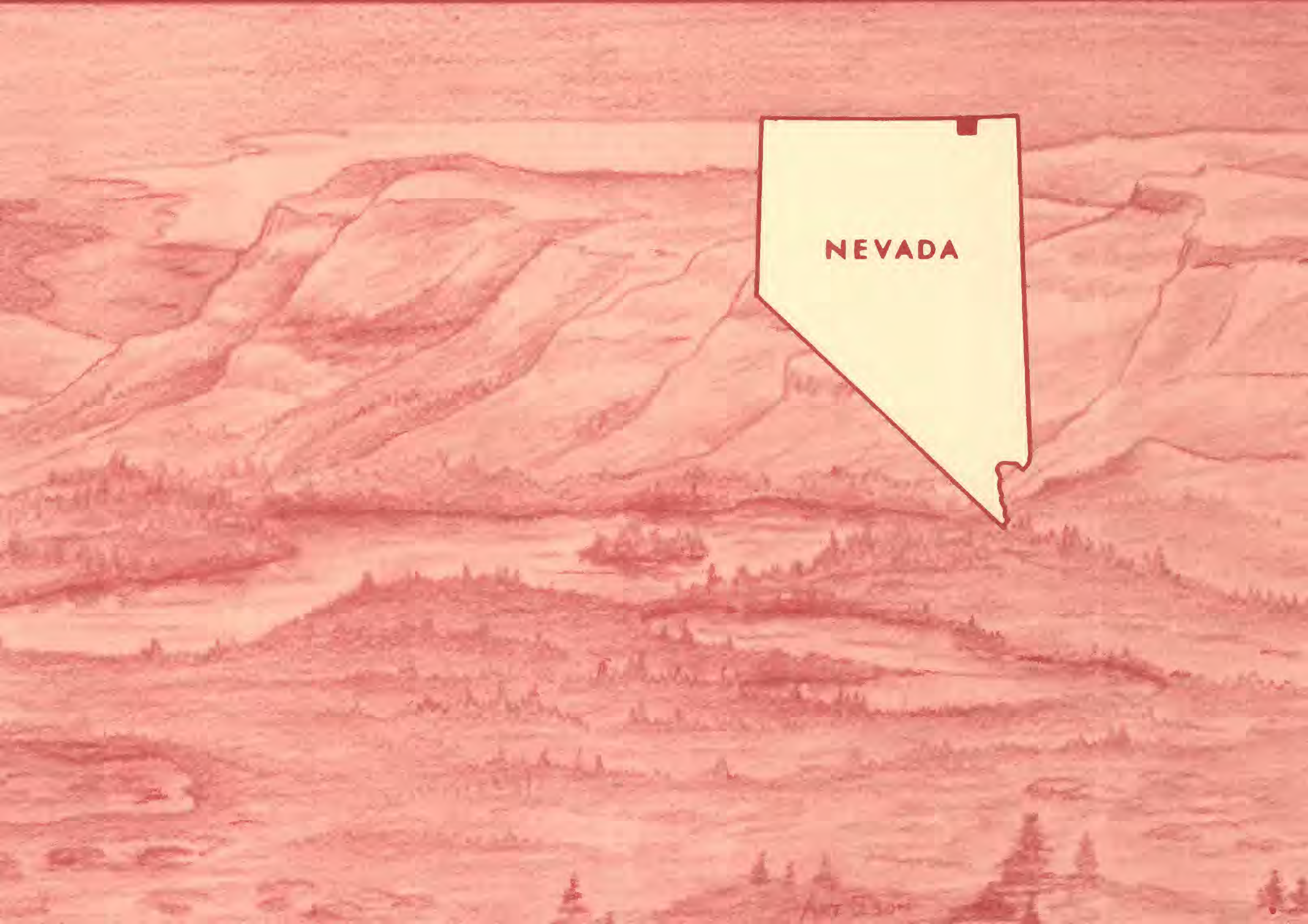
Mineral Resources of the Bad Lands Wilderness Study Area, Elko County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1725–A



Chapter A

Mineral Resources of the Bad Lands Wilderness Study Area, Elko County, Nevada

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U.S. GEOLOGICAL SURVEY BULLETIN 1725

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
NORTHEASTERN NEVADA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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

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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 Bad Lands Wilderness Study Area (NV-010–184), Elko County, Nev.

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Mineral Resources of the Bad Lands Wilderness Study Area, Elko County, Nevada

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U.S. Geological Survey

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SUMMARY

The U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) studied 8,415 acres of the Bad Lands Wilderness Study Area (NV–010–184). The study of this acreage was requested by the U.S. Bureau of Land Management (BLM). In this report the studied area is called the "wilderness study area" or simply the "study area." The study area has no identified resources; it has low mineral resource potential for undiscovered deposits of all metallic minerals, oil, gas, and coal, and for geothermal energy (fig. 1). Factors contributing to this conclusion include low metal content of all geochemical samples, lack of visible mineralized rock, lack of mining activity, lack of known structures or traps for petroleum resources, and lack of evidence of geothermal activity within the study area. This conclusion is based on surveys conducted by the U.S. Geological Survey and the U.S. Bureau of Mines from 1983 through 1985.

The study area is approximately 35 mi (miles) north of Wells, Nev., in northeastern Elko County, Nev. This area is in the northern part of the Basin and Range province, a large region of the Western United States, including virtually all of Nevada, that is characterized by subparallel, generally north-south-trending mountain ranges separated by broad alluvial valleys. The study area itself consists mostly of rugged ridges and narrow, steep-walled canyons. Elevations range from nearly 7,000 ft (feet) along the northeast boundary to about 5,500 ft in the southeast corner where Salmon Falls Creek flows out of the study area.

Except for two short sections on the west side, the boundaries of the wilderness study area are along four-wheel-drive roads that are accessible from the old mining town of Contact, Nev. Travel within the boundaries of the study area is mostly limited to foot or pack animal.

Upper Paleozoic (see geologic time chart in appendix) sedimentary rocks, the oldest rocks in the area, are exposed on the western slope of L & D Mountain, immediately east of the study area boundary. These rocks consist of a lower unit of thinly laminated detrital limestone and an upper unit of thinly bedded siliceous rocks including siltstone, mudstone, and argillite. The next oldest rock exposed in the vicinity, and the rock that underlies most of the study area, is the Tertiary Jarbidge Rhyolite, a thick sequence of reddish-gray, felsic volcanic extrusive rocks. The weathering of this unit is responsible for the rugged topography in most of the study area.

The Jarbidge Rhyolite is overlain by easily weathered Tertiary sedimentary and pyroclastic rocks. Capping the steep slopes of the sedimentary and pyroclastic rocks is the Tertiary Cougar Point Welded Tuff. A Tertiary basalt flow and lapilli tuff unit overlies the Cougar Point Welded Tuff at the top of Big Devils Table south of the study area. Quaternary alluvial and colluvial deposits of at least two ages cover many of the steep slopes around the periphery of the study area.

From late Precambrian through middle Paleozoic time, shelf-margin carbonate sediments, mud, and sand were deposited in northeastern Nevada. At the same time, carbonaceous mud and siliceous radiolarian sediments were deposited, and basaltic volcanic flows were erupted in western Nevada and southern Oregon. During the middle Paleozoic Antler orogeny (mountain-building event), a north-south-trending highland in cen-

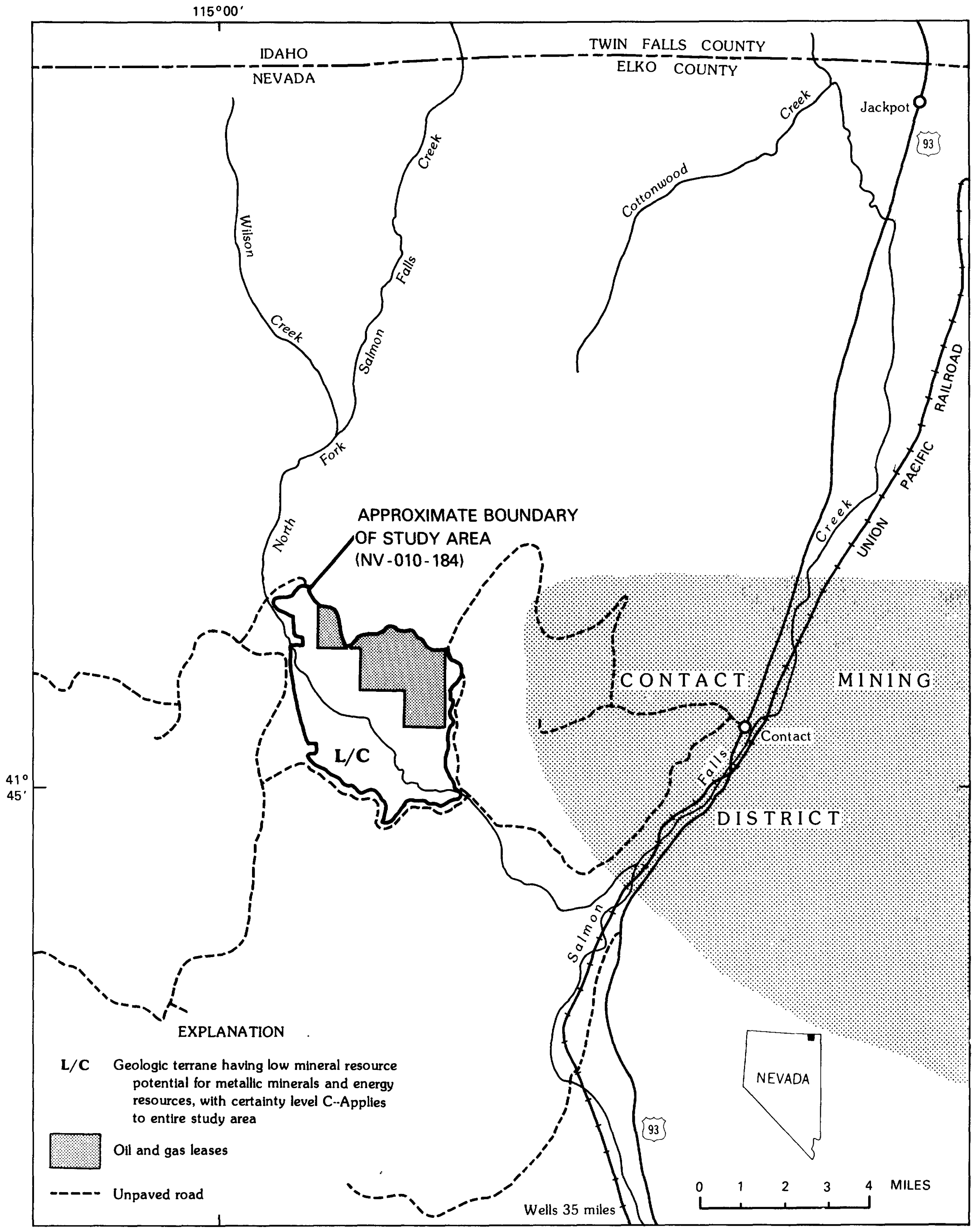

Figure 1. Map showing location, mineral resource potential, and oil and gas leases of the Bad Lands Wilderness Study Area, Elko County, Nev.

tral Nevada was formed when the suite of rocks from the west was deformed and thrust over the eastern suite. Late Paleozoic erosion of this highland caused large quantities of detrital material to be deposited in eastern Nevada. The rocks of eastern Nevada were further deformed during latest Paleozoic and Mesozoic orogenies and were intruded by numerous Mesozoic granitic and granodioritic plutons that are associated with mineralized rock in many places.

The sequence of Jarbidge Rhyolite, sedimentary and pyroclastic rocks, and Cougar Point Welded Tuff was deposited during Miocene time, when silicic volcanism was widespread in the northern Great Basin. Miocene or Pliocene basalt flows and lapilli tuffs were subsequently deposited on top of the Cougar Point Welded Tuff. Quaternary erosion has resulted in the large alluvial and colluvial deposits that mantle much of the periphery of the study area.

There has been no mining activity in, or within 2 mi of, the study area. The only mining in the vicinity has been in the Contact mining district, 2–5 mi to the east. As of November 1983, there were no mining claims within the study area. No drilling or other oil and gas exploration is known to have taken place in the study area, but about 3,200 acres of the northeastern part of the area (fig. 1) was under lease for oil and gas as of April 1983. According to Mathews and Blackburn (1983), the environment within the wilderness study area is not favorable for the occurrence of geothermal resources. To support their conclusion, they cite the lack of recent volcanic activity, major fault zones, and known geothermal activity.

The Bad Lands study area includes no mining districts. The Contact mining district, to the east, was organized in the late 1800's; nearly one-half of recorded production was between 1952 and 1957. Copper was the major commodity mined, along with lesser amounts of lead, silver, and gold. The Jarbidge Rhyolite, which is exposed over much of the study area, is of unknown thickness and does not appear, in hand specimen, to be hydrothermally altered; no surface evidence of mineralization was observed.

On the basis of geochemical analyses, geological surveys, and the absence of surface workings and (or) mineralized rock at the surface, the Bad Lands Wilderness Study Area is considered to have low mineral resource potential for undiscovered deposits of all metallic minerals and for all types of undiscovered energy sources, at a certainty level of C. Geochemical analysis of stream sediments showed no samples with analytical values above background levels. There are no mineralized areas within the study area, and mineralized structures outside the area (the Contact mineralization) are not known to extend into the area. There has been no mining activity within the study area. Known bedrock within the study area is not a suitable source or reservoir rock for oil or gas. No hot springs or remnants of hot springs have been found in the area.

INTRODUCTION

The U.S. Geological Survey and the U.S. Bureau of Mines, at the request of the U.S. Bureau of Land Management, studied 8,415 acres of the Bad Lands Wilderness Study Area (NV–010–184), in northeastern Elko County, Nev., about 35 mi north of Wells, Nev. (fig. 1). In this report, the area studied is referred to as the "wilderness study area" or as the "study area."

The study area is in the northern part of the Basin and Range province, a large region of the Western United States, including virtually all of Nevada, that is characterized by subparallel, generally north-south-trending mountain ranges separated by broad alluvial valleys. Topography within the study area is unusual for the northern part of the province, consisting mostly of rugged ridges and narrow, steep-walled canyons. Most of the stream beds are dry except following rain; the only perennial stream in the study area is Salmon Falls Creek, which flows across the study area from northwest to southeast. Elevations range from nearly 7,000 ft along the northeast boundary to about 5,500 ft where Salmon Falls Creek flows out of the study area in the southeast corner.

Except for two short sections on the west side (totaling about 1.5 mi), the study area boundaries are along four-wheel-drive roads accessible from the old mining town of Contact, Nev. (fig. 1). Contact is on U.S. Highway 93, about 5 mi east of the study area. The four-wheel-drive access roads become impassable following periods of prolonged wet weather. Travel within the boundaries of the study area is limited to foot or pack animal, except for one short section of four-wheel-drive road along the east side of the area.

Previous Work

Although the Contact mining district has been studied intermittently since the early part of this century (most notably by Schrader, 1935) and a reconnaissance geologic map of Elko County, Nev., was published by Hope and Coats (1976), there was no detailed study that included the Bad Lands Wilderness Study Area until the U.S. Bureau of Land Management's unpublished assessment of the Bad Lands GEM (geology, energy, and minerals) Resource Area (Mathews and Blackburn, 1983).

Investigations by the U.S. Bureau of Mines

USBM personnel reviewed various sources of minerals information including published and unpublished literature, USBM files, and mining-claim records at the Elko County courthouse in Elko, Nev., and in BLM recordation files. BLM personnel in the Elko district office were interviewed. During field reconnaissance in November 1983, no mineral workings in, or within 2 mi of, the study area were located.

Investigations by the U.S. Geological Survey

In 1985, USGS personnel conducted investigations to assess the potential for undiscovered deposits in the Bad Lands Wilderness Study Area. This assessment is based on the geologic map of Elko County (Hope and Coats, 1976), geochemical sampling in the study area, examination of the gravity and aeromagnetic maps of the study area, and field investigations in 1985. The mineral resource potential classification of Goudarzi (1984; see appendix) is used throughout this report.

APPRAISAL OF IDENTIFIED RESOURCES

By Terry J. Kreidler
U.S. Bureau of Mines

Mining Activity

There has been no mining activity in, or within 2 mi of, the Bad Lands Wilderness Study Area. All mining in the vicinity has been 2–5 mi east in the Contact mining district. As of November 1983, there were no mining claims within the study area.

Oil, Gas, and Geothermal Activity

No drilling or other oil and gas exploration is known to have occurred in the study area, but about 3,200 acres of the northeastern part (fig. 1) were leased for oil and gas as of April 1983. A favorable shelf facies within the upper Paleozoic marine sequence may occur at depth beneath the study area (Mathews and Blackburn, 1983), and is probably the impetus behind the leasing activity.

Mining Districts and Mineralized Areas

The Bad Lands Wilderness Study Area includes no mining districts, but the Contact mining district is 2–5 mi to the east (fig. 1). The district was organized in the late 1800's, but nearly one-half of the production was between 1952 and 1957. The deposits occur either as metasomatic replacement along the contact of Jurassic granodiorite with Paleozoic carbonate rocks or as quartz veins along faults, dikes, and the intrusive contact (Granger and others, 1957, p. 35). Copper was the major commodity mined along with lesser amounts of lead, silver, and gold. The contact between the granodiorite and carbonate sequence in the Contact mining district dips westward toward the wilderness study area.

The Jarbidge Rhyolite exposed in the study area is of unknown thickness and, in hand specimen, does not appear to be hydrothermally altered; no surface evidence of mineralization was observed. Elsewhere, the Jarbidge Rhyolite contains jasper and opal, commonly of gem quality (Steven Kluender, oral commun., 1983); however, these minerals were not seen in the study area.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Bruce R. Johnson, Donald H. Richter, and V. J. S. Grauch
U.S. Geological Survey

The Bad Lands Wilderness Study Area is judged to have low mineral resource potential (pl. 1) for undiscovered deposits of all metallic minerals and energy sources. The low mineral resource potential designation for the study area is assigned with a certainty level of C for all commodities because available information gives a good indication of the level of resource potential, but does not clearly define that level.

Geology

The Bad Lands Wilderness Study Area lies within the northern section of the Great Basin part of the Basin and Range physiographic province. The Basin and Range province consists predominantly of north-south-trending fault-block mountain ranges separated by wide intermontane valleys. In northern Nevada, the characteristic physiography of the Great Basin becomes subdued; the local relief is generally less than 5,000 ft, and the ranges and valleys are less uniform in size and orientation. The summit of L & D Mountain (also known as Ellen D Mountain), the highest point in the vicinity at 8,633 ft, is approximately 2 mi east of the boundary of the study area, just east of the area shown on plate 1. There is a marked change in drainage pattern and topography between L & D Mountain and the study area. L & D Mountain, a broad, isolated mountain with a radial drainage pattern, is underlain by a thick sequence of Paleozoic sedimentary rocks and Jurassic granodiorite. The Bad Lands Wilderness Study Area, which is composed of narrow ridges and deep canyons, is underlain by Tertiary felsic volcanic rocks.

A sequence of upper Paleozoic sedimentary rocks is exposed on the western slope of L & D Mountain, immediately east of the study area boundary (pl. 1). This sequence consists of a lower unit of thinly laminated detrital limestone and an upper unit of thinly bedded siliceous rocks including siltstone, mudstone, and argillite. The upper unit contains deep-water-facies Late Mississippian brachiopods and clams (Thomas Dutro, written commun., 1986). The entire sequence displays evidence of turbidite origin and was probably deposited in a slope environment between the continental shelf and deep ocean basin. The next oldest rocks exposed in the vicinity, and the rock that underlies most of the study area, is the Tertiary Jarbidge Rhyolite. The Jarbidge Rhyolite is composed of a thick sequence of reddish-gray, flow-banded, felsic volcanic deposits. Weathering of this unit is responsible for the rugged topography in most of the study area.

The Jarbidge Rhyolite is overlain by unnamed Tertiary sedimentary and pyroclastic rocks, a soft, easily weathered unit forming steep slopes around the periphery of the study area (pl. 1). Capping these unnamed rocks is the Tertiary Cougar Point Welded Tuff, apparently deposited as a single cooling unit within the study area, which forms a resistant caprock on most of the mesas surrounding the study area. A Tertiary basalt-flow and lapilli-tuff unit overlies the Cougar Point Welded Tuff on the top of Big Devils Table to the south. Quaternary alluvial fans, talus deposits, and debris flows of at least two ages cover many of the steep slopes around the periphery of the study area (pl. 1).

From the late Precambrian through the middle Paleozoic, northeastern Nevada was characterized by an environment in which shelf-margin carbonate rock, shale, and sandstone were deposited. At the same time, dark shaley sediment and radiolarian chert were deposited, and basaltic volcanic flows erupted in western Nevada and southern Oregon. The north-south-trending Antler highland in central Nevada formed during the middle Paleozoic Antler orogeny, when the suite of rocks from the west was deformed and thrust over the eastern suite. Late Paleozoic erosion of this highland caused large quantities of detrital material to be deposited in eastern Nevada. Many of the upper Paleozoic sedimentary rocks that are exposed east of the study area were formed in this manner. The rocks of eastern Nevada were further deformed during latest Paleozoic and Mesozoic orogenies and were intruded by numerous Mesozoic granitic and granodioritic plutons that are associated with mineralized rock in many places. The Jurassic granodiorite pluton associated with the mineralized rock in the Contact mining district was intruded at this time.

Silicic volcanism was widespread in the northern Great Basin from early to middle Cenozoic time. At that time the Tertiary Jarbidge Rhyolite, the unnamed sedimentary and pyroclastic rocks, and the Cougar Point Welded Tuff were sequentially deposited at the site of the wilderness study area. The Tertiary basalt flows and lapilli tuffs were subsequently deposited on top of the Cougar Point Welded Tuff. Quaternary erosion has resulted in the large alluvial and colluvial deposits that mantle much of the periphery of the study area.

Geochemistry

Stream-sediment samples were collected from major and minor streams in and near the Bad Lands Wilderness Study Area (pl. 1). A single sample collected from each locality was sieved to minus-80 mesh and analyzed for 31 elements by optical-emission six-step, semiquantitative spectrographic techniques (Grimes and Marranzino, 1968). No anomalous analytical values were found by the analysis of stream-sediment samples.

Of the 21 stream-sediment samples collected, 16 were collected within the study area and the remaining 5 were collected within 1 mi of the study area boundary. High, low, and mean values for each of the 31 elements are given in table 1. These values are similar to those for other normal felsic igneous rocks throughout the world; no indications of mineralization were found in these samples.

Geophysics

Gravity Data

The only gravity data available were acquired from the U.S. Department of Defense data bank (National Oceanic and Atmospheric Administration National Geophysical Data Center) and cover the region surrounding the Bad Lands Wilderness Study Area. None of the gravity stations is within the study area. The data coverage is too sparse to make any conclusions related to mineral resource potential in the wilderness study area.

Aeromagnetic Data

Data were available from a regional aeromagnetic survey that was flown 12,000 ft above sea level (U.S. Geological Survey, 1978), about 5,000–6,000 ft above the study area. Although this survey was flown too high above ground to resolve features related to mineral occurrences, the data show that the study area is at the western tip of a major positive anomaly that is elongate east-west. The high is associated with outcrops of intrusive rock (Stewart and Carlson, 1977). The study area may be underlain by this rock type at quite some depth.

Aeromagnetic data were also available from a survey that was flown along east-west lines having a 300-ft terrain clearance and a 3-mi line spacing (Bendix, 1983). Two flight lines from this survey cross the study area. One crosses just north of the central part of the area (latitude 41.787°), and the other crosses the southern tip of the area (latitude 41.746°). Because the lines are so widely spaced, profiles of the data were used.

Table 1. High, low, and mean analytical values for each of 31 elements for the 21 stream-sediment samples collected in and near the Bad Lands Wilderness Study Area, Elko County, Nev.

[Analyses by semiquantitative spectroscopic methods, reported as a six-step classification, with midpoints of classes at 1, 1.5, 2, 3, 5, 7, 10, and so on; ppm, parts per million; <, less than]

Element	High	Low	Mean
Fe (pct.)	7	3	4
Mg (pct.)	1	0.2	0.5
Ca (pct.)	3	1.5	2
Ti (pct.)	1	.2	.5
Mn (ppm)	700	300	400
Ag (ppm)[1]	0.5	<0.5	<0.5
As (ppm)	<700	<700	<700
Au (ppm)	<15	<15	<15
B (ppm)	50	<10	20
Ba (ppm)	3,000	700	1,500
Be (ppm)	2	1.5	2
Bi (ppm)	<10	<10	<10
Cd (ppm)	<30	<30	<30
Co (ppm)	10	<5	7
Cr (ppm)	150	7	50
Cu (ppm)	70	7	20
La (ppm)	100	30	70
Mo (ppm)	5	<5	<5
Nb (ppm)	50	<20	20
Ni (ppm)	50	<5	10
Pb (ppm)	30	15	20
Sb (ppm)	<100	<100	<100
Sc (ppm)	15	7	10
Sn (ppm)	<10	<10	<10
Sr (ppm)	500	300	300
Th (ppm)	<200	<200	<200
V (ppm)	100	30	60
W (ppm)	<50	<50	<50
Y (ppm)	70	30	50
Zn (ppm)	<200	<200	<200
Zr (ppm)	1,000	150	400

[1]One sample (no. 111, pl. 1) has a silver analytical value above the minimum detection level. This sample was collected just outside the study area boundary at the northeast corner from a stream bed that drains the upper slopes of L & D Mountain. The Paleozoic rocks that underlie this drainage basin are not exposed within the study area.

No anomalies indicating unknown subsurface bodies or structures were detected in the profile data. Anomalies reflect mostly the irregularities of topography, which is expected when near-surface rocks are magnetic. The relative magnitudes of the anomalies change across the profile over different mapped geologic units. These relative magnitudes suggest that the Cougar Point Welded Tuff (unit Tcpt, pl. 1) is locally very magnetic (probably due to a high remanent component of magnetization), the Jarbidge Rhyolite (unit Tjr) is moderately magnetic, and the sedimentary and pyroclastic rocks (unit Ts) are weakly magnetic.

Mineral and Energy Resource Potential

Metal Deposits Associated with Mesozoic Plutons

The only known mineral deposits in the vicinity of the wilderness study area are the vein and replacement deposits associated with the contact zone of the Contact mining district. The Contact mining district is named for the occurrence of mineral deposits along the intrusive contact of a Jurassic granodioritic pluton with a thick section of upper Paleozoic limestone and fine-grained, siliceous sedimentary rocks. The deposits consist both of metasomatic replacement of sedimentary rocks near the contact and of quartz veins that follow faults and fractures away from the contact zone (Granger and others, 1957). Copper was the major commodity mined in the Contact mining district. Lesser amounts of lead, silver, and gold were also extracted.

At its closest exposed point, mineralized rock of the type found in the Contact mining district is about 2 mi east of the study area. Within the study area, there is no evidence at the surface of rocks similar to the Paleozoic sedimentary rocks or to the Jurassic granodiorite that make up the Contact mining district. Surface exposures of the granodiorite-sedimentary rock contact within the Contact mining district indicate a steep westward dip of the contact along the western boundary of the granodiorite pluton. If the mineralized contact zone dips continuously to the west, there may be mineralized rock similar to that found in the Contact mining district (veins and (or) replacement deposits of copper with lesser amounts of lead, silver, and gold) at great depth (probably more than 5,000 ft) beneath the Tertiary volcanic rocks of the study area. Because of the lack of data on the subsurface nature of this contact, the possibility remains speculative.

If the dip of the Contact mineralized zone were shallow west of the exposed portion of the contact, mineralized rock similar to that found in the Contact district might exist at shallow depth within the study area. Evidence for the existence of such shallow base-metal (copper, lead, zinc), gold, silver, and other mineralization might be found in the geochemical studies, or evidence for a shallow mineralized contact zone might be found in the geophysical studies. No mineralized areas were identified within the Bad Lands Wilderness Study Area, no geochemical anomalies could be defined within the study area from the stream-sediment sampling, and no evidence of a shallow plutonic-sedimentary contact zone was found in the geophysical studies.

Because of the lack of evidence for a mineralized contact zone, the study area is assigned a low mineral resource potential for base-metal (copper, lead, zinc) vein and replacement deposits, with a certainty level of C; available data give a good indication of the level of resource potential. More detailed geophysical studies with more closely spaced sampling would be required to obtain a better indication of the depth to the plutonic rock–sedimentary rock contact if it exists within the study area. Stream-sediment geochemistry did not include analysis of panned-concentrate samples, which would have allowed detection of smaller amounts of metallic elements within the sediments.

Other Resources

The bedrock within the study area, Tertiary felsic volcanic rock and Tertiary sedimentary rock, is not known to be mineralized in the vicinity of the study area. Perlite in the felsic volcanic rocks (unit Tjr, pl. 1) is widely scattered and impure. No evidence or records of mining activity within the wilderness study area have been found.

Because of its proximity to the middle Paleozoic Antler highland, which has associated possible petroleum reservoir rocks, the study area may be underlain by the same reservoir rocks possibly containing oil and gas. However, the area is completely untested by industry, so the existence of petroleum resources must remain speculative. The study area lacks a favorable environment for the occurrence of geothermal resources or for the occurrence of coal deposits. The potential for oil, gas, coal, and geothermal sources is low, with a certainty level of C.

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APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

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

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

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

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

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

Levels of Certainty

LEVEL OF RESOURCE POTENTIAL →

<table>
<tr><td rowspan="4">U/A
UNKNOWN POTENTIAL</td><td>H/B
HIGH POTENTIAL</td><td>H/C
HIGH POTENTIAL</td><td>H/D
HIGH POTENTIAL</td></tr>
<tr><td>M/B
MODERATE POTENTIAL</td><td>M/C
MODERATE POTENTIAL</td><td>M/D
MODERATE POTENTIAL</td></tr>
<tr><td rowspan="2">L/B
LOW POTENTIAL</td><td rowspan="2">L/C
LOW POTENTIAL</td><td>L/D
LOW POTENTIAL</td></tr>
<tr><td>N/D
NO POTENTIAL</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td></tr>
</table>

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:

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RESOURCE / RESERVE CLASSIFICATION

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

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

GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey, 1986

EON	ERA	PERIOD		EPOCH	BOUNDARY AGE IN MILLION YEARS
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~ 240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~ 330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~ 570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				3800?
pre-Archean[2]					4550

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

[2] Informal time term without specific rank.

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