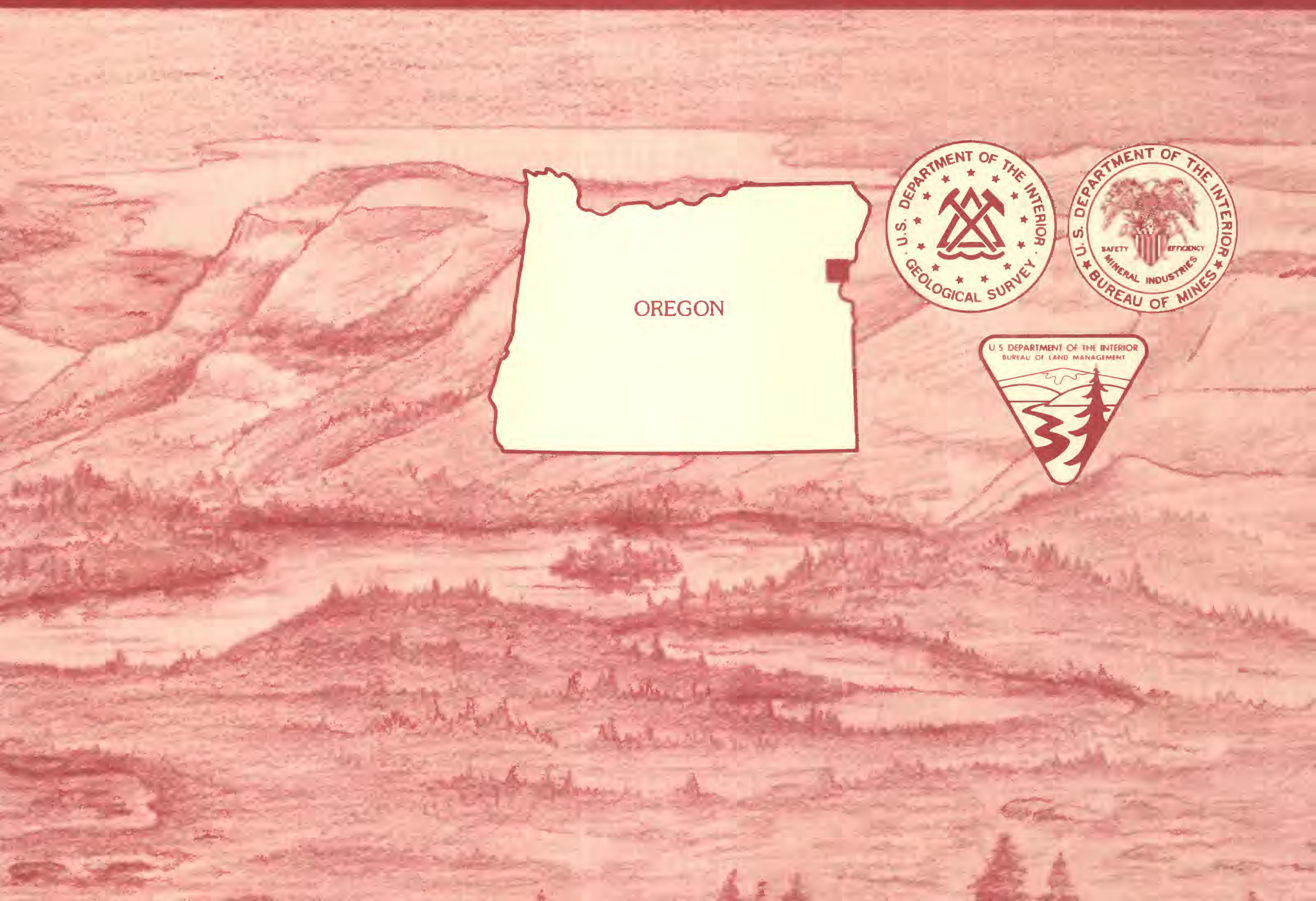
Mineral Resources of the Sheep Mountain Wilderness Study Area Baker County, Oregon

U.S. GEOLOGICAL SURVEY BULLETIN 1741–B



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Chapter B

Mineral Resources of the Sheep Mountain Wilderness Study Area, Baker County, Oregon

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U.S GEOLOGICAL SURVEY BULLETIN 1741

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
EAST-CENTRAL 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 U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of a part of the Sheep Mountain Wilderness Study Area (OR–006–003), Baker County, Oregon.

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Mineral Resources of the Sheep Mountain Wilderness Study Area, Baker County, Oregon

By Roger P. Ashley, Robert C. Roback, Robert L. Turner, *and* Robert C. Jachens
U.S. Geological Survey

Terry J. Close *and* Richard L. Rains
U.S. Bureau of Mines

SUMMARY

Abstract

At the request of the U.S. Bureau of Land Management, 7,040 acres of the Sheep Mountain Wilderness Study Area (OR-006-003) were evaluated for identified mineral resources (known) and mineral resource potential (undiscovered). In this report, the area studied is referred to as the "wilderness study area" or simply "the study area;" any reference to the Sheep Mountain Wilderness Study Area refers only to that part of the wilderness study area for which a mineral survey was requested by the U.S. Bureau of Land Management. Fieldwork was conducted in 1985 and 1986 to assess the mineral resources and resource potential of the area. No mineral resources were identified.

A low potential exists for silver, lead, zinc, copper, and gold in polymetallic vein deposits in the southeastern part of the Sheep Mountain Wilderness Study Area. The area has no geothermal energy, uranium and thorium, or oil and gas resource potential.

Character and Setting

The Sheep Mountain Wilderness Study Area is located on the west side of Hells Canyon, in the eastern part of Baker County, Oregon, about 46 mi east of the city of Baker (fig. 1). Elevations in the study area range from about 1,800 ft near the Snake River to about 4,900 ft on the high ridge in the central part of the study area.

The study area is underlain mainly by basaltic lava flows of the Columbia River Basalt Group of Tertiary (Miocene) age (see appendixes for geologic time chart). These rocks unconformably overlie plutonic and metasedimentary rocks of late Paleozoic and early Mesozoic age that are exposed along the southeast boundary of the study area.

Identified Mineral Resources

No mineral resources or prospects were identified within or adjacent to the Sheep Mountain Wilderness Study Area. Basalt, which covers most of the study area, contains common opal and agate that are of limited interest to mineral collectors. The basalt in the study area could be used locally as construction material (crushed stone or fill); however, suitable material is widespread in the region, and other areas of basalt are more accessible to possible markets.

Mineral Resource Potential

Geochemical data from stream-sediment and rock samples suggest that the exposed plutonic and metasedimentary rocks within the study area have low potential for silver, lead, zinc, copper, and gold in polymetallic vein deposits (fig. 2). The wilderness study area has no potential for geothermal energy, uranium and thorium, or oil and gas.

Manuscript approved for publication, June 21, 1988.

INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management and is the result of a cooperative effort by the U.S. Geological Survey and the U.S. Bureau of Mines. An introduction to the wilderness review process, mineral survey methods, and agency responsibilities was provided by Beikman and others (1983). The U.S. Bureau of Mines evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas. Identified resources are classified according to a system that is a modification of that described by McKelvey (1972) and U.S. Bureau of Mines and U.S. Geological Survey (1980). U.S. Geological Survey studies are designed to provide a 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.

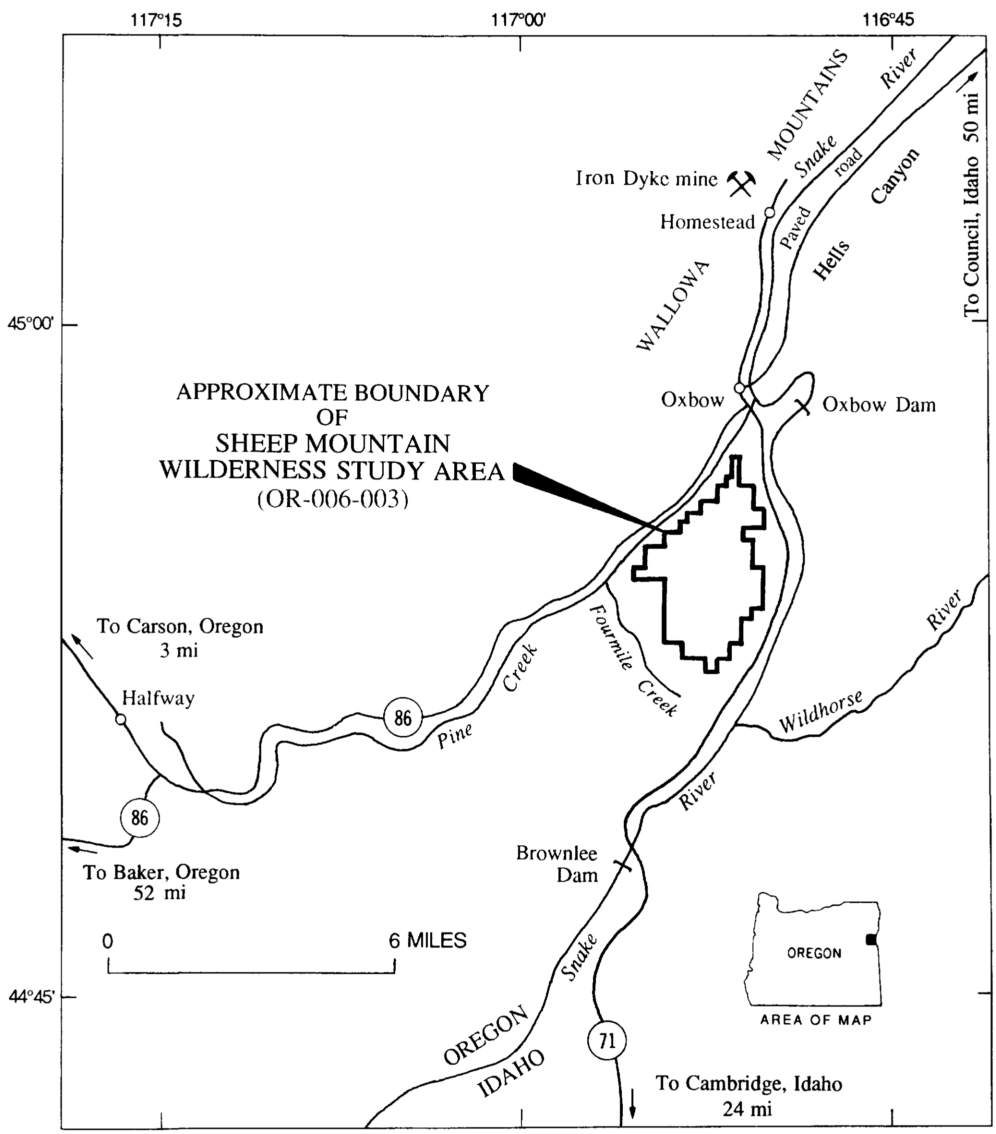

Figure 1. Index map showing location of the Sheep Mountain Wilderness Study Area, Baker County, Oregon.

Location and Physiography

The Sheep Mountain Wilderness Study Area comprises 7,040 acres near the north edge of the Payette section of the Columbia Plateau physiographic province (Fenneman, 1931). It is southwest of Oxbow Dam and occupies the divide between the Snake River and Pine Creek (fig. 1). The boundary of the study area follows the boundary between Federal and private land, except on the southeast side, where the area abuts a Federal power land withdrawal. The area is dominated by a nearly flat-topped ridge that reaches a maximum elevation of 4,940 ft and is dissected by rugged canyons. The lowest elevation, near the Snake River, is about 1,800 ft. Oregon Highway 86, located in the canyon of Pine Creek, passes close to the west boundary of the study area. Idaho Highway 71 extends from Cambridge, Idaho, to Brownlee Dam, then continues north on the Oregon side of the Snake River Canyon to Oxbow Dam, passing close to the east boundary of the study area.

The climate in the study area is semiarid. The lower and more exposed parts of the study area lie within the Big Sagebrush Vegetation Zone, characterized by big sagebrush (*Artemisia tridentata*), grasses, and various other shrubs (Frenkel, 1979). The higher and more sheltered parts of the area, including the valleys and north-facing slopes, support conifers, mainly Ponderosa pine (*Pinus ponderosa*).

Procedures and Sources of Data

Investigations of geology and mineral resources have been conducted north of the study area. Between 1973 and 1975, mines and prospects within Hells Canyon, north of the study area, were evaluated by Close and others (1982). Several reports describe the Homestead mining district and Iron Dyke mine (fig. 1; Oregon Department of Geology and Mineral Industries, 1939; Vallier and Brooks, 1970; Juhas and others, 1976, 1981). Vallier (1967, 1974) studied the geology of the Snake River Canyon, which includes only the northernmost part of the study area. Under a U.S. Bureau of Land Management contract, Fredericksen and Fernette (1983) conducted a GEM (geology, energy, and mineral resources) study of the Sheep Mountain Wilderness Study Area.

The U.S. Geological Survey conducted detailed field investigations of the Sheep Mountain Wilderness Study Area in the summers of 1985 and 1986. This work included geologic mapping at scales of 1:62,500 and 1:24,000, geochemical sampling, and examining outcrops for evidence of mineralization. Stream-sediment samples were collected at nine sites, and a fine fraction and heavy-mineral concentrate from each site were analyzed for minor elements. Rock samples were collected at 38 sites, mostly to obtain petrographic information; 18 samples from 11 of these sites were also analyzed for minor elements.

Prior to fieldwork, the U.S. Bureau of Mines searched Oregon State, Baker County, U.S. Bureau of Land Management, and U.S. Geological Survey records and publications for claim and minerals-related data. Fieldwork in 1986 involved a search for mineralized rocks that may not have been reported within or near the study area. Six rock and eight alluvium samples were taken. The rock samples were checked for radioactivity and fluorescence at the Western Field Operations Center of the U.S. Bureau of Mines and sent to a private laboratory for analysis. Concentrations of 18 elements were determined by inductively coupled plasma analysis. Reconnaissance samples of alluvium were reduced in the field by hand panning and further concentrated on a Wilfley table at the Western Field Operations Center. The resulting concentrate was then checked for gold, other heavy metals, and fluorescence and radioactivity. Complete results of sample analyses are available from the U.S. Bureau of Mines, Western Field Operations Center, 360 E. 3rd Ave., Spokane, WA 99202.

APPRAISAL OF IDENTIFIED RESOURCES

By Terry J. Close *and* Richard L. Rains
U.S. Bureau of Mines

No mining claims are known to have been located in the study area, and no mine workings were found during field investigations. Quartz-calcite veins in calcareous mudstone were examined at two sites in the southeastern part of the study area. At locality 1 (fig. 2), three parallel veins fill fractures in metasedimentary rocks over a distance of about 400 ft. The veins are as thick as 15 ft, strike N. 50° to 70° E., and dip 30° to 45° NW. At locality 2 (fig. 2), a 1-ft-thick vein strikes N. 15° E. and dips 65° SE. Country rock at both sites is sheared, kaolinized, and limonite-stained. Analyses of five samples from the veins, altered calcareous mudstone wallrock, and overlying basalt do not indicate the presence of metallic resources (Close and Rains, 1987).

Fredericksen and Fernette (1983) concluded that the study area has a moderate favorability for metallic resources based on the similarity of the geology to that at the Iron Dyke mine. The mine is in the Seven Devils Group, which hosts volcanogenic, Kuroko-type, silver-gold-copper deposits (Juhas and others, 1981; Close and others, 1982). However, recent studies by Morris and Wardlaw (1986) and Mann and Vallier (1987) indicate that rocks of the Seven Devils Group do not crop out or occur near the surface in the study area.

Eight reconnaissance samples of alluvium taken from drainages in and near the study area contain no gold or significant amounts of other heavy metals.

Basalt of the Columbia River Basalt Group can be used as construction material, including stone, crushed stone, or fill. Because of its low unit value and high transportation cost, basalt is a commodity that must have nearby markets, of which there are none at present. Ample supplies of suitable stone are available outside the study area to meet regional demand for rock products. Vugs and palagonite interbeds in the basalt contain common agate and opal of limited interest to mineral collectors.

There is no evidence of energy resources in the study area.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Roger P. Ashley, Robert C. Roback, Robert L. Turner, *and* Robert C. Jachens
U.S. Geological Survey

Geology

The Sheep Mountain Wilderness Study Area is dominated by a thick sequence of basaltic lava flows of Miocene age (fig. 2). These volcanic rocks overlie an older, com-

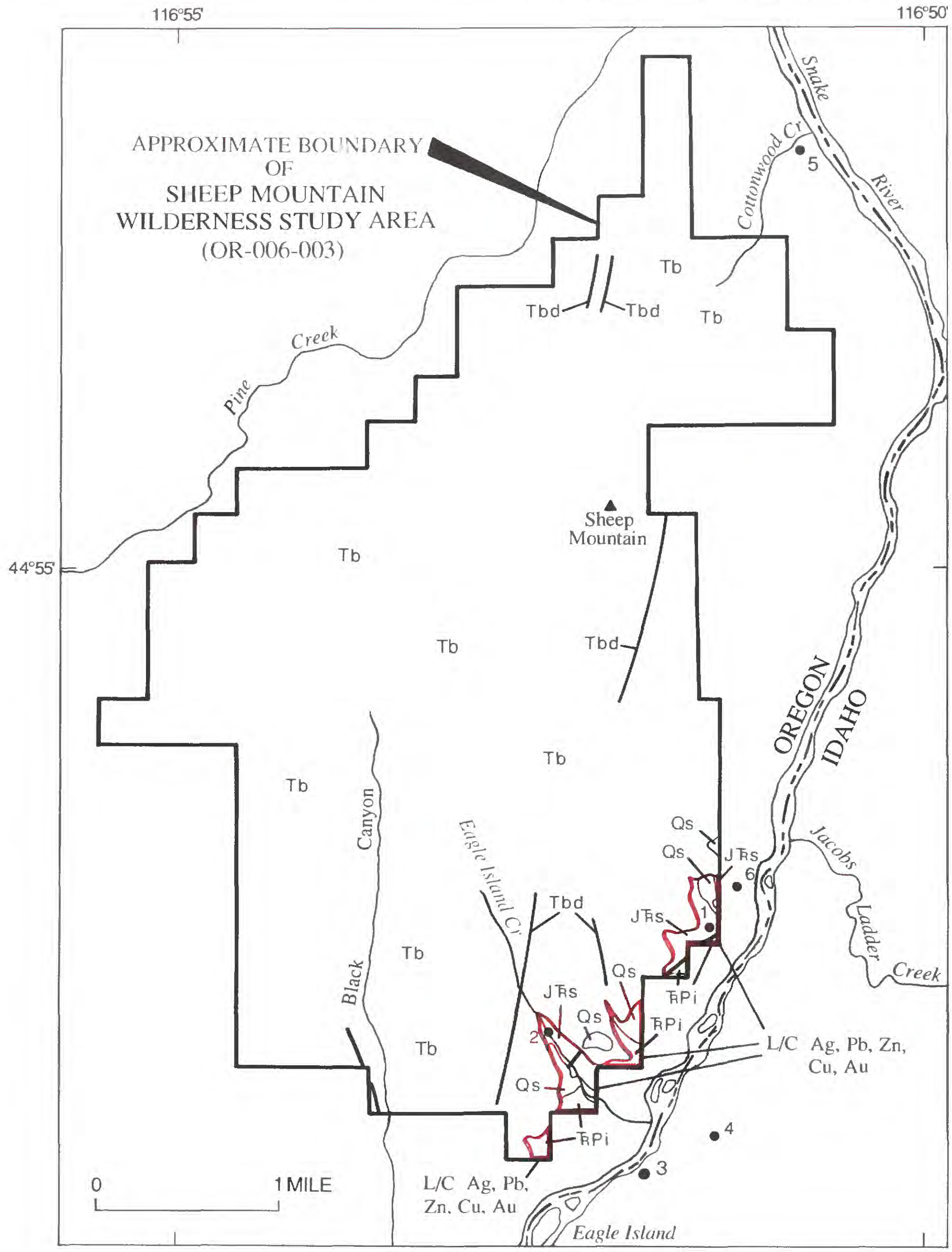

Figure 2. Mineral resource potential and generalized geology of the Sheep Mountain Wilderness Study Area, Baker County, Oregon.

plex geologic terrane composed of deformed and metamorphosed intrusive igneous rocks and sedimentary rocks of late Paleozoic and early Mesozoic age. After deformation and metamorphism, the Paleozoic and Mesozoic rocks were eroded for a long period, and the erosion surface was flooded by Tertiary lavas.

Paleozoic and Mesozoic Rocks

The Paleozoic and Mesozoic rocks are exposed only along the southeast edge of the study area (fig. 2). They are part of an inlier of older rocks exposed at the bottom of the Snake River Canyon from Eagle Island to the mouth of Jacobs Ladder Creek. To obtain adequate data for characterizing these rocks and determining their mineral resource potential, the entire pre-Tertiary inlier was examined. Another small pre-Tertiary inlier northeast of the study area, on both sides of the Snake River at the mouth of Cottonwood Creek, was also examined.

The oldest rock unit is an intrusive complex consisting mainly of plagiogranite, leucodiorite, and leucogabbro, as well as minor amounts of leucotonalite and diabase. These intrusive rocks have been metamorphosed; typical major constituents are albite, epidote, and chlorite, and typical minor constituents are white mica, sphene, and opaque oxides. Actinolite is a constituent of diabase, and relict quartz is a constituent of leucotonalite. Calcite is locally abundant in all rock types. The mineral assemblages are those formed under conditions of low-grade regional metamorphism (Winkler, 1979). All of these rocks show evidence of premetamorphic crushing and shearing, which produced cataclastic areas that were then rehealed by growth of metamorphic minerals, mainly epidote. Local breakage and suturing of plagioclase crystals indicate post-metamorphic shearing of some rocks.

The intrusive rocks are considered part of the (informal) Oxbow complex of Vallier (1974). The Oxbow complex consists of amphibolite, gabbro, plagiogranite, and diabase and is exposed in a northeast-trending belt at Oxbow Dam on the Snake River, about 2 mi northeast of the area (Brooks and Vallier, 1967; Vallier and others, 1977; Mann and Vallier, 1987). Radiometric dating indicates that intrusive rocks of this complex are probably Permian in age (Walker, 1981, 1983).

North of the intrusive complex is a belt of deformed sedimentary rocks that trends northeastward through the southeastern part of the study area. The southeastern part of this belt consists of interbedded limestone, argillite, graywacke, and volcanic sandstone and conglomerate. The northwestern part of the belt consists of conglomerate and breccia, locally including interbedded graywacke and argillite. Clasts in the conglomerates are mainly andesitic volcanic rocks; subordinate rock types include felsic volcanics, limestone, and chert. Beds strike northeastward to northward, and dip steeply to the northwest. Graded beds at one locality suggest the section is upright, so the strata are younger toward the northwest. The limestone and argillite part of the section contains conodonts of Late Triassic age (Morris and Wardlaw, 1986), and it is correlated with the Martin Bridge Limestone and Hurwal Formation (T.L. Vallier, oral commun., 1987). The volcaniclastic conglomerate and breccia are apparently in depositional contact with the limestone and argillite sequence, and therefore they must be younger, but have not been dated. They probably are correlative with one of the Triassic and Jurassic formations exposed to the north in the Wallowa Mountains and Snake River Canyon (Vallier, 1977; T. L. Vallier, oral commun., 1987).

The sedimentary rocks have also been metamorphosed. Major mineral constituents include albite, epidote or clinozoisite, chlorite, and calcite. Minor constituents include quartz, actinolite, white mica, hematite or opaques, and sphene or leucoxene. Some rocks have relict clinopyroxene, some have pumpellyite, and a few have both. The mineral assemblages generally reflect conditions of low-grade metamorphism. Locally, however, they reflect conditions of very low grade metamorphism.

EXPLANATION

Area having low mineral resource potential, (L); data give good indication of level of potential (C)

Commodities

Ag	Silver
Pb	Lead
Zn	Zinc
Cu	Copper
Au	Gold

Geologic map units

Qs	Surficial deposits (Quaternary)—Consists of alluvium and landslide deposits
Tbd	Basaltic dikes (Tertiary)—Feeder dikes in the Columbia River Basalt Group
Tb	Basalt flows (Tertiary)—Olivine-bearing lavas of the Columbia River Basalt Group
JTRs	Sedimentary rocks (Jurassic and Late Triassic)—Metamorphosed limestone, graywacke, argillite, and andesitic sandstone and conglomerate; in part correlative with the Martin Bridge Limestone and Hurwal Formation
TRPi	Intrusive rocks (Early Triassic and Permian)—Metamorphosed plagiogranite, leucodiorite, leucogabbro, leucotonalite, and diabase; correlative with the (informal) Oxbow complex
——	Contact
——	Fault
● 3	Geochemical sampling site—See text for discussion

Figure 2. Continued.

In the Sheep Mountain area, the intrusive complex is found only in fault contact with the deformed sedimentary rocks. In the Wildhorse River area, 2 mi to the southeast, similar plutonic rocks intrude a chert conglomerate and argillite sequence and are in fault contact with sedimentary rocks similar to those of the Sheep Mountain area (Mann and Vallier, 1987). The intrusive rocks also appear in the inlier just northeast of the area. These relations suggest that the Tertiary basalt section of the Sheep Mountain area is generally underlain by the Oxbow complex; they also suggest that metasedimentary rocks older than the complex and fault-bounded metasedimentary rocks younger than the complex are preserved locally.

Tertiary Rocks

The basaltic lava flows that dominate the Sheep Mountain area are part of the Columbia River Basalt Group (Waters, 1961). The erosion surface covered by the flows ranges from an altitude of 1,750 ft along the Snake River to 3,150 ft about 1 mi southeast of the study area, so local relief on the surface is at least 1,400 ft. The flows are nearly flat lying but dip about 5° westward. The dip-corrected thickness of the basalt section exposed from the Snake River to the top of Sheep Mountain is 3,180 ft.

The basalt section consists of numerous lava flows ranging from about 10 ft to as much as 200 ft in thickness, but most flows are between about 25 and 75 ft thick. Individual flows typically have a vesicular base overlain by a dense colonnade that grades upward into vesicular flow breccia. Lenses of bedded palagonite tuff are present locally between some flows; they contain fine to coarse basaltic fragments and are as much as tens of feet thick. Microscopic textures of most of the basalts are intersertal; brown basaltic glass fills interstices between plagioclase, clinopyroxene, opaque oxide, and clay-altered olivine crystals. Less commonly, the flows are hyalophitic; glass surrounds the crystalline minerals. About half the flows are porphyritic and contain plagioclase, clinopyroxene, and altered olivine phenocrysts. The dense interior parts of some of the thicker flows have subophitic to ophitic textures. The basaltic dikes that cut the flows also have intersertal or hyalophitic textures and are mineralogically similar to the flows. They were clearly feeders for flows higher in the section.

Quaternary Surficial Deposits

The lower reaches of the drainages contain poorly sorted, unconsolidated alluvium, within 0.5 to 1 mi of the Snake River. Colluvial basalt debris covers the easily eroded tops and bottoms of flows and, in some places, obscures the underlying pre-Tertiary rocks as well. A few small landslides are found at low altitudes in the southeastern part of the area.

Geochemistry

Methods

The U.S. Geological Survey collected and analyzed stream-sediment samples, heavy-mineral concentrates derived from stream-sediment samples, and rock samples. Stream sediments were collected at 9 sites and rock samples were collected at 11 sites.

The stream-sediment samples were collected from the active alluvium in the stream channels. Each sample is a composite of material from several localities along a channel length of approximately 50 ft. The stream sediments were sieved through an 80-mesh screen and pulverized to a fine powder before analysis. To obtain heavy-mineral concentrates, the stream sediments were sieved through a 10-mesh screen and then panned until most of the quartz, feldspar, clay-sized material, and organic matter were removed. The remaining light minerals were separated from the heavy minerals using a heavy liquid (bromoform). The magnetite and ilmenite were removed from the heavier fraction using an electromagnet. The nonmagnetic concentrates were ground to a fine powder before analysis.

Stream sediments represent a composite of rocks exposed in the drainage basin above the sample site. Heavy-mineral concentrates include most ore-forming and ore-related minerals and permit determination of some elements that are not easily detected in bulk stream sediments.

No evidence of alteration or mineralization was found within the area, but signs of alteration and mineralization were found at three localities within 0.5 mi of the wilderness study area boundary. Samples were collected from these localities to determine the suite of elements formed by alteration and mineralization. The rocks were pulverized to a fine powder before analysis.

All samples were analyzed using semiquantitative emission spectroscopy for 31 elements (Grimes and Marranzino, 1968; Crock and others, 1983). The rock samples were also analyzed for antimony, arsenic, bismuth, cadmium, and zinc using atomic-absorption spectrometry (O'Leary and Viets, 1986), for gold using atomic-absorption spectrometry (detection limit 0.1 parts per million, ppm; Thompson and others, 1968), and for mercury using cold-vapor atomic-absorption spectrometry (Koirtyohann and Khalil, 1976). A description of the analytical techniques is given by Crock and others (1987).

Results and Interpretations

Not enough data were available to establish geochemical background values by statistical methods. Analyses of altered basalts were compared to analyses for four unaltered basalt samples collected from three sites in the study area. Because basalt dominates all the drainage basins in the area, stream-sediment samples were also compared to the unaltered basalt samples. Analyses of altered intrusive rocks and one andesitic metavolcaniclastic rock were compared to average minor element abundances given for mafic, intermediate, and silicic igneous rocks by Rosler and Lange (1972) and Parker (1967). An element concentration was considered anomalous if it exceeded the appropriate comparison value by a factor greater than two.

The analytical data reveal that samples containing anomalous concentrations of various elements are limited to two areas. One area is defined by stream-sediment samples from drainages entering the Snake River between Black Canyon and the drainage about 1 mi northeast of Eagle Island Creek. These drainage basins include the southeastern part of the wilderness study area. One stream-sediment sample from the southeastern part of the study area contains an anomalous concentration of 0.11 ppm mercury. The heavy-mineral concentrates of two samples contain anomalous amounts of lead (2,000 ppm and 10,000 ppm). Except for the quartz-calcite veins described in the Appraisal of Identified Resources section, no notable evidence of alteration or mineralization was observed in outcrops on the west side of the Snake River in this area. On the east side of the river, however, altered and mineralized rocks are found within a 0.5 mi^2 area opposite the mouth of Eagle Island Creek (localities 3 and 4, fig. 2). Two rock samples contain anomalous concentrations of arsenic (33 and 88 ppm), bismuth (15 and 41 ppm), copper (200 and greater than 20,000 ppm), cadmium (0.8 and 1.0 ppm), and mercury (0.57 and 1.18 ppm). One of these rock samples contains anomalous values of silver (3 ppm) and zinc (250 ppm); the other contains an anomalous value of molybdenum (50 ppm). A third sample contains anomalous values of bismuth (2 ppm), molybdenum (7 ppm), cadmium (0.3 ppm), and mercury (0.64 ppm).

A rock sample collected at the mouth of Cottonwood Creek (locality 5, fig. 2) contains an anomalous concentration of mercury (0.24 ppm). This site is 0.5 mi from the northeast boundary of the wilderness study area.

Almost all the rock samples in both areas that contain anomalous values are from northeast-trending postmetamorphic shear zones in intrusive rocks of the Oxbow complex. Hydrothermal solutions moved along these shear zones, silicifying and mineralizing them, as shown by the presence of pyrite, limonite, and, more rarely, malachite. The mineralized rocks have anomalous concentrations of one or more of the elements arsenic, bismuth, copper, lead, mercury, molybdenum, cadmium, silver, and zinc.

One example of mineralized rock was found in rocks other than those of the Oxbow complex. Pyrite was observed along a northeast-trending postmetamorphic fault within the metasedimentary section at locality 6 (fig. 2). Amounts of cadmium (1.2 ppm) and antimony (2 ppm) in a sample of pyritic metavolcaniclastic rock from this fault zone are anomalous.

The basalt flows of the Columbia River Basalt Group within the study area have been altered locally. Evidence of alteration includes vesicle fillings of chalcedony (agate), opal, and zeolites; quartz stringers; and pervasive chalcedonic silica. Nine samples of altered basalt from four localities, however, have the same concentrations of elements as the four unaltered basalt samples collected to establish background abundances of elements. The lack of enrichment of ore-related elements suggests that the alteration was produced by circulation of groundwater through the basalt flows; it also suggests that the source of anomalous concentrations of elements in stream-sediment samples is most likely limited to the mineralized shear zones in the pre-Tertiary rocks.

Geophysics

Three types of geophysical data from northeastern Oregon (gravity, magnetic, and radiometric) were compiled and examined to aid in assessing the mineral resource potential of the Sheep Mountain Wilderness Study Area. The widely distributed nature of the three data sets makes them adequate for determining the regional structural and tectonic setting of the study area, but it does not permit detailed statements about mineral resource potential at the deposit scale, except in areas directly beneath detailed profiles.

Gravity Data

Gravity data for the region surrounding the study area were obtained from the National Geophysical Data Center, National Oceanic and Atmospheric Administration, Boulder, Colorado. Data points are scattered at 2- to 4-mi spacing in the region, but no data points are located within the study area boundary. The observed gravity data, based on the International Gravity Standardization Net datum (Morelli, 1974), were reduced to free-air gravity 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.

The Bouguer gravity field over the study area and surrounding regions reflects both shallow density contrasts and deep-crustal density distributions that correlate with the topography in a manner consistent with the concept of isostasy. To isolate that part of the gravity field that results from upper crustal density distributions, an isostatic residual-gravity map was constructed from the Bouguer gravity data. The method was removal of a regional gravity field computed from a model of the crustal-mantle interface. This model assumes Airy-type isostatic compensation (Jachens and Griscom, 1985).

The Sheep Mountain Wilderness Study Area lies near the east end of a gently curved, 50-mi-long by 15-mi-wide linear gravity high that trends mostly east-west. The gravity high lies a few miles south of the north edge of the pre-Cretaceous oceanic crust terrane of Brooks (1979) and roughly parallels the suture zone between this terrane and the Wallowa-Seven Devils terrane of Brooks (1979), to the north. Over much of its length, the source of the gravity high is concealed beneath Tertiary volcanic deposits; however, near Sparta, Oregon, about 20 mi west of the study area, the gravity anomaly culminates over a pre-Late Triassic intrusive complex composed predominantly of gabbro and altered gabbro (Brooks and others, 1976). Similar rocks are a likely source for the entire anomaly.

The gravity high near the study area suggests that the pre-Cretaceous basement beneath the area contains mafic intrusive rocks of the oceanic crust terrane similar to those exposed near Sparta. The study area lies within the gentle gravity gradient that defines the east end of the linear high. This gravity gradient may reflect a gradual transition from mafic intrusive rocks on the west to more felsic, less dense intrusive rocks to the east; or it may reflect an eastward increasing thickness of supracrustal sedimentary and volcanic rocks of the oceanic crust terrane.

Aeromagnetic Data

An aeromagnetic survey of the Baker 1° by 2° quadrangle, Oregon and Idaho, was flown and compiled under contract to the U.S. Department of Energy as part of the National Uranium Resource Evaluation program (Geodata International, Inc., 1978). Total-field magnetic data were collected along east-west flightlines spaced approximately 3 mi apart and at an average height of 400 ft above the terrain. Additional data were collected along north-south flightlines spaced approximately 12 mi apart. Corrections were applied to the data to compensate for diurnal variations of the Earth's magnetic field, and the International Geomagnetic Reference Field (updated to the months that the data were collected) was subtracted to produce a residual magnetic field.

Three flightlines traversed the study area. East-west flightlines crossed at latitudes 44°53'20" N. and 44°55'48" N. and a north-south flightline crossed at longitude 116°52'41" W. Magnetic measurements were made approximately every 250 ft along the flightlines.

The residual magnetic field over the study area is characterized by numerous short-wavelength anomalies (widths of 0.5 to 1 mi) superposed on a broad magnetic high that is bounded on the east by a broad magnetic low beginning about at the Snake River. The short-wavelength anomalies are caused by topography of the strongly magnetic Tertiary volcanic rocks exposed in the study area. The broad magnetic low east of the study area is spatially correlated with exposures of pre-Cretaceous basement (Mitchell and Bennett, 1979), thus indicating that the basement rocks are, for the most part, only weakly magnetic. Because the volcanic rocks within the broad low are strongly magnetic, they must be underlain at shallow depth by the pre-Cretaceous basement. The broad magnetic high over the study area probably reflects a section of Tertiary volcanic rocks that thickens to the west from near zero along the Snake River. A west-dipping surface on the pre-Cretaceous basement beneath the study area would account for the thickening.

Radiometric Data

Radiometric data were collected along the same flightlines and at the same altitude as the aeromagnetic data (Geodata International, Inc., 1978). Recordings were made of gamma-ray flux from radioactive isotopes of potassium, bismuth, and thallium. Count rates were low along flightlines over the study area and gave no indication of anomalous amounts of radioactive elements. However, because the flightlines are widely spaced and because gamma rays are attenuated by passage through Earth materials, these data do not preclude the presence of anomalous amounts of radioactive elements between flightlines or buried a few feet or more beneath the surface.

Mineral Resource Potential

The evaluation of mineral resource potential is based mainly on geologic and geochemical data, but it takes into account geophysical features and the absence of existing mines and prospects.

The southeastern part of the Sheep Mountain Wilderness Study Area has low mineral resource potential, certainty level C, for silver, zinc, lead, copper, and gold in polymetallic vein deposits. Geologic conditions suitable for these deposits are found only in the Paleozoic and Mesozoic plutonic and metasedimentary rocks. Because aeromagnetic data indicate that the Columbia River Basalt Group thickens to the west, the area of mineral resource potential is confined to the outcrop area of Paleozoic and Mesozoic rocks; however, any veins discovered near the basalt contact could conceivably be developed for short distances beneath the lavas. Although no polymetallic vein deposits have been found in the study area, such deposits are found in the Cuddy Mountain mining district, 6–8 mi to the southeast, and in the Homestead area (included in the Seven Devils mining district), 4–7 mi to the northeast (Livingston, 1923; Cook, 1954). The veins known in these districts have been explored and, in some cases, mined for one or more commodities including lead, zinc, copper, silver, and gold, but all the deposits were of small tonnage.

A descriptive model for polymetallic vein deposits is given by Cox (1986). A grade-tonnage model based on 75 deposits (Bliss and Cox, 1986) shows a median deposit size of 7,600 tons, and 10 percent of the deposits exceed 200,000 tons. Median grades for commodities in the model are 24 troy oz/ton for silver, 0.004 troy oz/ton for gold, 9 percent for lead, 2.1 percent for zinc, and less than 0.05 percent for copper. The small size of similar veins in northeastern Oregon and western Idaho and the low median tonnage in the grade-tonnage model indicate that any vein-type deposits found in shear zones or faults in the study area, although possibly high grade, are likely to contain only small quantities of base and precious metals (lead, zinc, copper, silver, and gold).

Fredericksen and Fernette (1983) concluded that the Sheep Mountain Wilderness Study Area is moderately favorable for metallic minerals, specifically in volcanogenic massive sulfide deposits, based on inferred similarity of the pre-Tertiary rocks to those that host such deposits in the Hells Canyon area to the north. As Fredericksen and Fernette (1983) note, however, all known deposits and occurrences of this type are restricted to metavolcanic and metavolcaniclastic rocks of the Seven Devils Group, and all are found north of Oxbow Dam. Paleontological data that were gathered during this study and by Morris and Wardlaw (1986) suggest that metavolcaniclastic rocks of the Sheep Mountain area are too young to be part of the Seven Devils Group. Massive sulfide deposits, which are characterized by conspicuous copper and zinc minerals and minor but often economically important amounts of precious metals, cannot be ruled out as a possible cause of some of the observed geochemical anomalies. We conclude, however, that no potential exists for base and precious metals in massive sulfide deposits. This conclusion is based on age of the metavolcanic rocks in the area and geologic observations that indicate all mineral occurrences in and near the area are of hydrothermal rather than volcanogenic origin.

The Sheep Mountain Wilderness Study Area lies within 20 mi of a large area in southwestern Idaho determined to be favorable for discovery and development of local sources of low-temperature (less than 90 °C) geothermal water (Sammel, 1979). The Blue Mountains region of Oregon, however, including the Sheep Mountain area, is characterized by normal heat-flow values (Blackwell and others, 1978), and the nearest known thermal spring is located 25 mi to the southwest (Oregon Department of Geology and Mineral Industries, 1982). Thus, there is no resource potential, certainty level D, for geothermal energy in the area.

No potential exists for oil and gas, certainty level D. This assessment is based on extensive metamorphism and plutonism in the Paleozoic and Mesozoic rocks and lack of hydrocarbon source rocks in the Tertiary volcanic section.

No potential exists for uranium and thorium, certainty level D. This assessment is based on lack of favorable igneous or sedimentary host rocks.

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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.

<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 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.
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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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