PHASE I

Geology, Energy, and Mineral (GEM) Resource Evaluation of Henry's Lake GRA, Idaho, including the Henry's Lake (35-77) Wilderness Study Area

Bureau of Land Management
Contract No. YA-553-CT2-1039

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ANCHORAGE, ALASKA
AUGUST 1983

WGM INC.
MINING AND GEOLOGICAL CONSULTANTS

EXECUTIVE SUMMARY

The Henry's Lake GRA is located in Montana and Idaho on the Continental Divide about sixteen miles west of West Yellowstone, Montana. The GRA contains one 350 acre Wilderness Study Area (WSA), Henry's Lake WSA (35-77) just north of Henry's Lake, Idaho.

Bedrock in the Henry's Lake GRA consists of Precambrian metasedimentary units, Paleozoic carbonate and clastic units, and Quaternary volcanic and alluvial and glacial deposits. The area is seismically active and subject to significant geologic hazards relating to earthquake activity.

The Henry's Lake GRA is not in a highly mineralized region. No metallic or non-metallic mineral deposits are known in the GRA although gravel and stone have been exploited. The geologic environment of the Henry's Lake GRA and interpretation of existing geologic data suggest a low potential for mineral and oil and gas resources. The GRA is in the Central Idaho Basin and Range geothermal province; therefore, a moderately favorable potential exists for geothermal resources.

SUMMARY OF GEM RESOURCES CLASSIFICATION FOR THE HENRY'S LAKE WSA, IDAHO

Resource	Classification
1. Locatable Resources	
a. Metallic Minerals	1D
b. Uranium and Thorium	1D
c. Non-Metallic Minerals	1D
2. Leasable Resources	
a. Oil and Gas	1D
b. Geothermal	3A
c. Sodium and Potassium	1D
d. Other	1D
3. Salable Resources	4D (sand and gravel) 1D (other)

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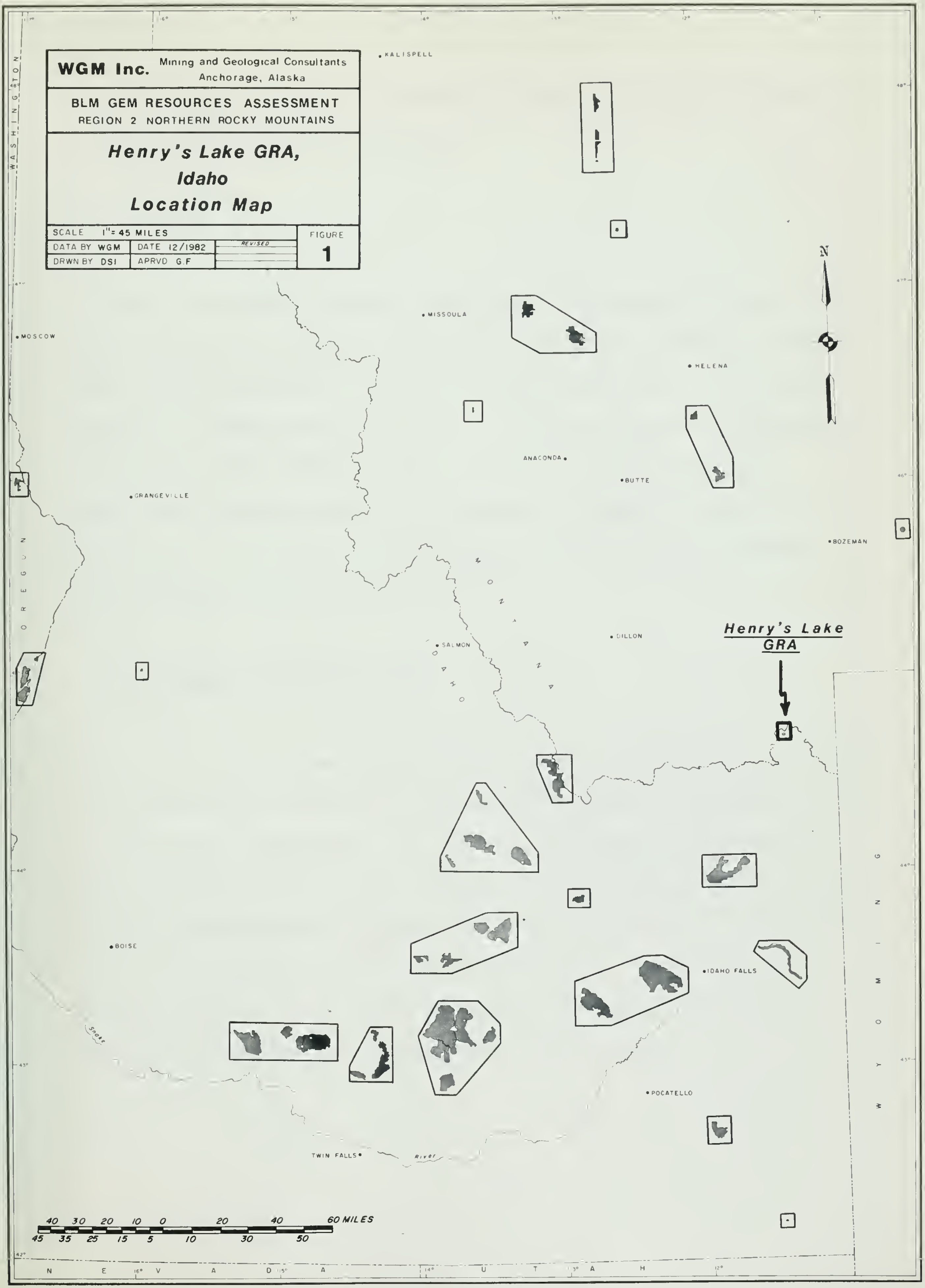
HENRY'S LAKE GRA, IDAHO-MONTANA

1.0 INTRODUCTION

The Bureau of Land Management has adopted a two-phase procedure for the integration of geological, energy and minerals (GEM) resources data into the suitable/non-suitable decision-making process for Wilderness Study Area (WSAs). The objective of Phase I is the evaluation of existing data, both published and available unpublished data, for interpretation of the GEM resources potential of the WSAs. Wilderness Study Areas are grouped into areas based on geologic environment and mineral resources for initial evaluation. These areas are referred to as Geology, Energy, Mineral Resource Areas (GRAs).

The delineation fo the GRAs is based on three criteria: (1) a 1:250,000 scale map of each GRA shall be no greater than 8½ x 11 inches: (2) a GRA boundary will not cut across a Wilderness Study Area; and (3) the geologic environment and mineral occurrences. The data for each GRA is collected, compiled, and evaluated and a report prepared for each GRA. Each WSA in the GRA is then classified according to GEM resources favorability. The classification system and report format are specified by the BLM to maintain continuity between regions.

This report is prepared for the Bureau of Land Management under contract number YA-553-CT2-1039. The contract covers GEM Region 2: Northern Rocky Mountains (Fig. 1). The Region includes 50 BLM Wilderness Study Areas



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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS
Henry's Lake GRA,
Idaho
Location Map
SCALE 1" = 45 MILES
DATA BY WGM
DATE 12/1982
REVISED
DRWN BY DSI
APRVD G.F
FIGURE
1
Henry's Lake GRA
N
KALISPELL
MISSOULA
HELENA
MOSCOW
ANACONDA
BUTTE
GRANGEVILLE
BOZEMAN
DILLON
SALMON
IDAHO
MONTANA
WASHINGTON
OREGON
WYOMING
IDAHO FALLS
BOISE
POCATELLO
TWIN FALLS
Snake
River
NEVADA
UTAH
40 30 20 10 0 20 40 60 MILES
45 35 25 15 5 10 30 50

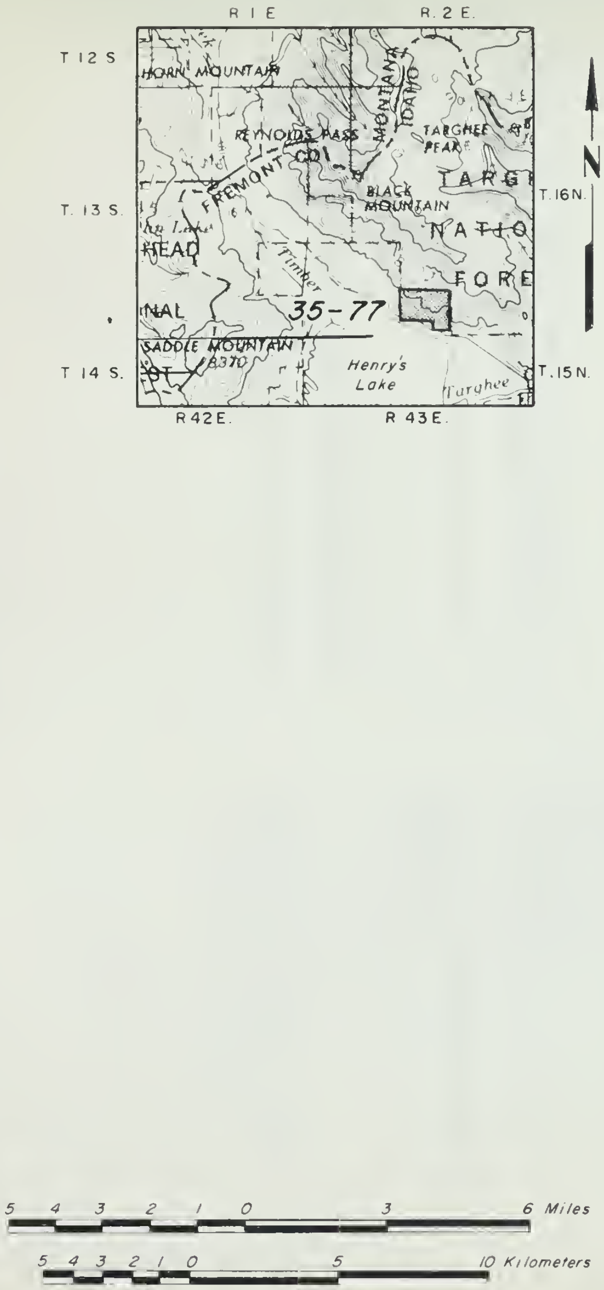
totalling 583,182 acres. The WSAs were grouped into 22 GRAs for purposes of the Phase I GEM resources evaluation.

1.1 Location

The Henry's Lake GRA is located in the Henry's Lake Mountains of the Madison Range in extreme southwestern Montana and southeastern Idaho just north of Henry's Lake in Ts.15-16N., Rs.42-43E. (Idaho) and T.12-13S., Rs.1-2E. (Montana). Administratively the area is within the Medicine Lodge Resource Area of the Idaho Falls BLM district. The Henry's Lake GRA totals approximately 68 square miles and encompasses the Henry's Lake Wilderness Study Area (37-77) which totals 350 acres. This is the only Wilderness Study Area within the GRA (Fig. 2).

1.2 Population and Infrastructure

There are no large communities within the Henry's Lake GRA. The settlements of Lake and Staley Springs are located on the northeast and northwest shores of Henry's Lake respectively. The center of the GRA is 16 miles west of West Yellowstone, Montana (pop. 735) and 14 miles north of Macks Inn, Idaho. The GRA is transected by Highway 87 which joins with U.S. 191 in the southeast corner of the GRA. An airstrip is located near the intersection between Targee and Howard Creeks on the south boundary of the GRA. The Henry's Lake WSA bordered by Highway 87 on the southwest.



Approximate Boundary of Wilderness Study Area.

BLM Wilderness Study Areas Included in the Henry's Lake GRA.

WSA	NAME	ACREAGE
35-77	Henry's Lake	350

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho

Topographic Map

SCALE 1" = 4 MILES (1:250,000)			FIGURE
DATA BY WGM	DATE 9/1982	REVISED	2
DRWN BY DSI	APPRVD G.F.		

1.3 Basis of the Report

This report is based on a compilation, review, and analysis of available published and unpublished data on the geology, energy, and mineral resources of the Henry's Lake GRA. The geology of the GRA has been mapped in detail by Witkind (1972) and a regional compilation is available by Mitchell and Bennett (1979). The data was compiled and reviewed by WGM project personnel and the panel of experts to produce the resource evaluation which comprises this report. Personnel are as follows:

Greg Fernette, Senior Geologist, WGM Inc.	Project Manager
C.G. Bigelow, President, WGM Inc.	Chairman, Panel of Experts
Joel Stratman, Geologist, WGM Inc.	Project Geologist
Jami Fernette, Land and Environmental Coordinator, WGM Inc.	Claims and Lease Compilation

Panel of Experts

C.G. Bigelow, President, WGM Inc.	Regional geology, metallic and non-metallic minerals, mineral economics.
R.S. Fredericksen, Senior Geologist, WGM Inc.	Regional geology, metallic minerals.
David Blackwell, Ph.D., Professor of Geophysics, Southern Methodist University	Geothermal.
Jason Bressler, Senior Geologist, WGM Inc.	Regional geology, metallic minerals.
Gary Webster, Ph.D., Chairman, Department of Geology, Washington State University	Oil and gas.
William Jones, Senior Geologist, WGM Inc.	Metallic minerals, coal, industrial minerals.

J.F. McOuat, President, Watts, Griffis & McOuat Ltd.	Mineral economics, and industrial minerals.
E.F. Evoy, Senior Geologist, Watts, Griffis & McOuat Ltd.	Uranium and thorium.

1.4 Acknowledgements

We would like to thank Tim Carroll, BLM District Geologist for the Idaho Falls district for assistance during the compilation phase of this project.

2.0 GEOLOGY

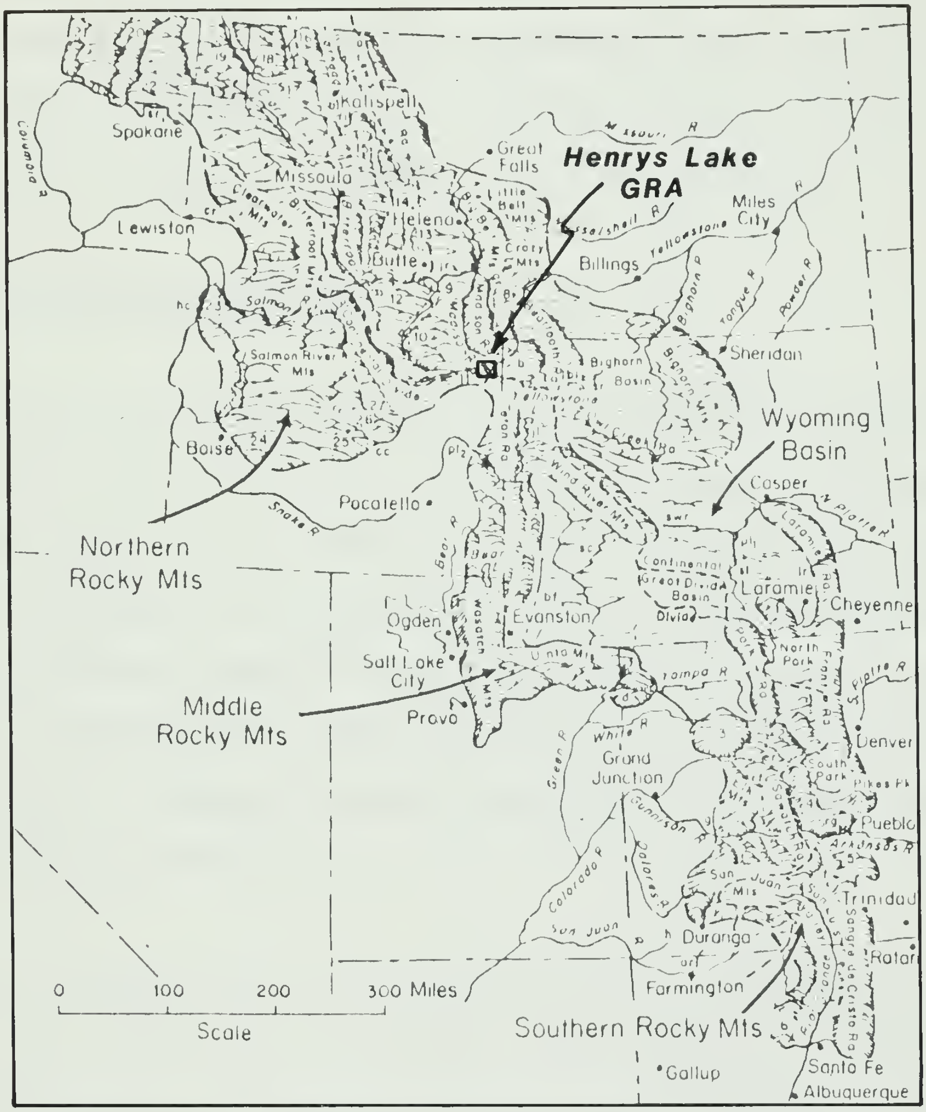
2.1 Introduction

The geology of the Henry's Lake GRA has been studied in detail by Irvin Witkind of the U.S. Geological Survey. This work has been published as a Folio of six maps describing the geology, geologic hazards, slope stability and construction materials of the Henry's Lake Quadrangle (Witkind, 1972).

The oldest rocks in the Henry's Lake GRA consist of pre-Belt Series crystalline rocks which include dolomite, quartzite, gneiss, amphibolite, mica schist and an orthogneiss. The mica schist and dolomite are the most abundant rock types. The pre-Belt rocks are overlain in some places by extensive deposits of Paleozoic (600-230 m.y.) rocks, ranging in age from Middle Cambrian (542-515 m.y.) to Mississippian (345-310 m.y.), and elsewhere by Quaternary (2 m.y. to present) felsic volcanic rocks. The eastern edge of the Henry's Lake Basin is clearly defined by a northwest-trending steep mountain front which reflects the Madison Range fault - a southwest dipping, front-range-type normal fault (Peterson and Witkind, 1975). The Precambrian (older than 600 m.y.) and Paleozoic rocks are deformed into a series of southwest plunging folds. Surficial deposits in the area consist of Quaternary fluvial, glacial, alluvial, and landslide deposits.

2.2 Physiography

The Henry's Lake GRA is in the Northern Rocky Mountains physiographic province (Hunt, 1974; Fig. 3). Elevations range from 6,596 feet at Henry's



Data from: Hunt (1974).

WGM Inc.	Mining and Geological Consultants Anchorage, Alaska		
BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS			
Henry's Lake GRA, Idaho ***Physiographic Setting***			
SCALE AS SHOWN			FIGURE
DATA BY	DATE 3/1983	REV. SEC.	3
DRWN BY DSI	APRVD G F		

Lake to 10,180 feet at Lionhead Peak. The rugged Henry's Lake Mountains of the Madison range form steep terrain northeast of Henry's Lake while to the west the Horn Mountains display somewhat less relief. The GRA straddles the Continental Divide and is drained by the Henry's Fork of the Snake River and tributaries of the Madison River. Tree line is at approximately 7,000 feet below which are stands of lodgepole pine and mixed conifers.

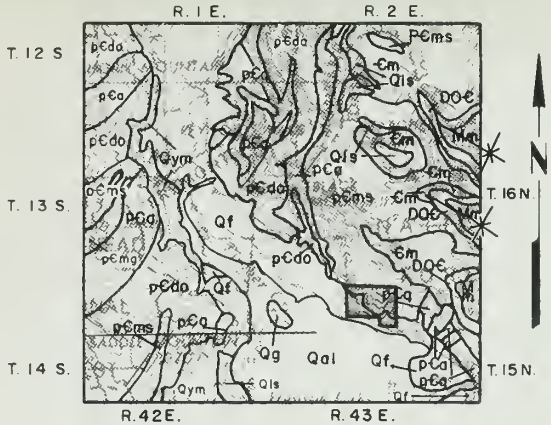
2.3 Description of Rock Units

The oldest rocks within the Henry's Lake GRA belong to an unnamed Precambrian mica schist unit (Fig. 4) described as a dark gray to brown, strongly micaceous foliate (Witkind, 1972). Major constituents are biotite, quartz, and potassic and plagioclase feldspar. Garnet and staurolite metacrysts are locally common as rods, grains, knots, and clusters. Accessory minerals include apatite, sphene, zircon, epidote, tremolite, and opaque iron minerals. Alteration products are sericite, chlorite and bleached biotite (Witkind, 1972).

Overlying the mica schist is Precambrian quartzite. The quartzite is a white, light gray, gray, green foliate which is thin- to thick-bedded, strongly micaceous, and medium- to coarse-grained. The rock is virtually bimodal consisting essentially of quartz and muscovite with accessory microcline, opaque iron minerals, sericite and chlorite (Witkind, 1972).

The quartzite is overlain by Precambrian dolomite. The dolomite is a light brown to light gray, thick-bedded to massive, coarsely crystalline foliate. It contains abundant thin to thick ridge forming sinuous quartz seams. Radiating blades of tremolite occur locally (Witkind, 1972).

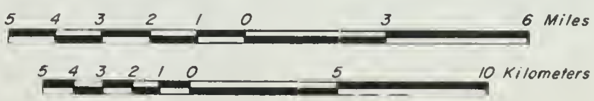
EXPLANATION



CENOZOIC	Qal	Streom alluvium	Recent	Quaternary
	Qls	Londslide debris		
	Qf	Alluviol fon deposits		
	Qg	Glocial deposits		
	Qym	Mesa Falls Tuff brownish groy, rhyolitic osh-flow tuff	Pleistocene	
PALEOZOIC	Mm	Modlson Group limestone, fossiliferous limestone, and bedded chert	Mississippian	
	DO€	Devonian, Ordovician and Cambrian undifferentioted		
	€m	Flathead Sandstone, Meagher Limestone and Park Shale	Middle Cambrian	
PRECAMBRIAN	p€mg	Metogronodiorite	Precambrian	
	p€a	Amphibolite		
	p€do	Dolomite		
	p€q	Quortzite		
	p€ms	Mica Schist		

—✳— Syncline

Approximate Boundary of Wilderness Study Area.



Data by: Mitchell and Bennett, 1979
Witkind, 1972

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REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho

Geologic Map

SCALE 1" = 4 MILES		FIGURE 4
DATA BY	DATE 1/1983	
DRWN BY DSI	APRVD G F	

Precambrian amphibolite overlies the dolomite. The amphibolite is a strongly foliated, dark gray, very fine-grained to fine-grained gneiss. It displays irregularly alternating laminae of hornblende and mixed quartz-plagioclase feldspar. Minor constituents include biotite, apatite, sphene, epidote, zircon and opaque iron minerals. Alteration products present in the rock include chlorite, sericite and calcite. Locally the biotite content increases and the unit resembles mica schist (Witkind, 1972).

West of Henry's Lake the foliated units contain a body of granodiorite gneiss. This orthogneiss is a light gray to gray, fine- to very coarse-grained, equigranular foliated rock composed of oligoclase, quartz, biotite and muscovite. Less common constituents are potassic feldspar, hornblende, apatite, zircon(?), sphene epidote and opaque iron minerals. Alteration products include sericite and chlorite (Witkind, 1972).

Unconformably overlying the Precambrian metamorphic rocks is a sequence of Middle Cambrian sedimentary units consisting of the Flathead Sandstone, the Meagher Limestone, and the Park Shale. The Flathead Sandstone is a brown, gray and white quartzose sandstone which is medium- to thick-bedded or massive. It is fine- to coarse-grained, poorly sorted and cross-bedded. In places pebbles and cobbles of Precamrbian rocks are present. The thickness of the unit varies from 20 to 200 feet (Witkind, 1972). The succeeding Meagher Limestone consists of light gray to gray limestone with brown and reddish siltstone mottles. The limestone is medium- to thick-bedded, locally massive, and weathers with a crenulated nodular surface. In the middle of the unit discontinuous intraformational conglomerates occur and at the base pebbles and grains of Precambrian rocks are present. The Meagher

is approximately 550 feet thick (Witkind, 1972). The overlying Park Shale is a gray, greenish-gray to grayish-red, even-bedded fissile unit which breaks into minute angular shale fragments. It contains thin, discontinuous interbeds of oolitic limestone which are rich in fossil fragments and pelletal debris. The Park Shale weathers recessively and is approximately 170 feet thick (Witkind, 1972).

Unconformably overlying the Park Shale is a sequence of Late Cambrian (515-500 m.y.) through Devonian (395-345 m.y.) age sedimentary units which probably correlate with the Pilgrim Limestone, Snowy Range Formation, Bighorn Dolomite, Jefferson Formation and Three Forks Formation. The lower portion of the mapped sequence (from top to bottom) contains light gray dolomite equivalent(?) to the Bighorn Dolomite (Upper Ordovician-450 to 435 m.y.), brown siltstone equivalent(?) to the Snowy Range Formation (Upper Cambrian) and blue-and-gold limestone equivalent(?) to the Pilgrim Limestone (Upper Cambrian). Many intraformational conglomerates are present. The combined thickness of these units is 350 to 525 feet. The uppermost unit of the sequence is the Middle (370-360 m.y.) and Upper Devonian (360-345 m.y.) Jefferson Formation comprised principally of dolomite. The dolomite is grayish brown, thick-bedded to massive, and locally contains scattered chert fragments. It totals about 240 feet in thickness (Witkind, 1972).

The Mississippian Madison Group unconformably overlies the sequence of Upper Cambrian to Devonian formations. The Madison Group is a bluish-gray carbonate sequence consisting of an upper unit, the Mission Canyon Limestone, composed of thick to massive limestone beds, and a lower unit, the Lodgepole

Limestone, composed of thin to medium limestone beds that are very fossiliferous and contain much bedded chert. The thickness of these rocks in the Henry's Lake Mountains is about 1,300 feet (Witkind, 1972).

Pleistocene (2-0.1 m.y.) felsic extrusive rocks of the Mesa Falls Tuff overlie older rock units along the east flank of the Horn Mountains west of Henry's Lake. These are brownish-gray, platy, lithodial tuffs with a fine-grained groundmass which contain pumice fragments locally well aligned. Phenocrysts are very abundant and make up 45% of the volume of the rock. Most pheoncrysts are larger than 1 mm and many (mainly sanidine) exceed 2 mm in diameter (Witkind, 1972).

Quaternary surficial deposits in the area consist of stream alluvium, alluvial fan deposits, glacial deposits and landslide debris (Witkind, 1972).

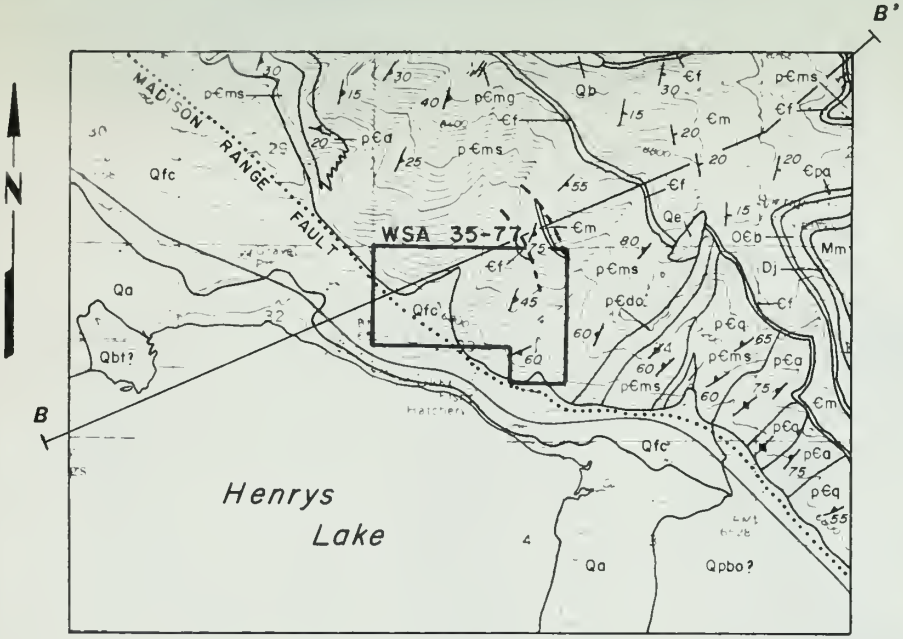
2.4 Structural Geology and Tectonics

The Henry's Lake Mountains geologically form the southern end of the Madison Range. The Henry's Lake GRA is located along the western margin of the Beartooth shelf northeast of the frontal Sevier orogenic belt (Peterson, 1981). Scholten (1967) considers this area to be part of the southern end of the Madison-Gravelly arch. Rock units have been deformed into a series of open southeast plunging folds. The core of the synclinal troughs consists of infolded Paleozoic sedimentary units. At the eastern edge of the GRA, Witkind (1972) recognizes two major synclines. The northernmost

syncline is named the Bald Mountain syncline whereas the southernmost syncline is unnamed.

The Henry's Lake mountains rise 1,350 to 2,760 feet above the valley floor containing shallow Henry's Lake. Gravity data suggests that the Henry's Lake Basin contains 3,400 feet or more of Cenozoic (65 m.y. to present) sediments and volcanic rocks (Peterson and Witkind, 1975). The Henry's Lake Basin is part of a graben. The northeastern edge of the basin is clearly defined by a northwest-trending steep mountain front that reflects the Madison Range fault (Fig. 5), a range-front fault which extends about 55 miles to the northwest terminating near Ennis, Montana. The southwestward dipping normal fault is believed to have at least 1,800 feet of stratigraphic throw. The presence of a scarp along the trace of the Madison fault indicates that the fault is still active (Peterson and Witkind, 1975) and probably has been active since latter Tertiary (65-2 m.y.) time (Pardee, 1950). The Centennial fault may intersect the Madison fault about 9 miles southeast of the GRA although direct evidence for this is lacking (Peterson and Witkind, 1975).

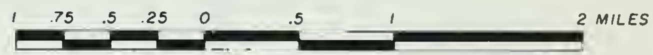
The Henry's Lake GRA is situated near the Yellowstone Park earthquake swarm within the Intermountain Seismic belt. This belt is a zone of pronounced earthquake activity extending from Arizona to northwestern Montana (Fig. 6). The belt is more than 3,000 miles long and 300 miles wide (Smith and Sbar, 1974). The Henry's Lake Quadrangle lies within seismic zone 3 of Algermissen's (1969) seismic map of the United States. Seismic zone 3 is defined as an area in which major destructive earthquakes may occur. The largest historic seismic event of the Intermountain Seismic belt was the

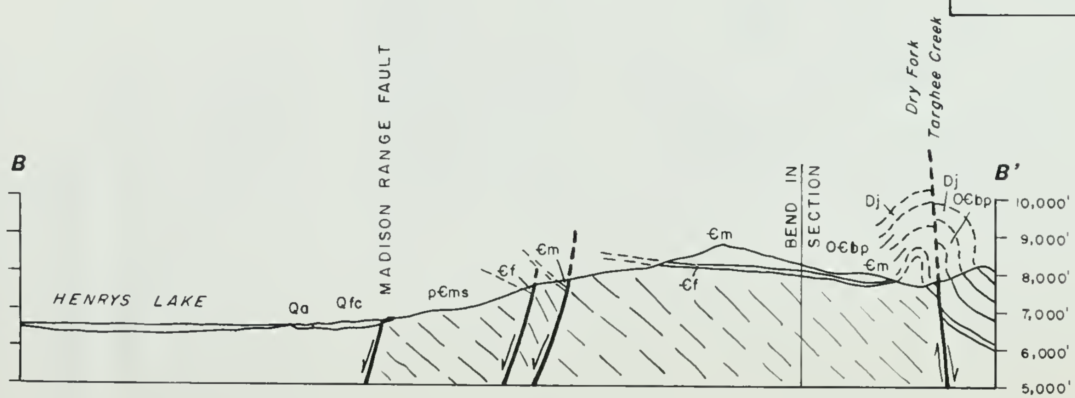


Data from: Witkind (1972).

Legend

Qa	Alluvium	Holocene
Qfc	Alluviol Fans	Holocene
Qb	Boulder Field	Holocene
Qbt	Bull Lake Till	Pleistocene
Qpbo	Outwosh, Pre Bull Lake	Pleistocene
Mm	Modison Group	Mississippion
Dj	Jefferson Formotion	Devonion
O€b	Bighorn (?) Dolomite, Snowy Range (?) Formation ond Pilgrim (?) Limestone	Upper Ordovicion, Upper Combrion
€m	Meoghar Limestone	Middle Cambrion
€f	Flathead Sondstone	Middle Cambrion
p€mg	Meto-gronodiorite	Precombrion
p€do	Dolomite	Precombrion
p€q	Quortzite	Precombrion
p€ms	Mico Schist	Precombrion
p€u	Pre-Belt Rocks Undivided (p€mg, p€do, p€q, p€ms)	Precombrion





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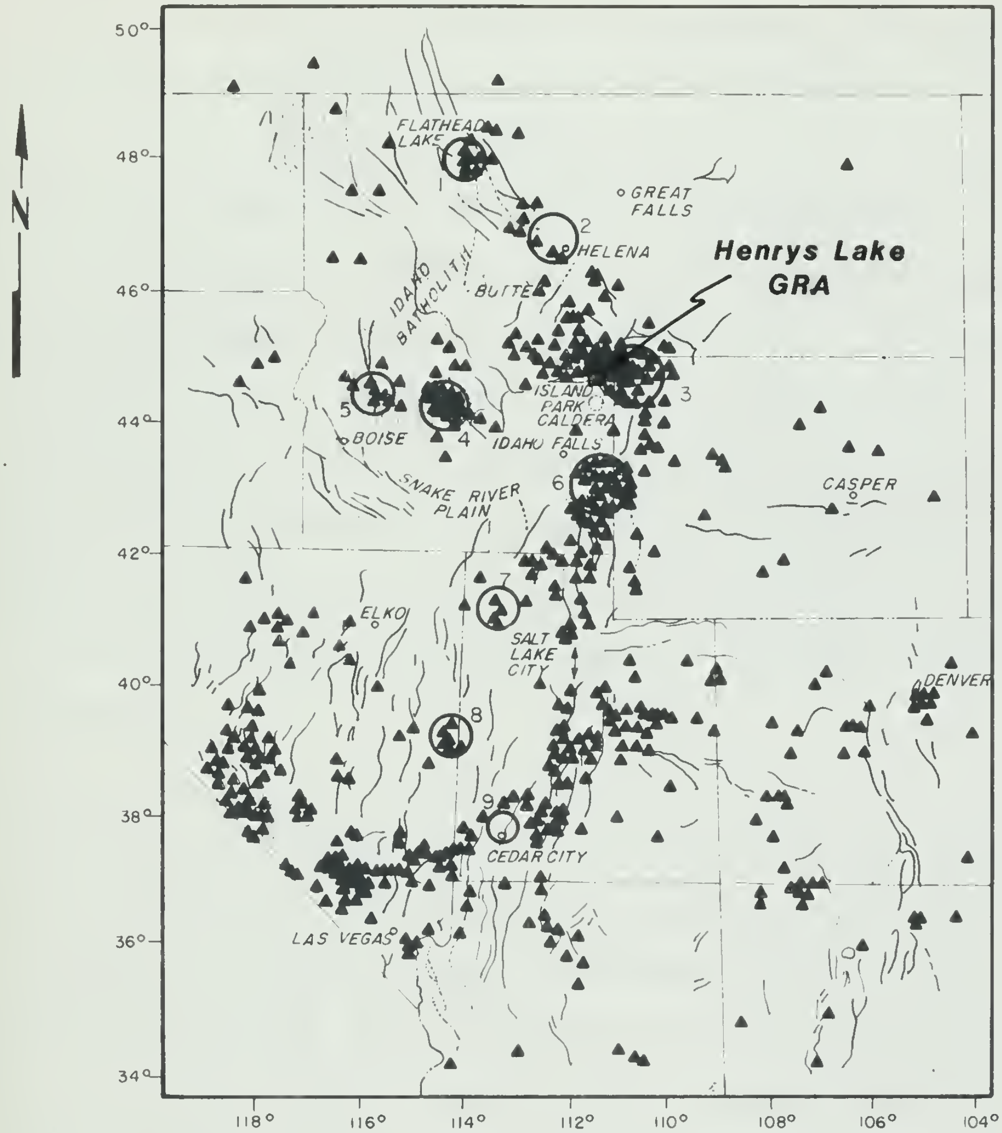
BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake WSA, Idaho

DETAILED GEOLOGY

1" = 1 MILE

5



EPICENTERS FOR INTERMOUNTAIN SIESMIC BELT SHOWING ALL EARTHQUAKES REPORTED BY NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA) OF ABOUT MAGNITUDE 3.0 OR GREATER FROM 1961 THROUGH 1970. DOUBLE ARROW SHOWS ZONE OF LOW SIESMICITY. CIRCLES MARK EARTHQUAKE SWARMS: 1, FLATHEAD LAKE, MONT.; 2, HELENA, MONT.; 3, YELLOWSTONE PARK; 4, SAWTOOTH RANGE, IDAHO; 5, IDAHO BATHOLITH; 6, CARIBOU RANGE, IDAHO; 7, GREAT SALT LAKE DESERT, UTAH; 8, LEHMAN CAVE MONUMENT, NEVADA; 9, CEDAR CITY, UTAH

DATA FROM SMITH AND SBAR (1974)

0 70 140 210 MILES

SCALE APPROXIMATE

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BLM GEM RESOURCES ASSESSMENT

REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho

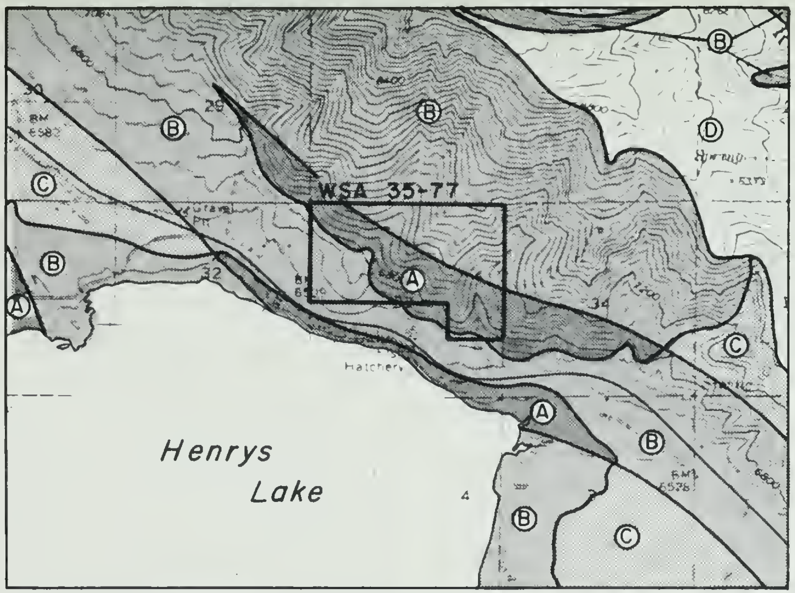
Regional Seismicity

SCALE AS SHOWN			FIGURE
DATA BY	DATE 1/1983	REVISED	6
DRWN BY DSI	APPR GF		

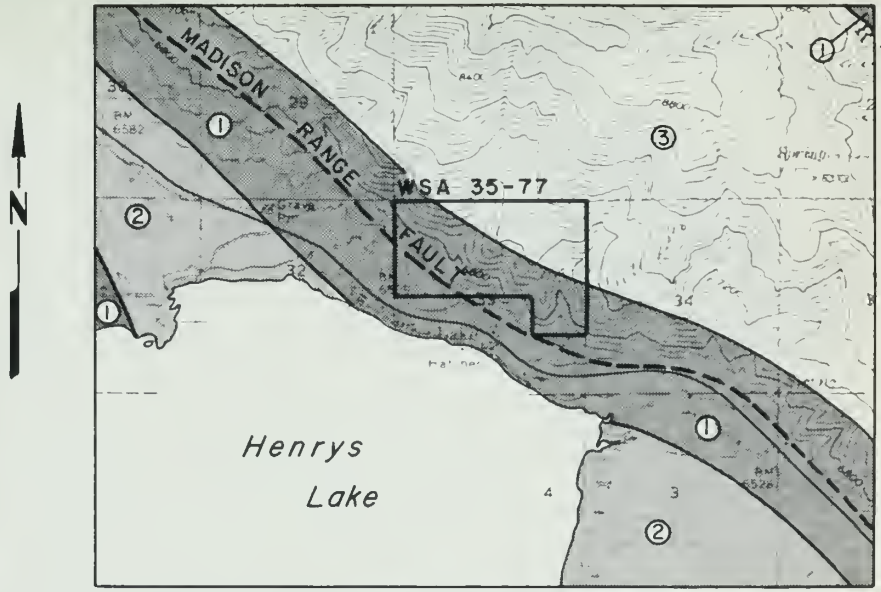
Hebgen Lake earthquake of magnitude 7.1 which occurred on August 17, 1959. It was centered about 10 miles north of the Henry's Lake WSA. The seismicity of the area is dominated by aftershocks of that event. The Hebgen Lake earthquake produced a vertical displacement of 20 feet.

One of the effects of the 1959 Hebgen Lake earthquake was to trigger a 90 million ton rockslide with sufficient velocity to create a massive airblast and momentum enough to bring the leading edge of the slide some 300 feet up the opposite wall of the Madison River canyon (Hadley, 1960). The slide blocked the Madison River six miles below Hebgen Lake eventually creating a lake which threatened the valley downstream. The rocks which failed during the earthquake belong to pre-Belt age dolomites, schists and gneisses and failure occurred along planes subparallel to a 45°-65° northerly dipping foliation.

Structures and rock types within Henry's Lake WSA are analagous with those in the Hebgen Lake area. The area is bounded by the active Madison fault and contains at least two mapped southwestward dipping faults along which failure might occur. Bedrock consists of well foliated muscovite schist - a rock type with low overall inherent shear strength. About 35% of the WSA is in Earthquake Hazard Zone A (double major hazard present) and the remainder is in Zone B (single major hazard present) (Fig. 7). The Henry's Lake WSA rates as Zone 1 with regard to ground breakage hazards - an area in which <u>major</u> ground breakage may occur during a major earthquake (Fig. 7). Seventy percent of the WSA contains slope angles of 24° and above (Fig. 8). And lastly, most of the WSA is classified as Zone 1 with regards to rockslides, rockfalls, or earthflow hazards which indicates that rockslides, rockfalls,



A. EARTHQUAKE HAZARD MAP



B. GROUND BREAKAGE HAZARD MAP

Ⓐ EARTHQUAKE HAZARD ZONE A – Double major hazard. Areas in which two kinds of major hazard are present. For example, includes areas most likely to undergo major ground breakage and inundation by a seiche

Ⓑ EARTHQUAKE HAZARD ZONE B – Single major hazard. Areas in which two kinds of hazard are present, one of which is major. For example, includes areas in which rockslides, rockfalls, or earthflows are very likely but in which only minor ground breakage is likely.

Ⓒ EARTHQUAKE HAZARD ZONE C – Moderate hazard. Areas in which moderate or lesser hazards are likely to be present. For example, includes areas in which both moderate ground breakage and rockslides, rockfalls, or earthflows may occur

Ⓓ EARTHQUAKE HAZARD ZONE D – Low hazard. Areas in which one or more lesser hazards are likely to be present. For example, includes areas in which only minor ground breakage is likely

① ZONE 1 – Area in which major ground breakage may occur during a major earthquake

② ZONE 2 – Area in which moderate ground breakage may occur during a major earthquake

③ ZONE 3 – Area in which minor ground breakage may occur during a major earthquake

1 .75 .5 .25 0 .5 1 2 MILES

Data from: Witkind (1972).

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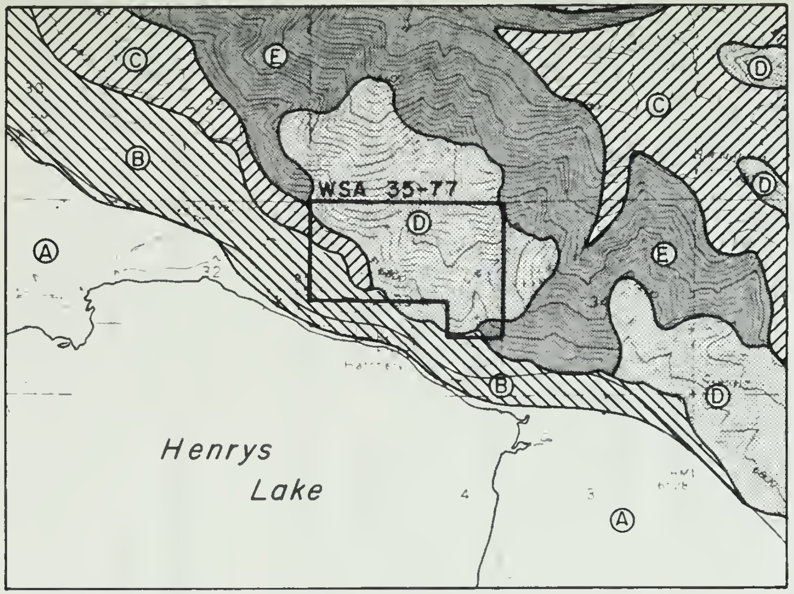
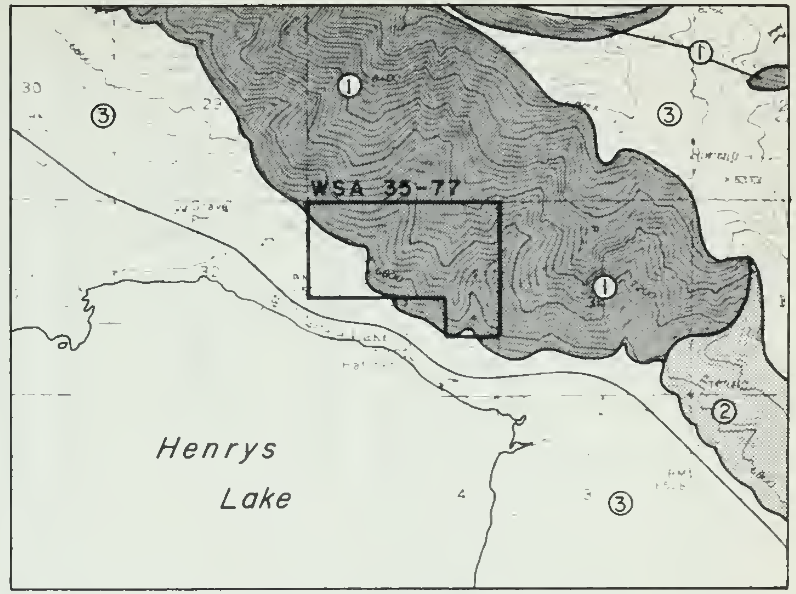
BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake WSA, Idaho
EARTHQUAKE AND GROUND BREAKAGE HAZARD MAPS

SCALE 1"=1 MILE
DATE 3/1983
APP'D G.F.
FIGURE 7



A. GENERALIZED SLOPE MAP



B. SEICHE, ROCKSLIDE, ROCKFALL, AND EARTHFLOW HAZARD MAP

- (A) VIRTUALLY FLAT TO VERY GENTLE SLOPES (Less than 5% — Less than about 3°)
- (B) GENTLE SLOPES (5-15% — Range is from about 3° to about 8.5°)
- (C) MODERATE SLOPES (15-25% — Range is from about 8.5° to about 14°)
- (D) STEEP SLOPES (25-45% — Range is from about 14° to about 24°)
- (E) VERY STEEP SLOPE (45% and above — above 24°)

- (1) ZONE 1 - Area in which rockslides, rockfalls, or earthflows are very likely to occur if area is shaken by a major local earthquake.
- (2) ZONE 2 - Area in which rockslides, rockfalls, or earthflows may occur if area is shaken by a major local earthquake.
- (3) ZONE 3 - Area in which rockslides, rockfalls, or earthflows are unlikely to occur if area is shaken by a major local earthquake

Data from: Witkind (1972).

1 .75 .5 .25 0 .5 1 2 MILES

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake WSA, Idaho
SLOPE AND ROCKFALL HAZARD MAPS

SCALE 1"=1 MILE | DATE 3 1983 | DRWN BY DSI | APPVD GF

8

or earthflows are very likely to occur if the area is shaken by a major local earthquake (Witkind, 1972) (Fig. 8).

2.5 Paleontology

No systematic investigation of paleontological resources exists for the Henry's Lake GRA. No especially noteworthy fossils are reported by previous investigations in the area.

2.6 Historical Geology

From a paleotectonic view the Henry's Lake GRA is located near the edge of the shelf of the North American craton. Very little is known of the Precambrian section comprising the oldest rocks underlying the GRA. The metamorphosed sedimentary units and amphibolite gneisses yield Precambrian "W" dates more than 2,600 m.y. old (King, 1976) and are likely correlative with the Cherry Creek sequence of Scholten et al. (1955) and Reid (1963). Deposition of these units took place over some 600 million years and culminated in an orogenic event about 1,600 million years ago in Precambrian X time. The pre-Belt rocks formed an emergent area east of a trough in which thick deposits of Belt Supergroup sediments accumulated some 1,600 to 800 million years ago. The GRA is located within the old emergent area; thus, Beltian age rocks were not deposited in the GRA.

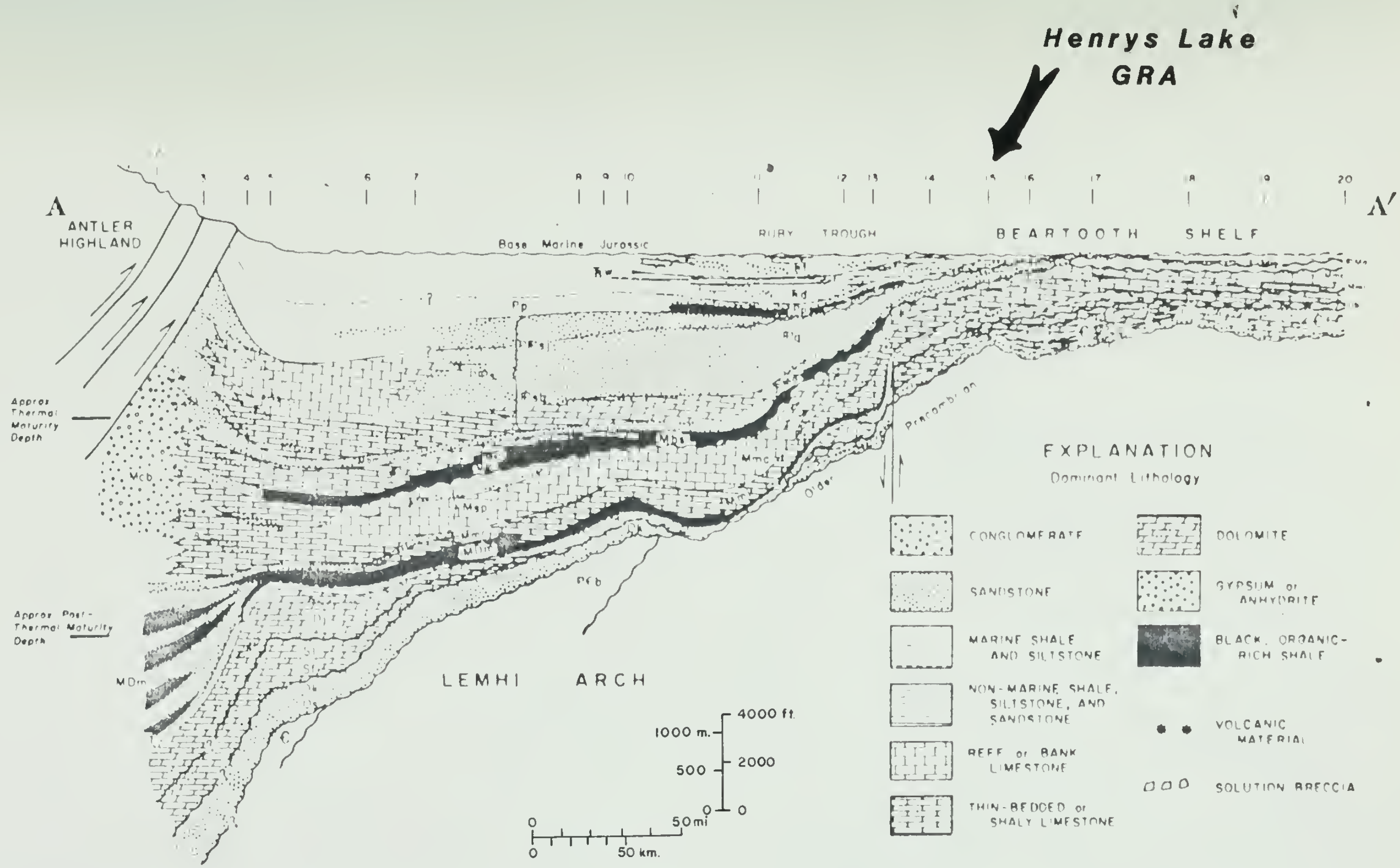
At the opening of the Paleozoic era the Henry's Lake GRA was located on the south flank of the east-west trending Beartooth shelf. The Beartooth shelf was the northwest extension of the Wyoming shelf and was bordered on the

north by the Montana trough and bounded on its west flank by the Greenhorn fault -- a fault which underwent several active periods during Paleozoic and later time (Peterson, 1981).

The Paleozoic stratigraphy displays a succession of facies changes which reflect oscillations of the Beartooth shelf hinge zone. This hinge zone migrated eastward as time progressed (Scholten, 1967). Deposition continued into the Mesozoic (230-65 m.y.) but Laramide orogenic activity and post-Laramide erosion has removed the upper Paleozoic and Mesozoic rocks which were present on the Beartooth shelf. The regional facies relationships are shown in Figure 9.

In Late Cretaceous (100-65 m.y.) to Paleocene (65-55 m.y.) time the pre-Laramide rocks were deformed into a series of roughly north-south trending (but divergent) arches and troughs (Fig. 10). Conglomerates derived from these structural and topographic highs (and from early mountains in central Idaho) accumulated in the synclinorial basins and flanking slopes (Scholten, 1967). The mixed structural trends in the area, consisting of normal northerly trends with less common east-west trending structures, reflects a combination of regional compressive stress oriented southwest-northeast complicated by diversely-oriented basement uplifts on the cratonic shelf produced by dominantly vertical forces.

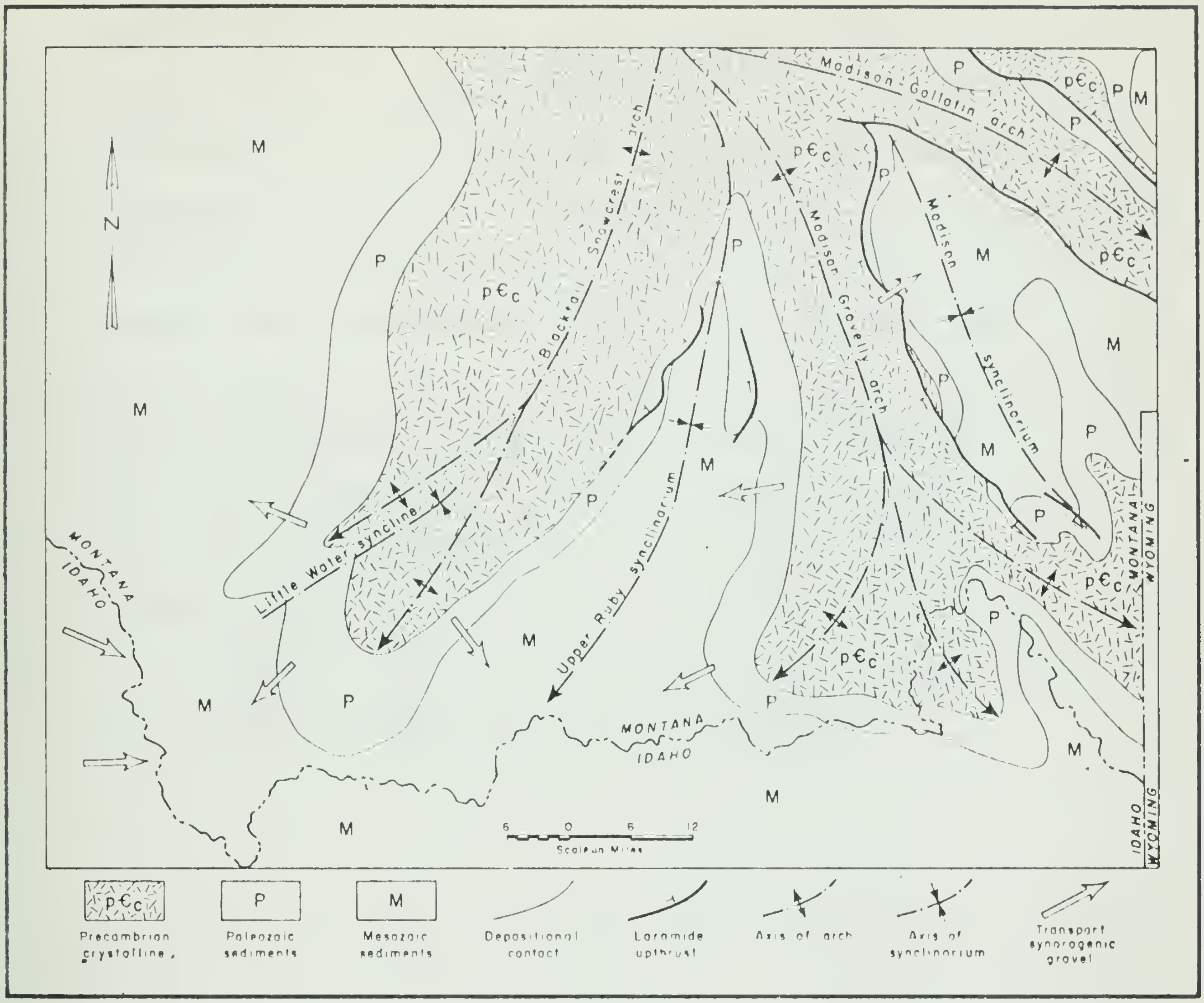
The Quaternary history of the Henry's Lake GRA is dominated by glacial activity. This area of Montana was overridden by one or more ice sheets during pre-Bull Lake time. The Bull Lake ice lobe advanced northwesterly into the area from the central Yellowstone Park region. The ice split into



Southwest-northeast lithofacies cross-section A-A', east-central Montana. Datum for upper section is base of marine Jurassic, datum for lower is estimated sealevel at close of Cretaceous time. Section is palinspastically restored in thrust belt.

From: Peterson (1981).

WGM Inc. Mining and Geological Consultants, Anchorage, Alaska	
BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS	
Henry's Lake GRA, Idaho ***Lithofacies Reconstruction East-Central Idaho to Central Montana***	
SCALE AS SHOWN	9
DATE 3/1983	
DRAWN BY DSI	GF



From: Scholten (1967).

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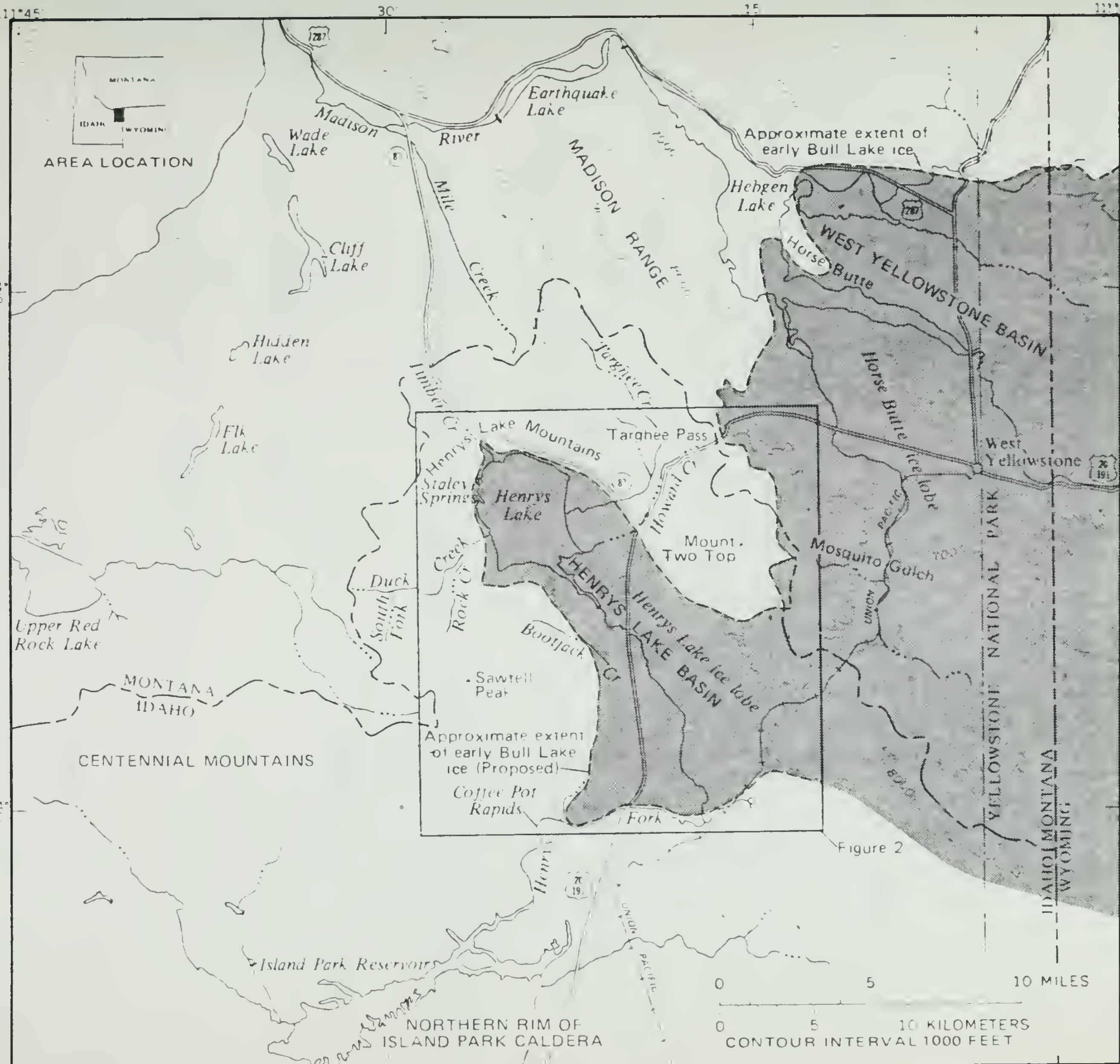
BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho
Late Cretaceous to Paleocene Tectonic Reconstruction

SCALE AS SHOWN			FIGURE
DATA BY	DATE 3/1983	REVISED	10
DRWN BY DSI	APRVD G.F.		

two lobes at the Henry's Lake Mountains forming a northern lobe which entered the West Yellowstone Basin (the Horse Butte ice lobe) and a lobe which entered the Henry's Lake Basin (the Henry's Lake ice lobe) and terminated at the north end of the Henry's Lake (Fig. 11). The ice advanced to elevations of 7,150 feet in the Henry's Lake Mountains and attained a thickness which ranged from a few feet at the northernmost edges to as much as 2,000 feet near centers of the lobes. Glacial deposits formed during ablation of the ice lobe include till or pitted outwash along the shores of Henry's Lake. Meltwaters from the Henry's Lake lobe and the Horse Butte lobe, which spilled into the area, produced various outwash deposits and channels along the flanks of the basin. A second stage of alpine glaciation followed retreat of the Bull Lake ice lobes. Valley glaciers flowed down canyons and several spread out onto the basin floor.

two lobes at the Henry's Lake Mountains forming a northern lobe which entered the West Yellowstone Basin (the Horse Butte ice lobe) and a lobe which entered the Henry's Lake Basin (the Henry's Lake ice lobe) and terminated at the north end of the Henry's Lake (Fig. 11). The ice advanced to elevations of 7,150 feet in the Henry's Lake Mountains and attained a thickness which ranged from a few feet at the northernmost edges to as much as 2,000 feet near centers of the lobes. Glacial deposits formed during ablation of the ice lobe include till or pitted outwash along the shores of Henry's Lake. Meltwaters from the Henry's Lake lobe and the Horse Butte lobe, which spilled into the area, produced various outwash deposits and channels along the flanks of the basin. A second stage of alpine glaciation followed retreat of the Bull Lake ice lobes. Valley glaciers flowed down canyons and several spread out onto the basin floor.



From: Witkind (1975).

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Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho

GLACIAL GEOLOGY

SCALE AS SHOWN			FIGURE
DATA BY	DATE 3/1983	REV SEC	11
DRWN BY DSI	APRVD G F		

3.0 ENERGY AND MINERAL RESOURCES

No specific mineral resource studies have been conducted in the Henry's Lake GRA. Witkind et al. (1980) studied the Centennial Mountains WSA which is west of the GRA and Suekawa et al. (1982) completed a NURE study of the Ashton NTMS Quadrangle. Additional information was gathered from reports by Mitchell et al. (1981), Breckenridge (1982), the U.S. Bureau of Mines MILS File and the U.S. Geological Survey's CRIB File.

3.1 Known Mineral and Energy Deposits

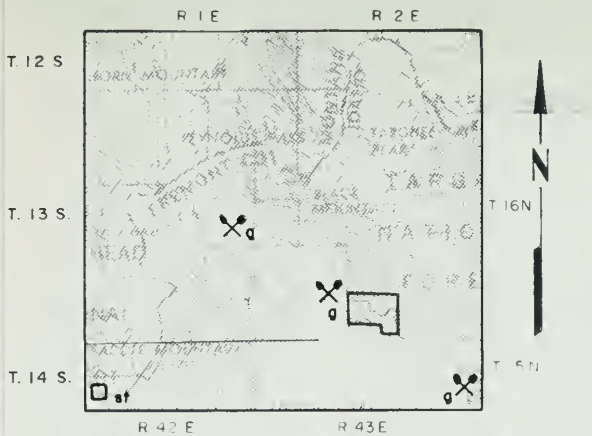
The Henry's Lake GRA contains three gravel pit sites along Highway 87 and a stone quarry west of Henry's Lake near Staley Springs on Rock Pass Road (Fig. 12). Except for these deposits there are no other known mineral or energy deposits within the boundaries of the GRA. The gravel pits are located in deposits of alluvial fan material which form extensive fans on the west side of Timber Creek flanking the mountain front. The stone quarry is apparently located in Precambrian quartzite or dolomite.

3.2 Known Mineral and Energy Prospects, Occurrences and Mineralized Areas

There are no reported mineral or energy prospects, occurrences or mineralized areas in the Henry's Lake GRA.

3.3 Mining Claims, Leases and Material Sites

A review of BLM claims records current to June 7, 1982 shows 11 mining claims, the Lakeview claims, recorded in sec. 4 and 5, T.15N., R.43E.,



LEGEND

- Mineral Orebody
- Mineral Deposit
- Mineral Occurence
- Active Quarry
- Inactive Quarry
- Active gravel or clay pit
- Inactive gravel or clay pit

1 occurence number
Cu commodity

g Gravel
st Stone

Approximote Boundory of Wilderness Study Areo.

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho

Mineral Deposits and Occurrences

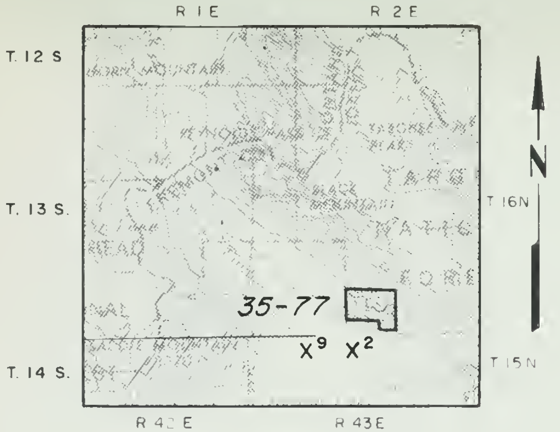
SCALE 1" = 4 MILES (1:250000)			FIGURE
DATA BY WGM	DATE 3/1983	REVISED	12
DRWN BY DSI	APRVD G.F		

(Fig. 13). As listed on the BLM microfiche the location of the claims seems in error as they plot in Henry's Lake. Upon closer inspection of the microfiche listing it is noted that the Lakeview #7 claim is reportedly located in the SE 1/4 sec. 33 and SW 1/4 sec. 34, T.14N., R.43E., and in the NW 1/4 sec. 4 and NE 1/4 sec. 5, T.15N., R.43E. It appears likely that the 11 Lakeview claims are actually located in Ts. 14 and 15N., R.43E. which is outside the boundary of the Henry's Lake GRA.

Oil and gas lease plats for the Henry's Lake GRA current to August 12, 1982 were reviewed. Much of two townships in Idaho (Ts.15 and 16N., R.42E.) are covered by oil and gas leases (Fig. 14). There are no oil and gas leases within the Henry's Lake WSA.

3.4 Mineral and Energy Deposit Types

The geologic character of much of the Henry's Lake GRA does not suggest a wide variety of mineral or energy deposit types. The protoliths of the Precambrian metamorphic sequence are dolomites, sandstones, and shales suggestive of nearshore, marine conditions. Although sandstone-type copper occurrences are found in quartzites of Precambrian Belt Series rocks, no such deposits have been recognized in the older Precambrian sequence. Likewise, the Paleozoic section is host to metalliferous deposits in many other areas but mainly where intruded by Nevadan or younger granitic rocks. Such circumstances are not present in the Henry's Lake GRA. The valleys are filled with Quaternary age glacial gravels, sands and debris and thus are not likely hosts for uranium deposits as are similar structural settings with Tertiary age sediment accumulations (Sekawa et al., 1982).

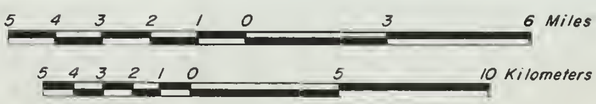


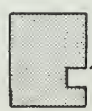
EXPLANATION

X Unpatented Mining Claim

▲ Patented Mining Claim

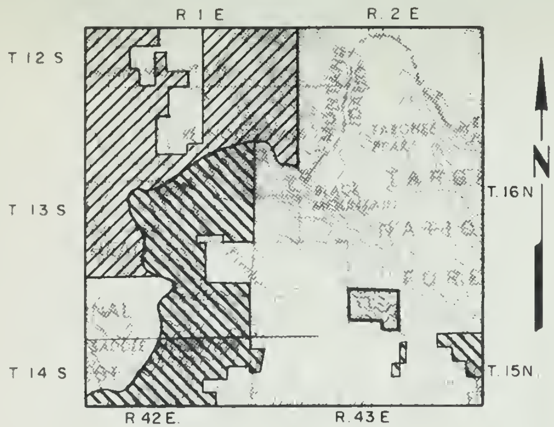
Notes:
1) Number adjacent to symbol indicates number of mining claims in that section.
2) Area of search: Entire GRA
3) Source of Data: BLM Claims Microfiche
4) Data current to: June, 1982





Approximate Boundary of Wilderness Study Area.

WGM Inc. Mining and Geological Consultants, Anchorage, Alaska	
BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS	
Henry's Lake GRA, Idaho **Mining Claims Density Map**	
SCALE 1" = 4 MILES (1:250,000)	FIGURE
DATA BY. WGM — DATE 3/1983 — REVISED	**13**
DRWN BY DSI — APRVD G.F	



LEGEND

Area covered by oil and gas leases.

Area covered by oil and gas lease application.

Notes: 1) Area of Search: Entire GRA
2) Data current to: Aug 12, 1982
3) Source of Data: BLM OG Plats

Approximate Boundary of Wilderness Study Area.

5 4 3 2 1 0 3 6 Miles

5 4 3 2 0 5 10 Kilometers

WGM Inc. Mining and Geological Consultants, Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho

Oil and Gas Lease Status

SCALE 1" = 4 MILES (1:250000)
DATA BY WGM | DATE 1/1983
DRWN BY DSI | APRVD G F

FIGURE 14

The major mineral resource identified by Witkind et al. (1980) in the Centennial Mountains is phosphate. Similarly uraniferous phosphorite was the only favorable environment for uranium deposits identified by Suekawa et al. (1982) in their study of the Ashton Quadrangle. The Phosphoria Formation does not outcrop in the Henry's Lake GRA.

Henry's Lake GRA does contain deposits of gravel which have been mined along Highway 87. Also much of the Precambrian quartzite may be good for riprap or similar uses. No data is available concerning the quality of limestone in the Paleozoic section for cement manufacturing purposes.

In the most recent geothermal classification of the United States (Muffler, 1979), geothermal resources were divided into six categories. These are:

1. Conduction-dominated regions
2. Igneous-related geothermal systems
3a. High temperature (over 150°C) hydrothermal convection systems
 b. Intermediate temperature (90-150°C) hydrothermal convection systems
4. Low temperature (less than 90°C) hydrothermal convection systems
5. Geo-pressured geothermal energy systems

For the purposes of this assessment these classes can be reduced to two: high temperature (over 150°C) hydrothermal convection systems and low/intermediate temperature (40-150°C) hydrothermal convection systems. Furthermore, for the purposes of this report geothermal resources are classified in terms of observed or expected system temperature.

The area of western Montana and southern Idaho within GEM Region 2 can be divided into six provinces of different goethermal significance (Table I).

TABLE I

GEOTHERMAL PROVINCES IN GEM REGION 2

1. Montana Thrust/Foothills
2. Montana Basin and Range
3. Central Idaho basin and Range
4. Idaho Batholith/Blue Mountains
5. Southeastern Idaho Basin and Range
6. Snake River Plains

The Henry's Lake GRA is part of the Central Idaho Basin and Range geothermal province and is near the boundary with the Snake River Plains province.

The major feature in the Henry's Lake GRA is a graben underlying Henry's Lake and valley of Henry's Fork. The northeastern boundary of the valley is a normal fault. The valley and adjacent ranges intersect the Snake River Plain geothermal province at right angles near the Island Park and Yellowstone calderas (Hamilton, 1965). Both calderas have been the site of voluminous ash flows during the Quaternary. The bedrock of the ranges to the north and south of the valley consists of Paleozoic and Mesozoic sedimentary rocks, Precambrian metamorphic rocks, and Cenozoic volcanic rocks. The epicenter of the 1959 Hebgen Lake earthquake was centered about 10 miles north of the Henry's Lake WSA and the seismicity of the area is dominated by the aftershocks of that event.

The fault marking the south flank of the Henry's Lake Mountains is more or less continuous with the Madison fault and is intersected by the Centennial fault about 9 miles southeast of the Henry's Lake GRA. Both the Madison and Centennial faults have probably been active in the Quaternary although neither is currently the site of microearthquakes (Smith, 1978; Smith and Braile, 1982). The existence of a major range bounding fault passing through the area is of major geothermal significance. There is no heat floor or geothermal gradient data within or near the Henry's Lake GRA and the nearest warm spring, the Targee Sulphur warm spring, is on the northeastern flank of the Henry's Lake Mountains about 10 miles away in Montana. The Targee warm spring has a flow rate 210 l/min. with a surface and estimated aquifer temperature of 18°C, (Sonderegger and Bergantino, 1981). Good geothermal potential in the Henry's Lake GRA is indicated by the high seismic activity in the region, apparent geologic youthfulness of the area, and the probable existence of high heat and geothermal gradients in the subsurface.

No hydrocarbon tests have been drilled in the Henry's Lake GRA and no oil or gas shows have been reported in the area. The nearest hydrocarbon production is from the Crazy Mountain Basin of Montana approximately 95 miles to the northeast, and from the Wyoming Thrust belt along the southern part of the Sweetgrass arch approximately 200 miles east-southeast. Both the Sweetgrass arch and Wyoming Thrust belt are considered major oil provinces (Halbouty, 1970; Lamb, 1980).

Metamorphic rocks such as those underlying most of Henry's Lake GRA are not hydrocarbon source beds. They are reservoir beds only when fractured and

covered by sedimentary strata. Sedimentary rocks are only present above the metamorphics in a small area in the northeast part of the Henry's Lake WSA. Therefore, any hydrocarbons trapped in fractures in the metamorphic rocks would have escaped as erosion removed the sedimentary overburden. Along the southwestern part of the WSA Quaternary sediments cover a frontal fault and older strata in the valley of Timber Creek. Small exposures of Cambrian and Precambrian strata three and five miles, respectively, northwest of the WSA suggest that the Quaternary sediments are not very thick and that the Paleozoic and younger strata are very thin where present in the subsurface; therefore, the hydrocarbon potential for the southwestern part of the WSA is probably very low to nil. This assessment agrees with the evaluation by Scholten (1967) which rated southwestern Montana as having low oil and gas potential.

3.5 Mineral and Energy Economics

The Henry's Lake GRA enjoys good infrastructure with regards to any potential development of minerals or energy resources. Paved and unpaved roads crisscross the area and water and electrical power are available. The nearest rail siding is 14 miles south at the Union Pacific Railroad's Trude Siding near Machs Inn. Any mineral or energy related developments would have to take into account the significant geologic hazards related to earthquake activity in the area.

The economic feasibility of geothermal resource development is determined by its distance to market and its temperature. Long-distance transportation of lower temperature geothermal energy is not feasible, whereas for electrical

grade resources, long transportation distances are feasible. Based on present requirements for the use of hot fluids in electrical generating techniques, geothermal systems with temperatures of less than 150°C do not have significant potential for electrical exploitation. However, geothermal resources with temperatures less than 150°C do have significant potential for low and intermediate temperature geothermal utilization for space heating, material processing, etc. if their minimum temperature exceeds 40°C. At the lower end of the spectrum, as the energy content of the resource becomes less, or the drilling depth necessary for exploitation becomes greater, there is a very ill-defined cutoff. For example, shallow ground water temperatures on the order of 10-20°C can be used for heat pump applications, and in some cases these are considered geothermal resources. However, in this evaluation, a lower temperature than approximately 40°C is considered uneconomic as a geothermal resource. The existence of developments within the Henry's Lake GRA ensures that even low temperature geothermal resources would be exploited, if found to exist.

4.0 LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

4.1 Explanation of Classification Scheme

In the following section the land in the Henry's Lake WSA is classified for geology, energy and mineral (GEM) resources potential. The classification scheme used is shown in Table II. Use of this scheme is specified in the contract under which WGM prepared this report.

The evaluation of resource potential and integration into the BLM classification scheme has been done using a combination of simple subjective and complex subjective approaches (Singer and Mosier, 1981) to regional resource assessment. The simple subjective approach involves the evaluation of resources based on the experience and knowledge of the individuals conducting the evaluations. The complex subjective method involves use of rules, i.e. geology inference, based on expert opinion concerning the nature and importance geologic relationships associated with mineral and energy deposits (Singer and Mosier, 1981).

The GEM resource evaluation is the culmination of a series of tasks. The nature and order of the tasks was specified by the BLM, however they constitute the general approach by which most resource evaluations of this type are conducted. The sequence of work was: (1) data collection, (2) compilation, (3) evaluation, and (4) report preparation. No field work was done in the Henry's Lake WSA.

TABLE II

BUREAU OF LAND MANAGEMENT GEM RESOURCES LAND CLASSIFICATION SYSTEM

CLASSIFICATION SCHEME	LEVELS OF CONFIDENCE
1. The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.	A. The available data are either insufficient and/or cannot be considered as direct evidence to support or refute the possible existence of mineral resources within the respective area.
2. The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.	B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.
3. The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.	C. The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.
4. The geologic environment, the inferred geologic processes, the reported mineral occurrences, and the known mines or deposits indicate high favorability for accumulation of mineral resources.	D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

4.2 Classification of the Henry's Lake (35-77 Wilderness Study Area

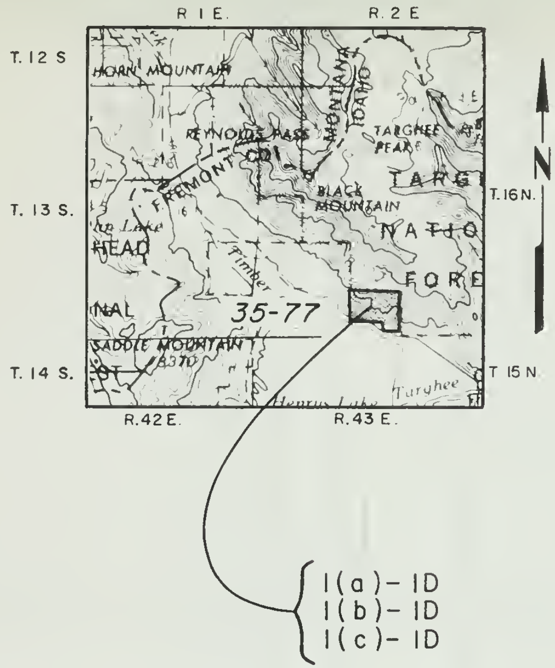
4.2.1 Locatable Minerals

Locatable minerals are those which are locatable under the General Mining Law of 1872, as amended, and the Placer Act of 1870, as amended. Minerals which are locatable under these acts include metals, ores of metals, non-metallic minerals such as asbestos, barite, zeolites, graphite, uncommon varieties of sand, gravel, building stone, limestone, dolomite, pumice, pumitice, clay, magnesite, silica sand, etc. (Maley, 1983).

4.2.1a Metallic Minerals. All of WSA 35-77 (1a, Fig. 15) is classified as unfavorable for metallic minerals based on direct evidence (1D). The basis of the classification is that Precambrian mica-schist is the only bedrock within the WSA and metallic mineral occurrences in the general area are absent.

4.2.1b Uranium and Thorium. WSA 35-77 (1b, Fig. 15) is classified as unfavorable for uranium and thorium based on direct evidence (1D). The basis of this classification is the character of the bedrock and absence of occurrences in the area.

4.2.1c Non-Metallic Minerals. All of WSA 35-77 (1c, Fig. 15) is classified as unfavorable for the occurrence of non-metallic minerals based on direct evidence (1D). The basis of this classification is the character of the bedrock (mica-schist) and lack of occurrences in the general area.



BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

LEVELS OF CONFIDENCE

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVLEY MINIMAL TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

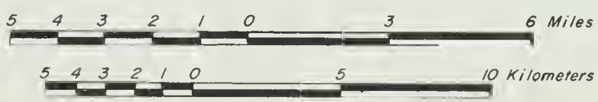
EXPLANATION

1(a)- 4D

- Area I.D. Number
- Commodity
- Classification
- Level of Confidence

a) Metallic Minerals
b) Uranium and Thorium
c) Non-Metallic Minerals

Approximate Boundary of Wilderness Study Area.



WGM Inc. Mining and Geological Consultants, Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho
Wilderness Study Area
Land Classification
Locatable Resources

SCALE 1" = 4 MILES (1 250,000)		FIGURE 15
DATA BY WGM	DATE 9/1982	REVISED
DRWN BY DSI	APRVD G.F	

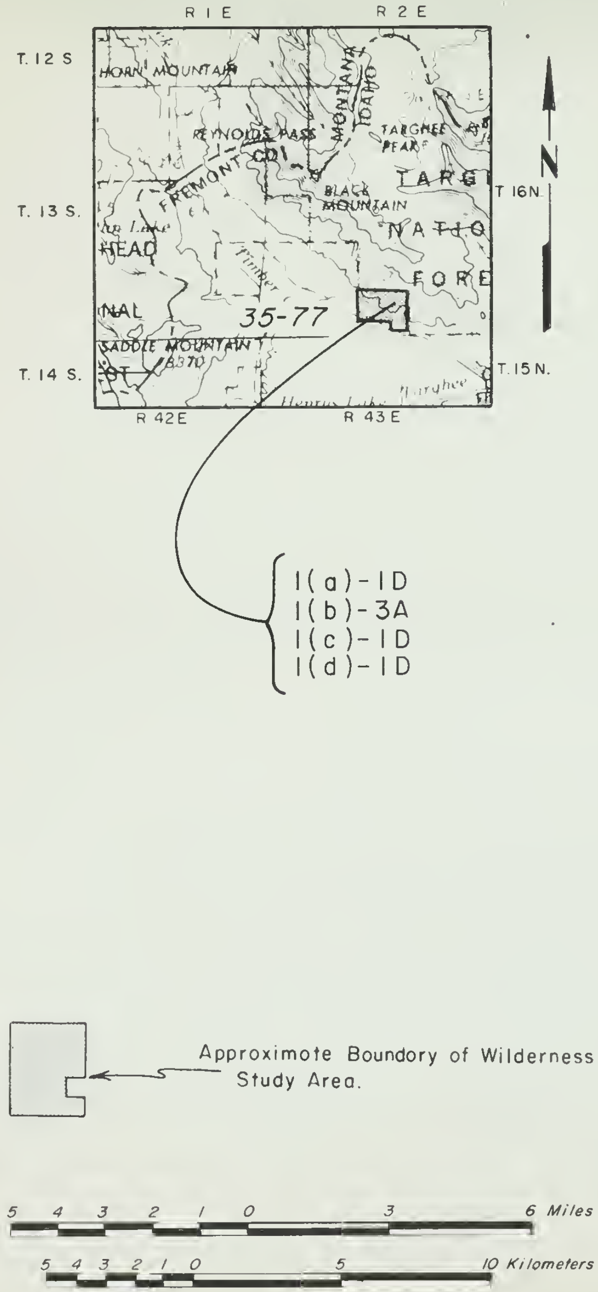
4.2.2 Leasable Resources

Leasable resources include those which may be acquired under the Mineral Leasing Act of 1920 as amended by the Acts of 1927, 1953, 1970 and 1976. Materials covered under this Act include: asphalt, bitumen, borates and sodium and potassium, carbonates of sodium and potassium, coal, natural gas, nitrates of sodium and potassium, oil, oil shale, phosphate, silicates of sodium and potassium, sulfates of sodium and potassium, geothermal resources, etc. (Maley, 1983).

4.2.2a Oil and Gas. All of WSA 35-77 (1a, Fig. 16) is classified as unfavorable for oil and gas based on direct evidence. The metamorphic rocks underlying the WSA are unfavorable for hydrocarbon accumulation as outlined in section 3.5.

4.2.2b Geothermal. WSA 35-77 (1b, Fig. 16) is classified as moderately favorable for the occurrence of low, intermediate, and high temperature geothermal resources based on inadequate data (3A). Good geothermal potential is indicated by the high seismic activity of the region, the apparent geologic youthfulness of the area, and the probable existence of high heat and geothermal gradients in the subsurface.

4.2.2c Sodium and Potassium. All of WSA 35-77 (1c, Fig. 16) is classified as unfavorable for sodium and potassium based on direct evidence (1D). The classification is based on the unfavorable metamorphic environment present in the WSA.



BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.
4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

LEVELS OF CONFIDENCE

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVLEY MINIMAL TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

EXPLANATION

1(a) - 4D

- Area I.D. Number
- Commodity
- Classification
- Level of Confidence

a) oil and gas

b) Geothermal: high temperature (H), Low temperature (L)

c) Sodium and Potassium

d) others: Asphalt (As) bitumen (bt), phosphate (ph), No specific commodity designation indicates that the rating applies to all of the above.

WGM Inc, Mining and Geological Consultants
Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho

Wilderness Study Area
Land Classification
Leasable Resources

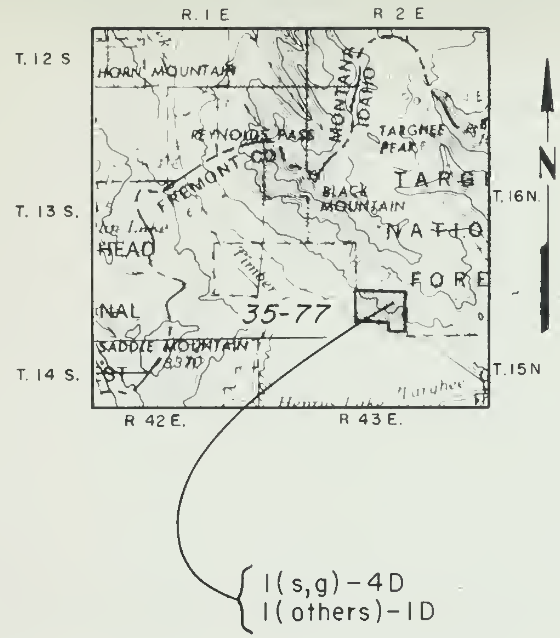
SCALE 1"=4 MILES (1:250,000)			FIGURE
DATA BY WGM	DATE 9/1982	REVISED	16
DRWN BY DS1	APRVD G.F		

4.2.2d Other. WSA 35-77 (1d, Fig. 16) is classified as unfavorable for other leasable resources including asphalt, bitumen and phosphate based on direct evidence (1D).

4.2.3 Salable Resources

Salable resources include those which may be acquired under the Materials Act of 1947 as amended by the Acts of 1955 and 1962. Included under this Act are common varieties of sand, gravel, stone, cinders, pumice, pumicite, clay, limestone, dolomite, peat and petrified wood (Maley, 1983).

The portion of WSA 35-77 which is covered by Quaternary gravels (1, Fig. 17) is classified as highly favorable for the occurrence of sand and gravel resources based on direct evidence (4D). The basis for the classification is the presence of several nearby gravel pits within the same alluvial unit. The remainder of the WSA (2, Fig. 17) is classified as unfavorable for other salable resources based on direct evidence (1D).



BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

LEVELS OF CONFIDENCE

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVLEY MINIMAL TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

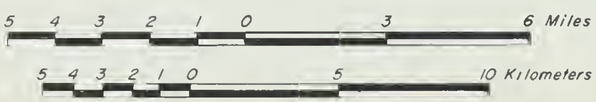
EXPLANATION

I(Is) - 4D

- Area I.D. Number
- Commodity
- Classification
- Level of Confidence

s	Sand
g	Gravel
st	Stone
c	Cinders
p	Pumice
pt	Pumicite
cl	Clay
Ls	Limestone
dl	Dolomite
P	Peat
pw	Petrified wood

Approximate Boundary of Wilderness Study Area.



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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Henry's Lake GRA, Idaho

Wilderness Study Area
Land Classification
Saleable Resources

SCALE 1"=4 MILES (1 250,000)			FIGURE
DATA BY WGM	DATE 9/1982	REVISED	17
DRWN BY DSI	APRVD G.F		

5.0 RECOMMENDATIONS FOR FURTHER WORK

The area should be evaluated by one to two 1,000-2,000 feet deep geothermal gradient/heat flow holes. Deep holes are required because cold ground water flow almost certainly exists in the alluvium on the down-thrown side of the Madison fault and the holes must penetrate this flow zone to adequately test the geothermal potential. Samples of any fluids encountered should be analyzed to test for any geothermal component and estimate aquifer temperatures.

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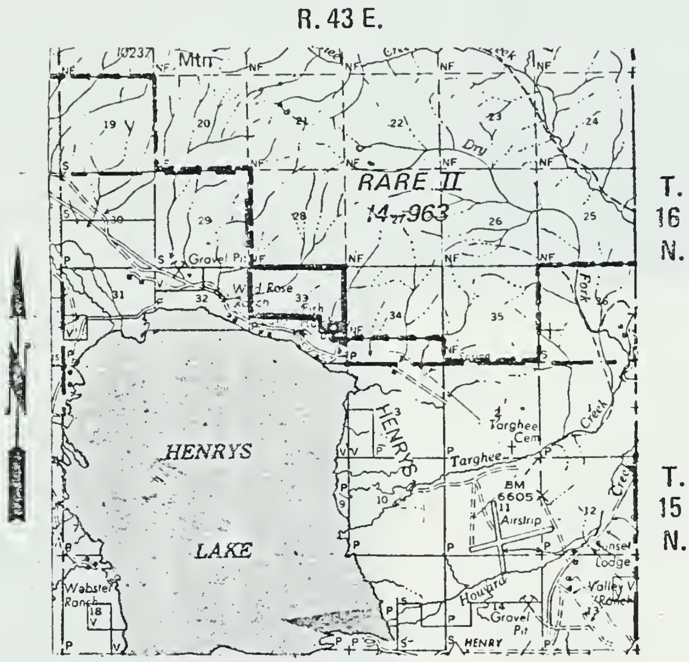
APPENDIX I

WILDERNESS STUDY AREA MAP

35–77
HENRY'S LAKE



LEGEND

WILDERNESS STUDY AREA

AREA WITHOUT CHARACTERISTICS

1 0 1 2 3 4 5

Scale in Miles

DATE LOANED	BORROWER