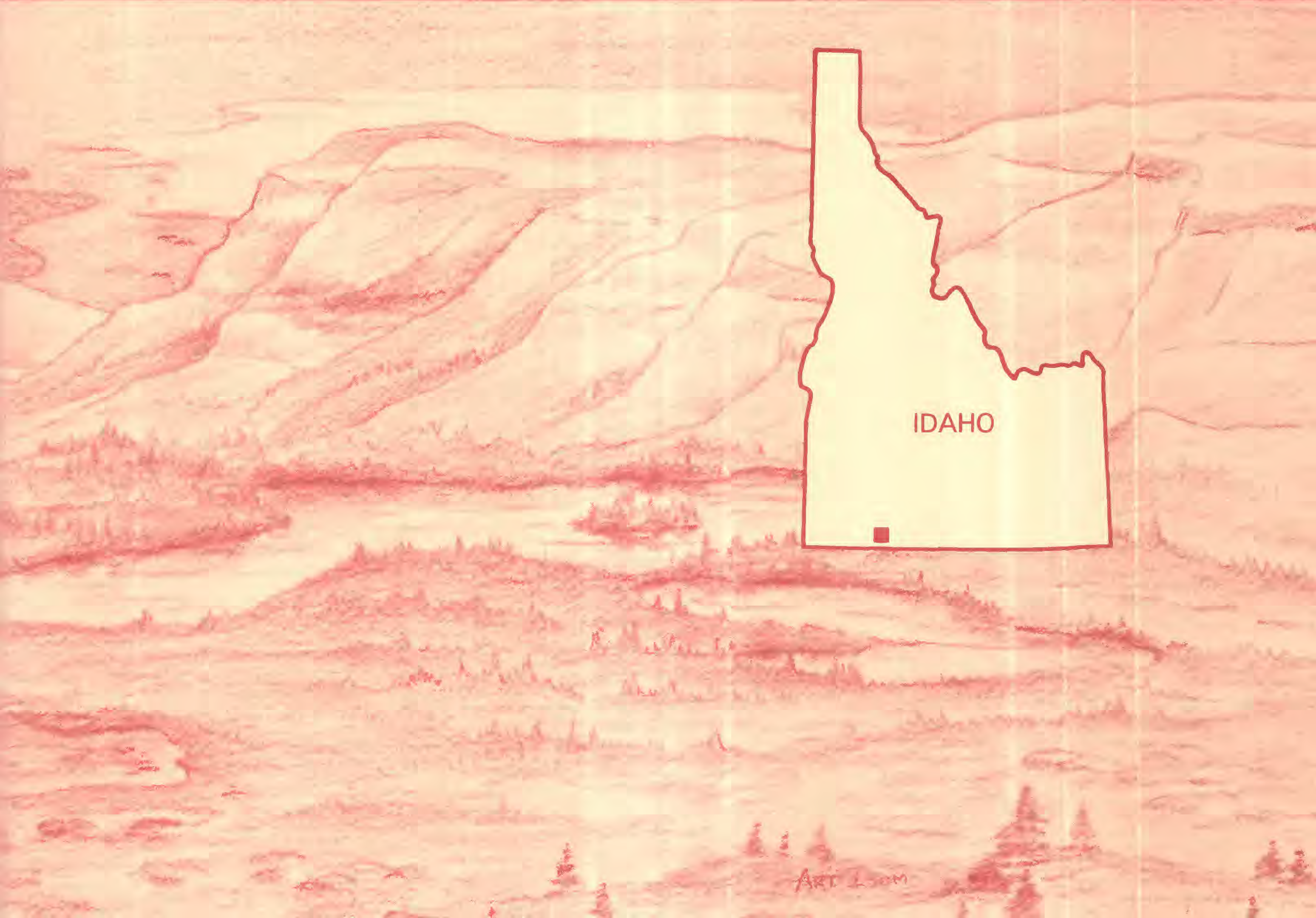
Mineral Resources of the Bruneau River, Jarbidge River, and Sheep Creek West Wilderness Study Areas, Owyhee County, Idaho

U.S. GEOLOGICAL SURVEY BULLETIN 1720–B



Chapter B

Mineral Resources of the Bruneau River, Jarbidge River, and Sheep Creek West Wilderness Study Areas, Owyhee County, Idaho

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U.S. GEOLOGICAL SURVEY BULLETIN 1720

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
BRUNEAU RIVER–JACKS CREEK REGION, IDAHO

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94–579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys 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 parts of the Bruneau River (ID–111–017) and Jarbidge River (ID–017–011) Wilderness Study Areas and of the entire Sheep Creek West (ID–111–036A) Wilderness Study Area, Owyhee County, Idaho.

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PLATE

[Plate is in pocket]

FIGURES

TABLE

Mineral Resources of the Bruneau River, Jarbidge River, and Sheep Creek West Wilderness Study Areas, Owyhee County, Idaho

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SUMMARY

In 1985, the USBM (U.S. Bureau of Mines) and the USGS (U.S. Geological Survey), in cooperation with the Idaho Geological Survey, examined 90,000 acres of the Bruneau River (ID–111–017) Wilderness Study Area, 47,000 acres of the Jarbidge River (ID–017–011) Wilderness Study Area, and the entire 11,680-acre Sheep Creek West (ID–111–036A) Wilderness Study Area to appraise their identified mineral resources and assess their mineral resource potential. Throughout this report, "study area" refers only to the acreage on which mineral surveys were conducted. Identified resources in or near the study areas are (1) Bruneau jasper (a gem-quality jasper) along the boundary between the Bruneau River and Jarbidge River study areas, (2) geothermal sources northwest of the Bruneau River study area (Indian Bathtub) and southeast of the Jarbidge River study area (Murphy Hot Springs), and (3) a limestone deposit northwest of the Bruneau River study area (fig. 1). Parts of the Bruneau River and Jarbidge River study areas have a moderate mineral and energy resource potential for Bruneau jasper and geothermal resources; the rest of these two study areas has a low mineral and energy resource potential for Bruneau jasper and geothermal resources (fig. 1). Both of these study areas have a low mineral and energy resource potential for metals and oil and gas. The Sheep Creek West study area has a low mineral and energy resource potential for Bruneau jasper, metals, geothermal resources, and oil and gas.

The Bruneau River, Jarbidge River, and Sheep Creek West Wilderness Study Areas are located in southwestern Idaho, in the southern part of the Snake River Plain (fig. 1). The countryside consists of gently rolling plateaus into which deep gorges have been cut by Bruneau River, Jarbidge River, and Sheep Creek. Access is provided by dirt roads and jeep trails, as well as from the waterways by raft.

Approximately 38 placer claims for gold and 182 lode and placer claims for jasper, agate, and limestone have been held within and adjacent to the Bruneau River and Jarbidge River Wilderness Study Areas from 1893 to 1981; however, no mining claims are in or adjacent to the Sheep Creek West Wilderness Study Area. Currently (1985), there are eight active mining claims for jasper near Indian Hot Springs along the boundary between the Bruneau River and Jarbidge River study areas. As much as several thousand pounds of gem-quality jasper are mined from the claimed area annually by blasting, bulldozing, and hand sorting. Select material is marketed worldwide as Bruneau jasper. Because demand is moderate, intermittent mining is expected to continue.

No geothermal leases have been issued within or near the Bruneau River, Jarbidge River, or Sheep Creek West study areas. However, geothermal reservoirs, manifested mainly as hot springs, are at three localities near

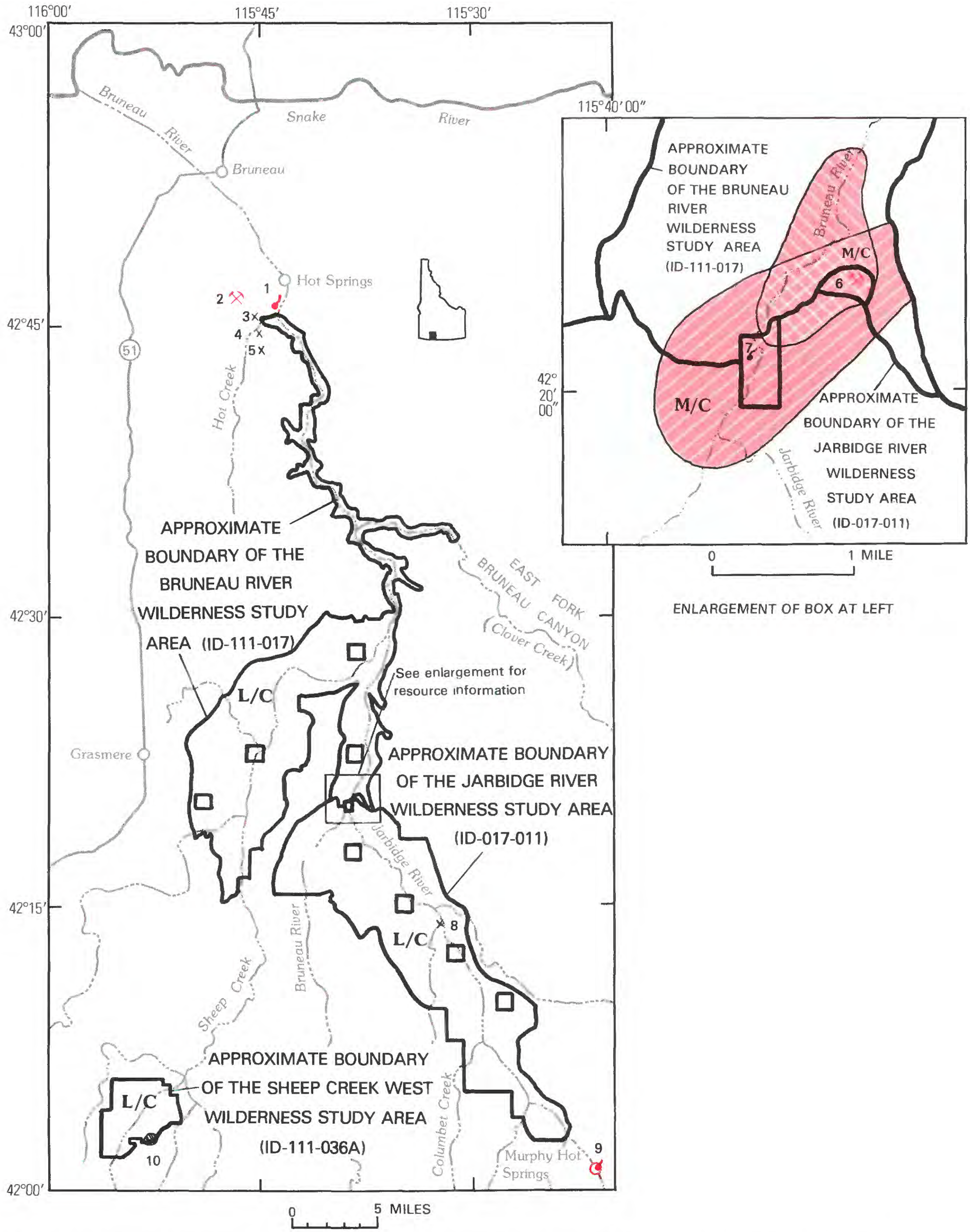

Figure 1 (above and facing page). Map showing (1) location, (2) identified resources and mineral and energy resource potential, and (3) localities of known mines, prospects, geothermal springs, and mineral occurrences of the Bruneau River, Jarbidge River, and Sheep Creek West Wilderness Study Areas and vicinity, Idaho.

EXPLANATION

6 1 **Sites of identified resources**—1 and 9, geothermal resources; 2, limestone; 6, Bruneau jasper. Numbers referred to in text and table 1

M/C **Geologic terrane having moderate mineral resource potential for Bruneau jasper, with certainty level C**

M/C **Geologic terrane having moderate energy resource potential for geothermal resources, with certainty level C**

L/C **Geologic terrane having low mineral and energy resource potential for Bruneau jasper, metals, geothermal resources, and oil and gas, with certainty level C**—Applies to entire study areas except as noted above

Mines, prospects, geothermal springs, and geode occurrence—Numbers referred to in text and table 1

- **Mine**
- X **Prospect**
- **Geothermal spring**
- **Geode occurrence**

Certainty level

C **Data indicate geologic environment and resource potential but do not establish activity of resource-forming processes**

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the Bruneau River and Jarbidge River study areas: (1) Indian Bathtub, near the north end of the Bruneau River study area; (2) Murphy Hot Springs, southeast of the Jarbidge River study area, and (3) Indian Hot Springs, along the boundary between the Bruneau River and Jarbidge River study areas. The low- to moderate-temperature systems are suitable for direct-use applications such as space heating, agriculture, and recreation. Current applications include a prototype commercial aquaculture operation at Indian Bathtub and a commercial resort at Murphy Hot Springs; Indian Hot Springs is used only for recreation.

The northern half of the Bruneau River study area is leased for oil and gas.

An identified subeconomic resource of cement-grade limestone, inferred to contain 20 million tons at an average grade of 50.5 percent CaO (lime), lies just to the west of the northern end of the Bruneau River study area. Approximately 100 tons of limestone were quarried from the deposit in the 1950's.

The Jarbidge mining district of northern Nevada is probably the source of placer gold found in sand and gravel bars recently deposited by the Bruneau–Jarbidge River system in the Bruneau River and Jarbidge River study areas. Values detected in placers along the Jarbidge River ranged from $0.01 to $15.00 per cubic yard and averaged $1.40 per cubic yard; excluding the $15.00 per cubic yard sample, the values averaged $0.57 per cubic yard. Because the gold values are moderate to low and the occurrences are sporadic and small, placers are probably suitable only for recreational panning, sluicing, and suction dredging.

The study areas are underlain primarily by Pliocene and Miocene (see geologic time chart in Appendix for relative ages) Snake River Plain basalts, which overlie a sequence of Miocene rhyolite flows and tuffs interbedded with basalts. Some sedimentary rocks are also interbedded with the volcanic rocks. The rocks show little deformation, and the high-angle faults that are present have only small amounts of displacement.

A geochemical survey of the areas, which included collection and analyses of stream-sediment, heavy-mineral-concentrate, and rock samples, indicated geochemically anomalous values for several elements, including barium, lead, tin, thorium, and silver, in the nonmagnetic fraction of the heavy-mineral concentrates. These anomalies are interpreted to be unrelated to notably mineralized rocks in the study areas. Most of the geochemical anomalies indicated by the analytical data are isolated occurrences chiefly of individual elements that can be explained either by characteristics of the sample medium or in a few instances by contamination.

Gravity and magnetic geophysical studies were used in an attempt to identify subsurface rock distributions. These studies suggest that the rhyolites that crop out in the bottom of the canyons are most likely underlain by more Snake River Plain basalts. The gravity survey reveals that the source area of the rhyolitic rocks was west of the study areas, in a location now obscured by the overlying basalts. A magnetic low over the area of Bruneau jasper occurrence is probably due to hydrothermal alteration, possibly along a major unexposed fault zone.

The geologic, geochemical, and geophysical studies indicate that the mineral and energy resource potential for Bruneau jasper, metals, oil and gas, and geothermal resources in all three study areas is low (except as noted in the following). The study areas lack significant hydrothermal alteration that might indicate metallic mineral deposits, and no surface evidence exists for oil and gas. However, there is a moderate mineral resource potential for deposits of Bruneau jasper within the jasper-bearing rhyolite unit that crops out along the boundary between the Bruneau River and Jarbidge River study areas. There is also moderate energy resource potential for geothermal resources in the area surrounding Indian Hot Springs, which lies near the boundary between the Bruneau River and Jarbidge River study areas.

INTRODUCTION

In 1985, at the request of the BLM (U.S. Bureau of Land Management), the USGS and the USBM, in cooperation with the Idaho Geological Survey, conducted mineral resource investigations of 90,000 acres of the Bruneau River Wilderness Study Area, 47,000 acres of the Jarbidge River Wilderness Study Area, and the entire 11,680-acre Sheep Creek West Wilderness Study Area (fig. 1). The study areas are located on a gently rolling plateau into which deep gorges have been incised by Bruneau River, Jarbidge River, and Sheep Creek. These gorges commonly are more than 1,000 ft (feet) deep. State Highway 51 passes west of the wilderness study areas, and light-duty roads and jeep trails provide access from all sides. When water conditions permit, Bruneau River and Jarbidge River can be floated by raft.

The study area boundaries are generally located along the rim of steep gorges, or along jeep roads or section lines. A jeep road between the Jarbidge River and Bruneau River study areas allows access into Indian Hot Springs and a jasper mine. The Sheep Creek West study area is about 15 mi (miles) southwest of the Bruneau River and Jarbidge River study areas.

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study areas and is the product of several separate studies by the USBM and the USGS, in conjunction with the Idaho Geological Survey. Identified resources are classified according to the system of the USBM and USGS (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), which is shown in the Appendix. The potential for undiscovered resources is studied by the USGS.

Investigations by the U.S. Bureau of Mines

The USBM studies were conducted during 1985 and 1986. Prefield studies included library research and perusal of Owyhee County and BLM mining and mineral lease records. USBM and other production records were searched, and claim owners were contacted for permission to examine properties and publish the results.

Field studies involved searches for all mines, prospects, and claims identified during prefield studies to be within the study areas. Those found were mapped and sampled. Claims outside, but near the study areas, were examined to determine whether mineralized zones extend into the study areas. Both ground and aerial reconnaissance were used to identify significant geologic structures and zones of alteration related to mineral deposits. Additional information is available from the USBM, Western Field Operations Center, E. 360 Third Avenue, Spokane, WA 99202.

Investigations by the U.S. Geological Survey

Geologic maps of the study areas were prepared for the USGS by Bill Bonnichsen, Margaret D. Jenks, and John L. Bernt of the Idaho Geological Survey. Harley D. King of the USGS conducted a geochemical survey within the study areas. A gravity survey was conducted by Dolores M. Kulik, USGS. The geology was written by David H. McIntyre, and the report compiled by Viki A. Lawrence.

Acknowledgments.—We thank personnel of the Boise district office of the BLM for support of raft traverses of the Bruneau and Jarbidge Rivers for geochemical sampling. The raft trips were guided by John Benedict and Walter Meyer, BLM outdoor recreation planners, and Gene Schloemer, assistant district manager–resource management. The geochemical sampling was also greatly benefited and expedited by the flying skills of helicopter pilot Tim Miller. The raft and helicopter traverses provided access to many otherwise inaccessible sites.

Field assistance in geochemical sampling was provided by Randal W. Baker, Tracy A. Delaney, Daniel W. Erskine, Kimberly R. Greene, Janet L. Jones, Gregory K. Lee, and Cliff D. Taylor, all of the USGS.

Personnel at the BLM Boise district office provided logistical support and information pertinent to the Bruneau River, Jarbidge River, and Sheep Creek West Wilderness Study Areas.

APPRAISAL OF IDENTIFIED RESOURCES

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U.S. Bureau of Mines

Mining and Exploration History

Since 1955, several groups of mining claims for gem-quality jasper have been held near Indian Hot Springs, mostly along the boundary between the Bruneau River and Jarbidge River study areas. Eight claims were held in 1986. A succession of claim groups have been held for agate and for limestone in the vicinity of Hot Creek, near the northern boundary of the Bruneau River study area. Within the Sheep Creek West study area, no claims have been held, no mineral production has been recorded, and no workings are in evidence.

The nearest significant lode mining occurred in the Jarbidge mining district, near the town of Jarbidge in northern Nevada, about 10 mi south of the Jarbidge River study area. The district produced gold from epithermal deposits in rhyolitic rocks. The East and West Forks Jarbidge River drain the northern parts of the district and are probably sources of much of the study area's placer gold. Thirty placer claims were held for gold along the Jarbidge River from 1893 to 1981; a few were also held near Hot Creek in 1972. In 1986, no placer-gold claims were known to be held in the Jarbidge River study area. In 1869, three mining districts were delineated about 8–12 mi from the Sheep Creek West study area in Elko County, Nev.; they are Hicks and Gold Basin to the southeast and Mountain City to the south (Granger and others, 1957; Smith, 1976). Primary production in the districts was gold from lode and placer deposits. Production from the Mountain City mining district also included silver, copper, lead, zinc, manganese, tungsten, and uranium (Smith, 1976).

No lands in or near the Bruneau River, Jarbidge River, or Sheep Creek West study areas were under lease for geothermal energy as of March 1986.

Twenty-three placer mining claims for oil and gas were located in 1901, 2–5 mi north of the Bruneau River study area. BLM master title plats, dated 1985, showed 53 mi^2 of oil and gas leases in a large block that included the northern half of the Bruneau River study area. An additional 38 mi^2 of leases are in two blocks near the southern end of the Bruneau River study area. Breckenridge (1982) reported that three dry exploration holes, ranging in depth from 2,068 to 3,808 ft, were drilled approximately 15–20 mi north-northwest of the Bruneau River study area. Small parcels of land southwest and northeast of the Sheep Creek West study area were leased for oil and gas in 1986.

Mines, Prospects, and Mineralized Areas

Ten localities (fig. 1, nos. 1–10) were examined and evaluated in and near the Bruneau River, Jarbidge River, and Sheep Creek West study areas. Four localities are considered to have identified resources: one locality (no. 6) is a current producer of Bruneau jasper, one (no. 2) has an identified limestone resource, and two (nos. 1 and 9) are geothermal hot springs areas used for commercial purposes. Detailed descriptions and resource evaluations of the 10 properties are presented in the following sections and in table 1.

Gemstone

Bruneau Canyon Jasper Mine

Forty-two mining claims for gem-quality jasper have been held in Bruneau Canyon near Indian Hot Springs (fig. 1 and table 1, no. 6). Workings consist of five large trenches or bulldozer cuts and at least 58 pits on terraces along both sides of the river. The mine workings lie within and along the southern border of the Bruneau River study area.

This locality is recognized as the sole source for a unique variety of jasper known among gem collectors and dealers as Bruneau jasper (Johnson, 1966; Johnson, 1969; Beckwith, 1972; Walton, 1978); several types of common jasper are found in volcanic rocks north of Indian Hot Springs. The Bruneau jasper occurs in veins and vugs typically as much as several inches in diameter (some cavity fillings are 2 ft in diameter) in a red and black vitrophyre informally named the Bruneau jasper-bearing rhyolite (Bonnichsen, 1982). Jasper is concentrated in zones of intensely hydrothermally altered vitrophyre; the alteration is probably associated with the Indian Hot Springs system. The Bruneau jasper variety generally consists of tan jasper with a distinct pattern of concentric or stacked semicircles and egg shapes likened to stylized clouds. Red, brown, tan, and green varieties of rather featureless jasper are common. Minor occurrences of chalcedony, white opal, fire opal, and calcite crystals are also associated with the zones of alteration.

Mining of Bruneau jasper consists of drilling and blasting followed by repeated cycles of hand sorting and bulldozing in search of the marketable variety. Massive, unfractured specimens with the distinct Bruneau jasper pattern are suitable for use as jewelry and as decorative pieces. Bruneau jasper is well known to dealers and is in moderate demand. Wholesale prices, in 1985, for good quality material range from $8 to $20/lb; $15/lb is typical. Common jasper from the deposit wholesales for $1–$5/lb (Moyle and Buehler, 1987). The BLM (1984a) estimated annual production at between 5,000 and 12,000 lbs and noted that the material is sold worldwide at prices ranging from $2 to $800/lb.

According to some dealers, Bruneau jasper has not been mined regularly for a couple of years; however, demand is expected to continue, resulting in intermittent mining. Due to the irregular nature of the deposits, the size of the resource cannot be determined without drilling. No other deposits of this variety of jasper were found by the authors in the Bruneau River, Jarbidge River, or Sheep Creek West study areas; however, Bonnichsen (1982) noted that "similar deposits are common in the upper and marginal parts of other rhyolite flows, but the jasper at most other localities is too fractured to be easily worked."

Royal Purple Agate Claims

Sixty mining claims for agate have been held along and south of Hot Creek in secs. 3, 4, 9, and 10, T. 8 S., R. 6 E. (fig. 1 and table 1, no. 3), partially within the northwestern part of the Bruneau River study area. Several small pits have been dug in mud-flow breccias and tuffaceous sediments associated with basaltic rocks south of Indian Bathtub.

Table 1. Mines, prospects, claims, geothermal springs, and mineral occurrences in the Bruneau River, Jarbidge River, and Sheep Creek West Wilderness Study Areas and vicinity, Idaho

[Location for numbers 1–10 shown on fig. 1 and pl. 1. Numbers 3, 6, and 10 are partly outside study area; numbers 1, 2, 4, 5, and 9 are outside study area. Underlined names indicate identified resources]

No.	Name	Summary	Workings and production	Sample and resource data
1	Indian Bathtub.	One of several hot springs and wells in the Bruneau-Grandview geothermal system. Surface temperatures of 99-124 °F and flow rates of 120-1,800 gpm (gallons per minute).	Geothermal well water on private land about 2 mi north of Bruneau River study area is being utilized to operate a prototype commercial prawn hatchery.	Published estimates of reservoir volume range from 45 to 437 mi^3. Best suited for direct-use applications such as space heating, agriculture/aquaculture, and recreation.
2	Limestone at Hot Creek Falls.	Light-gray to tan, very porous, algal-precipitated limestone occurs as remnants of a tabular, flat-lying deposit outside northern boundary of Bruneau River study area. Thickness from 12-18 ft. Three large and seven small blocks cover a total surface area of 2.3 mi^2; however, two of the large blocks have about 100 ft or more of overburden.	Quarry site consists of several bulldozed cuts. Powers (1956) reported about 100 tons of production.	Entire deposit is estimated to contain about 50 million tons; however, that part of the deposit without substantial overburden, about 0.8 mi^2, is inferred to contain a resource of 20 million tons. Eight samples were taken from six localities. CaO ranged from 48.0 to 52.9% and averaged 50.5%; MgO averaged 0.42%; Fe_2O_3 averaged 0.46%; Al_2O_3 averaged 1.1%, SiO_2 averaged 5.4%; and LOI (loss on ignition) averaged 40.82%. The limestone is suitable for use in cement and as an agricultural additive. The resource is easily accessible and amenable to direct open-pit mining; however, it is remote, being about 30 mi from the nearest railroad. The deposit may become economic if regional demand increases or if a local market develops.
3	Royal Purple agate claims.	Small pockets and vug fillings of a purple to brown, slightly translucent agate are in mud-flow breccias and tuffaceous sediments associated with basaltic rocks near Indian Bathtub. The material is known to rock hounds as "amethystine agate." Three mining claims were on the occurrence in 1986.	Small amounts of agate have probably been produced from several pits and small diggings; volume not documented.	The agate occurrences are widely scattered and of small size. White, black, and brown inclusions are common in the agate, reducing its gem desirability. Sporadic recreational prospecting and mining is expected to continue. One sample of agate and altered rock was analyzed; it did not contain metallic values significantly above normal crustal abundance for the type of rock sampled
4	Terry Linn claims.	A small group of placer mining claims were located in 1972 for gold in poorly consolidated, tuffaceous, pebbly sandstone bounded by basalt flows. The property was evaluated during a previous study by the USBM (Zilka, 1973); the claims are no longer active (1985).	No workings in evidence.	Gold values averaged $0.05/$yd^3$ at a gold price of $425/oz in 21 bulk placer samples taken by Zilka (1973).
5	Petrified wood.	Petrified wood, along with fish and mammal fossils, were found at two localities in a several-foot-thick siliceous sand and gravel bed above limestone. Tan to brown limb sections are 1-3 in. thick, but the material is incompletely silicified.	Small diggings are at each locality. Minor amounts of petrified wood have probably been removed by rock hounds.	No samples taken. The sand and gravel bed is widespread, but the petrified wood and fossils occur in small areas. Recreational use of these sites is expected to continue.

6	Bruneau Canyon jasper mine.	Bruneau jasper and several types of common jasper are in veins and vugs in a hydrothermally altered, red and black vitrophyre named the Bruneau jasper rhyolite. Red, brown, tan, and green varieties of rather featureless jasper are common, but Bruneau jasper is generally tan and has a distinct pattern of concentric or stacked semicircles and egg shapes likened to stylized clouds. Eight mining cl ms were on the deposit in 1986.	Five large trenches or bulldozer cuts and at least 58 pits. Sporadic production of Bruneau jasper for 20-30 years. Total production not documented.	Due to irregular nature of jasper deposits, size of resource cannot be determined without drilling. Good quality Bruneau jasper wholesales domestically for $8-$20/lb. Occasional mining is expected to continue. Thirty samples of hydrothermally altered rhyolite did not contain metallic values significantly above normal crustal abundance for the type of rock sampled.
7	Indian Hot Springs.	Several hot springs in fractured rhyolite produce about 1,900 gpm with a surface temperature of 161 °F. Two small zones of zeolitized tuff were also observed.	One bathtub for occasional recreational use.	Reservoir volume is unknown, but estimates of temperature range from 99 to 163 °F. Best suited for direct-use applications such as space heating, agriculture/aquaculture, and recreation. Of two samples of suspected zeolite, one contained 48% clinoptilolite. Zeolite is of low grade, and occurrence is too small to be a resource.
8	Jarbidge River placer gold deposits.	Placer deposits of recent origin, typically about 400 yd^3 in size, occur as accretion bars on the inside of some river meanders. Gold concentrations probably occur in point or skim bars on the top of accretion bars and in cracks in bedrock.	No workings are in evidence, and no production is recorded.	Four of five suction dredge samples and 13 of 14 pan samples of sand and gravel from the Jarbidge River contained gold. Values ranged from less than $0.01/$yd^3$ to $15.00/$yd^3$ and averaged $1.40/$yd^3$. Average was $0.57/$yd^3$ when the highest value was excluded. Gold values are too low and deposits are too small to support large-scale commercial mining (lowest cost of recently operating mine in Alaska was $3.95/$yd^3$); however, they could attract recreational miners.
9	Murphy Hot Springs.	Several hot springs have a total production of about 80 gpm with a surface temperature of 122-131 °F.	A small commercial resort.	Geothermal reservoir volume estimated to be 0.8 mi^3 at a mean temperature of 217 °F. Best suited for direct-use applications such as space heating, agriculture/aquaculture, and recreation.
10	Geode occurrence.	Two types of geodes occur as float over 1/4 mi^2 on the boundary of the Sheep Creek West Wilderness Study Area. Augen-shaped and spherical geodes are composed of reddish-brown, rhyolitic, ash-flow tuff with plain, white, chalcedonic fillings.	No workings in evidence.	Chalcedony fillings lack features, such as banding and mottling, that create high demand among rock hounds and gem dealers, but the occurrence may still be of interest to collectors.
(†)	Other placer gold deposits.	Small placer deposits, similar in type to those along Jarbidge River, are along parts of Bruneau River, Sheep Creek, and Clover Creek.	One bulldozer trench.	Four of five suction dredge samples contained less than $0.01/$yd^3$ gold; no gold was detected in the fifth. Of 38 reconnaissance pan samples of sand and gravel from the Bruneau River study area and parts of the Jarbidge River study area, 20 contained gold; values ranged from $0.01/$yd^3$ to $4.10/$yd^3$. Three samples exceeded $0.31/$yd^3$. One channel sample through siliceous sand and gravel exposed in a bulldozer trench in sec. 33, T. 7 S., R. 6 E. contained less than $0.01/$yd^3$. Two of five pan samples from the Sheep Creek West Wilderness Study Area contained $0.16/$yd^3$ and $0.58/$yd^3$. The deposits are small and of very low value, but they could attract occasional recreational panning.

†Locations not shown on figure 1 or plate 1.

Beckwith (1972) described the desirable material as partially opalized "amethystine agate" and noted that the source was possibly hot springs. Several small pockets and vug fillings of a purple to brown, slightly translucent agate were observed by the present authors. Small fracture fillings of white opal were also noted. White, black, and brown inclusions are common in the agate, reducing its gem desirability (Beckwith, 1972). The occurrences found were widely scattered and of such small size that large-scale commercial interest is not likely; however, sporadic recreational prospecting and mining is expected to continue.

Petrified Wood

Partially petrified wood, along with the remains of fish and mammal bones, were found at two localities west of the Bruneau River study area (fig. 1 and table 1, no. 5). The deposits are in a several-foot-thick siliceous sand and gravel horizon stratigraphically above the limestone at Hot Creek Falls. The petrified wood is only marginally suitable for cut sections. All of the observed localities have been picked over; the number of fossils appears to be insufficient and their condition too poor to support commercial development. Recreational use of these sites is expected to continue. No petrified wood localities were found in the study areas.

Geodes

Geodes occur as float over an area of approximately ¼ mi^2 within and adjacent to the Sheep Creek West study area (fig. 1 and table 1, no. 10). The geodes are composed of reddish-brown, rhyolitic, ash-flow tuff (Bernt, 1983) with a white chalcedonic filling, and are of two types. The first variety is augen shaped, ranges from 3 to 6 in. in length and 2 to 4 in. in width, is generally hollow, and has a chalcedony-encrusted interior. The second variety is nearly round, ranges from 2 to 4 in. in diameter, and has a triangular- to wedge-shaped cavity filled with chalcedony. The chalcedony generally lacks features, such as banding and mottling, that create high demand among rock hounds and gem dealers. No other geode occurrences were observed in or near the wilderness study areas (Moyle and Buehler, 1986).

Limestone at Hot Creek Falls

Since about 1910, more than 80 claims have been located for limestone in the vicinity of Hot Creek Falls, adjacent to the northern end of the Bruneau River study area (fig. 1 and table 1, no. 2). Several bulldozed cuts and roads are located north of Hot Creek in sec. 4, T. 8 S., R. 6 E. Some limestone has apparently been quarried; Powers (1956) estimated production of about 100 tons. The limestone occurs as remnants of a tabular, flat-lying deposit of probable lacustrine origin. It is a light-gray to tan, very porous, algal-precipitated limestone with abundant gastropods and algal forms (Littleton and Crosthwaite, 1957; Savage, 1969). Estimates of thickness range from 18 (Zilka, 1973) to 25 ft (Powers, 1956). Thicknesses range from 12 to 18 ft at six localities measured by the present authors. Although once covering 8–12 mi^2, the limestone has been eroded by Bruneau River and local tributaries; remnants lie to the north, east, and west of the northern end of the study area.

Eight samples were taken from six localities at the deposit. Analyses of the samples showed CaO (lime) to range from 48.0 to 52.9 percent and average 50.5 percent; equivalent $CaCO_3$ (calcium carbonate) is calculated to average 90 percent. The samples also contain an average of 0.42 percent MgO (magnesia), 0.46 percent Fe_2O_3 (ferrous oxide), 1.1 percent Al_2O_3 (alumina), and 5.4 percent SiO_2 (silica), and average 40.82 percent LOI (loss on ignition). The unusually high LOI is due to the high porosity of the rock. Samples show the limestone is suitable for use in the manufacture of cement and as an agriculture additive (Bowen and Gray, 1973, table 7). Lumijarvi and Peterson (1959) evaluated the deposit and determined it could be a potential source of chicken grit food supplement.

Estimates of the identified limestone resource range from 22 million tons (Zilka, 1973) to more than 25 million tons (Savage, 1969). Remnants of the deposit include three large (ranging from 0.05 to 0.1 mi^2) and seven smaller blocks within 1.5 mi of the Bruneau River study area; the total area covered is about 2.3 mi^2. Based on an average thickness of 20 ft, the deposit is inferred to contain a total of 50 million tons of limestone in the various blocks. A tonnage factor of 24 ft^3/ton is used because the limestone is estimated to contain 50 percent voids. Approximately 100 ft of overburden covers two large blocks to the east and south. The remaining 0.8 mi^2 of the deposit, which is without substantial overburden, is inferred to contain a resource of 20 million tons of limestone. These blocks are amenable to direct open-pit mining; however, they are relatively remote, being about 30 mi from the nearest railroad. The deposit could become economic if the regional demand for limestone increases or if a local market is developed; the surface disturbance caused by mining would visually impact the Bruneau River study area.

Placer Gold Deposits

In the Jarbidge River study area, approximately 30 placer mining claims have been held along parts of the Jarbidge River from the confluence of East and West Forks to the mouth at Bruneau River (fig. 1 and table 1, no. 8). The earliest placer claim locations were made in 1893; subsequent claim groups cover most of the 25 mi section of the Jarbidge River that lies within the study area. No production of gold has been recorded, no workings are in evidence, and no claims are currently active.

Placer occurrences on the river are probably all of recent origin; no elevated gravel bars or terraces from earlier periods of deposition were observed. Most gravel has accumulated as accretion bars on the inside of some river meanders. Zilka (1973) noted that the bars are typically about 400 yd^3 in size. Four suction dredge samples and all but 1 out of 14 pan samples taken from the main course of the Jarbidge River contained gold. Values of recovered gold ranged from less than $0.01/$yd^3$ to $15.00/$yd^3$ and averaged $1.40/$yd^3$ based on an assumed gold price of $425/oz. Excluding the $15.00/$yd^3$ pan sample, the values averaged $0.57/$yd^3$. Gold concentrations probably occur in point or skim bars (on the top of accretion bars) and in cracks in bedrock. No gold was observed in two samples from Columbet Creek (fig. 1).

Other parts of the drainage system that lie within the Bruneau River and Jarbidge River study areas include 41 mi of the main course of the Bruneau River, 25 mi of Sheep Creek, and about 9 mi of Clover Creek in East Fork Bruneau Canyon. Placers are similar in type to those deposited by the Jarbidge River; however, the basaltic component of the alluvium dominates to the north, away from the sources of rhyolitic rocks in the southern half of the study areas. Thirty-eight reconnaissance pan samples and five suction dredge samples were taken from the Bruneau River and tributaries (Moyle and Buehler, 1987). Four of the suction dredge samples contained less than $0.01/$yd^3$ in gold; no gold was detected in the fifth. Twenty of the pan samples contained gold that ranged in value from $0.01/$yd^3$ to $4.10/$yd^3$. Excluding the three highest value samples ($0.85–$4.10/yd^3), the remaining samples ranged from $0.01/$yd^3$ to $0.31/$yd^3$ and averaged $0.07/$yd^3$. A channel sample through siliceous sand and gravel exposed by a bulldozer trench above the limestone at Hot Creek Falls in the southwest corner of sec. 33, T. 7 S., R. 6 E., near the Bruneau River study area, contained less than $0.01/$yd^3$.

In 1972, the Terry Linn group of mining claims for placer gold was located along Hot Creek, west of the Bruneau River study area (fig. 1 and table 1, no. 4). The claimants reported high gold values from a "poorly consolidated, tuffaceous, pebbly sandstone which is bounded by basalt flows," according to Zilka (1973). Twenty-one bulk samples taken by Zilka (1973) contained an average of $0.05/$yd^3$ (at a gold price of $425/oz). The claims are no longer active, and there are no workings.

Gold was recovered from two of five reconnaissance placer samples taken from drainages within and adjacent to the Sheep Creek West study area; values of gold recovered were $0.16/$yd^3$ and $0.58/$yd^3$. No elevated gravel bars or terraces from earlier periods of deposition were observed, and the minor amount of gravel in Sheep Creek's drainage can be attributed to seasonal runoff.

Lode Deposits

No lode deposits are known in the study areas. However, pervasive silicification and intense alteration of country rock is exposed in workings at the Bruneau Canyon jasper mine at Indian Hot Springs (fig. 1 and table 1, no. 6) and the Royal Purple agate claims at Hot Creek (fig. 1 and table 1, no. 3). Because these localities are altered and silicified and exhibit geologic characteristics—such as thermal spring activity, felsic volcanic and volcaniclastic sedimentary rocks, high-angle faulting, and proximity to a complex volcanic center—listed by Silberman (1982) as associated with hot-spring-type (epithermal) gold deposits, 35 samples were taken from mineralized zones (Moyle and Buehler, 1987). For the rock types sampled, no metallic values significantly above normal crustal abundance were detected.

Two of the samples taken near Indian Hot Springs were of green, friable tuff suspected to be zeolitized. One sample was analyzed by X-ray diffraction and determined to contain 48 percent clinoptilolite, a zeolite associated with hydrothermal alteration due to hot-spring activity. The occurrences are too small to be a resource.

Slightly iron oxide stained, milky colored chalcedony and weakly banded agate occur as float along the southeastern boundary of the Sheep Creek West study area. A composite select sample of the material was collected from a small area in the E½ sec. 9, T. 16 S., R. 5 E., but it did not contain metallic values above normal crustal abundance for the host rock (Moyle and Buehler, 1986).

Geothermal Resources

The western Snake River Plain exhibits higher than normal heat flow and is reported to have 32 low-temperature geothermal systems (Mariner and others, 1983). Three known geothermal systems that occur near or within the boundaries of the Bruneau River and Jarbidge River study areas are: the Bruneau–Grandview system at the northern end of the Bruneau River study area (fig. 1 and table 1, no. 1, Indian Bathtub), Indian Hot Springs along the border between the study areas (fig. 1 and table 1, no. 7), and Murphy Hot Springs south of the Jarbidge River study area (fig. 1 and table 1, no. 9). Currently (1986), geothermal well water is being utilized by Geo-Tech Systems, Inc., to operate a prototype commercial prawn hatchery on private lands west of Indian Bathtub, about 2 mi north of the Bruneau River study area (Journal of Business, 1986). A small commercial resort operates at Murphy Hot Springs.

The Bruneau–Grandview system contains several wells and hot springs, including Indian Bathtub on Hot Creek (pl. 1). Reported surface temperatures range from 99 to 124 °F (Mabey, 1983; Zilka, 1973), flow rates range from 120 to 1,800 gpm (gallons per minute), and estimates of reservoir volume range from 45 to 437 mi^3 (Waring, 1965; Zilka, 1973; Breckenridge and others, 1980; Young and Lewis, 1982; Mariner and others, 1983; Mabey, 1983). Indian Hot Springs produces approximately 1,900 gpm with a surface temperature of 161 °F, and Murphy Hot Springs produces about 80 gpm with a surface temperature of 122–131 °F (Young and Lewis, 1982). Murphy Hot Springs is estimated to have a geothermal reservoir volume of 0.8 mi^3 at a mean temperature of 217 °F (Mabey, 1983).

With the exception of the aquaculture enterprise, hot springs in the area are used primarily for recreation; a small commercial resort is situated at Murphy Hot Springs. The geothermal systems discussed are in the low- to moderate-temperature range and are best suited for direct-use applications, such as space heating, agriculture, and recreation.

Parts of the study areas are included in three parcels classified by the BLM (1984b) as "valuable prospectively for geothermal resources." According to Robert Detar of the BLM (Boise, Idaho, oral commun., 1986), two of the land parcels at Bruneau and Castle Creek (Grandview), formerly classified by the BLM as KGRA's (Known Geothermal Resource Areas) are currently being declassified.

Conclusions

An identified resource of gem-quality jasper occurs north of Indian Hot Springs, within and near the southern end of the Bruneau River study area. The jasper is sporadically mined. Mining by blasting, bulldozing, and hand-sorting methods is expected to continue.

Recreational prospecting for agate and petrified wood is also expected to continue near the northern end of the Bruneau River study area.

In the same area, but outside the Bruneau River study area near Hot Creek, is an inferred subeconomic limestone resource of approximately 20 million tons that constitutes an identified resource. The limestone averages 50.5 percent CaO and is low in impurities. It could become economic if demand for limestone increases or if a new market is developed locally.

Identified geothermal resources are near the Bruneau River and Jarbidge River study areas and are currently used for recreation and aquaculture. The low- to moderate-temperature systems are suitable for direct-use applications but not for power generation. Indian Bathtub is being used to operate a commercial prawn hatchery, and is an identified resource. Murphy Hot Springs, where a small commercial resort operates, is also an identified resource.

Placer gold occurs throughout most of the river system in the Bruneau River and Jarbidge study areas; the highest values are concentrated along the Jarbidge River. The lowest cost domestic placer gold mine known to have operated in recent times (to 1984) had a total unit production cost of $3.95/$yd^3$ at a production rate of about 100,000 yd^3 per year (Schumacher, 1985). This is about seven times the estimated average value at the Jarbidge River deposits. Gold values are too low and the deposits are too small and difficult to access to support large-scale mining at a gold price of $425/oz. The deposits could be attractive for recreational panning, sluicing, and suction dredging.

Occurrences of clinoptilolite in hydrothermally altered tuff at Indian Hot Springs are of low grade and are too small to comprise a zeolite resource.

No mineral resources are identified within the Sheep Creek West study area. Placer gold, probably from deposits associated with the mining districts in northern Nevada, occurs in the sand and gravel of Sheep Creek. The gold values are too low and the placers are much too small and inaccessible to support commercial mining at the current market value of gold; however, the occurrence could attract recreational panning or sluicing. The occurrence of geodes along the boundary of the wilderness study area may be of interest to rock hounds.

The BLM (1984c) has classified lands encompassed by the Bruneau River, Jarbidge River, and Sheep Creek West study areas as "prospectively valuable for oil and gas;" however, no favorable geologic structures are identified in or near the study areas.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

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Geology

Stratigraphy

The Bruneau River, Jarbidge River, and Sheep Creek West study areas are underlain by three principal rock types. The oldest is a sequence of rhyolitic rocks that are best exposed in the canyons. The rhyolitic rocks are overlain by a thin veneer of basalt erupted mainly from vents within and near the study areas. Poorly consolidated sedimentary rocks are present in places between basalt flows and between the basalt and the underlying rhyolitic rocks as well as between rhyolite flows (pl. 1).

Rhyolitic Rocks

The rhyolitic rocks are divided into three groups, consisting of rhyolites older than the Cougar Point Tuff, the Cougar Point Tuff (also called Cougar Point Welded Tuff), and rhyolite lavas younger than the Cougar Point Tuff. These three groups are shown as one map unit on plate 1 (unit Tr).

The oldest rhyolitic units include two lavalike rhyolite units and a unit of rhyolitic lapilli tuff that underlie the Cougar Point Tuff. These rocks crop out only in the Sheep Creek West study area (unpub. mapping by Bill Bonnichsen, J.L. Bernt, and M.D. Jenks). The Cougar Point Tuff, better known from exposures east of the wilderness study areas, consists of several cooling units of densely welded ash-flow tuff, commonly flow laminated, that contain phenocrysts of plagioclase, pyroxene, and opaque oxides; sanidine, quartz, and fayalitic olivine also are present in some cooling units. The Cougar Point Tuff is exposed in the Sheep Creek West and the southern part of the Jarbidge River study areas. The tuff is overlain by a sequence of rhyolitic lavas that commonly are dark brown, reddish brown, or reddish purple, crystal poor, and contain sparse, small crystals of plagioclase, pyroxene, and opaque oxides; quartz and sanidine are minor constituents of some units. The upper group of rhyolites includes the informally named Bruneau jasper-bearing rhyolite (mapped separately as unit Tbj, pl. 1), which is a vitrophyre as much as 500 ft thick that contains the Bruneau jasper deposit in its upper zone. The Bruneau jasper-bearing rhyolite is extensively hydrothermally altered in the area of the jasper deposit. None of the other rhyolitic rocks are known to be hydrothermally altered except in the area of Indian Hot Springs. The upper rhyolite lavas are interbedded with basalts and also with poorly consolidated sedimentary rocks in places.

Potassium-argon age determinations for the rhyolitic rocks within the wilderness study areas range from about 11.3 m.y. (million years) for the Cougar Point Tuff (Bonnichsen and Citron, 1982) to about 8.0 m.y. for a unit within the rhyolite lavas (Hart and Aronson, 1983).

Basalt and Associated Sedimentary Rocks

Basalt lavas (unit QTb, pl. 1), erupted from vents within and near the wilderness study areas, flowed over a relatively flat surface on top of the rhyolitic rock sequence. The basalt is commonly dark gray to black and contains small, sparse phenocrysts of plagioclase and olivine. The flows are fine to medium grained and have intergranular textures. None are altered.

The basalt lava is commonly seen as one or more thin, black flows cropping out at canyon rims and, away from the canyon rims, as a widespread rough and rocky veneer on the plateau surface. The vents for the flows are expressed as low hills that rise above the general level of the plateau. No radiometric ages are available for these rocks, but they are considered to be Pliocene or Miocene in age (unpub. mapping by Bill Bonnichsen, J.L. Bernt, and M.D. Jenks).

Locally, poorly consolidated sedimentary rocks (included in unit QTb, pl. 1) are interlayered with or underlie the basalt. In many places within the wilderness study areas, sedimentary rocks are very thin or absent. In others, they might be present, but are concealed by debris shed from overlying outcrops of the basalt or rhyolite lavas. They are composed of tan silt, clay, and sand that locally contain lenses of pyroclastic rocks or gravel (unpub. mapping by Bill Bonnichsen and M.D. Jenks). These deposits also contain an unknown proportion of silicic volcanic ash.

Studies by Warner (1977, 1980) indicate that the Tertiary volcanic rocks may be underlain by Tertiary lacustrine beds.

Structure

The rocks in the wilderness study areas have been deformed only slightly. They dip northward at a very low angle and are cut by only a few high-angle faults, most of which have very small displacements. Only faults in the Sheep Creek West study area have displacements of more than a few tens of feet.

Geochemistry

Methods

The reconnaissance geochemical study of the Bruneau River, Jarbidge River, and Sheep Creek West study areas included the collection, analysis, and evaluation of samples from each area as shown in the following table.

	Minus-0.18-mm stream sediments	Nonmagnetic heavy-mineral concentrates	Rocks
Bruneau River-----	103	97	39
Jarbidge River-----	74	49	34
Sheep Creek West	16	9	1

Analyses of the stream-sediment samples reflect the chemistry of the rock material eroded from the drainage basin upstream from each sample site. Such information is useful in identifying those basins that contain concentrations of elements that may be related to mineral deposits. Nonmagnetic heavy-mineral-concentrate samples provide information about the chemistry of a limited number of minerals in rock material eroded from the drainage basin upstream from each sample site. The selective concentration of minerals, many of which may be ore related, permits determination of some elements that are not easily detected in raw stream-sediment samples.

Rock samples were crushed and pulverized to less-than-0.18-mm grain size prior to analysis. Stream-sediment samples were sieved using 80-mesh (0.18 mm) stainless-steel sieves, and the less-than-0.18-mm fraction was used for analysis. Bromoform (specific gravity, 2.86) was used to remove light-weight mineral grains from the pan-concentrated stream sediments. By use of an electromagnet, the resultant heavy-mineral concentrate was separated into three fractions: (1) a magnetic fraction of chiefly magnetite; (2) an intermediate magnetic fraction that consists largely of mafic rock-forming minerals; and (3) a nonmagnetic fraction composed mostly of light-colored rock-forming accessory minerals and primary and secondary metallic minerals. Using a microsplitter, the nonmagnetic fraction was split into two fractions. One of these splits was used for analysis and the other for visual examination with a binocular microscope. In some instances, sample volume was too small to provide a split for visual examination. These samples were examined visually prior to grinding for analysis; archived reference material for these samples contains no material not ground to fine powder.

All samples were analyzed semiquantitatively for 31 elements using direct-current arc emission spectrographic methods; rock and stream-sediment samples by the method described in Crock and others (1987), and nonmagnetic heavy-mineral-concentrate samples by the method described by Grimes and Marranzino (1968). Rock and stream-sediment samples were also analyzed for certain elements of special interest or that have high lower limits of determination by ICAP–AES (inductively coupled argon plasma–atomic emission spectroscopy) for antimony, arsenic, bismuth, cadmium, and zinc and by atomic absorption for gold and mercury (methods described in Crock and others, 1987). Analytical data are given by M.S. Erickson (USGS, unpub. data, 1986).

Results of Geochemical Survey

Anomalous values for elements were found in concentrates (nonmagnetic heavy-mineral-concentrate samples) from each of the wilderness study areas. Concentrates from the Bruneau River study area contained anomalous concentrations of barium (six samples had values ranging from 5,000 to >10,000 ppm (parts per million), tin (one sample, >2,000 ppm), thorium (three samples, 200–500 ppm), silver (one sample, 10 ppm), and lead (two samples, 100 and 500 ppm). Concentrates from the Jarbidge River study area contained anomalous concentrations of barium (five samples had values ranging from 7,000 to >10,000 ppm), tin (two samples, 2,000 and >2,000 ppm), thorium (three samples, 300–1,000 ppm), and lead (four samples, 100, 700, 7,000, and 10,000 ppm). Concentrates from the Sheep Creek West study area contained anomalous values of silver (one sample, 3 ppm). The locations of the anomalous samples are shown on plate 1.

No notably anomalous values for elements were found in stream-sediment or rock samples from any of the wilderness study areas.

The barium mineral barite was identified by microscopic examination in a few of the concentrates with highly anomalous barium values, and probably accounts for the high barium values in those and other concentrates with high barium values. Concentrates with anomalous barium values are from sites peripheral to Indian Hot Springs at the northern end of the Jarbidge River study area and the southeastern end of the Bruneau River study area and from a site adjacent to hot springs at the northern end of the Bruneau River study area. This latter site and its drainage area are located outside of the study area boundary. Other locations in the Bruneau River study area where concentrates were collected with anomalous values of barium are in the central part of the northern half and in about the center of the southwestern part of the study area. Concentrates with anomalous barium were also collected in about the center of the Jarbidge River study area.

The barite in the concentrates may have eroded from cavity or fracture fillings in bedrock. The proximity of some of the sample sites where the concentrates containing anomalous barium or barite were collected to areas of hot springs suggests that the barite may be genetically associated with the hydrothermal systems of the hot springs. The sources are believed to be small because the concentrates contained only extremely small amounts of barite, and anomalous barium was not found in stream-sediment samples. Further, barite veins have not been noted in the areas, although bedrock underlying drainage areas with barium anomalies is generally well exposed.

The tin mineral cassiterite (variety wood tin) was identified by microscope in a few of the concentrates with anomalous tin values from the Bruneau River and Jarbidge River study areas. High tin values in other concentrates are probably also due to the presence of this mineral in the samples. Possible sources of the cassiterite were not determined. Drainage areas of the sites with the high tin values are underlain by basalt, and only three widely scattered samples contained anomalous tin. The anomalous tin values are not believed to be related to significant deposits.

Most concentrates with high thorium values are from sites draining plateau areas chiefly underlain by basalt. A thorium-bearing mineral that would explain the anomalous thorium values was not specifically identified in any of the concentrate samples. The element may, however, occur in zircon, a common constituent of the concentrates. The anomalous thorium values only occur in six isolated samples and are not believed to be related to significant occurrences of that mineral.

The concentrates containing the two highly anomalous lead values in the Jarbidge River study area were collected in the northern end of the area. A jeep trail leading to the Bruneau jasper deposits, Indian Hot Springs, and the Bruneau River passes through the drainage area of the sample site where the concentrate containing 7,000 ppm lead was collected. Two jeep trails and a pack trail are within the drainage area of the site where the concentrate containing 10,000 ppm lead was collected. The amount of human activity in the area of these sites has apparently been much greater than for most sample sites in the study area. We believe that because of this greater amount of human activity the high lead values are probably due to contamination of the samples by artifacts such as bullet fragments. Furthermore, elements commonly associated with lead in lead deposits were not found in anomalous amounts in the samples.

The concentrate with 700 ppm lead was collected from a site located about 2 mi west of the site where the concentrate with 10,000 ppm lead was collected. The drainage area of this site is on the plateau outside of the study area and is underlain by basalt. The presence of roads and jeep trails in the drainage area of this site strongly suggests that the high lead value is more likely due to contamination than to a mineralized rock source.

The concentrate containing the value of 10 ppm silver from the Bruneau River study area was collected from a small tributary to the Bruneau River, along the Bruneau River in the northern half of the study area. The sample contained no other elements in anomalous concentrations, and no apparent reason for the anomalous value, such as altered rock, was observed at the sample site. The silver may have been contained in mineralized rock eroded from a fracture. Although no faults were mapped in the vicinity of the sample site, the site is along the trend of several faults mapped 5 mi to the southeast (unpub. mapping by M.D. Jenks and Bill Bonnichsen). Another possible explanation for the anomalous silver value is that the sample contained sediment deposited by the Bruneau River rather than by the small tributary, and the silver was contained in a grain of sediment transported into the study area from the silver deposits along the Jarbidge River near Jarbidge, Nev.

The silver value of 3 ppm detected in a concentrate from the Sheep Creek West study area may reflect mineralized rock along one of several faults located within the drainage area of the sample site.

Geophysics

Geophysical data provide information on the subsurface distribution of rock masses and on the structural framework. Gravity and magnetic studies were undertaken as part of the mineral resource evaluation of the Bruneau River, Jarbidge River, and Sheep Creek West study areas.

Regional gravity data were obtained from files maintained by the Department of Defense and from Bankey and others (1985). Bouguer anomaly values were computed using the 1967 gravity formula (International Association of Geodesy, 1967) and a reduction density of 2.67 g/cm^3 (grams per cubic centimeter). Mathematical formulas are given in Cordell and others (1982). Terrain corrections were made by computer for a distance of 167 km from the station using the method of Plouff (1977). The data are shown as a complete Bouguer gravity anomaly map on figure 2.

The aeromagnetic data on figure 3 are from an aeromagnetic map of Idaho (U.S. Geological Survey, 1978). Flight lines were flown east-west at 5-mi intervals and 12,500-ft barometric elevation.

High gravity values (−90 to −150 mGal (milligals)) occur over basalts of the Snake River Plain to the northeast of the study areas and decrease to the south where lower values (−175 to −195 mGal) occur over rhyolitic rocks and minor basalts along the Idaho–Nevada border. Intermediate values (−150 to −175 mGal) occur over the Owyhee Plateau, to the northwest, where rhyolites and thin basalt units are exposed at the surface. Low gravity values west of the area of figure 2 outline a volcano-tectonic depression in the Juniper Mountain area that may have been the source of some of the rhyolites in the study areas (McIntyre and others, 1987).

High aeromagnetic values (900–1,400 gammas) also are associated with outcropping basalts of the Snake River Plain northwest and northeast of the study areas (not shown on fig. 3) (U.S. Geological Survey, 1978). A linear high anomaly shown on figure 3 (A to A′) marks the southwestern margin of the Snake River Plain northwest of the study areas. The anomaly continues southward across the Owyhee Plateau nearly to the Idaho–Nevada border where it bends eastward for approximately 40 mi (A′ to A″ on fig. 3), and then trends northeastward where it corresponds to the southeastern boundary of the Snake River Plain (fig. 4) northeast of the study areas and beyond the eastern limits of the map area of figure 3. The continuous aeromagnetic anomaly and the intermediate gravity values over the Owyhee Plateau indicate that basalts of the Snake River Plain extend beneath relatively thin rhyolite flows of the Owyhee Plateau in the study areas.

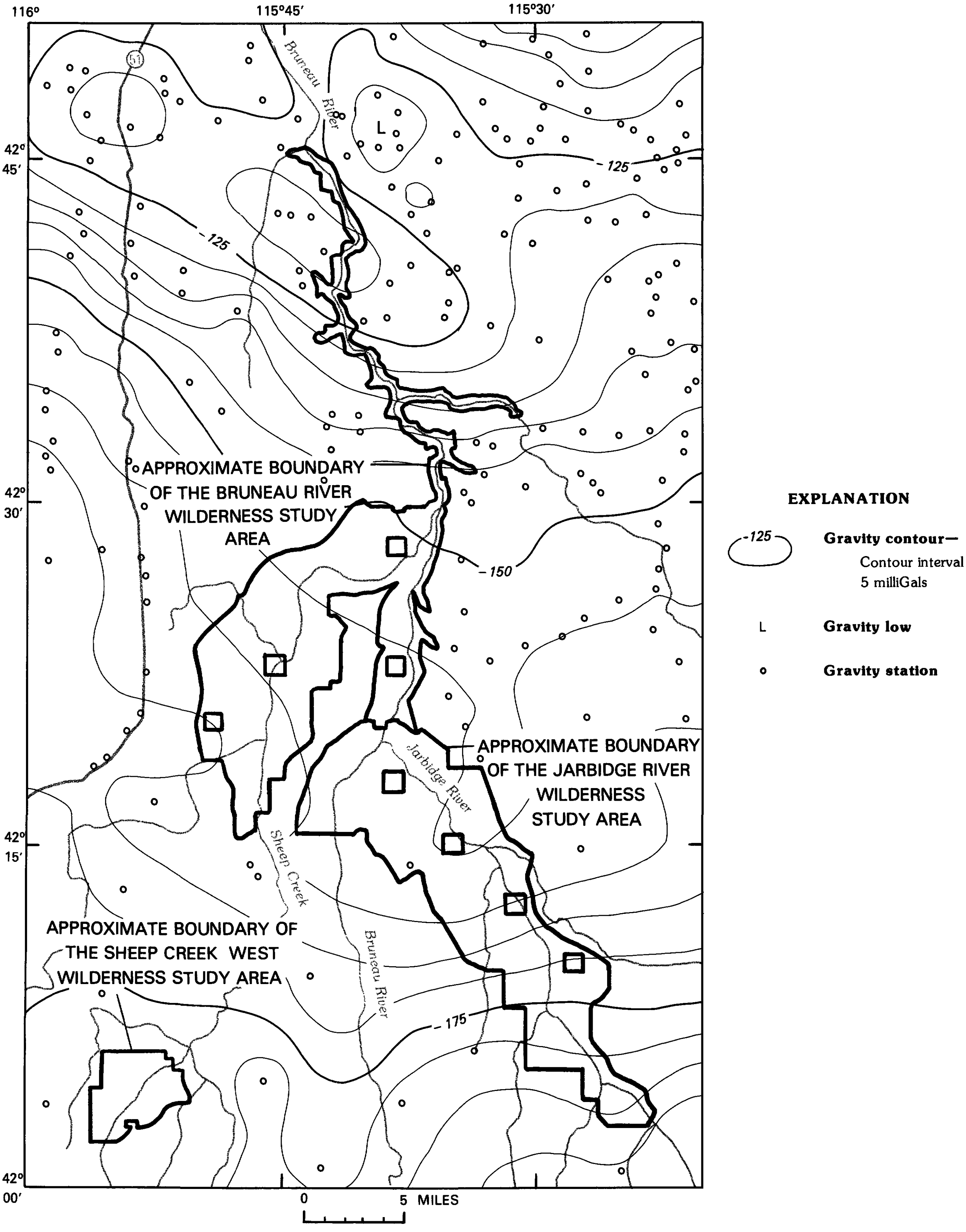

Figure 2. Complete Bouguer gravity anomaly map of the Bruneau River, Jarbidge River, and Sheep Creek West Wilderness Study Areas and vicinity, Idaho.

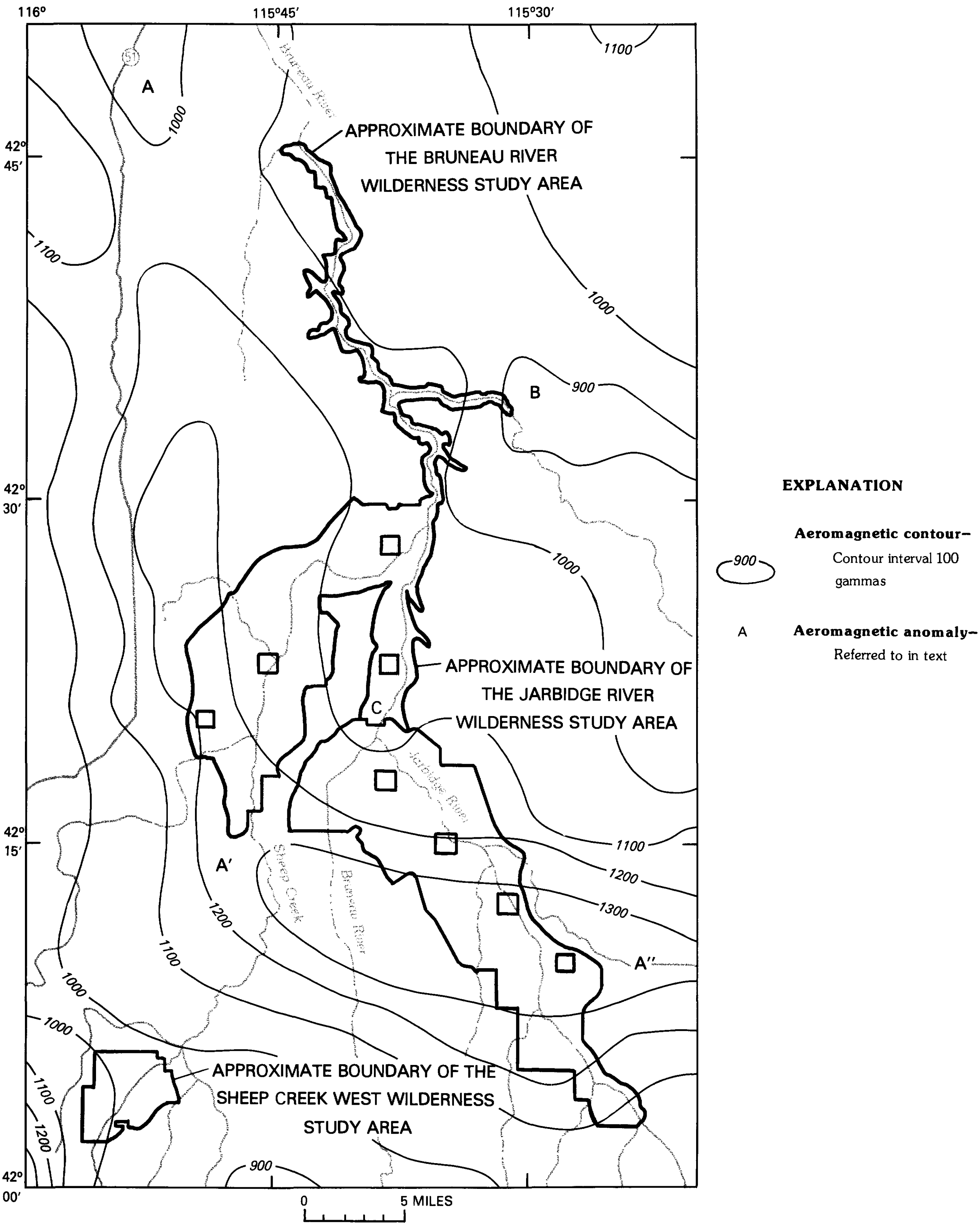

Figure 3. Total intensity aeromagnetic map of the Bruneau River, Jarbidge River, and Sheep Creek Wilderness Study Areas and vicinity, Idaho.

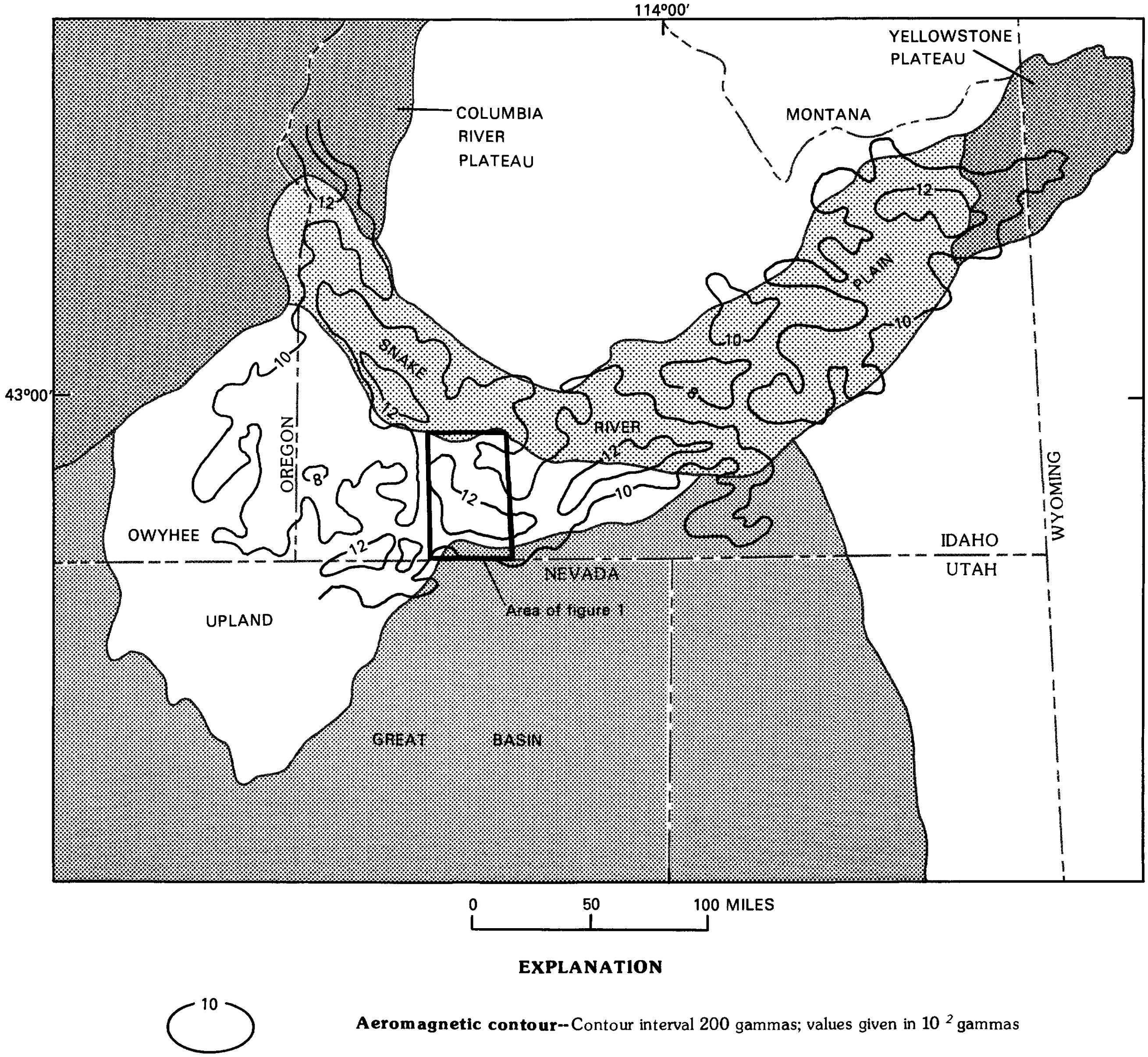

Figure 4. Generalized aeromagnetic anomaly map of the Snake River Plain and eastern Owyhee Plateau. (Modified from Kuntz and others, 1986.)

A magnetic low (B) trends south-southeast, east of the center of the Bruneau River study area (fig. 3). A magnetic low (C) extends southward along the Bruneau River to its confluence with the Jarbidge River where outcrops of jasper occur. The magnetic low probably is the result of hydrothermal alteration, possibly along a major fault zone. A northwest-trending gravity low (L, fig. 2) roughly coincides with the central part of magnetic low B and culminates in a 120-mGal low anomaly over unconsolidated sediments east of Hot Spring.

Northwest-trending normal faults mapped in the Bruneau River and Sheep Creek West study areas parallel gravity and magnetic gradients, which suggests that the faults extend into the Snake River Plain basalts beneath the Owyhee Plateau, although offset is not great where the faults are exposed.

Mineral and Energy Resource Potential

There is a moderate energy resource potential, with certainty level C, for geothermal resources in the area of Indian Hot Springs, along the boundary between the Bruneau River and Jarbidge River study areas. There is a moderate mineral resource potential, with certainty level C, for Bruneau jasper in the area of the Bruneau Canyon jasper mine and extending to the northeast, within the jasper-bearing rhyolite, in the Bruneau River and Jarbidge River study areas. Bruneau jasper is the only known mineral deposit within the wilderness study areas. The mineral and energy resource potential for undiscovered metals and oil and gas deposits in all three wilderness study areas is low, with certainty level C.

Geothermal Energy

A geothermal resource can occur when a heat source, generally hot magma, starts a convection cell of groundwater that travels through nearby faults or fractures. The heated water may rise to the surface and is expressed as hot springs. Because there are known hot springs within and around the Bruneau River and Jarbidge River Wilderness Study Areas, there must be a heat source at depth, and the magnetic and gravity lows over the Indian Hot Springs area indicate that the alteration and faulting may be more extensive than surface evidence indicates. However, the known reservoir temperatures are below or at boiling, which has made them useful for heating purposes but not for power generation. Therefore the area extending northeast and southwest from Indian Hot Springs, in the Bruneau River and Jarbidge River Wilderness Study Areas, has moderate energy resource potential for geothermal resources, probably of moderate temperature (near boiling—100 °C), with certainty level C. The remainder of these two study areas, as well as the entire Sheep Creek West study area, has a low potential for geothermal resources, with certainty level C.

Bruneau Jasper

Jasper and related silica deposits occur when hot silica-saturated water rises near the surface, where the temperature and the pressure drop, forcing deposition of the silica. Rarely, the silica will be gem quality. These types of epithermal deposits are closely related to hot springs, and the Bruneau jasper deposit is undoubtedly related to the nearby Indian Hot Springs system. Therefore, because geophysical data indicate more extensive alteration than seen on the surface, there is a moderate mineral resource potential, with certainty level C, for Bruneau jasper in the Bruneau jasper-bearing rhyolite in the Indian Hot Springs area of the Bruneau River and Jarbidge River study areas. The remainder of these two study areas, as well as the entire Sheep Creek West study area, has a low potential for Bruneau jasper, with certainty level C.

Metals

Other elements, including barium and gold, can also be carried and deposited by rising hot solutions in the same way as silica. Geochemical studies indicate that barium is probably related to the hot springs in the wilderness study areas, but it is present only in small amounts. Geochemical studies also indicate that the small amount of gold found in the study areas is not related to the jasper deposits nor to the hot springs, but was derived from gold mining districts upstream to the south.

No surface evidence exists for metallic-mineral deposits in the study areas, and there are no features that would suggest their presence at depths to several thousand feet. Hydrothermal alteration was not noted during geologic mapping in the three wilderness study areas (unpub. mapping by Bill Bonnichsen, J.L. Bernt, and M.D. Jenks), except in the area of the Bruneau jasper deposit, nor has alteration of the rocks been noted during past studies (for example, Ekren and others, 1984, and references cited therein). Although anomalous concentrations of barium, tin, thorium, silver, and lead were found in isolated panned-concentrate samples, none of these concentrations are believed to be related to any mineral deposits. Much of the surface in all three study areas is blanketed by basalt that is devoid of known mineral deposits. The rhyolitic rocks present beneath the basalt in the wilderness study areas are unaltered, and are a type not known to have associated mineral deposits. No anomalous concentrations of any elements in these rocks were detected by our analyses. Therefore all three wilderness study areas have a low mineral resource potential for metals, with certainty level C.

Oil and Gas

The geophysical data of the wilderness study areas indicate that the exposed volcanic rocks are underlain by Snake River Plain basalts, creating a fairly thick volcanic cover. Below this cover, slightly older Tertiary lacustrine beds may be present, possibly serving as source beds for oil and gas (Warner, 1977, 1980). The volcanic activity in the area may have acted to mature any source beds that existed within the lacustrine beds. However, extensive high-angle faulting has likely precluded any accumulation of oil and gas. All three wilderness study areas have a low energy resource potential for oil and gas, with certainty level 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.

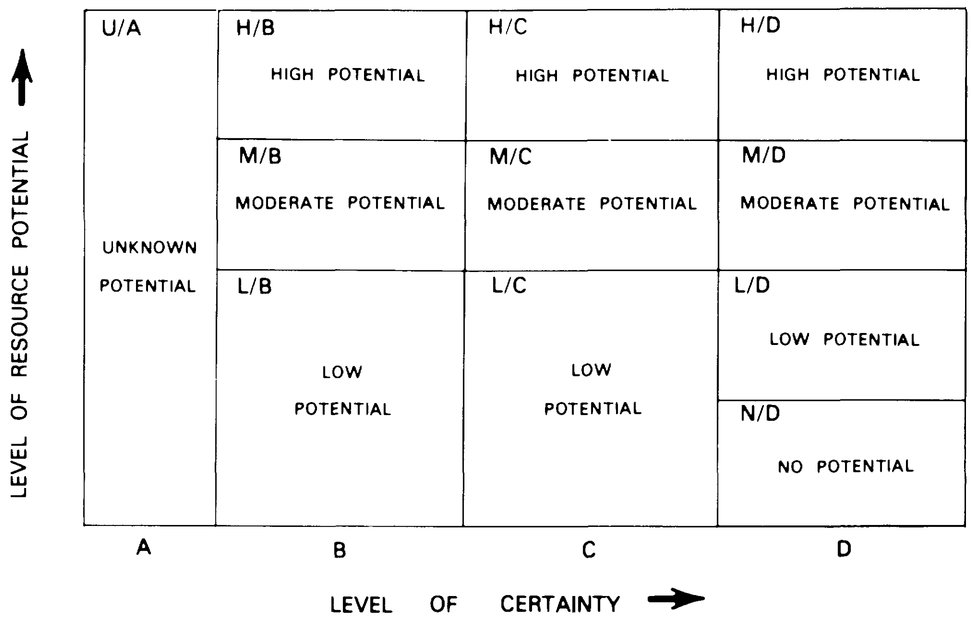
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application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



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.

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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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[Letters designate the chapters]