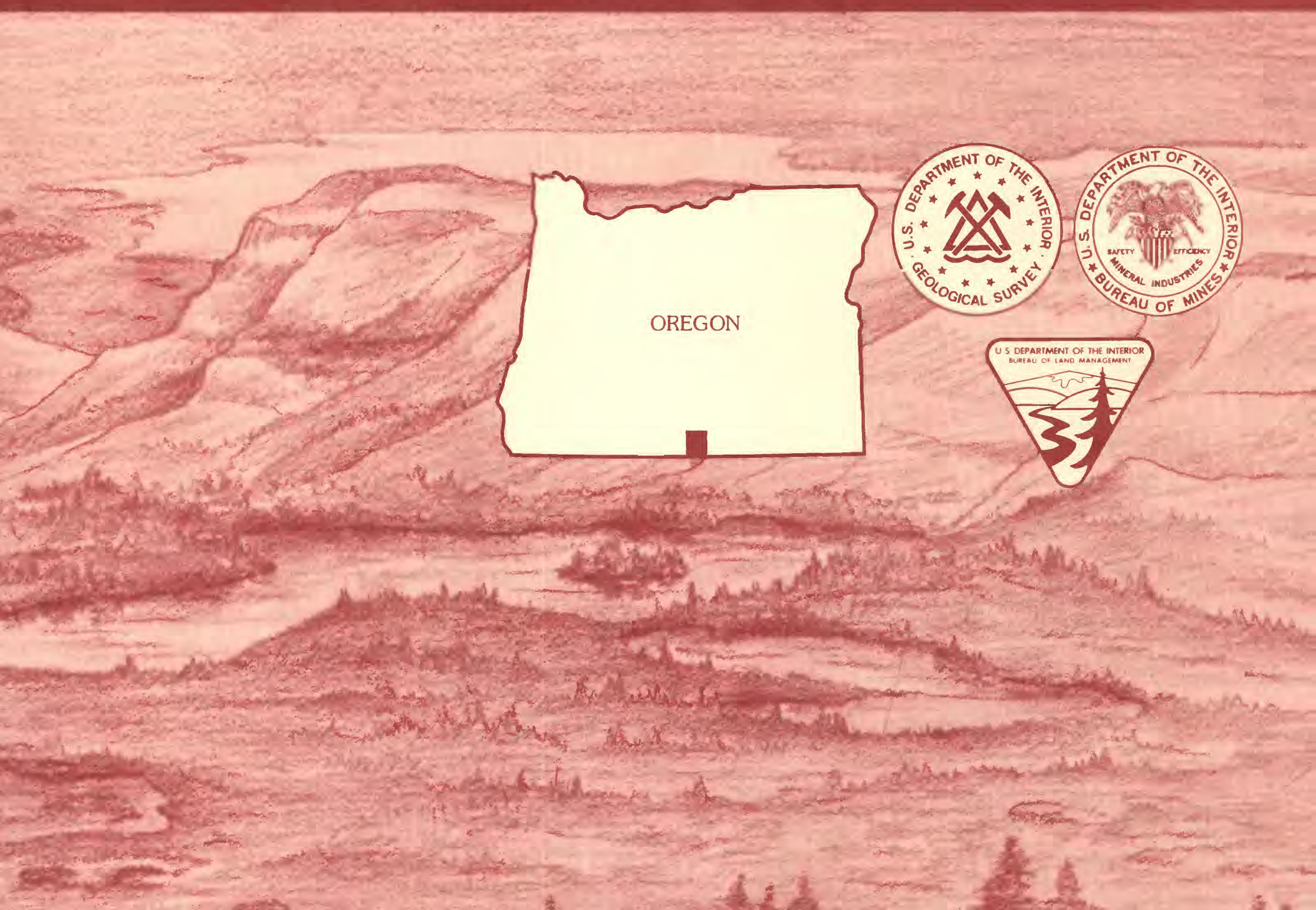
Mineral Resources of the Abert Rim Wilderness Study Area, Lake County, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1738-C



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Chapter C

Mineral Resources of the Abert Rim Wilderness Study Area, Lake County, Oregon

By MAUREEN G. SHERLOCK, MARK E. GETTINGS, *and* HARLEY D. KING
U.S. Geological Survey

TERRY R. NEUMANN
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1738

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
SOUTH-CENTRAL OREGON

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Area

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and 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 Abert Rim Wilderness Study Area (OR-001-101), Lake County, Oregon.

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Mineral Resources of the Abert Rim Wilderness Study Area, Lake County, Oregon

By Maureen G. Sherlock, Mark E. Gettings, *and* Harley D. King
U.S. Geological Survey

Terry R. Neumann
U.S. Bureau of Mines

SUMMARY

Abstract

At the request of the U.S. Bureau of Land Management, the 23,760-acre Abert Rim Wilderness Study Area (OR–001–101) was evaluated for identified mineral resources (known) and mineral resource potential (undiscovered). In this report, the area studied is referred to as the "wilderness study area" or simply "the study area." Fieldwork was conducted in late summer, 1986. No mineral resources were identified. A field reconnaissance of the study area revealed no areas of alteration that might be associated with mineralization. Results of geochemical analysis do not suggest mineralization. Rocks associated with gold, silver, mercury, and uranium mineralization are located in the surrounding region but do not crop out within the study area. Geophysical analysis suggests that these rock types may be located at shallow depths under parts of the Abert Rim Wilderness Study Area. Therefore, the northern and central parts of the study area have low potential for gold, silver, mercury, and uranium resources in epithermal deposits. The entire study area has moderate potential for geothermal energy resources and low potential for oil and gas resources. Basalt in the study area is suitable for local industrial use but does not currently constitute a resource.

Character and Setting

The Abert Rim Wilderness Study Area is located about 20 mi north of Lakeview, Oregon (fig. 1). It is a long north-south tract located along the east margin of Lake Abert. A total of 23,760 acres was evaluated for the study. Abert Rim is a 2,000-ft-high fault escarpment, popularly but erroneously termed the highest fault scarp in North America. Along the west margin of the study area, at Abert Rim, the terrain consists of steep talus-covered slopes below a near-vertical 400-ft-high cliff. East of Abert Rim, the study area forms a gently eastward-sloping plateau. Elevations in the study area rise from 4,255 ft at the shores of Lake Abert to 4,800 to 7,000 ft along the plateau rim. Access to the study area is provided by U.S. Highway 395 and by jeep trails from Oregon Highway 140 leading to the plateau along the north and south ends of the study area.

Abert Rim is a cliff and plateau composed predominantly of middle Tertiary basalt and andesite flows and minor lenses of interbedded tuffs and tuffaceous sedimentary rocks, which are capped by younger Tertiary basalt (fig. 2) (see appendixes for geologic time chart). Quaternary (Holocene) alluvium and playa deposits lie along the shores of Lake Abert and in small patches along the base of the Abert Rim escarpment. Adjacent to the wilderness study area, but not exposed within it, are Tertiary and Quaternary rhyolitic to dacitic plugs, dikes, domes, and intrusive breccias, which are associated with uranium, mercury, and gold mineralization in nearby mining districts.

Identified Mineral Resources

No metallic or nonmetallic resources were identified within the study area. Resources of gold, silver, mercury, diatomite, and bentonite were postulated in a 1985 U.S.

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Bureau of Land Management study of the area. Our study suggests that these resources do not exist within the study area. Two samples taken from tuffaceous rock units in the Rabbit Creek area contain anomalous zeolite concentrations.

U.S. Bureau of Land Management and Lake County records did not show any claim or lease activity in the study area. Field examinations did not reveal evidence of mines or claims within the study area.

Mineral Resource Potential

The Abert Rim Wilderness Study Area does not lie within any established mining district, nor does it contain mines, prospects, or occurrences of metallic or nonmetallic commodities. The study area, however, does lie within a region where Tertiary rhyolitic domes are associated with gold, silver, mercury, and uranium epithermal deposits. Furthermore, aeromagnetic studies suggest the possibility

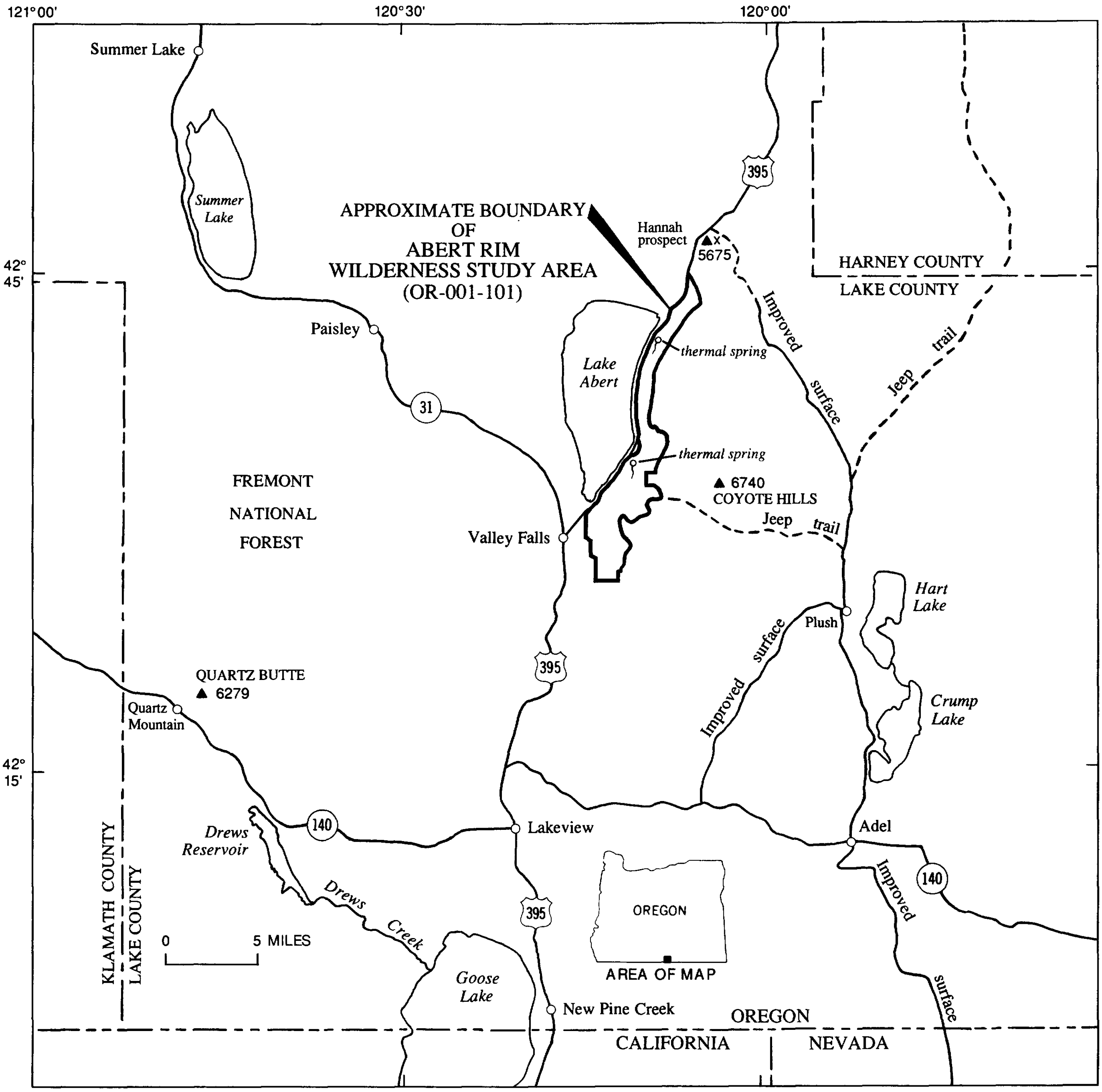


Figure 1. Index map showing location of the Abert Rim Wilderness Study Area, Lake County, Oregon.

of an intrusive body buried under the volcanic cover. Therefore, the northern and central parts of the Abert Rim Wilderness Study Area have a low potential for gold, silver, mercury, and uranium resources in epithermal deposits. The entire study area has moderate potential for geothermal energy resources and low potential for oil and gas resources. Industrial-grade rock, sand, and gravel are present in the wilderness study area, but their development is unlikely because of remoteness from markets.

INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management and is the result of a cooperative effort by the U.S. Geological Survey and the U.S. Bureau of Mines. An introduction to the wilderness review process, mineral survey methods, and agency responsibilities was provided by Beikman and others (1983). The U.S. Bureau of Mines 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 that is a modification of that described by McKelvey (1972) and the U.S. Bureau of Mines and U.S. Geological Survey (1980). U.S. Geological Survey studies 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 and Physiography

The Abert Rim Wilderness Study Area comprises 23,760 acres in the Basin and Range physiographic province and is situated in the central part of Lake County, Oregon, about 20 mi north of Lakeview. Abert Rim is the west margin of the Warner Mountains and is a steep, slightly eroded fault scarp of recent origin; movement along the fault may have begun in the Pliocene and continued intermittently into the Holocene (Baldwin, 1964). The terrain within the study area is dominated by a gently sloping plateau, the tilted fault block of the Warner Mountains, that is bounded on the west by the 2000-ft fault escarpment at Abert Rim. Elevations rise from 4,255 ft at the shores of Lake Abert to about 4,800 to 7,000 ft (north to south) along the crest of Abert Rim. The highest elevation within the study area, approximately 7,040 ft, is a low hill on the plateau near the south boundary. The west boundary follows the east edge of U.S. Highway 395 along the east shore of Lake Abert. The other boundaries are a powerline road and U.S. Bureau of Land Management roads.

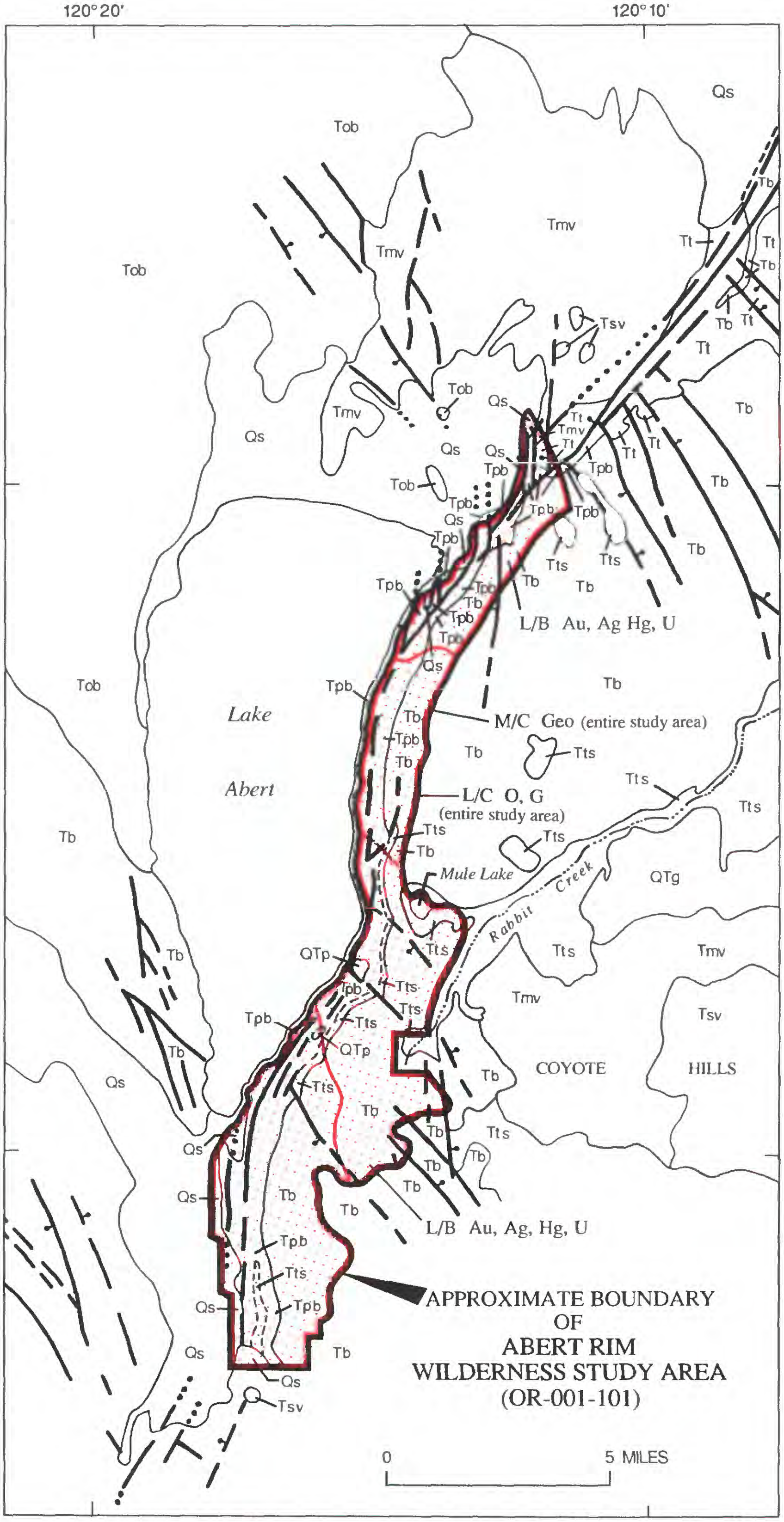
The region containing the study area is semiarid and contains several lakes, including Lake Abert, that occupy topographically closed basins between fault-scarp ridges (Phillips and Van Denburgh, 1971). Precipitation averages 12 in. per year at Valley Falls, near the southwest corner of the study area. Vegetation is predominantly sagebrush, but one remnant stand of Ponderosa pine grows at Colvin Timbers, which is the northernmost timber in the Warner Mountains. Upland game birds and game mammals, including Big Horn Sheep, as well as raptorial birds, wild horses, and other species inhabit the area (U.S. Bureau of Land Management, 1985; 1987).

Procedures and Sources of Data

The U.S. Geological Survey conducted detailed field investigations of the Abert Rim Wilderness Study Area in the late summer of 1986. This work included field checking existing geologic maps, geochemical sampling, and examining outcrops for evidence of mineralization. The geologic map of the wilderness study area is taken from Walker (1963; 1977).

During the summer of 1986, the U.S. Bureau of Mines conducted field examinations of the study area. All available information on geology, mining, and mineral resources in the area, including U.S. Bureau of Land Management and Lake County mining claim records, was reviewed prior to fieldwork. Field studies consisted of a search for mineralized zones within the study area. Mineralized zones near the study area were investigated to determine if they extended into the wilderness study area and to better understand mineralization in the region. Scintillometers were used during all ground traverses.

Twenty-eight samples were collected during the U.S. Bureau of Mines' study (Neumann, 1987). Most were rock-chip samples of tuffaceous interbeds and of brecciated basalt and rhyolite (from outcrops outside the wilderness study area) at or near fault contacts. A description of sample types is given by Neumann (1987). Thirteen rock samples were analyzed by an inductively coupled plasma method for the following elements: silver, arsenic, gold, copper, mercury, molybdenum, lead, antimony, titanium, zinc, bismuth, cadmium, gallium, palladium, platinum, selenium, tin, and tellurium. Twelve samples were assayed for arsenic, gold, and silver. Detection levels for gold and silver were in the parts per billion (ppb) range, whereas the other elements were detected at parts per million (ppm) limits. Additionally, all tuffaceous samples were tested at the U.S. Bureau of Mines Western Field Operations Center for zeolite content using an ion-exchange capability method



EXPLANATION

Area having moderate resource potential (M) for geothermal resources

Area having low mineral resource potential (L) for gold, silver, mercury, and uranium in epithermal deposits

Levels of certainty of assessment

B	Data only suggest level of potential
C	Data give good indication of level of potential

Commodities

Au	Gold
Ag	Silver
Hg	Mercury
U	Uranium
Geo	Geothermal
O,G	Oil and gas

Geologic map units

Qs	Surficial deposits (Holocene)
QTg	Pediment gravel (Quaternary and Tertiary)
QTp	Pyroclastic cinder mounds (Quaternary and Tertiary)
Tob	Olivine basalt (Pliocene)
Tt	Tuff (Pliocene)—Semiconsolidated tuff includes lacustrine tuffaceous sandstone and siltstone, ash, diatomite, ash-flow tuff, lapilli tuff, and tuff breccia
Tb	Basalt of Abert Rim (late Miocene)
Tts	Tuff and tuffaceous sedimentary rocks (middle Miocene)
Tpb	Porphyritic basalt and andesite flows of Abert Rim (middle Miocene)
Tmv	Mafic vent rocks (Miocene)
Tsv	Silicic vent rocks (Miocene(?) and Oligocene)

Contact—Dashed where approximate

Fault—Dashed where approximate or inferred; dotted where concealed; ball and bar on downthrown side

Figure 2. Mineral resource potential and generalized geology of the Abert Rim Wilderness Study Area, Lake County, Oregon. Geology from Walker (1963; 1977).

(Helfferich, 1964); three samples contained zeolite and were further analyzed by X-ray diffraction. Further information and complete analytical results are available from the Bureau of Mines, Western Field Operations Center, 360 E. Third Avenue, Spokane, WA 99202.

Other resource-related studies of the area include statewide studies of the mineral resources (Fern and Huber, 1984), the geothermal resources (Oregon Department of Geology and Mineral Industries and National Oceanic and Atmospheric Administration, 1982), and the oil and gas potential of wilderness lands (Fouch, 1983). Erikson and Curry (1977) described the uranium favorability of Tertiary rocks in southeastern Oregon. In 1983, the study area was part of the U.S. Bureau of Land Management geology, energy, and minerals (GEM) inventory program (Mathews and others, 1983).

Acknowledgments

M.I. Hornberger and J.A. Ach, geologists, U.S. Geological Survey, Menlo Park, Calif., assisted with the field checking of geologic maps and with rock geochemistry sampling. C.D. Taylor assisted in the stream-sediment geochemical sampling. D.A. Benjamin and S.L. Willett, geologists, Western Field Operations Center, Spokane, Wash., assisted the U.S. Bureau of Mines author with prefield work and field examination. The authors gratefully acknowledge the cooperation provided by personnel of the U.S. Bureau of Land Management, Lakeview, Oreg.

APPRAISAL OF IDENTIFIED RESOURCES

By Terry R. Neumann
U.S. Bureau of Mines

Mining and Mineral Exploration History

Although there has been no mining-related activity within the Abert Rim Wilderness Study Area, gold and mercury have been mined in the Coyote Hills area, 8 mi to the east. In 1906, gold was discovered in the Coyote Hills, prompting a small prospecting and claim-staking rush and the establishment of the Lost Cabin mining district, also known as the Coyote Hills, Camp Loftus, and Windy Hill districts. Absence of production records suggests interest in the gold occurrences was short-lived. Prospecting in the district was revived when cinnabar (mercury sulfide) was discovered in 1934. Mercury mines in the area were in production during 1941–1943; conflicting reports indicate that between three and seven flasks of mercury (76 pounds per flask) were produced from ore with a tenor (grade) of 0.15–0.95 percent (Thomas, 1981, p. 104). There was no mining activity in the district from the mid-1940's until 1978. In 1978, numerous mining companies began exploration in the area targeting large tonnage, low-grade epithermal precious-metal deposits (David Troutman, U.S. Bureau of Land Management staff, oral commun., 1986). Ongoing drilling programs are being conducted to continue exploration of the area.

Rocks in the Lost Cabin district include andesitic to rhyolitic flows, tuffs, breccias, and a hypabyssal quartz monzonite intrusive body representing a complex volcanic center. Most mineralized rock in the district consists of stockwork veinlets and disseminated ore minerals in argillically altered silicic volcanic rocks (Thomas, 1981).

Similar mineralized zones are associated with brecciated rhyolite at the Hannah prospect 2 mi north of the study area (fig. 1). The Hannah prospect comprises six claims that are owned and operated by John Cremin and Donald Fitzgerald of Lakeview, Oreg. The claims appear to be a relocation of earlier claims owned by the Frontier Mining Company. The prospect has no record of production. No extensions of the Coyote Hills or Hannah prospect host rocks crop out in the wilderness study area.

Mines, Prospects, Mining Claims, and Leases

U.S. Bureau of Land Management and historical mining records indicate that no mining claims, geothermal leases, or oil and gas leases were present within the wilderness study area as of January 1, 1987. A field investigation failed to identify any evidence of exploration or mining activities.

Two geothermal leases, probably for the water rights of Juniper and Poison Creeks, lie just outside the west boundary of the wilderness study area. Additionally, a highway borrow pit is adjacent to the northwest edge of the wilderness study area along U.S. Highway 395.

Appraisal of Identified Resources

The Abert Rim Wilderness Study Area contains no identified mineral resources. Samples contain no anomalous amounts of precious or base metals. Preliminary testing for zeolites from the Rabbit Creek area suggested zeolite concentrations, but further testing by X-ray diffraction demonstrated that the zeolite content is too low to quantify.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Maureen G. Sherlock, Mark E. Gettings, *and*
Harley D. King
U.S. Geological Survey

Geology

The geology of the Abert Rim Wilderness Study Area is included on regional maps by Walker (1963; 1977) and is shown in figure 2. The oldest unit in the study area is middle Miocene in age and comprises basaltic and andesitic flows; these flows form the majority of the slopes of the Abert Rim scarp and most of the cliff below the late Miocene basalt that caps the rim. Middle Miocene tuffaceous rocks are interbedded with the basaltic and andesitic flows and occur underneath the capping basalt. The younger map units include late Miocene, Pliocene, Pleistocene, and Holocene pyroclastic cinder mounds, gravel, alluvium, and playa sedimentary rock units. Mafic and silicic vent rocks are the oldest units in the area mapped, but they do not crop out within the study area. The silicic vent rocks are associated with mineralization in the general region.

Tertiary Volcanic Rocks

The middle Miocene basaltic and andesitic flows are distinctively plagioclase rich and porphyritic; they contain large white plagioclase laths in a dark, reddish-brown to black, vesicular matrix. Red scoriaceous basalt rubble marks the tops of some flows. Locally, at the base of the cliff, the vesicles follow planar horizontal cooling and shear planes. Minor sparsely porphyritic flows, which show flow alignment of plagioclase laths, crop out among the coarsely porphyritic plagioclase-rich basalts. The coarsely and sparsely porphyritic flows are both composed of calcic plagioclase, orthopyroxene, and partially to completely altered olivine phenocrysts in a dark matrix containing small plagioclase laths and many iron oxides. Vesicles are typically filled with radiating zeolite or calcite. These distinctive flows have been correlated with the Steens Basalt by Walker (1980) and are approximately 15 Ma in age (million years before present). McKee and others (1983) reported a potassium-argon age of 15.1±0.8 Ma from a basalt apparently just below the capping basalt in the southern part of the study area. Hart and Mertzman (1982) report a potassium-argon age of 14.62±0.72 Ma from an extremely porphyritic basalt in the central part of the study area. Exact stratigraphic location of neither sample is known.

Interbedded tuffs and tuffaceous sedimentary rocks of middle Miocene age form a persistent, thin unit below the capping basalt along the cliff rim in the southern part of the study area. The same unit crops out in large patches on the plateau top and along Rabbit Creek and Mule Lake near the east boundary of the study area. These tuffs and tuffaceous sedimentary rocks are rhyolitic and dacitic in composition and contain fresh glass shards, pumice lapilli, and locally abundant mammalian fossils. The fossils correlate with the middle Miocene fauna of the Mascall Formation of central Oregon. Small lenses of interbedded tuffs and tuffaceous sedimentary rocks crop out at a few localities in the northern part of the study area. These lenses that are exposed on cliff faces are typically 5 to 15 ft in thickness and a few tens of feet in length; they are white and pink and thinly bedded. These tuffaceous rocks consist of crystal fragments of feldspar, pyroxene and biotite, lithic fragments of scoriaceous basalt, and altered glass shards and pumice. The interbedded tuff unit is widespread to the west and south of the study area; at a few localities, adjacent to range-front faults, the unit is brecciated and altered to clays, calcite, gypsum, and other white alkaline precipitates (Brown and others, 1980). Similar brecciation and alteration are not found within the study area.

Basalt of Abert Rim of late Miocene age is a regionally widespread unit that crops out poorly, frequently only as loose rubble, on sage-covered plateau tops. These basalts are dark gray, platy jointed, and flat lying. This capping unit includes both vesicular and nonvesicular flows that are characteristically fine grained and contain sparse small plagioclase and olivine phenocrysts. Ophitic texture is well developed. The rocks contain clinopyroxene, calcic plagioclase, sparse olivine crystals only slightly altered to iddingsite, and iron titanium oxide minerals throughout the groundmass. Hart and Mertzman (1982) reported one potassium-argon age of 6.07±0.66 Ma from a sample of basalt from the northern part of the wilderness study area.

The tuff unit of Pliocene age crops out only in a very small area in the northern part of the wilderness study area. It is widespread in the general region and consists of lacustrine tuffaceous sandstone and siltstone, ash and ashy diatomite, ash-flow tuff, lapilli tuff, and tuff breccia. Some tuffs within the unit are partly or densely welded. The tuffs exposed in and near the study area are a distal part of a welded tuff (G.W. Walker, oral commun., 1988).

The olivine basalt unit of Pliocene age shown on figure 2 is not exposed in the study area.

Tertiary and Quaternary Volcanic and Surficial Deposits

Pyroclastic cinder mounds of Tertiary and Quaternary age were mapped by Walker (1963) in the study area. These mounds are highly modified by erosion. They have slopes of cindery red soil that contain sparse lava bombs and bomb fragments.

An unconsolidated unit of poorly sorted gravels and bouldery soil forms pediments above pluvial lake levels (fig. 2). This unit contains clasts composed mostly of basalt and andesite and is locally cemented by caliche. These pediment gravels are not within the study area.

Quaternary surficial deposits, composed of Holocene-age poorly sorted gravel, sand, and silt in stream-channel and flood-plain deposits, are part of an alluvial plain at the north end of the study area and the outlet channel at the south end. Sparse patches of rounded coarse gravel and cobbles were deposited along the shore of Lake Abert. Remnants of gravels from higher lake levels formed along strandlines of beaches a few tens of feet above the present lake level. The most distinct of these, 14.7 ft above the present lake level, probably formed about A.D. 1805 (Phillips and Van Denburgh, 1971). Other higher and less distinct strandlines probably formed over the last few thousand years. Playa deposits composed of clay, silt, sand, and local evaporites are present at the north end of Lake Abert, outside the study area boundary.

Regional Mineralization

Tertiary volcanic rocks of a bimodal basalt and rhyolite association are common in southeastern Oregon. These volcanic rocks are both intrusive and extrusive and are interpreted as mafic and silicic vent complexes and shield volcanoes. Some of these rocks form plugs, dikes, small endogenous domes, and intrusive breccias and are associated with gold, silver, uranium, and mercury mineralization in southeastern Oregon (Brooks, 1963; Brooks and Ramp, 1968). These rocks do not crop out within the Abert Rim Wilderness Study Area but are exposed near the north, south, and east boundaries (fig. 2).

The mafic vent rocks consist of a heterogeneous mixture of basaltic and andesitic extrusive rocks; these rocks include agglomerates, breccias, flows, and tuffs, and intrusive rocks forming constructional volcanic features, mostly lava cones and small shield volcanoes (Walker, 1977). North of the study area, a road cut along U.S. Highway 395 shows the heterogeneous nature of these mafic vent and flow rocks. Associated silicic vent rocks consist of intrusive rhyolites and dacites, rare soda rhyolite, and a few large masses of perlite that form small plugs, dikes, endogenous domes, and intrusive breccias. Three small silicic plugs that intrude the mafic vent rocks east of the highway have been prospected, presumably for gold and (or) mercury (Hannah prospect, fig. 1). Similar mafic and silicic rocks, apparently slightly older, which cover a much larger area, are exposed in the Coyote Hills 10 mi southeast. Two small silicic bodies, partly composed of a breccia containing subrounded to subangular volcanic clasts, are exposed 0.5 mi south of the study area.

Gold and mercury prospects of the Lost Cabin district in the Coyote Hills area are contained in intrusive silicic rocks, dated at about 26.5 to 28.5 Ma (Walker, 1981; Fiebelkorn and others, 1983), that are older than the Abert Rim basalt flows. Mineralization in the Lost Cabin district is associated with zones of shearing and brecciation in flat-lying agglomerates, flows intruded by small dacitic plugs, and opalized tuffs. Fine-grained pyrite and cinnabar are disseminated through brecciated rocks, and cinnabar occurs as films along fractures (Brooks, 1963); gold and copper oxide minerals are deposited in altered seams of clay, limonite, and quartz, which fill small irregular fractures (Brooks and Ramp, 1968).

The Quartz Mountain volcanic-hosted hot-spring gold deposit is about 32 mi southwest of the study area (fig. 1). At Quartz Mountain, rhyolitic domes and intrusive rocks similar to those near Abert Rim crop out as a series of domes aligned along northwest-trending faults (M.G. Sawlan, written commun., 1987). These domes have been dated at about 7 Ma (Walker, 1981; McKee and others, 1983). Prior to the recognition and development of the large-tonnage, low-grade disseminated gold deposit, Quartz Mountain produced minor amounts of mercury from altered rhyolitic volcanic rocks (Brooks, 1963).

Uranium mineralization is associated with rhyolitic domes and intrusive rocks of southeastern Oregon. The Lakeview uranium area, about 24 mi southwest of Abert Rim, produced about 145,000 tons of uranium ore having an average grade of 0.17 percent. The Lakeview uranium deposits are spatially related to areas of extensive silicification and clay alteration in rhyolitic intrusive rocks and in altered tuffs and tuffaceous sedimentary wall rocks along northwest-trending fault zones (Walker, 1980).

Structure

Basin-and-range normal faulting is the dominant structural feature of the area. A major north-northeast-trending normal fault is mapped along Abert Rim for the length of the study area. Parallel subsidiary faults and northwest-trending faults create the topography we see today. The Abert Rim fault offset the Tertiary-age volcanic flows as much as 2,000 ft in the southern part of the study area; the northwest-trending faults may have offset sections of the volcanic sequence as much as 500 ft. In the northern part of the study area, the stratigraphic section normally found higher on the slopes is apparently repeated as a result of movement along northwest-trending faults.

The northwest-trending faults are spatially related to the ore deposits of the region; the hot-springs gold deposits at Quartz Mountain and the volcanogenic uranium deposits of the Lakeview uranium area are localized along northwest-trending faults.

Geochemistry

Methods

In the summer of 1986, the U.S. Geological Survey collected 27 samples of rock, 23 samples of minus-80-mesh stream sediments, and 22 samples of nonmagnetic heavy-mineral concentrate derived from stream sediments from 46 sites in the Abert Rim Wilderness Study Area. Rock samples, which are representative of the lithologies present in the wilderness study area, were collected to determine geochemical background values. Hydrothermally altered or mineralized rocks were not observed in the study area during the reconnaissance survey. Two rock samples from

Tertiary silicic vent units outside the wilderness study area were collected for comparison.

All samples were analyzed for 31 elements using a six-step semiquantitative emission spectrographic method described by Grimes and Marranzino (1968). The rock and stream-sediment samples were analyzed for antimony, arsenic, bismuth, cadmium, and zinc by inductively coupled argon plasma-atomic emission spectroscopy and for gold and mercury by atomic absorption (methods described in Crock and others, 1987). M.S. Erickson (U.S. Geological Survey, unpub. data, 1988) provided tables of analytical data, descriptions of sampling, preparation, and analytical methods, and a map showing sample-collection sites.

Results and Interpretations

The geochemical analysis did not reveal significant anomalous concentrations of elements that suggest mineralization. A sediment sample collected at a site just downstream from a spring near the southern end of the study area contained slightly anomalous values of arsenic (37 ppm) and zinc (300 ppm). The concentrate sample from the same site contained a slightly anomalous value of copper (300 ppm). Stream-bed sediments at the site are coated with limonite, suggesting that the enrichment of elements is probably due to coprecipitation and adsorption of the elements with the limonite. The anomaly probably does not represent mineralization. A sample of tuff from near the northern end of the study area contains slightly anomalous values of silver (0.5 ppm) and lead (50 ppm). The values may reflect enrichment along a fault in that area.

Geophysics

Aeromagnetic Data

An aeromagnetic survey including the Abert Rim Wilderness Study Area was flown and compiled in 1972 under contract to the U.S. Geological Survey (U.S. Geological Survey, 1972). Total-field magnetic data were collected in analog form along east-west flightlines spaced at approximately 2-mi intervals. The lines were flown at a constant barometric altitude of 9,000 ft. Corrections were applied to the data to compensate for diurnal variations of the Earth's magnetic field. A regional magnetic field of 8 nanoTeslas (nT)/mi in the direction N. 30° E. was subtracted from the data to produce a residual magnetic anomaly data set. Using the corrected digitized analog data, an aeromagnetic map of the wilderness study area (fig. 3) was prepared at a contour interval of 50 nT for comparison with geologic and topographic maps. The topographic expression of Abert Rim seems to cause about a 50-nT perturbation in the aeromagnetic anomaly contours, particularly in the northern half of the study area (fig. 3).

The southern half of the study area lies on the west edge of a positive aeromagnetic anomaly of about 700 nT amplitude (fig. 3). Horizontal extents of the steepest gradients of this anomaly suggest a burial depth of 1,000 to 1,600 ft to the top of the magnetic anomaly source. The anomaly lies over a northwest-trending fault zone generally forming an uplifted fault block (Walker, 1963). The anomaly is interpreted to be due to an intrusive mass. The silicic volcanic rocks of the Coyote Hills to the east of the study area may be associated with the intrusion. Elsewhere in the area, intrusive domes and vents of silicic composition are spatially associated with positive magnetic anomalies, and the intrusions are generally located beneath the anomaly flanks or apophyses (fig. 3). These intrusive rocks are frequently emplaced along existing faults and are sometimes associated with mineralization. Thus the area within the north flank of the anomaly may have silicic intrusive rocks beneath it at depths of 1,600 ft or less. Anomalies having steep gradients are seldom associated with the silicic intrusive rocks (fig. 3), and thus the west side of the anomaly gradient does not suggest the presence of buried silicic intrusives.

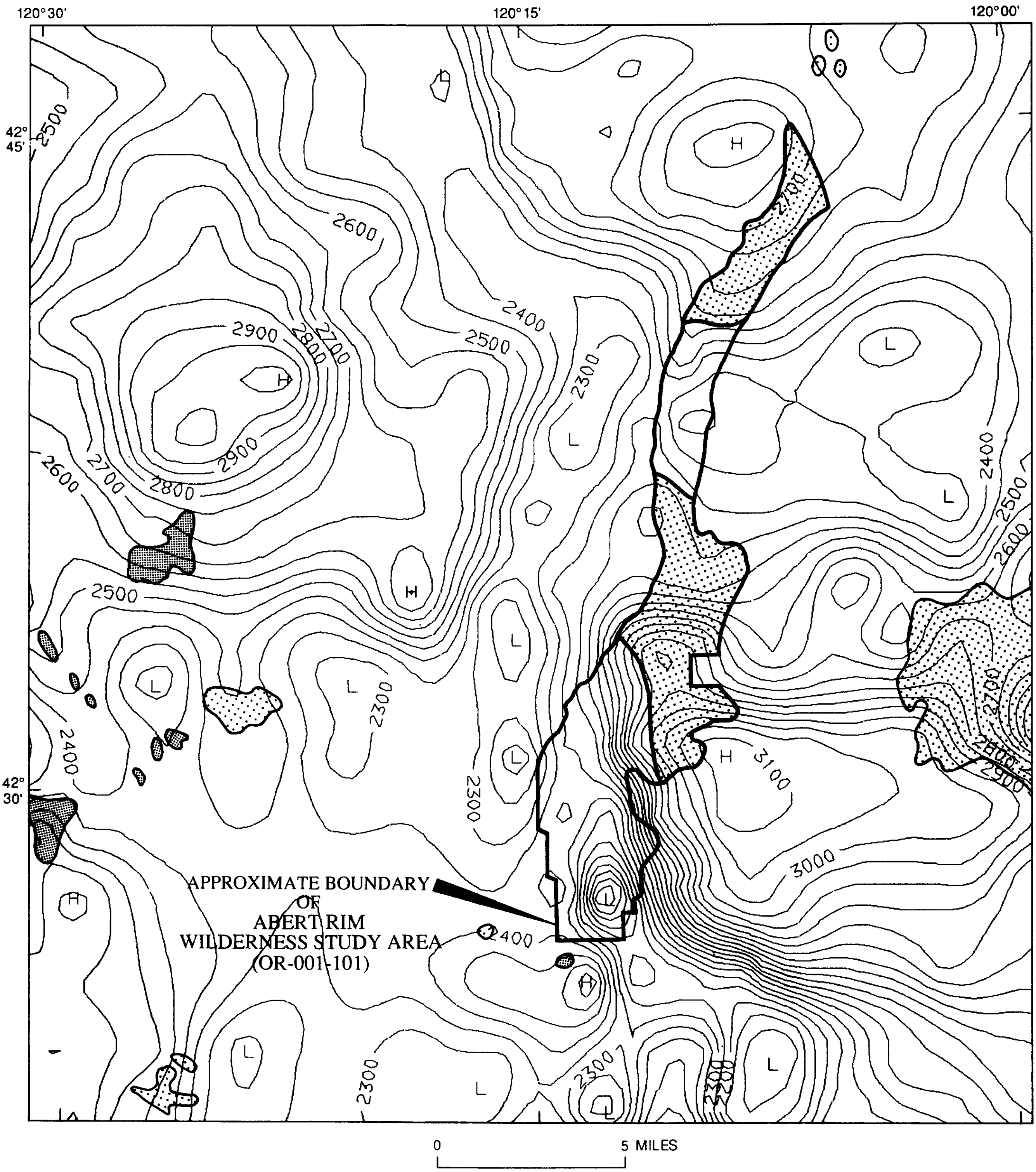
The north end of the Abert Rim Wilderness Study Area is within a smaller positive aeromagnetic anomaly (fig. 3), which has silicic intrusive rocks associated with it, north of the study area. The flank of this anomaly that is within the study area may have buried silicic intrusive rocks beneath it.

Magnetic anomaly relative minima characterize the areas to the west and south of the study area (fig. 3). These minima are probably due to an increase in depth to the magnetic basement that results from alluvial and sedimentary fill in fault-bounded depressions. East of the wilderness study area, trends of anomaly gradients in the aeromagnetic field correlate mainly with fault zones. The large magnetic-field relative minimum east of the northern half of the wilderness study area (fig. 3) suggests an area of local thickening of tuffaceous rocks underlying basalt flows on the surface (Walker, 1963).

Airborne radiometric and magnetic data of the Klamath Falls quadrangle are also available from the National Uranium Resource Evaluation (Geo-Life, 1980). Eight east-west flightlines, spaced 3 mi apart and flown at a terrain clearance of approximately 400 ft, crossed the wilderness study area during that study. These radiometric measurements sampled X-ray flux, which indicates concentrations of uranium, thorium, and potassium in the rocks. The radiometric profiles did not show any significant gamma-ray emission anomalies.

Gravity Data

Gravity survey data for the Abert Rim Wilderness Study Area are sparse, and only seven stations are in or near the wilderness study area (Defense Mapping Agency



EXPLANATION

Aeromagnetic contour—Contour interval 50 nanoTesla. Datum is arbitrary

Intrusive and extrusive rocks of dacitic and rhyolitic composition

L Relative magnetic low

H Relative magnetic high

Area possibly underlain by silicic intrusive rocks

Figure 3. Aeromagnetic map of Abert Rim Wilderness Study Area and surrounding region.

Aerospace Center, 1983). Of the seven stations, six are along U.S. Highway 395 on the west boundary of the study area. The remaining station is just outside the east boundary near the headwaters of Rabbit Creek. The Bouguer gravity anomaly field of the wilderness study area is a gentle northeast-trending gradient in which anomaly values increase to the northwest. Bouguer gravity anomaly values range from approximately –150 milliGal (mGal) in the northern part of the wilderness study area to about –165 mGal in the south. The data suggest that a gravity anomaly is associated with the large aeromagnetic anomaly in the southern half of the area. However, the data are so sparse that the existence of such an anomaly and even the trend of the regional field would require verification by obtaining further gravity data within and around the study area.

Remote Sensing

Landsat multispectral scanner (MSS) images at a scale of 1:800,000 were examined for southeastern Oregon. In the general region of the Abert Rim Wilderness Study Area, linear features are not well expressed owing to the nature of the surface cover (D.L. Sawatzky, written commun., 1987).

Mineral and Energy Resource Potential

There are no known metallic or nonmetallic deposits in the Abert Rim Wilderness Study Area. Southeastern Oregon has long been known to contain small deposits of gold, mercury, and uranium. Recently, a large-tonnage, low-grade gold deposit was discovered 32 mi southwest of the wilderness study area, but similar host rocks are not exposed within the study area. However, aeromagnetic studies suggest the possiblity that such rock types (i.e., silicic intrusive rocks) may exist at depth, possibly 1,000 to 1,600 ft beneath the surface. Two thermal springs are located within the study area (fig. 1). The study area does not contain rocks that would be suitable host or reservoir rocks for oil and gas. Industrial-grade rock, sand, and gravel are present in the wilderness study area, but development of these materials is unlikely because similar materials of equal or better quality are abundant closer to existing markets.

Epithermal Precious-metal and Energy Mineral Resource Potential

Known epithermal gold, silver, mercury, and uranium mineralization near the study area is of the hot-spring gold, silver (Berger, 1986), hot-spring mercury (Rytuba, 1986), and volcanogenic uranium (Bagby, 1986) deposit model types described in Cox and Singer (1986). In southeastern Oregon, significant economic concentrations of gold and uranium are known to occur in 7-Ma rhyolitic domes and intrusive rocks emplaced along northwest-trending faults in a near-surface environment. The surficial geology of the Abert Rim Wilderness Study Area and the results of geochemical rock and stream-sediment sampling do not suggest gold, silver, mercury, or uranium mineralization. However, the results of the aeromagnetic studies suggest a buried intrusive body at 1,000 to 1,600 ft that, by analogy with exposed intrusive bodies, is assumed to be rhyolitic in composition. These geophysically anomalous areas, in the northern and central parts of the wilderness study area, are assigned a low potential, with a certainty level of B, for gold, silver, mercury, and uranium resources (fig. 2). The lithology, age, and mineralization of the apparent intrusive rocks are unknown and could be determined only by sampling between 1,000 ft and 1,600 ft.

Oil and Gas Resource Potential

Fouch (1983) qualitatively assessed the High Plateau province of eastern Oregon as having a range of potential for oil and gas from zero to medium. He assigned a low potential for oil and gas to the Abert Rim Wilderness Study Area. He based this assessment on the presence of Neogene basalt, which is locally intercalated with nonmarine sedimentary rocks. In local basins formed during Neogene time, these nonmarine sedimentary rocks can include abundant coal beds and thus be a possible reservoir for gas. The interbedded tuffs and tuffaceous sedimentary rocks intercalated within the Miocene basalts of the Abert Rim Wilderness Study Area are both too thin and lacking in coal beds to be considered a potential reservoir for gas. The Abert Rim Wilderness Study Area has a low potential for oil and gas resources with a certainty level of C.

Geothermal Resource Potential

Two thermal springs are located within the Abert Rim Wilderness Study Area (approximate locations on fig. 1). Temperatures of the springs are warm and flow is moderate (Oregon Department of Geology and Mineral Industries and National Oceanic and Atomospheric Administration, 1982). Three other, imprecisely located, thermal springs (which may or may not correspond to the two above) are listed in the compendium by Waring (1965, as revised by Blankenship and Bentall). The springs are in Pliocene lake beds near faulted Tertiary lava; are used as water supply for cattle; and have temperatures of 65, 68, and 80 °F and flows of 20, 10, and 30 gallons per minute, respectively. Any of these springs may correspond to the two geothermal leases, apparently for water rights, known to exist along the west boundary of the wilderness study area. Based on the available data, the potential for geothermal energy resources within the Abert Rim Wilderness Study Area is moderate, certainty level C.

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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 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, and (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 no 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.

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

LEVEL OF RESOURCE 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	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	[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.

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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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