Mineral Resources of the High Steens and Little Blitzen Gorge Wilderness Study Areas, Harney County, Oregon

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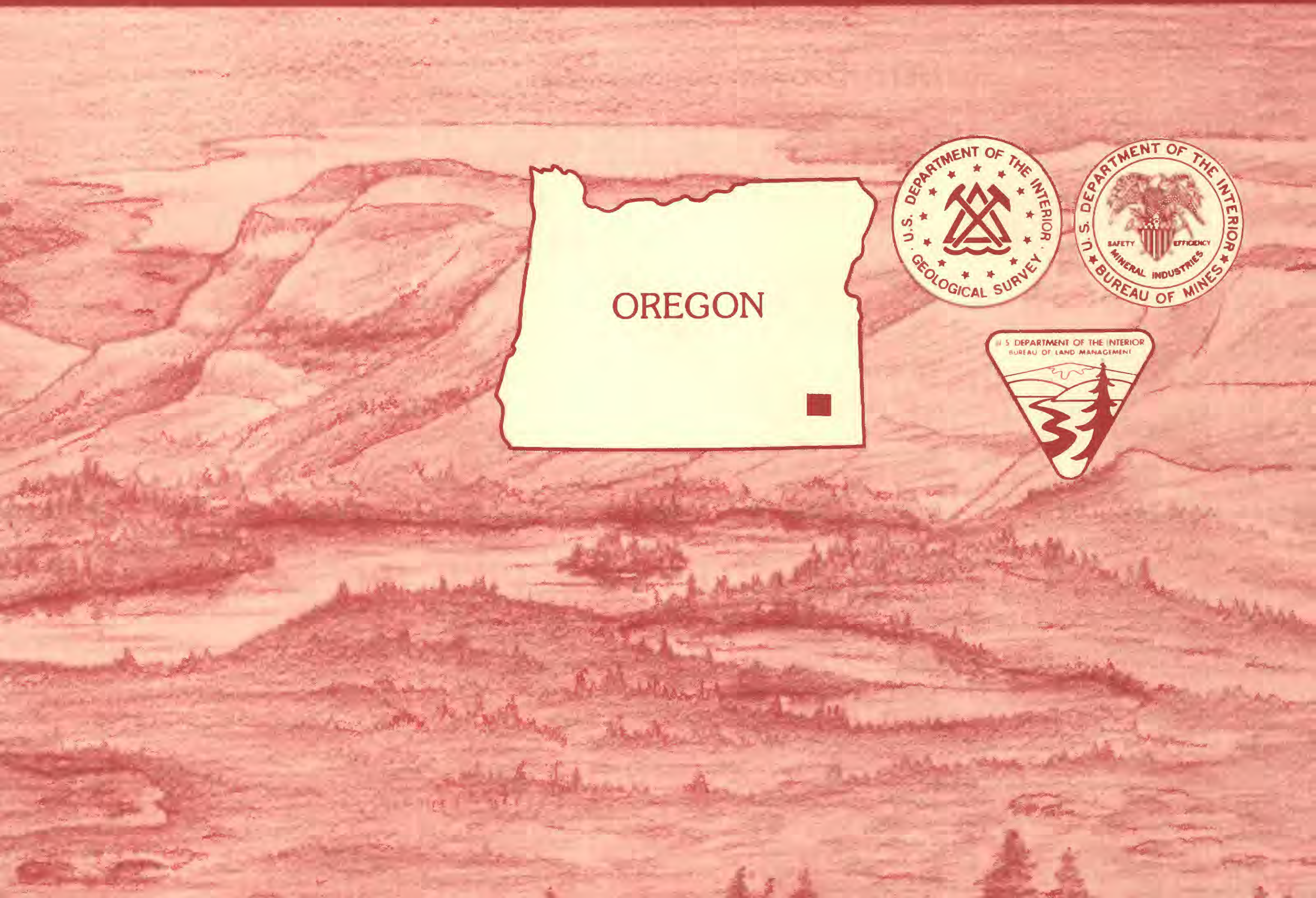

CHAPTER A

Mineral Resources of the High Steens and Little Blitzen Gorge Wilderness Study Areas, Harney County, Oregon

By SCOTT A. MINOR and DONALD PLOUFF
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U.S. Bureau of Mines

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS: STEENS MOUNTAIN—RINCON 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 a part of the High Steens (OR-002-085F) and Little Blitzen Gorge (OR-002-086F) Wilderness Study Areas, Harney County, Oregon.

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Mineral Resources of the High Steens and Little Blitzen Gorge Wilderness Study Areas, Harney County, Oregon

By Scott A. Minor *and* Donald Plouff
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SUMMARY

Abstract

The contiguous High Steens (OR-002-085F) and Little Blitzen Gorge (OR-002-086F) Wilderness Study Areas are located along east-central Steens Mountain, Harney County, southeastern Oregon. At the request of the U.S. Bureau of Land Management, a total of 35,930 acres of the High Steens and 6,430 acres of the Little Blitzen Gorge Wilderness Study Areas were studied. In this report, the combined area studied is referred to simply as "the study area." Field work for this report was conducted between 1983 and 1985. About 500 claims and prospects have been located within and adjacent to the High Steens Wilderness Study Area, 52 of which are still active. No mining claims or prospects have been recorded within the Little Blitzen Gorge Wilderness Study Area. Perlite, with inferred marginal reserves totaling about 400,000 tons, is the only identified resource within the High Steens Wilderness Study Area. No identified resources are located in the Little Blitzen Gorge Wilderness Study Area.

The potential for uranium resources is high in two areas along the southeast edge of the High Steens Wilderness Study Area; the potential for mercury resources is also high in one of these areas and the potential for gold resources is moderate in both areas. The potential for gold, mercury, and uranium resources in adjacent areas along the southeast and central-east edges of the High Steens Wilderness Study Area is moderate. The potential for resources of these commodities in an area along the northeast margin of the High Steens Wilderness Study Area is low. The western part of the High Steens Wilderness Study Area west of the Steens Mountain crest has unknown potential for these resources. The mineral resource potential for zeolites is low within a large area surrounding the southeast edge of the High Steens Wilderness Study Area; a low potential for perlite resources is assigned to the western part of this area. The potential for geothermal energy resources is low within a strip along the east margin of the High Steens Wilderness Study Area. The areas of known mineral resource potential and nearby mineral occurrences are related to a major basin-and-range fault zone existing along the base of the east escarpment of Steens Mountain. The entire High Steens Wilderness Study Area as well as the Little Blitzen Gorge Wilderness Study Area have a low potential for oil and gas resources. The Little Blitzen Gorge Wilderness Study Area has unknown potential for gold, mercury, and uranium resources.

Character and Setting

The High Steens (OR-002-085F) and Little Blitzen Gorge (OR-002-086F) Wilderness Study Areas are located along the east-central part of Steens Mountain in Harney County, Oreg., about 60 mi south-southeast of Burns, Oreg. The 9,500-ft-high crest of Steens Mountain divides the combined study area into an eastern part characterized by a precipitous, east-facing, 5,500-ft-high escarpment and a western part consisting of a gently west-dipping dissected plateau. The study area is underlain by a sequence of gently west-dipping Tertiary (see

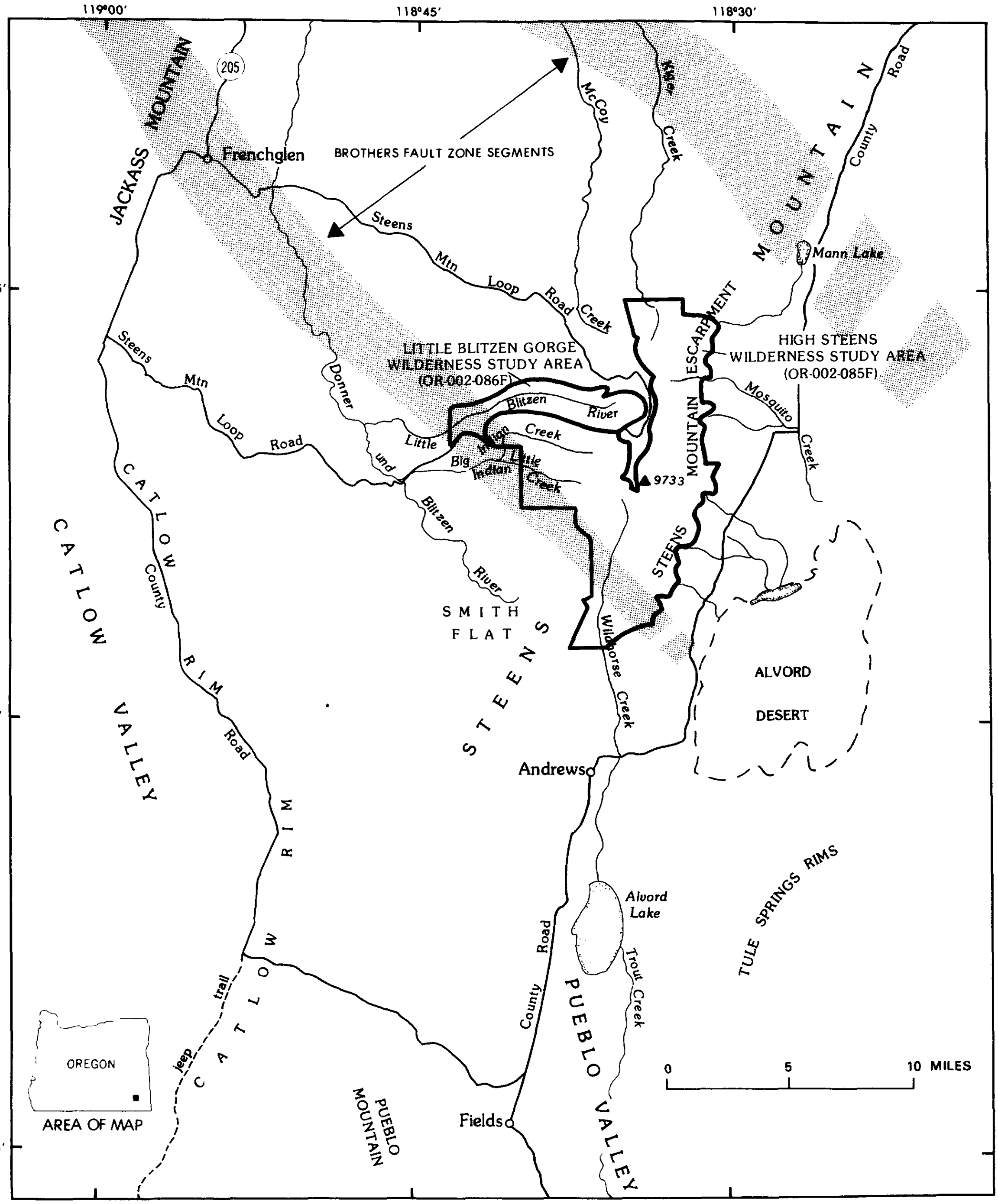

Figure 1. Index map showing location of the High Steens and Little Blitzen Gorge Wilderness Study Areas, Harney County, Oregon.

Appendix 1 for geologic time chart) volcanic, pyroclastic, and minor sedimentary rocks. The oldest rocks, which are present only along the east escarpment, consist of rhyolitic extrusive rocks, subordinate tuffs, and sedimentary rocks; these are overlain by andesitic flows, breccias, and pyroclastic rocks. A younger thick sequence of basalt flows caps the east escarpment and forms the bedrock within the western part of the combined study area. Steens Mountain, which is a large, uplifted and mildly tilted fault block, is bounded along the base of its east escarpment by a concealed range-front normal fault zone. Other subsidiary faults and flexures exist within the Steens Mountain block. Spectacular deep, U-shaped canyons located primarily on the west slope were formed by glaciers during Pleistocene time.

Prospecting, claim staking, and mining in the High Steens Wilderness Study Area has occurred intermittently since 1891. Harney County mining records show that about 450 lode and 50 placer claims were located within and adjacent to the High Steens Wilderness Study Area; presently (1985) 52 mining claims are considered active. Mercury and uranium were mined along the east escarpment just outside the southeastern part of the study area. Mercury production totaled approximately 55 flasks; uranium production is unrecorded. No prospects or workings were found in the Little Blitzen Gorge Wilderness Study Area.

Identified Resources

Inferred marginal reserves of perlite totaling about 400,000 tons are assigned to the Cinder Cone claims within the High Steens Wilderness Study Area (Appendix 2 and fig. 3, No. 1). The Little Blitzen Gorge Wilderness Study Area has no identified resources.

Mineral Resource Potential of the High Steens Wilderness Study Area

Areas having high, moderate, low, and unknown mineral potential for mercury and uranium resources are delineated for the High Steens Wilderness Study Area; areas having moderate, low, and unknown potential gold resources and low potential for resources of zeolite, perlite, oil and gas, and geothermal energy are also present (fig. 2).

The High Steens Wilderness Study Area overlaps the northern part of 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. Mercury- and uranium-bearing minerals are localized within fracture, shear, and breccia zones and along mafic dikes in veins and fracture coatings within the older rhyolitic extrusive and tuffaceous rocks along or just outside of the southeast part of the High Steens Wilderness Study Area; the metalliferous structures are likely related to the Steens Mountain range-front fault zone. Geochemical evidence and the distribution of mines and prospects in and near the High Steens Wilderness Study Area indicate a zone of metal concentration surrounding the southeast boundary that contains the metalliferous structures. This zone contains anomalous concentrations of uranium as well as gold-indicator elements (arsenic, barium, mercury, and molybdenum) in both rock and stream-sediment samples. The geologic environment within the zone, especially the alteration assemblages that accompanied the mercury-uranium mineralization, is favorable for undiscovered epithermal gold deposits. The metalliferous zone includes an area of high resource potential for mercury and uranium and a moderate potential for gold between Indian and Pike Creeks (extreme southeastern part of the study area, fig. 2). A high potential for uranium resources also exists in an area located just to the north in Little Alvord Creek canyon. A moderate resource potential for gold, mercury, and uranium is assigned to the remainder of the zone between Indian and Mosquito Creeks, and a low resource potential for these elements is designated for a narrow strip along the northeast edge of the High Steens Wilderness Study Area. The mineralized rocks exposed along the east escarpment may extend westward underneath the dip slope of Steens Mountain. Such rocks would be concealed by several thousand feet of basalt and andesite overburden, thus preventing an accurate evaluation of their mineral resource potential. An unknown resource potential for gold, mercury, and uranium is designated for the High Steens Wilderness Study Area west of the Steens Mountain crest.

A low resource potential for zeolites and perlite is assigned for that part of the High Steens Wilderness Study Area underlain by the rhyolitic extrusive rocks and tuffs (Pike Creek Formation, southeastern part of study area, fig. 2). Areas predominantly underlain by tuffaceous rocks (Alvord Creek Formation, fig. 2) along the southeast edge of the study area also have low potential for zeolite resources.

The potential for oil and gas resources in the High Steens Wilderness Study Area is considered to be low on the basis of unfavorable evidence regarding the presence of hydrocarbon source rocks. The easternmost part of the High Steens Wilderness Study Area has a low resource potential for undiscovered geothermal energy; active hot springs exist about 2 mi southeast of the study area (fig. 2).

Mineral Resource Potential of the Little Blitzen Gorge Wilderness Study Area

The Little Blitzen Gorge Wilderness Study Area, located on the structurally simple Steens Mountain dip slope and underlain by several thousand feet of basalt and andesite, has unknown mineral potential for gold, mercury, and uranium resources in concealed, possibly mineralized rocks similar to those of the Pike Creek and Alvord Creek Formations. The potential for oil and gas resources in the Little Blitzen Gorge Wilderness Study Area is considered to be low (fig. 2) on the basis of unfavorable evidence regarding the presence of hydrocarbon source rocks.

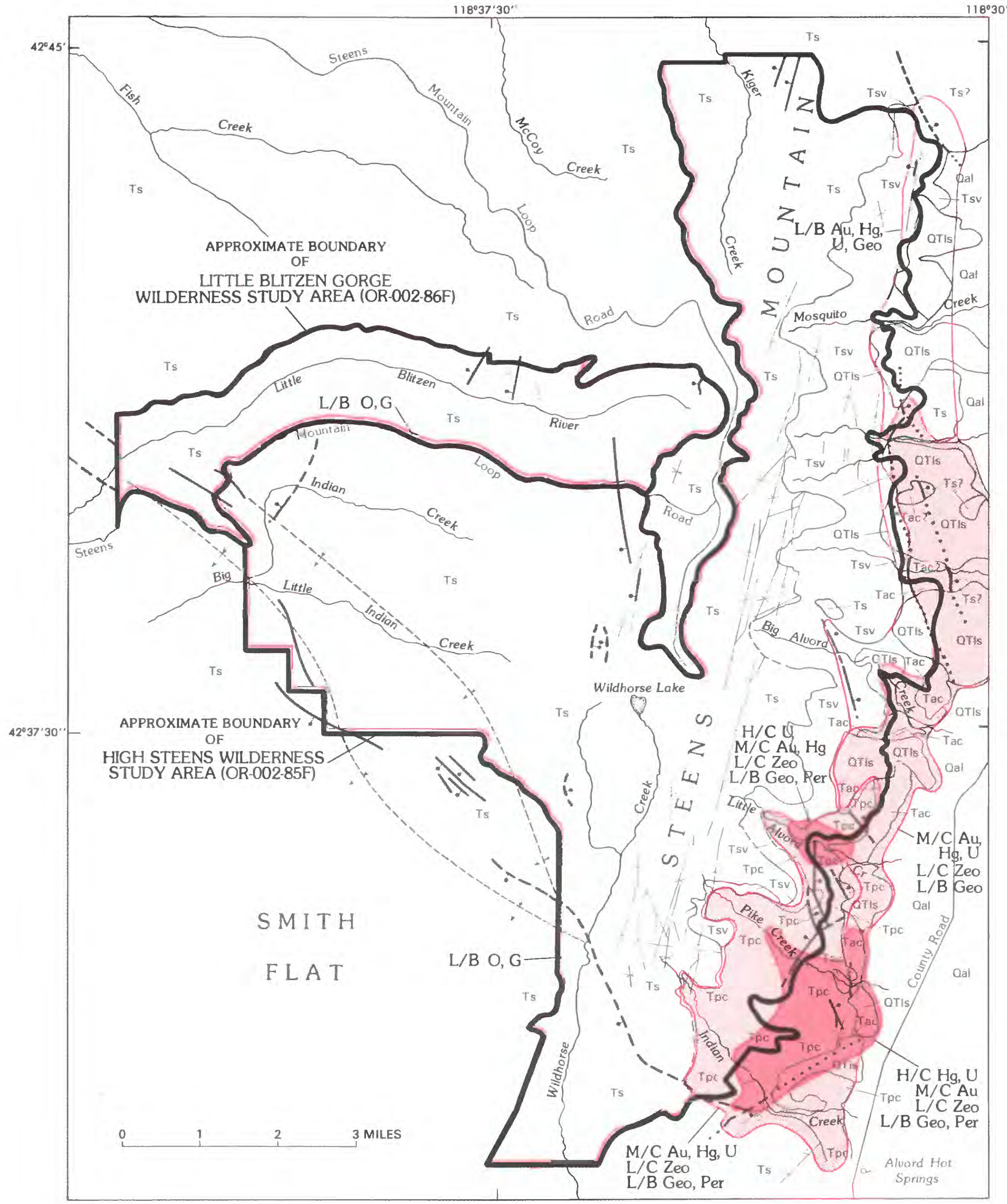

Figure 2. Mineral resource potential and geology of the High Steens and Little Blitzen Gorge Wilderness Study Areas, Harney County, Oregon.

EXPLANATION

Area with high mineral resource potential

Area with moderate mineral resource potential

Area with low mineral resource potential

See Appendix 1 for definition of levels of mineral resource and certainty of assessment

Commodities

Au	Gold
Hg	Mercury
U	Uranium
Geo	Geothermal
Per	Perlite
Zeo	Zeolites
O,G	Oil, Gas

Geologic map units

Qal	Alluvium (Quaternary)
QTls	Landslide deposits (Quaternary and Tertiary)
Ts	Steens Basalt (Tertiary)--Locally includes:
	Dikes
Tsv	Steens Mountain Volcanics (Tertiary)
Tpc	Pike Creek Formation (Tertiary)
Tac	Alvord Creek Formation (Tertiary)

Contact--Dashed where approximate

Fault--Dashed where approximate; dotted where concealed. Ball and bar on downthrown block

Upper monoclinal flexure axis

Lower monoclinal flexure axis

Figure 2. Continued.

INTRODUCTION

Location and Physiography

The High Steens (OR-002-085F) and Little Blitzen Gorge (OR-002-086F) Wilderness Study Areas are located in Harney County, Oreg., about 60 mi south-southeast of Burns, Oreg. (fig. 1). At the request of the U.S. Bureau of Land Management, 35,930 and 6,430 acres of the High Steens and Little Blitzen Gorge Wilderness Study Areas, respectively, were studied. The two wilderness study areas are contiguous and are referred to either individually or as "the study area" throughout this report. The study area is situated along Steens Mountain, a prominent north-northeast-trending range more than 60 mi long. The approximately 9,700-ft-high crest of the range extends across the eastern part of the study area (fig. 2). A steep escarpment with 5,500 ft of relief, which is dissected by numerous intermittent, eastward-flowing creeks, descends sharply from the mountain crest to the Alvord Desert basin along the east margin of the study area. The area west of the rangecrest is characterized by a gently west-tilted dip slope cut by deep (as great as 2,000 ft) glacially modified canyons of Little Blitzen River and Kiger, Big Indian, Little Indian, and Wildhorse Creeks (fig. 2). Three of these spectacular canyons drain onto Smith Flat, a plateau forming the base of a 2,000-ft-high, northwest-trending escarpment along the west boundary of the study area. Vegetation of the region is similar to that growing elsewhere in mountain ranges of the semiarid northern Great Basin; sage, aspen, and juniper are most common. There is a tendency for a greater density of trees and grasses on the cooler, wetter dip slope of Steens Mountain.

Road access along the east escarpment consists of jeep trails that extend into a few prominent canyons from an improved gravel county road along the west edge of the Alvord Desert (fig. 1). The west slope is accessible during the summer months along Steens Mountain Loop Road via its junction with Oregon State Highway 205 at Frenchglen. Several jeep and hiking trails intersect this road and extend into remote parts of the study area.

Previous and Present Investigations

Previous geologic mapping in the study area includes Williams and Compton (1953), Walker and Repenning (1965), Wilkerson (1958), and Fryberger (1959). Geochemical and geophysical reconnaissance surveys were conducted for the U.S. Department of Energy's National Uranium Resource Evaluation (NURE) program to assess the radioactive mineral potential of the region (Erikson and Curry, 1977; Geodata International, Inc., 1980). A preliminary evaluation of the mineral resources of the High Steens and Little Blitzen Gorge Wilderness Study Areas was made by the Oregon Department of Geology and Mineral Industries (DOGAMI) (Gray and others, 1983).

The U.S. Geological Survey (USGS) mapped the geology of the study area in 1984 (Minor and others, 1987). Rock samples were collected by the USGS in altered areas in the High Steens Wilderness Study Area for geochemical analysis and evaluation. Most of the geochemical data evaluated for this report are DOGAMI assay data initially presented by Gray and others (1983), which include 18 rock and 88 stream-sediment samples from the study area. Heavy mineral concentrates of the DOGAMI stream-sediment samples were analyzed and evaluated by Barringer Resources, Inc. (Bukofski and others, 1984), and were also considered in this study. NURE reports by Erikson and Curry (1977) and Geodata International, Inc. (1980), were also used to help evaluate the radioactive mineral potential of the study area.

The U.S. Bureau of Mines (USBM) conducted surveys of the study area from late 1983 to 1985, focusing on investigations of mines, prospects, and mineralized areas and checking geochemical anomalies identified by Gray and others (1983). Studies included a review of Harney County and U.S. Bureau of Land Management (BLM) mining and mineral-lease records and USBM production records. Field studies involved searches for all mines, prospects, and claims within and adjacent to the study area; those found were mapped and sampled for geochemical analyses. Ground and aerial reconnaissance for unrecorded exploration and mine workings and rock alteration was done in areas judged favorable for mineral deposits. Twenty-seven properties sampled by the USBM are shown on fig. 3 and individual descriptions provided in Appendix 2. Details of the sampling procedures and results of the Little Blitzen Gorge Wilderness Study Area are presented in Peters and Esparza (1986). Detailed information on the High Steens Wilderness

Study Area is available from the U.S. Bureau of Mines, Western Field Operations Center, E. 360 Third Avenue, Spokane, Washington, 99202.

Acknowledgments

The BLM in Burns, Oreg., kindly allowed USGS geologists access onto the higher part of the Steens Mountain Loop Road prior to public availability. They also generously permitted use of their fire guard station at Fields, Oreg., for lodging.

APPRAISAL OF IDENTIFIED RESOURCES

By Leon E. Esparza and Thomas J. Peters, U.S. Bureau of Mines

History and Production

The earliest recorded mining claim within the High Steens Wilderness Study Area was staked in late 1891. Since then, 450 lode and 50 placer mining claims have been staked in the study area. There are 52 active mining claims in and adjacent to the High Steens study area. No claims were filed for the Little Blitzen Gorge Wilderness Study Area.

There were four periods of intensive prospecting and claim staking in and near the High Steens Wilderness Study Area: 1891 to 1905, 1930 to 1942, 1953 to 1956, and 1973 to 1977. The first period was for gold, the second for mercury, and the remaining two for uranium. Most of the gold exploration was limited to searches for placer deposits west of the Steens Mountain crest. Prospecting and mining for mercury and uranium was concentrated within and adjacent to the southeastern part of the High Steens Wilderness Study Area. During the late 1970's, several mining companies explored for precious metals in the southeastern part of the study area. The only recorded production consisted of approximately 55 flasks of mercury, primarily from the Steens Mountain and Weston mines (Appendix 2 and fig. 3, Nos. 6 and 8) (Ross, 1942; Williams and Compton, 1953; Brooks, 1963; and Mike and John Weston, oral commun., 1984).

Mineral Deposits

Inferred marginal perlite reserves identified at one locality in the High Steens Wilderness Study Area are the only known resource. Gold, mercury, uranium, molybdenum, and zeolite minerals are present within and (or) adjacent to the High Steens Wilderness Study Area but are not of great enough significance to be considered resources. Despite minor occurrences of gold, the Little Blitzen Gorge Wilderness Study Area does not contain any identified resources.

Several small occurrences of perlite exist along the glassy margins of felsic flows and domes within the Pike Creek Formation in the southeastern part of the High Steens Wilderness Study Area (Fuller, 1931; Minor and others, 1987). One such occurrence at the Cinder Cone claims (Appendix 2 and fig. 3, No. 1) is of sufficient extent (5 acres) and thickness (at least 25 ft) to be considered a resource. A marginal reserve of 400,000 tons of perlite is estimated for the deposit.

Minor amounts of minute gold flakes were observed in alluvial samples collected from some of the major drainages of both the High Steens and Little Blitzen Gorge Wilderness Study Areas (Appendix 2 and fig. 3, Nos. 15, 16, and 18-20). The gold is not present in sufficient quantity to be considered a resource.

Mercury minerals were not observed within the study area, but eight known mercury occurrences lie within 1 mi of the southeast edge of the High Steens Wilderness Study Area (Appendix 2 and fig. 3, Nos. 6-11, 13, and 14). In general, the mercury occurs as cinnabar within altered, felsic volcanic rocks of the Pike Creek Formation and is associated with faults and fracture systems that dip away from the study area.

Uranium-bearing minerals, including autunite, torbernite, and uranophane(?) (Matthews, 1955 and 1956), are present in and adjacent to the High Steens Wilderness Study Area along faults and related structures within altered parts of the Pike Creek Formation; several uranium prospects are located along narrow fracture zones containing uranium minerals in and adjacent to brecciated rhyolite (Appendix 2 and fig. 3, Nos. 2-5). However, the uranium is not present in sufficient quantity to be considered a resource.

Molybdenum-bearing ilsemannite is reported by Gray and others (1983) to exist at two uranium prospects within the High Steens Wilderness Study Area (Appendix 2 and fig. 3, Nos. 2 and 4). This molybdenum oxide is present within altered and fractured parts of the Pike Creek Formation in quantities too small to be considered a resource.

Tuffaceous rocks belonging to the Alvord Creek(?) Formation, exposed along the southeast

EXPLANATION

1	Cinder Cone Nos. 1-6 claims
2	Knight Hawk No. 1 claim
3	Alvord Uranium Cave claims
4	Timberbeast Nos. 1-7 claims
5	Pike Creek Carnotite claims
6	Steens Mountain mine
7	Red Rock No. 6 claim
8	Weston mine
9	Last Chance claims
10	Jack Pot Nos. 1-9 claims
11	Alex-Ladd claim
12	Steens Nos. 1-74 claims
13	Aile Rouge No. 1 claim
14	Sunshine No.3 claim
15	Big Indian mine
16	Buckhorn mine
17	Daisy claims
18	Gold Crown claim
19	Gold Queen claim
20	Head Light mine
21	Homestretch lode
22	Jack Pot claim
23	Lady Washington claim
24	Miners Dream lode
25	Ole Olson lode
26	Snowbird claim
27	West End claim

Figure 3. Location of mines, prospects, and claims in and adjacent to the High Steens and Little Blitzen Gorge Wilderness Study Areas. Numbers refer to Appendix 2.

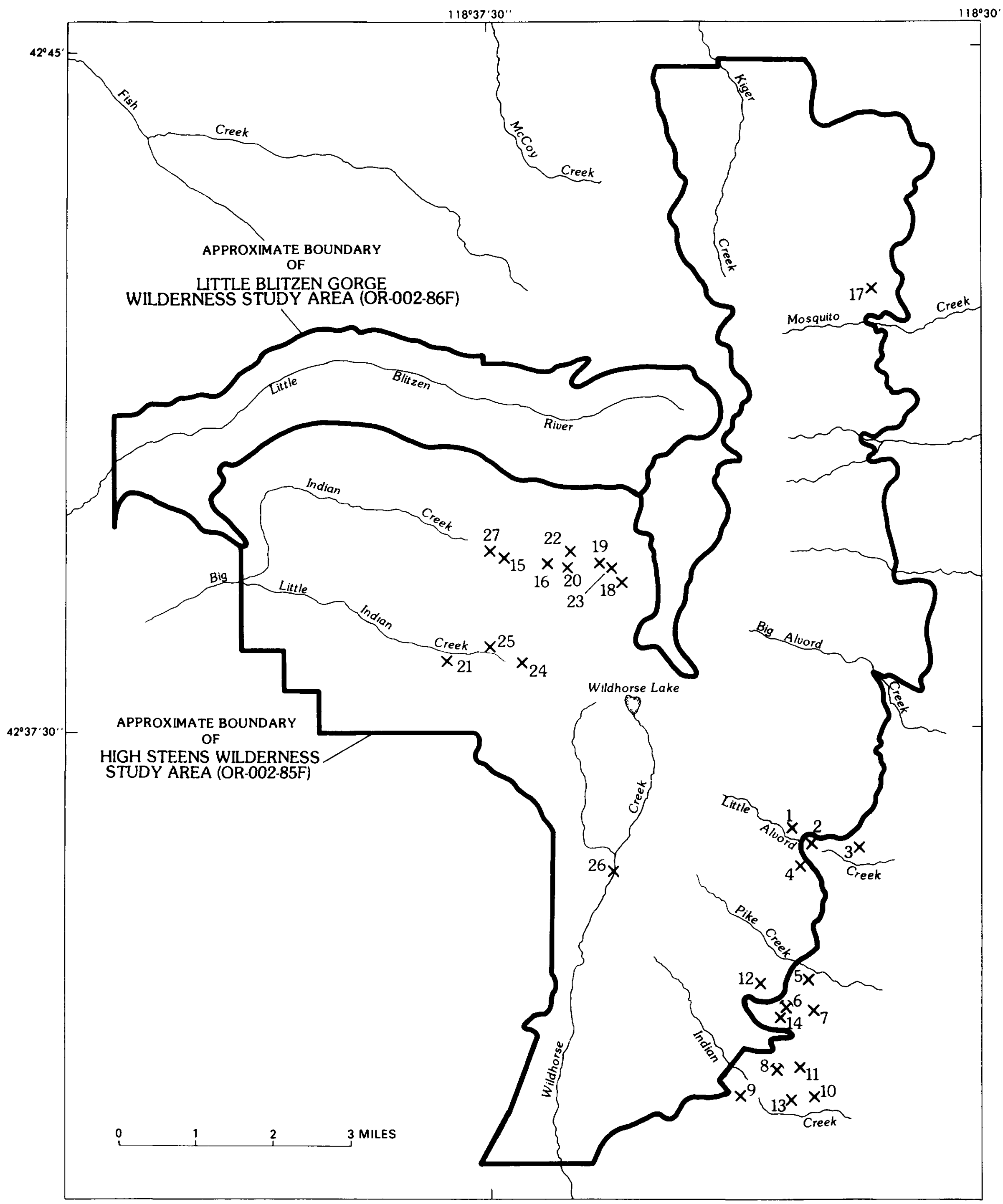

Figure 3. Continued.

boundary of the High Steens Wilderness Study Area, are altered to the zeolite mineral clinoptilolite (Walker and Repenning, 1965). Sample results from the USBM indicate that locally the tuffaceous rocks are composed of about 40 percent clinoptilolite. Minor amounts of zeolites also occur within vesicles in some of the volcanic flows exposed in the study area. The zeolites do not form resources in the study area due to their relatively low concentrations, the sparsity of exposed tuffaceous rocks, and remoteness to a mill or market.

Building-stone resources are limited. Although over 75 percent of the study area is underlain by basalt, quarrying of the basalt would not be feasible, as it does not meet required aesthetic characteristics or bulk density. It is adequate for use as fill material in local road construction, but other sources are located closer to areas of specific need. Surficial sand and gravel are present within the study area, but are not located close enough to a market to be commercially significant.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Scott A. Minor and Donald Plouff,
U.S. Geological Survey

Geology

Steens Mountain, located in the northwestern part of the Basin and Range province, is a major north-northeast-striking and gently (5°) west-northwest-dipping fault block. Its steep east escarpment developed along a range-front normal fault zone having as much as 10,800 ft of accumulative throw (Cleary and others, 1981). The range is primarily composed of a gently west-dipping sequence of Oligocene(?) and Miocene volcanic flows, pyroclastic rocks, and minor sedimentary rocks. Minor and others (1987) described in detail the geology of the study area.

The oldest rocks in the study area, exposed near the base of the east escarpment, consist of interstratified tuff and tuffaceous to volcaniclastic sedimentary rocks of the Alvord Creek Formation (Williams and Compton, 1953) (fig. 2). Possibly correlative rhyolitic ash-flow tuff and tuff breccia also crop out near the escarpment base. The Pike Creek Formation (Walker and Repenning, 1965) overlies the Alvord Creek Formation with slight angular discordance. It consists of several intercalated rhyolitic to dacitic flows and extrusive domes and minor associated tuff and tuffaceous sedimentary rocks. The Pike Creek is commonly silicified or argillized; near the base of the formation, two platy rhyolite flows are strongly silicified, argillized, and acid leached. The Pike Creek Formation is greater than 2,000 ft thick near the south end of the fault scarp, thins northward, and pinches out just north of Little Alvord Creek. The Steens Mountain Volcanics (Minor and others, 1987), which conformably onlaps the Pike Creek Formation from the north, is composed principally of interstratified andesitic flows, flow breccia, and pyroclastic rocks. The Steens Mountain Volcanics crops out along the lower part of the east escarpment near the northeast margin of the study area (fig. 2) and has a maximum thickness of 3,000 ft. Both the Pike Creek Formation and Steens Mountain Volcanics are disconformably overlain by the 15.5-Ma (million years before present) Steens Basalt (Piper and others, 1939; Baksi and others, 1967), which consists of a 4,300-ft-thick homogeneous sequence of thin (20 ft average) basalt flows. This sequence forms the upper part of the Steens Mountain escarpment and, except for Quaternary surficial deposits, underlies the entire west dip slope within the study area. Numerous dikes and sills of the Steens Basalt intrude the underlying units and extend up into flows of the Steens Basalt primarily along the east escarpment. Most of the dikes strike N. 15°-20° E. and dip 80°-90° ESE.

Several structures trend obliquely to the Steens Mountain fault block within and near the study area (fig. 2). Several north-northwest-trending normal faults are present along the base of the east escarpment. Also, some coherent landslide blocks present along the base of the escarpment may represent gravitationally remobilized fault blocks of the adjacent range-front fault zone. Uplift and tilting of the Steens Mountain block appears to have resulted from movement along both north-northeast- and north-northwest-trending normal faults. The most conspicuous of the structures oblique to the Steens Mountain fault block is a northwest-trending faulted monocline that forms the prominent escarpment along the southwest border of the area. The monocline and associated normal faults are considered to be elements of a southern branch of the Brothers fault zone (fig. 1), a deep-seated, possibly right-lateral shear zone first described by Walker (1969). Lawrence (1976) viewed the Brothers fault zone as a major right-lateral tear fault that forms part of the northwest boundary of the Basin and Range province.

The earliest known deformation in the study area occurred after deposition of the Alvord Creek Formation and before eruption of the overlying flows of the Pike Creek Formation, as indicated by the slight angular unconformity between the two units. Extensional deformation in the area, defined in part by the range-front fault zone and subparallel fractures along the eastern escarpment, may have begun prior to emplacement of the N. 15°-20° E.-striking, 15.5-Ma dikes of the Steens Basalt (fig. 2). Steens Mountain underwent minor uplift and tilting shortly after the eruption of the Steens Basalt, but major block faulting and uplift occurred no earlier than 9.3 Ma (Rytuba and McKee, 1984) and has probably continued into the Holocene.

Pleistocene glaciation resulted in the formation of extensive glacial deposits and large U-shaped canyons on Steens Mountain. A large pluvial lake occupied the Alvord Desert basin during glacial times and was the site of lacustrine sedimentation near the southeast margin of the study area.

Geochemical Studies

A geochemical evaluation of the study area was undertaken by the USGS using assay data from stream-sediment and rock samples. Most of the data were acquired by DOGAMI, which collected 88 stream-sediment samples and 18 rock samples from within and near the study area and analyzed them for 17 elements. A description of the sampling and analytical techniques used by DOGAMI and the resulting data were reported by Gray and others (1983). Heavy-mineral concentrates of the stream-sediment samples were analyzed by Barringer Resources, Inc.; the analytical data from the magnetic and nonmagnetic fractions of the concentrates were presented in Bukofski and others (1984).

Mineralized and (or) altered rock samples were collected by the USGS and analyzed semiquantitatively for 31 elements using a direct-current arc emission spectrographic method (Meyers and others, 1961). These samples were also analyzed for antimony, arsenic, bismuth, cadmium, gold, mercury, and zinc by atomic absorption, using modifications of methods of Thompson and others (1968) or Koirtyohann and Khalil (1976), or by inductively coupled argon plasma-atomic emission spectroscopy, using a modification of the O'Leary and Viets (1986) method. The analytical results were entered into a USGS computer-based file (Rock Analysis Storage System) that is accessible to the public. (Inquires should be made to: Job No. RT29; U.S. Geological Survey, Branch of Analytical Chemistry, Lakewood, Colo., 80225.)

Anomalous values were determined primarily by considering the range, distribution, and mean of the elemental concentrations. The only heavy mineral concentrate data considered in the present study were those element values determined to be anomalous by Barringer Resources, Inc. (Bukofski and others, 1984).

Stream-sediment samples collected within the study area that appear to be derived from the widespread Steens Basalt contain anomalous concentrations of copper (as much as 156 parts per million (ppm)), nickel (as much as 120 ppm), and zinc (as much as 80 ppm). These relatively high concentrations probably reflect strong initial magmatic levels of these elements in the Steens Basalt and thus are not considered significant.

High concentrations of mercury and uranium are associated with somewhat weaker and sporadic anomalous concentrations of arsenic, barium, and molybdenum within the older silicic extrusive and tuffaceous rocks in the southeastern part of the High Steens Wilderness Study Area (Pike Creek and Alvord Creek Formations). The anomalies are primarily reflected in the rock, stream-sediment, and, with the exception of mercury and uranium, heavy-mineral concentrate samples analyzed by DOGAMI. The highest mercury concentrations (as much as 444 ppm) are in samples from the lower Pike, Dry, and Indian Creek drainage basins, whereas the highest uranium concentrations (as much as 354 ppm) are in those samples collected from the Pike and Little Alvord Creek drainages (fig. 2). Weak but anomalous concentrations of arsenic, barium, mercury, molybdenum, and uranium were detected throughout most of the remaining exposures of the Pike Creek Formation. Anomalous lead (as much as 72 ppm) and tungsten (as much as 100 ppm) concentrations are also present in a few of the heavy-mineral concentrate samples from the southeast margin of the study area. Limonite and hematite grains also exist in some of these concentrates. These anomalies, and other geologic observations, indicate that epithermal mercury-uranium mineralization affected the area. Elsewhere Rytuba and Glanzman (1979) and Castor and others (1981) have found similar anomalous concentrations of arsenic, molybdenum, and, locally, tungsten associated with epithermal mercury-uranium mineralization; their anomalies are associated with mineralized silicic volcanic rocks of the McDermitt caldera complex located 50 mi southeast of the study area. Arsenic, barium, mercury, and molybdenum are also associated with disseminated epithermal gold mineralization (Lewis, 1982) and may reflect undiscovered gold deposits near the study-area anomalies.

One stream-sediment sample collected in the Little Blitzen Gorge Wilderness Study Area contains 4.0 ppm mercury, and two others collected on the western dip-slope in the High Steens Wilderness Study Area contain slightly anomalous concentrations of mercury. Weak concentrations of gold (0.005 ppm), silver (as much as 0.13 ppm), or tin (as much as 32.3 ppm) are also present in a few stream-sediment samples collected from major dip-slope drainages. These concentrations may reflect high initial magmatic levels of the metals in the Steens Basalt; the tin concentrations also may be a result of contamination by human artifacts.

Geophysical Studies

An aerial gamma-ray survey conducted in the region as part of the U.S. Department of Energy's NURE program (Geodata International, Inc., 1980) maintained flightlines at altitudes of 350 to 1,200 ft above the ground. One north-south and four east-west composite flightlines spaced at intervals of 3 mi traversed the study area. Equivalent uranium determinations exceeded the background level over the exposure area of the Pike Creek Formation along an east-west flightline located 4 mi north of the south edge of the High Steens Wilderness Study Area, approximately coincident with Little Alvord Creek. Rapid changes of flight altitude in short distances along that flightline, however, diminished the reliability of the measurements.

A complete Bouguer gravity anomaly map was prepared using data acquired from National Geophysical Data Center, Boulder, Colo., 80303. Local features of the gravity map could not be interpreted because the data coverage included only two gravity stations in the study area and a few stations outside the southeast edge, which proved inadequate to correlate with the mapped geology. The coverage outside the southeast edge of the study area includes a closely spaced set of gravity stations along Indian Creek from Cleary and others (1981, p. 936). A steep gravity gradient of about 10 milligals (mGal)/mi with gravity values increasing westward along Indian Creek reflects the underlying range-front fault zone between Alvord Desert and Steens Mountain. Gravity gradients of similar amplitude separate Pueblo Valley from the upthrown, west-bounding southern Steens-Pueblo Mountains fault block (fig. 1) for a distance of about 40 mi south from the study area. The range-front gravity gradient is terminated to the north by a poorly defined 10- by 20-mGal gravity low that has a gravity minimum centered near the north edge of the study area. The value of this gravity anomaly decreases about 27 mGal between the 9,733-ft summit of Steens Mountain and the south edge of the study area (fig. 1). Gettings and Blank (1974) interpreted their unpublished east-trending gravity profile across Steens Mountain to reflect a possible depression filled with the Pike Creek Formation underlying Steens Mountain at depth. However, we believe that the gravity low may be too extensive to support such an interpretation.

An aeromagnetic survey of the region was flown with an east-west flightline spacing of 2 mi and at a constant barometric elevation of 9,000 ft above sea level except over crestlines where the flight-path elevations were higher (U.S. Geological Survey, 1972). The mapped magnetic anomaly pattern over the study area is dominated by a series of north-trending magnetic highs and lows with amplitudes that exceed 200 nanotesla (nT), reflecting large contrasts in magnetization of the rocks.

A prominent magnetic high and an adjacent magnetic low along the crestline of Steens Mountain reflect normally and reversely magnetized sections, respectively, of the Steens Basalt (Mankinen and others, 1985). These anomalies, however, are absent along a flightline located near Mosquito Creek and the headwaters of Little Blitzen River (fig. 1). A pair of elongated magnetic lows along each side of Kiger Creek probably reflect exposures of reversely magnetized parts of the Steens Basalt, where magnetic effects of the exposures are not cancelled by overlying normally magnetized rocks. The sources of elongated magnetic anomalies farther west are unclear. Inasmuch as dikes exposed near the crestline of Steens Mountain have northerly trends, the anomalies farther west may reflect concealed thick feeder dikes or dike swarms emplaced during more than one geomagnetic polarity epoch.

The intense magnetic anomalies that overlie the study area are superimposed on a broad magnetic high over Steens Mountain. A prominent magnetic gradient expressing a total amplitude that exceeds 100 nT upward to the west generally follows the west edge or center of the Alvord Desert and Pueblo Valley (fig. 1) south for about 40 mi. Like the range-front gravity gradient, the magnetic gradient is interrupted on the north by a relative magnetic low between Big Alvord and Mosquito Creeks. The source of the magnetic low is uncertain because the position of the anomaly probably is displaced by the magnetic effects of near-surface sources with large contrasts of magnetization. Perhaps the coincidence of the magnetic low and the poorly defined regional gravity low reflects the location of a cupola of an underlying felsic intrusive body. Alternatively, the location of the geophysical lows may reflect uplifted pre-Tertiary basement rocks with low magnetization and density.

Magnetic-intensity contours are nearly parallel to the northeast-trending, normal-fault trace that crosses Indian Creek just southeast of the study area (fig. 2). The fact that the associated magnetic gradient extends for nearly 3 mi and magnetic contours cross the trend of topographic contours farther to the south suggests that the fault penetrates to great depth.

Mineral and Energy Resources of the High Steens Wilderness Study Area

The Steens-Pueblo mining district, a 40-mi-long, 2- to 3-mi-wide, epithermal base- and precious-metal (gold, copper, and mercury) mineralized belt, lies along the steep east escarpment of the Steens-Pueblo Mountains fault block (Ross, 1942; Williams and Compton, 1953; Bradley, 1982) and overlaps the southeastern part of the High Steens Wilderness Study Area. The localization of the mineralized belt along the range-front fault zone and the common presence of ore and gangue minerals as veins and fracture coatings indicate that the mineralization was structurally controlled.

Gold, Mercury, and Uranium

Reported mining activity, geologic investigations, the study of mines and prospects, and geochemical anomalies indicate mercury and uranium mineralization has affected the southeastern part of the High Steens Wilderness Study Area (fig. 2). Anomalous concentrations of uranium as well as the gold-indicator elements arsenic, barium, and molybdenum are spatially associated with mercury. Most of the mineralization was confined to northwest- to northeast-trending fracture, shear, gouge, and breccia zones and dikes within the older rhyolitic extrusive and tuffaceous rocks of the Pike Creek and Alvord Creek Formations (Williams and Compton, 1953; Wilkerson, 1958; Peterson, 1969). The structural zones are likely related to the concealed Steens Mountain range-front fault zone located along the base of the east escarpment. Veins, fracture coatings, and disseminations within these zones are the most common modes of occurrence of the metallic minerals. Wall rocks near the mineralized veins and fractures are typically silicified and argillized and locally have undergone kaolinization. Platy rhyolite flows near the base of the Pike Creek Formation also show effects of acid leaching.

Mercury commonly is present as cinnabar and is accompanied by quartz, chalcedony, opal, limonite, and (or) clay gangue (Ross, 1942; Williams and Compton, 1953; Wilkerson, 1958). Uranium generally exists as autunite or torbernite and is accompanied by the molybdenum-bearing mineral ilsemannite (minor) and iron-manganese oxides in a clay and (or) silica gangue (Matthews, 1955 and 1956; Gray and others, 1983).

The anomalous suite of gold-indicator elements, sporadic gold values (see sample data, Appendix 2), mercury deposits, and alteration types present in the Pike Creek Formation strongly suggest that undiscovered epithermal gold deposits may exist in or beneath the southeasternmost part of the High Steens Wilderness Study Area. The lack of observed free gold other than minute grains in a few stream-sediment samples suggests that any undiscovered gold is disseminated and (or) below the surface.

Some dikes belonging to the Steens Basalt that intrude mineralized rocks of the Pike Creek Formation are altered or mineralized (Williams and Compton, 1953), indicating that mineralization occurred after the eruption of the 15.5-Ma Steens Basalt. Mineralized zones located along north-trending faults and related structures that displace the Steens Basalt suggest that some mineralization occurred during or after major block faulting, possibly as late as 9.3 Ma.

A mineral-deposit model is suggested for the southeastern part of the High Steens Wilderness Study Area in which epithermal solutions containing mercury, uranium, arsenic, barium, molybdenum, tungsten, and probably gold permeated range-front fault- and dike-related structures, preferrentially depositing the metals primarily in the Pike Creek Formation. The metals could have come from a deep source that was penetrated by some of the major faults (expressed by large geophysical gradients). Gold is inferred to have precipitated mainly below the present erosional surface, and disseminated gold deposits may exist there.

Sporadic, weak concentrations of mercury, tin, silver, and gold were detected by geochemical analysis of stream-sediment samples collected on the west slope of Steens Mountain. Minor amounts of free gold were also seen in some of these samples. No mineralized or altered rocks were seen west of the Steens Mountain crest within the study area, suggesting that the metal concentrations may have been derived from now-eroded leakage haloes associated with mineralized rocks lying beneath the Steens Basalt. Leakage may have occurred along north-northeast-trending normal faults, fractures, and basalt dikes (fig. 2) from concealed, hydrothermally mineralized rocks similar to those of the Pike Creek Formation. Alternatively, the metal concentrations may reflect high background levels within the Steens Basalt and (or) residual anomalies from rocks overlying the Steens Basalt that are now eroded.

A high potential, certainty level C, for mercury and uranium resources is assigned to an area between and including Pike and Indian Creek canyons along the margin of the High Steens Wilderness Study Area (fig. 2). See Appendix 1 for levels of mineral resource potential and certainty of assessment. The area is characterized by ore mineral concentrations and pronounced metalliferous anomalies detected within a highly fractured, brecciated, and hydrothermally altered zone of the Pike Creek Formation. An additional area that has a high potential for uranium resources, certainty level C, is present along Little Alvord Creek canyon within a fractured and altered part of the Pike Creek Formation that contains uraniferous minerals and geochemical anomalies; the NURE aerial gamma-ray survey (Geodata International, 1980) also suggests the presence of uranium in this area. A moderate potential, certainty level C, for mercury and uranium resources is assigned to an area located along most of the east margin of the study area south of Mosquito Creek within faulted and fractured felsic flows and tuffaceous rocks (including some of the large landslide blocks). Weaker geochemical anomalies and alteration, and a lack of mineral occurrences, distinguish this area from those with high potential. The U.S. Department of Energy (1980, p. 86) considered the entire Pike Creek Formation to have "speculative potential" for uranium oxide.

Both the areas of high and moderate mercury and uranium resource potential described above have moderate resource potential, certainty level C, for gold, primarily on the basis of minor detrital gold and anomalous concentrations of gold-indicator elements (mercury, arsenic, molybdenum, and barium). The geologic environment there, including the forementioned alteration assemblages, is favorable for epithermal gold, and epithermal gold deposits exist elsewhere in the southern part of the Steens-Pueblo mining district (Gray and others, 1983). Anomalous elements detected at the sample sites include silver, arsenic, barium, and molybdenum and indicate that undiscovered gold or mercury deposits might contain these commodities as byproducts. The northeasternmost part of the study area is characterized by only weak metallic anomalies despite the likely presence of fractured rocks of the Steens Mountain range-front fault zone underneath and within landslide blocks there. A low potential, certainty level B, for mercury, uranium, and gold resources is assigned to this area. Some samples collected in the High Steens Wilderness Study Area west of the range crest contain weak concentrations of gold, silver, and mercury. These metal values may reflect the presence of mineralized silicic volcanic rocks at depth similar to those exposed along the southeastern part of the range-front escarpment. This part of the High Steens Wilderness Study Area has unknown potential, certainty level A, for gold, mercury, and uranium resources; any possible mineralized zones there are concealed by a considerable thickness (2,000-4,000 ft) of the Steens Mountain Volcanics and Steens Basalt, preventing meaningful mineral resource potential evaluations.

Zeolites

The occurrence of clinoptilolite, a zeolite mineral having numerous agricultural and industrial uses, within tuffaceous rocks of the Alvord Creek Formation (Walker and Repenning, 1965; USBM, unpublished data) indicates that favorable geologic conditions existed for the formation of zeolites in the southeastern part of the High Steens Wilderness Study Area. Under such conditions, other silicic volcanic glass and tuffaceous rocks of the Alvord Creek and Pike Creek Formations presumably would be susceptible to zeolitic alteration. However, samples collected from the Alvord Creek Formation contain relatively low concentrations of clinoptilolite, and exposed rocks of both the Alvord Creek and Pike Creek Formations typically have undergone silicification and (or) argillization rather than zeolitization. There is thus little likelihood for undiscovered zeolite resources in the areas underlain by the Pike Creek and Alvord Creek Formations. Most of the southeastern part of the High Steens Wilderness Study Area has a low resource potential, certainty level C, for zeolite resources (fig. 2).

Perlite

Perlite, a hydrated silicic volcanic glass having several industrial and agricultural applications, occurs within the thin (30 ft average) vitrophyric margins of some of the flows within the Pike Creek Formation (Fuller, 1931; Minor and others, 1986). The perlite resource identified along Little Alvord Creek (Appendix 2 and fig. 3, No. 1) is contained within the glassy margin of a rhyolite dome at the base of the formation; perlitic glass may be extensive just a few tens of meters below the surface along the dome margin. Nonetheless, the area underlain by the Pike Creek Formation (southeastern part of the study area) has a low potential, certainty level B, for additional undiscovered perlite resources (fig. 2). Although there are several isolated perlite occurrences in the southeastern part of the High Steens Wilderness Study Area, they are most likely not voluminous due to the generally thin nature of the vitrophyres.

Geothermal Energy

Alvord Hot Springs, a group of springs with an average surface temperature of 169^{o} F and flow rate of 132 gal/min (White and Williams, 1975), is located about 2 mi southeast of the High Steens Wilderness Study Area along the base of the Steens Mountain range-front escarpment (fig. 2). The source reservoir for the hot springs has a mean calculated temperature of about 356^{o} F, a calculated volume of about 1.2 mi^3, and can generate 49 megawatts of electrical energy over a 30 year period (Muffler, 1979). The presence of these and other hot springs and high temperatures detected in wells of the Alvord Desert basin indicate that the basin is geothermally active, with a potential for direct heat utilization and possibly electrical power production (Peterson and Brown, 1980). Cleary and others (1981) indicated that meteoric waters in the region probably have circulated and been heated at great depth along some of the major range-bounding faults. Geothermal fluids could also conceivably percolate upward to shallow depths along branching segments of the Steens Mountain range-front fault zone at the east edge of the study area. However, no hot springs or other indications of recent or active geothermal activity exist within the study area. The geothermal energy resource potential of the easternmost part of the High Steens study area is considered to be low, certainty level B (fig. 2).

Oil and Gas

Available geologic data do not indicate the presence of oil and gas resources in or near the High Steens Wilderness Study Area. The Tertiary volcanic rocks underlying most of the High Steens Wilderness Study Area are not sources of hydrocarbons, and the basal Alvord Creek Formation, a predominantly sedimentary unit exposed adjacent to the east boundary, contains only minor and local accumulations of carbonaceous (fossil plant) material. There are no surficial tar or oil seeps, black shales, or other evidence of hydrocarbon source beds in exposed parts of the formation. The existence of favorable source beds in unexposed, stratigraphically lower parts of the Alvord Creek Formation is highly speculative. Synvolcanic sedimentary strata of similar age exposed elsewhere in southeast Oregon that locally contain favorable hydrocarbon source rocks (Fouch, 1983; Warner, 1980) were likely deposited in basins isolated from that of the Alvord Creek Formation. The nearest exposed pre-Teriary basement rocks, located about 30 mi south of the High Steens Wilderness Study Area, consist of Mesozoic metamorphic and intrusive rocks (Walker and Repenning, 1965), which are unlikely sources for hydrocarbons.

In assessing the petroleum potential of wilderness lands in Oregon, Fouch (1983) determined the High Steens Wilderness Study Area to have "low potential" for yielding oil or gas. Wilderness lands located in the Alvord Desert basin directly to the east, however, were assessed as having "medium potential." At present, there are no active oil and gas leases nor producing wells in the High Steens Wilderness Study Area and surrounding areas.

In consideration of the unfavorable, although somewhat limited, geologic evidence regarding the presence of hydrocarbon source rocks and the lack of oil and gas leases, exploration, and production, the High Steens Wilderness Study Area is judged to have low potential, certainty level B, for oil and gas resources (fig. 2).

Mineral Resources of the Little Blitzen Gorge Wilderness Study Area

Gold, Mercury, and Uranium

Sporadic anomalous concentrations of silver and mercury were detected in stream-sediment samples collected along the Little Blitzen River. Very minor detrital gold was also seen in some of these samples. No mineralized or altered rocks were observed within the study area, suggesting that the metal concentrations may have been derived from now-eroded leakage haloes associated with mineralized rocks underlying the Steens Basalt. Leakage may have occurred along north-trending normal faults, fractures, and dikes (fig. 2) from concealed, hydrothermally mineralized rocks similar to those of the Pike Creek Formation. Alternatively, the metal concentrations may reflect high background levels within the Steens Basalt. The study area has unknown potential, certainty level A, for resources of gold, mercury, and uranium in epithermal-related deposits; any possible mineralized rocks are concealed by approximately 2,000 to 4,000 ft of rocks of the Steens Basalt and Steens Mountain Volcanics, preventing accurate mineral resource potential assessments.

Oil and Gas

Available geologic data do not indicate the presence of oil and gas resources in or near the Little

Blitzen Gorge Wilderness Study Area. Basalt flows of the Steens Basalt underlying most of the Little Blitzen Gorge Wilderness Study Area are not sources of hydrocarbons. The Alvord Creek Formation, a predominantly sedimentary unit exposed along the Steens Mountain range-front escarpment that possibly extends underneath the Little Blitzen Gorge Wilderness Study Area, contains only minor and local accumulations of carbonaceous (fossil plant) material. There are no surficial tar or oil seeps, black shales, or other evidence of hydrocarbon source beds in exposed parts of the formation; the existence of favorable source beds in unexposed parts of the formation is highly speculative. Synvolcanic sedimentary strata of similar age exposed elsewhere in southeast Oregon that locally contain favorable hydrocarbon source rocks (Fouch, 1983; Warner, 1980) were likely deposited in basins isolated from that of the Alvord Creek Formation. The nearest exposed pre-Tertiary basement rocks, located about 35 mi south of the study area, consist of Mesozoic metamorphic and intrusive rocks (Walker and Repenning, 1965)— unlikely sources for hydrocarbons.

In assessing the petroleum potential of wilderness lands in Oregon, Fouch (1983) determined the Little Blitzen Gorge Wilderness Study Area to have "low potential" for yielding oil or gas. At present, there are no active oil and gas leases nor producing wells in the Little Blitzen Gorge Wilderness Study Area and surrounding areas.

In consideration of the unfavorable, although somewhat limited, geologic evidence regarding the presence of hydrocarbon source rocks and the lack of oil and gas leases, exploration, and production, the Little Blitzen Gorge Wilderness Study Area is judged to have low potential, certainty level B, for oil and gas resources (fig. 2).

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APPENDIX 1. Definition of levels of mineral resource potential and certainty of assessment

Definitions of Mineral Resource Potential

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 unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

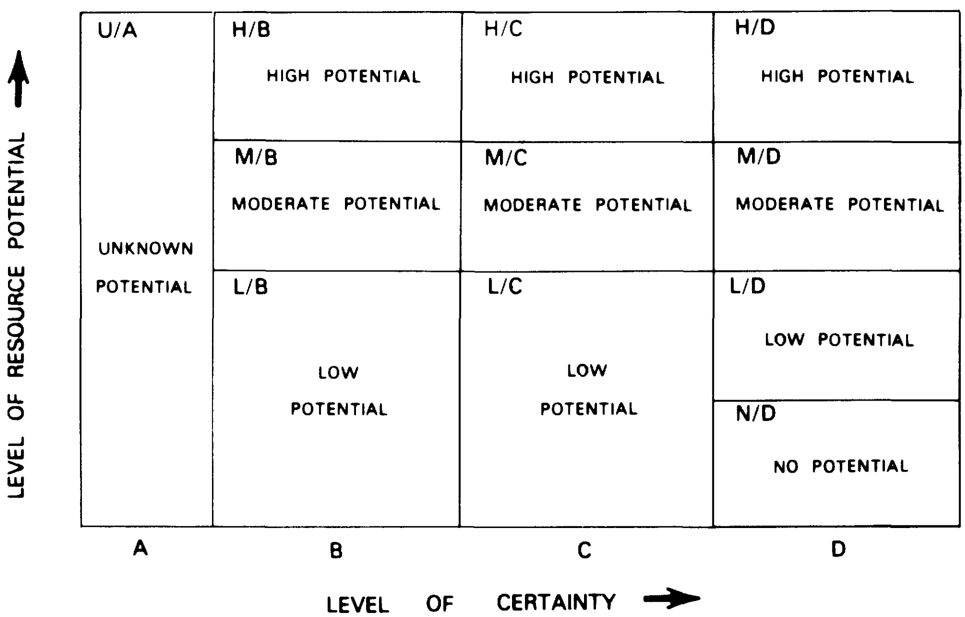
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

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.

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

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

Levels of Certainty



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

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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 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	~570[1]
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.

Appendix 2. Mines, prospects, and claims in and adjacent to the High Steens Wilderness Study Area, Harney County, Oregon
[* indicates outside the study area; color classification scheme by Munsell Color Co.]

Map No. (fig. 3)	Name (commodity)	Geology	Workings and production	Sample data
1	Cinder Cone Nos. 1-6 claims (perlite)	A perlite flow at least 25 ft thick crops out in vicinity of Little Alvord Creek. Surrounding flow are outcrops of moderate-pink (5R 7/4) rhyolite and pale-red (5R 6/2) biotite-dacite. Perlite is moderate brown (5YR 3/4) to dark gray (N3), moderately friable, and contains sporadic silica concretions. Perlite flow covers area of about 5.0 acres. Located by Lester Rhoads on April 1, 1966. Unpublished records of BLM (1984) indicate the claims are active.	A narrow, unmaintained, road leads to within 1,000 ft of the deposit, which is undeveloped.	All but one of nine random chip samples have refractive indices of 1.496±0.001; the other has an index of 1.494±0.001. Average analyses from additional physical testing: 93 percent glass, 6.5 percent impurities, 18.8 lb/ft^3 expanded density, 90.6 percent furnace yield, and 60 wt percent nonexpansibles. An estimated 400,000 tons of perlite classified as marginal reserves on property.
2*	Knight Hawk No. 1 claim (claim No. 6 and Rhoads prospect) (uranium)	Iron and manganese oxide-stained, vesicular flow-banded, silicified, white (N9) rhyolite cut by fault that strikes N. 30° E., and dips 65° W., and has a rake of 58° SW. Outcrop appears to be a small extrusive body that extends for about 40 ft and is about 24 ft thick. Lester Rhoads located claim on April 4, 1960. Prior to this date, the claim was apparently known as Claim No. 6. Claim also referred to as Rhoads prospect.	One adit 24 ft long with a 20-ft crosscut that extends to northwest lies along road parallel to Little Alvord Creek. Road terminates about 300 ft beyond adit at a shallow bulldozer cut about 50 ft in diameter. No record of production.	One chip sample of rhyolite collected. Analysis shows no significant metal values. Three random chip samples of iron oxide stained rhyolite average: no detectable gold or silver, 83 ppm arsenic, 4.3 ppm uranium oxide, 40 ppm thorium oxide, and 3 percent potassium oxide.
3*	Alvord Uranium Cave claims (uranium)	Pale-red (5R 6/2) biotite dacite crops out along resistent scarp. Isolated, small, podlike beds of dark-gray (N3) perlite crop out at and near base of the scarp. Dacite is slightly kaolinized and manganese and iron oxide stained. Joints strike N. 70° W. and dip vertically; another set strikes N. 3° W. and dips 45° E. Two faults were identified: the first fault strikes N. 15° E. and dips vertically; the second fault strikes N. 14° E. and dips 25° E. Claims were located by Dewey M. Quier and others on August 6, 1955.	A bulldozer-cut road leads to within 200 ft of an arcuate open cut. Open cut spans a distance of 30 ft, and averages less than 3 ft in depth. No recorded production.	Five grab samples of biotite dacite contain an average of 3.0 ppm uranium oxide and 3.7 percent potassium oxide. One of five samples has 45 ppm thorium oxide; remaining four samples have no thorium above detection limit. Radioactivity near the claims averages about 30 counts per second (cps), with no readings greater than two times background.
4*	Timberbeast Nos. 1-7 claims (uranium)	Country rock is composed of moderate-orange-pink (19R 7/4) silicified rhyolite; dusky-yellow-green (5GY 5/2) silicified dacite; and white (N9) to very light gray (N8) rhyodacite, which has been intruded by dark-gray (N3) to grayish-black (N2) lamprophyre dikes. Alteration consists of kaolinization and manganese and iron oxide staining. Fractures are commonly vertical and strike N. 55° E., N. 72° E., N. 30° E., N. 60° W., and N. 20° W. A local fault strikes N. 30° W. and dips 75° SE. to vertical. George Slack and others located claims for uranium on September 2, 1956. Raymond E. Dick and Neil Stockbrand relocated the claims on August 20, 1979.	Two collapsed adits and three bulldozer cuts, two of which may serve as part of the road system. Lower adit has at least 296 ft of crosscuts and drifts; upper adit has at least 70 ft of workings according to Erickson and Albee (1958). No recorded production.	Four grab samples of rhyolite average 6.73 ppm uranium oxide, 29.9 ppm thorium oxide, and 3.88 percent potassium oxide. Five grab samples of dacite average 20.9 ppm uranium oxide, 26.2 ppm thorium oxide, and 4.16 percent potassium oxide. Three chip samples of dacite average 6.29 ppm uranium oxide, 86.3 ppm thorium oxide, and 4.05 percent potassium oxide. A scintillometer survey indicated an average background count of 50 cps, with a 90 cps count rate at the contact between country rock and lamprophyre. Other zones of anomalous radioactivity are spotty and discontinuous and average about 50 cps.
5*	Pike Creek Carnotite claims (uranium)	Iron and manganese oxide stains along a fault associated with fractures in silicified, platy, pale-red-purple (5RP 6/2) rhyolite. Silicification exists as chalcedony and quartz veinlets that commonly parallel flow banding. Fractures also locally silicified. Four faults, all apparently normal, were recognized: one strikes N. 88° W., dips 85° N., and has a rake of 80° E.; another strikes N. 25° W. and dips 55° W.; a third strikes N. 12° W. and dips 72° E.; the fourth strikes N. 3° E. and dips 6° E. Uranium minerals not seen. Claims were located by Dewey M. Quier and others on June 22, 1955.	Two adits, one of which is collapsed, and about 1,000 ft of bulldozer cuts and roads. Open adit has a drift 95 ft long with a crosscut 30 ft long leading to vertical winze and manway. Winze and manway are at least 75 ft deep, lined with and separated by cribwork, and presumably intersect workings of now collapsed adit. No recorded production.	Eighteen chip samples of rhyolite, one chip sample of quartz, and two chip samples of gouge collected. Three rhyolite samples average 0.015 ppm gold, four average 58 ppm mercury, one 225 ppm thorium oxide, and three average 134 ppm uranium oxide. Quartz sample contains 63 ppm mercury and 350 ppm molybdenum. One gouge sample contains 373 ppm uranium oxide. Remaining samples contained no significant metal values.

Appendix 2. Mines, prospects, and claims in and adjacent to the High Steens Wilderness Study Area, Harney County, Oregon—Continued

Map No. (fig. 3)	Name (commodity)	Geology	Workings and production	Sample data
6*	Steens Mountain mine (Horse Heaven mine) (mercury)	Country rock consists of fractured and silicified, light-brownish-gray (5YR 6/1) and pale-red (5R 6/2) platy, flow-banded rhyolite; and light-greenish-gray (5GY 8/1) and light-bownish-gray (5YT 6/1) hornblende-biotite rhyodacite. Silicification confined to rhyolite and is present as veinlets of chalcedony, opal, and drusy, sucrosic quartz. Flow bands strike N. 25- 35° W. and dip 65° NE. to vertical. Fractures in rhyolite strike N. 20° E. and dip 75° SE. One of the fractures in largest adit is silicified across a zone 3.0 ft wide. Fractures in rhyodacite strike about N. 50° W. and dip about 80° NW. to vertical. A fault in rhyodacite strikes N. 2° E. and dips 55° SE. and has a rake of about 80° NW. Iron oxide stains fractures in rhyolite. Cinnabar exists as coatings in fractured rhyolite and in gouge seams along fault. Deposit was discovered by Bert Roark and Glenn Stephenson in October 1938 (Brooks, 1963, p. 193). Most of development work was done by Horse Heaven Mines, Inc., in 1939-1940.	Two adits, one open cut, and two trenches. One adit has 270 ft of drifts and crosscuts, one underhand stope, and two shallow winzes. Other adit is less than 10 ft long, but is entered through a 20-ft-long open cut. The two trenches are about 20 and 30 ft long. Ruins of two small retorts lie about 300 ft south of the workings. Incomplete production records indicate that about 45 flasks of mercury were produced through 1961 (Ross, 1942; Williams and Compton, 1953; and Brooks, 1963).	Fourteen samples of rhyolite collected; seven chip and seven grab. Mercury in three chip samples ranges between 57 and 75 ppm and another contains 6,650 ppm. Gold in six chip samples ranged from 0.010 to 0.025 ppm; remaining chip sample contains 0.124 ppm.
7*	Red Rock No. 6 claim (mercury)	Silicified grayish-orange-pink (10R 8/2) to moderate-pink (5R 7/4), platy, flow-banded, rhyolite country rock. Fault zone exposed in an open cut strikes N. 80° E. and dips 83° SE. Silicified zones consist of drusy and sucrosic quartz veinlets in fault breccia and fractures. Three sets of fractures: one set strikes N. 65° W. and dips steeply southwest; second strikes N. 50° E. and is vertical; third set strikes N. 75°-55° E. and dips 50° SE. to vertical. Fault zone exposed in one open cut strikes N. 80° E. and dips 83° SE. Flow banding strikes N. 10°-15° E. and dips 65° SE. to 80° NW. Cinnabar forms disseminations in some quartz, the latter of which is also rarely manganese oxide stained. Iron oxide stains are absent. Claim notice found near workings indicates claim located by Willard R. White for Norman C. Wood, on July 11, 1970. However, workings appear to be much older.	Two open cuts: one is 10 ft long and 5 ft wide; other is 20 ft long and 4 ft wide. No recorded production.	Four chips samples of silicified rhyolite contain no significant metal concentrations. One chip sample of silicified fault breccia contains 426 ppm mercury.
8*	Weston mine (Alexander mine, Juniper Mercury mine) (mercury)	Country rock moderate-pink (5R 7/4) rhyolite cut by grayish-black (N2) lamprophyre dike, both of which are locally brecciated and silicified. Silicified zones consist of 0.5- to 2.0-in.-thick calcedony and quartz veinlets. Brecciation confined to two sets of fractures: one strikes N. 25° E. and dips 80° SE., other strikes N. 10° E. and dip 70°NW. A sinuous normal fault strikes about N. 10° E. to N. 10° W. and dips 85° W. Quartz commonly present on hanging wall. Gouge along fault consists of clay mineral beidellite (Williams and Compton, 1953, p. 72). Cinnabar associated with clay, coats rhyolite, and disseminated in quartz. Iron oxide stains are localized, and form locally botryoidal goethite. Jim and Mike Weston acquired the mine and surrounding claims from Harry and Don Alexander in 1958, who originally located the mining claim June 25, 1941, under the name Juniper Cinnabar Quartz claim.	One adit, two inclined shafts, and open cut about 60 ft long. Adit has about 250 ft of workings and partially parallels fault. The two inclined shafts are 30 and 50 ft deep. The Westons have constructed a 1 ton/day retort and small jaw crusher, which were being repaired at time of the field work. Records are incomplete, but since 1941, at least 10 flasks of mercury were produced (Williams and Compton, 1953, and Jim and Mike Weston, oral commun., 1984).	Four chip samples of quartz have a weighted average of 58 ppm mercury and 0.51 ppm silver. One chip sample of rhyolite contains 24 ppm mercury and 0.46 ppm silver. One sample of fault gouge contains 170 ppm mercury.

Map No. (fig. 3)	Name (commodity)	Geology	Workings and production	Sample data
9*	Last Chance claims (mercury)	Host rock is silicified, platy, moderate-pink (5R 7/4) rhyolite and moderate-orange-pink (10R 7/4) to grayish-orange-pink (10R 8/2) biotite rhyodacite. Host rocks are locally brecciated along fractures that strike N. 80° W. and dip 85° to 90° N. Chalcedony and quartz fill fractures and cement breccia. Ironoxide locally stains fractures. Mercury minerals not seen. Mike F. Weston located the claims on August 29, 1951.	One collapsed adit and one pit. No recorded production.	One chip sample and one grab sample of rhyodacite contain no significant metal concentrations; three grab samples of rhyolite contain as much as 5.8 ppm silver, 0.059 ppm gold, 20 ppm mercury, and 40 ppm tin.
10*	Jack Pot Nos. 1-9 claims (No-Hole Nos. 1 and 2) (mercury)	Country rock consists of grayish-orange-pink (10R 8/2) biotite dacite, which is locally iron oxide stained and kaolinized(?). Mine workings exposed a fracture zone and fault. Fracture zone strikes about N. 37° W. and dips steeply northeast to vertical. Fault strikes N. 20° E. and dips 75° E. to vertical. Jack Pot Nos. 1-9 were located by Glen Stephenson in March 1955. Z.L. Cook relocated two of claims under name No-Hole Nos. 1 and 2 on April 24, 1965.	One open cut 27 ft long by 3 ft wide and one adit 84 ft long preceded by a 20-ft-long, 4-ft-wide open cut. No recorded production.	Two chip samples of biotite dacite and one chip sample of gouge contain no significant metal concentrations.
11*	Alex-Ladd claim (uranium)	Silicified and iron oxide stained, grayish-orange-pink (10R 8/2) to moderate-red (5R 5/4) brecciated rhyolite. Rock cut by a fracture zone that strikes N. 60° E. and dips 65° E. Silicification consists mostly of chalcedony. Harry Alexander located claims on September 25, 1955.	No workings were found. Production unknown.	One grab sample of silicified, brecciated rhyolite contains no significant metal values and no radioactivity greater than a background of about 30 cps.
12	Steens Nos. 1-74 claims (uranium)	Grayish-orange-pink (10R 8/2) flow-banded rhyolite and moderate-orange-pink (10R 7/4) flow-banded rhyodacite. Rocks are slightly iron oxide stained, partially kaolinized and intermittently silicified. Quartz veinlets generally are less than 0.10 in. thick, rarely vuggy, and translucent. Joints are oriented as follows: strike N. 67° W., dip 79° NE.; strike N. 89° E., dip 72° NW.; strike N. 15° E., vertical; and strike N. 55° W., dip 65° NE. Vertical fault near eastern edge(?) of claim group strikes N. 63° E. Wyoming Minerals located claims on April 22, 1977. Recent records indicate claims are no longer active.	No workings or record of production.	Average background for radioactivity is about 30 cps; no readings greater than two times background were observed. Three grab samples of rhyolite and two grab samples of rhyodacite collected contain no significant metal values.
13*	Aile Rouge [sic] No. 1 claim (mercury)	Grayish-orange-pink (10R 8/2) to moderate-pink (5R 7/4), silicified and brecciated rhyolite. Breccia associated with two faults, one with a strike of N. 35° W., a dip of 83° E., and a rake of 17° S., and appears to have right lateral separation. Other fault appears to be normal, strikes N. 28° E., dips 64° S., and has a rake parallel to dip. Iron oxide staining present along northwest-trending fault. Claim located by W.B. Stewart on August 26, 1942.	No workings or production	One chip sample of breccia from northwest-striking fault contains 0.36 ppm silver, 22 ppm mercury, and 2.3 ppm uranium oxide.
14*	Sunshine No. 3 claim (Red Rock No. 6 claim) (mercury)	Country rock is medium-light-gray (N6) and moderate-orange-pink (10R 7/4), silicified, iron oxide stained, flow-banded rhyolite. Silicification expressed by quartz-filled veinlets. Fault adjacent to workings strikes N. 83° E., dips 65° SE., and has a rake of about 45° E. This mining claim was originally located by Rosco A. Officer as the Red Rock No. 6 claim in March 1961. William R. White relocated claim for Norman C. Wood on July 10, 1970 as Sunshine No. 3.	Inclined shaft about 15 ft deep and about 6 ft wide. No recorded production.	One chip sample of silicified rhyolite has 0.014 ppm gold and one grab sample of rhyolite has 65 ppm mercury.

Map No. (fig. 3)	Name (commodity)	Geology	Workings and production	Sample data
15	Big Indian mine (placer gold)	Shallow gravel veneer along Big Indian Creek composed of fine to coarse sand, pebbles, and cobbles of andesite and basalt. Claim located by John Munch on August 17, 1901.	No workings or record of production.	One placer sample, consisting of three level 14-in.-diameter pans, contains 0.021 mg gold, a trace of garnet, and 2 percent black sand.
16	Buckhorn mine (placer gold)	Big Indian Creek here flows through medium-dark-gray (N4) and brownish-gray (5YR 4/1) basalt and brownish-gray (5RY 4/1) andesite of the Miocene Steens Mountain Volcanics. Claim is in middle of a group of placer claims that continue up creek for about 1/2 mi. T.C. Wright located this claim on August 17, 1901.	No workings or record of production.	One placer sample, consisting of three level 14-in. pans, contains 0.009 mg of fine angular gold and 2 percent black sand.
17	Daisy claims (gold)	Moderate-reddish-brown (10R 4/6) to moderate-red (5R 4/6) volcanic cinder and dark-gray (N3) scoraceous andesite. Cinder crops out over an area of less than one acre. W.R. Gray and S. Alberson located claims on January 22, 1908.	According to claim location notice, there is a 10-ft-deep shaft; however, it was not found during the field work in 1984. No record of production.	One random chip sample of volcanic cinder contains no significant metal values.
18	Gold Crown claim (placer gold)	Alluvium composed of sand and gravel derived from basalt and andesite. Gus Monroe located claim on September 17, 1901.	No workings or record of production.	One placer sample, consisting of three level 14-in.-diameter pans, contains 0.004 mg gold and a trace of black sand.
19	Gold Queen claim (placer gold)	Small point bar deposit composed of sand and gravel derived from basalt and andesites that overlie medium-dark-gray (N2) basalt bedrock. John X. Williams located claim on September 16, 1901.	No workings or record of production.	One placer sample, consisting of three level 14-in.-diameter pans, contains 0.044 mg gold, a trace of garnet and scheelite, and 2 percent black sand.
20	Head Light mine (placer gold)	Gravel bar with volume less than 2 yd^3 surrounded by large boulders of vesicular basalt. Claim located by Homer Rambo on October 10, 1901.	No workings or record of production.	One placer sample, consisting of three level 14-in.-diameter pans, contains 0.002 mg gold, trace garnet, and 2 percent black sand.
21	Homestretch lode (placer gold)	Point bar deposit composed of silt- to boulder-sized clasts of basalt and andesite. Charles Stacey located claim on October 16, 1901.	No workings or record of production.	One placer sample consisting of two level 14-in. pans contains 2 percent black sand.
22	Jack Pot claim (placer gold)	Small point bar deposits with less than 0.5 yd^3 of sand and gravel derived from basalt and andesite. Frank V. Armstrong located claim on August 20, 1901.	No workings or record of production.	Two placer samples, each consisting of three level 14-in.-diameter pans, contain a trace of garnet and 2 percent black sand. One sample has a trace of scheelite.
23	Lady Washington claim (placer gold)	Small gravel deposit, with a volume of less than one cubic yard, overlying bedrock (Steens Basalt). George L. Davidson located claim on September 17, 1901.	No workings or record of production.	One placer sample, consisting of three level 14-in.-diameter pans, contains a trace of black sand.
24	Miners Dream lode (gold)	Vesicular, platy, medium-dark-gray (N4) basalt cut by an iron oxide stained, dark-gray (N3) to grayish-black (N2) lamprophyre dike. Dike strikes N. 25° E., is vertical, and is adjacent to another vertical dike of medium-dark-gray (N4) brecciated basalt that strikes N. 5° E. Dikes can be traced spordically for at least 1,000 ft. Iron oxide staining exists as a coating on weathered surface of the dikes. Fractures in platy basalt either strike N. 5° W. and are vertical, or strike N. 80° E. and dip 45° NW.; latter are parallel to flow banding in basalt. Fractures in dikes predominantly strike in westerly direction and are vertical. Nearby fracture zone that strikes N. 37° W. and dips 50° NE cuts palagonite. Claim was located by James W. Griffin on October 14, 1901.	No workings or records of production.	One chip sample of brecciated basalt has no significant metal values. A grab sample of palagonite has 0.042 ppm gold.

Map No. (fig. 3)	Name (commodity)	Geology	Workings and production	Sample data
25	Ole Olson lode (gold)	Very pale green (10G 8/2) palagonite(?) tuff with moderate-reddish-brown (10R 4/6) to moderate-red (5R 4/6) cinder and volcanic bombs 1 ft in diameter. Tuff cut by a dark-gray (N3) to grayish-black (N2) vertical lamprophyre dike that is about 25 ft thick and strikes N. 65° W. Claim was located by L.A. Borgstrum on October 16, 1901.	No workings or record of production.	A chip sample of dike has no significant metal values. One of two grab samples of tuff had 0.012 ppm gold and 0.370 ppm silver; other had no significant metal values.
26	Snowbird claim (placer gold)	Alluvium consisting of silt- to boulder-sized clasts derived from basalt and andesite. Charlie Holtz located claim on August 14, 1902.	No workings or record of production.	Three level 14 in. pans collected along edge of creek has a trace of black sand.
27	West End claim (placer gold)	Alluvium derived from basalt and andesite. Harry Brown located the claim on August 17, 1901.	No workings or records of production.	Three level 14-in. pans collected from point bar have 2 percent black sand.

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