand, in press), a study of identified mineral resources by the Bureau of Mines (Johnson, 1986), a geochemical study of stream-sediment samples by Tucker and others (1984), a study of the geology of the Goshute Canyon area (Poole and Elrick, this report), an evaluation of coal and petroleum potential (Poole, this report), an interpretation of gravity and aeromagnetic data (Harris and Glen, 1986; Harris and Oliver, this report), and an interpretation of radiometric data (J.S. Duval, U.S. Geological Survey, written commun., 1987).

Acknowledgments.—Don Witter, exploration geologist, provided information about rock formations, alteration, and mineral deposits in the study area.

APPRAISAL OF IDENTIFIED RESOURCES

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Mining History

The Cherry Creek mining district, organized in 1872, extends from Egan Canyon, 3 mi southwest of the old mining town of Cherry Creek (fig. 1), north to Goshute Creek (Hill, 1916), in the central part of the study area. However, all known production is from mines south of the Goshute Canyon Wilderness Study Area. The town of Cherry Creek (6.5 mi south of the study area) was established in 1873, and by 1878 a 10-stamp mill was operating at the nearby Star mine (Hose and others, 1976). The district was most active between 1872 and 1883, producing gold and silver and minor amounts of copper and lead. During this time period, the population of Cherry Creek grew to about 6,000 (Hill, 1916). In 1884, mining activity began to decline and practically ceased with the demonetization of silver in 1893.

Estimates of the value of production from the district prior to 1916 range from \$6 to \$20 million (Hill, 1916). Base (copper, lead, and zinc) and precious (gold and silver) metal production since then has been sporadic and relatively small. Tungsten was discovered in 1915, but the principal production occurred from 1940 through 1958. Total production during this period is estimated at more than 30,000 short-ton units WO_3 (600,000 pounds) (Hose and others, 1976).

Moderate exploration activity has occurred in the Goshute Canyon Wilderness Study Area. A search of White Pine County and BLM mining records reveals that about 100 claims were located in the study area. No recent mining claims have been filed. Many of the descriptions for the old claims are vague and many more claims may have been located. For example, claim corners and prospect pits were found in areas not previously known to have been claimed.

American Selco, Inc. (Amselco), located 77 claims on the Snowdrift prospect during 1979 and 1980 in the southwest part of the study area to explore for hot-spring-type, large-tonnage, low-grade gold deposits, similar to the Alligator Ridge mine (fig. 1) 35 mi to the southwest. Exploration included geologic mapping, geochemical sampling, and drilling. During 1980, 17 holes, totalling 3,415 ft, were drilled. Results of the exploration were not encouraging, and the claims were subsequently dropped.

At this time, the only known exploration activity consists of oil and gas leases that extend into the northern and western part of the study area (fig. 2).

Prospects, Claims, and Mineralized Areas

Four major stratigraphically controlled jasperoid-silica zones within the study area have features similar to some low-grade, bulk-tonnage replacement ores at past and presently producing mines. These discontinuous jasperoids locally replace both limestone and limy shale along the base of the Chainman, Pilot, Kanosh, and Dunderberg Shales (pl. 1). The only mappable jasperoid at the base of the Kanosh Shale occurs on the ridge between Carry Creek and Flat Canyon. The Snowdrift, Buena Vista, Lucky No. 13, and Bullionaire prospects are located on one or more of the three main jasperoid zones. Several minor low- and high-angle faults within the lower Pogonip Group and the Raiff Limestone also contain podlike bodies of jasperoid. Four samples taken from silicified areas in the lower Pogonip Group north and south of Carry Creek assayed 0.02–0.52 ppm gold and 39–240 ppm arsenic. These concentrations are significant, but the silicified zones are not extensive.

Snowdrift prospect.—Amselco's exploration program focused on the lower Pilot Shale and the uppermost Guilmette Limestone in an area where high-angle faults have duplicated the stratigraphic section (pl. 1). Jasperoid bodies crop out locally along the contact of these formations and also along the Chainman Shale-Joana Limestone contact. Although these jasperoids are similar, Amselco personnel believe that the Pilot Shale is a better host for gold mineralization than the Chainman Shale. This may be due partly to a higher clay content and corresponding lower permeability in the Chainman Shale. Both contacts were sampled during the study.

Seventy-three rock samples were taken in the Snowdrift prospect area. Forty-six (63 percent) contain gold, 29 (40 percent) contain silver, 26 (36 percent) contain anomalous amounts of arsenic (>50 ppm (parts per million)), and 9 (12 percent) contain mercury. Maximum elemental concentrations are 0.35 ppm gold, 10.13 ppm silver, 4,700 ppm arsenic, and 9 ppm mercury.

The Chainman Shale-Joana Limestone and Pilot Shale-Guilmette Limestone contacts were also sampled north of the Snowdrift prospect. Of the 16 samples taken along the Chainman Shale-Joana Limestone contact, 7 (44 percent) contain gold, 8 (50 percent) contain silver, and 6 (38 percent) contain anomalous amounts of arsenic (>50 ppm); none contain mercury. Of the 22 samples taken along the Pilot Shale-Guilmette Limestone contact, 4 (17 percent) contain gold, 4 (17 percent) contain silver, 5 (22 percent) contain anomalous amounts of arsenic (>50 ppm), and 1 (4 percent) contains mercury. Maximum concentrations for all 38 samples are 0.65 ppm gold, 1.74 ppm silver, 4,000 ppm arsenic, and 2 ppm mercury.

Buena Vista prospect.—The Buena Vista prospect area, in the northern part of the study area, is underlain by the Mississippian Chainman Shale and Joana Limestone (pl. 1). Eight prospect pits and one 6-ft-long adit are at the base of the Chainman Shale in this area. The workings generally expose zones of jasperoid, hematitic-limonitic gossan, and silicified breccia. Although the zones may be as much as 10 ft thick in places, they generally are less than 3 ft thick and discontinuous. Of the 18 samples collected along the Chainman Shale-Joana Limestone contact, 9 (50 percent) contain gold, 13 (72 percent) contain silver, and 11 (61 percent) contain anomalous amounts of arsenic (> 50 ppm); none contain mercury. Maximum concentrations are 0.06 ppm gold, 2 ppm silver, and 170 ppm arsenic. One sample taken from a zone of silicified, brecciated sandstone in the lower Scotty Wash Quartzite near the head of Dry Canyon contained 0.03 ppm gold.

Lucky No. 13 prospect.—This prospect area is along the east front of the Cherry Creek Range near the mouth of Goshute Creek at and near the contact between the Cambrian Dunderberg Shale and Raiff Limestone (pl. 1). Here the Dunderberg Shale consists of medium- to dark-gray shaly mudstone and argillized limy siltstone with very thin beds of nodular limestone and silty limestone. The Raiff Limestone consists of thick-bedded, light- to medium-gray limestone and dolomitized limestone that is locally metamorphosed to marble and is also brecciated. Jasperoid bodies are in both formations. Dolomite-healed breccia, silica stockworks, and blebs of silicified dolomite also are associated with the jasperoid bodies. The contact between the Dunderberg and Raiff is covered by alluvium north and south of the prospect area. Seven old prospect pits were found. Of the 17 samples collected, 11 (65 percent) contain gold, 6 (35 percent) contain silver, 7 (41 percent) contain anomalous arsenic (> 50 ppm), and 4 (24 percent) contain mercury. Maximum assay concentrations are 0.07 ppm gold, 3.87 ppm silver, 1,350 ppm arsenic, and 20 ppm mercury.

Bullionaire prospect.—The Bullionaire prospect area, located along the east front of the Cherry Creek Range north of the lower part of Log Canyon, is also in jasperoid at the base of the Dunderberg Shale and the top of the Raiff Limestone (pl. 1). There, the jasperoid contains angular fragments of light-colored silicified Raiff Limestone and argillized Dunderberg Shale. The overlying Dunderberg Shale has argillic alteration where adjacent to the jasperoid. The jasperoid, which is as much as 100 ft thick, occurs discontinuously along the contact for about 4,000 ft and is terminated at both the north and south ends by major faults (pl. 1). Of the 10 samples taken from the jasperoid zone, 9 (90 percent) contain gold, 8 (80 percent) contain silver, and 2 (20 percent)

contain anomalous amounts of arsenic (> 50 ppm); none contain mercury. Maximum assay concentrations are 0.07 ppm gold, 1.29 ppm silver, and 110 ppm arsenic.

Crown Point prospect.—The Crown Point prospect consists of three bulldozer trenches about 0.5 mi south of the mouth of Flat Canyon at the eastern base of the Cherry Creek Range (pl. 1). The trenches are as long as 85 ft and as much as 8 ft deep, but expose no bedrock. Selected fragments of jasperoid breccia from the alluvium in and near the workings contained a maximum of 0.11 ppm gold and 430 ppm arsenic; no silver or mercury were detected. A random chip sample of silicified shale, taken from an outcrop above the workings, contains 0.02 ppm gold, 0.52 ppm silver, but no detectable arsenic or mercury. The silicified zone, which is localized along a bedding surface, is discontinuous and averages less than 2 ft in thickness. This zone appears to be in the lower Pogonip Group and is probably not the source of the jasperoid breccia fragments sampled in and near the workings.

Goshute Cave prospect.—Goshute Cave, a natural limestone cavern more than 1,000 ft long, is located in Lower Ordovician limestone about 1.2 mi north from the mouth of Goshute Creek (pl. 1). Bat guano in the cave was claimed by Mr. Keith Hinose for its value as a phosphate resource in 1951, but probably less than 100 cubic yards of impure guano was present at the time of this study.

Extensive sand and gravel, and stone occurrences in the study area are probably suitable for many construction purposes; however, transportation costs for these high-bulk and low-unit value commodities would push total production costs far beyond their current market value and they are not classified as an identified resource. Adequate material is available closer to existing markets in the region.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

**By Forrest G. Poole, Maya Elrick,
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Howard W. Oliver
U.S. Geological Survey**

Geology

The study area in the central Cherry Creek Range is underlain by a northwest-dipping homoclinal section of Paleozoic sedimentary rocks, of which the oldest are on the eastern side of the range and the youngest are on the

western side (pl. 1). The oldest rocks exposed in the study area include the Cambrian Monte Neva Formation, Raiff Limestone, and Dunderberg Shale. A thick section of Cambrian to Ordovician limestone with lesser amounts of shale overlies the Dunderberg Shale and underlies the Ordovician Eureka Quartzite. The Eureka Quartzite is overlain by a thick section of Ordovician to Devonian dolostone, Devonian limestone and shale, Mississippian limestone, siltstone, shale, and quartzite, and Pennsylvanian limestone. Discontinuous, tabular to lenticular bodies of jasperoid of undetermined age, probably Cretaceous or Tertiary, occur at the base of major shale units throughout the study area. Silicification by rising hydrothermal fluids resulted in alteration of limestone and limy shale to hard, dense, varicolored jasperoid that stands out in strong relief from the surrounding terrain. Numerous thin monzogranite dikes and sills of probable Tertiary age intrude the Paleozoic section throughout the study area. The dikes and sills are probably related to an unexposed pluton beneath the Cherry Creek Range.

The main structures in the area consist of four fault systems (pl. 1): (1) a low-angle thrust system in the southwestern part of the study area, which placed Mississippian Chainman Shale over Mississippian Joana Limestone and Devonian Guilmette Limestone and locally Joana Limestone over Chainman Shale; (2) the northwest-trending, high-angle, transverse Log Canyon fault system that offsets the Paleozoic section both vertically and horizontally and crosses the range along the southern margin of the study area; (3) a series of arcuate high- to low-angle concave- to convex-shaped faults of probable gravity-slide origin in the eastern part of the study area that moved large blocks of Paleozoic rocks downward toward Steptoe Valley; and (4) a system of northeast- to north-trending, high-angle faults that bound the eastern and southwestern parts of the range. Displacement along many high-angle faults has caused small-scale stratigraphic offsets within the sedimentary rocks and older alluvial deposits that could not be shown at the map scale. Small outcrops of sheared Chainman Shale and blocks of Mississippian Scotty Wash Quartzite occur in the range-front fault zone about 1,000 ft north of the mouth of Log Canyon (pl. 1) and suggest a vertical displacement in excess of 3,000 ft. The position of another major range-front fault separating the Cherry Creek Range block on the west from the Steptoe Valley block on the east may be as much as 2 mi east of the mapped range-front fault as suggested by a major horizontal gradient on the gravity map (fig. 3). This difference in position of the range-front fault does not affect assessment of the mineral resource potential of the area.

Geochemistry

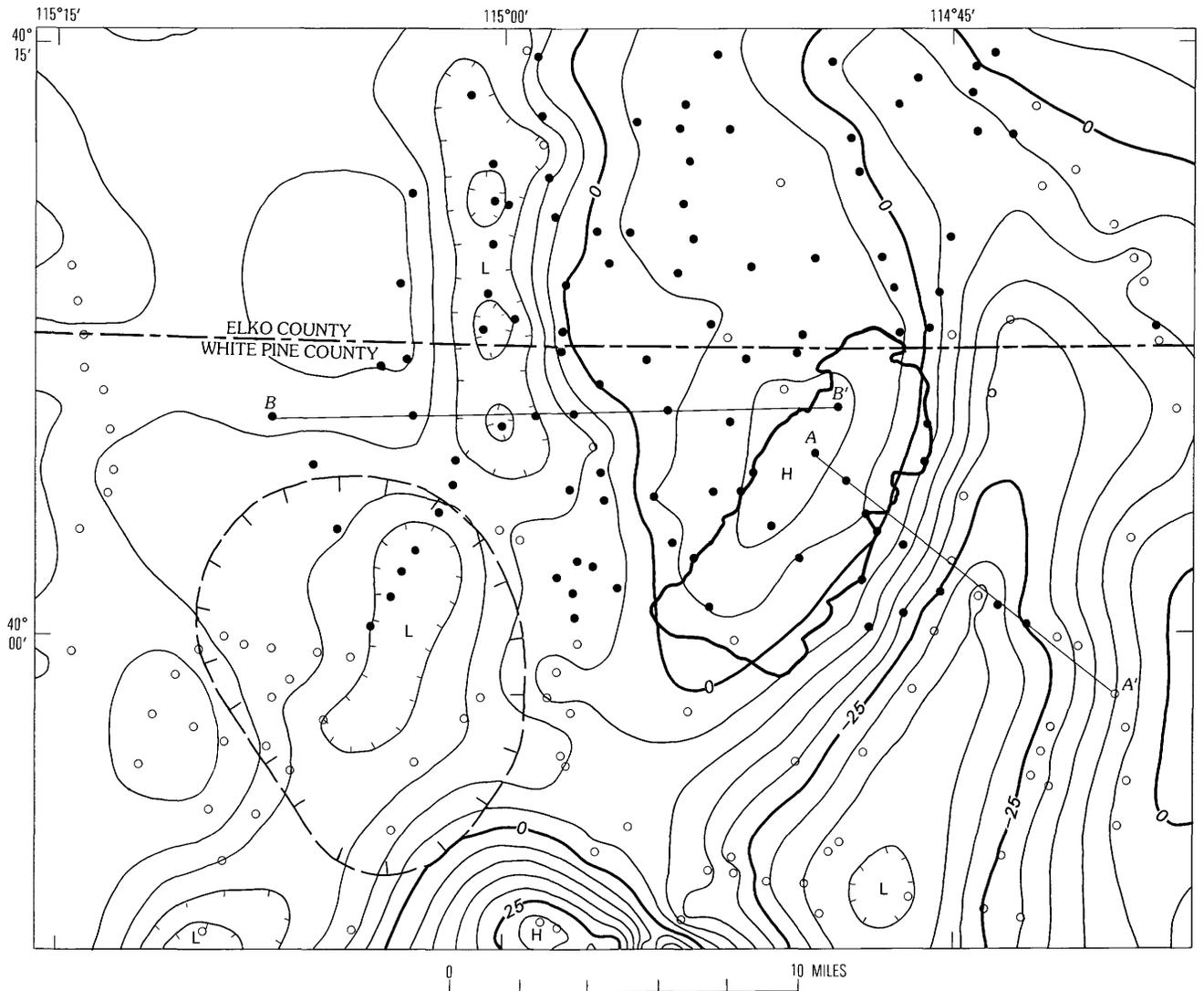
Sixty-seven samples of variably mineralized rock were collected from outcrops during geologic mapping of the Goshute Canyon Wilderness Study Area. Semiquantitative spectrographic, atomic absorption, and chemical analyses of these samples indicate that the discontinuous but widely distributed jasperoid replacement deposits in the study area contain nominally to highly anomalous concentrations of antimony, arsenic, barium, chromium, copper, gold, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, tungsten, vanadium, yttrium, zinc, and zirconium. The distribution and magnitude of these anomalous values are highly erratic within the mineralized rock. Similarly analyzed, unmineralized samples collected within the study area lack anomalous values. Metal concentrations as much as 1 ppm gold, 10 ppm silver, 100 ppm antimony, 100 ppm copper, 70 ppm lead, 7,000 ppm zinc, and 200 ppm tungsten were found in rocks collected within the study area.

Heavy-mineral concentrates were panned from 22 samples of stream sediment collected in the major drainages of the study area. Semiquantitative spectrographic analysis of the nonmagnetic fraction of the panned concentrates (Tucker and others, 1984) show only a few anomalous values and imply that undiscovered mineralized rock does not crop out in the study area. In general, elemental abundances in most of these samples approach the average abundances in unaltered carbonate rocks (Turekian and Wedepohl, 1961). However, copper, gold, lead, silver, tungsten, yttrium, and zinc values in 10 of the samples are high relative to average unaltered carbonate rock, and they show correlated covariation. The lack of spatial relationship and correlation with bedrock lithology precludes definitive interpretation of these data, and their anomalous character may not be meaningful. The anomalous values in several of these stream-sediment concentrate samples are comparable in type and magnitude to those in some jasperoids in the study area. Alternatively, some of the anomalous values may be a function of metal adsorption by oxide minerals during secondary weathering and soil-forming processes.

Geophysics

Gravity and Aeromagnetic Data

The wilderness study area is included within regional gravity and aeromagnetic surveys of the Elko and Ely 1°x 2° quadrangles. Gravity data for the study area were obtained from a preliminary regional gravity map by Saltus (in press) and from an updated gravity



EXPLANATION

- | | | | |
|---|---|-----|--|
| — | Gravity contour —Contour interval 5 milligals; hachures point in direction of lower gravity | L | Gravity low |
| ○ | Gravity station —Previously obtained by U.S. Geological Survey and U.S. Defense Mapping Agency | — — | Inferred caldera margin |
| ● | Gravity station —This study | — | Approximate boundary of Goshute Canyon Wilderness Study Area (NV-040-015) |
| H | Gravity high | | |

Figure 3. Isostatic residual gravity map of the Goshute Canyon Wilderness Study Area and vicinity. Reduction density 2.67 grams per cubic centimeter; terrain corrections applied to a radial distance of 103.6 mi from gravity station. Isostatic model used is Airy-Heiskanen. This model assumes a crustal thickness at sea level of 25 kilometers, a topographic density load of 2.67 grams per cubic centimeter, and a density contrast across the base of the model crust of 0.4 grams per cubic centimeter.

map of the same area by Harris and Glen (1986). The latter includes data made available by the U.S. Defense Mapping Agency. An additional 163 gravity stations were obtained during July 1986 (Harris and Glen, 1986). Gravity data were reduced by standard procedures using a Bouguer reduction density of 2.67 g/cm³ (grams per cubic centimeter); terrain corrections were applied to a radial distance of 103.6 mi from each station. The

resulting isostatic residual gravity map (fig. 3), based on the Airy-Heiskanen model, shows gravity contours at 5 mGal (milligal) intervals and emphasizes the effect of density distribution in the upper crust.

A pronounced north-trending isostatic gravity high of +12 mGal (milligals) delineates the Cherry Creek Range structural block (fig. 3). The gravity high associated with the Cherry Creek Range is bordered on

the east by a steep gradient leading to a gravity low of -36 to -40 mGal in Steptoe Valley. On the west the high is bordered by two lows of about -21 mGal separated by a gravity saddle of about -10 mGal in Butte Valley. The northernmost gravity low in Butte Valley is elongate in a north-south direction and parallels the western front of the Cherry Creek Range, whereas the southern low is more elliptical and occurs in an area where Tertiary volcanic rocks crop out on both sides of Butte Valley (see pl. 1 in Hose and others, 1976). Total anomaly relief across the range exceeds 52 mGal.

Gravity profiles (A-A' and B-B') across the central Cherry Creek Range and adjacent Steptoe and Butte Valleys were modeled for a general interpretation of the gravity-anomaly map (fig. 3). A reasonable fit with observed anomaly values was obtained using a density contrast of 0.67 g/cm^3 between alluvial fill of Steptoe Valley and Paleozoic sedimentary rocks that are assumed to constitute both the range and most of its deep core. Thickness of Cenozoic alluvial fill in Steptoe Valley exceeds 9,000 ft on the basis of an assumed average density of 2.0 g/cm^3 . More than 13,500 ft of relief on the pre-Cenozoic surface between Steptoe Valley and the crest of the Cherry Creek Range is indicated from the data. The steep gravity gradient bounding the Cherry Creek Range gravity high on the east suggests that a major east-dipping high-angle fault, located 1-3 mi east of the Paleozoic rocks exposed at the range front, separates the uplifted Cherry Creek Range block from the downdropped Steptoe Valley block. The gravity profile across Butte Valley was modeled using a lower density contrast of 0.47 g/cm^3 between Cenozoic valley fill and Paleozoic rocks. This lower contrast was used due to the greater abundance of Tertiary volcanic rocks in the valley area (Hose and others, 1976). A computed thickness of 8,200 ft for Cenozoic volcanic rocks and alluvial deposits in the center of the gravity low was obtained using an assumed average density of 2.2 g/cm^3 . The axis of the gravity low occurring in Butte Valley trends due north and maintains a constant distance from the Cherry Creek Range front for a distance of about 12 mi.

About 5 mi southwest of the wilderness study area, a closed gravity low indicates a depression in the Paleozoic rocks beneath Butte Valley (fig. 3). Along the margins of Butte Valley, outcropping volcanic rocks on both sides of the gravity anomaly, as well as the aeromagnetic data (fig. 4) discussed below, indicate that this feature may be a caldera. The margin of this inferred caldera is shown on figures 3 and 4.

The only available magnetic data in the study area are unpublished NURE (National Uranium Resource Evaluation) aeromagnetic profiles flown by helicopter at a nominal ground clearance of 500 ft along east-west flight lines approximately 3 mi apart using a nuclear

precession magnetometer. Four flight lines cross the study area. Digital tapes of the NURE magnetic data were obtained from DOE (U.S. Department of Energy) and computer processed by Hildenbrand (in press). The resulting aeromagnetic map (fig. 4) shows total-intensity contours at intervals of 20 nanoteslas.

In evaluating the aeromagnetic data, the 3-mi spacing of the NURE flight lines and the flight ground clearance must be considered, especially in interpretation of anomalies of shallow origin (fig. 4). Ground clearance was as little as 500 ft over the crest of the Cherry Creek Range and as much as 1,000 ft over adjacent valleys. Computer processing of the NURE magnetic profiles resulted in an aeromagnetic map on which the high-frequency variations are smoothed and the longer wave lengths are accurately preserved. The aeromagnetic map derived from the NURE data is poorly controlled because of flight line spacing and flight ground clearance and must be used judiciously.

The character of the magnetic data in the wilderness study area is generally flat (fig. 4). This magnetic flatness suggests that no significant volume of magnetic granitic rock is buried beneath the study area as is the case with the magnetic Tertiary granitic pluton exposed near Cherry Creek and elsewhere in the Ely $1^\circ \times 2^\circ$ quadrangle (Hildenbrand, in press). Most Cretaceous and Tertiary plutons in northeastern Nevada are characterized by distinct magnetic highs. One known exception is the magnetic low associated with the nonmagnetic Cretaceous or Tertiary pluton that makes up the Kern Mountains (fig. 1), 34 mi southeast of the wilderness study area (Hildenbrand, in press). The widespread occurrence of thin dikes, sills, and hydrothermal jasperoids throughout the study area suggests the possibility of nonmagnetic plutonic rocks beneath the central Cherry Creek Range.

Tertiary volcanic rocks exposed along the west side of the Cherry Creek Range and in the Butte Mountains, 2-12 mi southwest of the wilderness study area, coincide with the prominent magnetic high seen on figure 4. This magnetic high continues unabated across Butte Valley and suggests that volcanic rocks are continuous under the alluvium. The magnetic high and the elliptical gravity low in Butte Valley, both about 5 mi southwest of the study area (figs. 3 and 4), are similar to gravity and magnetic anomalies associated with known calderas in other parts of the Basin and Range physiographic province (Plouff, 1985, 1986).

Other features of the aeromagnetic map are not as relevant to the assessment of mineral resource potential. Most of the elongate north-trending magnetic features shown on figure 4 are related to the orientation of the ranges and intervening basins. Less conspicuous

aerial surveys reflect the concentrations of these elements in an area of about 0.02 mi² (square mile).

On the basis of three flight lines flown approximately 500 ft above the ground in an east-west direction with a flight-line spacing of about 3 mi, the radioactive level is low over the entire Goshute Canyon Wilderness Study Area. The aerial radiometric survey indicates values of 0–3 ppm (parts per million) equivalent uranium, 2–9 ppm thorium, and 0–2 percent potassium (J.S. Duval, U.S. Geological Survey, written commun., 1985). There are no significant radioactive anomalies within the boundaries of the wilderness study area or in the immediate vicinity.

Mineral and Energy Resources

Metals

Characteristics of the deposits in the wilderness study area resemble an ore-deposit model for epithermal replacement deposits.

Epithermal replacement deposits form in near-surface environments at low to moderate temperatures in the upper parts of geothermal systems (Berger, 1982, 1985). They occur in all host-rock types, but the most important deposits of this type are replacement and vein deposits in sedimentary rocks and vein, stockwork, and replacement deposits in volcanic rocks. Ore minerals include native gold and silver or gold and silver as the alloy electrum; telluride minerals; and sulfide minerals of arsenic, antimony, mercury, and minerals of the base metals, copper, lead, and zinc. Silicification and argillic (to clay) alteration are controlled by a variety of hydrothermal conditions (Fournier, 1985). The type of alteration and alteration zonation are the keys to understanding epithermal deposits. Altered rocks and ore deposits are strongly zoned both laterally and vertically along veins. Structures such as faults and folds can localize ore deposition.

Jasperoid replacement deposits that locally occur directly below and in the basal part of the Dunderberg Shale, Pilot Shale, and Chainman Shale throughout the wilderness study area are an integral part of an epithermal mineralization system. Magma at depth, represented by numerous monzogranite dikes and sills throughout the central Cherry Creek Range, was the probable heat source for the epithermal system. The relatively impervious shaly mudstone and siltstone units acted as barriers that caused stratigraphically controlled lateral diversion of the upward-moving hydrothermal fluids. Forceful lateral migration of the hot fluids and attendant overpressuring of the system resulted in local hydrothermal fracturing and brecciation of the uppermost Raiff, Guilmette, and Joana Limestones.

Simultaneous brecciation and silica deposition may have occurred as a result of sudden decrease in pressure. Silica replaced the brecciated limestone to form jasperoid seals or caps over several conduits of the hydrothermal system. These dense silica cappings (now quartz with as much as 50 percent chalcedony or opal) resist oxidation and argillization. The jasperoid breccias are cemented and veined with silica, indicating fluid recharge after initial hydrothermal brecciation. Few calc-silicates developed during silica replacement of the limestone and limy siltstone. Local anomalies of disseminated gold, silver, arsenic, antimony, mercury, tungsten, and base metals (copper, lead, and zinc) occur in the jasperoid replacement deposits in the study area. Alteration of rocks in most of the study area is weak. Local alteration of the Dunderberg Shale to kaolinite and illite occurs adjacent to thick jasperoid bodies. Additional detailed study of veining, alteration zonation, and zonation of precious and base metals is necessary to determine what level of the epithermal system is currently exposed and to determine the potential for the occurrence of metallic mineral resources at depth.

Gold-silver-base metal epithermal mineralized systems are the most likely deposit type in this area. Geologic evidence suggests that granitoid rock, which provided heat for the epithermal system, probably occurs beneath the central Cherry Creek Range. Faults are a major control of epithermal ore-deposit distribution (Berger, 1982, 1985). Thus the favorability of the geologic environment for occurrences of epithermal mineral deposits in the study area also depends on the existence of appropriate structural features. Numerous silica replacement deposits and associated argillic alteration, containing element suites like those found in many epithermal systems in the region, are associated with most of the jasperoids in the study area. These deposits and the hypothesized subsurface geology indicate moderate mineral resource potential for gold, silver, antimony, copper, lead, zinc, and tungsten in this area, with level C certainty.

Except for the thickest and most extensive jasperoids, the geologic environment appears to be unfavorable for metallic deposits. Mineralized rock was not identified at the surface during geologic field work, significant anomalous values are absent in the geochemical data base, and geophysical data do not indicate the existence of either mineralized rock or favorable geologic environments. These findings suggest that the mineral resource potential for gold, silver, antimony, copper, lead, zinc, and tungsten in the remainder of the study area is low, with level C certainty.

Coal

Poole and Claypool (1984) reported a low-volatile bituminous coal bed nearly 2 ft thick in the basal part of

the Scotty Wash Quartzite in the Paris mine about 0.4 mi west of the study area in the Paris Creek drainage (pl. 1). According to local residents, the coal was mined and hauled in wagons to the old mining camp of Cherry Creek where it was used by the town blacksmith. Although the geologic environment of the Scotty Wash Quartzite is favorable for lenticular beds of bituminous coal, the formation does not crop out in the study area. The energy resource potential for coal in the study area is low, with level C certainty.

Oil and Gas

Paleozoic sedimentary rocks, which are possible source rocks for petroleum, are present in the study area. The Chainman Shale, which crops out along the western margin of the study area, is a principal source rock for petroleum in several oil fields in eastern Nevada (Poole and Claypool, 1984). Conodont alteration colors, vitrinite reflectance values, and organic geochemical data obtained on samples collected during geologic field work indicate maximum rock temperatures between 150 and 350 °C and therefore suggest that the original organic matter in the rocks has been heated beyond the oil and gas generation stage. Therefore, the thermal maturity of the Chainman Shale in the central Cherry Creek Range indicates that the potential for oil and gas resources is low, with level C certainty.

Uranium

Radiometric data indicate that no significant, near-surface uranium deposit exists within the study area (J.S. Duval, written commun., 1985). The mineral resource potential for uranium is low, with certainty level C.

Geothermal

The absence of geothermal springs in the central Cherry Creek Range area indicates that potential for geothermal resources in the study area is low, with level C certainty.

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APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

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

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

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

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

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

Levels of Certainty

 LEVEL OF RESOURCE POTENTIAL	U/A	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
	UNKNOWN POTENTIAL	M/B MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/D MODERATE POTENTIAL
		L/B LOW POTENTIAL	L/C LOW POTENTIAL	L/D LOW POTENTIAL
				N/D NO POTENTIAL
	A	B	C	D
	LEVEL 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.
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RESOURCE / RESERVE CLASSIFICATION

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

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from U. S. Bureau of Mines and U. S. Geological Survey, 1980, *Principles of a resource/reserve classification for minerals*: U. S. Geological Survey Circular 831, p. 5.

GEOLOGIC TIME CHART
Terms and boundary ages used in this report

EON	ERA	PERIOD	EPOCH	BOUNDARY AGE IN MILLION YEARS			
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010		
				Pleistocene			
		Tertiary	Neogene Subperiod	Pliocene	1.7		
				Miocene	5		
			Paleogene Subperiod	Oligocene	24		
				Eocene	38		
				Paleocene	55		
					66		
			Mesozoic	Cretaceous		Late Early	96
							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						
pre-Archean ²		3800?		4550			

¹ Rocks older than 570 m.y. also called Precambrian, a time term without specific rank.

² Informal time term without specific rank.

Mineral Resources of Wilderness Study Areas— Northeastern Nevada

This volume was published
as separate chapters A–E

CONTENTS

[Letters designate the chapters]

- (A) Mineral resources of the Bad Lands Wilderness Study Area, Elko County, Nevada, by B.R. Johnson, D.H. Richter, V.J.S. Grauch, and T.J. Kreidler.
- (B) Mineral resources of the South Pequop Wilderness Study Area, Elko County, Nevada, by K.B. Ketner, C.N. Gerlitz, R.W. Saltus, and R.H. Wood, II.
- (C) Mineral resources of the Bluebell and Goshute Peak Wilderness Study Areas, Elko County, Nevada, by K.B. Ketner, W.C. Day, Maya Elrick, M.K. Vaag, C.N. Gerlitz, H.N. Barton, R.W. Saltus, and S.D. Brown.
- (D) Mineral resources of the Rough Hills Wilderness Study Area, Elko County, Nevada, by A.R. Wallace, R.J. Turner, V.J.S. Grauch, J.L. Plesha, and U.S. Bureau of Mines staff.
- (E) Mineral resources of the Goshute Canyon Wilderness Study Area, Elko and White Pine Counties, Nevada, by F.G. Poole, Maya Elrick, R.E. Tucker, R.N. Harris, H.W. Oliver, and F.L. Johnson.

