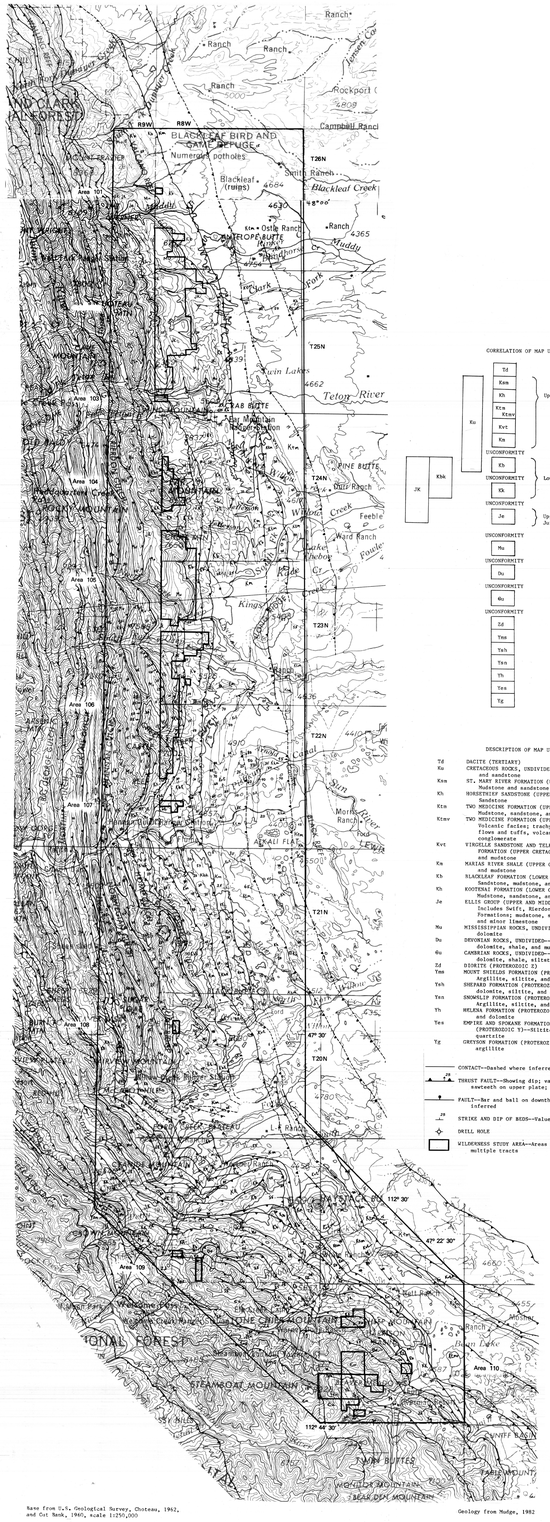
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

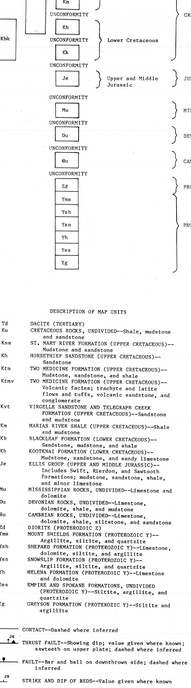
PREPARED IN COOPERATION WITH THE U. S. BUREAU OF LAND MANAGEMENT

OPEN-FILE REPORT 84-0566
PLATE 1 OF 1
(Pamphlet accompanies map)



MAP A. GEOLOGY

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

DACITE (TERTIARY)

Td

CRETACEOUS ROCKS, UNDIVIDED--Shale, mudstone and sandstone

Ka

ST. MARY RIVER FORMATION (UPPER CRETACEOUS)--Mudstone and sandstone

Kmv

HORSETHIEF SANDSTONE (UPPER CRETACEOUS)--Sandstone

Kb

TWO MEDICINE FORMATION (UPPER CRETACEOUS)--Mudstone, sandstone, and shale

Kbc

TWO MEDICINE FORMATION (UPPER CRETACEOUS)--Volcanic facies; trachyte and latite flows and tuffs, volcanic sandstone, and conglomerate

Ktw

VIRGELLE SANDSTONE AND TELEGRAPH CREEK FORMATION (UPPER CRETACEOUS)--Sandstone and mudstone

Kvt

MARIAS RIVER SHALE (UPPER CRETACEOUS)--Shale and mudstone

Ks

BLACKLEAF FORMATION (LOWER CRETACEOUS)--Sandstone, mudstone, and shale

Kh

KOOTENAI FORMATION (LOWER CRETACEOUS)--Mudstone, sandstone, and minor limestone

Kk

ELLIS GROUP (UPPER AND MIDDLE JURASSIC)--Includes Swift, Rierdon, and Sawtooth Formations; mudstone, sandstone, shale, and minor limestone

Ju

MISSISSIPPIAN ROCKS, UNDIVIDED--Limestone and dolomite

Mu

DEVONIAN ROCKS, UNDIVIDED--Limestone, dolomite, shale, and mudstone

Du

CAMBRIAN ROCKS, UNDIVIDED--Limestone, dolomite, shale, siltstone, and sandstone

Єu

DIORITE (PROTEROZOIC Z)

Zd

MOUNT SHIELDS FORMATION (PROTEROZOIC Y)--Argillite, siltite, and quartzite

Ym

SHEPARD FORMATION (PROTEROZOIC Y)--Limestone, dolomite, siltite, and argillite

Yeh

SNOWSLIP FORMATION (PROTEROZOIC Y)--Argillite, siltite, and quartzite

Yen

HELENA FORMATION (PROTEROZOIC Y)--Limestone and dolomite

Yh

EMPIRE AND GREYSTONE FORMATIONS, UNDIVIDED (PROTEROZOIC Y)--Siltite, argillite, and quartzite

Ys

GREYSON FORMATION (PROTEROZOIC Y)--Siltite and argillite

Yt

Yg

CONTACT--Dashed where inferred

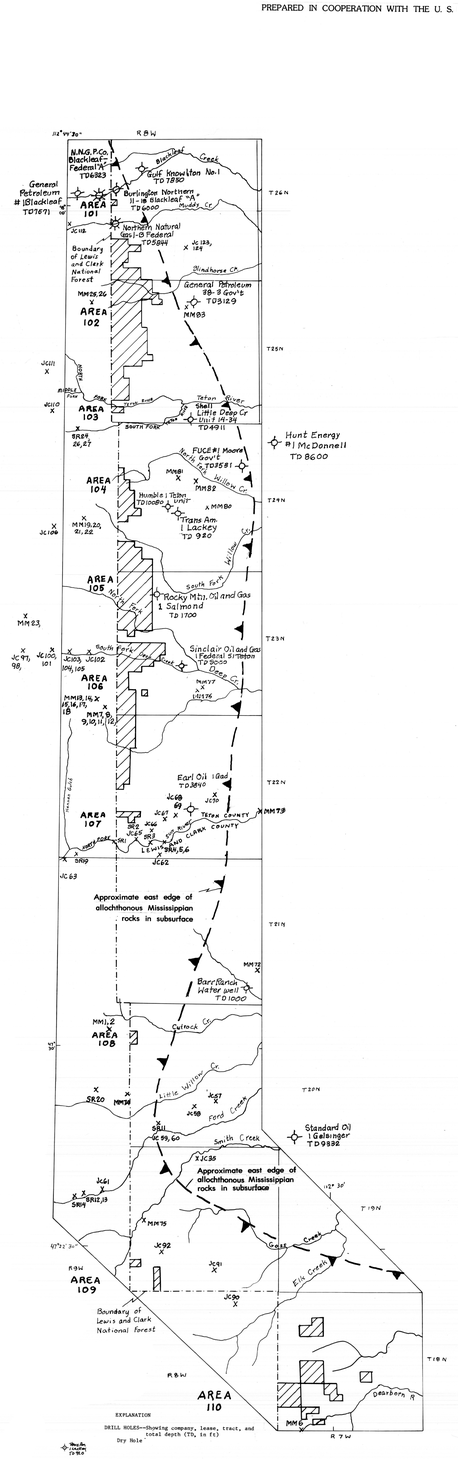
THRUST FAULT--Showing dip; value given where known; sawteeth on upper plate; dashed where inferred

FAULT--Bar and ball on downthrown side; dashed where inferred

STRIKE AND DIP OF BEDS--Value given where known

DRILL HOLE

WILDERNESS STUDY AREA--Areas 106, 109 and 110 are multiple tracts



EXPLANATION

DRILL HOLES--Showing company, lease, tract, and total depth (TD, in ft)

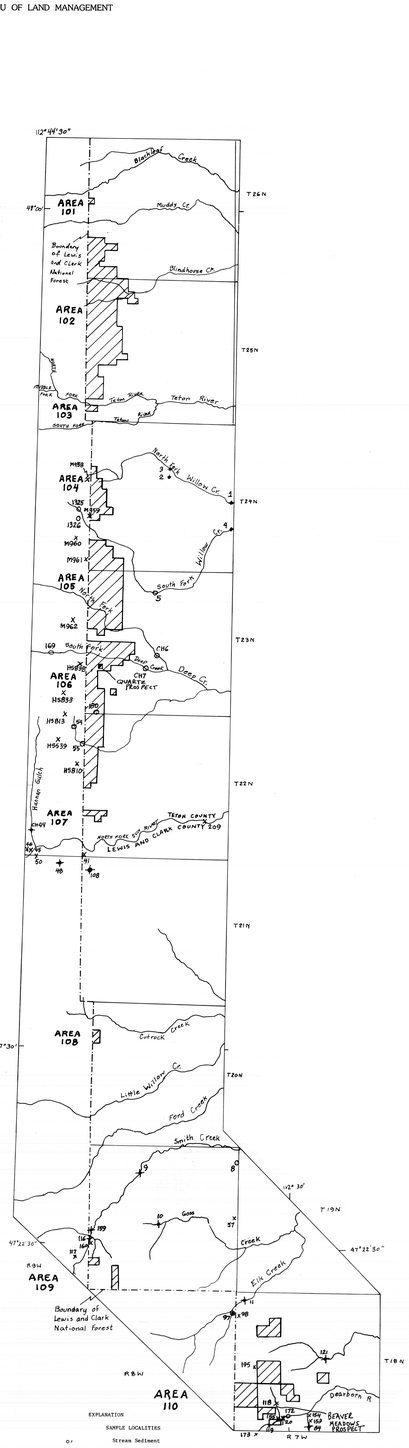
Dry hole

Shut-in Gas Well

HYDROCARBON SOURCE-ROCK SAMPLE LOCALITY

AREA 109 STUDY AREA

MAP B. MAP SHOWING HYDROCARBON SOURCE-ROCK SAMPLE LOCALITIES AND DRILL HOLES NEAR THE WILDERNESS STUDY AREAS EAST OF THE BOB MARSHALL WILDERNESS



EXPLANATION

SAMPLE LOCALITIES

Stream Sediment

Bedrock

Float

Stream Sediment and Float

AREA 109 STUDY AREA

MAP C. MAP SHOWING ROCK AND STREAM-SEDIMENT SAMPLE LOCALITIES NEAR THE WILDERNESS STUDY AREAS EAST OF THE BOB MARSHALL WILDERNESS (GEOLOGICAL SURVEY SAMPLES ONLY)

SCALE 1:125 000

2 0 2 4 6 8 MILES

2 0 2 4 6 8 KILOMETERS

STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and U.S. Bureau of Mines to jointly assess the mineral resource potential of wilderness study areas. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of U.S. Geological Survey geologic and mineral surveys of study areas MT-075-101 through MT-075-110, which originally were considered by the U.S. Bureau of Land Management (BLM) to be wilderness study areas. The Bureau of Mines studied only areas MT-075-102, 105, 106, 107, and 110; the others were dropped from consideration as wilderness study areas by BLM. The U.S. Bureau of Mines Western Resource Area, east of the Bob Marshall Wilderness, Teton and Lewis and Clark Counties, Montana.

SUMMARY

The 10 U. S. Bureau of Land Management areas have a high potential for hydrocarbon resources, mainly gas. The areas contain potential source and reservoir rocks and are in a structural setting favorable for hydrocarbon generation and accumulation. Seismic data and additional geologic mapping will determine if potential structural traps are present.

Area 110 has a low potential for lead resources. There are no identified mineral resources in study areas MT-075-102, 105, 106, 107, or 110.

INTRODUCTION

The 10 areas described in this report are administered by BLM in northwestern Montana (fig. 1). The areas, designated 101-110 in this report, adjoin the Bob Marshall Wilderness and Lewis and Clark National Forest along the eastern side of the northern Rocky Mountains; some of them extend west into the eastern part of the mountains. The northern areas (101-108) are in or adjacent to the Swan Range, whereas the southern areas (109-110) are in the eastern part of the Lewis and Clark Range. The areas total about 73 sq mi. Elevations range from about 5,000 ft in many places east of the mountains to 8,580 ft at Sun Mountain; the total relief is about 3,580 ft.

Only five of the areas are presently under consideration as wilderness study areas: area 102 (Wind Horse Creek), area 105 (Chute Mountain), area 106 (Deep Creek/Battle Creek), area 107 (North Fork of Sun River), and a part of area 110 (Beaver Meadows). These five areas were examined by both the Geological Survey and the Bureau of Mines. The five other areas (101, 103, 104, 108, 109, and part of 110) are BLM areas not proposed for wilderness designation and were examined solely by the U.S. Geological Survey.

PRESENT AND PREVIOUS STUDIES

Many reports and maps describe the geology of the 10 areas. Map A is from a geologic map of part of the disturbed belt of Montana at a scale of 1:125,000 (Mudge, 1979). All of the areas except 101 are shown on the Choteau 1°x2° quadrangle geologic map at a scale of 1:250,000 (Mudge and others, 1982). Areas 106 and 107 are also shown on bedrock and surficial geologic maps of the Ear Mountain quadrangle at a scale of 1:24,000 (Mudge, 1968, 1972a) and in reports on the geology of the Sun River Canyon area (Mudge, 1972b, 1972c). Areas 108 and 110 are discussed in a report on the geology, geophysics, and geochemistry of the southeastern part of the Lewis and Clark Range (Mudge and others, 1968). Parts of areas 105 and 106 adjoin a National Forest study area, adjacent to the Bob Marshall Wilderness, which was evaluated for its mineral potential by the Geological Survey and Bureau of Mines (1978). Areas 101-107 are included in a reconnaissance study of the geology of part of the Birch Creek-Dupuyer Creek area, northwestern Montana (Stebinger (1918). All of the areas are covered by aeromagnetic and gravity studies by Klepper and Mudge (1972).

Adjacent to and west of the BLM wilderness study areas are National Forest lands that have been studied for mineral resource potential. These areas include the Scapegoat Wilderness (Mudge and others, 1974), Bob Marshall Wilderness (U.S. Geological Survey and U.S. Bureau of Mines, 1978), and the southeastern part of the Lewis and Clark Range (Mudge and others, 1968).

U.S. Geological Survey personnel did geologic mapping, geochemical sampling, and geophysical surveys. During these studies, rock samples were collected from formations that crop out in and near the study areas, and sediment samples were taken from streams that drain the areas. Float samples collected consisted of pebbles and cobbles from stream gravel. All samples were analyzed by a semiquantitative spectrographic method for 30 elements. In addition, samples collected near areas 110 were analyzed for lead and zinc by a rapid chemical spectrophotometric method; were analyzed for citrate-soluble heavy metals, and rock and sediment samples collected near area 110 were analyzed for mercury. Analyses were by D. J. Grimes, G. C. Curtin, A. P. Marranzino, H. W. Knight, J. H. McCarthy, J. R. McHugh, and G. W. Van Sickle.

In 1983, Bureau of Mines personnel gathered data concerning mines, prospects, and mineralized areas by searching literature and courthouse records and making a field examination of the five wilderness study areas (Campbell and Scott, 1984). The field examination required 12 worker-days. Nine rock samples were collected and analyzed for copper, lead, zinc, gold, silver, calcium, magnesium, iron, aluminum, silicon, strontium, sodium, potassium, manganese, phosphorous, barium, titanium, and vanadium by inductively coupled plasma analysis, or fire-assay methods. At least one sample from each prospect was analyzed for 40 elements by semiquantitative spectrographic methods to determine the presence of unsuspected elements. Excluding coal, sample preparation was done by the Western Field Operations Center, Spokane, Wash., and analyses were done by the Bureau's Reno Research Center, Reno, Nev. The U.S. Department of Energy's Pittsburgh Energy Technology Center, Pittsburgh, Pa., determined heat value and moisture, ash, carbon, sulfur, and other abundances in a coal sample.

GEOLOGY

The surface geology of the 10 areas is shown on map A. The rocks are predominantly sedimentary and range in age from Precambrian (Belt Supergroup) to Late Cretaceous. A diorite sill of Proterozoic Z age (750 m.y.) near area 110 is the only igneous rock exposed near the areas. Upper Cretaceous sedimentary rocks underlie the plains east of the foothills west of the wilderness study areas (map A). Quaternary deposits locally mantle parts of each area.

All of the areas are in the northern disturbed belt of Montana, an arcuate zone of numerous closely spaced, northerly trending and westerly dipping thrust faults, many folds, and some longitudinal normal faults.

Thrust faulting in all 10 areas contributed to the development of structural traps that have potential for hydrocarbons.

GEOCHEMISTRY

Samples of outcrops in and near the 10 areas (map B) were tested for their potential as hydrocarbon source rocks. The results of these data together with a structural synthesis of the area suggest that the areas have a high potential for hydrocarbons.

The analytical results from rock and stream-sediment samples collected near the areas show no occurrences of economic minerals, but one sample from area 110 and four samples from near area 110 contain anomalous amounts of lead and zinc (map C).

Area 110 is near a northwesterly trending zone that locally contains visible amounts of lead and zinc minerals (Mudge and others, 1968). The mineralized zone extends for 19.3 mi to the northwest of area 110, and recent geochemical studies by D. J. Grimes and L. W. Leinz (oral commun., 1982) show that the zone continues well to the southeast of the area. The highest known lead and zinc concentrations in anomalous lead are given in table 1. Seven rock samples and three stream-sediment samples from near area 110 contain highly anomalous amounts of lead. Five of these samples (table 1) contain anomalous amounts of zinc (more than 200 ppm), or silver (0.5 ppm or more), or copper (70 ppm or more). The highest lead values are from a prospect pit (sample 118) near the contact of a diorite sill with limestone. Elsewhere near area 110, anomalous amounts of lead are in a variety of sedimentary rock types ranging in age from Precambrian to Devonian. Several of the anomalous samples were collected near thrust faults, which suggests that lead and the associated metals were either introduced or remobilized along these faults and were deposited in host rocks in the upper places. Parts of area 110 are cut by thrust faults that in the Beaver Meadows area contain highly anomalous amounts of lead.

MINES AND PROSPECTS

Bureau of Mines personnel examined mines and prospects only in the five BLM proposed wilderness study areas (MT-075-102, 105, 106, 107, and 110). No current mining claims were found in these areas in 1983, and evidence of mining activity was found only inside the Deep Creek/Battle Creek Wilderness Study Area at one prospect, where narrow quartz veins in limestone contain no significant metal values. Prospects examined during this study are shown on map C. Previous mining activity near the study areas occurred about the turn of the century when early settlers prospected for coal east of the Chute Mountain Wilderness Study Area and mined limestone bluffs on the Dearborn River, and prospected for lead east of the Beaver Meadows Wilderness Study Area (Lewis and Clark County mining claim records; James Salmond, personal commun., 1983). Titaniferous-magnetite deposits near Lake Thelma were prospected for iron during World War II.

Bureau of Land Management records indicate that 7,025 acres within the five wilderness study areas have been leased for oil and gas exploration. Several oil companies were actively exploring for oil and gas, including drilling exploratory tests, near the wilderness study areas in 1981.

The Beaver Meadows prospect (map C) is east of the Beaver Meadows Wilderness Study Area in a northwest-trending zone containing anomalous lead values. Quartzite at the prospect contains finely disseminated galena along a contact with a diorite sill; no evidence was found that this occurrence extends into the wilderness study area. Other prospects in the zone are 3.5 mi northwest of the wilderness study area, north of Elk Creek.

Carbonate rocks are abundant in the Montana disturbed belt, and limestone occurrences are in many places potential resources. Bureau of Mines analyses of limestone samples from the wilderness study areas (map C, nos. 1-5, 6, and 7) are shown in table 2.

A chip sample from a lens of impure coal exposed in an irrigation ditch (map C, no. 4) had a heating value of 782 Btu/lb and an ash content of 85 percent. This coal is in Cretaceous rocks and is probably part of the Blackleaf-Valier coal belt, which is characterized by coal in beds that are generally thin and discontinuous (Averitt, 1963, p. 49, fig. 7). No coal was found in any of the wilderness study areas.

Titaniferous magnetite occurs near Lake Thelma in Cretaceous beach placer deposits (map C). No evidence of titaniferous magnetite occurrences was found in any of the wilderness study areas.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The evaluation of the mineral resources exclusive of oil and gas is based on data obtained by geological, geochemical, and geophysical studies of adjacent areas (fig. 2). These areas include the Scapegoat Wilderness (Mudge and others, 1974), Bob Marshall Wilderness (U.S. Geological Survey and U.S. Bureau of Mines, 1978), and the southeastern part of the Lewis and Clark Range (Mudge and others, 1968).

Areas 101-109 are apparently devoid of occurrences of economic minerals. The geochemical studies do not indicate any unusual concentration of valuable elements, and the geophysical surveys do not indicate any aeromagnetic or gravity anomalies that would be caused by concealed plutons or certain limestone and dolomite deposits, possibly of commercial grade; however, larger deposits of these commodities are abundant in more accessible areas of northwestern Montana.

One prospect of the Beaver Meadows Wilderness Study Area has low potential for lead resources; outcrops at this prospect are not sufficient to define resources. Based on the probable extension of the zone of anomalous geochemical anomalies associated with the prospect, parts of the Beaver Meadows area have a low potential for lead resources.

Area 110 is in a northwesterly trending zone that locally contains visible amounts of lead and zinc minerals (Mudge and others, 1968). The mineralized zone extends for 19.3 mi to the northwest of area 110, and recent geochemical studies by D. J. Grimes and L. W. Leinz (oral commun., 1982) show that the zone continues well to the southeast of the area. The highest known lead and zinc concentrations in anomalous lead are given in table 1. Seven rock samples and three stream-sediment samples from near area 110 contain highly anomalous amounts of lead. Five of these samples (table 1) contain anomalous amounts of zinc (more than 200 ppm), or silver (0.5 ppm or more), or copper (70 ppm or more). The highest lead values are from a prospect pit (sample 118) near the contact of a diorite sill with limestone. Elsewhere near area 110, anomalous amounts of lead are in a variety of sedimentary rock types ranging in age from Precambrian to Devonian. Several of the anomalous samples were collected near thrust faults, which suggests that lead and the associated metals were either introduced or remobilized along these faults and were deposited in host rocks in the upper places. Parts of area 110 are cut by thrust faults that in the Beaver Meadows area contain highly anomalous amounts of lead.

Individual occurrences of lead and zinc along the mineralized trend are small and confined to a narrow zone. None of the known occurrences contain minable quantities of ore-grade material. However, the mineralized zone in area 110 has not been tested by drilling, and the area is considered to have a low potential for lead resources with associated zinc, silver, and copper.

Table 1.--Analytical results of samples of anomalous rocks collected near U.S. Bureau of Land Management area MT-075-110

[Analyses are spectrographic, by G. C. Curtin and A. P. Marranzino, except: Pb and Zn analyses are chemical, by J. R McHugh and G. W. Van Sickle; and Hg analyses are atomic absorption, by H. W. Knight and J. H. McCarthy. Values are in parts per million except Ca, Mg, and Fe, which are in percent. ND, not determined; >, greater than amount shown; <, less than amount shown]

Sample No.	Ca	Mg	Fe	Ti	Mn	Ag	B	Ba	Cd	Co	Cr	Cu	Ga	Hg	Mo	Ni	Pb	Sr	V	Y	Zn	Zr
118	<20	0.7	2	3,000	5,000	<1	<10	300	<20	7	20	20	10	0.02	<2	5	>15,000	150	150	50	200	20
119	.7	1	1	1,500	200	1.5	50	200	<20	15	20	50	15	.19	15	20	150	50	50	30	<200	150
120	.7	.5	15	80	2,000	5	100	200	<20	<5	15	30	20	.07	20	2	8,000	50	20	15	1,500	150
153	1	1	>30	5,000	5,000	5	150	300	20	20	5	1,500	50	.02	<2	15	>20,000	<50	100	30	<200	30
154	.1	.5	5	1,000	5,000	5	150	50	<5	5	50	<10	50	<2	<2	7	1,500	<50	30	10	7,000	150

Table 2.--Limestone sample analyses

[Values in percent; N, none detected]

Sample No. (map C)	CaO[1]	MgO[2]	Fe_2O_3	Al_2O_3	SiO_2	Na_2O	K_2O
1	35.4	15.4	0.09	0.17	6.6	N	0.17
2	37.5	19.4	.10	.14	3.5	N	.09
3	35.9	2.5	.12	.15	22.0	N	N
5	34.4	14.7	.15	.48	9.1	N	.08
7	49.5	2.6	.42	.91	4.0	0.05	.21

[1]If all the calcium in the sample is assumed to be in the form of carbonate molecules, the content of $CaCO_3$ in the analysis may be obtained by multiplying the CaO content by the factor 1.785.

[2]If all the magnesium in the sample is assumed to be in the form of carbonate molecules, the content of $MgCO_3$ in the analysis may be obtained by multiplying the MgO content by the factor 2.0915.

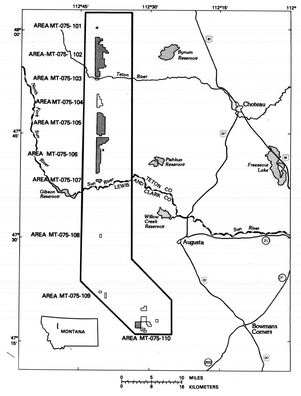


Figure 1.--Index map showing the location of the wilderness study areas east of the Bob Marshall Wilderness, northwestern Montana. Shaded areas were evaluated by both the Geological Survey and the Bureau of Mines.

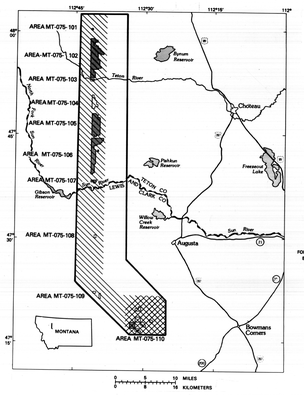


Figure 2.--Map showing the mineral resource potential of wilderness study areas east of the Bob Marshall Wilderness, northwestern Montana.

REFERENCES CITED

Averitt, Paul, 1963, Coal, in Mineral and water resources of Montana: Montana Bureau of Mines and Geology Special Publication 28, p. 46-52.

Campbell, Ma W., and Scott, D. F., 1984, Mineral investigations of the Beaver Meadows, Wind Horse Creek, Chute Mountain, Deep Creek/Battle Creek, and North Fork of Sun River Wilderness Study Areas (BLM Nos. MT-075-101, 102, 105, 106, and 107), Lewis and Clark, and Teton Counties, Montana: U.S. Bureau of Mines Open-File Report MLA 24-84, 33 p.

Earhart, R. L., 1976, A geological and geochemical evaluation of mineral resources of the Bob Marshall Wilderness and study areas, Chapter C, in Mineral resources of the Bob Marshall Wilderness and study areas, Lewis and Clark, Teton, Pondera, Flathead, Lake, Missoula, and Powell Counties, Montana: U.S. Geological Survey Open-File Report 76-395, p. 81-116.

Kleinkopf, M. D., and Mudge, M. R., 1972, Aeromagnetic, Bouguer gravity, and generalized geologic studies of the Great Falls-Winston Range Corridor, west-central Montana: U.S. Geological Survey Professional Paper 704, 19 p.

Montana Oil and Gas Statistical Bulletin, 1983, Quarterly activity summary, July through September 1983: Board of Oil and Gas Conservation, v. 31, no. 9, p.

Mudge, M. R., 1968, Bedrock geologic map of the Castle Reef quadrangle, Teton and Lewis and Clark Counties, Montana: U.S. Geological Survey Geologic Quadrangle Map GQ-711, scale 1:24,000.

_____1972a, Structural geology of the Sun River Canyon and adjacent areas, northwestern Montana: U.S. Geological Survey Professional Paper 663-B, 52 p.

_____1972b, Surficial geologic map of the Castle Reef quadrangle, Teton and Lewis and Clark Counties, Montana: U.S. Geological Survey Geologic Quadrangle Map GQ-993, scale 1:24,000.

_____1972c, Preliminary geologic map of part of the northern disturbed belt, Lewis and Clark, Teton, Pondera, Glacier, Flathead, Cascade, and Powell Counties, Montana: U.S. Geological Survey Open-File Report 72-913, 8 p., 2 oversize sheets.

Mudge, M. R., Earhart, R. L., Whipple, J. W., and Harrison, J. E., 1982, Geologic and structure map of the Choteau 1°x2° quadrangle, western Montana: U.S. Geological Survey Miscellaneous Investigations Map I-1300, scale 1:250,000, 2 sheets.

Mudge, M. R., Earhart, R. L., Watts, K. C., Jr., Bucknam, R. C., and Lyde, R. W., 1974, Mineral resources of the Scapegoat Wilderness, Powell and Lewis and Clark Counties, Montana, with a section on Geophysical surveys, by D. L. Peterson: U.S. Geological Survey Bulletin 1383-B, 82 p.

Mudge, M. R., Erickson, R. L., and Kleinkopf, M. D., 1968, Reconnaissance geology, geophysics, and geochemistry of the southeastern part of the Lewis and Clark Range, Montana: U.S. Geological Survey Bulletin 1252-C, 33 p.

Stebinger, Eugene, 1918, Oil and gas geology of the Birch Creek-Dupuyer Creek area, northwestern Montana: U.S. Geological Survey Bulletin 691, p. 149-181.

U.S. Geological Survey and U.S. Bureau of Mines, 1978, Mineral resources of the Bob Marshall Wilderness and study areas, Lewis and Clark, Teton, Pondera, Flathead, Lake, Missoula, and Powell Counties, Montana: U.S. Geological Survey Open-File Report 76-395, 187 p.

[1]Only part of area 110 was studied by the U.S. Bureau of Mines (fig. 1).

[2]Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, gallium, gold, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, nickel, niobium, palladium, potassium, phosphorus, platinum, scandium, silicon, silver, sodium, strontium, tantalum, tellurium, tin, titanium, vanadium, yttrium, zinc, and zirconium.

[3]In commercial usage, the word "limestone" is a general term for rocks containing at least 80 percent calcium and magnesium carbonate.

GEOLOGIC, SAMPLE LOCALITY, AND MINERAL RESOURCE POTENTIAL MAPS OF WILDERNESS STUDY AREAS EAST OF THE BOB MARSHALL WILDERNESS, TETON AND LEWIS AND CLARK COUNTIES, MONTANA

By
Melville R. Mudge, Robert L. Earhart, Jerry L. Clayton, and K. M. Nichols U. S. Geological Survey
and
Harry W. Campbell and Douglas F. Scott U. S. Bureau of Mines

1984

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.