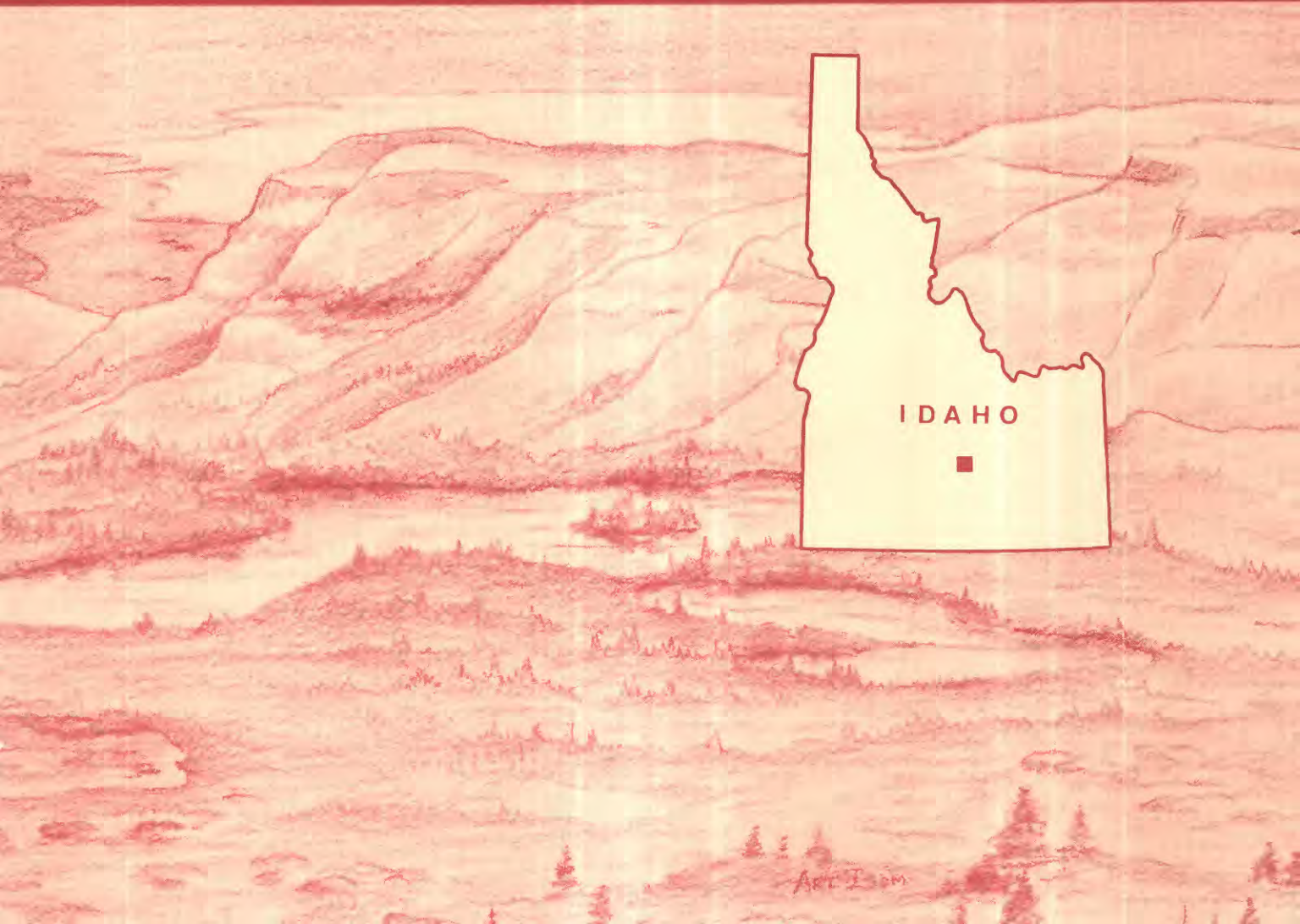
Mineral Resources of the Sand Butte Wilderness Study Area, Lincoln County, Idaho, and the Raven's Eye Wilderness Study Area, Blaine and Lincoln Counties, Idaho

U.S. GEOLOGICAL SURVEY BULLETIN 1721–C



Chapter C

Mineral Resources of the Sand Butte Wilderness Study Area, Lincoln County, Idaho, and the Raven's Eye Wilderness Study Area, Blaine and Lincoln Counties, Idaho

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MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
SOUTH-CENTRAL IDAHO

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94–579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the Sand Butte (ID-057–008) Wilderness Study Area, Lincoln County, Idaho, and the Raven's Eye (ID-057–010) Wilderness Study Area, Blaine and Lincoln Counties, Idaho.

CONTENTS

PLATE

FIGURES

TABLE

Mineral Resources of the Sand Butte Wilderness Study Area, Lincoln County, Idaho, and the Raven's Eye Wilderness Study Area, Blaine and Lincoln Counties, Idaho

By Margo I. Toth, Barbara B. Nevins, *and* Dolores M. Kulik,
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SUMMARY

The Sand Butte (ID–057–008) Wilderness Study Area, Lincoln County, Idaho, and the Raven's Eye (ID–057–010) Wilderness Study Area, Blaine and Lincoln Counties, Idaho, are southeast of the small town of Carey and southwest of the Craters of the Moon National Monument. A joint mineral resource study of the areas was completed in the summer of 1985 by the U.S. Geological Survey and the U.S. Bureau of Mines. The two wilderness study areas have low mineral resource potential for undiscovered metals, oil and gas, coal, and geothermal energy. Both wilderness study areas contain resources of decorative stone, and the Raven's Eye Wilderness Study Area also contains subeconomic resources of volcanic cinder.

Access to the wilderness study areas is provided by U.S. Highway 93 on the western and northern boundaries, and by secondary and unimproved roads along the eastern and southern boundaries. Rocks in the two areas are young basalt flows of the Snake River Plain that have a flat, moonscape terrain, which includes ridges, craters, fissures, depressions, crevices, and sparse vegetation. A few isolated volcanic buttes rise several hundred feet above the essentially flat terrain.

The Sand Butte Wilderness Study Area contains 2 tons of indicated subeconomic resources of decorative stone; several more tons, covered by a thin layer of loess, may occur nearby. The Raven's Eye Wilderness Study Area contains 18,000 tons of indicated reserves, 12,000 tons of indicated subeconomic resources, and 10,000 tons of inferred subeconomic resources of decorative stone. The area also contains 140,000 tons of identified resources of volcanic cinders and small occurrences of sand and gravel.

As part of this study, 73 rock samples and 1 water sample were collected for analysis. A stream-sediment sampling program could not be undertaken because of the lack of stream channels or sediment. None of the rock samples contained anomalous concentrations of any of the 31 elements for which we analyzed. Water sampled from a hot spring north of the Raven's Eye Wilderness Study Area did not contain anomalous concentrations of any of the analyzed elements. Geophysical studies suggest that the study areas are underlain by basalt, which thickens to the south of the study areas.

Both wilderness study areas have low mineral resource potential for undiscovered resources of all metals. The areas studied lack known host rocks and structures favorable for the occurrence of undiscovered oil, gas, or coal; thus the mineral resource potential for these commodities is also low. The potential of the occurrence of undiscovered oil, gas, or coal resources in the poorly known underlying rocks is also low.

Although hot springs occur to the north of the study areas, no thermal waters are known within the areas. The resource potential for undiscovered geothermal energy in the wilderness study areas is low.

INTRODUCTION

Young basalt flows cover the 20,792 acres of the Sand Butte (ID–057–008) Wilderness Study Area, Lincoln County, Idaho, and the 67,110 acres of the Raven's Eye (ID–057–010) Wilderness Study Area, Blaine and Lincoln Counties, Idaho. Because the two areas studied are contiguous and geologically similar, they are discussed together in this report.

Unimproved dirt roads form most of the boundary of the Sand Butte Wilderness Study Area. To the north, the Raven's Eye Wilderness Study Area is separated from the Sand Butte area by one of these roads (fig. 1). The Little Wood River is just west of the Raven's Eye Wilderness Study Area, and the western boundary is less than 2 mi (miles) east of the small towns of Carey and Tikura. The eastern boundary is less than 7 mi west of the Craters of the Moon National Monument.

U.S. Highway 93 roughly parallels part of the western and northern boundaries of the Raven's Eye Wilderness Study Area. The boundaries for both study areas are accessible by secondary and unimproved roads, and one four-wheel-drive road crosses Raven's Eye from Spud to Monument Butte; however, the interiors of the study areas are mostly inaccessible by vehicle because of the extemely rough surface of the young basalt flows.

The Sand Butte and Raven's Eye Wilderness Study Areas feature a flat, moonscape terrain, which includes ridges, craters, fissures, depressions, crevices, and a few isolated volcanic buttes rising several hundred feet above the terrain. Elevations in the Sand Butte Wilderness Study Area range from a low of 4,500 ft (feet) at the southern margin of the area, to a high of 4,974 ft at Sand Butte. In the Raven's Eye Wilderness Study Area, elevations range from about 4,600 ft at the southeastern edge of the study area to 5,003 ft at Spud Butte. Little or no vegetation grows on the younger lava flows, but bunch grass and sage cover the older lava flows. Perennial streams are not present within either study area, but there are ephemeral streams along the northern and northeastern margins of the Raven's Eye Wilderness Study Area.

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study area and is the product of several separate studies by the U.S. Bureau of Mines (USBM) and the U.S. Geological Survey (USGS). Identified resources are classified according to the system of the U.S. Bureau of Mines and the U.S. Geological Survey (1980) which is shown in the appendix of this report. Mineral resource potential is the likelihood of occurrence of undiscovered concentrations of metals and nonmetals, of unappraised industrial rocks and minerals, and of undiscovered energy sources (coal, oil, gas, oil shale, and geothermal sources). It is classified according to the system of Goudarzi (1984), which is shown in the appendix of this report.

EXPLANATION

- Area with identified resources of decorative stone
- ◆ C — Area with identified resources of cinder
- L/C — Terrane having low mineral resource potential for metals, oil, gas, coal, and geothermal energy, with certainty level C

Investigations by the U.S. Bureau of Mines

Work by USBM personnel entailed pre-field, field, and report preparation phases in 1985 and 1986. Pre-field studies included library research, review of aerial photographs, and perusal of U.S. Bureau of Land Management (BLM) mining and mineral lease records and of USBM and other production records. Field studies involved air and ground searches for deposits of decorative stone in localities chosen from aerial photographs. Areas with high concentrations of decorative stone were examined and, where warranted, mapped and sampled.

Areas that have high concentrations of decorative stone, traced from aerial photographs, are areas that have a high percentage of slab pahoehoe (smooth, ropy-textured lava). Six samples of stone suitable for decorative veneer were taken to determine the apparent density for resource calculation. Each sample was cut into a cube with a rock saw, and volume of the sample was determined. Apparent density was calculated by dividing the weight of the sample by the volume.

Cinder resources were calculated for a small spatter cone in SW¼ sec. 3, T. 2 S., R. 22 E. (pl. 1). Volume was determined by digitizing 10-ft contours of the cinder cone and applying Simpson's rule, a rule to determine the volume of an irregular shape. Apparent density was calculated by the same method used to calculate the density of decorative stone.

Investigations by the U.S. Geological Survey

The USGS undertook a mineral resource assessment of the Sand Butte and Raven's Eye Wilderness Study Areas in the summer of 1985. The work consisted of field checking previous mapping by LaPoint (1977), collecting rock samples, and reviewing the geology and published geochemistry of the Snake River Plain basalts. A stream-sediment sampling program was not undertaken because of the absence of flowing streams within the study areas and the lack of streams outside of the boundaries which exclusively drained the areas studied.

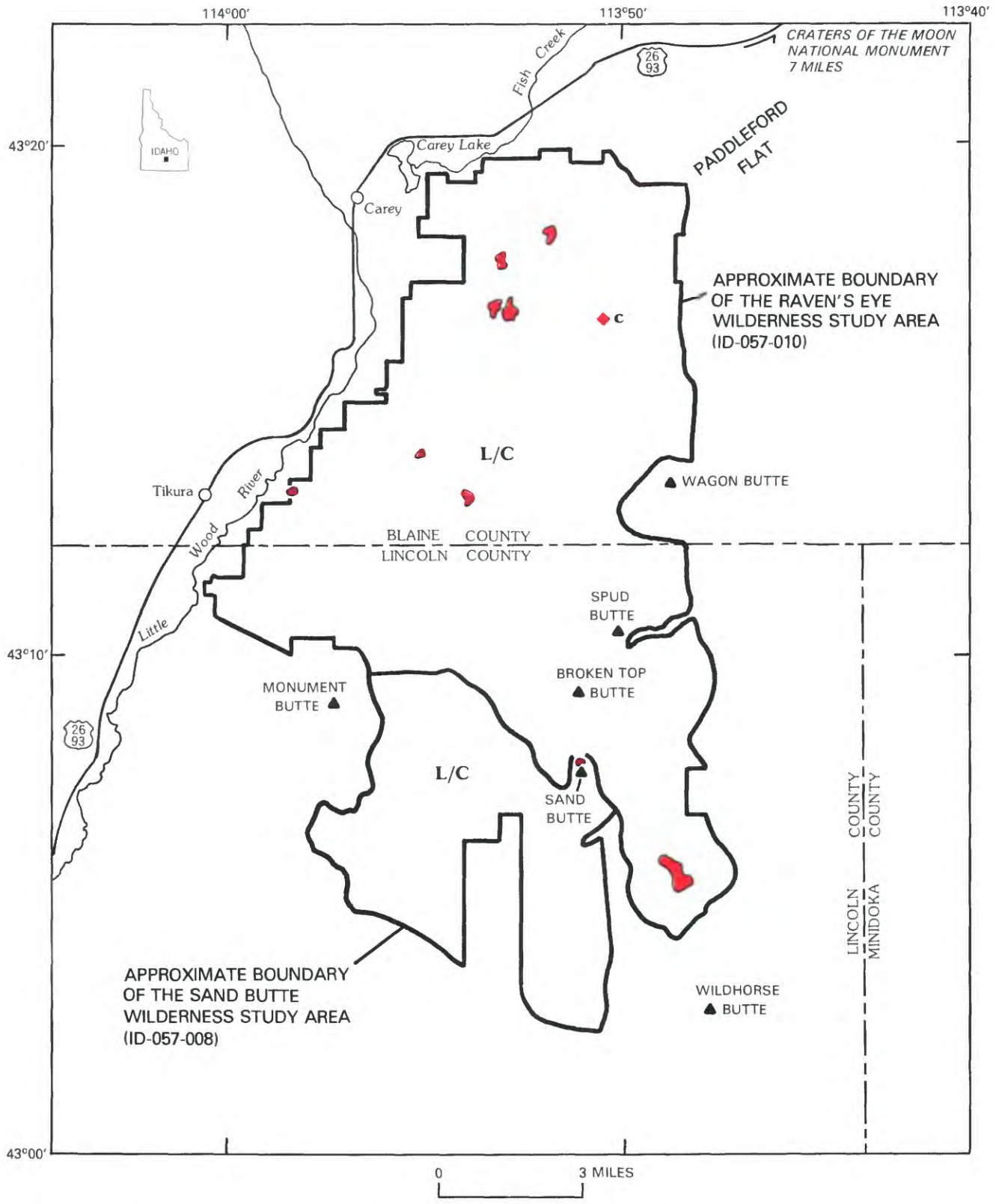

Figure 1 (above and facing page). Map showing mineral resource potential, identified resources, and location of the Sand Butte and Raven's Eye Wilderness Study Areas, Idaho

Acknowledgments.—D.S. Hovorka and D.J. Maloney assisted in sampling the two areas. Larry Dee, geologist, BLM, Shoshone district, provided aerial photographs and historical mining data. Terry Maley and Tim Carroll, geologists, BLM, Idaho State Office, shared decorative stone market data gathered by BLM staff geologists since 1980.

APPRAISAL OF IDENTIFIED RESOURCES

By Alan R. Buehler and Phillip R. Moyle
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Mining and Mineral Exploration History

Basaltic lava rock from the eastern Snake River Plain has been used as dimension stone in the Idaho Falls area since the 1880's (Mansfield, 1927), and more recently as decorative stone. The blocky building stone variety is no longer in vogue. Slabs of pahoehoe lava, found as float near the Raven's Eye Wilderness Study Area, have been mined and marketed as decorative stone for more than 15 years as a result of strong demand for earth-tone veneers. Mining of float consists of selecting suitable flat material, generally 1–3 inches thick and 8 or more inches in diameter, and loading it onto trucks.

Total annual trespass removal of decorative stone from the vicinity is unknown, but there are few known illegal removal sites (Larry Dee, personal commun., 1985). Currently, there are two common-use areas located near the Raven's Eye Wilderness Study Area which meet persistent local demand for decorative stone. One is at Black Butte, 18 mi west of the Raven's Eye Wilderness Study Area; the other is between Shoshone and Gooding, about 35 mi southwest.

Most decorative stone resources within the Raven's Eye Wilderness Study Area are concentrated as pahoehoe slabs within areas of the Sunset-Carey lava flow (unit Qbl, pl. 1). The flow originated in the Craters of the Moon National Monument and is the youngest in the study areas. The remaining decorative stone resources are in an aa flow which erupted at Sand Butte.

Mines and Prospects, Mining Claims, and Leases

No mines and prospects, mining claims, or leases occur within or adjacent to the study areas. However, the Lava Creek mining district is 10 mi northeast of the Raven's Eye Wilderness Study Area (Kuntz and others, 1980). Host rocks of the Lava Creek district are exposed 3–5 mi north of the Raven's Eye Wilderness Study Area, and a small number of claims have been filed there on base and precious metal occurrences.

Decorative Stone

Marketing

Slab pahoehoe, similar in most respects to that which occurs in the study area, is mined from the Hell's Half Acre lava field in the Idaho Falls–Blackfoot area, from Black Butte near the study area, and from other areas near Shoshone and Gooding. It is marketed as decorative veneer in Idaho and throughout the Pacific Northwest and competes with other varieties of decorative rock as well as brick and culture (synthetic) stone.

A 1984 market survey of stone dealers in Spokane, WA, and Boise and Idaho Falls, ID, showed retail prices for decorative stone ranging from $50 to $70/ton for field rubble (field basalt) to about $250/ton for travertine mined in Montana and a variety of slab pahoehoe mined from Black Butte. Slab pahoehoe from the Hell's Half Acre lava field, 70 mi east of the study area, retailed for $125/ton and competed well with other stone varieties (Moyle and Winters, 1985). Two dealers stated that slab pahoehoe, sold under the name Idaho Moss, is the most popular wall and fireplace veneer in the Spokane area. Annual sales in Spokane in the early 1980's were 500 to 1,000 tons/year.

Observed on pallets in stoneyards, the stone is slab-like, ranges in thickness from 1 to 3 in., is generally from 8 to 12 in. or more in diameter, and commonly has lichen or moss growth on the weathered surface. The tops of the slabs have a frothy or ropy appearance, whereas the undersides have some drip features and casts of older flows. The unweathered underside of slab pahoehoe is used by some masons for a decorative appearance. The relatively light weight (low apparent density due to numerous gas cavities or vesicles) eases handling and gives large coverage per ton of stone. According to dealers, 1 ton of slab pahoehoe will generally cover 70–120 ft^2 (square feet), depending on thickness, whereas 1 ton of nonvesicular decorative stone covers only 35–50 ft^2.

Production Costs

Detailed studies of the Hell's Half Acre lava field by Moyle and Winters (1985), and economic data from historic and analogous mining operations were used to determine the minability and production costs of slab pahoehoe from the Raven's Eye Wilderness Study Area. Mining typically includes removal of float or rock and transportation to a central point. The BLM assesses a royalty of $15/ton and $6/ton in the two common-use areas near the Raven's Eye Wilderness Study Area, based upon quality of the decorative stone.

An inventory conducted in 1980 by BLM staff geologist Tim Carroll (personal commun., 1984) deter-

mined that marketable slab pahoehoe on the Hell's Half Acre lava field, 70 mi east of the study areas, ranges from 0 to more than 5 tons/acre, and averages 1 ton/acre. Data from a 1979 competitive stone sale indicated mining costs of $10 to $20/ton, a shipping cost to Spokane, WA, of about $20/ton, and a profit of about $20/ton.

By comparison, the 1979–1980 mining cost for slab pahoehoe mined at Black Butte ranged from $32 to $35/ton with shipping costs of $4/ton to Boise, ID, and $20/ton to Bend, OR (Maley and Holland, 1981). The marketable Black Butte variety of slab pahoehoe is 90 tons/acre. Parcels considered depleted by commercial operators still contain from 6 to 16 tons/acre in accessible areas; this is an indication of the lower economic limit for commercial operations.

Reserves and Identified Decorative Stone Resources

The USBM mineral survey identified slab pahoehoe suitable for decorative wall veneer in 8 parcels in the Raven's Eye Wilderness Study Area (pl. 1, table 1). Stone resources and other pertinent data are given in detail in Buehler and Moyle (1986). Two tons of slab pahoehoe suitable for use as decorative stone are along the northeastern boundary of the Sand Butte Wilderness Study Area (pl. 1) (Buehler, 1986). Several more tons, covered by a thin layer of loess may occur nearby. The pahoehoe is part of a lava flow from Sand Butte which repeatedly overflowed the banks of its channel and formed 1.5- to 6-in.-thick layers of basalt.

The Raven's Eye Wilderness Study Area contains a total of about 40,000 tons of 1.5- to 4-in.-thick slab pahoehoe resources suitable for wall veneer. Two localities contain a total of 18,000 tons of indicated reserves (pl. 1, nos. 3 and 4); the marketable stone in these areas ranges from 160 to 170 tons/acre and the pahoehoe slabs range from 1.5 to 4 in. thick. Approximately 12,000 tons of indicated, subeconomic slab pahoehoe resources occur in the remaining 6 parcels; the marketable stone in these areas ranges from 23 to 59 tons/acre and the pahoehoe slabs range from 1.5 to 3 in. thick.

Field studies indicate that portions of the Raven's Eye Wilderness Study Area containing slab pahoehoe, but not included in the parcels shown in plate 1, total approximately 10,000 acres with an average of 1 ton of slab pahoehoe per acre. A total of 10,000 tons of subeconomic resources are inferred within these areas.

Decorative stone resources within the study areas will probably not attract commercial interest in the near future due to the difficult access and small size relative to other reserves elsewhere. Scattered throughout the remainder of the study areas are sites which contain a relatively low number of tons of suitable slab pahoehoe per acre and are considered subeconomic for large volume, commercial operations. The reserves and resources may be of interest to consumers who gather their own decorative stone to avoid wholesale and retail markup. The economic classifications given for slab pahoehoe, discussed previously, assume a continuing market of adequate volume.

Other Rock Commodities

The Raven's Eye Wilderness Study Area contains an occurrence of 140,000 tons of volcanic cinders which may be suitable as a surfacing for local roads, but they cannot compete commercially with large deposits closer to markets.

Two common-borrow or sand-and-gravel pits are shown on plate 1, and numerous others are within a few miles of the study areas (Strowd and others, 1981). A small amount of gravel has been removed from the pit at the western edge of the Raven's Eye Wilderness Study Area and has been used as surfacing for roads. The deposit is of small areal extent, is extremely thin, and is not large enough to attract commercial interest.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

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U.S. Geological Survey

Geology

Geologic Setting

The Sand Butte and Raven's Eye Wilderness Study Areas are on the western edge of the eastern Snake River Plain physiographic province. The Snake River Plain is a basalt-filled topographic depression, expressed as a 330-mi-long and 60-mi-wide arc across southern Idaho. Older rocks occur to the north and south of the plain. The eastern half of the plain has folded Paleozoic (see geologic time chart in appendix of this report) and Mesozoic rocks to the north and south. The western half of the plain has Cretaceous granitic rocks of the Idaho batholith on the north and Tertiary rhyolitic and basaltic rocks on the south.

The Snake River Plain contains as much as 6,000 ft of late Pliocene to Holocene basalts (Zohdy and Stanley, 1972). More silicic rocks form isolated outcrops (King, 1977). Volcanic rocks of the Snake River Group range in age from Late Pleistocene to Holocene. Volcanism of the eastern Snake River Plain shows charac-

Table 1. Decorative stone resources of the Raven's Eye Wilderness Study Area, Idaho

Site no. (plate 1)	Area (acres)	Usability factor[1] (percent)	Average thickness (inches)	Apparent density (lb/ft^3)	Resource size[2] (tons)	Frequency factor[3] (tons/acre)	Coverage factor[4] (ft^2/ton)
			INDICATED RESERVES				
3	42	40-50	1.5-2	120	7,200	170	110
4	69	20	3-4	127	11,000	160	54
			INDICATED SUBECONOMIC RESOURCES				
1	29	10	2-3	[5]126	1,700	57	76
2	19	10	2	130	900	47	92
5	10	10	2-3	129	590	59	74
6	12	10	2-3	[5]126	690	57	76
7	18	5	2	128	420	23	94
8	137	10-20	1.5-2	123	8,000	59	110
			INFERRED SUBECONOMIC RESOURCES				
Entire study area	10,000	(estimate 1 ton/acre average)			10,000		

Total indicated reserves	18,000
Total indicated subeconomic resources	12,000
Inferred subeconomic resources	10,000
Total resources	40,000

[1]Estimated percentage of area containing slab pahoehoe suitable for decorative stone veneer.
[2]Data may not add to totals because of independent rounding.
[3]Tons/acre of slab pahoehoe suitable for decorative stone veneer.
[4]Area in square feet that a mason can cover with 1 ton of decorative veneer.
[5]Estimated.

teristics of both basaltic shield volcanoes and flood basalts; Greeley (1976; 1977) has termed this combination eruptive style basaltic "plains" volcanism. In contrast to major flood basalt fields, the style of the Snake River Plain volcanism is characterized by small shield volcanoes erupted from central vents, thin sheet-flows fed from short fissures, tube-fed flows, and intracanyon flows.

A northeast-trending structural zone, the Humboldt lineament, dominates northern Nevada and extends through southern Idaho, adjacent to the study areas, into central Montana. This broad zone of left-lateral and dip-slip faulting was active in Nevada in post-middle Miocene time (Rowan and Wetlaufer, 1981). Springs with temperatures greater than 190 °F occur in northern Nevada (Blackwell, 1978) primarily along the Humboldt structural zone (Rowan and Wetlaufer, 1981). In Idaho, one hot spring (120 °F) is less than a mile northwest of the Raven's Eye boundary, but no hot springs are known within either study area.

Description of Rock Units

The Sand Butte and Raven's Eye Wilderness Study Areas contain basalts of the Snake River Group, which are consistent in texture, chemistry, and mineralogy. The lavas are low in silica, sodium, and potassium and are high in total iron content (Stone, 1967). The basalts are typically porphyritic, and crystals of olivine and plagioclase make up almost 20 percent by volume (Leeman, 1982). Petrologic data on the rock units within the Sand Butte and Raven's Eye areas are limited. Plate 1 is a geologic map of the two study areas, modified from LaPoint (1977).

The oldest unit in the area studied (unit QTb, pl. 1) extends into the north-central part of the Raven's Eye Wilderness Study Area. LaPoint (1977) includes the oldest flows of the Snake River Group and older, unformalized, flows in this map unit. To the south of the study areas the older basalt flows (unit QTb) are composed only of Pliocene flows of dark-gray to dark-brown, olivine-rich, pahoehoe basalt (Armstrong and others, 1978); this unit is mostly buried by younger basalt flows and its distribution is irregular. About 40 mi south of the study areas, at Antelope Hill, flows of this unit were dated at 2.3 ± 0.03 m.y. (million years) (Armstrong and others, 1975).

The lower basalt flows (unit Qbl, pl. 1) cover all of the Sand Butte Wilderness Study Area and the eastern and northern parts of the Raven's Eye Wilderness Study Area. This unit includes the Pleistocene flow units Qb_1, Qb_2, and Qb_4 of LaPoint (1977) who differentiated these flows by relative age based on aerial photographic interpretations. The Qb_4 flows have been mapped by Kuntz and others (1979) in the Lava Ridge–Hell's Half Acre area about 40 mi east-northeast of the study areas. In that area the unit is composed of a sequence of gray to black pahoehoe flows and associated pyroclastics that erupted about 12,000 to about 700,000 years ago from numerous fissure-controlled vents. LaPoint (1977) indicated two possible source vents for Qb_4 several miles southeast of the Sand Butte Wilderness Study Area.

The upper lava flows, (unit Qbu, pl. 1), cover about half of the Raven's Eye Wilderness Study Area. This unit consists of medium-gray pahoehoe lava flows that have fresh, relatively unweathered surfaces with a lustrous blue coating. Kuntz and others (1982) suggest that the Qbu flow covering the Raven's Eye Wilderness Study Area is part of the 12,000- to 12,900-year-old Craters of the Moon lava field. The source vent for the flows is thought to be at Sunset Cone, approximately 16 mi northeast of the flows.

Surficial deposits (unit Qs, pl. 1) are primarily alluvium in the Little Wood River drainage along the northwestern boundary of the Raven's Eye Wilderness Study Area.

Geochemistry

Methods

The geochemical survey of the study areas consisted of sampling rocks for analysis. A stream-sediment sampling program could not be undertaken because of the absence of flowing streams or sediment. Rock samples were collected at about 1-mi intervals along all of the roads that accessed the areas. About 0.5 lb (pound) of unweathered, thumb-size rock chips were collected at each locality. Fifty-nine samples were collected from the Raven's Eye Wilderness Study Area, and 14 samples were collected from the Sand Butte Wilderness Study Area. In the laboratory, samples were crushed and pulverized to less than 100 mesh (0.0059 in.), then analyzed by semiquantitative emission spectrography for 31 elements as described by Grimes and Marranzino (1968), and for arsenic, bismuth, cadmium, antimony, and zinc by flame atomic absorption. L.R. Layman, M.J. Malcolm, and D.L. Fey did the analyses.

North of the Raven's Eye Wilderness Study Area three hot springs are indicated on the U.S. Geological Survey quadrangles Carey and Paddleford Flat adjacent to State Highway 26. Two of these springs had cool water and had a very small discharge. The spring at Hot Springs Ranch, however, contained hot water (120 °F), and was sampled for analysis. Collection procedures and analytical techniques are described in McHugh and others (1981); J.B. McHugh analyzed the sample.

Results

The geochemical data for the rock samples show little variation. Of the elements analyzed for, only antimony, barium, beryllium, chromium, cobalt, copper, lanthanum, lead, nickel, vanadium, scandium, cadium, yttrium, niobium, zirconium, and strontium were present in detectable concentrations. Most of these elements were present in concentrations close to the detection limits, and many of them were detected in only a few of the samples. None of the elements was present in anomalous concentrations. Water sample RBN001 from the Hot Springs Ranch did not contain anomalous concentrations of any of the analyzed elements.

Geophysics

Geophysical data provide information on the subsurface distribution of rock masses and the structure of those masses. Gravity studies were undertaken as a part of the mineral resource evaluation of the study areas. Published aeromagnetic data were reviewed.

Gravity Data

Gravity data were obtained from files maintained by the Departmentof Defense and supplemented by data obtained by D.M. Kulik in 1985 at 70 stations. Bouguer gravity anomaly values were computed using the 1967 gravity formula (International Association of Geodesy, 1967) and a reduction density of 2.67 g/cm^3 (grams per cubic centimeter). Terrain corrections were made by computer for a distance of 100 mi from each station using the method of Plouff (1977). The data are shown on figure 2.

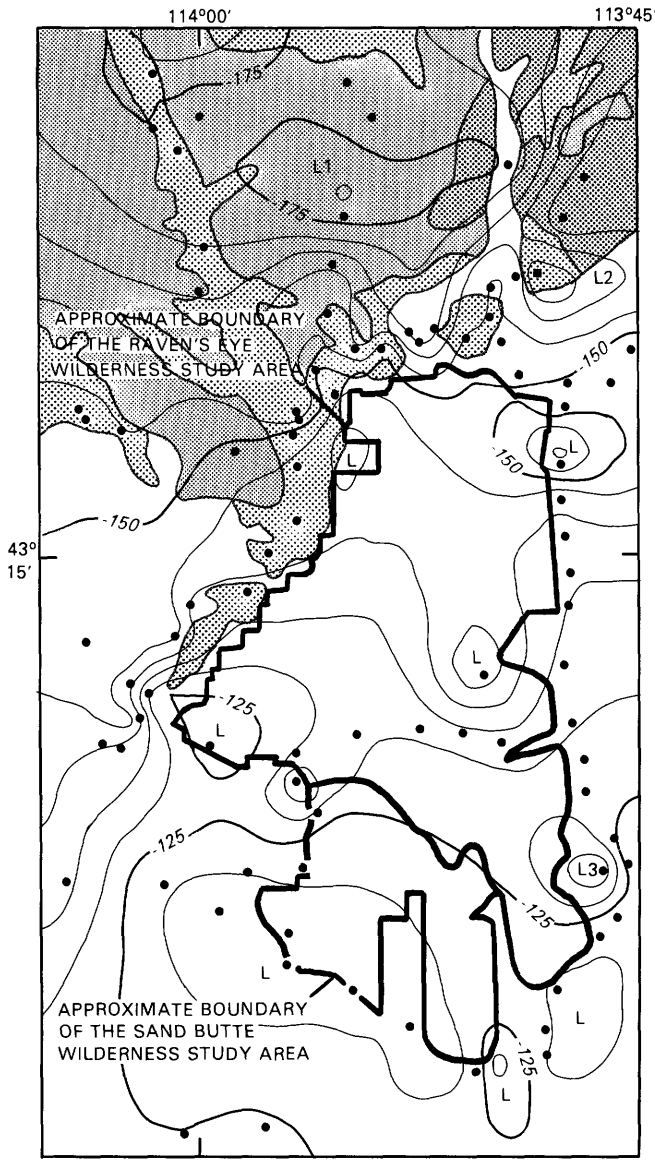

Figure 2. Bouguer anomaly gravity map of the Sand Butte and Raven's Eye Wilderness Study Areas, Idaho

A regional increase in gravity values from north to south, shown on figure 2 suggests that the basalts thicken southward. A steep gradient along the northwestern boundary of the Raven's Eye Wilderness Study Area marks a sharp contact between Tertiary volcanic and Paleozoic and Mesozoic sedimentary rocks to the northwest and Tertiary and Quaternary basalts to the southeast. This indicates that the study areas are probably underlain by basalts.

A gravity low in the northern part of the map (L1) (fig. 2) is associated with the low-density Tertiary volcanic rocks (Challis volcanics). The gravity low northeast of the Raven's Eye study area (L2) is centered over low-density Quaternary gravels. The gravity low at the southeast corner of the Raven's Eye study area (L3) is associated with a cinder-filled collapse structure. Other local high and low anomalies probably reflect variations in the composition and vesicularity of the basalts.

Aeromagnetic Data

The only available magnetic data in the area is from the aeromagnetic map of Idaho (Zietz and others, 1978) at 1:1,000,000 scale. The study areas lie in a transition zone between lower aeromagnetic values over older volcanic and sedimentary rocks to the north and higher values over basalts to the south. The higher values are part of a northwest-trending anomaly that may be caused by intrusive mafic rocks at depth along a northwest-trending fracture.

Mineral and Energy Resources

The Raven's Eye and Sand Butte Wilderness Study Areas contain recent basaltic lavas and have a low mineral resource potential for all metals, with certainty level C. This is supported by the geologic environment in which the areas occur, the lack of any mineralized rock, and the lack of any geochemical anomalies.

The wilderness study areas also lack host rocks and structures favorable for the occurrence of oil, gas, and coal. Resource potential for these commodities is therefore low, with certainty level C.

The thickness of the basalts in the study areas is unknown. Geophysical profiles in the central part of the Eastern Snake River Plain suggest that a basalt layer about 350–1,500 ft thick overlies a sedimentary and (or) rhyolitic ash-flow tuff layer approximately 1,800 ft thick (Kuntz, 1978). Seven miles east of the study areas, at Craters of the Moon National Monument, geophysical data of Kuntz and others (1980) indicate that the young basalts are as much as 3,100 ft thick. The basalts are underlain by a layer postulated to consist of basalts, rhyolite flows and tuffs, and sedimentary rocks, which range

from 3,000 to 6,000 ft thick. Doherty and others (1979) penetrated rhyolite ash flows in this depth interval at the Idaho National Engineering Laboratory in a drill hole about 50 mi northeast of the wilderness study areas. Without an extensive drilling or a geophysical exploration program, the thickness of the basalts in the study areas will remain unknown. However, geophysical data from this study suggest that sedimentary rocks or other types of volcanic rocks do not underlie the basalts of the area studied. The potential for resources of metals, oil, gas, and coal in the underlying rocks is therefore also low, with certainty level C.

The depths to the water table beneath the Snake River Plain basalts are from 200 to 800 ft (Mundorff and others, 1964), deep enough to inhibit the near-surface expression of any geothermal features. Numerous hot and warm springs and wells occur along the northern and southern margins of the Snake River Plain (Breckenridge and others, 1980) where geothermal systems are less diluted by the effects of the Snake River Plain aquifer. Three springs occur to the north of the Raven's Eye Wilderness Study Area that are indicated as hot springs on USGS topographic maps along State Highway 26 (pl. 1). The easternmost and westernmost springs had cool water in them, and had a very small discharge when they were examined. The central spring at Hot Springs Ranch had a water temperature of 120 °F. All of the springs occur in alluvial deposits. No thermal waters are known within the study areas. The resource potential for geothermal energy in the wilderness study areas is low, with certainty level C.

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APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

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

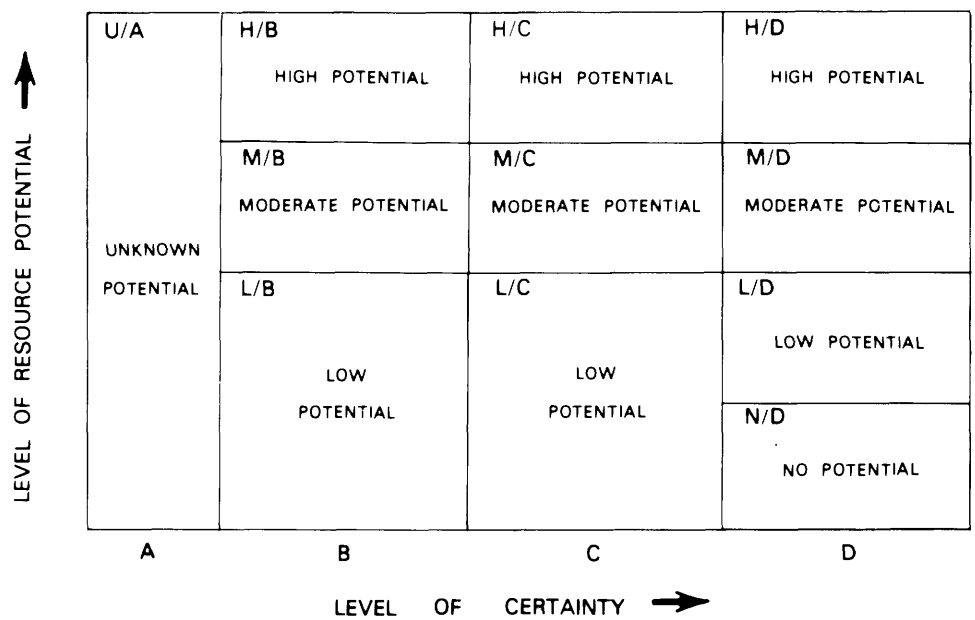
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application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

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

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

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

Levels of Certainty



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

B. Available information suggests the level of mineral resource potential.

C. Available information gives a good indication of the level of mineral resource potential.

D. Available information clearly defines the level of mineral resource potential.

Abstracted with minor modifications from:

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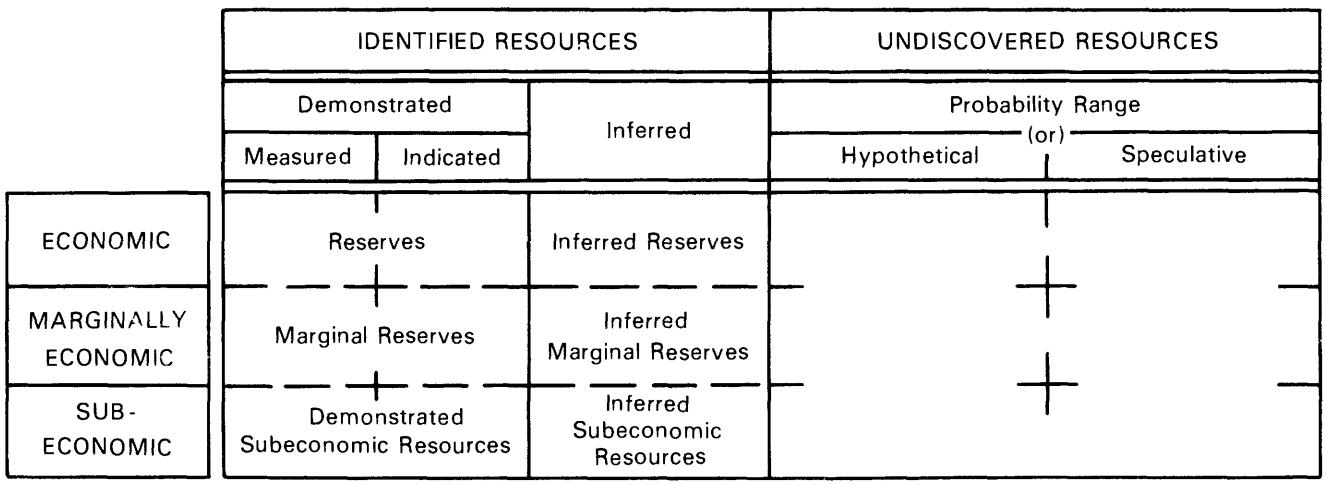
RESOURCE / RESERVE CLASSIFICATION



Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from 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 in this report

EON	ERA	PERIOD		EPOCH	BOUNDARY AGE IN MILLION YEARS
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 Early	96 138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~ 240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~ 330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~ 570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				
pre-Archean[2]		3800?			4550

[1] Rocks older than 570 m.y. also called Precambrian, a time term without specific rank.

[2] Informal time term without specific rank.

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CONTENTS

[Letters designate the chapters]