PHASE I

Geology, Energy and Mineral (GEM) Evaluation of the Beaver Meadows GRA, Montana, including the Beaver Meadows WSA (075-110)

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 Beaver Meadows Geology, Energy, Mineral Resource Area (GRA) is located in northwestern Montana ten miles southeast of the town of Augusta. The GRA includes one Wilderness Study Area - Beaver Meadows (075-110).

The GRA is in the Lewis and Clark Range, a portion of the Montana Disturbed Belt. The Disturbed Belt is a region extending along the Rocky Mountain front in which the rocks have been thrust eastward over one another to form repeated stacks of rock units. Bedrock in the GRA is mainly sediments intruded by a few igneous sills.

A northwest trending belt of lead-zinc-silver mineralization passes through the GRA. The mineralization consists of vein and replacement deposits but where mineralized the Belt is poorly explored so no data on the size of the deposits is available. The mineralized belt appears to be related to a major zone of thrust faulting known as the Eldorado Thrust. This zone passes directly through WSA 075-110.

In addition to lead-zinc-silver there is also potential for copper-silver mineralization in WSA 075-110. The rocks beneath the Eldorado Thrust are part of the Belt Supergroup which hosts copper-silver mineralization, similar to that being mined near Troy, throughout much of northwest Montana. There is no direct evidence of this type of mineralization in WSA 075-110, however, the favorable host rocks are present in the WSA and mineralization occurs in them to the north along the same regional geologic trend.

The Disturbed Belt also has potential for oil and gas. Work by the U.S. Geological Survey has shown that hydrocarbon source and reservoir rocks are present in the Beaver Meadows area and that the geologic structure is suitable to for oil and gas traps. Petroleum industry interest in the area is strong and two exploratory wells have been drilled within 30 miles of the Beaver Meadows WSA.

SUMMARY OF GEM RESOURCES

LAND CLASSIFICATION FOR THE BEAVER MEADOWS GRA

	Beaver Meadows WSA (075-110)
1. Locatable Resources	
a. Metallic Minerals	3C
b. Uranium and Thorium	2C
c. Non-Metallic Minerals	2C
2. Leasable Resourcs	
a. Oil and Gas	3C
b. Low Temperature Geothermal	2B
High Temperature Geothermal	1B
c. Sodium and Potassium	1C
d. Other	2C
3. Saleable Resources	3C(stone resources 2B (other)

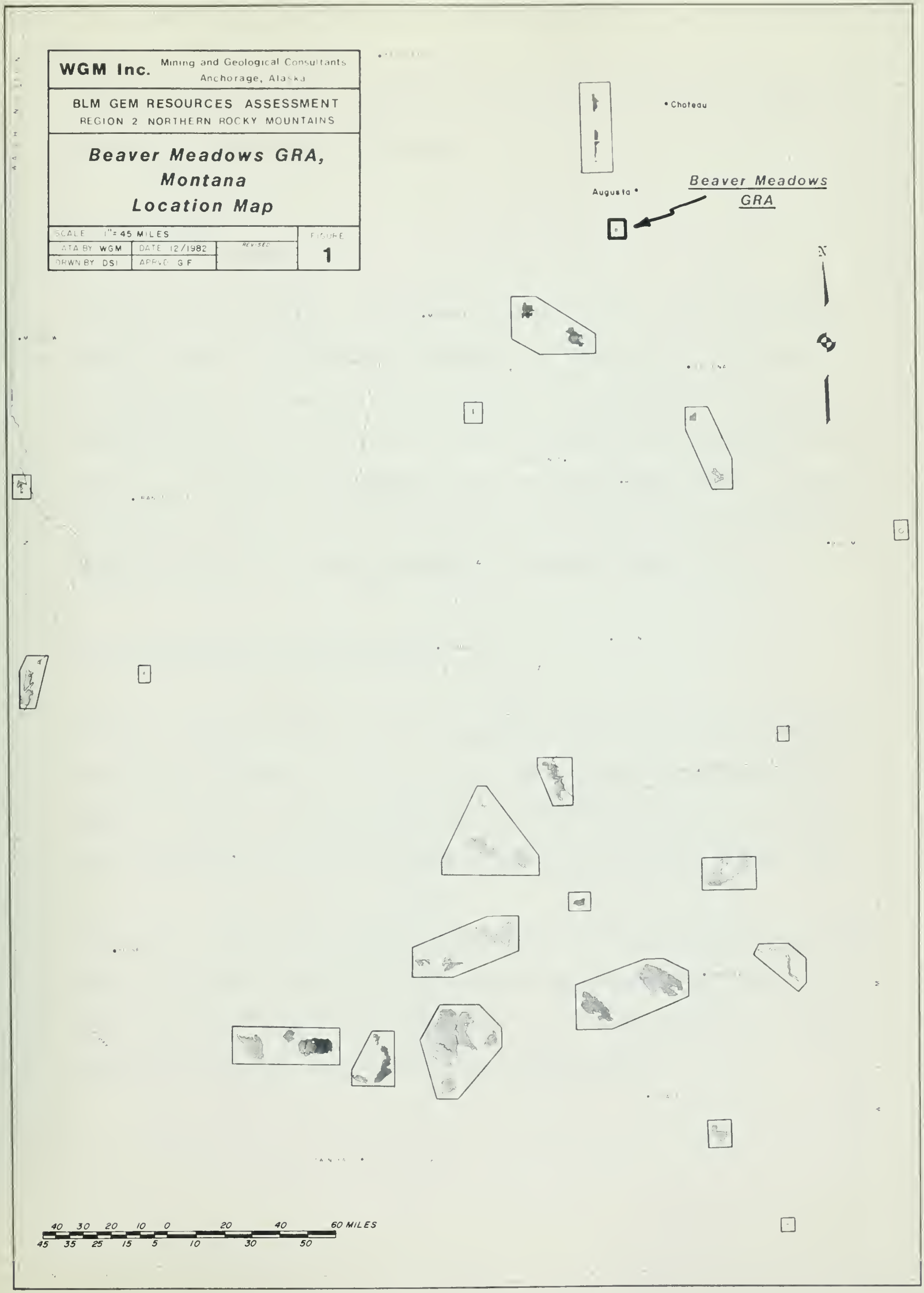
BEAVER MEADOWS GRA

1.0 INTRODUCTION

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

The delineation 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 Aras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Mining and Geological Consultants
Anchorage, Alaska
BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS
Beaver Meadows GRA,
Montana
Location Map
SCALE 1" = 45 MILES
DATA BY WGM
DATE 12/1982
REVISED
DRWN BY DSI
APPRVD GF
FIGURE
1
Choteau
Augusta
Beaver Meadows
GRA
N
40 30 20 10 0 20 40 60 MILES
45 35 25 15 5 10 30 50

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

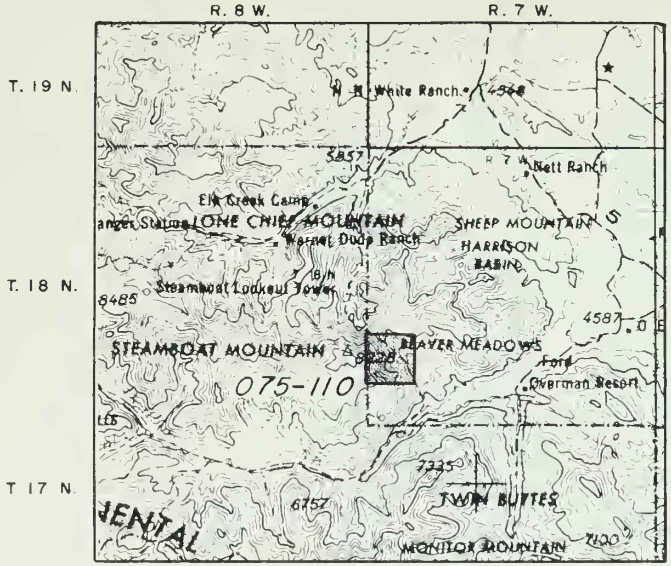
1.1 Location

The Beaver Meadows GRA is located along the east flank of the continental divide in Lewis and Clark County, Montana. The area is largely within Ts.18 and 19N., Rs.7 and 8W. in the Choteau 1°x2° quadrangle. The GRA is roughly eight miles southwest of the town of Augusta. Administratively the area is in the Headwaters Resource area of the Butte BLM district. The GRA covers about 180 square miles and includes the Beaver Meadows WSA (075-110) comprising 595 acres on the east slope of Steamboat Mountain (Fig. 2).

1.2 Population and Infrastructure

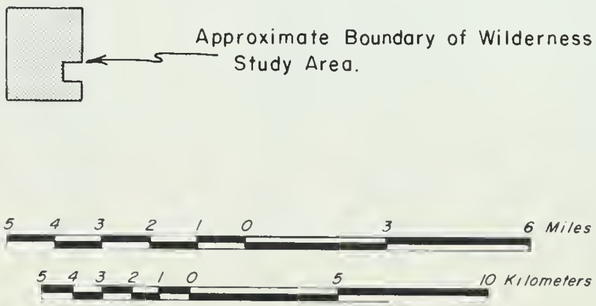
The Beaver Meadows GRA is sparsely populated. The town of Augusta, Montana, located just northeast of the area, has a population of less than 1,000 people. There are 8-10 ranches in the northeast third of the GRA and one ranch on Dearborn River, three miles southeast of the Beaver Meadows WSA.

Light duty roads provide access to the ranches in the northeast part of the Beaver Meadows GRA. Unpaved roads extend up the Dearborn River and Elk Creek Canyons. The map included in Mudge et al. (1968) shows a dirt road running from Dearborn Canyon to the Beaver Meadows WSA.



BLM Wilderness Study Areas Included in the Beaver Meadows GRA.

WSA	NAME	ACREAGE
075-110	Beaver Meadows	595



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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Topographic Map

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

1.3 Basis of Report

This report is based on a review, compilation and analysis of the available published and unpublished data on the geology, energy and mineral resources of the Beaver Meadows GRA. The area has been the focus of some government and university studies as well as exploration by private industry. The GRA is located in the Choteau NTMS quadrangle which has been the subject of a U.S. Geological Survey CUSMAP study and a Department of Energy NURE study. Consequently, a considerable amount of geologic, geochemical and geophysical data are available. BLM records of mining claims and oil and gas leases were compiled and records of oil and gas well data at the Montana Oil and Gas Conservation Board were reviewed. In addition, areal photographs, loaned to WGM by the Butte BLM office were examined. The data was compiled and reviewed by WGM project personnel and the panel of experts to produce the resource evaluation which follows.

Personnel involved in the project and their general areas of responsibility are listed below:

Greg Fernette, Senior Geologist, WGM Inc.	Project Manager
C.G. Bigelow, President, WGM Inc.	Chairman, Panel of Experts
Greg Fernette, Senior Geologist, WGM Inc.	Project Manager
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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David Blackwell, Ph.D., Professional of Geophysics, Southern Methodist University	Geothermal.
Jason Bressler, Senior Geologist, WGM Inc.	Regional geology, metallic minerals.
Gary Webster, Ph.D., Chairman, Department of Geology, Washington State University	Oil and gas.
William Jones, Senior Geologist, WGM Inc.	Metallic minerals, coal, industrial minerals.
J.F. McOuat, President, Watts, Griffis & McOuat Ltd.	Mineral economics, and industrial minerals.
E.F. Evoy, Senior Geologist, Watts, Griffis & McOuat Ltd.	Uranium and thorium.

1.4 Acknowledgements

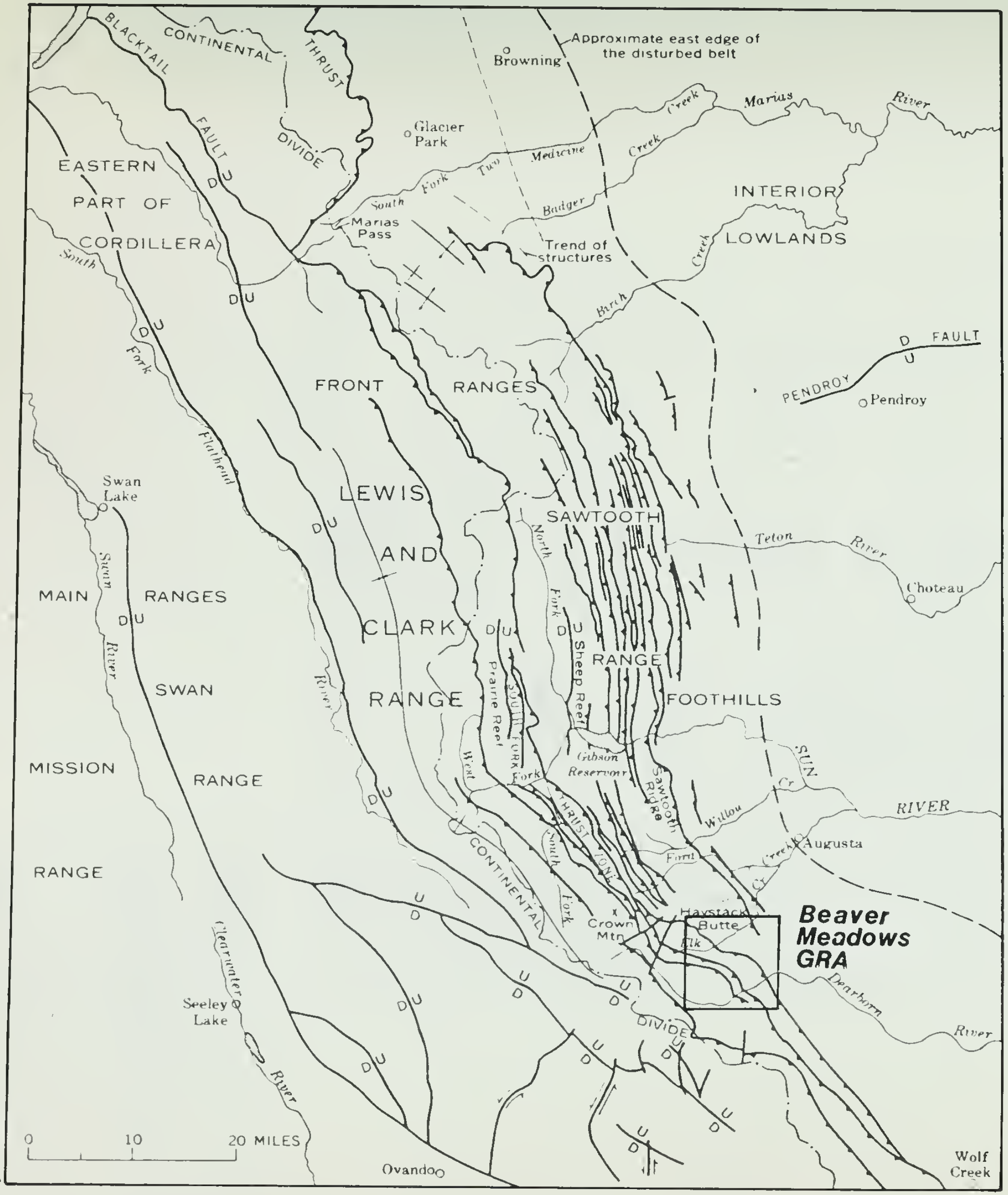
We would like to thank a number of individuals whose assistance contributed to the completion of this report. Dave Williams and Bill Weatherly, Butte BLM office, provided data, areal photos and geological information on the area. Jerry Klem, Billings BLM office, was extremely helpful in the land compilation and in gathering data on oil and gas wells. Dr. Syd Groff and Don Lawson at the Montana Bureau of Mines and Geology gave freely of their knowledge of the area.

2.0 GEOLOGY

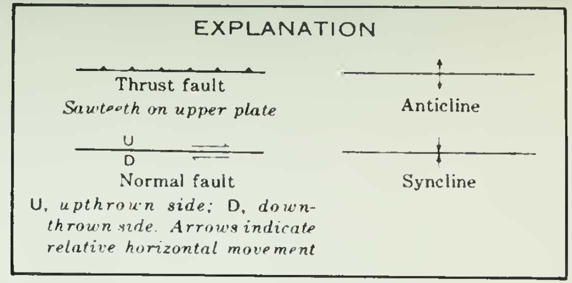
2.1 Introduction

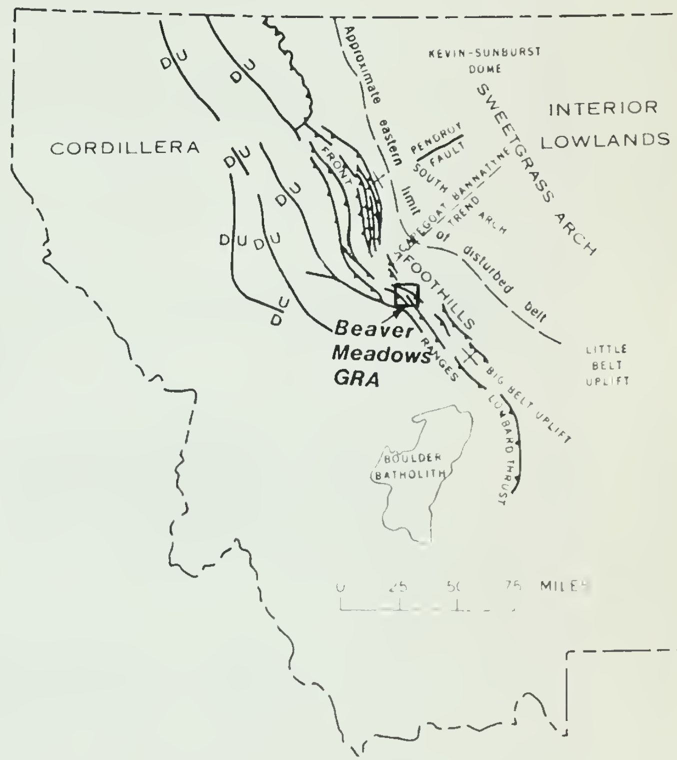
The Beaver Meadows GRA is located in the east-central part of the Disturbed Belt, west of the southern end of the Sweetgrass Arch (Fig. 3). The Disturbed Belt is a zone of imbricate thrust faulting and associated folding probably related to a Paleocene (65-55 m.y.) to Eocene (55-38 m.y.) orogeny (Mudge, 1972b). Sedimentary rocks ranging in age from Precambrian Y (1600-800 m.y.) through Late Cretaceous (100-65 m.y.) outcrop in the area (Fig. 4). A few intrusive diorite sills of Precambrian Z (760-600 m.y.) age are also present. The GRA can be divided into two geologic provinces: a mountainous southwest province underlain by Precambrian (more than 600 m.y.) and Cambrian (600-500 m.y.) to Mississippian (345-310 m.y.) rocks and a northeast province underlain mainly by Mesozoic (230-65 m.y.) rocks (Fig. 5, 6). In the Beaver Meadows WSA the Mesozoic part of the section may be present in the subsurface beneath thrust slices, but it is probably faulted out a few miles to the west. The Precambrian and Paleozoic (600-230 m.y.) strata extend to the east beneath the Mesozoic section.

Geologic studies and mineral resource evaluations have been done in the nearby Scapegoat Wilderness (Mudge et. al, 1974; Earhart et. al, 1977). The geology of the Beaver Meadows GRA, with emphasis on the Cambrian and Precambrian rocks was studied by Mudge et. al (1968), however their mapping was modified by Mudge et al. (1979a). The general geology of this part of the Disturbed Belt has been described in several papers over the past few years (Mudge, 1959, 1970, 1972a, b; Mudge et al., 1968; Kleinkopf and Mudge,



Data from Mudge (1972b).





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REGION 2 NORTHERN ROCKY MOUNTAINS

Regional Geologic Setting of the Beaver Meadows GRA, Montana

SCALE AS SHOWN			FIGURE
DATA BY	DATE 1/1983		3
DRWN BY DSI			

ERA	SYST.		GROUP	FORMATION	MEMBER	THICKNESS
MESOZOIC	Cretaceous	upper	Montana Group	Horsethief Sandstone		?
				Two Medicine Formation		1000+
				Virgelle Sandstone		150-200
				Telegraph Creek Formation	Upper Member	80
					Middle Member	90
					Lower Member	170
			Colorado Group	Marias River Formation	Kevin Shale Member	850-1050±
					Ferdig Shale Member	200-350
					Cone Cacareous Member	100
					Floweree Shale Member	30
				unconformity		
		lower		Blackleaf Formation	Vaughn Member	300-500
					Taft Hill Member	225-600
					Flood Shale Member	150-550
				unconformity		
				Kootenai Formation		650-800
				unconformity		
	Jurassic	upper	Ellis Group	Morrison Formation		170-250
				Swift Formation	Upper Member	140-300
					Lower Member	
				unconformity		
				Rierdon Formation		150-350
				unconformity		
		lower		Sawtooth Formation	Upper Member	40-200
					Middle Member	
					Lower Member	
				unconformity		
PALEOZOIC	Mississippian		Madison Group	Castle Reef Dolomite	Sun River Member	300-450
					Lower Member	250-475
				unconformity		
	Devonian			Three Forks Formation		50-589
				Jefferson Formation	Birdbear Member	200
					Lower Member	500
				Maywood Formation		150-300
				unconformity		
	Middle Cambrian			Flathead Sandstone		70-105
				unconformity		
PRECAMBRIAN	Precambrian Y		Missoula Group	Mount Shields Formation	Red Siltstone Member	500-925
					Red Sandstone Member	300-825
			Belt Supergroup	Shepard Formation		225-825
				Snowslip Formation		250-700
				Helena Dolomite		575-650
				Empire and Spokane Formations		1200±
				Greyson Formation		1000+

Data from: Mudge et.al. (1968) and Mudge (1972a)

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Beaver Meadows GRA, Montana

Stratigraphic Column

SCALE			FIGURE
DATA BY	DATE 9/1982	REVISED	4
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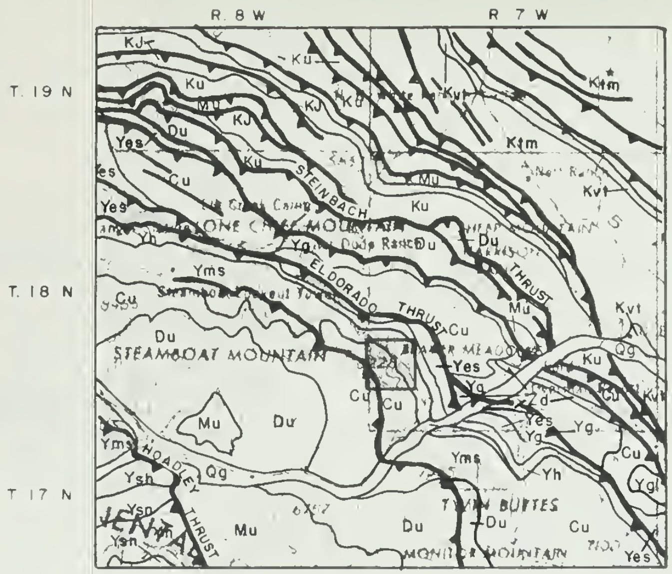

— Contact

Thrust Fault, teeth on upper plate.

Approximate Boundary of Wilderness Study Area.

EXPLANATION

Era	Unit	Description	Group	Age
CENOZOIC	Qg	olluvial and glacial deposits		Pleistocene and Quoternary
MESOZOIC	Kh (Ku)	Horsethief Sandstone		Upper Cretoceous
	Ktm (Ku)	Two Medicine Formation		Upper Cretoceous
	Kvt (Ku)	Virgelle Sandstone and Telegraph Creek Formation		Upper Cretoceous
	KJ (Ku)	undiffereniated Lower Cretoceous Blockleaf and Kootenai Formations and Jurassic Morrison, Swift, Rierdon, and Sawtooth Formations		Mid-Jurossic to lower Cretoceous
		Ku– undivided upper to lower Cretaceous Rocks		
PALEOZOIC	Mu	Madison Group Undivided		Mississ-ippion
	Du	undivided Jefferson and Three Forks Formotions		Devon-ion
	Cu	predominantly Flathead Sondstone		Comb-rion
	Zd	Diorite Sills		Precambrian Z
PRECAMBRIAN	Yms	Mount Shields Formation	Missoulo Group; Belt Supergroup	Precombrion Y
	Ysh	Shepard Formation	Missoulo Group; Belt Supergroup	Precombrion Y
	Ysn	Snowslip Formotion	Missoulo Group; Belt Supergroup	Precombrion Y
	Yh	Helena Formation	Belt Supergroup	Precombrion Y
	Yes	Empire ond Spokane Formations	Belt Supergroup	Precombrion Y
	Yg	Greyson Formation	Belt Supergroup	Precombrion Y

Data by: Mudge et al., 1968 and 1979a.

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Geologic Map

SCALE 1" = 4 MILES (1 250,000)		FIGURE
DATA BY	DATE 9/1982	REVISED
DRWN BY DSI	APRVD G.F	5

EXPLANATION

Ku	CRETACEOUS ROCKS
JKu	CRETACEOUS AND JURASSIC ROCKS
Mu	MISSISSIPPIAN ROCKS
Du	DEVONIAN ROCKS
Ꞓu	CAMBRIAN ROCKS
	PROTEROZOIC Y ROCKS
Ym	McNamara Formation
Ybo	Bonner Quartzite
Yms	Mount Shields Formation
Ysh	Shepard Formation
Ysn	Snowslip Formation
Yh	Helena Formation
Yes	Empire and Spokane Formations
Ye	Empire Formation
Ys	Spokane Formation
Yg	Greyson Formation

THRUST FAULT—Sawteeth on upper plate

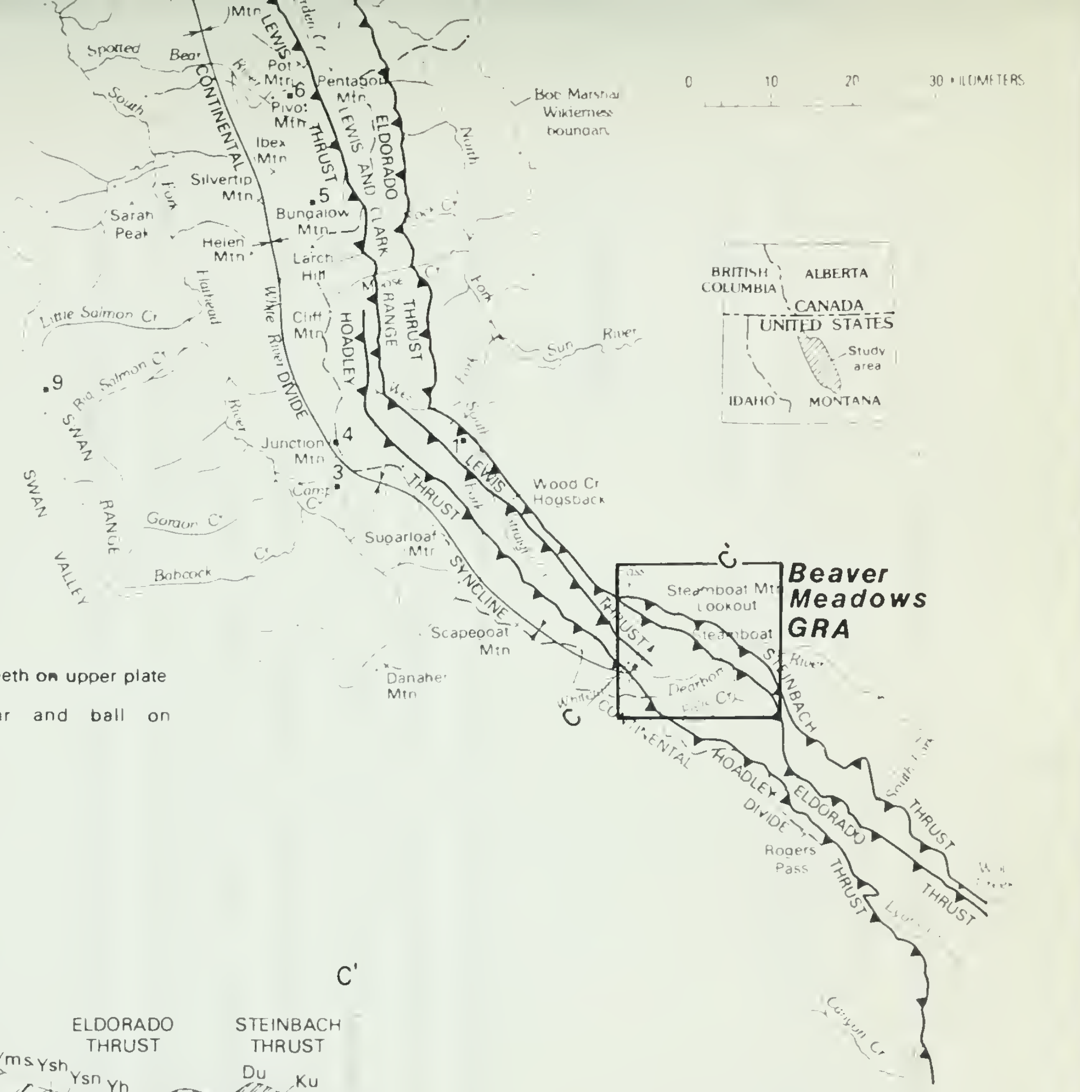
NORMAL FAULT—Bar and ball on downthrown side

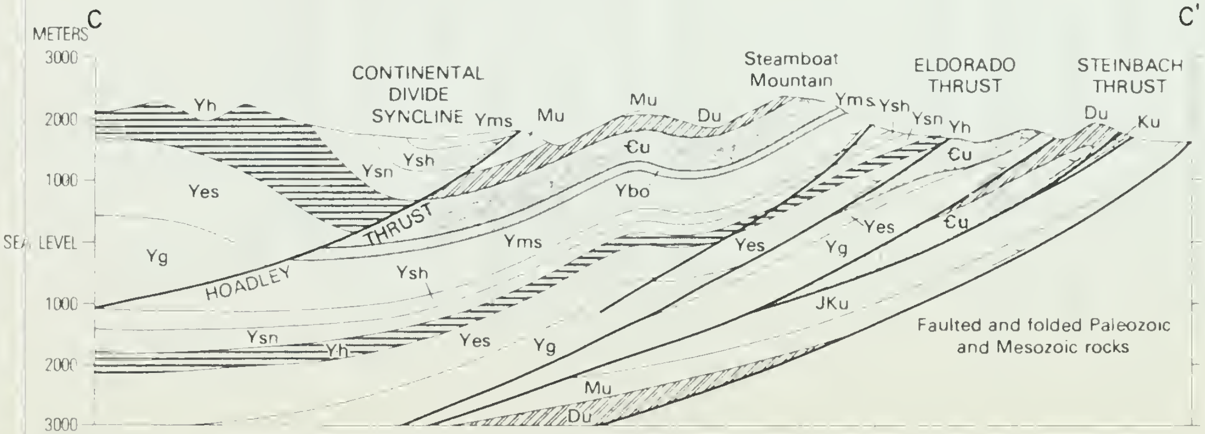
C——C' LINE OF SECTION

STRUCTURE SYMBOLS

Anticline

Syncline





Data from Mudge and Earhart (1980).

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BLM GEM RESOURCES ASSESSMENT REGION 2 NORTHERN ROCKY MOUNTAINS	
Structure and Geologic Cross Section of the Beaver Meadows GRA, Montana	
SCALE: AS SHOWN	6
DATE: 1/1983	
DRAWN: DSI	

1972; Mudge et al., 1974; Earhart et al., 1977). Recent papers have provided new regional interpretations of the structural history of western Montana and delineated additional thrust plates (Peterson, 1981; Robinson et al., 1968; Ruppel et al., 1981).

2.2 Physiography

The Beaver Meadows GRA is in the Lewis and Clark Range physiographic province (Hunt, 1974). The topography is characterized by structurally controlled northwest-trending ridges and east to northeast-flowing drainages. The major streams are the Dearborn River and Elk Creek (Fig. 2). The highest point in the GRA is 8,228 feet on Steamboat Mountain. The lower plains in the northeast part of the area average about 4,500 feet in elevation. The topography is youthful with steep V-shaped valleys.

2.3 Description of Rock Units

The oldest exposed rocks in the Beaver Meadows GRA are metasediments of the Precambrian Y Belt Supergroup (Harrison, 1972). Six of the nine formations comprising the Belt sequence are present in the GRA. These are the Greyson, Empire and Spokane, Helena, Snowslip, Shepard and Mt. Shields Formations (Fig. 4). The Bonner, McNamara and Garnet Range Formations are absent in the GRA (Mudge et. al, 1968). The Belt Supergroup is 1020-1135 m.y. old based on potassium-argon and rubidium-strontium age determinations of samples from the upper Spokane and Empire Formations (Obradovich and Peterman, 1968).

The Greyson Formation is the oldest unit of the Belt Supergroup exposed in the Beaver Meadows GRA where it outcrops in the core of an anticline (Fig. 5). The formation is made up of green-gray, laminated to thinly bedded, argillite and siltite. The base of the formation is not exposed in the GRA, however regionally it is over 1,000 feet thick (Mudge et al., 1968).

The Empire and Spokane Formations are not differentiated in the Beaver Meadows GRA (Fig. 5). The Empire ranges from 50 to 200 feet thick and consists mainly of gray to green-gray siltite with interbeds of fine sandstone. The overlying Spokane Formation is made up of finely micaceous, very thin bedded, red, green and gray argillite and siltite with interbeds of dolomitic sandstone and thin beds of dolomite. Prominent beds of stromatolites and conglomerate occur locally (Mudge, 1966). The Spokane Formation is 1,000 to 1,100 feet thick. Lead and zinc-bearing veinlets occur in the Spokane Formation just south of the Beaver Meadows WSA (Mudge et. al, 1968). Radiometric dates on samples from strata in the upper part of the Spokane and Empire Formations yield ages of 1020-1135 m.y. (Obradovich and Peterman, 1968).

The Helena Dolomite is the only predominantly carbonate Precambrian Y unit in the Belt Series and is often referred to as the middle belt carbonate (Harrison, 1972). The unit is well exposed along Dearborn River and consists of three units; sandstone, siltstone and dolomite. The basal sandstone and siltstone units are 110 feet thick and represent the transition from the underlying clastic Spokane Formation to the predominantly carbonate upper portion of the Helena. The lower sandstone is only 3 to 4 feet thick in the Beaver Meadows GRA and has been thrust out in many places (Mudge et.

al., 1968). It consists of very fine-grained, well sorted and well cemented quartzite. The siltstone unit is less than 100 feet thick in the GRA (Mudge, et. al, 1968) and thins from north to south. It is composed of gray dolomitic siltstone, with interbeds of dolomite and fine-grained sandstone. The upper Helena is a thick dolomite sequence made up of thin-bedded dolomite and argillaceous dolomite which grade upward into thicker bedded dolomite, calcitic dolomite, and dolomitic limestone. These rocks are hard, finely crystalline, dark-gray and weather to a distinctive yellow-gray. Stromatolite colonies up to eight feet thick are abundant in the upper part of the formation. The sandstone unit of the Helena commonly contains sphalerite and galena north of the Beaver Meadows WSA (Mudge et. al, 1968). Some lead mineralization is also reported in the stromatolitic rocks in the upper part of the formation.

The Snowslip Formation ranges from 250 to 700 feet thick. It consists of green, maroon and gray siltstone with some thin sandstone beds (Mudge et. al, 1968). The siltite is finely micaceous and thinly laminated to very thin bedded (Mudge et. al, 1974). Beds of flat pebble conglomerate, oolitic limestone and stromatolitic limestone occur locally. The stromatolite beds are commonly pyritic. The contact between the Snowslip and the underlying Helena is gradational over a 50 to 200 foot interval (Mudge et. al, 1974).

The Mt. Shields Formation gradationally overlies the Snowslip. It is a distinctive red-brown unit made up to two members (Mudge et. al, 1968). The lower red sandstone member is 300 to 825 feet thick and consists of red-brown, thin bedded sandstone that is hard and resistant to weathering. The upper member is red siltstone with some interbeds of sandstone and

green-gray siltstone. This member is non-resistant and ranges from 500 to 925 feet thick.

An angular unconformity separates the Precambrian Y Mt. Shields Formation from the overlying Cambrian Flathead Sandstone (Mudge et. al, 1974). The Bonner quartzite, McNamara and Garnet Range Formations have been removed by erosion over much of the Belt basin (Harrison, 1972). The unconformity is well exposed on the ridges just west of Beaver Meadows (Mudge et. al, 1968) and is present in WSA 075-110.

While eight units make up the Cambrian system in the northern part of the Disturbed Belt (Mudge, 1972a) only one, the Flathead Sandstone, is important in the Beaver Meadows GRA. It is described by Mudge et. al (1968, 1974) and Deiss (1938). Other Cambrian units are present west and north of the GRA. The Flathead Formation is Middle Cambrian (542-515 m.y.) in age and is the oldest Cambrian unit in the northern part of the Disturbed Belt (Mudge et. al, 1968). In this area it is 80 to 115 feet thick (Deiss, 1938, 1939) and consists of yellow-gray, poorly sorted, indurated quartz sandstone which locally grades into quartzite (Mudge et. al, 1968). Cross bedding is common and thin beds of conglomerate and red to gray shale are present locally. The Flathead Sandstone forms the steep cliffs which make up the western half of the Beaver Meadows WSA.

Devonian (395-345 m.y.) rocks, including the Maywood, Jefferson and Three Forks Formations, unconformably overly the Flathead Sandstone. The details of the distribution of these rocks in the Beaver Meadows GRA are not

described in the literature. Mudge et. al (1968) lump the Jefferson and Three Forks Formations into an undivided Devonian unit. Sloss and Laird (1946, 1947) describe the entire section but only in the southern part of the GRA. The Maywood is the lowermost Devonian unit; it outcrops on Monitor Mountain (Sloss and Laird, 1946), but may be absent elsewhere in the Beaver Meadows GRA. It is made up mainly of gray-green dolomitic mudstone which grades upward into thin bedded dolomite. Stratigraphic analysis of the Maywood south of the GRA indicates it was deposited in a tidal flat environment (Meyers, 1980). The Jefferson Formation consists of an unnamed lower member about 500 feet thick and an upper member named the Birdbear which is 200 feet thick (Mudge et. al, 1968). The lower member is mainly gray-brown fetid dolomite and limestone with minor amounts of intraformational breccia. The Birdbear is predominantly gray, thin bedded saccharoidal dolomite with small amounts of calcitic dolomite. The uppermost Devonian unit is the 300 foot thick Three Forks Formation. This formation consists of three lithologies: a lower magnesian limestone, a middle intraformational breccia, and an upper mudstone, siltstone and carbonaceous shale (Mudge et. al, 1968). The breccia unit is up to 85 feet thick along the Dearborn River and forms prominent resistant ledges (Viele, 1960).

The Devonian sequence is unconformably overlain by rocks of the Mississippian Madison Group. The Mississippian section in this region consists of two formations: The Allan Mountain Limestone and the Castle Reef Dolomite (Smith and Gilmour, 1979). Only the Castle Reef Formation is present in the Beaver Meadows GRA. The Castle Reef Dolomite is mostly thick bedded, gray dolomite in the lower part and light-gray thick bedded dolomite in the upper part (Mudge et. al, 1974). These rocks cap the ridges west of

Steamboat Mountain. To the north and along the Sweetgrass Arch the Madison Group is an important hydrocarbon reservoir rock (Montana Geol. Soc., 1979).

The northeast part of the Beaver Meadows GRA is underlain by Mesozoic clastic sedimentary rocks including the Jurassic (195-141 m.y.) Ellis Group and Morrison Formations; the Cretaceous (141-65 m.y.) Colorado Group represented by the Kootenai, Blackleaf; and Marias River Formations; and the Cretaceous Montana Group consisting of the Telegraph Creek; Virgelle; Two Medicine; and Horse Thief Formations (Fig. 4, 5). This section characterizes the Sweetgrass Arch area east of the Montana Disturbed Belt (Balster, 1980). Some of these rocks probably occur in the subsurface of the Beaver Meadows WSA (Fig. 6). The Mesozoic rocks comprise a thick section, over 6,000 feet of marine and non-marine mudstone and sandstone. There are pronounced unconformities between the Jurassic and Mississippian rocks, and the Jurassic and Cretaceous rocks as well as lesser unconformities within the systems. Detailed descriptions of the mesozoic strata are given by Mudge (1972a) and Cobban (1955).

The Ellis Group consists of three members: (1) the basal Sawtooth Formation, (2) the Rierdon Formation, and (3) the Swift Formation (youngest). The Sawtooth ranges from 50 to 225 feet in thickness. It is comprised of three lithologies. The lowermost unit, a thin sandstone overlies Mississippian rocks. The sandstone is locally conglomeratic with pebbles derived from the underlying Mississippian rocks. The middle unit is composed of dark gray pyritic shale and some siltstone which thickens northward. The upper lithology is a prominent unit of gray and brown siltstone. The Sawtooth locally contains cephalopod fossils which provide the

basis for assigning it a Middle Jurassic (176-158 m.y.) age. The Rierdon Formation consists mainly of claystone, siltstone and shale with scattered thin limestone beds ranging from 150 to as much as 500 feet in thickness. Phosphatic nodules occur in the lower part of the unit. The Rierdon is disconformably overlain by the Swift Formation. The Swift is comprised of a lower dark gray shale member and an upper thin bedded sandstone member which have a total thickness of 75 to 120 feet. Both the Rierdon and the Swift Formations are dated on the basis of fossils (Mudge, 1972a).

The conformably overlying Morrison Formation consists of two distinct facies referred to as the western and eastern facies by Mudge (1972a). The western facies, which outcrops in the Sawtooth range, is mainly red-brown mudstone with thick channel sandstone lenses. The eastern facies which outcrops in the low relief area east of the mountains and in the easternmost line of ridges, consists of gray-green interbedded siltstone and sandstone. The western facies ranges up to 550 feet thick whereas the eastern facies is a maximum of 200 feet thick. The two facies grade laterally into one another. Fossils occur locally in the Morrison Formation, but the age is determined primarily by lithologic correlation. The Jurassic-Cretaceous contact is a low-relief unconformity of regional extent marked by channels and basal conglomerate at the boundary (Mudge, 1972a).

The Kootenai Formation consists of variegated non-marine mudstone with numerous poorly sorted sandstone beds and lenticular basal conglomerates (Mudge and Shepard, 1968). It ranges from 650 to 800 feet thick and locally

contains fossil mollusks. The base of the Kootenai consists of a distinctive non-calcareous, thin bedded, quartz sandstone known as the Sunburst Member in the Sweetgrass Arch area (Mudge, 1972a).

The Blackleaf Formation is about 665 feet thick and is made up of three members. The lowermost member is the Flood Shale, mainly a dark gray to black marine shale with thin sandstone beds in its upper and lower part. The overlying Taft Hill Member is a prominent marine clastic unit composed of thin bedded gray sandstone with interbeds of dark gray mudstone and sandy shale. The uppermost Vaughn Member is highly variable in thickness, 300 to 700 feet, and is composed of alternating beds of non-marine mudstone with thin sandstone interbeds and bentonitic mudstone. Thin beds, usually 1-2 inches thick, of bentonite occur sparsely in the unit. Fossils are uncommon in most of the Blackleaf Formation, however, peleycpods are found in the Taft Hill Member which indicate that the unit is Early Cretaceous (141-100 m.y.). A slight disconformity which is believed to represent the transition from Early to Late Cretaceous (100-65 m.y.) marks the contact between the Blackleaf and the overlying Marais River Shale (Mudge, 1972a).

The overlying Marias River Shale is 1,200 to 1,300 feet thick and consists of four members. The basal Floweree Shale is a thin (30-40 feet thick) unit of non-calcareous dark-gray shale, with sparse beds of chert pebble conglomerate. The overlying Cone Member is gray calcareous siltstone and shale with thin beds of calcarenite. A widespread seven foot thick bed of bentonite occurs near the upper part of the Cone. The Cone Member typically has a kerosene odor when freshly broken (Mudge, 1972a) and is correlative with the Greenhorn Shale which is known to contain petroleum (J. Cannon,

Milestone Petroleum, pers. comm. 1982). The Cone is overlain by the Ferdig Shale Member which consists of lower nodular siltstones and sandy shales overlain by a middle unit of bedded sandstone and siltstone succeeded by light-gray sandstone. The top of the Marais River Formation is the Kevin Shale Member, composed mainly of dark gray calcareous shale, siltstone, and claystone, and characterized by numerous limestone concretions and bentonite beds. The Kevin Member is 750-900 feet thick and is the thickest member of the Marais River Formation. Fossils are not abundant in the Marais River, but they do occur in limestone concretions and limey beds.

The Telegraph Creek Formation is dominantly sandstone and sandy shale which comprises the transition between the underlying Marais River Shale and the overlying Virgelle Sandstone. The Telegraph Creek thickens from 340 feet in the west to 550 feet in the east. It is divisible into a lower thin bedded calcareous sandstone, a middle sandstone with sandy shale and siltstone beds and an upper thick-bedded sandstone and sandy shale (Mudge, 1972a).

The Virgelle Sandstone is a well-sorted, fine-grained, poorly indurated, micaceous arkose ranging from 150 to 200 feet in thickness (Mudge, 1972a). It has sparse iron-rich beds which weather to form distinctive cap rocks. To the east and the Virgelle contains titaniferous magnetite lenses (Wimmler, 1946; Earhart et al., 1981).

The Two Medicine Formation consists of up to 2,000 feet of non-marine mudstone and sandstone with carbonaceous and volcaniclastic beds in the lower part. To the east, the Two Medicine grades(?) laterally into the Horse

Thief Sandstone which is composed of massive cross-bedded sandstone (Mudge, 1972a).

Surficial deposits of Quaternary (2 m.y-present) and Pleistocene (2-0.1 m.y.) age mantle the floors and sides of most of the valleys in the Beaver Meadows GRA. Glacial till occurs in the headwaters of some drainages and alluvium is present along most streams. Landslide deposits are reportedly common in areas underlain by Cambrian carbonate rocks (Mudge et. al, 1974).

Diorite sills, up to 300 to 400 feet thick, intrude the Precambrian Y rocks in the Beaver Meadows GRA, especially the Spokane Formation (Mudge et. al, 1968). The sills range from diorite to gabbro in composition and typically contain abundant magnetite (Knapp, 1963). Contact metamorphism adjacent to the sills extends up to 200 feet into the country rocks. These sills have been dated at 750 ± 25 m.y. (Precambrian Z) by potassium-argon methods (Obradovich and Peterman, 1968; Mudge et. al, 1974). Cretaceous intrusives, including Haystack Butte (eight miles north of WSA 075-110), High Bridge Stock (six miles east of WSA 075-110), and an unnamed intrusive (16 miles south-southeast of WSA 075-110 are recognized in the region (Kleinkopf and Mudge, 1972).

2.4 Structural Geology and Tectonics

The structural geology of the Beaver Meadows GRA is characterized by thrust faults, folds and some normal faults which typify the northern Montana Disturbed Belt (Fig. 6). Mapping by Mudge et al. (1968) and Kleinkopf and Mudge (1972) shows that the GRA lies at the southeastern end of a flexure

between northwestward trending thrusts and nearly north trending thrusts (Fig. 3). The area is underlain by several upper plates of folded Precambrian Y and lower Paleozoic sedimentary strata thrusted over a lower plate of west dipping Paleozoic and Mesozoic rocks (Mudge et. al, 1968).

The central part of the Beaver Meadows GRA (Fig. 5), including WSA 075-110, is in a broad zone of complexly folded and faulted rocks between three major thrust faults: the Hoadley, the Eldorado, and the Steinbach (Mudge and Earhart, 1980). The South Fork thrust of Mudge et al. (1968) is the same fault as the Eldorado thrust shown by Mudge and Earhart (1980). The Eldorado thrust is exposed on the east side of Steamboat Mountain where it is marked by a large chevron fold (Mudge and Earhart, 1980). The Eldorado and Steinbach thrusts define a complexly deformed zone up to three miles wide that may include deformed earlier thrust faults (Fig. 5). Displacement on the thrusts within the GRA is small but increases rapidly to the north (Mudge and Earhart, 1980). Disseminated and fracture filling lead-zinc mineralization in the Cambrian and Devonian rocks shows a close spatial relationship to the Eldorado Thrust (Mudge et al., 1968; Leinz and Grimes, 1980a). The Hoadley thrust which is west of the Eldorado thrust, cuts steeply down through the section. The upper plate of the Hoadley thrust forms the east limb of the Continental Divide syncline, a major broad, open, doubly plunging fold of regional extent (Mudge and Earhart, 1980).

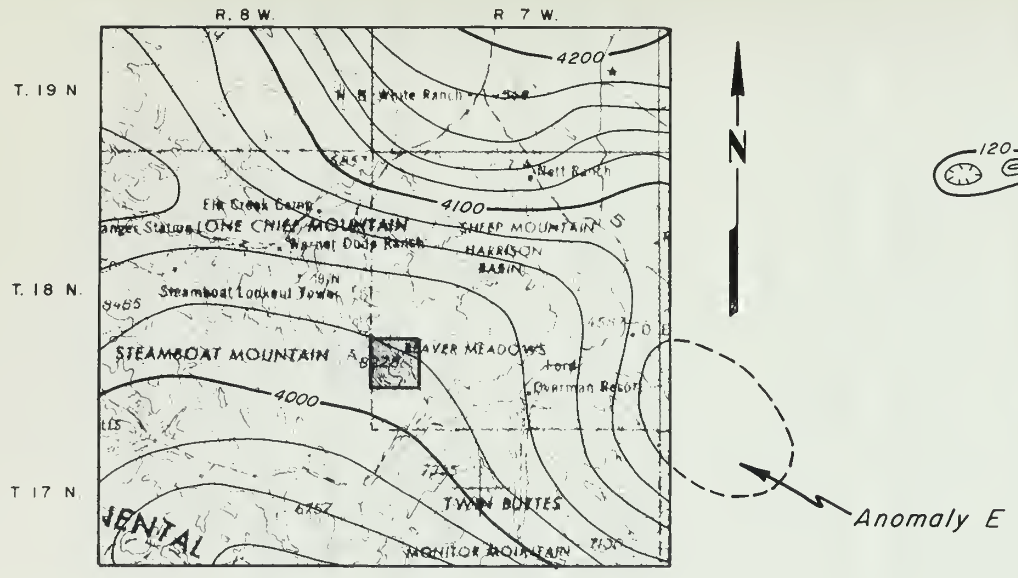
The thrust faulted Disturbed Belt lies west of and is underlain by structural lows which flank the Sweetgrass Arch. This Arch is a positive tectonic feature which was active at various times from Precambrian through Cretaceous time (Mudge, 1972b). Thrust faulting occurred during an orogeny

in very late Cretaceous through mid-Eocene time (Hoffman et. al, 1976; Mudge and Earhart, 1980).

Younger normal faults in the area trend northeast (Mudge et. al, 1968) parallel to a regional subsurface structure (Fig. 7) known as the Scapegoat-Bananatyne trend (Dobbin and Erdman, 1955). This trend which was active mainly in Precambrian and early Paleozoic time (Alpha, 1955) is a major tectonic feature associated with the Sweetgrass Arch. The structure was probably rejuvenated at various later times and so could have caused the younger normal faulting in the area (Mudge et. al, 1968).

2.5 Paleontology

No site-specific paleontologic studies have been done in the Beaver Meadows GRA. Data on fossils is from regional mapping and stratigraphic studies. With the exception of prominent stromatolite colonies in the upper Helena Dolomite (Mudge et. al, 1968), the Precambrian Y rocks in the GRA are largely unfossiliferous. The major Cambrian unit in the GRA, the Flathead Sandstone, is unfossiliferous (Deiss, 1939). The Devonian rocks have well developed and well preserved brachiopod and coral faunas (Sloss and Laird, 1945 and 1946). Fossils are abundant in Madison Group rocks north of the Beaver Meadows GRA (Mudge, et. al, 1962); thus, they are presumably abundant in the Madison underlying the GRA.



LEGEND

CONTOUR OF MAGNETIC INTENSITY – Showing magnetic intensity in nanotesla (gammas). Hatchured to indicate closed areas of lower intensity. Contour interval 10 and 20 nanotesla (nT).

Approximate Boundary of Wilderness Study Area.

Data from Kleinkopf (1980).

WGM Inc. Mining and Geological Consultants Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Aeromagnetic Map

SCALE 1" = 4 MILES (1 250,000)
DATA BY: | DATE 9/1982 | REVISED
DRWN BY DSI | APRVD GF

FIGURE 7

2.6 Historical Geology

The oldest exposed rocks in the Beaver Meadows GRA, the Belt Supergroup, were deposited along the eastern edge of a basin which was an epicratonic re-entrant of a sea to the west. The Spokane and Empire Formations were deposited as a sedimentary prism with a source to the east. The basin deepened considerably following deposition of the Empire Formation. The Helena Dolomite was deposited as the shoreward equivalent of the thick basinal Wallace Formation. This was followed by a major tectonic readjustment in which the basin became more stable and was characterized by limited differential subsidence in early Missoula time. The Mt. Shields and Snowslip Formations thin and coarsen eastward whereas the carbonate-bearing Shepard Formation becomes more clastic eastward. Thus a source area to the east is suggested. A period of uplift accompanied by minor tilting and folding along the east edge of the basin is indicated by the pre-Flathead erosion of the upper Missoula Group (Harrison, 1972).

The area was a shallow shelf again by Cambrian time as indicated by the nearshore Flathead Sandstone. This marked the beginning of a period of transgressions and regressions throughout Cambrian time. A region-wide period of erosion followed forming the pre-Devonian unconformity (Meyers, 1980) which was probably related to reactivation of the Sweetgrass Arch (Mudge, 1970). In Devonian time the area was a partly emergent shallow marine shelf with local restricted basins developed behind stromatoporoid-coral reefoid banks (Mudge, 1972a). This shelf persisted through Mississippian time and resulted in deposition of thick carbonate banks which comprise the Madison Group (Mudge et. al, 1962; Smith and Gilmour, 1979; Gutschick et

al., 1980). The Mississippian-Jurassic unconformity indicates a major period of uplift and erosion (Mudge, 1972a).

The Jurassic marks the beginning of a series of world-wide transgressive-regressive cycles which in North America involved the incursion of boreal seas onto the continent (Peterson, 1981). The Ellis Group records a period of complex gentle uplifts with deposition of clastic debris from the west. These uplifts may in part reflect the initial emplacement of the Idaho and Boulder Batholiths. Relatively gentle pulsating uplifts continued through the Cretaceous and into Tertiary (65-2 m.y.) time (Mudge, 1970). The Colorado Group sediments give evidence for as many as five transgressive-regressive cycles (Mudge, 1972a). The Montana Group records a period of predominantly non-marine brackish water deposition and terrestrial sedimentation with a minor transgression during which the Horsethief Sandstone was deposited (Cobban, 1955).

Emplacement of the Idaho and Boulder batholiths and associated volcanism were major tectonic events in Late Cretaceous time (Peterson, 1981). This may have been accompanied by the initial development of the Montana Disturbed Belt (Mudge, 1970). The major period of thrusting occurred in Paleocene (65-55 m.y.) to late Eocene (44-38 m.y.) time (Huffman et. al, 1976) by gravity sliding of plates along stratigraphically controlled decollments off the uplift to the west (Mudge, 1970). Block faulting followed the thrusting, continuing into Quaternary time (Mudge, 1972a, b) and may have been controlled by deep seated structures of the Scapegoat-Banantyne trend (Mudge et. al, 1968).

3.0 ENERGY AND MINERAL RESOURCES

3.1 Known Mineral and Energy Deposits

There are no known mineral or energy deposits in the Beaver Meadows GRA or WSA 075-110 and there has been no mineral or energy production from the GRA.

3.2 Known Mineral and Energy Prospects, Occurrences and Mineralized Areas

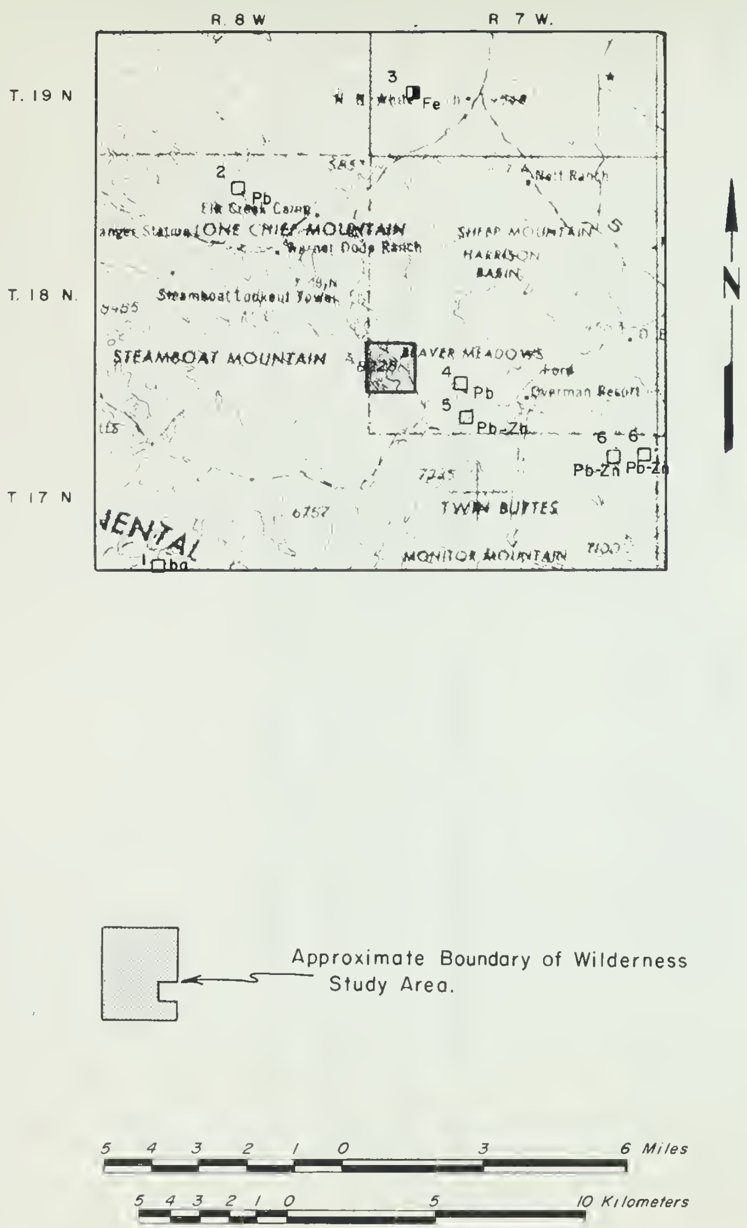
There are six reported mineral occurrences within the Beaver Meadows GRA (Fig. 8, Table I), two of which are just south of WSA 075-110. Four of the occurrences are lead or lead-zinc prospects or showings that are part of a northwest-trending mineralized belt which crosses the GRA (Mudge et al., 1968, Earhart et al., 1981). These occurrences consist of veins, disseminations, and pod-like masses of galena and sphalerite mainly in Cambrian and Devonian rocks. The mineralization is spatially related to the Eldorado thrust and Mudge et al. (1968) conclude that it is structurally controlled. Despite their apparent occurrence in a single belt the prospects have diverse characteristics. Three of the mineralized areas have been prospected by pits and shallow shafts or adits but there is no reported production or grade and tonnage figures (USBM MILS File, 1982).

Mineralization at the Ready Money Mine (loc. 2, Fig. 8) occurs as small masses of galena and pods and as breccia fillings in the infraformational breccia of the Devonian Three Forks Formation and in the fetid brown dolomite beds of the Jefferson formation. Mudge et al. (1968) suggest that

TABLE I

MINERAL OCCURRENCES IN THE BEAVER MEADOWS GRA, MONTANA

Map No.	Name	Location Sec.	T.	R.	Commodity	Type of Occurrence	Description	Source of Data
1	Hector Lode	17	17N	8W	Barite	Prospect pit	Five inch barite vein in Snowslip Formation.	USBM Choteau Quad. MILS File Mudge et al (1971) Berg (1982)
2	Ready Money Mine	3	18N	8W	Lead	Prospect pits and adits	Small masses and pods of galena in intraformational breccia of Three Forks Formation and Jefferson Formation. Area folded and fractured by thrust faults. Sample 526.	USBM Choteau Quad. MILS File Mudge et al. (1968)
3	Burrell and Evans	29	19N	7W	Iron	Prospect	None available. Area underlain by Cretaceous rocks, possibly a a titaniferous magnetite occurrence.	USBM Choteau Quad. MILS File
4	Unnamed	29	18N	7W	Lead	Prospect, shallow shaft	Galena disseminated in Flathead sandstone. Mineralization is in a fault zone adjacent to a diorite sill. The zone is up to 12 feet wide. Sample 430.	Mudge et al. (1968)
5	Unnamed	32	18N	7W	Lead-zinc	Mineral occurrence	Veinlets of coarse pink carbonate with disseminated sphalerite and galena in Spokane Formation sandstone, argillite and dolomite. Sample 395.	Mudge et al. (1968)
6	Cuniff Basin	1, 2	17N	7W	Lead-zinc	Mineral occurrence, possible prospect	Galena and sphalerite disseminated(?) in Paleozoic sandstone and dolomite. Sample 362, 363.	Mudge et al. (1968) Leinz and Grimes (1980a)



LEGEND

- *Mineral Orebody*
- *Mineral Deposit*
- *Mineral Occurrence*
- *Active Quarry*
- *Inactive Quarry*
- *Active gravel or clay pit*
- *Inactive gravel or clay pit*

1 — *occurence number*
Cu — *commodity*

ba - *Barite*
Pb - *Lead*
Fe - *Iron*
Zn - *Zinc*

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Anchorage, Alaska

BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Mineral Deposits and Occurrences

SCALE 1" = 4 MILES (1:250,000)		REVISED	FIGURE 8
DATA BY WGM	DATE 9/1982		
DRWN BY DSI	APRVD G.F		

the mineralization may be Mississippi Valley-Type. Dump material at one prospect in the Ready Money area assays 1% lead (Map No. 526, Table II). Grab samples of mineralized dolomite show over 0.5% lead. Zinc, copper and silver values are low. There are no descriptions of the extent of the mineralized area so it is not possible to make an estimate of the size of the deposits.

Descriptions of the mineralization in Cuniff basin (loc. 6, Fig. 8) are very brief. The prospects consist of galena and sphalerite disseminated in Cambrian and Devonian rocks (Mudge et al., 1968; Leinz and Grimes, 1980a, b). Grab samples of iron-stained sandstone and sulfide bearing dolomite show 0.1 to 0.5% lead and 0.3% zinc (Leinz and Grimes, 1980a, b).

An unnamed prospect in Beaver Meadows (loc. 4, Fig. 8), one mile east of WSA 075-110, consists of disseminated galena adjacent to a diorite sill intruding faulted Cambrian Flathead Sandstone (Mudge et al., 1968). The zone is up to 12 feet wide where exposed in a shallow vertical shaft. Grab samples of dump material assay over 7.5% lead (Map No. 430, Table II). Zinc and silver values are low.

One and one-half miles southeast of WSA 075-110, in Dearborn Canyon (loc. 5, Fig. 8), is an unnamed occurrence consisting of veinlets and disseminations of galena in sandstone and argillite of the Snowslip Formation (Mudge et al., 1968). Grab samples of mineralized sandstone assay over 2% lead and 0.5% zinc (Map No. 395, Table II).

TABLE II

ANOMALOUS ROCK GEOCHEMICAL SAMPLES FROM THE BEAVER MEADOWS GRA, MONTANA

Sample No.	Analytical Data[1] Cu (ppm)	Pb (ppm)	Zn (ppm)	Ag (ppm)	Mo (ppm)	As (ppm)	Description	Source of Data
CH-102	3	1500	300	<1	<2	--	Gray-brown brecciated dolomite, contains a few thin orange-brown iron oxide films on fractures. Fines from dump.	Mudge et al. (1968)
CH-104B	3	10000	250	<1	<2	--	Dolomite with galena as breccia filling. 30 ft. channel sample of dump next to caved shaft.	Mudge et al. (1968)
CH-107	3	>5000	1500	<1	<2	--	Dolomite. Fines from edge of dump at east edge of prospected area.	Mudge et al. (1968)
JAF-233	50	1000	ND	2	ND	ND	Iron-stained sandstone.	Leinz and Grimes (1980
JAF-130	100	5000	3000	ND	ND	ND	Dolomite with sulfides.	Leinz and Grimes (1980
AMS-914	50	>5000	200	7	ND	ND	Sandstone with sulfides.	Leinz and Grimes (1980
CH-118	50	15500	50	7	<2	--	Yellow, medium- to coarse-grained sandstone. Contains sparsely disseminated galena. Shallow prospect pit in Flathead sandstone.	Mudge et al. (1968)
CH-118B	10	20000	<25	2	<2	--	Sandstone, dump beside vertical shaft.	Mudge et al. (1968)
CH-118C	300	50000	50	15	2	--	Sandstone with a few crystals of Apple-green mineral. Dump beside shaft.	Mudge et al. (1968)
CH-118E	20	>75000	200	<10	<2	--	Light gray coarse-grained limestone, interlayered with fine-grained diabase; contains stringers of galena. Found as float below dump.	Mudge et al. (1968)
CH-118F	1000	3000	<200	<1	<2	--	Light gray dolomite cut by white quartz veinlets containing black specks of copper surrounded secondary green mineral. Found as float below dump.	Mudge et al. (1968)
791-BR	300	>20000	ND	10	ND	ND	Sandstone with sulfides.	Leinz and Grimes (1980
CH-120A	7	300	100	<1	<2	--	Yellow powdery material from altered argillite.	Mudge et al. (1968)
CH-120B	30	8000	1500	5	20	--	Iron-rich red-brown gossan-like material.	Mudge et al. (1968)
CH-120C	5	500	5000	<1	<2	--	Calcareous sandstone with sparsely disseminated gray sulfide.	Mudge et al. (1968)
CH-120D	10	150	<25	1	<2	--	Soft brown iron-rich material.	Mudge et al. (1968)
CH-120E	30	100	<25	<1	3	--	Orange-stained argillite.	Mudge et al. (1968)
AMS-916	1500	200	ND	5	ND	5000	Iron-stained diorite.	Leinz and Grimes (1980
AMS-917	200	500	200	15	ND	ND	Iron-stained hornfels.	Grimes and Leinz (1980

ectrographic analyses.

At the Hector lode (loc. 1, Fig. 8), in the southwest corner of the Beaver Meadows GRA, thin veins of barite occur in the Snowslip Formation (Mudge et al., 1971). Vein type barite occurrences are common in portions of the Belt Supergroup in western Montana (Berg, 1982).

The Burrell and Evans property (loc. 3, Fig. 8) is an iron prospect near White Ranch in the northern part of the Beaver Meadows GRA (USBM MILS File, 1982). There is no description of the prospect, however it is probably a titaniferous magnetite occurrence since it is in an area underlain by Cretaceous rocks. Beds of titaniferous magnetite are common in the Cretaceous Virgelle Sandstone (Mudge, 1972a) and the Horsethief Sandstone (Earhart et al., 1981). Deposits in the Virgelle Formation near the town of Choteau, north of the GRA, are extensive and were evaluated by the U.S. Bureau of Mines (Wimmler, 1946). The deposits in the Horsethief Sandstone tend to be small and discontinuous (Earhart et al., 1981).

A portion of the Beaver Meadows GRA is underlain by Mississippian Madison Group carbonate rocks (Fig. 5). Some units in the Madison Group are high calcium limestones or high magnesium dolomites suitable for industrial uses (Earhart et al., 1981). These rocks have been sampled to some extent north of the GRA (Mudge et al., 1962), but there is no data available within the GRA (Chelini, 1965; Earhart et al., 1981).

There are oil shows and seeps in the Lewis and Clark Range but none are reported within the Beaver Meadows GRA (Cavanaugh and Cavanaugh, 1982) nor are there coal-bearing rocks reported in the GRA (Cole et al., 1982).

Sand and gravel are present in the stream and river valleys in the Beaver Meadows GRA but there are no reported gravel pits.

3.3 Mining Claims, Leases and Material Sites

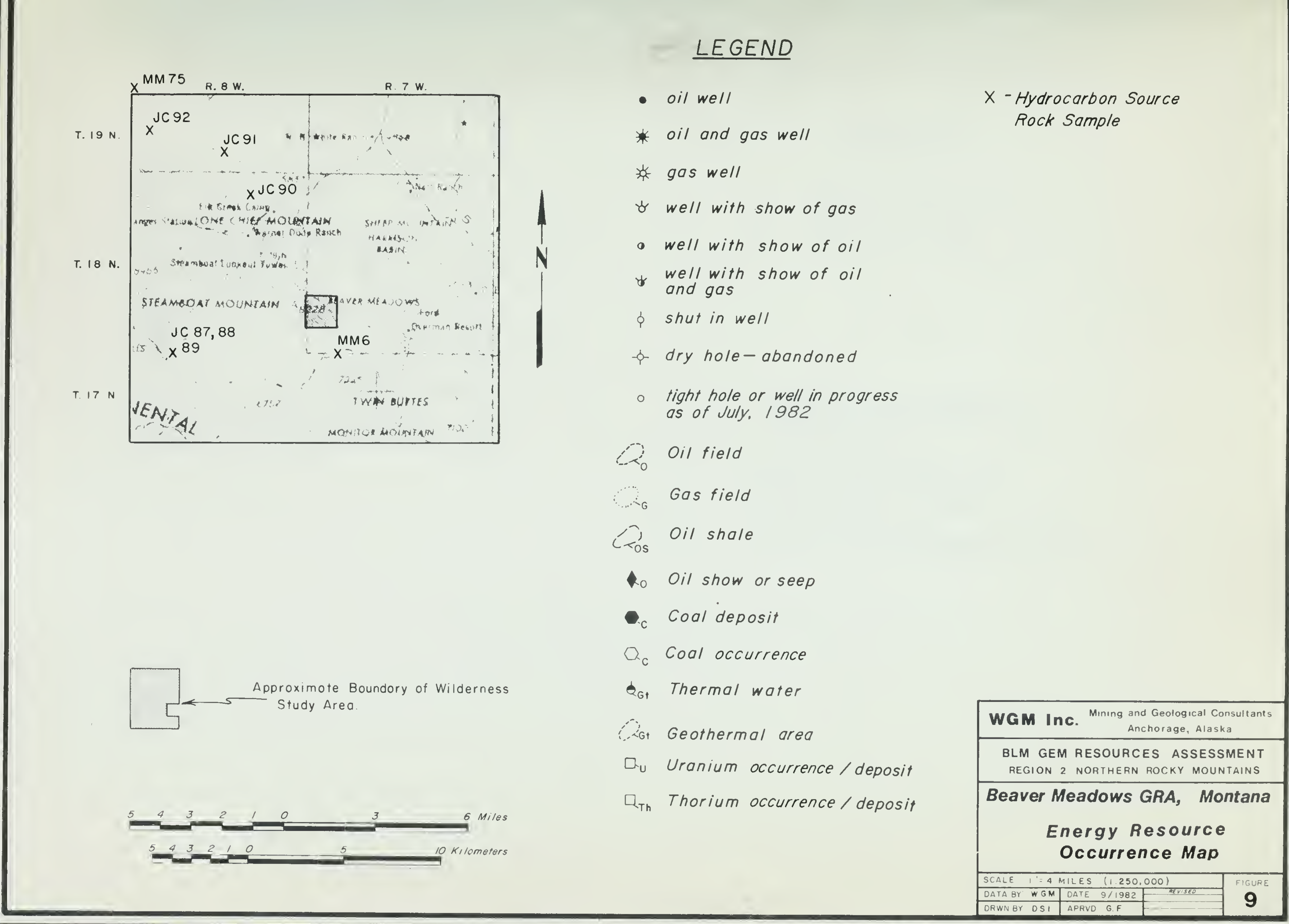
As of August 30, 1982 there are 12 active unpatented mining claims and no patented mining claims in the Beaver Meadows GRA (Fig. 10). All of the claims are located in the Elk Creek area around the Ready Money Mine. There are no mining claims within WSA 075-110.

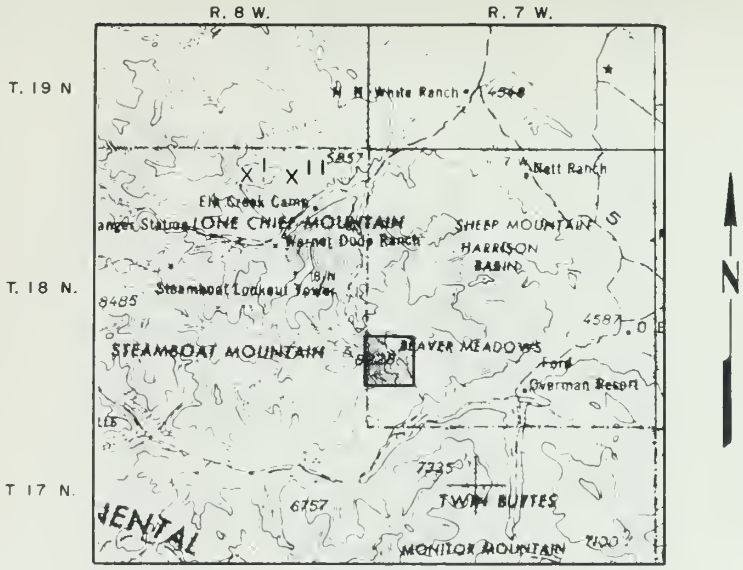
Status plats for T.18N., Rs.7-8W. west were searched for oil and gas leases (Fig. 11). As of August 4, 1982 there are 12 oil and gas leases and 6 lease applications in the two townships. WSA 075-110 is covered by lease no. M33443 issued October 1, 1979. The lease is owned by W.H. Hunt, 2500 First National Bank Bldg., Dallas, Texas 75202.

3.4 Mineral and Energy Deposit Types

Potential types of mineral deposits which could occur within the Beaver Meadows WSA can be assessed by evaluating the geologic setting, known mineral occurrences in the Beaver Meadows GRA, available geochemical and geophysical data, and comparison with regionally significant mineral deposits outside the GRA.

The known metallic mineral occurrences previously described in the Beaver Meadows GRA are of four types:


LEGEND
MM75
R. 8 W.
R. 7 W.
T. 19 N.
T. 18 N.
T. 17 N
JC 92
JC 91
JC 90
LONE CHIEF MOUNTAIN
Steamboat Lookout Tower
STEAMBOAT MOUNTAIN
BEAVER MEADOWS
JC 87, 88
89
MM6
TWIN BUTTES
MONITOR MOUNTAIN
N
Approximote Boundory of Wilderness Study Area.
5 4 3 2 1 0 3 6 Miles
5 4 3 2 1 0 5 10 Kilometers
oil well
oil and gas well
gas well
well with show of gas
well with show of oil
well with show of oil and gas
shut in well
dry hole—abandoned
tight hole or well in progress as of July, 1982
Oil field
Gas field
Oil shale
Oil show or seep
Coal deposit
Coal occurrence
Thermal water
Geothermal area
Uranium occurrence / deposit
Thorium occurrence / deposit
X - Hydrocarbon Source Rock Sample
WGM Inc. Mining and Geological Consultants Anchorage, Alaska
BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS
Beaver Meadows GRA, Montana
Energy Resource Occurrence Map
SCALE 1" = 4 MILES (1:250,000)
DATA BY WGM
DATE 9/1982
DRWN BY DSI
APRVD G.F
REVISED
FIGURE 9



EXPLANATION

X — *Unpatented Mining Claim*

▲ — *Patented Mining Claim*

NOTES:
1) Number adjacent to symbol indicates number of mining claims in that section.
2) Area of claims search: GRA
3) Data current to: August 30, 1982
4) Source of Data: BLM Claims Microfiche.

Approximate Boundary of Wilderness Study Area.

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Mining Claims Density Map

SCALE 1" = 4 MILES (1 250,000)			FIGURE
DATA BY WGM	DATE 9/1982	REVISED	10
DRWN BY DS1	APRVD G.F		

1. fracture filling and replacement lead-zinc mineralization or open-space filling (Mississippi Valley-Type) in lower Paleozoic sedimentary rocks along the Eldorado thrust,

2. lead-zinc mineralization in the Helena Dolomite,

3. barite veins(?) in Belt Group rocks,

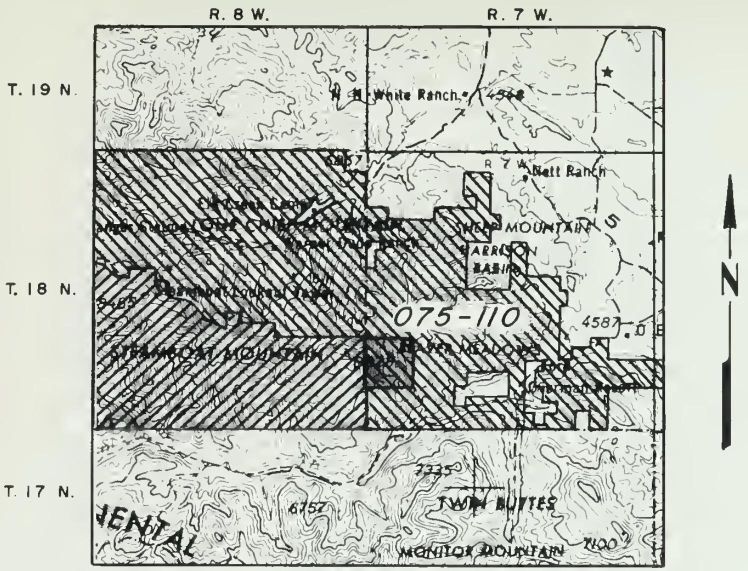
4. stratabound(?) iron (titaniferous magnetite?) in Cretaceous sedimentary rocks.

Evaluation of the available geochemical and aeromagnetic data discussed in the following sections suggests potential for two additional types of metallic mineralization (Grimes, Leinz and Hopkins, 1980; Kleinkopf, 1980):

1. copper mineralization associated with Precambrian diorite sills

2. vein-type mineralization peripheral to/or overlying stocks or volcanic breccia pipes.

The U.S. Geological Survey has published data (Appendix II and III) for 29 stream sediment samples and 61 rock geochemical samples from the Beaver Meadows GRA (Grimes, Leinz and Hopkins, 1980). Most of this data consists semi-quantitative spectrographic analyses which are of limited value because of the high detection limits of this analytical method. The sixty-one rock samples collected by the U.S. Geological Survey in the GRA are shown on Figure 12 and anomalous samples are listed and described in Table II. All



LEGEND

- AREA COVERED BY OIL AND GAS LEASES
- AREA COVERED BY OIL AND GAS LEASE APPLICATION

NOTES:
1) Area of seach: T 18 N, R 7, 8 W
2) Data current to: Aug. 4, 1982
3) Source of Data: BLM Status Plats

Approximate Boundary of Wilderness Study Area.

5 4 3 2 1 0 3 6 Miles

5 4 3 2 1 0 5 10 Kilometers

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Oil and Gas Lease Status

SCALE 1" = 4 MILES (1 250,000)			FIGURE
DATA BY WGM	DATE	REVISED	11
DRWN BY DSI	APRVD		

but two of the samples are from mineral occurrences described in Section 2.2.

The sediment sample data shows anomalous amounts of lead (loc. 313 and 332, Fig. 12; Appendix II) associated with the galena and sphalerite mineralization at Cuniff Basin in the southeast corner of the Beaver Meadows GRA (Leinz and Grimes, 1980a). Inspection of copper, zinc, and silver values (Table III) in comparison with data for the entire Choteau quadrangle shows no anomalies (Fig. 13). Most copper values are in the 20-30 ppm range, zinc less than 200 ppm (below the detection limit), and silver less than 0.5 ppm (below the detection limit). The sample distribution is not adequate to evaluate the GRA (Fig. 12) as samples have not been collected from all of the drainages nor is the sample density consistent. Since there are no sediment samples from the stream draining the Beaver Meadows WSA, sediment sample data is not of direct value in evaluating the WSA.

The two anomalous rock samples (nos. 916 and 917 at Site 394, Fig. 12; Appendix III), from an area not previously described, have anomalous copper, silver, and arsenic values (Leinz and Grimes, 1980c; Grimes and Leinz 1980a, b). The samples are iron-stained diorite and hornfels from a Precambrian sill on Falls Creek about three miles southeast of WSA 075-110. A similar diorite sill is associated with lead mineralization in Beaver Meadows about one-mile east of the southeast corner of the WSA (Mudge et al., 1968).

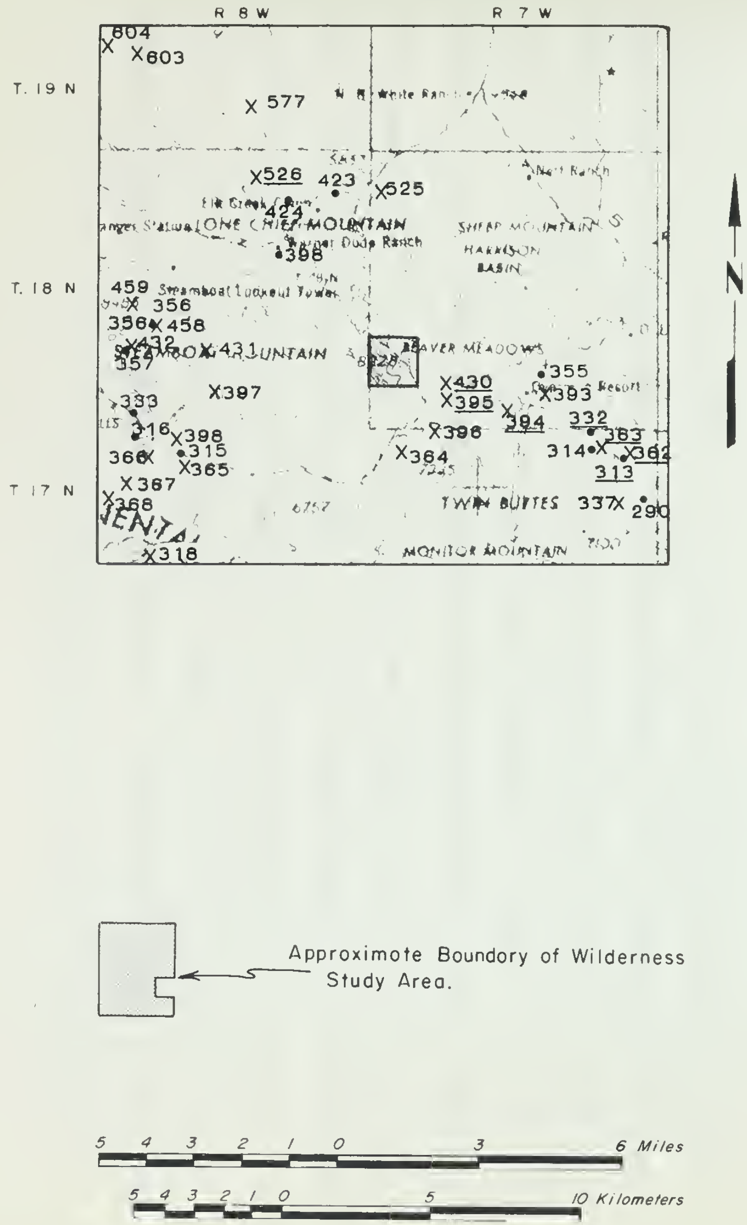
Aeromagnetic data for the Beaver Meadows GRA (Fig. 7) shows the edge of a positive magnetic anomaly over Cuniff Basin adjacent to the southeast corner of the GRA. This anomaly is referred to as "Anomaly E" by Kleinkopf (1980)

TABLE III

SUMMARY OF STREAM SEDIMENT SAMPLE DATA,

BEAVER MEADOWS GRA, MONTANA

Element	Range of Values (ppm)	Norm (ppm)	Anomalous Values (ppm)
Cu	5-30	20-30	---
Pb	10-2,000	10-50	100-2,000
Zn	<200	<200	---
Mo	ND	ND	---
Ag	ND	ND	---
Au	ND	ND	---
W	ND	ND	---
Sn	ND	ND	---
Hg	<0.02-0.06	---	---
Ba	150->5,000	1,000-5,000	---
Mn	150-1,500	200-700	1,500
As	ND	ND	---
B	<10-100	10-70	70-100
Be	<0.5-1.5	<0.5	1.5
Bi	ND	ND	---
Cd	ND	ND	---
Co	<5-10	<10	---
Cr	20-100	<50	70-100
La	<20-50	<50	---
Bb	<10-10	<10	10
Ni	10-100	50	100
Sb	ND	ND	---
Sc	<5-10	<10	---
Sr	<100-700	<700	---
V	20-300	70-100	>100
Y	<10-30	<10	15-30
Zr	<10-300	<10-70	100-300



X Rock Sample

• Stream Sediment Sample

NOTE: Locations with anamalous samples are underlined.

Data by: Grimes, Leinz and Hopkins, 1980

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

U. S. Geological Survey Geochemical Sample Locations

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

or "Anomaly 7" by Kleinkopf and Mudge (1972). The anomaly reflects the High Bridge stock which underlies the Cuniff Basin area (Kleinkopf, 1980). This stock is a trachyandesitic mass of probable Tertiary age which resembles a volcanic breccia pipe (Viele and Harris, 1965). The geochemical data previously discussed indicates potential for copper mineralization in or adjacent to the Precambrian diorite sills. The association of lead mineralization with a stock or breccia pipe at Cuniff Basin and with a sill in Beaver Meadows suggests that the association of mineralization with intrusive events may be of regional importance. If this association is valid, then the limits of the aeromagnetic high at Cuniff Basin give an indication of the extent of the favorable area for such mineralization. However, the aeromagnetic survey is insufficiently detailed to delineate the extent of the diorite sills.

A comparison of the geologic setting of mineral deposits elsewhere in Montana to the geologic setting of the Beaver Meadows GRA shows that potential exists in the GRA for the occurrence of porphyry molybdenum and copper-silver mineralization. Green-bed copper-silver mineralization consisting of grossly concordant concentrations of copper minerals in metasedimentary rocks of the Belt Supergroup (Earhart et al., 1981; Clark, 1971; Harrison, 1972, 1974) occurs in the Spar Lake deposit near Troy, Montana. The deposit falls into the class of sediment-hosted stratiform mineralization (Gustafson and Williams, 1981). The Spar Lake deposit has reserves of 63.8 million tons with an average grade of 0.76% copper and 1.58 oz of silver per short ton (Mining Magazine, 1982; Todd, 1982). This type of mineralization occurs in all of the units of the Belt Supergroup except the Bonner quartzite and the Garnet Range Formation (Harrison, 1972; Mudge et

al., 1979). The deposits occur in green quartzite, siltite and/or argillite in sections of interbedded green and red sediments. Bornite, chalcocite and chalcopyrite are the principal copper minerals. There are no reported occurrences of Beltian copper-type mineralization within the GRA, but mineralization of this type does occur in the Snowslip Formation at Wood Canyon northeast of the GRA and the favorable green-bed sequence is present in the Beaver Meadows GRA and in the northeast third of WSA 075-110 (Earhart et al., 1981). Porphyry molybdenum mineralization is associated with a quartz-monzonite stock in the Heddleston district southeast of the Beaver Meadows GRA (Miller et al., 1973). The lack of intrusive rocks in or below the Beaver Meadows WSA, as indicated by the aeromagnetic data, suggests that the potential for this type of deposit within the WSA is low.

The uranium potential of the Choteau quadrangle, which includes the Beaver Meadows GRA, was evaluated by the Department of Energy as part of the NURE program (Arendt, 1981; Zinkl et al., 1982). The NURE work consisted of a hydrogeochemical and stream sediment sampling reconnaissance program (Arendt, 1981). The data was compiled by Zinkl et al. (1982) who do not discuss or evaluate the data. Six stream sediment samples were collected in the GRA. All six contained approximately 3 ppm uranium which is the mean value of all of the samples collected in the Choteau quadrangle (Zinkl et al., 1982).

Uranium potential of the Beaver Meadows GRA can also be evaluated by comparison of the geologic environment in the GRA with that of known uranium producing environments. The average uranium content of the earth's crust is

about 2 ppm, and that of granite is about 4 ppm, or 4 grams per tonne. Felsitic volcanic rocks tend generally to contain more uranium than their plutonic equivalents, perhaps as much as 50% more. To be commercially exploitable, a uranium deposit must ordinarily contain at least 1,000 ppm or one kilogram per tonne, and many deposits being mined today contain appreciably more. The primary source of uranium is from felsic igneous rocks such as granite, syenite, pegmatite, and rhyolite. Because of its large ion size, uranium does not enter the ordinary rock-forming minerals except as inclusions; hence, in the formation of granitic masses, it forms its own minerals, forms an intergranular film, enters some accessory minerals such as zircon, sphene, or biotite, or it concentrates in late magmatic differentiates; hence, its occurrence in veins and pegmatites.

The uranium minerals, mostly in the tetravelent state in igneous rocks, oxidize readily to provide hexavalent uranium which is removed by surface waters. If carried by groundwater, the uranium may be partially absorbed by clay or carbonaceous matter, or it may be precipitated in a chemically hospitable environment by reduction or evaporation, or by combining with another element to form a mineral stable in the oxidized state. If carried to the ocean, it tends to precipitate with phosphatic sediments or be absorbed by organisms or carbonaceous mud. The uranium-bearing accessory minerals, being resistant to erosion, are more likely to weather out of the igneous host as detritus and become dispersed in detrital sediments or, more rarely, concentrated into placers.

Uranium deposits are of many types. However three ore environments, in about equal amounts, host 90% of the free world uranium reserves. These are:

1. early Precambrian quartz-pebble conglomerates,
2. sandstone-hosted roll-front deposits, mainly of post carboniferous continental sandstones, and
3. unconformity vein deposits, thus far known only in Proterozoic rocks.

Until the late 1960s, exploration emphasis was directed toward discovery of stratabound ores in sandstone and in quartz-pebble conglomerate. Such deposits are still the source of the most production. Vein deposits then known, although widespread and of high-grade, were generally small and in aggregate considered to be of lesser importance. However, the very important discoveries of the past 15 years, in northern Australia and in central Canada, comprise a distinctive type of pitchblende-lode deposit described as unconformity veins. These deposits occur at or near the unconformity between lower and middle Proterozoic rocks. They are high-grade orebodies of variable sizes, and collectively account for about one-third of free world uranium reserves.

In the classical vein deposits, uranium is almost always accompanied by hematite and in the unconformity veins nickel, cobalt, and arsenic may be present. Sulphides of copper, lead, and molybdenum may occur in either type. Uranium in peneconcordant sandstone deposits is accompanied by iron (as pyrite if the ore is unoxidized) and in many cases by copper, molybdenum, selenium, and vanadium. This type of deposit accounts for about 95% of U.S. reserves. The second type of sedimentary deposits, the Precambrian conglomerates, are very large, but also very limited in distribution.

In light of the above it can be seen that the marine sedimentary rocks which underlie most of the Beaver Meadows GRA and all of the WSA 075-110 are generally not a favorable environment for uranium deposits. The non-marine portions of the Mesozoic clastic sedimentary section in the northeast part of the GRA could be a favorable environment for sandstone-hosted uranium mineralization and these rocks may occur in the subsurface of the Beaver Meadows WSA.

In summary an evaluation the regional mineral deposits and occurrences, geochemical and aeromagnetic data, and the geologic environment of the area adjacent to the Beaver Meadows GRA indicates that the geological setting of the WSA is favorable for several types of mineral deposits. These are: (1) fracture filling and replacement mineralization in the Flathead Sandstone along the Eldorado Thrust, (2) base metal mineralization associated with Precambrian diorite sills, and (3) stratabound copper-silver mineralization in Belt Group sediments.

No hydrocarbon production is known within the Beaver Meadows GRA. Past hydrocarbon exploration in the Montana Thrust Belt is summarized by Darrow (1955) and the Montana Geological Society (1979). Exploration has been rather slow because no major discoveries were made during earlier years of low prices and seismic techniques were inadequate to properly interpret the subsurface structures (Hurley, 1959). Interest in the area has been sporadic but the potential has been postulated by several individuals over the years (Hurley, 1959; Cannon, 1971; Woodward, 1981; McCaslin, 1981). The interest has continued because: (1) the area is proximal to major oil and gas fields along the Sweetgrass Arch; (2) structures analogous to those in

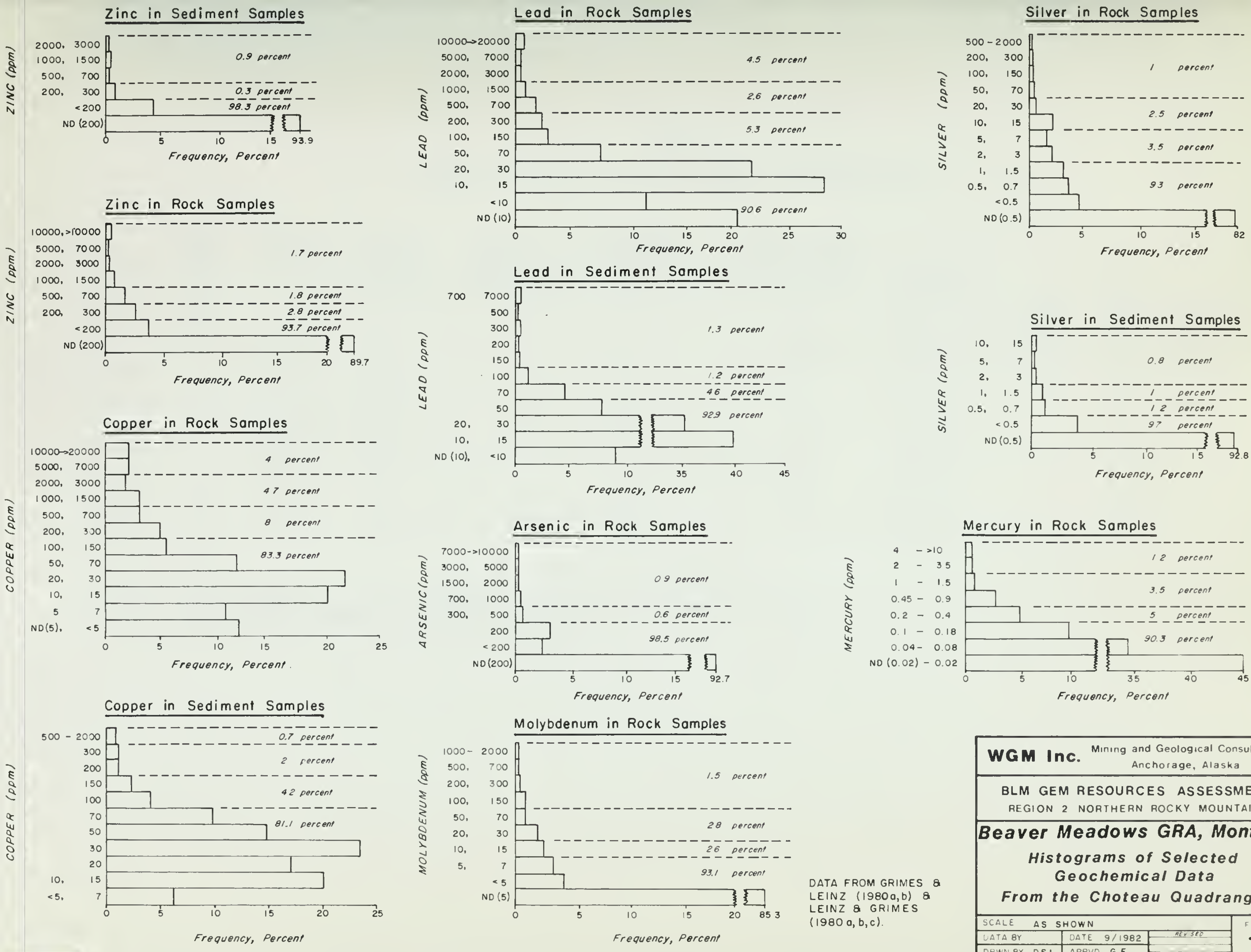
the Montana Disturbed Belt are prolific hydrocarbon producers in Alberta and Wyoming; (3) oil seeps are known in the Montana Disturbed Belt; and (4) commercial hydrocarbons have been discovered in the Blackleaf Canyon and Two Medicine fields within the Montana Disturbed Belt.

Potential hydrocarbon source beds from the eastern half of the Choteau quadrangle were analyzed by Mudge et al. (1980). Their analyses suggest that hydrocarbon source beds are present within the Beaver Meadows GRA (Table IV, Fig. 9). Known reservoir beds in some of the Sweetgrass Arch hydrocarbon fields are also present in the Beaver Mountains GRA. These are:

Age	Formation
Cretaceous	Blackleaf Formation
Jurassic	Swift Formation Sawtooth Formation
Mississippian	Sun River Member, Castle Reef Dolomite

Thermal maturation studies of source beds in the eastern half of the Choteau quadrangle by Mudge et al. (1980) suggested that the Thrust Belt potential is mainly for gas. This would include the Beaver Meadows GRA.

No wells have been drilled within the Beaver Meadows WSA but two wells have been drilled near the GRA. One in sec. 11, T.18N., R.6W. (Soap Creek Cattle Comany #1-A) and the other in sec. 9, T.19N., R.8W. The Soap Creek Cattle Company #1-A was 6,882 deep and bottomed in a sill within or below the Morrison Formation; no shows were reported (Montana Oil and Gas Conservation Commission, 1960). This well was not deep enough to adequately test the



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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Histograms of Selected Geochemical Data From the Choteau Quadrangle

SCALE AS SHOWN			FIGURE
DATA BY	DATE 9/1982	REV SED	13
DRWN BY DSI	APRVD G.F		

TABLE IV

BEAVER MEADOWS GRA, ANALYSES OF HYDROCARBON SOURCE ROCK SAMPLES[1,2]

Sample No.	Sample Interval (ft.)	Organic Carbon (%)	Pyrolitic Hydrocarbon Yield (%)	Volatile Hydrocarbon Content (ppm)	Pyrolitic Hydrocarbon Organic Carbon (%)	Temperature of Maximum Pyrolisis Yield (°C)	Formation	Age
MM 75	Grab	1.49	0.14	51	9.6	487	Blackleaf, Flood Member	Upper Cretaceous
JC 92	"	0.77	0.02	19	2.5	502	Blackleaf, Flood Member	Upper Cretaceous
JC 90	"	0.90	0.04	14	4.2	505	Blackleaf, Flood Member	Upper Cretaceous
JC 91	"	0.37	0.02	16	4.3	520	Sawtooth	Middle Jurassic
JC 87	"	0.32	0.06	71	18.3	499	Threeforks	Devonian
JC 88	"	0.11	0.03	36	28.1	492	Threeforks	Devonian
JC 89	"	0.36	0.08	94	22.3	491	Threeforks	Devonian
MM 6	"	0.08	0.010	30	12.9	---	Gordon Shale	Cambrian

Notes: 1. Organic carbon by combustion and pyrolitic hydrocarbon yield by thermal analysis.
2. Data from Mudge, Clayton and Nichols (1980), Table 2.

entire stratigraphic section having hydrocarbon potential. It should at least have penetrated the Mississippian strata and probably should have tested any suspected lower thrust plates. The other well was projected to be a 12,000 foot Sun River test, but no data is available on the well at this time.

The presence of intrusives within a few miles of the Beaver Meadows GRA may reduce its hydrocarbon potential. Earhart et al. (1977) concluded that the eastern part of the Silver King-Falls Creek addition to the Scapegoat Wilderness Area, six miles south of the Beaver Meadows WSA, required further study before a proper evaluation could be made for hydrocarbon potential. However Mudge et al. (1980) concluded that much of the eastern half of the Choteau quadrangle including the Beaver Meadows GRA, has high potential for hydrocarbon discovery. Considering the regional oil and gas potential of the Montana Disturbed Belt, additional studies are needed to fully evaluate the hydrocarbon potential within the Beaver Meadows GRA.

In conclusion, hydrocarbon source beds and reservoir beds are known within the Beaver Meadows GRA (Mudge et al., 1980). In addition, thermal maturation studies suggest a potential for gas production (Mudge et al., 1980), but structural data is insufficient to determine if adequate traps for hydrocarbons exist within the Beaver Meadows GRA.

There is no data on geothermal resources in the GRA. Consequently, the potential must be evaluated by analogy with areas in similar geologic settings. 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 (150°C) hydrothermal convection systems
3b. Intermediate temperature (90-150°C) hydrothermal convection systems
4. Low temperature (90°C) hydrothermal convection systems
5. Geo-pressured geothermal energy systems

For the purposes of this evaluation these classes can be reduced to two: (1) high temperature (greater than 150°C) hydrothermal convection systems and (2)low/intermediate temperature (40-150°C) hydrothermal convection systems.

Based on present requirements for use of hot fluids in electrical generating techniques, geothermal systems with temperatures of less than 150°C cannot be considered to have significant potential for electrical exploitation. Geothermal resources with temperatures less than 150°C can be considered to 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 of 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 discussion, a lower

temperature than approximately 40-60°C is considered uneconomic as a geothermal resource. Another 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.

Most geothermal exploitation to the present time has involved areas with surface manifestations. There are geothermal systems which have no surface manifestations and are therefore "blind". An example of this sort of system exists in the Marysville mining district in central Montana (Blackwell et al., 1975; Blackwell and Morgan, 1976). The area is near the Continental Divide and the bedrock is contact metamorphosed Precambrian Belt Series rocks underlain by Cretaceous and Cenozoic (65 m.y. to present) intrusive rocks. An area of approximately 50 square miles has a heat flow well above the regional background and at least half that area is underlain by a geothermal system with temperatures of approximately 100°C. The possibility of the existence of such systems is always present and cannot be ruled out without site-specific geothermal exploration data.

The Beaver Meadows GRA is within the Cordilleran Mountain Belt of western North America. Volcanic and tectonic processes have been active in these areas within the past few millions of years and there are extensive manifestations at the surface of geothermal resources. However, within this area there are quite significant geographic variations. GEM Region 2, which includes the Beaver Meadows GRA can be divided into six provinces of different geothermal significance.

TABLE V

GEOTHERMAL PROVINCES IN GEM REGION 2

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

The Beaver Meadows GRA is in the Montana Thrust/Foothills geothermal province.

The Montana Thrust/Foothills geothermal province is bounded on the west by the Montana Basin and Range province and on the east by the Great Plains province. Heat flow values in the Great Plains are normal at approximately 40-60 milliwatts per square meter (Blackwell, 1969). Because the heat flow is normal, gradients are generally fairly low in typical rocks within the Great Plains province (20-40°C/km, 1.1-2.2°F/100 ft.). However, there are many artesian aquifers in the sedimentary section. Some of these aquifers are quite deep, and thus have quite warm water due to the burial depth. The Madison Limestone, one of the deeper major aquifers, underlies much of eastern and central Montana. Average geothermal gradients from the surface to the Madison Limestone have been calculated by Balster (1975) and, given the depth of the Madison, these gradients can be used to estimate the temperature in the Madison. In most cases the depths are too great for exploitation except in the case where deep holes may already be drilled for hydrocarbon exploration which, if unproductive, can be turned into geothermal wells. Temperatures and gradients in this province are such that

only the occurrence of low and intermediate temperature geothermal resources can be expected.

The Montana Thrust/Foothills province probably has a geothermal setting similar to the Great Plains province. However, virtually nothing is known about the hydrologic or geothermal character of the Thrust/Foothills region because of the lack of drilling and the complex geology. It is likely that recharge for some of the aquifers in the Great Plains might take place through rocks exposed at high elevations in the Thrust/Foothills province; therefore, temperature gradients may be depressed in this region. On the other hand, there is a transition within the Thrust/Foothills province to higher heat flows which are characteristic of the Montana Basin and Range province to the west. Thus, along the western margin of the Thrust/Foothills province the background conductive heat flows might be higher than observed in the Great Plains province where maximum aquifer temperatures at a depth of 1 km or less are generally less than 40 to 50°C.

Subsurface temperatures in the Beaver Meadows GRA may be controlled by regional groundwater circulation in the sands, shales, and limestones of the Thrust Belt. No heat flow measurements exist in this hydrologic or geologic setting in western Montana and there are no known geothermal data on water in the GRA or Beaver Meadows WSA. Conclusions derived from the analysis of regional data pertaining to the Sawtooth GRA (WGM, 1983) can be extended to the Beaver Meadows GRA as well. The nearest heat flow measurements are from the Heddleston Mining district (20 miles south) which is in a different geologic setting; Belt series sedimentary rocks intruded by Mesozoic granitic rocks. The heat flow value there is typical of the Montana Basin and

Range province. The nearest hot springs are at Sun River Springs approximately 30 miles to the north, along geologic strike and in a similar geologic setting to the GRA. The Marysville system, with no surface manifestations, occurs in an area where Cenozoic granitic rocks have intruded the Belt Series, and is located about 38 miles to the south. The maximum temperature observed in the Marysville system is 105°C.

3.5 Mineral and Energy Economics

Economically the most significant potential which might be present in the Beaver Meadows GRA is for oil and gas. With the increase in the price of imported oil in the past decade, the deregulation of domestic natural gas prices, and increasing government emphasis on energy self sufficiency, exploration and development of domestic oil and gas resources has proceeded at an accelerated pace. Natural gas reserves discovered in the late 1950s and 1960s north of the GRA were not developed because of a lack of market (Heany, 1961). However, under present conditions development drilling is taking place with an eye to near-term production.

Metallic mineral exploration in the region surrounding the Beaver Meadows GRA has fluctuated with variations in metal prices. Strong demand coupled with high prices led to discovery of the Heddleston molybdenum deposit south of the GRA (Miller et al., 1973) and exploration of the lead-silver belt associated with the Eldorado Thrust zone. The rise in the price of silver in the late 1970s spurred considerable exploration interest. U.S. market demand has steadily increased as more industrial uses for silver are found (Rosta, 1982). Silver deposits formerly considered to be low grade are now

economically attractive at present prices. Additionally, recoverable silver values in base metal ores, e.g. lead or copper, now make a substantial contribution to mine profits. Despite low copper prices the Troy Mine, a copper-silver deposit in Belt rocks, is presently very profitable (Todd, 1982).

None of the potential mineral commodities in the Beaver Meadows GRA are classed as a strategic mineral.

4.0 LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

4.1 Explanation of Classification Scheme

In the following subsection the land in the Beaver Meadows WSA is classified for geology, energy and mineral (GEM) resources potential. The classification scheme used is shown in Table VI. Use of this scheme is specified in the contract under which WGM prepared this report.

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

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

TABLE VI

BUREAU OF LAND MANAGEMENT GEM RESOURCES LAND CLASSIFICATION SYSTEM

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

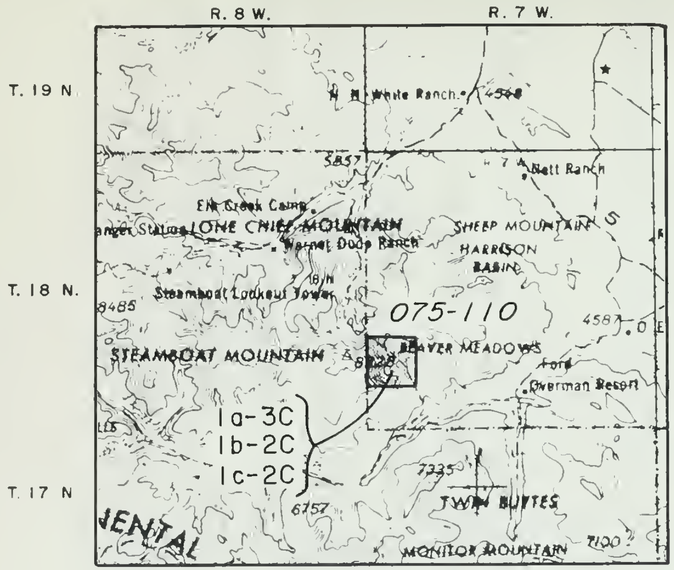
4.2 Classification of the Beaver Meadows Wilderness Study Area

4.2.1 Locatable Minerals

Locatable minerals are those which are locatable under the General Mining Law of 1872, as amended, and the Placer Act of 1870, as amended. Minerals to which are locatable under these acts include metals, ores of metals, non-metallic minerals such as asbestos, barite, zeolites, graphite, uncommon varieties of sand, gravel, building stone, limestone, dolomite, pumice, pumicite, clay, magnesite, silica sand, etc. (Maley, 1980).

4.2.1a Metallic Minerals. All of WSA 075-110 (1a, Fig. 14) is classified as having moderate favorability for metallic minerals based on limited direct evidence (3C). Vein and replacement lead-zinc-silver mineralization associated with the Eldorado Thrust zone and stratabound copper-silver mineralization in Beltian sedimentary rocks have the highest potential. The basis of the classification is: (1) the WSA lies astride the Eldorado Thrust, (2) mineral showings are associated with the thrust adjacent to the WSA, and (3) a favorable green-bed sequence is present in the northeast third of the WSA. The Belt sediments and the Thrust zone dip to the southwest beneath the Flathead Sandstone which outcrops in the southwest two thirds of the WSA; therefore, the 3C classification is applied to the entire WSA.

4.1.1b Uranium and Thorium. All of WSA 075-110 (Area 1b, Fig. 14) is classified as having low favorability for uranium and thorium based on limited direct evidence (2C). This classification is based on a review of



Approximate Boundary of Wilderness Study Area.

5 4 3 2 1 0 3 6 Miles

5 4 3 2 1 0 5 10 Kilometers

BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

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

LEVELS OF CONFIDENCE

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

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

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

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

EXPLANATION

1 a - 4D

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

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

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Wilderness Study Area
Land Classification
Locatable Resources

SCALE 4 MILES (1:250,000)		FIGURE
DATA BY WGM	DATE 9/1982	14
DRWN BY DS	APPRVD GF	

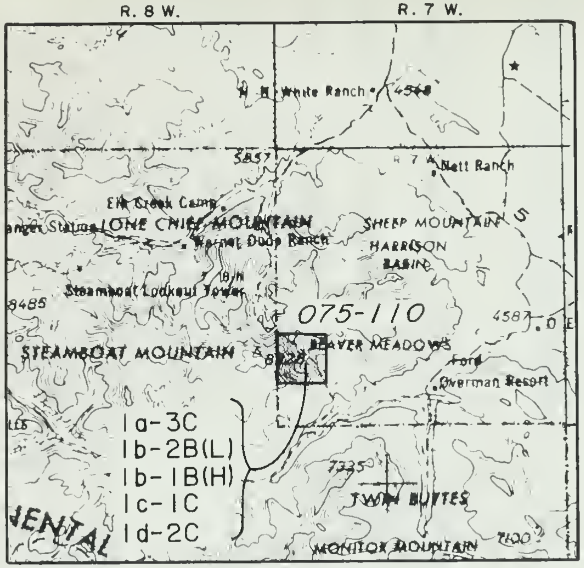
NURE data for the area, a lack of known occurrences and/or geochemical anomalies, and the similarity of the geologic environment to known uranium-thorium producing environments.

4.1.1c Non-Metallic Minerals. The entire area of WSA 075-110 (1c, Fig. 14) is classified as having low favorability for non-metallic locatable mineral resources based on limited direct evidence (2C) because known occurrences are absent regionally as well as within the WSA.

4.2.2 Leasable Resources

Leasable resources include those which may be acquired under the Mineral Leasing Act of 1920 as amended by the Acts of 1927, 1953, 1970, and 1976. Materials covered under this Act include: asphalt, bitumen, borates 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, 1980).

4.2.2a Oil and Gas. The entire area of WSA 075-110 (1a, Fig. 15) is classified as having moderate favorability for oil and gas resources based on limited direct evidence (3C). The basis of this classification is the location of the Beaver Meadows GRA in a geologic province with known potential hydrocarbon production, the presence of hydrocarbon source and reservoir beds productive elsewhere in the region, and the probable presence of structures suitable to for hydrocarbon traps.



Approximate Boundary of Wilderness Study Area.

BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

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

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

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

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

LEVELS OF CONFIDENCE

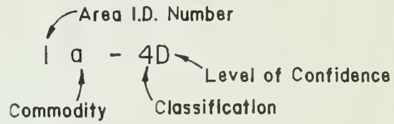
A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

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

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

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

EXPLANATION



a) oil and gas

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

c) Sodium and Potassium

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

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Wilderness Study Area Land Classification Leasable Resources

SCALE 4 MILES (1:250,000)			FIGURE
DATA BY WGM	DATE 9/1982	REVISED	15
DRWN BY DS	APPVD GF		

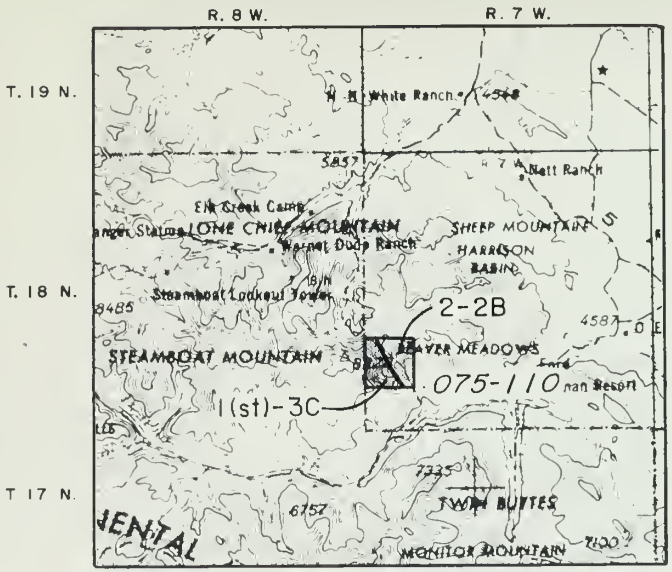
4.2.2b Geothermal. The entire area of WSA 075-110 (1b, Fig. 15) is classified as having low favorability for low and intermediate temperature geothermal resources based on indirect evidence (2B) and as unfavorable for high temperature geothermal resources based on indirect evidence (1B). The evaluation is based the discussion in Section 3.4 and on an assessment of available geothermal information by analogy with better known areas in similar settings.

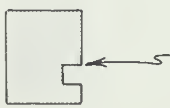
4.2.2c Sodium and Potassium. The entire area of WSA 075-110 (1c, Fig. 15) is classified as unfavorable for sodium and potassium based on limited direct evidence (1C). The basis of this classification is the low favorability of the geologic environment.

4.2.2d Other. All of WSA 075-110 (1d, Fig. 15) is classified as having low favorability for other leasable resources not discussed above based on limited direct evidence (2C).

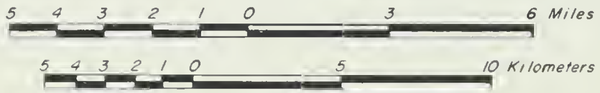
4.2.3 Saleable Resources

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, 1980).
The southwest portion of WSA 075-110 (1, Fig. 16) is classified as moderately favorable for stone resources based on limited direct evidence (3C). This portion of the WSA is underlain by the Flathead Sandstone which is quartzite; therefore, it may be suitable for use as crushed rock or





Approximate Boundory of Wilderness Study Areo.



BLM LAND CLASSIFICATION SYSTEM FOR GEM RESOURCES

CLASSIFICATION SCHEME

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

EXPLANATION

1(ls) - 4D

- 1 — Area I.D. Number
- ls — Commodity
- 4 — Classification
- D — Level of Confidence

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

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BLM GEM RESOURCES ASSESSMENT
REGION 2 NORTHERN ROCKY MOUNTAINS

Beaver Meadows GRA, Montana

Wilderness Study Area Land Classification Saleable Resources

SCALE 1" = 4 MILES (1:250,000)			FIGURE 16
DATA BY WGM	DATE 9/1982	REVISED	
DRWN BY DSI	APPVD GF		

possibly high silica sand. The northeast portion of WSA 075-110 (2, Fig. 16) is classified as having low favorability for saleable resources based on indirect evidence (2B).

5.0 RECOMMENDATIONS FOR FURTHER WORK

Given the relatively high metallic mineral potential of the Beaver Meadows WSA, additional data is needed to complete the evaluation. Geologic mapping of the WSA and surrounding area should be upgraded to 1:24,000 scale. Geochemical samples of major rock types and from sediments in streams draining the WSA should be collected.

In order to properly assess the oil and gas potential, a detailed structural study of the area should be completed. Emphasis of this study should be on proper interpretation of surface structures and their subsurface expression. Seismic studies should be conducted in order to help delineate subsurface structures. These will undoubtedly be done by industry should the area be open to oil and gas exploration.

Given the size of the Beaver Meadows WSA, approximately 1 square mile, sampling of a single 1,000 foot hole and collection of spring samples for geochemical analyses would raise the levels of confidence in the geothermal evaluation to C or D for both high temperature and low to intermediate resources. Additional deep hydrocarbon tests in the area are likely and these should be evaluated for geothermal resources.

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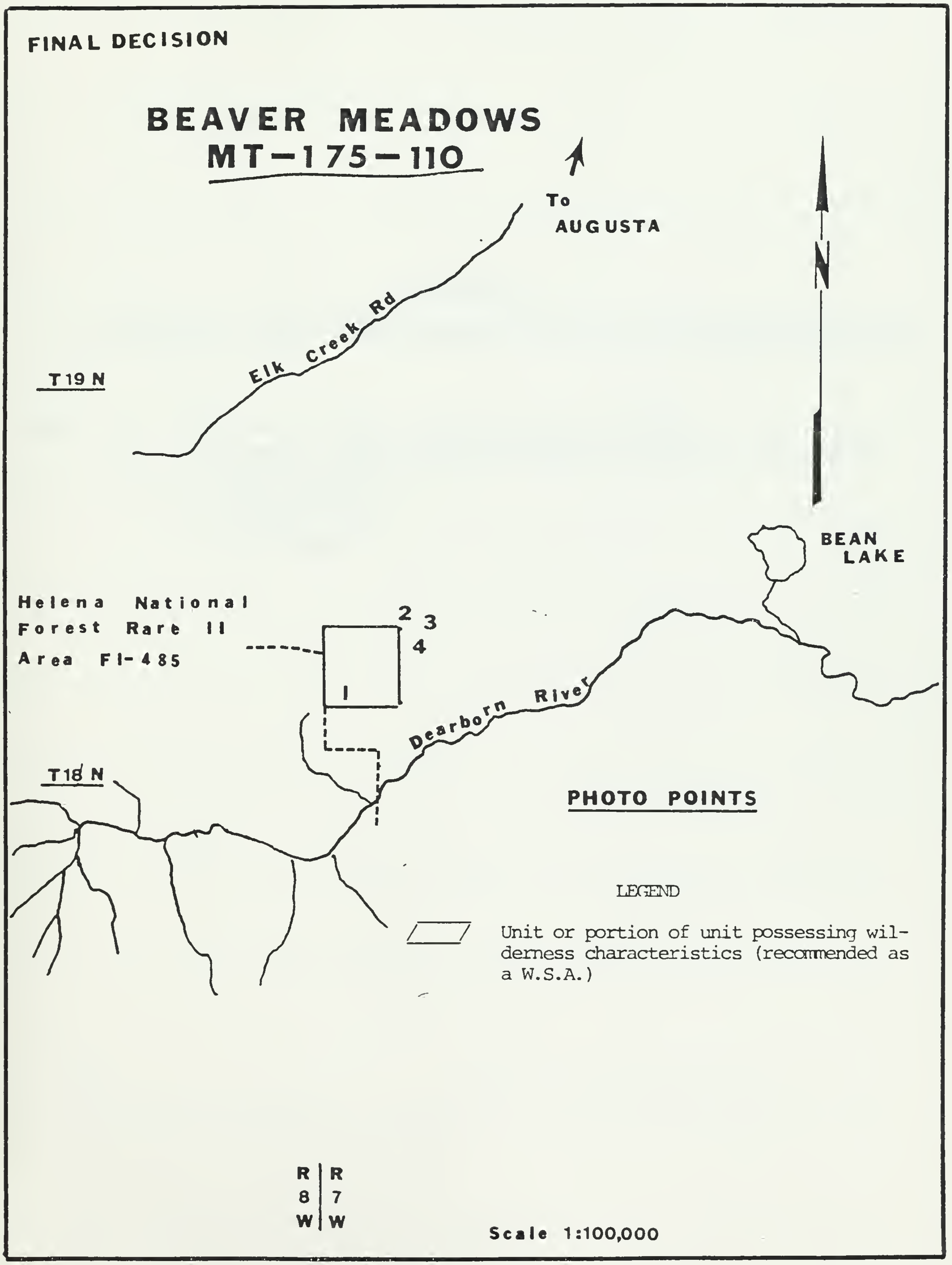
APPENDIX I

WILDERNESS STUDY AREA MAPS


FINAL DECISION
BEAVER MEADOWS
MT-175-110
To
AUGUSTA
N
Elk Creek Rd
T19 N
BEAN
LAKE
Helena National
Forest Rare II
Area FI-485
2
3
4
1
Dearborn River
T18 N
PHOTO POINTS
LEGEND
Unit or portion of unit possessing wilderness characteristics (recommended as a W.S.A.)
R 8 W
R 7 W
Scale 1:100,000

APPENDIX II

U.S. GEOLOGICAL SURVEY STREAM SEDIMENT SAMPLE DATA FOR BEAVER MEADOWS GRA

Notes:
1. Data from: Grimes, Leinz and Hopkins (1980).
2. All elements except gold and mercury by emission spectrograph.
3. --: Not determined
   N: Not detected
   G: Greater than
   L: Less than

Map No.	USGS Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Ag (ppm)	Au (ppm)	Au (ppm)[1]	W (ppm)	Sn (ppm)	Hg (ppm)[2]	Ba (ppm)
263	EFB458	10	30	N	N	2.0	N	-	N	N	0.02	1,500
264	AMS883	G5	20	N	N	N	-	-	-	N	-	700
"	S26	15	20	N	N	N	N	N	N	N	0.02	500
"	S27	20	20	N	N	N	N	-	N	N	0.04	150
"	S28	15	15	N	N	N	N	N	N	N	0.02	700
265	S29	7	15	N	N	N	N	N	N	N	0.02	70
"	S30	20	20	N	N	N	N	N	N	N	0.02	700
"	S31	7	N	N	N	N	N	N	N	N	0.02	300
266	S14	30	20	N	N	N	N	N	N	N	0.02	200
"	S15	15	15	N	N	N	N	N	N	N	0.02	700
"	S16	30	G10	N	N	N	N	N	N	N	0.04	200
"	S17	10	15	N	N	N	N	N	N	N	0.02	100
267	S32	30	20	N	N	N	N	N	N	N	0.02	300
269	397	15	15	N	N	N	N	-	N	N	0.04	500
"	398	15	30	N	N	N	N	-	N	N	0.08	300
"	399	15	30	N	N	N	N	-	N	N	0.02	300
"	400	15	30	N	N	N	N	-	N	N	G0.02	300
290	JAF007	20	30	N	N	N	N	-	N	N	-	1,000
"	JAF008	20	30	N	N	N	N	-	N	N	-	2,000
312	JAF012	15	50	N	N	N	N	-	N	N	-	1,000
313	JAF003	15	50	N	N	N	N	-	N	N	-	700
"	JAF004	20	100	N	N	N	N	-	N	N	-	1,000
"	JAF005	20	300	N	N	N	N	-	N	N	-	1,000
"	JAF009	15	500	N	N	N	N	-	N	N	-	2,000
"	JAF010	20	2,000	N	N	0.5	N	-	N	N	-	L5,000
"	JAF011	30	100	N	N	N	N	-	N	N	-	5,000
"	JAF019	20	2,000	N	N	0.5	N	-	N	N	-	5,000
"	JAF020	20	150	N	N	N	N	-	N	N	-	1,500
314	JAF001	20	50	N	N	N	N	-	N	N	-	700
"	JAF050	30	50	N	N	N	N	-	N	N	-	1,000
315	218	15	G10	N	N	N	N	N	N	N	0.02	700
"	219	20	20	N	N	N	N	-	N	N	0.02	300
316	217	20	10	N	N	N	N	-	N	N	0.06	1,000
332	JAF002	20	200	N	N	N	N	-	N	N	-	100
333	CH81	5	20	N	N	N	-	-	G50	N	-	

Map No.	USGS Sample No.	Cr (ppm)	La (ppm)	Nb (ppm)	Ni (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	V (ppm)	Y (ppm)	Zr (ppm)
263	EFB458	50	70	N	30	N	-	150	50	15	-
264	AMS883	30	-	-	10	-	-	-	50	N	-
"	S26	70	50	N	30	N	7	100	70	20	200
"	S27	70	20	N	15	N	G5	100	20	10	30
"	S28	70	50	N	30	N	7	G100	50	30	300
265	S29	15	G20	N	G5	N	N	200	10	G10	10
"	S30	100	50	N	30	N	7	G100	70	20	200
"	S31	20	30	N	10	N	5	G100	30	15	100
266	S14	50	20	N	20	N	10	N	100	15	100
"	S15	70	30	N	15	N	5	100	50	15	200
"	S16	30	20	N	15	N	5	100	20	20	100
"	S17	70	20	N	15	N	G5	G100	20	G10	20
267	S32	100	30	N	20	N	10	100	70	15	150
269	397	50	50	G10	15	N	7	N	30	20	150
"	398	50	70	G10	15	N	7	N	30	20	150
"	399	50	50	G10	15	N	7	N	50	20	150
"	400	30	50	G10	15	N	7	N	30	20	150
290	JAF007	100	-	-	50	N	-	-	100	-	-
"	JAF008	100	-	-	50	N	-	-	100	-	-
312	JAF012	70	-	-	30	N	-	-	100	-	-
313	JAF003	70	-	-	30	N	-	-	70	-	-
"	JAF004	100	-	-	70	N	-	-	100	-	-
"	JAF005	70	-	-	50	N	-	-	100	-	-
"	JAF009	100	-	-	50	N	-	-	100	-	-
"	JAF010	70	-	-	50	N	-	-	100	-	-
"	JAF011	50	-	-	20	N	-	-	70	-	-
"	JAF019	70	-	-	70	N	-	-	70	-	-
"	JAF020	100	-	-	100	N	-	-	100	-	-
314	JAF001	70	-	-	50	N	-	-	100	-	-
"	JAF050	70	-	-	50	N	-	-	70	-	-
315	218	20	50	N	10	N	5	N	20	20	150
"	219	100	30	10	20	N	10	N	70	30	150
316	217	50	30	G10	15	N	7	G100	50	30	200
332	JAF002	50	-	-	50	N	-	-	100	-	-
333	CH81	20	G20	-	10	G100	G5	700	30	N	G10

Map No.	USGS Sample No.	Fe %	Mg %	Ca %	Ti %	Mn (ppm)	As (ppm)	B (ppm)	Be (ppm)	Bi (ppm)	Cd (ppm)	Co (ppm)
333	215	1.5	10.00	15.00	0.070	200	N	50	G1.0	N	N	N
"	216	1.5	0.70	3.00	0.150	150	N	70	G1.0	N	N	G5
355	AMS881	-	-	-	-	300	-	-	-	-	-	N
356	208	1.0	5.00	7.00	0.100	150	N	70	1.0	N	N	N
357	209	1.5	5.00	10.00	0.070	200	N	70	1.0	N	N	G5
"	210	1.5	0.70	0.70	0.150	150	N	70	1.5	N	N	G5
"	222	1.5	0.50	0.15	0.150	150	N	100	1.0	N	N	G5
398	AMS880	-	-	-	-	300	-	-	-	-	-	7
423	AMS879	-	-	-	-	1,500	-	-	-	-	-	10
424	AMS878	-	-	-	-	1,500	-	-	-	-	-	5
503	AMS875	-	-	-	-	500	-	-	-	-	-	10
544	AMS873	-	-	-	-	500	-	-	-	-	-	20
545	AMS874	-	-	-	-	300	-	-	-	-	-	20

Map No.	USGS Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Ag (ppm)	Au (ppm)	Au (ppm)[1]	W (ppm)	Sn (ppm)	Hg (ppm)[2]	Ba (ppm)
333	215	10	10	N	N	N	N	N	N	N	0.04	700
"	216	30	G10	N	N	N	N	N	N	N	G0.02	700
355	AMS881	15	15	N	N	N	-	-	-	N	-	500
356	208	30	10	N	N	N	N	-	N	N	G0.02	300
357	209	30	15	N	N	N	N	-	N	N	0.04	150
"	210	10	G10	N	N	N	N	-	N	N	0.02	1,000
"	222	15	10	N	N	N	N	-	N	N	G0.02	700
398	AMS880	10	30	N	N	N	-	-	-	N	-	700
423	AMS879	30	10	N	N	N	-	-	-	N	-	1,000
424	AMS878	20	20	N	N	N	-	-	-	N	-	500
503	AMS875	20	15	N	N	N	-	-	-	N	-	500
544	AMS873	50	50	N	N	N	-	-	-	N	-	1,500
545	AMS874	50	20	N	N	N	-	-	-	N	-	700

Map No.	USGS Sample No.	Cr (ppm)	La (ppm)	Nb (ppm)	Ni (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	V (ppm)	Y (ppm)	Zr (ppm)
333	215	50	N	N	15	N	G5	G100	20	10	70
"	216	30	20	G10	10	N	5	N	30	30	150
355	AMS881	50	-	-	15	-	-	-	70	10	-
356	208	50	G20	N	10	N	5	N	30	15	100
357	209	70	G20	N	15	N	5	G100	30	15	100
"	210	30	30	10	10	N	5	N	30	30	300
"	222	30	G20	G10	10	N	5	N	20	20	200
398	AMS880	70	-	-	15	-	-	-	70	10	-
423	AMS879	70	-	-	70	-	-	-	300	G10	-
424	AMS878	50	-	-	30	-	-	-	150	G10	-
503	AMS875	70	-	-	30	-	-	-	100	20	-
544	AMS873	70	-	-	50	-	-	-	300	20	-
545	AMS874	50	-	-	30	-	-	-	100	15	-

APPENDIX III

U.S. GEOLOGICAL SURVEY ROCK SAMPLE DATA FOR THE BEAVER MEADOWS GRA

Notes:
1. Data from: Grimes, Leinz and Hopkins (1980).
2. All elements except gold and mercury by emission spectrograph. Gold by atomic absorption. Mercury by vapor detector.
3. --: Not determined
   N: Not detected
   G: Greater than
   L: Less than

Map No.	USGS Sample No.	Fe %	Mg %	Ca %	Ti %	Mn (ppm)	As (ppm)	B (ppm)	Be (ppm)	Bi (ppm)	Cd (ppm)	Co (ppm)
273	R27	0.70	0.70	20.00	0.015	700	N	N	N	N	N	N
"	R28	0.05	10.00	7.00	0.003	20	N	N	N	N	N	N
"	R29	0.20	5.00	20.00	0.015	30	N	N	N	N	N	N
"	R30	-	10.00	10.00	0.007	100	N	N	N	N	N	N
"	R31	1.00	10.00	15.00	0.015	100	N	N	N	N	N	N
"	R47	0.30	1.00	20.00	0.020	100	N	N	N	N	N	N
"	R48	0.30	10.00	10.00	0.010	10	N	N	N	N	N	N
274	R25	0.15	5.00	20.00	0.007	N	N	N	N	N	N	N
"	R26	0.07	2.00	20.00	0.015	20	N	N	N	N	N	N
"	R71	G0.05	1.00	20.00	0.007	10	N	N	N	N	N	N
"	R72	0.05	0.70	20.00	0.015	300	N	N	N	N	N	N
"	R73	0.07	5.00	20.00	0.015	50	N	N	N	N	N	N
"	R74	0.07	7.00	10.00	0.003	20	N	N	N	N	N	N
"	R75	1.00	3.00	20.00	0.100	100	N	N	N	N	N	N
"	R76	1.00	5.00	10.00	0.030	200	n	G10	N	N	N	G5
275	R13	0.15	10.00	15.00	0.010	30	N	G10	N	N	N	N
"	R19	0.30	0.70	2.00	0.010	G10	N	70	N	N	N	N
"	R20	G0.05	10.00	10.00	0.002	50	N	N	N	N	N	N
"	R68	0.10	3.00	7.00	0.010	70	N	30	N	N	N	N
"	R69	0.05	5.00	10.00	0.002	G10	N	N	N	N	N	N
"	R70	G0.05	2.00	20.00	0.005	15	N	N	N	N	N	N
277	8399	1.50	0.70	0.20	0.150	50	N	70	1.5	N	N	7
"	8400	1.50	7.00	10.00	0.015	1,000	N	15	G1.0	N	N	N
"	8401	1.50	5.00	7.00	0.070	500	N	20	G1.0	N	N	N
"	8402	G0.05	0.30	20.00	0.003	70	N	N	N	N	N	N
"	R12	0.30	0.70	20.00	0.007	150	N	N	N	N	N	N
278	8386	3.00	3.00	2.00	0.200	300	N	70	1.5	N	N	10
"	8387	3.00	3.00	2.00	0.200	300	N	70	1.5	N	N	10
"	8388	3.00	2.00	0.20	0.200	500	N	70	1.5	N	N	15
"	8389	10.00	2.00	3.00	G1.000	1,000	N	G10	N	N	N	70
"	8390	7.00	2.00	3.00	1.000	700	N	G10	N	N	N	50
"	8391	7.00	2.00	3.00	0.700	700	N	20	G1.0	N	N	50
"	8392	0.30	0.10	G0.05	0.020	15	N	15	N	N	N	N
"	8393	0.50	7.00	15.00	0.030	150	N	30	N	N	N	N
"	8394	1.50	5.00	20.00	0.070	700	N	15	N	N	N	N

Map No.	USGS Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Ag (ppm)	Au (ppm)	Au (ppm)[1]	W (ppm)	Sn (ppm)	Hg (ppm)[2]	Ba (ppm)
273	R27	5	10	N	N	N	N	N	N	N	0.06	G20
"	R28	N	N	N	N	N	N	N	N	N	0.04	N
"	R29	N	N	N	N	N	N	N	N	N	0.02	N
"	R30	N	N	N	N	N	N	N	N	N	0.02	N
"	R31	15	G10	N	N	N	N	N	N	N	G0.02	N
"	R47	N	N	N	N	N	N	N	N	N	0.08	G20
"	R48	N	G10	N	N	N	N	N	N	N	0.08	G20
274	R25	N	N	N	N	N	N	N	N	N	0.10	N
"	R26	7	N	N	N	N	N	N	N	N	0.04	G20
"	R71	N	N	N	N	N	N	N	N	N	G0.02	N
"	R72	N	N	N	N	N	N	N	N	N	0.04	N
"	R73	N	N	N	N	N	N	N	N	N	0.06	N
"	R74	N	N	N	N	N	N	N	N	N	0.04	N
"	R75	5	N	N	N	N	N	N	N	N	0.04	30
"	R76	100	N	N	N	N	N	N	N	N	0.05	20
275	R13	N	N	N	N	N	N	N	N	N	0.04	N
"	R19	N	N	N	N	N	N	N	N	N	G0.02	30
"	R20	G5	N	N	N	N	N	N	N	N	N	N
"	R68	N	N	N	N	N	N	N	N	N	0.04	G20
"	R69	N	N	N	N	N	N	N	N	N	0.04	N
"	R70	N	N	N	N	N	N	N	N	N	N	N
277	8399	10	G10	N	N	N	N	N	N	N	0.02	150
"	8400	10	50	G200	N	N	N	N	N	N	0.04	150
"	8401	7	N	N	N	N	N	N	N	N	0.06	200
"	8402	N	15	N	N	N	N	N	N	N	0.06	20
"	R12	N	N	N	N	N	N	N	N	N	N	N
278	8386	7	10	N	N	N	N	N	N	N	0.04	500
"	8387	G5	G10	N	N	N	N	N	N	N	0.04	500
"	8388	70	50	N	N	N	N	N	N	N	0.04	300
"	8389	300	10	N	N	N	N	N	N	N	G0.02	200
"	8390	150	10	N	N	N	N	N	N	N	0.06	150
"	8391	200	15	N	N	N	N	N	N	N	0.04	300
"	8392	5	G10	N	N	N	N	N	N	N	0.04	300
"	8393	G5	G10	N	N	N	N	N	N	N	0.02	G20
"	8394	N	N	N	N	N	N	N	N	N	0.02	50

Map No.	USGS Sample No.	Cr (ppm)	La (ppm)	Nb (ppm)	Ni (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	V (ppm)	Y (ppm)	Zr (ppm)
273	R27	10	G20	N	15	N	N	200	G10	G10	N
"	R28	G10	G20	N	N	N	N	N	10	N	N
"	R29	G10	G20	N	N	N	N	200	10	N	N
"	R30	G10	G20	N	N	N	N	N	10	N	N
"	R31	15	G20	N	15	N	N	N	10	10	15
"	R47	10	N	N	N	N	N	G100	15	N	10
"	R48	15	N	N	N	N	N	G100	10	N	N
274	R25	30	G20	N	G5	N	N	150	10	10	N
"	R26	50	20	N	G5	N	N	1,000	15	G10	N
"	R71	10	N	N	N	N	N	200	G10	G10	N
"	R72	N	N	N	N	N	N	200	G10	N	N
"	R73	N	N	N	N	N	N	100	10	N	G10
"	R74	G10	N	N	N	N	N	N	10	N	G10
"	R75	50	N	N	7	N	G5	200	15	10	20
"	R76	15	N	N	7	N	N	N	10	G10	15
275	R13	G10	N	N	N	N	N	100	10	N	N
"	R19	N	N	N	G5	N	N	100	10	N	N
"	R20	10	G20	N	G5	N	N	N	10	N	N
"	R68	G10	N	N	N	N	N	G100	10	N	G10
"	R69	15	N	N	N	N	N	N	15	N	N
"	R70	N	N	N	N	N	N	100	G10	N	N
277	8399	20	50	G10	15	N	7	N	30	20	100
"	8400	N	50	N	G5	N	N	N	G10	30	10
"	8401	10	20	N	7	N	5	N	10	15	30
"	8402	N	N	N	N	N	N	300	N	N	N
"	R12	N	N	N	G5	N	N	200	10	N	N
278	8386	50	30	G10	20	N	10	N	50	20	150
"	8387	50	70	G10	20	N	15	N	50	30	150
"	8388	50	70	10	20	N	15	N	50	30	200
"	8399	G10	G20	G10	30	N	30	150	200	50	100
"	8390	100	N	G10	50	N	30	100	150	30	70
"	8391	70	N	G10	50	N	30	N	150	50	150
"	8392	N	G20	N	5	N	N	N	G10	T10	50
"	8393	G10	N	N	5	N	N	G100	10	N	N
"	8394	10	20	N	7	N	N	500	10	10	20

Map No.	USGS Sample No.	Fe %	Mg %	Ca %	Ti %	Mn (ppm)	As (ppm)	B (ppm)	Be (ppm)	Bi (ppm)	Cd (ppm)	Co (ppm)
280	L345	1.50	0.50	1.00	0.200	2,000	N	50	1.0	N	N	10
"	L346	3.00	0.70	0.07	0.200	300	N	100	1.0	N	N	10
"	L347	0.70	0.50	1.00	0.200	1,000	N	70	1.0	N	N	7
"	L348	0.30	0.20	0.07	0.050	300	N	15	G1.0	N	N	N
"	L349	1.00	1.50	2.00	0.150	1,000	N	50	1.0	N	N	10
"	L350	0.30	0.10	G0.05	0.020	50	N	15	N	N	N	N
"	L351	0.50	0.50	0.15	0.050	150	N	30	G1.0	N	N	G5
309	R60	0.70	2.00	20.00	0.050	150	N	N	N	N	N	N
"	R61	3.00	1.50	20.00	0.150	1,000	N	20	N	N	N	5
"	R62	1.50	1.00	15.00	0.030	500	N	N	N	N	N	G5
"	R63	0.70	0.15	0.30	0.150	300	N	20	N	N	N	G5
"	R64	0.50	0.10	G0.05	0.150	300	N	15	N	N	N	N
310	R15	0.15	0.30	20.00	0.010	70	N	N	N	N	N	N
311	R59	0.70	10.00	10.00	0.015	30	N	N	N	N	N	N
312	R52	0.10	0.70	20.00	0.015	20	N	N	N	N	N	N
"	R53	1.50	10.00	15.00	0.100	50	N	20	1.0	N	N	5
"	R54	0.50	10.00	15.00	0.020	150	N	N	N	N	N	N
"	R58	0.30	10.00	15.00	0.010	500	N	N	N	N	N	N
313	R49	0.07	7.00	10.00	0.005	20	N	N	N	N	N	N
"	R50	0.15	10.00	10.00	0.007	10	N	N	N	N	N	N
"	R51	0.30	0.70	20.00	0.030	20	N	N	N	N	N	N
314	R45	0.10	10.00	10.00	0.005	G10	N	15	N	N	N	N
"	R46	0.30	10.00	10.00	0.005	50	N	N	N	N	N	N
315	R22	0.05	10.00	15.00	0.007	50	N	N	N	N	N	N
"	R23	G0.05	7.00	15.00	0.005	G10	N	N	N	N	N	N
"	R24	0.05	10.00	10.00	0.002	G10	N	N	N	N	N	N
316	B403	0.10	0.70	20.00	0.010	7	N	G10	G1.0	N	N	N
"	B404	1.50	5.00	7.00	0.100	300	N	50	N	N	N	G5
317	B395	1.00	3.00	20.00	0.050	300	N	G10	N	N	N	N
"	B396	0.20	7.00	20.00	0.007	300	N	N	N	N	N	N

Map No.	USGS Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Ag (ppm)	Au (ppm)	Au (ppm)[1]	W (ppm)	Sn (ppm)	Hg (ppm)[2]	Ba (ppm)
279	L339	N	N	N	N	N	N	N	N	N	0.02	150
"	L340	G5	10	N	N	N	N	N	N	N	0.04	200
"	L341	7	G10	N	N	N	N	N	N	N	0.05	2,000
"	L342	150	N	N	N	N	N	N	N	N	0.04	2,000
"	L343	30	G10	N	N	N	N	N	N	N	0.02	700
280	L345	300	150	N	N	N	N	N	N	N	0.04	300
"	L346	7	G10	N	N	N	N	N	N	N	0.02	500
"	L347	5	N	N	N	N	N	N	N	N	G0.02	500
"	L348	5	G10	N	N	N	N	N	N	N	0.04	300
280	L349	5	G10	N	N	N	N	N	N	N	G0.02	200
"	L350	G5	G10	N	N	N	N	N	N	N	0.02	200
"	L351	G5	G10	N	N	N	N	N	N	N	0.04	300
309	R60	7	15	N	N	N	N	N	N	N	0.02	70
"	R61	7	10	N	N	N	N	N	N	N	G0.02	200
"	R62	7	15	N	N	N	N	N	N	N	0.04	300
"	R63	N	15	N	N	N	N	N	N	N	0.08	150
"	R64	5	G10	N	N	N	N	N	N	N	G0.02	L5,000
310	R15	5	N	N	N	N	N	N	N	N	0.02	N
311	R59	10	30	N	N	N	N	N	N	N	0.02	20
312	R52	N	N	N	N	N	N	N	N	N	0.02	G20
"	R53	5	G10	N	N	N	N	N	N	N	G0.02	200
"	R54	7	N	N	N	N	N	N	N	N	0.02	G20
"	R58	G5	N	N	N	N	N	N	N	N	0.02	G20
313	R49	N	N	N	N	N	N	N	N	N	0.04	N
"	R50	G5	NN	N	N	N	N	N	N	N	0.06	N
"	R51	G5	N	N	N	N	N	N	N	N	G0.02	20
314	R45	N	N	N	N	N	N	N	N	N	0.02	N
"	R46	N	N	N	N	N	N	N	N	N	0.02	N
315	R22	N	N	N	N	N	N	N	N	N	N	N
"	R23	N	N	N	N	N	N	N	N	N	0.02	N
"	R24	N	N	N	N	N	N	N	N	N	0.02	N
315	R403	N	N	N	N	N	N	N	N	N	0.04	N
"	B404	G5	15	N	N	N	N	N	N	N	G0.02	700
317	B395	N	1,000	G200	N	N	N	N	N	N	0.02	100
"	B396	G5	100	N	N	N	N	N	N	N	G0.02	N

Map No.	USGS Sample No.	Cr (ppm)	La (ppm)	Nb (ppm)	Ni (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	V (ppm)	Y (ppm)	Zr (ppm)
279	L339	G10	30	N	G5	N	G5	150	G10	15	50
"	L340	20	30	N	15	N	5	N	30	15	70
"	L341	20	30	G10	15	N	5	G100	70	15	200
"	L342	20	20	G10	15	N	5	G100	50	15	150
"	L343	30	20	G10	15	N	7	N	50	15	150
280	L345	30	50	N	15	N	10	G100	30	30	100
"	L346	30	50	G10	20	N	10	N	70	30	200
"	L347	30	50	G10	15	N	7	N	30	30	300
"	L348	N	G20	N	7	N	N	N	G10	N	70
"	L349	20	20	G10	20	N	7	N	30	30	300
"	L350	15	G20	N	G5	N	N	N	G10	15	50
"	L351	20	G20	N	5	N	G5	N	15	15	70
309	R60	20	N	N	N	N	N	500	10	N	20
"	R61	150	20	N	20	N	15	300	30	30	50
"	R62	20	30	N	G5	N	N	500	10	10	20
"	R63	10	50	N	G5	N	G5	200	15	10	200
"	R64	G10	30	N	G5	N	N	200	15	N	100
310	R15	N	N	N	5	N	N	200	10	N	N
311	R59	20	N	N	N	N	N	N	10	G10	15
312	R52	N	N	N	N	N	N	150	10	N	G10
"	R53	70	N	N	10	N	5	G100	20	15	50
"	R54	10	N	N	N	N	N	N	10	N	10
"	R58	N	N	N	N	N	N	N	15	N	N
313	R49	G10	N	N	N	N	N	N	10	N	N
"	R50	15	N	N	N	N	N	N	15	N	N
"	R51	10	N	N	N	N	N	150	15	N	15
314	R45	10	N	N	N	N	N	N	10	N	10
"	R46	10	N	N	N	N	N	N	G10	N	G10
315	R22	15	G20	N	N	N	N	100	15	G10	N
"	R23	N	G20	N	N	N	N	N	G10	N	N
"	R24	30	G20	N	N	N	N	N	10	G10	N
316	B403	N	N	N	N	N	N	200	G10	N	N
"	B404	15	N	N	10	N	G5	100	10	G10	100
317	B395	G10	G20	N	5	N	N	300	G10	N	15
"	B396	N	G20	N	N	N	N	150	G10	N	G10

Map No.	USGS Sample No.	Fe %	Mg %	Ca %	Ti %	Mn (ppm)	As (ppm)	B (ppm)	Be (ppm)	Bi (ppm)	Cd (ppm)	Co (ppm)
318	L333	1.50	5.00	15.00	0.030	700	N	15	N	N	N	N
"	L334	2.00	0.70	G0.05	0.200	150	N	70	1.0	N	N	10
"	L335	2.00	1.00	0.07	0.200	300	N	30	G1.0	N	N	10
"	L336	1.50	0.70	3.00	0.100	700	N	50	G1.0	N	N	7
"	L337	2.00	0.50	20.00	0.020	700	N	G10	N	N	N	10
"	L338	0.70	0.20	0.05	0.150	100	N	30	G1.0	N	N	G5
319	401B	1.50	5.00	5.00	0.150	500	N	20	N	N	N	5
"	L344	1.00	2.00	15.00	0.070	500	N	10	N	N	N	7
337	JAF134	0.15	0.05	0.10	-	150	N	30	5.0	N	N	G5
338	B272	0.50	1.00	20.00	0.030	1,000	N	G10	N	N	N	N
"	B273	1.50	5.00	15.00	0.100	1,500	N	50	N	N	N	5
"	B274	7.00	3.00	20.00	0.200	3,000	N	100	G1.0	N	N	20
"	B274	2.00	1.00	3.00	0.300	500	N	100	1.5	N	N	10
"	B276	3.00	1.50	0.15	0.150	300	N	70	N	N	N	10
"	B277	5.00	1.50	1.00	0.300	500	N	100	G1.0	N	N	70
"	B278	1.50	1.00	1.00	0.200	500	N	70	1.0	N	N	10
"	B279	3.00	2.00	20.00	0.150	5,000	N	30	G1.0	N	N	10
361	JAF135	5.00	0.70	1.50	-	1,000	N	20	5.0	N	N	7
"	JAF136	0.15	10.00	20.00	-	150	N	20	5.0	N	N	N
362	EFD168	2.00	1.00	1.00	0.300	300	N	N	5.0	N	N	N
"	JAF129	2.00	0.10	0.30	-	700	N	70	5.0	N	N	N
"	JAF138	2.00	0.15	0.15	-	70	N	50	5.0	N	N	N
"	JAF140	0.10	0.03	G0.05	-	150	N	20	5.0	N	N	N
"	JAF141	0.50	0.02	G0.05	-	20	N	20	5.0	N	N	N
"	JAF142	1.00	0.03	G0.05	-	500	N	20	5.0	N	N	N
"	JAF143	0.30	0.03	0.05	-	20	N	20	5.0	N	N	N
"	JAF144	3.00	0.20	0.07	-	700	N	20	5.0	N	N	N
"	JAF233	1.00	0.03	N	-	300	N	70	5.0	N	N	N
"	JAF234	0.50	0.02	N	-	200	N	20	5.0	N	N	N
363	JAF130	2.00	5.00	10.00	-	G5,000	N	70	5.0	N	50	N
"	JAF131	0.07	0.03	0.05	-	70	N	20	5.0	N	N	N
"	JAF132	3.00	5.00	15.00	-	G5,000	N	70	5.0	N	50	5
"	JAF133	2.00	1.00	20.00	-	700	N	70	5.0	N	N	5
"	JAF139	0.30	0.03	0.05	-	70	N	20	5.0	N	N	N
"	JAF135	0.70	0.02	N	-	700	N	20	5.0	N	N	G5
364	AMS918	7.00	0.50	0.20	-	50	N	-	-	-	-	7
365	B284	N	1.00	20.00	0.005	10	N	N	N	N	N	N

Map No.	USGS Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Ag (ppm)	Au (ppm)	Au (ppm)[1]	W (ppm)	Sn (ppm)	Hg (ppm)[2]	Ba (ppm)
318	L333	7	G10	N	N	N	N	N	N	N	0.06	50
"	L334	10	G10	N	N	N	N	N	N	N	0.04	200
"	L335	30	20	N	N	N	N	N	N	N	0.11	1,000
"	L336	15	G10	N	N	N	N	N	N	N	0.04	3,000
"	L337	20	500	500	N	1.5	N	N	N	N	0.30	100
"	L338	N	N	N	N	N	N	N	N	N	0.04	200
319	401B	7	G10	N	N	N	N	N	N	N	0.02	3,000
"	L344	7	15	N	N	N	N	N	N	N	0.10	100
337	JAF134	10	70	N	N	N	N	-	N	N	N	50
338	B272	N	30	N	N	N	N	N	N	N	0.12	30
"	B273	70	50	N	N	N	N	N	N	N	0.06	200
"	B274	10	50	N	N	N	N	N	N	N	0.06	L5,000
"	B275	2,000	G10	N	N	3.0	N	N	N	N	0.15	1,500
"	B276	N	N	N	N	N	N	N	N	N	0.08	700
"	B277	1,000	1,500	N	N	N	N	N	N	N	0.16	1,500
"	B278	7	G10	N	N	N	N	N	N	N	0.04	1,000
"	B279	15	30	N	N	N	N	N	N	N	0.40	1,000
361	JAF135	30	30	N	N	N	N	-	N	N	G0.02	700
"	JAF136	5	50	N	N	N	N	-	N	N	N	N
362	EFD168	5	70	N	N	N	N	-	N	N	G0.02	2,000
"	JAF129	15	30	N	N	N	N	-	N	N	G0.02	500
"	JAF138	G5	20	N	N	N	N	-	N	N	N	200
"	JAF140	7	20	N	N	N	N	-	N	N	N	30
"	JAF141	20	100	N	N	N	N	-	N	N	N	2,000
"	JAF142	10	200	N	N	N	N	-	N	N	G0.02	3,000
"	JAF143	7	150	N	N	N	N	-	N	N	0.03	700
"	JAF144	7	30	N	N	N	N	-	N	N	N	500
"	JAF233	50	1,000	N	N	2.0	N	-	N	N	0.07	1,000
"	JAF234	15	300	N	N	N	N	-	N	N	G0.02	3,000
363	JAF130	100	5,000	3,000	N	N	N	-	N	N	0.28	150
"	JAF131	15	20	N	N	N	N	-	N	N	F0.02	20
"	JAF132	50	200	10,000	7	N	N	-	N	N	2.20	200
"	JAF133	5	20	N	N	N	N	-	N	N	0.03	150
"	JAF139	G5	20	N	N	N	N	-	N	N	N	200
"	JAF135	20	20	N	N	N	N	-	N	N	G0.02	100
364	AMS918	30	70	N	50	0.5	-	-	N	N	-	1,500
365	B284	N	N	N	N	N	N	N	N	N	0.02	N

Map No.	USGS Sample No.	Cr (ppm)	La (ppm)	Nb (ppm)	Ni (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	V (ppm)	Y (ppm)	Zr (ppm)
318	L333	N	G20	N	G5	N	G5	G100	G10	15	30
"	L334	20	30	10	20	N	7	N	50	20	100
"	L335	30	50	G10	15	N	7	N	50	20	200
"	L336	15	30	G10	15	N	5	100	30	30	150
"	L337	N	20	N	15	N	N	300	G10	20	20
"	L338	15	30	N	7	N	5	N	30	15	200
319	401B	20	39	N	10	N	5	100	15	20	100
"	L344	20	20	N	15	N	G5	100	10	15	30
337	JAF134	50	-	-	G5	N	-	-	15	N	-
338	B272	N	30	N	N	N	N	300	G10	G10	N
"	B273	30	50	G10	10	N	5	N	20	20	100
"	B274	30	70	G10	15	N	G7	N	50	70	150
"	B275	70	70	G10	20	N	10	N	100	30	300
"	B276	20	20	G10	30	N	7	N	50	20	300
"	B277	50	70	15	30	N	10	N	70	50	500
"	B278	30	50	G10	15	N	7	N	30	20	200
"	B279	50	70	G10	15	N	7	N	70	50	200
361	JAF135	50	-	-	10	N	-	-	150	20	-
"	JAF136	50	-	-	N	N	-	-	15	N	-
362	EFD168	50	-	-	30	N	5	1,000	50	10	70
"	JAF129	50	-	-	15	N	-	-	50	50	-
"	JAF138	50	-	-	7	N	-	-	30	G10	-
"	JAF140	50	-	-	G5	N	-	-	15	N	-
"	JAF141	50	150	-	N	N	-	-	30	30	-
"	JAF142	50	-	-	10	N	-	-	20	G10	-
"	JAF143	50	-	-	G5	N	-	1,000	30	20	-
"	JAF144	50	-	-	20	N	-	-	30	30	-
"	JAF233	50	100	-	7	N	-	-	50	30	-
"	JAF234	50	-	-	5	N	-	-	20	G10	-
363	JAF130	50	-	-	5	N	-	-	20	30	-
"	JAF131	50	-	-	N	N	-	-	15	N	-
363	JAF132	50	-	-	G5	N	-	-	30	30	-
"	JAF133	50	-	-	15	N	-	-	20	20	-
"	JAF139	50	-	-	G5	N	-	-	15	G10	-
"	JAF135	50	-	-	5	N	-	-	20	G10	-
364	AMS918	50	-	-	10	-	-	-	70	20	-
365	B284	N	N	N	N	N	N	300	G10	N	N

Map No.	USGS Sample No.	Fe %	Mg %	Ca %	Ti %	Mn (ppm)	As (ppm)	B (ppm)	Be (ppm)	Bi (ppm)	Cd (ppm)	Co (ppm)
366	B281	1.00	0.70	7.00	0.150	300	N	30	G1.0	N	N	G5
"	B282	1.00	0.70	5.00	0.150	500	N	N	G1.0	N	N	G5
"	B283	G0.05	10.00	20.00	0.007	15	N	N	N	N	N	N
367	B280	3.00	5.00	7.00	0.150	1,500	N	70	G1.0	N	N	G5
393	AMS915	15.00	3.00	3.00	-	2,000	N	-	-	-	-	50
394	AMS916	G20.00	0.30	1.00	-	2,000	5,000	-	-	-	-	20
"	AMS917	15.00	1.50	0.20	-	200	N	-	-	-	-	N
"	JAF128	0.15	0.05	0.50	-	15	N	50	5.0	N	N	N
395	791AR	1.00	-	0.05	-	700	N	50	-	N	N	10
"	791BR	0.10	-	G0.05	-	20	N	20	-	N	N	N
"	791CR	0.70	-	G0.05	-	70	N	20	-	N	N	7
"	AMS920	3.00	7.00	20.00	-	5,000	N	-	-	-	-	N
396	AMS919	7.00	1.00	0.20	-	200	N	-	-	-	-	15
397	L248	N	0.70	20.00	0.003	N	N	N	N	N	N	N
398	EFB303	1.00	10.00	10.00	0.100	200	N	30	5.0	N	N	5
"	EFB304	0.05	10.00	15.00	0.002	150	N	G10	5.0	N	N	N
"	EFB305	1.00	10.00	10.00	0.100	200	N	50	5.0	N	N	7
430	AMS914	0.10	0.10	0.10	-	70	N	-	-	-	-	N
431	L249	0.30	5.00	20.00	0.015	300	N	10	N	N	N	N
"	L250	0.70	0.30	20.00	0.015	700	N	N	N	N	N	N
"	L251	0.70	5.00	20.00	0.020	300	N	N	N	N	N	7
"	L252	N	7.00	10.00	G0.002	30	N	10	N	N	N	N
432	L244	G5.00	0.50	20.00	0.300	G300	N	15	N	N	N	10
458	L242	N	7.00	7.00	N	15	N	N	N	N	N	N
"	L245	N	10.00	10.00	G0.002	10	N	G10	N	N	N	N
459	L239	1.50	10.00	20.00	0.150	300	N	50	N	N	N	N
"	L240	1.50	3.00	20.00	0.020	100	N	N	N	N	N	N
"	L241	5.00	0.70	20.00	0.030	50	N	G10	N	N	N	N
525	AMS913	3.00	2.00	10.00	-	700	N	-	-	-	-	10
526	AMS909	0.50	7.00	15.00	-	150	N	-	-	-	-	5
"	AMS910	0.50	5.00	10.00	-	100	N	-	-	-	-	N
"	AMS911	0.50	3.00	15.00	-	50	N	-	-	-	-	G5
"	EFB306	5.00	1.00	0.30	0.300	100	N	100	5.0	N	N	15
577	EFB307	3.00	1.00	0.20	0.500	100	N	200	5.0	N	N	15
601	EFD	3.00	0.70	5.00	0.300	1,500	N	10	5.0	N	N	10
602	AMS905	7.00	1.50	5.00	-	3,000	N	-	-	-	-	10
603	EFB308	3.00	0.70	0.20	0.700	150	N	70	5.0	N	N	15
604	EFB336	3.00	0.70	0.30	0.500	150	N	150	5.0	N	N	15
672	EFB280	2.00	0.70	0.50	0.500	200	N	200	5.0	N	N	10

Map No.	USGS Sample No.	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Ag (ppm)	Au (ppm)	Au (ppm)[1]	W (ppm)	Sn (ppm)	Hg (ppm)[2]	Ba (ppm)
366	B281	200	10	N	N	N	N	N	N	N	0.04	300
"	B282	5	G10	N	N	N	N	N	N	N	0.04	300
"	B283	G5	30	N	N	N	N	N	N	N	0.04	N
367	B280	20	G10	N	N	N	N	N	N	N	0.02	300
393	AMS915	300	70	200	N	N	-	-	N	N	-	300
394	AMS916	1,500	200	N	N	5.0	-	-	N	N	-	300
"	AMS917	200	500	200	N	15.0	-	-	N	N	-	300
"	JAF128	7	20	N	N	N	N	-	N	N	0.02	500
395	791AR	100	G10	N	N	N	N	-	N	N	N	300
"	791BR	300	L20,000	N	N	10.0	N	N	N	N	N	L1,500
"	791CR	10	70	N	N	1.0	-	N	N	N	N	1,500
"	AMS920	10	150	200	N	2.0	-	-	N	N	-	50
396	AMS919	50	150	N	15	1.0	N	N	N	N	-	300
397	L248	N	N	N	N	N	N	-	N	N	0.02	N
398	EFB303	7	G10	N	N	N	N	-	N	N	G0.02	100
"	EFB304	N	N	N	N	N	N	-	N	N	N	G20
"	EFB305	7	10	N	N	N	N	-	N	N	0.04	100
430	AMS914	50	L5,000	200	N	7.0	-	-	N	N	-	300
431	L249	N	N	N	N	N	N	N	N	N	0.04	N
"	L250	N	N	N	N	N	N	N	N	N	0.04	N
"	L251	N	N	N	N	N	N	N	N	N	G0.02	G20
"	L252	N	N	N	N	N	N	N	N	N	0.04	N
432	L244	50	N	G200	N	1.5	N	N	N	N	0.04	N
458	L242	N	N	N	N	N	N	N	N	N	0.06	N
"	L245	N	N	N	N	N	N	N	N	N	0.06	N
459	L239	15	G10	N	N	N	N	N	N	N	G0.02	70
"	L240	N	N	N	N	N	N	N	N	N	0.06	N
"	L241	N	10	N	N	N	N	N	N	N	0.02	N
525	AMS913	10	20	N	N	N	-	-	N	N	-	1,500
526	AMS909	G5	1,500	300	N	N	-	-	N	N	-	70
"	AMS910	G5	L5,000	1,500	G5	N	-	-	N	N	-	50
"	AMS911	N	50	N	N	N	N	-	N	N	-	-
"	EFB306	50	20	N	N	N	N	-	N	N	0.02	700
577	EFB307	30	15	N	N	N	N	-	N	N	0.02	300
601	EFD174	N	15	N	G5	N	N	-	N	N	G0.02	3,000
602	AMS905	7	30	N	N	N	-	-	N	N	-	2,000
603	EFB308	50	50	N	N	G0.5	N	-	N	N	0.04	500
604	EFB336	50	30	N	N	N	N	-	N	N	0.02	700
672	EFB280	15	30	N	5	G0.5	N	-	N	N	0.06	1,000

Map No.	USGS Sample No.	Cr (ppm)	La (ppm)	Nb (ppm)	Ni (ppm)	Sb (ppm)	Sc (ppm)	Sr (ppm)	V (ppm)	Y (ppm)	Zr (ppm)
366	B281	20	30	G10	15	N	5	N	20	20	100
"	B282	20	20	G10	10	N	5	N	30	20	150
"	B283	30	N	N	N	N	N	N	G10	G10	N
367	B280	20	20	G10	15	N	7	N	30	15	70
393	AMS915	30	-	-	30	-	-	-	2,000	50	-
394	AMS916	G10	-	-	15	-	-	-	2,000	30	-
"	AMS917	30	-	-	10	-	-	-	200	10	-
"	JAF128	50	-	-	N	-	-	-	30	10	-
395	791AR	50	-	-	10	N	-	-	50	-	-
"	791BR	10	-	-	5	N	-	-	20	-	-
"	791CR	30	-	-	5	N	-	-	20	-	-
"	AMS920	N	-	-	N	-	-	-	70	30	-
396	AMS919	20	-	-	20	-	-	-	50	30	-
397	L248	N	N	N	N	N	N	150	10	G10	N
398	EFB303	30	-	N	20	N	5	100	30	10	50
"	EFB304	N	-	N	N	N	N	100	N	15	N
"	EFB305	30	-	N	20	N	5	100	30	10	30
430	AMS914	G10	-	-	N	-	-	-	10	G10	-
431	L249	N	N	N	20	N	N	200	10	N	N
"	L250	N	N	N	10	N	N	300	10	G10	N
"	L251	N	G20	N	15	N	N	100	G10	G10	N
"	L252	N	N	N	N	N	N	N	N	N	N
432	L244	100	N	N	70	N	N	300	70	20	N
458	L242	G10	N	N	N	N	N	N	N	N	N
"	L245	N	N	N	N	N	N	N	N	N	N
459	L239	50	G20	N	20	N	G5	N	30	N	N
"	L240	G10	N	N	7	N	N	G100	15	N	N
"	L241	15	N	N	15	N	N	300	50	N	G10
525	AMS913	700	-	-	15	-	-	-	70	G10	-
526	AMS909	30	-	-	5	-	-	-	30	G10	-
"	AMS910	30	-	-	7	-	-	-	100	N	-
526	ASM911	-	-	-	5	-	-	-	15	N	-
"	EFB306	150	-	N	100	N	15	150	200	20	100
577	EFB307	150	-	N	50	N	15	100	100	15	100
601	EFD174	G10	-	N	15	N	7	2,000	70	20	100
602	AMS905	G10	-	-	5	-	-	-	150	15	-
603	EFB308	100	-	N	70	N	15	100	200	30	150
604	EFB336	100	-	N	70	N	15	100	150	30	150
672	EFB280	100	-	N	50	N	7	150	150	20	150

DATE LOANED	BORROWER