Mineral Resources of the Little Wood River Wilderness Study Area, Blaine County, Idaho

U.S. DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY
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Chapter D

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U.S. GEOLOGICAL SURVEY BULLETIN 1721

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
SOUTH-CENTRAL IDAHO

DEPARTMENT OF THE INTERIOR
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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 the Little Wood River Wilderness Study Area (ID–053–004), Blaine County, Idaho.

CONTENTS

PLATE

[Plate is in pocket]

FIGURES

TABLES

Mineral Resources of the Little Wood River Wilderness Study Area, Blaine County, Idaho

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ABSTRACT

The Little Wood River Wilderness Study Area (ID-053-004) covers 4,385 acres in south-central Idaho east of Hailey. The part of the study area underlain by Paleozoic sedimentary rocks has moderate mineral resource potential for undiscovered silver, barite, copper, lead, zinc, gold, and tungsten. The remainder of the study area, which is underlain by Tertiary volcanic rocks, has low mineral resource potential for undiscovered silver, barite, copper, lead, zinc, gold, and tungsten. The entire study area has low resource potential for other undiscovered metals, oil and gas, geothermal energy, uranium, sand and gravel, and building materials. The study area contains no identified mineral resources.

SUMMARY

Character and Setting

The Little Wood River Wilderness Study Area is in south-central Idaho east of the Big Wood River, south of the Boulder-Pioneer Mountains, and north of the Snake River Plain (figs. 1, 2). In this report, the studied area is called "wilderness study area" or simply "study area." The wilderness study area is bordered by the Sawtooth National Forest and Boulder-Pioneer Wilderness Study Area on the north and by State and private land on the other sides. The margins of the Little Wood River Wilderness Study Area can be reached by an unimproved road along the Little Wood River and by 4-wheel-drive trails at the east and west ends of the area (pl. 1). Elevations range from 5,600 ft (feet) in the valley of the Little Wood River to 8,000 ft in the northwest part of the area. The terrain is generally steep and covered by sagebrush and grass.

The wilderness study area is in an area of complexly folded and thrust faulted Paleozoic (see Geologic Time Chart in the Appendix) sedimentary rocks that are unconformably overlain by Tertiary volcanic rocks. Sandstone, calcareous sandstone, and quartzite of the Wood River Formation (Middle Pennsylvanian to Lower Permian) form resistant ridges and hills that make up most of the study area. Argillite of the underlying Devonian Milligen Formation is exposed in a small area. Lava and tuff breccia of the Eocene Challis Volcanics depositionally lap onto these Paleozoic rocks, generally around the margins of the study area. Quartz and quartz-calcite veins in the Paleozoic rocks appear to be associated with low-grade metamorphism and are locally mineralized. Quartz and calcite vug fillings and veins in the volcanic rocks appear to be associated with shallow circulation of heated ground water and are not mineralized.

The wilderness study area is situated among several mining districts (fig. 2). The value of the combined production of these districts through 1981 was about $65 million (Simons, 1981) (about $400 million after adjusting for inflation), most of which came from the Mineral Hill and Alder Creek districts (Ross, 1941). Commodities that were produced varied with each district and include silver, gold, copper, lead, zinc, barite, and tungsten. The closest district to the study area is the Muldoon (or Little Wood River) district, about 3 mi (miles) to the northeast, which produced more than $200,000 ($1.2 million after adjusting for inflation), mostly in silver, lead, zinc, copper, and barite (Ross, 1941).

A geochemical survey of the Little Wood River Wilderness Study Area was conducted in the spring of 1987. Stream-sediment and heavy-mineral-concentrate samples

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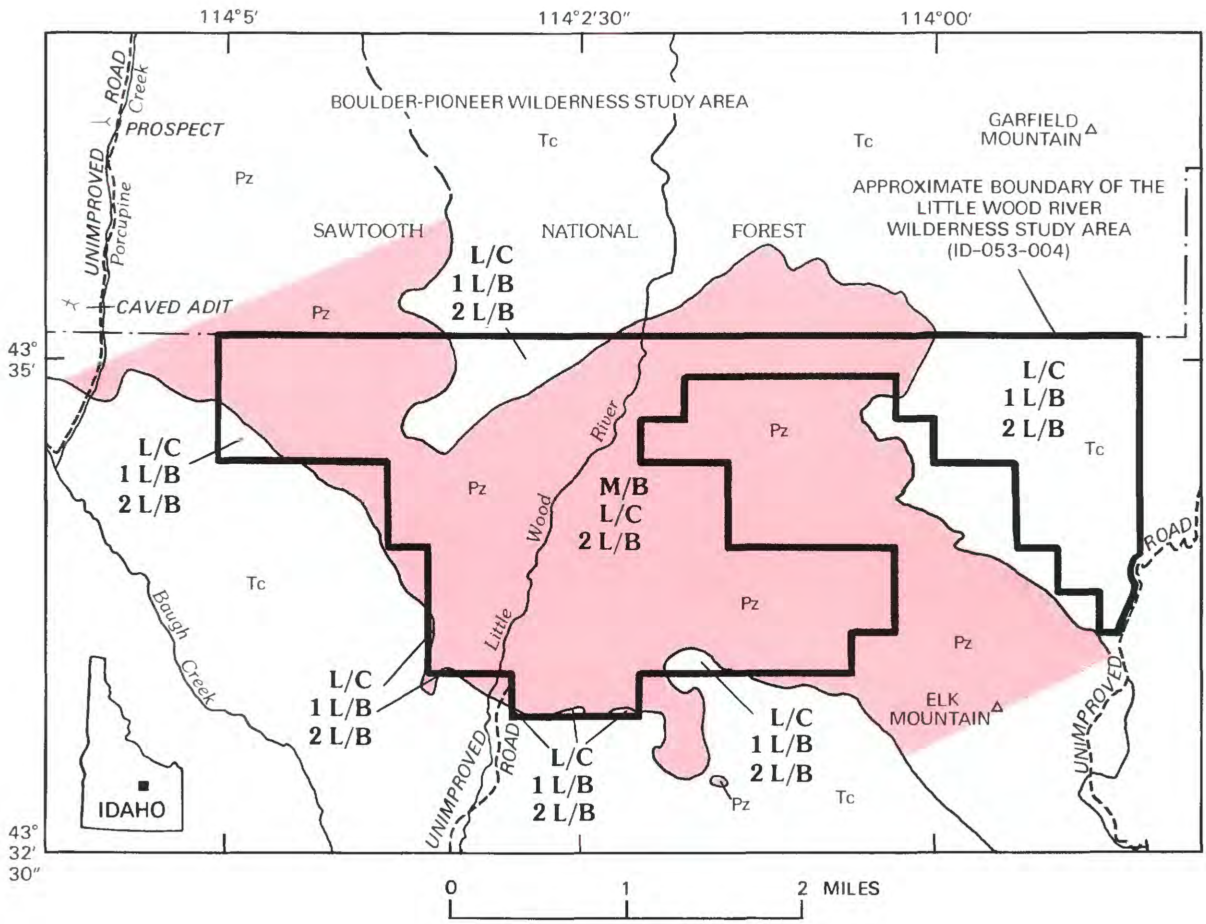

EXPLANATION

M/B	Geologic terrane having moderate mineral resource potential for silver, barite, copper, lead, zinc, gold, and tungsten, with a certainty level of B
L/C	Geologic terrane having low mineral resource potential for oil and gas, uranium, sand and gravel, and building materials, with a certainty level of C–Applies to entire study area
1 L/B	Geologic terrane having low mineral resource potential for silver, barium, copper, lead, zinc, gold, and tungsten, with a certainty level of B
2 L/B	Geologic terrane having low mineral resource potential for other metals and geothermal energy, with a certainty level of B–Applies to entire study area

Levels of certainty

B	Data indicate geologic environment and suggest level of resource potential
C	Data indicate geologic environment and resource potential, but do not establish activity of resource-forming processes
Tc	Challis Volcanics (Eocene)
Pz	Paleozoic rocks (Permian, Pennsylvanian, and Devonian)

Figure 1. Summary map showing mineral resource potential of the Little Wood River Wilderness Study Area and vicinity.

were collected from active alluvium in first- and second-order streams. Rock samples of quartz and quartz-calcite veins were collected both in and near the study area. Analytical results for stream sediments and concentrates reflect the shale lithologies of the Middle Pennsylvanian to Lower Permian Wood River Formation and Devonian Milligen Formation as well as possible epithermal deposits and plutonic rocks. Significant metal anomalies occur in a prospect

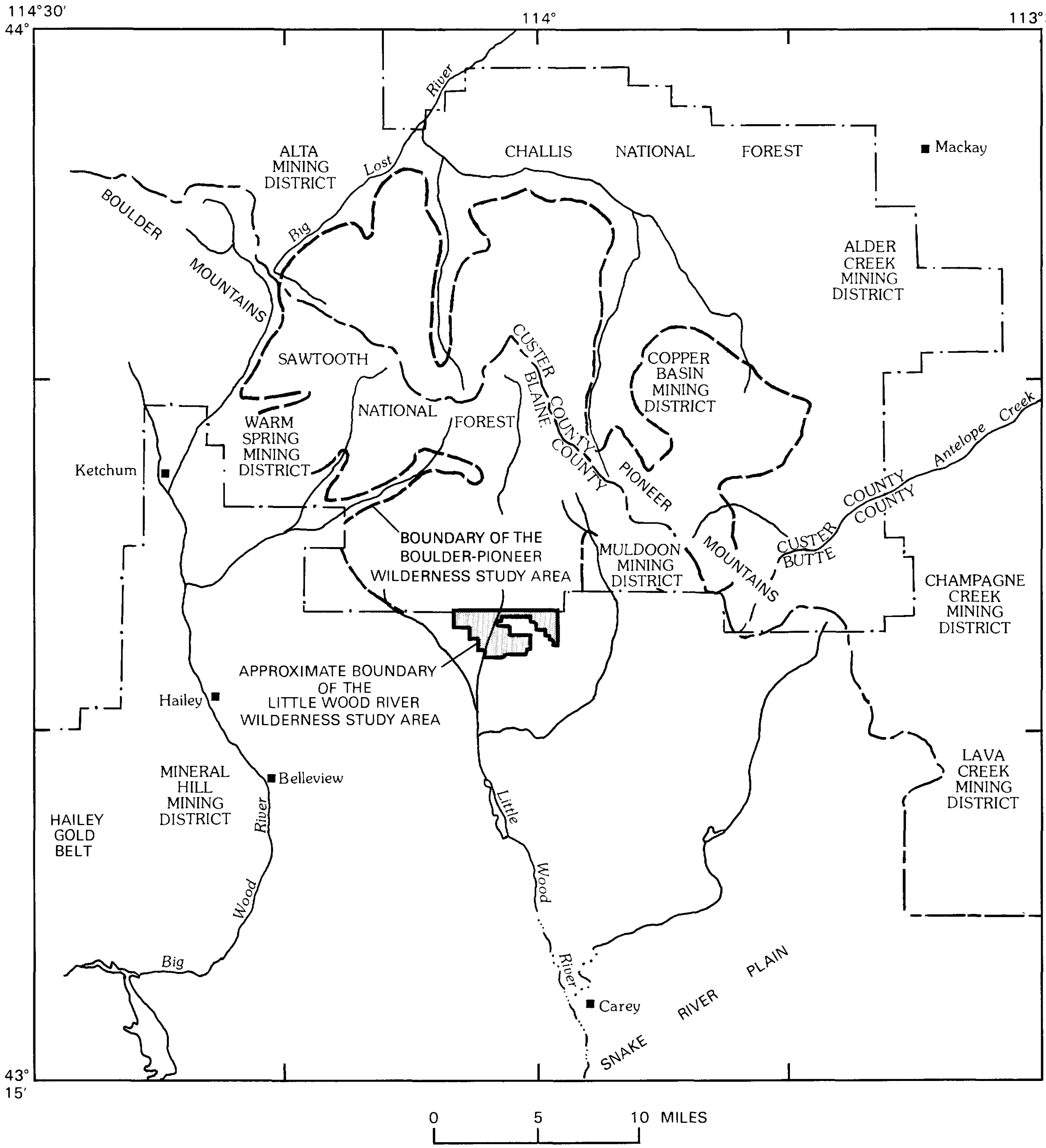

Figure 2. Index map showing location of the Little Wood River Wilderness Study Area (pattern).

in the Milligen Formation 1.4 mi northwest of the study area and in fracture zones in the Wood River Formation east of Chicken Creek in the study area. Quartz and quartz-carbonate veins similar to those that contain anomalous concentrations of metals outside the study area occur in Paleozoic rocks in the study area but typically lack significant concentrations of metals.

Gravimetric, aeromagnetic, and aeroradiometric data were interpreted for the study area. The gravity field in and around the study area generally varies according to the density and thickness of the Challis Volcanics. Magnetic highs suggest that a northwest-trending band of quartz monzonitic intrusions is probably buried beneath the Challis Volcanics northeast of the study area. Aerial gamma-ray spectrometric data suggest no unusual concentrations of uranium in the study area.

Identified Mineral Resources

The study area does not contain identified mineral resources, but low-quality sand and gravel are present. A prospect in a quartz-carbonate vein 1.4 mi northwest of the study area contains anomalous concentrations of silver, barium, copper, lead, and zinc. However, the vein is not known to extend into the study area.

Mineral and Energy Resource Potential

Quartz and quartz-calcite veins and pods are common in the Devonian Milligen and Middle Pennsylvanian to Lower Permian Wood River Formations in the study area. These deposits are locally enriched in silver, barium, copper, lead, and zinc, and resemble deposits in Paleozoic rocks in neighboring mining districts. The part of the study area that is underlain by Paleozoic sedimentary rocks has moderate mineral resource potential for undiscovered silver, barite, copper, lead, zinc, gold, and tungsten (fig. 1). The remainder of the study area, which is underlain by Tertiary volcanic rocks, has low mineral resource potential for undiscovered silver, barite, copper, lead, zinc, gold, and tungsten. The entire study area has low mineral resource potential for other undiscovered metals. Although source rocks and structure are favorable for the generation, transport, and trapping of oil and gas, the temperatures reached by the rocks during deformation were probably too high for the retention of fluid hydrocarbons. Therefore, the entire study area has low energy resource potential for undiscovered oil and gas. Although geothermal energy sources are common in the central Idaho region, no hot springs or wells are known in the study area. The entire study area has low resource potential for undiscovered geothermal energy. Lack of aeroradiometric anomalies and suitable mineral deposits indicate the entire study area has low mineral resource potential for undiscovered uranium. Sand and gravel occur in small amounts in the study area; however, larger quantities are available closer to population centers. The entire study area has low potential for undiscovered sand and gravel. The Tertiary volcanic rocks and associated sedimentary rocks in the study area are unsuitable as a source of building stone, pumice, and diatomite. The entire study area has low mineral resource potential for building materials.

INTRODUCTION

At the request of the U.S. Bureau of Land Management (BLM), the entire 4,385 acres of the Little Wood River Wilderness Study Area were studied. The study area is bordered by the Sawtooth National Forest and Boulder-Pioneer Wilderness Study Area on the north and by State and private land on the other sides. The margins of the study area can be reached by an unimproved road along the Little Wood River and by 4-wheel-drive trails at the east and west ends of the area (pl. 1). Altitude ranges from 5,600 ft in the valley of the Little Wood River to 8,000 ft in the northwest part of the area. The terrain is generally steep and covered by sagebrush and grass. Evergreen trees are confined to north-facing slopes. The narrow valley bottom along the Little Wood River supports lush growth of deciduous trees and undergrowth.

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

Investigations by the U.S. Bureau of Mines

Prior to the field investigation, pertinent published and unpublished literature was reviewed. Files at the BLM state office in Boise, Idaho, were checked for patented and unpatented mining claim locations and oil and gas leases and lease applications. Two USBM geologists spent five days in the field during the summer of 1987 and collected 28 rock-chip samples for chemical analysis. The samples were analyzed by inductively coupled argon-plasma atomic emission spectroscopy (ICP) for 33 elements and by atomic absorption by Chemex Labs, Inc., Sparks, Nev. Results of the USBM investigation are presented in Gese (1988).

Investigations by the U.S. Geological Survey

During the summer of 1987, the USGS conducted geological, geophysical, and geochemical surveys of the wilderness study area. The geology of the area was mapped at a scale of 1:24,000. Gravity and magnetic surveys were conducted to cover the area. Rock chips and stream sediments were sampled and analyzed for valuable commodities and trace elements.

Acknowledgments.—We gratefully acknowledge the cooperation of the regional office of the BLM, especially Larry Dee, during the course of this study. We also thank the private land owners who generously allowed access to their land. Discussions with Betty Skipp, USGS, were very productive. Ed Ratchford,

Department of Geology, University of Idaho, Moscow, provided information on the Milligen Formation.

Geology of South-Central Idaho

South-central Idaho contains a variety of rock types and is structurally complex. The oldest rocks in the area are 2-billion-year-old Early Proterozoic gneisses that form the core of the Boulder-Pioneer Mountains (Dover, 1981). These are overlain by Proterozoic(?) and Ordovician medium- to high-grade metasedimentary rocks, dominantly pelitic schists and calc-silicates. Two distinct sequences make up the overlying Ordovician, Silurian, and Devonian sedimentary rocks (Dover, 1981). A western sequence is dominantly composed of argillite and shale. These rocks form the "black shale belt" of the Big Wood River valley, and one of these units, the Milligen Formation, crops out in the wilderness study area. The eastern sequence is dominated by limestone and dolomite. The western sequence represents deposition in deep water in a continental-rise environment (Sandberg and others, 1975), whereas the eastern sequence represents an age-equivalent shallow-marine shelf environment (Skipp and Hait, 1977). During the Mississippian Antler orogeny, sediments were eroded from emerging highlands in the west and deposited as coarse-grained, thickly bedded turbidites of the Copper Basin Formation (Paull and others, 1972; Nilsen, 1977). These rocks crop out just east of the study area in the Muldoon mining district (fig. 2). During Pennsylvanian and Permian time, these turbidites were uplifted, and erosional debris was shed toward the west to form the Wood River Formation (Skipp and Hall, 1975), which underlies much of the study area.

An unconformity marks a gap in sedimentation during Mesozoic time. During this time, the Paleozoic sedimentary rocks were thrust eastward as a series of four stacked allochthons (Skipp and Hait, 1977), probably during the Sevier orogeny (Hall and others, 1975). Also during this time, the voluminous Idaho batholith was intruded. Deformation of the Paleozoic sediments was intense, and beds in the study area are commonly steeply dipping and locally overturned. Unconformably overlying the Paleozoic rocks is a discontinuous pre-Challis conglomerate unit (Lukowitz, 1971; Volkmann, 1972), which appears to have been tilted prior to eruption of the Eocene Challis Volcanics, which cover much of the region.

The Challis Volcanics in and around the study area consist of andesitic tuff breccia and lava flows, dacitic tuff breccia and lava flows, and dacitic to rhyolitic ash-flow tuff. These units were deposited on rugged topography that had relief of about 2,000 ft. A series of intrusive bodies were emplaced contemporaneously with the volcanic rocks. All units were subsequently tilted along northwest-trending faults that were related to Basin and Range tectonics.

Miocene ash-flow tuff unconformably overlies the Challis Volcanics just south of the study area. The tuff is rhyolitic in composition, contains locally abundant lithophysal cavities, and contains phenocrysts of plagioclase, iron-titanium-oxides, and clinopyroxene, as well as lithic and pumice fragments.

Pleistocene lava flows related to Snake River Plain volcanism occur locally south of the study area and are intimately associated with glacial deposits (Schmidt, 1961).

The study area is situated among several mining districts (fig. 2). The combined production of these districts was about $65 million (Simons, 1981) (about $400 million after adjusting for inflation), most of which came from the Mineral Hill and Alder Creek districts (Ross, 1941). Commodities produced varied with each district, but the important ones were silver, gold, copper, lead, zinc, barite, and tungsten. Deposits belong to four classes. (1) Deposits that produced mainly silver and lead with some gold are typified by the Minnie Moore mine in the Mineral Hill district. Most of these deposits are in the Milligen Formation, but some are in the Wood River Formation (Simons, 1981). (2) Deposits that produced copper as the principal commodity along with significant silver, lead, gold, and tungsten are in the Alder Creek and Copper Basin districts and include skarns and other deposits closely related to igneous intrusions. (3) The Alta (in some reports spelled Alto) and Muldoon (or Little Wood River) districts contain replacement deposits of silver, lead, and zinc, locally with copper, tungsten, or barite, along bedding planes in sedimentary rocks. Significant barite without associated base-metal minerals is found in epithermal veins in the Muldoon district. The Muldoon district is the closest district to the study area, about 3 mi to the east, and produced more than $200,000 ($1.2 million after adjusting for inflation), mostly in silver, lead, zinc, copper, and barite (Ross, 1941; Anderson and Wagner, 1946). (4) Polymetallic deposits in the Lava Creek district produced lead, silver, copper, zinc, gold, and bismuth, and are hosted by Eocene Challis Volcanics (Anderson, 1929). In the discussion of mineral resource potential, these four classes of deposits will be considered under the general heading of "epithermal deposits."

The age of the deposits that are clearly related to intrusions can be confidently estimated as Late Cretaceous or Tertiary depending on the intrusion. The age of other deposits is less well known. Bedding-plane replacement deposits may be epigenetic (formed shortly after deposition and burial of the host sediments), or they may be hydrothermal (related to much later deformation and low-grade metamorphism).

Geology of the Little Wood River Area

Prior to this investigation, parts of the area had been mapped on a reconnaissance level by Umpleby and others (1930), Nelson and Ross (1969), Lukowitz (1971), and W.E. Hall and J.N. Batchelder (unpub. field notes, 1973–1975, USGS files). The area was also included in geologic compilations by Dover (1981) and Rember and Bennett (1979a, b). The wilderness study area and adjacent areas were completely remapped by R.F. Sanford at a scale of 1:24,000 for this study (pl. 1).

The oldest unit in the study area is the Devonian Milligen Formation, which crops out in the extreme western end of the study area (pl. 1). The Milligen consists dominantly of tightly folded black carbonaceous to siliceous argillite, gray-weathering phyllitic argillite, fine-grained quartzite, siltite, and micritic limestone. Lenses, veinlets, and irregular masses of hydrothermal quartz and local calcite are common. Two of the quartz-calcite masses west and northwest of the study area have been prospected in the past.

The Middle Pennsylvanian to Lower Permian Wood River Formation is the most widespread unit in the study area. It is in thrust contact with the underlying Milligen Formation, and the basal conglomerate member of the Wood River Formation overlies the thrust fault in the study area. The middle part of the Wood River Formation consists of gray shaly to massive limestone, calcareous siltstone, and conglomerate. The upper part is dominantly gray and light-brown, fine-grained calcareous sandstone and sandy limestone, quartzite, siltite, and chert. The more limy layers form slopes and are poorly exposed, whereas the quartzite layers form prominent ridges. Quartzite layers tend to be highly fractured with numerous slickenside surfaces. Mapping of overlying units shows that the pre-Tertiary erosion surface was as rugged as the present topography and was similarly controlled by more resistant quartzite and less resistant calcareous units. Beds strike north-south and are typically steeply dipping and commonly overturned with tops toward the east. Quartz lenses, veinlets, and irregular masses are numerous in the study area and are particularly common on the west-facing slope west of the Little Wood River.

Unconformably overlying the Wood River Formation is a pre-Challis conglomerate unit that was recognized by Lukowitz (1971) and Volkmann (1972). Although this unit is not exposed in the study area, it does crop out south and southeast of the study area; a description is included here because of the proximity and tectonic significance of the unit. This resistant unit is composed of coarse quartz-pebble conglomerate and quartzite. Quartzite pebbles are generally gray in a white, fine-grained matrix. Volcanic fragments are absent, which indicates that the Challis Volcanics were erupted after deposition of the pre-Challis conglomerate. Fractures and slickensides are common. Bedding dips steeply to the south and strikes parallel to the contact with the Wood River Formation. The thickness varies from 0 to about 200 ft. The unit appears to terminate where more resistant beds of the Wood River Formation formed paleoridges.

The Challis Volcanics are in depositional contact with the Wood River Formation and the pre-Challis conglomerate of Lukowitz (1971) and Volkmann (1972). The distribution of units in the Challis Volcanics is different north of the outcrop of Wood River Formation than south of it. The northern part of the mapped area (pl. 1) consists of extensive interbedded andesitic flows and tuff breccia overlain by equally extensive dacitic flows. The total thickness of these two units may be about 5,000 ft. The area south of the outcrop of Wood River Formation consists of andesitic tuff breccia at the base, overlain by dacitic to rhyolitic flows, tuff breccia, and tuff, locally with vitrophyre. Individual units are relatively thin and local and are confined to relatively low elevations. Dacite plugs intrude the tuff breccia. The andesitic tuff breccia forms dark-greenish-brown soil on rounded slopes; the dacitic tuff breccia is more resistant; and the andesitic and dacitic flows form resistant cliffs and knobs. Locally, probably at the tops of flows, cavities and fractures in the volcanic rocks are impregnated with calcite and quartz. The quartz varies from cryptocrystalline and opalescent to coarse grained and euhedral, and is typically clear but locally is purple amethyst. The calcite locally is fine grained and resembles travertine. Typically, the volcanic rocks are altered and bleached white in a halo around fractured areas. These features suggest that near-surface hydrothermal (hot spring) circulation was probably active while the volcanic pile was still hot.

Two types of Pleistocene deposits are present. The older, possibly Bull Lake age, deposits form terraces high on the sides of the Little Wood River valley. These unconsolidated deposits consist of prominent white quartzite cobbles and less prominent sandstone cobbles and pebbles, sand, and silt. These deposits probably are the remnants of valley-filling glacial outwash (D.L. Schmidt, oral commun., 1988). A small area of this material is at the mouth of Chicken Creek on the south-central edge of and just within the study area. The flat-bottomed valleys of the Little Wood River and its major tributaries are filled with younger, probably Pinedale age, glacial debris. Where exposed by Holocene erosion (to a depth of no more than 4 ft), this material is composed of unconsolidated gravel, sand, and silt.

APPRAISAL OF IDENTIFIED RESOURCES

By Diann D. Gese
U.S. Bureau of Mines

Mining History

There has been no mineral production from within the study area. The nearest production was from the Muldoon and Eagle Bird mines in the Muldoon mining district about 3 mi northeast of the study area where silver-lead-bearing ore occurred as replacement deposits along bedding planes in highly fractured limestones and argillaceous rocks of the Mississippian Copper Basin Formation, commonly associated with Tertiary quartz monzonite intrusives (Tuchek and Ridenour, 1981, p. 249).

There are no current mining claims or oil and gas leases within the study area; however, BLM records show that mining claims were staked in the central and north-central parts of the study area in 1982 (Fernette and Stratman, 1983, fig. 15).

Appraisal of Sites Examined

Eighteen rock-chip samples were taken along shatter and fault zones in the Wood River Formation in secs. 24, 25, and 36, T. 3 N., R. 20 E. Twelve of these samples were taken along three faults in the Wood River Formation in the south-central part of the study area. The most extensive fault zone trends northeasterly, is traceable along strike for more than 1,200 ft, is as much as 30 ft wide, and consists of fractured silicified host rock. Sections of this fault are highly brecciated and contain small quartz veins and abundant iron oxides. All samples taken from these three faults contained minor silver [0.2–5.2 ppm (parts per million)]; some of the samples contained as much as 340 ppm arsenic, 550 ppm barium, and 999 ppm zinc (Gese, 1988, table 2; samples 17–28). No resource could be identified in this part of the study area.

Six samples were taken from a north-trending shatter zone in the south-central part of the study area that has been fractured, silicified, and brecciated. Although parts of this zone appear to be highly altered and oxidized, assay results showed only 0.2 ppm silver (Gese, 1988, table 2; samples 13–16) and a few high concentrations of arsenic, barium, and zinc (Gese, 1988, table 2; samples 12, 13, 15, and 16). Shatter zones and faults within the study area have been altered, and surface sampling indicates that sections are mineralized; however, additional detailed work would be required to determine the extent of mineralization along these shatter zones and faults and if resources are present at depth.

The Porcupine Creek prospect, about 1.4 mi northwest of the study area, consists of two adits, one of which is caved. The upper, accessible adit was driven about 130 ft northwesterly along a quartz-calcite vein in the Milligen Formation. The vein is truncated by a 5-ft-wide, northeast-trending fault 60 ft from the portal. The adit was flooded at 65 ft, and its total length was obtained from a 1974 map of the prospect (USBM, Western Field Operations Center, Spokane, Wash., mineral property file). Pods and lenses that contain pyrite, chalcopyrite, sphalerite, copper carbonates, and iron oxides were found in calcite. Five rock-chip samples were taken in the adit; only one sample contained more than 0.2 ppm silver (Gese, 1988, table 1; sample 2). A dump sample analyzed by the USGS contained 64 ppm silver and anomalous concentrations of copper, zinc, cadmium, and iron. The vein at the Porcupine Creek prospect does not appear to extend into the study area.

Minor amounts of sand and gravel occur along the Little Wood River. However, deposits of better quality occur outside the area much closer to local markets.

Conclusions

Low-quality, uneconomic sand and gravel are present within the Little Wood River Wilderness Study Area. Shatter and fault zones within and near the central part of the study area contain minor silver and anomalously high amounts of arsenic, barium, and zinc; however, additional detailed work would be required to determine the extent of mineralization and if resources are present at depth. An adit about 1.4 mi northwest of the area contains anomalous concentrations of silver, copper, lead, zinc, cadmium, and iron, but the vein does not appear to extend into the study area. There are no oil and gas leases or lease applications within the study area, and there has been no oil exploration or production.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Richard F. Sanford, Helen A. Whitney, and Anne E. McCafferty
U.S. Geological Survey

Geochemistry

Analytical Methods

A geochemical survey of the Little Wood River Wilderness Study Area was conducted in the spring of 1987. Stream-sediment and heavy-mineral-concentrate samples were collected from active alluvium in first- and second-order streams. Rock-chip samples of quartz and calcite veins were collected both in and near the study area.

Twenty-one stream-sediment samples, 21 heavy-mineral-concentrate samples, and 23 rock-chip samples were collected in this study. The stream sediments were sieved to -80 mesh and analyzed by semiquantitative six-step emission spectrography for 32 elements (Grimes and Marranzino, 1968) and by ICP methods for antimony, arsenic, bismuth, cadmium, and zinc (Crock and others, 1987). The nonmagnetic fraction of the heavy-mineral concentrates was analyzed by semiquantitative six-step emission spectrography only. The mineralogy of the concentrates was determined prior to analysis. Rock-chip samples were analyzed for 40 elements by ICP methods (Crock and others, 1987). Concentrations of selected elements in stream sediments and heavy-mineral concentrates are shown in tables 1 and 2, respectively. Results of analysis of rock-chip samples reported by the USBM (Gese, 1988) were also incorporated in the present study. The threshold levels determined by Simons (1981) for anomalous values in the adjacent Boulder-Pioneer Wilderness Study Area are used in this study.

Results of Analysis of Stream-Sediment Samples

Stream sediments from drainages in the area are enriched in silver, barium, chromium, copper, lanthanum, molybdenum, nickel, lead, vanadium, and zinc (table 1). These elements are characteristic of black shales (Vine and Tourtelot, 1970). However, some of these elements, namely, silver, barium, copper, lead, and zinc, are also characteristic of epithermal deposits, and small contributions of these metals from an epithermal deposit would be masked by the high metal content of the black shales.

Results of Analysis of Heavy-Mineral-Concentrate Samples

Analysis of panned heavy-mineral concentrates revealed few significant metal anomalies (table 2). Samples from three drainage basins contained anomalous tin (20, 150, 200 ppm), a sample from one drainage basin contained anomalous molybdenum (200 ppm) and detectable tungsten (50 ppm), and a sample from one drainage basin contained 500 ppm thorium. Although these elements (tin, molybdenum, tungsten, and thorium) suggest plutonic affinities, they do not occur together. Heavy-mineral-concentrate samples consist of zircon, barite, anatase, rutile, sphene, biotite, apatite, amphibole, rare sapphire and pyrite, and black-shale fragments. Several heavy-mineral-concentrate samples contained more than 10,000 ppm barium and visible barite.

Results of Analysis of Rock-Chip Samples

Analysis of rock-chip samples from veins and fracture zones show some anomalous concentrations of metals. Samples from a prospect in the Milligen Formation 1.4 mi north of the study area contained anomalous amounts of silver (64 ppm), cadmium (250 ppm), copper (more than 10 percent), iron (24 percent), and zinc (10 percent). Anomalous concentrations of silver, arsenic, lead, and zinc occur in iron-oxide-stained, fractured, silicified, and brecciated quartzite (probably unit 5 of Hall and others, 1974) of the Wood River Formation in the study area east of Chicken Creek (pl. 1; Gese, 1988). One sample from a quartz vein in the Wood River Formation near the Little Wood River contained 220 ppm zinc. Several samples of quartz-carbonate vein contained anomalous calcium and manganese, which reflect the locally abundant calcite.

In summary, analytical results for stream sediments and heavy-mineral concentrates reflect the shale lithologies of the Middle Pennsylvanian to Lower Permian Wood River Formation and Devonian Milligen Formation as well as possible epithermal deposits and plutonic rocks. Significant metal anomalies occur in a prospect in the Milligen Formation 1.4 mi northwest of the study area and in fracture zones in the Wood River Formation east of Chicken Creek in the study area. Quartz and quartz-calcite veins similar to those that contain anomalous concentrations of metals outside the study area occur in Paleozoic rocks in the study area but typically lack significant concentrations of metals.

Geophysics

Gravity, aeromagnetic, and aeroradiometric data were interpreted for the study area. Due to the lack of detailed data, only a regional interpretation is possible.

Gravity Survey and Results

Gravity data were collected in the summer of 1987 in and near the study area and combined with available data from the Department of Defense data bank (National Oceanic and Atmospheric Administration National Geophysical Data Center). The complete (terrain corrected) Bouguer gravity field was calculated using a reduction density of 2.67 grams per cubic

Table 1. Concentrations of selected elements in stream sediments

[Zinc was determined by inductively coupled plasma method (Crock and others, 1987); all other elements were determined by emission spectrography (Grimes and Marranzino, 1968). All concentrations are reported in parts per million. Threshold values are from Simons (1981). N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown; leaders (---), not available]

Sample	Ag	B	Ba	Co	Cr	Cu	La	Mo	Ni	Pb	Sr	V	Zn
LWR001S	N	10	1,500	30	500	100	50	<5	100	70	500	200	63
LWR002S	2.0	100	1,000	20	150	100	50	30	200	70	200	1,000	490
LWR003S	.7	50	1,000	10	70	30	50	<5	50	30	300	300	180
LWR004S	.5	70	1,000	15	100	50	70	<5	50	50	500	200	98
LWR005S	N	<10	1,500	20	300	70	70	<5	70	50	500	300	88
LWR006S	N	<10	2,000	20	500	70	70	<5	70	50	700	200	69
LWR007S	N	<10	1,000	20	200	70	100	<5	70	30	500	200	81
LWR051S	N	<10	1,000	30	700	50	100	<5	100	50	500	300	43
LWR053S	N	<10	1,500	20	1,000	50	70	<5	100	20	300	300	500
LWR054S	N	70	1,500	15	200	30	70	10	70	30	500	300	180
LWR055S	N	<10	1,000	30	500	20	70	<5	100	30	700	200	44
LWR056S	<.5	30	1,000	15	100	50	70	<5	70	50	500	100	83
LWR101S	N	N	1,000	15	200	30	50	<5	70	50	700	100	42
LWR102S	N	10	1,500	20	1,000	70	70	7	100	50	300	300	92
LWR104S	N	15	1,500	15	150	70	70	5	50	20	500	150	100
LWR106S	N	10	1,000	20	150	50	50	<5	50	30	500	200	84
LWR107S	N	10	1,000	20	300	50	50	<5	100	50	500	200	87
LWR110S	N	15	1,500	20	200	50	70	<5	100	20	500	200	73
LWR111S	N	<10	1,500	10	200	10	50	<5	30	30	500	200	83
LWR112S	N	50	1,500	30	500	70	70	<5	100	20	500	200	89
LWR113S	<.5	70	1,000	10	100	70	<50	7	100	30	300	150	130
Threshold values.	1.5	150	2,000	100	200	70	150	10	200	100	---	500	300

centimeter, and a regional field was removed. The contour lines of the gravity map (fig. 3) reflect contrasts in rock densities associated with changes in geologic structure or lithology.

A prominent regional gravity gradient crosses the study area. The lowest gravity values center over the Idaho batholith west and northwest of the study area, and the highest gravity values are over the Snake River Plain to the south and southeast of the study area. Superimposed on this regional gradient are more local anomalies that can be best identified after removal of a regional field.

A first-order regional field was removed (R.R. Wahl, USGS unpub. program, 1976) from the Bouguer gravity to emphasize these local features and to remove the gradient caused by granitic rocks of the Idaho batholith and by the Snake River basalts.

The gravity field in and near the study area generally shows variations that reflect variable densities and thickness of the Challis Volcanics. The lower values of gravity just south of the study area correlate with the thinner beds of the more abundant tuff breccias and dacitic flows. The gravity values tend to be higher to the north of the area due to the thicker and possibly more dense sequence of andesitic tuff breccia and andesitic to dacitic flows there.

Aeromagnetic Survey and Results

The aeromagnetic data were obtained from Aerial Surveys, Inc., under contract to the USGS (U.S. Geological Survey, 1979). Flight lines were flown north-south at a spacing of 1 mi and at a barometric altitude of 12,000 ft. The data were later analytically downward

Table 2. Concentrations of selected elements in heavy-mineral concentrates

[All elements were determined by emission spectrography (Grimes and Marranzino, 1968). All concentrations are reported in parts per million. Contamination by lead solder was found in sample LWR113C; the solder contained equal parts tin and lead. N, not detected; <, detected but below the limit of determination shown; >, determined to be greater than the value shown]

Sample	Ba	Cr	Cu	La	Mo	Pb	Sn	Sr	V	W	Th
LWR001C	1,000	1,000	10	700	<10	20	N	2,000	100	<50	N
LWR002C	>10,000	200	15	2,000	<10	30	N	3,000	700	<50	N
LWR003C	>10,000	300	100	2,000	<10	<20	200	2,000	200	<50	<200
LWR004C	1,000	200	30	2,000	<10	<20	N	2,000	300	<50	<200
LWR005C	>10,000	200	10	2,000	<10	20	N	1,000	70	<50	N
LWR006C	700	200	<10	>2,000	<10	20	N	2,000	70	<50	N
LWR007C	1,500	70	<10	500	<10	20	N	2,000	50	<50	N
LWR051C	1,000	100	<10	500	<10	2,000	N	2,000	100	<50	N
LWR053C	5,000	500	10	2,000	<10	<20	N	2,000	100	<50	N
LWR054C	>10,000	50	<10	500	<10	70	N	2,000	100	<50	N
LWR055C	2,000	70	<10	500	<10	50	N	3,000	30	<50	N
LWR056C	1,000	20	<10	300	<10	<20	N	700	30	<50	N
LWR101C	1,000	150	<10	700	<10	20	N	1,000	20	<50	N
LWR102C	2,000	100	<10	2,000	<10	<20	N	2,000	30	<50	N
LWR104C	>10,000	150	10	1,500	<10	<20	N	3,000	50	<50	N
LWR106C	1,500	20	<10	1,000	<10	<20	150	1,000	20	<50	N
LWR107C	500	30	<10	1,500	<10	20	N	1,000	30	<50	N
LWR110C	700	50	<10	1,000	<10	<20	N	1,000	50	<50	N
LWR111C	1,000	20	<10	500	200	70	N	1,500	<20	50	N
LWR112C	7,000	300	10	1,000	<10	50	20	1,000	100	<50	N
LWR113C	5,000	200	15	500	<10	3,000	200	700	150	<50	500

continued and draped (Cordell, 1985) to simulate the magnetic field at an average height of 1,000 ft above topography. A regional magnetic field (Definitive International Geomagnetic Reference Field), updated to the time of the survey, was removed from the total intensity data to yield the residual magnetic intensity field in figure 4. The aeromagnetic contours primarily represent changes in the earth's magnetic field due to variations in the magnetic properties of rocks.

Magnetic highs correspond with outcrops of granitic intrusions in much of the region (Mabey, 1981). Magnetization boundaries that produce the highs were inferred by applying the horizontal gradient method of Cordell (1979). The boundaries calculated with this method are larger than the outcrops themselves, which suggests that the granitic intrusions are more extensive in the subsurface. The three magnetic highs (marked A, B, and C on fig. 4) suggest that an intrusive mass, possibly an extension of the exposed quartz monzonite, is buried beneath the overlying Challis Volcanics. The gradient on the southwest side of the anomalies is steep, which indicates that this side of the mass is nearly vertical and relatively shallow. The gradient on the northeast side of the anomalies is more gently dipping, which indicates either that the body increases in depth to the north or that this side of the mass has a gentler slope.

Aeroradiometric Survey and Results

Aerial gamma-ray spectrometry data were compiled at a scale of 1:250,000 for the study area and vicinity. The data were obtained by the National Uranium Resource Evaluation (NURE) program of the U.S. Department of Energy (1980). Spectrometric data described in this report were derived from the NURE data for the Hailey and Idaho Falls 1° × 2° quadrangles. No uranium anomalies occur in the study area. The levels of uranium in the study area are of reasonable concentrations for the rock that is exposed.

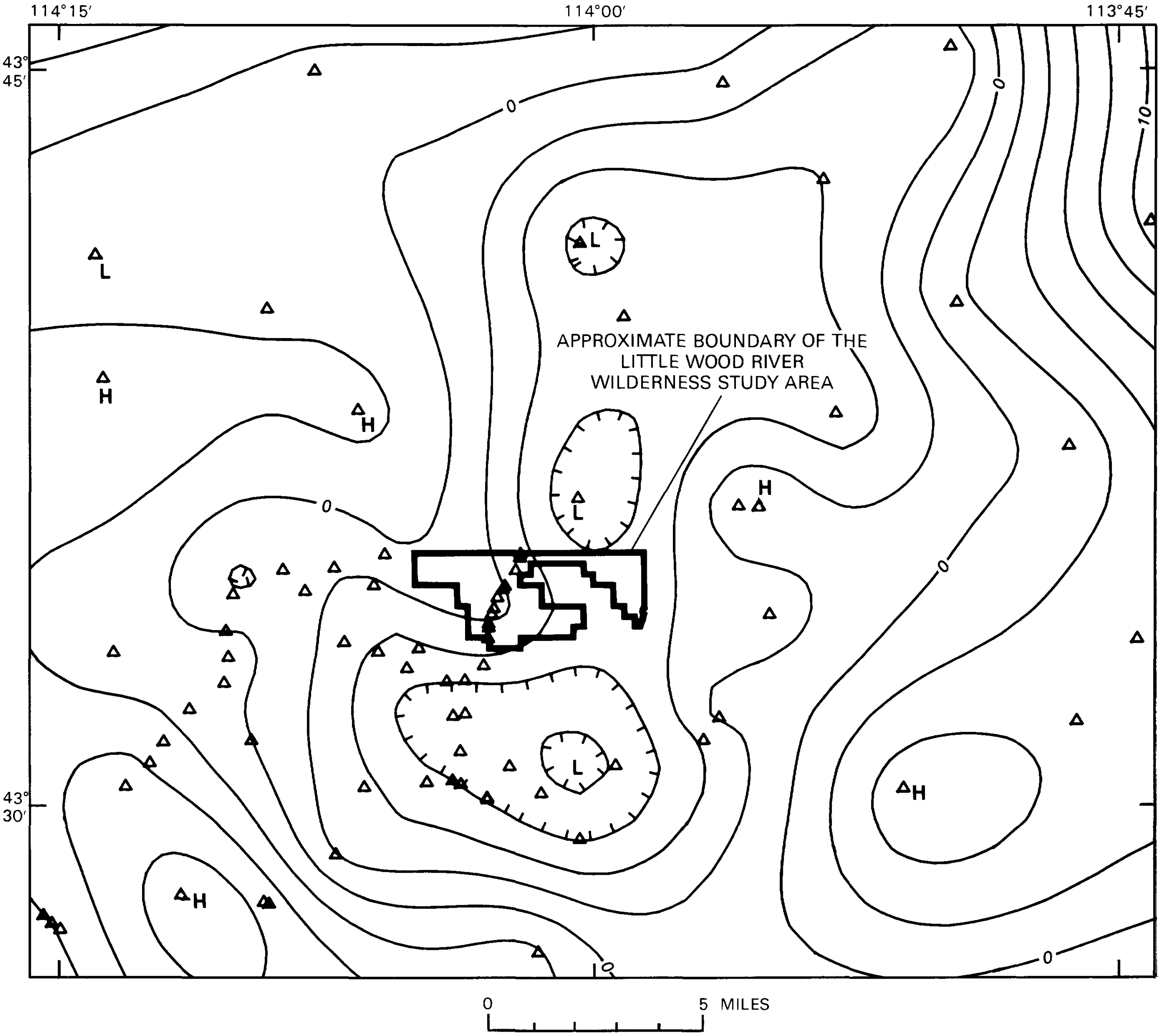

Figure 3. Complete Bouguer anomaly map of the Little Wood River Wilderness Study Area and vicinity. A first-order regional gravity field has been removed. Reduction density is 2.67 grams per cubic centimeter. Study area is outlined by thick solid line. Gravity station locations are indicated by triangles. H, gravity high; L, gravity low. Hachures indicate closed gravity lows. Contour interval is 2 milligals.

Mineral and Energy Resource Potential

Silver, Barite, Copper, Lead, Zinc, Gold, and Tungsten

Silver, barite, copper, lead, zinc, gold, and tungsten may occur in epithermal deposits in the study area. As mentioned above, the term "epithermal deposits," as used here, includes a variety of specific deposit types, principally hydrothermal deposits but also including skarn and replacement deposits. Because the data available for the Little Wood River Wilderness Study Area are not specific enough to distinguish between these deposit types, and because the commodities associated with these deposit types are similar, we refer to them collectively as "epithermal deposits."

Epithermal deposits form by precipitation of metals from heated aqueous solutions. Heated water, an essential ingredient, may be meteoric water that has circulated near an igneous intrusion or may be "formation water" from the original sediments that have been heated by burial and metamorphism. Sources of both types of water were available in the study area. Aeromagnetic evidence and lineaments on Landsat imagery (Fernette and Stratman, 1983) suggest buried intrusions north, west, and southeast of the study area.

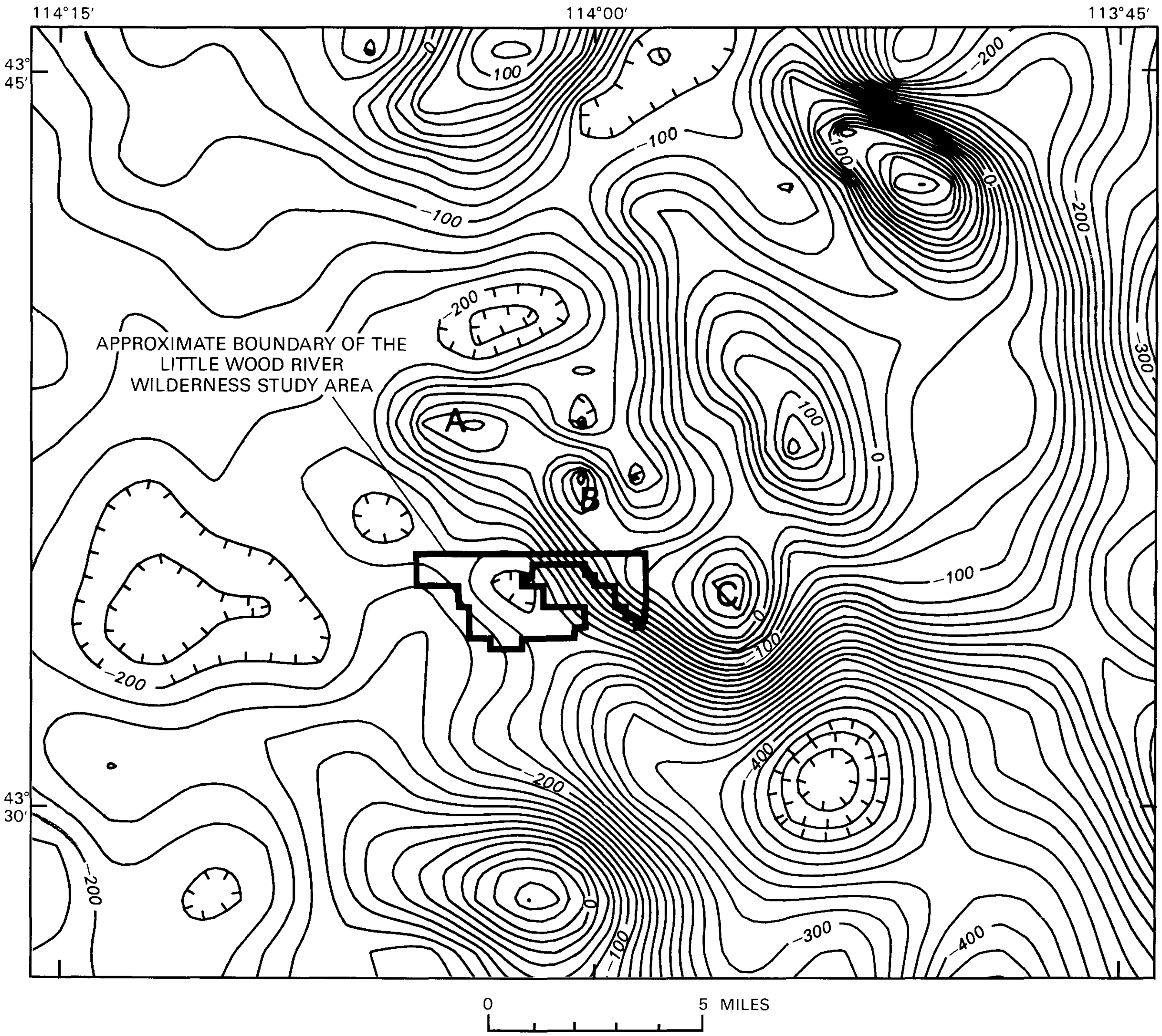

Figure 4. Residual total-field aeromagnetic map of the Little Wood River Wilderness Study area and vicinity. Study area is outlined by thick solid line. Letters are referred to in the text. Hachures indicate closed magnetic lows. Contour interval is 20 nanoteslas.

These intrusions probably would have been capable of driving hydrothermal convection systems. The Paleozoic sedimentary rocks are likely sources for voluminous amounts of heated "formation water." In addition, meteoric water may have circulated extensively through the highly fractured sedimentary rocks.

The heated water must scavenge metals from the rocks through which it circulates. Hall and others (1978) showed that the Milligen Formation could easily have been the source of all the metals in deposits of the Big Wood River area. Similarly, there are ample quantities of metals available for potential ore deposit formation in the study area.

Skarn deposits may be present at the contacts of the buried intrusions. If present, they would most likely be found at depth beneath the east end of the study area where the aeromagnetic highs suggest the presence of intrusions at depth.

Hydrothermal vein and replacement deposits can be located at a distance from igneous intrusions, and commonly mining districts have no known associated intrusions. A requirement for hydrothermal circulation is a large volume of permeable rock. Fractured quartzites, porous sandstones, and soluble limestones in the study area are favorable for hydrothermal circulation. Argillites may have permeability parallel to bedding planes and cleavage and in fractures transverse to bedding and cleavage. All the rock units in the study area (Milligen Formation, Wood River Formation, and Challis Volcanics) are hosts to ore deposits elsewhere, which indicates that they also might be hosts to ore deposits in the study area.

Filling of cavities by hydrothermal minerals is evidence of hydrothermal transport and deposition of dissolved constituents. Evidence for hydrothermal activity in the study area is quartz- and calcite-filled fractures and irregular spaces in the Milligen and Wood River Formations. These open-space fillings resemble those of productive mining districts such as Mineral Hill and Muldoon. Challis Volcanics locally show similar evidence for hydrothermal circulation, probably related to near-surface, hot-spring activity.

The anomalous concentrations of silver, copper, lead, zinc, cadmium, barium, and arsenic in veins and fracture zones in the Milligen and Wood River Formations at two localities, one of which is in the study area, shows that the open-space filling can be enriched in metals locally. Anomalous concentrations of these metals in stream sediments may also be attributed to mineralized quartz and quartz-carbonate bodies, although the same suite of elements could also be due to the metal-rich black shales.

The size of the individual mineralized bodies is quite small; most are no more than 100 ft long in outcrop. If the bodies exposed on the surface are representative of what is in the subsurface, then any deposits are likely to be small and scattered. However, surface evidence could be the manifestation of larger deposits such as those in neighboring mining districts in south-central Idaho.

In summary, the essential conditions for formation of epithermal deposits are present in the study area. Although large deposits are possible, the available evidence suggests that such deposits are small, irregular, and scattered. Thus, the part of the study area that is underlain by Paleozoic sedimentary rocks has moderate mineral resource potential, with a certainty level of B, for undiscovered silver, barite, copper, lead, zinc, gold, and tungsten. The remainder of the study area, which is underlain by Tertiary volcanic rocks, has low mineral resource potential, with certainty level of B, for undiscovered silver, barite, copper, lead, zinc, gold, and tungsten.

Other Metals

Other metals either have no anomalous concentrations or have anomalous concentrations that are a result of the local host rocks and not of mineralized rock. Also, no other metals have had significant production in nearby mining districts. The entire study area has low mineral resource potential with a certainty level of B, for other undiscovered metals.

Oil and Gas

Favorable source rocks, reservoir rocks, and structural traps probably underlie the study area. Oil and gas are being produced in western Wyoming, Montana, and eastern Nevada in rocks that are similar in age and type to those in the study area (Fernette and Stratman, 1983; Sandberg, 1983). The carbonaceous Milligen Formation is a favorable source rock for hydrocarbon generation. The sandstone, fractured quartzite, and fractured limestone of the Milligen and Wood River Formations could be favorable reservoir rocks. The near-vertical bedding in the Wood River Formation is not particularly favorable for hydrocarbon accumulation, although the thrust faults and complex folds could provide structural traps. Rocks in the two allochthons beneath the Milligen allochthon (Skipp and Hall, 1975) could also be favorable as sources, reservoirs, or traps.

However, the maturation levels of sedimentary rocks in the area are high for both oil and gas. The conodant color alteration index of Paleozoic rocks near the study area is 4.5 and higher (Harris and others, 1980; Sandberg, 1983). The index level of the upper thermal limit for oil is 2 and for dry gas is 4–4.5 (Epstein and others, 1977). Previously, Sandberg (1983) rated the potential for petroleum resources as “low to zero.” Although the thermal maturation is high, Sandberg (1983) felt that the favorable source rocks and the possibility for local pockets of thermally less mature rocks allowed for some petroleum accumulation. Therefore, the entire study area has low energy resource potential, with a certainty level of C, for undiscovered oil and gas.

Geothermal Resources

Idaho contains numerous areas of geothermal energy (Stearns and others, 1937; Ross, 1941). Hot springs are currently active in the valley of the Big Wood River 12 mi west of the study area and along the edge of the Snake River Plain 20 mi south of the study area. Although the study area in general is favorable for geothermal resources, and there could be thermal water at depth, no evidence of geothermal activity was observed on the surface in the study area. The entire study area has low resource potential, with a certainty level of B, for undiscovered geothermal energy.

Uranium

Lack of significant aeroradiometric gamma-ray anomalies and mineral deposits that contain concentrations of uranium indicate that the entire study area has low mineral resource potential, with a certainty level of C, for undiscovered uranium.

Sand and Gravel and Building Materials

Pleistocene and Holocene alluvium in the Little Wood River valley can be classed as inferred subeconomic sand and gravel resources. However, abundant alluvial deposits of similar or higher quality exist much closer to population centers, and therefore the small deposits in the study area are not likely to be developed. Volcanic rocks and associated sedimentary rocks in Idaho are locally favorable for various building materials (Asher, 1965); however, the Challis Volcanics in the study area lack any lava flows or ash beds suitable for building stone, pumice, or diatomite. The entire study area has low mineral resource potential, with a certainty level of C, for undiscovered sand and gravel, diatomite, and building materials.

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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.

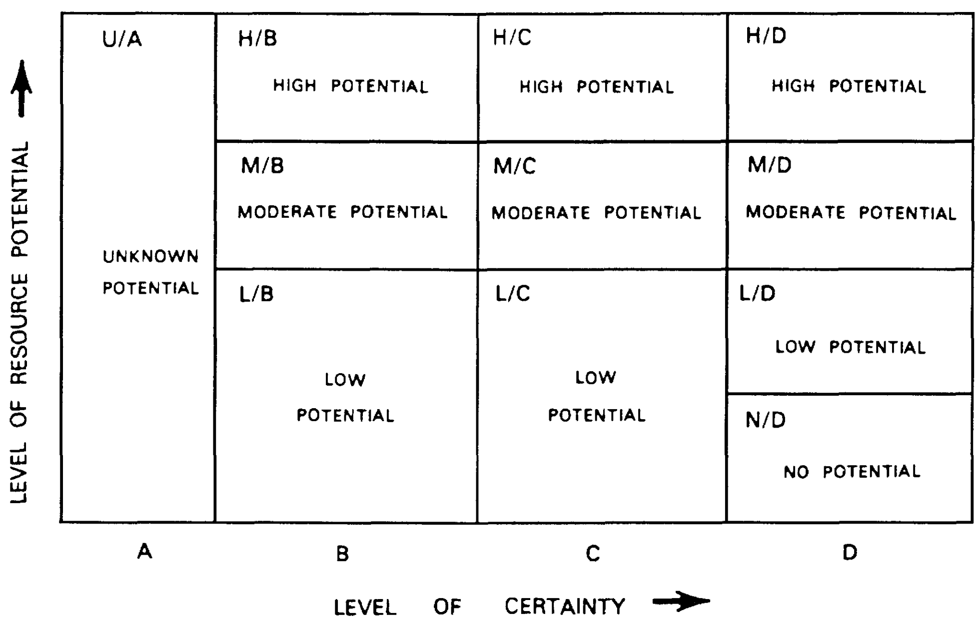
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application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

Abstracted with minor modifications from:

Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268–1270.

Taylor, R. B., Stoneman, R. J., and Marsh, S. P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40–42.

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RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (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 McKelvey, 1972, Mineral resource estimates and public policy: American Scientist, v.60, p.32-40, and U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, p.5.

GEOLOGIC TIME CHART

Terms and boundary ages used in this report

EON	ERA	PERIOD		EPOCH	BOUNDARY AGE IN MILLION YEARS
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	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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CONTENTS

[Letters designate the chapters]