Mineral Resources of the North Pole Ridge Wilderness Study Area, Sherman and Gilliam Counties, Oregon

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Chapter B

Mineral Resources of the North Pole Ridge Wilderness Study Area, Sherman and Gilliam Counties, Oregon

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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 Area

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and submitted to the President and the Congress. This report presents the results of a mineral survey of part of the North Pole Ridge Wilderness Study Area (OR-005-008), Sherman and Gilliam Counties, Oregon.

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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, *and* Richard J. Blakely
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SUMMARY

Abstract

At the request of the U.S. Bureau of Land Management, 5,830 acres of the North Pole Ridge Wilderness Study Area (OR–005–008) in Sherman and Gilliam Counties, north-central Oregon, were evaluated for identified mineral resources (known) and mineral resource potential (undiscovered). Throughout this report, "wilderness study area" and "study area" refer to those acres for which mineral surveys were requested. Fieldwork for this report was carried out from 1985 through 1987. No mines or mining districts are located inside the study area; however, 11 active (1986) gold claims are in the study area, and the study area is under lease for oil and gas. The study area has no identified mineral resources. The eastern part of the study area has moderate potential and the rest of the area has low potential for gold resources in small epithermal deposits. Along the John Day River there is low potential for gold resources in small placer deposits. The entire study area has low potential for oil and gas and no potential for geothermal energy resources.

Character and Setting

The North Pole Ridge Wilderness Study Area is located on the Deschutes-Umatilla plateau of north-central Oregon (fig. 1), about 45 mi southeast of The Dalles, Oreg. The terrain is dominated by the precipitous, 1,500-ft-deep canyon entrenched by the meandering John Day River. Segments of several prominent tributary canyons are also present in the study area. Bedrock in the study area consists of Miocene (see appendixes for geologic time chart) basalt flows of the Columbia River Basalt Group (fig. 2) that are predominantly gently tilted toward the north. Older Paleogene volcanic and sedimentary rocks and Mesozoic sedimentary rocks are exposed just south of the study area and probably extend underneath the study area at shallow depths. A north-trending zone of normal faulting, folding, and related deformation that crosses the eastern part of the study area terminates a regional, gentle, east-trending fold structure located east of the zone (fig. 2). The study area contains alluvium-mantled meander scars perched as much as 600 ft above river level in the John Day River canyon. Massive landslide deposits and recent and active alluvium conceal much of the bedrock in the deeper parts of the John Day River canyon.

Identified Resources

No mineral resources were identified in the North Pole Ridge Wilderness Study Area. The Micron claim group (11 claims), located in the southern part of the study area (fig. 2), was staked at the site of a previously reported geochemical anomaly of gold. No gold or other mineral resources were identified on these claims.

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

Manuscript approved for publication, June 21, 1988.

Mineral Resource Potential

The North Pole Ridge Wilderness Study Area has moderate and low resource potential for gold in epithermal deposits and low resource potential for placer gold. The study area has low energy resource potential for oil and gas and no potential for geothermal energy.

Spotty, locally strong gold and gold-pathfinder geochemical anomalies have been detected primarily in the eastern part of the study area in the general area of a group

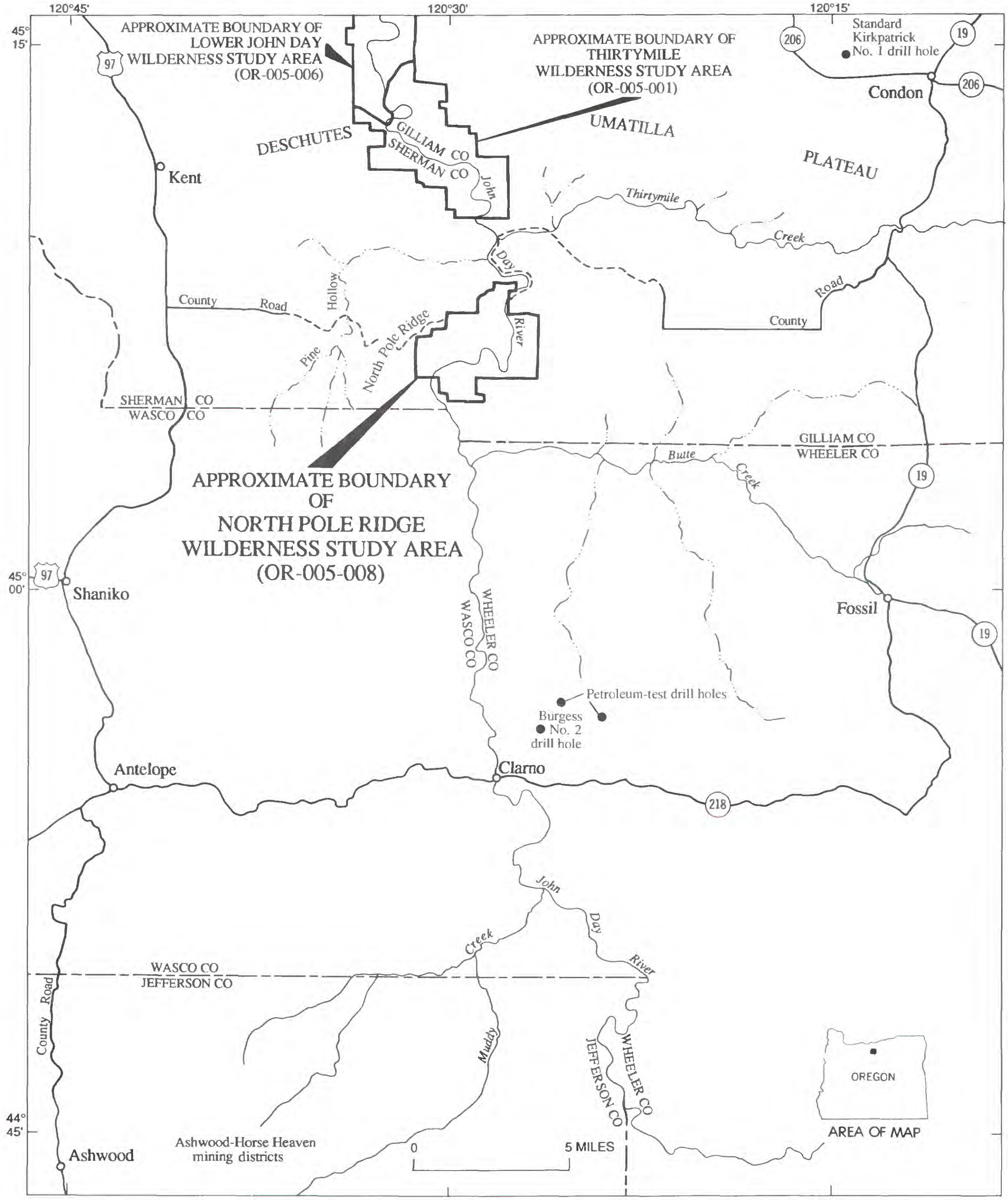


Figure 1. Index map showing location of North Pole Ridge Wilderness Study Area, Sherman and Gilliam Counties, Oregon. Locations of Lower John Day and Thirtymile Wilderness Study Areas shown for reference purposes.

of active gold claims. No obvious hydrothermally altered or mineralized rocks occur there or elsewhere in the study area. Most of the geochemical anomalies are within or near a north-trending zone of folding, fracturing and high-angle faulting that may have provided localized conduits for auriferous hydrothermal fluids leaking from concealed mineralized rocks. There is moderate resource potential for gold in small epithermal deposits in the eastern part of the study area that contains the north-trending zone of deformation, active gold claims, and most of the geochemical anomalies (fig. 2). The surrounding parts of the study area, which contain scattered, weak gold-related anomalies, have low potential for gold resources in epithermal deposits.

Stream-sediment, stream-sediment-concentrate, and alluvial (placer) samples collected in the study area indicate the presence of small amounts of placer gold in John Day River alluvium. There is a remote possibility that undiscovered, more concentrated deposits of placer gold lie concealed within active, recent, and (or) older perched alluvium in the John Day River canyon. The deeper parts of the John Day River canyon in the study area have low potential for gold resources in small placer deposits (fig. 2).

The entire study area has low potential for energy resources of oil and gas. Four petroleum test holes, all of which were essentially dry, have been drilled as close as 13 mi from the study area. Rocks that underlie Columbia River basalts were encountered in the drill holes but do not appear to be suitable source or reservoir rocks for hydrocarbons, even though some of these lower rocks have been determined to be thermally mature. Although similar unfavorable basement rocks probably extend underneath the study area, the existence of promising source or reservoir rocks cannot be completely ruled out.

The study area lies in an area of relatively low heat flow that lacks hot or warm springs, and thus the area has no potential for geothermal energy resources.

INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management and is the result of a cooperative effort by the U.S. Geological Survey and the U.S. Bureau of Mines. An introduction to the wilderness review process, mineral survey methods, and agency responsibilities was provided by Beikman and others (1983). The U.S. Bureau of Mines evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas. Identified resources are classified according to a system that is a modification of that described by McKelvey (1972) and U.S. Bureau of Mines and U.S. Geological Survey (1980). 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 geologic units and structures, possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. Goudarzi (1984) discussed mineral assessment methodology and terminology as they apply to these surveys. See appendixes for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

Location and Physiography

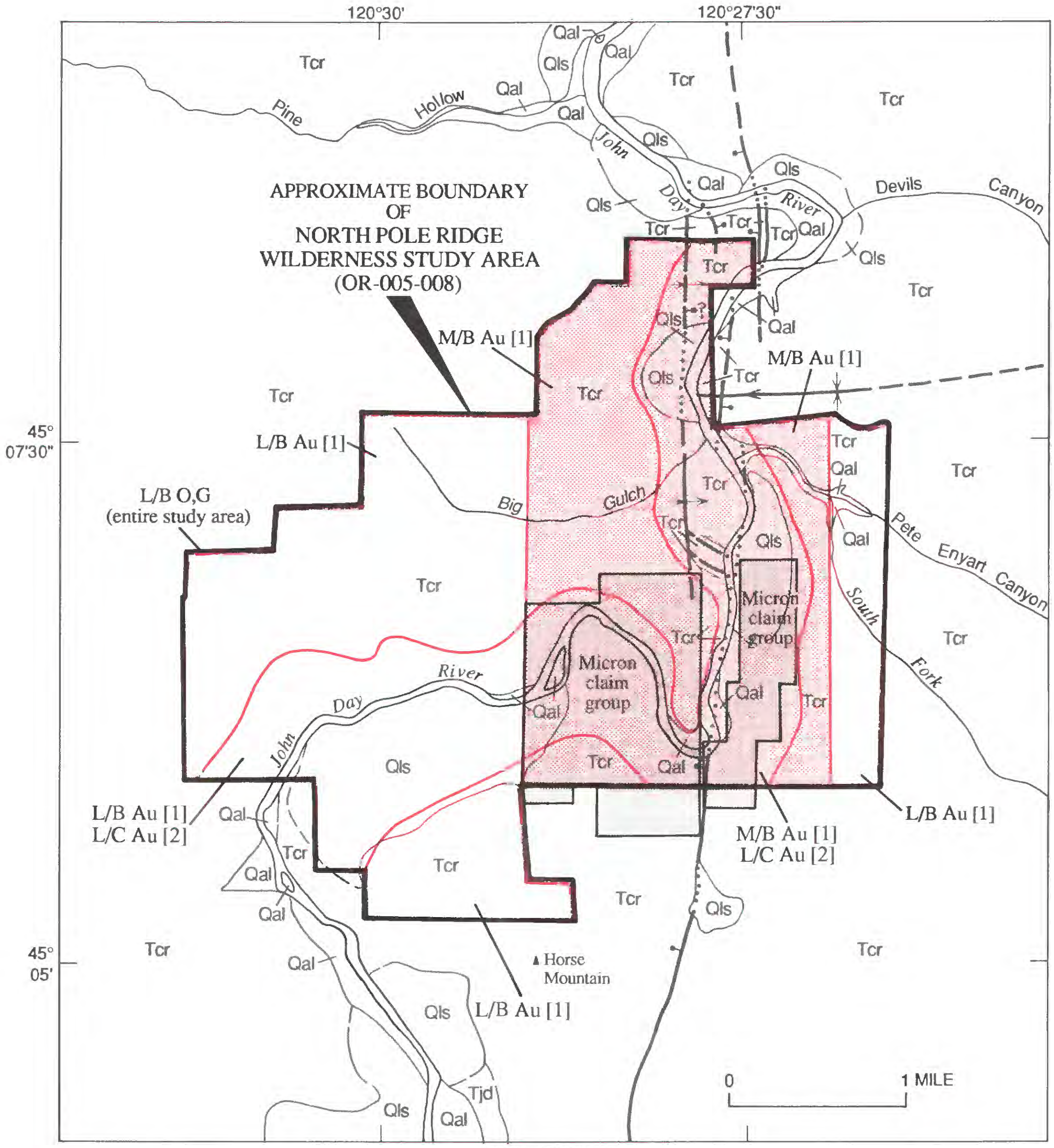
The North Pole Ridge Wilderness Study Area consists of 5,830 acres and is located on the Deschutes-Umatilla plateau of north-central Oregon in Sherman and Gilliam Counties (fig. 1), about 45 mi southeast of The Dalles, Oreg. The Deschutes-Umatilla plateau forms part of the extensive Columbia Plateau physiographic province that also includes much of eastern Washington and parts of western Idaho. The Thirtymile (OR–005–001) and the contiguous Lower John Day (OR–005–006) Wilderness Study Areas (Ach and others, 1988) are located 2 mi and 7 mi north, respectively, of the study area.

The study area contains a 6.5-mi stretch of the meandering lower John Day River (fig. 1). The John Day River, which drains into the Columbia River 40 mi to the north, has entrenched a deep, precipitous, winding canyon into the Deschutes-Umatilla plateau in the vicinity of the study area. The terrain in the study area consists mainly of the sinuous John Day River canyon, which has an average depth of about 1,500 ft. Elevations in the study area range from about 2,920 ft above sea level on Horse Mountain along the south border to 1,020 ft where the John Day River crosses the northeast border (fig. 2). Several tributary streams that drain into the river, including those occupying Big Gulch and Pete Enyart Canyon (fig. 2), are intermittent, reflecting the semiarid climate of the region. Juniper trees, low-lying sage and other brush, and seasonal varieties of grasses and wildflowers grow locally in the study area. The larger stream channels and banks of the John Day River support a variety of riparian vegetation.

The most direct access into the study area is down the John Day River by raft from Clarno 12 mi south of the study area (fig. 1). Several jeep and hiking trails extend to the edge of the study area from county roads to the west and east.

Previous and Present Investigations

Few investigations have been made in the vicinity of the study area. The earliest published geologic map of the region (Newcomb, 1970) was reconnaissance in nature (1:500,000 scale), addressing the tectonic structure of the



EXPLANATION

Area having moderate mineral or energy resource potential (M)

Area having low mineral resource potential (L)

Levels of certainty of assessment

- B Data only suggest level of potential
- C Data give good indication of level of potential

Commodities

- Au Gold
- O,G Oil and Gas

[ ] Deposit types

- 1 Epithermal deposits of gold
- 2 Placer deposits of gold

Geologic map units

- Qal Alluvium (Quaternary)
- Qls Landslide deposits (Quaternary)
- Tcr Columbia River Basalt Group (Tertiary)
- Tjd John Day Formation (Tertiary)

Contact–Dashed where approximate

Fault–Dashed where approximate, dotted where concealed. Bar and ball on apparent downthrown side; double-headed arrows indicate uncertain sense of strike-slip displacement

Syncline–Dashed where approximate. Large arrow points in direction of plunge

Anticlinal bend–Dashed where approximate; dotted where concealed. Bar and ball on apparent downthrown side where accompanied by inferred normal fault

Figure 2. Generalized geology, mineral resource potential, and location of claim group in North Pole Ridge Wilderness Study Area, Sherman and Gilliam Counties, Oregon.

Columbia River basalts. Swanson and others (1981), using established stratigraphic nomenclature for the Columbia River basalts (Swanson and others, 1979), mapped the geology of the Columbia River basalts in northern Oregon and western Idaho at a scale of 1:250,000. Bela (1982) compiled a geologic map of the The Dalles 1° by 2° sheet chiefly from the mapping of Swanson and others (1981). The U.S. Bureau of Land Management prepared a geology, energy, and mineral (GEM) resources report on the Lower John Day Resource Area, which includes this study area (Davis, 1983). The petroleum potential of Oregon wilderness study areas, including this one, was evaluated by Fouch (1983).

The U.S. Geological Survey visited the study area during the 1985, 1986, and 1987 field seasons. Fieldwork included geochemical sampling and checking of existing geologic mapping supplemented, locally, by additional mapping. Gravity, aeromagnetic, and aerial gamma-ray data covering the study area were compiled and interpreted. Geochemical analyses were obtained for 1 water, 15 stream-sediment, 21 stream-sediment-concentrate, and 35 rock samples collected in the study area.

The U.S. Bureau of Mines conducted a library search for information on mines and prospects in and near the study area. This search included checking U.S. Bureau of Land Management mining claim recordation indices, Gilliam and Sherman County mining claim records, and the U.S. Bureau of Mines Mineral Industry Location System. Field studies by U.S. Bureau of Mines personnel were conducted in 1986. Active claims in the study area were examined, and 11 rock samples were collected from the claims for geochemical analysis. Two alluvial (placer) samples were collected to help evaluate any possible placer-gold resources. The methods and results of the U.S. Bureau of Mines investigation in the study area were reported by Campbell (1987). Additional information is available from 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 personnel of the U.S. Bureau of Land Management Prineville District Office, Prineville, Oreg., for providing access information and maps of the study area. We thank Harold D. Tracy for information concerning the Micron Exploration Company claim group. The able field assistance of Jeanette Smith, David Roth, Jim Fox, Steven Smith, and Randy Baker of the U.S. Geological Survey and Edward McHugh of the U.S. Bureau of Mines is greatly appreciated.

APPRAISAL OF IDENTIFIED RESOURCES

By Harry W. Campbell
U.S. Bureau of Mines

Mining History

There are no mining districts in or near the study area. The closest districts, the Ashwood (gold) and Horse Heaven (mercury) mining districts, are located 20 to 25 mi south of the study area just east of the small town of Ashwood (fig. 1). In September 1983, Micron Exploration Company began locating 11 lode mining claims in the study area (Micron claim group, fig. 2) following the report of very high gold contents in reconnaissance geochemical samples of Columbia River basalt collected by the U.S. Bureau of Land Management (Davis, 1983). The claims were still active in 1986 according to U.S. Bureau of Land Management claim recordation indices. The entire study area was leased for oil and gas exploration during 1986.

Appraisal of Mineral Resources

Micron Exploration Company collected rock samples on their claims in the study area to determine the amount of gold present. Company representative H.D. Tracy (written commun., 1986) indicated that "company assays show a much stronger gold content than 150 parts per million" (ppm). Additionally, the representative stated that gold values were not restricted to any particular geologic structure, for basalt samples collected throughout the claim group yielded consistently high gold assays (as much as 250 ppm) (H.D. Tracy, oral commun., 1986). In order to evaluate the mineral resources of the Micron claim group, 11 rock samples were collected by the U.S. Bureau of Mines in the study area (Campbell, 1987). No gold was detected in any of the samples at a detection limit of 5 parts per billion (ppb). No mineral resources were identified at the Micron claim group for the following reasons: (1) the absence of detectable gold or anomalous concentrations of other metals in the U.S. Bureau of Mines samples, (2) the lack of visible mineralization and significant alteration, and (3) no reports of gold mineralization in the Columbia River basalts in the region.

Two reconnaissance alluvial samples were also collected by the U.S. Bureau of Mines from a river bar in the study area adjacent to the Micron claim group (Campbell, 1987). Both samples contain gold in very fine (less than 0.001 in.), subrounded, flat flakes. One of the samples also contains a trace of cinnabar (a common mercury-ore mineral). Gold contents of the samples do not exceed about 0.0002 oz/yd^3. At a gold price of $400/troy oz, the gravel would be worth about $0.07/yd^3—too low a grade to be considered a resource under foreseeable economic conditions.

Stone (basalt), sand, and gravel are abundant in the study area and could be used for aggregate and fill. However, these commodities have low unit value and high bulk, which precludes their use for any purposes other than for local construction projects. Ample, more accessible supplies of stone, sand, and gravel outside the study area are adequate for regional demand.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

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

Geology

The study area is located in the southern part of the Columbia Plateau physiographic province, which is characterized by extensive sequences of gently north-tilted, middle 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. Directly south of the study area the Columbia River basalts are underlain by Eocene and Oligocene volcanic and associated rocks that, in turn, overlie Mesozoic marine sedimentary rocks. Columbia River basalt in the region has locally been folded and faulted during the Miocene and Pliocene.

The oldest exposed rocks in the study area, at the bottom of the John Day River canyon, consist of basalt flows of the Columbia River Basalt Group (fig. 2) (Swanson and others, 1981). However, rocks of the John Day Formation (Merriam, 1901a) of chiefly Oligocene age, which lie unconformably below the Columbia River Basalt Group (Swanson, 1969), are exposed in the John Day River canyon just 1 mi south of the study area (fig. 2) (Swanson, 1969; Robinson, 1975; Swanson and others, 1981). The John Day Formation near the study area consists of intercalated tuffs, tuffaceous sedimentary rocks, and mafic flows. Unconformably underlying the John Day Formation and exposed just a few miles farther south up canyon are rocks of the Clarno Formation (Merriam, 1901b). The Clarno Formation, principally Eocene in age, consists chiefly of interfingering andesitic flows, domes, plugs, and breccias and associated volcaniclastic and tuffaceous rocks. Presumably both the John Day and Clarno Formations, which have a combined thickness of several thousand feet in the area, extend northward underneath the study area. This assumption is supported by data from Standard Oil Company's Kirkpatick No. 1 petroleum test hole (Fox and Reidel, 1987), which is located 13 mi northeast of the study area (fig. 1). The hole penetrated 2,440 ft of rocks of the Columbia River Basalt Group before encountering 4,255 ft of John Day and possibly Clarno rocks. These data suggest that the base of the Columbia River Basalt Group may be only a few hundred feet below river level at the northern end of the study area.

Flows of the Columbia River Basalt Group form the bedrock throughout the study area (fig. 2). The maximum exposed thickness of the basalts in the study area is about 1,600 ft, equivalent to the maximum depth of the John Day River canyon. The gray Columbia River basalt flows typically range in thickness from 50 to 100 ft and have conspicuous columnar joints, especially near the base of each flow. The upper parts of the flows are usually vesicular and autobrecciated 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 commonly results in "stair-step" topography along the canyon walls. Interflow layers of tuffaceous rocks are present only locally in the sequence and rarely exceed 10 ft in thickness.

Swanson and others (1981) subdivided rocks of the Columbia River Basalt Group in the study area into two formations following the stratigraphic nomenclature of Swanson and others (1979). The two formations, the Picture Gorge and Grande Ronde Basalts, are in part contemporaneous and interfinger. The Picture Gorge Basalt, which is only exposed in the southern part of the study area near river level, is distinguished in the field by its medium- to coarse-grained, porphyritic (plagioclase) texture as compared to the generally aphyric, fine-grained nature of the Grande Ronde Basalt (Swanson and others, 1981). Rocks of the Picture Gorge and Grande Ronde Basalts have yielded potassium-argon radiometric ages ranging from 16.5 to 14 million years before present (Ma).

Large (1 mi or more in length) landslide deposits near the base of the John Day River canyon in and near the study area (fig. 2) are typically expressed by hummocky topography, contain jumbled blocks of basalt, and are bounded on their up-slope sides by prominent arcuate headwall scarps. Some of the landslides, which border long stretches of the John Day River, may have slid off of the canyon walls before the river cut down to its present level and thus may contain and (or) conceal older river alluvium. The larger landslides in and south of the southern part of the study area, including a slide mass more than 10 mi long (Swanson, 1969; Swanson and others, 1981), most likely failed along incompetent, clay-altered tuffaceous layers in the John Day Formation (Peck, 1964; Swanson, 1969).

There is abundant geomorphic evidence in the study area of older, shallower (less entrenched) channels of the John Day River, the most conspicuous of which are several meander scars perched as much as 600 ft above the present river level along the canyon wall. Erosional remnants of river alluvium deposited in these older channels locally mantle the meander scars. Active and recent alluvium in the study area consist primarily of sand and gravel deposits that blanket the inside banks of the John Day River entrenched meanders (fig. 2). Talus aprons and cones composed of basalt debris mantle the bases of most of the large subvertical cliffs along canyon walls.

The area occupied by the Columbia Plateau was probably the location of a broad northeast-trending rift zone that developed across the Mesozoic continental margin in the Early Cretaceous (Fritts and Fisk, 1985a). This zone of rifting was inferred by Fritts and Fisk to have subsided and accumulated sediment and volcanic material (including the Columbia River basalts) more or less continuously for the duration of the Tertiary, thus forming the Columbia basin. Uplift of the Blue Mountains at the south end of the Columbia Plateau began in Eocene time during deposition of the Clarno Formation and continued for the remainder of the Tertiary (Fox and Reidel, 1987). Angular unconformities that separate rocks of the Clarno Formation, John Day Formation, and Columbia River Basalt Group south of the study area (Swanson, 1969; Robinson, 1975) provide supporting evidence that uplift and subsidence continued in the region 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 and (or) subsidence of the central part of the plateau may have continued intermittently into the latest Tertiary or Quaternary.

In an overall sense, the Columbia River basalt flows that underlie the study area form part of a regionally extensive, gently (less than 5°) northward-tilted homocline. This simple structural geometry is complicated in the eastern part of the study area by a relatively complex north-trending zone of deformation that partly coincides with the straight, north-trending segment of the John Day River (fig. 2). The zone is dominated by a discontinuous north-striking, high-angle normal fault that extends across the study area. The throw along this fault, which has down-to-the-west apparent displacement, decreases from about 600 ft 0.5 mi south of the study area to a negligible amount at the mouth of Pete Enyart Canyon (fig. 2). No fault displacement is evident along a projected strike distance of 0.5 mi north of this point. The fault reappears, along with an adjoining fault splay, in the vicinity of the tight river meander near the northeast corner of the study area, where the average fault throw is about 200 ft. The fault extends north of this point for 3 mi into the Thirtymile Wilderness Study Area. (Ach and others, 1988). The east-trending, west-plunging axis of a broad synclinal fold extends from the east across the area where the projected main fault trace shows no displacement. This fold, which most likely is the westward extension of a regional fold mapped by Swanson and others (1981), terminates against a partly concealed north-trending anticlinal bend and (or) normal fault about 0.25 mi west of the main fault (fig. 2). The latter structure, which downdrops rocks eastward toward the subparallel main fault (or its projection), is expressed by abrupt changes in flow dip (as steep as 21° E.), small-displacement high-angle faults, and areas of complexly sheared and fractured rock. The zone of deformation associated with the anticlinal bend extends as far east as the main fault. The increase in throw along the main fault north and south of the syncline axis suggests that the fault, and perhaps the entire north-trending zone of deformation, acted as a structural accomodation zone during deformation that separated folded rocks to the east from unfolded rocks to the west.

Several other east- to northeast-trending broad, open folds are in the region, mainly east of the study area (Swanson and others, 1981). Some of these folds are cut by subparallel high-angle faults that also 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 million years ago (see Bela, 1982, for references). Much of the tilting and subsidence of the southern part of the plateau was approximately coeval with this deformation.

Geochemical Studies

A reconnaissance geochemical study was undertaken using rock, stream-sediment, nonmagnetic- and bulk-panned-concentrate, and spring-water samples collected from the study area. Stream-sediment samples represent eroded bedrock and surficial material from drainage basins that collectively cover most of the surface of the study area. The stream-sediment medium reflects bedrock background geochemistry and can indicate major areas of mineralization. The prepared nonmagnetic fraction of panned concentrates may be useful for detecting minerals associated with mineralization and alteration and is more likely to reveal small or poorly exposed mineralized areas. The rock samples provide background geochemical data and may be used to more precisely locate mineralized areas. Spring water is collected to determine the presence of uranium.

We collected 15 stream-sediment, 11 nonmagnetic-concentrate, 10 bulk-concentrate, and 35 rock samples from in and near (within 0.25 mi of) the study area. One water sample was collected from a spring in the study area. All but three of the rock samples are from outcrops; the remaining rock samples are stream cobbles. All of the rock samples are basalt and are not obviously mineralized or altered. The stream-sediment, nonmagnetic-concentrate, and rock samples were analyzed for 31 elements using a six-step semiquantitative emission spectrographic method described by Grimes and Marranzino (1968) and were analyzed for gold by an atomic-absorption method described by Thompson and others (1968). The bulk-concentrate, stream-sediment, and rock samples were also analyzed for gold by a graphite-furnace atomic-absorption method (Meier, 1980) that provides a lower limit of detection of 0.002 parts per million (ppm) as compared to 0.05 or 0.1 ppm with the Thompson method. The stream-sediment and rock samples were analyzed for mercury by a method described by Koirtyohann and Khalil (1976) and for arsenic, antimony, bismuth, cadmium, and zinc by an inductively coupled argon plasma-atomic emission spectrographic method described by Crock and others (1987). The sediment, stream-cobble, and water samples were analyzed for thorium and (or) uranium by methods described by Millard (1976), Centanni and others (1956), and the Scintex Corporation (1978), respectively. The nonspectrographic analyses were conducted to provide data on elements not determined spectrographically or to provide data at lower levels of detection. Details of the sampling, preparation, and analytical methods and results are being prepared by B.M. Adrian and others (written commun., 1988)

For the purposes of defining anomalies, the geochemical threshold values for rocks and sediments have been calculated at either (1) three times the arithmetic means of elemental concentrations obtained for basalt samples collected from this study area and the two other nearby wilderness study areas or (2) three times the published average elemental concentrations in basalts (Levinson, 1980). For elements having calculated mean values below the lower limit of detection, the lower limit of detection is assigned as the threshold value. The threshold values for the nonmagnetic concentrates are chosen on the basis of experience with the medium. The threshold value for uranium in water was chosen as two times the average value in river waters (Levinson, 1980).

Anomalous concentrations of gold, silver, arsenic, copper, lead, tin, and (or) tungsten occur in four of the stream-sediment and three of all of the concentrate samples collected from the study area. A flake of gold and a grain of the mercury-ore mineral cinnabar were observed in two of the concentrate samples. Stream-sediment and concentrate samples collected in the study area are not considered to be as reliable as they are in other areas because of the strong possibility of contamination from flood-stage and older (perched) alluvium along the John Day River. All of the sediment-derived samples were collected at lower elevations than those of most of the perched alluvial deposits (see geology section), so at least some of the anomalies (and mineral grains) may be derived from the John Day River basin upstream from the study area. The anomalies are significant, however, in that they indicate the presence of some placer gold in the study area. Even if the anomalies are accepted as representative of bedrock in the study area, all but two concentrate anomalies are for single elements and are not considered significant by themselves. The two multi-element concentrate anomalies include large concentrations of tin and lead (as much as 2,000 ppm for each), both of which may result from contamination by lead shot and (or) other human artifacts that were seen in some concentrates.

Anomalous concentrations of gold, antimony, arsenic, barium, bismuth, cadmium, and mercury occur in 11 of the rock samples from the study area. The only gold value detected, 2.6 ppm (average of two analyses), is from a vesicular, silica- and clay-filled basalt sample collected on a ridge about 0.25 mi north of Big Gulch and 0.5 mi west of the John Day River (fig. 2). This sample also contains anomalous concentrations of the gold-pathfinder elements antimony, arsenic, and mercury. The other anomalous rock samples from the study area contain weak, generally single-element anomalies of bismuth and cadmium as well as the gold-pathfinder elements arsenic and barium. None of the remaining U.S. Geological Survey rock samples, however, contain detectable gold at the lower limit of determination (0.002 ppm). Gottfried and others (1972) reported that gold is most concentrated in mafic igneous rocks and that analyzed samples of Columbia River basalt averaged 0.005 ppm gold and ranged up to 0.011 ppm. The analytical method we used did not break down the silicate minerals, and this perhaps accounts for our lower readings. Any secondary gold introduced by mineralizing solutions, however, should have been detected by our method.

A rock sample collected by the U.S. Bureau of Land Management (Davis, 1983) about 1 mi southeast of the collection site of our auriferous rock sample contains anomalous concentrations of gold (0.150 ppm), silver (0.6 ppm) and molybdenum (7 ppm). An additional U.S. Bureau of Land Management sample collected near Horse Mountain in the southern part of the study area (fig. 2) contains 0.060 ppm gold and 8 ppm molybdenum. These data, together with the U.S. Geological Survey data, give weak geochemical evidence that gold mineralization has taken place in the study area. The gold anomalies, however, are very spotty and are isolated from many of the gold-pathfinder-element anomalies. No corroborative evidence of epithermal alteration or mineralization, such as quartz veins or hydrothermal breccia, is present in or near the study area. Rock samples collected within the north-trending zone of faulted, sheared, and folded rock in the study area (see geology section and fig. 2) do not contain detectable gold but do show most of the gold-pathfinder anomalies. The anomalies may be derived from localized, inconspicuous, permeable fracture zones in and outside of the zone of deformation along which auriferous hydrothermal solutions flowed over a period of time. Concealed silicic intrusive rocks, if present, could possibly drive such a system.

No uranium or thorium anomalies were detected in any of the samples collected in the study area.

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 North Pole Ridge Wilderness Study Area. The sparsely distributed nature of all three data sets is adequate for addressing the regional structural and tectonic setting of the study area but does not permit assessment of mineral resource potential at deposit scales except in limited areas directly beneath detailed profiles.

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 400 ft above average terrain along east-west profiles spaced 6 mi apart and north-south profiles spaced 24 mi apart. Only one NURE profile actually crossed the study area; it was flown approximately east-west at latitude 45° 6.5' N. Anomalies within the study area are characterized by short wavelengths (500 to 6,000 ft), high amplitudes (100 to 1,500 nanoteslas, nT), and high gradients (1 nT per ft). Unmetamorphosed basaltic rocks, such as the Columbia River basalt flows exposed throughout the study area, commonly have high magnetic susceptibilities and high remanent magnetizations. In low-level aeromagnetic profiles, these volcanic rocks typically cause high-amplitude, short-wavelength magnetic anomalies that often obscure anomalies caused by deeper magnetic sources. Some of the individual highs and lows along magnetic profiles may indicate mineralized areas, but they are more likely to be the result of lateral variations in the abundance and characteristics of magnetite grains in shallow basaltic rocks.

The NURE magnetic profile indicates a region of relatively low magnetic intensity about 1 mi wide and centered at longitude 120°28' W. This depression approximately coincides with the north-trending zone of deformation in the eastern part of the study area (fig. 2) and may indicate associated alteration of magnetic minerals. There is no clear continuation of this magnetic depression, however, to adjacent NURE profiles to the north and south.

Gravity data from the vicinity of the study area were obtained from the National Geophysical Data Center, National Oceanic and Atmospheric Administration, Boulder, CO 80303. Gravity measurements are scattered at 3- to 6-mi spacing in the region, and none are actually within the study area. 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 cm^3 (167 lb per ft^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 to 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 from the Bouguer gravity data by removing a regional gravity field computed from a model of the crust-mantle interface, assuming Airy-type isostatic compensation (Jachens and Griscom, 1985). A regional perspective of the gravitational setting of the area can be seen on the isostatic residual map of 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. The study area lies within a broad positive isostatic residual anomaly. The anomaly is 20 milligals higher in amplitude than measurements in surrounding areas, has lateral dimensions of approximately 15 mi east-west and 30 mi north-south, and forms part of a chain of anomalies that trends northeast through northern Oregon. Riddihough and others (1986) noted that this lineament is on strike with similar gravity features in the Klamath Mountains in northwest California and have suggested that it reflects a pre-Tertiary continental boundary extending across this part of Oregon and Washington.

Radiometric data were collected as part of the NURE 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 along east-west flightlines spaced approximately 6 mi apart and at an average altitude of 400 ft above terrain. Only one profile actually crossed the study area. Count rates were low on this profile, and no anomalous radiation was detected. However, because only one flightline 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 flightline or buried a few feet or more beneath the ground surface.

Mineral and Energy Resource Potential

The North Pole Ridge Wilderness Study Area has moderate to low resource potential for gold in two types of deposits. The study area has low energy resource potential for oil and gas. There is no potential for geothermal energy.

The active Micron claims in the eastern part of the study area (fig. 2) reportedly yielded rock samples containing economically significant concentrations of gold. Our geologic investigations in this and all other parts of the study area did not indicate the presence of any hydrothermally altered or mineralized rocks. Aeromagnetic data collected over the eastern part of the study area, however, give some indication of altered magnetic minerals in rocks near the north-trending zone of deformation that crosses the eastern part of the study area (fig. 2). A few gold and gold-pathfinder geochemical anomalies detected in the present study also remotely suggest that auriferous hydrothermal fluids may have permeated localized fracture networks and porous rocks, mainly in the eastern part of the study area. These fluids may have deposited small amounts of gold or gold-bearing minerals at or near the surface. Such metal-bearing fracture networks, if present, may be interconnected with, and genetically related to, the north-trending zone of deformation. A possible heat source for a hydrothermal convection system in the region would be shallow, silicic-to-intermediate intrusions emplaced after eruption of, but concealed by, flows of the Columbia River Basalt Group. Mineralized fluids could have migrated upward from such intrusions into wall rock along pre-existing conduits such as high-angle faults and fractures. Gold and mercury epithermal ore deposits in the Ashwood and Horse Heaven mining districts south of the study area are associated with rhyolitic to andesitic near-surface plugs and adjoining faults of probable Oligocene age (Brooks, 1963; Peck, 1964; Brooks and Ramp, 1968). However, no intrusive rocks younger than Oligocene have been recognized in the region, and existing geophysical data do not suggest the presence of subsurface intrusive bodies. Thus, hydrothermal leakage along faults and fractures as a cause of the spotty gold geochemical anomalies in the study area is highly speculative, and assessing the likelihood for undiscovered ore deposits of gold and gold-related metals is difficult. The eastern part of the study area has moderate potential, certainty level B, for gold resources in epithermal deposits (fig. 2). This part of the study area contains most of the geochemical anomalies, the north-trending zone of faults, fractures, and folds, and the Micron (gold) claim group. The remainder of the study area, lacking any noticeable deformation and containing weak, scattered geochemical anomalies, has low resource potential, certainty level B, for gold in epithermal deposits.

Geochemical results from the U.S. Geological Survey and U.S. Bureau of Mines stream-sediment and concentrate sampling indicate small amounts of placer gold in the active, recent, and possibly reworked older alluvium of the John Day River. The source of this gold may have been mineralized intrusive rocks of the John Day Formation that are present upstream from the study area and are similar to those in the Ashwood and Horse Heaven mining districts. Alternatively, the gold may have traveled far down river from gold deposits in the Blue Mountains region (Brooks and Ramp, 1968). Although no placer gold resources have been identified in the study area, it is remotely possible that small undiscovered gold placers are contained in the older and (or) recent alluvium in the study area. The lower depths of the John Day River canyon in the study area, at or below the level of the perched, alluvium-mantled meander scars, have low resource potential, certainty level C, for gold in small placer deposits (fig. 2).

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 only 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 the thick Cenozoic volcanic cover causes difficulty in the interpretation of geophysical data (Newton, 1974). In addition, Cenozoic structures of the region differ from more structurally complex, 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 largest and oldest is the Columbia River basin of Cretaceous age (Newton, 1966, 1977; Fritts and Fisk, 1985a, b). The North Pole Ridge Wilderness Study Area is in the southwestern part of this basin. The smaller and slightly younger (latest Cretaceous) Ochoco basin (Thompson and others, 1984) lies to the south and does not extend as far north as this study area.

Oil and gas leases cover the study area. Four test holes were drilled in the vicinity of the study area between 1929 and 1957: three near Clarno, 12 mi to the south, and one near Condon, 13 mi to the northeast. Well logs for all holes are on file at the Oregon Department of Geology and Mineral Industries (DOGAMI), Portland, Oreg. The holes near Clarno indicate that pre-Tertiary rocks are overlain by 2,870 to 4,000 ft of rocks of the John Day and (or) Clarno Formations. One hole near Clarno, the Clarno Basin Oil Company's Burgess No. 2 (fig. 1), had a gas show, presumably from Cretaceous rocks. Asphalt-bearing geodes have also been found in the vicinity of Clarno (Collier, 1914; Buwalda, 1921).

The best studied and documented hole in the region is Standard Oil Company's Kirkpatrick No. 1, located near Condon (fig. 1; see also geology section). The lower 2,031 ft of the 8,726-ft hole was in Mesozoic sedimentary rocks, primarily argillite but including some graywacke and siltstone (Fox and Reidel, 1987). While the Mesozoic sedimentary rocks are thermally mature (Newton, 1979; L.H. Fisk, unpub. data, 1986; Summer and Verosub, 1987), the total organic content (TOC) of these rocks is low to very low (Brown and Ruth Laboratories, Inc., 1983; Fox and Reidel, 1987). Most of the organic material present is terrigenous, hydrogen poor, and gas prone (Brown and Ruth Laboratories, Inc., 1983).

For purposes of an oil and gas resource potential assessment, it is assumed that the subsurface stratigraphy of the study area is similar to that in the Kirkpatrick No. 1 hole. The types of Mesozoic rocks present in the lower part of the hole usually have poor porosity, thereby limiting their potential as reservoir rocks. Their lack of potential as source rocks is indicated by their low TOC. Whereas the rocks have been determined to be thermally mature, local Oligocene rhyolite intrusions (Fox and Reidel, 1987) may have produced intense local heating, degrading or driving off nearby hydrocarbons.

Fouch (1983) rated the study area as having "low potential" for oil and gas, and Fox and Reidel (1987) considered the area around the Kirkpatrick No. 1 well to have "marginal hydrocarbon potential." However, Davis (1983) considered the study area to have "moderate potential" for hydrocarbons. The possible lack of both suitable source and reservoir rocks and the possible local overheating indicate that there is little likelihood for the occurrence of oil and gas in the study area. Therefore, under the definitions used in this study, the entire study area is assessed as having low resource potential for oil and gas (fig. 2). The stratigraphy in the nearest drill holes may differ from that of the study area, and the lack of available seismic data precludes any knowledge of subsurface structure or potential hydrocarbon traps; a certainty level of B is assigned.

The study area has no resource potential for geothermal energy, certainty level D. The study area contains no hot 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). In addition, 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.

A	B	C	D
U/A UNKNOWN POTENTIAL	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
	M/B MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/D MODERATE POTENTIAL
	L/B LOW POTENTIAL	L/C LOW POTENTIAL	L/D LOW POTENTIAL
			N/D NO POTENTIAL

LEVEL OF RESOURCE POTENTIAL →

LEVEL OF CERTAINTY →

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		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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SELECTED SERIES OF U.S. GEOLOGICAL SURVEY PUBLICATIONS

Periodicals

Earthquakes & Volcanoes (issued bimonthly).
Preliminary Determination of Epicenters (issued monthly).

Technical Books and Reports

Professional Papers are mainly comprehensive scientific reports of wide and lasting interest and importance to professional scientists and engineers. Included are reports on the results of resource studies and of topographic, hydrologic, and geologic investigations. They also include collections of related papers addressing different aspects of a single scientific topic.

Bulletins contain significant data and interpretations that are of lasting scientific interest but are generally more limited in scope or geographic coverage than Professional Papers. They include the results of resource studies and of geologic and topographic investigations; as well as collections of short papers related to a specific topic.

Water-Supply Papers are comprehensive reports that present significant interpretive results of hydrologic investigations of wide interest to professional geologists, hydrologists, and engineers. The series covers investigations in all phases of hydrology, including hydrogeology, availability of water, quality of water, and use of water.

Circulars present administrative information or important scientific information of wide popular interest in a format designed for distribution at no cost to the public. Information is usually of short-term interest.

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.

Open-File Reports include unpublished manuscript reports, maps, and other material that are made available for public consultation at depositories. They are a nonpermanent form of publication that may be cited in other publications as sources of information.

Maps

Geologic Quadrangle Maps are multicolor geologic maps on topographic bases in 7 1/2- or 15-minute quadrangle formats (scales mainly 1:24,000 or 1:62,500) showing bedrock, surficial, or engineering geology. Maps generally include brief texts; some maps include structure and columnar sections only.

Geophysical Investigations Maps are on topographic or planimetric bases at various scales; they show results of surveys using geophysical techniques, such as gravity, magnetic, seismic, or radioactivity, which reflect subsurface structures that are of economic or geologic significance. Many maps include correlations with the geology.

Miscellaneous Investigations Series Maps are on planimetric or topographic bases of regular and irregular areas at various scales; they present a wide variety of format and subject matter. The series also includes 7 1/2-minute quadrangle photogeologic maps on planimetric bases which show geology as interpreted from aerial photographs. Series also includes maps of Mars and the Moon.

Coal Investigations Maps are geologic maps on topographic or planimetric bases at various scales showing bedrock or surficial geology, stratigraphy, and structural relations in certain coal-resource areas.

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Hydrologic Investigations Atlases are multicolored or black-and-white maps on topographic or planimetric bases presenting a wide range of geohydrologic data of both regular and irregular areas; principal scale is 1:24,000 and regional studies are at 1:250,000 scale or smaller.

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