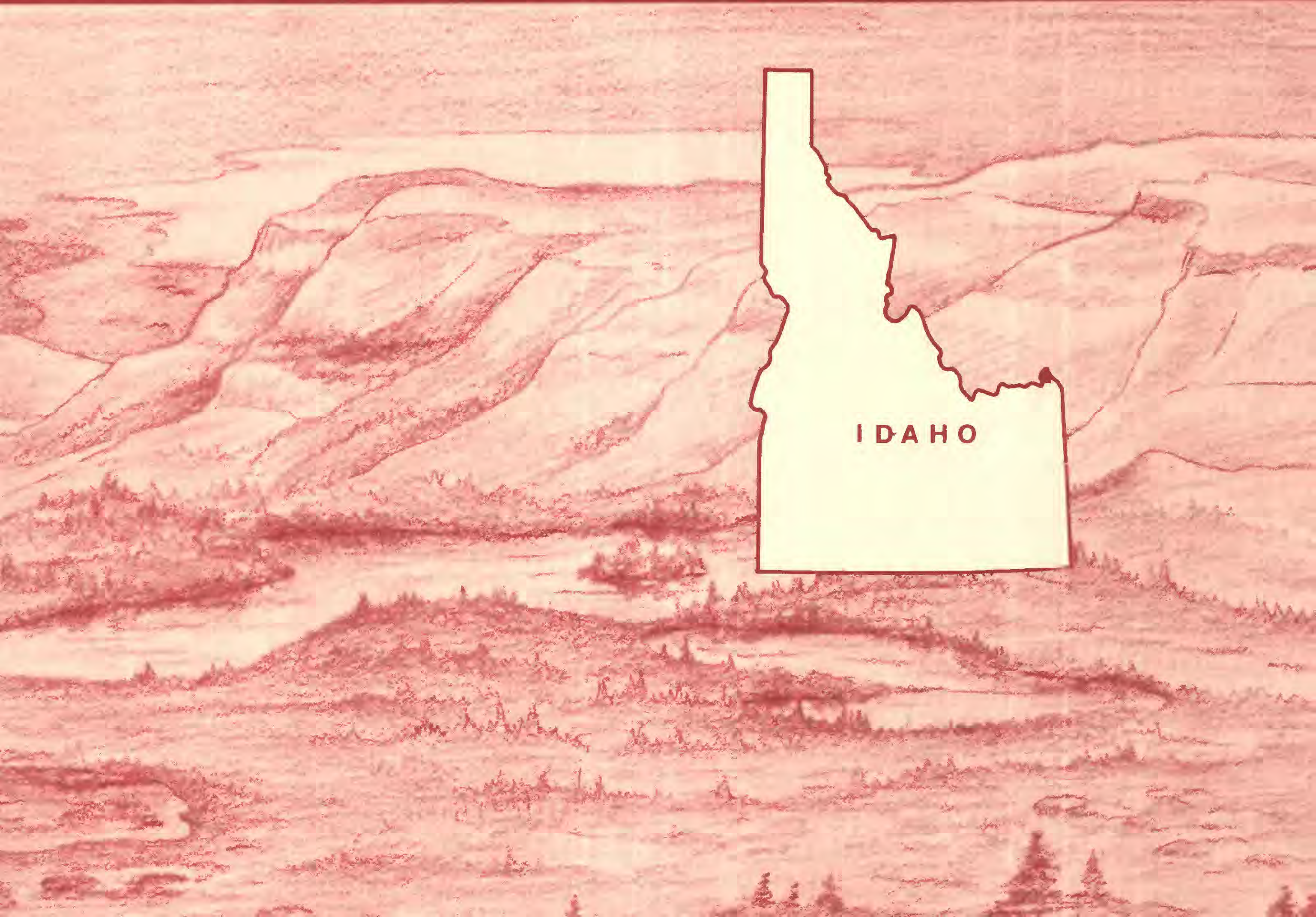
Mineral Resources of the Henry's Lake Wilderness Study Area, Fremont County, Idaho

U.S. GEOLOGICAL SURVEY BULLETIN 1718–D



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Chapter D

Mineral Resources of the Henry's Lake Wilderness Study Area, Fremont County, Idaho

By R.G. TYSDAL and D.M. KULIK
U.S. Geological Survey

T.J. PETERS
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1718-D

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—SOUTHEASTERN IDAHO

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94–979, 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 Henry's Lake Wilderness Study Area (ID–035–077), Fremont County, Idaho.

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Mineral Resources of the Henry's Lake Wilderness Study Area, Fremont County, Idaho

By R.G. Tysdal *and* D.M. Kulik
U.S. Geological Survey

T.J. Peters
U.S. Bureau of Mines

SUMMARY

Abstract

A mineral resource survey of the 350-acre Henry's Lake Wilderness Study Area (ID–035–077) was made in 1986–87. The wilderness study area is in the southern part of the Madison Range, Fremont County, Idaho, and is about 17 mi (miles) north of the hamlet of Island Park. No identified resources (known) or currently active claims exist within or adjacent to the wilderness study area. There is potential for several types of undiscovered mineral resources within the study area. The southwestern part of the wilderness study area, along the Madison Range fault, is rated as having a moderate energy resource potential for geothermal water; the remainder of the study area has a low potential for resources of this commodity. A small outcrop of marble in the southernmost part of the study area has a low mineral resource potential for talc; for talc in marble possibly concealed beneath the study area the mineral resource potential is rated as unknown. The study area has a low mineral resource potential for iron in hematite-mineralized amphibolite gneiss, and for gold, silver, and uranium. The area has no mineral resource potential for phosphate, because the host strata have been eroded; and no resource potential for oil and gas.

Character and Setting

The Henry's Lake Wilderness Study Area is in the southern part of the Madison Range of the Rocky Mountains, in Fremont County, Idaho (fig. 1). It is between 6,600 and 7,600 ft (feet) in elevation on the south-facing slope of the range, which rises steeply from the north side of the sedimentary basin that contains Henrys Lake. The study area is about 17 mi north of Island Park, Idaho, 13 mi west of West Yellowstone, Montana, and is directly north of Idaho State Highway 87.

The study area largely consists of Precambrian-age rocks (see geologic time chart in Appendix) that were metamorphosed about 2,750 m.y. (million years) ago. In the northeast corner of the study area, the metamorphic rocks are overlain by sandstone strata of Cambrian age, and in the southern part by unconsolidated sediments of Holocene age. Mountain-building forces deformed this part of the Rocky Mountains during the Laramide orogeny, approximately 60–80 m.y. ago. Rocks of the general region were folded and faulted. The range itself began to emerge as a discrete mountain mass a few million years later, when the Madison Range fault developed along the west and southwest flank of the range. Displacement on this fault served to separate the rising Madison Range from the downdropped sedimentary and volcanic rocks that lie beneath the basin which contains Henrys Lake. The wilderness study area is in the Intermountain Seismic Belt, a zone of pronounced earthquake activity, and is adjacent to a region that historically has been the most seismically active in the Rocky Mountains.

Mineral Resource Potential

Field and laboratory studies were conducted to assess the mineral resource potential of the study area. Limited geologic mapping was undertaken to supplement that done previously; existing geophysical data were adequate for the region of the wilderness study area. A geochemical study was undertaken and was based mainly on spectrographic

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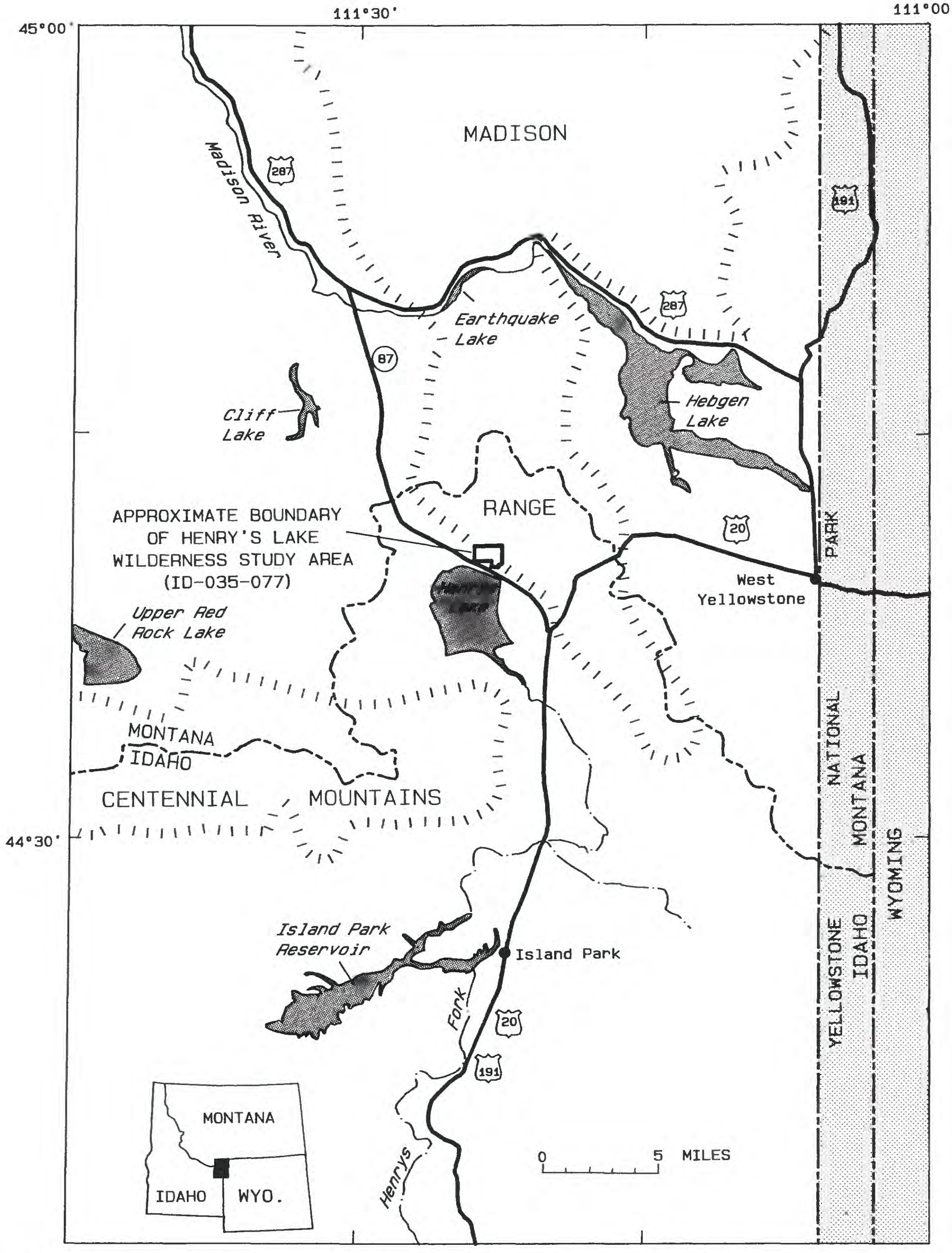


Figure 1. Index map showing location of Henry's Lake Wilderness Study Area, Fremont County, Idaho.

and chemical analysis of rocks but also was based on stream-sediment and heavy-mineral concentrate samples collected by the USGS (U.S. Geological Survey). The USBM (U.S. Bureau of Mines) examined and sampled prospects and mineral occurrences.

The three prospect pits in and immediately adjacent to the northeastern part of the wilderness study area occur in hematite-mineralized amphibolitic gneiss. A talc prospect lies about ¼ mi east of the study area. The entire wilderness study area is rated as having a low mineral resource potential for gold, silver, uranium, and iron in amphibolitic gneiss; and no resource potential for phosphate in the Phosphoria Formation, or for oil and gas. In the southeasternmost part of the wilderness study area, talc in marble is rated as having a low mineral resource potential. Marble also may occur beneath the surface of the study area and possibly could contain talc, but the potential for such an occurrence of talc is unknown. The southwestern part of the wilderness study area is rated as having a moderate potential for geothermal water, along the Madison Range fault, but the remainder of the area has a low potential for this resource.

INTRODUCTION

The USGS (U.S. Geological Survey) and the USBM (U.S. Bureau of Mines) studied the 350-acre Henry's Lake Wilderness Study Area (ID–035–077) at the request of the BLM (U.S. Bureau of Land Management). The study area is located in the southern part of the Madison Range in Fremont County, Idaho (fig. 1). It is directly north of Idaho State Highway 87, about 13 mi (miles) west of West Yellowstone, Mont. The wilderness study area ranges from about 6,600 to 7,600 ft in elevation and is on a south-facing slope of the Madison Range.

This report presents an evaluation of the mineral resource endowment (identified resources and mineral resource potential) of the study area and is the product of several separate studies by the USBM and the USGS. Identified resources are classified according to the system of the U.S. Bureau of Mines and U.S. Geological Survey (1980), which is shown in the Appendix of this report. Identified resources are studied and evaluated by the USBM. Mineral resource potential is the likelihood of occurrence of undiscovered metals and nonmetals, 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) and is shown in the Appendix of this report. Classification is according to type of deposit, level of potential, and level of certainty. The mineral resource potential for undiscovered resources is studied and evaluated by the USGS. In this report, the term "deposit," unmodified, carries no connotation of economic value.

Investigations by the U.S. Bureau of Mines

The USBM part of the wilderness study included pre-field, field, and report preparation phases. Pre-field preparation included a library search of pertinent geological and mining literature and examination of BLM master title plats to search out actively held mineral properties and property owners. Field work, in June 1987, included examination of a talc prospect east of the study area, and examination of an area of iron oxide mineralized gneiss in the northeast corner of the study area. A total of 16 rock and 2 alluvial samples were taken by the USBM, and prepared for analysis at WFOC (Western Field Operations Center), Spokane, Wash. Rock samples were analyzed for 25 elements by a commercial laboratory and alluvial samples were analyzed at WFOC's placer laboratory; Peters and Winters (1988) reported the results of these analyses. Complete assay data are available from Western Field Operations Center, U.S. Bureau of Mines, E. 360 Third Ave., Spokane, WA 99202.

Investigations by the U.S. Geological Survey

During the summers of 1986–87, stream-sediment and heavy-mineral concentrate samples were collected from the area and analyzed chemically and spectrographically. Rock samples were collected and analyzed chemically to aid in the interpretation of the stream-sediment and concentrate data. No new geophysical data were obtained. Geologic mapping was conducted within the area to supplement previously conducted mapping of Witkind (1972a, b).

Acknowledgments

The authors thank R.L. Weeks, Geologist, Cyprus Industrial Minerals Company, Englewood, Colo., and John Childs, Consulting Geologist, Bozeman, Mont., for helpful information on the Tick Heaven talc claims, and talc deposits of the region. Mr. and Mrs. E.L. Machamer,

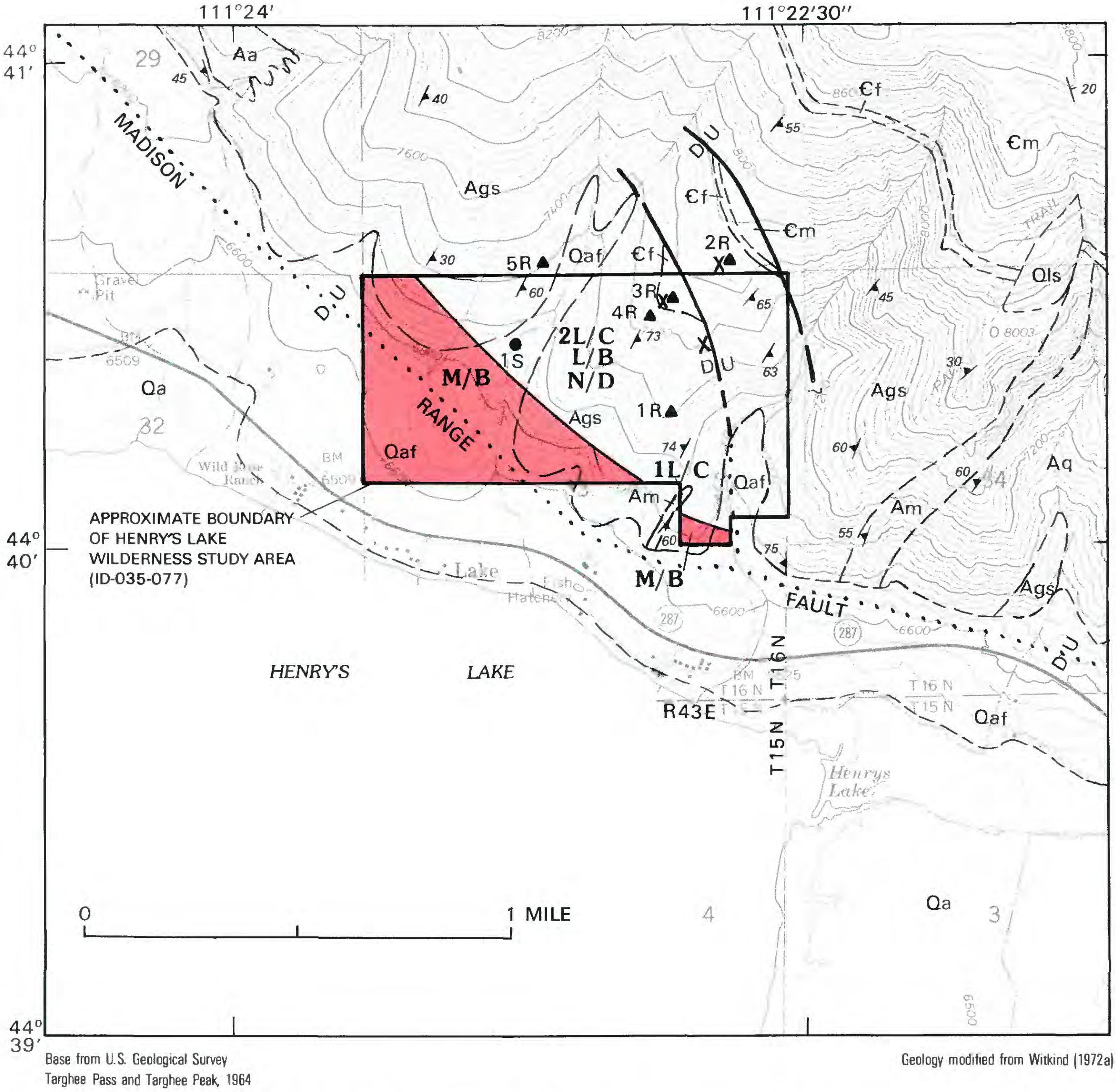


Figure 2. Geologic map showing areas of mineral resource potential and prospects in the Henry's Lake Wilderness Study Area.

and Stanley Goode, granted access to the study area across their properties.

For the one stream-sediment sample reported herein, the spectroscopic analyst was R.T. Hopkins and the chemical analyst was J.D. Sharkey. For the one heavy-mineral concentrate sample, the spectrographic analysts were B.M. Adrian and O. Erlich; the chemical analysts were P.L. Hageman, R.H. Hill, and T.A. Roemer. All analysts are members of the USGS.

APPRAISAL OF IDENTIFIED RESOURCES

By T.J. Peters
U.S. Bureau of Mines

Mining and Mineral Exploration History

Two prospect areas occur in the Henry's Lake Wilderness Study Area and vicinity (fig. 2). The name

EXPLANATION OF MINERAL RESOURCE POTENTIAL

M/B Geologic terrane having moderate resource potential for geothermal energy, at certainty level B

1 L/C Geologic terrane having low resource potential for talc, at certainty level C

2 L/C Geologic terrane having low resource potential for geothermal energy, iron in amphibolite, gold, and silver, at certainty level C—Applies to entire wilderness study area, except as noted above

L/B Geologic terrane having low resource potential for uranium, at certainty level B—Applies to entire wilderness study area

N/D Geologic terrane having no resource potential for phosphate and oil and gas, at certainty level D—Applies to entire wilderness study area

U/A Geologic terrane having unknown mineral resource potential for talc in concealed marble, at certainty level A—Applies to entire wilderness study area, except as noted above

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

LEVEL OF CERTAINTY →

LEVELS OF RESOURCE POTENTIAL

- **H** High mineral resource potential
- **M** Moderate mineral resource potential
- **L** Low mineral resource potential
- **U** Unknown mineral resource potential
- **N** No known mineral resource potential

LEVELS OF CERTAINTY

- **A** Available data not adequate
- **B** Data indicate geologic environment and suggest level of resource potential
- **C** Data indicate geologic environment, give good indication of level of resource potential, but do not establish activity of resource-forming processes
- **D** Data clearly define geologic environment and level of resource potential and indicate activity of resource-forming processes in all or part of the area

Diagram showing relationships between levels of mineral resource potential and levels of certainty. Shading shows levels that apply to this study area

CORRELATION OF MAP UNITS

Units		
Qa, Qaf, Qls	Holocene	QUATERNARY
Unconformity		
€m, €f		CAMBRIAN
Unconformity		
Ags, Am, Aa, Aq	Relative age not implied	ARCHEAN

LIST OF MAP UNITS

Unit	Description
Qa	Alluvium (Holocene)
Qaf	Alluvial fan (Holocene)
Qls	Landslide (Holocene)
€m	Meagher Limestone (Cambrian)
€f	Flathead Sandstone (Cambrian)
Ags	Gneiss and schist (Archean)
Am	Marble (Archean)
Aa	Amphibolite (Archean)
Aq	Metaquartzite (Archean)

EXPLANATION

Contact—Approximately located

Fault—Dotted where concealed. U, upthrown side; D, downthrown side

Strike and dip of beds

Strike and dip of beds of foliation

Sample locality

- ● Stream sediment and heavy-mineral concentrate
- ▲ Rock

× Prospect pit

and history of the prospect area of iron oxide enriched amphibole gneiss at the northeast corner of the study area are unknown. The pits, discovered during field work, appear to be tens of years old; no claim markers or other indications of recent activity were observed.

The Tick Heaven group of eight talc claims extends northeast across the north half of sec. 34, T. 16 N., R. 43 E. (fig. 2), covering an area about 1,200 ft wide by 6,000 ft long. The claims encompass outcrops of Archean dolomitic marble east of the boundary of the study area. The claims were acquired by Cyprus Minerals Company on July 7, 1985 (R.L. Weeks, oral commun., 1987).

There are no oil and gas leases in the wilderness study area.

Claim and Prospect Areas

An area of iron oxide mineralized Precambrian gneiss occurs unconformably beneath the Cambrian Flathead Sandstone within down-dropped fault blocks. Iron oxide minerals (primarily hematite) form veinlets within, and coatings on, the gneiss. Workings consist of three shallow pits (fig. 2); the north and south pit are within Archean gneiss, and the west pit appears to be underlain by Flathead Sandstone. Four samples of the iron oxide mineralized gneiss averaged 17.08 percent Fe (iron) (Peters and Winters, 1988); five background samples of unmineralized gneiss and schist averaged 6.84 percent Fe. Base metals (copper, lead, and zinc), ferro-alloys, and major elements are depleted in the mineralized gneiss. The possible origin of the iron mineralization is discussed in Peters and Winters (1988, appendixes C–E).

The Tick Heaven talc claim group covers an Archean dolomitic marble unit. Dark-bluish-gray talc schist was seen only as pebble and cobble float between elevations of 7,000 and 7,200 ft along the northwest contact of the dolomitic marble. A select grab sample analyzed by X-ray diffraction contained talc (approximately 75 percent), lesser calcite, and minor dolomite and tremolite (Peters and Winters, 1988).

Identified Resources

No resources of iron, talc, marble, or other lode or placer commodities were identified. The iron occurrence is too low in grade, small in size, and remote from markets to be classified as an identified resource. The known extent of the Tick Heaven talc occurrence is limited to a small area of talc schist float outside the wilderness study area, and cannot be classified as an identified resource. The term "marble" as used in this report, refers to dolomite that has been recrystallized by metamorphism into medium- or coarse-grained metadolomite. It lacks attractive textures and patterns commonly associated with decorative marble, and cannot be classified as an identified resource. Sand and gravel occur in alluvial fans in the southern part of the wilderness study area but are not classified as identified resources because more accessible deposits have been quarried for local use in other parts of the region, as shown on the map of Mitchell and others (1981), and extensive deposits exist outside the wilderness study area, as shown on the construction materials map of Witkind (1972f).

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By R.G. Tysdal and D.M. Kulik
U.S. Geological Survey

Geology

Geologic Setting

The Henry's Lake Wilderness Study Area is located at the south end of the Madison Range and is composed of Archean metamorphic rocks that are overlain locally by Cambrian strata and Holocene unconsolidated deposits. The Archean rocks are contiguous with those farther north in the Madison Range, in Montana, which were metamorphosed to upper amphibolite grade or granulite grade (Erslev, 1983) about 2,750 m.y. (million years) ago (James and Hedge, 1980). The wilderness study area apparently is south of the southwestern Montana region that underwent a second, milder thermal event, dated at 1,600 m.y. by Giletti (1966, 1971).

Rocks of the Henrys Lake area, including those in the southern part of the Madison Range and the eastern end of the Centennial Mountains (fig. 1), were mapped in detail and published in a folio of six maps by Witkind (1972a-f). A geologic map of the region (fig. 3), generalized from Witkind (1972a), shows that Archean metamorphic rocks are overlain by Paleozoic strata that aggregate as much as 4,200 ft thick and are chiefly limestone and dolomite. An incomplete Mesozoic sequence in the eastern part of the Centennial Mountains totals about 2,200 ft (Witkind, 1982). In comparison, a nearly complete Mesozoic sequence in the central part of the Madison Range, about 25 mi north of the wilderness study area, is more than 10,000 ft thick and is composed chiefly of clastic strata (Tysdal and Simons, 1985); a similar thickness of Mesozoic strata may have overlain the Archean and Paleozoic rocks of the wilderness study area.

Eocene(?) mafic volcanic rocks as much as 2,000 ft thick overlie Archean and Phanerozoic rocks of the eastern part of the Centennial Mountains south of Henrys Lake (Witkind, 1972a, 1982). A sequence of late Pliocene and Quaternary volcanic rocks, produced by volcanism in and near Yellowstone National Park (Christiansen and Blank, 1972; Hamilton, 1965) covers extensive areas south of Henrys Lake (Hamilton, 1965; Witkind, 1972a, 1982), and to the east in the Park (U.S. Geological Survey, 1972). These young volcanic rocks tend to be thinner, and are preserved in less extensive areas, north of the wilderness study area (Witkind, 1972a; Tysdal and Simons, 1985). The Henrys Lake basin is believed to contain a fill of about 3,500 ft of Cenozoic sedimentary and volcanic rocks (Peterson and Witkind, 1975).

The region was deformed during the Late Cretaceous-early Tertiary Laramide orogeny, and rocks of the area were faulted and folded. A Laramide-style thrust formed along what is now the western flank of the Madison Range, and displaced metamorphic rocks eastward onto Phanerozoic strata (Tysdal, 1986). The rocks of the southern part of the Madison Range are interpreted to be part of the terrane that was thrusted (Tysdal, 1986; Witkind, 1969). The Madison Range fault, a Cenozoic basin-and-range normal fault (Pardee, 1950), formed later and severed the leading edge of the thrust plate. Part of the thrust plate was downdropped beneath what is now the Madison Valley, along the western side of the Madison Range, and the Henrys Lake basin along the southern to southwestern part of the range. The two normal faults at the northeast corner of the wilderness study area are considered to be down-to-the-basin faults related to the Madison Range fault.

The Henrys Lake region is in the Intermountain Seismic Belt, a zone of pronounced earthquake activity extending north from Arizona through Utah, eastern Idaho, western Wyoming, and western Montana (Smith and Sbar, 1974). The Hebgen Lake area, north of the wilderness study area (fig. 1), and Yellowstone National Park have been the most seismically active areas in the Rocky Mountains in historic time, experiencing the 7.1 magnitude 1959 Hebgen Lake earthquake as well as seven other earthquakes of greater than 6 magnitude (Trimble and Smith, 1975; Smith and Braile, 1984). The epicenter of the 1959 Hebgen Lake earthquake lies about 10 mi north of the Henry's Lake Wilderness Study Area.

Description of Rock Units

Rock units within and adjacent to the Henry's Lake Wilderness Study Area are described below, with letter symbols as shown in figure 2. Descriptions of the rock units are from Witkind (1972a), supplemented with data obtained during the present investigation. No relative age is implied by the order of the Archean rock units.

Archean gneiss and schist (Ags).—Chiefly light- to dark-gray, foliated, fine- to coarse-grained biotite-quartz-feldspar gneiss and schist. Within the wilderness study area and west of the drainage that contains sample locality 1S, the unit is biotite-staurolite-feldspar schist; the staurolite typically forms knots, but in some places it occurs as crystals as much as 2 in. long. Staurolite is absent east of this drainage and the rocks generally are biotite-quartz-feldspar gneiss, and in a few places hornblende-feldspar-quartz gneiss. Thin units of amphibolitic gneiss, garnet-amphibolite, and quartz-feldspar pegmatite are present locally east of the drainage.

Archean marble (Am).—Light-brown to light-gray, thin- to thick-bedded, medium- to coarse-crystalline metadolomite (marble). Bedding is defined by thin seams of quartz.

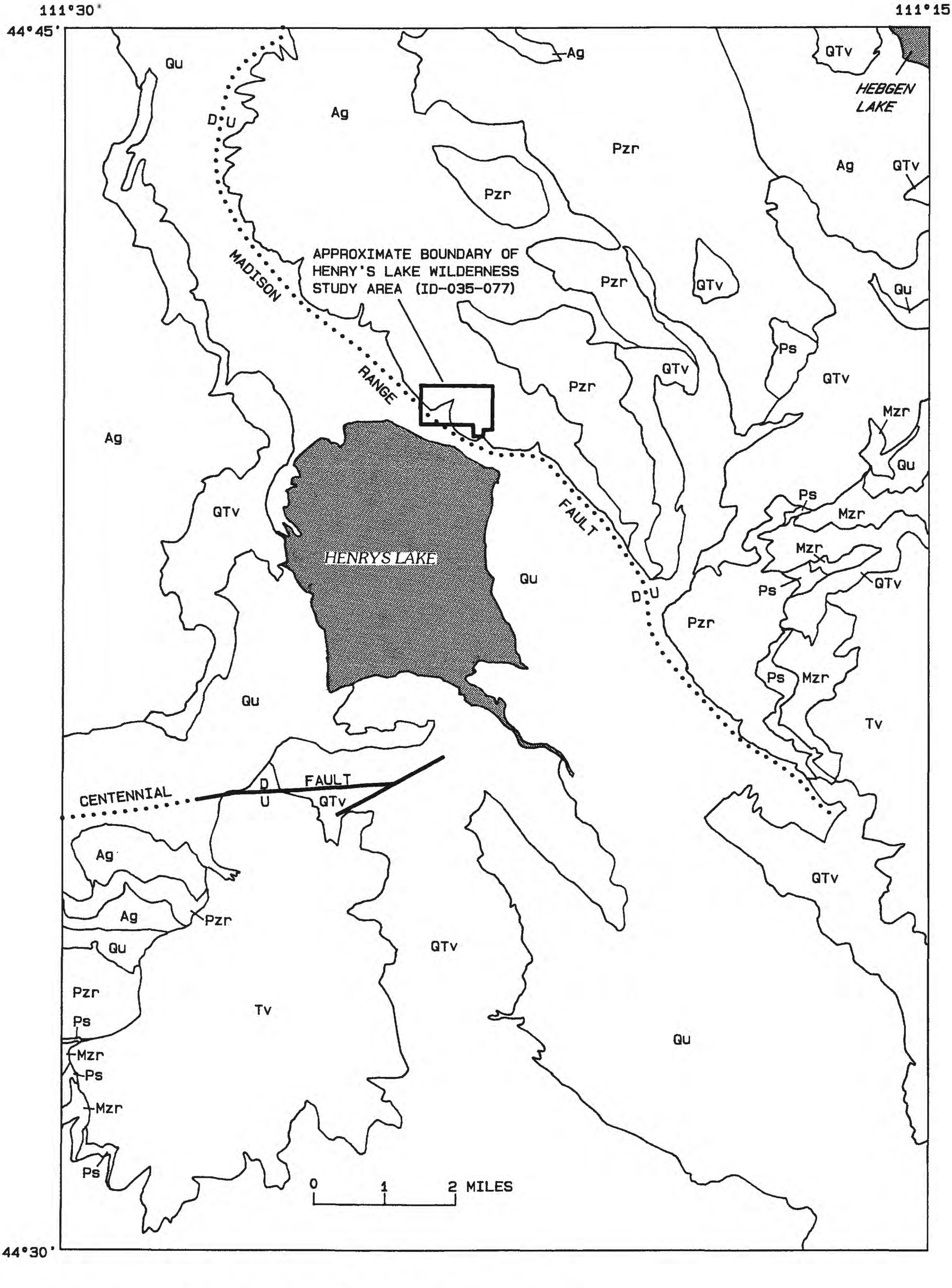
Archean amphibolite (Aa).—Dark-gray, strongly foliated, fine- to coarse-grained rock that is banded due to alternating laminae of hornblende and quartz-plagioclase.

Archean metaquartzite (Aq).—White, light-gray, and green foliated thin- to thick-bedded, medium- to coarse-grained micaceous metaquartzite; contains minor accessory minerals.

Cambrian Flathead Sandstone (C-f).—Tan to brown, thin- to thick-bedded, fine- to coarse-grained sandstone. The strata commonly are crossbedded, and locally are cemented by hematite. Witkind (1972a) noted that the unit locally contains 5–10 ft of glauconitic shaly siltstone beds in the uppermost part; he tentatively assigned these strata to the Wolsey Shale, a unit that is otherwise absent from the general area. No shaly strata were observed in the wilderness study area. The unit ranges from 20 to 200 ft thick but is about 50 ft thick in the wilderness study area.

Cambrian Meagher Limestone (C-m).—Gray thin-bedded limestone that contains abundant light-brown and pale-red siltstone mottles. The unit locally contains intraformational limestone conglomerate. It is about 550 ft thick.

Holocene alluvial fan (Qaf).—Fan- or cone-shaped deposits of unconsolidated silt, sand, gravel, and cobbles.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Qu
Ag
Pzr
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Tv
Ps
Mzr
HEBGEN LAKE
HENRYS LAKE
APPROXIMATE BOUNDARY OF HENRY'S LAKE WILDERNESS STUDY AREA (ID-035-077)
MADISON RANGE FAULT
CENTENNIAL FAULT
D
U
0 1 2 MILES

EXPLANATION

Qu	Quaternary unconsolidated sedimentary rocks
QTv	Quaternary and Tertiary volcanic rocks of rhyolitic composition
Tv	Eocene(?) volcanic rocks of trachyitic and basaltic composition
Mzr	Mesozoic rocks, chiefly clastic strata
Ps	Permian Phosphoria Formation, chiefly sandstone and cherty sandstone
Pzr	Paleozoic rocks, chiefly limestone and dolomite
Ags	Archean gneiss and schist
———	Contact
U/D	Fault—Dotted where concealed. U, upthrown side; D, downthrown side

Figure 3 (above and facing page). Generalized geologic map of Henrys Lake region ; geology from Witkind (1972a). (Note—The name "Shedhorn Sandstone" has been applied in the Madison Range (to the north) to rocks here indicated as the Phosphoria Formation.

Holocene alluvium (Qa).—Unconsolidated deposits of fluvial silt, sand, and gravel in area marginal to Henrys Lake.

Holocene landslide deposits (Qls).—Unconsolidated water-saturated deposits of soil, sand, and other rock materials that have slid under the influence of gravity.

Geochemistry

Geochemical data for use in this study were obtained from stream-sediment and heavy-mineral concentrate samples, and rock samples collected during the summer of 1986.

Analytical Methods

The one stream-sediment sample collected during this study was obtained from an intermittent stream. A composite sample of fine detritus was collected from several places within the stream bed and later air dried and sieved for analysis. The heavy-mineral concentrate of stream sediment was panned from coarser detritus believed to represent a relatively high-energy depositional environment.

Rock samples were collected (1) to identify and evaluate places where obvious mineralized or altered rock exist within the wilderness study area, and (2) to determine background abundances of elements to help evaluate the stream-sediment and heavy-mineral concentrate samples. The samples were taken as representative composites of chips from outcrops.

All samples were analyzed for 31 elements using a six-step, direct-current arc, optical-emission, spectrographic method (Grimes and Marranzino, 1968). The stream-sediment sample was sieved through an 80-mesh (177 micron) screen, and a split of the portion passing through the sieve was analyzed. A split of each crushed and ground rock sample, and a small split of the heavy-mineral concentrate sample, also were analyzed by this method. Atomic-absorption analyses for gold were made on the remainder of each concentrate sample, and on each rock sample, using the method of Thompson and others (1968). Splits of the rock samples also were analyzed for antimony, arsenic, bismuth, cadmium, and zinc using the partial extraction, atomic-absorption method of Viets and others (1984), in which the readily soluble portion of these elements is dissolved and analyzed.

Results of Study

Semiquantitative spectrographic analyses of the stream-sediment sample (locality 1S, fig. 2) yielded elevated values of manganese (7,000 ppm (parts per million)), chrome (100 ppm), nickel (20 ppm), and vanadium (50 ppm). The heavy-mineral concentrate sample, from the same locality, yielded anomalous amounts of the same elements, as follows: manganese (1,000 ppm), chrome (100 ppm), nickel (50 ppm), and vanadium (70 ppm). No silver was detected in the spectrographic analyses of either sample, and no gold was detected in either sample although it was analyzed for by both spectrographic and chemical methods. These samples are from a stream that drains the staurolite schist terrane, and rock sample 5R (table 1) of the schist shows similar values for the same elements. An exception is manganese, which could readily be concentrated by stream processes. The values determined are not unusual for staurolite schist; hence, the four elements are not considered anomalous.

None of the rock samples showed values for silver or gold. Small amounts of copper, lead, and zinc were found in the metamorphic-rock samples (table 1, sample localities 1R, 2R, 4R, 5R). A value of 70 ppm for zinc was detected at locality 4R, but the sample is not considered anomalous. None of the geochemical data are believed to indicate significant mineralization.

Geophysics

Gravity and magnetic studies were undertaken as part of the mineral resource assessment of the Henry's Lake Wilderness Study Area. Data from the studies provide information on the subsurface distribution of density and magnetization and can be used to infer geological structure and rock composition. The gravity and magnetic data are of a reconnaissance nature and are adequate only to define regional (large scale) features. A study of linear structural, topographic, and other patterns on Landsat multispectral scanner images of southern Idaho revealed no features within the wilderness study area (D.L. Sawatzky, written commun., 1988).

The gravity map (fig. 4) is from Peterson and Witkind (1975), who conducted a study of the Henrys Lake region shown in figure 1. Complete Bouguer gravity values were computed using an assumed average density of 2.67 g/cm^3 (grams per cubic centimeter). Terrain corrections were made for a distance of 103 mi from each station by a method described by Plouff (1977). The Henrys Lake basin coincides with a gravity low that narrows northwestward (fig. 4), decreasing in amplitude across a gravity saddle (3 mi northwest of the study area), which Peterson and Witkind (1975) interpreted as reflecting a bedrock high. Gravity data from files maintained by the U.S. Department of Defense (not shown in fig. 4) indicate that the saddle is part of a regional high gravity trend that extends at least 10 mi to the northeast and 50 mi to the southwest beyond the area shown in figure 4.

Peterson and Witkind (1975) interpreted the Henrys Lake basin to be bounded by at least three major faults. They believed the east-west-trending gravity gradient immediately south of Henrys Lake to be associated with the Centennial fault (fig. 4); the steep gradient immediately west of Henrys Lake to be associated with a north-trending fault concealed beneath unconsolidated sediments and volcanic rock; and the steep southwest-dipping gradient (bracketed between points **A** and **B** in fig. 4) on the northeast side of the Henrys Lake basin to be associated with the Madison Range fault. Their gravity model across the gradient between points A and B indicates the Madison Range fault has a steep dip to the southwest. The wilderness study area lies northwest of the bracketed area, where the gradient broadens and the gravity values increase to the northeast over the core of the Madison Range. Peterson and Witkind (1975) believed this broad gradient over the range to reflect an increase in density of the crystalline rocks toward the core of the range, rather than displacement on the Madison Range fault, but their geologic map (Peterson and Witkind, 1975, figs. 1 and 2) and that of Witkind (1972a) show the fault as continuous along the range front. The broader gradient may reflect diminishing displacement on the Madison Range fault and thinning of the low density Cenozoic rocks of the basin over the bedrock high in the valley north of Henrys Lake. The increased gravity values over the core of the range reflect a northeastward continuation of the subsurface bedrock high beneath the exposed Archean rocks of the Madison Range itself, similar to a parallel gravity high associated with the southern part of the Blacktail-Snowcrest uplift about 65 mi to the west (Kulik and others, 1982).

The aeromagnetic anomaly map (fig. 5) is an enlargement of part of the residual intensity magnetic anomaly map of the Ashton 1°x2° topographic quadrangle (scale 1:250,000) (U.S. Department of Energy, 1982), in which the study area lies. The map was compiled from data collected along east-west flight lines spaced at 3–5 mi intervals at 400 ft above the ground surface. Magnetic data primarily reflect differences in the composition of the Archean crystalline rocks. The wilderness study area lies within a regional low magnetic anomaly that extends another 25 mi to the northeast and is associated with Archean biotite-quartz-feldspar gneiss and schist, marble, and metaquartzite of the southern part of the Madison Range (fig. 5). The high anomaly southwest of Henrys Lake is part of a magnetic high ridge that extends to the west-southwest beyond the area of figure 5, and the high probably reflects a change in composition of the metamorphic rocks in the basement. Volcanic rocks at the surface do not appear to have a characteristic magnetic signature. The low culmination of the magnetic anomaly over Henrys Lake may be augmented by the dipole effect—the high-low anomaly pair relationship commonly seen in magnetic data.

The geophysical data suggest the location of faults and compositional differences in rocks or the subsurface but do not directly indicate the existence or location of mineral resources.

Mineral and Energy Resources

Talc

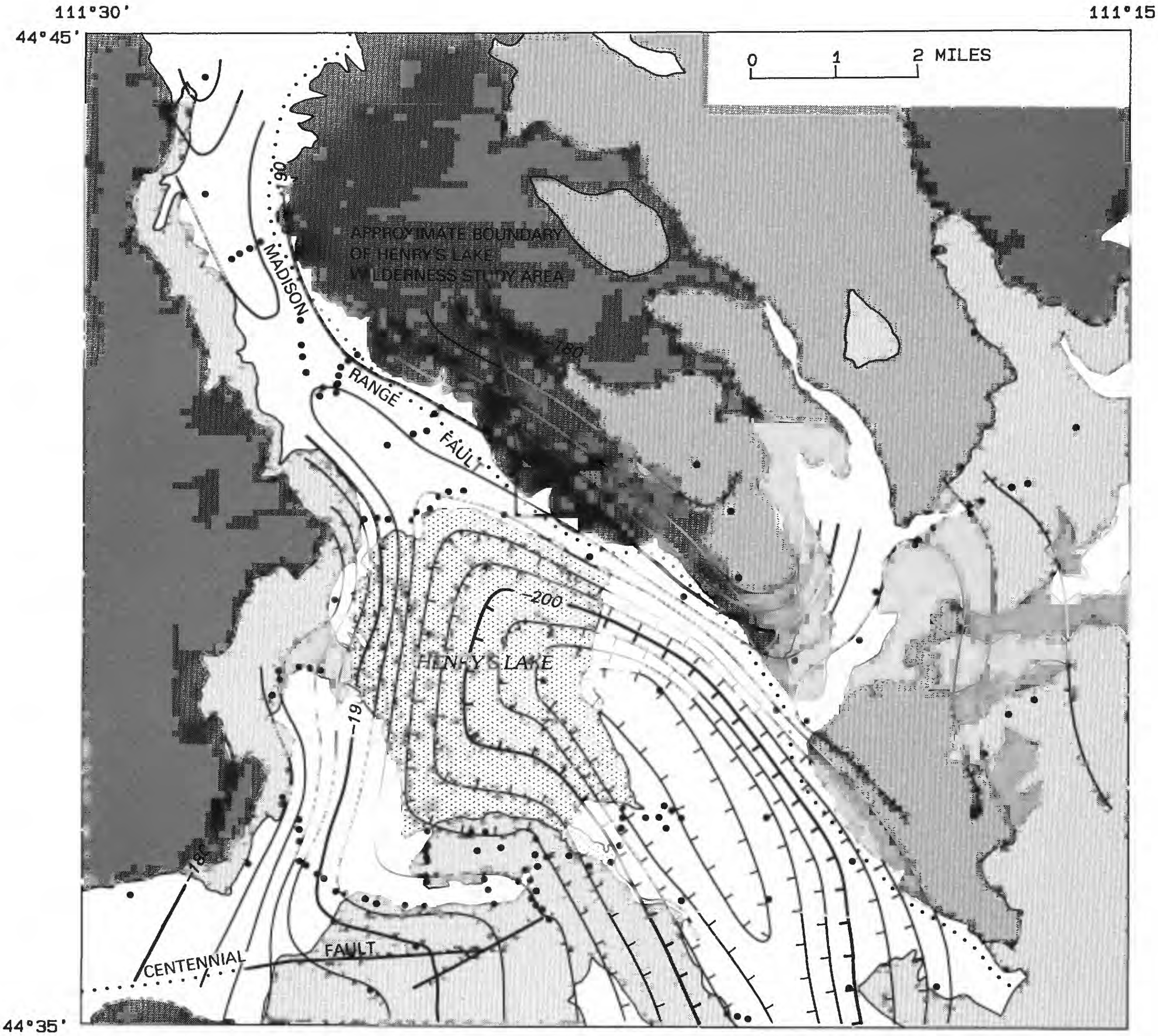
Talc deposits occur locally in marble of Archean metamorphic rocks in southwestern Montana, and the marble-bearing metamorphic rocks of the Henry's Lake Wilderness Study Area were examined for talc because they are a contiguous part of the same metamorphic terrane. In a discussion of the Montana talc deposits, Berg (1979) stated that all the known talc deposits of economic importance occur in the Precambrian marble. He further stated that most of the talc deposits formed by reaction of the Archean marble with siliceous fluids, an event that Garihan (1973) suggested may have occurred during the retrograde metamorphic episode 1,600 m.y. ago. An exception to this origin are three talc occurrences associated with mafic dikes that cut an extensive area of dolomitic marble in the Henrys Lake Mountains west of Henrys Lake (Berg, 1979, p. 58; Sonderegger and others, 1982), about 10 mi west of the wilderness study area. The only other talc described in the Henrys Lake Mountains was a minor occurrence adjacent to a small body of metagranodiorite (Berg, 1979).

Table 1. Semiquantitative spectrographic and chemical analyses of rock samples, in and near Henry's Lake Wilderness Study Area, Fremont County, Idaho

[Values are reported in the six-step classification, at midpoints 1, 1.5, 2, 3, 5, 7, 10, and so forth; L, detected but less than limit of determination shown in parentheses; N, not detected at limit of determination. R.T. Hopkins, spectrographic analyst, USGS; T.A. Roemer, chemical analyst, USGS]

					Spectrographic analyses																
					In percent				In parts per million												
Locality No. (fig. 2)	Sample No.	Latitude deg-min-sec	Longitude deg-min-sec	Rock type	Fe (0.05)	Mg (0.02)	Ca (0.05)	Ti (0.002)	Mn (10)	Ag (0.5)	As (200)	Au (10)	B (10)	Ba (20)	Be (1)	Bi (10)	Cd (20)	Co (5)	Cr (10)	Cu (5)	La (20)
1R	86MTz35	44-37-56	111-22-41	Quartz vein	2	0.5	0.7	0.15	300	N	N	N	20	1000	2	N	N	10	150	L	20
2R	86MTz39	44-38-15	111-22-36	Oxidized hornblende gneiss	10	.07	.3	.002	150	N	N	N	10	70	L	N	N	N	L	30	N
3R	86MTz40	44-38-12	111-22-42	Hematite sandstone	1	.03	L	.2	L	N	N	N	50	L	N	N	N	N	70	L	N
4R	86MTz41	44-38-10	111-22-43	Biotite gneiss	3	1	.3	.3	300	N	N	N	L	500	L	N	N	15	150	30	L
5R	86MTz42	44-38-16	111-22-52	Staurolite schist	5	2	.7	.5	300	N	N	N	L	500	1	N	N	30	500	30	L

	Spectrographic analyses, in parts per million													Chemical analyses, in parts per million					
Locality No. (fig. 2)	Mo (5)	Nb (20)	Ni (5)	Pb (10)	Sb (100)	Sc (5)	Sn (10)	Sr (100)	V (10)	W (50)	Y (10)	Zn (200)	Zr (10)	Th (200)	As (10)	Bi (1)	Cd (0.1)	Sb (2)	Zn (5)	Au (0.05)
1R	N	N	30	15	N	5	N	N	30	N	15	N	100	N	N	N	0.1	N	15	N
2R	N	N	5	10	N	N	N	N	10	N	10	N	N	N	N	N	.1	N	10	N
3R	N	N	7	N	N	N	N	N	15	N	L	N	300	N	N	N	N	N	N	N
4R	N	N	50	30	N	7	N	L	70	N	15	N	150	N	L	N	.1	N	70	N
5R	N	L	100	30	N	20	N	100	150	N	15	L	100	N	N	1	.1	N	35	N



EXPLANATION

Gravity contours—Contour interval 2 milligals; hachured contours enclose area of low gravity. Dots show location of measurement stations

Quaternary and Tertiary unconsolidated sedimentary rocks

Quaternary and Tertiary volcanic rocks

Mesozoic and Paleozoic sedimentary rocks

Archean crystalline rocks

Contact

Fault—Dotted where concealed. U, upthrown side; D, downthrown side

Figure 4. Complete Bouguer gravity anomaly map and generalized geology in the vicinity of the Henry's Lake Wilderness Study Area. Gradient between points A and B is discussed in text. Gravity stations from Peterson and Witkind (1975); geologic base generalized from Witkind (1972a)

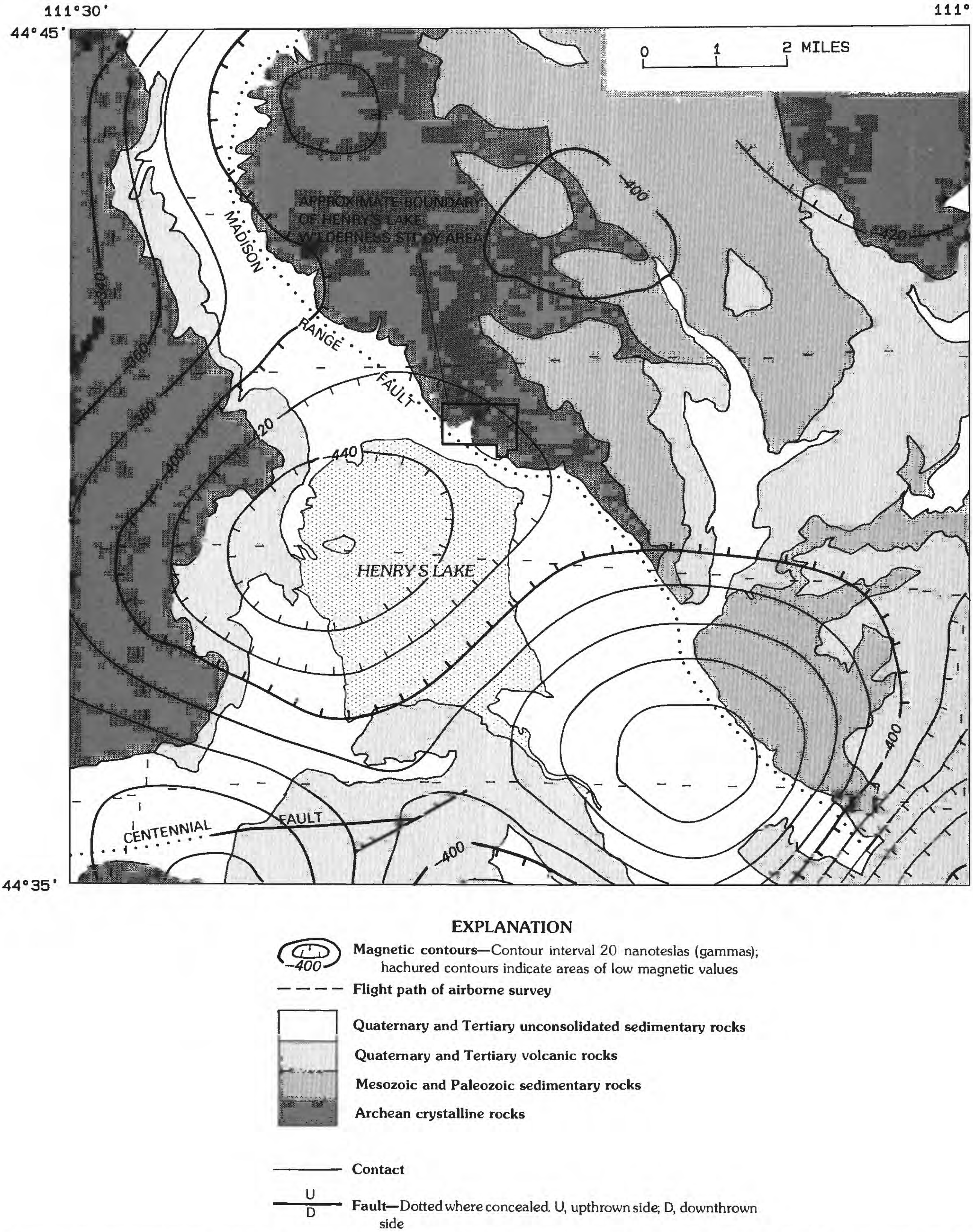


Figure 5. Aeromagnetic anomaly map and generalized geology in the vicinity of the Henry's Lake Wilderness Study Area. Magnetic data from U.S. Department of Energy (1982); geologic base generalized from Witkind (1972a).

Talc was not found in the small outcrop of marble that lies in and adjacent to the southernmost part of the wilderness study area (fig. 2). No mafic dikes were observed to cut the marble and no granitic intrusive rocks, from which siliceous fluids might have originated and reacted with marble to form talc, were found in the vicinity by us or mapped by Witkind (1972a). However, traces of talc were found in the tabular body of marble that crops out about 0.25–0.75 mi east of the study area (fig. 2), where the USBM (this report, and Peters and Winters, 1988) found talc in float chips. The tabular marble body also contains small quartz knots and tremolite, a fibrous amphibole. The tabular marble unit is inclined to the west and part of it could lie concealed beneath the study area. Rocks exposed in the study area have been downdropped and displaced basinward along the two arcuate, north-trending normal faults shown in figure 2. If part of this tabular marble body is present beneath the study area, it likely was downdropped and would lie at a greater depth beneath the surface than would otherwise be the case.

Resource potential.—The mineral resource potential for talc in marble exposed in the southeasternmost part of the study area is rated as low, with a certainty level of C. The mineral resource potential for talc in marble strata that could lie concealed beneath the study area is rated as unknown, with a certainty level of A.

Other Mineral Resources

No gold, silver, or significant concentrations of iron or other metals were found in the wilderness study area. Gold and associated silver occur locally in Archean metamorphic rocks in the adjacent region of southwestern Montana, but neither of these elements is known to be present in Archean rocks in or near the wilderness study area. No gold or silver was detected in the rock, stream-sediment, or concentrate samples analyzed. The one quartz vein that was sampled yielded only an elevated value for barium, but no other anomalous metal value (table 1, locality 1R). The resource potential for gold and silver is rated as low with a certainty level of C.

Iron in hematite of oxidized Archean amphibolite gneiss occurs in and adjacent to the northeast corner of the wilderness study area, but, as discussed in the USBM section of this report, the iron is not so significantly enriched as to constitute a resource. No hematite of oxidized Archean amphibolite was found in other parts of the study area. The mineral resource potential for iron in hematite of oxidized amphibolite gneiss in the entire wilderness study area is rated as low, with a certainty level of C.

Uranium potential of the Ashton 1°x2° topographic quadrangle, in which the wilderness study area occurs, was evaluated during the NURE (National Uranium Resource Evaluation) program. No samples were collected from the study area, but samples collected from similar metamorphic rocks nearby do not show anomalous concentrations of uranium (Shannon, 1980, 1982). As part of the NURE study, Suekawa and others (1982) concluded that the Archean metamorphic rocks within the Ashton quadrangle contain environments that are unfavorable for uranium deposits. The resource potential for uranium is rated as low, with a certainty level of B. Geochemical sampling within the wilderness study area would be necessary to have a higher level of certainty.

The major source of phosphate in the Western United States is the Permian Phosphoria Formation. Although phosphate resources exist in the Centennial Mountains a few miles southwest of the wilderness study area (fig. 1), phosphate-bearing strata have been eroded from the general vicinity of the study area (fig. 3). No resource potential for phosphate of the Phosphoria Formation exists within the Henry's Lake Wilderness Study Area. The rating is made with a certainty level of D.

Geothermal Energy

No hot springs, or tufa deposits of former hot springs, occur within or adjacent to the wilderness study area. But the area lies just north of the eastern part of the Snake River Plain, a region of geologically young volcanic rocks that are suggestive of high heat flow (Brook and others, 1979; Smith and Shaw, 1979). Yellowstone National Park (about 9 mi east of the wilderness study area) lies at the northeast end of the Snake River Plain and contains abundant resources of geothermal energy; and a known geothermal resource area (KGRA) lies about 7 mi east of the study area, along the western border of the Park (Muffler, 1979). About 25 mi south of the wilderness study area, Muffler (1979) showed many KGRA's present in the vicinity of the Island Park Caldera. Although the Henry's Lake Wilderness Study Area and the immediately adjacent terrain do not contain the geologically young volcanic rocks, the close proximity of the Snake River Plain and Yellowstone National Park with their geothermal waters suggests that the wilderness study area must be considered favorable for geothermal resources.

Movement along the Madison Range fault possibly could provide a conduit for geothermal water to reach the ground surface. The wilderness study area lies in a region that, historically, is the most seismically active in the Rocky Mountains (Smith and Braile, 1984), and it is within seismic risk zone 3, defined on the Seismic Map of the United States (Algermissen, 1969) as an area in which major destructive earthquakes may occur. Some segments of the Madison Range fault underwent movement during the 1959 Hebgen Lake earthquake (U.S. Geological Survey, 1964), but the southeast-trending, southern extent of the fault north of Henrys Lake is concealed beneath alluvial deposits, as shown on the geologic map of Witkind (1972a). Peterson and Witkind (1975) stated that the trace of the fault is marked by a scarplet 10–30 ft high, indicating that the fault is active, but no ground breakage in or adjacent to the wilderness study area took place during the 1959 Hebgen Lake earthquake (U.S. Geological Survey, 1964, pl. 5). Interpretative maps of Witkind (1972d, e) show that a zone along the concealed trace of the Madison Range fault, including the segment in the wilderness study area (fig. 2), could experience fault movement and ground breakage during an earthquake.

The resource potential for geothermal water along the Madison Range fault is rated as moderate, with a certainty level of B. A higher level of certainty would require specific studies, such as heat flow measurements and collection of data from existing wells, to better evaluate the potential for geothermal resources. For the remainder of the wilderness study area, the resource potential for geothermal water is rated as low, with a certainty level of C.

Oil and Gas

The energy resource potential for oil and gas in the wilderness study area is not considered favorable because of the thermal effects of the geologically young volcanic systems in the nearby Snake River Plain and Yellowstone National Park. Sandberg (1983, p. F4) stated that conodont alteration index values of 1.5 to 2 were obtained from (Paleozoic) strata at Targhee Peak, 3 mi north of the wilderness study area, which he stated indicated optimum maturation for oil and gas generation in the area. These strata overlie Archean metamorphic rocks and have been eroded from all but the crestal area of the southern part of the Madison Range, and eroded from the Henrys Lake Mountains west of Henrys Lake; hence, potential source rocks no longer exist in the wilderness study area. No resource potential exists for oil and gas in the wilderness study area, with a certainty level of D.

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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.

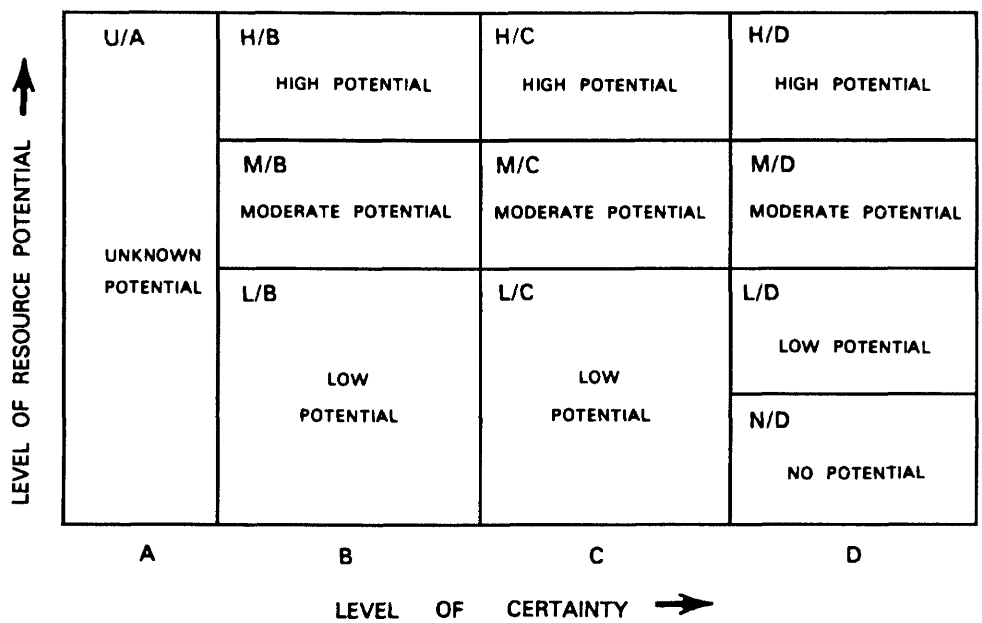
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application 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.

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RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	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, 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 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	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	~ 570[1]
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 m.y. also called Precambrian, a time term without specific rank.

[2] Informal time term without specific rank.

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

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

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

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