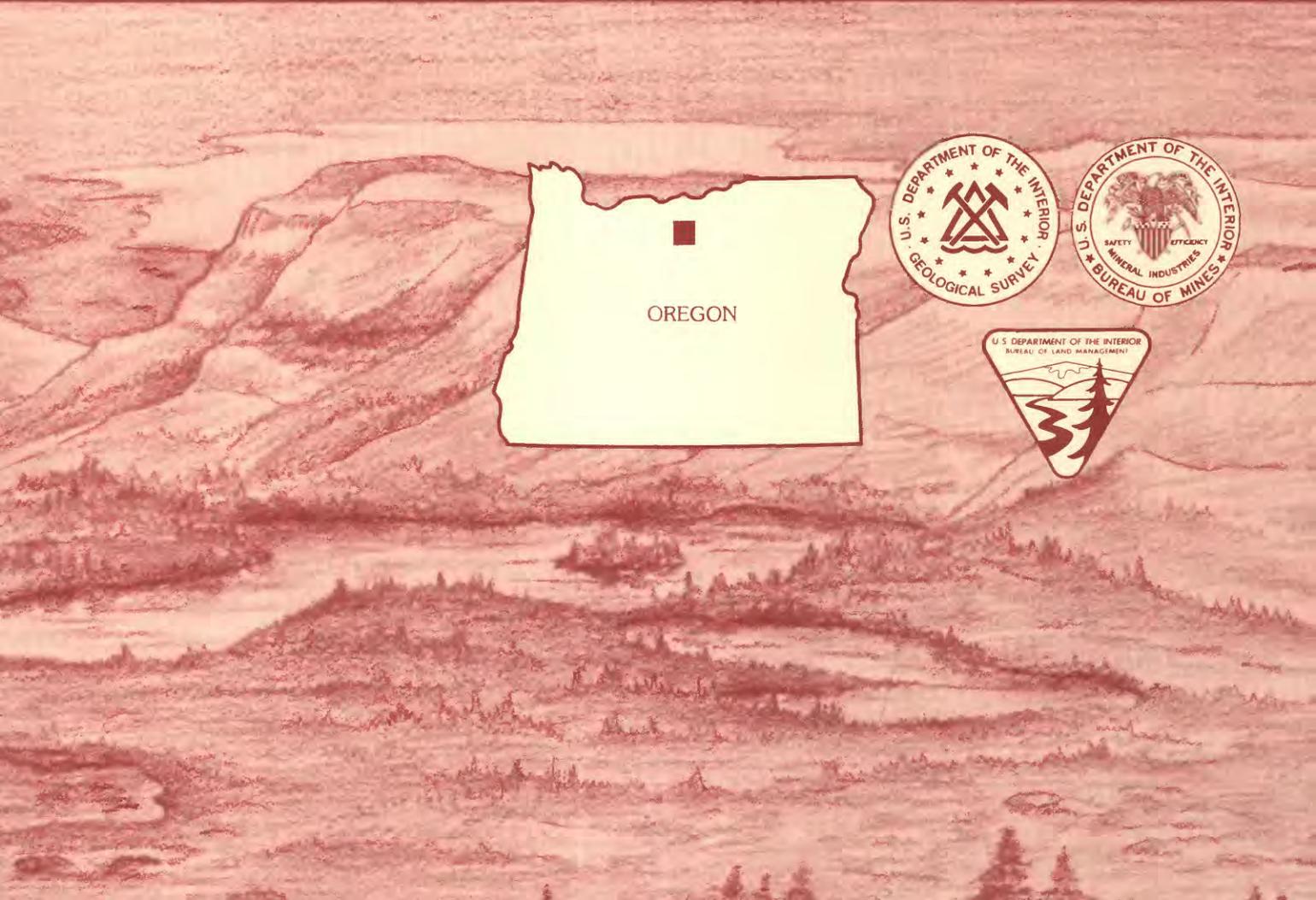


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# Mineral Resources of the Spring Basin Wilderness Study Area, Wheeler County, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1743-C



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Chapter C

# Mineral Resources of the Spring Basin Wilderness Study Area, Wheeler County, Oregon

By JAY A. ACH, SCOTT A. MINOR, JAMES G. FRISKEN, and  
RICHARD J. BLAKELY  
U.S. Geological Survey

RICHARD A. WINTERS and THOMAS J. PETERS  
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1743

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:  
JOHN DAY REGION, OREGON

DEPARTMENT OF THE INTERIOR  
DONALD PAUL HODEL, Secretary

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



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Area, Wheeler County, Oregon.

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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 of 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 Spring Basin (OR-005-009) Wilderness Study Area, Wheeler County, Oregon.



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# Mineral Resources of the Spring Basin Wilderness Study Area, Wheeler County, Oregon

By Jay A. Ach, Scott A. Minor, James G. Frisken, and Richard J. Blakely  
*U.S. Geological Survey*

Richard A. Winters and Thomas J. Peters  
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## SUMMARY

### Abstract

At the request of the U.S. Bureau of Land Management, approximately 5,982 acres of the Spring Basin (OR-005-009) Wilderness Study Area in north-central Oregon were evaluated for mineral resources (known) and mineral resource potential (undiscovered). In this report, "wilderness study area" and "study area" refer to the 5,982 acres for which mineral surveys were requested. Fieldwork for this report was carried out in 1987. No identified mineral resources are known to exist within the study area. No mines or mining districts are located inside the study area; however, a part of the area is under lease for oil and gas exploration.

An area in the easternmost part of the study area has low mineral resource potential for silver, gold, and mercury. A small area in the central part of the study area has low mineral resource potential for mercury. The study area has a low resource potential for oil and gas and no resource potential for uranium or for geothermal energy.

### Character and Setting

The Spring Basin Wilderness Study Area is located in the northwestern part of the Blue Mountains physiographic province of north-central Oregon and is centered about 13 mi southwest of Fossil, Oregon (fig. 1). The canyon of the John Day River bounds the west side of the study area. In the study area, the terrain consists of moderately steep, rugged volcanic uplands and has several buttes that rise as high as 1,000 ft above surrounding areas. Most of the study area is underlain by Eocene and early Oligocene (see appendixes for geologic time chart) andesite flows, plugs, and domes and associated intertonguing volcanoclastic

rocks. Rhyolite ash-flow tuff that was erupted sometime between the late Eocene and early Miocene unconformably overlies these rocks in a small part of the study area. Mesozoic marine sedimentary rocks have been encountered in drill holes in the vicinity, and similar rocks are probably present a few thousand feet beneath the study area. Structurally the study area is simple. The rocks generally dip less than 5° and are cut by a few normal faults of small displacement.

### Identified Resources

No identified mineral resources are known to exist within the study area. Three extant claims apparently were located for lapidary material. Samples of agate from the claims were evaluated and found to be of poor quality. No mines or mining districts are located inside the study area; however, approximately 23 percent of the area is under lease for oil and gas exploration.

### Mineral Resource Potential

The Spring Basin Wilderness Study Area has a low mineral resource potential for silver and gold in epithermal deposits in the easternmost part of the study area. This part of the area also has a low mineral resource potential for epithermal mercury deposits. The potential for both types of deposits is indicated by low-level geochemical anomalies and by geologic similarities to deposits in the Ashwood/Horse Heaven mining district 10 to 15 mi to the west-southwest. Low-level geochemical anomalies indicate that a small area in the center of the study area also has low mineral resource potential for mercury in epithermal deposits.

The study area has low potential for oil and gas. Dry holes are located approximately 3, 4, and 26 mi from the study area. Well logs and various geochemical studies indicate that suitable source and reservoir rocks are not present at these drill sites, but the possibility of more favorable source and reservoir rocks beneath the study area cannot be ruled out. No favorable reservoir structures are known in the study area.

No resource potential exists for uranium or for geothermal energy in the study area.

## 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. The U.S. Bureau of Mines evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas. Identified resources are classified according to the system that is a modification of that described by McKelvey (1972) and U.S. Bureau of Mines and U.S. Geological Survey (1980). Studies by the U.S. Geo-

logical Survey 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 the appendixes for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

## Area Description

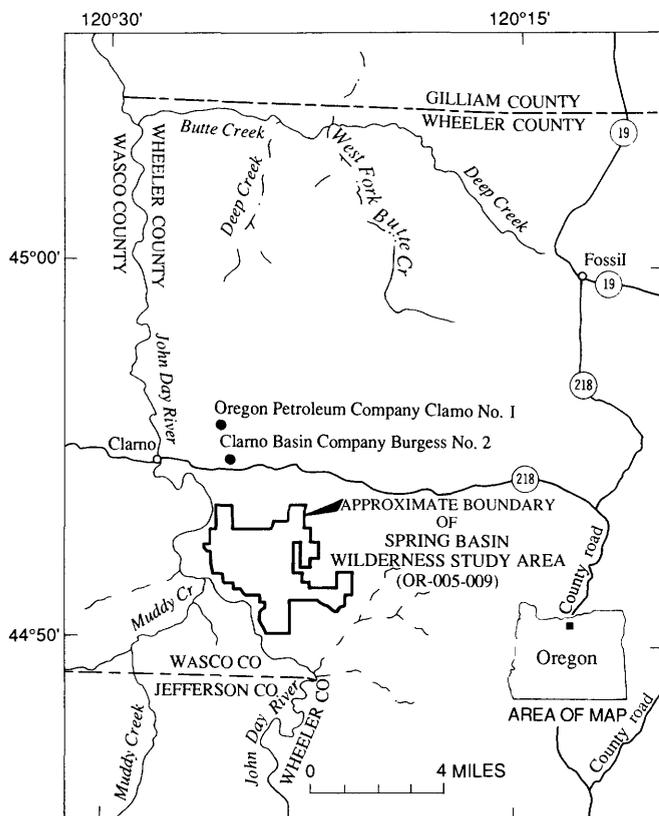
The part of the Spring Basin Wilderness Study Area (OR-005-009) evaluated for mineral resource potential encompasses 5,982 acres in north-central Oregon. It is located just east of the John Day River about 13 mi southwest of Fossil, Oregon (fig. 1). The area is characterized by a high ridge along the north and east boundaries. The principal drainages in the area, Spring Basin Canyon, Hay Bottom Canyon, and Eagle Canyon, flow south and west off this ridge and into the John Day River. Elevations range from 2,827 ft on Horse Mountain to 1,360 ft near the John Day River. The area has a semiarid climate (Strahler, 1969) and an average of about 12 in. of precipitation a year (Meteorology Committee, Pacific Northwest River Basins Commission, 1969). Vegetation consists primarily of grasses, some sagebrush, and scattered juniper. Access to the area is provided by a dirt road and jeep trails that lead to the area from Oregon Highway 218.

## Previous and Present Investigations

Little previous geologic work has been done in the study area. Swanson (1969) included the study area in a reconnaissance geologic study and extensively mapped the Columbia River Basalt Group beginning just north of the study area (Swanson and others, 1979, 1981). Peck (1964) mapped a small area a few miles west of the study area.

Previous reconnaissance studies of the geology and mineral resources of wilderness study areas in the region were carried out by Davis (1983) and Fouch (1983). Regional uranium resource potential was evaluated as part of the U.S. Department of Energy National Uranium Resource Evaluation (NURE) program (High Life Helicopters, Inc./ QEB, Inc., 1981).

The U.S. Geological Survey conducted field studies in the study area in 1987. These studies consisted of geologic mapping, including checking of previously published geologic mapping, conducting further mapping, and collecting 60 rock samples, 29 stream-sediment samples, and 22 stream-sediment heavy-mineral-concentrate samples for chemical analysis. Available geophysical data were compiled and examined.



**Figure 1.** Index map showing location of the Spring Basin Wilderness Study Area, Wheeler County, Oregon. Dots are dry wells.

The U.S. Bureau of Mines conducted a library search for information on the geology, mines, and prospects within the study area. Additional data were obtained from Wheeler County and U.S. Bureau of Land Management mining, lease, claim, and land status records. These data were used to determine the geologic setting, mining history, possible mineral commodities, mining claim ownership, and claim localities. Field studies by U.S. Bureau of Mines personnel were carried out in 1987 (Winters and Peters, 1988) and involved searches for any existing mines, prospects, claims, or mineralized geologic structures; 8 rock samples and 13 alluvial samples were collected. Rock samples were checked for radioactivity and fluorescence. The rock samples also were analyzed for 34 elements by instrumental neutron activation by a contract laboratory. Alluvial samples were concentrated and inspected for gold and other valuable minerals. Complete analytical data are on file at the U.S. Bureau of Mines, Western Field Operations Center, E. 360 Third Ave., Spokane, WA 99202.

### Acknowledgments

The authors gratefully acknowledge the cooperation of the U.S. Bureau of Land Management personnel of the Prineville District Office, Prineville, Oregon, in providing access information and maps of the study area. Ranchers Jon Bowerman and Bill Cross graciously provided access to their land. Dan E. Wermiel, Oregon Department of Geology and Mineral Industries, provided much information pertaining to the petroleum potential of central Oregon.

### APPRAISAL OF IDENTIFIED RESOURCES

By Richard A. Winters and Thomas J. Peters  
*U.S. Bureau of Mines*

No mining districts exist in or near the Spring Basin Wilderness Study Area. Three lode mining claims in the study area (fig. 2) apparently were located for lapidary material. The Crystal Peak and MEM-CAF mining claims were located in 1978 and 1975, respectively. The name and date of location of a third claim is unknown. Approximately 23 percent of the area studied is currently covered by oil and gas lease applications.

No identified mineral resources exist within the study area. Samples of agate were evaluated and determined to be of poor quality. Four of thirteen alluvial samples contain gold ranging from 0.0000097 to 0.000416 troy ounces per cubic yard (\$0.005 to \$0.21 per cubic yard assuming gold at \$500 per troy ounce); significant accumulations of alluvium have not been deposited in the study area.

No economic concentrations of minerals were observed in the rock or alluvial samples, and concentrations of elements detected in rock samples do not differ from

expected crustal abundances. The basalt, andesite, and dacite that underlie the area studied could be used for construction blocks and rubble. However, these low-unit-value, high-bulk commodities are available throughout Oregon in areas of better access (Barton, 1968, p. 62).

### ASSESSMENT OF MINERAL RESOURCE POTENTIAL

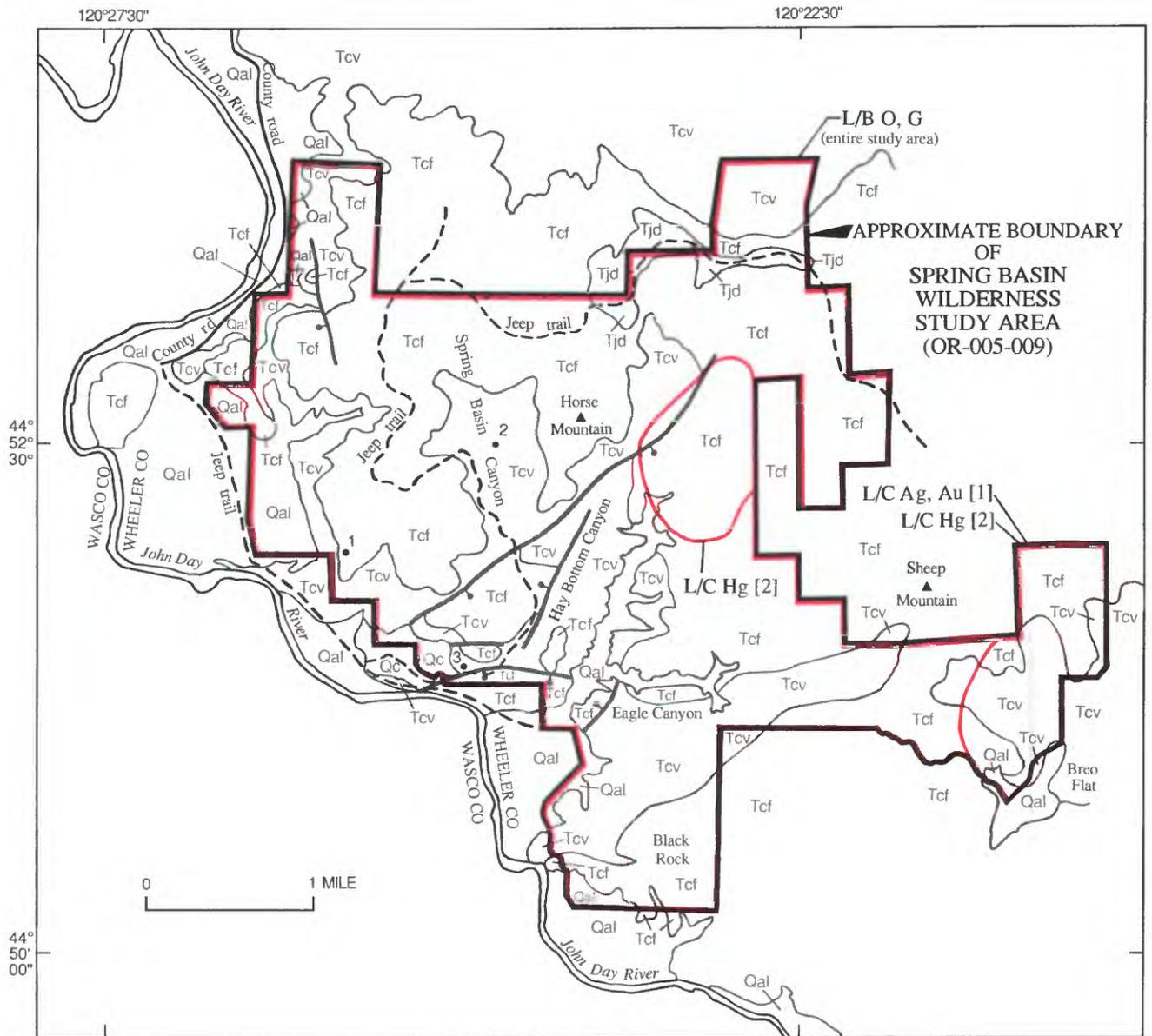
By Jay A. Ach, Scott A. Minor, James C. Frisken, and Richard J. Blakely  
*U.S. Geological Survey*

### Geology

The Spring Basin Wilderness Study Area is located in the northwestern part of the Blue Mountains physiographic province, about 10 mi south of the adjoining Columbia Plateau. In the vicinity of the study area, the Blue Mountains province is characterized by complexly interbedded and interfingering Tertiary volcanic rocks that unconformably overlie pre-Tertiary sedimentary and metasedimentary basement rocks (Swanson, 1969). The rocks in the region are broadly folded and uplifted along northeast trends and are only locally faulted. The Columbia Plateau, just to the north of the study area, is formed by extensive sequences of gently north-tilted Miocene basalt flows of the Columbia River Basalt Group (Swanson and others, 1981; Walker, 1977).

The oldest rocks exposed in the study area (fig. 2) form part of the Eocene and lowermost Oligocene(?) age Clarno Formation (Walker and Robinson, in press), which was originally named and described by Merriam (1901a, b). The Clarno Formation crops out in nearly the entire study area, where it has a maximum exposed thickness of about 1,700 ft. However, drill hole data from nearby localities suggest that the Clarno is at least 3,000 ft thick within the study area. The same holes indicate that Mesozoic marine sedimentary rocks occur beneath the Clarno Formation. Within the study area, the Clarno is divided into two inter-tonguing subunits, lava flows (including plugs and domes) and volcaniclastic rocks.

The lava flows, plugs, and domes range in composition from basalt to dacite, although most appear to be andesite. They commonly display columnar cooling joints and typically form cliffs. Phenocrysts mainly consist of plagioclase, pyroxene, and locally hornblende. Many of the plugs and domes are shallow intrusions that both cut and are overlain by surrounding Clarno rocks. Most of the more resistant rocky buttes and hills in and near the study area, such as Sheep Mountain and Black Rock, are probably intrusive plugs (Taylor, 1960) of the Clarno. Locally the lava flows include layers and lenses of breccia (including flow breccia) and volcaniclastic and tuffaceous sedimentary



**EXPLANATION**

<span style="border: 1px solid red; display: inline-block; width: 20px; height: 10px; vertical-align: middle;"></span> Area of low mineral resource potential (L)	<b>Geologic map units</b>
<b>Levels of certainty of assessment</b>	Qal Alluvium (Quaternary)
B Data only suggest level of potential	Qc Colluvium (Quaternary)
C Data give good indication of level of potential	Tjd John Day Formation (Tertiary)—Ash-flow tuffs
<b>Commodities</b>	Tcf Clarno Formation (Tertiary)—Volcanic flows, plugs, and domes
Ag Silver	Tcv Clarno Formation (Tertiary)—Volcaniclastic rocks
Au Gold	— Contact
Hg Mercury	— Normal fault—Bar and ball on downthrown side
O,G Oil, Gas	• Claims
[ ] Deposit types	1 Crystal Peak claim
1 Epithermal precious- and base-metal deposits	2 MEM-CAF claim
2 Epithermal mercury deposits	3 Unnamed claim

**Figure 2.** Map showing mineral resource potential and geology of the Spring Basin Wilderness Study Area, Wheeler County, Oregon.

rocks. Most of the clasts in these rocks are lithologically identical to the enclosing flows, plugs, and domes.

The volcanoclastic facies of the Clarno Formation consist chiefly of andesite mudflow breccia, pyroclastic deposits, and minor tuff. A few andesite lavas are interbedded with these rocks. Poorly sorted sedimentary rocks composed of clasts of the various volcanic rocks are exposed locally, and at one locality a 150-ft-thick, well-bedded fluvial sequence is exposed. Clasts in this sequence reach diameters of several feet and consist almost entirely of locally derived basalt, andesite, and dacite. The clasts are enclosed in tuffaceous or silt- and clay-rich matrices. The volcanoclastic rocks, which form exposures as thick as 600 ft along the canyon wall of the John Day River near the northwest edge of the study area, probably originated as volcanic mudflow deposits that descended the steep flanks of nearby volcanoes (Taylor, 1960; Swanson, 1969). The lava flows of the Clarno Formation may have formed the volcanic edifices from which the mudflows were derived.

Welded rhyolite ash-flow tuff and basal nonwelded tuffaceous deposits of the John Day Formation unconformably overlie rocks of the Clarno Formation with slight angular discordance near the northeast corner of the study area (Taylor, 1960; Swanson, 1969; Robinson, 1975). The John Day Formation is uppermost Eocene to lower Miocene in age (Robinson and others, in press), and consists of intercalated ash-flow tuff, volcanoclastic rocks, and rhyolitic and mafic extrusive and intrusive rocks. The ash-flow tuff in the study area is approximately 75 ft thick, nonwelded to densely welded, and has a cliff-forming upper part. Welded parts of the tuff contain fiamme (flattened pumice) that define a compaction foliation.

Overall, the rocks in the study area dip gently towards the northwest (Taylor, 1960; Robinson, 1975). The regional tilt may be an expression of the northwest flank of the northeast-trending Blue Mountain anticline, a broad regional structure that involves rocks as young as the Columbia River Basalt Group (Swanson, 1969). Other smaller, more local northeast-trending folds are present a few miles north and west of the study area. A few high-angle normal faults having apparent displacements as great as 400 ft have been delineated in the study area; other faults undoubtedly are present. Three of the faults strike northeast subparallel to the nearby Hay Bottom Canyon, suggesting that the canyon has been eroded along another fault. Similarly, an east-striking normal fault mapped just west of the east-trending Eagle Canyon may extend farther east along the canyon.

Uplift and folding in the Blue Mountains province began in the Eocene during deposition of the Clarno Formation and continued for the remainder of the Tertiary (Fox and Reidel, 1987). Angular unconformities separating rocks of the Clarno Formation, John Day Formation, and Columbia River Basalt Group in and north of the study area (Swanson, 1969; Robinson, 1975) provide evidence that

uplift and tilting continued in the region during the Oligocene and early Miocene. Faulting in the region may have been contemporaneous with this deformation and (or) may have taken place between about 11 and 3 Ma (million years ago), late Miocene and early Pliocene, during deformation recognized on the Columbia Plateau (see Bela, 1982, for references).

Clarno lava flows and domes in the southeastern part of the study area locally contain zones of east-striking, calcite veins that reach thicknesses of 2 ft and lesser veins and veinlets of silica. Rocks in a small area (less than 0.1 mi<sup>2</sup>) surrounding a vein zone 0.5 mi north of Breo Flat have undergone pervasive silicification and local argillic alteration. A zone of veins in Eagle Canyon is on trend with the east-striking fault just to the west, suggesting that these veins are related to an eastward extension of the fault.

Thick, extensive alluvium underlies the flood plain of the John Day River adjacent to the west boundary of the study area. Toward the study area, the alluvium grades into locally thick colluvium near the base of the east wall of the river canyon. Smaller amounts of alluvial sand and gravel form bars and terraces along the major drainages in the study area.

## Geochemical Studies

A reconnaissance geochemical investigation of the study area was made using samples of rock, stream sediment, and the nonmagnetic fraction of heavy-mineral concentrates from stream sediments. The stream-sediment and concentrate samples contain material derived from alluvium and rock units of the drainage basins within the study area. Sampled drainage basins range in area from less than one to several square miles.

From the study area, 60 rock samples, 29 stream-sediment samples, and 22 heavy-mineral-concentrate samples were analyzed for 35 elements by six-step semiquantitative emission-spectrographic methods (Crock and others, 1987). Additional analyses for arsenic, antimony, bismuth, cadmium, and zinc were made using inductively coupled argon plasma-atomic emission spectroscopy (Crock and others, 1987). Samples were analyzed for gold by an atomic-absorption method (Crock and others, 1987) and a graphite furnace/atomic-absorption method that has a lower detection limit of 0.002 ppm (parts per million) (Meier, 1980). Analyses for mercury used the atomic absorption method of Koirtzmann and Khalil (1976). Five rock and two stream-sediment samples were analyzed for fluorine by a specific-ion electrode method (Crock and others, 1987) and for uranium by a fluorometric method (O'Leary and Meier, 1986). M.J. Malcolm and others (written commun., 1988) provided sample locations, complete analytical data, and a description of sampling, sample preparation, and analytical methods.

Analyses of stream-sediment and heavy-mineral-concentrate samples are used to identify drainages that have anomalously high concentrations of metallic and metal-related elements. Rock samples were collected from areas of altered bedrock and from each lithologic unit to obtain information on trace-element signatures associated with potentially mineralized areas and to provide data on background trace-element concentrations. For this study, anomalous geochemical values are considered to be those that exceed by a factor of two to three the mean concentration in local andesites, the dominant rock type in the study area.

A group of multiple-element, low-level geochemical anomalies delineates a part of the study area that was subjected to hydrothermal alteration and perhaps mineralization. This anomalous area surrounds an altered dacite plug located in the easternmost part of the study area, 0.5 mi north of Breo Flat and 1 mi southeast of Sheep Mountain. The dacite and some of the surrounding rock have been variously altered, bleached, silicified, and (or), in a few locations, stained by iron oxides. Of 11 rock samples collected in this area, 6 are anomalously high in one or more elements; 5 of 7 stream-sediment samples from the area are similarly anomalous. Elements found in anomalous concentrations are gold, mercury, arsenic, and molybdenum. Of the six rocks having geochemical anomalies, one contains an anomalous concentration of gold (0.009 ppm), six contain mercury (0.14 to 0.52 ppm), three contain arsenic (5 to 34 ppm), and one contains molybdenum (5 ppm). Of the five stream-sediment samples having geochemical anomalies, the sample with the strongest anomaly contains 0.035 ppm gold, 0.30 ppm mercury, and 44 ppm arsenic. Two other stream-sediment samples contain 0.005 and 0.004 ppm gold, two contain 0.16 ppm mercury, and two contain 7 and 6 ppm arsenic.

An additional rock sample, collected at Sheep Mountain about 1/2 mi north of the study area boundary and about 1 mi northwest of this anomalous area, has similarly anomalous geochemistry (24 ppm arsenic, 7 ppm molybdenum, and 3 ppm antimony). Sheep Mountain is another andesite or dacite plug that may have undergone hydrothermal alteration similar to that in the part of the study area near Breo Flat.

Anomalously high values for mercury, arsenic, molybdenum, and antimony are among those often associated with epithermal mercury mineralization (Rytuba and Glanzman, 1979) or epithermal silver-gold-base-metal mineralization (Bonham, 1984; Bonham and Giles, 1983), both of which tend to occur in silicic volcanic or related host rocks. Important mineral deposits of these two types are usually associated with the complex structures, including domes and plugs, found in volcanic eruptive centers (Berger, 1982).

In the central part of the study area, a zone of weak hydrothermal alteration is indicated by geochemical

anomalies in three of the eight rock samples collected for this study from within the zone. Two samples have low-level mercury anomalies (0.18 and 0.14 ppm) and the third contains antimony (3 ppm) and beryllium (7 ppm) in slightly anomalous concentrations. An additional rock sample collected by the U.S. Bureau of Land Management (Davis, 1983) reportedly contains 0.45 ppm mercury and 29 ppm molybdenum. Of the two rock samples collected for this study within 1/8 mi of the sample described by Davis (1983), one has only a slightly anomalous mercury content (0.14 ppm) and the other is not geochemically anomalous. No stream-sediment samples collected in this area have geochemical anomalies, but one heavy-mineral-concentrate sample contains 50 ppm molybdenum.

In the northernmost part of the study area, a ridge top is capped by a thin layer of ash-flow tuff of the John Day Formation. The tuff locally is somewhat altered and slightly stained with iron oxides. Three rock samples of this tuff all have low-level anomalies of boron, beryllium, zirconium, yttrium, and lead. No stream-sediment samples collected in this area have geochemical anomalies. Ash-flow tuffs are frequently enriched in these elements, so, although the concentrations in the tuff are greater than the surrounding andesites, the values are not actually anomalous. However, one sample does contain 24 ppm arsenic and 100 ppm cobalt, concentrations that are anomalous. This may indicate that this tuff has been affected by some minor hydrothermal alteration or remobilization of these elements within the tuff. The tuff and nearby andesites and stream sediments were analyzed for fluorine and uranium, elements diagnostic of volcanogenic uranium/beryllium deposits of the Spor Mountain type (Lindsey, 1982; Cox, 1983); these analyses indicate low, background concentrations (1.1 ppm or less uranium and 0.01 percent or less fluorine). These data contradict the airborne radiometric survey mentioned below under "Geophysical Studies" that indicated a uranium anomaly in this area (High Life Helicopters, Inc./QEB, Inc., 1981).

In the western one-third of the study area, four of nine rock samples collected from andesite flows of the Clarno Formation contain somewhat anomalous concentrations of chromium, nickel, and vanadium. However, no stream-sediment samples collected in this area have geochemical anomalies. These elements are concentrated in mafic minerals and oxide minerals, which may be more abundant than average in these andesites. The anomalies are most likely unrelated to alteration or mineral-deposit-forming processes because chromium and nickel deposits are only known to occur in ultramafic rocks.

## Geophysical Studies

Magnetic, gravity, and radiometric data from north-central Oregon were compiled and examined in order to aid assessment of the mineral resource potential of the Spring

Basin Wilderness Study Area. The sparsely distributed flightlines and ground stations do not permit assessment of mineral resource potential at deposit scales except in limited areas directly beneath detailed profiles. The data are adequate to address the regional structural and tectonic setting of the study area.

#### Magnetic Data

The only publicly available aeromagnetic data within the study area were compiled under contract to the U.S. Department of Energy as part of the National Uranium Resource Evaluation (NURE) program (High Life Helicopters, Inc./QEB, Inc., 1981). These data were measured approximately 400 ft above average terrain along east-west flightlines spaced approximately 3 mi apart and along north-south flightlines spaced approximately 12 mi apart. Only three NURE flightlines actually crossed the study area. Two of these were directed approximately east-west at lat 44° 51' 00" N. and 44° 53' 30" N.; the third was directed north-south at long 120° 23' 00" W. The magnetic data from the northern east-west profile were unusable, apparently because of magnetometer malfunction.

Magnetic anomalies within the study area are characterized by short wavelengths (800 to 4,000 ft), high amplitudes (400 nanoteslas (nT) peak to trough), and high horizontal gradients (0.1 to 1 nT per ft). Relatively unmetamorphosed volcanic rocks, such as the andesitic lava flows and volcanoclastic deposits of the Clarno Formation, commonly have high magnetic susceptibilities and high remnant magnetizations. In low-level aeromagnetic profiles, these volcanic rocks typically cause high-amplitude, short-wavelength magnetic anomalies that commonly obscure anomalies caused by deeper magnetic sources. Some of the individual highs and lows along the magnetic profiles may indicate mineralized areas, but more likely they result from lateral variations in the abundance and characteristics of magnetite grains in shallow andesitic and basaltic rocks.

#### Gravity Studies

Gravity data from the vicinity of Spring Basin Wilderness Study Area were obtained from the National Geophysical Data Center, National Oceanic and Atmospheric Administration, Boulder, Colorado. Closely spaced (approximately 0.5 mi) measurements are available along Pine Creek just north of the study area. Elsewhere measurements are scattered at 3- to 6-mi spacing in this region. No measurements are available from within the study area. The observed gravity data, based on the International Gravity Standardization Net datum (Morelli, 1974), were reduced to free-air anomalies by using standard formulas (Telford and others, 1976). Bouguer, curvature, and terrain corrections (out to a distance of 100 mi from each station) at a standard reduction density of 2.67 g/cm<sup>3</sup> were added to

the free-air anomaly at each station to determine complete Bouguer gravity anomalies.

Bouguer anomalies typically reflect shallow density contrasts of interest to resource appraisals, but also include contributions from deep-crustal masses that correlate with topography in a manner consistent with the concept of isostasy. To reduce the effect of deep sources related to isostasy, an isostatic residual-gravity map was constructed from the Bouguer gravity data. Isostatic residual-gravity data were generated by removing a regional gravity field from the Bouguer gravity data. The regional field was computed from a model of the crust-mantle interface that assumes Airy-type isostatic compensation (Jachens and Griscom, 1985). A regional gravity perspective of the setting of the area can be seen on Jachens and others (1985).

The sparse distribution of gravity measurements precludes a detailed analysis of mass distributions within or adjacent to the study area but is sufficient to illuminate the regional tectonic and structural setting of the area. The Spring Basin Wilderness Study Area lies at the southeastern edge of a positive isostatic residual anomaly. The anomaly is 20 milligal (mGal) higher than surrounding areas and has lateral dimensions of approximately 15 mi east-west and 36 mi north-south. A method to locate edges of mass concentrations from gravity data (Blakely and Simpson, 1986) was applied to this anomaly. Results indicate that the study area straddles the southeastern edge of this buried mass.

The positive anomaly forms part of a chain of anomalies and gradients that trend northeast through northern Oregon. Northeast of the study area, the chain of anomalies is coincident with pre-Cenozoic rocks of the Blue Mountain anticline (Walker, 1977). Riddihough and others (1986) noted that this lineament is on strike with similar gravity features in the Klamath Mountains and have suggested that it reflects a pre-Tertiary continental boundary extending across this part of Oregon and Washington. The continuation of this chain of anomalies to the study area suggests that the study area is underlain by similar pre-Cenozoic rocks at shallow depth. The Mesozoic sedimentary rocks encountered in drill holes to the north of the study area provide geologic confirmation of this hypothesis.

#### Radiometric Data

Radiometric data were collected as part of the NURE airborne survey discussed earlier (High Life Helicopters, Inc./QEB, Inc., 1981). Recordings were made of gamma-ray flux from radioactive isotopes of potassium, thorium, and uranium. Flightlines were approximately 400 ft above average terrain and were flown along east-west flightlines spaced approximately 3 mi apart and along north-south flightlines spaced 12 mi apart. Only three flightlines cross

the study area. A "uranium anomaly" was detected within the study area along the north-south profile over the area where ash-flow tuff of the John Day Formation caps a ridge. The definition of a uranium anomaly is described in detail by High Life Helicopters, Inc./QEB, Inc. (1981). In summary, anomalous amounts of uranium are expected if uranium radiation, thorium radiation, and the ratio of uranium to thorium radiation all exceed specific statistical thresholds. One measurement within the uranium anomaly showed equivalent uranium radiation four standard deviations above the mean level. Geochemical samples collected from within this area did not contain anomalous quantities of uranium, however.

No other anomalous radiation was detected within the study area. However, because only three flightlines cross the study area and because gamma rays are strongly attenuated by passage through earth materials, the data do not preclude the presence of anomalous amounts of radioactive elements away from the flightlines or buried a few feet or more beneath the ground surface.

## Conclusions

The short-wavelength, high-amplitude magnetic anomalies observed in low-altitude profiles over the study area are typical for this region. They are caused principally by lateral variations in abundance and characteristics of magnetite in the unmetamorphosed volcanic rocks exposed throughout the area. Gravity data neither indicate nor preclude the presence of mineralization in this area.

Radiometric data indicate anomalous amounts of uranium radiation within the study area along the 120° 23' W. meridian. This uranium anomaly is based on criteria described by High Life Helicopters, Inc./QEB, Inc., (1981). The uranium anomaly may indicate the presence of radiometric mineral accumulations, but it should be noted that other explanations such as meteorologic effects are possible.

## Mineral and Energy Resource Potential of the Spring Basin Wilderness Study Area

### Mineral Resource Potential

Investigations by the U.S. Geological Survey indicate that the easternmost part of the Spring Basin Wilderness Study Area has low mineral resource potential, certainty level C, for silver and gold in epithermal vein deposits. In addition, the same easternmost area has a low mineral resource potential, certainty level C, for mercury in epithermal deposits. Near the center of the study area, a small area also has low mineral resource potential, certainty level C, for mercury in epithermal deposits. The northern part of the study area has no mineral resource potential, certainty

level D, for uranium in volcanogenic deposits. (See appendixes for definitions of levels of mineral resource potential and certainty of assessment.)

In the easternmost part of the study area, the altered dacite dome and surrounding area has low mineral resource potential for silver, gold, and mercury. The geologic setting of the area of potential is similar to that of the mines and prospects in the Ashwood/Horse Heaven mining district, located between 10 and 15 mi to the west southwest. The mines and geology of the district are discussed by Libbey and Corcoran (1962), Brooks (1963), Peck (1964), and Brooks and Ramp (1968). Two types of mineral deposits, Comstock-type epithermal veins and epithermal mercury deposits, occur in the district in or near andesite-to-rhyolite domes and plugs that intrude andesites and volcanic breccias of the Clarno Formation. The Ashwood mine exploited an epithermal vein deposit localized along a fault zone in the Clarno Formation. A description of this deposit in Libbey and Corcoran (1962) corresponds with the Comstock epithermal vein deposit model of Mosier and others (1986). This deposit type is mined for silver and gold and may produce minor quantities of copper, lead, and zinc as by-products. The Ashwood mine produced approximately 300,000 troy oz silver, 3,700 troy oz gold, 59,000 lbs copper, and 110,000 lbs lead between 1899 and 1964 (Brooks and Ramp, 1968). Igneous plugs are found in the immediate area of the Ashwood mine, but it is not known if the plugs and this deposit are related. However, the Horse Heaven mine and the other mercury mines and prospects in the district are almost all hosted by or immediately adjacent to altered plugs of biotite rhyolite. The Horse Heaven mine, the largest mercury producer in the district, produced 17,214 flasks of mercury between 1934 and 1958 (Brooks, 1963).

Low-level geochemical anomalies in rock and stream-sediment samples are present near the altered dacite dome. Although parts of the dome have been bleached, altered, or silicified, no direct evidence of ore mineralization was observed. However, the presence of low-level mercury anomalies, along with arsenic, antimony, and molybdenum anomalies, near an altered dome indicates low potential in this area for a mercury deposit similar to the Horse Heaven deposit. The same geochemical anomalies, in conjunction with the low-level gold anomalies, could also be faint indicators of a precious- and base-metal deposit similar to that at the Ashwood mine, hence the low potential for this type of deposit. Since the Ashwood deposit may not be dome- or plug-related, the proximity of the anomalies to the plug here may not be of importance in determining the potential for this type of deposit. Because of the intimate dome and mercury-deposit relation in the region, the existence of a mercury deposit is considered more likely than that of a precious- and base-metal deposit. It is important to note as well that volcanic domes and plugs are very common in this region (Brooks, 1963; Brooks and Ramp,

1968), but that mineral deposits are only known to occur at a few.

A small area in the central part of the study area also has low potential for mercury in epithermal deposits. This potential is assigned solely on the basis of low-level mercury, antimony, and molybdenum anomalies in some of the rock and heavy-mineral-concentrate samples collected within the area. No evidence of hydrothermal alteration or mineralization was found within this area. If such alteration or mineralization is present, it is likely to be localized along the fault or fault zone in Hay Bottom Canyon.

The ridge in the north part of the study area that is capped by ash-flow tuff of the John Day Formation has no mineral resource potential for volcanogenic uranium. The NURE flightline that crosses this area gave radiometric data that were interpreted as a uranium anomaly (High Life Helicopters, Inc./QEB, Inc., 1981), but analyses of the tuff and stream sediments within the area indicate only low, background concentrations of uranium and related indicator elements. Additionally, the geological setting is not favorable for volcanogenic uranium. Volcanogenic uranium deposits are closely associated with ring-fractures, shallow intrusive rocks, and domes related to calderas (Rytuba and Glanzman, 1979; Lindsey, 1982; Cox, 1983). No calderas are known to exist in or near the study area.

Small deposits of sand and gravel suitable for construction are present in the study area but are too small to constitute a resource. No undiscovered sand and gravel resources are likely to be found beyond known deposits. The volcanic rocks that underlie the study area could be used for construction blocks and rubble, but suitable material is available throughout Oregon in areas of better access.

### Energy Resource Potential

Investigations by the U.S. Geological Survey indicate that the Spring Basin Wilderness Study Area has low resource potential for oil and natural gas, certainty level B. The study area has no geothermal resource potential, certainty level D.

Central Oregon has been explored for oil since the late 1920's, but no economic discoveries of oil or gas have been made (Thompson and others, 1984). Exploration efforts and petroleum resource appraisals are hampered by the meager data available on subsurface geology in central Oregon (Thompson and others, 1984; Fritts and Fisk, 1985a, b). Few deep wells have been drilled, outcrops of pre-Cenozoic rocks are rare, and thick Cenozoic volcanic cover causes difficulty in the interpretation of geophysical data (Newton, 1974). Additionally, the region is structurally complex and has Cenozoic structures that differ from underlying Mesozoic structures. Little is known about pre-Mesozoic structures.

The primary petroleum exploration targets in central Oregon have been within two Cretaceous basins (Newton,

1968; Fritts and Fisk, 1985a, b). The larger and older of the basins is the Columbia River Basin of mid- to Late Cretaceous age (Newton, 1966, 1977; Fritts and Fisk, 1985a, b). The study area is in the western part of this basin (Fritts and Fisk, 1985a, b). The smaller and slightly younger (latest Cretaceous) Ochoco Basin lies to the south and probably does not extend as far north as the study area (Thompson and others, 1984).

Oil and gas leases cover approximately 23 percent of the study area. Three deep test holes were drilled near the study area between 1929 and 1957, two near Clarno (3 to 4 mi to the northwest; fig. 1) and one near Condon (26 mi to the northeast). Of the two wells near Clarno, the most detailed analysis available is on the Oregon Petroleum Company's Clarno No. 1. The hole was drilled in 1957 to a total depth of 4,340 ft, passing through volcanic tuffs and minor interbeds of shale and argillite of the John Day and (or) Clarno Formations (0-3,280 ft) and into pre-Tertiary shales and argillites (3,280-4,340 ft). Some graywacke was present toward the bottom of the hole. No oil or gas shows were reported from this hole. The other hole near Clarno, the Clarno Basin Oil Company's Burgess No. 2, had a gas show, presumably from Cretaceous rocks. Asphalt-bearing geodes have also been found near Clarno (Collier, 1914; Buwalda, 1921). Well logs and other records for all holes are on file at the Oregon Department of Geology and Mineral Industries in Portland, Oregon.

Brown and Ruth Laboratories, Inc. (1983a) conducted a detailed geochemical survey of the Clarno No. 1 hole to determine source-rock potential of the formations encountered. The results indicate low source-rock potential on the basis of low kerogen contents (kerogen is the organic precursor to oil and gas) and low hydrogen indexes, despite average to locally high total organic carbon contents (TOC). From visual analysis and comparison of hydrogen indexes to oxygen indexes, the kerogen in the rocks was determined to be type III, indicating a definite terrestrial kerogen source. This means that if these rocks produced any hydrocarbons, the products would be in the form of natural gas. Thermal maturation data from the hole are unusual, showing that rocks are thermally immature at 1,000 ft, increasing to moderately mature at 2,500 ft. However, thermal maturation increases abruptly at approximately the 2,500 ft depth, and rocks below this level are post-mature. Brown and Ruth Laboratories, Inc. (1983a) suggests that the 2,500-ft depth marks the Cretaceous-Tertiary boundary, inferring that the sharp change in thermal maturity indicates that a thermal event occurred before deposition of the Tertiary rocks. Sharp increases in thermal maturity could also be due to either heat from local intrusions (Fox and Reidel, 1987) or heat from geothermal systems (Summer and Verosub, 1987a).

Fritts and Fisk (1985a, b) and Fisk (written commun., 1987) propose the existence in central Oregon of organic-rich Tertiary rocks (Herren unit) that overlie the Mesozoic

rocks and underlie the Tertiary Clarno Formation. Lithologic descriptions of the Clarno No. 1 hole give little indication of such a formation, but the mention of minor tuffaceous sandstone and the slight increase in kerogen content (S2) and hydrogen index between depths of 2,200 and 2,500 ft may be slim evidence of such a formation. However, geochemical analyses from this section of the hole (Brown and Ruth Laboratories, Inc., 1983a) indicate only marginally better source-rock potential for these rocks.

The other well-studied and documented hole in the region is Standard Oil Company's Kirkpatrick No. 1, 26 mi northeast of the study area. From the surface, this hole penetrated the Columbia River Basalt Group (0–2,440 ft) then passed through volcanic and sedimentary rocks of the John Day and (or) Clarno Formations (2,440–6,135 ft). These rocks have no source-rock potential in this hole. The interval from 6,695 ft to the bottom of the hole at 8,726 ft was through Mesozoic sedimentary rocks, primarily argillite but including some graywacke and siltstone (Fox and Reidel, 1987). Although the Mesozoic sedimentary rocks are thermally mature (Newton, 1979; Summer and Verosub, 1987b), the total organic content of these rocks is low to very low (Brown and Ruth Laboratories, 1983b; Fox and Reidel, 1987). Most of the organic material present is of terrestrial origin and is hydrogen poor and gas prone (Brown and Ruth Laboratories, 1983b).

For purposes of an oil and gas resource potential assessment, it is assumed that the subsurface stratigraphy of the wilderness study area is similar to that in the Oregon Petroleum Company's Clarno No. 1 hole. The study area does lie within the Cretaceous Columbia River Basin. The Mesozoic rocks are primarily argillite but include some graywacke and siltstone, lithologies usually having low porosity, thereby limiting their potential as reservoir rocks. Geochemistry indicates their lack of potential as source rocks. The Mesozoic rocks have been determined to be thermally post-mature.

Tertiary rocks encountered in the hole are also unlikely to be either good source or reservoir rocks. Most of the Tertiary section is composed of volcanic tuffs, which have no potential as source rocks. The volcanoclastic and sedimentary rocks within the section have low total organic contents, are mostly thermally immature, and are gas prone. Suitable reservoir rocks are also unlikely to occur beneath the study area. In rare instances, volcanic tuffs are known to form reservoir rocks (Bortz and Murray, 1979; Duey, 1979), but the poorly sorted volcanoclastic rocks are unlikely reservoir rocks. The sparsely distributed sedimentary rocks are primarily shale and argillite, rocks that usually have poor porosity and are therefore not good reservoir rocks. Clarno-age magmatism may have produced intense local heating, thereby degrading or driving off nearby hydrocarbons from both Tertiary and pre-Tertiary rocks.

Fouch (1983) rated the study area as having low potential for oil and gas. Fox and Reidel (1987) considered the

area around the Standard Kirkpatrick No. 1 well to have "marginal hydrocarbon potential." However, Davis (1983) considered the study area to have moderate potential for hydrocarbons. Given the lack of both suitable source and reservoir rocks in drill holes and the possible local overheating, the likelihood of the occurrence of oil and gas in the study area is small, and so, under the definitions used in this study, the area is given a low resource potential for oil and gas. A certainty level of B is assigned because of the absence of any subsurface data, either seismic or drill hole, from within the study area. The stratigraphy in the nearest drill holes may differ from that of the study area, and more favorable source and reservoir rocks could exist beneath the study area. The lack of available seismic data precludes any knowledge of pre-Clarno structure or potential traps beneath the study area.

The study area has no resource potential for geothermal energy, certainty level D. The study area contains no hot springs or warm springs (Bliss, 1983), and previous regional geothermal surveys have not indicated any geothermal resource potential for the area (Bowen and others, 1978; Riccio, 1978; Muffler, 1979; National Geophysical Data Center, 1982; Reed, 1983; Bliss, 1983).

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## APPENDIXES

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# 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
LEVEL OF RESOURCE POTENTIAL ↑	UNKNOWN POTENTIAL	U/A	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
		M/B MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/D MODERATE POTENTIAL	
		L/B LOW POTENTIAL	L/C LOW POTENTIAL	L/D LOW POTENTIAL	
				N/D NO POTENTIAL	
		LEVEL OF CERTAINTY →			

Abstracted with minor modifications from:

Taylor, R.B., and Steven, T.A., 1983, Definition of mineral resource potential: *Economic Geology*, v. 78, no. 6, p. 1268-1270.  
 Taylor, R.B., Stoneman, R.J., and Marsh, S.P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40-42.  
 Goudarzi, G.H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84-0787, p. 7, 8.

## RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES		UNDISCOVERED RESOURCES	
	Demonstrated		Probability Range	
	Measured	Indicated	Inferred	
			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	205
				Middle	
				Early	~240
		Triassic		Late	
	Paleozoic	Permian		Late	290
				Early	
		Carboniferous Periods	Pennsylvanian	Late	~330
				Middle	
			Mississippian	Late	360
				Early	
		Devonian		Late	410
		Middle			
		Early	435		
Silurian		Late			
		Middle	500		
		Early			
Ordovician		Late	500		
		Middle			
		Early	500		
Cambrian		Late			
		Middle	500		
		Early			
Proterozoic	Late Proterozoic			<sup>1</sup> ~570	
	Middle Proterozoic			900	
	Early Proterozoic			1600	
Archean	Late Archean			2500	
	Middle Archean			3000	
	Early Archean			3400	
pre-Archean <sup>2</sup>		(3800?)			
				4550	

<sup>1</sup>Rocks older than 570 Ma also called Precambrian, a time term without specific rank.

<sup>2</sup>Informal time term without specific rank.

# Mineral Resources of Wilderness Study Areas: John Day Region, Oregon

This volume was published as separate chapters A–C

DEPARTMENT OF THE INTERIOR  
DONALD PAUL HODEL, Secretary

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



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[Letters designate the separately published chapters]

- (A) Mineral Resources of the Lower John Day and Thirtymile Wilderness Study Areas, Sherman and Gilliam Counties, Oregon, by Jay A. Ach, Scott A. Minor, James G. Frisken, Richard J. Blakely, Harry W. Campbell, and Edward L. McHugh.
- (B) Mineral Resources of the North Pole Ridge Wilderness Study Area, Sherman and Gilliam Counties, Oregon, by Scott A. Minor, Jay A. Ach, James G. Frisken, Richard J. Blakely, and Harry W. Campbell.
- (C) Mineral Resources of the Spring Basin Wilderness Study Area, Wheeler County, Oregon, by Jay A. Ach, Scott A. Minor, James G. Frisken, Richard J. Blakely, Richard A. Winters, and Thomas J. Peters.







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