PHASE I

Geology, Energy, and Mineral (GEM) Resource
Evaluation of Sand Mountain GRA, Idaho
including the Sand Mountain (35-3)
(Wilderness Study Area

Contract No. YA-553-CT2-1039

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WGM INC.
MINING AND GEOLOGICAL CONSULTANTS

EXECUTIVE SUMMARY

The Sand Mountain Geology, Energy, and Mineral Resource Area (GRA) is located in southeastern Idaho about ten miles northwest of Rexburg. The GRA contains the Sand Mountain (35-3) Wilderness Study Area (WSA).

Bedrock in the area consists of a small amount of Tertiary rhyolites and a large volume of younger flood basalts. Surficial deposits consist of alluvial and fluvial deposits and sand dunes.

A modest amount of geologic data is available for the area. There is no geochemical data and very little information on energy or saleable resources. The overall geologic setting is not favorable for accumulation of metallic, non-metallic, or hydrocarbon resources. The resource with greatest potential geothermal energy. The Sand Mountain WSA (35-3) is rated as moderately favorable for high temperature geothermal resources and as having moderate to low favorability for low to moderate temperature geothermal resources. The land classification of the Sand Mountain WSA is summarized in the accompanying table.

GEM RESOURCES CLASSIFICATION OF THE SAND MOUNTAIN WSA (35-3), IDAHO

Resource	Classification
1. Locatable Resources	
a. Metallic Minerals	1C
b. Uranium and Thorium	2C
c. Non-Metallic Minerals	4D (building stone)
2. Leasable Resources	
a. Oil and Gas	2B
b. Geothermal Resources	
High Temperature	3A
Low/Intermediate Temperature	3B/2B
c. Sodium and Potassium	1C
d. Other	1C
3. Saleable Resources	4D (sand) 3D (cinders) 3C (pumice and pumicite)

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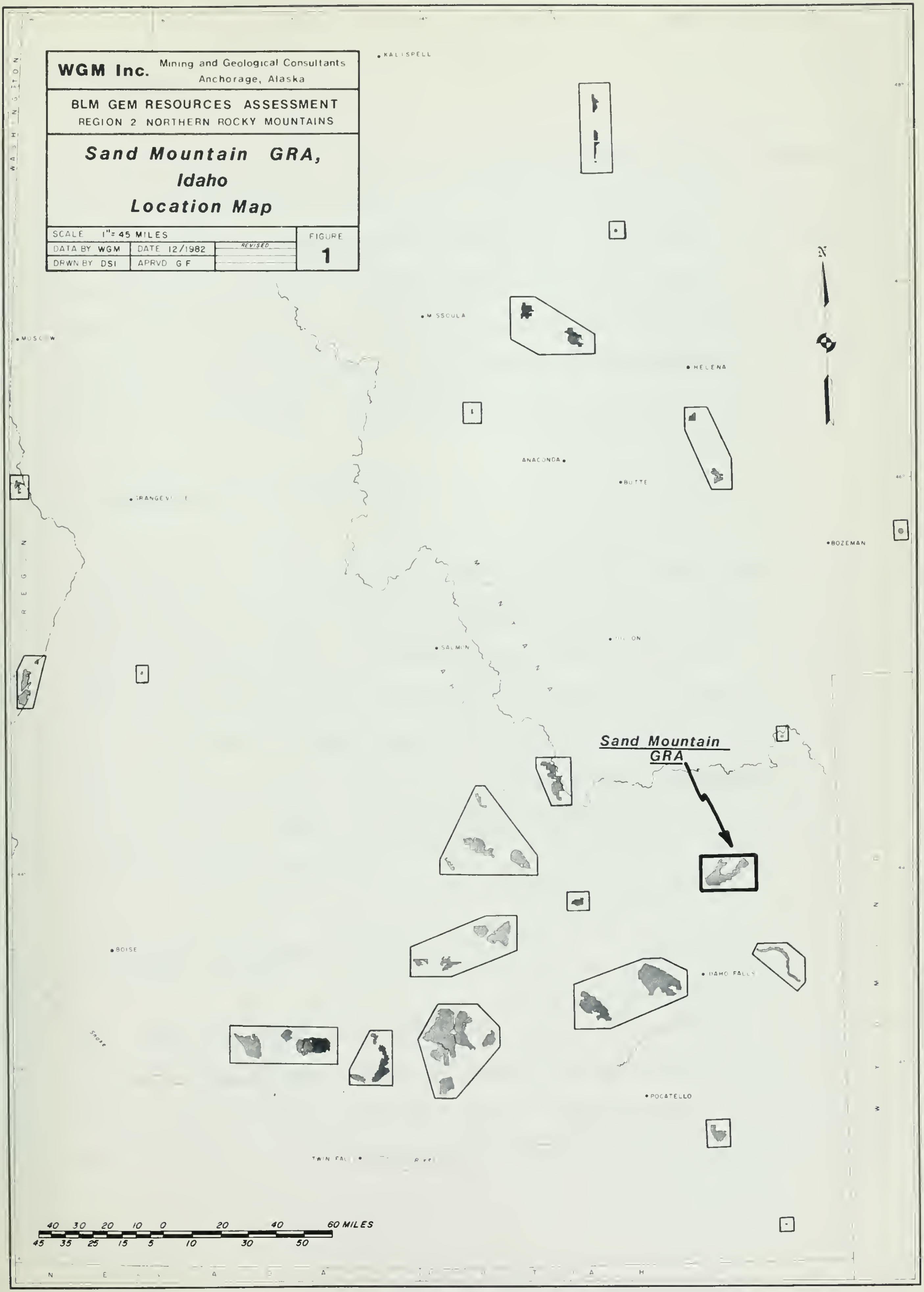
SAND MOUNTAIN GRA, IDAHO

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 The objective of Phase I is the evaluation of existing data, both published and available unpublished data, for interpretation of the GEM resources potential of the WSAs.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 delination of the GRAs is based on three criteria: (1) a 1:250,000 scale map of each GRA shall be no greater then 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 totalling 583,182 acres. The WSAs were grouped into 22 GRAS for purposes of the Phase I GEM resources evaluation.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Anchorage, Alaska
BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS
Sand Mountain GRA,
Idaho
Location Map
SCALE 1"=45 MILES
DATA BY WGM
DATE 12/1982
REVISED
DRWN BY DSI
APRVD GF
FIGURE
1
KALISPELL
HELENA
ANACONDA
BUTTE
BOZEMAN
SALMON
Sand Mountain
GRA
BOISE
IDAHO FALLS
POCATELLO
40 30 20 10 0 20 40 60 MILES
45 35 25 15 5 10 30 50

1.1 Location

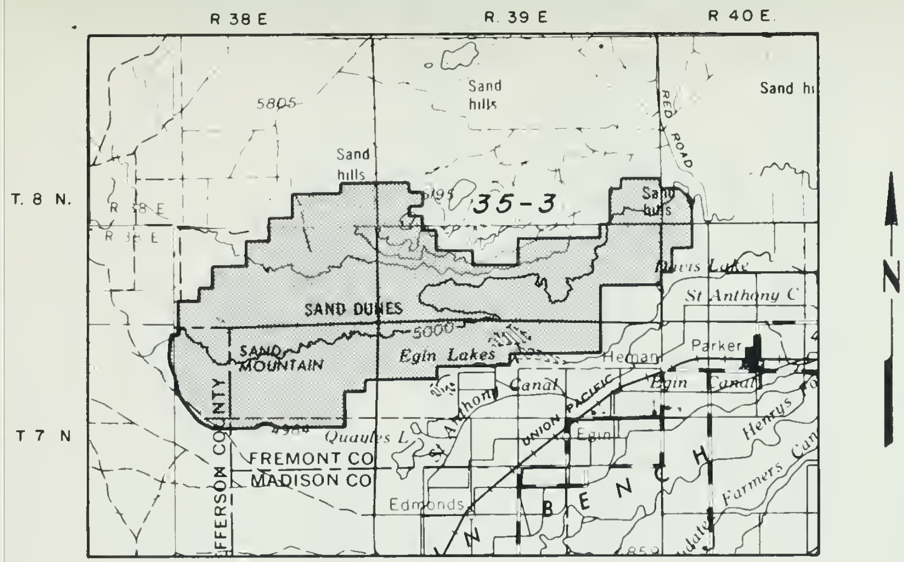
The Sand Mountain GRA is located in northern Madison, southern Freemont and eastern Jefferson Counties, Idaho in Ts.7 and 8 N., Rs.38 to 40E. The center of the area lies ten miles north of Rexburg and 7 miles west of St. Anthony. Administratively the GRA is within the Medicine Lodge Resource Area in the Idaho Falls BLM district. The Sand Mountain GRA contains approximately 171 square miles and encompasses the Sand Mountain Wilderness Study Area (WSA) which totals 21,100 acres. This is the only WSA within the GRA (Fig. 2).

1.2 Population and Infrastructure

The Sand Mountain GRA contains the community of Parker, Idaho, population 262. The largest towns nearby include St. Anthony (pop. 3,212), seven miles east of the GRA, and Rexburg (pop. 11,559), ten miles south of the GRA. The southeast portion of the GRA contains a network grid of section line roads which service farms in the area. A large network of unimproved roads and trails provides access to the remainder of the GRA. Interstate Highway 15 borders the GRA to the west and U.S. Highway 20 borders the GRA on the east. The area is serviced by the Union Pacific Railroad.

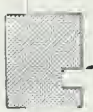
1.3 Basis of the Report

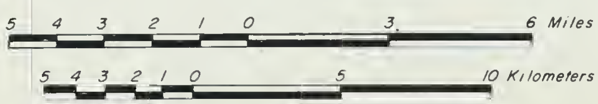
This report is based on compilation, review, and analysis of available published and unpublished data on the geology, energy, and mineral resources of the Sand Mountain GRA. The GRA is part of the Juniper Buttes area as mapped by LaPoint (1977) and Kuntz (1979), both of whose mapping is compiled on the



BLM Wilderness Study Areas Included in the Sand Mountain GRA.

WSA	NAME	ACREAGE
35-3	Sand Mountain	21,100





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BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS	
Sand Mountain GRA, Idaho **Topographic Map**	
SCALE 1"=4 MILES (1 250,000)	FIGURE
DATA BY WGM · DATE 9/1982 · REVISED	2
DRWN BY DSI · APRVD G.F.	

Ashton Quadrangle (Mitchell and Bennett, 1979a) and Driggs Quadrangle (Mitchell and Bennett, 1979b). 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 acknowledge the assistance of Tim Carroll, BLM-Idaho Falls District Geologist, during the compilation stage of this project.

2.0 GEOLOGY

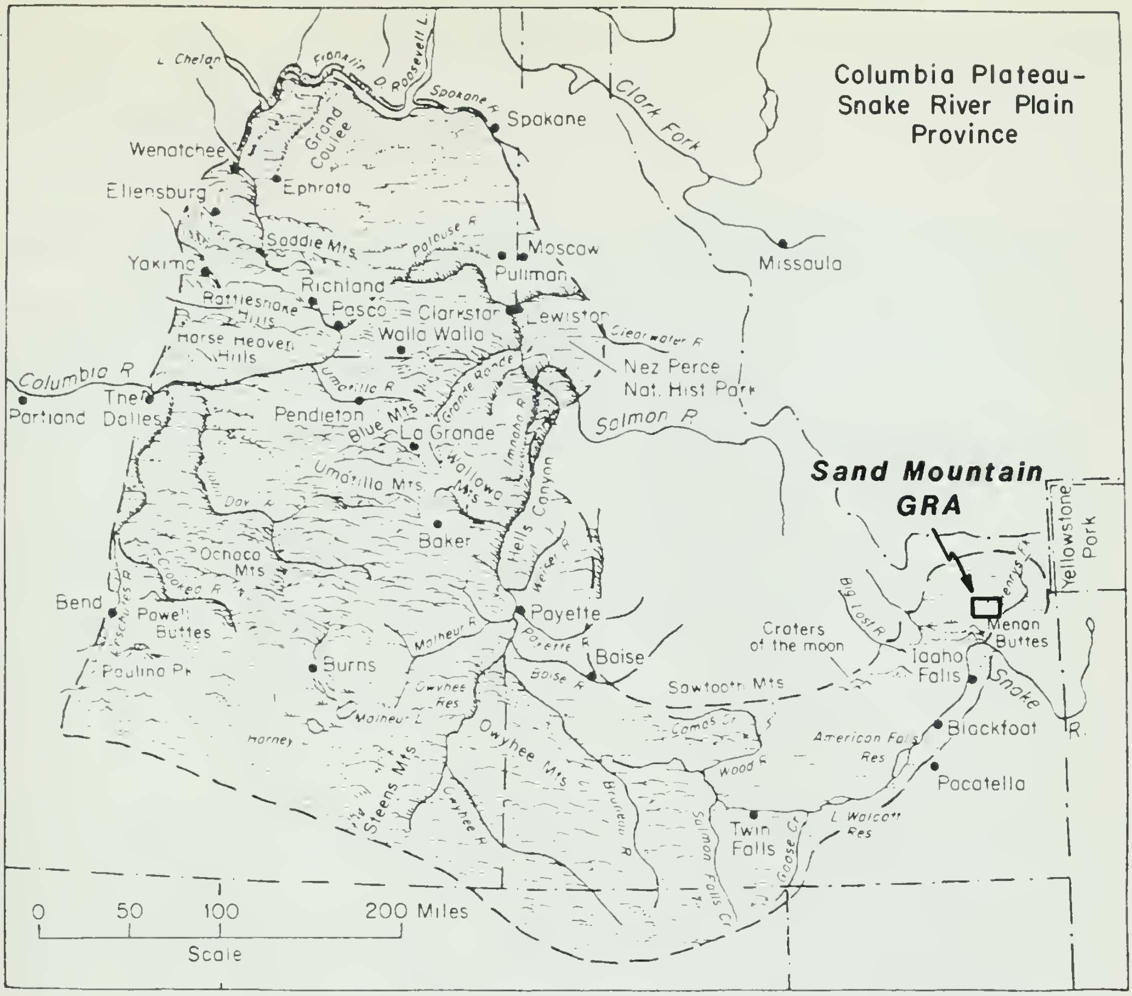
2.1 Introduction

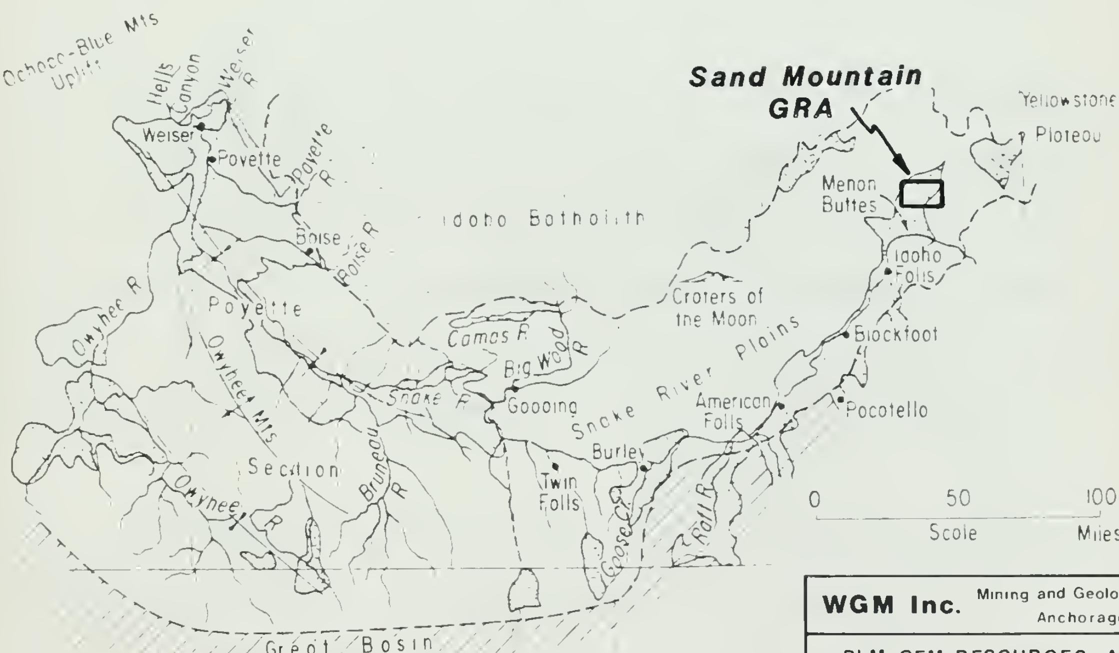
The surficial geology of the Sand Mountain GRA consists of Pliocene (6-2 m.y.) and Pleistocene (2-0.1 m.y.) volcanic flows and pyroclastic deposits overlain by colluvium and eolian deposits. Several basalt vents occur in the western and north-central part of the GRA. These volcanics mask the underlying structure and stratigraphy. Estimated thicknesses of the volcanics range from 3,000 meters (9,850 feet) to 9,000 meters (29,500 feet) (Mitchell et al., 1980).

2.2 Physiography

The Sand Mountain GRA is situated in the far northeastern end of the Snake River Plain (Fig. 3) within the Columbia Plateau - Snake River Plain physiographic province (Hunt, 1974). The area is drained by Henrys Fork of the Snake River. The south boundary of the GRA is within one mile of the intersection of the Teton and Henrys Fork Rivers.

Elevations range from about 1,463 meters (4,800 feet), along Henrys Fork, to over 1,768 meters (5,800 feet) in the Juniper Buttes area. The floodplain of Henrys Fork contains a large number of canals and irrigation ditches which support farming activities, the mainstay of the local economy. The climate is high desert, semi-arid and vegetation consists essentially of sagebrush and grasses. Northwest of the Henrys Fork floodplain the terrain consists of volcanic buttes surrounded by sand dunes.





Cenozoic Lake, Playa, and stream deposits.

Lava

From Hunt (1974).

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REGION 2 NORTHERN ROCKY MOUNTAINS

Sand Mountain GRA, Idaho

Physiographic Setting

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

2.3 Description of Rock Units

The oldest bedrock in the Sand Mountain GRA consists of Pliocene rhyolite flows, breccias, and pyroclastic deposits (Fig. 4). These units underlie the north-central portion of the GRA. The rhyolite lava flows, breccias, and pyroclastic deposits are chiefly tan, gray, orange, purple, and pink, flow banded crystal-poor flow rocks. Laminae range from 1 mm to 10 mm in thickness. Phenocrysts are chiefly plagioclase (andesine), pyroxene, sanidine, and biotite; the flow banded matrix consists mostly of devitrified, spherulitic glass (Kuntz, 1979).

Unconformably overlying the rhyolites is a Pliocene basalt unit. The flow is a reddish-brown to dark gray, porphyritic basalt flow three (3 feet) to ten meters (33 feet) thick. Plagioclase and rare olivine phenocrysts occur in an ophitic groundmass with large augite crystals (Kuntz, 1979).

A Pleistocene age basalt flow belonging to the Juniper Butte Complex overlies the Pliocene basalt flow in one locality. This flow is a dark gray, weakly porphyritic vent flow which displays small rare phenocrysts of plagioclase and olivine in a dense groundmass of plagioclase, augite, and olivine. A distinctive feature of the flow is the alteration of olivine to phenocrysts of opaque iron oxides and iddingsite (Kuntz, 1979).

South of the aforementioned Pleistocene basalt flow and also part of the Juniper Butte Complex is a slightly younger Pleistocene sequence of basalt lava flows and pyroclastic deposits which were derived from a nearby vent. These fountain-fed and tube-fed flows and scoreaceous pyroclastic deposits

Sedimentary

SURFICIAL DEPOSITS OF THE JUNIPER BUTTES AREA

Qc	Calluvium
Qd	Dune sond

ALLUVIAL AND TERRACE DEPOSITS OF THE HENRYS FORK AND TETON RIVERS

Qal	Alluvium
Qfg	Terrace deposits
Qao	Alluvium of Egin Bench

Igneous

SNAKE RIVER GROUP BASALTS YOUNGER THAN THE JUNIPER BUTTE COMPLEX

Qb	Basalt of Little Grassy Butte
Qlcb	Basalt of Little Croter
Qnb	Basalt; pohaehoe flows
Qkb	Basalt
QKbo	Basalt; parphyritic

Unconformity

JUNIPER BUTTE COMPLEX

Qbj	Bosalt
Qbgb	Basolt of Big Grassy Ridge
Qpb	Basolt; flows and pyraclastics
Qob	Basalt; weokly porphyritic

Unconformity

Tlb	Basalt

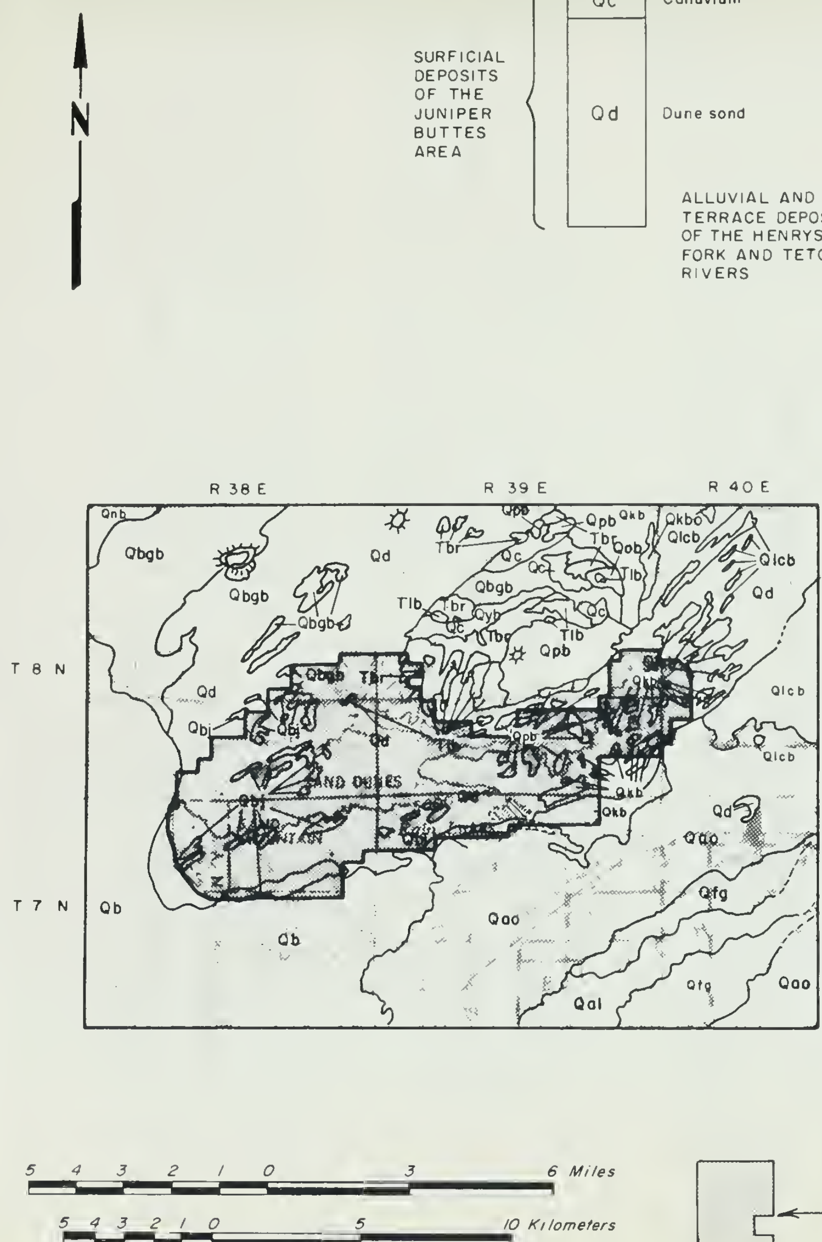
Unconformity

Tbr	Rhyolite; flaws, breccias, and pyraclastics

Basalt Vent ☼

Holocene (Recent) — Peistocence — Quaternary

Pliocene — Tertiary



Data by: Mitchell and Bennett, 1979; Rember and Bennett, 1979; Kuntz, 1979

Approximate Boundary of Wilderness Study Area.

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Sand Mountain GRA, Idaho

Geologic Map

SCALE: 1" = 4 MILES (1:250,000)			FIGURE
DATA BY.	DATE 3/1983	REVISED	4
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are typically dark gray and strongly porphyritic. Phenocrysts of plagioclase about 3 mm long and of olivine about 1 mm in diameter occur in an intergranular groundmass of plagioclase, altered pyroxene and olivine crystals (Kuntz, 1979).

The succeeding unit of the Juniper Butte Complex is a Pleistocene age basalt termed Basalt of Big Grassy Ridge. This unit consists of dark gray, porphyritic to non-porphyritic, diktytaxitic, tube-fed, pahoehoe lava flows from a vent at Big Grassy Ridge and two smaller vents to the east. The flow units contain abundant phenocrysts of plagioclase and olivine in diktytaxitic, intergranular groundmass of plagioclase, augite, and olivine crystals (Kuntz, 1979).

The uppermost unit of the Juniper Butte Complex is composed of Pleistocene age basalt lava flows which are medium gray, laminated, and porphyritic with rare plagioclase and olivine phenocrysts. The flows and the vent area from which they were derived are thickly mantled with eolian deposits (Kuntz, 1979).

The youngest sequence of volcanics in the Sand Mountain GRA consists of flows belonging to the Snake River Group of Basalts. Five such basalt sequences occur in the Sand Mountain GRA.

The oldest unit in the Snake River Group is a basalt flow sequence exposed in kipukas (openings surrounded by lava flows) northeast of Juniper Buttes. It consists of brownish-gray to dark gray, tube-fed, pahoehoe flows composed

of plagioclase and olivine porphyritic basalt with extensive caliche filling of vesicles (Kuntz, 1979).

The next youngest basalt flow unit in the Snake River Group is a Pleistocene age, brownish to dark gray, tube-fed, sequence of pahoehoe flows exposed in a large kipuka north, northeast, and east of Juniper Buttes. The lava flows are composed of plagioclase and olivine porphyritic basalt with vesicules filled with caliche (Kuntz, 1979).

The succeeding basalt lava flows are Pleistocene, dark gray, even-grained, tube-fed pahoehoe lava flows (Qnb, Fig. 4) with olivine and plagioclase phenocrysts, 1 mm to 2 mm long, set in an intergranular groundmass of plagioclase, olivine, and augite crystals about 1 mm across (Kuntz, 1979).

Basalt of Little Crater (Pleistocene) overlies the above basalt (Qnb). This unit is a dark gray, porphyritic to non-porphyritic, tube-fed, series of flows. The flows display olivine and plagioclase phenocrysts about 2 mm across set in a diktytaxitic, intergranular groundmass of plagioclase, olivine, and augite crystals about 0.3 mm across (Kuntz, 1979).

The youngest unit in the Snake River Group is the Basalt of Little Grassy Butte. This sequence of Pleistocene basalt flows consists of gray to dark gray, porphyritic to non-porphyritic, tube-fed pahoehoe flows about 10 meters (33 feet) thick. The flows contain rare phenocrysts of olivine and plagioclase which are set in a diktytaxitic groundmass of plagioclase, olivine, and augite. The flows overlie and are partly buried by the

alluvium beloging to Egin Bench (Kuntz, 1979). This sequence is the youngest volcanic unit within the Sand Mountain GRA.

Three types of alluvial and terrace deposits of the Henrys Fork and Teton Rivers are recognized. The oldest unit is alluvium of Egin Bench (Pleistocene) which consists of unconsolidated deposits, largely sandy pebble gravel near Parker which grades southwestward to pebbly sand. Gravel consists of subrounded to rounded clasts of quartzite, obsidian, welded tuff, and basalt; sand is chiefly composed of obsidian grains. The alluvium is as thick as 30 meters (100 feet) but averages about 13 meters (43 feet) (Kuntz, 1979).

Terrace deposits of Holocene (0.1 m.y. to present) and Pleistocene age form a broad-fill terrace along the margins of the Henrys Fork and Teton Rivers. These deposits consist of unconsolidated, dominately obsidian sand and pebble gravel. The deposits are similar to and derived from the alluvium of Egin Bench and form terraces 1.5 meters (5 feet) to 12 meters (40 feet) above the floodplains of the two rivers. Gravel consists of quartzite, obsidian, welded tuff, and basalt. Meander scars and poorly drained areas contain several meters (6 feet) of fine-grained humic alluvium (Kuntz, 1979).

Recent alluvium (Holocene), up to several meters (6 feet) thick, consisting of unconsolidated silt and sand overlies sand and pebble gravel belonging to the floodplain deposits of the Henrys Fork and Teton Rivers. The alluvium is both horizontal and cross-bedded. Locally it contains graded beds which range from sand to silt-clay.

Two major types of surficial deposits occur in the Juniper Buttes area: (1) dune sands of Holocene and Pleistocene age and (2) Holocene colluvium. The dune sand deposits consist of an older set of longitudinal eolian dunes and somewhat younger set of parabolic and transverse dunes. The longitudinal dunes occur as narrow dunes or ridges parallel to the prevailing wind direction (N45°E). These dunes are generally 1 meter (3 feet) to 3 meters (10 feet) high and spaced about 50 meters (165 feet) to 300 meters (985 feet) apart. Individual dunes are as long as 7 kilometers (4.35 mi.) but average 3 kilometers (1.85 mi.). The dunes are composed of brown unconsolidated, well sorted grains of obsidian and quartz-rich sand. Most longitudinal dunes are stabilized by rye grass, sagebrush, and some juniper trees. The dunes are derived chiefly from older alluvial deposits of the Henrys Fork, Teton, and Snake Rivers to the south and southwest of Juniper Buttes. The parabolic and tranverse dunes are active dunes overlying the longitudinal dunes. They have linear to crescent-shaped crests which trend approximately normal to the prevailing wind direction (N45°E). These dunes range in height from about 1 meter (3 feet) to as much as 100 meters (330 feet) and average about 5 meters (16 feet). Distances between dune crests range from 75 meters (245 feet) to as much as 400 meters (1,315 feet) for large dunes, and average about 100 meters (330 feet). Sand grains are well sorted obsidian and quartz. These dunes are locally covered with sparse vegetation, chiefly rye grass. These dunes are also derived from older alluvial deposits of the Henrys Fork, Teton and Snake Rivers to the south and southwest of Juniper Buttes. The recent deposits of colluvium consisting of heterogeneous deposits of soil and rock fragments occur at the base of steep slopes. Locally these deposits contain abundant eolian sand (Kuntz, 1979).

2.4 Structural Geology and Tectonics

The crustal structure of the eastern Snake River Plain (ESRP) has been recently studied by Braile et al. (1982) and summarized as follows:

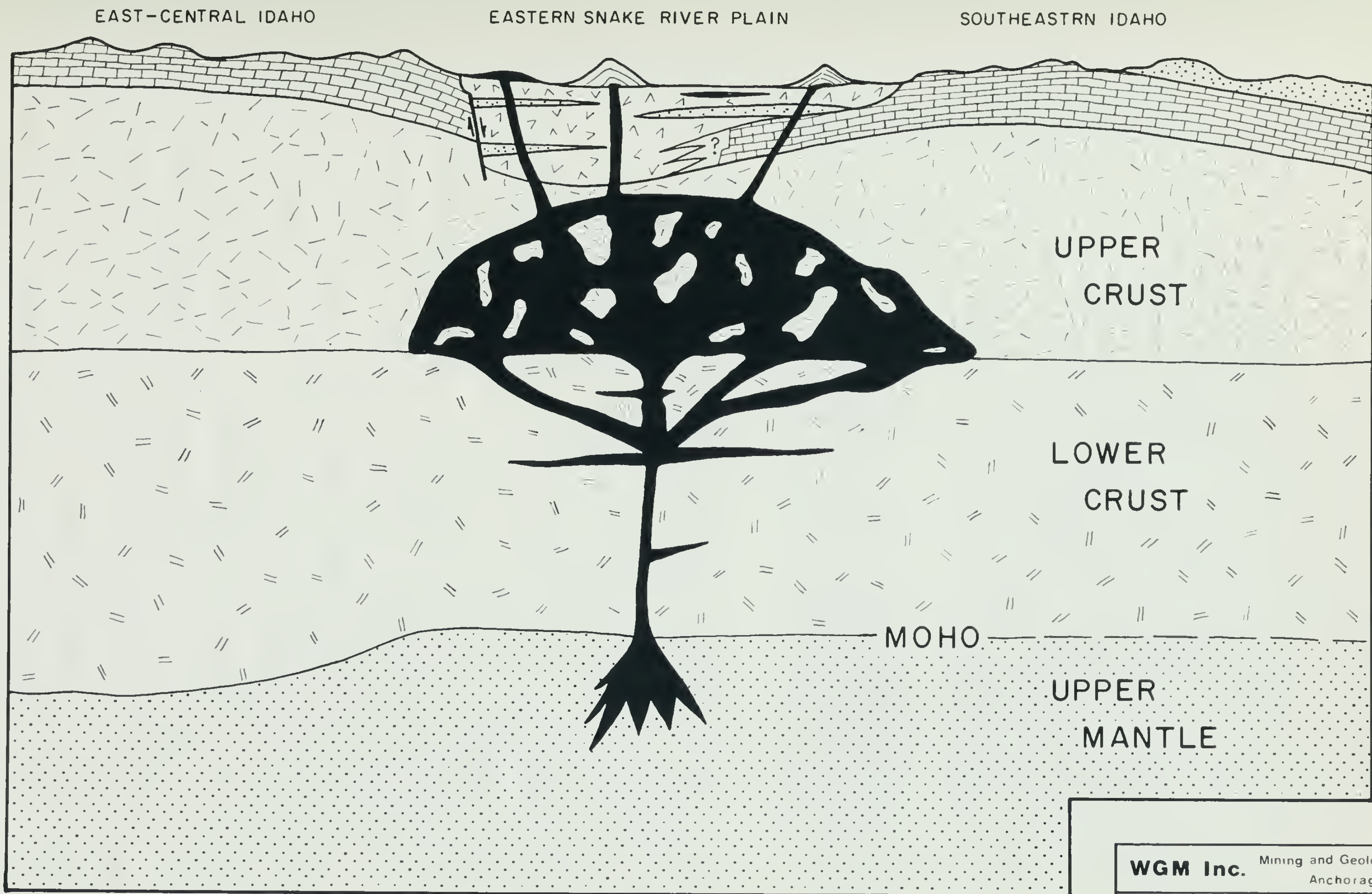
> Previous geological and geophysical studies of the ESRP indicate that it is a volcanic-filled depression which trends nearly perpendicular to the regional structures of the Basin and Range, Northern Rocky Mountains, and Middle Rocky Mountains Provinces which bound the ESRP. To the northeast of the ESRP are the Island Park and Yellowstone Calderas which have displayed volcanic, seismic, and hydrothermal activity within the last million years. Kirkham (1931) suggested that the ESRP is a simple downwarp and that faulting along the margins of the plain has been of minor importance. However, Sparlin et al. (1982) have demonstrated the existence of major faulting along the northwestern boundary of the ESRP from seismic and gravity modeling. Gravity studies (Hill, 1963; Mabey, 1976; Mabey et al., 1978; LeFehr and Pakiser, 1962) have identified a prominent positive gravity anomaly which approximately coincides with the axis of the ESRP, but is more localized toward the northern part of the downwarp in the western Snake River Plain. Deep crustal structure information from seismic data is absent in the ESRP, but a seismic refraction profile from Mountain City to Boise in the western Snake River Plain (Hill and Pakiser, 1966; Prodehl, 1979) has demonstrated that the western Snake River Plain consists of a thick, high-velocity (6.7 km/s) crust with a surface layer of lower-velocity volcanic materials. To the south of the ESRP, the northeastern Basin and Range Province is characterized by a lower, average crustal-velocity (6.3 km/s) and a crustal thickness of about 30 km (Braile et al., 1974; Keller et al., 1975; Smith, 1977, 1978; Hill and Pakiser, 1966). Armstrong et al. (1975) utilized K-Ar dates of late Cenozoic silicic volcanic rocks of the ESRP to demonstrate a systematic age progression of volcanism along the ESRP. Their data indicate that silicic volcanic activity began about 15 m.y. ago in southwestern Idaho and progressed at an average rate of approximately 3.5 cm/yr. northeastward toward its present site at the Yellowstone plateau. They also indicate that the initiation of basaltic volcanism has followed this same time progression, with a lag of approximately 2 to 5 m.y. after the silicic volcanism. In addition, the basaltic volcanism in the southwestern portion of the ESRP has remained active sporadically to the present. Today, the Yellowstone Caldera is representative of this silicic phase of volcanism which characterizes the volcanic progression, and the Island Park region represents the leading edge of the basaltic volcanic activity. Brott et al. (1978) utilized heat flow data on the western Snake River Plain and an observed heat flow-elevation relationship for the western and eastern Snake River Plain to propose a tectonic model for the development of the Y-SRP (Yellowstone-Snake River Plain) volcanic province. According to their model, the time progression of volcanism along the eastern Snake River Plain is accompanied by intrusion into the crust and rapid

transfer of heat to the surface by intrusion and eruptions. High heat-flow adjacent to the margins of the ESRP is observed, but low values are observed in the ESRP itself due to ground water circulation in the Snake River Plain aquifer (Brott et al., 1978). According to the model suggested by Brott et al., cooling of the crust after the intense silicic volcanic activity results in the subsidence which is presently observed as the eastern Snake River Plain downwarp.

Several additional tectonic models have been proposed to describe the geologic evolution of the eastern Snake River Plain during the past 15 m.y. Hamilton and Myers (1966) suggested that the ESRP consists of a tensional rift. Morgan (1972) and Smith and Sbar (1974) described the eastern Snake River Plain-Yellowstone system as the track of a mantle plume or hotspot. Finally, Taubeneck (1971) suggests that the ESRP was laterally faulted and the upper crust pervasively intruded by dikes.

A schematic diagram illustrating the crustal structure of the eastern Snake River Plain is shown in Figure 5. Braile et al. (1982, p. 2607) have suggested a tectonic model which seeks to provide a reasonable qualitative explanation for the observable crustal structure (based on seismic profiles), thermal anomalies, and volcanic history during evolution of the Yellowstone-Snake River Plain system. Their model is as follows:

When these observations are considered in conjunction with the volcanic age progression relationships described by Armstrong et al. (1975) and the thermal model proposed by Brott et al. (1978) for the evolution of the eastern Snake River Plain, a possible evolutionary model of the crust during the past 15 m.y. is suggested. Initially, a thermal perturbation of the crust results in 3 to 4 km of surface uplift, intense silicic volcanism, and subsequent caldera collapse. During this stage, basaltic magma from the upper mantle rises rapidly through the lower crust, producing only minor velocity structure perturbations. As the hot magma contacts the sialic upper crust, it causes partial melting of a part of the upper-crustal layer (as evidenced by the low velocity upper-crust beneath the Yellowstone area) during the process of rapid transfer of volcanic material and heat to the surface. Partial melting of these upper crustal rocks generates the silicic volcanism. This phase is presently represented by the Yellowstone plateau. As the 'hotspot' moves to the northeast, cooling of the intruded upper-crust generates the high-density, high-velocity intermediate layer in the ESRP and results in rapid subsidence of the crust.



From: Sparlin, et. al. (1982).

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Sand Mountain GRA, Idaho

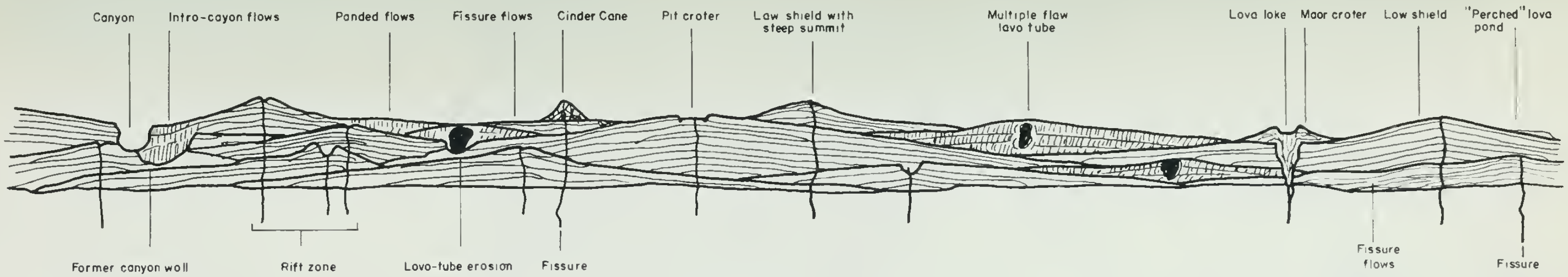
Schematic Diagram of Crustal Structure Eastern Snake River Plain

SCALE			FIGURE
DATA BY	DATE 3/1983	REV. SEC.	5
DRWN BY DSI	APRVD G F		

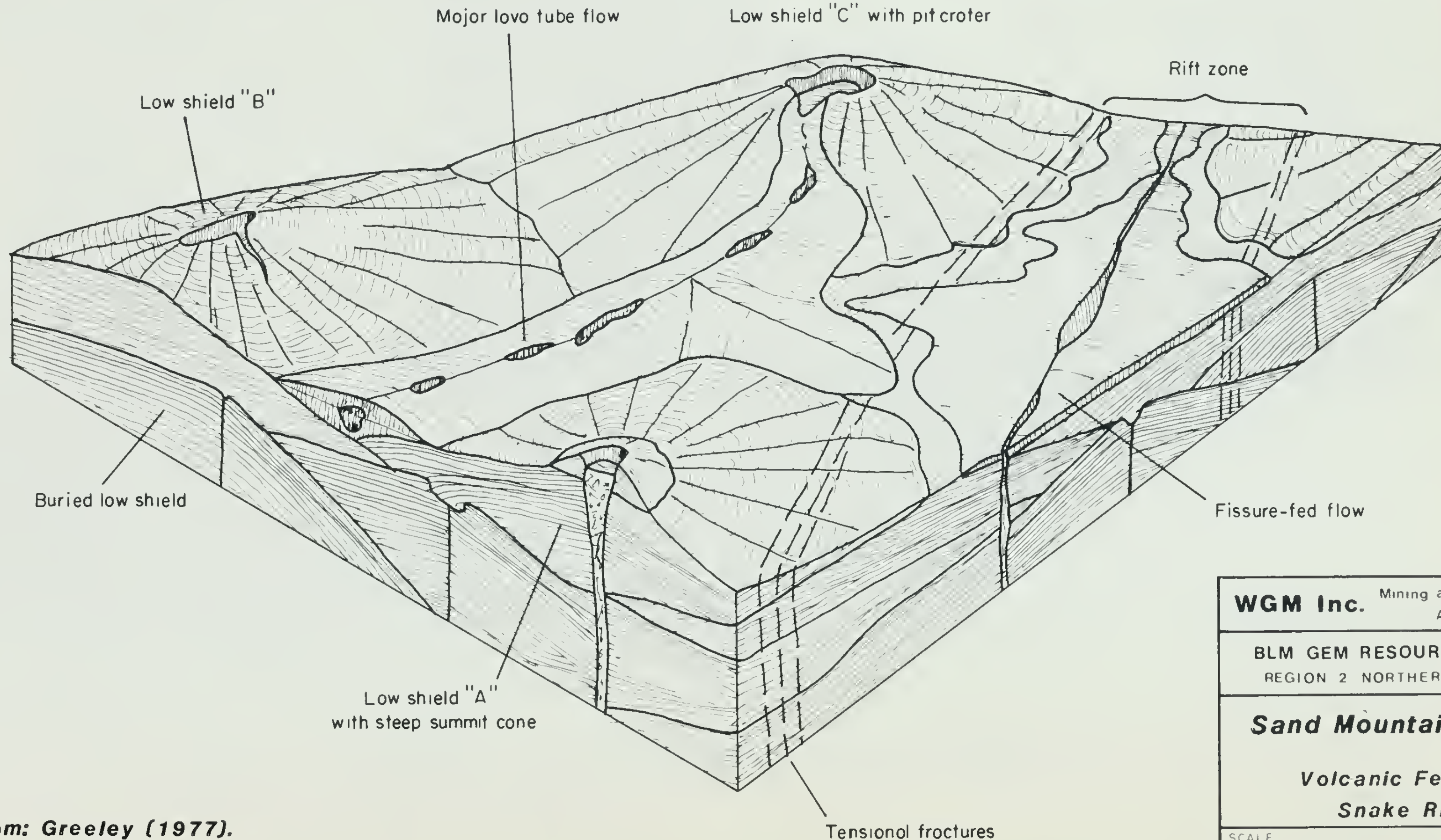
Continued cooling, subsidence due to thermal contraction, and minor, periodic basaltic volcanic activity persists through the remainder of the at least 15 m.y. evolutionary sequence. Due to the depletion of silicic material in the crust, this late-stage volcanism is of lesser intensity and probably represents rapid ascent of magma through small dikes or pipes from the upper mantle. An example of these late-stage volcanics is found in the Craters of the Moon, Idaho, area. Considering the potential geothermal anomalies along the Y-SRP system, the recent basaltic volcanism would represent a minor thermal anomaly in the crust. However, partial melt zones in the upper crust associated with silicic volcanism could produce significant temperature anomalies but would be restricted to the Yellowstone plateau and extreme northeastern part of the ESRP. Additional geothermal anomalies could be present near the axis of the ESRP due to shallow (7 to 10 km) intrusion of high-density and high-velocity rocks of the intermediate layer, or along the northwestern margin of the ESRP where a fault of at least 4 km offset could provide a route for upward migration of hot fluid.

Although much remains to be learned about the geology and tectonics of the Yellowstone-Snake River Plain area, the model described above provides a reasonable, qualitative explanation for the observed crustal structure, thermal anomalies, and volcanic history during crustal evolution of the Yellowstone-Snake River Plain system.

The Sand Mountain GRA is situated on the northwestern edge of a 28 to 30 mile wide composite caldera complex termed the Rexburg Caldera (Protsha and Embree, 1978; Mabey, 1978). Within the GRA no surface manifestations of the Rexburg Caldera are known as the feature is masked by Quaternary (2 m.y. to present) basalts and sediments (Fig. 7). Local structural features in the Juniper Butte area are limited to near-vertical faults of minor displacement in the pre-Juniper Butte rhyolites and basalts. Basaltic flows and pyroclastics of the Juniper Butte Complex originate from local vent features. The younger basalt flows of the Snake River Group were derived from vents in the Spencer-High Point rift zone about 25 kilometers north of Juniper Buttes in the case of the basalt of Little Crater and the underlying flows (Qnb, Fig. 4). In the case of the Little Grassy Butte basalts the source is from a vent about 7.5 miles southwest of Juniper Buttes. Figure 6 shows typical volcanic features found within the Snake River Plain.



Block diagram showing relationship of low shields, major lava tube flows, and fissure flows.



Data from: Greeley (1977).

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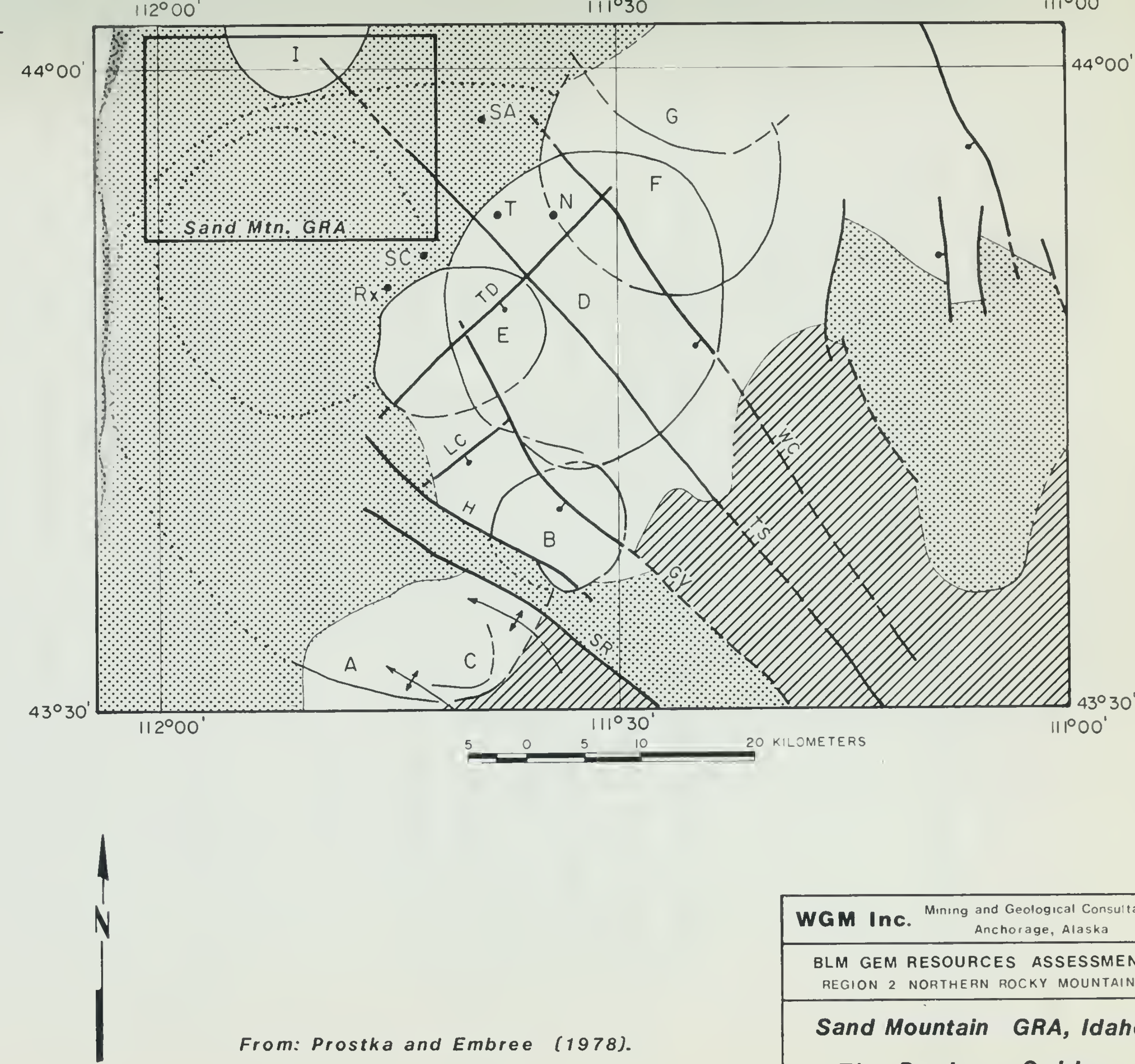
BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Sand Mountain GRA, Idaho

Volcanic Features of the Snake River Plain

SCALE			FIGURE
DATA BY	DATE 3/1983	REVISED	6
DRWN BY DSI	APRVC G F		



From: Prostka and Embree (1978).

Legend

SOME MAJOR FAULTS -- Bar and ball on downthrown side, dashed where located approximatly.

- TD Tetan Dam fault
- WC Warm Creek fault
- GV Grand Valley fault
- H Heise fault
- SR Snake River fault
- LC Lyons Creek fault
- TS Thousand Springs Line

CALDERAS -- Dashed where indefinite; datted where buried and location is determined by Bouguer gravity data

- A Willaw Creek calderas Segment.
- B Kelley Mountain calderas
- C Meadaw Creek calderas Segment
- D Maady Creed calderas
- E Rexburg Bench calderas
- F Teton Canyon caldera
- G Hag Hollow caldera
- I Juniper Butte Rhyalite Dome complex.

ANTICLINE -- Dashed where located approximately.

PRINCIPAL TOWNS

- • N Newdale
- • T Teton
- • SC Sugar City
- • Rx Rexburg
- • SA St Anthony

Quaternary Basalts and Sediments.

Pliocene Rhyolites

Paleozoic and Mesozoic Rocks

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Sand Mountain GRA, Idaho

The Rexburg Caldera Complex

SCALE AS SHOWN		FIGURE
DATA BY	DATE 3/1983	REVISED
DRWN BY DSI	APRVD G F	7

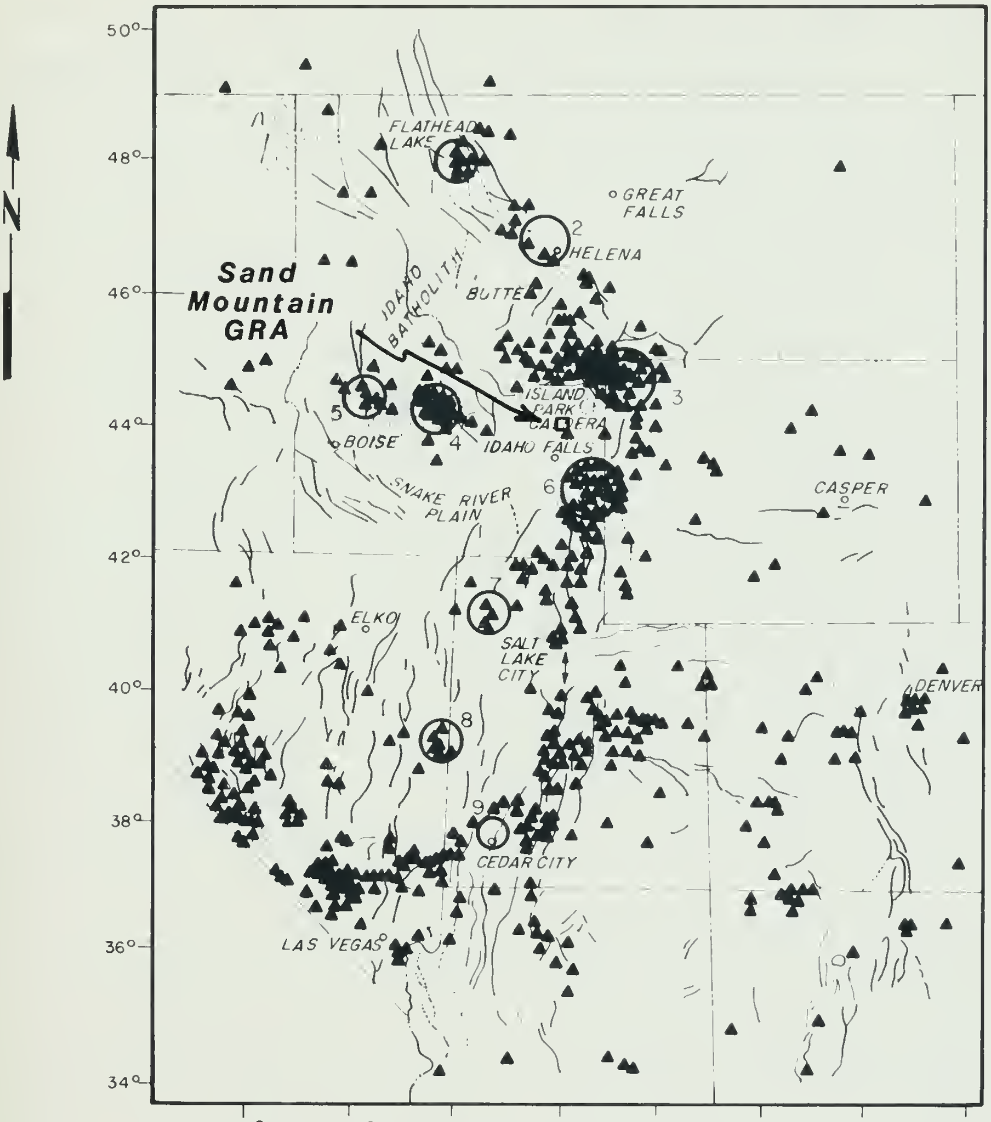
Geologic hazards in the Sand Mountain GRA are related to seismic activity in the area (Fig. 8) and potential renewed basaltic volcanism. The GRA is located in an area that is seismicially active; the areas with most seismic activity lie north and south of the GRA.

2.5 Paleontology

Fossils within the Sand Mountain GRA would be restricted to alluvial deposits of the Henrys Fork River and in any existing carnivore traps within the volcanic terrane. Pleistocene alluvial and fluvial deposits along the Snake River Plain have yielded important finds of fossil vertebrates such as mammoths and sloths. No important paleontological resources are known to be present within the confines of the GRA but data is presently lacking.

2.6 Historical Geology

The general overview of the geologic evolution of the eastern Snake River Plain is summarized in section 2.4 as put forward by Braile et al. (1982, p. 2607). In regards to specific aspects pertaining to the Sand Mountain GRA it seems likely that the oldest rock unit, the Pliocene rhyolites, is more closely related to volcanics of the Rexburg Caldera complex than to the subsequent flood basalts. An unconformity separates these older Pliocene age rhyolites and basalts from the Pleistocene Juniper Butte basalt complex. Minor normal faulting disrupted the Juniper Butte complex prior to near burial by younger flood basalts of the Snake River Group. These flows originated from vent areas north, northwest, and southwest of the Sand Mountain GRA. Alluvial deposits belonging to the Egin Bench overlap in age



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

Sand Mountain GRA, Idaho

Regional Seismicity

SCALE AS SHOWN			FIGURE
DATA BY	DATE 3/1983	REVISED	8
DRWN BY DSI	APRVD G F		

with the Snake River Group basalts. By the time the Basalt of Little Crater and Basalt of the Little Grassy Butte erupted, longitudinal dunes may have been forming. These eolian deposits continue to form with parabolic and transverse dunes comprising the most recent features.

3.0 ENERGY AND MINERAL RESOURCES

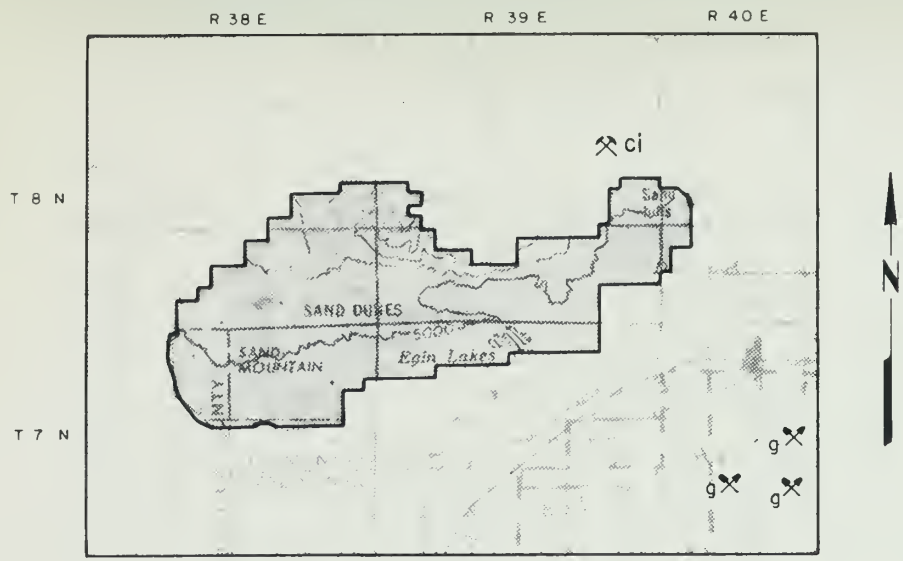
No specific mineral resource studies have been conducted within the Sand Mountain GRA. Suekawa et al. (1982) completed the NURE study of the Ashton NTMS Quadrangle which includes part of the GRA. Additional information was gathered from prospect compilations in the Ashton and Driggs Quadrangles by Mitchell et al. (1981a, b).

3.1 Known Mineral and Energy Deposits

The Sand Mountain GRA contains three gravel pits in terrace deposits and alluvium belonging to the Egin Bench deposits and one cinder pit (Fig. 9). The cinder pit is located in deposits of basaltic pyroclastics of the Juniper Butte Complex (Fig. 9). None of these deposits is within the Sand Mountain WSA. There are no reported energy deposits in the Sand Mountain GRA.

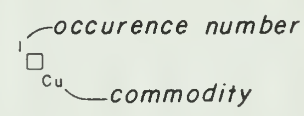
3.2 Known Mineral and Energy Prospects, Occurrences and Mineralized Areas

Vanadium occurrences are believed to be present in eolian sands within both the Sand Mountain GRA and the WSA. Fisher (1964) notes that vanadium is present in black sands at several localities in Idaho. Vanadium contents range from 0.05 to 0.42 percent, but no large tonnages of commercial quantities have been proven. Samples with a V_2O_5 content approaching commercial values have been found in the (1) Horse basin, (2) Warren district, (3) Rexburg dune sands, (4) Cascade-Long Valley area, and (5)

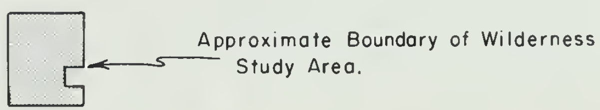


LEGEND

- ■ *Mineral Orebody*
- ◧ *Mineral Deposit*
- □ *Mineral Occurrence*
- ⚒ *Active Quarry*
- *Inactive Quarry*
- *Active gravel or clay pit*
- *Inactive gravel or clay pit*



ci - *Cinders*
g - *Sand and gravel*



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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

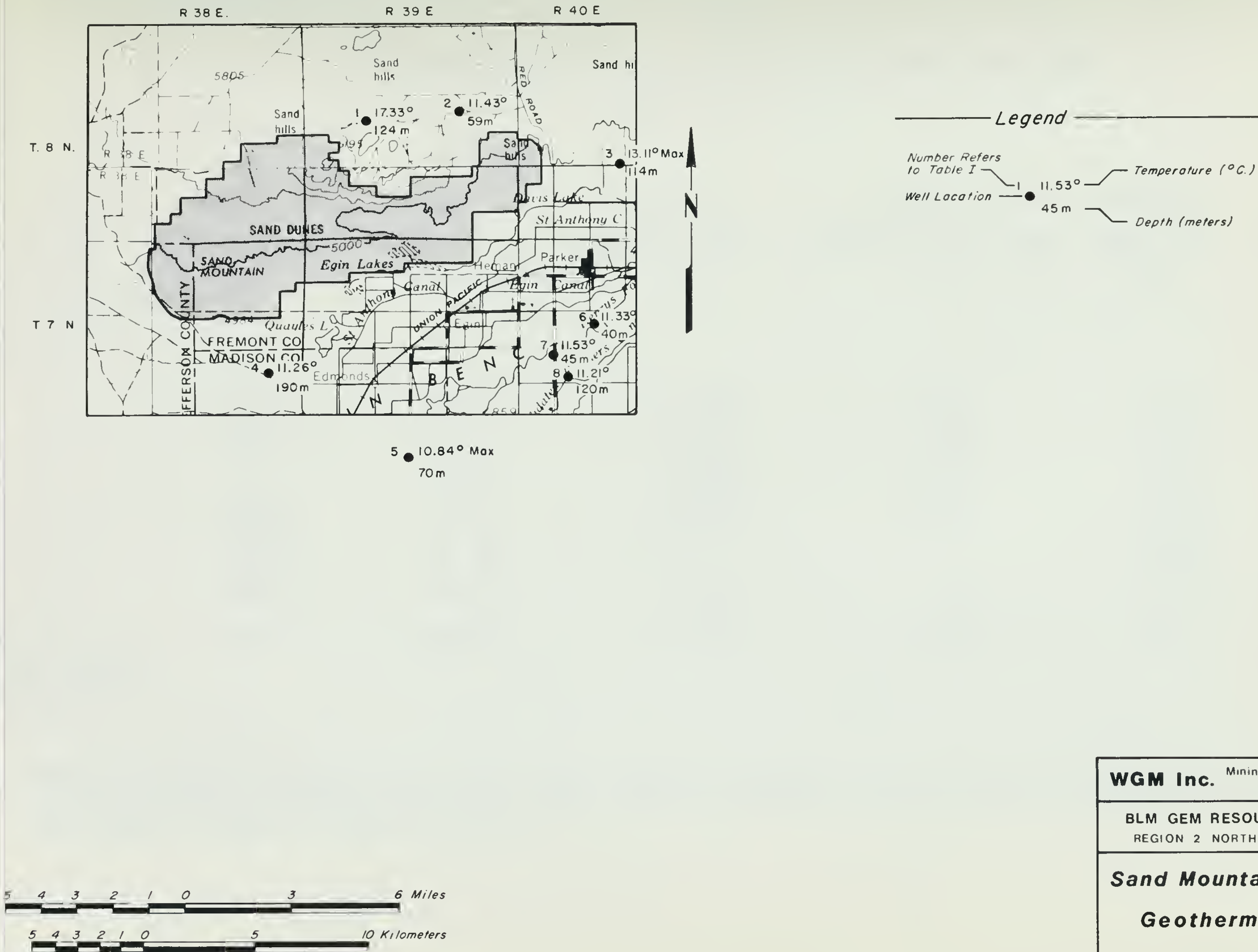
Sand Mountain GRA, Idaho

Mineral Occurrences

SCALE 1:250000			FIGURE
DATA BY WGM	DATE 1/1983	REV SEC	9
DRWN BY DSI	APRVD G.F.		

lower Deadwood River basin and reservoir area. No additional information on these occurrences is available.

Some data is available concerning geothermal resources in the Sand Mountain GRA. Brott et al. (1981) report the results of temperature-depth measurements in eight holes within five miles of the WSA (Table I, Fig. 10). Seven of these holes are within the GRA. The holes south of the WSA were drilled in the Snake River Group basalts and the data are characteristic of the holes penetrating the Snake Plain aquifer. Details of the hydrology of the Snake Plain aquifer and well logs from test wells penetrating the aquifer near and in the GRA (Haskett et al., 1977; Haskett and Hampton, 1979) show that the holes (locs. 4-8, Fig. 10) are isothermal to depths of at least 190 meters (623 feet). Temperatures range from 10.8 to 11.5°C (about 52°F). In contrast two holes drilled in silicic volcanics at locations 1 and 2 (Fig. 10) have geothermal gradients of 62 and 42°C/km (3.4 and 2.3°F/100 ft.) respectively, and are clearly not part of the Snake Plain aquifer system. The heat flow values for the latter two holes are typical for holes located along the margin of the Snake River Plain. The Snake Plain aquifer is quite deep along Henrys Fork and deep holes have subnormal gradients. For example, the hole in sec. 4, T.6N., R.40E. (Brott et al., 1981) has very low geothermal gradients to a depth of 425 meters (1,394 feet) and gradients of 44°C/km (2.4°F/100 ft.) between 425 meters (1,394 feet) and 688 meters (2,257 feet). A deep hole drilled near Rexburg about 10 miles to the south of the Sand Mountain WSA has subnormal temperatures perhaps persisting to a depth of 1,200 meters (4,000 feet) (Frank Childes pers. comm.). A 1,200 meter (4,000 foot) deep well was drilled northeast of Ashton (Table I). This well intersected rhyolitic ash flow tuffs from the top to the bottom of



WGM Inc. Mining and Geological Consultants, Anchorage, Alaska		
BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS		
Sand Mountain GRA, Idaho ***Geothermal Well Data***		
SCALE 1" = 4 MILES (1:250,000)		FIGURE
DATA BY	DATE 9/1982	REVISED
DRWN BY DSI	APRVD G.F	**10**

TABLE I

GEOTHERMAL DATA FROM WELLS IN OR NEAR SAND MOUNTAIN GRA, IDAHO

(Brott et al., 1981)

Map Location (Fig. 10)	Collar Elevation (m)	Depth Interval (m)	Geothermal Gradient (°C/km)	Heat Flow (10^{-6} cal./cm^2/ sec.)	Maximum Temp. (°C)	Relation to Snake Plain Aquifer
Sec. 19, T.9N., R.43E[1] (not shown on Fig. 10)	1,597	1,159-1,219	73	2.70	65	Outside
1	1,602	7.5-123.5	61.6/1.0	1.82	17.33	Outside
2	1,684	12.5-59	42.3/1.0	1.58	11.43	Outside
3	1,513	20- 50	45.0/1.9	1.58	12.92	Above
		50-114	21.0/1.7	0.74	13.11	In
4	1,479	79-190	1.9/0.2	0.05	11.26	In
5	1,472	30- 70	16.7/1.5	0.57	10.84	Above
6	1,489	0- 40	---	----	11.33	In
7	1,480	0- 45	---	----	11.53	In
8	1,484	45-120	-7.1/2.0	-0.23	11.21	In
Sec. 4, T.6N., R.40E. (not shown on Fig. 10)	1,489	425-688	44.3/1.0	1.89	20.5	Below

1. Temperature log of Occidental Geothermal, Inc., Sturm well available from Petroleum Information Corp. Temperature rises at 78°C/km (4.3°F/100 ft) to 43°C (110°F) at 427 m (1,400 ft). Temperatures are essentially isothermal from that depth to a depth of 1159 m (3,800 ft).

the hole. The temperature in the well was 43°C (110°F) at a depth of 427 meters (1,400 feet) and 65°C (149°F) at 1,200 meters (4,000 feet).

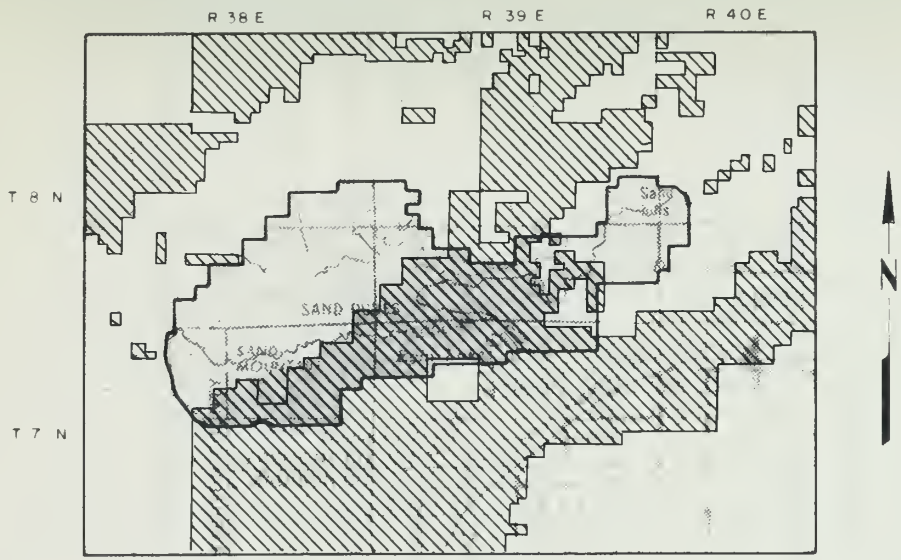
The gravity gradient that has been related to the edge of the postulated Rexburg Caldera (Mabey, 1978) passes just south of the Sand Mountain WSA. The major low temperature resource is represented by the Newdale anomaly (Brott et al., 1976; Mitchell et al., 1980), a zone of high heat flow extending from Rexburg northeast to Newdale (includes the well location in sec. 4, T.1N., R.40E., Table I) and located about 6 to 12 miles southeast of the WSA. Shallow temperatures in wells are over 40°C, silica geothermometer temperatures range from 115-125°C and possible mixing geochemical temperatures are as high as 260°C (Crosthwaite, 1978).

3.3 Mining Claims, Leases, and Material Sites

A review of BLM claim records current to June 7, 1982 shows that no mining claims are present in the Sand Mountain GRA. Oil and gas lease plats current to August 12, 1982 show that approximately 50% of the GRA is covered by oil and gas leases (Fig. 11). These leases cover about one half of the Sand Mountain WSA.

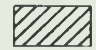
3.4 Mineral and Energy Deposit Types

The geologic character of the Sand Mountain GRA precludes the presence of a wide variety of deposit types. The absence of known metallic mineral deposits and occurrences in the eastern Snake River Plain makes evaluation of the metallic mineral potential difficult. The potential of the area must

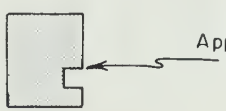


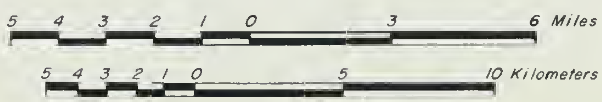
LEGEND

 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 O.G. Plats.

 Approximate Boundary of Wilderness Study Area.



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BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS	
Sand Mountain GRA, Idaho	
Oil and Gas Lease Status	
SCALE 1" = 4 MILES	FIGURE
DATA BY WGM · DATE 1/1983 · REV. SEC.	**11**
DRWN BY DSI · APRVD G F	

be evaluated by analogy and by comparison of the tectonic setting and geologic processes active in the area to those of similar mineralized areas. The eastern Snake River Plain, as discussed earlier, can be described as a continental hotspot, rift zone or aulacogen. Most workers favor the mechanism described by Morgan (1972) and Burke and Dewey (1973) which envisions formation of the Plain by movement of a continental plate over a fixed "hotspot" of rising mantle material (Smith and Christiansen, 1980).

The near-surface rocks in the Snake River Plain are subareal basalt flows which cover a series of rhyolitic calderas (Armstrong et al., 1975; Walker, 1964; Eaton et al., 1975; Christiansen and McKee, 1978; Mabey et al., 1978; Protska and Embree, 1978). The underlying rocks are rhyolitic flows and volcaniclastic caldera-fill deposits (Doherty et al., 1979). The volcanics have been intruded by rhyolitic to latitic plugs (Schoen, 1974; Spear, 1977; Kuntz, 1978). Thus the eastern Snake River Plain consists of three lithologic environments: (1) subareal basalt flows; (2) rhyolitic calderas; and (3) felsic plugs.

Mineral deposits associated with submarine basaltic volcanism along submarine rift zones such as the Red Sea and East Pacific Rise are well known. However, there are no known metallic mineral deposits associated with the subareal basaltic volcanism of the eastern Snake River Plain (Kuntz et al., 1980). The deposits in oceanic settings are formed within hydrothermal systems involving convective circulation of sea water. The apparent absence of hydrothermal activity in basaltic plains volcanism (Greeley, 1977, 1982) precludes formation of this type of mineral deposit in the eastern Snake River Plain.

Mineralization of several types, including precious metal-rich veins (Lipman et al., 1976) and massive sulfide deposits (Hodgson and Lyden, (1977) are associated with caldera systems. The current hydrothermal activity in the Yellowstone Caldera indicates that similar processes may have been active in the older calderas buried beneath the basalt plains (Smith and Christiansen, 1980). It is virtually impossible to evaluate the potential of mineralization in the buried calderas because of the thickness of the basalt cover. In addition the basalts obscure most caldera associated structures which could serve as hydrothermal conduits (Kuntz, 1978; Mabey, 1978; Protska and Embree, 1978).

In a recent review of the relationship of mineral deposits and tectonic settings Mitchell and Garson (1981) suggest that mineral deposits in rifted continental settings such as the Snake River Plain are mainly related to alkaline intrusives and peraluminous granites. Deposits of tin, uranium and molybdenum could be expected in this environment (Mitchell and Garson, 1981). Rhyolitic and ferrolatite domes occur at Big Southern, East, Middle and Cedar Buttes in the eastern Snake River Plain and are indicative of possibly more widespread intrusive activity. There are no reported occurrences of metallic mineral deposits at these domes. However, recent exploration work by AMAX Inc. at Big Southern Butte has resulted in discovery of subsurface stockwork molybdenum mineralization (S. Hamilton pers. comm., 1982).

The average uranium content of the earth's crust is about 2 ppm, and that of granite is about 4 ppm. Felsitic volcanic rocks generally contain more uranium than their plutonic equivalents, perhaps as much as 50% more. To be

commercially exploitable, a uranium deposit must ordinarily contain at least 1,000 ppm or one kilogram per ton. Thus, concentration by later geologic processes is usually necessary to form an economic uranium deposit. The uranium minerals in igneous rocks are mostly in the tetravalent state and oxidize readily to provide hexavalent uranium. Hexavalent uranium is soluble in ground waters. During transport by ground water, uranium may be: (1) partially absorbed by clay or carbonaceous matter, (2) precipitated in a chemically hospitable environment by reduction or evaporation, or (3) combine with another element to form a mineral stable in the oxidized state. If carried to the ocean, it tends to: (1) precipitate with phosphatic sediments, or (2) be absorbed by organisms and/or carbonaceous mud. The uranium-bearing accessory minerals, being resistant to erosion, are more likely to weather out of the igneous host as detritus and become dispersed in detrital sediments or, more rarely, concentrated into placers.

Sandstone deposits account for about 95% of United States uranium reserves. The hosts are river-borne arkosic sandstone deposits, commonly intercalated with acidic tuff and clay beds. The tuffs and/or nearby granitic uplifts, and the arkose itself, are thought to be the source rocks. The uranium is dissolved from the source rocks by meteroic water. The course of these uranium-bearing meteoric waters is directed by clay beds or old channel scours, and the precipitating medium for the uranium is believed to be organic matter. Deposits are individually small (with exceptions) with grade ranging from 3 to 8 pounds per ton. Uranium in peneconcordant sandstone deposits is accompanied by iron (as pyrite if the ore is unoxidized) and in many cases by copper, molybdenum, selenium, and vanadium.

From the preceeding discussion, it is evident that the silicic volcanics present in the subsurface of the Sand Mountain GRA are possible source rocks for uranium. In order to test the uranium favorability of these rocks, they were sampled around the Island Park Caldera by Suekawa et al (1982). The rhyolite sample sites were concentrated along rim fractures of the caldera and were found to contain 2.0 to 12.0 ppm U_3O_8 and 10.0 to 40.0 ppm thorium. The thorium-to-uranium ratios are typical of original composition and do not indicate any uranium mobilization. Radiometric anomalies are associated with the volcanics, but no uranium occurrences were reported in the literature. Due to the lack of evidence of hydrothermal alteration and vein development and the overall absence of evidence that any concentrating processes have taken place, the Island Park Caldera is considered unfavorable for uranium deposits (Suekawa et al., 1982).

Building stone, cinder and common stone are the most abundant mineral resources in the eastern Snake River Plain (Asher, 1965; Kuntz et al., 1980). Of these resources, building stone is the most valuable. The best building stone is pahoehoe lava (Maley and Holland, 1981). Slab pahoehoe occurs mainly along flow margins and at the rims of lava lakes (Kuntz et al., 1980). Cinders occur in cinder cones, around the margins of Holocene lava flows and along rift zones (Kuntz et al., 1980; Asher, 1965).

Vanadium in commercial amounts may be present in the form of resistate minerals in dune sands. The action of the wind, winowing away the lighter particles and leaving behind the heavies could be responsible for concentrating heavy resistate minerals. However, little data is present to

indicate the likelihood that such deposits are present, except for a brief mention in Fisher (1964).

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 Wilderness Study Area assessment these classes can be reduced to two: (1) high temperature (over 150°C) hydrothermal convection systems, and (2) low/intermediate temperature (40-150°C) hydrothermal convection systems. Geo-pressured geothermal energy systems do not exist in the areas discussed. Theoretically, geothermal resources exist everywhere because the temperature of the earth's crust everywhere increases with depth; thus, high temperatures are reached at some depth below any given point on the earth's surface. At the present time, and in the foreseeable future, a naturally occurring hot fluid coupled with sufficiently porous and permeable rocks to allow fluid migration are prerequisites for practical use of geothermal energy; thus conduction-dominated and "magma-tap" geothermal systems are not included in this evaluation.

There are many exploration techniques used in the evaluation of geothermal systems. The most practical techniques, in order of costs and recommended

application, are: geologic mapping; spring and well geochemical analysis for "reservoir" temperature determination (Ellis and Mahon, 1977); and temperature gradient/heat flow determination in existing wells and drill holes. Other geophysical techniques such as electrical resistivity, gravity, seismic studies, etc., are not specific to geothermal resources and may generate anomalies which little or no relationship to geothermal systems. However, in specific geothermal areas, all of these techniques are often used in exploration. Ball et al. (1979) present a brief discussion of exploration and reservoir assessment techniques and costs.

The Sand Mountain GRA is in the Snake River Plain geothermal province. This area is one of the major volcanic and tectonic provinces of the western United States and consequently has major geothermal potential. The volcanic history of the Snake River Plain is quite varied and extends into the Holocene. Buried calderas in the Snake River Plain were once the source of extensive siliciic ash flow tuffs underlying the eastern Snake River Plains. These deposits range in age from approximately 12 m.y. at the western edge of the eastern Snake River Plain to approximately 4 m.y. at the eastern margin of the province. Siliciic ash flow tuffs as young as 1.2 m.y. are present in the Island Park Caldera. In the middle of the Snake River Plain, the Big Southern Butte dome has been dated as approximately 300,000 years old (Armstrong et al., 1975). Basaltic volcanic activity throughout the whole area succeeded the silicic volcanic activity and has been continuous up into the Holocene. Large areas of the eastern Snake River Plain are covered by basalts which are less than 10,000 years old (Greeley, 1977). So far there has been no deep drilling in the vicinity of any of these sites of

Pleistocene and Holocene volcanism so the potential for geothermal resource is as yet unexplored.

The geothermal character of the Snake River Plain has been discussed by Mitchell et al. (1980) and by Brott et al. (1976, 1981). Surface evidence of any geothermal systems present in much of the area is obliterated by a major, rapidly moving, ground water aquifer in the near-surface Quaternary Snake River basalts; therefore, the geothermal character can only be evaluated by drilling beneath this aquifer, or by making estimates of heat input into the aquifer, and by evaluating the local geochemical variations within the aquifer (the latter has not yet been done).

As yet exploration drilling in this area has been quite sparse. In the eastern Snake River Plain only one deep hole, located on the Idaho National Engineering Laboratory test site, has been drilled (Walker, 1964). The bottom hole temperature at a depth of 3 kilometers (9,845 feet) was approximately 150°C. While there is evidence for circulation of water within the hole, economic quantities of fluid were not produced (Prestwich and Mink, 1979). A deep drill hole west of the eastern Snake River Plain near the town of Mountain Home encountered temperatures of 190°C at a depth of 3 kilometers (9,845 feet) (Arney et al., 1981). It is not known whether the hole was capable of producing fluid because it was initially drilled as a hydrocarbon test.

There are numerous hot and warm springs and wells on both the north and south margins of the Snake River Plain where the geothermal systems present

are less diluted by the effects of the Snake Plain aquifer. In most areas along these margins where extensive drilling has been conducted, warm water has been discovered, but no economic high grade (greater than 150°C) geothermal systems have been located. However, in view of the extensive warm water occurrences in shallow wells, the demonstrated existence of such temperatures at depths of less than 3,000 meters (9,845 feet) and the favorable volcanic history, it seems quite likely that in the future such systems will be discovered. Major areas of warm water occurrences along the north margin of the Snake River Plain are present near Magic Reservoir and near Arco. Along the southern margin extensive warm water resources occur near Rexburg and near Twin Falls.

No hydrocarbon tests have been drilled in the eastern Snake River Plain. The nearest hydrocarbon tests to the Sand Mountain GRA were drilled about 40 miles southeast in the Thrust Belt of southeastern Idaho. All were dry holes (Breckenridge, 1982).

The volcanic rocks which underly the Sand Mountain GRA are not favorable source rocks for hydrocarbons although under some conditions they may act as reservoir rocks. Fluvial and lake sediments which are interbedded with the volcanic rocks (Walker, 1964) are potential source and reservoir units.

The Sand Mountain GRA lies on strike with the Cordilleran fold-thrust belt as defined by Blackstone (1977) among others. If the thick Paleozoic section described by Skipp and Hait (1977) extends under the Snake River Plain from the south, the Paleozoic sections should interfinger and the Mesozoic section should thin or pinch out to the northwest. Both of the

stratigraphic sections present north and south of the Plain have recognized potential source and reservoir beds in them. To the north, the dark shales of the Trail Creek, Milligen, McGowan Creek and Phosphoria Formations are potential major source beds, and shaley limestones in the White Knob and Wood River Formation are potential minor source beds. South of the Snake River Plain, the Phosphoria Formation and numerous Mesozoic dark shales are potential major source beds. Minor source beds include shaley limestones of the Gallatin, Lodgepole and several Mesozoic formations. Only the Phosphoria has had extensive hydrocarbon potential studies made on it (Claypool et al., 1978; Peterson, 1980). These studies clearly show that it is a major hydrocarbon source bed throughout southeastern Idaho, western Wyoming, and southwestern Montana. Analyses of two samples of the Milligen Formation (probably McGowan Creek Formation) from the White Knob and Lost River Ranges, approximately 90 miles west of the Sand Mountain GRA, show that the Milligen Formation in those areas has a mature, very poor oil, good to excellent wet gas-condensate source character (Nance Petroleum pers. comm., 1982)

Potential reservoir beds of fractured limestones, vuggy limestones and porous sandstones are also recognized both north and south of the Plain. They could be present in the subsurface of the Sand Mountain GRA. Thrust belt structures form producing hydrocarbon fields in southwestern Wyoming and northeastern Utah (McCaslin, 1981; Powers, 1977) and in north-central Montana (McCaslin, 1980). These structures trend towards the eastern Snake River Plain and similar structures could be present in the subsurface of the Plain.

The presence of several volcanic vents decrease considerably the hydrocarbon potential within the Sand Mountain GRA. The extent of the metamorphism surrounding the vents and depths to the magmatic masses which supplied the vents are unknown. The position of the magmatic masses could probably be determined by geophysical studies, but the extent of the metamorphism can only be determined by drilling.

Many similarities in thickness and lithology are present between Paleozoic strata exposed in mountain ranges north and south of the Snake River Plain. Geophysical studies also suggest that Paleozoic strata continue across or extend into the Snake River Plain from the north and south (Stanley et al., 1977; Kuntz et al., 1980; Sparlin et al., 1982; Braile et al., 1982). These geophysical studies clearly show that several intervals of distinct rock types may be recognized under the Snake River Plain. Stanley et al. (1977) interpreted the third layer below the surface to represent the basement complex including sedimentary and metamorphic rock units. These are probably of Paleozoic and Mesozoic age. Strata overlying the basement complex and below the surficial volcanics are interbedded alluvial and fluvial clastics and volcanics (Walker, 1964; Stanley et al., 1977).

3.5 Mineral and Energy Economics

The Sand Mountain GRA enjoys good infrastructure with regards to any potential development of mineral or energy resources. A supply of labor, power, and water are nearby. The Union Pacific railway passes through the GRA.

The most significant potential in the Sand Mountain GRA is for geothermal resources. Based on present requirements for 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. These systems, however, can have a 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, for the purpose of this evaluation, a lower temperature than approximately 40°C is considered an economic cutoff for a geothermal resource. Another important economic factor affecting the viability of a geothermal resource is the distance from the source to the point of consumption. At lower temperatures it is not feasible to consider long-distance transportation of geothermal energy whereas for electrical grade resources long transportation distances are of course feasible. The presence of developments within and adjacent to the GRA would ensure that geothermal resources, even low temperature ones, would be exploited.

4.0 LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

4.1 Explanation of Classification Scheme

In the following section land within the Sand Mountain WSA (35-3) 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. geologic inference, based on expert opinion concerning the nature and importance of geologic relationships associated with mineral and energy deposits (Singer and Mosier, 1981).

The GEM 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 94) report preparation. No field work was done in the Sand Mountain GRA.

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.

The Sand Mountain WSA (35-3) is classified for locatable, leasable, and saleable resources potential.

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 to 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, pumicite, clay, magnesite, silica sand, etc. (Maley, 1983).

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 of 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).

Saleable 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).

4.2 Classification of the Sand Mountain WSA (35-3)

4.2.1 Locatable Minerals

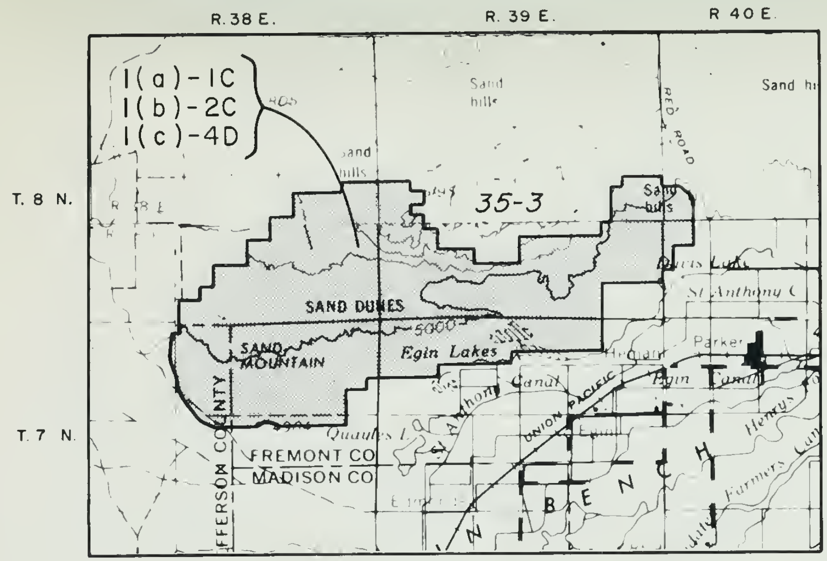
4.2.1a Metallic Minerals. The Sand Mountain (35-3) WSA (1a, Fig. 12) is classified as unfavorable for metallic mineral resources based on direct but minimal evidence (1C). The classification is based on the concepts outlined in Section 3.0.

4.2.1b Uranium and Thorium. All of the Sand Mountain (35-3) WSA (1b, Fig. 12) is classified as having low favorability for uranium and thorium based on direct but minimal evidence (2C). The basis of this classification is the possible presence of silicic volcanics and caldera structures in the subsurface of the WSA. However, no potential host rocks are known, nor is there evidence that concentrating processes have occurred.

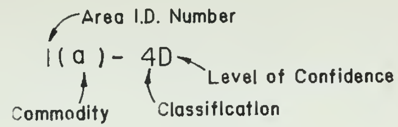
4.2.1c Non-Metallic Minerals. All of the Sand Mountain WSA (1c, Fig. 12) is classified as highly favorable for building stone resources, primarily slab basalt, based upon abundant direct evidence (4D).

4.2.2 Leasable Resources

4.2.2a Oil and Gas. The Sand Mountain (35-3) WSA (1a, Fig. 13) is classified as having low favorability for accumulation of hydrocarbon resources based on indirect evidence (2B). The basis for the classification is the data and concepts outlined in Section 3.4.



EXPLANATION



a) Metallic Minerals

b) Uranium and Thorium

c) Non-Metallic Minerals

BLM LAND CLASSIFICATION SYSEM 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

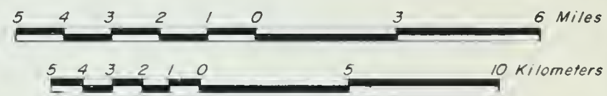
A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

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.

Approximate Boundary of Wilderness Study Area.



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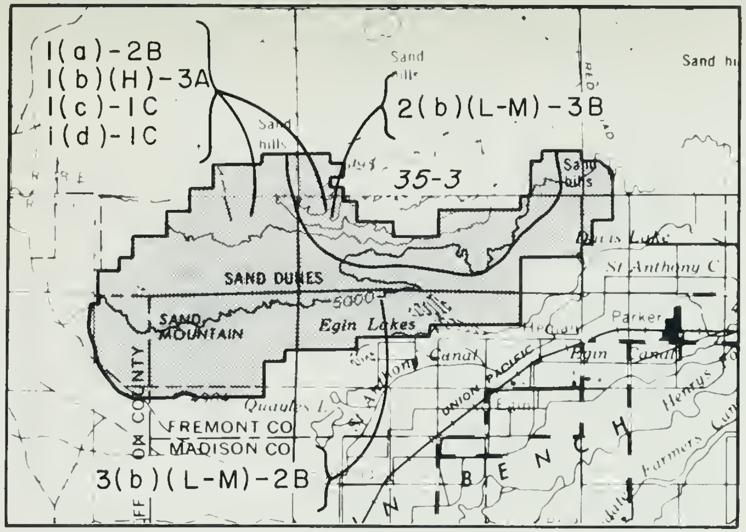
Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Sand Mountain GRA, Idaho
Wilderness Study Area
Land Classification
Locatable Resources

SCALE 1" = 4 MILES (1:250,000)		FIGURE 12
DATA BY. WGM	DATE 9/1982	REVISED
DRWN BY DSI	APRVD G.F	



BLM LAND CLASSIFICATION SYSEM FOR GEM RESOURCES

EXPLANATION

1(a) - 4D

- 1 = Area I.D. Number
- (a) = Commodity
- 4 = Classification
- D = Level of Confidence

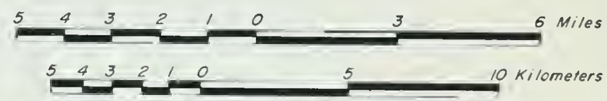
a) oil and gas

b) Geothermal: high temperature (H), moderate temperature (M), 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.

[Boundary symbol] Approximate Boundary of Wilderness Study Area.



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.

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Sand Mountain GRA, Idaho
Wilderness Study Area
Land Classification
Leasable Resources

SCALE 1" = 4 MILES (1 250,000)			FIGURE
DATA BY. WGM	DATE 9/1982	REVISED	13
DRWN BY DSI	APRVD G.F		

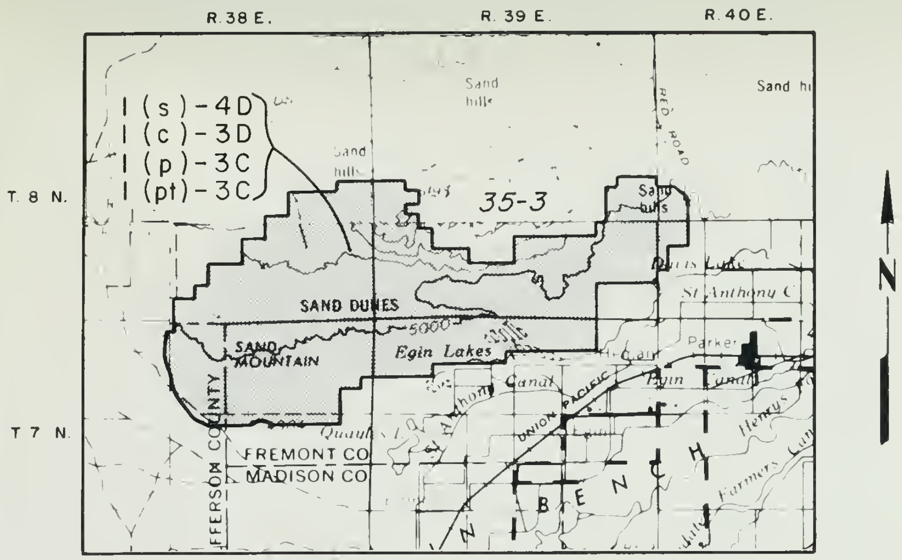
4.2.2b Geothermal. The entire area of Sand Mountain (35-3) WSA (1b(H), Fig. 13) is classified as having moderate favorability for high temperature geothermal resources based on insufficient data (3A). The portion of the Sand Mountain (35-3) WSA adjacent to silicic volcanic rocks (2b(L-M), Fig. 13) is classified as having moderate favorability for low and moderate temperature geothermal resources based on indirect evidence (3B). The southern portion of Sand Mountain (35-3) WSA (3b(L-M), Fig. 13) is classified as having low favorability for low and moderate temperature geothermal resources based on indirect evidence (2B). The basis for the classification is the data and concepts outlined in Sections 3.2 and 3.4.

4.2.2c Sodium and Potassium. The entire area of Sand Mountain (35-3) WSA (1c, Fig. 13) is classified as unfavorable for accumulation of sodium and potassium resources based on direct but quantitatively minimal evidence (1C). The classification is based upon the unfavorable geological setting.

4.2.2d Other. The Sand Mountain (35-3) WSA (1d, Fig. 14) is classified as unfavorable for asphalt, bitumen, and phosphate resources based on direct but qualitatively minimal data (1C). Any phosphate-bearing formations underlying the WSA would be too deeply buried beneath volcanic rocks to constitute a viable resource. No evidence for the existence of any other resources exsits.

4.2.3 Saleable Resources

All of the Sand Mountain (35-3) WSA (1s, Fig. 14) is classified as highly favorable for accumulation of sand based on direct and abundant evidence



BLM LAND CLASSIFICATION SYSEM
FOR GEM RESOURCES

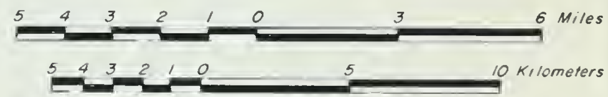
EXPLANATION

1(1s) - 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.



CLASSIFICATION SCHEME

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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.

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Sand Mountain GRA, Idaho
Wilderness Study Area
Land Classification
Saleable Resources

SCALE: 1" = 4 MILES (1:250,000)		FIGURE
DATA BY WGM	DATE 9/1982	REVISED
DRWN BY DSI	APRVD G.F	14

(4D). The classification is based on the presence of sand dunes blanketing the WSA. The entire WSA (35-3) is also classified as moderately favorable for accumulation of cinder (1c, Fig. 14) based upon direct evidence (3D) including the presence of a cinder pit north of the WSA and as moderately favorable for the accumulation of pumice and pumicite (1p-pt, Fig. 14) based upon limited direct evidence (3C). However, all of these resources are abundant outside of the WSA.

5.0 RECOMMENDATIONS FOR FURTHER WORK

Although Fisher (1964) indicates that dune sand in the Rexburg area contains high concentrations of vanadium no systematic sampling results are available. Thus, it is recommended that samples be collected and analyzed to determine if significant vanadium is present.

In order to more fully evaluate the hydrocarbon potential several recommendations follow:

1. Detailed geophysical studies in the eastern Snake River Plain should be continued to delinate subsurface structures that could contain potential hydrocarbon reservoirs.

2. Hydrocarbon characterization and thermal maturity studies should be completed on potential source beds on both sides of the Snake River Plain since the units are believed to extend beneath the Plain. These studies will indicate the type of hydrocarbons to be anticipated in the area and delineate those horizons where burial depths have removed hydrocarbons.

3. One or two deep tests need to be drilled in the Snake River Plain. These tests would provide data to verify geophysical interpretations of the deeper structures and stratigraphy. They would also give some indication of the extent of metamorphism from the volcanic vents if located in proximity to a vent. Potential hydrocarbon source and reservoir beds could be evaluated by a test well.

Evaluation of the geothermal potential will be very difficult and expensive given the nature of the terrain and the possible depth of targets. Deep drilling supplemented by a deep-seeking resistivity survey are the only practical ways to approach the evaluation. Electromagnetic techniques can also be used to look for conductors below the high resistivity basalts of the Snake Plain aquifer. The presence of a conductor would not necessarily mean geothermal potential, however, and drilling would be required to identify the geothermal significance of any conductive anomaly located.

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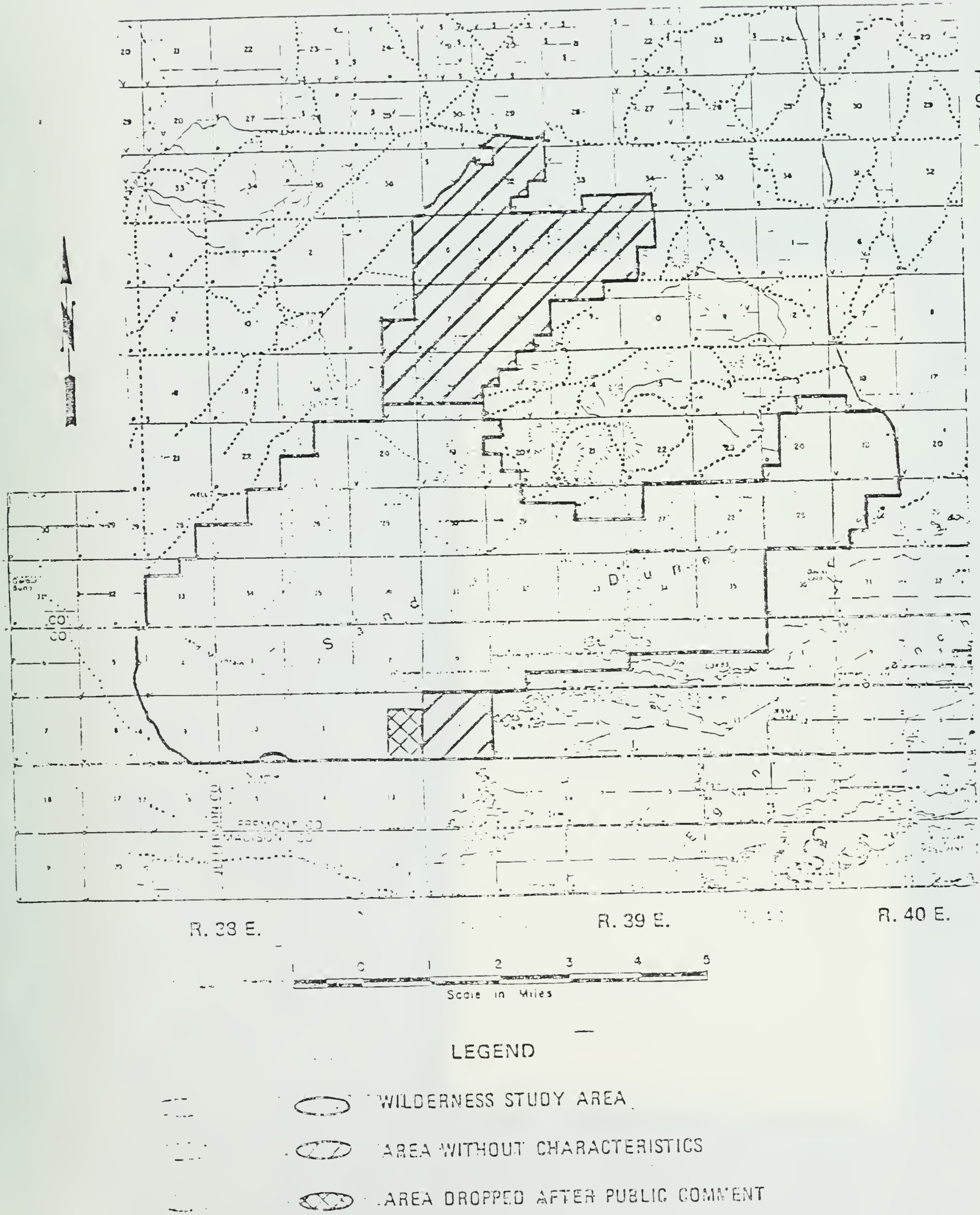
APPENDIX I

Wilderness Study Area Maps

SAND MOUNTAIN
35–3



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