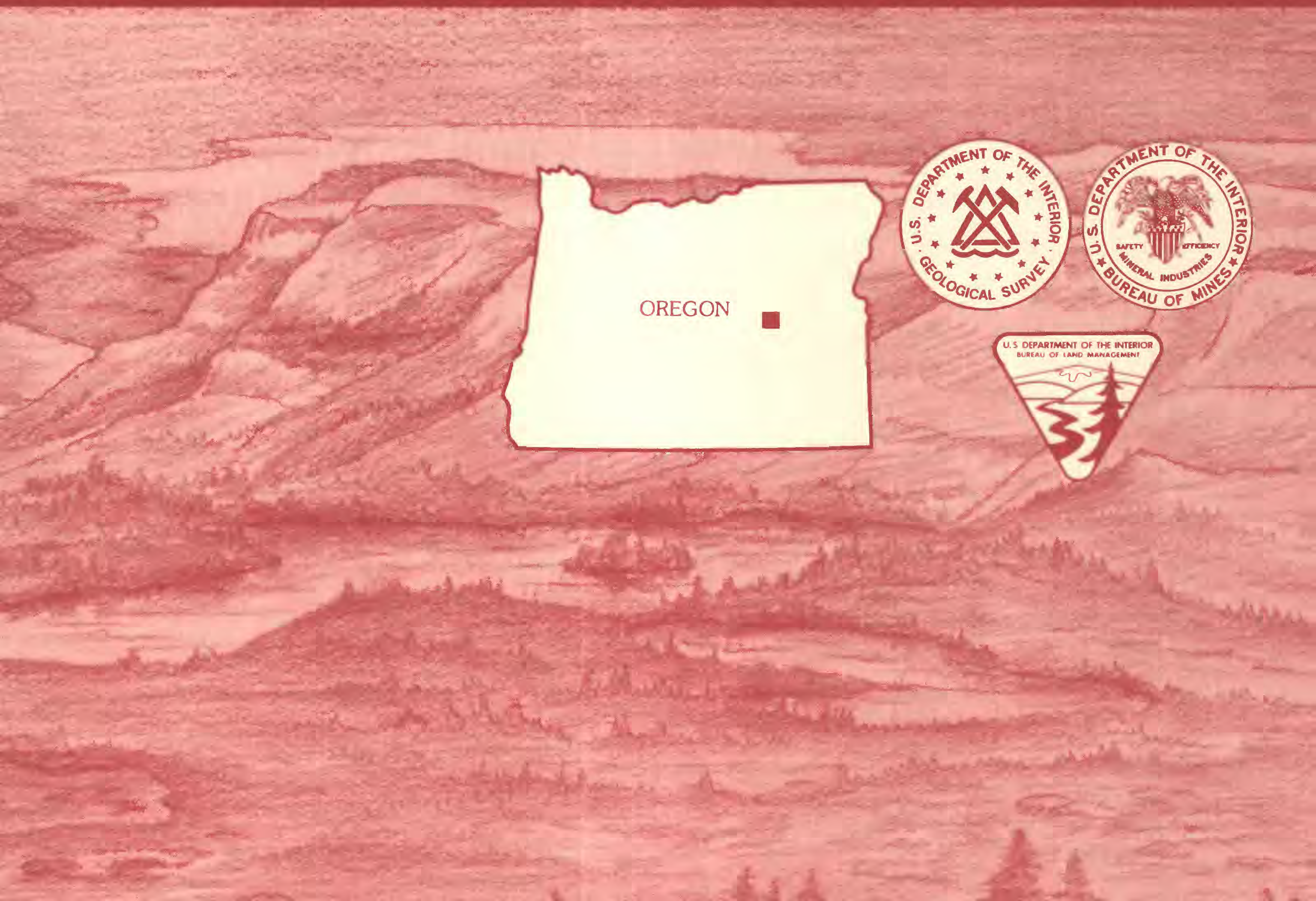
Mineral Resources of the Malheur River–Bluebucket Creek Wilderness Study Area, Harney County, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1741–H



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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

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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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 Malheur River-Bluebucket Creek Wilderness Study Area (OR–002–014), Harvey County, Oregon.

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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 northwest-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.

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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.

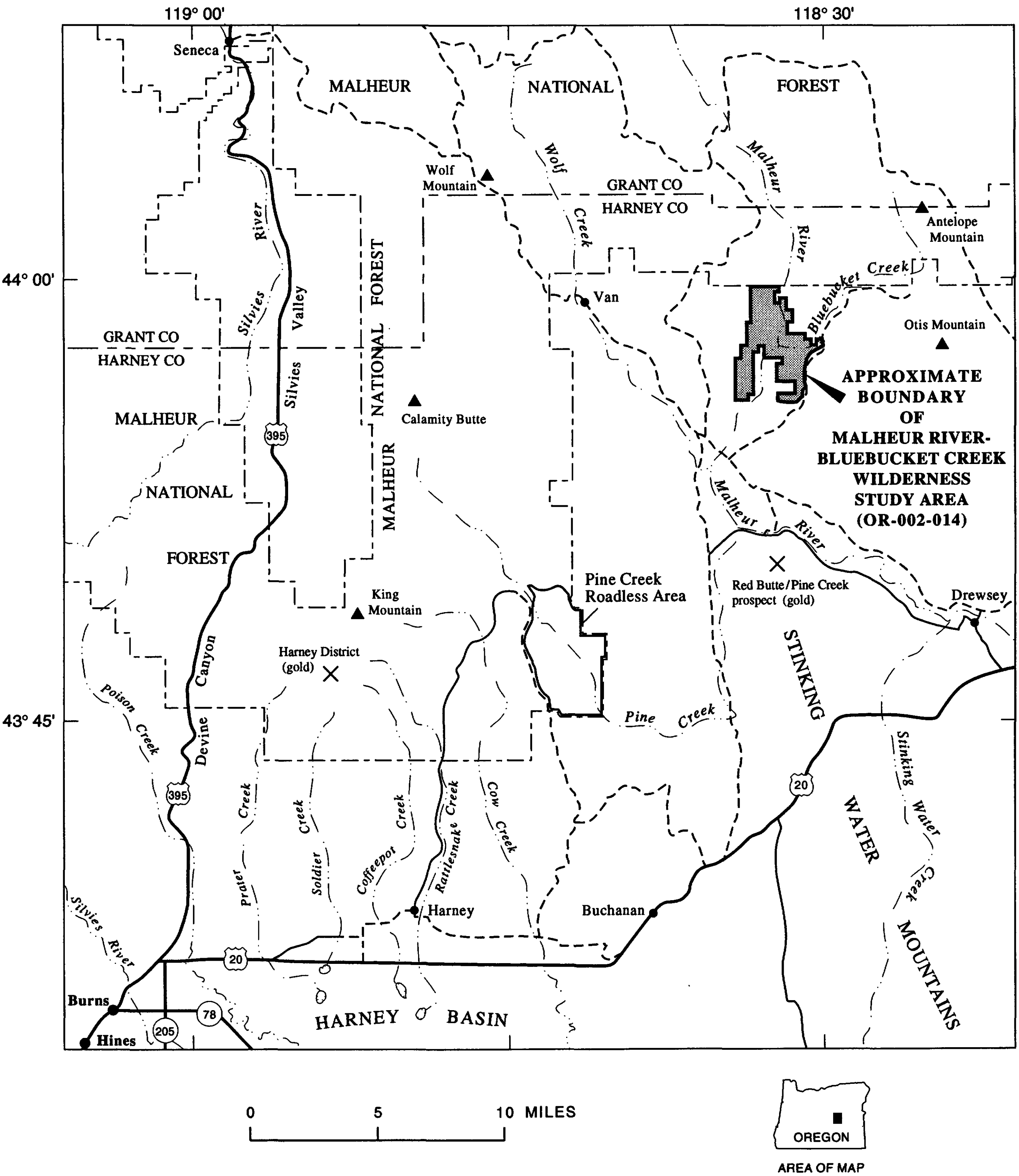
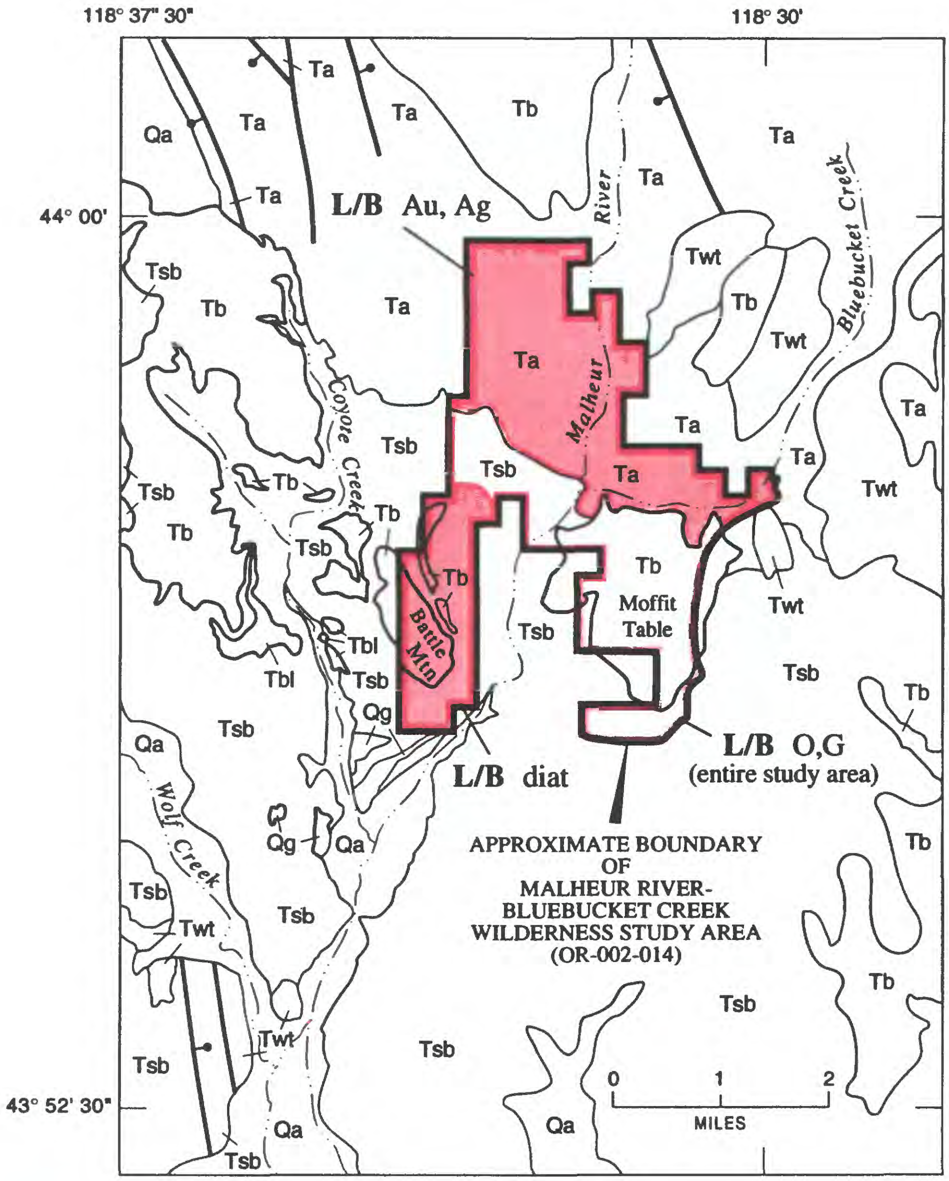


Figure 1. Index map showing location of Malheur River-Bluebucket Creek Wilderness Study Area, Harney County, Oregon. Unlabeled solid lines are secondary paved roads. Unlabeled dashed lines are gravel roads or jeep trails.



EXPLANATION

(pink area)	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

showing low levels of metals associated with precious-metal deposits were found nearby. The southwestern part of the study area has low potential for diatomite. The entire study area is considered to have low potential for oil and gas but there are no indications in the surface geology to indicate the presence of either hydrocarbon source rocks or structural traps. There is no potential for geothermal energy resources in the study area.

INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management (BLM) and is the result of a cooperative effort by the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM). An introduction to the wilderness review process, mineral survey methods, and agency responsibilities was provided by Beikman and others (1983). The USBM evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas. Identified resources are classified according to the system modified from that described by McKelvey (1972) and the U.S. Bureau of Mines and U.S. Geological Survey (1980). Studies by the USGS are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. Goudarzi (1984) discussed mineral assessment methodology and terminology as they apply to these surveys. See "Appendixes" for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

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 an-alyses 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

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.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

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

Geology

The Malheur River-Bluebucket Creek Wilderness Study Area is underlain by flat-lying to gently east-dipping middle and late Miocene volcanic and sedimentary rocks (fig. 2), which are correlative with regionally extensive stratigraphic units. Early and middle Miocene andesite underlies the northern part of the study area. The andesite is overlain by fine-grained tuffaceous sedimentary rocks that are locally intercalated with basalt. These sedimentary rocks were deposited in a narrow northwest-trending basin, roughly 7 to 10 mi wide, extending from several miles northwest of Van to southeast of Drewsey (fig. 1). The interbedded sedimentary rocks and basalt unit is capped by basalt that forms northwest-trending elongate mesas. The Devine Canyon Ash-Flow Tuff is found locally in and near the study area.

Stratigraphy

The oldest rocks exposed in the study area are andesitic lavas (unit Ta, fig. 2), that underlie the northern part of the study area along Malheur River and Bluebucket Creek. The stack of andesite and basaltic andesite lavas along the Malheur River is at least 800 ft thick, and may be as much as 3,000 ft thick judging from the thickness of correlative volcanic sections in and around Harney Basin (Walker and Denton, 1982). The andesitic lavas are mostly sparsely porphyritic basaltic andesite containing phenocrysts of olivine±plagioclase±clinopyroxene and abundantly porphyritic andesite containing mostly plagioclase phenocrysts. These rocks dip gently, less than about 5° to the north, and are part of a regionally extensive andesite unit named the Strawberry Volcanics (Brown and Thayer, 1966). Although this unit consists of lavas in the northern part of the study area, are lavas, it is largely composed of andesite tuff breccia formed from volcanic debris flows southwest of the study area. The age of andesite in the study area is not known precisely but is probably early and middle Miocene on the basis of potassium-argon (K-Ar) ages ranging from about 19 to 12 million years (Ma) on correlative andesite within the surrounding region (Greene and others, 1972; Walker and Denton, 1982) (see "Appendixes" for geologic time scale).

Tuffaceous sedimentary rocks with local intercalated basalt underlie the southern part of the study area (unit Tsb, fig. 2). The tuffaceous rocks are mostly poorly bedded, weakly lithified, and friable siltstone and fine-grained sandstone. The siltstone is locally diatomaceous, and thin, relatively pure diatomite interbeds are found in the area between Battle Mountain and Coyote Creek (fig. 2). These poorly lithified rocks are easily eroded, characteristically form recessive slopes, and are poorly exposed. Attitudes of these strata are best seen in the basalt layers which, in the area south of Moffit Table, dip 5 to 10° northeast. The age of this unit is probably between 12 and 9 Ma (late middle Miocene and (or) early late Miocene) given the age of the underlying andesite is 19 to 12 Ma (Greene and others, 1972; Walker and Denton, 1982), and that the age of the Devine Canyon Ash-Flow Tuff which overlies these rocks is about 9 Ma (Walker, 1979; Greene and others, 1972).

North of Battle Mountain, basalt horizons appear to be absent from the tuffaceous sediment and basalt unit. Basalt is intercalated with sedimentary rocks mostly south, southeast, and southwest of the study area and consists of lava flows, 10 to 20 ft thick, that form thin lenses that can be traced laterally for about a mile or less. A sequence of four to five flows, each separated by sedimentary interbeds, is present southwest of Moffit Table. These flows are characteristically vesicular, strongly weathered, and are aphyric or sparsely porphyritic with olivine phenocrysts. Locally, these flows have pahoehoe (ropey) surface textures. 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 northwest-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 northwest 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 andesitic 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 basalts have not been dated in or near the study area. The mesa-forming basalts 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 correlative 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, 1986), 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).

Results and Interpretations

Anomalous geochemical values were found in samples from three sites in the corner of the study area. Gold (0.2 ppm) was detected in one stream-sediment sample, bismuth (3 ppm) in one heavy-mineral concentrate, and zinc (200 ppm) and molybdenum (5 ppm) in a boulder of basalt or andesite. The sample sites are short drainages west of the Malheur River, in an area underlain principally by andesite (fig. 2). Although gold was found in only one sample, detection of gold in a stream-sediment sample (as opposed to a heavy-mineral concentrate) is notable. The low but anomalous values of bismuth, molybdenum, and zinc do not suggest the possible occurrence of deposits of these metals; they are, however, commonly associated with epithermal precious-metal deposits. 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/cm^3 were added to the free-air anomaly at each station to determine complete Bouguer gravity anomalies.

The Bouguer 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 (updated to the month that the data were collected) was subtracted to yield a residual magnetic field.

The contoured magnetic data near the study area show a "birds-eye" pattern of highs and lows with characteristic dimensions of about 5 mi that is typical of the magnetic field over the volcanic terrane of east-central Oregon. Depth-to-source estimates based on the steep gradients that flank some of the anomalies and the presence of magnetic highs over some topographic highs indicate that the exposed Tertiary volcanic rocks are magnetic and probably can account for most of the anomalies. Highs and lows within mapped volcanic units probably reflect differing magnetic properties of individual flows or sets of lows within the units. The lack of a spatial correlation between the magnetic and gravity anomalies in the areas suggests that any magnetic anomalies caused by magnetization variations within the basement rocks are masked by anomalies owing to the overlying volcanic rocks.

Radiometric Data

A radiometric survey of the Burns 1° by 2° quadrangle, Oreg., was flown and compiled under contract to the U.S. Department of Energy as part of the National Uranium Resource Evaluation (NURE) program (High Life Helicopters, Inc./QEB, Inc., 1981). Recordings were made of gamma-ray flux from radioactive isotopes of potassium, thorium, and uranium along east-west flightlines spaced approximately 6 mi apart and at a height of 400 ft above average terrain. One flightline from the survey crossed the study area at lat. 43°58.63' N. Count rates were low along this line over the study area and gave no indication of anomalous amounts of radioactive elements. However, because only one flightline crossed the study area and because gamma rays are strongly attenuated by passage through earth materials, these data do not preclude the presence of anomalous amounts of radioactive elements away from the flightline or buried more than a few feet beneath the ground surface.

Summary

The geophysical data provide no constraints on the distribution of mineralized areas in the study area. Altered areas are typically only several feet wide and these features can not be resolved with geophysical data based on widely spaced flightlines or stations. No areas were identified that might contain altered or mineralized rock.

MINERAL RESOURCE POTENTIAL

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.

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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 t 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.

LEVEL OF RESOURCE POTENTIAL ↑

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

LEVEL OF CERTAINTY →

Abstracted with minor modifications from:

Taylor, R.B., and Steven, T.A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268-1270.
Taylor, R.B., Stoneman, R.J., and Marsh, S.P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40-42.
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RESOURCE/RESERVE CLASSIFICATION

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

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from McKelvey, V.E., 1972, Mineral resource estimates and public policy: American Scientist, v. 60, p. 32-40; and U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, p. 5.

GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey in this report

EON	ERA	PERIOD		EPOCH	AGE ESTIMATES OF BOUNDARIES IN MILLION YEARS (MA)
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	
		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	[1]~570
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 Ma also called Precambrian, a time term without specific rank.
[2]Informal time term without specific rank.

Mineral Resources of Wilderness Study Areas: East-Central Oregon

This volume was published as separate chapters A–H

U.S. GEOLOGICAL SURVEY BULLETIN 1741

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

CONTENTS

[Letters designate the separately published chapters]

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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.

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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.

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