

UNITED STATES DEPARTMENT OF THE INTERIOR
(BUREAU OF MINES)

MINERAL RESOURCES OF THE HELL'S HALF ACRE WILDERNESS STUDY AREA
(BLM NO. ID-33-15), BINGHAM AND BONNEVILLE COUNTIES, IDAHO

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This open-file report presents the results of a Bureau of Mines wilderness study and will be incorporated in a joint report with the U.S. Geological Survey. The report is preliminary and has not been edited or reviewed for conformity with the U.S. Bureau of Mines standards and nomenclature. Work on this study was conducted by personnel from Western Field Operations Center, East 360 Third Avenue, Spokane, Washington 99202.

PREFACE

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 U.S. Bureau of Land Management (BLM) administered land designated as Wilderness Study Areas (WSA) "...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 Bureau of Mines mineral survey of the Hell's Half Acre Wilderness Study Area (BLM NO. ID-33-15)), Bingham and Bonneville Counties, Idaho.

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LIST OF UNIT OF MEASURE ABBREVIATIONS

in.	inch
ft	feet
ft ²	square feet
ft ² /ton	square feet per ton
lb/ft ³	pounds per cubic foot
%	percent
oz/ton	troy ounces per ton

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AREA (BLM NO. ID-33-15), BINGHAM AND BONNEVILLE COUNTIES, IDAHO

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ABSTRACT

A mineral survey of the 66,200-acre Hell's Half Acre Wilderness Study Area (WSA) in the eastern Snake River Plain was conducted by the U. S. Bureau of Mines in 1984. No mining districts or claims are in or near the WSA; it is nearly covered with lava. The only mineral commodity in the WSA and produced nearby is basaltic slab pahoehoe lava. It is marketed as decorative stone retailing for \$125/ton. The rock has also been removed illegally from small areas near the edge of the lava field.

About 150,000 tons of indicated and inferred resources of slab pahoehoe are contained in the WSA. Of these, reserves totaling 43,000 tons are at thirty-two locations. The localities contain an average of 170 tons of decorative stone per acre. Subeconomic resources totaling 46,000 tons are at fourteen predominantly aa flows near the center of the lava field. These areas average 35 tons of decorative stone per acre. An inferred, subeconomic resource of 60,000 tons is distributed over the remainder of the fresh lava flows of the WSA. These average about 1 ton/acre.

About half the WSA is under oil and gas lease. Its proximity to the Overthrust Belt indicates that further studies are needed to evaluate potential hydrocarbon resources.

The recency of volcanism indicates a favorable environment for geothermal resources; however, these were not evaluated during this Bureau of Mines study.

INTRODUCTION

This mineral survey of the Hell's Half Acre Wilderness Study Area (WSA) was conducted by the U.S. Bureau of Mines and the U.S. Geological Survey at the request of the U.S. Bureau of Land Management (BLM). The Bureau of Mines researched the mining and mineral exploration history, evaluated decorative-stone resources and searched for mining-related activities within or adjacent to the WSA. The U.S. Geological Survey evaluated the gross mineral potential of the WSA by regional geochemical and geophysical surveys and geological mapping. Results of the investigations will be summarized in a joint report used to help determine the acceptability of the WSA for inclusion into the National Wilderness Preservation System. Although the immediate goal of this and other mineral surveys is to provide data for the President, Congress, government agencies, and the public for land-use decisions, the long-term objective is to insure the nation has an adequate and dependable supply of minerals at a reasonable cost.

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Setting

Hell's Half Acre WSA encompasses 66,200 acres of a basaltic lava field in the Snake River Plain section of the Columbia Intermontane (Plateau) geomorphic province (Thornbury, 1965). The WSA is on public land administered by the BLM, Idaho Falls District. Its center is about 18 miles west of Idaho Falls (fig. 1). Major access is provided by Interstate 15 to the southeast and U. S. Highways 20 and 26 to the north and southwest, respectively. Secondary and unimproved roads provide access to most of the boundary, and several jeep trails access portions of the lava field and kipukas 3/ within the WSA (fig. 2).

The lava field has a very rough and chaotic surface due to aa 4/ fields and overlapping flows of pahoehoe 5/. Overall relief is about 660 ft; elevations range from a low of 4,690 ft in a depression east of Morgans Pasture to 5,351 ft on the top of the neck at the main volcanic vent (fig. 2). Most of the lava field dips slightly to the southeast.

Lands to the north, east, and south of the lava field are generally cultivated, as are some loess-filled 6/ kipukas near the border of the field. In the lava field, however, only sparse sagebrush, rabbit brush, occasional juniper, and various grasses are present due to scarcity of soil cover. The climate is semi-arid; average annual precipitation is less than 10 in. No streams drain the study area. Annually, temperatures range from -37° to 104° Fahrenheit and average about 45°.

Previous Studies

Early reconnaissance studies of the geology and water resources of the Snake River Plain, Idaho, are reported in Russell (1902) and Stearns and others (1938). Greeley and King (1977), LaPoint (1977), Kuntz and others (1979), Kuntz and Dalrymple (1979), and Greeley (1982) describe the geology of the eastern Snake River Plain, with an emphasis on volcanism. Rember and Bennett (1979) compiled a 1:250,000-scale geologic map of the Idaho Falls quadrangle which includes the study area. Detailed geologic mapping specific to the Hell's Half Acre lava field is reported in Hotchkiss (1976) and Karlo (1977).

Mineral resources of the area were studied by Savage (1961), but no consideration was given to basaltic decorative stone. A reconnaissance study of the geology, energy, and mineral (GEM) resources of the WSA and surrounding areas is reported in a BLM contract report by Fredericksen and Fernette (1983). Ridenour (1980) investigated the Wapi (basalt) Flow about 60 miles to the southeast and determined resources for decorative stone similar to that present in Hell's Half Acre.

3/ kipuka: Hawaiian for "opening", meaning an area surrounded by a lava flow.

4/ aa: Hawaiian for rough, jagged lava flows with a clinkery surface.

5/ pahoehoe: Hawaiian for basaltic lava flows with a smooth, billowy, or ropey surface.

6/ loess: windblown dust, predominantly silt.

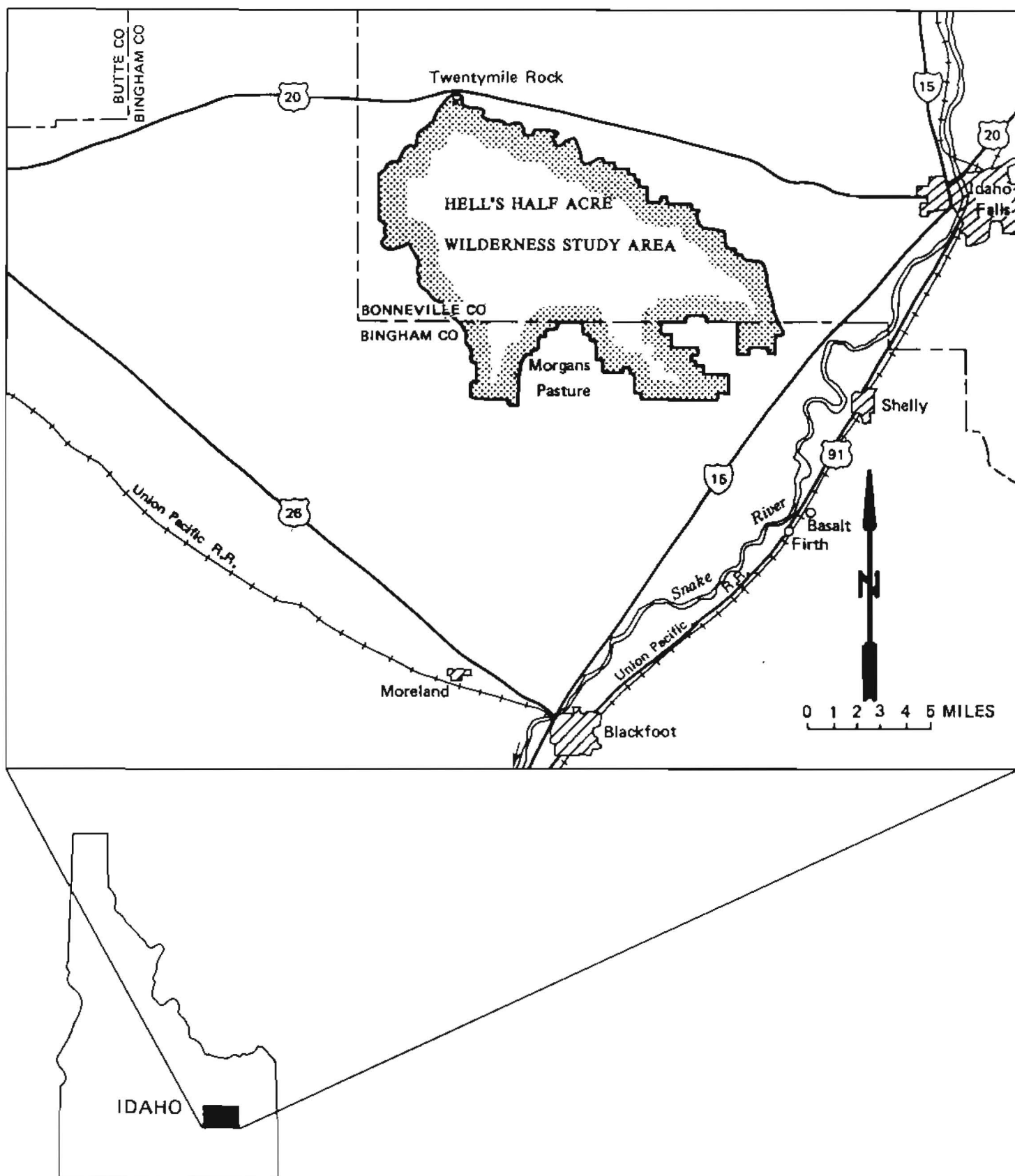


FIGURE 1. — Location map of the Hells Half Acre Wilderness Study Area

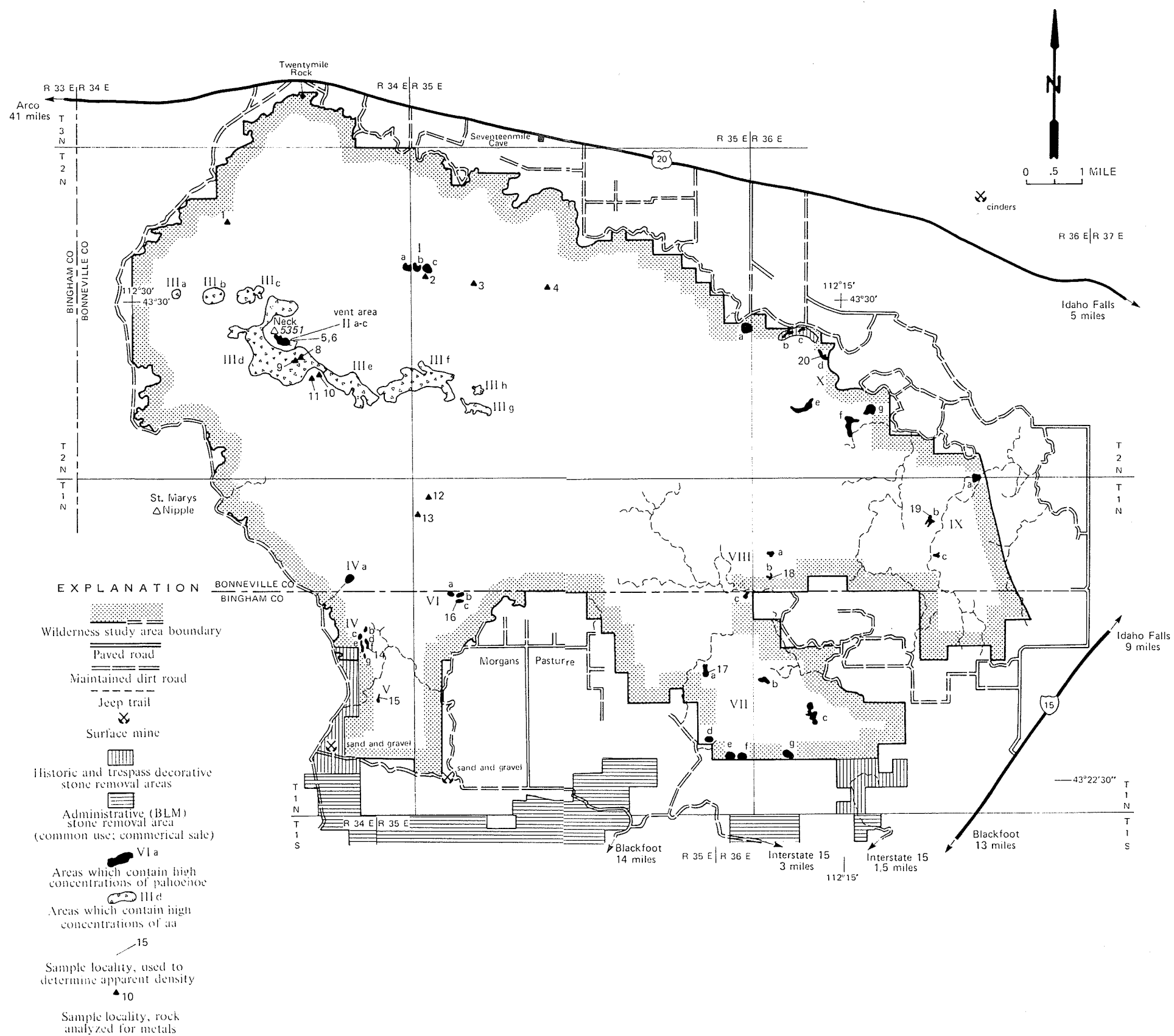


FIGURE 2. — Map showing mineral resource localities and mineral related activity, Hells Half Acre Wilderness Study Area

Present Study

Work by the Bureau of Mines entailed pre-field, field, and report preparation phases in the years 1984 and 1985. Pre-field studies included library research and perusal of BLM mining and mineral lease records. Bureau of Mines, state, and other production records were searched and pertinent data compiled. Field studies involved air and ground reconnaissance of all decorative-stone production areas and searches for other deposits of decorative stone within and adjacent to the WSA, in localities appearing to be promising on aerial photographs. Those found were examined and, where warranted, mapped and sampled. A brief study was conducted of the decorative-stone market in Idaho Falls and Boise, ID, and Spokane, WA.

Volcanic vent areas and lava flows were examined for indications of metallic mineral values. Ten random chip samples were taken from the various volcanic flows and vents. A random chip sample is an unsystematic series of chips taken from an exposure of apparently homogeneous rock. Each of these samples of volcanic rock was fire-assayed for gold and silver and analyzed for 40 elements ^{7/} by semi-quantitative spectrographic methods to detect unsuspected elements of possible significance.

Ten representative samples were taken of stone suitable for decorative veneer to determine apparent density (lb/ft³) for resource calculation. Each sample was weighed before and after coating with wax of known specific gravity, and volume was determined by displacement of water. The wax coating seals the vesicles of the basalt. Apparent density was calculated after subtraction of the wax volume. Resource classifications in this report are based on principles developed by the U. S. Bureau of Mines and U. S. Geological Survey (1980). Relevant terms are defined in the appendix.

ACKNOWLEDGMENTS

The authors were ably assisted in the field by Steven Robinson. Tim Carroll, BLM geologist, Idaho Falls District, provided aerial photographs, historical mining data, and field guidance to current stone removal areas. Terry Maley, BLM geologist, Idaho State Office, shared decorative stone market data gathered by BLM staff geologists since 1980.

^{7/} Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, gallium, gold, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, nickel, niobium, palladium, phosphorus, platinum, potassium, scandium, silicon, silver, sodium, strontium, tantalum, tellurium, tin, titanium, vanadium, yttrium, zinc, and zirconium.

GEOLOGY

The WSA is underlain mainly by Holocene basaltic lavas of the youngest member of the Snake River Basalt Group (LaPoint, 1977; Rember and Bennett, 1979). Adjacent areas are covered by older lava, much of which is concealed by colluvium or loess. Several kipukas within the fresh lava field are also covered with wind-blown sediments.

The style of volcanism exhibited in the eastern Snake River Plain is identified by Greeley (1982, p. 407) as "gradational between flood basalt volcanism and Hawaiian volcanism". Hell's Half Acre is one of a few very young, large-volume lava flows in southern Idaho. Most of the field consists of a network of plateaus, pressure ridges, and depressions which have smooth (pahoehoe) or clinkery (aa) surfaces. Other typical basaltic flow features include ropey structures, squeeze-ups, fractures, lava tubes and tunnels, blisters, spatter cones and ramparts, and minor cinder cones.

In detailed studies of the Hell's Half Acre lava field, Hotchkiss (1976) mapped eight distinct flows (A through H), and Karlo (1977, p. 125) mapped four separate eruptive phases. Karlo (1977, p. 124) reported that the flow units all originated from a single vent; a small caldera-like crater (fig. 2). The back-drained lava lake which now occupies the vent is 1,600 ft long by 700 ft wide. It is located along a N. 40° to 50° W.-striking fissure and tube system that is several miles long. Hotchkiss (1976) hypothesized a rift, at least 6.8 miles long, and an additional major eruptive center along the structure. This older, buried, eruptive center is identified by a 3.5 mile diameter ring of 36 minor vents located east of the younger vent. The two oldest lava flows comprise approximately 80% of the field (Hotchkiss, 1976, p. 33). The younger flows are generally within one or two miles of the vent. Karlo (1977, p. 129) reported that fractures associated with the Hell's Half Acre lava field are parallel to regional structures. The age of the basalt flows ranges from about 4,100 years old, as shown by charred material from below the flows, to 1,660 years old, as indicated by tree ring counts (Karlo, 1977, p. 122). The basalts are olivine tholeiites typical of the Snake River Group. Various calcium, sodium, and magnesium sulfates identified by Karlo (1977, p. 129) occur as crusts and powders in the lava lake flows and are indicative of late-stage fumarolic activity.

MINING HISTORY AND PRODUCTION

No mining districts or claims are within or adjacent to the WSA. Basaltic lava rock from the eastern Snake River Plain has been used as a dimension stone in this area since the 1880's (Mansfield, 1927, p. 338) and more lately as decorative stone. The "blocky" building stone variety is no longer in vogue. Slabs of pahoehoe lava, found as float 8/ in the Hell's Half Acre lava field, have been mined and marketed as decorative stone for more than 15 years, as a result of a strong demand for earth-tone veneers. Mining of float consists of selecting suitable flat material, generally 1 to 3 in. thick and 8 or more in. in diameter, and loading it on a truck.

8/ Float: general term which in this report indicates slablike pieces of basaltic rock lying on the surface and separated from the parent rock, generally along flow surfaces.

BLM records (Idaho Falls District Office) show sales to the American Stone Co., from 1969 to 1971, of approximately 1,000 tons each from two areas just south of the WSA in sections 2 and 11, and section 32, T.1 S., R.35 E. (fig. 2). Royalty (fair market value) to the BLM at that time was \$0.15/ton. A three-year competitive sale was made to another party in 1979 for a \$28,000 bid. Cumulative sales were 1,176 tons at a price of approximately \$52-to-\$55/ton f.o.b. 9/ mine or up to \$75/ton f.o.b. stone yard. The sale area included 400 acres in section 9, T.1 S., R.36 E. (fig. 2). The contract went into default in 1982 with about 20 to 30 tons of 1-to-6 in.-thick, clinkery, probably non-marketable stone left on pallets in the sale area.

Several unauthorized removals of pahoehoe have been made from the lava field. At least one removal occurred from the WSA; most of the marketable stone in a 55-acre area in sections 19 and 20, T.2 N., R.36 E. was mined illegally in the early 1980's. Trespass removal of decorative stone from the lava field amounts to at least several hundred tons (Tim Carroll, personal communication, 1984). Currently, most of the public lands immediately south of the study area (fig. 2) are classified as a common use area 10/ by the BLM to meet persistent local demand for the material.

MINERAL COMMODITIES

Nonmetallic Minerals

Decorative Stone

Marketing

Slab pahoehoe, similar in all respects to that which occurs in abundance in the WSA, is mined in the Idaho Falls - Blackfoot area. It is marketed as a decorative veneer in the Pacific Northwest and competes with other varieties of decorative rock as well as brick and culture (synthetic) stone.

9/ F.O.B.: free on board; indicates material that is loaded and ready for delivery.

10/ Common use area: an administrative area open to the public for non-commercial mining of decorative stone. A royalty plus a reclamation fee is charged by the BLM.

A market survey of stone dealers in Spokane, WA, and Boise and Idaho Falls, ID, in 1984 showed retail prices for decorative stone ranging from a low of \$50-to-\$70/ton for locally-mined field rubble (field basalt) to about \$250/ton for travertine mined in Montana and a variety of slab pahoehoe mined from Black Butte near Shoshone, ID. Slab pahoehoe from the Hell's Half Acre lava field retails for \$125/ton and competes well with the other stone varieties. Observed on pallets in stoneyards, it is slab-like, ranges in thickness from 1 to 3 in., is generally 8-to-12 in. or more in diameter, and often has lichen or moss growth on the weathered surface. The tops of the slabs have a frothy or ropey 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 different decorative appearance. Masons prefer the blunted or squared edges of slab pahoehoe over other feather-edged varieties of stone, because of the ease of application. Also, the light weight (low apparent density due to numerous vesicles--gas cavities) eases handling and gives large coverage per ton of stone. According to dealers, one ton of slab pahoehoe will generally cover 70-to-120 ft², depending on thickness, whereas one ton of non-vesicular varieties of decorative stone covers only 35-to-50 ft². 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 are about 500-to-1,000 tons per year. Figures 3 and 4 show slab pahoehoe on display and stacked on pallets in a Spokane stoneyard.

Production Costs

Detailed studies of the Hell's Half Acre lava field, and economic data from historic and analogous mining operations, were used to determine the minability and production costs of slab pahoehoe from the WSA. Mining typically includes only: 1) removal of rock naturally detached from outcrops (float) or which can easily be pried loose with a steel bar, and 2) transportation to a central point. Public lands immediately south of the WSA (fig. 2) are currently open to common-use mining of decorative stone, generally by home owners and other low-volume users. The BLM assesses a royalty of \$4/ton. An inventory conducted by BLM staff geologist Tim Carroll (personal communication, 1984) in 1980 determined that marketable slab pahoehoe on the lava field that includes the WSA typically ranges from 0 to more than 5 tons/acre, and averages 1 ton/acre. Data from a 1979 competitive stone sale indicated a mining cost of \$10-to-\$20/ton, a shipping cost to Spokane of about \$20/ton, and a profit of about \$20/ton (Tim Carroll, personal communication, 1984). By comparison, the 1979-1980 mining cost for slab pahoehoe mined from mining claims on Black Butte near Shoshone ID (Maley and Holland, 1981) ranged from \$32-to-\$35/ton with a shipping cost of \$4/ton to Boise and \$20/ton to Bend, Oregon. The marketable Black Butte variety of slab pahoehoe ranges from 0 to 90 tons/acre. Parcels considered depleted by commercial operators still contained from 6 to 16 tons/acre in accessible areas; this is an indication of the lower economic limit for commercial operations.



Figure 3 - Photo of slab pahoehoe from the eastern Snake River Plain on display in a Spokane, WA stoneyard.



Figure 4 - Photo of slab pahoehoe sorted and stacked on pallets in a Spokane, WA, stoneyard.

Decorative Stone Resources

The mineral survey identified slab pahoehoe suitable for decorative wall veneer in forty-six parcels in ten clusters (I through X, fig. 2). The slab pahoehoe occurs in high concentrations in solidified lava lakes and squeeze-up areas. Small tonnages also occur in some aa fields. Boundaries of the favorable areas were plotted on aerial photos, traverses were conducted over representative plots to determine the percentage of float suitable as a decorative veneer, and samples were taken to determine apparent density. The acreage of each parcel was digitized and a tonnage calculated. Resource calculations consider only the surface layer (1 to 3 in. thick).

Table 1 lists stone resources and contains other data pertinent to evaluation of those resources in the WSA. The WSA contains a total of about 150,000 tons of 1-to-3 in.-thick slab pahoehoe resources suitable for wall veneer. Thirty-two parcels of the lava field in the WSA contain a total of 43,000 tons of indicated reserves; the marketable stone in these areas ranges from 78 to 370 and averages 170 tons/acre. Approximately 46,000 tons of indicated, subeconomic resources of slab pahoehoe occur in the remaining 14 parcels (fig. 2); the marketable stone in these areas ranges from 25 to 87 and averages 35 tons/acre, and the pahoehoe slabs average 2 to 3 in. thick or more.

Based on BLM data, it is estimated that those portions of the WSA containing slab pahoehoe, but not included in the parcels shown on figure 2 or in kipukas, total approximately 60,000 acres with an average of 1 ton of slab pahoehoe per acre. A total of 60,000 tons are inferred.

Other Rock Commodities

Numerous cinder cones occur on the eastern Snake River Plain; one to the northeast of the WSA (fig. 2) is being mined. Although cinder and pumice deposits are reported within the WSA (Fredericksen and Fernetto, 1983, p. 59), none are considered to be of sufficient size or quality to attract commercial interest.

No dirt or sand and gravel cover the fresh basalts of the Hell's Half Acre lava field; however, wind-deposited sediments (loess) have accumulated on older flows near the WSA and are exposed in some kipukas within the area. Two, minor, common borrow or sand-and-gravel pits are located immediately to the south (fig. 2), and numerous others are within a few miles of the WSA (Strowd and others, 1981). Although crushed basalt has been used as a road base, Hell's Half Acre basalt is not an optimum source because the abundant vesicles cause the rock to have relatively low density and strength characteristics.

TABLE 1. - Decorative stone resources in the Hell's Half Acre Wilderness Study Area
(see figure 2)

Site no.	Area (acres)	Usability factor 1/ (t)	Average thickness (in.)	Apparent density (lb/ft ³)	Resource size 2/ (tons)	Frequency factor 3/ (tons/acre)	Coverage factor 4/ (ft ² /ton)
INDICATED RESERVES							
II a	7.8	40	[]	[]	1,300	160	[]
b	3.9	40	> 2	> 109	630	160	> 110
c	2.6	90	[]	[]	970	370	[]
d	1.5	90	1	[]	260	170	230
					3,160		
IV a	14.	[]	[]	[]	2,000	[]	[]
b	2.2	[]	[]	[]	310	[]	[]
c	4.7	[]	[]	[]	670	[]	[]
d	4.8	> 30	> 1-3	> 129	700	> 140	> 91
e	5.6	[]	[]	[]	810	[]	[]
f	1.9	[]	[]	[]	270	[]	[]
g	2.4	[]	[]	[]	340	[]	[]
					5,100		
V	3.6	35	1-3	127	580	160	93
VI a	4.2	[]	[]	[]	480	[]	[]
b	4.4	> 20-25	> 1-3	> 139	510	> 120	> 85
c	4.2	[]	[]	[]	480	[]	[]
					1,470		
VII a	9.1	10-15	[]	[]	910	100	[]
b	9.	30	[]	[]	2,100	240	[]
c	20.	30	[]	[]	4,800	240	[]
d	7.5	[]	> 3	> 147	900	[]	> 54
e	7.9	> 15	[]	[]	950	> 120	[]
f	7.8	[]	[]	[]	940	[]	[]
g	8.5	[]	[]	[]	1,000	[]	[]
					11,600		
VIII a	8.2	30	1-3	[]	1,100	140	[]
b	11.	10-30	> 1-3	> 123	1,000	91	> 96
c	3.6	20-25	1-3	[]	360	100	[]
					2,460		
X a	20.	15	[]	[]	1,600	78	[]
b	7.4	30	[]	[]	1,200	160	[]
c	3.	30	[]	[]	470	160	[]
d	11.	40	> 1-3	> 141	2,300	210	> 83
e	20.	40	[]	[]	4,300	210	[]
f	20.	45	[]	[]	4,700	230	[]
g	18.	45	[]	[]	4,200	230	[]
					18,770		
Total indicated reserves					43,140		
rounded total					43,000 tons		
INDICATED SUBECONOMIC RESOURCES							
I a	10.	[]	[]	[]	250	[]	[]
b	10.	> <5	> 2 (est.)	> 135 (est.)	250	> 25	> 87
c	13.	[]	[]	[]	320	[]	[]
					820		
III a	15.	[]	[]	[]	380	[]	[]
b	59.	> <5	[]	[]	1,500	> 25	[]
c	64.	[]	[]	[]	1,600	[]	[]
d	600.	[]	[]	[]	15,000	[]	> 87
e	170.	15-20	> 2 (est.)	> 135 (est.)	14,000	87	[]
f	300.	5-10	[]	[]	11,000	38	[]
g	35.	<5	[]	[]	870	25	[]
h	14.	<5	[]	[]	350	25	[]
					44,710		
VIII a	6.4	5-10	[]	[]	300	47	[]
b	4.7	5-10	> 2-3	> 138	220	47	> 69
c	5.4	5	[]	[]	170	32	[]
					690		
Total indicated subeconomic resources					46,210		
rounded total					46,000 tons		
INFERRED SUBECONOMIC RESOURCES							
WSA	60,000 (estimate 1 ton/acre average)				60,000 tons		
Total resources					149,000 tons		
Rounded total					150,000 tons		

1/ Percentage of loose surface slab pahoehoe suitable as a decorative veneer.

2/ Data may not add to totals shown because of independent rounding.

3/ Tons/acre of slab pahoehoe suitable as a decorative veneer.

4/ Number of square feet of wall that a mason can cover with 1 ton of decorative veneer.

Metallic Minerals

No metallic mineral deposits are known within or adjacent to the WSA. Ten representative chip samples were taken (fig. 2); eight from the flow units (A through H) mapped by Hotchkiss (1976) and two from vents possibly associated with late-stage fumarolic activity reported by Karlo (1977, p. 129). Two of the ten samples contained detectable gold or silver; rock from sample locality 10 contained 0.001 oz/ton gold and rock from sample locality 1 contained 0.02 oz/ton silver (fig. 2).

Energy Resources

Most of southern Idaho is identified by the U. S. Geological Survey (1980) as prospectively valuable for oil and gas; however, no structures are known in the WSA. The thick section of Snake River Basalt masks the relatively untested underlying rock. BLM oil and gas title plats, current to August 1982, indicate that over 90% of the WSA was covered by oil and gas leases (Fredericksen and Fernette, 1983, p. 35). Lease plats current to June 1984 indicate that less than one-half of the study area is now covered by oil and gas leases. The nearest oil and gas exploration drill holes lie approximately 20 miles to the southeast (Breckenridge, 1980, 1982). A seismic survey for hydrocarbon structures was conducted near the study area by industry in 1974 (Tim Carroll, personal communication, 1984), but the results of the study are not available.

Breckenridge and others (1980) did not identify any energy resources within or near the study area. There was no geothermal lease activity in or near the WSA as of June, 1984. No manifestations of geothermal energy were observed beyond the indications of late-stage fumarolic activity reported by Karlo (1977).

APPRAISAL OF MINERAL RESOURCES

The WSA contains 43,000 tons of indicated reserves and more than 100,000 tons of indicated and inferred, subeconomic resources of slab pahoehoe suitable for use as a decorative wall veneer. Based on networks of hand-constructed jeep trails over portions of the Hell's Half Acre lava field (fig. 2), it is assumed that most portions of the WSA are accessible. With the exception of the vent area (fig. 2, II a through d), most parcels containing suitable stone lie near the edge of the lava field and would require minimal jeep-trail construction.

Slab pahoehoe from the WSA would have a 1985 retail price of about \$125/ton. Production costs would be about \$35/ton, and the mine operator would make a profit of \$30-to-\$45/ton. The remaining \$45-to-\$60/ton value would be divided between shipping costs, estimated to range from \$10-to-\$25/ton depending on distance to market, and the retailer, who would probably require about \$35/ton for handling and profit. The mining cost and profit margin are primarily dependant on the amount of marketable stone present in a given area. The surface areas of those parcels considered to be economic generally contain greater than 20% marketable stone; greater than 100 tons/acre. Aa fields will probably not attract commercial interest in the foreseeable future, due to the more difficult access to those areas. Most of the remainder of the lava field has a relatively low number of tons of suitable slab pahoehoe per acre and is considered subeconomic for large volume, commercial operations. However, the remainder of the lava field does have value for consumers who gather their own decorative stone to avoid the wholesale and retail mark-up.

Decorative stone consumption varies considerably in the short-term (seasonally, annually, etc.) depending on the amount of new construction. The economic classifications assume a continuing market of adequate volume.

No other significant resources are known to occur in the WSA. Current oil and gas leases and the relative location of the WSA to the Overthrust Belt indicate that further studies are needed to evaluate potential hydrocarbon resources.

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APPENDIX A.--RESOURCE/RESERVE DEFINITIONS

(From U.S. Geological Survey Circular 831, 1980)

RESOURCE.--A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

MEASURED.--The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, depth, and mineral content of the resource are well established.

INDICATED.--Quantity and grade and (or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough for continuity between points of observation to be assumed.

INFERRED.--Estimates are based on an assumed continuity beyond measured and (or) indicated resources for which there is geologic evidence. There may be no samples or measurements.

RESERVES.--That part of the reserve base which could be economically 1/ extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

MARGINAL RESERVES.--That part of the reserve base which, at the time of determination, borders on being economically producible. 2/

SUBECONOMIC RESOURCES.--The part of identified resources that does not meet the economic criteria 3/ of reserves and marginal reserves.

1/ In this report, reserves are expected to yield at least a 20% rate of return.

2/ In this report, marginal reserves are expected to yield less than a 20% rate of return, but to return at least the production expenditures.

3/ In this report, subeconomic resources are expected to return at least 20%, but less than all production expenditures.