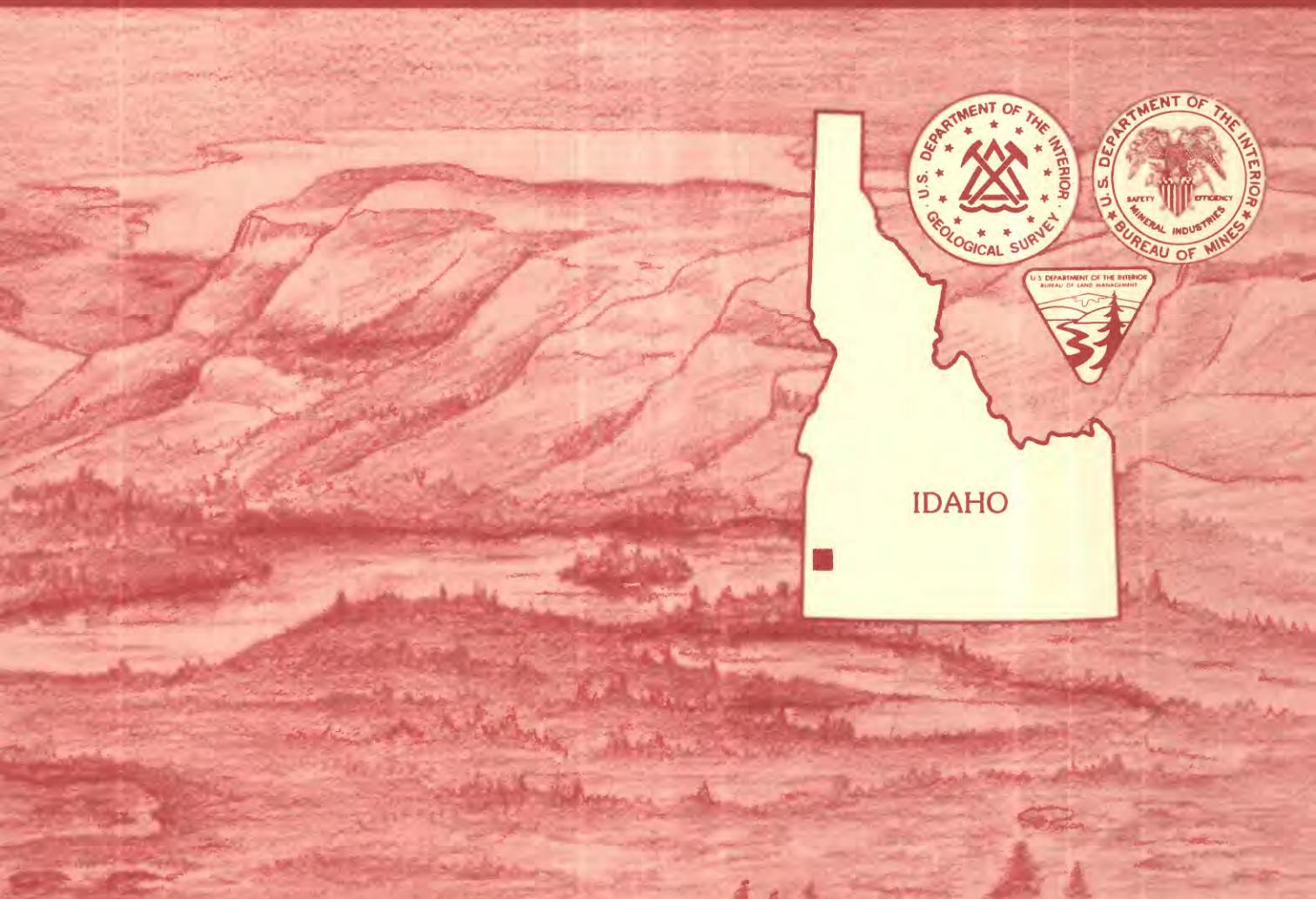


Mineral Resources of the North Fork Owyhee River Wilderness Study Area, Owyhee County, Idaho

U.S. GEOLOGICAL SURVEY BULLETIN 1719-A



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Chapter A

Mineral Resources of the North Fork Owyhee River Wilderness Study Area, Owyhee County, Idaho

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U.S. GEOLOGICAL SURVEY BULLETIN 1719–A

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
OWYHEE RIVER REGION, IDAHO AND NEVADA

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 the North Fork Owyhee River Wilderness Study Area (ID-16-40) within the southern Owyhee Mountains in southwest Idaho.

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Mineral Resources of the North Fork Owyhee River Wilderness Study Area, Owyhee County, Idaho

By Scott A. Minor and Donnie Sawatzky
U.S. Geological Survey

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SUMMARY

Abstract

The North Fork Owyhee River Wilderness Study Area (ID-016-040), within the southern Owyhee Mountains in southwest Idaho, encompasses 49,470 acres, of which the U.S. Geological Survey and the U.S. Bureau of Mines were asked to study 39,745 acres. Hereafter, the terms "study area" and "wilderness study area" refer only to the smaller acreage. Field work for this report was carried out between 1984 and 1985. No mines or prospects are located in the study area, although a few borrow pits exist just outside its southern boundary. The only identified resource is blocky basalt suitable for use as building or decorative stone. The study area has a low resource potential for gold, silver, zinc, and uranium. The potential for petroleum and natural gas and geothermal energy is unknown.

Character and Setting

The North Fork Owyhee River Wilderness Study Area is located in the southern Owyhee Mountains in southwest Idaho, about 75 mi southwest of Boise (fig. 1). The area is situated along a stream-dissected plateau with canyons as deep as 400 ft. The study area is underlain by a thick pile of Miocene (about 5 to 24 million years before present) volcanic flows and minor interbedded sedimentary rocks. A thick rhyolite ash-flow tuff sheet is exposed throughout most of the study area; the tuff is overlain in the southern part of the study area by another rhyolite ash-flow tuff and a younger sequence of thin basalt flows and interbedded sedimentary rocks. The older ash-flow tuff fills a collapse caldera formed due to the emplacement of the tuff. Several small-displacement normal faults of various trends cut the rocks. The rhyolite ash-flow tuffs are also intensely fractured locally.

There are no known mines, prospects, claims, or mineral leases in the study area or its immediate vicinity. Several small borrow pits for road construction material exist along the southern boundary (fig. 2).

Identified Resources

The only identified resource in the study area is blocky basalt suitable for use as building or decorative stone. The thin, blocky slabs of basalt occur over an area of several square miles in the southern part of the study area.

Mineral Resource Potential

Gold, silver, zinc, and uranium have minor resource potential in the wilderness study area (fig. 2). The potential for geothermal energy and petroleum and natural gas is unknown.

Two mining districts occur in the region near the wilderness study area: the South Mountain (silver-lead-zinc) and the Silver City (gold-silver) districts. Mineralization in the former takes the form of silver-lead replacement veins and silver-lead-zinc skarn within regionally metamorphosed rocks. The Silver City district, in particular the Delamar mine area, is characterized by epithermal mineralization along Miocene normal faults and fractures within a contemporaneous, inferred silicic ring complex. Anomalous concentrations of antimony, arsenic, copper, mercury, selenium, and zinc are associated with the gold-silver deposits.

Relatively high concentrations of arsenic, molybdenum, silver, and zinc have been detected in samples collected in the wilderness study area. A similar geologic environment (caldera-related silicic volcanic rocks and contemporaneous faults and fractures) and trace-element anomalies similar to those in the Silver City district suggest that

epithermal mineralization has occurred beneath the study area. No mineral deposits or evidence of secondary hydrothermal alteration have been found in the area. Thus, the study area is judged to have a low resource potential for gold, silver, and zinc (fig. 2).

Weakly anomalous uranium concentrations occur in a few places in the southern part of the wilderness study area. The rhyolite ash-flow tuffs that underlie most of the study area have relatively high background levels of uranium and are probably the source of the anomalies. Therefore, the study area is considered to have a low resource potential for uranium (fig. 2).

No evidence of geothermal activity exists in the wilderness study area, and pertinent subsurface data is lacking to quantify the resource potential. The study area is considered to have an unknown potential for geothermal energy.

No evidence of hydrocarbons has been found in the study area, and pertinent subsurface data is lacking to quantify resource potential. The study area has an unknown potential for petroleum and natural gas.

INTRODUCTION

Character and Setting

The North Fork Owyhee River Wilderness Study Area (ID-016-040), located about 30 mi southeast of Jordan Valley, Oregon, and 75 mi southwest of Boise, encompasses 49,470 acres within the Owyhee Mountains of southwest Idaho (fig. 1). Elevations range from about 4,800 ft, where the North Fork of the Owyhee River crosses the western boundary of the study area, to about 6,800 ft along the northeastern boundary. South Mountain (7,850 ft), located 5 mi northwest of the study area, is the only prominent peak in the immediate vicinity. The rugged, extensively stream-dissected northern part of the study area contrasts greatly with the locally incised tablelands of the southern part. With a depth as great as 400 ft, the gorge of the North Fork of the Owyhee River is the deepest canyon in the study area. All of the other streams in the study area are intermittent, reflecting the semi-arid climate of the region. Juniper trees, low-lying sage and other brush, and seasonal varieties of grasses and wild flowers grow throughout most of the area. The larger stream channels support a variety of riparian vegetation.

An improved county-maintained gravel road that extends from Jordan Valley, Oregon, to Grand View, Idaho provides the best access to the study area. Several jeep trails branching off this road extend into the study area (fig. 1). The rugged northeastern part of the study area is accessible only by foot, horse, or helicopter.

Previous and Present Investigations

The first published geologic map of the study area region was a reconnaissance map (1:62,500-scale) accompanying the report by Bennett (1976) on the geology and geochemistry of the South Mountain-

Juniper Mountain area. The only other geologic map covering the area is that of Owyhee County by Ekren and others (1981; 1:125,000-scale).

The U.S. Geological Survey conducted field studies in the study area during 1984 and 1985. These studies included geologic mapping and collection of rock samples for petrographic studies. In addition, a geologic reconnaissance of the region surrounding the study area was conducted as an aid to formulating ore-deposit models. Linear features that appeared in Landsat multispectral-scanner images were mapped by photogeologic interpretation for the region. Geochemical data used in making mineral-resource evaluations in this report include stream-sediment data obtained from both Bennett (1976) and a U.S. Department of Energy National Uranium Resource Evaluation (NURE) report (Oak Ridge Gaseous Diffusion Plant, 1982).

U.S. Bureau of Mines personnel conducted a library search of Owyhee County, state, and U.S. Bureau of Land Management mining-production and mineral-lease records for information on mines, prospects, and claims within the study area. A ground and air reconnaissance was undertaken to check for undocumented mining activity. The Bureau of Mines conducted field studies during 1984. Rock and stream-sediment samples were collected to help evaluate the mineral resources of the study area. Complete analytical data are on file at the U.S. Bureau of Mines, Western Field Operations Center, Spokane, Washington, 99202.

APPRAISAL OF IDENTIFIED RESOURCES

By Andrew M. Leszczykowski, U.S. Bureau of Mines

History and Production

There are no known mines, prospects, claims, or mineral leases in the wilderness study area. There are, however, two mining districts nearby. The South Mountain district is located 7 mi northwest of the study area near South Mountain (fig. 1). Silver-lead-zinc ore was produced there intermittently from the early 1870's (Sorenson, 1927) to 1945. The ore occurs as replacement-vein and skarn deposits in limestone (Beaver, 1984). The Silver City mining district, located 24 mi north of the study area (fig. 1), has been active since 1863, most recently at the Delamar open-pit mine, a large-tonnage, low-grade, gold and silver mine. More than \$40 million of gold and silver (derived from epithermal veins) have been produced in this district.

Four small borrow pits are located along the county road that skirts the southern part of the study area (fig. 2). Material for road metal was extracted from the pits for use on nearby roads.

Mineral Deposits

No mineral deposits have been identified within the wilderness study area. The only identified resource is tabular, blocky basalt suitable for use as

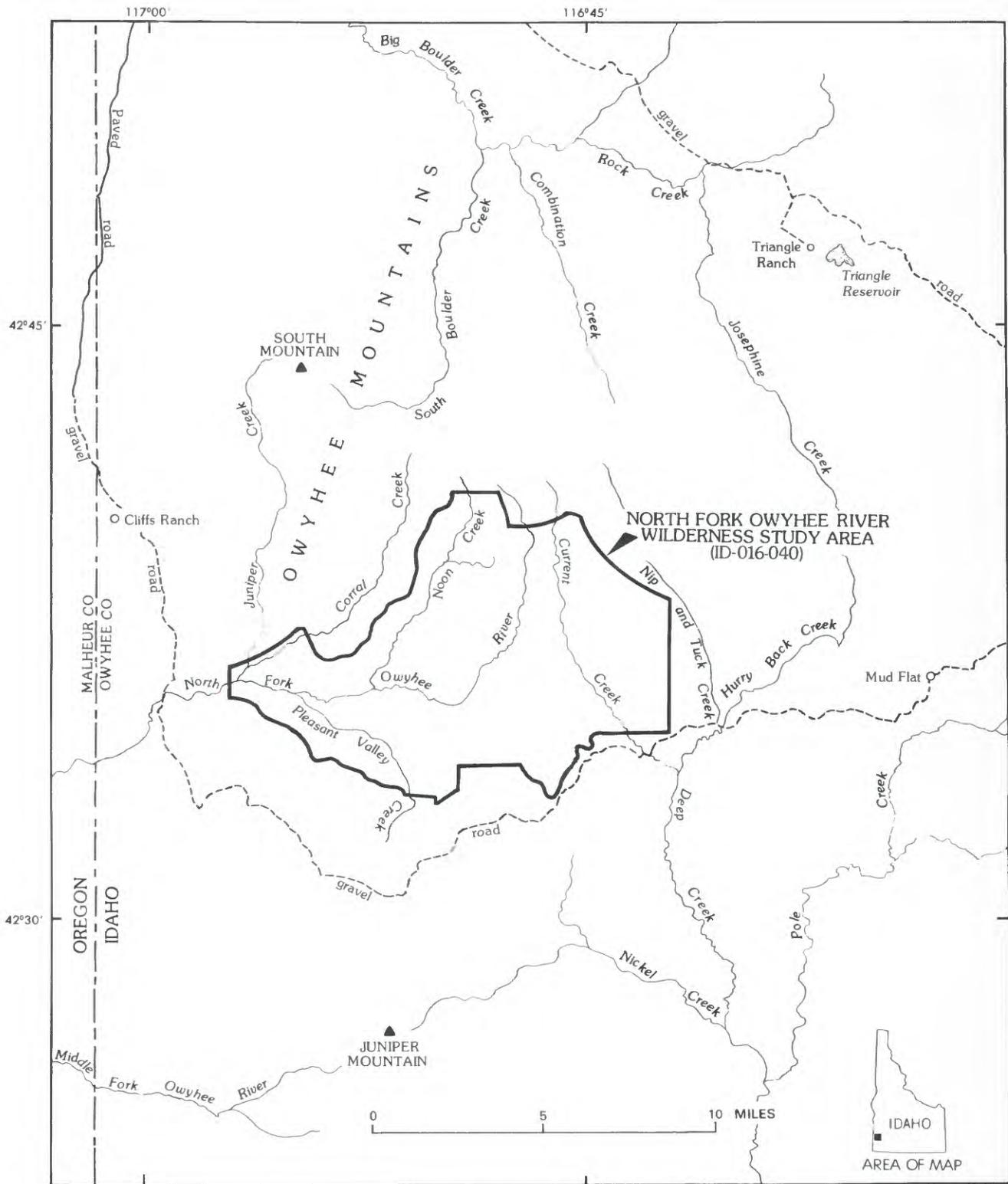
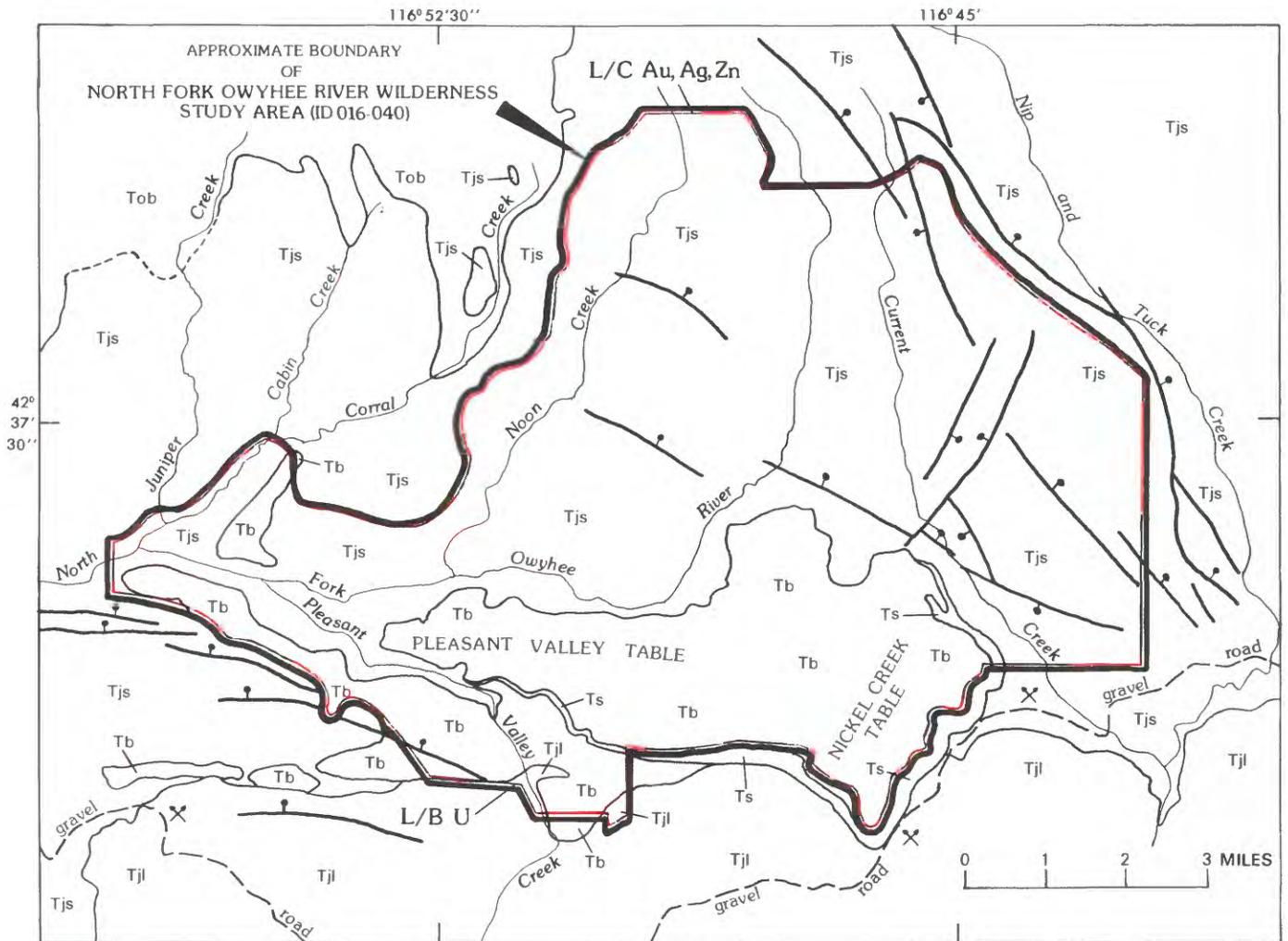


Figure 1. Index map showing location of the North Fork Owyhee River Wilderness Study Area, Owyhee County, Idaho.

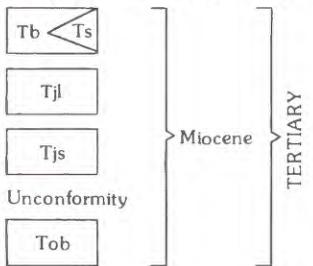


EXPLANATION

Geology modified from Ekren and others (1981)

 Area with low mineral resource potential. See Appendix 1 and Figure 3 for definition of levels of mineral resource potential and certainty of assessment.

CORRELATION OF MAP UNITS



COMMODITIES

- Au Gold
- Ag Silver
- U Uranium
- Zn Zinc

GEOLOGIC MAP UNITS

- Tb Banbury Basalt (Miocene)
- Ts Sedimentary rocks (Miocene)-interbedded with Banbury Basalt
- Rocks of Juniper Mountain volcanic center (Miocene)-In this area, consists of:
 - Tjl Lower lobes of Juniper Mountain
 - Tjs Swisher Mountain Tuff
- Tob Older basalt flows (Miocene)

MAP SYMBOLS

-  Contact-Dashed where approximately located
-  Fault-Bar and ball on downthrown side
-  Borrow pit

Figure 2. Map showing mineral resource potential of the North Fork Owyhee River Wilderness Study Area, Owyhee County, Idaho.

building or decorative stone. It crops out over an area of several square miles on Nickel Creek and Pleasant Valley tables in the southern part of the study area (fig. 2). Although the basalt is in sufficient quantity to supply any local demand, transportation costs to get the stone to a major market area would be considerable.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Scott A. Minor and Donnie Sawatzky

U.S. Geological Survey

Geology

The wilderness study area lies within the Owyhee volcanic field (Panze, 1975), which consists of a thick pile of complexly interfingering and overlapping Tertiary volcanic, pyroclastic, and subordinate sedimentary rocks. Basement rocks, consisting of Mesozoic intrusive and metamorphic rocks, crop out within the mountainous parts of the region, including South Mountain 5 mi northwest of the study area. The rocks are locally displaced along primarily north-northwest-trending normal faults.

The study area is underlain by flat-lying, middle and late Miocene rhyolitic ash-flow tuffs, basalt flows, and minor intercalated sedimentary rocks (fig. 2). The oldest rock unit is the Swisher Mountain Tuff, the lowermost subunit of the Juniper Mountain volcanic center (Ekren and others, 1981; Ekren and others, 1984). The Swisher Mountain Tuff is a rhyolitic ash-flow tuff made up of several cooling units, including an intracaldera phase. The tuff underlies the northern two-thirds of the study area. Older basalts that disconformably underlie the Swisher Mountain Tuff are exposed less than 1 mi west of the study area. The Swisher Mountain Tuff has a minimum thickness of about 500 ft within the study area; its base is not exposed. Its rhyolitic composition is expressed, in part, by phenocrysts of plagioclase, potassium feldspar, pyroxene, and opaque iron oxides. The groundmass consists of gray, devitrified glass that weathers reddish to orangish brown. Flow foliations are ubiquitous and usually folded, with amplitudes as great as 300 ft. The tuff is characterized by outcrops that form jagged pinnacles and precipitous cliffs along major drainages. The unit is interpreted by Ekren and others (1984) and the senior author of this report to be an ash-flow tuff sheet composed of several cooling units. The unit's large areal extent, locally preserved vitroclastic texture, and the sporadic occurrence of black vitrophyre layers within the unit all support this interpretation. A geologic reconnaissance of the region indicates the existence of a collapse caldera, the western part of which includes the study area. The northern part of the caldera is well delineated by a large semicircular area devoid of rocks older than the Swisher Mountain Tuff. Much of this area is underlain by an extensive domal mass of the Swisher Mountain Tuff that may be a younger intracaldera phase of the unit; to the north, it laps onto an earlier outflow facies of the Swisher Mountain Tuff that is tilted and

underlain by older rocks. An inferred caldera-moat-filling sedimentary sequence laps onto the intracaldera-tuff phase along the northern margin of the caldera, north of Big Boulder and Rock Creeks (fig. 1). South of the study area, the caldera is buried by younger volcanic units. The eruption of the Swisher Mountain Tuff probably resulted in the formation of the caldera and a late phase of the tuff was ponded within the resulting basin, thus concealing much of the caldera structure; rocks in the western part of the study area likely conceal a western segment of the caldera's ring fracture.

The lower lobes of the Juniper Mountain subunit of the rocks of the Juniper Mountain volcanic center unit (Ekren and others, 1981), a rhyolitic ash-flow tuff, lap onto the Swisher Mountain Tuff along the southern boundary of the study area. The lower lobes of Juniper Mountain are very similar to the Swisher Mountain Tuff to the north in both lithology and field expression, the main distinction of the former being the occurrence of a large amount of quartz phenocrysts. Ekren and others (1984) identify this unit as an ash-flow tuff sheet on the basis of similar evidence. Its name is derived from Juniper Mountain, 7 mi south of the study area (fig. 1), a broad dome-shaped landform thought to be a vent complex from which the tuff erupted (Ekren and others, 1981; Ekren and others, 1984).

In the southern part of the wilderness study area, the ash-flow tuffs are overlain by flat-lying basalt flows and intercalated sedimentary rocks mapped by Ekren and others (1981) as the Banbury Basalt and unnamed interbedded sedimentary rocks. The basalt flows range from 25 to 50 ft in thickness and have a maximum cumulative thickness of about 150 ft. They form mesas that dominate the landscape of the southern study area (Pleasant Valley and Nickel Creek tables). The tabular upper parts of the flows commonly possess vesicles that are locally lined with calcite, clay, and (or) zeolite minerals. The basalts are aphyric to weakly porphyritic and contain phenocrysts of olivine and (or) plagioclase, as well as iron oxides and pyroxene. The interbedded sedimentary rocks have a maximum exposed thickness of about 100 ft along the southeastern boundary of the study area, where they rest directly on the tuff and below the basalt. To the west, the sedimentary rocks pinch out locally and are intercalated with a lower and upper set of basalt flows. The sedimentary rocks consist primarily of variegated vitric-ash tuff, tuffaceous sandstone and siltstone, and basaltic sandstone and conglomerate. The sedimentary rocks and some of basalt flows may correlate with the caldera-fill sequence recognized to the north.

Small amounts of Quaternary alluvium occur along the major stream channels and consist of unconsolidated silt, sand, and gravel.

Several small-displacement, widely spaced normal faults exist within the wilderness study area (fig. 2); most have less than 50 ft of throw. Those located in the eastern part of the study area have predominantly N. 30° W. trends and down-to-the-southwest and -northeast apparent displacement. Faults with approximately N. 60° W. trends and principally down-to-the-northeast apparent displacement occur in the western part of the study

area. Using color and infrared U-2 imagery, Bennett (1976) noted the existence of a zone of intense fracturing approximately 4 mi wide that extends east to west across the central part of the study area. This zone lies entirely within the outcrop area of the Swisher Mountain Tuff and is only locally accompanied by faulting. Ekren and others (1984) determined that north-northwest-trending faults in the region began to develop about 16 Ma and continued to form until at least as recently as 8 Ma, subsequent to the eruption of the Banbury Basalt. Panze (1975) inferred that west-northwest-trending faults in the region formed concurrently with the other fault set.

Geochemical Studies

The principal source of geochemical data evaluated in this report was the reconnaissance study by Bennett (1976); 91 stream-sediment samples collected within the study area were analyzed for copper, lead, nickel, silver, and zinc. Fourteen stream-sediment samples collected within and adjacent to the study area by the U.S. Department of Energy were analyzed for 33 elements (including copper, lead, molybdenum, nickel, silver, uranium, and zinc) as part of the NURE assessment of the region (Oak Ridge Gaseous Diffusion Plant, 1982). Four rock samples collected by the U.S. Bureau of Mines were fire-assayed for gold and silver and analyzed for 40 elements by semiquantitative methods (Leszykowski, 1986). These data were evaluated along with those of Bennett's. Anomalous values were determined primarily by considering the range, distribution, and mean of the elemental concentrations.

Anomalously high molybdenum, silver, uranium, and zinc concentrations occur in several of the stream-sediment samples. High lead and nickel values were also detected, but these appear to be associated with rock types having primary high background levels in those elements, and are not further considered in this study. Relatively high silver concentrations (0.51-2 ppm) occur sporadically in sediment samples collected from drainages within both basalt and rhyolite tuff. All the high zinc concentrations (90-125 ppm) occur in sediment samples from widely scattered localities within the outcrop area of the Swisher Mountain Tuff in the northern part of the wilderness study area; most of these samples were collected within the highly fractured zone described by Bennett (1976). Two sediment samples collected along the study area's southern boundary are weakly anomalous in molybdenum (10-11 ppm); their source(s) is uncertain. Stream-sediment samples apparently anomalous in uranium (4.1-5.5 ppm) were also collected along the southern boundary and may have been derived from rock units located there. The source of one of these samples, however, was clearly the Swisher Mountain Tuff.

High concentrations of arsenic (300-500 ppm) were detected in two of the rock samples. Both of these samples were collected from unaltered Swisher Mountain Tuff in the central part of the study area.

Geophysical Studies

An aerial gamma-ray survey was performed in the region as part of the U.S. Department of Energy's NURE program (Geodata International, 1979). One north-south and three east-west composite flightlines spaced at intervals of 3 mi traversed the wilderness study area. Values of equivalent uranium exceeded the background level over the Swisher Mountain Tuff along various segments of all four flightlines, principally over the eastern part of the study area. Values of equivalent uranium for rocks in the area determined from the aerial survey indicate that both rhyolite ash-flow tuff units have comparatively high background levels.

Linear features in Landsat multispectral-scanner (MSS) images were mapped by photogeologic interpretation for the region of southwestern Idaho. Linear features are the surface expression of rock fracture patterns and other structural and lithologic lineaments. Analysis of linear features, in conjunction with geologic and geophysical maps, may reveal relationships such as structural control of mineralization.

Surface expression of linear features is generally very poor in the volcanic deposits of southwestern Idaho, especially in the Snake River plain. Linear features are well expressed in an area bounded by 116°-117° W. longitude and 42°30'-43° N. latitude, which includes the wilderness study area. Concentrations of linear features indicate dominant N. 20° W. and N. 60-80° E. trends. Maximum concentrations lie in an elongate area trending N. 20° W., with the N. 20° W. trend prominent at the south end of the area near the study area and changing northwestward around to the N. 80° E. trend. The dominant north-northwest trend is consistent with a major fault zone trending N. 20° W. south and east of the study area and another fault zone to the northeast trending N. 40° W. The east-northeast trend is probably typical of a pervasive (but unmapped) regional-fracture set found in the investigations of other linear features (Rowan and Purdy, 1984) that proved to be an important structural control of mineralization.

Mineral and Energy Resources

Base and Precious Metals

Similarities in geologic setting, age, and trace-element geochemistry of the rocks of the wilderness study area to the Delamar mineral deposits suggest that epithermal gold-silver mineralization may have occurred at depth. At the Delamar Silver mine, about 25 mi north of the study area in the Silver City range, epithermal gold-silver deposits occur primarily as vein fillings along north-northwest-trending faults and fractures (Panze, 1975; Halsor, 1983). Rhyolitic lava flows and domes, apparently comprising a silicic ring complex, host the mineralization; the rhyolitic extrusive rocks are inferred to be localized along a

ring fracture developed during the shallow emplacement of a body of magma (Halsor, 1983). Acid leaching and kaolinization are the most common types of alteration observed at Delamar. The mineralization (14.8-15.2 Ma) is closely associated in time with the rhyolitic volcanism (15.6-15.7 Ma) (Panze, 1975). Antimony-, arsenic-, copper-, lead-, and selenium-bearing minerals also occur in the deposits (Panze, 1975). Anomalous concentrations of copper, gold, lead, mercury, silver, and zinc have been detected in stream-sediment samples collected near the mine (Bennett and Galbraith, 1975). Furthermore, there is a high geochemical correlation between gold and silver in this area. No clear evidence of secondary hydrothermal alteration has been observed in the study area, despite the existence of the anomalous geochemical concentrations of arsenic, molybdenum, silver, and zinc in many of the stream-sediment samples. Commonly, the rhyolite tuff exhibits limonite staining along small fractures in surface exposures, but this is most likely a weathering feature. The likelihood that the study area is located within the marginal part of a caldera suggests that a precollapse rhyolitic ring complex similar to that in the Delamar area may exist beneath the Swisher Mountain Tuff. Hydrothermal activity would be expected to have occurred within the ring complex and in the Swisher Mountain Tuff. The trace-element signatures detected in the study area likely reflect leakage haloes related to gold-silver epithermal mineralization at shallow depth. Previous regional investigations (Ekren and others, 1981; Panze, 1975; Ekren and others, 1984) and the present geologic reconnaissance study indicate that faulting (and probably localized fracturing) of rocks within the study area occurred almost at the same time as emplacement of the Swisher Mountain Tuff (that is, formation of the proposed caldera) and silicic volcanism and mineralization in the Silver City district. The numerous faults and the zone of intense fracturing within the area may have acted as conduits for ascending metal-bearing fluids.

The cause of the sporadic anomalous arsenic, molybdenum, silver, and zinc concentrations in the wilderness study area remains indefinite due to the lack of identified mineral occurrences and alteration zones. The entire study area has a low mineral resource potential, with certainty level C, for gold, silver, and zinc (fig. 2) (see appendix 1 and fig. 3 for definitions of mineral resource potential and certainty levels).

Uranium

Uraniferous-mineral deposits have been identified within the McDermitt caldera complex 100 mi southwest of the wilderness study area and in the Triangle Ranch area located 10 mi to the northeast (fig. 1). The McDermitt deposits occur in tuffaceous caldera-fill sedimentary and volcanic rocks, and in intrusive bodies and flow domes (Rytuba and Glanzman, 1979). The uranium ore was deposited by an epithermal system and is associated with mercury deposits and anomalous concentrations of arsenic, molybdenum, and silver. The Triangle Ranch deposit

contains as much as 0.03 percent equivalent uranium and occurs in what are thought to be hydrothermally altered tuffaceous caldera-moat-fill sedimentary rocks (Berry and others, 1982) that overlie the Swisher Mountain Tuff. The sedimentary rocks interbedded with basalt in the southern part of the study area (fig. 2) are at the same stratigraphic level as the uranium-bearing sedimentary rocks at Triangle Ranch and may also be part of a caldera-fill sequence. The high equivalent-uranium values within the study area determined by aerial survey (Geodata International, 1979) and the weakly anomalous uranium concentrations detected in samples from the study area may be expressions of undiscovered uranium mineralization. No uranium-bearing mineral occurrences or secondary hydrothermal alteration have been identified in the study area, suggesting that the equivalent-uranium values are expressions of a leakage halo from a concealed uranium deposit(s). The anomalous geochemical concentrations may also reflect the relatively high background levels of equivalent uranium associated with both rhyolitic-tuff units (see Geophysical Studies section). The study area has a low mineral resource potential, certainty level B, for uranium.

Geothermal Energy

Evidence of geothermal activity, such as hot springs, recent volcanism, and geothermal wells, is lacking in the wilderness study area. Furthermore, a list of thermal springs and wells in Idaho compiled by Bliss (1983) did not include such features in the vicinity of the study area. Therefore the study area has an unknown potential, certainty level A, for geothermal-energy resources.

Petroleum and Natural Gas

The rock units exposed in the wilderness study area, as well as the basement rocks cropping out to the north, are not capable of generating hydrocarbons. It is remotely possible that hydrocarbons exist at depth within concealed stratigraphic units, but subsurface data is lacking. Therefore, the study area has an unknown potential, certainty level A, for petroleum and natural gas.

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

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

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

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

Moderate mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable chance for resource accumulation, and where an application of genetic and (or) occurrence models indicates favorable ground.

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

Unknown mineral resource potential is assigned to areas where the level of knowledge is so inadequate that classification of the area as high, moderate, or

low would be misleading. The phrase "no mineral resource potential" applies only to a specific resource type in a well-defined area. This phrase is not used if there is the slightest possibility of resource occurrence; it is not appropriate as the summary rating for any area.

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

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

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

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

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

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

LEVEL OF RESOURCE POTENTIAL	U/A	H/B	H/C	H/D
	UNKNOWN POTENTIAL	HIGH POTENTIAL	HIGH POTENTIAL	HIGH POTENTIAL
		M/B	M/C	M/D
		MODERATE POTENTIAL	MODERATE POTENTIAL	MODERATE POTENTIAL
L/B	L/C	L/D	LOW POTENTIAL	
			N/D	
	LOW POTENTIAL	LOW POTENTIAL	NO POTENTIAL	
	A	B	C	D
	LEVEL OF CERTAINTY			

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

