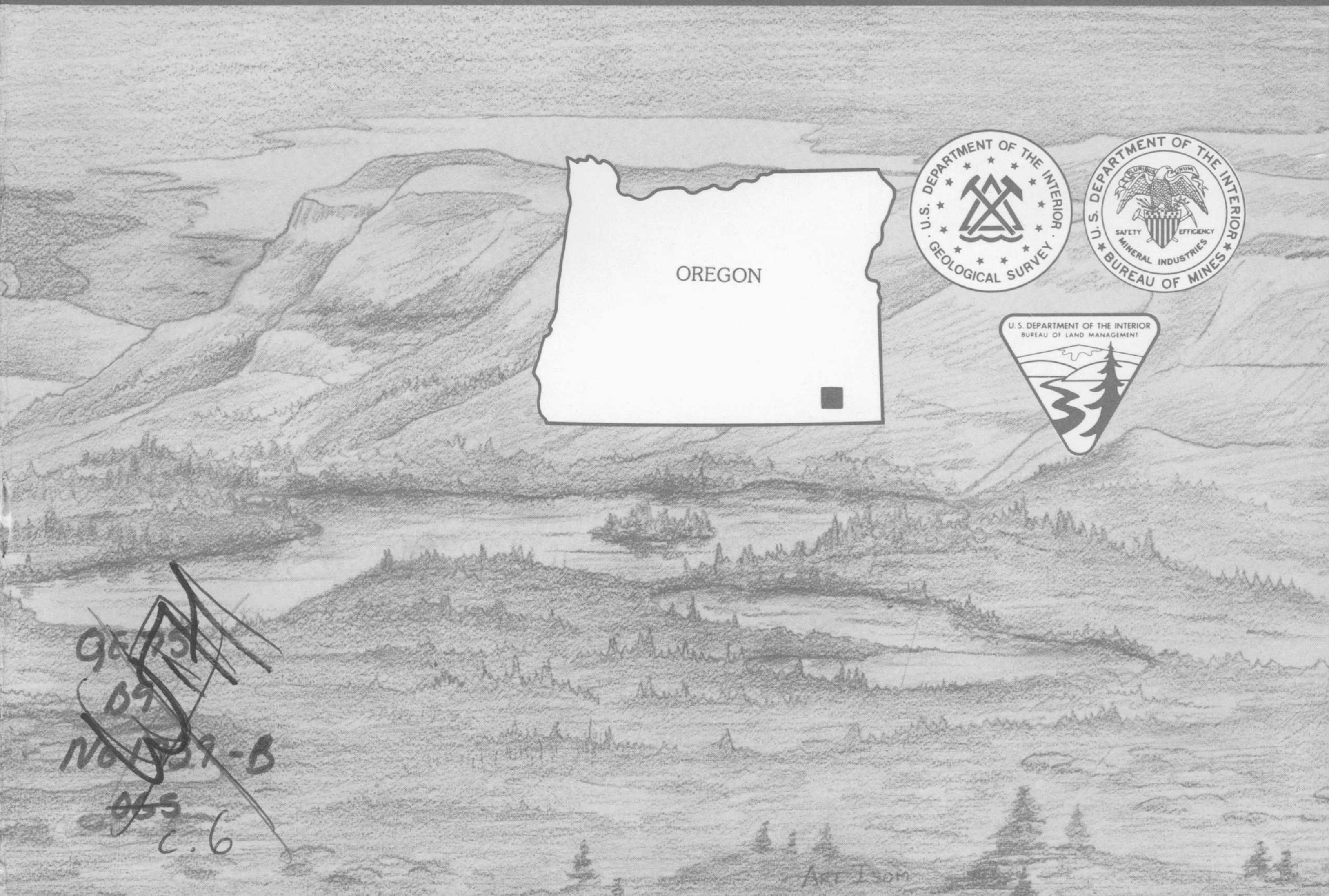
Mineral Resources of the Alvord Desert and East Alvord Wilderness Study Areas, Harney and Malheur Counties, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1739-B



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Chapter B

Mineral Resources of the Alvord Desert and East Alvord Wilderness Study Areas, Harney and Malheur Counties, Oregon

By BRENT D. TURRIN, ANDREW GRISCOM,
ROBERT L. TURNER, and WILLIAM A. LAWSON
U.S. Geological Survey

ALAN R. BUEHLER and DONALD E. GRAHAM
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1739

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
ALVORD DESERT REGION, 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 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 part of the Alvord Desert (OR–002–074) and East Alvord (OR–002–073A) Wilderness Study Areas, Harney and Malheur Counties, Oregon.

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PLATE
[In pocket]

FIGURES

Mineral Resources of the Alvord Desert and East Alvord Wilderness Study Areas, Harney and Malheur Counties, Oregon

By Brent D. Turrin, Andrew Griscom, Robert L. Turner, *and* William A. Lawson
U.S. Geological Survey

Alan R. Buehler *and* Donald E. Graham
U.S. Bureau of Mines

SUMMARY

Abstract

The Alvord Desert (OR–002–074) and East Alvord (OR–002–073A) Wilderness Study Areas encompass approximately 69,165 acres and 15,785 acres, respectively. In this report, the area(s) studied are referred to as the "wilderness study area(s)" or simply as "the study area(s);" any reference to the Alvord Desert or East Alvord Wilderness Study Area(s) refers only to that part of the wilderness study area(s) for which a mineral survey was requested by the U.S. Bureau of Land Management. The contiguous study areas, located along the eastern side of the Alvord Desert, Harney and Malheur Counties, Oreg., will be referred to as simply the study area unless otherwise noted.

Geologic, geochemical, geophysical, and mineral surveys of the study areas were conducted by the U.S. Geological Survey and U.S. Bureau of Mines between 1986 and 1987 to evaluate the identified (known) mineral resources and to assess the mineral resource potential (undiscovered). There are no identified mineral resources, mining districts, mines, claims, oil , gas, or geothermal leases, or resource production in either of the study areas. Basalt and large quantities of dune sand that are present within the study areas are suitable for construction purposes but are not classified as an identified resource because they are not proximal to current or prospective markets.

Geochemical and geophysical data suggest that the western part of the East Alvord Wilderness Study Area has a moderate potential for low- to medium-temperature geothermal resources. The remainder of the study area has a low potential for geothermal resources. In addition, the southwestern part has a low mineral resource potential for gold, silver, mercury, and boron in epithermal deposits. The northwestern part of the East Alvord Wilderness Study Area, near Mickey Springs, has a moderate resource potential for gold, silver, and mercury in epithermal deposits and a low resource potential for boron. The entire East Alvord Wilderness Study Area has a low potential for oil, gas, and uranium energy resources. A weak geochemical anomaly suggests a small area of low resource potential for gold and silver in epithermal deposits in the southern part of the East Alvord Wilderness Study Area as well.

Geochemical and geophysical data suggest that the western part of the Alvord Desert Wilderness Study Area has a moderate mineral resource potential for low- to medium-temperature geothermal resources. The remaining part has a low potential for low- to medium-temperature geothermal resources. The western part of the Alvord Desert Wilderness Study Area also has a low mineral resource potential for gold, silver, mercury, and boron in epithermal deposits. A geochemical anomaly suggests a small area of moderate resource potential for gold, silver, and mercury in epithermal deposits in the western part of the Alvord Desert Wilderness Study Area as well. The entire Alvord Desert Wilderness Study Area has a low potential for oil, gas, and uranium energy resources.

Manuscript approved for publication, July 26, 1988.

Character and Setting

The Alvord Desert and East Alvord Desert Wilderness Study Areas are situated in the transition zone between the Basin and Range and Columbia Plateau physiographic provinces. The Basin and Range province is an extensive semiarid to arid tract of subparallel, north-trending, en echelon mountain ranges and intervening valleys. The Columbia Plateau physiographic province is a high dissected plateau of Tertiary volcanic rocks (see appendixes for Geologic Time Chart).

The study area is located in Harney and Malheur Counties, Oreg., about 25 mi northeast of Fields (fig. 1). The U.S. Bureau of Land Management requested studies on 84,950 acres in the two contiguous study areas along the eastern edge of the Alvord Desert. In the rest of this report, except where noted, the two areas will be referred to col-

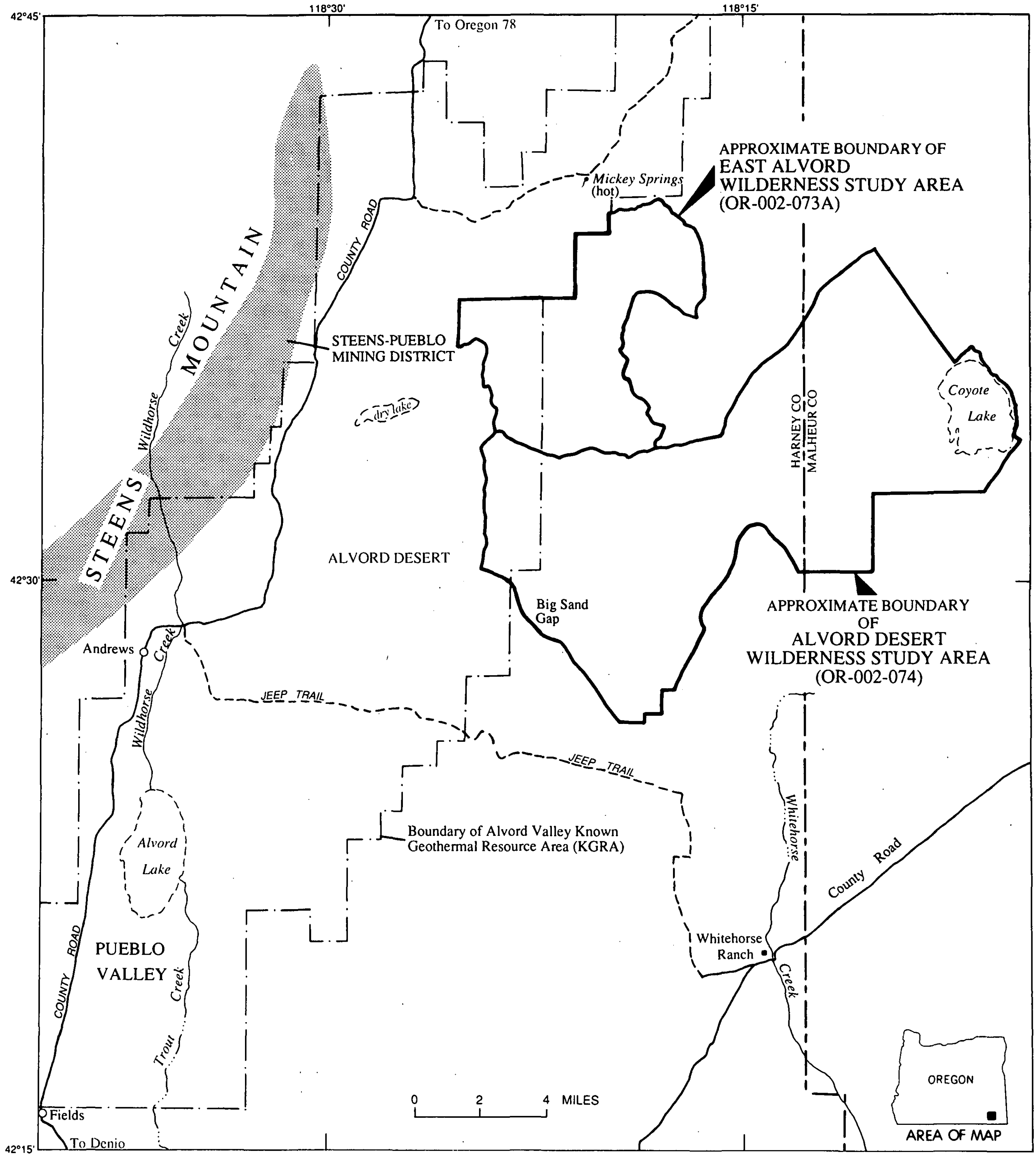

Figure 1. Index map showing location of the Alvord Desert and East Alvord Wilderness Study Areas, Harney and Malheur Counties, Oregon.

lectively as one study area. The area is bounded on the west by the Alvord Desert, a playa basin at an elevation of 4,020 ft, and on the east by the Coyote Lake basin, a playa at an elevation of 4,070 ft. The west margin of the study area is characterized by a west-facing fault escarpment having over 600 ft of relief; the escarpment extends from Mickey Springs at the north end to Big Sand Gap at the south end of the area (figs. 1, 2). The study area is underlain by a sequence of Tertiary volcanic and volcaniclastic rocks.

Identified Resources

The Alvord Desert and East Alvord Wilderness Study Areas contain no identified mineral resources. In addition, no mines, claims, prospects, or mineralized zones were found in the study area. Basalt and large quantities of dune sand are present within the study areas and are suitable for construction purposes but are not classified as an identified resource because they are not proximal to current or prospective markets.

The following five mining districts are located near the study area: (1) the Steens-Pueblo mining district, a 40-mi-long belt of epithermal gold, copper, and mercury deposits located along the east edge of the Steens and Pueblo Mountains, approximately 10 to 15 mi west-southwest of the study area; (2) the Warm Springs gold and tungsten mining district located approximately 55 mi southwest of the study area; (3) the Opalite mercury, lithium, and uranium mining district, approximately 55 mi south of the study area; (4) the National gold-silver mining district located 55 mi south of the study area; and (5) the Disaster gold-silver mining district located 50 mi south of the study area.

Mineral Resource Potential

The Alvord Desert and East Alvord Wilderness Study Areas are part of a regional area that is characterized by extensive exposures of Tertiary volcanic rocks that are locally hydrothermally altered and silicified. In this region hydrothermally altered rocks may host deposits of base (copper, lead, and zinc) and precious metals (silver, and gold), mercury, and industrial minerals.

The western part of the East Alvord Wilderness Study Area has a moderate potential for low- to medium-temperature geothermal resources. The remaining part of the study area has a low potential for low- to medium-temperature geothermal resources. The southwestern part has a low mineral resource potential for gold, silver, mercury, and boron in epithermal deposits. The northwestern part of the East Alvord study area, near Mickey Springs, has a moderate resource potential for gold, silver, and mercury in epithermal deposits and a low resource potential for boron. The entire East Alvord Wilderness Study Area has a low potential for oil, gas, and uranium energy resources. In addition, a geochemical anomaly suggests a small area of low resource potential for gold and silver in epithermal deposits in the southern part of the study area.

The western part of the Alvord Desert Wilderness Study Area has a moderate mineral resource potential for low- to medium-temperature geothermal resources. The remaining part has a low potential for low- to medium-temperature geothermal resources. A low mineral resource potential for gold, silver, mercury, and boron in epithermal deposits exists in the western part of the Alvord Desert Wilderness Study Area. In addition, a geochemical anomaly suggests a small area of moderate resource potential for gold, silver, and mercury in epithermal deposits in the western part of the Alvord Desert Wilderness Study Area as well. The entire Alvord Desert Wilderness Study Area has a low potential for oil, gas, and uranium energy resources.

INTRODUCTION

A mineral resource survey of the study area was conducted in the spring of 1986. This mineral survey was requested by the U.S. Bureau of Land Management and is a collective effort by the U.S. Geological Survey and U.S. Bureau of Mines. Identified resources and known mineralized areas are evaluated by the U.S. Bureau of Mines by collecting data on current and past mining activities and through field examination of known 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 U.S. Bureau of Mines and U.S. Geological Survey (1980).

Studies by the U.S. Geological Survey are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources within the wilderness study area. Field mapping of geologic units and structures, geochemical sampling, and geophysical studies were performed to provide the necessary data to evaluate, with respect to known ore-deposit models, the potential for undiscovered mineral resources in the study area. 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, certainty of assessment, and resource/reserve classification.

The climate in the Alvord Desert region is semiarid to arid, dominated by continental tropical air masses in summer and continental polar air masses in winter, typical of a middle-latitude desert climate (Sthraler, 1969; Houghton and others, 1975). Annual temperatures range from about –4 °F in winter to more than 100 °F during the summer.

Daily summer temperature changes frequently exceed 50 °F. Precipitation ranges from 5 to 15 in. annually, mostly as winter snow and rain. During summer, relative humidity averages about 20 percent but may fall to 10 percent.

Several varieties of sagebrushes and grasses cover most of the area. Wildlife in the area includes pronghorn antelope, deer, coyote, bobcat, mountain lion, and a variety of smaller mammals. Feral horses and burros are also abundant. The avian population varies seasonally in numbers and species.

Road access to the study area is provided by three unmaintained roads and jeep trails, which extend eastward from the east edge of the Alvord Desert basin. However, these roads are subject to periodic washouts and in places may only be passable to high-clearance four-wheel-drive vehicles.

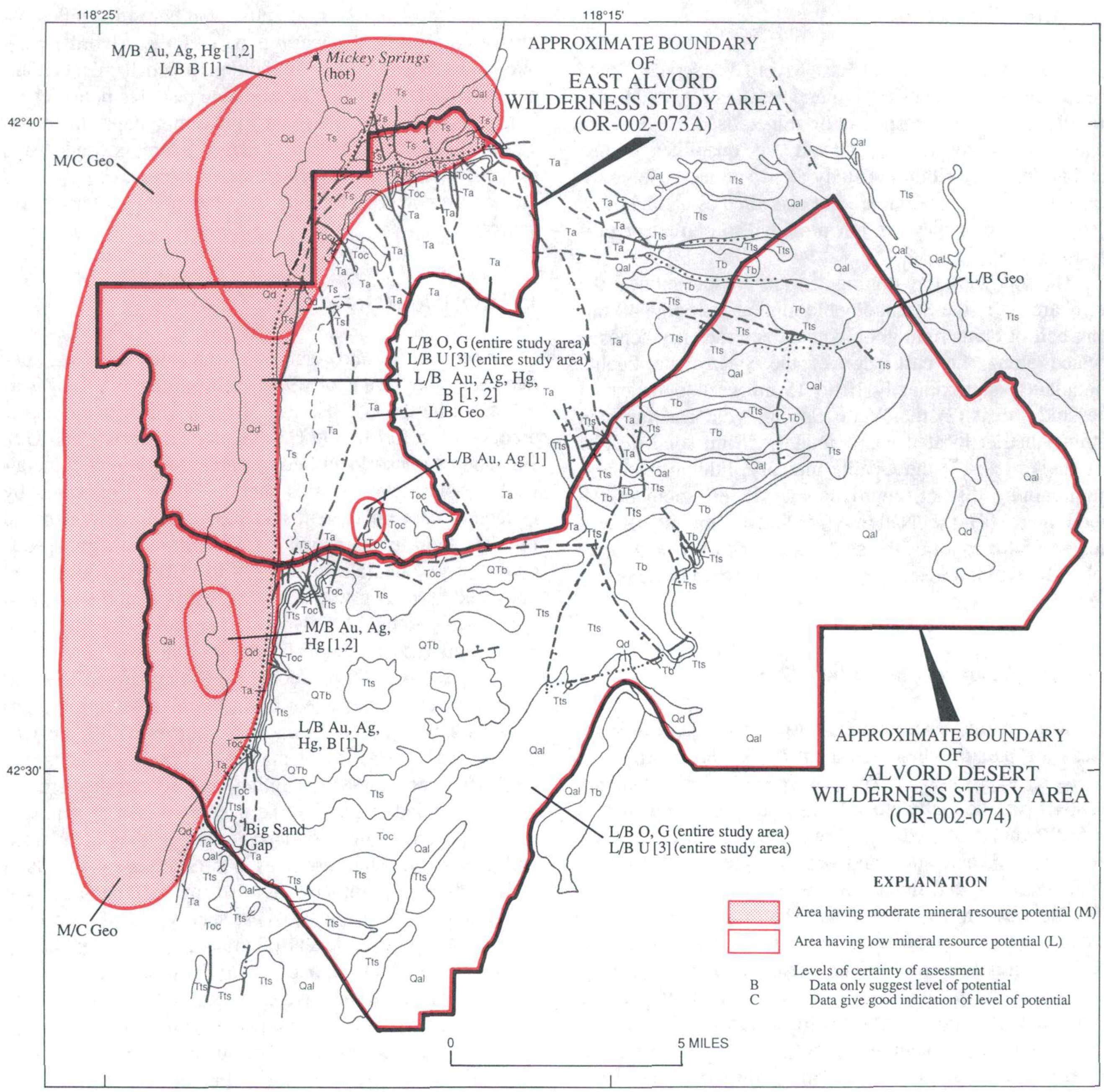

Figure 2. Map showing generalized geology and mineral resource potential of the Alvord Desert and East Alvord Wilderness Study Areas, Harney and Malheur Counties, Oregon.

APPRAISAL OF IDENTIFIED RESOURCES

By Alan R. Buehler *and* Donald E. Graham
U.S. Bureau of Mines

Methods and Scope of Investigation

Eighty-five samples were collected in the study areas, including 69 rock and sediment samples from 23 locations and 16 placer (alluvial) samples (Buehler and Graham, 1987).

EXPLANATION

Commodities

Au	Gold
Ag	Silver
Geo	Geothermal
Hg	Mercury
B	Boron
O, G	Oil and Gas
U	Uranium

[ ] Deposit types

1	Epithermal or hot-spring gold and silver in volcanic and volcaniclastic rocks
2	Epithermal mercury in volcanic and volcaniclastic rocks
3	Volcanogenic uranium

Description of Map Units

Qal	Alluvium (Quaternary)
Qd	Dune sand and eolian deposits (Quaternary)
QTb	Younger basalt (Tertiary)—Some original flow morphology preserved
Tts	Tuffaceous sediments (Tertiary)—Includes lacustrine sedimentary rocks, air-fall tuffs, and water-reworked ash interbedded with discontinuous outcrops of basalt and the tuff of Whitehorse Creek
Tb	Older basalt (Tertiary)—Discontinuous outcrops interbedded with tuffaceous sediments of Tts
Toc	Ash-flow Tuff of Oregon Canyon (Tertiary)
Ta	Andesite flows with interstratified pyroclastic rocks and tuffaceous sediments (Tertiary)
Ts	Steens Basalt (Tertiary)

Contact—Dashed where approximate

Normal fault—Dashed where approximate; dotted where concealed. Bar and ball on downthrown side

Figure 2. Continued.

Eleven of the samples were analyzed by plasma emission spectroscopy (inductively coupled argon-plasma) for 24 elements. Thirty-one sediment samples were analyzed for boron and lithium. Thirty-two rock samples were analyzed for zeolites and fluorine. Three sediment and three rock samples were analyzed for gold; the three rock samples were also analyzed for mercury. Two samples were analyzed for perlite, and one sample of petrified wood was taken for appraisal.

The 16 alluvial samples were panned to a rough concentrate, screened, and processed on a Wilfley table. The resulting heavy-mineral fractions were checked for the type and amount of heavy minerals present and then examined for radioactivity and fluorescence. Detailed analytical data are in Buehler and Graham (1987) and are on file at Western Field Operations Center, U.S. Bureau of Mines, E. 360 3rd Ave., Spokane, WA 99202.

Mining and Mineral Exploration History

No mines, claims, prospects, or mineralized zones were found, and no mineral or energy resources were identified in the Alvord Desert or East Alvord Wilderness Study Areas. As of December 1986, approximately 3,700 acres within the study area were under lease for oil and gas exploration. No land was leased for geothermal resources in 1986, however. There were several leases in the recent past, and exploratory drilling for low-temperature geothermal resources occurred near the north border of the East Alvord Wilderness Study Area.

The nearest mining district (Steens-Pueblo) is on the west side of the Alvord Desert, 10 mi west of the study areas (fig. 1). The district has produced a small amount of mercury, and occurrences of lode and placer gold, perlite, uranium-bearing minerals, and zeolite were reported (Minor and others, 1987). Rocks exposed in the study area correlate with those in the Steens Mountains (Hook, 1981), but little exploration has been done on the east side of the Alvord Desert or within the study area.

Identified Resources

Samples of black, fetid, very fine grained lacustrine sediments in the southwestern part of the Alvord Desert Wilderness Study Area contain higher-than-background (expected) amounts of zinc, cobalt, nickel, barium, iron, manganese, aluminum, and potassium, but no resources were identified. The samples were from an area that may contain concealed thermal waters, and precipitation of minerals from the waters might explain the above-average concentrations of these elements. It is also possible that the sediments contain the remains of plants that selectively absorbed elements from groundwaters and concentrated these specific elements in the sediments.

Small quantities of very fine grained gold are found in dry stream channels within the study area. The quantities and particle sizes are similar to placer gold occurrences reported in other drainages in the vicinity (Minor and others, 1987; Munts and Willett, 1987; Graham and Buehler, 1987). These placer gold occurrences are too low grade to attract commercial interests.

Small amounts of chalcedony (banded agate and coated vugs), petrified wood, and common opal are found in the lacustrine sediments and basalt flows within the study area. These materials are not commercially minable but may be of interest to hobbyists. The petrified wood and opal are in lacustrine sediments near the road dividing the two study areas. The easily polished, black, nearly fracture-free interiors of some of the petrified wood may be suitable backing material for soft, thin, and brittle gemstones, such as precious opal.

The basalt flows exposed along the west-facing escarpment contain chalcedony-lined vugs and banded agate. The vug linings (similar to geodes) and banded agate are generally not of gem quality; most are tan to gray or white and range in thickness from 1/16 to 1 in. Some of the vugs, however, are greater than 3 in. across and many contain botryoidal coatings of light-green to white chalcedony.

Most of the unconsolidated lacustrine sediments within the study area contain diatoms and clays, but these occurrences are too impure for commercial uses.

Large quantities of dune sand, which may be suitable for construction purposes, lie within the Alvord Desert Wilderness Study Area, but this material is not classified as an identified resource because transportation costs to current and prospective regional markets would be prohibitive.

The western parts of both study areas are within the Alvord Valley Known Geothermal Resource Area (KGRA). As of December 1986, no land in the study area was under lease for geothermal exploration. However, there were several leases in the recent past, and exploratory drilling for low-temperature geothermal resources north of the East Alvord Wilderness Study Area (fig. 1). Evaporite crusts, possibly associated with paleothermal springs, occur at two locations inside the study area. However, there are no thermal springs presently associated with these occurrences. The crusts may be the surface manifestation of thermal waters venting into lacustrine sediments at depth. The evaporite crusts are enriched in boron (0.01 to 0.09 percent) but not sufficiently large enough to be profitably mined as was done in the Borax Lake area, 15 mi to the southwest.

In December 1986, approximately 3,700 acres within the Alvord Desert Wilderness Study Area were under lease for oil and gas exploration. At that time, no drilling or other exploration had been done inside the study area.

A rhyolitic ignimbrite flow in the northeastern part of the East Alvord Wilderness Study Area contains volcanic glass with refractive indices in the range of perlite; however, the material contains 40 to 60 percent feldspar crystals as contaminants. This amount renders the material unsuitable for commercial uses; perlite presently mined contains 5 percent or less contaminants.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Brent D. Turrin, Andrew Griscom,
Robert L. Turner, *and* William A. Lawson
U.S. Geological Survey

Geology

The Alvord Desert and East Alvord Wilderness Study Areas are underlain by a series of Tertiary volcanic flows and volcaniclastic sediments (fig. 2). The basal contact of the Tertiary section is not exposed; however, local relief indicates that the volcanic section is at least 1,100 ft thick. Normal faulting is prevalent in the study area. Faults trend north-northwest and north-northeast, which is typical for this part of the Basin and Range province.

Structurally, the study area is an eastward-tilted fault block that exposes approximately 1,100 ft of Tertiary volcanic and volcaniclastic rocks. The geologic units exposed in the block become younger toward the east. The west side of the study area is bounded by a north-trending, west-side-down normal fault. The oldest exposed geologic unit in the fault scarp is the Steens Basalt. This unit has been referred to by a variety of names, including the Steens Mountain andesite series (Fuller, 1931); Steens Basalt (Fuller, 1931; Piper and others, 1939); and Steens Mountain volcanic series (Williams and Compton, 1953). The youngest units exposed consist of Quaternary alluvial, fluvial, and eolian sediments that onlap the structural block from the east (fig. 2).

In the study area, 700 to 800 ft of Steens Basalt is exposed. The unit is composed of 10- to 20-ft-thick basalt flows and rare interstratified pyroclastic rocks and tuffaceous sedimentary rocks. Overlying the Steens Basalt is a 150- to 200-ft-thick series of platy andesite flows and flow breccia. Disconformably overlying the andesite is the tuff of Oregon Canyon, a 10- to 20-ft-thick, welded to densely welded, light-blue-green to white comenditic ash-flow tuff. This unit forms a distinctive marker unit throughout the study area. Disconformably overlying the tuff of Oregon Canyon is a unit of tuffaceous sedimentary rocks that consists of fluvial and lacustrine sediments interbedded with discontinuous outcrops of basalt and the tuff of Whitehorse Creek of Rytuba and others, (1981). The tuffaceous sedimentary unit ranges from 50 to 100 ft thick. Unconformably overlying the tuffaceous sedimentary unit is a younger basalt. Some original flow morphology is still preserved, suggesting a Late Miocene or Early Pliocene age. In addition, Quaternary alluvial, fluvial, and eolian sediments unconformably overlie the tuffaceous sedimentary unit, onlapping the east side of the eastward-tilted fault block.

Geochemical Studies

Fifty-four stream-sediment samples were collected from active alluvium in stream channels. 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 and pulverized to a fine powder before analysis. The heavy-mineral concentrates, which are derived from the stream-sediment samples, were sieved through a 10-mesh screen and then panned until most of the quartz, feldspar, clay-sized material, and organic material were removed. The remaining light minerals were separated from the heavy minerals with a heavy liquid. Magnetite and illmenite were removed with an isodynamic magnetic separator. The concentrates were ground to a fine powder before analysis.

Stream sediments represent a composite of the rock and soil exposed upstream from the sample site. The heavy-mineral concentrate represents a concentration that may include ore-forming and ore-related minerals that, if present, permit determination of some elements that are not easily detected in bulk stream sediments.

Twenty-one rock samples were taken from mineralized and unmineralized outcrops and stream float. Samples that appeared fresh and unaltered were collected to provide geochemical background values. Altered or mineralized samples were collected to determine the suite of elements associated with the observed alteration or mineralization. The rocks were crushed and pulverized to a fine powder before analysis.

The heavy-mineral concentrates, stream sediments, and rocks were analyzed for 31 elements by direct-current arc, semiquantitative, emission spectrographic analysis (Grimes and Marranzino, 1968; Crock and others, 1983). In addition, the rocks and stream sediments were also analyzed for arsenic, bismuth, cadmium, antimony, zinc, gold, and mercury using the methods described by O'Leary and Viets (1986), Thompson and others (1976), and Koirtyohann and Kahlil (1976). Analytical data and a description of the sampling and analytical techniques are given in Adrian and others (1987).

Geochemical Results

A geochemically anomalous area is present approximately 1 mi outside the northwest corner of the East Alvord Wilderness Study Area. This anomalous zone contains rocks with high concentrations of arsenic (as much as 35 parts per million, (ppm)), antimony (3–100 ppm), and mercury (20–69 ppm), and stream sediments with anomalous concentrations of arsenic (as much as 10 ppm), antimony (9–13 ppm), and mercury (49–570 ppm). A north-trending fault intersects with an east-trending fault near this sample site. The intersection of these two faults could have acted as a conduit for ascending hydrothermal fluids, which could account for the anomalous values found there.

Sample sites scattered within the study areas have slightly anomalous geochemical values for arsenic (less than 20 ppm) from stream sediments and rock samples. However, these sites tend to be concentrated along the west-facing fault scarp in the western part of both the Alvord Desert and East Alvord Wilderness Study Areas. In the south-southeastern part of the East Alvord Wilderness Study Area, a rock sample yielded a slight molybdenum anomaly (10 ppm) that is associated with an arsenic (15 ppm) and silver anomaly (1.5 ppm). An arsenic geochemical anomaly (10–20 ppm) in stream–sediments and an arsenic (26–74 ppm) and molybdenum (10–15 ppm) geochemical anomaly in rock samples is found in the western part of the Alvord Desert Wilderness Study Area. These anomalous values are most likely derived from local hydrothermal activity along local fault zones.

Geophysical Studies

Geophysical data used to evaluate the mineral resource potential consist of aerial gamma-ray spectroscopy, aeromagnetic, and gravity surveys. Geophysical investigations included an aerial radiometric and aerial magnetic survey by Geodata International, Inc. (1980a, b) for the U.S. Department of Energy NURE program and a U.S. Geological Survey aeromagnetic survey of the Adel and parts of the Burns, Boise, and Jordan Valley 1° by 2° quadrangles (U.S. Geological Survey, 1972). In addition, a gravity survey was done to supplement available gravity data from the National Geophysical Data Center, National Oceanic Atmospheric and Administration, Code E/GC3, 325 Broadway, Boulder, CO 80303.

Aeromagnetic Survey

The aeromagnetic data were collected along parallel east-west flightlines spaced approximately 2 mi apart at a constant flight elevation of 9,000 ft above sea level. The data are corrected for the Earth's magnetic field. The residuals are plotted and contoured at a scale of 1:250,000 (U.S. Geological Survey, 1972). Additional aeromagnetic data are available in the atlases of the Adel and Jordan Valley 1° by 2° quadrangles (scale 1:250,000) published by the U.S. Department of Energy (Geodata International, Inc., 1980a, b). These data consist of aeromagnetic profiles flown east-west at an average height of 400 ft above ground and a profile spacing of 3 mi. Nine of these profiles cross the study area.

Variations in the Earth's magnetic field on an aeromagnetic residual map are, in general, caused by variations in the amounts of magnetic minerals within different rock units; magnetite is the common magnetic mineral in this area. Magnetic minerals, where either locally concentrated or absent, may cause a high or low magnetic anomaly that can be a guide to mineral occurrences or deposits. Boundaries between magnetic and relatively less magnetic rock units are located approximately at the steepest gradient on the flanks of the magnetic anomaly at these magnetic latitudes.

Because of the preponderance of lava flows and other volcanic rocks in this area, the majority of the anomalies are probably caused by the variable iron content in the volcanic rocks. The survey aircraft was about 4,000–4,500 ft above the surface of the ground; this distance is sufficiently great to suppress most of the short wavelength anomalies generated by the smaller rock units at or near the surface. The aeromagnetic patterns form broad, subcircular, low-amplitude anomalies. The steep linear topographic scarp on the east side of Alvord Valley, shown as a major normal fault on the geologic map, shows as a major north-trending boundary and gradient on the aeromagnetic map, extending north as far as Mickey Springs on the north border of the East Alvord Wilderness Study Area.

Gravity Survey

A gravity survey of the Alvord Desert region (fig. 3) was conducted by the U.S. Geological Survey in 1986 to supplement already available data obtained from the National Geophysical Data Center, Boulder, Colo. Station spacing ranges from 1 to 5 mi. Approximately 70 stations are situated in the study area. Station accuracy is better than 0.3 milligal (mGal). The relatively large number of gravity stations is a result of geothermal exploration in and near the sedimentary basin of Alvord Valley (Griscom and Conradi, 1975). Except for Alvord Valley, the gravity field of the study area is nearly flat and featureless. The gravity field of Alvord Valley within the Alvord Desert Wilderness Study Area (fig. 3) produces a gravity low of about 38 mGal, which is probably caused by low-density sediments of the valley fill. The fact that the topographic scarp and mapped fault on the east side of the valley is located near the top of the gravity gradient (rather than in the middle of the gradient, as expected) suggests that the major downdropping of the east side of the valley floor does not take place at the topographic scarp. Judging by the location of the steepest gravity gradients, it appears that there are additional concealed major normal faults 1–1.5 mi west of the topographic scarp. The steepest gradients (fig. 3) can be followed north to Mickey Springs, which is located on the steepest slope of a gravity gradient striking about N. 20° E.; the gradient probably being evidence for a major normal fault having the same strike. These steep gravity gradients indicate that there are faults systems that may provide conduits for hydrothermal waters.

The 38-mGal gravity low of Alvord Valley is probably caused by low-density sedimentary fill in a similar fashion as other major basins within the Basin and Range province. Although the density contrast between the basement rock and sedimentary fill is unknown, based on other examples (table 6, p. 35, Oliver, 1980) it is assumed that the contrast ranges between 0.35 and 0.50 g/cm^3. Using the estimated density contrast the gravity anomaly indicates a maximum thickness of 3200–6400 ft of valley fill.

Aerial Gamma-ray Spectroscopy

Aerial gamma-ray spectrometer measurements are available along 3-mi-spaced east-west profiles (Geodata International, Inc., 1980a, b). The results indicate that statistically significant anomalies for uranium, potassium, and thorium are not present within the borders of the study area.

Mineral and Energy Resources of the East Alvord Wilderness Study Area

Mineral Resources

In the northwestern part of the study area, near Mickey Springs (fig. 2), arsenic, antimony, and mercury geochemical anomalies are found in rocks and stream sediments. In addition, evaporite crusts associated with some thermal springs in the region are enriched in boron (0.01 to 0.09 percent). This suggests a moderate resource potential for gold, silver, and mercury in epithermal deposits, certainty level B, and a low resource potential for boron, certainty level B, for the northwestern part of the study area (fig. 2). A low resource potential for gold, silver, and mercury in epithermal deposits and for boron associated with hot-spring evaporite deposits, certainty level B, exists in the southwestern part of the study area. In addition, an arsenic, silver, and molybdenum geochemical anomaly in the south-southeastern part of the East Alvord Wilderness Study Area suggests an area of low potential for gold and silver, certainty level B.

Energy Resources

The western part of the East Alvord Wilderness Study Area lies in the Alvord Valley Known Geothermal Resource Area (KGRA). Parts of the study area were rated as having high favorability for the occurrence of geothermal resources by Brown and Peterson (1980). However, as of December 1986, exploratory drilling had not led to the development of any low-temperature geothermal resources in the East Alvord or Alvord Desert Wilderness Study Areas. Gravity data indicate that northeast-trending faults are the major conduits for the hydrothermal systems. The western part of the East Alvord Wilderness Study Area, from Mickey Springs south to approximately 2 mi north of Big Sand Gap along the west-facing fault scarp and west to the study area boundary (see fig. 2), has a moderate potential for low- to medium-temperature geothermal resources, certainty level C. The remaining part of the East Alvord Wilderness Study Area has a low potential for geothermal resources, certainty level B.

The East Alvord Wilderness Study Area reportedly has a medium favorability for the occurrence of oil and gas (Fouch, 1983a, b). In December 1986, approximately 3,700 acres within the Alvord Desert study area were under lease for oil and gas exploration. At that time, no drilling or other exploration had been done inside the study area. The entire study area is given a low potential for oil and gas resources, certainty level B for the following reasons: (1) Generally the Basin and Range province is too thermally mature due to the extensive Miocene volcanic

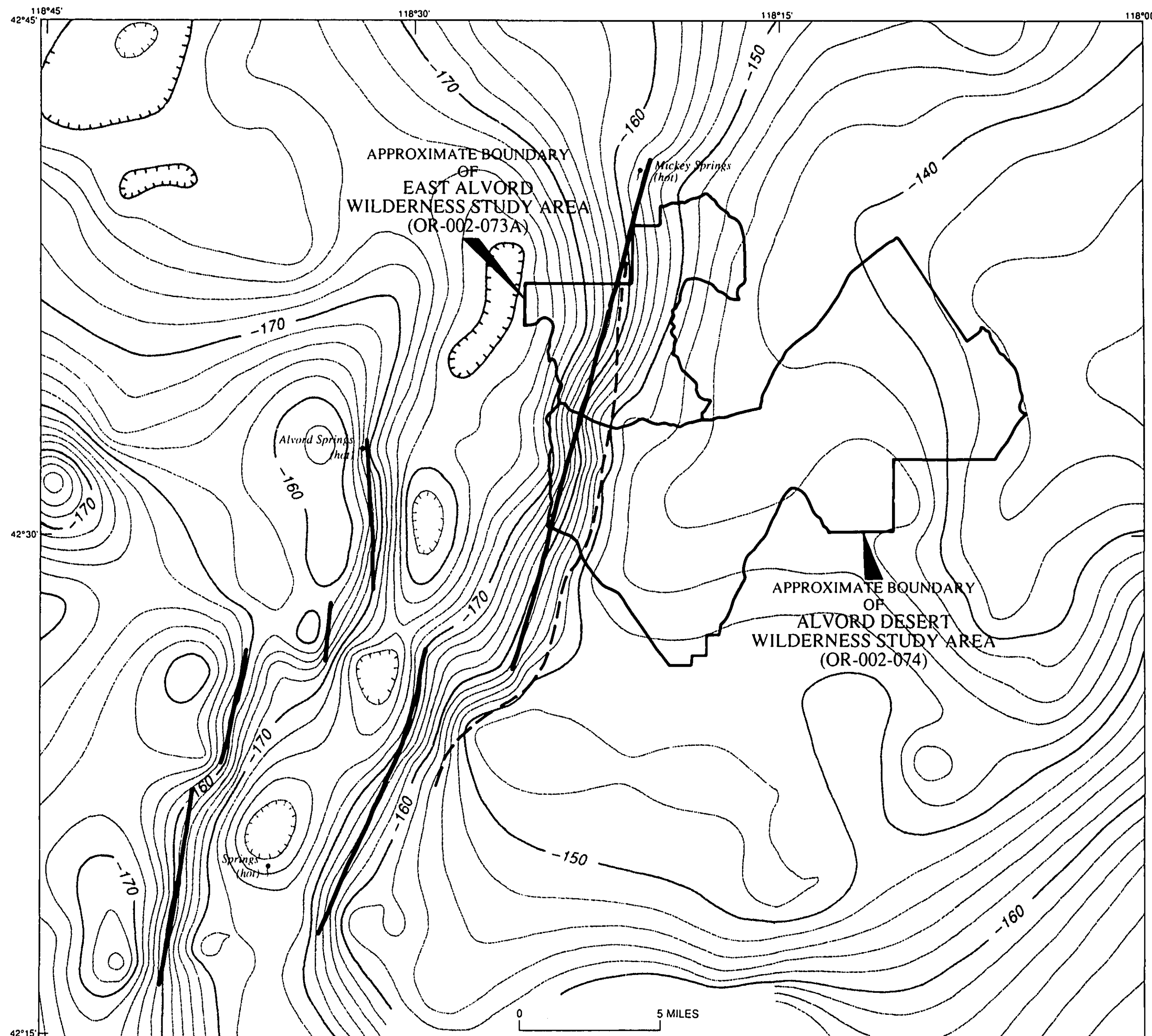

Figure 3. Complete Bouguer gravity anomaly map of the Alvord Valley area, Harney and Malheur Counties, Oregon. Values in milligals; contour interval 2 milligals; hachured in direction of gravity low. Heavy line, location of interpreted major fault; short dashed line, base of topographic scarp.

activity to have formed any hydrocarbon reserves (Sandberg, 1983) and (2) the area lacks suitable source rocks for hydrocarbon generation. Aerial gamma-ray spectroscopy data, which do not show any anomalies, indicate the entire study area has a low potential for uranium, certainty level B.

Mineral and Energy Resources of the Alvord Desert Wilderness Study Area

Mineral Resources

A low resource potential for gold, silver, and mercury in epithermal deposits, certainty level B, and a low potential, certainty level B, for boron associated with hot-spring evaporite deposits, is present along the west boundary of the Alvord Desert Wilderness Study Area (fig. 2). Moreover, an arsenic and molybdenum geochemical anomaly in the rock samples and arsenic anomalies in stream-sediment samples in the western part of the Alvord Desert Wilderness Study Area suggests a small area of moderate potential for epithermal-type gold, silver, and mercury mineral resources, certainty level B.

Energy Resources

Parts of this study area were rated as having high favorability for geothermal resources by Brown and Peterson (1980). As of December 1986, however, exploratory drilling for low-temperature geothermal resources had not led to the development of any low-temperature geothermal resources in the Alvord Desert Wilderness Study Area. Gravity data (fig. 3) indicate that northeast-trending faults are the major conduits for the hydrothermal systems. The western part of the Alvord Desert Wilderness Study Area lies in the Alvord Valley KGRA. The western part of the Alvord Desert Wilderness Study Area, from approximately 2 mi north of Big Sand Gap to the south boundary of the study area, along the west-facing fault scarp and west to the study area boundary (fig. 2), has a moderate potential for low- to medium-temperature geothermal resources, certainty level C. The remainder of the study area has a low potential for geothermal resources, certainty level B.

The western part of the study area reportedly has a medium favorability for the occurrence of oil and gas (Fouch, 1983a, b). Approximately 3,700 acres within the Alvord Desert Wilderness Study Area were under lease for oil and gas exploration in December of 1986. There has been no reported drilling or other exploration inside the study area. Because of the extensive Miocene volcanic activity, the Basin and Range province is too thermally mature to have formed any hydrocarbon reserves (Sandberg, 1983). The area lacks suitable source rocks for hydrocarbon generation. Therefore, the entire study area has a low potential for oil and gas resources, certainty level B. On the basis of the aerial gamma-ray spectroscopy data, which do not show any anomalies, the entire area has a low potential for uranium, certainty level B.

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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.

LEVEL OF RESOURCE POTENTIAL (increasing upward)

A	B	C	D
U/A	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
UNKNOWN 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 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.

Mineral Resources of Wilderness Study Areas: Alvord Desert Region, Oregon

This volume was published as separate chapters A–B

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DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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

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[Letters designate the separately published chapters]

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U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849