Mineral Resources of the Burnt Creek Wilderness Study Area, Custer County, Idaho

U.S. GEOLOGICAL SURVEY BULLETIN 1718–C

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.

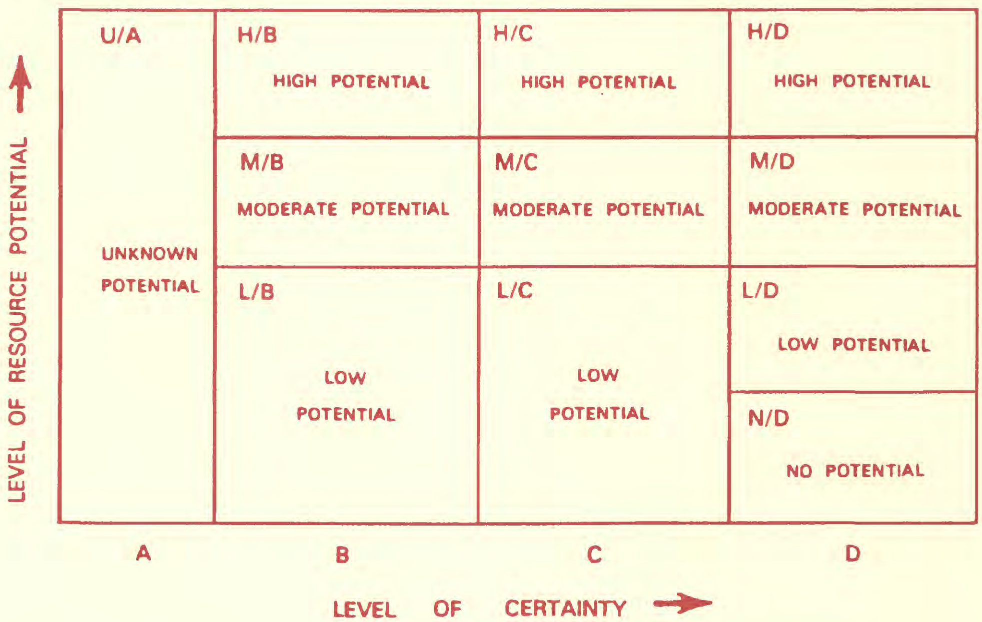
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application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

Mineral Resources of the Burnt Creek Wilderness Study Area, Custer County, Idaho

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U.S. GEOLOGICAL SURVEY BULLETIN 1718

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
SOUTHEASTERN IDAHO

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94–579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of a part of the Burnt Creek (ID–045–012) Wilderness Study Area, Custer County, Idaho.

RESOURCE/RESERVE CLASSIFICATION

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

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

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[Plate is in pocket]

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Mineral Resources of the Burnt Creek Wilderness Study Area, Custer County, Idaho

By Betty Skipp, Harley D. King, David H. McIntyre, *and*
Don L. Sawatzky
U.S. Geological Survey, and

Peter N. Gabby,
U.S. Bureau of Mines

SUMMARY

Abstract

The Burnt Creek (ID–045–012) Wilderness Study Area lies in the Basin-and-Range province of east-central Idaho. The area has no identified mineral or energy resources. A high resource potential for undiscovered resources of high-calcium limestone suitable for the manufacture of Portland cement is present in three areas in the Upper Mississippian Surrett Canyon Formation and in one area in the Middle Pennsylvanian part of the Snaky Canyon Formation (fig. 1). The entire wilderness study area has low resource potential for undiscovered metals, oil and gas, and geothermal energy. Paleozoic limestone units have a low resource potential for undiscovered barite resources in veins.

Character and Setting

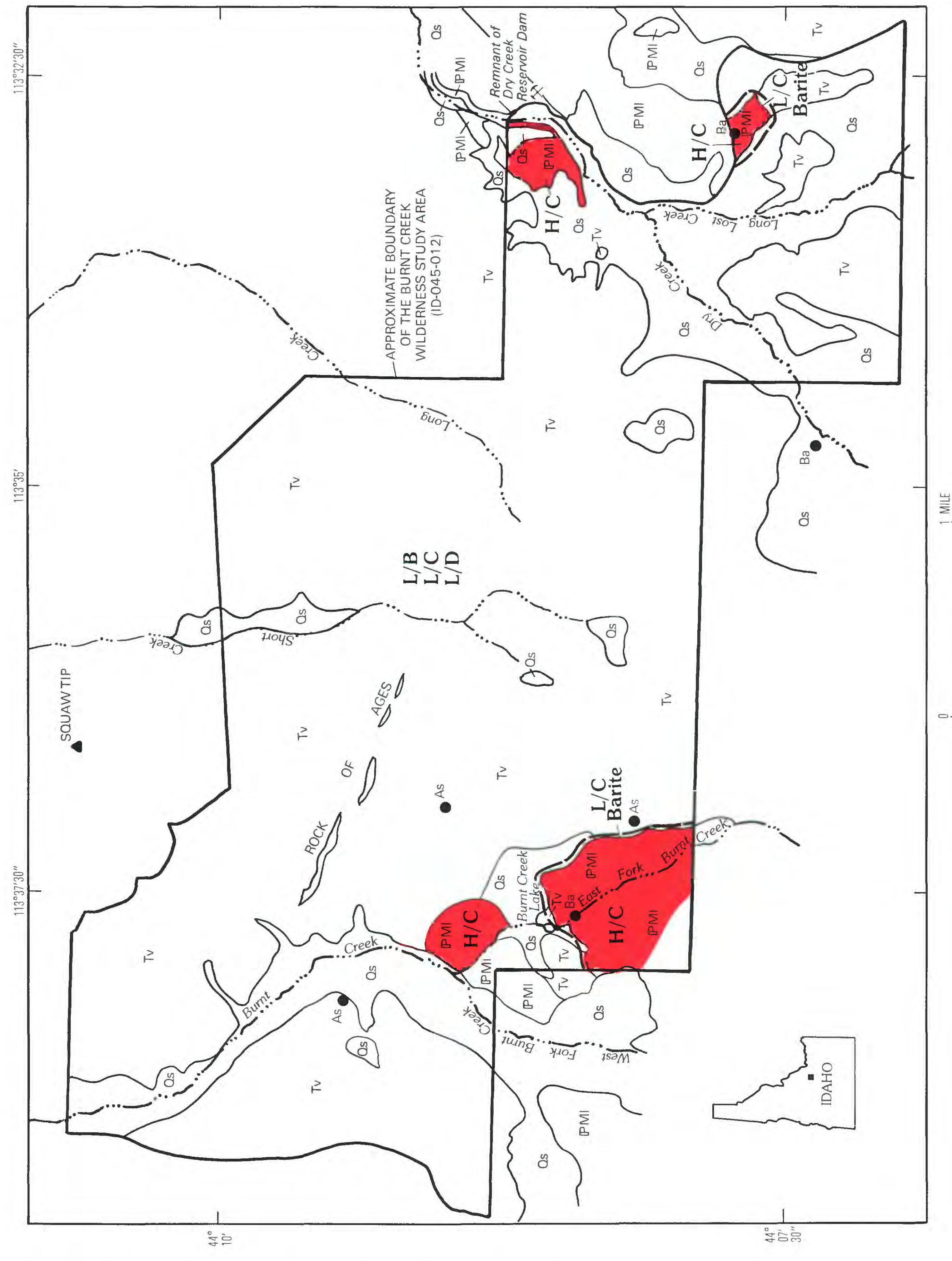
The Burnt Creek Wilderness Study Area lies at the head of the Pahsimeroi Valley on the northeastern slope of the Lost River Range, Custer County, Idaho. Elevations in the area, which includes parts of the Burnt Creek, Short Creek, Long Creek, and Dry Creek drainages (fig. 1), range from a high of 9,808 ft (feet) to a low of about 7,450 ft. Borah Peak, the highest point in Idaho (12,662 ft), is about 7 mi (miles) west of the study area (fig. 2), and Burnt Creek and Dry Creek have their origins in cirques and glacial valleys on the eastern side of the Lost River Range.

The wilderness study area is in the Mesozoic (see geologic time chart at the end of this report for geologic ages) Cordilleran thrust belt and the Neogene Basin-and-Range extensional province. Thrust plates in the area probably moved into place in Cretaceous time about 65 to 100 million years ago, along folded west-dipping thrust faults. Regionally, the first normal faults formed between 65 and 50 million years ago. The northwest-trending narrow, high mountain ranges and intervening deep, elongate valleys that are characteristic of south-central Idaho and the study area, however, developed largely during late Cenozoic basin-range normal faulting that culminated between 7 and 4 million years ago and has continued to the present time. Normal faults moved again on the western flank of the Lost River Range just west of the study area during the 1983 Borah Peak earthquake.

Mineral Resource Potential

A high mineral resource potential for limestone pure enough to be used in the manufacture of Portland cement is present in four small areas in the southeastern and southwestern parts of the study area in parts of the Surrett Canyon and Snaky Canyon Formations (pl. 1).

A low mineral resource potential for all metals is present in the andesite and rhyodacite plugs and sills that intrude the lower part of the Eocene Challis Volcanics and in the Paleozoic limestone units in the study area. No anomalous metal concentrations were identified by the geochemical survey, but isolated anomalous arsenic was noted at three sample sites. The potential for resources of metals is low throughout the study area. A low mineral resource potential also exists for barite in limestone, though anomalous barium was identified at two sample sites in the study area. Barite probably is locally present in small veins in the limestones.



113°32'30"
113°35'
113°37'30"
44° 10'
44° 07' 30"
APPROXIMATE BOUNDARY OF THE BURNT CREEK WILDERNESS STUDY AREA (ID-045-012)
Remnant of Dry Creek Reservoir Dam
SQUAWTIP
ROCK OF AGES
Long Creek
Short Creek
Long Lost Creek
Dry Creek
Burnt Creek
East Fork Burnt Creek
West Fork Burnt Creek
Burnt Creek Lake
H/C
L/C Barite
L/B L/C L/D
Tv
Qs
ℙMl
As
Ba
0
1 MILE
IDAHO

EXPLANATION

H/C	Geologic terrane having high mineral resource potential for high-calcium limestone, with certainty level C
L/B	Geologic terrane having low resource potential for dry gas (methane), with certainty level B—Applies to entire study area
L/C	Geologic terrane having low mineral resource potential for all metals, geothermal energy, and barite in limestone, with certainty level C—Rating for metals and geothermal energy applies to entire study area; rating for barite applies only to areas outlined with dashed line
L/D	Geologic terrane having low resource potential for oil, with certainty level D—Applies to entire study area
Qs	Surficial deposits (Quaternary)
Tv	Challis Volcanics and associated dikes, plugs, and sills (Eocene)
PMl	Limestone (Pennsylvanian and Mississippian)
⚒	Limestone quarry
———	Contact
● As	Anomalous rock or stream-sediment geochemical sampling site for arsenic (As) or barium (Ba)
	Certainty levels
B	Available information suggests level of mineral resource potential
C	Available information gives a good indication of level of mineral resource potential
D	Available information clearly defines the level of mineral resource potential

Figure 1. Summary map showing mineral resource potential of the Burnt Creek Wilderness Study Area, Custer County, Idaho.

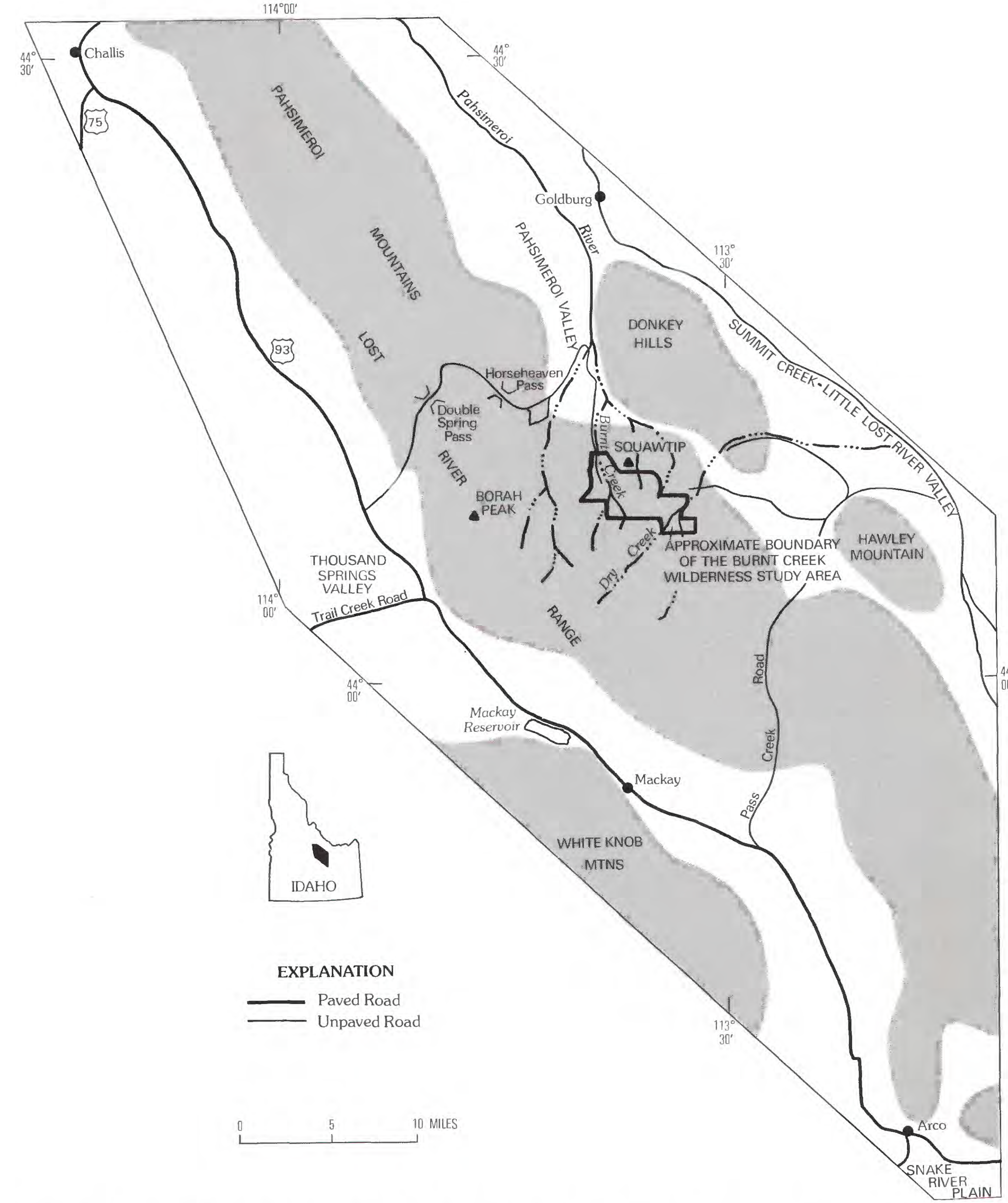


Figure 2. Index map showing location of the Burnt Creek Wilderness Study Area, Custer County, Idaho.

The energy resource potential for oil and gas is considered low because possible source and reservoir rocks in the study area have been heated above 180 °C. Liquid hydrocarbons have been destroyed. The resource potential for dry gas (methane) is considered low because abundant Cenozoic extension faults in the region probably have breached any favorable Mesozoic traps that might have been present. The potential for geothermal energy is low because no hot springs or other geothermal indicators are present in or near the area.

INTRODUCTION

At the request of the U.S. Bureau of Land Management, 8,300 acres of the Burnt Creek (ID–045–012) Wilderness Study Area were studied by the U.S. Bureau of Mines (USBM) and the U.S. Geological Survey (USGS). In this report, the studied area is called the "wilderness study area" or simply "study area."

The Burnt Creek Wilderness Study Area lies on the northeastern slope of the Lost River Range, along the southern margin of the Pahsimeroi Valley. Burnt Creek and Dry Creek, the major drainages in the study area, head in cirques and glaciated valleys of the Lost River Range to the west. The sources of smaller drainages, Short Creek and Long Creek, are cold springs within the study area. Elevations in the study area range from about 7,450 ft to 9,808 ft. A prominent topographic feature in the study area is the Rock of Ages, an Eocene rhyodacitic dike complex that locally forms a vertical wall 50 ft high. The most prominent topographic feature in the area is a dark-colored conical peak named Squawtip or Squawtit (9,046 ft) that lies about ¾ mi north of the study area and is visible from many vantage points in the Pahsimeroi Valley. Squawtip consists of northeast-dipping andesite breccia flows.

Access to the study area is primarily from the Doublespring Pass and Pass Creek gravel roads, which exit to the northeast from U.S. Highway 93 north and south of Mackay, respectively. Challis is a 62-mi drive via Doublespring Pass and U.S. Highway 93. The study area can also be reached from gravel roads along the Pahsimeroi River and Dry Creek that exit to the west from the paved road in the Summit Creek-Little Lost River Valleys east of the study area (fig. 2).

Annual precipitation in the study area averages 16 to 20 in. (inches). Sagebrush, various grasses, and scattered small stands of evergreen trees and mountain mahogany are the characteristic vegetation.

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study area and is the product of several separate studies by the USBM and the 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 on page IV 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 on the inside front cover of this report. Undiscovered resources are studied by the USGS.

Investigations by the U.S. Bureau of Mines

USBM personnel completed prefield, field, and report-preparation phases of study of the Burnt Creek Wilderness Study Area in 1985 and 1986. Prefield studies included library research and perusal of Custer County and U.S. Bureau of Land Management mining and mineral-lease records. USBM, State, and other production records were searched, and pertinent data were compiled. A limestone quarry near the study area was examined, and areas of obvious rock alteration were checked for mining-related activities that may not have been recorded.

Eleven rock and two placer samples were taken during the study. Most rock samples were pulverized and analyzed for gold and silver by fire assay, at detection limits of 0.005 and 0.2 oz/ton (troy ounce per ton), respectively, and analyzed for 40 elements by semiquantitative emission spectrography to detect unsuspected elements of possible significance. Two limestone samples were analyzed for a suite of oxides and loss on ignition (Bowen and others, 1973) to determine applicability for various uses. One sample was examined petrographically to identify rock type, alteration suite, and mineral assemblage. Placer samples were partly concentrated in the field and further concentrated on a laboratory-size Wilfley[1] table. Resulting heavy-mineral fractions were scanned with a binocular microscope to determine heavy-mineral content. Concentrates also were checked for radioactivity and fluorescence. Complete analyses are on file at the U.S. Bureau of Mines Western Field Operations Center, E. 360 3rd Ave., Spokane, Wash. 99202.

[1]Use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Bureau of Mines or U.S. Geological Survey.

Table 1. Analyses of limestone samples from the Upper Mississippian Surrett Canyon and Pennsylvanian Snaky Canyon Formations, Burnt Creek Wilderness Study Area, Idaho

[Sample localities shown on plate 1. <, less than shown]

Sample No.	CaO	LOI*	SiO_2	Al_2O_3	Fe_2O_3†	K_2O	MgO	MnO	Na_2O	P_2O_5	TiO_2	SO_3
	In percent							In parts per million				
1	53.2	43.00	1.8	0.24	0.12	<0.02	0.42	41	<50	<100	200	0.32
2	50.7	43.09	1.9	.05	.06	<.02	.55	28	<50	<100	110	.33

*Loss on ignition, the loss in weight that results from heating a sample to 1,000 °C (includes organic material).

†Total iron reported as Fe_2O_3.

SAMPLE DESCRIPTIONS

1. From quarry in coarse limestone talus. Dark-gray, fine-grained crystalline limestone with some poorly preserved bryozoan and (or) coral fossils on weathered surfaces.

2. From outcrop. Dark-gray, fine-grained crystalline limestone with slight fetid smell when freshly broken and some poorly preserved bryozoan and (or) coral fossils on weathered surfaces.

Investigations by the U.S. Geological Survey

Field data for assessing the mineral resource potential of the Burnt Creek Wilderness Study Area were collected during the summer of 1986. A new geologic map at a scale of 1:24,000 was prepared by Betty Skipp and D.H. McIntyre in 1986–87. Volcanic petrography and identifications of Mississippian and Pennsylvanian foraminifers and algae are by Betty Skipp. Conodonts and conodont color-alteration index (CAI) values, which indicate the highest temperature to which a rock has been subjected (Epstein and others, 1977), were determined by R.T. Lierman in 1986. Corals were identified by W.J. Sando and Betty Skipp and brachiopods by J.T. Dutro, Jr. in 1987. The reconnaissance geochemical survey by H.D. King utilized rock, stream-sediment, and heavy-mineral-concentrate samples collected by H.D. King, C.D. Taylor, Betty Skipp, and D.H. McIntyre in 1986. Semiquantitative spectrographic analyses were made by M.S. Erickson. Atomic-absorption and inductively coupled argon plasma-atomic emission spectrometry (ICAP-AES) analyses were made by D.L. Fey, C.A. Gent, and K.R. Kennedy. Major oxide analyses were made by A.J. Bartel using X-ray spectroscopy. Examination and identification of minerals in nonmagnetic heavy-mineral-concentrate samples using a binocular microscope were made by S.M. Smith.

Acknowledgments.—We thank T.R. Neumann and N.L. Logue of the USBM Western Field Operations Center for assistance in the field. We also thank Darlene Condray of the U.S. Bureau of Land Management for information on leases, and John Mitchell of the Idaho Bureau of Water Resources Dam Safety Section for information on the old Dry Creek Reservoir dam. We thank J.M. LaDue and C.D. Taylor for assistance in geologic mapping and sample collection during the summer of 1986.

APPRAISAL OF IDENTIFIED RESOURCES

By Peter N. Gabby, U.S. Bureau of Mines

The USBM investigation showed that the Burnt Creek Wilderness Study Area has no identified mineral resources. No anomalous concentrations of metals were found in rock samples, and no gold or silver were detected in placer samples. Limestone of suitable quality for use in the manufacture of Portland cement and limestone that is near the quality (more than 95 percent $CaCO_3$) needed for high-purity uses (Danner, 1966, p. 4) was found at two localities in and near the study area (pl. 1, table 1). However, ample limestone outside the study-area boundary is closer to most current and prospective markets.

No active or historic mining claims are in or adjacent to the Burnt Creek Wilderness Study Area. East of the study area is a quarry in limestone talus that was used for sized, 100-lb (pound) rock fill in the old Dry

Creek Reservoir dam. The dam was built between 1916 and 1919 and collapsed in 1956. A nearby source of sand and gravel was used for fine fill (John Mitchell, Idaho Department of Water Resources, Dam Safety Section, oral commun., 1985), but the source of this material could not be located during the field examination.

The nearest active mines are the Clayton lead-silver mine (temporarily closed in early 1986) and the Thompson Creek molybdenum mine, about 40 mi and 50 mi west, respectively. About 20 mi to the east, the properties of the Little Lost River mining district had sporadic lead-silver production from the late 1880's to the early 1930's (Wells, 1983, p. 132). Approximately 12 lead-silver prospects and one barite prospect in Paleozoic carbonate rocks are in or near the adjacent U.S. Forest Service-administered Borah Peak study area, but only minor production came from these properties (Capstick and others, 1987). The total value of mineral production from five mining districts within 35 mi of the study area is $41.1 million in silver, copper, lead, and tungsten (Wells, 1983, p. 160).

The northern half of the study area and adjacent lands to the north, northeast, and east are now or were recently under oil and gas leases (Darlene Condray, U.S. Bureau of Land Management, Idaho State Office, oral commun., 1985). The nearest well, 25 mi northeast, is a 6,700-ft dry well drilled by AMOCO Production Company in 1981 in the valley east of the Lemhi Range (Breckenridge, 1982). A warm spring (28 °C) is about 10 mi northeast of the study area (Breckenridge and others, 1980), but no geothermal leases are in the vicinity (Darlene Condray, oral commun., 1985).

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Betty Skipp, Harley D. King, David H. McIntyre, and Don L. Sawatzky, U.S. Geological Survey

Geology

Geologic Setting

The Burnt Creek Wilderness Study Area is in the middle part of the elongate north-northwest-trending Lost River Range that extends from the Snake River Plain on the southeast to beyond Challis on the northwest (fig. 2). Precambrian and Paleozoic rocks of the Lost River Range were moved from the southwest to the northeast an undetermined distance in Mesozoic, probably Cretaceous, time, as part of a large thrust plate that encompasses the entire mountain range (Skipp, 1987; Skipp and Hait, 1977).

Paleozoic rocks of the study area range in age from Mississippian through Pennsylvanian and are folded and faulted along northwest trends as a result of the Mesozoic northeastward-directed compression. Fold axes mapped in the Burnt Creek area and the Mississippian rocks in the Dry Creek area both strike northwest (pl. 1). Ross (1947) mapped large northeast-verging, northwest-trending fold axes in the high mountains adjacent to the study area on the south. Segments of possible minor northwest-trending thrust faults that juxtapose older rocks against younger rocks were mapped in both the Burnt Creek and Dry Creek areas. The segment in Dry Creek is concealed. Stratigraphic separations on these faults are small. Segments of two northwest-trending normal faults that appear to be confined to Paleozoic rocks are present in the Burnt Creek area. The Rock of Ages dike also has a northwest trend that probably was controlled by a pre-Challis Volcanics (possibly Mesozoic) structure in the underlying Paleozoic rocks.

Post-Cretaceous and pre-Challis (Eocene?) normal faults resulting from regional extension have been recognized in the mountain ranges east and west of the study area (Skipp, 1984; Nelson and Ross, 1969; McIntyre and others, 1982). The Borah Peak uplift or horst that includes Borah Peak west of the study area may also be an Eocene(?) structure bounded by northeast-trending faults (Skipp and Harding, 1985). Any of the normal faults that do not offset Challis Volcanics in the study area could possibly have a Paleogene ancestry.

Several extension faults offset and tilt the Eocene Challis Volcanics that unconformably overlie Paleozoic rocks in the study area; these are basin-and-range faults that probably formed in Miocene time or later. The present minimum topographic relief (about 5,000 ft) of the Lost River Range may be the result of faulting that took place largely between 7 and 4 million years ago, though movement on the range-front faults occurred as recently as 1983 (Scott and others, 1985). Ages of the basin-and-range faults in the study area are not known precisely, but predominant fault trends are northeast and northwest. Two faults have east-west-trending segments as well. Bedded volcanic breccias of Squawtip, north of the study area, now dip as much as 65° northeastward into the Short Creek normal fault; some of this tilt may be initial dip. Similar breccias with interbedded flows are tilted 20° to 25° southeastward along the northeast-trending Dry Creek fault zone.

Pleistocene glacial gravels of at least two ages unconformably overlie both Paleozoic rocks and Challis Volcanics in the Burnt Creek, Dry Creek, and Long Lost

Creek drainages. Locally the younger as well as the older glacial gravels are faulted in the West Fork of Burnt Creek (pl. 1).

Description of Rock Units

In an earlier report on the geology of the Borah Peak 30-minute quadrangle, Ross (1947) identified all of the Paleozoic rocks in the study area as Brazer Limestone of Mississippian age. Detailed mapping and the identification of small calcareous foraminifers and algae, conodonts, and a sparse megafauna consisting of corals and brachiopods indicate that Pennsylvanian rocks are present as well as Mississippian rocks. The following Paleozoic rock units are included on the geologic map of the study area (pl. 1):

Lower Mississippian McGowan Creek Formation (unit Mm*).*—One 5-ft-thick bed of medium-gray limestone, gypsiferous black mudstone, and thin-bedded silty fossiliferous (brachiopods, corals, bryozoans, and echinoderm debris) limestone make up about 30 ft of outcrop along the southern bank of Dry Creek about 1/3 mi northeast of the study area. Gypsum crystals as long as 3 in. cover the mudstone slopes. The beds making up the outcrop are both folded and faulted. Corals and brachiopods found in the thin-bedded limestones (table 2) are Early Mississippian in age (J.T. Dutro, Jr., and W.J. Sando, written communs., 1987). Shallow-water faunas such as these and gypsum are not common in the McGowan Creek Formation; the formation contains an unusual facies at this location. A fault separates this unit from younger rocks.

Upper Mississippian Scott Peak Formation (unit Ms*).*—Southwest-dipping medium-dark-gray, medium- to thick-bedded, pure, moderately fossiliferous, medium-grained, cliff-forming limestones present on both sides of Dry Creek at the old dam site are assigned to the upper part of the Scott Peak Formation. The assignment is made on the basis of stratigraphic position below the Surrett Canyon Formation, and on the contained Meramecian (Late Mississippian) megafauna and microfauna (table 2). A minimum of 500 ft of continuous section is exposed along Dry Creek. A total thickness of 2,040 ft was measured at Hawley Mountain, 12 mi east of the study area (fig. 2) (Mapel and Shropshire, 1973; Mamet and others, 1971).

Upper Mississippian South Creek Formation (unit Msc*).*—Southwest-dipping, dark-gray, very thin to thin bedded, silty and argillaceous, fossiliferous, fine-grained, medium-dark-gray-weathering limestones in the Dry Creek area are assigned to the South Creek Formation. Beds of the formation are exposed in an unstable fractured cliff below the Surrett Canyon Formation in sec. 1, T. 9 N., R. 24½ E.; talus derived from this cliff makes up the sliderock on which a part of the access road into Dry Creek and Long Lost Creek is located. The formation is 220 ft thick at Hawley Mountain to the east (Mamet and others, 1971). About 200 ft are exposed beneath the Surrett Canyon Formation at Dry Creek.

Upper Mississippian Surrett Canyon Formation (unit Msu*).*—Medium-dark-gray to dark-gray, medium-to thick-bedded, pure, sparsely fossiliferous, locally sandy, medium-grained, variably cherty, ledge-forming limestone makes up this unit in both the Burnt Creek and Dry Creek areas. Sparse megafaunas and an abundant microfauna (table 2) indicate a Chesterian (late Late Mississippian) age. The conodont CAI value from locality 1 (pl. 1) is 3.5 to 4, indicating that the host rock reached temperatures of at least 180 to 200 °C. Conodonts from locality 2 (pl. 1) yielded a CAI value of 4.5, indicating that the host rock reached temperatures of at least 200 to 250 °C. Conodont locality 2 and limestone sample 1 (table 1) are both from the limestone quarry just east of the study area in Dry Creek (pl. 1). This limestone from the Surrett Canyon Formation is

Table 2. Megafaunas, microfaunas, and algae from upper Paleozoic limestones in the Burnt Creek Wilderness Study Area, Idaho

McGowan Creek Formation (Lower Mississippian)
Brachiopods: *Brachythyris* cf., *B. suborbicularis* (Hall), *Composita* sp., *Marginatia* sp., *Punctospirifer* sp. Corals: *Amplexizaphrentis* sp.
Scott Peak Formation (Upper Mississippian)
Corals: *Faberophyllum* sp. Foraminifers: *Betpakodiscus* sp., *Brunsia* spp., *Eoendothyranopsis* sp., *Eoforschia* sp., *Globoendothyra tomiliensis* (Grozdilova), *Mediocris* sp.
Surrett Canyon Formation (Upper Mississippian)
Conodonts: *Adetognathus unicornis* (Rexroad and Burton), *Cavusgnathus* sp., *Gnathodus bilineatus* (Roundy), *Kladognathus* sp. Corals: *Siphonophyllia* sp. Foraminifers: *Asteroarchaediscus* sp., *Brenckleina* sp., *Eosigmoilina* sp., *Planospirodiscus* sp.
Snaky Canyon Formation, lower part (Lower and Middle Pennsylvanian)
Algae: *Komia* sp. Corals: *Pseudozaphrentoides* sp. Foraminifers: *Bradyina cribrostomata* Rauzer-Chernousova and Reitlinger, *Eostaffella* spp., *Globivalvulina moderata* Reitlinger, *Hemigordius harltoni* Cushman and Waters, *Millerella extensa* Marshall, *Millerella pressa* Thompson, *Pelaeonubecularia* spp., *Planoendothyra* spp., *Pseudostaffella* sp.

chemically pure. The formation is 850 ft thick at Hawley Mountain. An incomplete thickness of about 700 ft is exposed in the Dry Creek area adjacent to the study area on the east.

Upper Mississippian Arco Hills Formation and Upper Mississippian and Lower Pennsylvanian Bluebird Mountain Formation (unit PMba*).*—Light-grayish-orange-pink to very light gray, moderately sorted, fine-grained calcareous quartzose sandstone that weathers light brown is present at the top of hill 8483 east of Burnt Creek, stratigraphically above sandy parts of the Surrett Canyon Formation, and is assigned to the Bluebird Mountain Formation. Black fissile shale that crops out locally in a gully southwest of the limestone quarry above Surrett Canyon limestones in Dry Creek tentatively is assigned to the Arco Hills Formation. This unit is poorly exposed within the study area. Thickness of this combined unit is 310 ft at Hawley Mountain east of the study area (Mapel and Shropshire, 1973).

Lower and Middle Pennsylvanian parts of the Pennsylvanian and Lower Permian Snaky Canyon Formation (unit Ps*).*—Mostly medium-gray to medium-dark-gray, and some yellowish-gray and medium-light-gray, thin- to thick-bedded, poorly fossiliferous, mostly medium-grained, slightly sandy and silty in places, variably cherty, ledge- and slope-forming limestones make up this unit in the Burnt Creek area on the high mountain slopes. Because some of the limestones of this unit are remarkably clean (table 1, sample 2) in this area, it is easy to understand how Ross (1947) mistook them for Mississippian. In most places they are distinguished on the basis of microfaunas (table 2). In general, Pennsylvanian limestones contain much more sand and silt and more impurities than Mississippian limestones in south-central Idaho (Skipp and others, 1979). A minimum of 1,000 ft of the formation is exposed in the study area. The entire formation is at least 3,500 ft thick in the Hawley Mountain area (Mapel and Shropshire, 1973).

Ross (1947) assigned the Eocene Challis Volcanics and related rocks in the study area to three units: (1) a basalt and calcic andesite member, (2) a latite-andesite member, and (3) basalt and andesite intrusions. New geologic mapping and chemical and petrographic studies indicate that all of the rocks are of intermediate composition—andesite, latite (potassium-rich andesite), quartz latite, and rhyodacite—and most are rich in potassium. Volcanic rocks commonly are classified according to their SiO_2 content, from basalt (low in SiO_2) through an intermediate series to rhyolite (high in SiO_2). All of the volcanic rocks in the Burnt Creek Wilderness Study Area have intermediate SiO_2 content, which is reflected in their mineralogy. The following seven principal rock units are distinguished (pl. 1):

Sandstone and conglomerate with limestone blocks and interbedded andesite lava flows (unit Tcs*).*—Sandstone is grayish yellow green and light olive gray, fine grained to conglomeratic, poorly to well indurated, locally laminated and crossbedded, and tuffaceous. Volcanic detritus and subordinate sedimentary rock clasts are the major constituents. Conglomerate is light olive gray to dusky green, unindurated to well indurated, poorly bedded and clast supported. Clasts chiefly are well-rounded fragments, as much as 6 in. in diameter, of quartzite, sandstone, siltstone, chert, and limestone. Local included limestone blocks are several feet in diameter (ls on pl. 1). Quartz sand, volcanic detritus, and green clay fill interstices between the clasts. A thin pyroxene andesite flow interbedded in the upper 100 ft of the unit is grayish black and weathers olive gray. The andesite has 5 percent augite phenocrysts and 2 percent biotite phenocrysts in a fine-grained matrix of small plagioclase laths, specks of opaque minerals, and pyroxene. The shiny biotite flakes in this flow are distinctive. This poorly exposed, slope-forming unit was mapped only in the Burnt Creek area where a thickness of about 500 ft is present. Elsewhere, thin intervals of well-indurated, fine-grained volcanic sandstone are present locally at the base of the unit consisting of pyroxene potassium-rich andesite flow breccias, air-fall tuffs, and unbrecciated flows (unit Tcap).

Quartz latitic ash-flow tuff (unit Tct*).*—Largely unwelded devitrified (crystallized from volcanic glass) tuff is medium gray, grayish green, or olive gray, and contains flattened pumice locally altered to chlorite. Chalcedony and green celadonite fill cavities and are principal alteration products. As much as 20 percent of the rock consists of broken crystals of zoned plagioclase, biotite, amphibole, quartz, and minor pyroxene. Fragments of devitrified or recrystallized volcanic rocks and sedimentary quartzose sandstone constitute about 10 percent of the rock. The estimated maximum thickness is about 200 ft. This unit is present only in the Burnt Creek area as a local tongue with a probable western source.

Pyroxene potassium-rich andesite flow breccias, interbedded air-fall tuffs, and unbrecciated flows (unit Tcap*) and pyroxene andesite and rhyodacite plugs and sills (unit* Tdap*).*—These units, the most areally extensive and diverse in the study area, are characterized by visible phenocrysts of green clinopyroxene, chiefly augite. Additional phenocrysts include olivine and locally altered orthopyroxene in a very fine grained matrix of feldspar, pyroxene, and opaque iron oxide minerals. Phenocrysts or clusters of phenocrysts generally make up 10 to 20 percent of the rock. Grayish-red, grayish-olive-green, and dark-yellowish-brown, thick-bedded potassium-rich pyroxene andesite flow breccias, some with basal black vitrophyre (volcanic glass) zones as much as 5 ft thick, some vesicular, and interbedded grayish-pink and tan, well-bedded, largely thin bedded, rhyodacitic crystal-lithic, biotite-pyroxene air-fall tuffs make up the unit in the eastern two-thirds of the study area. Unbrecciated potassium-rich andesite and interbedded rhyodacite flows in the lower part of the unit on the eastern side of Burnt Creek are olive gray, dark gray, and olive brown and weather the same color or pale brown. The estimated thickness of flows and flow breccias is about 3,000 ft on the ridge between Burnt Creek and Short Creek. Squaw-tip consists of this unit. Pyroxene andesite and rhyodacite plugs and sills (unit Tdap) are either olive gray or grayish red with yellowish-green mottles that are clusters of clinopyroxene phenocrysts partly altered to chlorite and calcite. Amphibole is a common additional phenocryst. The rocks contain vugs lined with tridymite and (or) bluish-green celadonite. A sill that intrudes the sandstone, conglomerate, and andesite flow unit (Tcs) on the western side of Burnt Creek is light olive gray and contains clusters of clinopyroxene phenocrysts largely replaced by iddingsite that make up 10 percent of the rock. Embayed phenocrysts of biotite (5 percent), amphibole (2 percent), and quartz (<1 percent) are also present in a very fine grained matrix with microlites (tiny crystals) of feldspar and opaque minerals. Apatite is a common accessory. In thick sills, the biotite is more visible than the pyroxene.

Pyroxene latite flows (unit Tclp*) and dikes and plugs (unit* Tdlp*).*—Dark-gray to black, weathering pale-brown to moderate-brown, locally vesicular latite having 15 to 20 percent phenocrysts of predominantly clinopyroxene, largely augite, olivine, and minor amphibole in a very fine grained matrix of feldspar laths, clinopyroxene, and opaque iron oxide minerals. Olivine is largely altered to iddingsite or chlorite and calcite. Flows have local inclusions of boulders and pebbles of sedimentary quartzite. These latite flows were called basalts by Ross (1947). They aggregate about 500 ft in thickness on the western side of Burnt Creek.

Oxyhornblende latite flow (unit Tclo*) and dikes (unit* Tdlo*).*—Grayish-red-purple to pale-red oxyhornblende (iron-rich hornblende) latite containing 15 to 20 percent mafic phenocrysts of basaltic hornblende (oxyhornblende), augite, and reddish-brown biotite in a very fine grained matrix containing as much as 15 percent small oligoclase laths. Most oxyhornblende phenocrysts have opaque altered rims; some have calcite centers rimmed with opaque minerals; some have been partly replaced by fresh augite. The distinctive ledge-forming flow north of Dry Creek is as much as 400 ft thick.

Pyroxene rhyodacite dikes and plug (units Tdrp *and* Tprp*).*—Light-olive-gray, dense rock, sparsely porphyritic, containing less than 10 percent phenocrysts consisting of zoned and twinned intermediate plagioclase, pyroxene, and minor hornblende, in a very fine grained matrix of feldspar laths and quartz make up the Rock of Ages dike complex (unit Tdrp). An adjacent plug (unit Tprp) is slightly darker in color, olive gray, and contains as much as 20 percent phenocrysts of largely intermediate plagioclase with clinopyroxene and opaque iron oxide minerals, many after amphibole, in a fine-grained matrix containing tiny crystals of plagioclase and opaque specks.

Hornblende rhyodacite dikes, plugs, and sills (unit Tdrh*).*—Olive-gray to olive-black rhyodacite containing phenocryst assemblages of intermediate plagioclase (10–20 percent), and hornblende and pyroxene in about equal amounts (5 percent) with lesser biotite or just hornblende and biotite in a very fine grained matrix. A sill topographically below the oxyhornblende latite flow north of Dry Creek is assigned to this unit with question. No feldspar phenocrysts were noted in the sill, but mafic phenocrysts of hornblende and minor biotite and pyroxene make up 5 percent of the rock, which has a very fine grained matrix. No lava flows of this composition are present in the study area.

Quaternary surficial deposits unconformably overlie all other geologic units in the study area and consist of older glacial deposits (unit Qgo), younger glacial deposits (unit Qgy), landslide deposits (unit Ql), fan gravel deposits (unit Qf), colluvial deposits, including talus (unit Qc), and alluvium deposited along the major drainages (unit Qa). The alluvium (unit Qa) also includes sediment formerly deposited in the reservoir behind the Dry Creek dam that ruptured in 1956.

Geochemistry

Introduction

A reconnaissance geochemical survey was conducted in the Burnt Creek Wilderness Study Area in the summer of 1986. Minus-80 mesh (0.18-mm) stream sediments, nonmagnetic heavy-mineral concentrates of stream sediments, and rock samples were used as the sample media in this survey. Fifteen minus-80 mesh stream-sediment, 14 nonmagnetic heavy-mineral-concentrate, and two rock samples were collected from 15 sites; 21 rock samples were collected from 21 additional outcrop sites. The stream sediments and the stream sediments from which the concentrates were derived were taken from active alluvium in the stream channel.

Stream sediments were selected as a sample medium because they represent a composite of the rock and soil exposed upstream from the sample site. Nonmagnetic heavy-mineral-concentrate samples provide information about the distribution of a limited number of minerals in rock material eroded from the drainage basin upstream from each sample site. Many of the minerals found in the nonmagnetic fraction of heavy-mineral concentrates may be ore or ore related. The selective concentration of minerals permits determination of some elements that are not easily detected in bulk stream-sediment samples.

Most rock samples appeared fresh and unaltered and were collected to provide information on background concentrations of elements. One of the rock samples appeared altered and possibly mineralized and was collected to determine the suite of elements associated with the observed alteration and (or) mineralization.

Analytical Methods

Rock samples were crushed and pulverized to less-than-80-mesh grain size prior to analysis. Stream-sediment samples were sieved using 80-mesh stainless-steel sieves, and the minus-80 fraction was used for analysis. The heavy-mineral concentrate was produced by panning minus-10-mesh (less than 2.0 mm) stream sediment to remove most of the quartz, feldspar, organic materials, and clay-size material. Bromoform (specific gravity 2.86) was then used to remove light mineral grains from the panned concentrate. The resultant heavy-mineral concentrate was separated, by use of an electromagnet, into three fractions: a magnetic fraction, chiefly magnetite; an intermediate magnetic fraction consisting largely of mafic rock-forming minerals, and a nonmagnetic fraction which is composed predominantly of light-colored rock-forming accessory minerals and primary and secondary ore-forming and ore-related minerals. Using a microsplitter, the nonmagnetic fraction was split into two fractions. One of these splits was used for analysis and the other for visual examination with a binocular microscope. In some instances, the sample volume was too small to provide a split for visual examination. These samples were examined visually prior to grinding for analysis; archived reference material for these samples contains no material not ground to fine powder.

All samples were analyzed semiquantitatively for 31 elements using direct-current arc emission spectrographic methods. Rock and stream-sediment samples were analyzed by the method described in Crock and others (1987), and nonmagnetic heavy-mineral-concentrate samples were analyzed by the method described by Grimes and Marranzino (1968). Rock and stream-sediment samples also were analyzed for certain elements of special interest or elements which have high lower limits of determination by emission spectrography. Antimony, arsenic, bismuth, cadmium, and zinc were determined by ICAP–AES, and gold and mercury were determined by atomic absorption (methods described in Crock and others, 1987).

Results of Study

Anomalously high arsenic concentrations (in three samples, one containing 200 ppm (parts per million), and two containing amounts less than the 200-ppm detection limit) were identified by semiquantitative spectrographic analysis in samples from small hypabyssal rock units in the western half of the study area (fig. 1, pl. 1). Analysis by ICAP-AES of these same samples, however, showed only background values for arsenic (reported as less than 5 ppm). The reason for the discrepancy in amounts between the two analytical techniques was not determined. Arsenic is of interest in geochemical surveys chiefly as an indicator of deposits of other elements, particularly gold and silver. Anomalous values of elements commonly associated with arsenic were not found in the samples. Even if the anomalously high arsenic values are valid, the lack of anomalous amounts of other elements commonly associated with arsenic in mineral deposits and a lack of altered rock in the area suggest that these are isolated concentrations.

Nonmagnetic heavy-mineral-concentrate samples from three widely separated sites (fig. 1, pl. 1) contained anomalous values of barium (10,000 ppm and greater). Two of the sites are in the southern half of the study area, one on the East Fork of Burnt Creek and the other on a tributary to Long Lost Creek; the third site is outside of the study area to the south. Large parts of the drainage areas of all three of these sites are outside of the study-area boundary. Stream-sediment samples contained only background amounts of barium (500–700 ppm). The high values of barium in the concentrates were determined, by microscopic examination, to be due to the presence of barite in the samples. Lack of anomalous barium in the stream-sediment samples and the presence of only small amounts of barite in the concentrates suggest that the barium sources, possibly veins, are small. Barite veins have not been observed within the study area. A barite prospect, however, is present in Paleozoic carbonate rocks to the south of the study area in the Borah Peak area (Gabby, 1986).

No additional anomalous element values were found in rock or nonmagnetic heavy-mineral-concentrate samples. No anomalous values were found in stream-sediment samples.

Linear Features in Landsat Multispectral Scanner Images

Linear features in Landsat multispectral scanner (MSS) images at a scale of 1:800,000 were mapped by photogeologic interpretation for the area of southern Idaho. Linear features are the topographic and spectral expression of rock fracture patterns and other structural and lithologic lineaments. This expression can be enhanced or subdued by scanner resolution, sun orientation, atmospheric phenomena, and vegetation. Analysis of linear features in conjunction with study of geologic and geophysical maps may reveal new geologic relationships such as control of mineralization by fractures.

Linear features of every orientation are clearly expressed on the surface of central Idaho. The Burnt Creek Wilderness Study Area has many mapped faults. Linear features in the study area primarily trend N. 40° E., but linear features trending N. 20° E. are numerous over a wider area. These strong trends extend northward to the Idaho-Montana border. A more weakly developed trend of N. 0–20° W. is more widespread over east-central Idaho.

Mineral and Energy Resources

Limestone

Two small areas of Mississippian and Pennsylvanian limestone within the study area contain limestone of the purity required for the manufacture of Portland cement, and some is near the quality (more than 95 percent $CaCO_3$) for other high-purity uses (Danner, 1966, p. 4). Based on the USBM analyses (table 1) and on field observations, four areas of thick limestone within the Surrett Canyon and Snaky Canyon Formations have a high resource potential for high-calcium limestone (pl. 1, fig. 1) at certainty level C.

Oil and Gas

Oil and gas have been found in structural traps such as frontal ramp anticlines in the Idaho-Wyoming thrust belt southeast of the Snake River Plain. Thrust-belt structures in the Burnt Creek Wilderness Study Area have some similarities to those in southeast Idaho and adjacent Wyoming. Abundant thermally mature source rocks and thick, permeable reservoir rocks characterize the productive parts of the Idaho-Wyoming belt (Powers, 1977). However, source rocks of the study area have been heated to temperatures of 180 to 250 °C as indicated by conodont CAI values obtained from limestone samples (pl. 1, locs. 1, 2), and liquid hydrocarbons would have been destroyed. The resource potential for oil in the entire study area therefore is low at certainty level D. The resource potential for dry gas (methane) is more difficult to assess, but probably also is low. Potential structural traps formed in Mesozoic time may have been breached by the numerous later Cenozoic extension faults present in the region. Because of the lack of seismic surveys or bore holes, the resource potential for dry gas in the entire study area is considered low at certainty level B.

Metals

The entire wilderness study area, including plugs and sills of the Eocene Challis Volcanics, has low mineral resource potential for all metals, with certainty level C. No anomalous concentrations of metals were identified in any of the rock or stream-sediment samples, even though anomalous concentrations of arsenic, which can be an indicator of mineral deposits in other areas, were found in three volcanic-rock samples (pl. 1). No mines are in the study area, and no mineralized rocks were observed during field examination.

Barite

A low mineral resource potential for barite in veins in limestone is assigned the study area at certainty level C, because no barite veins were observed during the field study. Nonmagnetic heavy-mineral-concentrate samples contained anomalous values of barium at two sites, but the areas drained by the stream or gully that contained the concentrations probably have small veins that are difficult to locate. Most of the volcanic rocks in the area overlie unexposed limestones.

Geothermal Energy

No hot springs or other geothermal indicators were found in or near the study area. The nearest geothermal indicator is a warm spring (28 °C) about 10 mi northeast of the study area (Breckenridge and others, 1980). Therefore, the geothermal energy resource potential in the study area is low at certainty level C.

Recommendations for Further Study

More limestone analyses are needed to delimit the areas of high-purity limestone. Further geochemical study of the plugs and sills of the Challis Volcanics in the study area would resolve a discrepancy noted in arsenic values.

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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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