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PHASE I

Geology, Energy, and Mineral (GEM)
Resource Evaluation of Twin Buttes GRA,
Idaho including the Shale Butte (57-2),
Sand Butte (57-8), Raven's Eye (57-10),
Little Deer (57-11), and Bear Den Butte
(57-14), Wilderness Study Areas

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

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ANCHORAGE, ALASKA
JULY 1983

WGM INC.
MINING AND GEOLOGICAL CONSULTANTS

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EXECUTIVE SUMMARY

The Twin Buttes Geology, Energy, and Mineral Resource Area (GRA) is situated on the Snake River Plain in south-central Idaho north of Twin Falls and southwest of Craters of the Moon National Monument.

Bedrock in the Twin Buttes GRA consists of Pleistocene to Holocene basalt flows and vent sites. The five Wilderness Study Areas (WSAs) in the GRA cover areas underlain by the youngest basalts. The source area for many of the Holocene basalt flows is the Great Rift within the Craters of the Moon National Monument.

A very modest amount of geologic data is available for the area. There is no geochemical data available and little information on energy resources. The overall geologic setting is not very favorable for accumulation of metallic or non-metallic minerals. Hydrocarbon and low/intermediate geothermal favorability is rated as low. More potential may exist for high temperature geothermal resources, but the data base on which to base an evaluation is inadequate. The resource with the greatest favorability consists of cinders and decorative lava rock. The classification of potential resources in the Twin Buttes GRA is shown in the accompanying table.

SUMMARY OF GEM RESOURCES

LAND CLASSIFICATION FOR THE TWIN BUTTES GRA

	Shale Butte WSA (57-2)	Sand Butte WSA (57-8)	Raven's Eye WSA (57-10)	Little Deer WSA (57-11)	Bear Den Butte WSA (57-14)
1. Locatable Resources					
a. Metallic Minerals	1C	1C	1C	1C	1C
b. Uranium and Thorium	1C	1C	1C	1C	1C
c. Non-Metallic Minerals					
i. Uncommon stone	3C	3C	3C	3C	3C
ii. Other	1C	1C	1C	1C	1C
2. Leasable Resources					
a. Oil and Gas	2B	2B	2B	2B	2B
b. Geothermal					
i. High temperature	2A-3A	2A-3A	3A-2A	3A-2A	2A-3A
ii. Low temperature	2B	2B	2B/3A	2B/3A	
c. Sodium and Potassium	1C	1C	1C	1C	1C
d. Other	1C	1C	1C	1C	1C
3. Saleable Resources	4C/1C	4C/1C	4C/1C	4C/1C	4C/1C

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TWIN BUTTES GRA, IDAHO1.0 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 Areas (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. Phase I 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 of 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**

***Twin Buttes GRA,
Idaho
Location Map***

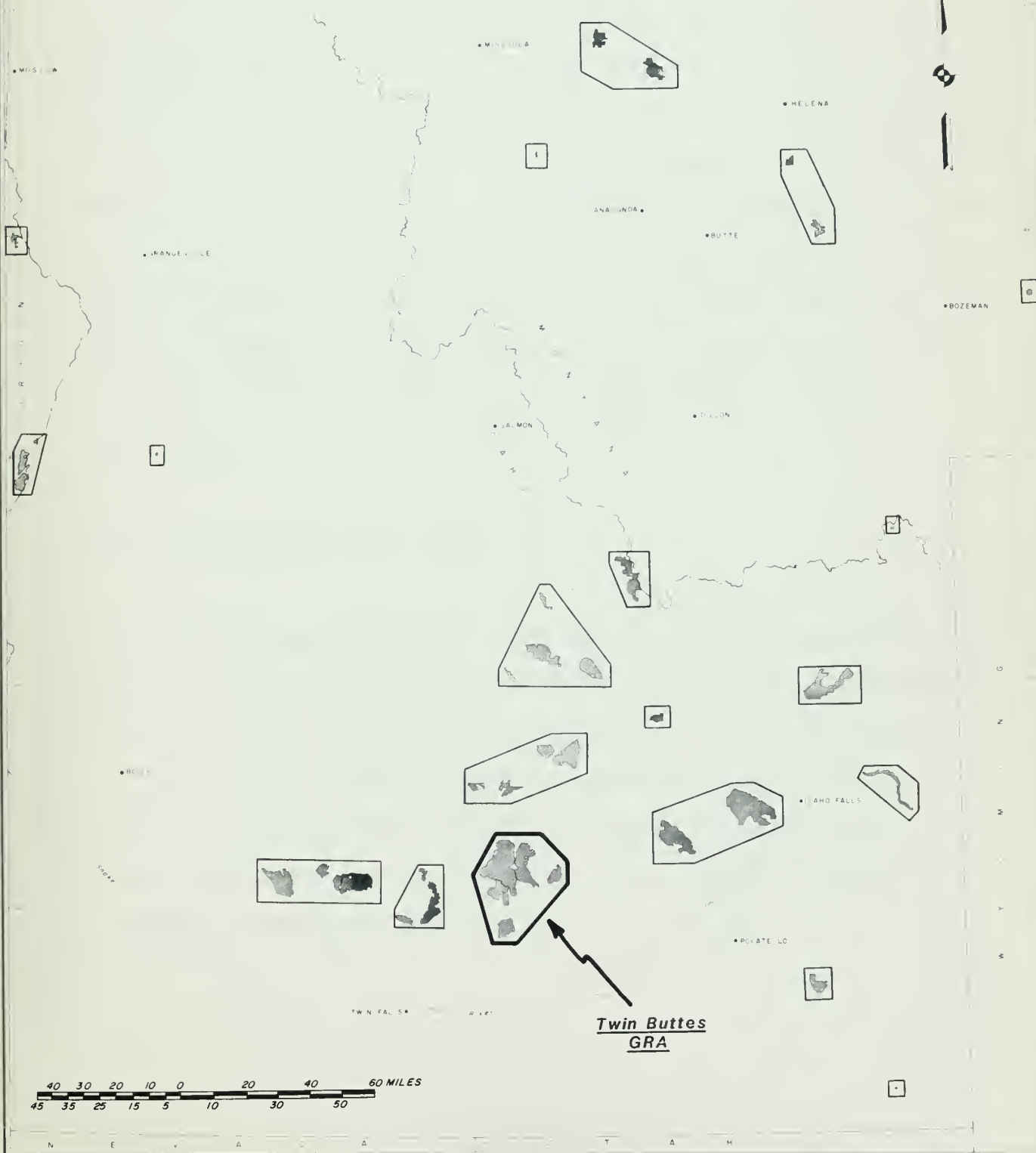
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FIGURE

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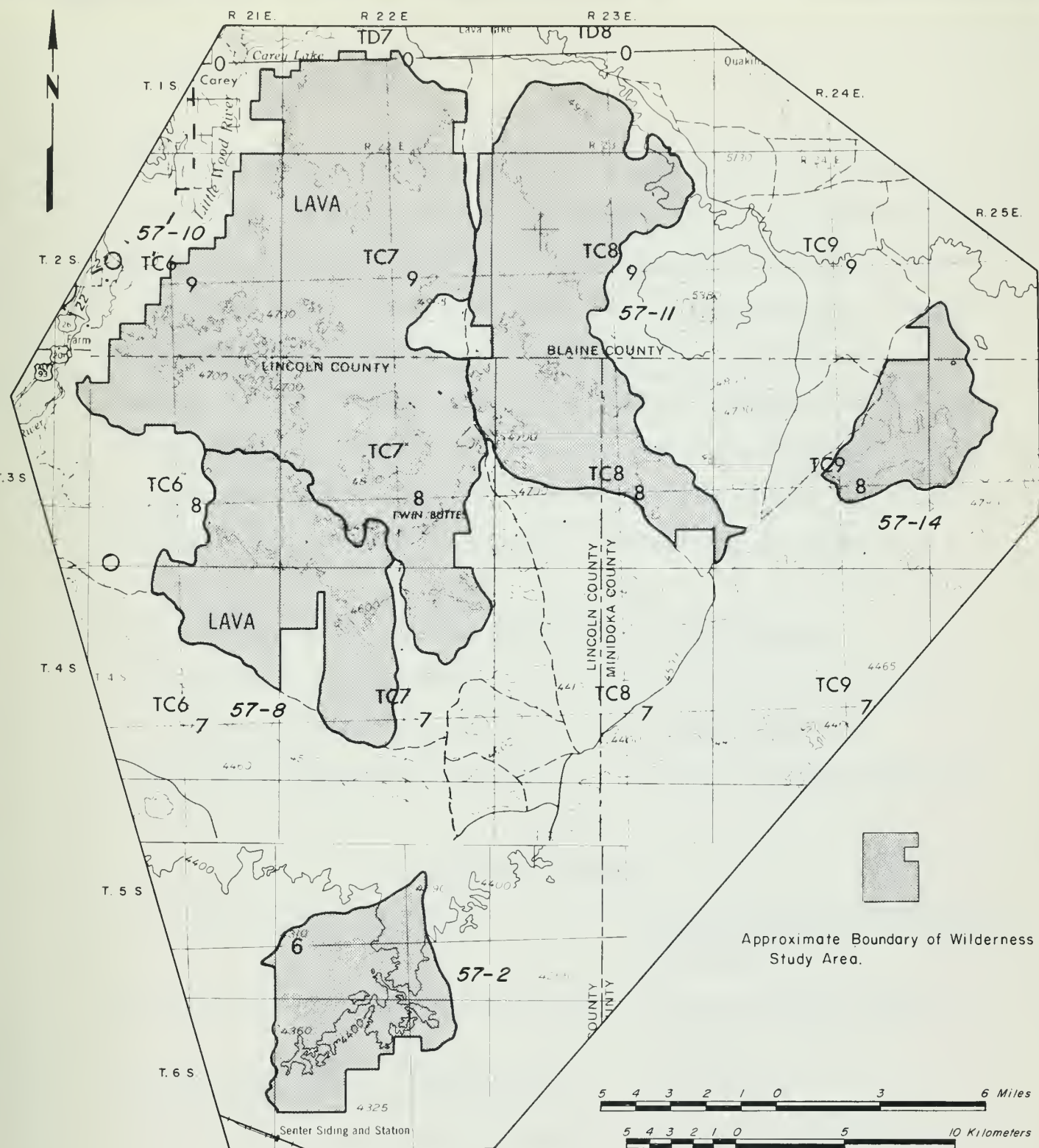
totalling 583,182 acres. The WSAs were grouped into 22 GRAs for purposes of the Phase I GEM resources evaluation.

1.1 Location

The Twin Buttes GRA is located in south-central Idaho in Blaine, Lincoln, and Minidoka Counties, Ts.1-6S., Rs.22-25E (Fig. 2). The center of the area is approximately 16 miles southeast of Carey and 45 miles north of Burley, Idaho. Administratively the GRA is within the Monument Resource Area in the Shoshone BLM district. Craters of the Moon National Monument is adjacent to the GRA on the northeast. The Twin Buttes GRA contains approximately 400 square miles and encompasses the Shale Butte (57-2) WSA (15,968 acres), Sand Butte (57-8) WSA (27,792 acres), Raven's Eye (57-10) WSA (67,110 acres), Little Deer (57-11) WSA (33,531 acres), and Bear Den Butte (57-14) WSA (9,700 acres).

1.2 Population and Infrastructure

The northeast corner of the Twin Buttes GRA contains the community of Carey, population 300, which is the only settlement within the GRA. The community of Richland (pop. 357) is situated immediately west of the GRA boundary. U.S. Highway 26-20 (93 Alt.) crosses the northwestern corner of the Twin Buttes GRA and State Highway 24 and the Union Pacific Railroad cut the extreme southwestern corner of the GRA (Fig. 2). A network of improved light duty and unimproved dirt roads criss-cross the GRA.



**BLM Wilderness Study Areas Included in the
Twin Buttes GRA.**

WSA	NAME	ACREAGE
57-2	Shale Butte	15,968
57-8	Sand Butte	27,792
57-10	Ravens Eye	67,110
57-11	Little Deer	33,531
57-14	Bear Den Butte	9,700

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***Twin Buttes GRA, Idaho
Topographic Map***

SCALE: 1"=4 MILES	FIGURE
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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 Twin Buttes GRA. The GRA is partly covered by the geologic mapping of Armstrong et al. (1978), Kuntz et al. (1980), and photogeologic mapping by LaPoint (1977). The geology has been compiled at a 1:250,000 scale by Rember and Bennett (1979a, b, c). In general the data base upon which to base an evaluation of the GRA is weak. 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

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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 Larry Dee, District Geologist, of the BLM-Shoshone for assistance during the compilation stage of this report.

2.0 GEOLOGY

2.1 Introduction

The Twin Buttes GRA is situated within the Snake River Plain. The surficial geology is comprised essentially of basalts which range in age from Pliocene (6-2 m.y.) to Holocene (0.1 m.y. to present). These basaltic lava flows mask the underlying structure and stratigraphy. Estimated thicknesses of the volcanics range from 9,850 feet to 29,500 feet (Mitchell et al., 1980).

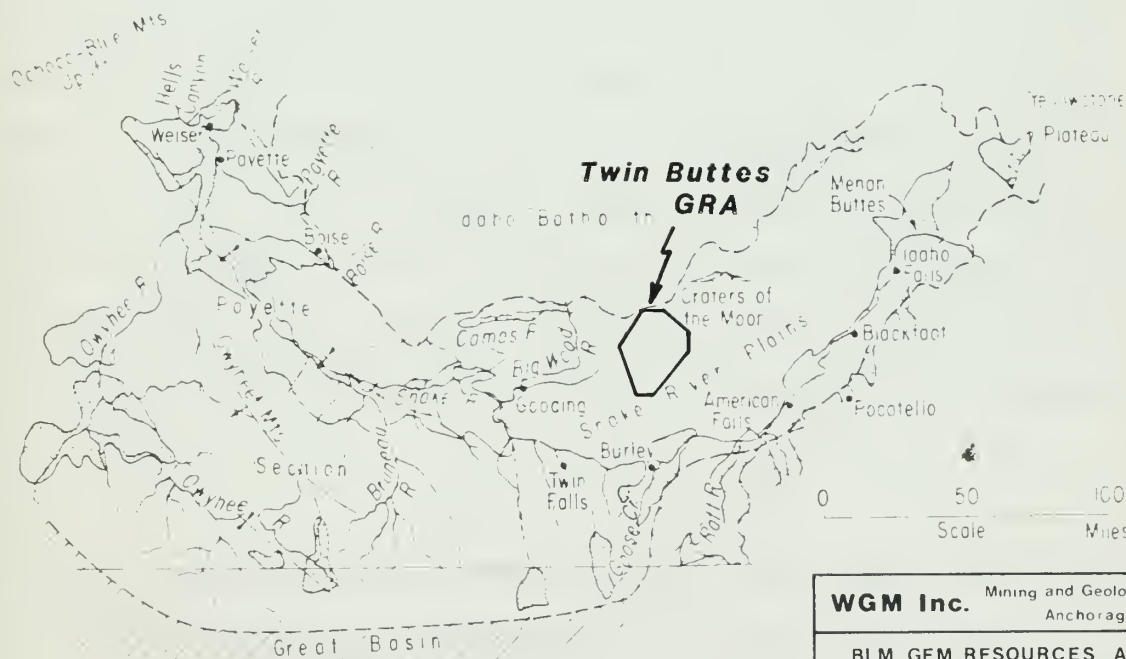
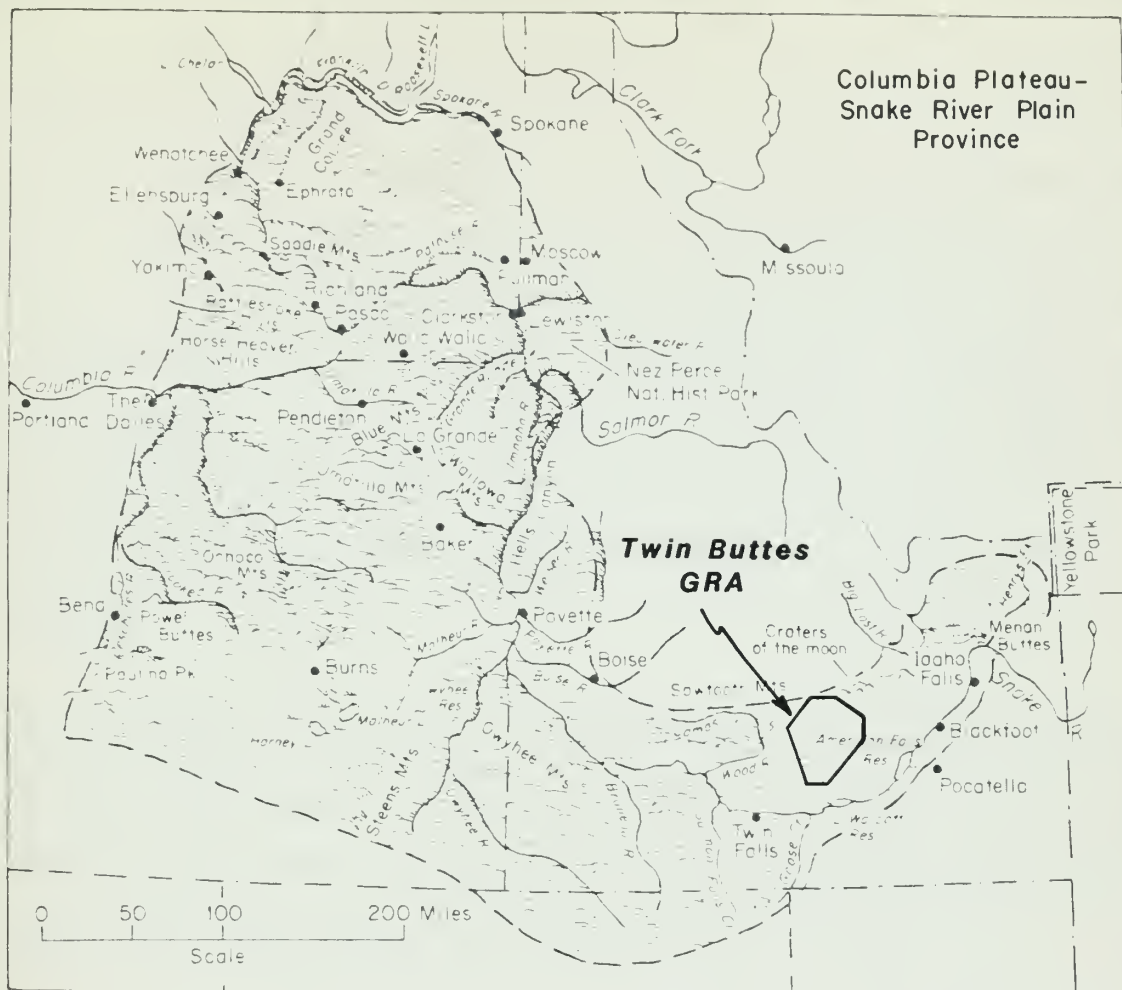
2.2 Physiography

The Twin Buttes GRA is located in the central Snake River Plain (Fig. 3) of the Columbia Plateau-Snake River Plain physiographic province (Hunt, 1974). The Little Wood River, which crosses through the northwest corner of the GRA is the only major drainage system present within the GRA. The climate is semi-arid, high-desert terrain. Vegetation consists principally of sagebrush and bunch grass and may be very sparse depending upon the age of the underlying lava rock.

Elevations vary from 5,400 feet to less than 4,300 feet. Volcanic buttes form the major topographic features on the otherwise monotonous rolling terrain.

2.3 Description of Rock Units

Little geologic data is available for rock units found within the Twin Buttes GRA. The main sources of data for this compilation are the photo-



- Cenozoic Lake, Playa, and stream deposits
- Lava

Fram Hunt (1974).

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Twin Buttes GRA, Idaho
Physiographic Setting

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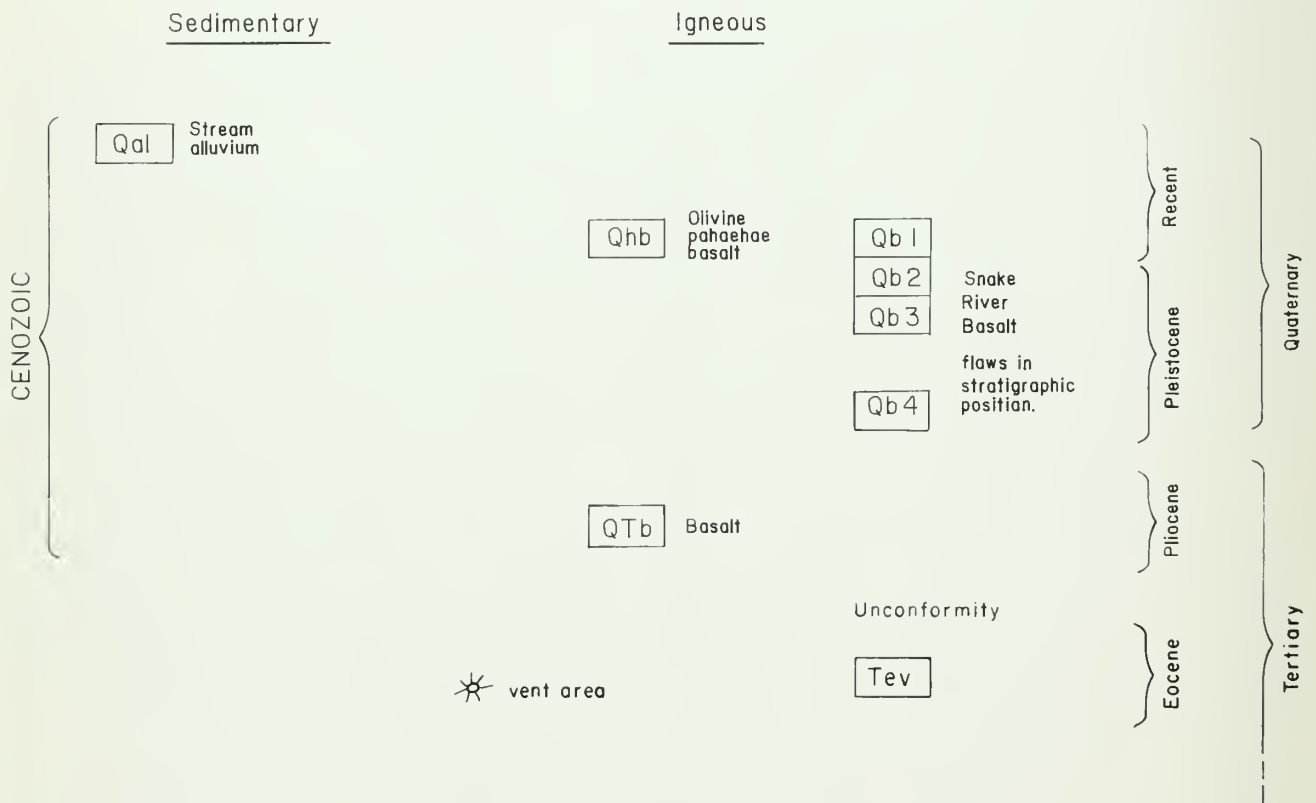
geologic map of LaPoint (1977) and the report of Kuntz et al. (1980). LaPoint's map provides useful data on the distribution and relative ages of basalt flows in the GRA but rock descriptions of individual units are not given. The work by Kuntz et al. (1980) provides good data on the Craters of the Moon Lava Field. The reader is referred to general references on Snake Plain volcanism, especially those of Greeley and King (1977), Higdem (1973), and Greeley (1982). Typical relationships among the various volcanic features and units underlying the Snake River Plain are illustrated in Figure 5.

The oldest rock units exposed in the Twin Buttes GRA are Eocene (55-38 m.y.) volcanic rocks exposed in a small area within the GRA about one mile southwest of Carey. These rocks consist of mixed silicic and basaltic flows, ejecta and volcanic debris (Tev, Fig. 4).

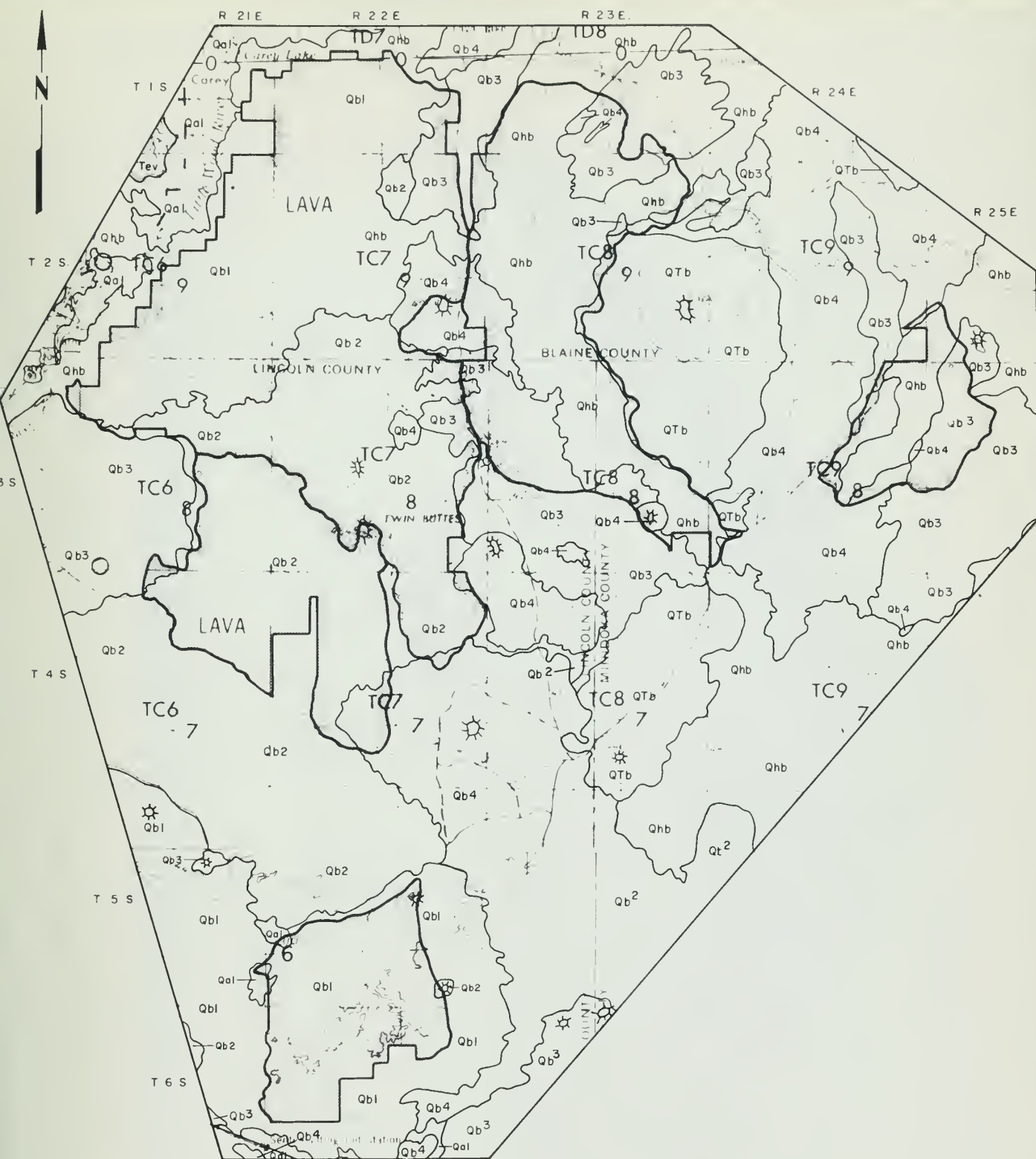
An unconformity separates the Eocene volcanics from Pliocene age basalt flows. These older Pliocene basalt flows (QTb, Fig. 4) now occur as remnants of early outpourings largely buried by Pleistocene (2-0.1 m.y.) and Holocene basalt flows. QTb consists of dark gray to dark brown flows of olivine-rich pahoehoe basalt. Outcrops are exposed along stream cuts and locally on the windward side of larger vents (Armstrong et al., 1978). Antelope Butte, south of Burley, is dated as 2.3 ± 0.3 m.y. old (Armstrong et al., 1975).

The next youngest basalt unit (Qb4, Fig. 4) is delineated from interpretation of aerial photographs and is believed to comprise the oldest flows belonging to the Snake River Group (LaPoint, 1977). About 40 miles east-

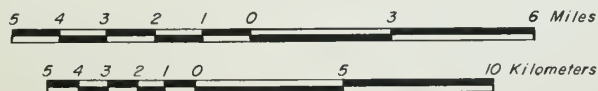
Twin Buttes GRA, Idaho
Explanation for Figure 4



Data by: LaPoint, 1977; Armstrong et al., 1978; Rember and Bennet, 1979.



Approximate Boundary of Wilderness Study Area.



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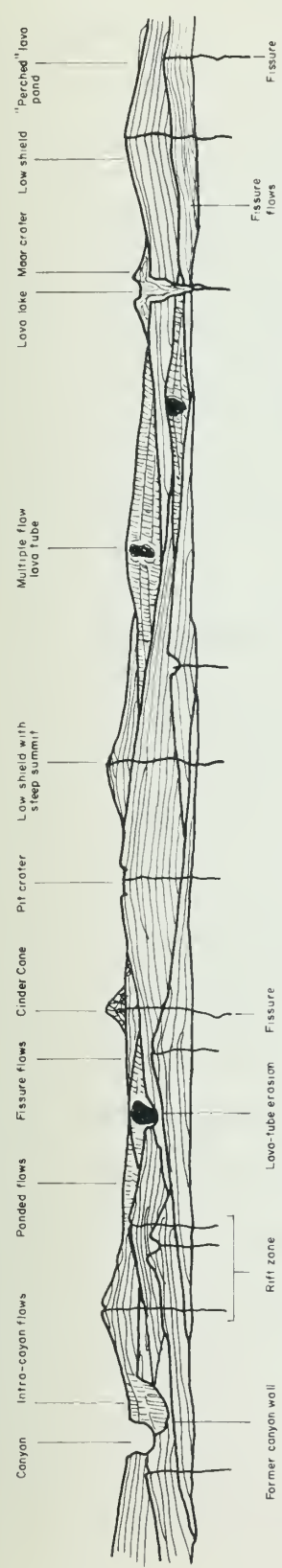
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Twin Buttes GRA, Idaho

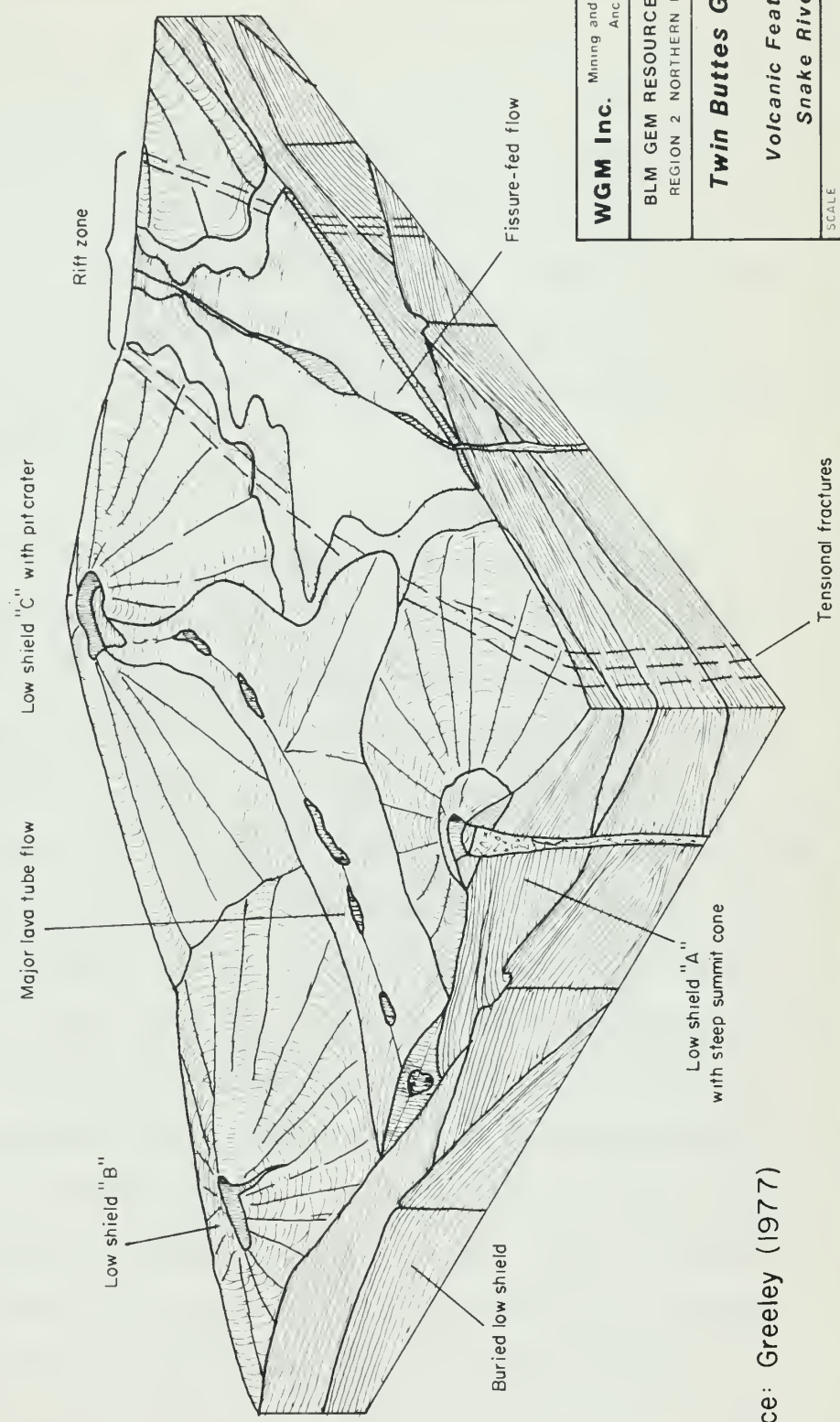
Geologic Map

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Schematic cross section showing the salient features of a 'plains' basalt region, typified by the central Snake River Plain.



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



Source: Greeley (1977)

WGM Inc. Mining and Geological Consultants Anchorage, Alaska		BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS		Twin Buttes GRA, Idaho Volcanic Features of the Snake River Plain	
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FIGURE					5

northeast in the Lava GRA these flows have been field mapped (Kuntz et al., 1979). In the Lava GRA map unit Qb4 consists of a sequence of flows originating from a number of scattered vents. The flows range from about 12,000 to about 700,000 years old. Most of the sequence is gray to black basaltic pahoehoe flows and associated pyroclastics erupted from fissure controlled vents. Qb4 is probably of similar composition and age in the Twin Buttes GRA. LaPoint (1977) indicates one possible source vent for Qb4 at a site (Fig. 4) six miles southeast of Twin Buttes. Qb3 and Qb2 are similar flow sequences to Qb4, but they are interpreted to be younger from studies of aerial photographs.

The youngest flows within the Twin Buttes GRA are pahoehoe and basaltic lava flows which originated six to ten miles northeast of the GRA at Craters of the Moon (Qhb, Fig. 4). These basalts represent some of the youngest volcanism on the Snake River Plain. The age of the Craters of the Moon eruptions is not precisely known but various age dates obtained from carbonized tree roots and similar material indicate an age of 1,500 to 2,200 years (Papson, 1977). The Craters of the Moon source area is situated on part of the Idaho Rift System, a 34 mile long set of en echelon fissures which strike N35°W in a zone up to 1.85 miles wide. Flows originating from the Craters of the Moon complex are highly evolved basalt of an iron- and alkalai-enriched lava series (Stone, 1969). Stone feels that the composition of these basalts indicates that they were derived from residual liquid belonging to the Snake River magma source and that more than 80% crystallization of the parent magma is indicated. Unit Qb1 (Fig. 4) in the extreme south-central part of the Twin Buttes GRA is also classified with the

youngest flows based on analysis of aerial photographs (LaPoint, 1977). Their relationship, if any, to the Craters of the Moon source area is not known.

Deposits of alluvium are present primarily along the drainage of the Little Wood River in the northwestern portion of the Twin Buttes GRA and in the southern portion of the GRA near Senter Siding and Station (Fig. 4). The deposits of alluvium near Carey have been exploited as a source of sand and gravel.

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 modelling. Gravity studies (Hill, 1963; Mabey, 1976, 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 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.

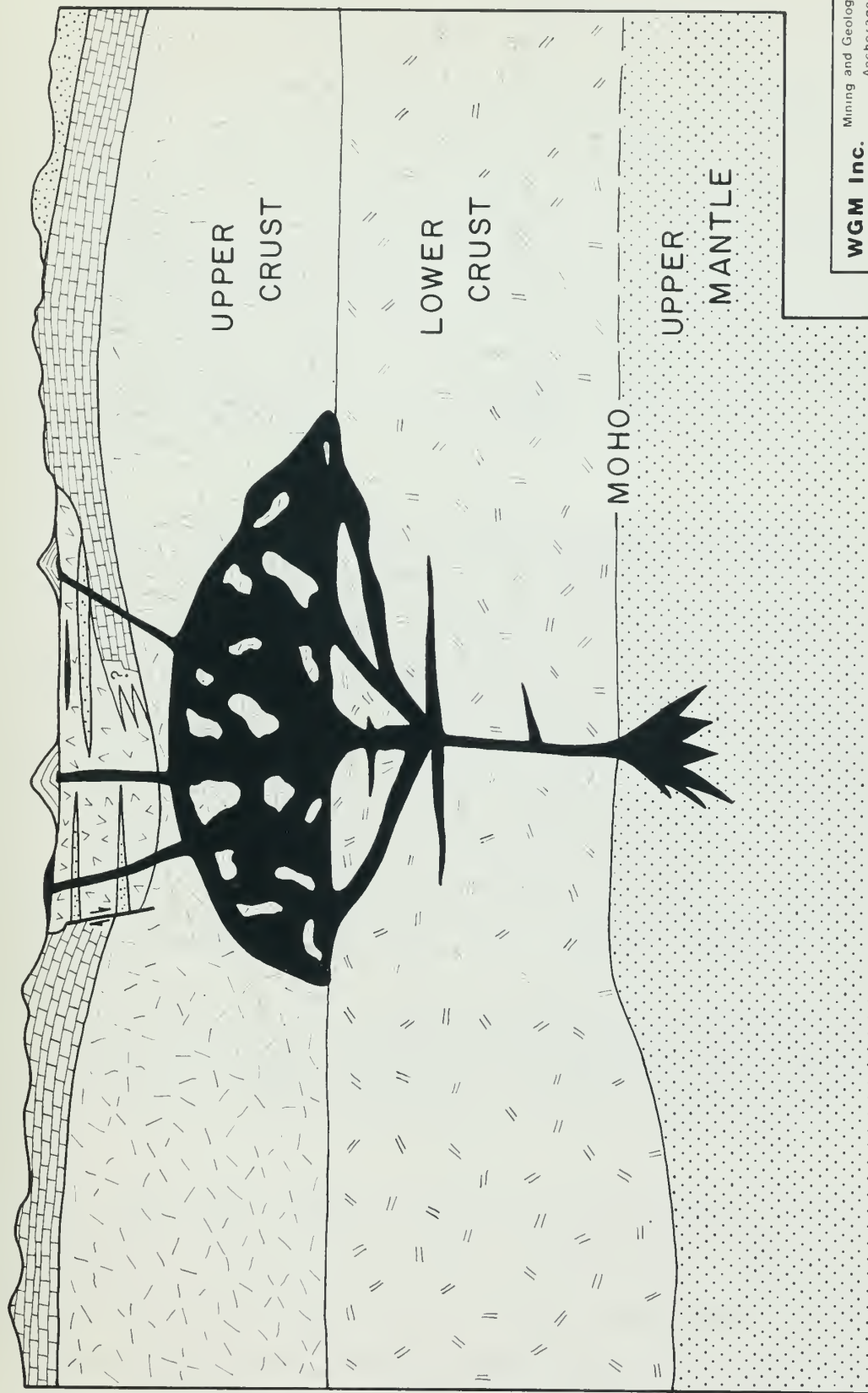
Several additional tectonic models have been proposed to describe the geologic evolution of the eastern Snake River Plain during the past 15 m.y. Hamilton and Myers (1966) suggested that the ESRP consists of a tensional rift. Morgan (1972) and Smith and Sbar (1974) described the eastern Snake River Plain-Yellowstone system as the track of a mantle plume or hotspot. Finally, Taubeneck (1971) suggested 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 6. 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:

EAST-CENTRAL IDAHO

EASTERN SNAKE RIVER PLAIN

SOUTHEASTERN IDAHO



From: Sparlin, et al. (1982).

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Twin Buttes GRA, Idaho
Schematic Diagram of
Crustal Structure
Eastern Snake River Plain

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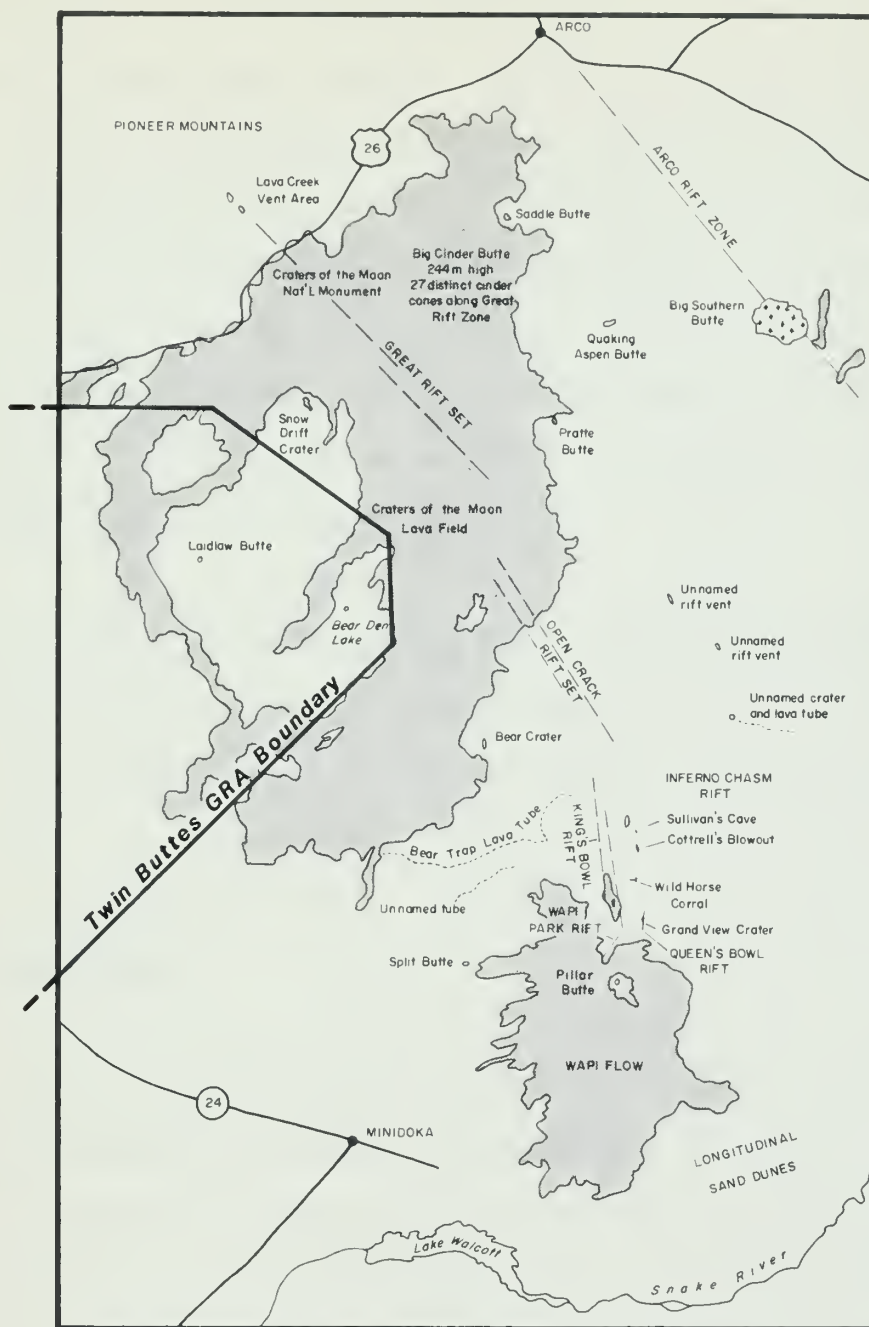
FIGURE
6

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 silicic 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.

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 youngest basalt flows in the Twin Buttes GRA (Qhb, Fig. 7) are part of the Craters of the Moon lava field. This field originated from outpourings of basalt on the northern end of the Idaho Rift System, a series of aligned vents and discontinuous fractures that extend from the northern margin of



after Prinz, (1970), and King, (1977).

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REGION 2 NORTHERN ROCKY MOUNTAINS

Twin Buttes GRA, Idaho
Major Features Along
the Idaho Rift System

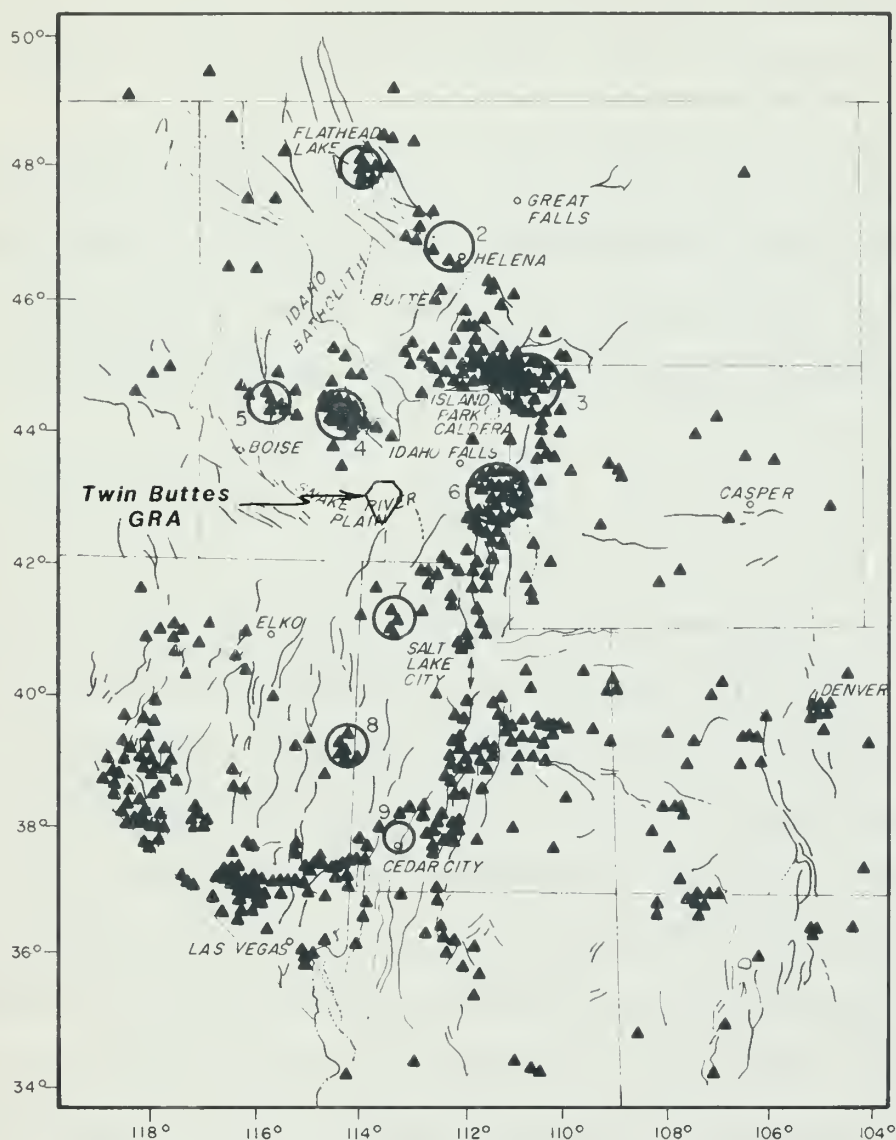
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DRWN BY	DSI	APRVD	G.F.	

the Snake River Plain in the vicinity of Craters of the Moon National Monument southeastward to the Wapi lava field (Fig. 7) where the fractures either terminate or are obscured by young lavas of the Wapi flow. The Idaho Rift System was originally termed the Great Rift but was redesignated by Prinz (1970) who subdivided the system into several rift sets of differing trends. The term Great Rift set is used for that segment within Craters of the Moon National Monument. An open fissure located northwest of the Monument in the Pioneer Mountains suggests an extension of the Great Rift beyond the limits of the Snake River Plain.

Geologic hazards in the Twin Buttes GRA are related to potential renewed volcanism. Little seismic activity is present in the area as the Snake River Plain tends to be aseismic with respect to the surrounding terranes (Fig. 8).

2.5 Paleontology

In Craters of the Moon National Monument, basalt flows have in many instances buried trees forming tree molds. Similar tree molds are probably present at some sites within the Twin Buttes GRA. Wood from these trees, some of which were not killed by the eruption, has proved useful in dating the age of the flows by tree ring counts or by carbon-14 dating. Papson (1977) summarizes Alexrod's (1968) paleo-botanical studies of Eocene and Miocene (23-6 m.y.) sedimentary rocks adjacent to the Snake River Plain. Before the advent of volcanism the Eocene environment contained forests of hemlock, spruce, pine, maple, birch, aspen, fir and oak, implying moderately high attitudes. Broad-leaved evergreens usually typical of tropical



EPICENTERS FOR INTERMOUNTAIN SEISMIC 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 SEISMICITY. 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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REGION 2 NORTHERN ROCKY MOUNTAINS

Twin Buttes GRA, Idaho **Regional Seismicity**

SCALE AS SHOWN		FIGURE
DATE BY	DATE 1/1983	REVISED
DRAWN BY DSI	APPROVED G.F.	

climates were present on what is now fringes of the Plain. Volcanism and embryonic formation of the Snake Plain began in the Oligocene (38-23 m.y.). By Miocene subsidence of the plain resulted in the disappearance of earlier plant species such as the Tree-of-Heaven, beach, and dogwood.

Predator traps formed by volcanic collapse features and alluvial and fluvial deposits along the margins of the Snake River Plain have yielded important finds of vertebrate fossils. No important paleontological resources are known to be present in the Twin Buttes GRA but data is presently lacking.

2.6 Historical Geology

A general overview of the geologic evolution of the eastern Snake River Plain is summarized in Section 2.4 as proposed by Braile et al (1982, p. 2607). With regards to specific aspects pertaining to the Twin Buttes GRA, the earliest rock units formed were the mixed silicic and basaltic volcanics and volcaniclastics which were erupted during the Eocene. These rock units are now exposed along the flanks on the Snake River Plain near Carey. Elsewhere in the GRA these Eocene volcanics have been buried by later basalt flows. The Eocene volcanics of mixed silicic and basaltic composition are representative of early volcanism elsewhere on the Plain and indicate involvement of crustal materials during early rifting. Later volcanic events produced basaltic lavas with only minor amounts of silicic to intermediate volcanic components. The Holocene basaltic eruptives in the Twin Buttes GRA, whose source area is the Great Rift, are compositionally highly evolved basalts. Stone (1969) feels that the composition of these basalts reflect a fractionated magma source that is 80% crystallized.

The alluvial deposits along the Little Wood River are the youngest surficial deposits in the area, although some Holocene basalt flows are younger than the oldest alluvial deposits.

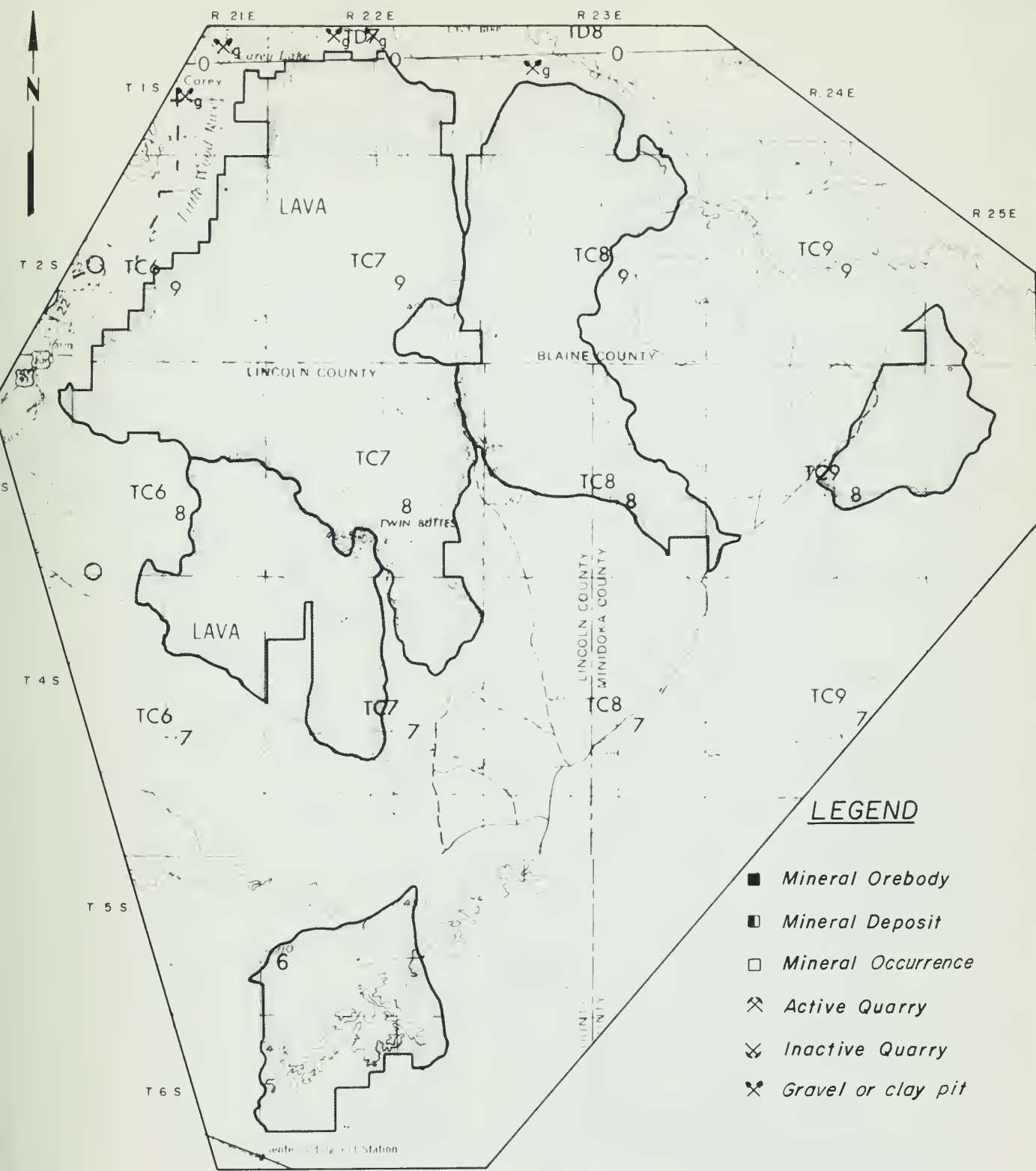
3.0 ENERGY AND MINERAL RESOURCES

A large portion of the Twin Buttes GRA was included in an investigation by Kuntz et al. (1980) who evaluated the mineral resource potential of the proposed Great Rift Wilderness area. Additional information was gathered from the compilation of mines and prospects of the Idaho Falls Quadrangle by Strowd et al. (1981). Kuntz et al. (1980) concluded that the lavas underlying the proposed Great Rift Wilderness appear to contain no mineral deposits of significance and that sand and gravel, cinders, and decorative stone constitute the greatest potential resource.

3.1 Known Mineral and Energy Deposits

The Twin Buttes GRA contains a cluster of gravel pits in alluvial and fluvial deposits along the Little Wood River drainage (Fig. 9). One other site is located along an improved gravel road on a small tributary stream in T.1S., R.23E. No other deposits of metallic or non-metallic minerals are known occur within the GRA.

A hot spring, Condie Hot Springs, is located within the Twin Buttes GRA near Carey in sec. 14, T.1S., R.21E. (Fig. 10). Condie Hot Springs, located near the edge of a basalt flow, has a flow of 1,309 l/min. of 51°C water. The geochemical aquifer temperature may be as high as 80°C (Mitchell et al., 1980); the spring is less than one mile from the north edge of the Raven's Eye WSA. Two other hot springs occur about six miles north of the Raven's Eye and Little Deer WSAs (Fig. 10). These are the Milford Sweat Warm Spring

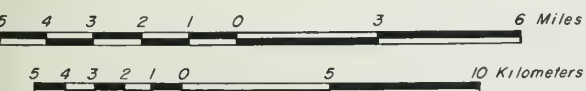


LEGEND

- Mineral Orebody
- Mineral Deposit
- Mineral Occurrence
- ⊗ Active Quarry
- ⊗ Inactive Quarry
- ⊗ Gravel or clay pit

g - Sand and gravel

Approximate Boundary of Wilderness Study Area.

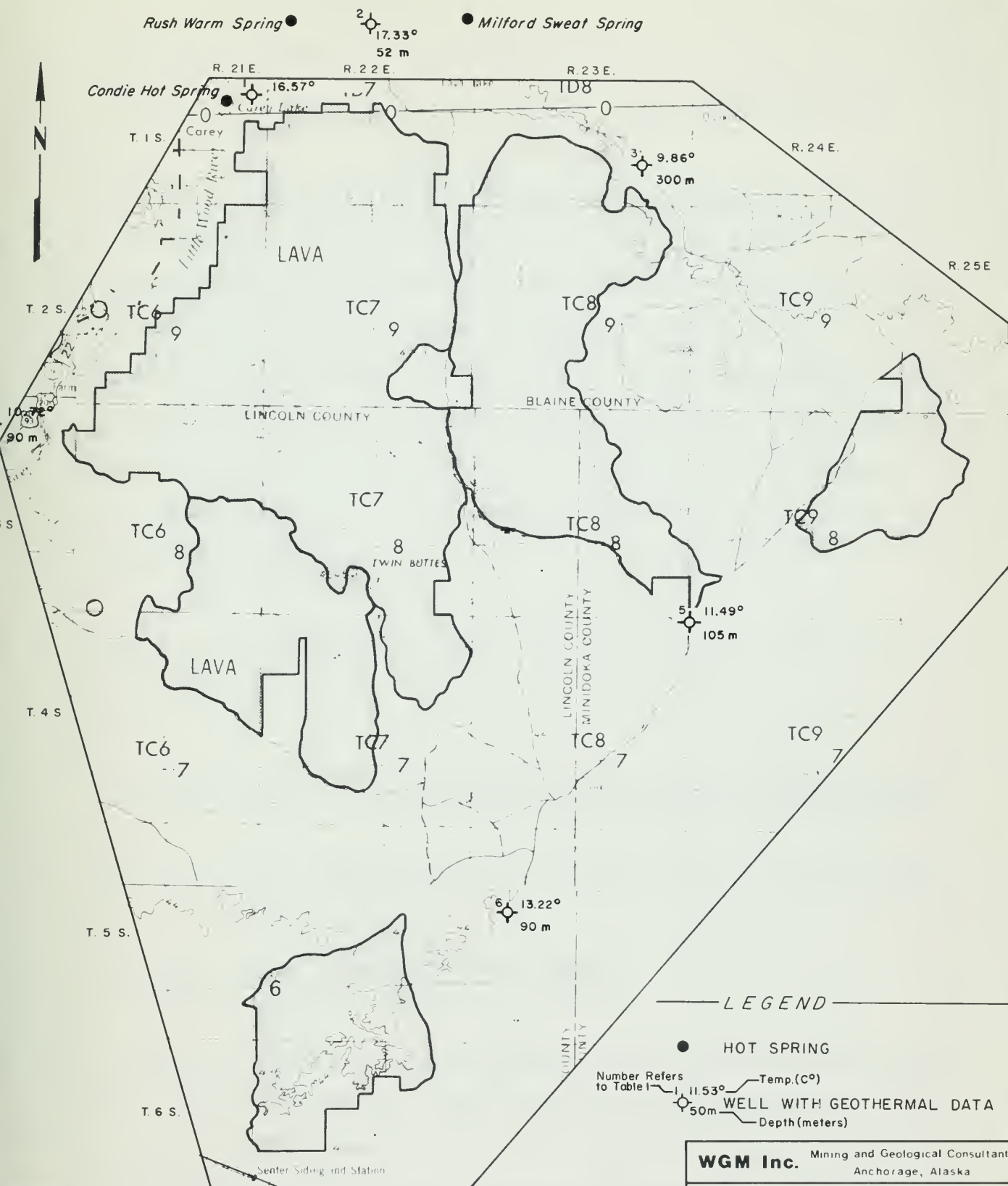


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Twin Buttes GRA, Idaho **Mineral Occurrences**

SCALE	1"=4 MILES	FIGURE	9
DATA BY	WGM	DATE	1/1983
DRWN BY	DSI	APRVD	G.F.



LEGEND

● HOT SPRING

Number Refers to Table 1

Temp. (C°)

WELL WITH GEOTHERMAL DATA

50m Depth (meters)

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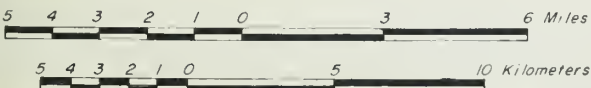
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REGION 2 NORTHERN ROCKY MOUNTAINS

Twin Buttes GRA, Idaho
Location of Hot Springs and
Geothermal Data Sites

SCALE 1" = 4 MILES	FIGURE
DATA BY WGM DATE 1/1983	REV 500
DRWN BY DSI	APRVD G.F.

10

Approximate Boundary of Wilderness Study Area



(sec. 1, T.1S., R.22E.) which produces 75 l/min. of 44°C water and Rush Warm Spring (sec. 6, T.1S., R.22E.) which produces water at 22°C (Fig. 10).

The Snake River aquifer underlies at least the southern half of the Twin Buttes GRA. The elevation of the water table is about 4,100-4,050 feet; thus, the depth of the aquifer is generally 600 feet or more except at the north edge of the GRA and in the Shale Butte WSA where the depth to the aquifer is 300-400 feet (Crosthwaite, 1978). Aquifer temperatures are quite low (Table III) ranging from 10.7 to 13.3°C (Brott et al., 1978), typical of aquifers with nearby recharge or fast lateral flow. Since the thickness of the aquifer is unknown, the projection to depth of the observed heat flow gradients is impossible.

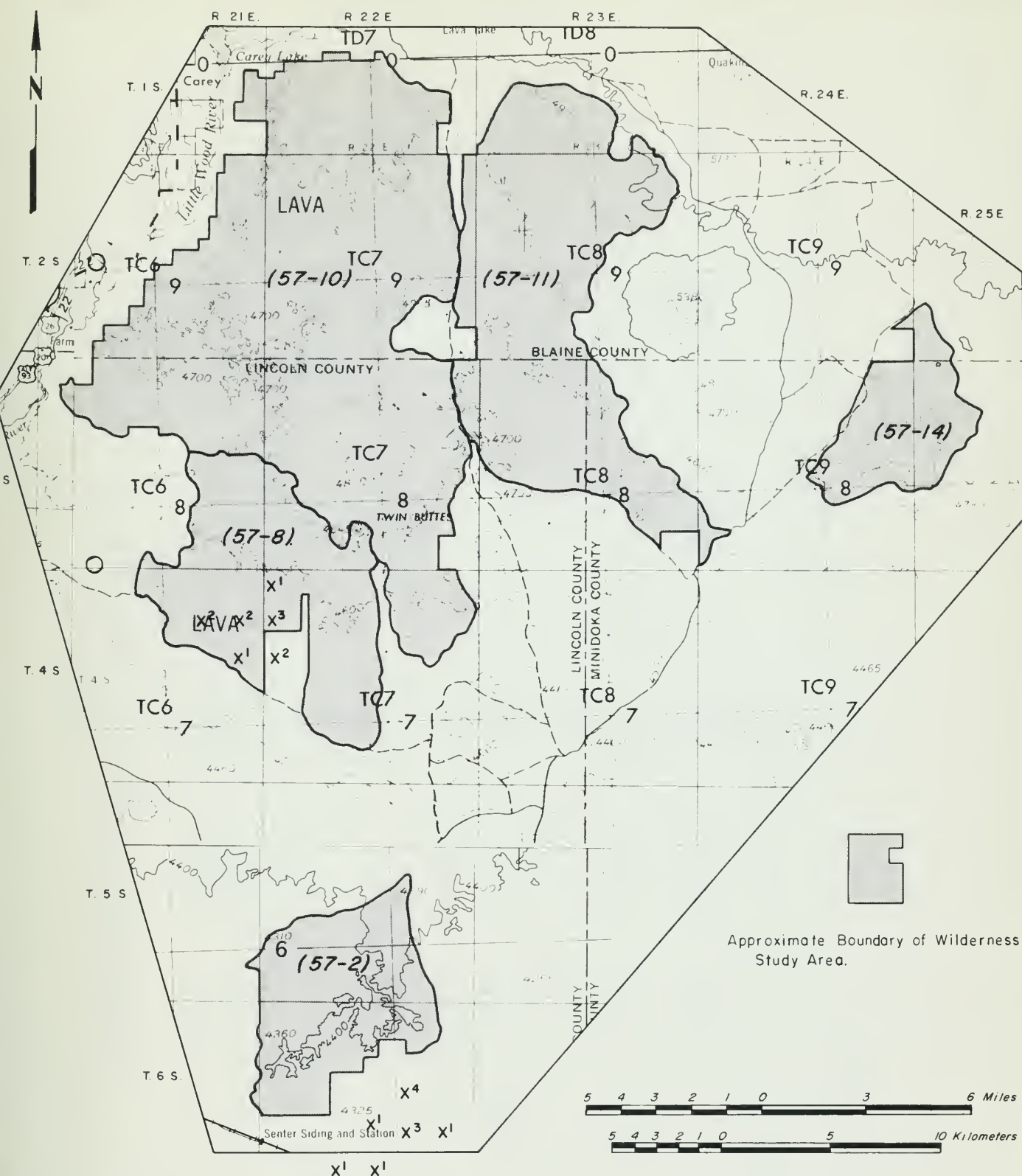
None of the known mineral or energy deposits are within the WSAs of the Twin Butte GRA.

3.2 Known Mineral and Energy Prospects, Occurrences and Mineralized Areas

There are no known mineral or energy prospects within the Twin Buttes GRA.

3.3 Mining Claims, Leases and Material Sites

A review of mining claim records current to June 7, 1982 shows that approximately 22 unpatented mining claims are within the Twin Buttes GRA. The claims are clustered in two groups, one in the southern portion of the Sand Butte (57-8) WSA and the other in the extreme southern part of the GRA (Fig. 11). The commodity of interest is not known for any of the claims. It is



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 Files & LSBL Min. Plats

4) Data current to: June 7, 1982

EXPLANATION

X Unpatented Mining Claim

▲ Patented Mining Claim

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Anchorage, Alaska

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REGION 2 NORTHERN ROCKY MOUNTAINS

Twin Buttes GRA, Idaho Mining Claims Density Map

SCALE: 1" = 4 MILES (1:250,000)

DATA BY WGM DATE 9/1982

DRWN BY DSI APRVD G.F.

REVISED

FIGURE

11

TABLE I
GEOHERMAL DATA FROM WELLS IN OR NEAR THE TWIN BUTTES GRA, IDAHO¹

Map Location (Fig. 10)	Collar Elevation (m)	Depth Interval (m)	Geothermal Gradient (°C/km)	Heat Flow (10 ⁻⁶ cal/cm ² sec)	Maximum or Bottom Hole Temp. (°C)	Relation to Snake Plain Aquifer
1	1,457	5- 80	-60.0	----	15.22 MAX 16.57 BHT	ABOVE IN
2	1,493	0- 52	-----	----	17.33 MAX BHT	ABOVE IN
3	1,532	10-300	0.5	----	9.86 BHT	IN
Sec. 1, T.2S., R.20E. not shown	1,460	20- 50	54.3 1.5	1.7	-----	ABOVE
4	1,403	10- 90	2.0 0.3	0.17	10.72 BHT	ABOVE
5	1,377	10-105	5.4 0.3	0.18	11.49 BHT	ABOVE
6	1,341	15- 90	17.7 0.3	0.58	13.22 BHT	ABOVE

1. Source: Brott et al., 1981

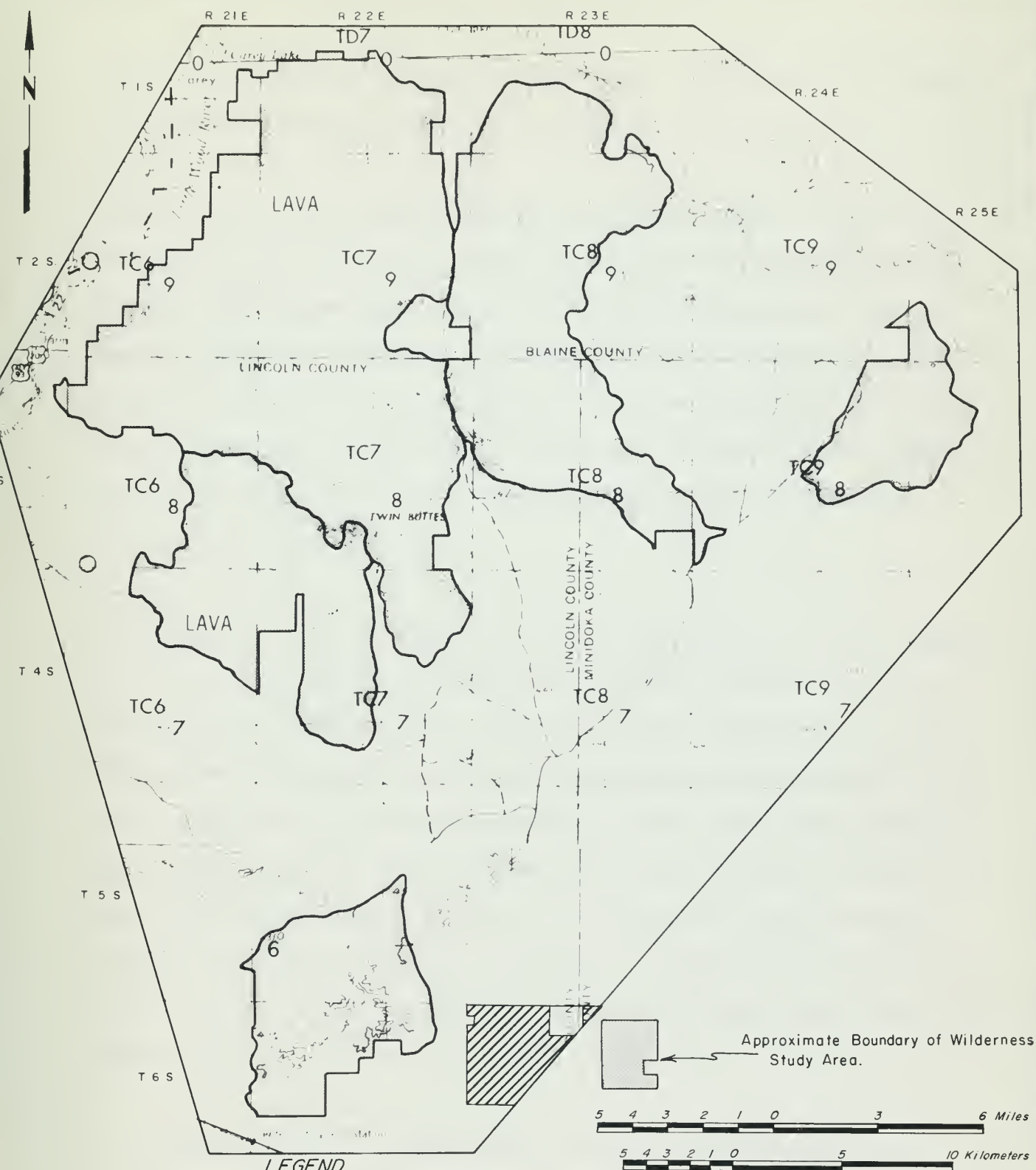
likely, however, that the claims within the Sand Butte (57-8) WSA are located for decorative lava rock.

A small area (N $\frac{1}{2}$, T.6S., R.23E.) in the southern part of the Twin Buttes GRA is covered by an Oil and Gas Lease application (Fig. 12). No Oil and Gas Leases or applications are within any of the WSAs.

3.4 Mineral and Energy 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 be evaluated by analogy and by comparison of the tectonic setting and geologic processes active in the area with those of similar mineralized areas. The eastern Snake River Plain, as discussed earlier, can be described as a continental hot spot, 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 "hot spot" of rising mantle material (Smith and Christiansen, 1980).

The near-surface rocks of the 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 volcanoclastic caldera-fill deposits (Doherty et al., 1979). The volcanics have been intruded by rhyolitic to latitic plugs (Schoen, 1974; Spear, 1977, Kuntz, 1978a). Thus the gross tectonic setting comprising the eastern Snake River



Notes: 1) Area of Search: Entire GRA
 2) Data current to: August 12, 1982
 3) Source of Data: BLM O&G Plats

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BLM GEM RESOURCES ASSESSMENT
 REGION 2 NORTHERN ROCKY MOUNTAINS

Twin Buttes GRA, Idaho

Oil and Gas Lease Status

SCALE 1"=4 MILES	FIGURE
DATA BY WGM DATE 1/1983	REVISED
DRWN BY DSI	APPRV G F
	12

Plain consists of three geologic 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 in hydrothermal systems involving convective circulation of sea water. The absence of hydrothermal activity in basaltic Plains volcanism (Greeley, 1977, 1982) precludes formation of mineral deposits.

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 for 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).

Silicic volcanics present in the subsurface of the Twin Buttes GRA are possible source rocks for uranium. Similar rocks were sampled for uranium around the Island Park Caldera, about 70 miles northeast of the GRA 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). No evidence exists that felsic rocks within the Twin Buttes GRA have any better uranium potential than those around the Island Park Caldera.

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 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).

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: (a) high temperatures (over 150°C) hydrothermal convection systems and low/intermediate temperature (40-150°C) hydrothermal convection systems. Geo-pressured geothermal energy systems do not exist in the area 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 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 cost 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 Twin Buttes GRA is in the Snake River Plains geothermal province. This area is one of the major volcanic and tectonic provinces of the western U.S.; therefore, it has major geothermal potential. The volcanic history of the Snake River Plains is quite varied and extends into the Holocene. Buried calderas in the Snake River Plains were the source of extensive silicic 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 Plains to approximately 4 m.y. at the eastern margin of the province. Silicic ash flow tuffs as young as 1.2 m.y. occur in the Island Park Caldera. In the middle of the Snake River Plains, 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 into the Holocene. Large areas of the eastern Snake River Plains 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 resources is as yet unexplored.

The geothermal character of the Snake River Plains 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 (2 m.y. to present) 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 Plains 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 9,845 feet was approximately 150°C. While there is evidence for circulation of water within the well, economic quantities of fluid were not produced (Prestwich and Mink, 1979). A deep drill hole west of the eastern Snake River Plains near the town of Mountain Home encountered temperatures of 190°C at a depth of 9,845 feet (Arney, 1982). 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 Plains where the geothermal systems present are less diluted by the effects of the Snake Plain aquifer. In most areas 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 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 include areas along the north margin of the Snake River Plains are present near Magic Reservoir and near Arco. Along the southern margin extensive warm water resources occur near Rexburg and near Twin Falls.

There are several extrusive centers within the WSAs contained in the Twin Buttes GRA, but none of these are as extensive as the Great Rift that was the source of the Craters of the Moon flows. The underlying geology beneath the basalts is completely unknown as no deep holes exist between the INEL test site and the hole near Mountain Home. The units underlying the basalts are probably rhyolitic welded and unwelded ash flows, and flow rocks ranging in age from 5-10 m.y. The structures, caldera locations, and fault zones are not discernible below the cover of basaltic rocks and no pertinent geophysical data are available. The weak lineations of vent areas may or may not reflect deeper-seated structures. Generally geothermal resources are not associated with basaltic volcanism except in Hawaii and Iceland. Unless some buried young basalts associated with the Craters of the Moon rift zone underlie the area, the existence of a shallow young heat source

within the WSAs is unlikely. The exposed volcanic centers within the WSAs are older than the Craters of the Moon activity.

No hydrocarbon tests have been drilled in the eastern Snake River Plains. The nearest hydrocarbon tests to the Twin Butte GRA were drilled approximately 40 to 80 miles southeast in the Thrust belt of southeastern Idaho. All were dry holes (Breckenridge, 1982).

The volcanic rocks which underly the Twin Butte 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 Twin Butte GRA lies on strike with the western margin of the frontal salient of the Cordilleran Thrust belt as defined by Blackstone (1977). Many similarities in the thickness and rock types may be noted in 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, 1977; Kuntz et al., 1980; Sparlin et al., 1982; Braile, 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).

Should the thick Paleozoic section described by Skipp and Hait (1977) extend under the Snake River Plains from the north and the thick Paleozoic section as described by Trimble and Carr (1976) extend under the Plains from the south, then the Paleozoic sections should interfinger in the subsurface of the Twin Butte area. Both of the stratigraphic sections present to the north and south of the Plain have recognized potential hydrocarbon source and reservoir beds in them. The dark shales of the Trail Creek and McGowan Creek Formations are potential major source beds and shaley limestones in the White Knob and Wood River Formations are potential minor hydrocarbon source beds north of the Plains. South of the Plains the dark shales of the Manning Canyon Formation are potential major hydrocarbon source beds and dark shaley limestones of the Laketown, Deep Creek, and Oquirrh Formations are potential minor source beds. Approximately 45 miles northeast of the Twin Butte GRA, two samples of the McGowan Creek Formation from the White Knob and Lost River Ranges were analyzed by Nance Petroleum of Billings, Montana. These analyses reveal that the McGowan Creek Formation in those areas has a mature, very poor oil, good to excellent wet gas-condensate source character (pers. comm., November 1982).

The presence of several volcanic vents considerably decreases the hydrocarbon potential within the Twin Butte GRA. The extent of the metamorphism surrounding the vents and depth to the magmatic masses underlying the vents are unknown. The position of the magmatic masses can probably be determined

by geophysical studies, but the extent of the metamorphism can only be determined by drilling.

3.5 Mineral and Energy Economics

The Twin Buttes GRA is near the population centers of the Twin Falls-Burley area and roads provide adequate access to these markets. Supplies of water and electric power in the GRA are minimal however. Deposits of cinder and decorative lava have been exploited on other portions of the Craters of the Moon-Walipi lava fields suggesting that similar resources can also be economically recovered within the GRA. Those areas most likely to be developed first would be along the edges of Holocene lava flows where access is favorable. Mining costs of decorative slab lava from the Idaho Falls area are about \$40 to \$50 per ton. The product retails for about \$80 to \$90 per ton.

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. In the Twin Buttes GRA, high temperature geothermal resources could likely be developed if found. Along the northern and western margins of the GRA, low to intermediate temperature geothermal resources could likely be exploited by the communities of Corey and Richfield.

4.0 LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

4.1 Explanation of Classification Scheme

In the following sections the land in the Twin Buttes GRA is classified for geology, energy and mineral (GEM) resources potential. The classification scheme used is shown in Table II. Use of this system is specified in the contact 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 in 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 (4) report preparation. No field work was done in the Twin Buttes GRA.

TABLE II

BUREAU OF LAND MANAGEMENT GEM RESOURCES LAND CLASSIFICATION SYSTEM

CLASSIFICATION SCHEMELEVELS OF CONFIDENCE

- | | |
|---|---|
| <p>1. The geologic environment and the inferred geologic processes do not indicate favorability for accumulation of mineral resources.</p> <p>2. The geologic environment and the inferred geologic processes indicate low favorability for accumulation of mineral resources.</p> <p>3. The geologic environment, the inferred geologic processes, and the reported mineral occurrences indicate moderate favorability for accumulation of mineral resources.</p> <p>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.</p> | <p>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.</p> <p>B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.</p> <p>C. The available data provide direct evidence, but are quantitatively minimal to support or refute the possible existence of mineral resources.</p> <p>D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.</p> |
|---|---|

Each WSA 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 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 Shale Butte (57-2) WSA

4.2.1 Locatable Minerals

4.2.1a Metallic Minerals. The Shale Butte (57-2) WSA (1a, Fig. 13) is classified as unfavorable for metallic mineral resources based on direct but minimal evidence (1C). This classification is based on the unfavorable geologic setting, the lack of mineral occurrences and on data and concepts outlined in Section 3.4.

4.2.1b Uranium and Thorium. The Shale Butte (57-2) WSA (1b, Fig. 13) is classified as unfavorable for uranium and thorium resources based on direct but minimal evidence (1C). This classification is based on the unfavorable geologic setting, the lack of uranium and thorium occurrences and on data and concepts outlined in Section 3.4.

4.2.1c Non-Metallic Minerals. All of the Shale Butte (57-2) WSA (1c-s, Fig. 13) is classified as moderately favorable for accumulation of uncommon varieties of stone (decorative lava rock) based on direct but minimal evidence (3C). This classification is based upon the presence of nearby mining claims, the relative youth of volcanics within the WSA, and on concepts and data outlined in Section 3.4. The entire area of the Shale Butte (57-2) WSA (1c-other, Fig. 13) is classified as unfavorable for the accumulation of other non-metallic resources based on direct but minimal evidence (1C). The classification is based upon the lack of occurrences, the unfavorable geologic setting, and upon data and concepts outlined in Section 3.4.

Twin Buttes GRA, Idaho
Legend For Figure 13

BLM LAND CLASSIFICATION SYSTEM
FOR GEM RESOURCES

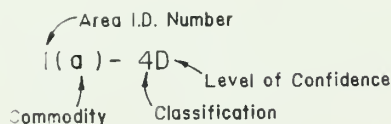
CLASSIFICATION SCHEME

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.

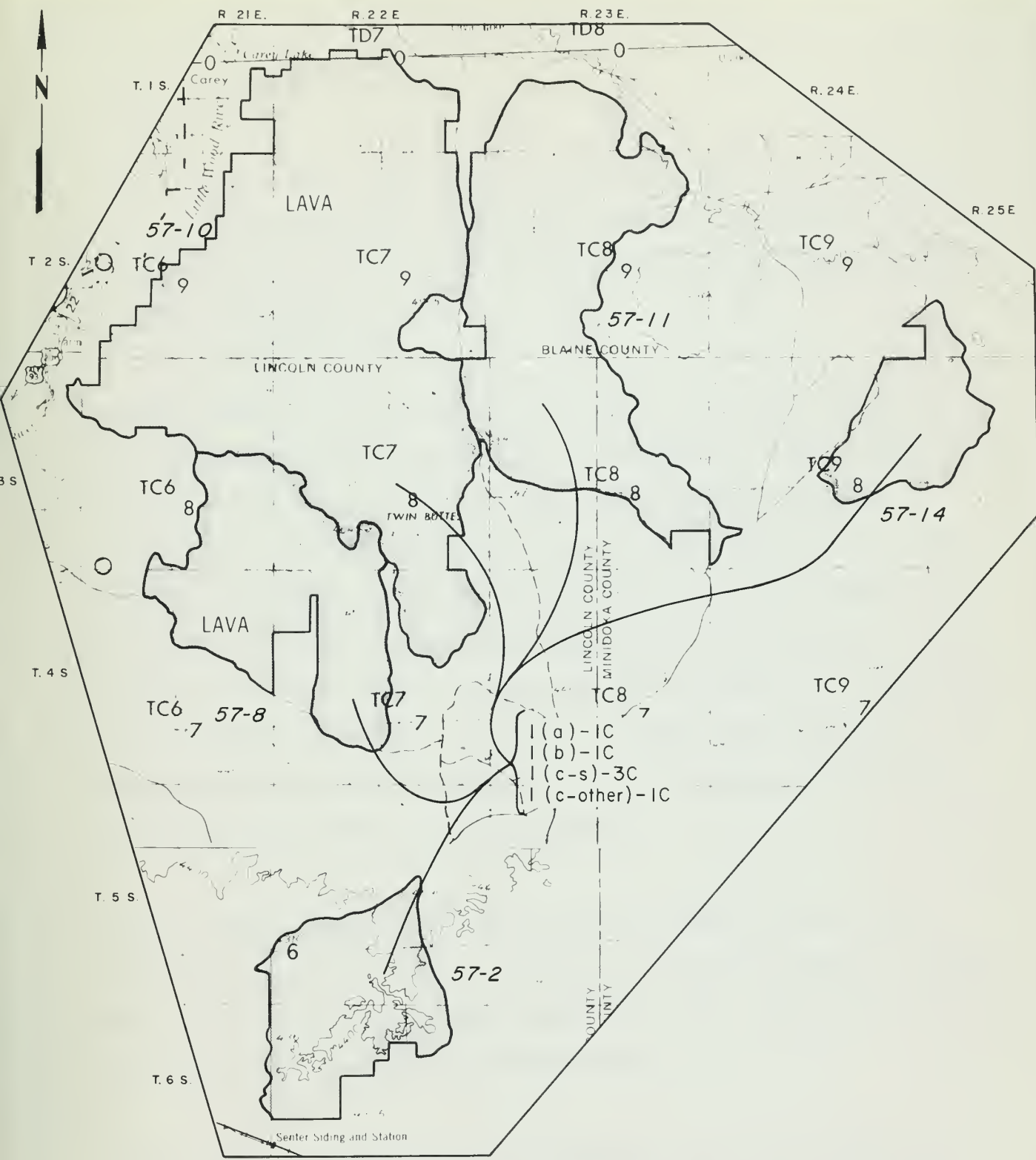
LEVELS OF CONFIDENCE

- 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 QUANTITATIVELY 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.

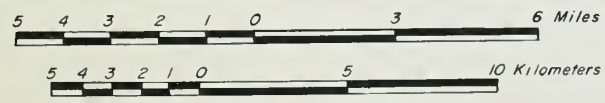
EXPLANATION



- 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			
Twin Buttes GRA, Idaho Wilderness Study Area Land Classification Locatable Resources			
SCALE 1" = 4 MILES		FIGURE	
DATA BY WGM	DATE 12/1982	REVISED	
DRWN BY DSI	APRVD G.F.		
		13	

4.2.2 Leasable Resources

4.2.2a Oil and gas. Shale Butte (57-2) WSA (1a, Fig. 14) is classified as having low favorability for accumulation of hydrocarbon resources based on indirect evidence (2B). The classification is based upon data and concepts outlined in Section 3.4.

4.2.2b Geothermal. All of the Shale Butte (57-2) WSA (1b-L/M, Fig. 14) is classified as having low favorability for accumulation of low to intermediate geothermal resources based upon indirect evidence (2B) and classified as having low to moderate favorability for accumulation of high temperature geothermal resources (1b-H, Fig. 14) based upon inadequate data (2A to 3A). The WSA is classified by comparison to surrounding areas since there is no data available within the WSA. The existence of the Snake Plain Aquifer probably precludes the existence of shallow warm or hot water. The deep geothermal setting is unknown and no special features separate the Shale Butte (57-2) WSA from surrounding areas.

4.2.2c Sodium and Potassium. Shale Butte (57-2) WSA (1c, Fig. 14) is classified as unfavorable for accumulation of sodium and potassium resources based on direct but quantitatively minimal data (1C). The classification is based upon data and concepts outlined in Section 3.4.

4.2.2d Other. The Shale Butte (57-2) WSA (1d, Fig. 14) is classified as unfavorable for asphalt, bitumen, and phosphate resources based on direct but quantitatively minimal data (1C). Potential source units may be present beneath the Plain but only at uneconomic depths.

Twin Buttes GRA, Idaho
Legend For Figure 14

*BLM LAND CLASSIFICATION SYSTEM
 FOR GEM RESOURCES*

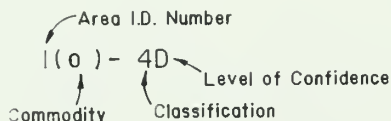
CLASSIFICATION SCHEME

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.

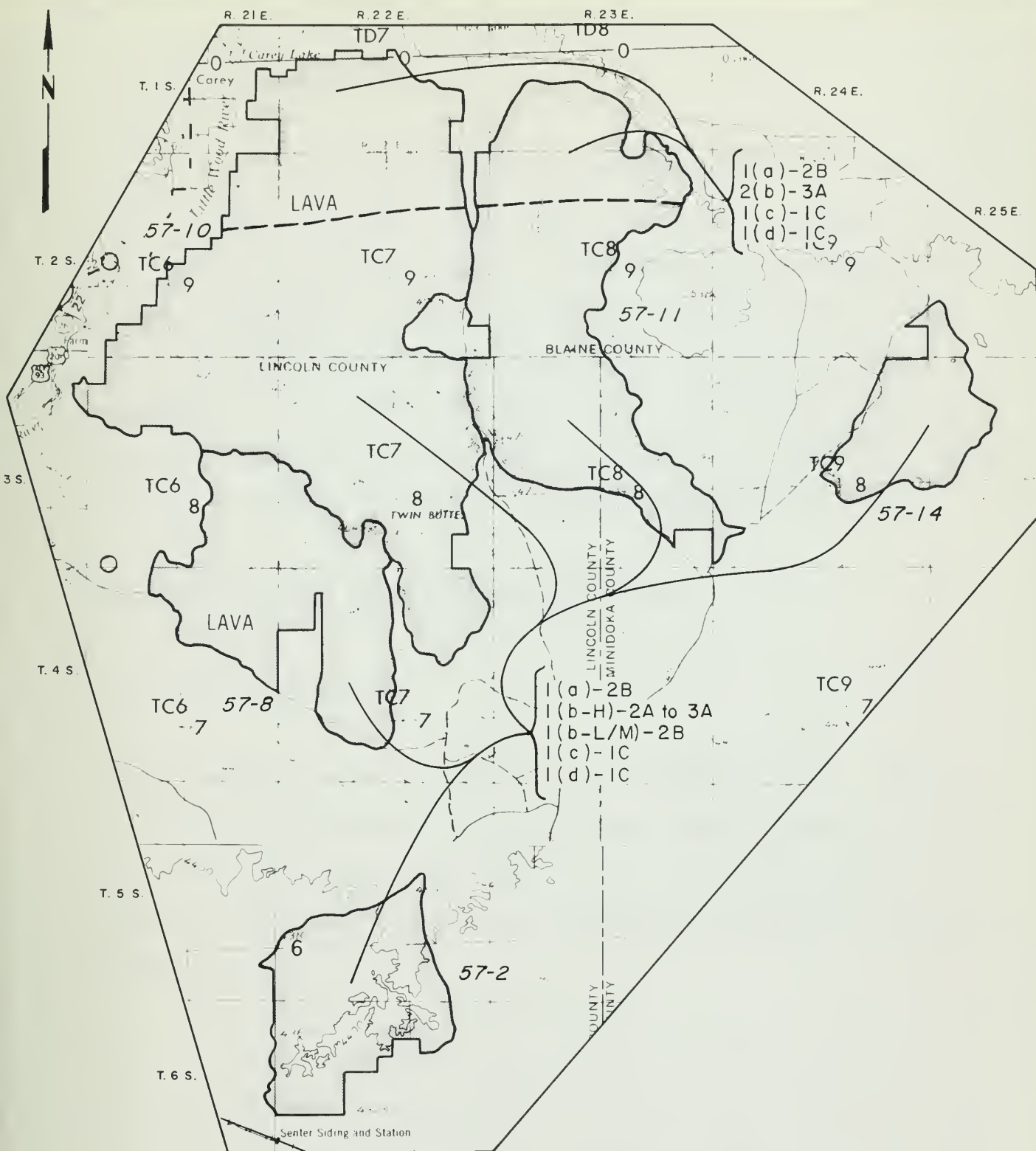
LEVELS OF CONFIDENCE

- 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 QUANTITATIVELY 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.

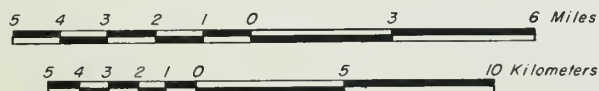
EXPLANATION



- 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.



Approximate Boundary of Wilderness Study Area.



WGM Inc. Mining and Geological Consultants
Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Twin Buttes GRA, Idaho
Wilderness Study Area
Land Classification
Leasable Resources

SCALE 1"= 4 MILES	FIGURE
DATA BY WGM DATE 12/1982	REVISED
DRWN BY DSI APRVD G F	
	14

4.2.3 Saleable Resource

The Shale Butte (57-2) WSA (Fig. 15) is classified as highly favorable for the accumulation of stone, cinders, pumice, and pumicite based upon direct but quantitatively minimal data (4C). The classification is based upon the presence of youthful volcanic rocks and vent sites near or within the WSA. Shale Butte (57-2) WSA (Fkg. 15) is classified as unfavorable for the accumulation of clay, limestone, dolomite, peat, petrified wood, sand and gravel based upon direct but minimal data (1C). The classification is based upon the unfavorable thicknesses of volcanic cover present in the WSA.

4.3 Classification of the Sand Butte (57-8) WSA

4.3.1 Locatable Minerals

4.3.1a Metallic Minerals. The Sand Butte (57-8) WSA (1a, Fig. 13) is classified as unfavorable for metallic mineral resources based on direct but minimal evidence (1C). This classification is based on the geologic setting, lack of mineral occurrences and on data and concepts outlined in Section 3.4.

4.3.1b Uranium and Thorium. The Sand Butte (57-8) WSA (1b, Fig. 13) is classified as unfavorable for uranium and thorium resources based on direct but minimal evidence (1C). This classification is based on the unfavorable geologic setting, the lack of uranium and thorium occurrences and on data and concepts outlined in Section 3.4.

Twin Buttes GRA, Idaho
Legend For Figure 15

*BLM LAND CLASSIFICATION SYSTEM
 FOR GEM RESOURCES*

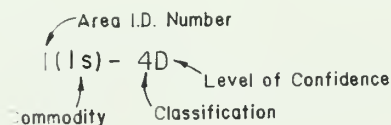
CLASSIFICATION SCHEME

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.

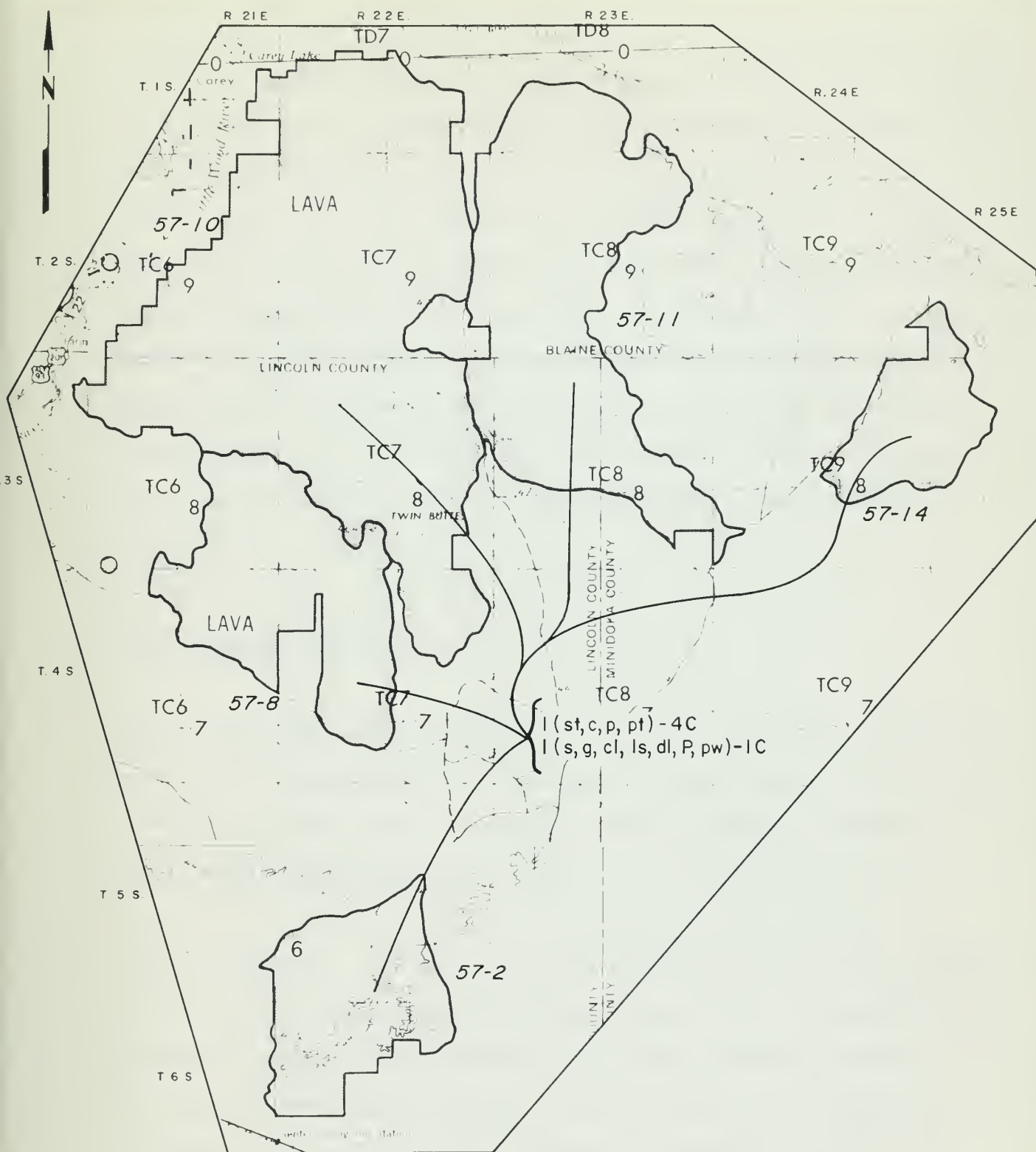
LEVELS OF CONFIDENCE

- 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 QUANTITATIVELY 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.

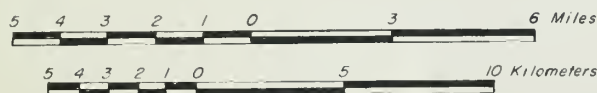
EXPLANATION



- | | |
|----|----------------|
| 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.



WGM Inc. Mining and Geological Consultants
Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Twin Buttes GRA, Idaho
Wilderness Study Area
Land Classification
Saleable Resources

SCALE 1"=4 MILES	FIGURE
DATA BY WGM	DATE 12/1982
DRWN BY DSI	APRVD G F
	15

4.3.1c Non-Metallic Minerals. All of the Sand Butte (57-8) WSA (1c-s, Fig. 13) is classified as moderately favorable for accumulation of uncommon varieties of stone (decorative lava rock) based on direct but minimal evidence (3C). This classification is based upon the presence of nearby mining claims, the relative youth of volcanics within the WSA, the favorable geologic setting, and on concepts and data outlined in Section 3.4. Sand Butte (57-8) WSA (1c-other, Fig. 13) is classified as unfavorable for the accumulation of other non-metallic resources based on direct but minimal evidence (1C). The classification is based upon the lack of occurrences, the unfavorable geologic setting, and upon data and concepts outlined in Section 3.4.

4.3.2 Leasable Resources

4.3.2a Oil and Gas. The Sand Butte (57-8) WSA (1a, Fig. 14) is classified as having low favorability for accumulation of hydrocarbon resources based on indirect evidence (2B). The classification is based upon data and concepts outlined in Section 3.4.

4.3.2b Geothermal. The Sand Butte (57-8) WSA (1b-4L/M, Fig. 14) is classified as having low favorability for accumulation of low to intermediate geothermal resources based upon indirect evidence (2B) and classified as having low to moderate favorability for accumulation of high temperature geothermal resources (1b-H, Fig. 14) based on inadequate data (2A to 3A). The WSA is classified by comparison to surrounding areas since there is no data available within the WSA. The existence of the Snake Plain Aquifer probably precludes the existence of shallow warm or hot water. The

deep geothermal setting is not known and no special features separate the Sand Butte (57-8) WSA from surrounding areas. Additionally, the classification is based upon data and concepts outlined in Section 3.4.

4.3.2c Sodium and Potassium. Sand Butte (57-8) WSA (1c, Fig. 14) is classified as unfavorable for the accumulation of sodium and potassium resources based on direct but quantitatively minimal data (1C). The classification is based upon the unfavorable geologic setting.

4.3.2d Other. The Sand Butte (57-8) WSA (1d, Fig. 14) is classified as unfavorable for asphalt, bitumen, and phosphate resources based on direct but quantitatively minimal data (1C). Potential host units may be present beneath the Plains but only at uneconomic depths.

4.3.3 Saleable Resources

The Sand Butte (57-8) WSA (Fig. 15) is classified as highly favorable for accumulation of stone, cinders, pumice, and pumicite based upon direct but quantitatively minimal data (4C). The classification is based upon the presence of youthful volcanic rocks and of vent sites near or within the WSA in addition to data and concepts outlined in Section 3.4. Sand Butte (57-8) WSA (Fig. 15) is classified as unfavorable for the accumulation of clay, limestone, dolomite, peat, petrified wood, sand and gravel based upon direct but minimal data (1C). The classification is based upon the unfavorable thicknesses of the volcanic cover present in the WSA.

4.4 Classification of the Raven's Eye (57-10) WSA

4.4.1 Locatable Minerals

4.4.1a Metallic Minerals. The Raven's Eye (57-10) WSA (1a, Fig. 13) is classified as unfavorable for the accumulation of metallic mineral resources based on direct but minimal evidence (1C). This classification is based on the unfavorable geologic setting, the lack of mineral occurrences and on data and concepts outlined in Section 3.4.

4.4.1b Uranium and Thorium. The Raven's Eye (57-10) WSA (1b, Fig. 13) is classified as unfavorable for uranium and thorium resources based on direct but minimal evidence (1C). This classification is based on the unfavorable setting, the lack of uranium and thorium occurrences and on data and concepts outlined in Section 3.4.

4.4.1c Non-Metallic Minerals. All of Raven's Eye (57-10) WSA (1c-s, Fig. 13) is classified as moderately favorable for the accumulation of uncommon varieties of stone (decorative lava rock) based on direct but minimal evidence (3C). This classification is based upon the presence of nearby mining claims, the relative youth of the volcanics within the WSA, the favorable geologic setting, and on concepts and data outlined in Section 3.4. The Raven's Eye (57-10) WSA (1c-other, Fig. 13) is classified as unfavorable for the accumulation of other non-metallic resources based on direct but minimal evidence (1C). The classification is based upon the lack of occurrences, the unfavorable geologic setting, and upon the data and concepts outlined in Section 3.4.

4.4.2 Leasable Resources

4.4.2a Oil and Gas. The Raven's Eye (57-10) WSA (1a, Fig. 14) is classified as having low favorability for accumulation of hydrocarbon resources based on indirect evidence (2B). The classification is based upon data and concepts outlined in Section 3.4.

4.4.2b Geothermal. The northern portion of Raven's Eye (57-10) WSA (2b, Fig. 14) is classified as having moderate favorability for accumulation of low, moderate, and high temperature geothermal resources based upon inadequate data (3A). This classification is based upon the proximity of thermal springs to the northern edge of the Raven's Eye (57-10) WSA. The remaining portion of the WSA is classified as having low to moderate favorability for accumulation of high temperature geothermal resources (1b-H, Fig. 14) based on inadequate data (2A to 3A) and classified as having low favorability for geothermal resources of low to moderate temperature (1b-L/M, Fig. 14) based on indirect evidence (2B). The WSA is classified by comparison to surrounding areas since there is no data available within the WSA. The existence of the Snake Plain Aquifer probably precludes the existence of shallow warm or hot water. The deep geothermal setting is unknown and no special features separate the Raven's Eye (57-10) WSA from surrounding areas. Additionally, the classification is based upon data and concepts outlined in Section 3.4.

4.4.2c Sodium and Potassium. Raven's Eye (57-10) WSA (1c, Fig. 14) is classified as unfavorable for accumulation of sodium and potassium resources

based on direct but quantitatively minimal data (1C). The classification is based upon data and concepts outlined in Section 3.4.

4.4.2d Other. The Raven's Eye (57-10) WSA (1d, Fig. 14) is classified as unfavorable for asphalt, bitumen, and phosphate resources based on direct but quantitatively minimal data (1C). Potential source units may be present beneath the Plains but only at uneconomic depths.

4.4.3 Saleable Resources

The Raven's Eye (57-10) WSA (Fig. 15) is classified as highly favorable for accumulation of stone, cinders, pumice, and pumicite based upon direct but quantitatively minimal data (4C). The classification is based upon the presence of youthful volcanic rocks and vent sites near or within the WSA and upon data and concepts outlined in Section 3.4. The Raven's Eye (57-10) WSA (Fig. 15) is classified as unfavorable for the accumulation of clay, limestone, dolomite, peat, petrified wood, sand and gravel based upon direct but minimal data (1C). This classification is based upon the great thicknesses of the volcanic cover and upon data and concepts outlined in Section 3.4.

4.5 Classification of the Little Deer (57-11) WSA

4.5.1 Locatable Mineral

4.5.1a Metallic Minerals. The Little Deer (57-11) WSA (1a, Fig. 13) is classified as unfavorable for metallic mineral resources based on direct but

minimal evidence (1C). This classification is based on the unfavorable geologic setting, the lack of mineral occurrences and on the data and concepts outlined in Section 3.4.

4.5.1b Uranium and Thorium. The Little Deer (57-11) WSA (1b, Fig. 13) is classified as unfavorable for uranium and thorium resources based on direct but minimal evidence (1C). This classification is based on the unfavorable geologic setting, the lack of uranium and thorium occurrences and on data and concepts outlined in Section 3.4.

4.5.1c Non-Metallic Minerals. The Little Deer (57-11) WSA (1c-s, Fig. 13) is classified as moderately favorable for accumulation of uncommon varieties of stone (decorative lava rock) based on direct but minimal evidence (3C). This classification is based upon the presence of nearby mining claims, the relative youth of the volcanics within the WSA, the favorable geologic setting, and on concepts and data outlined in Section 3.4. Little Deer (57-11) WSA (1c-other, Fig. 13) is classified as unfavorable for the accumulation of other non-metallic resources based on direct but minimal evidence (1C). The classification is based upon the lack of occurrences, the geologic setting, and upon data and concepts outlined in Section 3.4.

4.5.2 Leasable Resources

4.5.2a Oil and Gas. The Little Deer (57-11) WSA (1a, Fig. 14) is classified as having low favorability for accumulation of hydrocarbon resources based on indirect evidence (2B). The classification is based upon data and concepts outlined in Section 3.4

4.5.2b Geothermal. The northern portion of the Little Deer (57-11) WSA (2b, Fig. 14) is classified as having moderate favorability for the accumulation of low, moderate, and high temperature geothermal resources based upon minimal data (3A). The classification is based upon the proximity of thermal springs to the northern edge of the Little Deer (57-11) WSA. The remaining portion of the WSA is classified as having low to moderate favorability for accumulation of high temperature geothermal resources (1b-H, Fig. 14) based on inadequate data (2A to 3A) and classified as having low favorability for geothermal resources of low to moderate temperature (1b-L/M, Fig. 14) based on indirect evidence (2B). The WSA is classified by comparison to surrounding areas since there is no data available within the WSA. The existence of the Snake Plain Aquifer probably precludes the existence of shallow warm or hot water. The deep geothermal setting is unknown and no special features separate the Little Deer (57-11) WSA from surrounding areas. Additionally, the classification is based upon data and concepts outlined in Section 3.4.

4.5.2c Sodium and Potassium. The Little Deer (57-11) WSA (1c, Fig. 14) is classified as unfavorable for accumulation of sodium and potassium resources based on direct but quantitatively minimal data (1C). The classification is based upon data and concepts outlined in Section 3.4.

4.5.2d Other. The Little Deer (57-11) WSA (1d, Fig. 14) is classified as unfavorable for asphalt, bitumen, and phosphate resources based on direct but quantitatively minimal data (1C). Potential source units may be present beneath the Plains but only at uneconomic depths.

4.5.3 Saleable Resources

The Little Deer (57-10) WSA (Fig. 15) is classified as highly favorable for accumulation of stone, cinders, pumice, and pumicite based upon direct but quantitatively minimal data (4C). The classification is based upon the presence of youthful volcanic rocks and vent sites near or within the WSA and upon data and concepts outlined in Section 3.4. The Little Deer (57-10) WSA (Fig. 15) is classified as unfavorable for the accumulation of clay, limestone, dolomite, peat, petrified wood, sand and gravel based upon direct but minimal data (1C). The classification is based upon the unfavorable thicknesses of the volcanic cover within the WSA.

4.6 Classification of the Bear Den Butte (57-14) WSA

4.6.1 Locatable Minerals

4.6.1a Metallic Minerals. The Bear Den Butte (57-14) WSA (1a, Fig. 13) is classified as unfavorable for metallic mineral resources based on direct but minimal evidence (1C). This classification is based on the unfavorable geologic setting, the lack of mineral occurrences and on data and concepts outlined in Section 3.4.

4.6.1b Uranium and Thorium. All of the Bear Den Butte (57-14) WSA (1b, Fig. 13) is classified as unfavorable for uranium and thorium resources based on direct but minimal evidence (1C). This classification is based on the unfavorable geologic setting, the lack of uranium and thorium occurrences and on data and concepts outline in Section 3.4.

4.6.1c Non-Metallic Minerals. The Bear Den Butte (57-14) WSA (1c-s, Fig. 13) is classified as moderately favorable for the accumulation of uncommon varieties of stone (decorative lava rock) based on direct but minimal evidence (3C). This classification is based upon the presence of nearby mining claims, the relative youth of volcanics within the WSA, the favorable geologic setting, and on concepts and data outlined in Section 3.4. Bear Den Butte (57-14) WSA (1c-other, Fig. 13) is classified as unfavorable for the accumulation of other non-metallic resources based on direct but minimal evidence (1C). The classification is based upon the lack of occurrences, the unfavorable geologic setting, and upon data and concepts outlined in Section 3.4.

4.6.2 Leasable Resources

4.6.2a Oil and Gas. Bear Den Butte (57-14) WSA (1a, Fig. 14) is classified as having low favorability for the accumulation of hydrocarbon resources based on indirect evidence (2B). The classification is based upon data and concepts outlined in Section 3.4.

4.6.2b Geothermal. Bear Den Butte (57-14) WSA (1b, Fig. 14) is classified as having low favorability for accumulation of low to intermediate geothermal resources based upon indirect evidence (2B) and classified as having low to moderate favorability for accumulation of high temperature geothermal resources (1b-H, Fig. 14) based on inadequate data (2A to 3A). The WSA is classified by comparison to surrounding areas since there is no data available within the WSA. The existence of the Snake Plain Aquifer probably precludes the existence of shallow warm or hot water. The deep

geothermal setting is unknown and no special features separate the Bear Den Butte (57-14) WSA from surrounding areas. Additionally, the classification is based upon data and concepts outlined in Section 3.4.

4.6.2c Sodium and Potassium. Bear Den Butte (57-14) WSA (1c, Fig. 14) is classified as unfavorable for the accumulation of sodium and potassium resources based on direct but quantitatively minimal data (1C). The classification is based upon data and concepts outlined in Section 3.4.

4.6.2d Other. The Bear Den Butte (57-2) WSA (1d, Fig. 14) is classified as unfavorable for asphalt, bitumen, and phosphate resources based on direct but quantitatively minimal data (1C). Potential source units may be present beneath the Plains but only at uneconomic depths.

4.6.3 Saleable Resources

The Bear Den Butte (57-14) WSA (Fig. 15) is classified as highly favorable for accumulation of stone, cinders, pumice, and pumicite based upon direct but quantitatively minimal data (4C). The classification is based upon the presence of youthful volcanic rocks and vent sites near or within the WSA and upon data and concepts outlined in Section 3.4. The Bear Den Butte (57-14) WSA (Fig. 15) is classified as unfavorable for the accumulation of clay, limestone, dolomite, peat, petrified wood, sand and gravel based upon direct but minimal data (1C). The classification is based upon the unfavorable thicknesses of the volcanic cover within the WSA.

5.0 RECOMMENDATIONS FOR FURTHER WORK

The resources most likely to be developed in the Wilderness Study Areas within the Twin Buttes GRA are decorative lava rock and accumulations of cinders and pumice. To evaluate these resources requires geologic mapping of the WSAs emphasizing the identification of favorable areas and an appraisal of the value of the commodities.

Direct 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 resistivity survey are the only practical ways to approach the evaluation. Electromagnetic techniques used to look for conductors below the high-resistivity basalts of the Snake River Aquifer could also be used. 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.

In order to further evaluate potential hydrocarbon resources the following recommendations are made:

1. Geophysical studies in the eastern Snake River Plain should be continued in greater detail. This will allow the recognition of subsurface structures that could contain potential hydrocarbon reservoirs.

2. Hydrocarbon characterization and thermal maturity studies should be made of potential source beds on both sides of the Snake River Plain since these same units are believed to extend beneath the Plain. This will indicate the type of hydrocarbons to be anticipated in the area and delineate those horizons where burial depths have removed hydrocarbons.
- C. One or two deep tests need to be drilled in the Snake River Plains. 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 surrounding the volcanic vents if located in proximity to a vent. Potential hydrocarbon source and reservoir beds could also be evaluated by a test well.

6.0 REFERENCES CITED AND SELECTED BIBLIOGRAPHY

- Armstrong, R.L., Leeman, W.P. and Malde, H.E., 1975, Dating of Quaternary and Neogene volcanic rocks of the Snake River Plain, Am. J. Sci., Vol. 275, 225-251.
- Armstrong, R.L., Smith, J.F., Covington, H.R. and Williams, P.L., 1978, Preliminary geologic map of the west half of the Pocatello 1°x2° Quadrangle, Idaho: U.S. Geol. Survey, Open-File Rpt. 78-533.
- Arney, B.H., 1982, Evidence of former higher temperatures from alteration minerals, Bostic 1-A Well, Mountain Home, Idaho: Geothermal Resources Council Trans., Vol. 6, pp. 3-6.
- Asher, R.R., 1965, Volcanic construction materials in Idaho: Idaho Bureau of Mines and Geol., Pamph. 135, 150 p.
- Axelrod, 1968, Tertiary floras and topographic history of the Snake River basin, Idaho: Geol. Soc. Amer. Bull., Vol. 79, p. 713-734.
- Ball, L., Salisbury, J.W., Kintzinger, D.R., Veneruso, A.F. and Ward, S.H., 1979, The national geothermal exploration technology program, Geophysics 44, p. 1721-1737.
- Barracough, J.T., Teasdale, W.E., Robertson, J.B. and Jensen, R.G., 1966, Hydrology of the National Reactor Testing Station, U.S. Geol. Survey Open File Rpt. (Waste Disposal and Processing, TID-4500), 75 pp.
- Blackstone, D.L., Jr., 1977, The overthrust belt salient of the Cordilleran fold belt-western Wyoming, southeastern Idaho, northeastern Utah: Wyoming Geol. Assoc. Guidebook 29th Ann. Field Conf., p. 367-384.
- Braile, L.W., Smith, R.B., Ansorge, J., Baker, M.R., Sparlin, M.A., Prodehl, C., Schilly, M.M., Healy, J.H., Mueller, St., and Olsen, K.H., 1982, The Yellowstone-Snake River Plain seismic profiling experiment: Crustal structure of the Eastern Snake River Plain: J. of Geophys. Res., Vol. 87, No. B4, p. 2597-2609.
- Braile, L.W., Smith, R.B., Keller, G.R., Welch, R., and Meyer, R.P., 1974, Crustal structure across the Wasatch front from detailed seismic refraction studies, J. Geophys. Res., Vol. 79, p. 1295-1317.
- Breckenridge, R.M., 1982, Oil and gas exploration in Idaho: Idaho Bureau of Mines and Geology, 1 sheet.
- Brott, C.A., Blackwell, D.D., Mitchell, J.C., 1976, Geothermal investigations in Idaho, 8, Heat flow study of the Snake River Plain, Idaho, Water Info. Bull. Idaho Dept. Water Resources, 30, 195 pp.
- _____, 1978, Tectonic implications of the heat flow of the western Snake River Plain, Idaho, Geol. Soc. Am. Bull. Vol. 89, p. 1697-1707.

- Brott, C.A., Blackwell, D.D. and Ziagos, J.P., 1981, Thermal and tectonic implications of heat flow in the Eastern Snake River Plain, Idaho, J. Geophys. Res. Vol. 86, p. 11709-11734.
- Burke, K.C. and Dewey, J.F., 1973, Plume-generated triple junctions: Key indicators in applying plate tectonics to old rocks: Jour. Geol., Vol. 81, pp. 406-433.
- Christiansen, R.L. and McKee, E.H., 1978, Late Cenozoic volcanic and tectonic evolution of the Great Basin and Columbia Intermontane regions: Geol. Soc. America Mem. 152, p. 283-312.
- Claypool, G.E., Love, A.H. and Maughan, E.K., 1978, Organic geochemistry, incipient metamorphism, and oil generation in black shale members of Phosphoria Formation, western interior United States: American Assoc. of Petroleum Geologists Bull., Vol. 62, p. 98-120.
- Crosthwaite, E.G., 1978, Chemical analysis of ground water related to geothermal investigations in the Teton River area, eastern Idaho: U.S. Geol. Survey Open-File Rpt. 79-687, 14 p.
- Doherty, D.J., McBroome, L.A. and Kuntz, M.A., 1979, Preliminary geological interpretation and lithologic log of the geothermal exploration well (INEL-1), Idaho National Engineering Laboratory, Eastern Snake River Plain, Idaho: U.S. Geol. Survey, Open-File Rpt. 79-1258, 7 p.
- Eaton, G.P., Christiansen, R.C., Iyer, H.M., Pitt, A.M., Mabey, D.R., Blank, H.R., Zietz, I. and Gettings, M.E., 1975, Magma beneath Yellowstone National Park: Science, Vol. 188, pp. 787-796.
- Ellis, A.J. and Mahon, W.A.J., 1977, Chemistry and geochemistry systems, Academic Press, New York, 392 pp.
- Greeley, R., 1977, Basaltic "Plains" volcanism, in Greeley, R. and King, J.S. (ed.), Volcanism of the Eastern Snake River Plain, Idaho: A Comparative Planetary Geology Guidebook: NASA Report, CR-154621, pp. 23-44.
- _____, 1982, The Snake River Plain, Idaho: Representative of a new category of volcanism: Jour. Geophys. Res., Vol. 87, No. B4, pp. 2705-2717.
- Greeley, R. and King, J.S., 1977, Volcanism of the eastern Snake River Plain, Idaho: Office Planetary Geology National Aeronautics and Space Administration, 308 p.
- Hamilton, S., 1982, Personal communication regarding Amax Inc. exploration work at Big Southern Butte, Idaho.
- Hamilton, W. and Myers, W.B., 1966, Cenozoic tectonics of the western United States, Rev. Geophys., Vol. 4, p. 509-549.
- Higdon, M., 1973, Geology of the Snake River basin: College of Idaho, Occasional Paper No. 14, 8 p.

- Hill, D.P., 1963, Gravity and crustal structural in the western Snake River Plain, Idaho, J. Geophys. Res., Vol. 68, p. 5807-5818.
- Hill, D.P. and Pakiser, L.C., 1966, Crustal structure between the Nevada test site and Boise, Idaho, from seismic-refraction measurements, in The Earth Beneath the Continents; Geophys. Monogr. Ser., Vol. 10, edited by J.S. Steinhart and T.J. Smith, pp. 391-419, AGU, Washington, D.C.
- Hodgson, C.J. and Lyden, J.W., 1977, Geological setting of volcanogenic massive sulfide deposits and active hydrothermal systems: Some implications for exploration: Can. Inst. Mining and Metall. Bull., Vol. 70, p. 95-106.
- Hunt, C.B., 1974, Natural regions of the United States and Canada: W.H. Freeman and Company, San Francisco, 725 p.
- Keller, G.R., Smith, R.B. and Braile, L.W., 1975, Crustal structure along the eastern margin of the Great Basin from detailed refraction measurements, J. Geophys. Res. 80, p. 1093-1099.
- King, J.S., 1977, Regional setting of the Snake River Plain, Idaho in Greeley, R. and King, J.S., (eds.), Volcanism of the Eastern Snake River Plain, Idaho: A Comparative Planetary Geology Guidebook: NASA Rpt. CR-154621, pp. 45-58.
- Kirkham, V.R.D., 1931, Snake River downwarp: J. Geol., Vol. 39, p. 456-482.
- Kuntz, M.A., 1977, Extensional faulting and volcanism along the Arco Rift Zone, eastern Snake River Plain, Idaho, Geol. Soc. Amer. Abs. with Prog. (Rocky Mtn. Section), Vol. 9.
- _____, 1978a, Geologic map of the Arco-Big Southern Butte area, Butte, Blaine and Bingham Counties, Idaho: U.S. Geologic Survey Open-File Rpt. 78-302, 1 sheet.
- _____, 1978b, Geology of the Arco-Big Southern Butte area, eastern Snake River Plain, and potential volcanic hazards to the radioactive waste management complex, and other waste storage and reactor facilities at the Idaho National Engineering Laboratory, Idaho: U.S. Geol. Survey Open-File Rpt. 78-691, 70 p.
- Kuntz, M.A., Skipp, B., Embree, G.F., Jr., Hoga, R.D. and Williams, E.J., 1979, Geologic map of the Lava Ridge-Hell's Half Acre area, Eastern Snake River Plain, Idaho: U.S. Geol. Survey, Open-File Rpt. 79-669.
- Kuntz, M.A., Lefebvre, R.H., Champion, D.E., McBroome, L.A., Mabey, D.R., Stanley, W.D., Covington, H.R., Ridenour, J. and Stotelmeyer, R.N., 1980, Geological and geophysical investigations and mineral resources potential of the proposed Great Rift Wilderness area, Idaho: U.S. Geol. Survey Open-File Rpt. 80-475, 48 p.

- LaPoint, P.J., 1977, Preliminary photogeologic map of the eastern Snake River Plain, Idaho: U.S. Geol. Survey Misc. Field Studies Map MF-850, 1 sheet.
- LaFehr, T.R. and Pakiser, L.C., 1962, Gravity, volcanism and crustal deformation of the eastern Snake River Plain, U.S. Geol. Survey Prof. Paper 450-D, p. 76-78.
- Lipman, P.W., Fisher, F.S., Mehnert, H.H., Naeser, C.W., Luedke, R.G. and Steven, T.A., 1976, Multiple ages of mid-Tertiary mineralization and alteration in the western San Juan Mountains: Econ. Geol., Vol. 71, pp. 571-588.
- Mabey, D.R., 1966, Relation between bouguer gravity anomalies and regional topography in Nevada and the eastern Snake River Plain, Idaho in Geol. Survey Research 1966: U.S. Geol. Survey Prof. Paper 550-B p. B108-B110.
- _____, 1976, Interpretation of a gravity profile across the western Snake River Plain, Geol. 4, p. 53-56.
- _____, 1978, Regional gravity and magnetic anomalies in the eastern Snake River Plain; Idaho: U.S. Geol. Survey Jour. of Research, Vol. 6, p. 553-562.
- Mabey, D.R., Peterson, D.L. and Wilson, C.W., 1974, Preliminary gravity map of southern Idaho: U.S. Geol. Survey Open-File Rpt. 74-78.
- Mabey, D.R., Zietz, I., Eaton, G.P. and Keinkopf, M.D., 1978, Regional magnetic patterns in part of the Cordillera in the western United States: Geol. Soc. America Mem. 152, pp. 93-106.
- Maley, T., 1983, Handbook of mineral law: MMRC Publ., Boise, Idaho 293 p.
- Maley, T.S. and Holland, T.W., 1981, Validity determination of the distinctive lava stone Association Placer Mining claims, Idaho: Bureau of Land Management, Mineral Examiners Report, 47 p.
- McCaslin, J.C., 1980, Action returns to Disturbed belt in Montana: Oil and Gas Journal, Vol. 78, No. 48, p. 193.
- _____, 1981, "Overthrust": magic word in exploration: Oil and Gas Journal, Vol. 79, No. 27, p. 181-182.
- Mitchell, A.H.G. and Garson, M.S., 1981, Mineral deposits and global tectonic settings: Academic Press, New York, 405 p.
- Mitchell, J.C., Johnson, L.L. and Anderson, J.E., 1980, Geothermal investigations in Idaho: Part 9, potential for direct heat application of geothermal resources: Idaho Dept. of Water Resources, Water Inf. Bull. No. 30, 396 p.

- Morgan, W.J., 1972, Plate motions and deep mantle convection; in Shangam, et al. (eds.), Studies in Earth and Space Sciences (Hess Vol.): Geol. Soc. America Mem. 132, pp. 7-22.
- Muffler, L.J.P. (ed.), 1979, Assessment of geothermal resources of the United States, 1978: U.S. Geol. Survey Circ. 790, 163.
- Mundorff, M.J., Crosthwaite, E.G. and Kilbur, C., 1964, Ground water for irrigation in the Snake River Basin in Idaho, U.S. Geol. Survey Water Supply Paper 1654, 224 pp.
- Papson, R.P., 1977, Geologic guide to Craters of the Moon Monument: in Volcanism of the Eastern Snake River Plain, Idaho: A Comparative Planetary Geology Guidebook: NASA Report, CR-154621, pp. 215-232.
- Peterson, J.A., 1977, Paleozoic shelf-margins and marginal basins, western Rocky Mountains-Great Basin, United States: Joint Wyoming-Montana-Utah Geol. Assoc. Guidebooks, p. 135-153.
- _____, 1980, Depositional history and petroleum geology of the Permian Phosphoria, Park City, and Shedhorn Formations, Wyoming and southeastern Idaho: U.S. Geol. Survey Open-File Rpt. 80-667, 42 p.
- Powers, R.B., 1977, Assessment of oil and gas resources in the Idaho-Wyoming Thrust Belt: Wyoming Geol. Assoc. Guidebook 19th Annual Field Conf., pp. 629-937.
- Prestwich, S.M. and Mink, L.L., 1979, Snake River Plain geothermal exploration well: Geothermal Resources Council Trans., Vol. 3, pp. 549-552.
- Prinz, M., 1970, Idaho Rift system, Snake River Plain, Idaho: Geol. Soc. Amer. Bull., Vol. 81, p. 941-947.
- Prodehl, C., 1979, Crustal structure of the western United States: U.S. Geol. Survey Prof. Paper 1034, 74 pp.
- Prostka, H.J. and Embree, G.F., 1978, Geology and geothermal resources of the Rexburg area, eastern Idaho: U.S. Geol. Survey Open-File Rpt. 78-1009, 14 p.
- Rember, W.C. and Bennett, E.H., 1979a, Geologic map of the Idaho Falls Quadrangle Idaho: Idaho Bureau of Mines and Geology Geologic Map Series Idaho Falls 2° Quadrangle, 1 sheet.
- _____, 1979b, Geologic map of the Pocatello Quadrangle, Idaho: Idaho Bureau of Mines and Geology Geologic Map Series Pocatello 2° Quadrangle, 1 sheet.
- _____, 1979c, Geologic map of the Hailey Quadrangle, Idaho: Idaho Bureau of Mines and Geology Geologic Map Series Hailey 2° Quadrangle, 1 sheet.

- Morgan, W.J., 1972, Plate motions and deep mantle convection; in Shangam, et al. (eds.), Studies in Earth and Space Sciences (Hess Vol.): Geol. Soc. America Mem. 132, pp. 7-22.
- Muffler, L.J.P. (ed.), 1979, Assessment of geothermal resources of the United States, 1978: U.S. Geol. Survey Circ. 790, 163.
- Mundorff, M.J., Crosthwaite, E.G. and Kilbur, C., 1964, Ground water for irrigation in the Snake River Basin in Idaho, U.S. Geol. Survey Water Supply Paper 1654, 224 pp.
- Papson, R.P., 1977, Geologic guide to Craters of the Moon Monument: in Volcanism of the Eastern Snake River Plain, Idaho: A Comparative Planetary Geology Guidebook: NASA Report, CR-154621, pp. 215-232.
- Peterson, J.A., 1977, Paleozoic shelf-margins and marginal basins, western Rocky Mountains-Great Basin, United States: Joint Wyoming-Montana-Utah Geol. Assoc. Guidebooks, p. 135-153.
- _____, 1980, Depositional history and petroleum geology of the Permian Phosphoria, Park City, and Shedhorn Formations, Wyoming and southeastern Idaho: U.S. Geol. Survey Open-File Rpt. 80-667, 42 p.
- Powers, R.B., 1977, Assessment of oil and gas resources in the Idaho-Wyoming Thrust Belt: Wyoming Geol. Assoc. Guidebook 19th Annual Field Conf., pp. 629-937.
- Prestwich, S.M. and Mink, L.L., 1979, Snake River Plain geothermal exploration well: Geothermal Resources Council Trans., Vol. 3, pp. 549-552.
- Prinz, M., 1970, Idaho Rift system, Snake River Plain, Idaho: Geol. Soc. Amer. Bull., Vol. 81, p. 941-947.
- Prodehl, C., 1979, Crustal structure of the western United States: U.S. Geol. Survey Prof. Paper 1034, 74 pp.
- Prostka, H.J. and Embree, G.F., 1978, Geology and geothermal resources of the Rexburg area, eastern Idaho: U.S. Geol. Survey Open-File Rpt. 78-1009, 14 p.
- Rember, W.C. and Bennett, E.H., 1979a, Geologic map of the Idaho Falls Quadrangle Idaho: Idaho Bureau of Mines and Geology Geologic Map Series Idaho Falls 2° Quadrangle, 1 sheet.
- _____, 1979b, Geologic map of the Pocatello Quadrangle, Idaho: Idaho Bureau of Mines and Geology Geologic Map Series Pocatello 2° Quadrangle, 1 sheet.
- _____, 1979c, Geologic map of the Hailey Quadrangle, Idaho: Idaho Bureau of Mines and Geology Geologic Map Series Hailey 2° Quadrangle, 1 sheet.

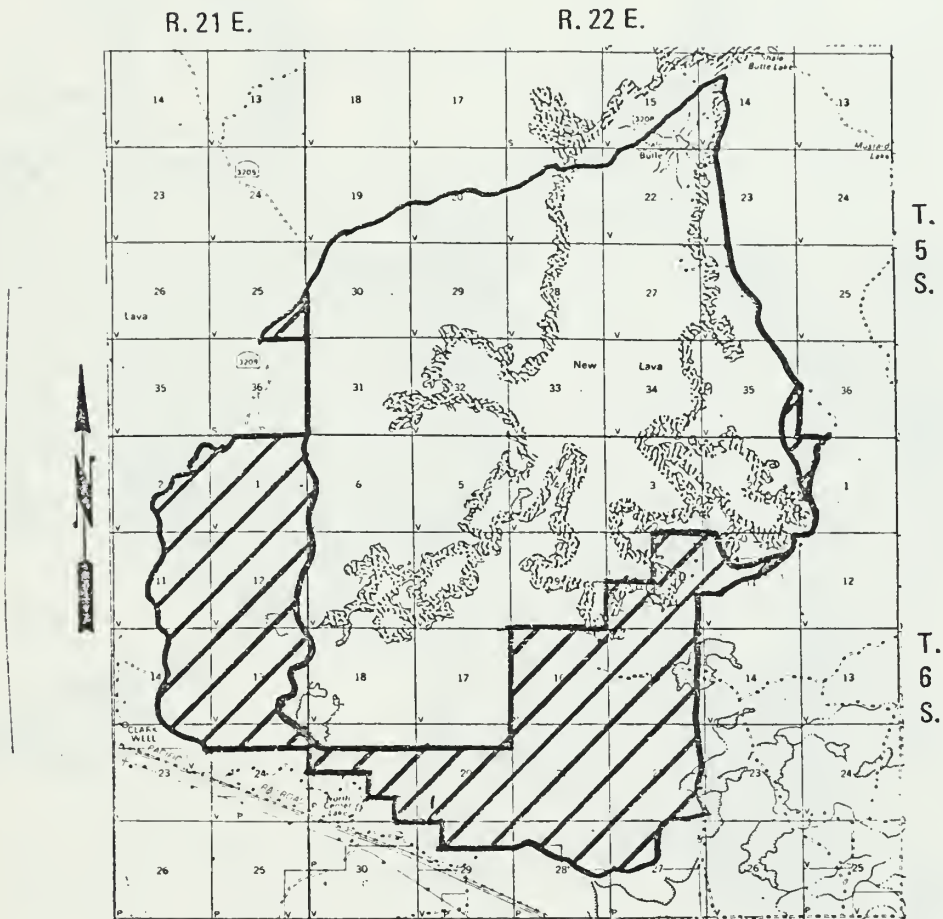
- Schoen, R., 1974, Geology, Part III, in Robertson, J.B., Schoen, R. and Barraclough, J.T., The influence of liquid waste disposal on the geochemistry of water at the National Reactor Testing Station, Idaho: U.S. Geol. Survey Open File Rpt. EDO-22053, 231 p.
- Singer, D.A. and Mosier, D.L., 1981, A review of regional mineral resource assessment methods: Econ. Geology, Vol. 76, No. 5, pp. 1006-1015.
- Skipp, B. and Hait, M.H., Jr., 1977, Allochthons along the northeast margin of the Snake River Plain, Idaho: Joint Wyoming-Montana-Utah Geol. Assoc. Guidebook, p. 499-515.
- Smith, R.B., 1977, Intraplate tectonics of the western North American plate: Tectonophysics, Vol. 37, p. 323-336.
- _____, 1978, Seismicity, crustal structure and intraplate tectonics of the interior of the western Cordillera, Geol. Soc. America Mem. 152, p. 111-144.
- Smith, R.B. and Christiansen, R.L., 1980, Yellowstone Park as a window on the earth's interior: Scientific American, Vol. 242, pp. 84-95.
- Smith, R.B. and Sbar, M.L., 1974, Contemporary tectonics and seismicity of the western United States: Geol. Soc. America Bull., Vol. 85, p. 1205-1218.
- Sparlin, M.A., Braile, L.W. and Smith, R.B., 1982, Crustal structure of the eastern Snake River Plain determined from ray trace modeling of seismic refraction data: Journal of Geophys. Research, Vol. 87, No. B4, p. 2619-2633.
- Spear, D.B., 1977, Big Southern, Middle and East Buttes, in Greeley, R. and King, J.S. (ed.), Volcanism of the Eastern Snake River Plain, Idaho: A Comparative Planetary Geology Guidebook: NASA Rpt. CR-154621, pp. 113-120.
- Stanley, W.D., Boehl, J.E., Bostick, F.X. and Smith, H.W., 1977, Geothermal significance of magnetotelluric sounding in the eastern Snake River Plain-Yellowstone region: Journal of Geophys. Research, Vol. 82, No. 17, p. 2501-2514.
- Stone, G.T., 1969, Preliminary petrologic appraisal of Craters of the Moon, Idaho: Geol. Soc. America Abs. with Programs, Vol. 1, No. 7, p. 217.
- Strowd, W.B., Mitchell, V.E., Hustedde, G.S., Bennett, E.H., 1981, Mines and prospects of the Idaho Falls Quadrangle, Idaho: Idaho Bureau of Mines and Geology, Mines and Prospects Map Series.
- Suekawa, H.S., Merrick, D., Clayton, J. and Rumba, S., 1982, National uranium resource evaluation, Ashton Quadrangle, Idaho, Montana and Wyoming: U.S. Dept. of Energy, Open-File Rpt., PGJ/F-074(82), 24 p.

- Taubeneck, W.H., 1971, Idaho batholith and its southern extension, Geol. Soc. America Bull., Vol. 82, p. 1899-1928.
- Trimble, D.E. and Carr, W.J., 1976, Geology of the Rockland and Arbon Quadrangles, Power County, Idaho: U.S. Geol. Survey Bull., 1399 p.
- Walker, E.H., 1964, Subsurface geology of the National Reactor Testing Station, Idaho: U.S. Geol. Survey Bull. 1133-E, 22 p.

APPENDIX I

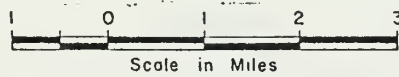
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57-2 SHALE BUTTE



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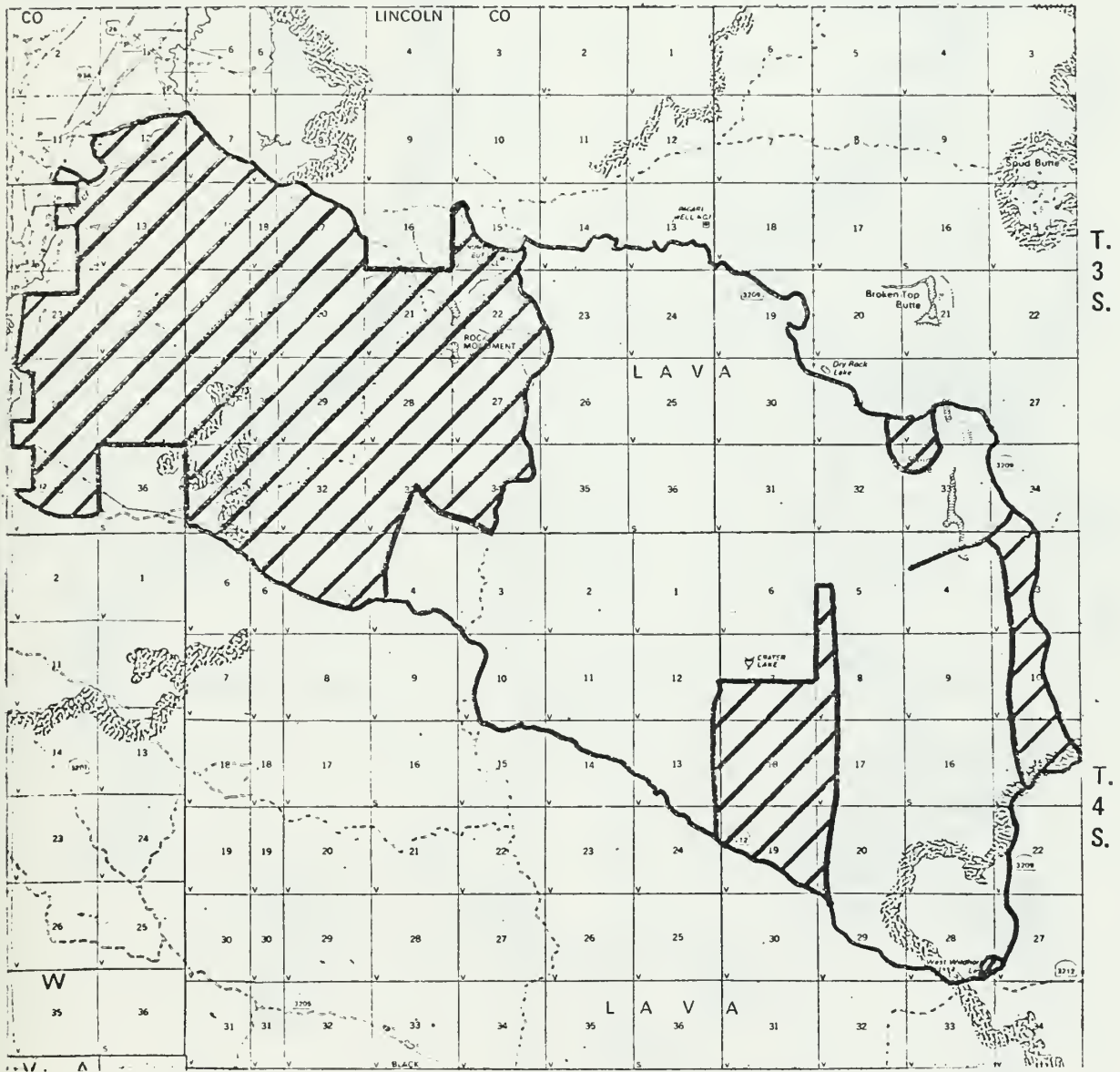


57-8 SAND BUTTE

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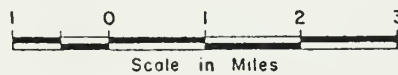
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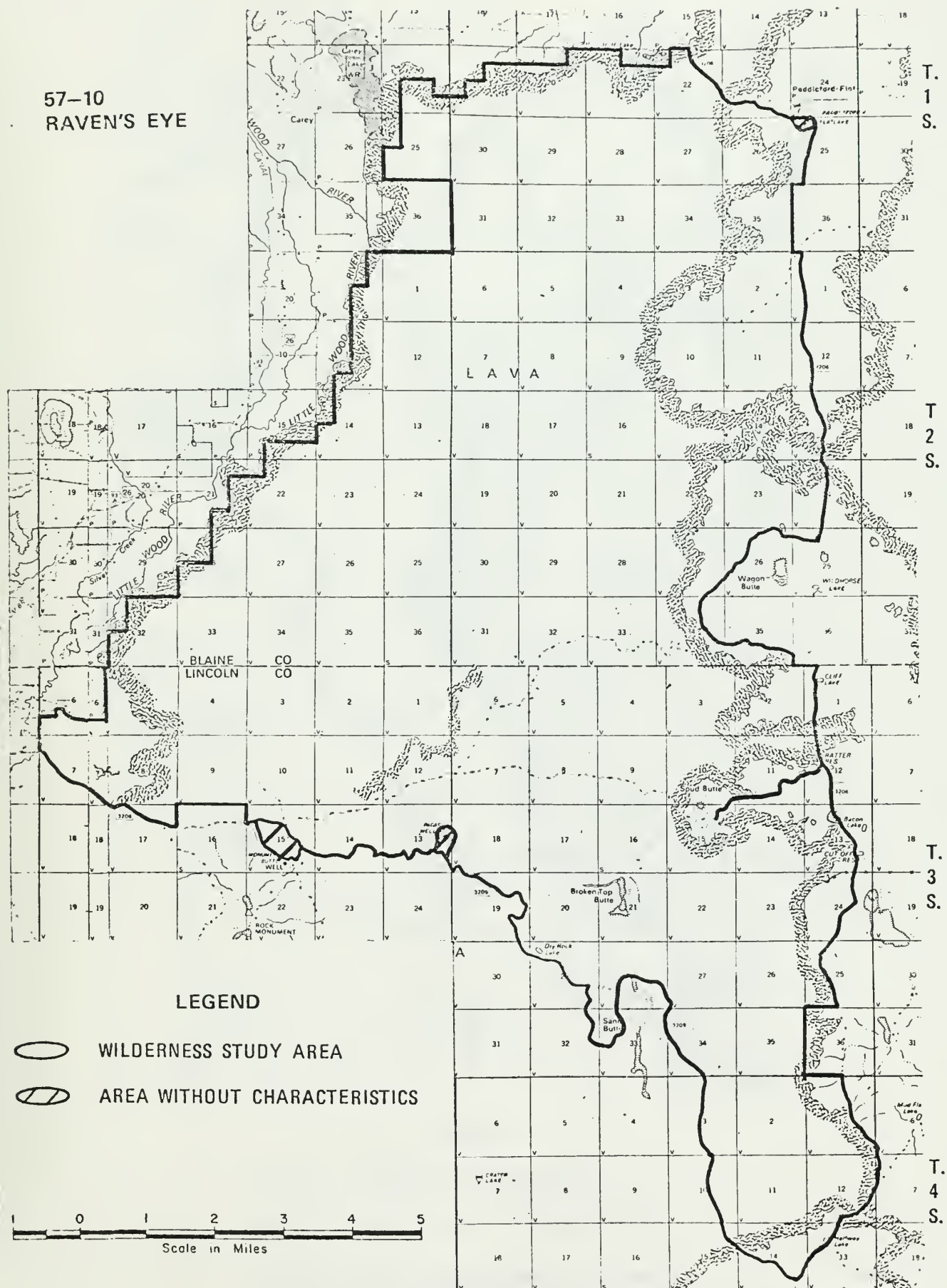
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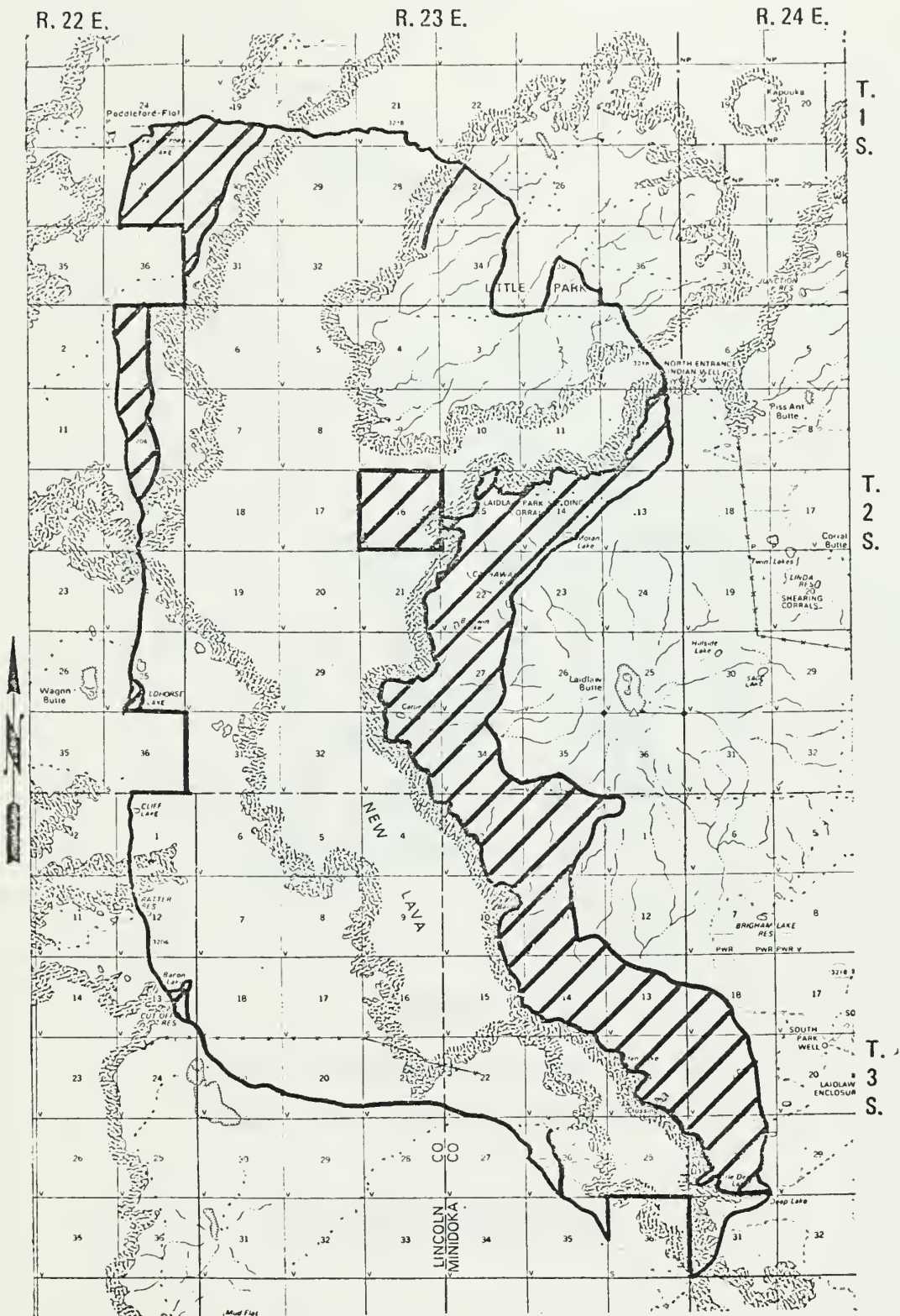
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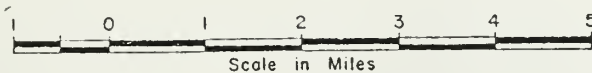
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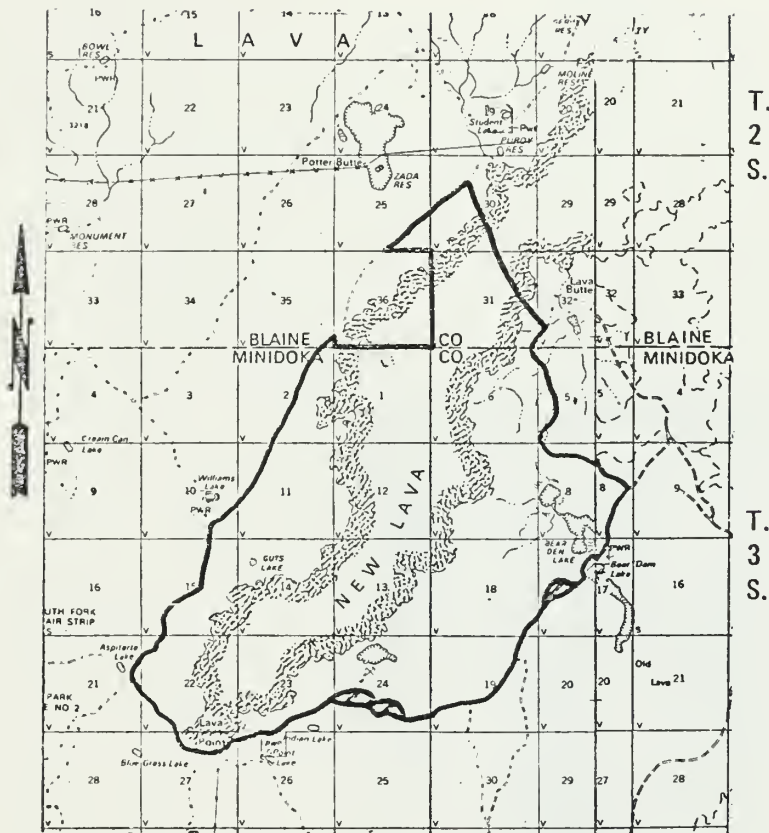
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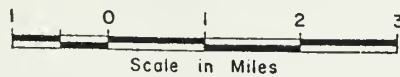
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