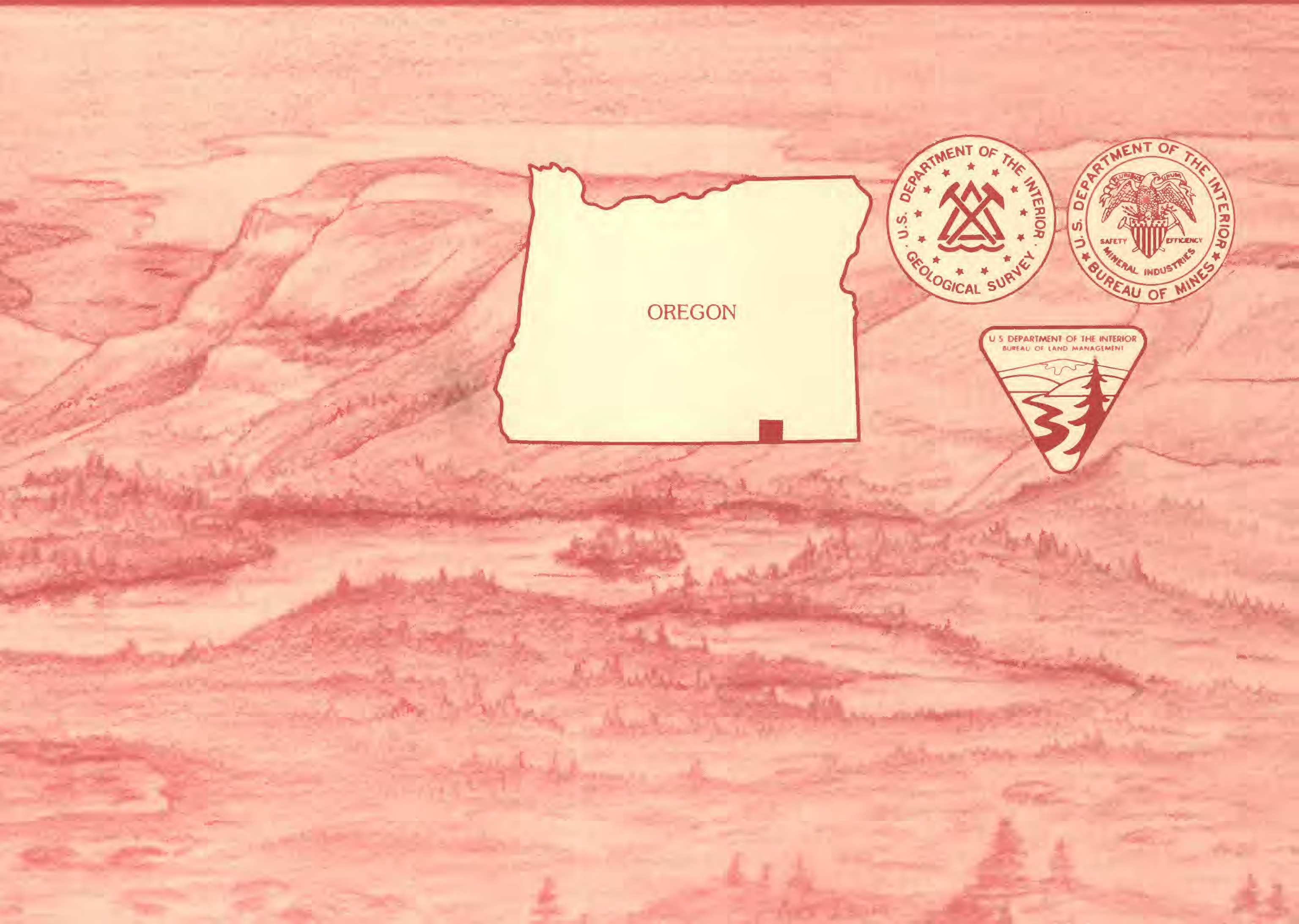
Mineral Resources of the Hawk Mountain Wilderness Study Area, Harney County, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1740–F



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Chapter F

Mineral Resources of the Hawk Mountain Wilderness Study Area, Harney County, Oregon

By BRENT D. TURRIN, JAMES E. CONRAD,
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U.S. GEOLOGICAL SURVEY BULLETIN 1740

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
STEENS MOUNTAIN-RINCON REGION, OREGON

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., 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 Hawk Mountain (OR-001–146A) Wilderness Study Area, Harney County, Oregon.

CONTENTS

FIGURES

TABLE

Mineral Resources of the Hawk Mountain Wilderness Study Area Harney County, Oregon

By Brent D. Turrin, James E. Conrad, Donald Plouff, *and* Harley D. King
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Ronald T. Mayerle *and* Richard L. Rains
U.S. Bureau of Mines

SUMMARY

Abstract

The Hawk Mountain Wilderness Study Area (OR-001-146A) encompasses approximately 69,640 acres along the Oregon-Nevada State line. The study area lies in southwestern Harney County, Oreg., approximately 20 mi southeast of Fields, Oreg., and 12 mi west of Denio, Nev. In this report, "study area" or "wilderness study area" refers to that area for which the mineral survey was requested by the U.S. Bureau of Land Management. Geologic, geochemical, and geophysical surveys of the study area were conducted by the U.S. Geological Survey and U.S. Bureau of Mines to evaluate the identified (known) mineral resources and to assess the mineral resource potential (undiscovered). No resources were identified in the study area. No mines or claims were observed in the study area nor are there any records of production or oil, gas, or geothermal leases for the study area. The study area is underlain by Tertiary volcanic rocks that are locally hydrothermally altered and silicified. In this region, altered rocks may host deposits of mercury, silver, and gold and industrial minerals (clay and zeolite). In addition, the geologic setting of the study area is favorable for rhyolite-hosted tin deposits. No evidence of mercury, silver, or tin mineralization or of clay and zeolites was found in the study area. However, geochemical data indicate that the west half of the study area has low resource potential for gold in epithermal deposits. Low potential for uranium in localized, small-volume deposits is associated with the tuffaceous sedimentary rock exposed in the south-central and eastern parts of the study area. Secondary uranium minerals (carnotite and schroeckingerite?) are reportedly associated with opalized zones in tuffaceous lacustrine sedimentary rock exposed south of the study area. The entire study area has low potential for geothermal resources and low potential for oil and gas resources.

Manuscript approved for publication August 14, 1989.

Character and Setting

The Hawk Mountain Wilderness Study Area (OR-001-146A) is situated in the transition zone between the Basin and Range and Columbia Plateau physiographic provinces. The Basin and Range province in Oregon and adjacent parts of Nevada is an extensive semiarid to arid tract of subparallel, north-trending en echelon mountain ranges and intervening valleys. The Columbia Plateau province is a high dissected plateau consisting mostly of Tertiary volcanic rocks. The 69,640-acre study area is situated along the Oregon-Nevada State line approximately 20 mi southwest of Fields, Oreg., and approximately 12 mi west of Denio, Nev. (fig. 1). Elevations range from 5,000 ft at the valley bottoms to almost 7,000 ft at the highest peaks. The study area is underlain by a sequence of Tertiary rhyolitic ash-flow tuffs and lava flows (see geologic time chart in "Appendixes" for age definitions). Two major sets of faults that trend northwest and northeast cut the rocks of the study area.

Identified Resources

The Hawk Mountain Wilderness Study Area does not contain any identified mineral resources. In addition, no mines, claims, prospects, or mineralized zones were identified in the study area. However, four mining districts are located near the study area. They are (1) the Steens-Pueblo mining district, a 40-mi-long belt of epithermal gold, copper, and mercury deposits that lies along the east edge of the Steens and Pueblo Mountains, approximately 30 and 10 mi northeast and east of the study area, respectively, (2) the Warm Springs gold and tungsten mining district that is approximately 20 mi east of the study area, (3) the Virgin Valley opal mining district that is approximately 10 mi south of the study area, and (4) the Lone Pine gold-mercury mining district that is approximately 30 mi southwest of the study area.

Mineral Resource Potential

The Hawk Mountain Wilderness Study Area is part of a region characterized by extensive exposures of Tertiary volcanic rocks that are locally hydrothermally altered and silicified. Outside the study area, these altered rocks host deposits of base and precious metals (mercury, silver, and gold) and industrial minerals (zeolites and clays). Of these commodities, gold is the only one found in the study area. The western part of the study area has low resource potential for gold in epithermal deposits (fig. 2).

The entire study area has low favorability for the occurrence of oil and gas resources. No drilling or other exploration for oil and gas has been done inside the study area. Because of the extensive Miocene magmatism and associated high heat flow in this part of the Basin and Range province, the region is generally too thermally mature to have developed hydrocarbon reserves. Therefore, the entire study area has low potential for oil and gas resources.

On the basis of the aerial gamma-ray spectroscopy data, there is low potential for uranium in localized, small-volume deposits in tuffaceous sedimentary rock. This unit is widespread in the eastern and southern parts of the study area. Secondary uranium minerals (carnotite

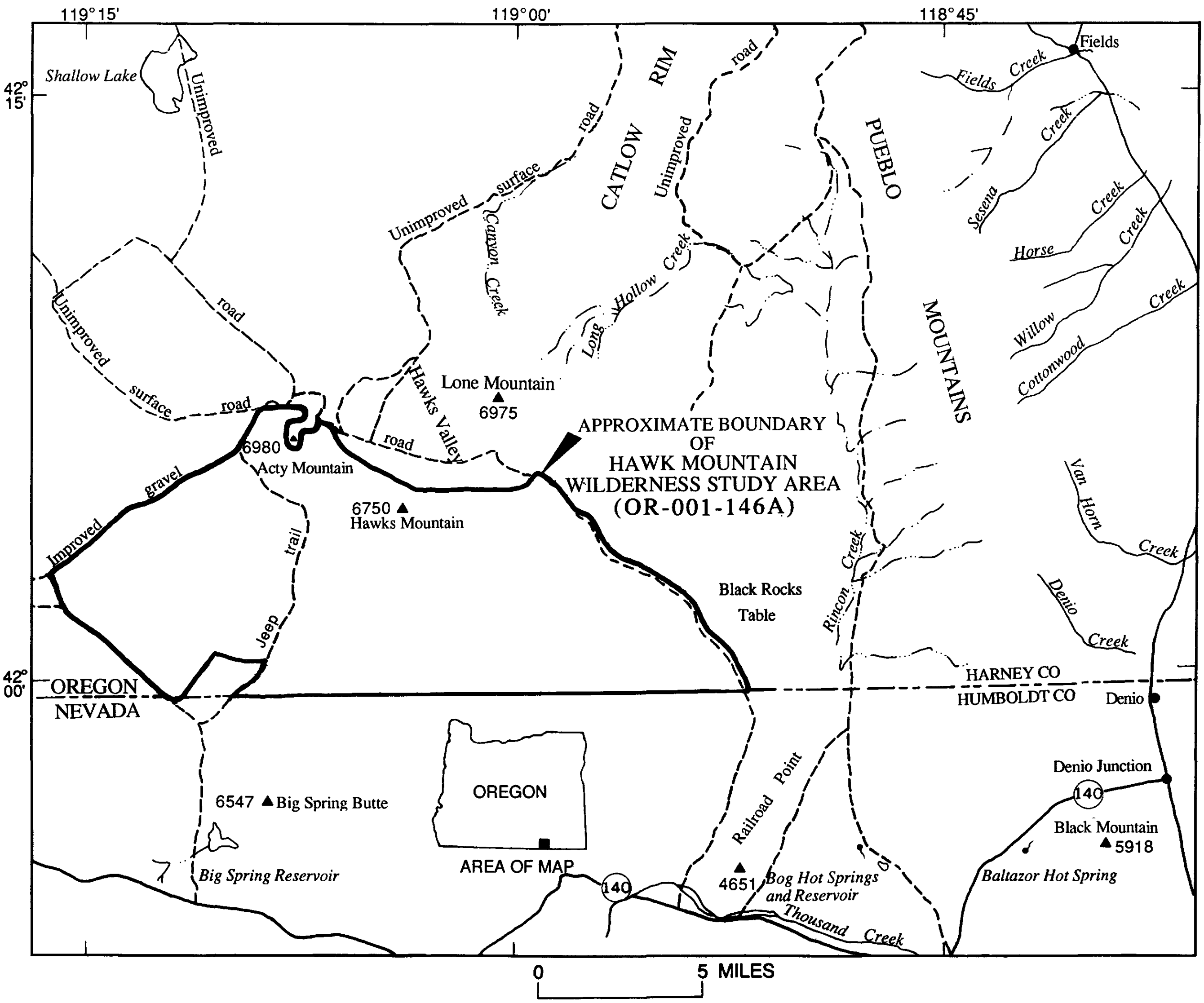

Figure 1. Index map showing location of Hawk Mountain Wilderness Study Area, Harney County, Oregon.

and schroeckingerite?) are reportedly associated with opalized zones in the tuffaceous lacustrine sedimentary rock of the Virgin Valley Formation south of the study area.

No hot springs were found in the study area nor are there any geothermal production leases for land in the study area. However, the presence of young volcanic rock (less than 2 Ma) and the occurrence of hot springs within 10 mi of the study area suggest that the entire study area has low potential for geothermal resources.

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 a system that is a modification of that described by McKelvey (1972) and 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 Hawk Mountain Wilderness Study Area comprises approximately 69,640 acres along the Oregon-Nevada State line in eastern Harney County, Oreg., approximately 20 mi southwest of Fields, Oreg., and approximately 12 mi west of Denio, Nev. (fig. 1). Most parts of the study area are accessible via unimproved roads from Nevada Highway 140 and Oregon Highway 140. The study area also can be accessed from the north on a partly improved gravel road leading from the Fields-Frenchglen road, which is northeast of the area shown in figure 1. Unimproved roads parallel the north, northeast, and northwest borders of the study area. These roads, however, are periodically washed out and in places may only be passable to high-clearance four-wheel-drive vehicles.

The climate in the study area, typical of a middle-latitude desert, is semiarid to arid; it is dominated by continental tropical air masses in summer and continental polar air masses in winter (Sthraler, 1969; Houghton and others, 1975). Annual temperatures range from less than –4 °F in winter to more than 100 °F during the summer. Daily summer temperature changes frequently exceed 90 °F. Precipitation, mostly as snow and winter rain, ranges from 5 to 15 in. annually. During summer, relative humidity averages about 20 percent but may fall to 10 percent.

Several varieties of sagebrush and grass flourish in most of the study area. Willow, cottonwood, and aspen occur along drainages. 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 number and species.

Previous and Present Investigations

A reconnaissance geologic map of the Adel quadrangle, Lake, Harney and Malheur Counties, Oregon, by Walker and Repenning (1965) at a scale of 1:250,000 includes the study area. In addition, radiometric data, compiled by Geodata International, Inc. (1980) for the National Uranium Resource Evaluation (NURE) program of the Department of Energy and regional aeromagnetic surveys (U.S. Geological Survey, 1972a, b) by the U.S. Geological Survey cover the area. In 1980 the U.S. Bureau of Land Management conducted a reconnaissance geochemical survey in the Hawk Mountain Wilderness Study Area (Rimal, 1980). The adjoining Charles Sheldon Wilderness Study Area, south of the study area in Nevada, was examined for mineral resource potential by the U.S. Geological Survey and the U.S. Bureau of Mines (Greene, 1984; Plouff, 1984; Cathrall and others, 1984; and Tuchek and others, 1984).

The U.S. Geological Survey conducted field investigations of the Hawk Mountain Wilderness Study Area in the spring of 1986. This work included geologic mapping at scales of 1:62,500 and 1:24,000, geochemical sampling, and examining outcrops for evidence of mineralization. The geochemical survey utilized rock and stream-sediment (including a fine fraction and heavy-mineral concentrate) samples that were analyzed for 33 elements by semiquantitative emission spectrography. Gold, arsenic, antimony, cadmium, mercury, zinc, and bismuth were detected using atomic-absorption methods, and uranium and thorium were detected using delayed-neutron count. Earlier geophysical data, which consisted of regional gravity and magnetic surveys, were compiled and analyzed for this study. Further details on analytical procedures used for this resource assessment are given in the appropriate sections that follow.

The U.S. Bureau of Mines gathered data on mines, claims, prospects, and mineralized areas from U.S. Bureau of Land Management records, published literature, U.S. Bureau of Mines files and production records, and county mining records. Fieldwork was conducted during the summer of 1986.

APPRAISAL OF IDENTIFIED RESOURCES

By Ronald T. Mayerle *and* Richard L. Rains,
U.S. Bureau of Mines

Mining and Mineral Exploration History

The U.S. Bureau of Mines found no record of mining activities for the study area. The nearest mining district, the Virgin Valley, is about 10 mi south of the study area in the Charles Sheldon National Antelope Range. Precious opal is currently being produced in the district and building stone was previously produced in the district (Tuchek and others, 1984). Uranium occurs in the district and the adjacent region.

The only reported mineral exploration in the study area is a reconnaissance geochemical survey of the Hawk Mountain area and the adjoining Lone Mountain area conducted by the U.S. Bureau of Land Management (Rimal and others, 1980). The results of this study are discussed in the "Geochemical Studies" section.

Identified Resources

No mineral resources were identified within the Hawk Mountain Wilderness Study Area (Mayerle and Rains, 1988). During the U.S. Bureau of Mines field study, special attention was given to three drainages in the northern part of the study area west of Hawks Mountain (fig. 1). These drainages were considered by the U.S. Bureau of Land Management on the basis of anomalous gold found during their geochemical study as suitable for "further scrutiny" (Rimal and others, 1980) that might reveal evidence of possible mineral deposits. Of the 12 alluvium (placer) samples taken by the U.S. Bureau of Mines, 7 were collected from dry streambeds in the three drainages; 1 alluvium sample from each of the three drainages was taken as close to the U.S. Bureau of Land Management stream-sediment sample locality as possible. The other five alluvium samples were taken from drainages adjacent to the three drainages, at localities that were not sampled by the U.S. Bureau of Land Management.

No gold or other heavy minerals were found in any of the 12 alluvium samples collected, and no mineralized or significantly altered rock was found in outcrops or as float[1] in the drainages. The anomalous concentrations of gold found in the stream-sediment samples taken by the U.S. Bureau of Land Management, however, show that small amounts of gold are present in the study area. The U.S. Bureau of Mines and U.S. Bureau of Land Management studies indicate that the distribution of gold in the study area is irregular and is probably not related to gold deposits in the drainages sampled.[2]

Common opal and fossil mammalian bones of Hemphillian age (late Miocene) are contained in ash beds east and southeast of the study area. Although these fossils do not constitute a mineral resource, they are deemed valuable by some collectors and paleontologists. Precious opal and building stone resources, and uranium occurrences similar to those found in the Virgin Valley mining district to the south are not known in the wilderness study area.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Brent D. Turrin, James E. Conrad, Donald Plouff, *and* Harley D. King
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Geology

The Hawk Mountain Wilderness Study Area is underlain by a sequence of late Tertiary volcanic flows, volcaniclastic, and continental sedimentary rocks and Quaternary alluvium and playa deposits. Although the basal contact of the Tertiary section is not exposed, local relief indicates that the volcanic section is more than 1,500 ft thick. Major fault trends within the study area, northwest and northeast, are typical of this part of the Basin and Range province.

The oldest geologic unit, exposed just south of the study area, is the Idaho Canyon Tuff of Noble and others (1970); it is 200 to 400 ft thick and consists mostly of densely welded, devitrified tuff that is medium gray to light brown and weakly porphyritic. Phenocrysts in the Idaho Canyon Tuff are predominantly alkali feldspar and

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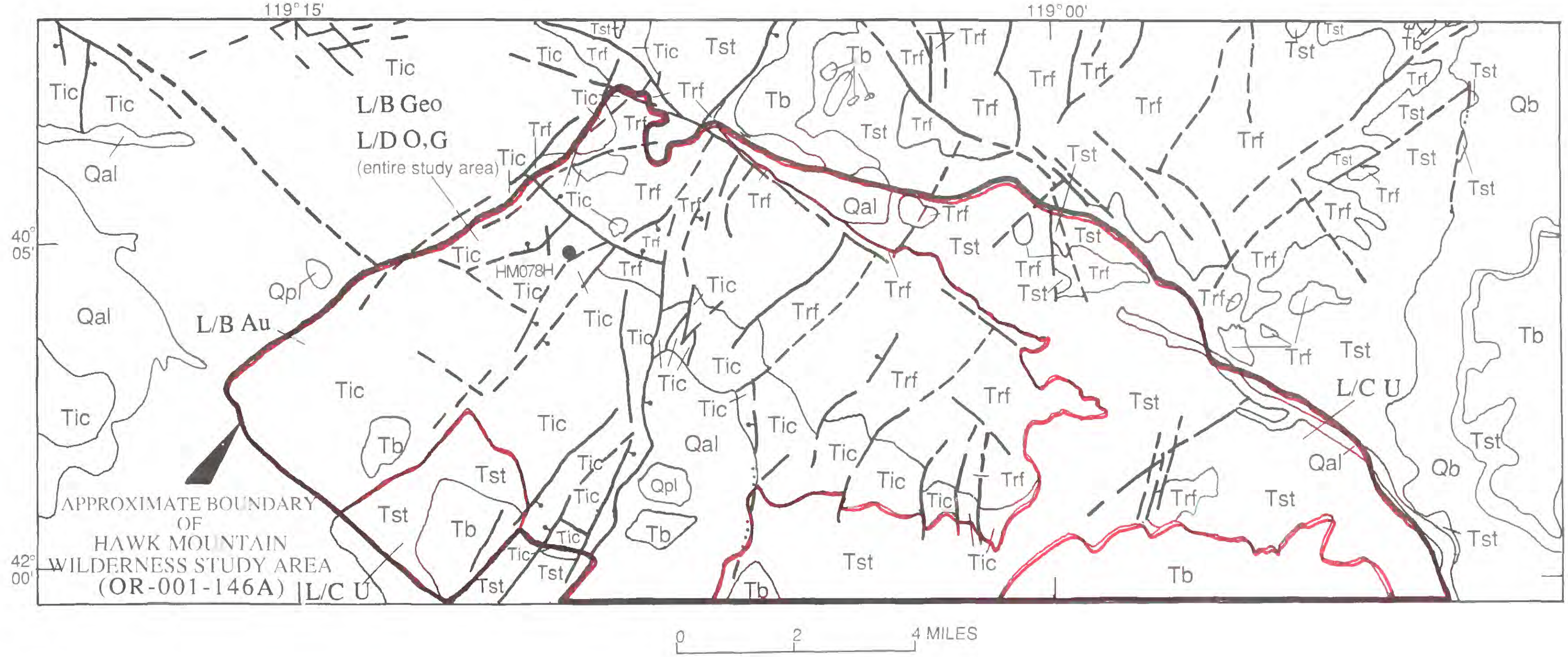
[1]Float–pieces of rock lying on the surface and which may have been transported some distance from their origin, generally by water or gravity.

[2]The stream-sediment samples taken by the BLM were assayed for a variety of elements by laser-induced fluorescence, atomic absorption, chemical, and other analytical methods. In comparison, alluvium (placer) sampling analyses are relatively unsophisticated; however, alluvium sampling has been used for centuries to detect heavy metals or minerals that are commonly associated with a variety of mineral deposits and, coupled with a ground reconnaissance, can provide much valuable data.



EXPLANATION

[red outlined box]	Area having low mineral resource potential (L)
	Levels of certainty of assessment
B	Data only suggest level of assessment
C	Data give good indication of assessment
D	Data clearly define level of assessment
	Commodities
Au	Gold
Geo	Geothermal
O,G	Oil and Gas
U	Uranium
• HM078H	Sample locality—See text for discussion

Geologic map units

Qal	Alluvium (Quaternary)
Qpl	Playa deposits (Quaternary)
Qb	Basalt of Railroad Point of Greene (1984) (Quaternary)—Olivine basalt
Tb	Basalt of Catnip Creek of Greene (1984) (Tertiary)—Discontinuous outcrops unconformably overlying and interbedded with tuffaceous sedimentary rock of Tst
Tst	Tuffaceous sedimentary rock (Tertiary)—Consists of Virgin Valley and Thousand Creek Formations of Merriam (1910, 1911), undivided
Trf	Canon Rhyolite of Merriam (1910) (Tertiary)—Rhyolite flows, domes, and pyroclastic deposits
Tic	Idaho Canyon Tuff of Noble and others (1970) (Tertiary)—Densely welded, devitrified ash-flow tuff
——	Contact
——•—— - - - ...	Normal fault—Dashed where approximate; dotted where concealed. Bar and ball on downthrown side

Figure 2. Mineral resource potential and generalized geology (from Walker, 1965) of Hawk Mountain Wilderness Study Area, Harney County, Oregon.

quartz but include trace amounts of fayalite and magnetite.

Overlying the Idaho Canyon Tuff is the middle Miocene Canon Rhyolite of Merriam (1910, 1911). This unit is composed of rhyolite flows, domes, and subordinate intercalated pyroclastic deposits. A potassium-argon (K-Ar) age of 15 Ma for the unit is reported in Noble and others (1970) and Harvey and others (1986). The unit mostly consists of light-purplish-gray to reddish-brown, microcrystalline to fine-grained silicic lava flows containing fractured phenocrysts of alkali feldspar, quartz, and minor amounts of euhedral to subhedral biotite and alkali amphibole. Flow banding, flow foliations, and ramp structures are common features of the Canon Rhyolite. Rocks of the unit are peralkaline, as are most rhyolitic tuffs and lava flows of middle Miocene age in the region (Noble and others, 1968; Noble and others, 1970; Korringa, 1973; Bonham, 1969; and Harvey and others, 1986).

Interbedded with and unconformably overlying the Canon Rhyolite and Idaho Canyon Tuff is a sequence of tuffaceous sedimentary rock. Common opal and fossil mammalian bones are contained within this unit. This sequence was divided into two units by Merriam (1910, 1911); they are the Virgin Valley Formation, which contains Barstovian (approximately 14 to 17 Ma) fauna and the Thousand Creek Formation, which contains Hemphillian (approximately 4 to 8 Ma) fauna. The tuffaceous sedimentary rock unit is mostly white to light-gray claystone and tuffaceous siltstone, sandstone, and waterworked air-fall tuff. However, there is no clear lithologic break between the Virgin Valley Formation and the Thousand Creek Formation, so they are shown as one unit in figure 2.

Unconformably overlying and interbedded with the tuffaceous sedimentary unit is the Basalt of Catnip Creek of Greene (1984). This basalt forms a distinct mesa-capping unit in the southeastern part of the study area. Two K-Ar ages of 8.84±0.1 Ma and 9.87±1.2 Ma are reported for this unit (Greene, 1984).

The youngest volcanic unit in the study area is the Basalt of Railroad Point of Greene (1984), a canyon-filling flow. Subsequent erosion has inverted the topography and produced an elongated basalt-capped ridge. K-Ar ages reported for the unit are 1.2±0.1 Ma (McKee and Marvin, 1974) and 1.58±0.2 Ma (Greene, 1984).

The youngest units in the study area are Quaternary playa and alluvium deposits; the playa unit consists of clay, silt, sand, and some evaporites, and the alluvium consists of unconsolidated fluvatile gravel, sand, and silt.

Fossil Vertebrates from Sedimentary Deposits

No fossil vertebrate remains have been recorded from the Hawk Mountain Wilderness Study Area. However, late Miocene sedimentary rock contiguous with those exposed in the study area occur to the east and southeast along the Black Rocks Table escarpment and along the northern end of Railroad Point (fig. 1) near the Nevada-Oregon State line. Fossil vertebrates from these rocks known collectively as the Thousand Creek Fauna indicate an early Hemphillian age (late Miocene, approximately 9–7 Ma). No formal geologic name has been given to these deposits, but they have been informally referred to as the Thousand Creek beds. Farther southwest, the underlying Virgin Valley Formation contains older vertebrate fauna of Barstovian or middle Miocene age (approximately 15 Ma). However, faunas of this age have not been found in the vicinity of Black Rocks Table or near the Hawk Mountain Wilderness Study Area. In addition, no intermediate faunas of Clarendonian age (approximately 12–9 Ma) have been reported from this region.

The most recent review of the Thousand Creek Fauna is that of MacDonald and Pelletier (1956). Merriam (1907, 1909, 1910, 1911, 1915, and 1917) first mapped the geology and described the vertebrate fauna of these fossil-bearing deposits. Later, fossil collections were made by C. Stock at the Carnegie Institute of Technology in the 1930's (collection now stored in the Los Angeles County Museum), by A. Shotwell at the University of Oregon in the 1960's, by C. Falkenbach from the American Museum of Natural History in New York in the late 1950's and early 1960's, and by C. Repenning at the U.S. Geological Survey. Various field parties from the University of California at Berkeley Museum of Paleontology have also made fossil collections of the Thousand Creek Fauna. The vertebrate collections housed at the aforementioned institutions are the most complete collections of these fauna. A general list of the Thousand Creek Fauna from MacDonald and Pelletier (1956) is given in table 1.

Geochemical Studies

The reconnaissance geochemical study of the Hawk Mountain Wilderness Study Area included the collection and analysis of 93 stream-sediment samples, 90 nonmagnetic heavy-mineral-concentrate samples of stream sediment, and 14 rock samples. The stream-sediment samples are representative of the rock eroded from drainage basins upstream from sample sites. Chemical analyses of stream sediment are useful in identifying those basins containing concentrations of elements that may be related to mineralization. Nonmagnetic heavy-mineral-concentrate samples provide information about the chemical composition of a limited number of minerals in rock eroded from the drainage basin upstream from each sample site. Minerals in heavy-mineral concentrates are commonly ore related. Analyses of the concentrates permit detection of some elements that are not easily detected in bulk stream-sediment samples.

Table 1. Vertebrate fauna from the Thousand Creek beds (from MacDonald and Pelletier, 1959)

PISCES
    Indeterminate fragments.
REPTILIA
    SQUAMATA
        OPHIDIA gen. indet.
AVES
    ANSERIFORMES
        Branta sp.
MAMMALIA
    INSECTIVORA
        Scapanus sp.
    LAGOMORPHA
        Hypolagus vetus (Kellogg) (type locality).
    RODENTIA
        Liodontia furlongi Gazin (type locality).
        Mylagaulus cf. M. monodon.
        Marmota nevadensis (Kellogg) (type locality).
        Marmota minor (Kellogg) (type locality).
        Dipoides sp.
        Diprionomys parvus (Kellogg) (type locality).
        Diprionomys minimus (Kellogg) (type locality).
        Cupidinimus magnus (Kellogg) (type locality).
        Citellus sp.
        Peromyscus antiquus (Kellogg) (type locality).
    PROBOSCIDEA
        Mammut (Pliomastodon) nevadanus (Stock) (type locality).
    CARNIVORA
        Canis sp. or *Vulpes* sp.
        Taxidea nevadensis Butterworth (type locality).
        Pliogale furlongi (Merriam) (type locality).
    PERISSODACTYLA
        Neohipparion leptode Merriam (type locality).
        Pliohippus sp.
        Teleoceras sp.
    ARTIODACTYLA
        Prosthennops sp.
        Paracamelus? sp.
        Sphenophalos nevadanus Merriam (type locality).
        Illingoceros alexandrae Merriam (type locality).
        Illingoceros schizoceros Merriam (type locality).

All samples were analyzed semiquantitatively for 31 elements using a direct-current arc emission spectrographic method (Grimes and Marranzino, 1968). For detecting certain ore-related elements or those that have high limits of detection by emission spectrography, inductively coupled argon plasma-atomic emission spectroscopy (ICP-AES) was used to analyze for antimony, arsenic, bismuth, cadmium, and zinc. Atomic-absorption methods (described in Crock and others, 1987) were used to analyze for gold and mercury.

A reconnaissance geochemical study was conducted by the U.S. Bureau of Land Management in the Hawk Mountain Wilderness Study Area (Rimal and others, 1980). In that study, stream-sediment samples were collected at 45 sites within and along the boundary of the study area and were analyzed for 15 elements. In the study by Rimal and others (1980), gold was analyzed by an atomic-absorption method with a lower limit of detection of 0.001 ppm (parts per million). The atomic-absorption method used by the U.S. Geological Survey for detecting gold and mercury in this study has a lower limit of determination of 0.05 ppm for gold.

Rimal and others (1980) reported anomalous values of gold in three stream-sediment samples. Gold values of 0.030 and 0.040 ppm were found in two samples from sites just west of Hawk Mountain and a gold value of 0.170 ppm was reported from a sample collected from a site along the west boundary of the study area. This site is about 2 mi north of a U.S. Geological Survey sample site where a particle of gold less than 0.02 in. in diameter was found in a nonmagnetic heavy-mineral-concentrate sample (HM078H, fig. 2). Analyses of U.S. Geological Survey samples from the same drainages where the U.S. Bureau of Land Management sediment samples containing these anomalous gold values were obtained did not detect any gold. (All of the above noted gold values are detectable with the atomic-absorption method used by the U.S. Geological Survey but the values of 0.030 or 0.040 ppm would be reported as less than 0.05 ppm, the lower limit of determination for the method used in this study).

The sample containing the gold grain also contains several grains of pyrite and one grain of scheelite. Additional sampling near site HM078H, as part of a follow-up study, did not show any additional gold.

These results indicate that gold in the study area is apparently very sporadically distributed as microscopic particles in the alluvium of a few drainages. The small amounts of gold found suggest that bedrock sources also have sporadically distributed gold. All samples anomalous in gold were obtained from drainages that are cut by faults. Sporadic gold may occur in these faults, which could have served as pathways for ascending hydrothermal and ore-forming fluids. Whether greater amounts of gold occur at depth in the study area could not be determined on the basis of the results of these investigations.

Bismuth at values ranging from less than 20 ppm to greater than 2,000 ppm was detected in heavy-mineral concentrates from 20 sites in the west half of the study area. A yellowish earthy grain, bismite(?), a secondary bismuth mineral formed by the oxidation of native bismuth or other bismuth minerals, was observed in one of the concentrates with an anomalous concentration of bismuth. However, no other bismuth minerals were definitely identified in samples having high bismuth concentrations.

The area of the anomalous bismuth concentrations is chiefly underlain by welded rhyolitic tuff. Bismuth was not detected in any steam-sediment or rock samples. The bismuth in the heavy-mineral concentrates may have been eroded from faults or other fractures in the drainage areas.

Bismuth occurs in a number of deposit types and often indicates various types of mineral deposits (Boyle, 1974, p. 29). It is largely a by-product from ores of other metals (Hasler and others, 1973). The amounts of bismuth contained in the heavy-mineral-concentrate samples, together with the absence of detected bismuth in stream-sediment and rock samples, is evidence that bismuth occurs only in trace amounts in the alluvium or bedrock. The geochemical data and the geologic setting of the area suggest that the bismuth anomaly could be related to tin or gold mineralization, although the bismuth shows little or no correlation with gold found in the area. Whether or not the bismuth anomaly suggests gold at depth in the study area cannot be determined with available data.

Bismuth shows some correlation with tin values. Heavy-mineral concentrates with tin values ranging from less than 20 ppm to 1,000 ppm were measured, but only a few of the samples are considered anomalous with respect to tin. Anomalous concentrations of tin are values that exceed 500 ppm. The two highest tin values, 700 and 1,000 ppm, were found in the western part of the study area in samples from a small drainage on the east slope of Acty Mountain. The bedrock in this drainage is cut by a northeast-trending fault, which suggests that this fault is weakly mineralized.

The geologic setting is permissible for rhyolite-hosted tin deposits (Reed and others, 1986, p. 168). However, the evidence does not support the existence of such a deposit in the study area. Furthermore, such a deposit is not suggested in exposed bedrock of the study area.

Geophysical Studies

Aerial Gamma-Ray Spectroscopy

Radiometric data were compiled by Geodata International, Inc. (1980) for the National Uranium Resource Evaluation (NURE) program of the Department of Energy. The coverage consists of three east-west flightlines spaced 3 mi apart and totaling about 32 mi in length and two north-south flightlines spaced 13 mi apart and totaling 8 mi in length. Flight altitudes ranged from 200 ft to an unacceptable 800 ft above the ground. Recordings were made of gamma-ray flux from radioactive isotopes of uranium, thorium, and potassium. Radioactivity count rates exceed the mean background level for uranium and thorium in most of the study area and for potassium in the eastern third of the study area. High count rates for uranium and thorium reflect the chemical composition of the exposed Tertiary rhyolite and tuffaceous sedimentary rock. No localities were identified where the concentration of either element is high enough to constitute a mineral resource.

Aeromagnetic Survey

Regional aeromagnetic surveys were flown at constant barometric elevations of 9,000 ft above sea level and east-west flightline spacings of 2 mi (U.S. Geological Survey, 1972a, b). A 6- by 9-mi, 800-nanotesla magnetic high centered 1 mi south of Hawk Mountain dominates the aeromagnetic map (Plouff, 1984, p. 40). The magnetic high mostly reflects the shape of a mass of volcanic rock concealed beneath the surface because the anomaly is neither congruent with topography nor with the extent of exposed rhyolitic rock, and the flanks of the anomaly span a circle about 7 mi in diameter. The weak magnetic low in the westernmost 5 mi of the study area may represent low elevation and low or possibly reversed remanent magnetization of underlying volcanic rock.

Gravity Survey

The U.S. Geological Survey established 31 gravity stations in and within 5 mi of the study area in 1986 (Plouff, 1987). These data were supplemented by data from 37 gravity stations that were part of the gravity survey of the Charles Sheldon Wilderness Study Area (Plouff, 1977, 1984). The most conspicuous anomaly on a preliminary gravity map prepared from these data is an east-trending 7- by 16-mi gravity low with an amplitude of 8 milligals, which is centered about 2 mi south of the study area (Donald Plouff, unpub. data). An extension of the gravity low projects into the southern part of the study area (fig. 3).

The gravity low is the northeasternmost of a series of gravity lows extending almost 50 mi northwest from the study area (Plouff, 1984, pl. 2; Ach and others, 1987, fig. 3; and Turrin and others, 1988, fig. 3). The number and intensity of gravity lows in this part of Oregon suggest the possible occurrence of a series of nested underlying calderas (Greene and Plouff, 1981; Plouff, 1984, p. 46; Ach and others, 1987; and Turrin and others, 1988). Presumably, the gravity low is present because of the accumulation of fairly low density tuffaceous sedimentary rock within the caldera depression. Caldera subsidence is likely the result of large volumes of silicic magma being erupted from shallow magma chambers. Thus, each gravity low may represent a bowl-shaped basin filled with tuffaceous sediment that is surrounded by denser wallrock. The study area contains tuffaceous sedimentary rock, rhyolite, and numerous normal faults, which suggest an underlying caldera. However, the presence of a caldera is speculative because the amplitude of this gravity low is small compared to other gravity lows of the region.

A 4-mi-diameter gravity high is centered in Hawk Valley about 2 mi north of Hawk Mountain. The gravity high may represent the center of a mass of intrusive rocks that formed a conduit for extrusive volcanic rocks exposed at the surface. The nose of the large magnetic high extends about 1 mi east of the gravity high. The intensity of this part of the large magnetic high is low near the gravity high because the ground surface is 1,000 ft below the level of observation at Hawk Mountain. The weakened north wall of this area of subsidence is a likely place for a conduit from a renewed magma system.

Mineral and Energy Resources of the Hawk Mountain Wilderness Study Area

Mineral Resources

The Hawk Mountain Wilderness Study Area is part of a region characterized by extensive exposures of Tertiary volcanic rock that are locally hydrothermally altered and silicified. In this region hydrothermally altered rocks may host deposits of mercury, silver, and gold, and industrial minerals (clay and zeolite). No evidence of mercury or silver mineralization or of clay and zeolites was observed in the study area. However, geochemical data and the geologic setting of the area suggest that the west half of the study area has low resource potential for gold in epithermal deposits, certainty level B (fig. 2).

Energy Resources

The entire study area has a low favorability for the occurrence of oil and gas (Fouch, 1983a, b). No drilling

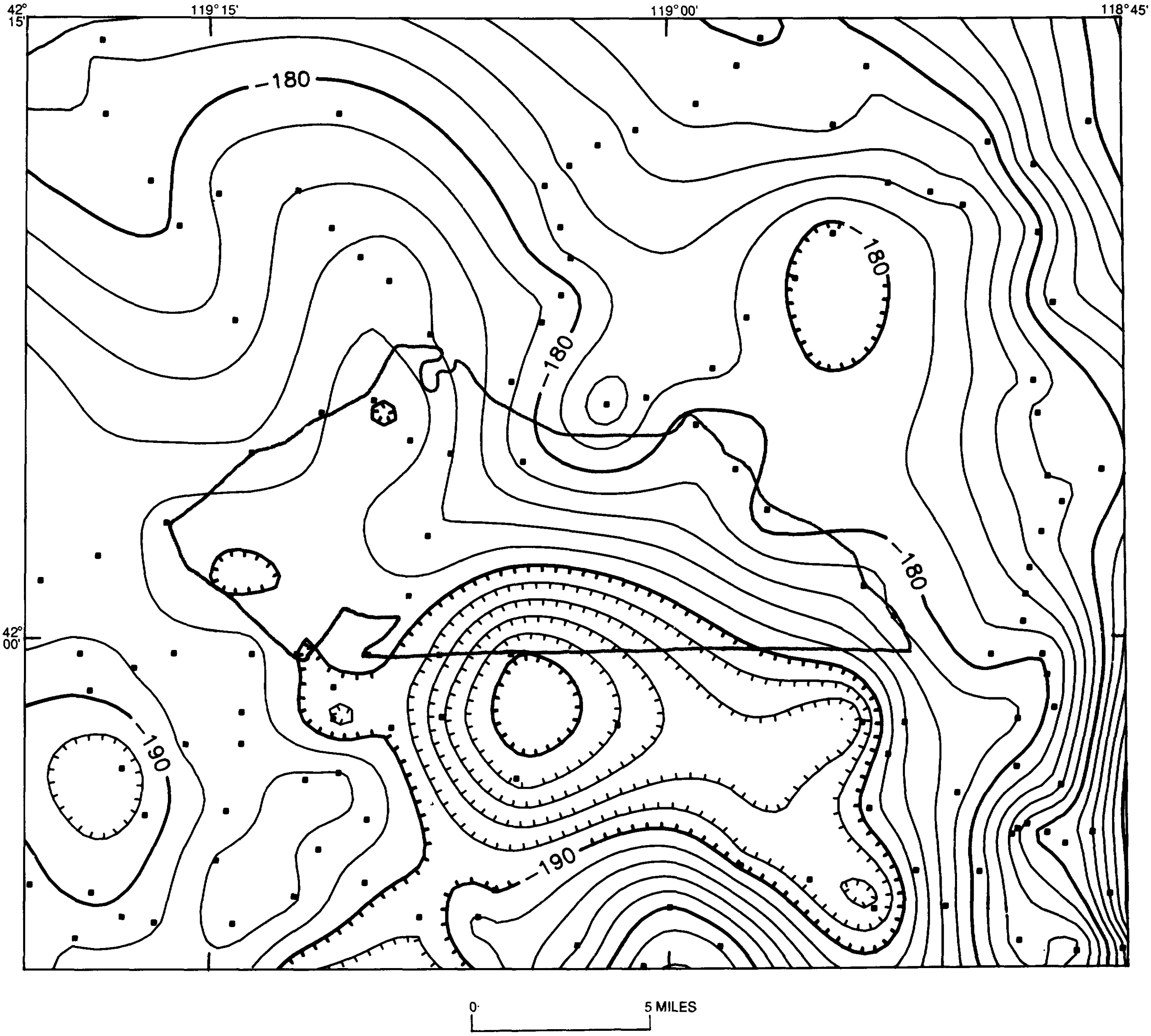


Figure 3. Complete Bouguer gravity anomaly map of region near Hawk Mountain Wilderness Study Area, Harney County, Oregon. Approximate boundary of study area shown in gray. Contour interval 2 milligals; hachured in direction of gravity low. Small squares denote gravity stations. South boundary of study area lies along Oregon-Nevada State line.

or other exploration has been done in the study area. Because of extensive Miocene volcanic activity in this part of the Basin and Range province, the area is too thermally mature to have formed any hydrocarbon reserves (Sandberg, 1983). Moreover, the area lacks suitable source rocks for hydrocarbon generation. Therefore, the entire study area has low potential for oil and gas resources, certainty level D.

Several radioactive prospects are located within the Virgin Valley Formation south of the study area in northwestern Humboldt County, Nevada. Secondary uranium minerals (carnotite and schroeckingerite?) are reportedly associated with opalized zones within the tuffaceous lacustrine sedimentary rock (Garside, 1973). Although no localities were identified where the uranium concentrations were high enough to be considered a mineral resource, the aerial gamma-ray spectroscopy data and the large amount of tuffaceous sedimentary rock suggest that the eastern and southern parts of the study area have low potential for uranium in localized, small-volume deposits, certainty level C.

No hot springs are present in the study area, nor are there any geothermal production leases for the study area. However, the occurrence of young volcanic rock and of hot springs within 10 mi of the study area indicates that the entire study area has low potential for geothermal resources, 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.

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 →

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Taylor, R.B., and Steven, T.A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268-1270.
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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: Steens Mountain–Rincon Region, Oregon

This volume was published as separate chapters A–F

U.S. GEOLOGICAL SURVEY BULLETIN 1740

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, Jr., Secretary

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

CONTENTS

[Letters designate the separately published chapters]

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