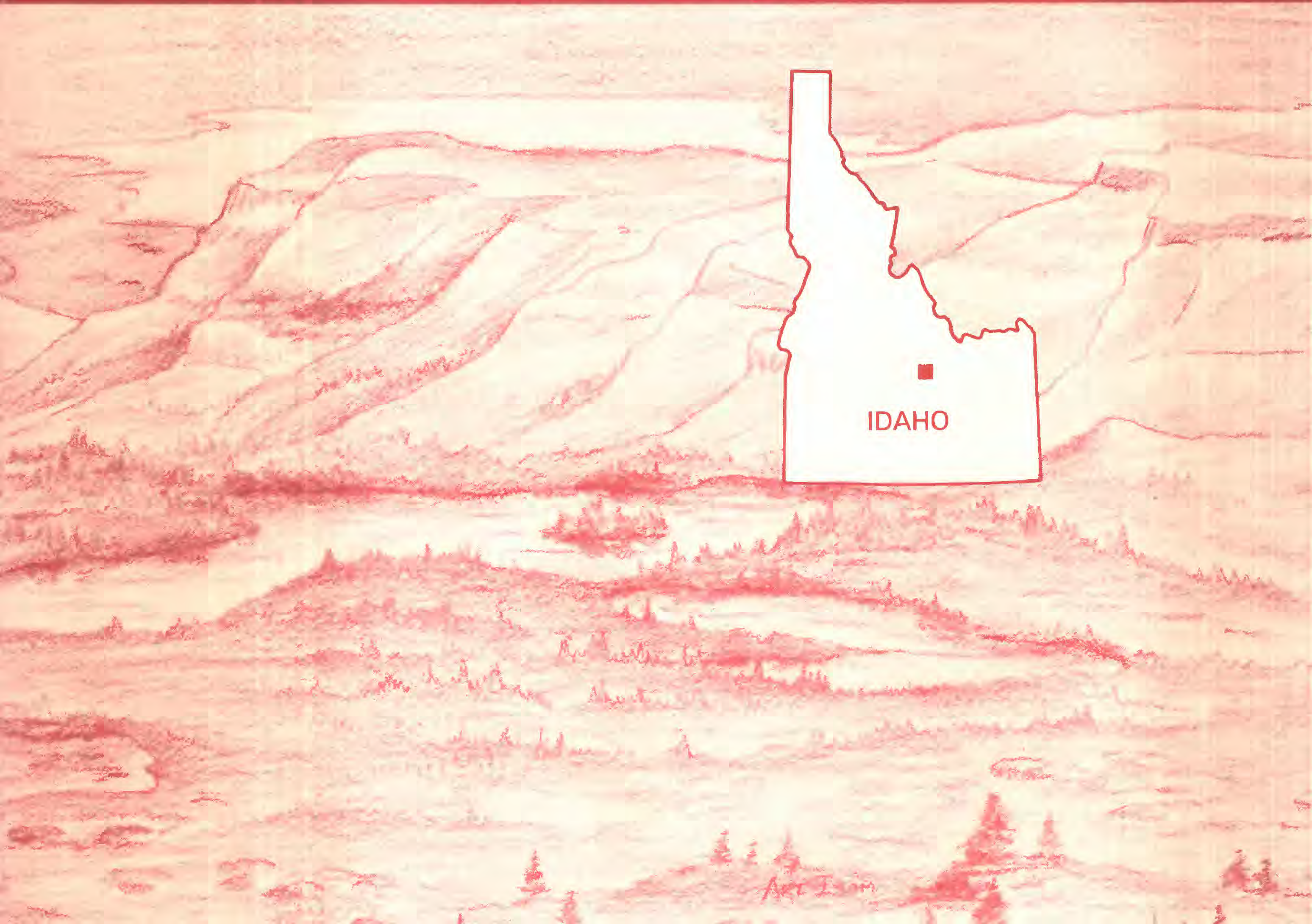
Mineral Resources of the Borah Peak Wilderness Study Area, Custer County, Idaho

U.S. GEOLOGICAL SURVEY BULLETIN 1718–E



Chapter E

Mineral Resources of the Borah Peak Wilderness Study Area, Custer County, Idaho

By ANNA B. WILSON, SUSANNE U. JANECKE, BETTY SKIPP,
M. DEAN KLEINKOPF, ANNE E. McCAFFERTY,
and HARLAN N. BARTON
U.S. Geological Survey

MICHAEL S. MILLER
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1718

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—SOUTHEASTERN IDAHO

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary

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

UNITED STATES GOVERNMENT PRINTING OFFICE: 1990

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center
Box 25425
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Mineral resources of the Borah Peak Wilderness study area / by Anna B. Wilson ... [et al].

p. cm. — (Mineral resources of wilderness study areas—southeastern Idaho ; ch. E) (U.S. Geological Survey bulletin ; 1718–E)
Includes bibliographical references.
Supt. of Docs. no.: I 19.3: 1718E
1. Mines and mineral resources—Idaho—Borah Peak Wilderness.
2. Borah Peak Wilderness (Idaho) I. Wilson, Anna B. II. Series.
III. Series: U.S. Geological Survey bulletin ; 1718–E.
QE75.B9 no. 1718–E
[TN24.I2]
557.3 s—dc20 90–3528
[553.'09796'72] CIP

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 Borah Peak (ID–047–004) Wilderness Study Area and additional adjacent area recommended for inclusion in the wilderness study area, Custer County, Idaho.

CONTENTS

Abstract E1
Summary E1
  Character and setting E1
  Identified resources E1
  Potential for undiscovered resources E2
Introduction E2
  Investigations by the U.S. Bureau of Mines E2
  Investigations by the U.S. Geological Survey E3
  Acknowledgments E3
Appraisal of identified resources E3
  Mining history E3
  Mineral commodities and appraisal E3
    Sand and gravel E3
    Limestone and dolostone E3
    Silica E5
Assessment of potential for undiscovered resources E6
  Geology E6
    Geologic setting E6
    Description of rock units E6
  Geochemistry E7
    Introduction E7
    Analytical methods E8
    Results of survey E8
  Geophysics E8
  Mineral and energy resources E11
    Barite E11
    Metals E11
    Geothermal energy E11
    Oil and gas E11
Recommendations E12
References cited E12
Appendix E17

PLATE

[Plate is in pocket]

1. Map showing mineral resource potential, geology, and geochemical sample sites, Borah Peak Wilderness Study Area

FIGURES

1. Map showing mineral resource potential and location of the Borah Peak Wilderness Study Area and vicinity E4
2. Bouguer gravity anomaly and geologic map of the Borah Peak Wilderness Study Area and vicinity E10
3. Regional magnetic anomaly and geologic map of the Borah Peak Wilderness Study Area and vicinity E12

Mineral Resources of the Borah Peak Wilderness Study Area, Custer County, Idaho

By Anna B. Wilson, Susanne U. Janecke, Betty Skipp,
M. Dean Kleinkopf, Anne E. McCafferty, *and* Harlan N. Barton
U.S. Geological Survey

Michael S. Miller
U.S. Bureau of Mines

ABSTRACT

The Borah Peak (ID–047–004) Wilderness Study Area and an adjacent tract recommended as suitable for wilderness are on the western flank of the Lost River Range in east-central Idaho. An investigation of these areas indicates that they have no known economic mineral resources. They do have occurrences of sand and gravel, dolostone (a source of magnesium metal), limestone, and silica. The areas have low mineral resource potential for barite, all metals, geothermal energy, and oil and gas.

SUMMARY

Character and Setting

In 1987 and 1988, the U.S. Bureau of Mines (USBM) and the U.S. Geological Survey (USGS) conducted investigations to appraise the identified mineral resources (known) and assess the mineral resource potential (undiscovered) of the Borah Peak (ID–047–004) Wilderness Study Area and a contiguous area to the north recommended as an addition to the proposed wilderness by the U.S. Bureau of Land Management (BLM) (fig. 1 and pl. 1). The study area is in Custer County, Idaho, between the towns of Mackay and Challis. It is on the western flank of the Lost River Range, 2.5 mi (miles) west of Borah Peak, the highest mountain in Idaho.

Manuscript approved for publication March 22, 1990.

The Lost River Range is composed of sedimentary rocks, predominantly quartzite and carbonate, deposited in Paleozoic time (see the geologic time chart in the Appendix). These rocks were extensively folded and thrust from the southwest into their present postion during the second half of the Mesozoic Era. A northeast-striking fault block near Borah Peak, including most of the study area, was then uplifted in Eocene time. Current topography is primarily due to uplift along the still-active, northwest-striking Lost River fault that parallels the west side of the range front.

The USBM collected and analyzed 38 rock and 11 alluvial-sediment samples, and the USGS collected and analyzed 1 rock, 11 stream-sediment, and 11 heavy-mineral-concentrate samples. Analyses of these samples are useful in identifying those drainage basins that contain concentrations of elements that may be derived from mineral deposits. Gravity and aeromagnetic data were evaluated to determine hidden stuctures and geologic trends. Detailed geologic mapping was carried out by the USGS, and the rock units were identified and correlated with similar units elsewhere.

Identified Resources

Five mining claims were located in the study area, but none is active. No oil and gas leases or geothermal energy leases or applications for them are in the study area.

Large volumes of industrial minerals are in the study area, but because of their remote location and low quality, none of these mineral commodities is currently minable. Sand and gravel, dolostone (used for lime production or magnesium metal), limestone, and silica are present in the study area and are classified as occurrences. Sand and gravel are unlikely to be mined because large deposits of suitable material are closer to roads and markets. The dolostone is probably of sufficient quantity but is too low grade and too far from markets to be minable for lime. Dolostone for magnesium metal and limestone for cement are neither of sufficient quantity nor quality to qualify as identified resources. Silica occurrences are present throughout much of the study area. However, due to impurities, the silica is probably suitable only for metallurgical uses and thus would have a limited market.

Gold, silver, copper, lead, zinc, barium, and rare-earth-related elements (thorium, uranium, beryllium, and zirconium) are present in quantities too small or too low grade, by about 100 times, to be mined from the study area.

Potential for Undiscovered Resources

Anomalous concentrations of barium were detected in samples from throughout the study area. Small veinlets of barite are present in both outcrop and float. Although widespread, barite is not present in large amounts. The mineral resource potential for barite in veins is low.

Concentrations of metals detected in various types of samples were not high enough to suggest the presence of an ore deposit. Concentrations of silver, bismuth, and tungsten in samples from Elkhorn Creek and the two drainages to the north are considered anomalous but nevertheless too low to be significant. The mineral resource potential for all metals is interpreted as low.

The only warm spring in the wilderness study area is Coyote Spring on the southernmost boundary. It was measured at 57 °F, but both it and the stream it feeds may be intermittent. No other thermal springs or indications of geothermal energy were noted. The potential for geothermal energy is low.

The possibility of finding oil and gas in the wilderness study area is reduced by the absence of likely source rocks, by heating that may have raised the paleotemperature above the limit for oil stability, and by extensive faulting that would have allowed any gas to escape. The resource potential for oil and gas is low.

INTRODUCTION

In 1987 and 1988 the USGS and the USBM studied 3,100 acres of the Borah Peak (ID–047–004) Wilderness Study Area and 780 acres adjoining the wilderness study area on the north, which were recommended as suitable for additional wilderness, as requested by the BLM. In this report the entire area studied is called the "wilderness study area" or simply the "study area."

This report evaluates both known (identified) resources and undiscovered resources (mineral resource potential) of the study area and is the result of separate studies by the USBM and USGS. Identified resources are classified according to the system of the U.S. Bureau of Mines and the U.S. Geological Survey (1980), which is shown in the Appendix. Identified resources are studied by the USBM. Mineral resource potential (the likelihood of occurrence of undiscovered metals, nonmetals, industrial rocks and minerals, and energy sources, such as oil, gas, and geothermal sources) was studied by the USGS and classified according to the system of Goudarzi (1984), which is also shown in the Appendix.

The study area is on the western flank of the Lost River Range, east of U.S. Highway 93 (labeled Alt. 93 on pl. 1) near its intersection with Trail Creek Road (Idaho Highway 75) (fig. 1). The area is approximately 38 mi south of Challis and 16 mi north of Mackay. It is named for Borah Peak, which is less than 2.5 mi east of the northeast corner of the study area, and at 12,662 ft (feet) is the highest mountain in Idaho. Elevations in the study area range from 6,360 ft near Elkhorn Creek to 9,360 ft east of Whiskey Springs (pl. 1). The study area is accessible by unimproved gravel roads and four-wheel-drive trails east from Highway 93.

The region is well known for the October 28, 1983, Borah Peak earthquake that produced surface ground ruptures along the Lost River Range front. The southern end of these recent fault scarps extends along more than two-thirds of the length of the study area (pl. 1), and the scars were still visible in 1988.

The topography of the study area is characterized by well-developed alluvial fans issuing from gullies deeply incised into the steep western slopes of the Lost River Range. At the lower elevations vegetation is sparse, mostly grasses and sagebrush, but the incised valleys commonly contain juniper (*Juniperus scopulorum*) (locally termed cedar) thickets, and at the higher elevations the steep slopes support large coniferous trees.

Investigations by the U.S. Bureau of Mines

The USBM investigation conducted by personnel from the Western Field Operations Center (WFOC), Spokane, Wash., during 1988 and 1989, consisted of a pre-field record search, field work, and report preparation.

Pre-field studies included a literature search and an examination of Custer County and BLM records of mining claims and mineral leases. USBM production records were searched. Field studies included a search for all mineralized sites within the study area. Those found were examined, mapped, and sampled. Mineralized sites close to the study area were also studied to determine if mineralized zones extend into the area and to better understand mineralization of the region. Ground reconnaissance was done to find extensions from known mineralized sites. Details of sampling and sample analyses are reported in Miller (1989).

Investigations by the U.S. Geological Survey

The USGS study included reviewing published and unpublished maps and information about the region. Janecke, Skipp, and Wilson independently mapped and together determined the rock units and their stratigraphic succession and compiled the geologic map of the study area (pl. 1); they also collected rock and mine-dump samples for mineral identification and petrographic study. Barton collected samples for geochemical analyses and interpreted the results. Kleinkopf and McCafferty reviewed aeromagnetic and gravity data from a regional geophysical survey and made gravity measurements at several ground stations.

Acknowledgments

J.D. Causey, USBM, assisted Miller during field work. Dan Bartholme and Bob Hium of the BLM in Salmon, Idaho, and Howard Rosenkrance, Bob Ennis, and the staff of the Challis National Forest office in Mackay, Idaho, provided aerial photographs, access maps, and information about roads and geology in the study area. A.J. Crone, USGS, provided maps showing ground ruptures that formed during the 1983 Borah Peak earthquake. In the field, D.J. Maloney, K.L. Schmidt, and S.J. Soulliere, USGS, assisted Wilson; J.P. Evans, Utah State University, JoAnn Hollaway, University of Utah, and Beth Geiger assisted Janecke; and J.M. LaDue assisted Skipp. Janecke discussed new interpretations of local geology with R.L. Bruhn, University of Utah, and K.R. Vincent, University of Arizona. P.K. Link, Idaho State University, and S.W. Hobbs, USGS, made reconnaissance traverses with the authors and contributed to discussions concerning the identity of stratigraphic units.

APPRAISAL OF IDENTIFIED RESOURCES

By Michael S. Miller
U.S. Bureau of Mines

Mining History

The earliest mining claims near Borah Peak were located in the early 1880's (Capstick and others, 1987). Five mining claims were once located in the study area, but none is currently active. The Inter-Ocean lode claim was recorded in 1892, and the Golden Rule lode claim was recorded in 1897. The Mineral King, Mineral Queen, and Twin Falls claims are described in 1918 county records. Maps showing the exact claim locations could not be found and may never have existed. A caved adit at Coyote Springs and a nearby adit with about 40 ft of underground workings are of unknown age but are estimated to be at least 30 years old (Miller, 1989).

No oil and gas or geothermal energy leases or applications are current.

Mineral Commodities and Appraisal

Sand and Gravel

Sand and gravel are widespread in the western part of the study area and vicinity. The sand and gravel are mostly in Quaternary and Pleistocene alluvial fans containing dolostone, limestone, quartzite, and phyllite. The alluvial fans were deposited by streams draining the Lost River Range, east of the study area. The fans are extensive, several miles long and wide, and tens to hundreds of feet thick.

About 30 million yd^3 (cubic yards) of sand and gravel deposits are in the study area, and an additional 410 million yd^3 are adjacent. Sand and gravel in the study area are probably similar to road fill and crushed aggregate mined intermittently at two Idaho Department of Transportation sites about 1 mi west of the north end of the study area. However, no sand and gravel borrow pits were found in the study area, and future mining there is unlikely because of the abundance nearby of suitable material closer to existing and foreseeable markets.

Limestone and Dolostone

Limestone (calcium carbonate) necessary for cement or lime manufacture is limited in the Borah Peak Wilderness Study Area, where most of the carbonate rocks are dolostone (calcium-magnesium carbonate). One limestone sample from a thin, faulted, and folded limestone bed in the Elkhorn Creek area contained 45 percent CaO, 8 percent Fe_2O_3, 1.5 percent MgO, and 3 percent SiO_2. Loss on ignition was nearly 40 percent. No resources were estimated as the quality was poor (Boynton, 1980; Bowen, 1973), and the occurrence is too small to mine.

Dolostone from the study area could be used for low-grade chemical and industrial lime. There are two sites favorably situated for mining that have a total of at least 10 million tons of dolostone. At these sites, the dolostone contains approximately 20 percent MgO, 31 percent CaO, 3.7 percent SiO_2, 1 percent Fe_2O_3, 0.2

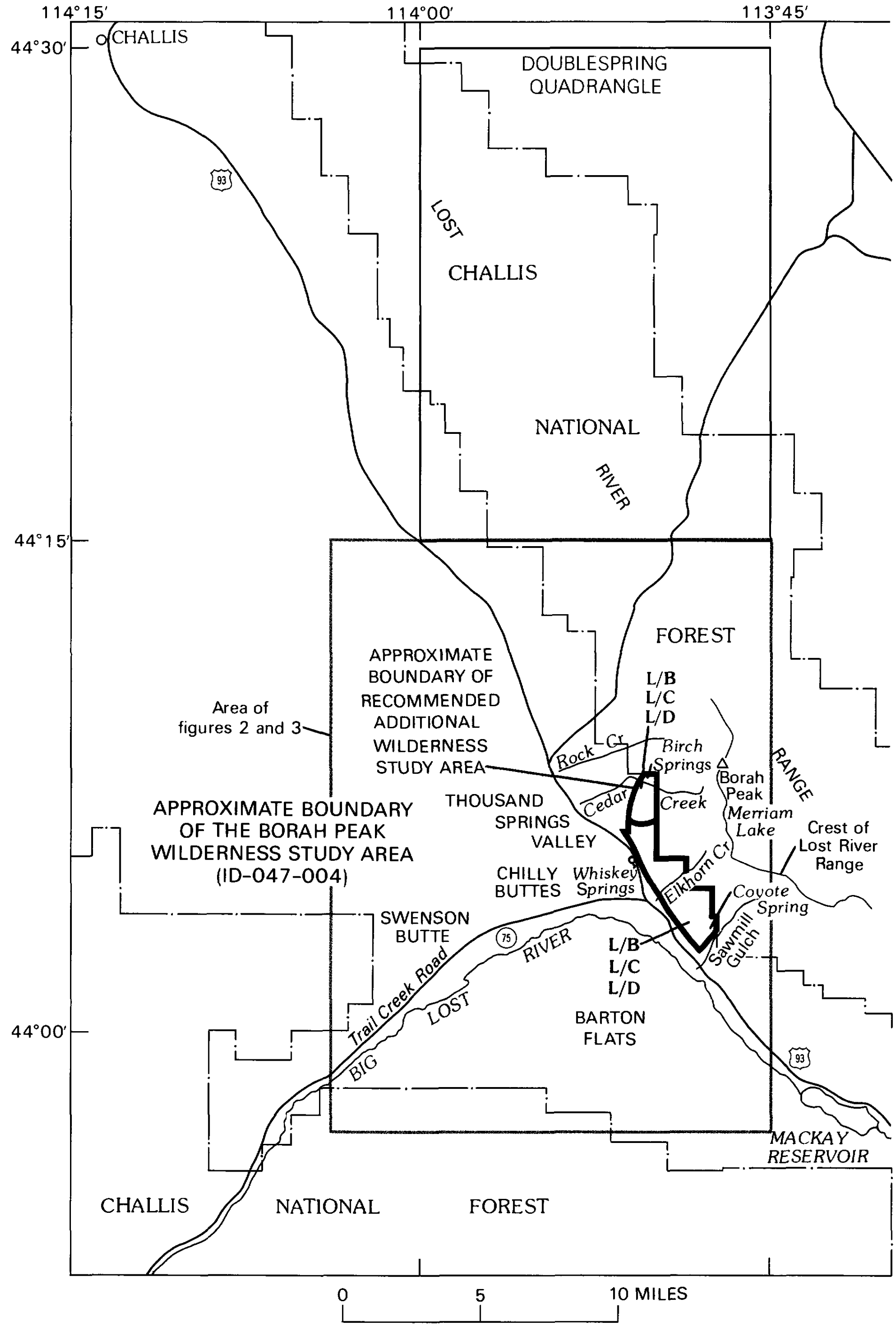
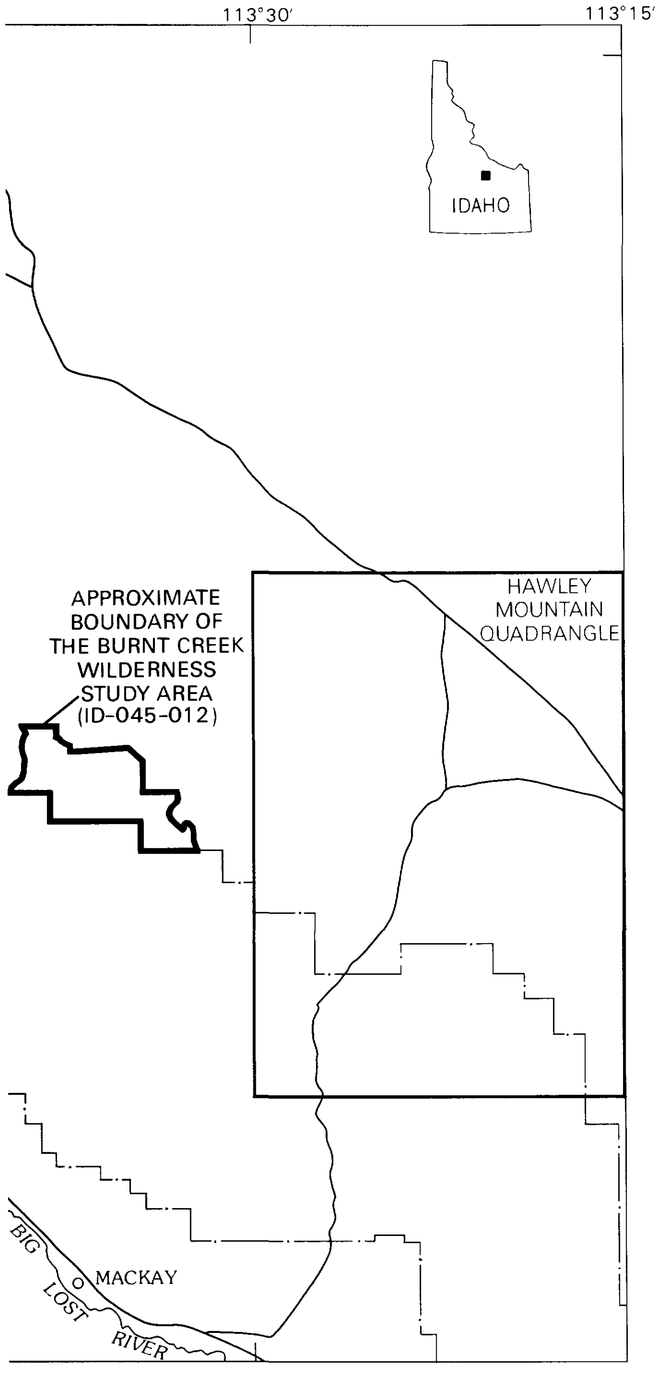


Figure 1 (above and facing page). Mineral resource potential and location map of the Borah Peak Wilderness Study Area, Idaho.

percent P_2O_5, and 0.9 percent Al_2O_3. Although the quantity of dolostone is probably adequate for mining, it is unlikely to be mined because it is too low grade for uses such as steel flux, refractories, glass-making, and magnesium lime (Boynton, 1980; Bowen, 1973) and because of lack of markets. Dolostone for lime production is classified as an uneconomic occurrence.

The dolostone considered for lime production is similar to rock being mined for magnesium metal elsewhere (Bennett, 1944, p. 6–7; 1945), although silica,



EXPLANATION

L/B	Geologic terrane having low mineral resource potential for gas, with certainty level B—Applies to entire study area
L/C	Geologic terrane having low mineral resource potential for barite, all metals, and geothermal energy, with certainty level C—Applies to entire study area
L/D	Geologic terrane having low mineral resource potential for oil, with certainty level D—Applies to entire study area
	Certainty levels
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

alumina, and iron oxide contamination is excessive in the Borah Peak Wilderness Study Area. Three percent is the maximum desirable amount of silica, alumina, and iron oxides; 6 percent is the average amount of these impurities from five dolomite samples in the study area. Locally, dolostone may meet purity standards. The relative impurity, lack of a nearby market, and competition from established sources suggests classifying the dolostone in the study area as an occurrence of magnesium, unlikely to be mined.

Silica

An estimated 6 million tons of silica-rich quartzite (greater than 97 percent silica) is in the study area at three sites favorably situated for mining. The quartzite is

Paleozoic and is in massive, gently or moderately dipping, gray, brown, blue, yellow, and purple beds that are exposed locally in about one-third of the study area. The Kinnikinic Quartzite (pl. 1) is probably mostly silica rich, but the quartzites in the Summerhouse Formation contain excessive amounts of objectionable aluminum, calcium, and iron.

Silica-rich quartzite in the study area is probably adequate for metallurgical uses such as ferrosilicon, fluxes, silica brick, and linings (Griffiths, 1987; Murphy and Henderson, 1983). The quartzite occurrences are unlikely to be mined because of lack of markets.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Anna B. Wilson, Susanne U. Janecke, Betty Skipp, M. Dean Kleinkopf, Anne E. McCafferty, and Harlan N. Barton U.S. Geological Survey

Geology

Geologic Setting

The Borah Peak Wilderness Study Area is on the western flank of the central Lost River Range, in the shadow of the highest peaks in Idaho. The range extends north-northwest more than 80 mi from the Snake River Plain to northwest of Challis (fig. 1).

The Lost River Range is part of the Mesozoic Cordilleran thrust belt. Proterozoic to Paleozoic rocks in the range are complexly folded and were carried from southwest to northeast on buried thrust faults in Middle Jurassic to Cretaceous time (Skipp and Hait, 1977; Skipp and Harding, 1985; Skipp and others, 1988).

In Eocene time, a wedge-shaped horst, which includes all but the northern tip of the wilderness study area, was uplifted along northeast-trending normal faults. The horst may have lifted previously highly faulted Paleozoic rocks (predominantly quartzite and dolostone) as much as 9,000 ft vertically (Baldwin, 1951; Skipp and Harding, 1985). The lower part of the Paleozoic rock sequence is unique in the Lost River Range, but similar rocks crop out to the east in the Lemhi Range and to the west near Challis (Hays and others, 1978; McCandless, 1982; McIntyre and Hobbs, 1987).

Earlier fault systems were truncated by the Basin and Range extensional fault system, including the Lost River fault, that has been active since Miocene time (Scott and others, 1985). This system remains active today, as indicated by fresh fault scarps formed during the October 1983 earthquake. Older fault scarps along the Lost River Range front and within the study area formed during the Quaternary (Scott and others, 1985). Almost 2.5 mi (13,000 ft) of cumulative dip separation is distributed across the northwest-striking faults in the area (Susong and others, 1990) between the basement of Thousand Springs Valley (fig. 1 and pl. 1) and the summit of Borah Peak.

Description of Rock Units

The following description of rock units and interpretation of the stratigraphy results from the work of the three senior authors of this report and is built on interpretations by previous workers (Baldwin, 1951; Crone and others, 1987; Ingwell, 1980; Isaacson and others, 1983; McCandless, 1982; Ross, 1947; Ruppel and others, 1975; Susong, 1987). Published work varies in stratigraphic name and age assignments, but the lithologic descriptions of the units are similar. Thicknesses given are estimates based on the authors' observations and those reported for the Merriam Lake area (Ingwell, 1980), for the Doublespring quadrangle (Mapel and others, 1965), and for the Hawley Mountain quadrangle (Mapel and Shropshire, 1973) (fig. 1).

The oldest unit exposed in the study area may be equivalent to the Wilbert Formation (unit ЄZw, pl. 1) (McCandless, 1982; Susong, 1987) of Early Cambrian and Late Proterozoic(?) age. In the study area, it is a tan-pink, flesh-colored, coarse-grained to pebbly, thick bedded, locally crossbedded quartzite or quartz arenite, with interbedded conglomerate. Locally, red jasperoid clasts are distinctive. Approximately 1,370 ft of this unit is exposed on the hillside just north of Sawmill Gulch.

Conformably overlying the quartzite is a a unit that consists of greenish-gray to red-brown to silvery phyllite of possible Cambrian age. Near its upper contact, the phyllite is interbedded with thick-bedded, orange-weathering, sandy carbonate that thickens and changes in lithology laterally, in places. The interbedded phyllite and carbonate rock (unit Єu, pl. 1) is present only at the south end of the study area where a minimum of 330 ft is exposed.

Quartzite and dolostone of the Lower Ordovician Summerhouse Formation unconformably overlie the phyllite-bearing unit. For this report, the Summerhouse Formation is divided into three informal members. The basal, or lower member (unit Osl, pl. 1) is primarily distinctive lavender to dark purple, fine- to coarse-grained, medium- to thick-bedded, crossbedded, pebble-bearing quartzite. The middle member (unit Osm) is a predominantly clean, white to very pale pink, fine-grained, vitreous, bimodal quartzite. Where present, the bimodal size distribution of quartz grains is very distinctive. The upper member (unit Osu) is composed of interbedded quartzite, sandy dolostone, minor limestone, and phyllite that vary widely in color and texture. The quartzite is gray brown to purple gray, fine to coarse grained, medium to thick bedded, crossbedded, impure, and stained with dark-brown limonite spots ranging from 0.1 in. (inch) to 1.5 in. in size. The quartzite is interbedded with silvery-white, medium-gray or purple-gray phyllite and sandy and silty carbonate beds. Other rocks in the upper member are gray to black, medium-bedded, micritic dolostone that weathers tan to rust; brown, thin-bedded, *Skolithos*-bearing, slaty siltstone and calcareous sandstone; and locally, gray, fine-grained limestone. The strata assigned to the Summerhouse Formation are nearly 3,000 ft thick, based on correlations with strata near Merriam Lake.

Light-gray to white, fine- to medium-grained, vitreous, Middle Ordovician Kinnikinic Quartzite (unit Ok, pl. 1) unconformably overlies the Summerhouse Formation. Some beds are mottled and contain impurities. It is difficult to differentiate between the Kinnikinic and the clean, white to pale-pink quartzite of the middle member of the Summerhouse, especially where the rocks are sheared or fractured in isolated fault blocks. In places, the Summerhouse quartzite is distinctly bimodal, whereas the Kinnikinic is commonly equigranular, but finding distinctive samples of either is the exception. The Kinnikinic Quartzite measures 755 ft thick near Merriam Lake (Ingwell, 1980) but is estimated to be 1,800 ft in the Hawley Mountain quadrangle and 2,400 ft in the Doublespring quadrangle (fig. 1).

Above the Kinnikinic Quartzite are Middle Ordovician to Silurian dolostones (unit SOlf, pl. 1). These include the Upper Ordovician and Lower Silurian Fish Haven Dolostone and the Lower and Upper Silurian Laketown Dolostone. Because the rocks are within the zone of range-front faulting along the earthquake scarp, it was not always possible to differentiate dolostone units. The Ordovician dolostones are medium light gray to black, finely crystalline, and thick bedded to massive. Locally, beds of chert nodules and layers of lighter gray mottling are present. The Silurian dolostones are light olive to medium light gray, medium crystalline, granular, and vuggy. In several places the Fish Haven Dolostone (SOf) can be distinguished from the Laketown Dolostone. Estimated thickness of the Fish Haven Dolostone is 1,009 ft near Merriam Lake (Ingwell, 1980), 1,170 ft in the Hawley Mountain quadrangle, and 1,335 ft in the Doublespring quadrangle. The Laketown ranges from 505 to 1,300 ft in the same two quadrangles.

The Middle and Upper Devonian Jefferson Formation (unit Dj, pl. 1) overlies the Silurian and Ordovician dolostones. Dolostones of the Jefferson Formation are medium dark gray to dark gray, or locally light gray, finely crystalline to sugary, and characteristically fetid. Some interbeds are limestone, limestone sedimentary breccia, and sandstone. The Jefferson Formation is exposed only at the north end of the study area. In the Doublespring quadrangle (fig. 1), the estimated thickness is 1,590 ft.

At the very northern end of the study area, a small outcrop of the Upper Devonian Three Forks Formation (unit Dt, pl. 1) consists of calcareous, medium-gray, finely crystalline, fissile, platy, fossiliferous (brachiopods) limestone and interbedded silty limestone and siltstone. The thickness of the Three Forks Formation in the study area is probably between the 150 ft estimated in the Hawley Mountain quadrangle and the 250–300 ft in the Doublespring quadrangle.

The Lower Mississippian McGowan Creek Formation (unit Mmg, pl. 1) (equivalent to the Milligen Formation of older reports) comprises black to medium-gray, chippy to shaly, carbonaceous siltstone, mudstone, and shale and thin interbeds of finely crystalline limestone (Sandberg, 1975). It is a prominent slope-forming unit. The estimated thickness in the study area is probably closer to the 3,670 ft in the Doublespring quadrangle than to the 480 ft in the Hawley Mountain quadrangle.

The youngest of the Paleozoic units exposed near the study area is the lower half of the Middle Canyon Formation (unit Mmc, pl. 1), which is the only formation of Late Mississippian age in this area. The Middle Canyon is mostly limestone that is medium gray, very fine to fine grained, thin to medium bedded, sandy, silty, and weathers medium yellow brown. Typically, bedded chert is abundant. The thickness was estimated at 680–725 ft in the Hawley Mountain quadrangle.

All of the unconsolidated Quaternary deposits in the study area unconformably overlie the Paleozoic rock units. These include alluvium (unit Qal, pl. 1), colluvium (unit Qc), glacial deposits (unit Qg), landslide deposits (unit Ql), younger alluvial-fan deposits (unit Qfy), alluvial-fan deposits (unit Qf), and older alluvial-fan deposits (unit Qfo).

Geochemistry

Introduction

A reconnaissance geochemical survey was conducted in the wilderness study area in July 1988. Stream-sediment samples and heavy-mineral-concentrate samples were collected from 11 sites (pl. 1). Sampling every available drainage along the range front yielded a fairly uniform distribution of sample sites. Only one stream, Cedar Creek, near the north end of the study area, was flowing at the time of sampling. In addition, one rock sample was collected to provide geochemical background values.

Stream-sediment samples and panned-concentrate samples (derived from the stream sediments) were selected as the primary sample media. Both sample types were collected from active alluvium from 11 first- or second-order ephemeral streams.

Stream-sediment samples represent a mechanical mixture of fragments of rock and soil exposed in the drainage basin upstream from the sample site. Chemical analysis of this material provides information that helps to identify those basins containing unusually high concentrations of elements that may be related to mineral deposits.

Chemical analysis of heavy minerals concentrated by panning stream sediments provides information about the geochemistry of certain high-density, resistant minerals eroded from the drainage basin upstream. The removal of most of the rock-forming carbonate, silicate, and clay minerals and organic material permits the determination of the amount of elements in the concentrate that are not generally detectable in bulk stream sediments by the analytical methods available. Some of these elements can be constituents of minerals related to ore-forming processes rather than rock-forming ones.

Analytical Methods

The stream-sediment, heavy-mineral-concentrate, and rock samples were prepared using standard procedures described in Bullock and others (1989, p. 3–4). All samples were analyzed for 35 elements by a semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). In addition, heavy-mineral concentrates were analyzed for palladium and platinum by the same method.

Rock and stream-sediment samples were also analyzed by an inductively coupled plasma spectrographic method (Crock and others, 1987) for arsenic, bismuth, cadmium, antimony, and zinc; by delayed neutron activation (McKown and Millard, 1987) for thorium and uranium; and by flame atomic absorption (modified method of Thompson and others, 1968) for gold.

Analytical data and sample sites are described by J.H. Bullock, Jr. (unpub. data, 1989). Analysis-method references and a detailed description of the sampling and analytical techniques are given in Bullock and others (1989, p. 3–4).

Results of Survey

Comparison of the analytical data with the average crustal abundance (Rose and others, 1979) of elements in rocks similar to those in the study area suggests that the study area is not mineralized. Only the heavy-mineral-concentrate samples show any sign of enrichment. Statistical treatment of the data is not considered valid as there are too few samples, and many elements are not present in quantities above the detection limits.

Sites in the southern one-third of the study area (samples 1–4, pl. 1) had 300–700 ppm (parts per million) chromium, 1,000–7,000 ppm barium, 10–18 ppm thorium, and, consistently, 4 ppm uranium, in the heavy-mineral concentrates. Samples from the northern half of the study area (samples 6–11) contained scattered anomalous vaules: one had 7 ppm silver and 20 ppm bismuth, another had 50 ppm bismuth and 70 ppm tungsten. Uranium (1.5–2.8 ppm) and thorium (2–8.7 ppm) concentrations were consistently lower than in the south. Only the northernmost sample (11), from a northern tributary to Cedar Creek, contained anomalous strontium (7,000 ppm) and zirconium (1,500 ppm). The two northernmost samples (10 and 11) and the sample from Elkhorn Creek (5) contained greater than 10,000 ppm barium. In addition to barium, the sample site on Elkhorn Creek also contained 5 ppm silver, 200 ppm chromium, 1,500 ppm lead, 11.5 ppm thorium, and 3 ppm uranium.

Elkhorn and Cedar Creeks transport more sediment and penetrate more deeply into the range through more lithologic units than the other drainages sampled, so they would be expected to carry more and varied trace elements. South of Elkhorn Creek, samples 1–4 represent sediments derived from lower Paleozoic strata, primarily impure quartzites. From Elkhorn Creek and to the north (samples 5–11), the sediments are derived from Middle Ordovician and younger strata, mostly pure quartzite and dolostone.

Prospect workings that explored scattered occurrences of barite, lead, and zinc along with minor silver, gold, and copper in the adjacent Challis National Forest were described by Capstick and others (1987). The workings are along the northwest-trending fault-bounded range front where solutions may pass through brecciated rocks to reach readily alterable and replaceable carbonate rocks. Although similar favorable geologic structure and lithology exist within or near the study area, the geochemical values for heavy-mineral-concentrate samples are not sufficiently high to indicate the possible existence of mineral deposits.

Geophysics

By M. Dean Kleinkopf and Anne E. McCafferty

The Borah Peak Wilderness Study Area and surrounding areas along the western flank of the Lost

River Range are covered by regional gravity and magnetic anomaly data (figs. 2 and 3, respectively). The anomaly patterns provide insight about the regional geologic setting and possible influences of large-scale structural and lithologic features. Because the evidence for mineralization is minimal, no further geophysical surveys were undertaken, except for a few gravity measurements to increase the regional control in the vicinity of the study area. For reference, interpretations of magnetic anomalies associated with mineral-deposit models in neighboring areas are in the publication on mineral resource assessment of the Challis National Forest (Worl and others, 1989), which adjoins the study area.

The Bouguer gravity anomaly data were compiled from digital data used to prepare a gravity map of Idaho (Bankey and others, 1985), plus data from four new stations added during this study (fig. 2). Gravity reductions are based on an assumed crustal density of 2.67 grams per cubic centimeter. Standard USGS gravity-reduction procedures used are discussed in Cordell and others (1982). Terrain corrections were made by digital computer from each station to a radius of 166.7 kilometers (Plouff, 1977).

Seven gravity stations are within or near the study area and help define a steep regional gravity-gradient zone of some 10-milligals amplitude that correlates with the Lost River fault zone. Two main trends are in the gravity-anomaly data. One parallels northwest-trending basin-and-range structure, such as the Lost River fault. The other trend is discontinuous in a northeast direction and may reflect faults in some places, such as in the gravity patterns across the Borah Peak horst block and along its northeast-bounding faults (fig. 2). The gravity contours are poorly controlled due to lack of gravity stations just northeast of the study area. Little gravity expression of the horst block is expected because of minor density contrasts predicted between units of the largely carbonate sequence of rocks of the lower Paleozoic section.

The regional steep gravity-gradient zone also reflects the boundary between uplifted high-density Proterozoic(?) and Paleozoic sedimentary carbonate rocks of the Lost River Range with less dense sediments deposited in young graben structures that form Thousand Springs Valley and Barton Flats. Part of this steep gravity-gradient zone forms the northeast flanks of two prominent gravity troughs associated with Barton Flats and Thousand Springs Valley (fig. 2). Along the south side of the Thousand Springs Valley anomaly, the postulated Chilly Buttes fault has some expression, and the gravity data suggest that the fault, instead of changing to a westerly trend as suggested by Skipp and Harding (1985), extends southwest from Swenson Butte along a zone of steep southwest-trending gravity gradients (fig. 3).

The steep northwest-trending gravity-gradient zone correlates with the Lost River fault, which broke the ground surface during the 1983 Borah Peak earthquake. In studies of the Borah Peak earthquake, Skipp and Harding (1985) reported results of a high-resolution seismic-reflection survey conducted across the Lost River fault about 2 mi northeast of the study area. Skipp and Harding (1985) found that the seismic data confirm that the fault is a zone about one-third mile (1,850 ft) wide and dips steeply to the west. The gravity data, by projection along strike to the southeast, suggest the possibility of a buried fault of a similar nature within the study area.

The magnetic anomaly data (fig. 3) are from aerial reconnaissance surveys of the DuBois and Idaho Falls $1° \times 2°$ quadrangles flown as part of the National Uranium Resource Evaluation (NURE) program of the U.S. Department of Energy (1982, 1983). The NURE surveys were not designed for mineral exploration but for regional assessment of uranium resources. Although the surveys were flown close to the ground at an average flight altitude of 400 ft draped above terrain for effective gamma-ray detection, the flight-line spacing of some 3 mi far exceeds that used in conventional industry-type exploration for metallic mineral deposits.

Interpretation of the aeromagnetic anomaly map affects the mineral resource assessment of the study area. Two east-west-oriented flight lines cross the study area (fig. 3). No magnetic anomalies were found on either the profiles along the flight lines (fig. 3) or on the magnetic anomaly map that would suggest the presence of near-surface igneous rocks or mineralized zones within the boundaries of the study area. However, very local, shallow magnetic sources may not have been detected, because of the 3-mi flight-line spacing of the aeromagnetic surveys. The study area lies on the eastern flank of a broad 100-gamma regional positive magnetic anomaly that may reflect multiple bodies at shallow depths or possibly a large intrusion buried several thousand feet below the Chilly Buttes area (fig. 3). The lithology of such bodies is unknown, but about 20 mi to the southwest the exposed Tertiary Mackay stock, called White Knob horst by Skipp and Harding (1985), is magnetic and has an associated positive magnetic anomaly (U.S. Department of Energy, 1983). Skipp and Harding (1985) suggested, based on an earlier gravity compilation by Mabey and others (1974), that the gravity ridge in the southern part of Thousand Springs Valley may be a downdropped western projection of the Borah Peak horst in the shallow subsurface.

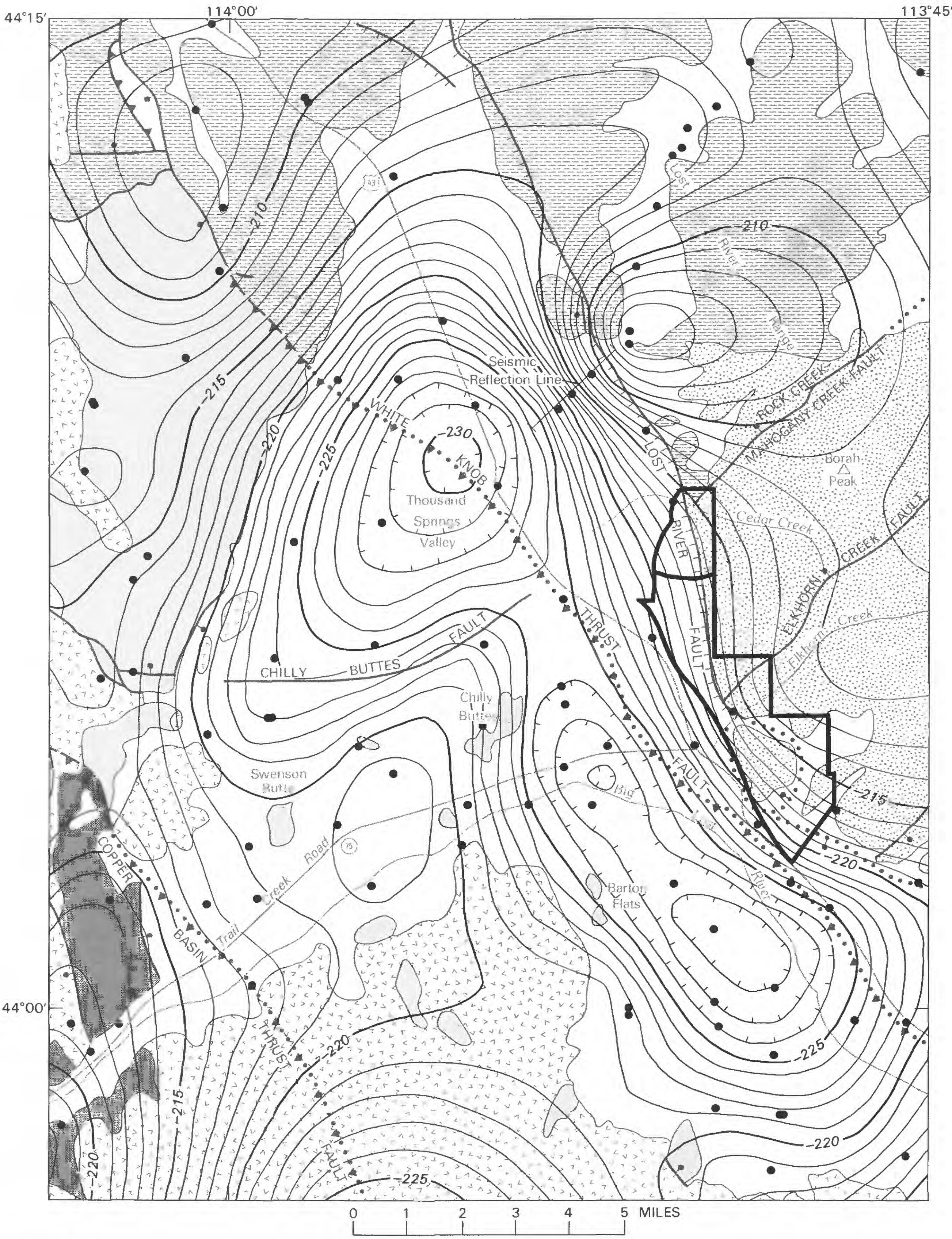


Figure 2 (above and facing page). Bouguer gravity anomaly and geologic map of the Borah Peak Wilderness Study Area, Idaho . Geology from Skipp and Harding (1985). Contour grid 2 km. Data compiled by A.E. McCafferty.

EXPLANATION

—215— Gravity contour—Contour interval 1 milligal. Hachures indicate closed areas of lower gravity values

● Gravity station

Approximate boundary of the Borah Peak Wilderness Study Area and additional area recommended for inclusion in the wilderness study area

Quaternary and Tertiary deposits, undivided

Challis Volcanics—Largely Eocene

Mississippian McGowan Creek, Scott Peak, South Creek, and Surrett Canyon Formations of Lost River thrust plate—Includes minor Pennsylvanian rocks

Mississippian McGowan Creek and White Knob Formations of White Knob thrust plate—Includes minor Pennsylvanian rocks

Mississippian Copper Basin Formation of Copper Basin thrust plate

Lower Paleozoic and Proterozoic sedimentary rocks, undivided, of Lost River thrust plate

Contact

Faults—Dashed where approximately located, dotted where concealed

Normal—Bar and ball on downthrown side

Thrust—Sawteeth on upper plate

Segment of Lost River normal fault that ruptured in 1983

In view of the correlation of high magnetic values with the gravity ridge, there is an alternative interpretation to that of the gravity ridge being an expression of the Borah Peak horst block. The gravity and magnetic anomalies just northeast of Chilly Buttes and less than 3 mi west of the study area may have a common source, such as a Tertiary igneous intrusion or intrusive complex in the subsurface beneath thick valley sediments.

Mineral and Energy Resources

Barite

Barite veinlets are present throughout much of the study area in shear zones in both the carbonate rocks and quartzite. However, although widespread, barite does not occur in significant amounts.

High barium contents (more than 10,000 ppm) were found in the two northernmost panned-concentrate samples (samples 10 and 11, pl. 1) and in the sample from Elkhorn Creek (sample 5). The presence of barite in the northernmost samples may be significant because it may be related to the McGowan Creek Formation, which could host a bedded barite deposit. However, very little McGowan Creek Formation actually crops out in the study area, and no barite was observed where it does. Most of the barite in the panned-concentrate samples apparently originated from source rocks outside of the study area. Therefore, there is a low resource potential for barite, with certainty level C, in the Borah Peak Wilderness Study Area.

Metals

No metal deposits are known in the study area nor does the geochemical sampling suggest their presence. Silver, bismuth, and tungsten were detected in anomalous concentrations (7, 50, and 70 ppm, respectively) in two samples (6 and 7) from the northern part of the study area but not in sufficent amounts to indicate the presence of an ore deposit. Minor amounts of lead (1,500 ppm) were detected in a sample (5) from Elkhorn Creek. Samples of faulted and sheared quartzite and dolostone, some of them collected from slopewash, from the Birch Springs area contained barely detectable amounts of gold, at most 14 parts per billion (Miller, 1989). However, no gold was detected in any of the stream-sediment and panned-concentrate samples. Only minor amounts of beryllium, chromium, scandium, thorium, uranium, vanadium, and yttrium were detected. In general, these elements were more prevalent in samples from the southern part of the study area. Therefore, the study area has a low mineral resource potential for all metals, with certainty level C.

Geothermal Energy

Major faults such as the Lost River Range fault can localize geothermal energy sources, but insignificant surface expressions of such energy were observed. Springs in and adjacent to the Borah Peak Wilderness Study Area flow between 44 °F and 57 °F, temperatures which, although slightly elevated, are not warm enough for most geothermal energy uses (Miller, 1989). The study area has a low resource potential for geothermal energy, with certainty level C.

Oil and Gas

No indications of oil or gas are at the ground surface in the Borah Peak Wilderness Study Area. None of six samples from high-angle structures or other sites likely to serve as conduits for oil and gas from rocks at depth contained detectable hydrocarbons (detection limit about 0.05 percent; Miller, 1989). Sandberg (1983, p. F4) classified the potential for oil and gas in this region as "low to zero."

Presence of hydrocarbons requires porous reservoir rocks; organic-rich source beds; stratigraphic, lithologic, or structural traps; and favorable thermal history. The first three of these conditions may be met locally, but the thermal history has not been suitable for preservation of oil in the study area.

Rock units approximately 9 to 14 mi east of the study area, in the Burnt Creek Wilderness Study Area (fig. 1), were heated to temperatures of 180 to 250 °C (Skipp and others, 1988), which is hot enough to destroy any oil that may have accumulated. The rocks in the Borah Peak Wilderness Study Area are stratigraphically lower and, therefore, were probably buried more deeply and subjected to even higher temperatures. Lack of knowledge of the subsurface geology, especially of thrust faults postulated at depth, suggests that the same stratigraphic sequence exposed at the surface could be repeated at depth, but these rocks, too, would have been buried too deeply to contain oil. Consequently, the likelihood of oil (or liquid hydrocarbons) existing is low, with certainty level D.

Gas, produced by the thermal destruction of oil, may not be destroyed at these temperatures. The presence of gas (methane) in the study area would depend on favorable traps. If relatively undeformed source rocks and traps are present at depth in the study area, gas could be trapped there. The study area has low potential for gas, with certainty level B.

RECOMMENDATIONS

No additional study is recommended for locating resources in the study area. If markets and other conditions favoring mining of sand and gravel, limestone, dolostone, and silica from the study area develop, additional sampling and use-specific testing of these commodities would be necessary.

Detailed geologic mapping of the study area would be useful. Because the rocks that crop out in the study area are different from those that are exposed elsewhere in the Lost River Range or adjacent ranges, the stratigraphic unit correlations and ages are tentative.

REFERENCES CITED

Baldwin, E.M., 1951, Faulting in the Lost River Range area of Idaho: American Journal of Science, v. 249, p. 884–902.

Bankey, Viki, Webring, M.W., Mabey, D.R., Kleinkopf, M.D., and Bennett, E.H., 1985, Complete Bouguer anomaly map of Idaho: U.S. Geological Survey Miscellaneous Field Investigations Map MF–1773, scale 1:500,000.

Bennett, W.A.G., 1944, Dolomite resources of Washington: Washington State Division of Geology Report of Investigations 13, part 1, 35 p.

——— 1945, Dolomite resources of Washington: Washington State Division of Geology Report of Investigations 13, part 1, supplement, 16 p.

Bowen, O.E., ed., 1973, Limestone and dolomite resources of California: California Division of Mines and Geology Bulletin 194, 60 p.

Boynton, R.S., 1980, Chemistry and technology of lime and limestone (2nd ed.): New York, John Wiley and Sons, Inc., 578 p.

Bullock, J.H., Jr., Barton, H.N., Briggs, P.H., and Roemer, Ted, 1989, Analytical results and sample locality map of stream-sediment, heavy-mineral concentrate, and rock samples from the Gunnison Gorge Wilderness Study Area (CO–030–388), Delta and Montrose Counties, Colorado: U.S. Geological Survey Open-File Report OF–89–439, 10 p.

EXPLANATION

—100— Magnetic contour—Contour interval 20 nanoteslas. Hachures indicate closed areas of lower magnetic intensity. Dashed where control is lacking

– – – – Flight line

Approximate boundary of the Borah Peak Wilderness Study Area and additional area recommended for inclusion in the wilderness study area

Quaternary and Tertiary deposits, undivided

Challis Volcanics—Largely Eocene

Mississippian McGowan Creek, Scott Peak, South Creek, and Surrett Canyon Formations of Lost River thrust plate—Includes minor Pennsylvanian rocks

Mississippian McGowan Creek and White Knob Formations of White Knob thrust plate—Includes minor Pennsylvanian rocks

Mississippian Copper Basin Formation of Copper Basin thrust plate

Lower Paleozoic and Proterozoic sedimentary rocks, undivided, of Lost River thrust plate

Contact

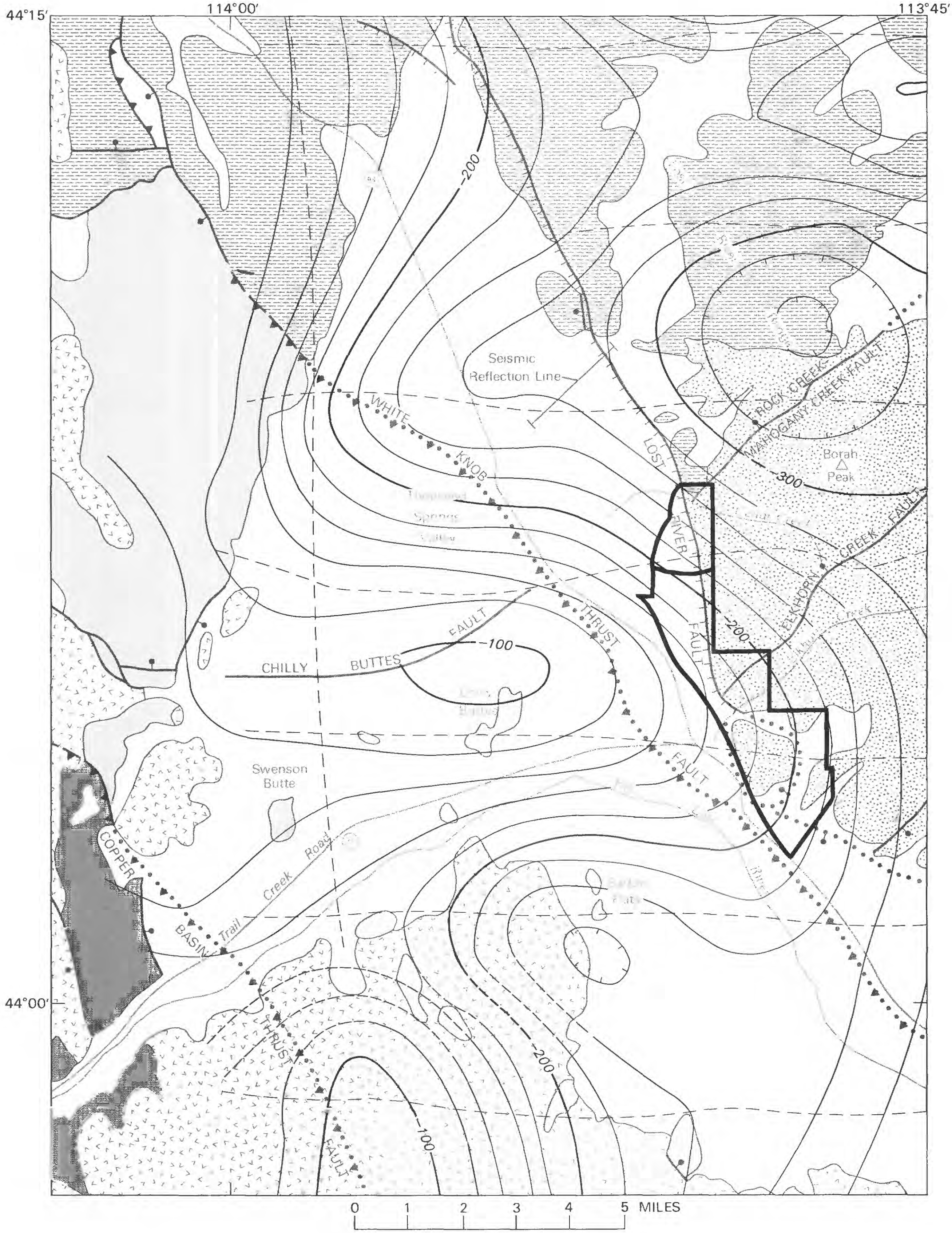
Faults—Dashed where approximately located, dotted where concealed

Normal—Bar and ball on downthrown side

Thrust—Sawteeth on upper plate

Segment of Lost River normal fault that ruptured in 1983

Figure 3 (above and facing page). Regional magnetic anomaly and geologic map of the Borah Peak Wilderness Study Area, Idaho. Magnetic data from U.S. Department of Energy (1982, 1983). Geology from Skipp and Harding (1985). Survey north of 44° latitude flown in September 1977 by Aero Service; survey south of 44° latitude flown in August 1979 by Geometrics. Flight specifications for both surveys: line spacing 3 mi; elevation 400 ft draped above mean terrain. Updated International Geomagnetic Reference Field 1975 core-derived field removed. Map compiled by A.E. McCafferty and M.D. Kleinkopf.


44°15'
114°00'
113°45'
44°00'
-200
-300
-100
-200
-200
-100
Seismic
Reflection Line
WHITE KNOB THRUST FAULT
LOST RIVER FAULT
ROCK CREEK
MAHOGANY CREEK FAULT
ELKHORN CREEK FAULT
Borah
Peak
CHILLY BUTTES FAULT
Swenson
Butte
COPPER BASIN THRUST FAULT
Trail Creek Road
0 1 2 3 4 5 MILES

Capstick, D.O., Mayerle, R.T., and Buehler, A.R., 1987, Mineral resources of the Borah Peak Study Area, Custer County, Idaho: U.S. Bureau of Mines Open-file Report MLA 79–87, 39 p.

Cordell, Lindrith, Keller, G.R., and Hildenbrand, T.G., 1982, Complete Bouguer gravity anomaly map of the Rio Grande rift, Colorado, New Mexico, and Texas: U.S. Geological Survey Geophysical Investigations Map GP–949, scale 1:100,000.

Crock, J.G., Briggs, P.H., Jackson, L.L., and Lichte, F.E., 1987, Analytical methods for the analysis of stream sediments and rocks from wilderness study areas: U.S. Geological Survey Open-File Report 87–84, 35 p.

Crone, A.J., Machette, M.N., Bonilla, M.G., Lienkaemper, J.J., Pierce, K.L., Scott, W.E., and Bucknam, R.C., 1987, Surface faulting accompanying the Borah Peak earthquake and segmentation of the Lost River fault, central Idaho: Seismological Society of America Bulletin, v. 77, no. 3, p. 739–770, map scale 1:24,000.

Goudarzi, G.H., 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–787, 42 p.

Griffiths, Joyce, 1987, Silica, is the choice crystal clear?: Industrial Minerals, no 235, p. 25–43.

Grimes, D.J., and Marranzino, A.P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic material: U.S. Geological Survey Circular 591, 6 p.

Hays, W.H., McIntyre, D.H., and Hobbs, S.W., 1978, Geologic map of the Lone Pine Peak quadrangle, Custer County, Idaho: U.S. Geological Survey Open-File Report 78–1060, scale 1:62,500.

Ingwell, T.H., 1980, Stratigraphy and structural geology of the Merriam Lake area, Lost River Range, Idaho: Los Angeles, University of California M.S. thesis, 173 p.

Isaacson, P.E., Bachtel, S.L., and McFaddan, M.D., 1983, Stratigraphic correlation of the Paleozoic and Mesozoic rocks of Idaho: Idaho Bureau of Mines and Geology Information Circular 37, 1 sheet.

Mabey, D.R., Peterson, D.L., and Wilson, C.W., 1974, Preliminary gravity map of southern Idaho: U.S. Geological Survey Open-File Report 74–78, scale 1:500,000.

Mapel, W.J., Read, W.H., and Smith, R.K., 1965, Geologic map and sections of the Doublespring quadrangle, Custer and Lemhi Counties, Idaho: U.S. Geological Survey Geologic Quadrangle Map GQ–464, scale 1:62,500.

Mapel, W.J., and Shropshire, K.L., 1973, Preliminary geologic map and section of the Hawley Mountain quadrangle, Custer, Butte, and Lemhi Counties, Idaho: U.S. Geological Survey Miscellaneous Field Studies Map MF–546, scale 1:62,500.

McCandless, D.O, 1982, A reevaluation of Cambrian through Middle Ordovician stratigraphy of the southern Lemhi Range: State College, Penn., Pennsylvania State University M.S. thesis, 157 p.

McIntyre, D.H., and Hobbs, S.W., 1987, Geologic map of the Challis quadrangle, Custer and Lemhi Counties, Idaho: U.S. Geological Survey Geologic Quadrangle Map GQ–1599, scale 1:62,500.

McKown, D.M., and Millard, H.T., Jr., 1987, Determination of uranium and thorium by delayed neutron counting, *in* Baedecker, P.A., ed., Methods for geochemical analysis: U.S. Geological Survey Bulletin 1770, p. I1–I12.

Miller, M.S., 1989, Mineral resources of the Borah Peak study area, Custer County, Idaho: U.S. Bureau of Mines report MLA 16–89, 37 p.

Murphy, T.D., and Henderson, G.V., 1983, Silica and silicon, *in* Lefond, S.J., ed., Industrial minerals and rocks (5th ed.): Baltimore, Md., Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers, v. 2, p. 1167–1185.

Plouff, Donald, 1977, Preliminary documentation for a FORTRAN program to compute gravity terrain corrections based on topography digitized on a geographic grid: U.S. Geological Survey Open-File Report 77–535, 45 p.

Rose, A.W., Hawkes, H.E., and Webb, J.S., 1979, Geochemistry in mineral exploration (2d ed.): San Francisco, Academic Press, p. 549–581.

Ross, C.P., 1947, Geology of the Borah Peak quadrangle, Idaho: Geological Society of America Bulletin, v. 58, no. 12, p. 1085–1160, map scale 1:125,000.

Ruppel, E.T., Ross, J.R., and Schleicher, David, 1975, Precambrian Z and Lower Ordovician rocks in east-central Idaho: U.S. Geological Survey Professional Paper 889–B, p. 24–34.

Sandberg, C.A., 1975, McGowan Creek Formation, new name for Lower Mississippian flysch sequence in east-central Idaho: U.S. Geological Survey Bulletin 1405–E, 11 p.

——— 1983, Petroleum potential of wilderness lands in Idaho, *in* Miller, B.M., Petroleum potential of wilderness lands in the western United States: U.S. Geological Survey Circular 902 A–P, p. F1–F6.

Scott, W.E., Pierce, K.L., and Hait, M.H., Jr., 1985, Quaternary tectonic setting of the 1983 Borah Peak earthquake, central Idaho: Seismological Society of America Bulletin, v. 75, no. 4, p. 1053–1066.

Skipp, Betty, and Hait, M.H., Jr., 1977, Allochthons along the northeast margin of the Snake River Plain, Idaho, *in* Heisey, E.L., ed., Rocky Mountain thrust belt—geology and resources: Wyoming Geological Association, 29th Annual Field Conference Guidebook, p. 499–515.

Skipp, Betty, and Harding, S.T., 1985, Preliminary report on geology of Borah Peak area, Idaho, including interpretation of seismic and gravity data, *in* Stein, R.S., and Bucknam, R.C., eds., Proceedings of Workshop XXVIII on the Borah Peak, Idaho, earthquake: U.S. Geological Survey Open-File Report 85–290–A, p. 657–671.

Skipp, Betty, King, H.D., McIntyre, D.H., Sawatzky, D.L., and Gabby, P.N., 1988, Mineral resources of the Burnt Creek Wilderness Study Area, Custer County, Idaho: U.S. Geological Survey Bulletin 1718–C, 13 p.

Susong, D.D., 1987, Structure of an earthquake rupture segment boundary in the Lost River fault zone, Idaho—Implications for rupture propagation during the 1983 Borah Peak earthquake: Salt Lake City, University of Utah M.S. thesis, 52 p., map scale 1:24,000.

Susong, D.D., Janecke, S.U., and Bruhn, R.L., 1990, Structure of a fault segment boundary in the Lost River fault zone, Idaho, and possible effect on the 1983 Borah Peak earthquake rupture: Seismological Society of America Bulletin, v. 80, no. 1, p. 56–68.

Thompson, C.C., Nakagawa, H.M., and Van Sickle, G.H., 1968, Rapid analysis for gold in geologic materials, *in* Geological Survey research 1968: U.S. Geological Survey Professional Paper 600–B, p. B130–B132.

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, 5 p.

U.S. Department of Energy, 1982, Residual intensity magnetic anomaly contour map of the DuBois 1°×2° quadrangle, Idaho: U.S. Department of Energy open-file map GJM–201(82). Available from Books and Open-File Reports Section, U.S. Geological Survey, Federal Center, Box 25425, Denver, CO 80225.

_____ 1983, Residual intensity magnetic anomaly map of the Idaho Falls 1°×2° quadrangle, Idaho: U.S. Department of Energy open-file map GJM–310(83). Available from Books and Open-File Reports Section, U.S. Geological Survey, Federal Center, Box 25425, Denver, CO 80225.

Worl, R.G., Wilson, A.B., Smith, C.L., Kleinkopf, M.D., and Sykes, R.C., 1989, Mineral resource potential and geology of the Challis National Forest, Idaho: U.S. Geological Survey Bulletin 1873, 101 p.

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.

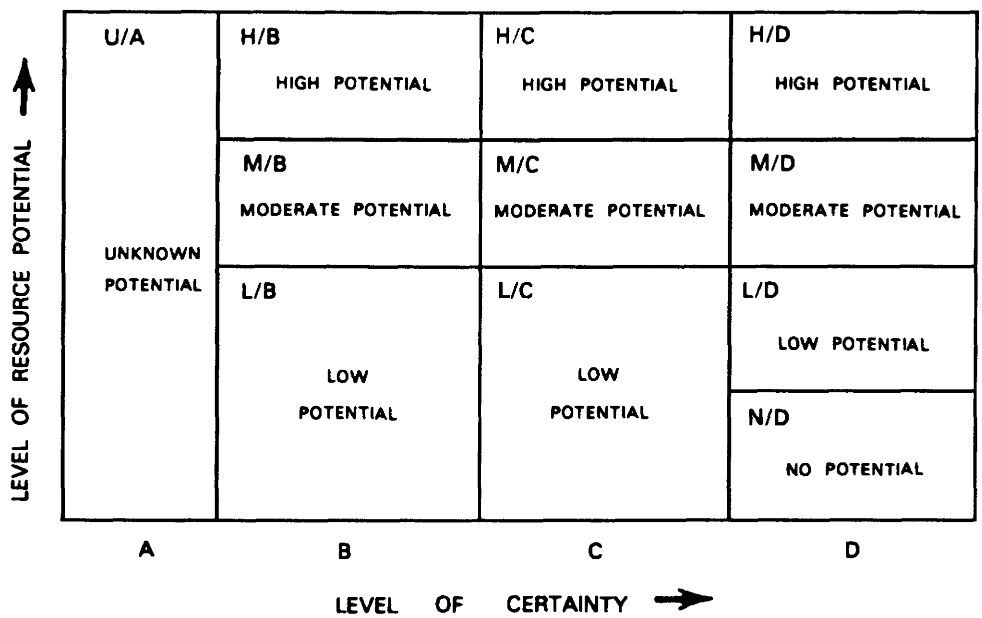
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application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

Goudarzi, G. H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–0787, p. 7, 8.

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.

Mineral Resources of Wilderness Study Areas—Southeastern Idaho

This volume was published
as separate chapters A–E

U.S. GEOLOGICAL SURVEY BULLETIN 1718

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary

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

CONTENTS

[Letters designate the chapters]

(A) Mineral Resources of the Hell's Half Acre Wilderness Study Area, Bingham and Bonneville Counties, Idaho, by Margo I. Toth, Ronny A. Martin, Phillip R. Moyle, and Richard A. Winters
(B) Mineral Resources of the Eighteenmile Wilderness Study Area, Lemhi County, Idaho, by Betty Skipp, Jerry R. Hassemer, Dolores M. Kulik, Don L. Sawatzky, Andrew M. Leszcykowski, and Richard A. Winters
(C) Mineral Resources of the Burnt Creek Wilderness Study Area, Custer County, Idaho, by Betty Skipp, Harley D. King, David H. McIntyre, Don L. Sawatzky, and Peter N. Gabby
(D) Mineral Resources of the Henry's Lake Wilderness Study Area, Fremont County, Idaho, by R.G. Tysdal, D.M. Kulik, and T.J. Peters
(E) Mineral Resources of the Borah Peak Wilderness Study Area, Custer County, Idaho, by Anna B. Wilson, Susanne U. Janecke, Betty Skipp, M. Dean Kleinkopf, Anne E. McCafferty, Harlan N. Barton, and Michael S. Miller

☆ U.S. GOVERNMENT PRINTING OFFICE: 1990—773-047/06,057 REGION NO. 8