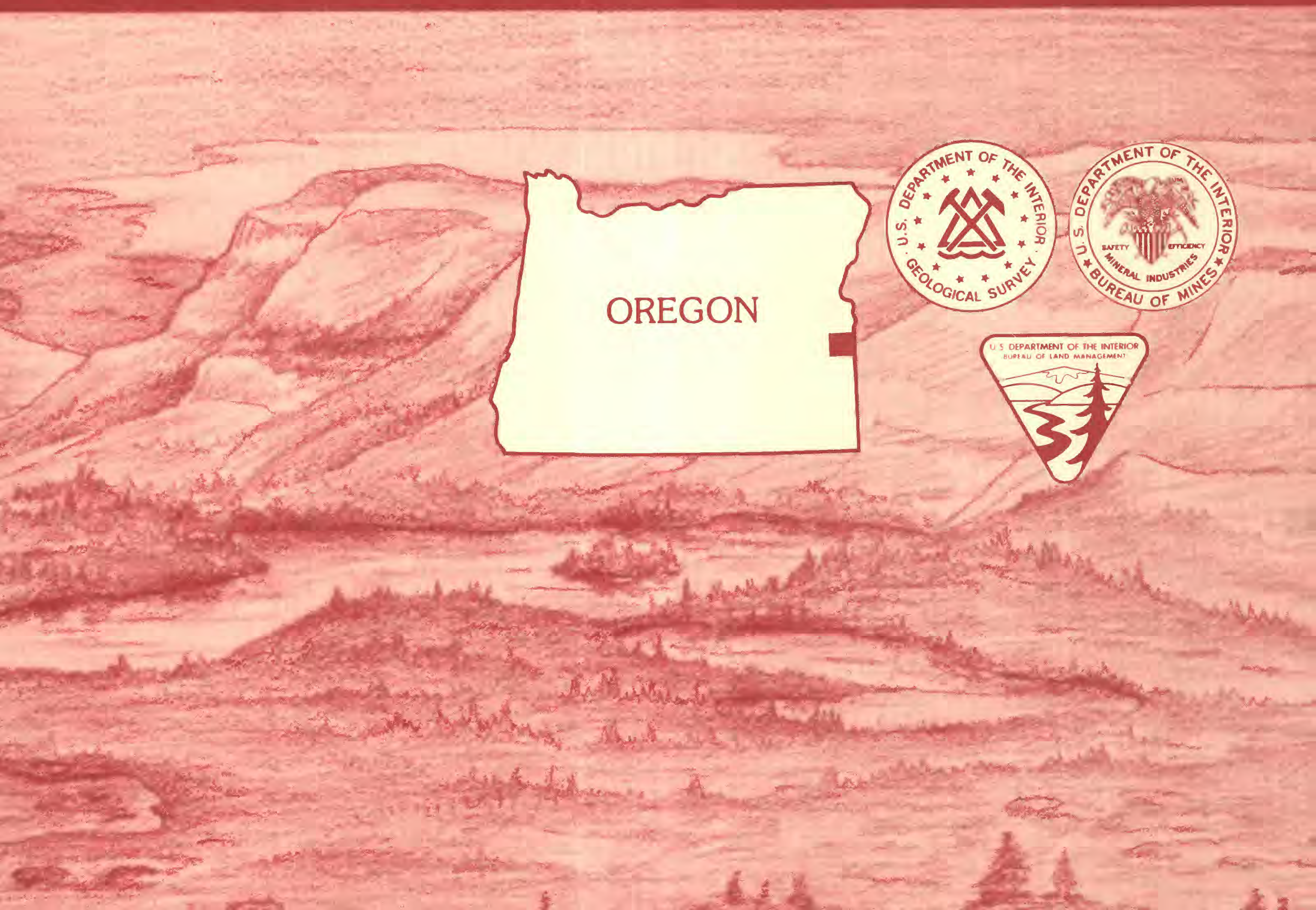
Mineral Resources of the Honeycombs Wilderness Study Area, Malheur County, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1741–A



Chapter A

Mineral Resources of the Honeycombs Wilderness Study Area, Malheur County, Oregon

By DEAN B. VANDER MEULEN, J.J. RYTUBA, H.D. KING, and D. PLOUFF

U.S. Geological Survey

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U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1741

MINERAL RESOURCES OF WILDERNESS STUDY AREAS: EAST-CENTRAL OREGON

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 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 Honeycombs Wilderness Study Area (OR-003-77A), Malheur County, Oregon.

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Mineral Resources of the Honeycombs Wilderness Study Area, Malheur County, Oregon

By Dean B. Vander Meulen, J.J. Rytuba, H.D. King, *and* D. Plouff
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SUMMARY

Abstract

The Honeycombs Wilderness Study Area (OR-003-77A) encompasses approximately 39,000 acres adjacent to the Owyhee Reservoir in eastern Oregon. Field work was conducted by the U.S. Geological Survey during 1983 and 1984, and by the U.S. Bureau of Mines during 1984, to evaluate the mineral resources and the mineral resource potential of the study area. At the request of the Bureau of Land Management (BLM), the U.S. Geological Survey and the U.S. Bureau of Mines conducted field studies of 36,284 acres, of the 39,000 acre Honeycombs Wilderness Study Area. No mineral resources were identified in the study area. However, the study indicates moderate potential for uranium, thorium, and lithium resources in sedimentary and volcanic rocks, moderate potential for arsenic, lead, mercury, molybdenum, and zinc resources in caldera moat-fill sedimentary rocks and quartz veins, and moderate potential for arsenic and mercury resources in hydrothermal vein systems. The study area has moderate potential for zeolite resources in air-fall tuff beds and tuffaceous sedimentary rocks, moderate potential for geothermal resources, and low potential for zinc resources in volcanic rocks. The study area has low potential for fluorite resources in lacustrine deposits, low potential for tin and copper resources in hydrothermal vein systems, and low potential for petroleum and natural gas resources in sedimentary rocks. The eastern part of the study area has identified resources of "picture jasper." In this report, the area studied is referred to as the "wilderness study area", or simply "the study area."

Character and Setting

The study area is located in the northern Basin and Range physiographic province approximately 50 mi west of Boise, Idaho, and 40 mi north of Jordan Valley, Oregon (fig. 1). Topography and drainage are dominated by north-trending ridges and valleys, deeply eroded east-trending canyons, and the north-trending Owyhee River canyon (Owyhee Reservoir). These features generally reflect local fault patterns. The northern topographic margin of the Mahogany Mountain caldera extends east-west across the southern third of the study area (fig. 2). The caldera

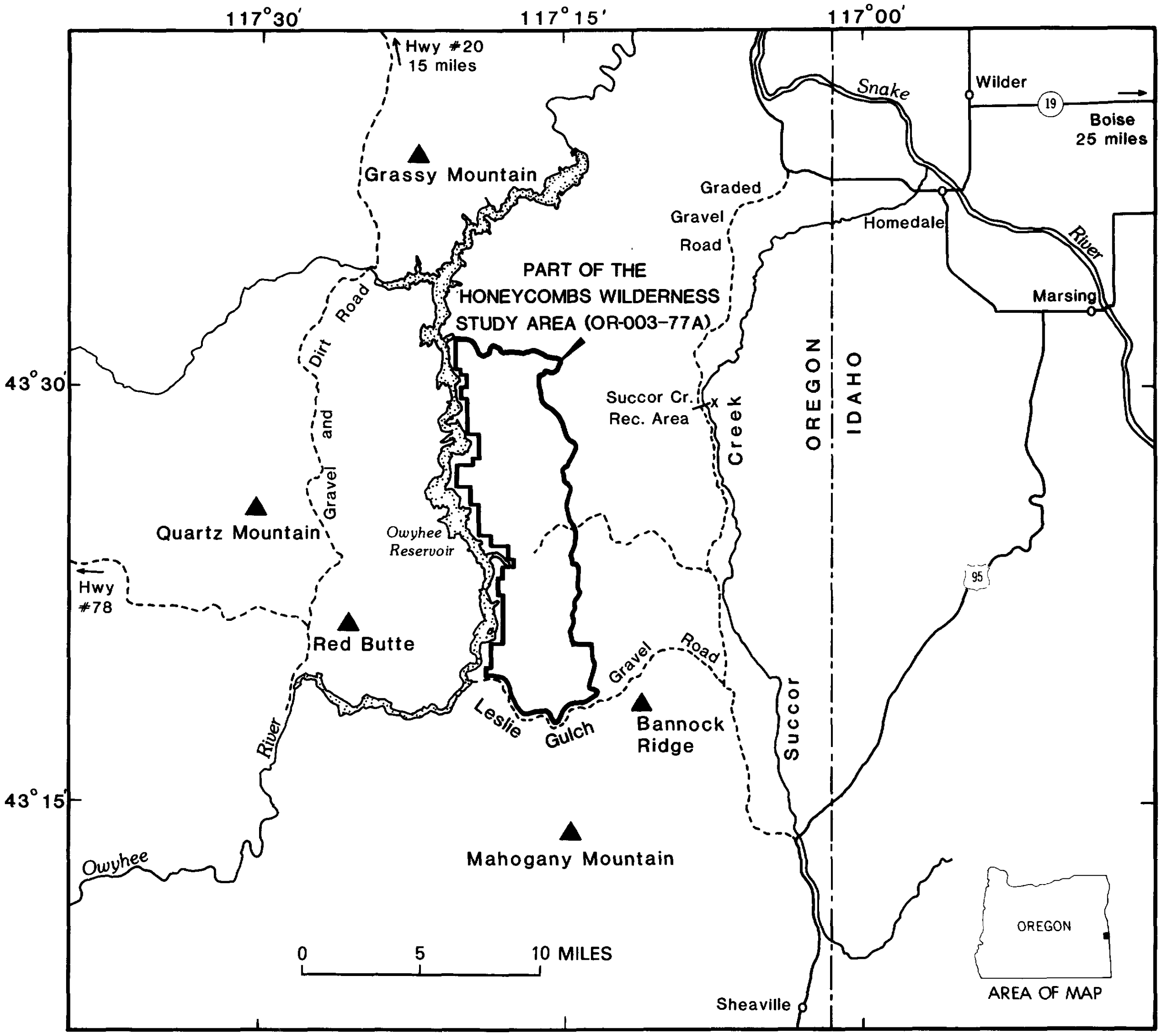


Figure 1. Index map showing location of the Honeycombs Wilderness Study Area, Malheur County, Oregon.

collapse structure forms a topographic low south of the caldera margin. Rhyolitic flows and volcaniclastic rocks of Miocene age (5 to 24 million years before present, or Ma; see Geologic Time Chart, last page of this report) form a thick basal section and are the oldest rocks in the region. The rhyolitic flows are overlain by sedimentary rocks interbedded with ash-flow and air-fall tuffs. Dikes, plugs, and sills of basalt, andesite, and rhyolite intrude the entire sequence. Basalt flows of Pliocene and Pleistocene age cap the stratigraphic section.

Identified Resources

No mineral resources were identified in the study area.

Mineral Resource Potential

The north-central and southern parts of the study area have moderate potential for uranium and thorium resources. High anomalous concentrations of these elements occur in rhyolite tuff, rhyolite intrusions, and tuffaceous sedimentary rocks. The mineral resource potential rating is based on anomalous aerial gamma-ray values and anomalous concentrations of uranium and thorium in rock samples.

The north-central and southern parts of the study area have moderate potential for strata-bound lithium resources, and low potential for volcanogenic disseminated-zinc resources.

Areas adjacent to the Mahogany Mountain caldera topographic margin (fig. 2, stipple pattern) have moderate potential for mercury and arsenic resources. Rocks exposed along fault and fracture zones parallel to the caldera wall are locally hydrothermally altered and silicified. Geochemical analyses indicate anomalous concentrations of mercury and arsenic in these altered rocks. Although no gold was detected in the samples analyzed, mercury and arsenic are good pathfinder elements for gold resources.

An area south of the caldera topographic margin has moderate potential for arsenic, molybdenum, lead, and zinc resources. Anomalous concentrations of these elements are found in silicified and pyritized moat-fill sedimentary rocks (fig. 2, unit Ts south of the caldera margin). Potential mineral resources associated with post-caldera ring-fracture volcanism, and caldera-related hydrothermal activity are depicted as a single area of resource potential on figure 2 (stipple pattern).

Numerous high-silica rhyolite intrusions (fig. 2, unit Tr) located in the southern and central parts of the study area have moderate potential for arsenic, mercury, and zinc resources. The rhyolite intrusions are locally brecciated and cut by quartz veins. Geochemical analyses indicate that the brecciated rhyolite contains anomalous concentrations of these elements.

The study area has low potential for copper, tin, and fluorite resources. Anomalous concentrations of copper are probably associated with fracture fillings in mafic and intermediate intrusions. The anomalously high tin concentrations seem to be spatially associated with rhyolite intrusions. Anomalous fluorite concentrations are probably associated with diagenetic fluorite in lacustrine deposits.

The study area has moderate potential for zeolite resources. Although zeolite concentrations are highest in air-fall tuff layers, they occur in various rock types throughout the study area.

The study area has moderate potential for geothermal energy resources. Numerous thermal springs and wells occur north of the study area. One area near the northern boundary is underlain by a thermal water reservoir less than 1,000 m from the surface (Oregon Department of Geology and Mineral Industries, 1982).

Sedimentary rocks in the northern and central parts of the study area have low potential for petroleum and natural gas resources. A seismic study and drilling program are needed to help determine their resource potential.

Prospects and claims located near the eastern boundary of the study area (fig. 2) contain identified resources of "picture jasper." "Picture jasper" is a locally derived name for cryptocrystalline, nearly opaque, variegated silica containing as much as 1 percent disseminated pyrite (Scott, 1986). Picture jasper commonly occurs along known fault and fracture zones.

INTRODUCTION

Area Description

The Honeycombs Wilderness Study Area (OR-003-77A) consists of approximately 39,000 acres in the north-central Basin and Range physiographic province of eastern Oregon. The area is located adjacent to the Owyhee Reservoir, approximately 30 mi west of the Idaho state line and 40 mi north of Jordan Valley, Oregon (fig. 1). The study area is accessible from U.S. Highway 95 via an improved gravel road paralleling Succor Creek and several unimproved gravel roads and jeep trails. Westward-draining creeks have eroded deep gulches in the pyroclastic deposits. Normal pool elevation of the Owyhee Reservoir is 2,655 ft. The maximum elevation in the study area is about 5,000 ft along Bannock Ridge. The climate is semiarid; vegetation is sparse with sage brush and grasses dominant at all elevations. Juniper trees are found along creek bottoms and in protected gulches.

Previous and Present Investigations

A reconnaissance geologic map of the Owyhee region by Kittleman and others (1967) was used, in part, as a basis for preliminary investigations. In addition, the U.S. Geological Survey conducted a

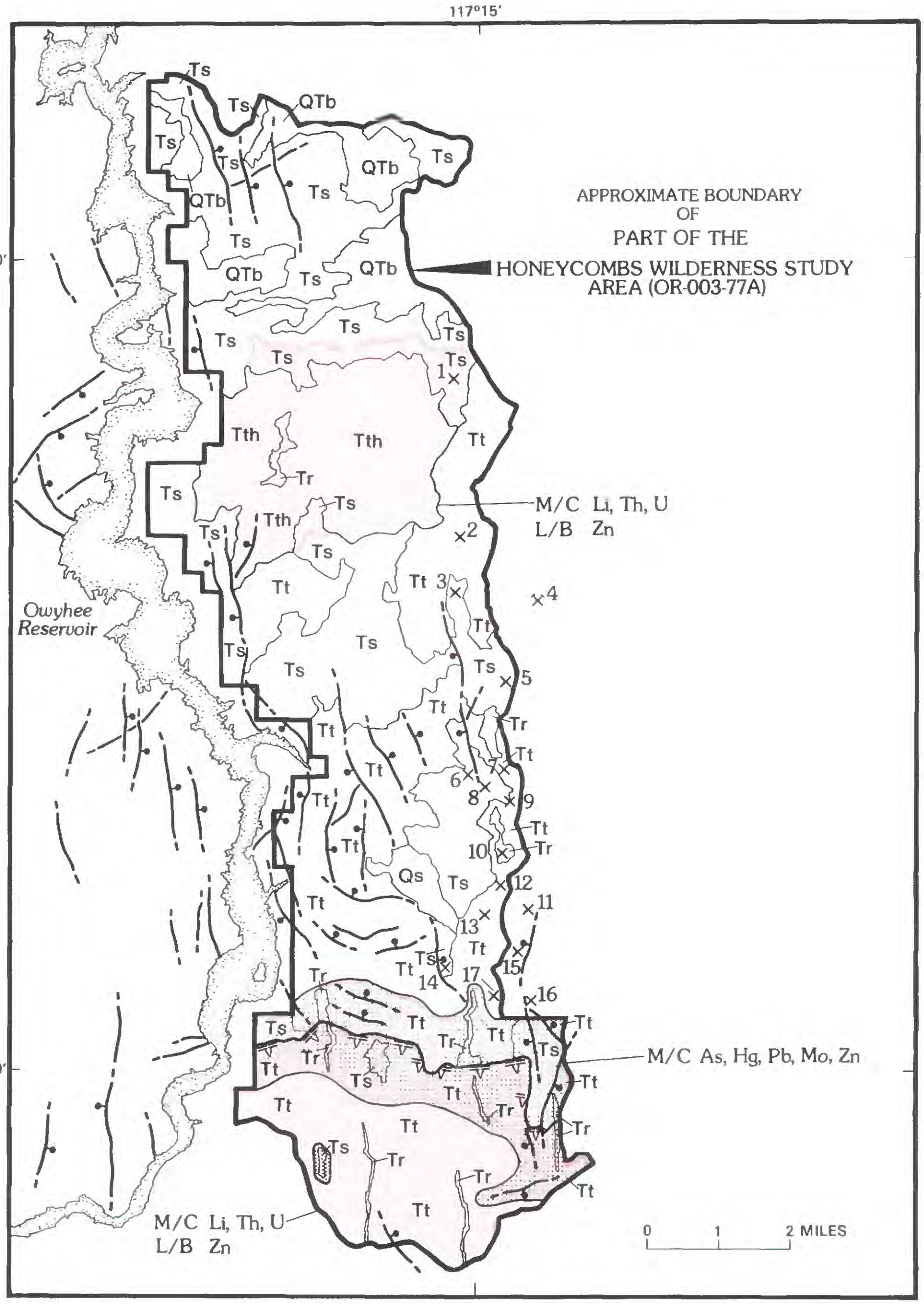


Figure 2. Map showing geology and mineral resource potential of the Honeycombs Wilderness Study Area, Malheur County, Oregon.

ERRATA FOR U.S. GEOLOGICAL SURVEY BULLETIN 1741-A

Several commodities and their resource potential were inadvertently omitted from figure 2 (pages A4-A5). The corrections are as follows:

1. The entire study area has moderate potential for undiscovered zeolite and geothermal resources, with level C certainty.

2. The entire study area has low potential for undiscovered copper, tin, and fluorite resources, with level B certainty.

3. The Tertiary age sedimentary rocks (unit Ts) in the northern and central parts of the study area have low potential for undiscovered petroleum and natural gas resources, with level B certainty.

4. Several mines, claims, and prospects within the study area (map numbers 1-3, 5-10, 12-14, and 17) have low potential for undiscovered picture jasper resources, with level D certainty. (Also, this sentence should replace the entire last paragraph of the text on page A10 regarding picture jasper.)

EXPLANATION

AREA WITH MODERATE MINERAL RESOURCE POTENTAIL--Lithium, thorium, and uranium. See appendix 1 and figure 3 for definition of mineral resource potential and certainty of assessment.

AREA WITH MODERATE MINERAL RESOURCE POTENTIAL--Arsenic, mercury, molybdenum, lead, and zinc.

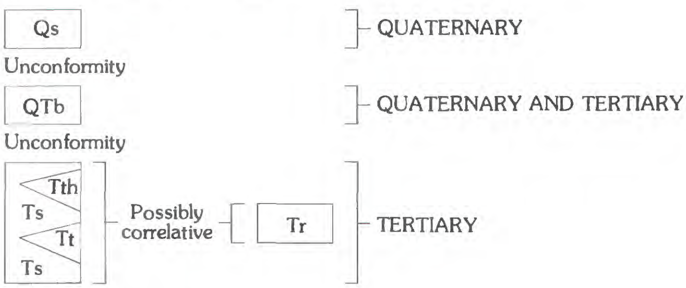
COMMODITIES

As	Arsenic
Hg	Mercury
Li	Lithium
Mo	Molybdenum
Pb	Lead
Th	Thorium
U	Uranium
Zn	Zinc

MINES, PROSPECTS, AND CLAIMS

1. Painted Rock Canyon No. 1 claim
2. Pinto claim
3. unnamed prospect
4. Wild Horse mine
5. unnamed prospect
6. Madonna No. 3 claim
7. Betty No. 1 and Thunder Ridge claims
8. unnamed prospect
9. unnamed prospect
10. unnamed prospect
11. Desert Queen No. 2 claim
12. Owyhee Green Streak claim
13. Big 4 and More No. 1 and 2 claims
14. Lucky Sunday prospect
15. Jackpot No. 2 and J.B. No. 1 claims
16. O.R.T. 1-4 claims
17. Hobnob claim

CORRELATION OF MAP UNITS



GEOLOGIC MAP UNITS

Qs	SURFICIAL DEPOSITS (QUATERNARY)
QTb	BASALT FLOWS, DIKES, AND SILLS (QUATERNARY AND TERTIARY)
Ts	SEDIMENTARY ROCKS (TERTIARY)
Tr	RHYOLITE FLOWS, DOMES, AND DIKES (TERTIARY)
Tth	TUFF OF HONEYCOMBS VOLCANIC CENTER (TERTIARY)
Tt	TUFF (TERTIARY)

MAP SYMBOLS

CONTACT

FAULT--Bar and ball on downthrown side; dashed where uncertain

CALDERA TOPOGRAPHIC MARGIN--Teeth on downthrown side (Mahogany Mountain caldera)

MINE

PROSPECT OR CLAIM

Figure 2. Continued.

combined geological (Vander Meulen and others, 1986a, b, c), geochemical, and geophysical study of the area during the 1984 and 1985 field seasons. The U.S. Bureau of Mines examined all mines, prospects, and claims in or near the study area (Scott, 1986).

Acknowledgments

The authors gratefully acknowledge the help of Mike (Gruby) Grubensky, Kathy Tegtmeyer, Carol Goeldner, and Scott Minor of the U.S. Geological Survey, and Mitch Linne, Dick Winters, Andy Leszcykowski, Dale Avery, John Benham, Nick Winslow, and Brian Ballou of the U.S. Bureau of Mines, during fieldwork of this study.

APPRAISAL OF IDENTIFIED RESOURCES

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

History and Production

Gold placer claims were located south of Leslie Gulch (fig. 1) as early as 1906. Potash exploration began in 1915, but ended abruptly. Gemstone exploration for picture jasper may have started as early as 1932; however, most gemstone exploration began in the late 1960's and continues. Several mining exploration companies have been prospecting in and near the study area for disseminated silver and gold deposits.

At least 329 potash claims were located within the area studied during 1915; they appear to have been abandoned within one year of discovery. Since 1932, an estimated 21 claims within the present study area, and 122 claims within 2 mi of the east edge of the study area, have been located for picture jasper. Seven of these are current mining claims according to 1983 Bureau of Land Management records. At least 74 workings (pits, bulldozer cuts, and open cuts) are in or adjacent to the study area. Of these, 22 are located in the study area.

Approximately 13 placer claims are south of Leslie Gulch, and one placer claim is in the study area. Oil and gas leases occupy 6,560 acres in the northern half of the study area, according to 1983 Bureau of Land Management records.

Several tons of picture jasper have been produced in and adjacent to the study area; however, no production records are available. Value of the picture jasper varies; most of the material averages at least $2.50 per pound ($5,000 per short ton). A zeolite mineral (clinoptilolite) is mined by Teague Minerals near Adrian, Oregon, about 15 mi north of the study area. A zeolite mill, also owned by Teague Minerals, is located about 2 mi south of Adrian, Oregon and processes about 400 tons of zeolites per month (Glen Teague, personal commun., 1985). Silver and gold are produced from veins, fracture fillings, and veinlets in a caldera-related porphyritic rhyolite at the DeLamar mine, about 30 mi east of the study area.

Mines, Prospects, Claims, and Mineralized Areas

Picture jasper is present in small quantities at each of the 6 prospects, 10 claim groups, and 1 mine that were mapped and sampled (fig. 2). Gemstone collectors work some of these deposits on a seasonal basis. The largest deposit, the Wild Horse mine (fig. 2, no. 4), is adjacent to the east boundary of the study area and is worked from June to November. Most of the surface area of the mine is overlain by at least 35 ft of ash-flow tuff of the Leslie Gulch Tuff Member of the Sucker Creek Formation (Kittleman and others, 1965; Kittleman, 1973).

Zeolites are present in air-fall tuff layers in the Sucker Creek Formation. Seventy-five samples of tuff collected at 67 locations were analyzed for zeolites. Twenty-four samples contained at least 50 percent zeolites. Zeolite composition ranged from 6 to 72 percent clinoptilolite and 15 to 55 percent mordenite. Samples with total zeolite composition greater than 50 percent (clinoptilolite and mordenite percentages combined) were tested for ammonia cation exchange capacity (CEC). CEC's ranged from 0.02 to 1.6. Erratic zeolite (CEC) values and (or) the intermittent nature of exposures of zeolite-bearing rock preclude estimation of grade, tonnage, and areal extent of any zeolite resource.

Although most of the study area was claimed in 1915 for potash, no potash occurrences were found. Seventy-four samples analyzed for potassium ranged from 0.99 to 5.4 percent potassium, values typical of unmineralized rock.

One sample of clayey, volcaniclastic material from Craig Gulch in the southern part of the area was evaluated for its possible use as a structural clay product (construction-grade brick fired at 1,000 to 1,050 $^{\circ}$C). The sample came from a zone 2 to 3 in. thick and limited to about 100 ft of exposure; therefore, a clay resource is not apparent.

A 50-ft-long, 0.5-ft-thick carbonaceous zone exists in air-fall tuff layers in the northern part of the study area. The zone contained no detectable gold, uranium oxide, or thorium oxide.

No detectable gold was found in one placer sample collected near Mud Spring, in the southern part of the study area.

Appraisal of Mineral Resources

No significant mineral resources were identified in or adjacent to the study area.

Small amounts of picture jasper are removed annually from prospects in and adjacent to the study area.

Zeolites are found in tuff and volcanic sedimentary rocks throughout the study area; however, exposures contain erratic concentrations and are limited in size. Twenty-four samples contained zeolite concentrations greater than 50 percent. Of these, eight contain CEC's of 1.5 or more. If deposits of material approaching this grade are delimited by detailed mapping, mining companies may become interested in the area. Zeolites of this grade can be used for absorbent material.

Sand and gravel are present throughout the study area. There are adequate and more accessible deposits of sand and gravel outside the study area.

Recommendations for Further Work

Ash-flow tuff in and adjacent to the study area was sampled for the presence of zeolites. Twenty-four of 75 samples meet industry requirements for commercial zeolites. Based on these samples,detailed sampling and mapping of zeolite-bearing tuff in an area north of Leslie Gulch may reveal accumulations of zeolites.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Dean B. Vander Meulen, James J. Rytuba, Harley D. King, and Donald Plouff
U.S. Geological Survey

Geology

The Honeycombs Wilderness Study Area is underlain by rhyolite flows, air-fall and ash-flow tuffs, interbedded arkosic and tuffaceous sedimentary rocks, basalt flows, and silicic, intermediate, and mafic intrusions. All rocks in the area are of Miocene or younger age. The volcanic and sedimentary rocks were deposited in a broad,north-plunging lacustrine basin that evolved in eastern Oregon and western Idaho beginning in late Miocene time (Gray and others, 1983).

Peralkaline rhyolite ash-flow and air-fall tuffs are the dominant rock type within the study area. Two major air-fall tuffs and four separate ash-flow tuffs are distinguishable. They are mapped together as units Tt and Tth (fig. 2). The ash-flow sheet with the greatest volume and areal extent in the study area is the Leslie Gulch Tuff Member. The tuff is divided into outflow facies, air-fall facies, and intracaldera facies. Eruption of the tuff resulted in the formation of the Mahogany Mountain caldera (Rytuba, 1985). A potassium-argon (K-Ar) age obtained from the tuff is 15.5±0.5 Ma. The southern third of the study area includes part of the caldera collapse structure. The intracaldera facies of the Leslie Gulch Tuff Member is the lowest exposed stratigraphic unit within the collapse structure. Overlying and interbedded with the intracaldera facies is the air-fall facies of the Leslie Gulch Tuff Member, both of which were erupted from a vent in the center of the caldera. Outflow facies of the Leslie Gulch Tuff Member overlie bedded tuffaceous siltstone, mudstone, and fine- to medium-grained arkosic sandstone. Sedimentary rocks are exposed along the northern topographic margin of the caldera and are the oldest rocks in the study area. Fine- to coarse-grained arkosic sandstone and interbedded tuffaceous siltstone overlie the outflow facies of the tuff. Stratigraphically above these sedimentary rocks is the ash-flow tuff of Spring Creek.

The tuff of Spring Creek and sedimentary rocks thicken to the north and east. The thickest sections of the tuff of Spring Creek are localized within the moat of the Mahogany Mountain caldera and along the east-central margin of the study area. Moat-fill sedimentary rocks (confined to the subsided part of the caldera collapse structure) overlie the tuff of Spring Creek and the Leslie Gulch air-fall deposit. The moat-fill sedimentary rocks are thin-bedded, fine-grained sandstone, siltstone, and shale locally altered and mineralized.

Two north-striking rhyolite dike systems intrude the floor of the Mahogany Mountain caldera. The rhyolite dikes are exposed in the southernmost part of the study area (fig. 2), parallelling both sides of a graben in the resurgent dome of the Mahogany Mountain caldera. Potassium-argon ages obtained from the rhyolite dikes are 14.7±0.4 Ma and 14.9±0.4 Ma. The caldera margin within the study area is intruded by one rhyolite dome and several rhyolite plugs and dikes. A K-Ar age obtained from one of the rhyolite plugs is 14.9±0.4 Ma. Rhyolite domes and plugs are common along the southeastern boundary of the study area. Rhyolite intrusions are locally brecciated, silicified, and cut by quartz veins.

The Honeycombs volcanic center (Vander Meulen and others, 1986b), located in the north-central part of the study area, contains voluminous air-fall tuff and several rhyolite dikes and plugs. Near-vent air-fall deposits form coalescing pumice cones armored with rhyolite agglutinate. Distal vent deposits are well-bedded pumice lapilli air-fall tuff. The tuff and pumice cones were subsequently intruded by rhyolite dikes and plugs, all with a similar high-silica rhyolite composition. Geochemical and stratigraphic relations suggest that the tuff erupted from the Honeycombs volcanic center is younger than the tuff erupted from the Mahogany Mountain caldera.

North-dipping volcaniclastic and arkosic sedimentary rocks onlap the air-fall tuff in the northern part of the Honeycombs volcanic center. An intermediate-to-mafic, lithic-rich palagonite ash-flow tuff is interbedded with the sedimentary rocks. The sequence of volcanic and sedimentary rocks is intruded by numerous dikes and sills of pyroxene andesite. Pyroxene andesite is exposed in large sills (2 to 3 mi long) that intrude tuffs of the Honeycombs volcanic center, and in north-trending dikes cutting sedimentary rocks immediately north and west of the Honeycombs volcanic center. Basalt flows, dikes, and sills cap and (or) intrude the entire sequence of sedimentary rocks in the northern part of the study area. The basaltic rocks are the youngest volcanic rocks in the study area.

Stream-bed and alluvial-fan deposits form the thickest accumulations of Quaternary sediment in the study area. Lag gravels and colluvium form extensive veneer deposits on low-angle slopes and terraces.

The study area is located within the Basin and Range physiographic province, a region characterized by extensional tectonism. Volcanic and sedimentary rocks of Miocene age within the study area are broken by several north- to north-northwest-trending horst and graben stuctures; the resulting fault blocks form the dominant structural pattern in the study area. The central part of the Owyhee reservoir is located within a north-trending graben, which is the largest fault block in the study area. Normal faults along the west side of the Owyhee reservior (fig. 2) help delineate the graben. Poorly exposed, northwest-trending faults cross the northern and central part of the study area. These faults control tributary drainage and truncate north-trending normal faults. Faults in the southern part of the study area reflect both east-west extension and collapse along an east-west-trending caldera ring fracture. The topographic margin of the Mahogany Mountain caldera is, in part, controlled by north-trending normal faults, indicating caldera collapse may have occurred along preexisting north-trending normal faults.

Geochemical Studies

In 1984, the U.S. Geological Survey conducted a geochemical study of the Honeycombs Wilderness Study Area based on the analysis of stream sediments, stream-sediment heavy-mineral concentrates, and rock samples. Geochemical data obtained from stream-sediment analyses represents the composite chemistry of rock units in a particular drainage basin. Drainage basins within the study area range from 0.5 to several square miles in size.

Fifty-three stream-sediment samples, 49 heavy-mineral-concentrate samples, and 12 rock samples were analyzed for 31 elements by six-step semiquantitative emission-spectrographic methods (Myers and others, 1961; Grimes and Marranzino, 1968). Several samples were analyzed by inductively coupled argon plasma atomic-emission spectroscopy (ICAP-AES) (Crock and others, 1983) using a modification of the O'Leary and Viets digestion method (1986). Atomic-absorption and cold-vapor atomic-absorption methods were used to determine concentrations of gold and mercury (Thompson and others, 1968; Koirtyohann and Khalil, 1976).

Peralkaline rhyolite tuffs and intrusions, which comprise the Honeycombs volcanic center (unit Tth, fig. 2), have the highest uranium (12 parts per million, or ppm) and thorium (20 ppm) concentration in the study area. Tuffaceous sedimentary rocks derived from the Honeycombs volcanic center also have high uranium and thorium contents. Aerial gamma-ray surveys (EG and G geoMetrics, 1979), which cover part of the Honeycombs volcanic center, revealed uranium and thorium anomalies over the volcanic center approaching five times one standard deviation from the mean uranium and thorium concentrations for rocks in the Boise 2^{o} quadrangle. The anomalies closely correspond to the distribution of rock types within the Honeycombs volcanic center and associated tuffaceous sedimentary rocks. The anomalies most likely reflect high magmatic concentrations of the elements dispersed throughout the strata, rather than local high-grade concentrations of uranium and thorium. Although no zones of hydrothermal alteration were noted in or adjacent to intrusive rocks within the Honeycombs volcanic center, vein-type uranium deposits typically associated with peralkaline may be present at depth.

Peralkaline rhyolite tuffs and intrusions associated with the Mahogany Mountain caldera have high uranium (8 ppm) and thorium (18 ppm) contents. Aerial gamma-ray surveys (EG and G geoMetrics, 1979), which cover part of the caldera, show uranium anomalies over the caldera. The anomalies likely reflect the high concentrations of uranium present in the Leslie Gulch Tuff Member and rhyolite intrusions associated with the Mahogany Mountain caldera. Hydrothermal alteration associated with rocks intruded by rhyolite along the margin of the caldera, as well as geochemical anomalies of arsenic, mercury, molybdenum and zinc, indicate that local high-grade concentrations of uranium and thorium may be present. Vein-type uranium deposits in the McDermitt caldera complex (Rytuba and Glanzman, 1979) are associated with peralkaline rhyolite intrusions and may be present within the Mahogany Mountain caldera complex. Sedimentary rocks that fill the moat of the caldera have been zeolitized, silicified, and pyritized. Geochemical anomalies of arsenic, mercury, zinc, and molybdenum in these rocks indicate the possible existence of stratiform uranium deposits similar to those associated with the peralkaline calderas in the McDermitt volcanic field (Rytuba, 1981).

Lithium concentration in peralkaline volcanic and volcaniclastic rocks associated with the Honeycombs volcanic center and the Mahogany Mountain caldera is the highest known for peralkaline rocks (200 ppm). High initial concentrations of lithium in the volcanic rocks, as well as widespread occurrences of zeolites in these rocks, suggest that stratiform lithium deposits, similar to occurrences in peralkaline rhyolite of the McDermitt caldera (Rytuba, 1981), may be present in the study area.

The peralkaline rhyolite associated with the Honeycombs volcanic center and the Mahogany Mountain caldera has the highest zinc concentration for peralkaline rocks known to the authors. The high zinc content of the peralkaline rhyolite is attributed to chlorine enrichment of the magma (Rytuba, 1981). Fifty rock samples of ash-flow and air-fall tuff were analyzed for zinc by X-ray fluorescence (kevex). Concentrations typically ranged from 200 to 500 ppm, with some values as high as 700 ppm (T. L. Vercoutere, written commun., 1986).

Various rock types along the Mahogany Mountain caldera ring fracture are hydrothermally altered and silicified. Samples of intracaldera tuff collected from a silicified fracture, which trends parallel to the northern caldera margin, contain anomalous concentrations of arsenic (120 ppm) and mercury (0.7 ppm). Samples of silicified and pyritized moat-fill sedimentary rock collected a little south of the topographic wall of the caldera contain anomalous concentrations of arsenic (140 ppm), lead (126 ppm), molybdenum (65 ppm), and zinc (90 ppm). The northern margin of the caldera is intruded by several high-silica rhyolite plugs and dikes. Locally, rhyolite intrusions are cut by quartz veins. Samples of the fractured rhyolite and quartz veins contain anomalous concentrations of arsenic (30 ppm), mercury (2.8 ppm), and zinc (250 ppm). The high zinc content probably reflects normal magmatic enrichment and (or) concentrations derived from hydrothermal systems active during the close of the caldera cycle. No gold was detected in these samples.

Several stream-sediment samples collected in the study area contain anomalous concentrations of copper (300 to 3,000 ppm), tin (799 to 1,000 ppm), and fluorine (600 to 850 ppm) (Gray and others, 1983; Erickson and others, 1986). Samples containing anomalous concentrations of copper are restricted to the northern part of the study area and seem to be associated with intrusions of basalt and andesite. The distribution of samples containing anomalous concentrations of tin seem to correlate with rhyolite plugs and dikes in the Honeycombs volcanic center, and with dikes in the southern part of the study area. Potential tin resources in the study area may have formed in an environment similar to the tin deposits found in Tertiary rhyolite of the Black Range (Lufkin, 1976) in southwestern New Mexico. Stream-sediment samples collected in the central part of the study area contain microscopic grains of fluorite (H.D. King, written commun., 1986). Authigenic fluorite in lacustrine and tuffaceous sedimentary rocks is reported by Sheppard and Gude (1969) 30 mi southeast of the study area. Diagenetic fluorite in lacustrine and tuffaceous sedimentary rocks may occur in the study area.

Near the eastern boundary of the study area, identified resources of picture jasper are mined from silicified and pyritized tuffaceous and sedimentary rocks. The pattern of alteration in the rocks roughly corresponds with known fault zones.

Geophysical Studies

The U.S. Geological Survey established 11 gravity stations in and near the study area to supplement gravity data obtained from the National Geophysics Data Center (1984). Other gravity data were obtained by Couch and Baker (1977). A preliminary Bouguer gravity-anomaly map of the study area (Plouff, 1985, unpublished map) is dominated by a north-south-elongated, 8- by 20-mi gravity low with an amplitude of about 20 mGal. The gravity low probably reflects the presence of a subsided wedge of tuffaceous sediments of relatively low density within a caldera. The steep gravity gradients at the edges of the anomaly (9 mGal/mi near the south and southwest edges of the study area) indicate that the wall of the caldera is steep and the top of the intracaldera fill is buried at a shallow depth. Furthermore, the intracaldera fill is thickest where the gravity low has a minimum value, about 4 mi north of the south edge of the study area. Spatial associations indicate that the caldera may have subsided in response to depletion of an underlying magma chamber after extrusion of the Leslie Gulch Tuff Member.

An aeromagnetic survey of the region was flown at a barometric elevation of 9,000 ft above sea level with east-west flightlines spaced at 2-mi intervals (U.S. Geological Survey, 1972). The aeromagnetic map is dominated by a north-south-elongated, 6- by 10-mi magnetic high centered over the Owyhee reservoir. The only other magnetic anomaly in the study area is a small magnetic low located in its northwest corner. The magnetic low probably is a normal polarization effect of the large magnetic high. A small gravity high with an amplitude of less than 3 mGal nearly coincides with the crest of the large magnetic high. The axis of the magnetic high is located along the west edge of the gravity low. Therefore, although the two geophysical anomalies are roughly the same size, the lack of coincidence suggests a separate source for the magnetic anomaly. The magnetic high may reflect a large intrusive body with moderate to high magnetization centered beneath the west wall of the caldera.

CONCLUSIONS

Geologic and geochemical investigations indicate that there are several levels of mineral resource potential in the Honeycombs Wilderness Study Area.

Areas within the Honeycombs volcanic center and Mahogany Mountain caldera (fig. 2) have moderate potential for lithium, thorium, and uranium mineral resources with level C certainty. The mineral resource potential rating is based on anomalous concentrations of these elements in rock samples, and anomalous aerial gamma-ray values for thorium and uranium. The level of certainty rating is based on the preceeding data, and genetic models presented in previous sections that describe possible resource-forming processes. See appendix 1 and figure 3 for definitions of levels of mineral resource potential and certainty.

Large volumes of peralkaline rhyolite tuff associated with the Honeycombs volcanic center and Mahogany Mountain caldera have extraordinarily high zinc concentrations. Volcanogenic disseminated-zinc resources of this type were previously unrecognized; therefore, low potential for zinc resources is assigned to areas underlain by the rhyolite tuff, with level B certainty.

Rocks present along the northern margin of the Mahogany Mountain caldera contain anomalous concentrations of arsenic, lead, mercury, molybdenum, and zinc. Hydrothermal systems active during the close of the caldera cycle likely concentrated these elements; therefore, areas adjacent to the caldera margin (fig. 2, stipple pattern) have moderate potential for arsenic, lead, mercury, molybdenum, and zinc resources, with level C certainty.

The study area has low potential for copper, tin and fluorite resources, with level B certainty. The mineral resource potential rating is based on anomalous concentrations of these elements in soil samples.

The study area has moderate potential for zeolite resources, with level C certainty. Zeolite minerals occur in various rock types throughout the study area, with the highest concentrations occurring in air-fall tuff beds.

Resource potential for geothermal energy in the study area is moderate, certainty level C. An unnamed hot spring is located along a north-trending normal fault 3 mi southwest of the study area. Recorded temperature of the spring water is 50° C (Bliss, 1983). Several thermal springs and wells are located about 10 mi north of the study area (Oregon Department of Geology and Mineral Industries, 1982). One area, less than 3 mi north of the northwest boundary of the study area, may be underlain at shallow depth (less than 1,000 m) by thermal water of sufficient temperature for direct heat applications (Oregon Department of Geology and Mineral Industries, 1982).

Sedimentary rocks in the northern and central parts of the study area have low potential for petroleum and natural gas resources, with level B certainty. The sedimentary rocks are intruded and interbedded with volcanic rocks. Heat which accompanied the volcanic intrusions likely destroyed nearby petroleum and natural gas reservoirs. A drilling program in conjunction with seismic studies is needed to test the sedimentary rocks for the presence of hydrocarbons.

Several prospects and claims, and one mine near the eastern boundary of the study area contain identified resources of picture jasper, with level D certainty. The deposits are small, commonly restricted to silicified and pyritized fault and fracture zones. Because of the small and confined nature of the deposits, the economic value of the picture jasper is considered low.

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Table 1. Mines, claims, and prospects in and adjacent to the Honeycombs Wilderness Study Area [(*) indicates outside study area]

Map No.	Name	Geology	Workings/Production	Sample Data
1	Painted Rock Canyon No. 1 claim	Tabular outcrop of vitrophyre exposed in Sucker Creek Fm. Mafic rocks capped by zone of red oxidized mafic rocks and volcanic detritus.	No workings; no known production; claim prospected for picture jasper.	Four samples: 2 chip samples from mafic sill, one grab sample of sill rock contained no gold or silver; 1 chip and 1 grab sample contain <5.7 percent iron oxide; 1 grab sample of oxidized zone contains no gold, silver or iron oxide.
2	Pinto claim	Fractures in Leslie Gulch Tuff Member are filled with green limonite-stained cryptocrystalline silica.	1 trench 125 ft long, 12 ft wide, and 3 ft deep prospected for picture jasper; no known production.	1 select sample of silica contained no gold or silver.
3	Unnamed prospect	Gray to white, clayey, poorly consolidated volcaniclastic rock.	3 shallow pits, each < 25 ft long and 12 ft wide, were prospected for picture jasper; no known production.	2 chip samples of volcaniclastic rock contained no diatoms, and from 2.3 to 3.3 percent potassium, 0.03 percent chlorine, and 0.14 to 0.26 percent sulfate.
4 *	Wild Horse mine	5-ft-thick fracture zone in Leslie Tuff Member filled with limonite-stained brown to blue cryptocrystalline silica; fault adjacent to fracture strikes N. 37°-54° W. and dips 47°-75° SW; fault contains brecciated cryptocrystalline silica with <1 percent disseminated pyrite.	1 open cut about 300 ft long, 40 ft wide, and 20 ft deep, 1 trench 60 ft long by 20 ft and 3 ft deep, and 3 shallow trenches <50 ft long and 12 ft wide were mined in 1984 for picture jasper; no known production.	10 samples: 4 chips of silica, 2 chip and 4 grab samples of tuff; of 9 samples analyzed, none contained gold, 1 contained 0.2 oz/ton silver, 1 contained 6 ppm antimony, 5 contained 4.0-8.3 ppm arsenic, 1 contained low concentrations of mercury and thallium, and 1 contained 8,900 ppm fluorine; of 8 samples analyzed for magnesium, all contained >150 ppm; 1 grab sample of tuff contained 15 percent mordenite, a zeolite mineral.
5	Unnamed prospect	A 2-4-ft-thick fracture zone striking N. 44° E. and dipping 80° NW. in Leslie Gulch Tuff Member is filled with limonite- and manganese-stained blue to brown cryptocrystalline silica.	2 pits <4 ft in diameter and < 3 ft deep were prospected for picture jasper; no known production.	2 samples (1 select, 1 chip) of the silica contained no gold or silver.
6	Madonna No. 3 claim	Frature zone 22 ft thick striking N. 25° W. and dipping 70° NE. in Leslie Gulch Tuff Member is filled with blue to brown cryptocrystalline silica.	Prospected for picture jasper; no known production.	1 chip sample of silica contained no gold, silver, antimony, mercury, or thallium, 5 ppm arsenic, 82 ppm fluorine, and 150 ppm magnesium; 1 grab sample of tuff contained no gold or silver.
7	Betty No. 1 and Thunder Ridge claims	1-2-ft-thick fracture zone in Leslie Gulch Tuff Member is filled with blue to green limonite-stained cryptocrystalline silica; vitrophyre caps the tuff.	Trench 50 ft long, 12 ft wide, and <3 ft deep, was prospected for picture jasper; no known production.	4 samples (3 chip of silica, 1 chip of tuff) collected; none contained gold or silver; of 2 samples analyzed for antimony, mercury, and thallium, none contained detectable amounts; 2 analyzed for arsenic contained 7 and 11.9 ppm; 1 contained >150 ppm magnesium.
8	Unnamed prospect	A 5-ft-thick fracture zone in Leslie Gulch Tuff Member is filled with gray cryptocrystalline silica.	Pit <6 ft in diameter and < 3 ft deep was prospected for picture jasper; no known production.	1 chip sample of gray silica contained no gold, silver, antimony, mercury, thallium, or sulfate, 11 ppm arsenic, 0.004 percent chlorine, 76 ppm fluorine, 480 ppm magnesium, and 3.2 percent potassium.
9	Unnamed prospect	Fracture zone 2.5 ft thick in Leslie Gulch Tuff Member filled with buff to green cryptocrystalline silica.	2 trenches <50 ft long, 12 ft wide, and 3 ft deep were prospected for picture jasper; no known production.	2 chip samples of silica contained no gold or silver; 1 chip sample contained no antimony, mercury, or thallium, 15 ppm arsenic and 819 ppm magnesium.

Table 1. Mines, claims, and prospects in and adjacent to the Honeycombs Wilderness Study Area--Continued

Map No.	Name	Geology	Workings/Production	Sample Data
10	Unnamed prospect	Fracture in the Leslie Gulch Tuff Member is filled with blue to green cryptocrystalline silica with <1 percent disseminated pyrite.	2 shallow trenches <50 ft long and 12 ft wide were prospected for picture jasper; no known production	3 chip samples of silica were collected; 2 contained trace of gold; none contained silver; 3 contained 31, 32, and 36 ppm arsenic; none contained mercury or thallium; 1 contained 2 ppm antimony, and 1 contained >150 ppm magnesium.
11*	Desert Queen No. 2 claim	Buff to brown tuff of the Leslie Gulch Tuff Member.	3 pits, <20 ft in diameter, and 1 trench <50 ft long and 12 ft wide were prospected for picture jasper; no known production.	3 samples collected; 1 grab sample of buff-colored tuff contained no gold, silver, antimony, mercury, or thallium, 4 ppm arsenic, 200 ppm fluorine, and 1,420 ppm magnesium; 2 chip samples of tuff contained 4 and 16 percent analcime.
12	Owyhee Green Streak claim	Buff to brown tuff of Leslie Gulch Tuff Member exposed here; limonite-stained blue to green silica found in trenches and on dumps.	2 trenches <50 ft long and 12 ft wide were prospected for picture jasper; no known production.	Grab sample of silica contained no gold, silver, or mercury, and 5.7 ppm uranium.
13	Big 4 and More claims 1 and 2	Buff to brown tuff of Leslie Gulch Tuff Member is exposed here; limonite-stained blue to green silica found in trenches and on dumps.	4 trenches <60 ft long and 12 ft wide were prospected for picture jasper; no known production.	10 samples of silica collected; no gold detected; 4 contained 0.1 oz/ton silver; none contained antimony or thallium; 3 contained 3 ppm mercury; 8 contained 3-11 ppm arsenic and >150 ppm magnesium.
14	Lucky Sunday prospect	Fractures in Leslie Gulch Tuff Member filled with tan to brown cryptocrystalline silica	Trench <100 ft long and 12 ft wide prospected for picture jasper; no known production.	Chip sample of silica contained no gold, silver,antimony, mercury, or thallium; sample contained 10.8 ppm arsenic, 0.03 percent chlorine, 12 ppm fluorine, 270 ppm magnesium, 2.8 percent potassium, and 0.04 percent sulfate.
15*	Jackpot No. 2 and J.B. No. 1 claims	A 4-7-ft-thick fracture zone in Leslie Gulch Tuff Member filled with cryptocrystalline silica; adjacent fault zone strikes N. 75° E. and dips 68° NE. in Leslie Gulch Tuff Member and is filled with brown to blue brecciated cryptocrystalline silica.	Trench <70 ft long and 12 ft wide, and shallow pit <10 ft in diameter prospected for picture jasper; no known production.	Seven chip samples of silica and 5 chip and one grab of tuff collected; of 12 analyzed for gold, 2 contained a trace; of 12 analyzed for silver, 4 contained 0.1 oz/ton and 1 contained 0.2 oz/ton; none contained antimony, mercury, or thallium; 5 contained 3-7 ppm arsenic; of 9 analyzed for magnesium, 7 contained > 150 ppm; 3 chip samples of tuff contained 47-100 ppm fluorine.
16*	O.R.T 1-4 claims	Fault zone striking N. 80° E. and dipping 80° SE. in Leslie Gulch Tuff Member is filled with green to blue cryptocrystalline silica.	2 shallow pits <20 ft in diameter prospected for picture jasper; no known production.	3 chip samples and 1 grab sample of silica, and 2 chip samples of tuff collected; none contained gold; 2 contained 0.1 and 0.2 oz/ton silver; of 5 analyzed for mercury and thallium, none contained detectable concentrations; 1 contained 3 ppm antimony; 5 samples contained 5-70 ppm arsenic; 4 contained >150 ppm magnesium.
17	Hobnob claim	A 0.5-ft-thick fracture zone in Leslie Gulch Tuff Member filled with blue to brown cryptocrystalline silica.	Trench <100 ft long and 12 ft wide was prospected for picture jasper; no known production.	2 samples of silica collected; 1 grab sample contained no gold or silver; one chip sample contained no gold, silver, antimony, arsenic, mercury, or thallium; 1 contained 150 ppm fluorine and 1,020 ppm magnesium.

APPENDIX 1. Definition of levels of mineral resource potential and certainty of assessment

Mineral resource potential is defined as the likelihood of the presence of mineral resources in a defined area; it is not a measure of the amount of resources or their profitability.

Mineral resources are concentrations of naturally occurring solid, liquid, or gaseous materials in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Low mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment where the existence of resources is unlikely. This level of potential embraces areas of dispersed mineralized rock as well as areas having few or no indications of mineralization. Assignment of low potential requires specific positive knowledge; it is not used as a catchall for areas where adequate data are lacking.

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 chance for resource accumulation, and where an application of genetic and (or) occurrence models indicates favorable ground.

High mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resources, where interpretations of data indicate a high likelihood for resource accumulation, where data support occurrence and (or) genetic models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential requires positive knowledge that resource-forming processes have been active in at least part of the area; it does not require that occurrences or deposits be identified.

Unknown mineral resource potential is assigned to areas where the level of knowledge is so inadequate that classification of the area as high, moderate, or low would be misleading. The phrase "no mineral resource potential" applies only to a specific resource type in a well-defined area. This phrase is not used if there is the slightest possibility of resource occurrence; it is not appropriate as the summary rating for any area.

Expression of the certainty of the mineral resource assessment incorporates a consideration of (1) the adequacy of the geologic, geochemical, geophysical, and resource data base available at the time of the assessment, (2) the adequacy of the occurrence or the genetic model used as the basis for a specific evaluation, and (3) an evaluation of the likelihood that the expected mineral endowment of the area is, or could be, economically extractable.

Levels of certainty of assessment are denoted by letters, A-D (fig. 3).

A. The available data are not adequate to determine the level of mineral resource potential. Level A is used with an assignment of unknown mineral resource potential.

B. The available data are adequate to suggest the geologic environment and the level of mineral resource potential, but either evidence is insufficient to establish precisely the likelihood of resource occurrence, or occurrence and (or) genetic models are not known well enough for predictive resource assessment.

C. The available data give a good indication of the geologic environment and the level of mineral resource potential, but additional evidence is needed to establish precisely the likelihood of resource occurrence, the activity of resource-forming processes, or available occurrence and (or) genetic models are minimal for predictive applications.

D. The available data clearly define the geologic environment and the level of mineral resource potential, and indicate the activity of resource—forming processes. Key evidence to interpret the presence or absence of specified types of resources is available, and occurrence and (or) genetic models are adequate for predictive resource assessment.

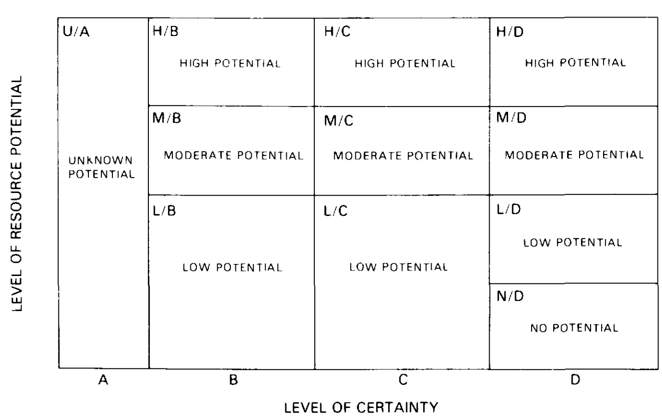

Figure 3. Major elements of mineral resource potential/certainty classification.

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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