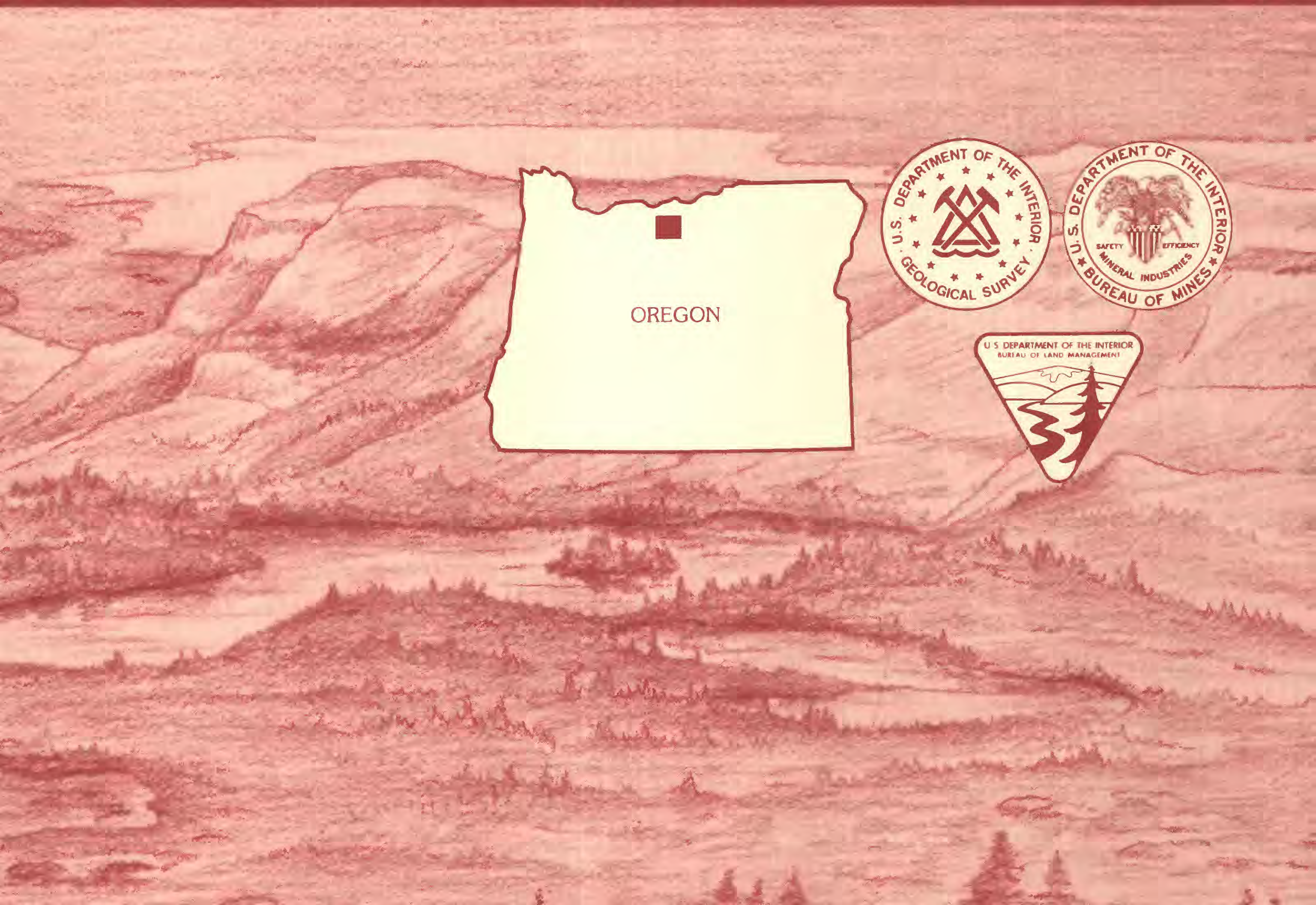
Mineral Resources of the Lower John Day and Thirtymile Wilderness Study Areas, Sherman and Gilliam Counties, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1743–A



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Chapter 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,
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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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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 parts of the Lower John Day (OR–005–006) and Thirtymile (OR–005–001) Wilderness Study Areas, Sherman and Gilliam Counties, Oregon.

CONTENTS

FIGURES

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, *and* Richard J. Blakely
U.S. Geological Survey

Harry W. Campbell *and* Edward L. McHugh
U.S. Bureau of Mines

SUMMARY

Abstract

At the request of the U.S. Bureau of Land Management, approximately 25,163 acres of the Lower John Day (OR–005–006) and Thirtymile (OR–005–001) Wilderness Study Areas (17,831 and 7,332 acres, respectively) in north-central Oregon were evaluated for identified mineral resources (known) and mineral resource potential (undiscovered). In this report, "wilderness study areas" and "study areas" refer to the 25,163 acres for which mineral surveys were requested. Fieldwork for this report was carried out in 1985 and 1986. No mines or mining districts are located inside the study areas; however, both areas are under lease for oil and gas. The Thirtymile Wilderness Study Area has 790,000 cubic yards of subeconomic gold resources averaging 0.003 troy ounces per cubic yard in two river bars along the John Day River. The Lower John Day Wilderness Study Area has five river bars that have gold occurrences. The Lower John Day and the Thirtymile Wilderness Study Areas both have a low mineral resource potential for placer gold in the canyon of the John Day River. In addition, part of the Thirtymile Wilderness Study Area has a low mineral resource potential for gold and (or) mercury in hydrothermal deposits. Both study areas have a low resource potential for oil and gas and no potential for geothermal energy resources.

Character and Setting

The Lower John Day and Thirtymile Wildernesss Study Areas are located in north-central Oregon about 40 mi southeast of The Dalles and about 15 mi west of Condon (fig. 1). Within the study areas, the gently rolling hills of the region are deeply incised by the steep, 1,800-ft-deep canyon of the John Day River.

Basalt flows of the Columbia River Basalt Group cover the entire area studied. A drill hole to the east indicates that the basalt is at least 2,000 ft thick and that it overlies rocks of the John Day Formation. Entrenched meanders and perched alluvium were left along canyon walls by the John Day River as it cut into the surrounding terrain.

Identified Resources

Deposits of alluvium along the John Day River in the study areas contain placer gold. The Thirtymile Wilderness Study Area has 790,000 yd^3 of inferred subeconomic gold resources averaging 0.003 troy ounces per cubic yard (oz/yd^3) in two river bar deposits. No mineral resources were identified in the Lower John Day Wilderness Study Area; however, five river bars in the study area have gold occurrences totaling 1.0 million yd^3 averaging 0.0004 troy oz/yd^3 gold.

Stone, sand, and gravel from the study areas could be quarried and used for construction purposes; however, suitable material is common elsewhere in the region and more accessible to possible markets.

Mineral Resource Potential of the Lower John Day Wilderness Study Area

The Lower John Day Wilderness Study Area has low mineral resource potential for placer gold in alluvium occurring in scattered small river bars in the canyon of the John Day River. This potential is indicated by anomalously high gold concentrations in stream-sediment samples.

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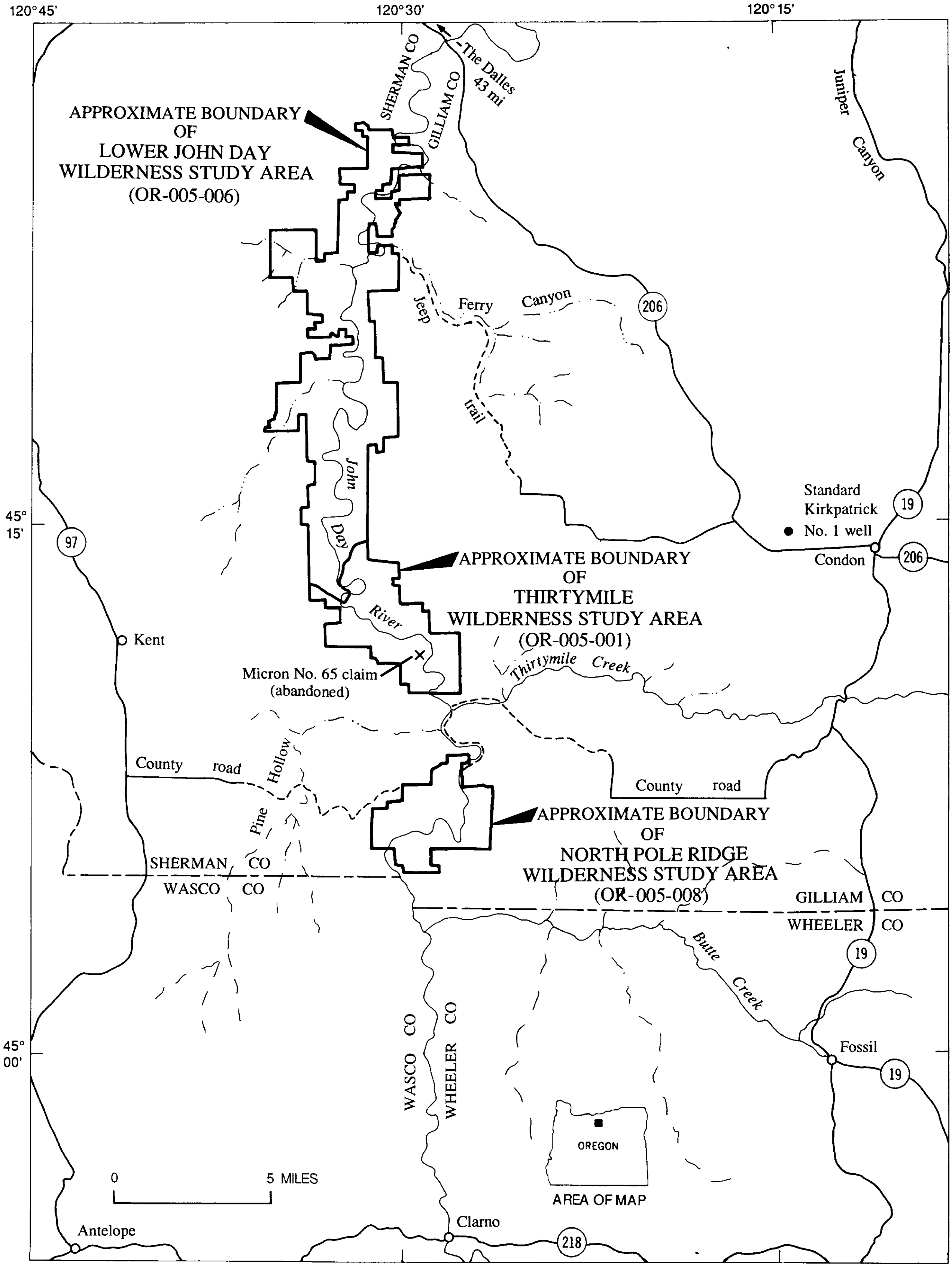

Figure 1. Index map showing location of the Lower John Day and Thirtymile Wilderness Study Areas, Sherman and Gilliam Counties, Oregon. See Minor and others (1988) for discussion of the mineral resource potential of North Pole Ridge Wilderness Study Area.

The study area also has low potential for oil and natural gas. Dry holes are located about 14 mi east and 22 mi south of the study area. Well logs and various studies indicate that suitable source and reservoir rocks are not present at these drill sites. However, the existence 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 potential exists for geothermal energy in the study area.

Mineral Resource Potential of the Thirtymile Wilderness Study Area

In the Thirtymile Wilderness Study Area, a low mineral resource potential exists for placer gold in scattered, small deposits of alluvium in the John Day River canyon. This potential is indicated by anomalously high gold concentrations in stream-sediment samples. The southern part of the study area also has low potential for gold and (or) mercury in epithermal deposits. This potential is based on a low-level gold and mercury anomaly in a single rock sample.

The study area has low potential for oil and natural gas. The dry holes mentioned above are located about 14 and 18 mi from the study area. Potential source and reservoir rocks are likely to be of poor quality. No favorable reservoir structures are known in the study area.

No potential exists for geothermal energy resources in the study area.

INTRODUCTION

This mineral resource study is a joint effort by the U.S. Geological Survey and the U.S. Bureau of Mines. Mineral assessment methods and terminology are discussed in Goudarzi (1984). 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). See the appendixes for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification. Studies by the U.S. Geological Survey are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geological units and structures, possible environments of mineral deposition, presence of geophysical and geochemical anomalies, and applicable ore-deposit models. 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.

Area Description

The U.S. Bureau of Land Management requested that a total of 25,163 acres of the Lower John Day (OR–005–006) and Thirtymile (OR–005–001) Wilderness Study Areas, 17,831 and 7,332 acres, respectively, be evaluated for mineral resources and resource potential. The study areas are about 40 mi southeast of The Dalles and about 15 mi west of Condon, in north-central Oregon (fig. 1). The topography of the areas is dominated by the precipitous canyon of the John Day River, which has cut approximately 1,800 ft below the surrounding topography. Elevations range from approximately 600 ft at the canyon bottom in the north end to approximately 2,600 ft at the canyon rim in the south end of the study areas. 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). The vegetation in the canyon consists mainly of range grasses, sagebrush, and juniper trees.

The best access to the study areas is from the John Day River via raft or canoe. In a few places, the canyon rim is accessible by graded dirt and gravel roads and jeep trails leading from Oregon Highways 97 and 206.

Previous and Present Investigations

Swanson and others (1979, 1981) included the study areas in regional geologic mapping of the Columbia River Basalt Group. The areas are also included in regional mapping by Bela (1982).

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). The uranium resource potential for the region 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 carried out field investigations in the study areas during the summers of 1985 and 1986. This work included geologic mapping and geochemical sampling. An analysis was made of available geophysical data.

The U.S. Bureau of Mines conducted a library search for information on mines and prospects within the study areas. Additional data were obtained from U.S. Bureau of Land Management mining claim records, from Sherman and Gilliam Counties mining claim records, and from the U.S. Bureau of Mines Mineral Industry Location System. Field studies by U.S. Bureau of Mines personnel were carried out in 1986 (Campbell and McHugh, 1987). Rock samples were checked for radioactivity and fluorescence. The rock samples were also analyzed for gold by combined

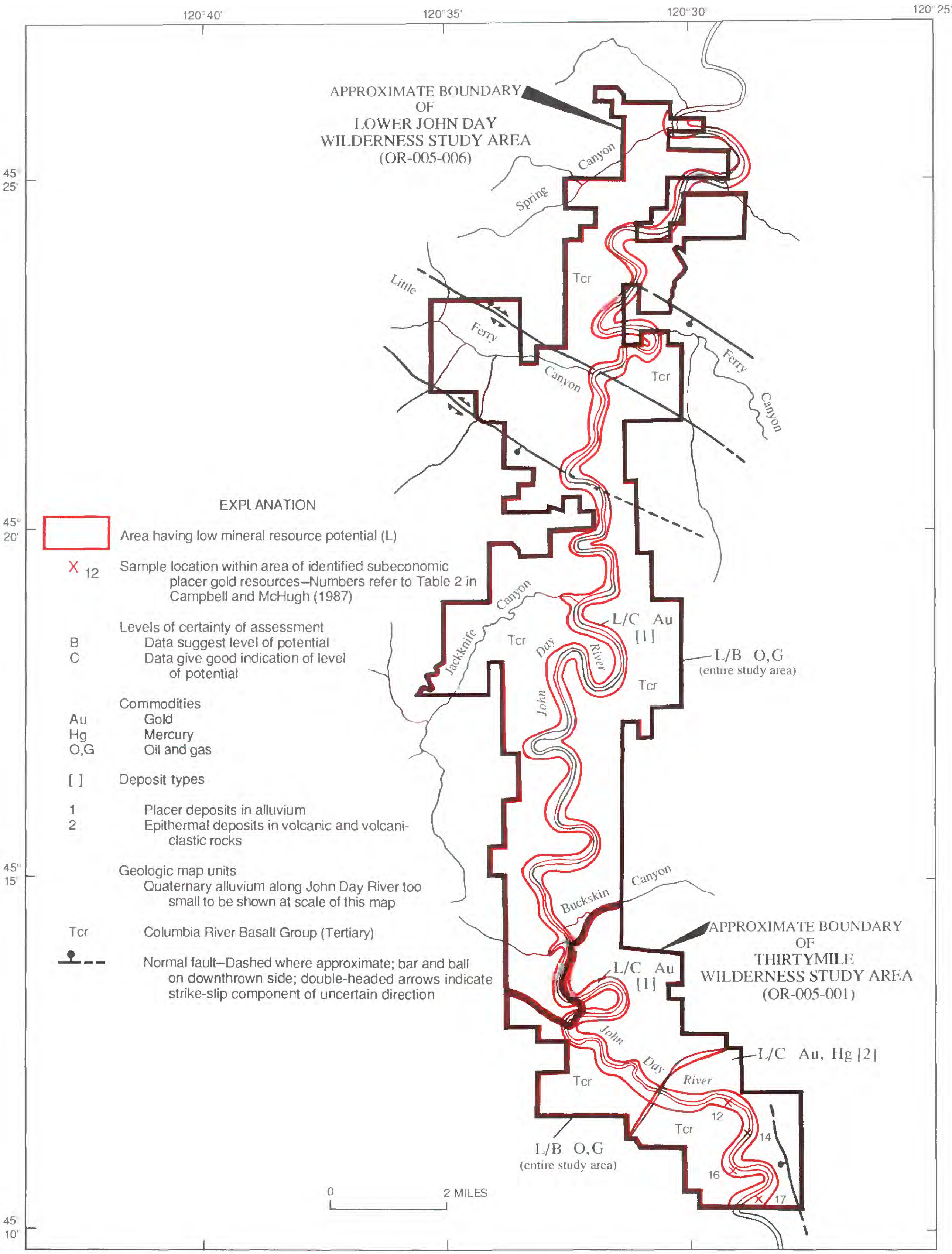

Figure 2. Mineral resource potential and geology of the Lower John Day and Thirtymile Wilderness Study Areas, Sherman and Gilliam Counties, Oregon.

fire assay and atomic-absorption analysis and for a variety of elements by inductively coupled plasma methods. 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, for providing access information and maps of the study areas. 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 Harry W. Campbell *and* Edward L. McHugh
U.S. Bureau of Mines

Mining History

No evidence of mining activity was found in or near the Lower John Day or Thirtymile Wilderness Study Areas. One abandoned mining claim (Micron No. 65, fig. 1) was located in the Thirtymile Wilderness Study Area in 1983; 11 other claims in the Micron group were located at the same time about 5 mi to the south in the North Pole Ridge Wilderness Study Area following a report of geochemically anomalous concentrations of gold, silver, and zinc in rock chip samples from the area (Davis, 1983). The nearest historical claim was located for placer gold in 1906 along the John Day River, about 16 mi north of the study areas.

The lower part of the John Day River has had little mining-related activity. Gold placers were worked in the upper John Day River basin in the 1850's, centered near Canyon City, 85 mi southeast of the study areas. Records are incomplete, but earliest reported production was in 1852 (Brooks and Ramp, 1968). By 1864, placer gold was being mined in the Spanish Gulch mining district, on a tributary of the John Day River, 60 mi southeast of the study areas. Gold and silver were also found in quartz veins and silicified zones in the district.

Other metals have been mined south of the study areas from mineralized zones in Eocene and earliest Oligocene(?) volcanic and volcaniclastic rocks of the Clarno formation. The Ashwood mining district, about 30 mi southwest of the study areas, produced silver, gold, copper, and lead valued at the time at more than $530,000, mainly from the Oregon King mine, between 1899 and 1965. The Horse Heaven mine, about 30 mi south of the study areas, produced 17,216 flasks of mercury between 1934 and 1958, when the deposit was mined out (Brooks, 1971).

Petroleum leases cover the study areas and the surrounding region. Three wells were drilled near Clarno between 1929 and 1957 (Davis, 1983); one had a gas show, but none contained oil or commercial quantities of gas. An additional dry hole (Standard Kirkpatrick No. 1) was drilled near Condon in 1957 to a depth of 8,726 ft.

Sand, gravel, and stone have been quarried from at least 13 sites along State and Federal highways between 6 and 30 mi from the study areas. Most is used as fill or as a base or topping for roads. Sites are reopened or new sites are developed as needs arise. Supplies of stone, sand, and gravel outside the study areas are more accessible and are ample to supply regional demand.

Appraisal of Mineral Resources

Although no evidence of mining activity was found, production of both placer and lode gold in upper parts of the John Day River basin and small-scale placer mining along the Columbia River suggest that gold may be present in fluvial gravels within the study areas. Preliminary sampling of seven gravel bars confirmed the presence of gold (Campbell and McHugh, 1987).

Five gravel bars in the Lower John Day Wilderness Study Area were sampled for placer gold. Each of the 10 samples collected contains tiny flakes of gold less than 0.008 in. across. Estimated average gold content for individual bars ranges from 0.00004 to 0.0007 troy oz/yd^3. Estimated gravel volumes ranged from 150,000 to 260,00 yd^3. Total gravel volume in the five bars is estimated at 1.0 million yd^3 and averages 0.0004 troy oz/yd^3 gold ($0.17/yd^3 at a gold price of $400/ troy oz).

Two gravel bars in the southern part of the Thirtymile Wilderness Study Area contain an estimated 790,000 yd^3 of inferred subeconomic resources averaging 0.003 troy oz/yd^3 gold ($1.20/yd^3) (fig. 2). Samples from these bars contain considerably more gold than those from gravel in the Lower John Day Wilderness Study Area. Because of the reconnaissance nature of the alluvial samples, the significance of this apparent difference in gold content of bars between the two study areas is unknown. However, backflooding up the John Day River from the catastrophic Lake Missoula and Lake Bonneville floods may have affected the distribution of gold in river sediments.

Volumes were estimated for 21 other gravel bars in the Lower John Day Wilderness Study Area (4.8 million yd^3) and 9 other bars in the Thirtymile Wilderness Study Area (1.7 million yd^3). Results from the sampled sites suggest an overall gold content of 0.0016 troy oz/yd^3 (or $0.64/yd^3) for gravel in the study areas.

Alluvium samples were collected for reconnaissance purposes during this study, so only preliminary estimates of volume and grade could be made. The bar with the highest estimated grade contains about $1.41/yd^3 at a gold price of $400/troy oz. For this bar, mining operations would approach feasibility with gold contents of approximately $3.80/yd^3 (Campbell and McHugh, 1987). The estimated grade would be valued at $3.80/yd^3 if gold increased in value to $1080/troy oz. For other gravel bars within the study areas, mining costs would be somewhat higher due to more difficult access.

Lode samples of basalt taken from an abandoned mining claim and from an area with anomalous metal concentrations, as reported by Davis (1983), contain no metal concentrations of economic significance.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

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

Geology

The Lower John Day and Thirtymile Wilderness Study Areas are located in the southern part of the Columbia Plateau physiographic province, which is characterized by an extensive sequence of gently north-tilted Miocene basalt flows of the Columbia River Basalt Group (Swanson and others, 1981; Walker, 1977). Less than 100 mi southeast of the study area, the Columbia Plateau terminates against the Blue Mountains, an uplifted block containing Mesozoic volcanic-arc basement rocks (Brooks and Vallier, 1978). The active Cascades volcanic arc bounds the southwest side of the province about 50 mi west of the study area. South of the study area, flows of the Columbia River Basalt Group are primarily underlain by Eocene and Oligocene volcanic and volcaniclastic rocks that, in turn, overlie Mesozoic marine sedimentary rocks. The Columbia River Basalt Group in the region was locally folded and faulted, primarily during the Miocene and Pliocene.

Only basalt flows of the Columbia River Basalt Group (Swanson and others, 1981) are exposed in the study areas (fig. 2). However, older rocks are exposed upriver to the south. The oldest rocks exposed nearby in the region are those of the Eocene and earliest Oligocene(?) Clarno Formation (Merriam, 1901a; G.W. Walker, oral commun., 1987), which crop out approximately 20 mi south of the study areas. The Clarno Formation consists predominantly of interfingering andesite flows, domes, plugs, and breccias and associated volcaniclastic and tuffaceous rocks.

The John Day Formation (Merriam, 1901b) unconformably overlies the Clarno Formation and is exposed in the John Day River canyon 7 mi south of the study areas (Swanson, 1969; Robinson, 1975; Swanson and others, 1981). The age of the John Day Formation ranges from about 37 Ma (million years before present) to about 19 Ma, latest Eocene to early Miocene (G.W. Walker, oral commun., 1987). The John Day Formation near the study areas consists of intercalated tuffs, tuffaceous sedimentary rocks, and mafic lava flows. Geologic evidence suggests that both the John Day and Clarno Formations, which have a combined thickness of several thousand feet where exposed, extend northward underneath the study areas. This is also suggested by data from the Standard Kirkpatrick No. 1 test hole (Fox and Reidel, 1987), 14 mi east of the study areas (fig. 1). The hole penetrated 2,440 ft of rocks of the Columbia River Basalt Group before it passed through 4,255 ft of John Day and possibly Clarno rocks. This also suggests that the base of the Columbia River Basalt Group may only be a few hundred feet below river level at the south end of the Thirtymile Wilderness Study Area.

Flows of the Columbia River Basalt Group form the bedrock throughout the study areas. The maximum exposed thickness of the basalts in the study areas is about 1,800 ft, equivalent to the maximum depth of the John Day River canyon. The dark-gray to black Columbia River Basalt flows typically range in thickness from 50 to 100 ft and are conspicuously columnar jointed. The upper parts of the flows are usually vesicular and readily erode into ledges, whereas the denser, more resistant middle and lower parts of the flows form prominent cliffs. Such topographic expression of the subhorizontal flows results in "stair-step" topography along the canyon walls. Interflow layers of tuffaceous rocks occur only locally in the sequence and rarely exceed 10 ft in thickness.

Swanson and others (1981) divided rocks of the Columbia River Basalt Group in the study areas into two formations following earlier stratigraphic nomenclature (Swanson and others, 1979). The oldest formation, the Grande Ronde Basalt, forms most of the bedrock within the study areas. The Grande Ronde Basalt is at least 1,400 ft thick in the study areas; its base is not exposed. The overlying Frenchman Springs Member of the Wanapum Basalt caps the rim of the John Day River canyon and thus is only locally exposed in outlying parts of the study areas. The Wanapum Basalt has a maximum exposed thickness of about 250 ft in the study areas. The Grande Ronde flows are generally aphyric, whereas many of the Wanapum flows in the study areas contain conspicuous clusters of plagioclase phenocrysts and are medium grained (Swanson and others, 1981). The Grande Ronde Basalt has potassium-argon ages ranging from 16.5 to 14 Ma (Watkins and Baksi, 1974) and stratigraphy indicates that the overlying Wanapum Basalt is older than 12 Ma (Swanson and others, 1979).

In the study areas, there is abundant geomorphic evidence of older, less entrenched channels of the John Day

River, the most obvious of which are several meander scars perched along the canyon walls as high as 500 ft above the present river level. Erosional remnants of river alluvium deposited in these older channels mantle the meander scars in some places. Active and recent alluvium in the study areas consists primarily of point-bars of sand and gravel blanketing the inside banks of the John Day River meanders. Talus aprons and cones composed of basalt debris are found at the bases of most of the large cliffs along canyon walls. On the plateau surrounding the study areas, loess, deposited by Pleistocene winds, is a major component of soils.

The area occupied by the Columbia Plateau was probably the location of a broad northeast-trending basin that developed within the Mesozoic continental margin during the Early Cretaceous. This basin subsided as sediment and volcanic material (including flows of the Columbia River Basalt Group) accumulated throughout the Tertiary, forming the Columbia Basin (Fritts and Fisk, 1985a). Uplift of the Blue Mountains, at the south end of the Columbia Plateau, began in the Eocene during deposition of the Clarno Formation and continued for the remainder of the Tertiary (Fox and Reidel, 1987). Angular unconformities separate rocks of the Clarno Formation, John Day Formation, and Columbia River Basalt Group (Swanson, 1969; Robinson, 1975), suggesting that uplift of the Blue Mountains and subsidence of the Columbia Basin continued during the Oligocene and early Miocene. Entrenchment of the meandering John Day River into its canyon and the perched meander scars in the canyon suggest that northward tilting of the southern part of the Columbia Plateau, subsidence of the central part of the plateau, or both continued intermittently into the Quaternary.

In an overall sense, flows of the Columbia River Basalt Group underlying the study areas form a gently northward-tilted (less than 5°) homocline. Some high-angle oblique-slip faults and minor normal faults cut the homocline, primarily near the northern part of the Lower John Day Wilderness Study Area (Swanson and others, 1981). The normal faults strike either northwest or north-northwest; the oblique-slip faults all strike northwest. A north-northwest-striking normal fault near the south end of the Thirtymile Wilderness Study Area forms the northernmost part of a complex, north-trending zone of deformation that extends several miles south of the study area into the North Pole Ridge Wilderness Study Area (Minor and others, 1988). Several east- to northeast-trending gentle, open folds are present in the region, particularly southeast of the study areas (Swanson and others, 1981). Some of these folds are cut by faults, subparallel to the fold axes, that appear to be genetically related to the folds.

Faulting and folding on the Columbia Plateau, which is attributed primarily to regional north-south compression, was most active between about 11 and 3 Ma (Bela, 1982). Much of the tilting and subsidence of the southern part of the plateau was approximately coeval with this deformation.

The late Pleistocene catastrophic Lake Missoula floods that cut the Channeled Scablands in central Washington also caused backflooding that flowed up the John Day River. Earlier backflooding related to the Lake Bonneville flood may also have affected the John Day River. Geomorphic evidence at the confluence of the John Day and Columbia Rivers indicates that at least one of the Lake Missoula floods overtopped landforms at an elevation of 956 ft above sea level. This backflooding carried sediments ranging from silt to cobbles(?) upstream through both study areas, and floodwaters possibly reached elevations of over 1,000 ft above sea level (Bretz, 1969).

Geochemical Studies

A reconnaissance geochemical investigation of the study areas was made using samples of rock, water from springs, 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 areas. Sampled drainage basins range in area from less than one to several square miles.

From the two study areas, 45 rock samples, 42 stream-sediment samples, and 42 heavy-mineral-concentrate samples were analyzed for 31 elements by six-step semiquantitative emission-spectrographic methods (Myers and others, 1961; Grimes and Marranzino, 1968). 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 (Thompson and others, 1968) and a graphite furnace/atomic-absorption method that has a lower detection limit of 0.002 parts per million (ppm) (Meier, 1980). Analyses for mercury by the method of Koirtyohann and Khalil (1976) and for uranium and thorium by methods described by Millard (1976) and Centanni and others (1956) were also performed. Three samples of water from springs were analyzed for uranium using a method described by Scintex Corporation (1978). Complete analytical data and a description of sampling techniques, sample preparation, and analytical methods were provided by Adrian and others (written commun., 1987).

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 any 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 either exceed by a factor of three the mean concentration in basalt samples collected from the region or exceed three times the average concentration in basalt (Levinson, 1974).

Data from stream-sediment and heavy-mineral-concentrate samples show only a few scattered, mostly single-element anomalies. Elements found in anomalous concentrations are gold, lead, tin, and bismuth. Stream-sediment and heavy-mineral-concentrate sample media from the study areas are not considered as reliable as in most other areas, the reason being contamination from older, perched alluvium and from alluvium deposited by catastrophic Lake Missoula- and Lake Bonneville-related flooding. Perched alluvium, deposited by a younger John Day River, is common at many levels within the canyon as high as 500 ft above current river level. Flooding due to catastrophic lake release may have deposited alluvium from outside present drainages in the John Day River canyon to levels of over 1,000 ft above sea level (Bretz, 1969). Present-day tributary streams that enter the John Day canyon cut through both the older alluvium and the flood-deposited alluvium. These materials may be contained in active alluvium of the streams. Loess from the surrounding plateau might also be added to the alluvium by either runoff or wind. This resulting alluvial mix therefore does not solely represent the bedrock within the sampled drainage basin. The anomalies noted in stream-sediment and heavy-mineral-concentrate samples are therefore difficult to ascribe to a single source. The gold is most likely alluvial in nature and not derived locally. Lead shot is found in some of the samples that contain lead anomalies, indicating that contamination is a likely source of those anomalies. Tin is associated with lead in the concentrates and could be a cocontaminant. With the exception of gold, these anomalies are low, single element, and scattered. This suggests that they would not indicate significant mineral resource potential even if contamination by older alluvium, flood alluvium, loess, or human activities was not a problem.

Analyses of rock samples from the study areas provide the best basis for a geochemical survey because they are resistant to contamination by alluvium or humans. Analyses of rocks from the study areas revealed no anomalies in the Thirtymile Wilderness Study Area and only a single anomaly each for lead (200 ppm), mercury (0.19 ppm), and zinc (350 ppm) in the Lower John Day Wilderness Study Area. These anomalies are from scattered locations, are low and single element, and therefore are not of great significance.

In the Geology, Energy, and Minerals (GEM) reconnaissance of the study area (Davis, 1983), low-level geochemical anomalies are reported for rock samples from both areas. In samples from the southern part of the Thirtymile Wilderness Study Area, there is one anomaly each of gold (0.02 ppm, the lower limit of detection for that study), mercury (0.58 ppm), and uranium (5.4 ppm). Three other samples have mercury concentrations between 0.10 and 0.20 ppm. The 0.02 ppm gold content is probably not anomalous because the concentration is at the detection limit of the method used and therefore not completely accurate, and because this concentration is only slightly more than typical concentrations (as much as 0.011 ppm gold) for the Columbia River Basalt Group (Gottfried and others, 1972). Six GEM samples from the Lower John Day Wilderness Study Area contain low levels of mercury (0.10 to 0.17 ppm). The fact that 10 of 12 rock samples in the GEM study have mercury concentrations of 0.10 ppm or more, whereas only 1 of 45 of the samples collected by the U.S. Geological Survey for the current study contains mercury at these concentrations, suggests that either the GEM analyses or the U.S. Geological Survey analyses are incorrect. Quality control in U.S. Geological Survey laboratories is usually good, suggesting that the GEM analyses may have given concentrations higher than are actually present, but there are not enough data to determine absolutely which set of analyses is correct. Assuming the GEM analyses are correct, the gold and mercury anomalies might be evidence of either epithermal mercury or epithermal gold deposits, but the likelihood of the occurrence of either of these types of deposit is remote because unaltered basalt is not usually a suitable host rock for such deposits. Epithermal deposits are marked by zones of pervasive hydrothermal alteration; no traces of such alteration were found in fault zones or elsewhere within the study area. Faulting, necessary to provide fluid pathways for the formation of hydrothermal deposits, is minimal in the area where the anomalies occur.

Geophysical Studies

Magnetic, gravity, and radiometric data from north-central Oregon were compiled and examined to aid assessment of the mineral resource potential of Lower John Day and Thirtymile Wilderness Study Areas. The sparsely distributed nature of all three data sets is adequate for examining the regional structural and tectonic setting of the study areas, but it does not permit assessment of mineral resource potential at the scale of individual deposits except in areas located directly beneath detailed profiles.

Magnetic Data

The only publicly available aeromagnetic data collected from the study areas were compiled under contract to the U.S. Department of Energy as part of the NURE program (High Life Helicopters, Inc./QEB, Inc., 1981). These data were collected at an average of 400 ft above the terrain along east-west flightlines spaced 6 mi apart and north-south flightlines spaced 24 mi apart. Only three NURE flightlines actually crossed the study areas; these were directed approximately east-west at latitudes 45°12' N., 45°17' N., and 45°22' N. Anomalies within the study areas are characterized by short wavelengths (500 to 8,000 ft), high amplitudes (100 to 2,000 nanotesla, nT), and high gradients (1 to 4 nT/ft). Unmetamorphosed basaltic rocks, such as the Miocene basalt flows exposed throughout the study areas, commonly have high magnetic susceptibilities and high remanent magnetizations. In aeromagnetic profiles constructed from the data of low-altitude flights, such rocks typically show high-amplitude, short-wavelength magnetic anomalies that often obscure anomalies caused by deeper magnetic sources. Some of the individual highs and lows along the magnetic profiles may indicate mineralized areas, but they are more likely the result of lateral variations in the abundance and characteristics of magnetite grains in shallow basaltic rocks.

The northernmost NURE flightline (latitude 45°22' N.) crossed the northern part of the Lower John Day Wilderness Study Area. The resulting profile shows a long-wavelength anomaly superimposed on the short-wavelength anomalies described above. The long-wavelength anomaly is negative in sign, approximately 1,500 nT in amplitude, approximately 4 mi in width, and centered around latitude 45°22' N. in the Lower John Day Wilderness Study Area. The horizontal gradient and general shape of the anomaly indicate that it is caused by a source located at shallow depth. The anomaly is located in an area of minor deformation, as demonstrated by mapped normal faults (fig. 2). The decreased magnetic intensity of the anomaly may be caused by pervasive alteration (and consequent reduction of magnetic susceptibility and remanent magnetization) of the volcanic rocks associated with the deformation, but no alteration was observed in this area. Alternatively, the anomaly may be caused by a buried intrusion of silicic composition. Silicic intrusive rocks typically have lower susceptibility and remanent magnetization than basaltic volcanic rocks. No silicic igneous rocks are exposed within the study areas, but silicic intrusive rocks of Tertiary age crop out 40 mi southwest of the anomaly (Swanson, 1969); similar rocks of Oligocene age were recovered from the Standard Kirkpatrick No. 1 well located 14 mi east of the study areas (Fox and Reidel, 1987).

A regional compilation of aeromagnetic data (Committee for the Magnetic Anomaly Map of North America, 1987) shows a linear magnetic depression extending the entire length of the two study areas. The NURE magnetic profiles were the only magnetic data available for this part of Oregon. The linear anomaly evident in these regional profiles probably reflects a highly smoothed version of the negative anomaly discussed in the previous paragraph.

Gravity Studies

Gravity data from the vicinity of Lower John Day and Thirtymile Wilderness Study Areas were obtained from the National Geophysical Data Center of the National Oceanic and Atmospheric Administration in Boulder, Colo. Gravity measurements are scattered at a 3- to 6-mi spacing in this region, and none are actually within the study areas. Observed gravity measurements, based on the International Gravity Standardization Net datum (Morelli, 1974), were reduced to free-air anomalies using standard formulas (Telford and others, 1976). Bouguer, curvature, and terrain corrections (out to a distance of 103.6 mi from each station) at a standard reduction density of 2.67 grams per cubic centimeter (g/cm^3) 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 in resource appraisals, but they 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. The map was constructed from the Bouguer gravity data by removing a regional gravity field computed from a model of the crust-mantle interface that assumes Airy-type isostatic compensation (Jachens and Griscom, 1985). A regional perspective of the gravitational setting of the area can be seen on Jachens and others (1985).

The sparse distribution of gravity measurements precludes a detailed analysis of mass distribution within and adjacent to the study areas, but it is sufficient to illuminate the regional tectonic and structural setting of the area. The Lower John Day and Thirtymile Wilderness Study Areas lie on the northern edge of a positive isostatic residual anomaly. The anomaly is 20 milligals (mGal) higher in amplitude than surrounding areas, has lateral dimensions of approximately 15 mi east-west and 30 mi north-south, and forms part of a 250-mi-long chain of anomalies that trends northeast through northern Oregon and southeastern Washington. Riddihough and others (1986) noted that this lineament is on-strike with similar gravity features in the Klamath Mountains and suggested that it reflects a pre-Tertiary continental boundary extending across north-central Oregon and southeastern Washington.

Radiometric Data

Radiometric data were collected as part of the NURE survey (High Life Helicopters, Inc./QEB, Inc., 1981). Recordings were made of gamma-ray flux from radioactive isotopes of potassium, thorium, and uranium along east-west flightlines spaced approximately 6 mi apart and at an average altitude of 400 ft above the terrain. Only three flightlines actually crossed the study areas. Count rates were low during all three flights and no anomalous radiation was detected. However, because only three flightlines crossed the study area and because gamma rays are strongly attenuated by passage through earth materials, these 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 surface.

Conclusions

The short-wavelength, high-amplitude magnetic anomalies observed in profiles derived from the data of low-altitude flights over the study areas are typical for this region. They are caused principally by variations in abundance and characteristics of magnetite in the unmetamorphosed basalt flows exposed throughout the area. However, a possible magnetic source located beneath the topographic surface was detected in one east-west profile at latitude 45°22' N. The source may be a buried silicic intrusion, which may have had local hydrothermal phenomena associated with it, but there may be other explanations for the anomaly. Gravity and radiometric data neither indicate nor preclude the presence of mineralization within the study areas.

Mineral and Energy Resource Potential of the Lower John Day Wilderness Study Area

Mineral Resource Potential

Investigations by the U.S. Geological Survey and the U.S. Bureau of Mines indicate that the Lower John Day Wilderness Study Area has low mineral resource potential, certainty level C, for placer gold in scattered, small river bars of alluvium located in the canyon of the John Day River.

Stream-sediment samples collected by the U.S. Geological Survey for this study and by the U.S. Bureau of Mines (Campbell and McHugh, 1987) indicate that active alluvium in the John Day River and its tributaries contains small quantities of placer gold. Older perched alluvium also may contain similar small quantities of gold, but these perched river bars were not sampled. The chance that any alluvium within the study area contains significant gold deposits is considered remote. A certainty level of C is assigned because a significant number of samples were analyzed and their gold contents were uniformly low.

The magnetic low indicated by geophysical surveys in the northern part of the study area could indicate the existence of a shallow-level silicic pluton. Hydrothermal systems associated with such plutons may produce epithermal mineral deposits. If this pluton does indeed exist, however, it is probably of an age similar to that of the rhyolite pluton found in the Standard Kirkpatrick No. 1 hole, 14 mi to the east. That pluton was dated at 28.8 Ma, late Oligocene (Fox and Reidel, 1987). A pluton of this age would have been emplaced in rocks of the John Day Formation and would predate the middle Miocene Columbia River Basalt Group. This precludes the pluton from having provided a source of heat to drive a hydrothermal system within the overlying Columbia River Basalt Group. The absence of geochemical anomalies in the area of the magnetic anomaly and the absence of any visible alteration in the area suggest that significant hydrothermal alteration has not occurred in this area. Therefore, the chance that epithermal mineral deposits formed is extremely remote.

Small deposits of sand and gravel suitable for construction use 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.

Energy Resource Potential

Investigations by the U.S. Geological Survey indicate that the Lower John Day Wilderness Study Area has low resource potential for petroleum 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 1930'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 (G.W. Walker, oral commun., 1987).

The primary 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 middle to Late Cretaceous age (Newton, 1966, 1977; Fritts and Fisk, 1985a, b). The study area is in the southwestern part of this basin (Fritts and Fisk, 1985a, b). The smaller and slightly younger (latest Cretaceous) Ochoco Basin lies to the south and never extended as far north as the study area (Thompson and others, 1984).

Oil and gas leases cover the entire study area. Four test holes were drilled near the study area between 1929 and 1957; three of these are near Clarno, 22 mi to the south, and one is near Condon, 14 mi to the east. The holes near

Clarno indicate that pre-Tertiary rocks are overlain by 2,870 to 4,000 ft of rocks of the Tertiary-age John Day and (or) Clarno Formations. One hole near Clarno, the Clarno Basin Oil Company's Burgess No. 2, had a gas show, presumably from Cretaceous-age rocks. Asphalt-bearing geodes have also been found near Clarno (Collier, 1914; Buwalda, 1921). Well logs for all holes are on file at the Oregon Department of Geology and Mineral Industries in Portland, Oreg.

The best studied and documented hole in the region is Standard Oil Company's Kirkpatrick No. 1, located near Condon (fig. 1). From the surface, this hole penetrated 2,440 ft of the Columbia River Basalt Group. Between depths of 2,440 and 6,135 ft, the hole passed through volcanic and sedimentary rocks of the John Day Formation. Volcanic and sedimentary rocks of either the John Day or Clarno Formation were encountered between depths of 6,135 and 6,695 ft. 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, 1987), the total organic content of these rocks is low to very low (Brown and Ruth Laboratories, 1983; 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, 1983).

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 Standard Kirkpatrick No. 1 hole. The study area does lie within the Cretaceous Columbia River Basin. The Mesozoic rocks are primarily argillites but include some graywackes and siltstones, lithologies usually having low porosity, thereby limiting their potential as reservoir rocks. Their lack of potential as source rocks is indicated by their low total organic content. Although these Mesozoic rocks have been determined to be thermally mature, local rhyolite intrusions (Fox and Reidel, 1987) may have produced intense local heating, thereby degrading or driving off nearby hydrocarbons. An analysis of organic carbon from the Standard Kirkpatrick No. 1 hole (Brown and Ruth Laboratories, 1983) suggests that if hydrocarbons are present, they are more likely to occur as gas than oil. 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 probable lack of both suitable source and reservoir rocks and the possible local overheating, the likelihood of the occurrence of oil and gas in the study area is not great, 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, 14 to 22 mi away, 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 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). Additionally, the study area lies within a small area that has lower heat flow than the rest of eastern Oregon and Washington (Nathenson and others, 1983).

Mineral and Energy Resource Potential of the Thirtymile Wilderness Study Area

Mineral Resource Potential

Investigations by the U.S. Geological Survey and the U.S. Bureau of Mines indicate that the Thirtymile Wilderness Study Area has low mineral resource potential for placer gold in scattered, small alluvial deposits, certainty level C. The study area also has low mineral resource potential, certainty level C, for gold and mercury in epithermal deposits.

A low resource potential exists for gold in placer deposits in the canyon of the John Day River. Stream-sediment samples collected by the U.S. Geological Survey and the U.S. Bureau of Mines (Campbell and McHugh, 1987) show that active alluvium in the John Day River and its tributaries contains small quantities of gold, locally reaching subeconomic concentrations. Older perched alluvium may also contain similar small quantities of gold, but these deposits were not sampled. The chance that any alluvium within the study area contains significant gold deposits is considered remote. A certainty level of C is assigned because a significant number of samples were analyzed, and gold, when present, was found in only low concentrations. Some gravel bars sampled by the U.S. Bureau of Mines contain gold in subeconomic quantities. A slight chance exists that further sampling would reveal a bar with economic quantities of gold.

The southern part of the Thirtymile Wilderness Study Area has low mineral resource potential for gold and (or) mercury in epithermal deposits, certainty level C. Several low-level mercury anomalies and one low-level gold anomaly in rock sample data reported in the GEM study (Davis, 1983) are the sole basis for this potential. The accuracy of these data is not certain. Rock samples collected by both the U.S. Geological Survey and U.S. Bureau of Mines from the same area do not contain anomalous concentrations of either mercury or gold. Permeability of the rocks is an important prerequisite for the emplacement of epithermal mercury deposits (Brooks, 1963) and epithermal gold deposits. The Columbia River Basalt Group flows generally lack permeability and therefore are unlikely host rocks for epithermal deposits, although faults, vesicular flow tops, or contacts between successive flows might provide some limited fluid pathways. However, no hydrothermal alteration, diagnostic of epithermal mineralization, was observed within fault zones or elsewhere within the study area. Brooks (1963) observed the notable lack of mineral deposits within the Columbia River basalts and characterized them as "remarkably unmineralized." A certainty level of C is assigned because the only evidence of epithermal deposits is not only scanty, but also questionable.

Small sand and gravel deposits suitable for construction use are present in the study area but are too small to constitute a resource. Other suitable deposits occur outside the study area and closer to potential markets. No undiscovered sand and gravel resources are likely to be found beyond known deposits.

Energy Resource Potential

The investigations by the U.S. Geological Survey indicate that the Thirtymile Wilderness Study Area has low resource potential for petroleum and natural gas, certainty level B. Oil and gas leases cover the study area. The study area has no geothermal resource potential, certainty level D.

The study area lies within the Cretaceous Columbia River Basin. Mesozoic rocks are unexposed in the study area but are assumed to be similar to those in the Standard Kirkpatrick No. 1 hole, 14 mi to the east. The Mesozoic rocks found in this drill hole have limited potential as either source or reservoir rocks. Although the rocks have been determined to be thermally mature, they may have undergone intense local heating, thereby degrading or driving off any nearby hydrocarbons. If hydrocarbons are present, they are more likely to be gas than oil. 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 possible lack of both suitable source and reservoir rocks and the possible local overheating, the likelihood of oil and gas occurring in the study area is not great. Under the definitions used in this study, the area is given a low resource potential for oil and gas. See previous discussion in the "Energy Resource Potential" section for the Lower John Day Wilderness Study Area. A certainty level of B is assigned because no subsurface data, either seismic or drill hole, were available for the study area. The stratigraphy in the nearest drill holes, 14 and 18 mi away, may differ from that of the study area and more favorable source and reservoir rocks could exist beneath the study area. The lack of seismic data precludes any knowledge of 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). Additionally, the study area lies within a small area that has lower heat flow than the rest of eastern Oregon and Washington (Nathenson and others, 1983).

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APPENDIXES

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

LEVELS OF RESOURCE POTENTIAL

H **HIGH** mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

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

L **LOW** mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is permissive. This broad category embraces areas with dispersed but insignificantly mineralized rock, as well as areas with little or no indication of having been mineralized.

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

U **UNKNOWN** mineral resource potential is assigned to areas where information is inadequate to assign a low, moderate, or high level of resource potential.

LEVELS OF CERTAINTY

A Available information is not adequate for determination of the level of mineral resource potential.
B Available information only suggests the level of mineral resource potential.
C Available information gives a good indication of the level of mineral resource potential.
D Available information clearly defines the level of mineral resource potential.

LEVEL OF RESOURCE POTENTIAL →

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td rowspan="4">U/A
UNKNOWN POTENTIAL</td><td>H/B
HIGH POTENTIAL</td><td>H/C
HIGH POTENTIAL</td><td>H/D
HIGH POTENTIAL</td></tr>
<tr><td>M/B
MODERATE POTENTIAL</td><td>M/C
MODERATE POTENTIAL</td><td>M/D
MODERATE POTENTIAL</td></tr>
<tr><td rowspan="2">L/B
LOW POTENTIAL</td><td rowspan="2">L/C
LOW POTENTIAL</td><td>L/D
LOW POTENTIAL</td></tr>
<tr><td>N/D
NO POTENTIAL</td></tr>
</table>

LEVEL OF CERTAINTY →

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RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from McKelvey, V.E., 1972, Mineral resource estimates and public policy: American Scientist, v. 60, p. 32-40; and U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, p. 5.

GEOLOGIC TIME CHART

Terms and boundary ages used by the U.S. Geological Survey in this report

EON	ERA	PERIOD		EPOCH	AGE ESTIMATES OF BOUNDARIES IN MILLION YEARS (Ma)
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	[1]~570
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				(3800?)
pre-Archean[2]					4550

[1]Rocks older than 570 Ma also called Precambrian, a time term without specific rank.
[2]Informal time term without specific rank.

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Water-Resources Investigations Reports are papers of an interpretive nature made available to the public outside the formal USGS publications series. Copies are reproduced on request unlike formal USGS publications, and they are also available for public inspection at depositories indicated in USGS catalogs.

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