Mineral Resources of the Malheur River–Bluebucket Creek Wilderness Study Area, Harney County, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1741–H
Instructions on ordering publications of the U.S. Geological Survey, along with prices of the last offerings, are given in the current-year issues of the monthly catalog "New Publications of the U.S. Geological Survey." Prices of available U.S. Geological Survey publications released prior to the current year are listed in the most recent annual "Price and Availability List." Publications that are listed in various U.S. Geological Survey catalogs (see back inside cover) but not listed in the most recent annual "Price and Availability List" are no longer available.

Reports released through the NTIS may be obtained by writing to the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161; please include NTIS report number with inquiry.

Order U.S. Geological Survey publications by mail or over the counter from the offices given below.

**BY MAIL**

**Books**

Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Circulare, publications of general interest (such as leaflets, pamphlets, booklets), single copies of Earthquakes & Volcanoes, Preliminary Determination of Epicenters, and some miscellaneous reports, including some of the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from

U.S. Geological Survey, Map Distribution  
Box 25286, MS 306, Federal Center  
Denver, CO 80225

Subscriptions to periodicals (Earthquakes & Volcanoes and Preliminary Determination of Epicenters) can be obtained ONLY from the

Superintendent of Documents  
Government Printing Office  
Washington, DC 20402

(Check or money order must be payable to Superintendent of Documents.)

**Maps**

For maps, address mail orders to

U.S. Geological Survey, Map Distribution  
Box 25286, Bldg. 810, Federal Center  
Denver, CO 80225

Residents of Alaska may order maps from

U.S. Geological Survey, Earth Science Information Center  
101 Twelfth Ave., Box 12  
Fairbanks, AK 99701

**OVER THE COUNTER**

**Books and Maps**

Books and maps of the U.S. Geological Survey are available over the counter at the following U.S. Geological Survey offices, all of which are authorized agents of the Superintendent of Documents:

- **ANCHORAGE, Alaska**—4230 University Dr., Rm. 101
- **LAKEWOOD, Colorado**—Federal Center, Bldg. 810
- **MENLO PARK, California**—Bldg. 3, Rm. 3128, 345 Middlefield Rd.
- **RESTON, Virginia**—National Center, Rm. 1C402, 12201 Sunrise Valley Dr.
- **SALT LAKE CITY, Utah**—Federal Bldg., Rm. 8105, 125 South State St.
- **SPOKANE, Washington**—U.S. Post Office Bldg., Rm. 135, W. 904 Riverside Ave.
- **WASHINGTON, D.C.**—Main Interior Bldg., Rm. 2650, 18th and C Sts., NW.

**Maps Only**

Maps may be purchased over the counter at the U.S. Geological Survey offices:

- **FAIRBANKS, Alaska**—New Federal Building, 101 Twelfth Ave.
- **ROLLA, Missouri**—1400 Independence Rd.
- **STENNIS SPACE CENTER, Mississippi**—Bldg. 3101
Chapter H

Mineral Resources of the Malheur River-Bluebucket Creek Wilderness Study Area, Harney County, Oregon

By MICHAEL G. SAWLAN, ROBERT L. TURNER, and ROBERT C. JACHENS
U.S. Geological Survey

THOMAS J. PETERS and RICHARD A. WINTERS
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1741

MINERAL RESOURCES OF WILDERNESS STUDY AREAS: EAST-CENTRAL OREGON
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 Malheur River-Bluebucket Creek Wilderness Study Area (OR–002–014), Harvey County, Oregon.
CONTENTS

Summary H1
Abstract H1
Location and setting H1
Identified resources H1
Mineral resource potential H2
Introduction H4
Location, access, and character H4
Previous investigations H4
Present investigations H4
Acknowledgments H5
Appraisal of identified resources H5
Mining activity H5
Diatomaceous sediment H5
Basalt H6
Placer samples H6
Identified resources and recommendations H6
Assessment of mineral resource potential H6
Geology H6
Stratigraphy H6
Structure H8
Geochemistry H8
Introduction H8
Samples H8
Analytical methods H8
Results and interpretations H9
Geophysics H9
Introduction H9
Gravity data H9
Aeromagnetic data H9
Radiometric data H10
Summary H10
Mineral resource potential H10
References cited H10
Appendices
Definition of levels of mineral resource potential and certainty of assessment H14
Resource/reserve classification H15
Geologic time chart H16

FIGURES
1. Location of the Malheur River-Bluebucket Creek Wilderness Study Area, Harney County, Oregon H2
2. Generalized geology and mineral resource potential of the Malheur River-Bluebucket Creek Wilderness Study Area, Harney County, Oregon H3
Mineral Resources of the Malheur River-Bluebucket Creek Wilderness Study Area, Harney County, Oregon

By Michael G. Sawlan, Robert L. Turner, and Robert C. Jachens
U.S. Geological Survey

Thomas J. Peters and Richard A. Winters
U.S. Bureau of Mines

SUMMARY

Abstract

The Malheur River-Bluebucket Creek Wilderness Study Area (OR-002-014) is located about 40 mi northeast of the city of Burns in central Oregon (fig. 1). At the request of the U.S. Bureau of Land Management 5,560 acres of the Malheur River-Bluebucket Creek Wilderness Study Area were evaluated for mineral resources (known) and mineral resource potential (undiscovered). In this report, the area studied is referred to as the "Malheur River-Bluebucket Creek Wilderness Study Area" or the "study area."

The study area is underlain by flat-lying to gently dipping Neogene andesite, basalt, and tuffaceous sedimentary rocks, and Quaternary surficial deposits. No mineral resources are identified in the study area, nor are there any active mining claims or mineral leases. The northern part of the study area has low potential for gold and silver (fig. 2); gold was detected in one stream-sediment sample and low levels of metals associated with epithermal precious-metal deposits were found in nearby samples. The study area has low potential for oil and gas. There are no indications of oil and gas in the surface geology; however, if these resources are present in the study area, they would likely be buried by several thousand feet of volcanic rocks. The study area has no potential for geothermal resources. No young volcanic centers or active thermal springs are present in or near the study area. The southwestern part of the study area has low potential for diatomite.

Location and Setting

The Malheur River-Bluebucket Creek Wilderness Study Area (OR-002-014) is located in northern Harney County, Oreg., about 35 mi northeast of Burns, Oreg. (fig. 1). The study area comprises 5,560 acres of land administered by the U.S. Bureau of Land Management. Part of the north boundary of the study area adjoins the Malheur National Forest. The study area lies about 18 mi east of U.S. Highway 395, and about 15 mi north of U.S. Highway 20. Paved county roads and improved gravel roads provide access from the main highways to the study area.

The southern part of the study area consists of sparsely vegetated mesas 300 to 450 ft above the northwesterly trending valley along Wolf Creek and the Malheur River to the south. The northern part of the study area includes forested highlands incised by steep, rugged canyons along the Malheur River and Bluebucket Creek.

The study area is underlain largely by flat-lying to gently dipping, Neogene (see "Appendixes" for geologic time chart) volcanic rocks and volcanogenic sedimentary rocks. Middle to late Miocene andesite lavas underlie the northern part of the study area. In the southern part of the study area, the andesite is completely buried beneath tuffaceous sedimentary rocks and interlayered basalt which, in turn, are overlain by mesa-forming basalt.

Identified Resources

No mineral resources were identified in the study area; there are no active mining claims or mineral leases. Diatomaceous sediment that is present west of the study area may extend into the study area beneath the basalt mesas of Battle Mountain. The diatomaceous sediment is too impure to be considered a diatomite resource. Basalt is abundant and could be used for construction material; however, it is abundant throughout the region in areas closer to potential markets. There are no oil and gas or geothermal leases or applications. No geothermal or mineral energy resources were identified.
Mineral Resource Potential

The northern part of the study area has low potential for gold and silver (fig. 2). One stream-sediment sample contains an anomalous amount of gold. Other samples

Figure 2. Generalized geology and mineral resource potential of Malheur River-Bluebucket Creek Wilderness Study Area, Harney County, Oregon. Geology modified from Greene and others (1972) for areas south of 44° N. and from Brown and Thayer (1966) for areas north of 44° N.

Figure 1. Index map showing location of Malheur River-Bluebucket Creek Wilderness Study Area, Harney County, Oregon. Unlabeled solid lines are secondary paved roads. Unlabeled dashed lines are gravel roads or jeep trails.
Area having low mineral resource potential

B Certainty level of assessment—Data only suggest level of potential

Commodities
Au Gold
Ag Silver
O, G Oil and gas
diat Diatomite

Map units
Qa Alluvium (Quaternary)
Qg Gravel deposits (Quaternary)
Tb Basalt (late Miocene and (or) Pliocene)
Twt Welded tuff (late Miocene)
Tbl Lower basalt (middle and (or) late Miocene)
Tsb Tuffaceous sedimentary rocks and basalt (middle and (or) late Miocene)
Ta Andesite (early and middle Miocene)

Contact
Fault—Bar and ball on downthrown block
Location, Access, and Character

The study area lies in northern Harney County in east-central Oregon (fig. 1). The nearest city is Burns, Oreg., about 35 mi southwest of the study area; the small community of Drewsey is about 11 mi to the southeast. The U.S. Forest Service maintains a guard station during the summer months at Van, about 6 mi west of the study area.

The principal access to the study area is along the graded and, in part, paved road between Seneca, along U.S. Highway 395, and Drewsey, 2 mi north of U.S. Highway 20. Along this road, the study area is about 35 mi from U.S. Highway 395, and about 20 mi from U.S. Highway 20 via Drewsey. A gravel road leads up to and follows the east boundary of the study area to Bluebucket Creek and a jeep trail is located about a mile west of the study area.

Relief in the area is about 1,100 ft; elevations range from about 4,000 ft along the Malheur River to about 5,100 ft on the ridge west of the Malheur River in the northern part of the study area. The southern part of the study area comprises sparsely vegetated mesas 300 to 450 ft above the northwest-trending valley along Wolf Creek and the Malheur River to the south and southwest. The northern part of the study area includes forested highlands that are incised by rugged canyons along the Malheur River and Bluebucket Creek.

The study area is underlain chiefly by flat-lying to gently dipping Neogene volcanic rocks and volcanogenic sedimentary rocks (fig. 2). The northern part of the study area is underlain largely by andesite. Tuffaceous sedimentary rocks and interbedded basalt, locally covered by mesa-forming basalt, overlie the andesite from the central part of the study area to the south. Small areas adjacent to the study area are underlain by late Miocene ash-flow tuff.

Previous Investigations

The Malheur River-Bluebucket Creek Wilderness Study Area is included in regional reconnaissance and compilation geologic maps by Greene and others (1972) and Walker (1977). Topical studies on the widespread ash-flow tuffs in this part of Oregon were undertaken by Greene (1973) and Walker (1979); geologic studies pertaining to the ash-flow tuffs were also done by Walker and Swanson (1968). The geology of the Canyon City 1° by 2° quadrangle, north of the study area, was mapped by Brown and Thayer (1966). Walker and Denton (1982) reported the results of a mineral resource appraisal of the Pine Creek Roadless Area, located about 10 mi south of the Malheur River-Bluebucket Creek Wilderness Study Area in the Malheur National Forest (fig. 1).

The study area is included in regional surveys aimed at assessing potential for uranium resources (High Life Helicopters, Inc./QEB, Inc., 1981), oil and gas (Fouch, 1982, 1983), and geothermal resources (Riccio, 1978).

Present Investigations

The USGS conducted field investigations in the study area in 1986. These consisted of geologic mapping at a scale of 1:24,000, field checking of existing maps, geochemical sampling, and examining outcrops for evidence of mineralization. Thirty-one rock samples, mostly from outcrop, seven stream-sediment samples, and seven nonmagnetic heavy-mineral-concentrate samples panned from stream sediment were analyzed to reveal areas having anomalous concentrations of elements of interest. All analyses were performed at USGS laboratories in Denver, Colo., and were reported by Erickson and others (1989).
The investigation by the USBM included prefield library research and examinations of BLM and Harney County mining records. In July 1986, ground searches were made for any indication of possible mineral resources such as prospect workings, mineralized structures, alteration zones, or rock types having potential value as industrial minerals. Six rock samples and six alluvial samples were taken. All samples were checked for radioactivity and fluorescence. Rock samples were prepared for analysis at the USBM Western Field Operations Center, Spokane, Wash., and analyses were done by a contract laboratory. Alluvial samples were concentrated on a laboratory-size Wilfley table to extract possible free gold and other heavy minerals. Results of the USBM study were reported by Peters and Winters (1987).

Acknowledgments

T.J. Peters and R.J. Winters thank Roger Britton and Mark Hosket, BLM, Burns, Oreg., and Victor Bartkus, BLM, Portland, Oreg., for helpful advice on logistics and land status. Andrew E. Visocan, Mine and Mill Manager, Eagle-Picher Industries, Vale, Oreg., provided tours for USGS and USBM personnel of the Celatom diatomite mine, east of the study area, and helpful insight into diatomite resources of the region. M.G. Sawlan thanks the U.S. Forest Service, Burns, Oreg., for providing lodging and use of facilities at the Van Guard Station.

APPRAISAL OF IDENTIFIED RESOURCES

By Thomas J. Peters and Richard A. Winters
U.S. Bureau of Mines

Mining Activity

There are no active mines, prospects, patented mining claims, or mineral leases in the Malheur River-Bluebucket Creek Wilderness Study Area. There is no record of mineral production from within the study area, and there are no oil and gas or geothermal leases or lease applications.

Harney County records indicate the Riley claim was located by George V. Riley in April 1940, 0.5 mi south of Sage Hen Flat in T. 18 S., R. 34 E., which includes the north half of the study area (fig. 2). The courthouse records, available maps, and a subsequent ground search did not disclose specific locations for Sage Hen Flat or the mining claim. Courthouse records indicate several scattered placer and lode claims and small claim groups for precious metals in the headwaters of the Malheur River drainage basin north of the study area.

The recently active Red Butte/Pine Creek gold prospect is located in the northern Stinking Water Mountains south of the Malheur River, 5 to 7 mi south of the study area (fig. 1). Permits for exploration drilling in this area were issued to Battle Mountain Exploration Company in 1990 (Wiley, 1991). Alteration occurs in and adjacent to a rhyolite mass shown on Greene's (1972) map as unit Trd ("rhyodacite"). A sample of silicified rhyolite breccia from this unit contained anomalous amounts of gold (71 ppb) and molybdenum (70 ppm). The rhyolite and associated alteration do not extend into the study area.

About $50,000 in gold, equivalent to about 2,400 ounces of gold (using a gold value of $20.67 per ounce for the late 1880's to 1934), was produced around the turn of the century from the Harney (Idol City-Trout Creek) Mining District about 18 mi southwest of the study area (fig. 1). Most production was from placer deposits although some lode gold apparently was also mined from andesite along a northwest-trending shear zone (Brooks and Ramp, 1968; Walker and Denton, 1982). In 1981, Noranda Exploration, Inc., explored for lode gold in the district (Denton, 1982, p. 6), and placer deposits in young valley fill were also being worked by seven claimants (Denton, 1981, p. 8). In 1989, Newmont Exploration, Ltd., did exploration drilling for lode gold in the district (Wiley, 1991).

Eagle-Picher Industries' Celatom diatomite mine, Drewsey, Oreg., is 15 mi southeast of the study area and is the only operating mine nearby. Miocene lake deposits stratigraphically equivalent to those at the Celatom diatomite mine are found in the study area.

Small borrow pits in gravel deposits between Wolf Creek and the Malheur River (fig. 2) have probably been used in construction by local ranchers. There is no record of commercial production and the gravel deposits do not extend into the study area.

Diatomaceous Sediment

No diatomite or diatomaceous sediment was observed in the study area, but an occurrence of diatomaceous sediment as thick as 365 ft is found directly west of the study area, and it probably extends under part of the study area near Battle Mountain. The sediment is generally tan to cream colored and ash and silt laden. Between 10 and 20 percent of the sediment is relatively pure white diatomite, which formed as 1- to 2-ft-thick beds. The diatomaceous sediment is covered by a 165-ft-thick basalt cap that forms Battle Mountain (fig. 2).

Diatomaceous sediment west of the study area is too impure to be considered a diatomite resource. The thin beds of relatively pure diatomite, which make up less than 20 percent of the sedimentary pile, can not be separated economically, and the cost of underground mining or the removal of the overlying basalt would be prohibitive. Economic exploitation of the diatomaceous sediment is unlikely.
Basalt and andesite are abundant in the study area. Five of the six rock samples taken by the USBM in the study area were of mafic volcanic flows; analytical results are presented in Peters and Winters (1987). The basalt is too low in alumina to be a future source of aluminum (Avent, 1970). It could possibly be used for products such as basalt fiber (Wullenwaber and Dailey, 1975), road metal, or stone products but it is not classified as a resource (U.S. Bureau of Mines and U.S. Geological Survey, 1980; see “Appendixes”), because there is no commercial demand for basalt fiber, convenient sources of road metal are abundant in the region, and markets for stone are remote.

Placer Samples

Six alluvial placer samples were taken but none contained free gold.

Identified Resources and Recommendations

There are no identified resources (U.S. Bureau of Mines and U.S. Geological Survey, 1980) in the Malheur River-Bluebucket Creek Wilderness Study Area. No further work is recommended.
tures. Basalt of this unit was mapped separately in the area southwest of Battle Mountain along Coyote Creek (unit Tbl, fig. 2), where dissected remnants of basalt vents comprising agglutinated lava, cinders, and feeder dikes are found. Basalt from the vent area west of Coyote Creek is distinctive in that it contains abundant large phenocrysts of olivine and plagioclase. Palagonite tuff is present locally.

These sediments and lavas were deposited in a north-west-trending basin extending from near Van to at least 20 mi southeast (fig. 1). The tuffaceous sedimentary rocks and basalt unit is at least 1,000 ft thick in the area southwest of Battle Mountain but pinches out against andesite beneath Moffit Table and north of Battle Mountain. These deposits apparently lap onto the andesite in erosional unconformity but no outcrops were found that explicitly show this relation. Gravity data (see “Geophysics” section) suggest that the northeast to southwest increase in thickness of the tuffaceous sedimentary rocks is gradual across the basin’s northeast margin, which trends north-west across the center of the study area. That is, there appear to be no significant bounding faults that controlled basin formation. The basin in the vicinity of the study area most likely represents an erosional landform or a homoclinal downwarp of the andesite basement, dipping about 10° southwest.

Welded ash-flow tuff underlies areas northeast and east of the study area, and small areas southwest of the study area at the confluence of Wolf Creek and the Malheur River (unit Twt, fig. 2). Two tuff units are represented: the Devine Canyon Ash-Flow Tuff, which erupted at about 9.2 Ma, and the Rattlesnake Ash-Flow Tuff, which erupted at about 6.5 Ma (Walker, 1979; Greene and others, 1972). The younger Rattlesnake Ash-Flow Tuff crops out at elevations about 400 ft higher than the Devine Canyon Ash-Flow tuff. The Devine Canyon Ash-Flow Tuff underlies small areas at elevations around 4,500 ft in and adjacent to the central part of the study area north of Battle Mountain, and to the east along Bluebucket Creek. This tuff is crystal-rich and contains 25 to 30 percent crystals and crystal fragments mostly of alkali feldspar (sanidine and anorthoclase(?)) and minor amounts of quartz. Welded tuff, tentatively correlated with the Rattlesnake Ash-Flow Tuff, crops out in small areas northeast of the study area, about 1 mi north of Bluebucket Creek and 1 mi east of the Malheur River, at elevations around 4,900 ft. This tuff is generally thin (3–6 m thick) and crystal poor; it contains less than 2 percent phenocrysts mostly of alkalic feldspar, quartz, clinopyroxene (pale green in thin section) and rare grains of oxidized biotite(?). Both tuffs are regionally extensive and thicken southwest toward Harney Basin where the tuffs erupted from a caldera that is now buried by younger sediments (Walker, 1979).

A thin sequence of fluvial sandstone and pebble conglomerate caps the tuffaceous sedimentary rocks and directly underlies mesa-forming basalt. Owing to generally poor exposure and thinness, these deposits are included in the tuffaceous sedimentary rocks and basalt unit in mapping but are probably penecontemporaneous with the overlying mesa-forming basalt. These fluvial deposits, about 15 to 40 ft thick, show numerous sedimentary structures including channels, scour and fill structures, crossbedding, and soft-sediment load structures. These rocks contain abundant vesicular basalt detritus most likely derived from pyroclastic material associated with eruptions that produced the mesa-forming basalt.

Basalt lavas cap mesas in a northwest-trending belt across the southern part of the study area (unit Tb, fig 2). Moffit Table and Battle Mountain are two prominent mesas that are mostly included in the southern parts of the study area and stratigraphically equivalent basalt overlies andesite and ash-flow tuff north and northeast of the study area. Mesa-forming basalt in the region has been mapped as the Drinkwater Basalt (Greene and others, 1972), which was named by Bowen and others (in Shotwell, 1963, p. 31–32). Greene and others (1972) reported a K-Ar age of 6.91±1.09 Ma on Drinkwater Basalt from 40 mi south of the study area. The mesa-forming basalt in the study area is, therefore, probably late Miocene and (or) Pliocene in age; these basalt are not been dated in or near the study area. The mesa-forming basalt typically comprise one to four flows having a composite thickness of 30 to 150 ft. They are aphyric or contain phenocrysts of olivine+plagioclase, and commonly show a diktytaxitic (spongy) groundmass texture. These basalts are nearly flat lying or dip gently, less than 2 to 3° southeast. They lie in slight angular unconformity over the tuffaceous sedimentary rocks and basalt unit which, southwest of Moffit Table, dips to the northeast 5 to 10°.

Basalt-capped mesas are found at elevations that differ by as much as 440 ft. Individual flows cannot be correlated across these mesas and the number and thickness of flows differ between adjacent mesas. Three levels of mesas are present in the area. The highest level of mesa basalt, at about 4,840 ft, includes Moffit Table and narrow mesas of the northeast side of Battle Mountain; the middle level, at about 4,700 ft, is represented by the large basalt mesa of Battle Mountain; and the lowest level, at about 4,450 to 4,500 ft, includes basalt on the northwest side of Battle Mountain and mesas to the west. The basalts most likely flowed into shallow, elongate, fluvial drainages that possibly were established by normal faulting. Erosion of poorly lithified tuffaceous sediments not covered by basalt lavas likely occurred between emplacement of individual flow units of the mesa basalt sequence. Thus, the basalt lavas forming the highest mesas are the oldest, and those forming the lower mesas are younger, having flowed into more deeply incised drainages adjacent to older lavas. The northwest trend of the mesas, and the gentle southwest dip of the mesas suggests that a northwest to southeast drainage pattern covered this area during eruption of the mesa basalts.
Differences in elevations of the mesas that cannot be attributed to faulting suggest that the mesa basalts erupted during an extended period of time during which the tuffaceous unit was incised by erosion. The presence of fluvial sandstone and gravel, as well as the basalt debris within these gravels beneath the basalt mesa of Moffit Table suggest that these basalts were deposited in fluvial channels.

Quaternary alluvial gravels locally form low dissected benches about 10 to 20 ft thick along the Malheur River near the confluence with Coyote Creek, southwest of the study area (unit Qg, fig. 2). Recent alluvium (unit Qa, fig. 2) comprises coarse angular gravel, sand, and silt in and along active streams.

Structure

The sedimentary rocks and interbedded basalt were deposited in a narrow northwest-trending basin roughly 7 to 10 mi wide, floored by Miocene andesite, extending from several miles northwest of Van to southeast of Drewsey (fig. 1). Although depth to underlying andesite increases, from northeast to southwest, more than 800 ft over a distance of about 1 mi, no significant offsets of the andesite basement to the basin are suggested in the gravity data. If bounding faults along the northeast margin of the basin exist, these have been covered by the tuffaceous sedimentary rocks and basalt. As noted above, the basin probably represents an erosional surface, or possibly a homoclinal downwarp of the andesitic basement, dipping about 10° southwest. Local and minor tilting of ash-flow tuff, from 15 to 25°, is observed only in small areas adjacent to faults south of the study area near Wolf Creek.

The mesa basalts appear to be younger than north-northwest-trending faults mapped by Brown and Thayer (1966) in adjacent areas to the north. The elongation and northwest trend of basalt mesas of a given height (broadly correliative with age) may be explained as the result of lavas flowing into shallow northwest-trending basins that deepened by about 400 ft during the time in which the mesa-forming basalts erupted. Deepening of the basins is probably the result of erosion because the mesa basalts are not faulted.

Geochemistry

Introduction

A reconnaissance geochemical survey was conducted in the Malheur-Bluebucket Creek Wilderness Study Area by the USGS in the summer of 1986. This study consisted of collecting, analyzing, and evaluating rock, minus-80 mesh (0.18 mm) stream sediment, and nonmagnetic heavy-mineral panned-concentrate (hereafter referred to as heavy-mineral concentrate) samples. Seven sites were sampled for stream sediments and 31 sites were sampled for rocks; heavy-mineral concentrates were obtained at six of the seven stream-sediment sites.

The stream-sediment and heavy-mineral concentrate samples are collected primarily for their ability to reveal metal anomalies within drainage basins. Stream sediments represent a composite of the rock and soil exposed upstream from the sample site. The processing of heavy-mineral concentrates tends to remove common rock-forming minerals and to concentrate ore and ore-related minerals. The selective concentration of minerals permits determination of some elements that are not easily detected in bulk stream-sediment samples (if mineralization has occurred in the study area).

The rock samples, nearly all of which appeared unaltered and unmineralized, were collected from outcrop and stream float to determine if analysis might reveal an indication of mineralization. Samples that appeared fresh and unaltered were collected to provide information on geochemical background values. Anomalous values were determined by statistical methods, by comparison of mineralized and altered samples with their unaltered equivalents, and by comparison with published data for common rock types.

Samples

The stream-sediment samples were collected from active alluvium in the stream channel. Each sample was composited from several localities along a channel length of approximately 50 ft. The stream sediments were sieved through an 80-mesh screen. The heavy-mineral concentrates were obtained by sieving stream sediment through a 10-mesh screen and then panning the passing fraction until most of the quartz, feldspar, clay-sized material, and organic matter were removed. The remaining light minerals were separated from the heavy minerals with a heavy liquid (bromoform, specific gravity 2.8). Magnetite and ilmenite were removed from the material having a specific gravity greater than 2.8 using an electromagnet. Before analysis, the stream-sediment, heavy-mineral concentrate, and rock samples were ground to a fine powder.

Analytical Methods

All samples were analyzed for 31 elements by direct-current arc, semiquantitative emission spectrographic analysis routinely used by the USGS (Grimes and Marranzino, 1968; Crock and others, 1983). The rock and stream-sediment samples were, in addition, analyzed for arsenic, bismuth, cadmium, antimony, and zinc (O'Leary and Viets, 1985), gold (Thompson and others, 1968), and mercury (Koirtyohann and Khalil, 1976). We were unable to analyze the heavy-mineral concentrate samples by these additional methods because of insufficient amounts of sample material. Analytical data and description of the sampling and analytical techniques are given in Erickson and others (1989).
The Bouguer gravity field over the study area and surrounding the area are sparsely distributed near the study area. The observed gravity data, based on the International Gravity Standardization Net datum (Morelli, 1974), were reduced to free-air gravity anomalies. These data suggest that mineralized rock containing gold and associated silver may be present in andesitic rocks in the northern part of the study area. Andesite, cut by a northwest-trending shear zone, is the host for gold in the Harney Mining District (Brooks and Ramp, 1968, p. 160). Thin hyalite veins are present as coatings on fractures in the andesite; no geochemical anomalies were detected in analyses of these veins.

Geophysics

Introduction

Three types of geophysical data (gravity, magnetic, and radiometric) from east-central Oregon were compiled and examined to aid in assessment of the mineral resource potential of the Malheur River-Bluebucket Creek Wilderness Study Area. The sparsely distributed nature of the three data sets makes them adequate for addressing only the regional structural and tectonic setting of the study area and it does not permit statements about mineral resource potential at the deposit scale.

Gravity Data

Gravity data for the region surrounding the study area were obtained from the National Geophysical Data Center, National Oceanic and Atmospheric Administration, Boulder, Colo. Data points are scattered at 3- to 5-mi spacings in the region but no data points fall within the study area. The observed gravity data, based on the International Gravity Standardization Net datum (Morelli, 1974), were reduced to free-air gravity anomalies using standard formulas (Telford and others, 1976). Bouger, curvature, and terrain corrections (to a distance of 103.6 mi from each station) at a standard reduction density of 2.67 g/cm³ were added to the free-air anomaly at each station to determine complete Bouger gravity anomalies.

The Bouger gravity field over the study area and surrounding regions reflects both shallow density contrasts and deep-crustal density distributions that correlate with the topography in a manner consistent with the concept of isostasy. To isolate that part of the gravity field that arises from upper crustal density distributions, an isostatic residual-gravity map was constructed from the Bouguer gravity data by removing a regional gravity field computed from a model of the crust-mantle interface, assuming Airy-type isostatic compensation (Jachens and Griscom, 1985). A regional gravity perspective of the setting of the study area can be seen on the map of Jachens and others (1985).

The study area lies near the center of a gravity gradient that connects a 40-mi-long by 15-mi-wide east-northeast-trending gravity high to the south with a roughly circular 20-mi-diameter gravity low to the north. Gravity contours near the study area are nearly perpendicular to the structural grain defined by numerous north-northwest-trending normal faults that cut the exposed Tertiary volcanic rocks. The contours also cut across the northwest-trending basin filled with tuffaceous sedimentary rocks that lies south of and includes the southern half of the study area.

The gravity gradient that crosses the study area probably is caused by a combination of two sources, both related to the pre-Tertiary basement that lies beneath the volcanic cover. Part of the gradient most likely reflects a southward increase in density of the basement rocks from mainly clastic strata of the Forearc Basin terrane (Brooks, 1979) on the north, to denser rocks to the south that may be part of the Huntington volcanic-arc terrane (Brooks, 1979). The contact between these two terranes is exposed 45 mi northeast of the study area where it is marked by a gravity gradient that tentatively can be followed southwest to near the study area.

An additional contribution to the gravity gradient in the vicinity of the study area probably arises from a northward dip of the basement surface and the associated northward thickening of the overlying volcanic section. Geologic mapping (Brown and Thayer, 1966) indicates a large depression filled with Tertiary volcanic rock north of the study area; the associated gravity low of about 30 milliGals (mGal) in this area suggests this basin may be 10,000 ft or more deep.

Although the gravity data are sparsely distributed near the study area, the lack of a recognizable gravity low associated with the tuffaceous sedimentary rocks that fill the basin south of the study area suggests that these sedimentary rocks are not thicker than 1,000 ft.

Aeromagnetic Data

An aeromagnetic survey of east-central Oregon, including the study area, was flown and compiled under contract to the USGS in 1983 (U.S. Geological Survey, 1984). Total field magnetic data were collected along east-west flightlines spaced approximately 3 mi apart and at a constant barometric elevation of 7,000 ft. Corrections were applied to the data to compensate for diurnal variations of the Earth's magnetic field, and the international Geomagnetic Reference Field...
The mineral resource potential of the Malheur River-Bluebucket Creek Wilderness Study Area was assessed on the basis of geologic investigations, geochemical and geophysical studies, and studies of prospects and claims in areas of reported mineral occurrences and of deposits in nearby regions. The northern part of the study area has low potential for gold and silver resources in epithermal deposits, with a certainty level of B. This area includes all parts of the study area underlain by andesite. This assignment is based on the detection of gold in one stream-sediment sample and low amounts of related metals in nearby samples.

There is low potential for oil and gas in the entire study area (Fouch, 1982, 1983). The tuffaceous sedimentary rocks, the only likely exposed source rock for hydrocarbons, do not contain significant amounts of organic material. There are no geologic indications of oil and gas or structural traps for hydrocarbon accumulation in or around the study area; hence, the assessment of low potential may be too high. If oil and gas are present at depth in the area, they are buried by volcanic rocks as much as several thousand feet thick, and they could only be found with detailed geophysical surveys. The certainty of assessment, therefore, is B.

The Malheur River-Bluebucket Creek Wilderness Study Area has no geothermal energy potential (Muffler, 1979). No young volcanic centers are present in or near the study area. The youngest volcanic rocks in the study area are the basalts capping mesas, which are probably older than 5 Ma, and no fossil or active hot springs are present in the study area. Therefore, the level of certainty of this assessment is D. The study area has no potential for mineral energy resources.

REFERENCES CITED


Denton, D.K., 1981, Mineral resources of the Pine Creek RARE II Area (no. 6248), Harney County, Oregon: U.S.
APPENDIXES
DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

LEVELS OF RESOURCE POTENTIAL

H 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.

M 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 reasonable likelihood for resource accumulation, an (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

L 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 permissive. This broad category embraces areas with dispersed but insignificantly mineralized rock, as well as areas with little or not indication of having been mineralized.

N NO mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

U UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign a low, moderate, or high level of resource potential.

LEVELS OF CERTAINTY

A Available information is not adequate for determination of the level of mineral resource potential.

B Available information only 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.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>U/A</td>
<td>U/B</td>
<td>H/B</td>
<td>H/C</td>
<td>H/D</td>
</tr>
<tr>
<td>HIGH POTENTIAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M/B</td>
<td>M/B</td>
<td>M/C</td>
<td>M/D</td>
<td></td>
</tr>
<tr>
<td>MODERATE POTENTIAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L/B</td>
<td>L/B</td>
<td>L/C</td>
<td>L/D</td>
<td>N/D</td>
</tr>
<tr>
<td>LOW POTENTIAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNKNOWN POTENTIAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LEVEL OF CERTAINTY

Abstracted with minor modifications from:

H14 Mineral Resources of Wilderness Study Areas: East-Central Oregon
### RESOURCE/RESERVE CLASSIFICATION

<table>
<thead>
<tr>
<th>IDENTIFIED RESOURCES</th>
<th>UNDISCOVERED RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECONOMIC</td>
</tr>
<tr>
<td></td>
<td>Inferred</td>
</tr>
<tr>
<td></td>
<td>Hypothetical</td>
</tr>
<tr>
<td>Measured</td>
<td>Reserves</td>
</tr>
<tr>
<td>Indicated</td>
<td>Inferred Reserves</td>
</tr>
</tbody>
</table>

## GEOLOGIC TIME CHART
Terms and boundary ages used by the U.S. Geological Survey in this report

<table>
<thead>
<tr>
<th>EON</th>
<th>ERA</th>
<th>PERIOD</th>
<th>EPOCH</th>
<th>AGE ESTIMATES OF BOUNDARIES IN MILLION YEARS (MA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>66</td>
</tr>
<tr>
<td>Cenozoic</td>
<td>Tertiary</td>
<td>Quaternary</td>
<td>Holocene</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neogene Subperiod</td>
<td>Pliocene</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paleogene Subperiod</td>
<td>Miocene</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oligocene</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Eocene</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Paleocene</td>
<td></td>
</tr>
<tr>
<td>Phanerozoic</td>
<td>Mesozoic</td>
<td>Cretaceous</td>
<td>Late</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jurassic</td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Triassic</td>
<td>Late</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Permian</td>
<td>Late</td>
<td>~240</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carboniferous Periods</td>
<td>~290</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pennsylvania</td>
<td>Late</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mississippian</td>
<td>~330</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Late</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paleozoic</td>
<td>~360</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Devonian</td>
<td>Late</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silurian</td>
<td>Late</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ordovician</td>
<td>Late</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cambrian</td>
<td>Late</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Middle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Early</td>
<td></td>
</tr>
<tr>
<td>Proterozoic</td>
<td></td>
<td>Late Proterozoic</td>
<td>~570</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle Proterozoic</td>
<td>~900</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Early Proterozoic</td>
<td>1600</td>
<td></td>
</tr>
<tr>
<td>Archean</td>
<td></td>
<td>Late Archean</td>
<td>2500</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle Archean</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Early Archean</td>
<td>3400</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pre-Archean</td>
<td>(3800?)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4550</td>
<td></td>
</tr>
</tbody>
</table>

1Rocks older than 570 Ma also called Precambrian, a time term without specific rank.
2Informal time term without specific rank.
Mineral Resources of Wilderness Study Areas: East-Central Oregon

This volume was published as separate chapters A–H
CONTENTS

[Letters designate the separately published chapters]


(C) Mineral Resources of the Camp Creek and Cottonwood Creek Wilderness Study Area, Malheur County, Oregon, by William J. Keith, Robert L. Turner, Andrew Griscom, John R. Benham, and Michael S. Miller.

(D) Mineral Resources of the Upper Leslie Gulch and Slocum Creek Wilderness Study Area, Malheur County, Oregon, by Dean B. Vander Meulen, Andrew Griscom, Harley D. King, and John R. Benham.

(E) Mineral Resources of the Gold Creek and Sperry Creek Wilderness Study Area, Malheur County, Oregon, by James G. Evans, James G. Frisken, Andrew Griscom, Don L. Sawatzky, and Michael S. Miller.

(F) Mineral Resources of the Lower Owyhee Canyon Wilderness Study Area, Malheur County, Oregon, by James G. Evans, Robert L. Turner, Andrew Griscom, Don Sawatzky, and J. Douglas Causey.

(G) Mineral Resources of the Blue Canyon and Owyhee Breaks Wilderness Study Areas, Malheur County, Oregon, by Dean B. Vander Meulen, Vincent E. Barlock, Patrick S. Plumley, James G. Frisken, Andrew Griscom, and J. Douglas Griscom.

SELECTED SERIES OF U.S. GEOLOGICAL SURVEY PUBLICATIONS

Periodicals

Earthquakes & Volcanoes (issued bimonthly).
Preliminary Determination of Epicenters (issued monthly).

Technical Books and Reports

Professional Papers are mainly comprehensive scientific reports of wide and lasting interest and importance to professional scientists and engineers. Included are reports on the results of resource studies and of topographic, hydrologic, and geologic investigations. They also include collections of related papers addressing different aspects of a single scientific topic.

Bulletins contain significant data and interpretations that are of lasting scientific interest but are generally more limited in scope or geographic coverage than Professional Papers. They include the results of resource studies and of geologic and topographic investigations, as well as collections of short papers related to a specific topic.

Water-Supply Papers are comprehensive reports that present significant interpretive results of hydrologic investigations of wide interest to professional geologists, hydrologists, and engineers. The series covers investigations in all phases of hydrology, including hydrogeology, availability of water, quality of water, and use of water.

Circulars present administrative information or important scientific information of wide popular interest in a format designed for distribution at no cost to the public. Information is usually of short-term interest.

Water-Resource Investigations Reports are papers of an interpretive nature made available to the public outside the formal USGS publications series. Copies are reproduced on request unlike formal USGS publications, and they are also available for public inspection at depositories indicated in USGS catalogs.

Open-File Reports include unpublished manuscript reports, maps, and other material that are made available for public consultation at depositories. They are a nonpermanent form of publication that may be cited in other publications as sources of information.

Maps

Geologic Quadrangle Maps are multicolor geologic maps on topographic bases in 7 1/2- or 15-minute quadrangle formats (scales mainly 1:24,000 or 1:62,500) showing bedrock, surficial, or engineering geology. Maps generally include brief texts; some maps include structure and columnar sections only.

Geophysical Investigations Maps are on topographic or planimetric bases at various scales; they show results of surveys using geophysical techniques, such as gravity, magnetic, seismic, or radioactivity, which reflect subsurface structures that are of economic or geologic significance. Many maps include correlations with the geology.

Miscellaneous Investigations Series Maps are on planimetric or topographic bases of regular and irregular areas at various scales; they present a wide variety of format and subject matter. The series also includes 7 1/2-minute quadrangle photogeologic maps on planimetric bases that show geology as interpreted from aerial photographs. Series also includes maps of Mars and the Moon.

Coal Investigations Maps are geologic maps on topographic or planimetric bases at various scales showing bedrock or surficial geology, stratigraphy, and structural relations in certain coal-resource areas.

Oil and Gas Investigations Charts show stratigraphic information for certain oil and gas fields and other areas having petroleum potential.

Miscellaneous Field Studies Maps are multicolor or black-and-white maps on topographic or planimetric bases on quadrangle or irregular areas at various scales. Pre-1971 maps show bedrock geology in relation to specific mining or mineral-deposit problems; post-1971 maps are primarily black-and-white maps on various subjects, such as environmental studies or wilderness mineral investigations.

Hydrologic Investigations Atlases are multicolor or black-and-white maps on topographic or planimetric bases presenting a wide range of geohydrologic data of both regular and irregular areas; principal scale is 1:24,000, and regional studies are at 1:250,000 scale or smaller.

Catalogs

Permanent catalogs, as well as some others, giving comprehensive listings of U.S. Geological Survey publications are available under the conditions indicated below from the U.S. Geological Survey, Books and Open-File Reports Sales, Federal Center, Box 25286, Denver, CO 80225. (See latest Price and Availability List.)

"Publications of the Geological Survey, 1879-1961" may be purchased by mail and over the counter in paperback book form and as a set of microfiche.

"Publications of the Geological Survey, 1962-1970" may be purchased by mail and over the counter in paperback book form and as a set of microfiche.

"Publications of the Geological Survey, 1971-1981" may be purchased by mail and over the counter in paperback book form (two volumes, publications listing and index) and as a set of microfiche.

Supplements for 1982, 1983, 1984, 1985, 1986, and for subsequent years since the last permanent catalog may be purchased by mail and over the counter in paperback book form.

State catalogs, "List of U.S. Geological Survey Geologic and Water-Supply Reports and Maps For (State)," may be purchased by mail and over the counter in paperback booklet form only.

"Price and Availability List of U.S. Geological Survey Publications," issued annually, is available free of charge in paperback booklet form only.

Selected copies of a monthly catalog "New Publications of the U.S. Geological Survey" are available free of charge by mail or may be obtained over the counter in paperback booklet form only. Those wishing a free subscription to the monthly catalog "New Publications of the U.S. Geological Survey" should write to the U.S. Geological Survey, 582 National Center, Reston, VA 22092.

Note.—Prices of Government publications listed in older catalogs, announcements, and publications may be incorrect. Therefore, the prices charged may differ from the prices in catalogs, announcements, and publications.