Mineral Resources of the Ferris Mountains Wilderness Study Area, Carbon County, Wyoming

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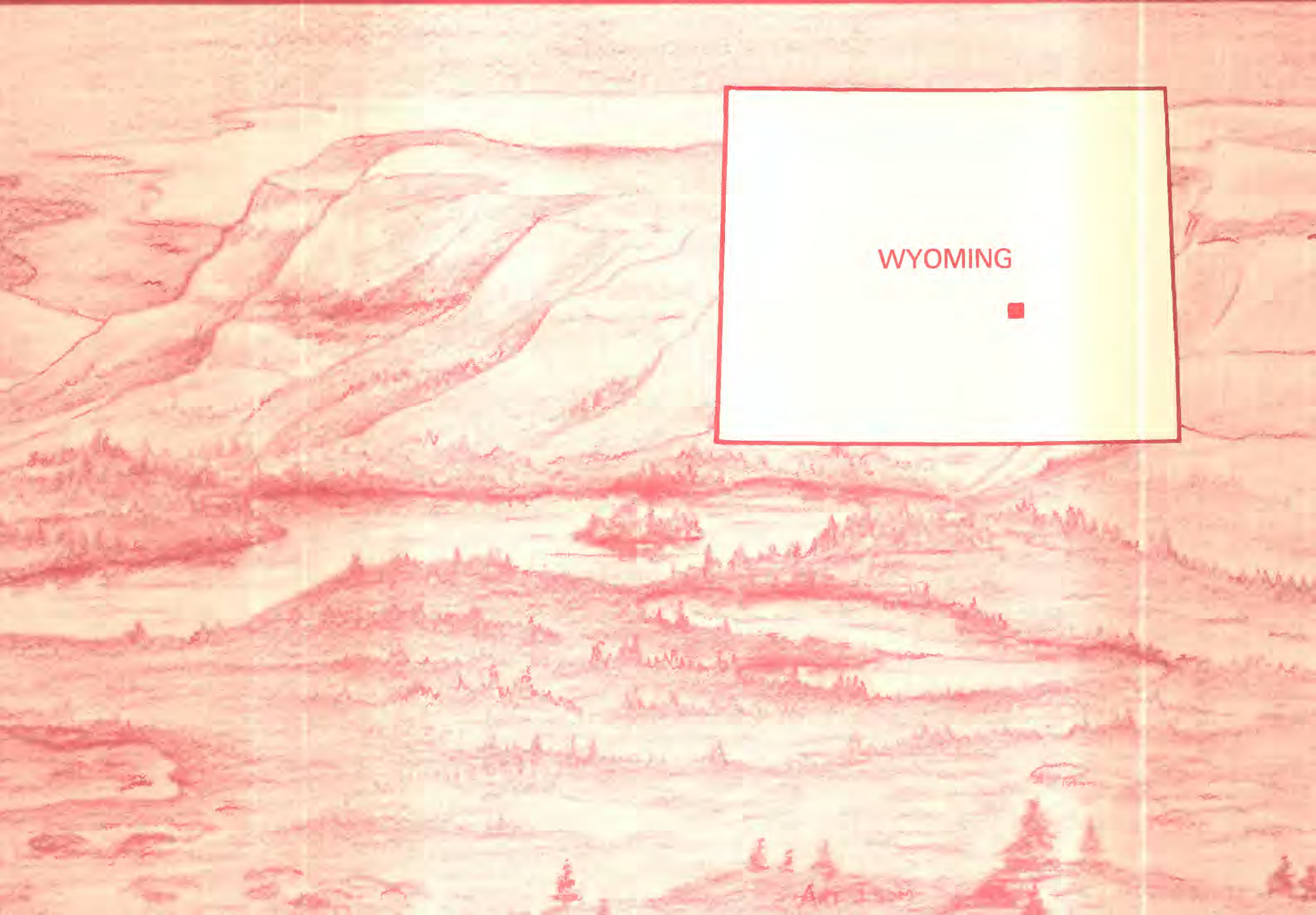

Chapter C

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By MITCHELL W. REYNOLDS
U.S. Geological Survey

JOHN T. NEUBERT
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1757

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
SOUTHERN WYOMING

DEPARTMENT OF THE INTERIOR
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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 the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of the Ferris Mountains Wilderness Study Area (WY–030-407), Carbon County, Wyoming.

CONTENTS

Abstract C1
Summary C1
    Character and setting C1
    Mineral occurrences C3
    Mineral resource potential C3
Introduction C3
    Area description C3
    Previous and present investigations C5
Appraisal of identified resources C6
    History and production C6
    Mineral occurrences C6
Assessment of potential for undiscovered resources C7
    Geology C7
        Late Archean and older crystalline rocks C7
        Mesozoic and Paleozoic sedimentary rocks C8
        Tertiary sedimentary rocks C8
        Quaternary surficial deposits C8
        Structure C9
    Geochemistry C12
    Geophysics C12
    Mineral and energy resource potential C14
        Metallic minerals C14
        Nonmetallic minerals C15
        Energy minerals C15
        Oil and natural gas C16
References cited C17
Appendix C19

PLATE

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1. Map showing mineral resource potential, geology, and prospects of the Ferris Mountains Wilderness Study Area

FIGURES

1. Index map showing location of the Ferris Mountains Wilderness Study Area C2
2. Summary map showing mineral resource potential and generalized geology of the Ferris Mountains Wilderness Study Area C4
3. Map showing complete Bouguer gravity anomalies of the Ferris Mountains Wilderness Study Area and adjacent areas C13

TABLE

1. Sequence of stratigraphic units in the Ferris Mountains Wilderness Study Area and their regional significance for mineral and fossil-fuel occurrences C10

Mineral Resources of the Ferris Mountains Wilderness Study Area, Carbon County, Wyoming

By Mitchell W. Reynolds
U.S. Geological Survey

John T. Neubert
U.S. Bureau of Mines

ABSTRACT

The Ferris Mountains Wilderness Study Area (WY–030–407) encompasses most of the Ferris Mountains in south-central Wyoming. It contains 20,495 acres across the narrow, rugged mountain range. Field investigations of the mineral resources of the area were conducted during 1983 and 1984. Mineral exploration, which began in 1870 and has been intermittent since, concentrated on the Babbs mine and Spanish mine areas and on numerous small sites at which very low grade occurrences of silver, copper, lead, zinc, and gold had been identified. During the present study, all workings were examined and representative rock and mineral samples from them were analyzed. Reconnaissance geochemical sampling of rocks, minerals, and stream sediments was conducted for the entire area. Low, but anomalous concentrations of silver, copper, arsenic, and locally gold, lead, and zinc were identified in rock and mineral samples from areas of the workings and at three other sites within the study area. Small isolated occurrences of copper or silver in very low concentrations were identified at several other localities. All metallic mineral occurrences are in quartz veins or narrow shear zones in dikes and in lenses of metamorphic rock in granite. There are no identified resources in the area. Crystalline rocks of the study area have low mineral resource potential, with a certainty level of C, for all undiscovered metallic minerals including gold, silver, copper, lead, zinc, iron, nickel, molybdenum, tungsten, lithium, beryllium, and manganese. Sedimentary rocks of the study area have no resource potential for any metallic elements, at certainty level D. Resource potential for undiscovered calcium carbonate and silica is low, with a certainty level of C, and no resource potential exists, with a certainty level of D, for undiscovered phosphate, gypsum, uranium and thorium, coal, and oil and gas.

SUMMARY

Character and Setting

The Ferris Mountains Wilderness Study Area is in south-central Wyoming (fig. 1) about 35 mi (miles) north of Rawlins and 65 mi west of Casper. The area contains about 20,495 acres in the Ferris Mountains, a narrow rugged mountain range where 9,400- to 10,037-ft-high peaks rise above adjacent dissected rolling terrain. Unimproved ranch roads lead to the base of the mountains, but access within the mountains is only by foot. Archean (see geologic time chart in appendix) granite and granodiorite, which contain lenses of older metasedimentary and metavolcanic rock and are intruded by linear dikes of basalt and diorite, support the northern and southwestern parts of the mountains. Sedimentary rocks of Cambrian through Cretaceous age unconformably overlie the Archean crystalline rocks (pl. 1 and table 1). All of the rocks along the north flank and east half of the area are folded monoclinally and dip south. All rocks in the southwestern part are folded anticlinally; a shallow syncline that trends northwest diagonally across the area separates the tilted and folded blocks. Strata on the west and south flanks dip steeply into the adjacent structurally deep Camp Creek syncline (fig. 1). The steep north flank of the range marks a zone of normal faults, segments of which have moved during Quaternary time. Tertiary rocks on the north are faulted down relative to Archean crystalline and Paleozoic sedimentary rocks of the mountains on the south.

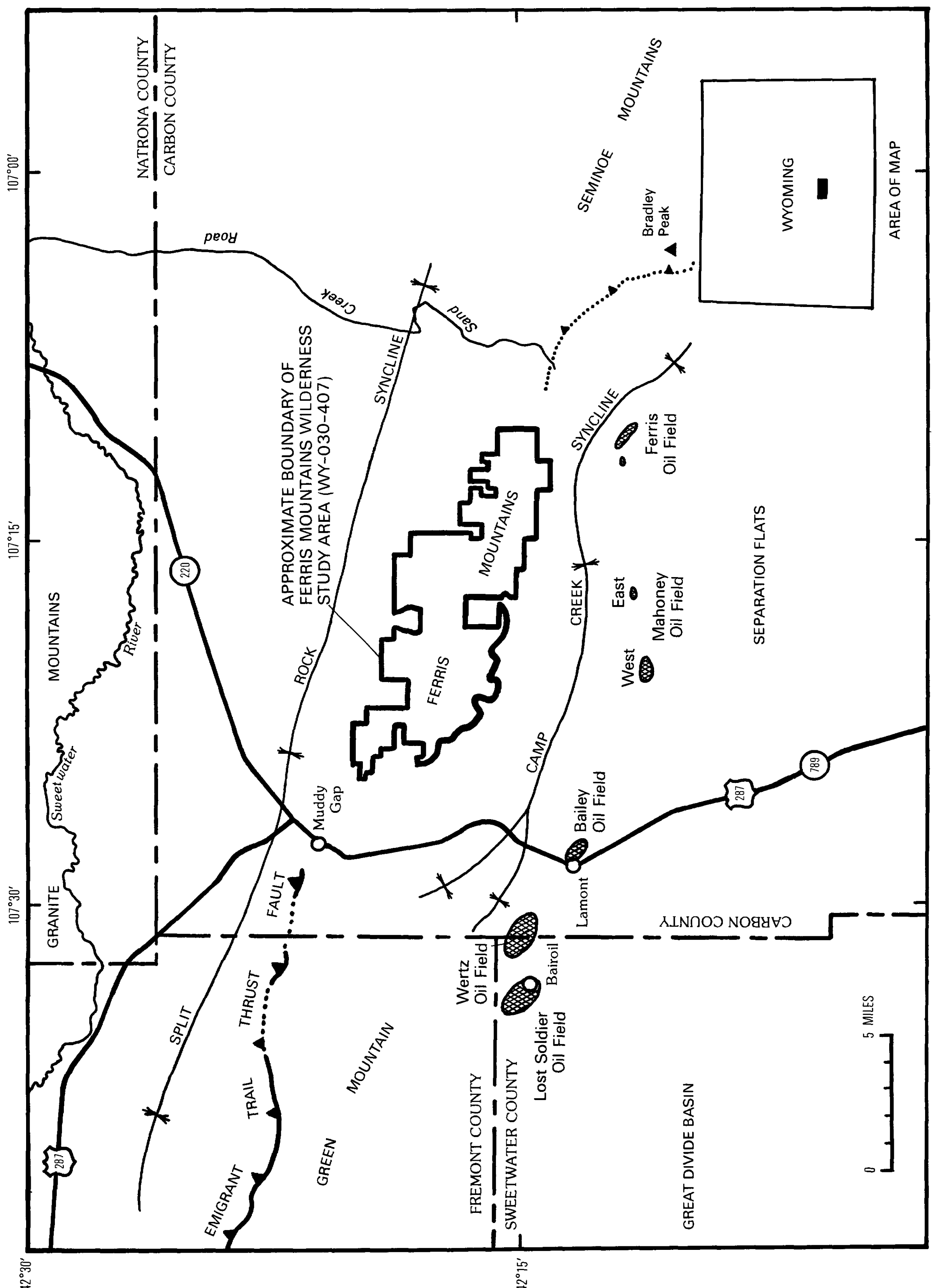


Figure 1. Index map showing location of the Ferris Mountains Wilderness Study Area, Carbon County, Wyo.

Mineralized rock in Miners Canyon (pl. 1; fig. 2), at the east end of the study area, was prospected between 1870 and 1890. Small amounts of gold were reportedly milled from vein quartz prior to 1890. Intermittent, but poorly documented activity continued until the 1980's, when claims were filed and sampling programs were conducted in the Miners Canyon area. During the early 1950's, near the center of the wilderness study area, exploration was conducted at the Babbs mine (fig. 2; pl. 1). Open cuts and two shallow adits were excavated to examine silver, copper, lead, and, rarely, gold occurrences. The Babbs mine area has not been worked since. Numerous prospect pits have been excavated along quartz veins, in ferruginous shear zones, and in inclusions of metamorphic rock in the widespread Late Archean granitoid rocks of the area.

Mineral Occurrences

Small occurrences of copper, lead, and silver, and trace amounts of gold exist in the Babbs mine (fig. 2) and Miners Canyon areas. Other isolated occurrences in the upper part of Garden Creek drainage and on the mountain crest at the head of Pete Creek contain small amounts of copper, silver, and zinc or lead. Concentrations of these metals are extremely low and limited in areal extent, and no identified resources are present.

Mineral Resource Potential

Low anomalous concentrations of copper, silver, locally gold, and zinc or lead are present at widely separated localities in the Ferris Mountains Wilderness Study Area. The mineral occurrences and locally associated characteristic suites of trace elements are in quartz veins, diabase dikes, and inclusions of metamorphic rocks in granite and granodiorite. These occurrences are typical of gold-quartz vein deposits in cores of ancient mountain ranges. However, the widely scattered, yet highly localized distribution of the metallic minerals in low concentrations demonstrates a low mineral resource potential for undiscovered gold, silver, copper, lead, zinc, iron, nickel, molybdenum, tungsten, lithium, beryllium, and manganese in crystalline rocks of the study area. Other rocks of the study area have no resource potential for any metallic elements.

Calcium carbonate of sufficiently high purity to be suitable for cement is present locally in widely exposed limestone units of the study area. The suitability of the units as cement or refining flux resources is poor because of lateral variation in dolomite, clay, and silica content in the limestone. Limestone in the study area is not classified as an identified resource. We assign a low resource potential for undiscovered calcium carbonate. Low resource potential exists for silica. No phosphate, gypsum, or energy-mineral resources such as uranium and thorium or coal are present, and no potential exists for undiscovered resources. No oil and gas resource potential exists for the Ferris Mountains Wilderness Study Area.

INTRODUCTION

Area Description

The Ferris Mountains Wilderness Study Area (WY–030–407) was studied at the request of the U.S. Bureau of Land Management (BLM); it contains approximately 20,495 acres in the Ferris Mountains, south-central Wyoming (figs. 1, 2). The area is about 1.5–4 mi wide and 13.5 mi long, elongate in a general west-northwest direction parallel to the crest of the Ferris Mountains. The narrow mountain range rises abruptly from the broad valley of the Sweetwater River on the north and from Separation Flat on the south (fig. 1). From an elevation of about 9,100 ft near the east end of the study area, the range crest rises to 10,037 ft at Ferris Mountain in the north-central part of the range (fig. 2; pl. 1). Near the center of the area, the mountain crest is offset southwest across Youngs Pass, elevation 8,750 ft. The southwest segment of the crest rises near Muddy Creek to elevations of 9,350–9,670 ft and extends west-northwest to Black Canyon (fig. 2). Near Cherry Creek the mountain crest of the eastern part of the range declines in elevation progressively west to form a subordinate northwest-striking ridge north of the southwestern crest. Terrain is particularly steep on the south flank of the mountains where picturesque flatirons of white limestone and locally of pale-yellow sandstone rise at very steep angles from adjacent rolling surfaces. Permanent and intermittent streams drain north, northwest, and south from the mountains. These streams have eroded deep water gaps through strike ridges of the steeply tilted resistant strata on the flanks of the range. Dissected pediment and terrace surfaces that head at elevations of about 7,700 ft on the north flank and about 8,100 ft on the south flank slope away from the narrow mountain range.

Access to the north flank of the Ferris Mountains is by unimproved ranch roads that extend south from Wyoming State Highway 220 to the base of the mountains (fig. 1). The south flank is accessible by unimproved ranch roads that extend east and north from U.S. Highway 287. Those roads become impassable during storms. Access to the Miners Canyon area at the east end is from the Sand Creek road, but drifting sand and extensive erosion of existing jeep trails have made access to the southeast flank very difficult by vehicle. The rugged mountains within the study area are accessible only by foot.

Vegetation above 7,900 ft is mainly limber pine, yellow pine, and Douglas fir. Blue spruce grows in several drainages on the steep north side of the range, and aspen grows along open margins of conifer stands or along

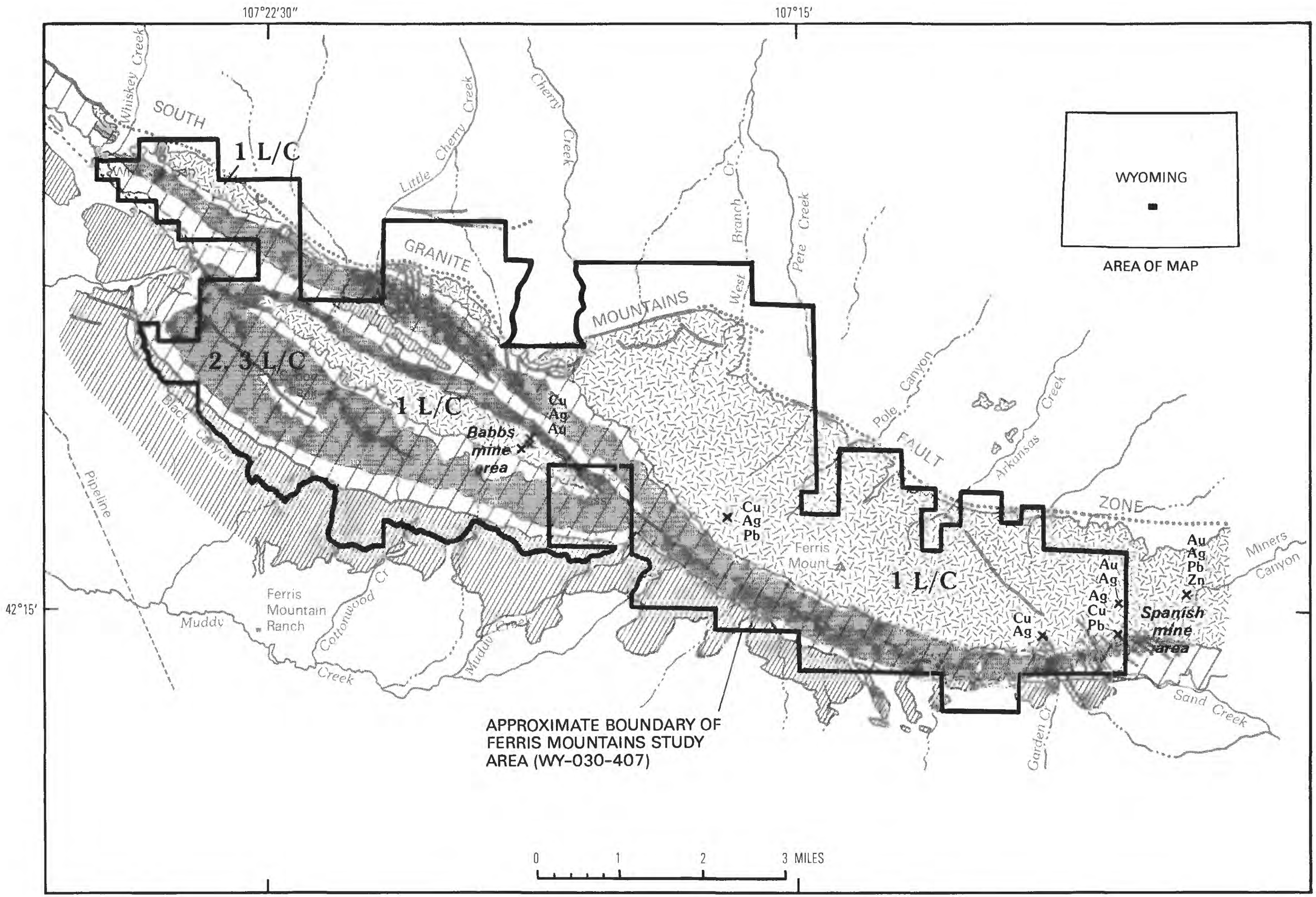


Figure 2 (above and facing page). Summary map showing mineral resource potential and generalized geology of the Ferris Mountains Wilderness Study Area, Carbon County, Wyo.

EXPLANATION

[No geologic terrane having high or moderate mineral resource potential for any commodity was identified by this study. The entire study area has no mineral resource potential for commodities 4 and 5 (see list below), at certainty level D. Phanerozoic rocks have no resource potential for any metallic elements, at certainty level D]

1 L/C	**Geologic terrane having low mineral resource potential for commodity 1, at certainty level C**
2, 3 L/C	**Geologic terrane having low mineral resource potential for commodities 2 and 3, at certainty level C**
	Quaternary sediments and Tertiary sedimentary rocks
	Mesozoic sedimentary rocks
	Paleozoic sedimentary rocks
	Archean crystalline rocks
	Geologic contact
	Fault—Dotted where concealed
× Cu	**Mineral occurrence showing metallic elements in low, but anomalous concentrations**—Ag, silver; Au, gold; Cu, copper; Pb, lead; Zn, zinc

Commodities

1. Gold, silver, copper, lead, zinc, iron, nickel, molybdenum, tungsten, lithium, beryllium, manganese
2. Limestone ($CaCO_3$), cement or flux use
3. Silica
4. Gypsum, phosphate, uranium, thorium, coal
5. Oil and natural gas

Levels of certainty

C Available data give a good indication of the geologic environment and the level of mineral resource potential, but additional evidence is needed to establish precisely the likelihood of resource occurrence, the activity of resource-forming processes, or available occurrence

D Available data clearly define the geologic environment and the level of mineral resource potential, and indicate the activity of resource-forming processes. Key evidence to interpret the presence or absence of specific types of resources is available, and occurrence or genetic models are adequate for predictive assessment

drainages at the break in slope between mountain and pediment. Grasses, sagebrush and rabbitbrush, and wild flowers vegetate land surfaces sloping away from the mountains. Deer, elk, and rare bighorn sheep and mountain lion live in the mountainous terrain, and numerous antelope graze on adjacent slopes. The climate is generally semiarid, although microclimates in individual drainages on the north flank are wetter.

Previous and Present Investigations

Early geologic investigations near the Ferris Mountains examined the rocks and structure as they relate to petroleum occurrences that extend from the Lost Soldier to the Ferris oil fields south of the mountains (fig. 1). Fath and Moulton (1924) and Knight (1951) described the geology and structure adjacent to the mountains. Three theses written at the University of Wyoming described rock successions and geologic structure south and west of the crest of the Ferris Mountains (Heisey, 1949; Lawson, 1949; Weimer, 1949; summarized in Heisey, 1951). Veronda (1951) summarized the geology of the Big Sandy area at the east end of the Ferris Mountains. Detailed geologic mapping by the U.S. Geological Survey (Reynolds, 1968a, 1971, 1976; Rioux and Staatz, 1974) provided detailed information regarding the geology and the history of development of geologic structures in part of the area. Love (1970) described Tertiary rocks and structure north of the mountains.

Mineral resources in the Ferris Mountains area were summarized by Osterwald and others (1959). Master (1977) subsequently studied the Archean crystalline rocks exposed in the core of the mountains to evaluate the rock types and mineral occurrences. The work by Master formed the basis for an unpublished BLM report on the minerals of the Ferris Mountains (Janssen, 1980).

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study area and is the product of separate studies by the U.S. Bureau of Mines (USBM) in 1983 and 1984, and by the U.S. Geological Survey (USGS) during 1984. Identified resources are classified according to the system of the U.S. Bureau of Mines and the U.S. Geological Survey (1980), which is shown in the appendix of this report. Identified resources are studied by the USBM. Mineral resource potential is the likelihood of occurrence of undiscovered metals and nonmetals, of unappraised industrial rocks and minerals, and of undiscovered energy sources (coal, oil, gas, oil shale, and geothermal sources). It is classified according to the system of Goudarzi (1984), which is also shown in the appendix to this report. The potential for undiscovered resources is studied by the USGS.

From its own records and files of the BLM, the USBM compiled background information on the geology, mining history, and records of mineral claims and oil and gas leases in or adjacent to the wilderness study area. The USBM sampled mineralized areas, mines, and prospects. Analyses were made of 147 chip samples, 16 select samples, 111 dump samples, 14 stream-sediment samples, and 1 panned-concentrate sample.

Work by the USGS included field checking existing geologic maps of the western and southeastern parts of the area, new geologic mapping of the remainder of the study area, geochemical sampling of the entire area, and a reconnaissance gravity survey of a selected part of the area. Rock samples were collected from all representative rock types, prospect pits and adits, and areas of possible altered rock to develop information on the distribution of elements in the rocks and mineralized localities. A total of 254 rock and mineral samples and 62 stream-sediment samples were analyzed (D.E. Detra, unpub. data, 1987).

Acknowledgments.—Excellent cooperation by ranchers and residents of the Ferris Mountains area enabled the USGS and USBM to conduct field investigations efficiently. In particular, Gary Raymond and the K.W. and R.B. Raymond families of the Ferris Mountain Ranch were gracious hosts and provided accounts of the history of settlement and mineral exploration on the south flank of the mountains. Bernard and Dennis Sun of the Sun Ranch granted access to large areas on the north flank. Gary and Vivi Crandell of the Bar Eleven Ranch cordially provided assistance, hospitality, and information about the land. During earlier geologic investigations across the west end of the Ferris Mountains, rancher, teacher, and historian Ruth Beebe provided not only access to the area but also lively accounts of the history of settlement of the region and insights concerning the natural resources. William Burnside, claim owner in the Spanish mine area, kindly provided information concerning his claim block.

Dolores M. Kulik, USGS, compiled gravity data and made gravity measurements at selected sites adjacent to and in the study area. H. Roberta Dixon, USGS, provided rock samples for analysis from several localities and discussed rock types in the Cherry Creek area. Brian J. Hannigan assisted in field investigations by the USBM.

APPRAISAL OF IDENTIFIED RESOURCES

By John T. Neubert
U.S. Bureau of Mines

History and Production

No mining district exists in the Ferris Mountains Wilderness Study Area. Near the center of the area, the Babbs mine (or Cherry Creek prospect) (fig. 2; pl. 1) has been the site of exploration for gold and silver in quartz veins associated with diabase dikes in granite and presumably for gold, silver, and copper disseminated in fractured granite. Exploration using adits and shallow open cuts was conducted during the early 1950's, but documentation of specific activity and dates was not found. The Babbs mine area is inactive and no claims are currently registered with the BLM. No production from the Babbs mine has been recorded.

Approximately 1 mi east of the wilderness study area, mineralized rock was discovered in Miners Canyon in about 1870. The area became known as "Spanish mine," and numerous prospect pits and several shallow adits were excavated during exploration. Osterwald and others (1959) and Janssen (1980) reported that free-milling gold was extracted from the ores by a stamp mill on Sand Creek, about 3 mi east of the wilderness study area. Activity between 1880 and 1983 was sporadic and generally poorly documented. Between 1980 and 1983, several adits were reopened for sampling, but no production resulted. Unpatented mining claims extend from about 0.25 mi within the wilderness study area to nearly 2 mi east of the proposed area boundary, generally in the drainage basin of Miners Creek (Neubert, 1985).

As of 1985 the wilderness study area was entirely under lease for oil and gas exploration, but no exploratory drilling for oil and gas had been conducted within the area. The nearest such drilling was 2 mi south of the study area on the north flank of the Camp Creek syncline (fig. 1); that drilling did not encounter oil or gas, and the hole was plugged and abandoned.

Mineral Occurrences

The Babbs mine and Spanish mine mineralized areas were examined and sampled in detail by the USBM (Neubert, 1985).

Three open cuts, an open adit and a caved adit constitute the principal workings in the Babbs mine area. There were no current claims in 1984. Discontinuous quartz veins within and adjacent to diabase dikes are weakly mineralized with precious and base metals including silver, copper, and, rarely, gold. Fractures in granite are locally weakly mineralized with copper. Veins are generally about 1.5 ft wide but locally are as wide as 3 ft; they are as long as 300 ft. Most veins strike north to 15° N.-NW. and dip steeply east or west; in the lower open cut the principal vein and diabase dike strike N. 5°-8° E. Observed minerals include malachite, chalcopyrite, azurite, and bornite. Granite intruded by finely crystalline granite and by pegmatite dikes is the host rock.

Among all samples analyzed from the Babbs mine area, only small amounts of gold, 0.05 troy oz/t (ounces per ton) or less, were identified in a few samples. Silver in amounts smaller than 0.5 troy oz/t and copper less than 1 percent were present in fewer than half the samples analyzed. Two select samples contained 4.7 and 6.2 percent copper. Most samples collected were barren of either precious or base metals. Selected samples from scattered prospect pits east of the Babbs mine contained trace amounts of gold (0.002 oz/t or less), some contained 0.6 oz/t or less silver, and some contained less than 1 percent copper; most samples, however, were barren. No occurrence of base or precious metals is laterally persistent and none constitutes a resource.

In the Spanish mine area, parts of three unpatented mining claims are within the wilderness study area and the majority of the workings are less than 1 mi east of the proposed area boundary. Evidence of mineralization consists generally of low-grade copper, lead, zinc, silver, and arsenic and rare traces of gold in discontinuous fracture-related veins of quartz and calcite. The veins have a maximum width of 12 ft, but most are less than 2 ft wide. The maximum exposed length of veins is 150 ft. Orientations of veins sampled are in three classes: (1) strike N. 10°–15° W. and steep dip east or west; (2) strike N. 40°–52° W., and dip about 45° southwest or northeast; and (3) strike about N. 60°–80° E., and moderate- to high-angle dip northwest and southeast. The host rock is rusty-brown-weathering biotite schist and hornfels; biotite and chlorite are abundant near and within fractures and faults. Pyrite and arsenopyrite are the most common visible sulfide minerals, and galena, chalcopyrite, and sphalerite are evident locally. The mineralized rock was explored in four adits and numerous prospect pits.

Fewer than one-fifth of samples analyzed from workings in the Spanish mine area contained gold (Neubert, 1985). Of these, 1 sample contained 0.19 oz/t, 6 contained more than 0.01 oz/t but less than 0.19 oz/t, and 15 contained a trace to 0.01 oz/t. In samples containing silver, amounts were generally less than 1 oz/t silver, although one sample contained 4.3 oz/t. Most samples contained anomalous concentrations of arsenic; some samples contained anomalous concentrations of copper, lead, and zinc.

Although metallic mineral occurrences exist in the Spanish mine area, none is classified as an identified resource. Metal concentrations in samples from veins in underground workings and pits are low. The highest concentrations measured were from select samples of high-grade material or samples from thin veins exposed for only a short distance. Within the easternmost part of the wilderness study area, select samples from quartz veins that cannot be traced beyond the limits of the workings contain measurable, but very low concentrations of gold, silver, arsenic, and copper.

Limestone was sampled by the USBM at seven localities in the Madison Limestone. The highest $CaCO_3$ content in limestone samples was 89 percent (Neubert, 1985). Limestone of this purity is suitable for agricultural purposes. Higher purity limestone occurs south of the study area and closer to railroad transportation and markets (Osterwald and others, 1959, p. 163–169). Limestone in the study area is not classified as an identified resource.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Mitchell W. Reynolds
U.S. Geological Survey

Geology

Three general suites of rocks underlie the Ferris Mountains Wilderness Study Area (pl. 1): (1) Archean crystalline rocks that range in age from older than 2,860 to about 2,500 million years (Peterman and Hildreth, 1978); (2) Mesozoic and Paleozoic sedimentary rocks that are about 76–540 million years old; and (3) Tertiary strata that are about 6–12 million years old. These suites of rocks are mantled by gravel and sand deposited on pediment and terrace surfaces and along stream bottoms, by talus and colluvium on steep slopes, and by windblown sand in dunes south of the mountains.

Late Archean and Older Crystalline Rocks

Late Archean and older crystalline rocks are widely exposed across the eastern half of the study area, in narrow belts along the north flank of the mountains west of Cherry Creek, and in the core of a narrow anticline in the west-central part of the mountains (pl. 1). The rocks host small occurrences of copper, lead, zinc, silver, and gold. The rocks are continuous north beneath a succession of Tertiary strata with a suite of crystalline rocks that are widely exposed in the Granite Mountains (fig. 1). Intrusive granodiorite and granite are the most widespread crystalline rocks of the study area. They contain inclusions of metavolcanic and probable metasedimentary rocks. The metamorphic rocks crop out more widely at the east end of the study area where they are intruded by granodiorite and granite. Abundant basaltic and diabasic dikes were intruded into all the other crystalline rocks.

Medium-grained, locally porphyritic hornblende granodiorite showing pervasive fine hematitic alteration underlies much of the eastern part of the mountains. The granodiorite encloses small bodies of more mafic igneous rocks and foliated, banded, fine-grained metavolcanic rocks. Lenses of finely interlayered epidote-quartz-chlorite rock, hematite-rich quartz rock, and foliated epidote-chlorite micaceous rock, 2–200 ft across and as much as 950 ft long, may be remnants of older sedimentary rocks included in both the granodiorite and granite. Contacts between the granodiorite and granite are gradational or interfinger over a few to tens of feet.

Porphyritic granite is the dominant crystalline rock of the western part of the study area and the south and west margins of the eastern part. Hematite staining is widespread, and locally the rocks are epidotized adjacent to younger diorite dikes. Along faults bounding the northeast flank of the mountains, both the granite and the granodiorite are strongly fractured and altered by development of clay and hematite. The granite is likely part of a widespread deep-seated granite intrusive that in the Granite Mountains has been dated as 2,550 million years old (Late Archean; Peterman and Hildreth, 1978).

Metamorphic rocks of the Miners Canyon area are rusty-brown-weathering chlorite and biotite schists. Laminae and thin stringers of quartz occur in the schists, and epidote is present adjacent to the quartz stringers. Thin lenses of amphibolite and biotite gneiss are interleaved with the schists. The rocks may have originated as a sequence of interbedded volcanic tuffs, thin volcanic flows, and sedimentary rocks. Both the granodiorite and porphyritic granite, widely distributed to the west and north, seem to intrude the metamorphic rocks. All the crystalline rocks in the Miners Canyon area are strongly sheared and heavily stained with iron oxides. The metamorphic rocks are probably remnants of a rock suite, more widely exposed in the Granite Mountains to the northwest, that was metamorphosed about 2,860 million years ago (Peterman and Hildreth, 1978).

Two sets of mafic dikes intrude the granitoid rocks (pl. 1). One set consists of very finely crystalline basaltic dikes. These dikes range in thickness from a feather edge to about 25 ft, but are mostly less than 16 ft thick; they trend about N. 20°–30° W. in the eastern part of the study area, N. 0°–N. 15° E. in the central part, and N. 0°–N. 30° W. in the western part. The second and most conspicuous set of mafic dikes consists of hornblende diorite and hornblende gabbro. These dikes range from a few feet to as much as 175 ft thick and follow two trends: N. 20°–0° W. and N. 25°–45° E. The diorite dikes cut all granitoid rocks, generally at high angles to foliation, and are locally intruded across dikes of the first set. Thin quartz veins are common along the margins of the mafic dikes. Halos of epidotization extend from the margins of the thickest diorite dikes into the host rocks. The diorite dikes are probably equivalent to dikes of similar composition and trends that are about 2,500 million years old (Late Archean) in the Granite Mountains (Peterman and Hildreth, 1978).

Mesozoic and Paleozoic Sedimentary Rocks

A succession of Mesozoic and Paleozoic sedimentary rocks about 8,400 ft thick is exposed in the western half and along the southern margin of the Ferris Mountains. The succession rests unconformably on the Archean crystalline rocks. Table 1 summarizes the sequence of formations, their principal rock types, thicknesses, and regional significance for mineral and fossil-fuel occurrences. Additional information about the units is given in Reynolds (1968a, 1971) and Rioux and Staatz (1974). Generally, Paleozoic strata from the Flathead Sandstone through the Tensleep Sandstone resist erosion and form steep slopes on the flanks of the crystalline core of the mountains. Carbonate rocks of the Madison Limestone support the steepest terrain, of difficult access, along the south flank of the wilderness study area. Sedimentary rocks of late Paleozoic and Mesozoic age are mainly shale and sandstone that erode more readily to form rolling surfaces and low ridges along the south and west base of the mountains.

Tertiary Sedimentary Rocks

Rocks of the late Miocene Ogallala Formation underlie dissected lowlands along the north flank of the Ferris Mountains. Interbedded conglomerate, pebbly sandstone, siltstone, and rare tuffaceous siltstone constitute the formation. The formation characteristically weathers very pale orange and pinkish gray, and locally weathers white. Near the mountain front, clasts in the upper part of the formation are as large as 1.5 ft across, but the size diminishes north away from the mountains and sandstone and siltstone beds are more abundant. Strata of the lower part are generally pebbly sandstone or sandstone.

Near the study area the Ogallala Formation unconformably overlies Archean crystalline rocks. On the northeast flank of the mountains in the Arkansas Creek drainage, beds of the Ogallala lap onto and across former hills of granite (pl. 1). Along the north base of the mountains, the formation is everywhere faulted downward against Archean crystalline or lower Paleozoic sedimentary rocks. The steep north flank marks the eroded trace of a major normal fault zone. Where exposed, bedding in the formation dips north away from the fault zone toward the axis of the Split Rock syncline in the valley of the Sweetwater River (fig. 1).

Quaternary Surficial Deposits

Within the Ferris Mountains Wilderness Study Area, surficial deposits are of three general types: (1) gravels that mantle pediment and terrace surfaces at the base of the mountains or that fill channels of streams that issue from the mountains; (2) deposits of angular rock fragments or finer landslide debris that have moved downslope by gravity; and (3) sand and silt that have been blown along the east flank of the mountains as part of the major dune field that covers much of the northern part of Separation Flat (fig. 1).

Pediment, terrace, and stream gravels consist of angular to rounded pebbles, cobbles, and boulders, derived from the Ferris Mountains, in a matrix of coarse sand. South of the mountains, windblown sand is mixed with stream-deposited sediment. The youngest gravels are confined to narrow stream channels or to narrow floodplains, but older deposits are distributed more widely on higher erosion surfaces adjacent to the mouths of mountain valleys. Along the south flank of the range, boulders as large as 12 ft across, rarely as large as 28 ft across, have been transported as far as 2 mi from the mouths of steep valleys. On the north side, boulder gravels consisting of clasts commonly larger than 1 ft across are present along stream channels and on all higher erosional levels adjacent to mouths of the mountain valleys. Boulders extend several miles downstream on all erosional surfaces. The boulder gravels are significant for they probably were transported from steep mountain valleys by catastrophic mud and debris flows accompanying torrential storms. Such storms and flows are clearly a recurring hazard to some forms of land use in and adjacent to the mountains.

From Cherry Creek east to West Branch Creek and discontinuously from Pete Creek east to Arkansas Creek (fig. 2; pl. 1), older pediment and terrace gravels are displaced downward on the north by faults. Fault scarps in the gravels have been degraded by erosion and are likely very old. In the drainage of Little Cherry Creek, on the north margin of the study area, beds of the Ogallala Formation and younger gravel and sand deposits also seem to be offset by faults; offsets are marked by a topographic scarp and subtle reversals of topography. Springs are aligned along the fault traces. Scarps in the gravels suggest that relatively late in geologic time, perhaps continuing at present, significant earthquakes caused by fault movements may have affected the area.

Accumulations of unconsolidated rock fragments that move downslope by gravity are common along steep valleys within the Ferris Mountains. At several sites in the south, west-central, and northern parts of the range, debris flows consisting of rock fragments in muddy matrices are flowing intermittently down narrow valleys eroded in the Amsden Formation. These debris flows override and incorporate trees, soil, and rock fragments as they move, but cover limited areas and pose little hazard in the area.

Structure

The distribution of Archean crystalline rocks defines two principal structural blocks in the study area (pl. 1; fig. 2). The northern block extends continuously east-southeast across the area from Muddy Gap to Spanish mine and consists of a core of crystalline rocks mantled on the south by a south-dipping succession of Paleozoic and Mesozoic rocks. East from the upper reaches of Muddy Creek in the south-central part of the area (pl. 1), the northern structural block underlies the entire study area. The second principal structural block, the southwestern block, consists of two tightly folded anticlines, the Whiskey Creek and Black Canyon anticlines, which trend from Black Canyon east-southeast to the upper reaches of Muddy Creek. The Youngs Pass syncline, a faulted, tight syncline, separates the principal structural blocks. That syncline extends from near the center of the area west-northwest to near Whiskey Gap (pl. 1). A major zone of normal faults, the South Granite Mountains fault zone (pl. 1), bounds the north side of the mountains. The mountains have risen relative to the valley of the Sweetwater River on the north (fig. 1) along faults in this zone. For about 25 mi west of the study area, the zone of normal faults closely parallels the edge of an older thrust fault called the "Emigrant Trail thrust fault" (Wyoming Geological Association, 1951; Blackstone, 1951; Stephens and Healey, 1964; Love, 1970; Reynolds, 1976).

Archean and Paleozoic rocks of the northern structural block emerge from the South Granite Mountains fault zone near Whiskey Gap and rise structurally east-southeast more than 3,000 ft (pl. 1). Paleozoic rocks overlie in unconformable stratigraphic contact the Archean crystalline core of the northern block across the full length of the study area. In that core northwest-trending small faults and shear zones displace foliated and fractured crystalline rocks. At the east end of the area, the south margin of the Archean core is uplifted adjacent to the steeply dipping Paleozoic and Mesozoic strata on the south flank. Two miles east of the study area, the Archean core breaks from, and rides in fault contact over, those Paleozoic and Mesozoic strata in the Bradley Peak area (figs. 1, 3). That fault contact is unrelated spatially to the Granite Mountains fault zone on the north flank of the mountains.

Faulted anticlines of the southwestern block are asymmetric, their north flanks dipping more steeply than their south flanks (pl. 1). The Archean granite core of the Whiskey Creek anticline has risen along a north-dipping fault relative to tectonically thinned Paleozoic rocks of the steep north limb. That limb is common both to the anticline and to the Youngs Pass syncline, which separates the northern block from the southwestern block. Structural relief on the Whiskey Canyon anticline is about 3,000 ft. At the west end of the southwestern structural block, the Black Canyon anticline, cored by Cambrian rocks, bifurcates the southwest limb of the Whiskey Creek anticline. Upper Paleozoic and Mesozoic rocks form a steeply dipping carapace around the southwestern core; both northwest of Black Canyon and east of Muddy Creek, those rocks form the south-dipping flank of the northern structural block (pl. 1). Structural discontinuity between principal structural blocks is accommodated in middle and upper Paleozoic strata by shear along faults that strike parallel to beds (pl. 1).

Table 1. Sequence of stratigraphic units in the Ferris Mountains Wilderness Study Area and their regional significance for mineral and fossil-fuel occurrences

[WSA, wilderness study area]

Era	System	Unit	Thickness in feet	Rock or sediment type	Comments regarding mineral and fossil-fuel occurrences[1]
Cenozoic	Quaternary	Surficial deposits		Boulder gravel, pebbly sand, sand, silt; angular rock fragments; rock fragments in silt matrix.	Gravel and sand resources nearby outside WSA.
	Tertiary	Ogallala Formation		Conglomerate, sandstone, thin siltstone.	Gravel and sand resources nearby outside WSA.
Mesozoic	Cretaceous	Cody Shale (part)	1,000 (part)	Shale, calcareous, dark-gray.	
	Cretaceous	Frontier Formation	1,000	Shale in lower part, sandstone in upper part.	Oil and gas production at Lost Soldier, Wertz, Bailey, Mahoney, Ferris.
	Cretaceous	Mowry Shale	350	Siliceous shale, dark-gray, local very thin beds of bentonite.	
	Cretaceous	Thermopolis Shale	235	Shale at base and top; Muddy Sandstone Member near center.	Oil and gas production from Muddy Sandstone Member at Lost Soldier, Wertz, Bailey, Mahoney, and Ferris.
	Cretaceous	Cloverly Formation	50-150	Conglomerate, conglomeratic sandstone, and sandstone.	Oil and gas production at Lost Soldier, Wertz, Mahoney, and Ferris.
	Jurassic	Morrison Formation	150-300	Mudstone, siltstone, sandstone	
	Jurassic	Sundance Formation	270	Siltstone, mudstone, sandstone and thin limestone.	Oil production at Lost Soldier, Wertz, Bailey, Mahoney, and Ferris.
	Triassic?	Bell Springs Member of Nugget Sandstone	100-300	Siltstone and sandstone, red, pale-orange.	Oil and gas production at Lost Soldier, Wertz, Bailey, and Ferris.

	Triassic	Popo Agie and Jelm Formations undivided	350-400	Siltstone, sandstone, mudstone, generally reddish-brown, pale-red.	
	Triassic	Alcova Limestone	7-12	Limestone, local mudstone	Possible limestone source; no resource potential in WSA.
	Triassic	Red Peak Formation	930	Sandstone, siltstone, and some mudstone, pale-reddish-brown.	
	Triassic and Permian	Goose Egg Formation	280	Siltstone, thin dolostone and limestone; chert nodules; nodules and lenses of gypsum.	Oil at Ferris; possible gypsum source but no resource potential in WSA.
Paleozoic	Pennsylvanian	Tensleep Sandstone	500-750	Sandstone, thin limestone and dolostone in lower part.	Major oil and gas production at Lost Soldier, Wertz, Bailey; low resource potential for silica sand in WSA.
	Pennsylvanian and Mississippian	Amsden Formation; Darwin Sandstone Member at base	200-250	Siltstone, mudstone, interbedded limestone; sandstone.	Oil production at Lost Soldier; low resource potential for silica sand in WSA.
	Mississippian	Madison Limestone	300	Limestone, medium-gray and medium-light-gray.	Major oil and gas production at Lost Soldier, Wertz; low resource potential for cement in WSA.
	Cambrian	Buck Spring Formation	600	Sandstone and siltstone, reddish-brown, dark-olive-green	Possible phosphate and glauconite source but no resource potential in WSA.
	Cambrian	Flathead Sandstone	70-280	Sandstone and pebbly sandstone, pale-red, pale-reddish-brown.	Oil production at Lost Soldier.

[1]Location of oil fields shown on figure 1. Mahoney includes east and west Mahoney fields; Ferris includes east and west Ferris fields. WSA denotes Ferris Mountains Wilderness Study Area.

Strata on the south flank of the mountains dip steeply south into the Camp Creek syncline (fig. 1). Structural relief on Archean crystalline rocks between the anticlinal crest of the southwestern Ferris Mountains block and the trough of the Camp Creek syncline is as much as 11,000 ft. On the north flank of the mountains, Tertiary strata faulted against the core of the northern structural block dip north into the Split Rock syncline (fig. 1; pl. 1; Love, 1970). Structural relief on the syncline may be as much as 3,000 ft. Displacement on normal faults bounding the north flank of the mountains is at least 800 ft, but probably more than 3,000 ft.

Geochemistry

Geochemical study of the Ferris Mountains Wilderness Study Area was based on analysis and interpretation of stream-sediment samples from 62 sites and 254 rock samples from 204 sites. Rock samples included bedrock for determination of background values for all representative rock types, host-rock, vein and select minerals from prospect pits and adits, and altered rock. Stream-sediment samples contain material representative of rock types exposed in a drainage basin. Most drainage basins in the study area have areas of less than 0.5 square mile; three basins include 1–2 square miles. Sediment samples sieved to silt size and finer were used for analysis. Because of the high relief and short stream segments within the narrow study area, stream beds are generally filled with sand-size or coarser sediment and contain insufficient finer sediment to obtain adequate panned concentrates for analysis.

All samples were analyzed for 31 elements by a six-step semiquantitative spectrographic method (Grimes and Marranzino, 1968). Selected samples were analyzed by X-ray spectroscopy, uranium fluoroscopy, or atomic-absorption techniques for specific elements related to metallic minerals, nonmetallic minerals, or energy minerals. The data (D.E. Detra, unpub. data, 1987) are available from the Branch of Geochemistry, U.S. Geological Survey, Denver Federal Center Denver, CO 80225. Histograms were constructed and analyzed together with frequency distributions expressed as percentiles to identify anomalous concentrations of elements.

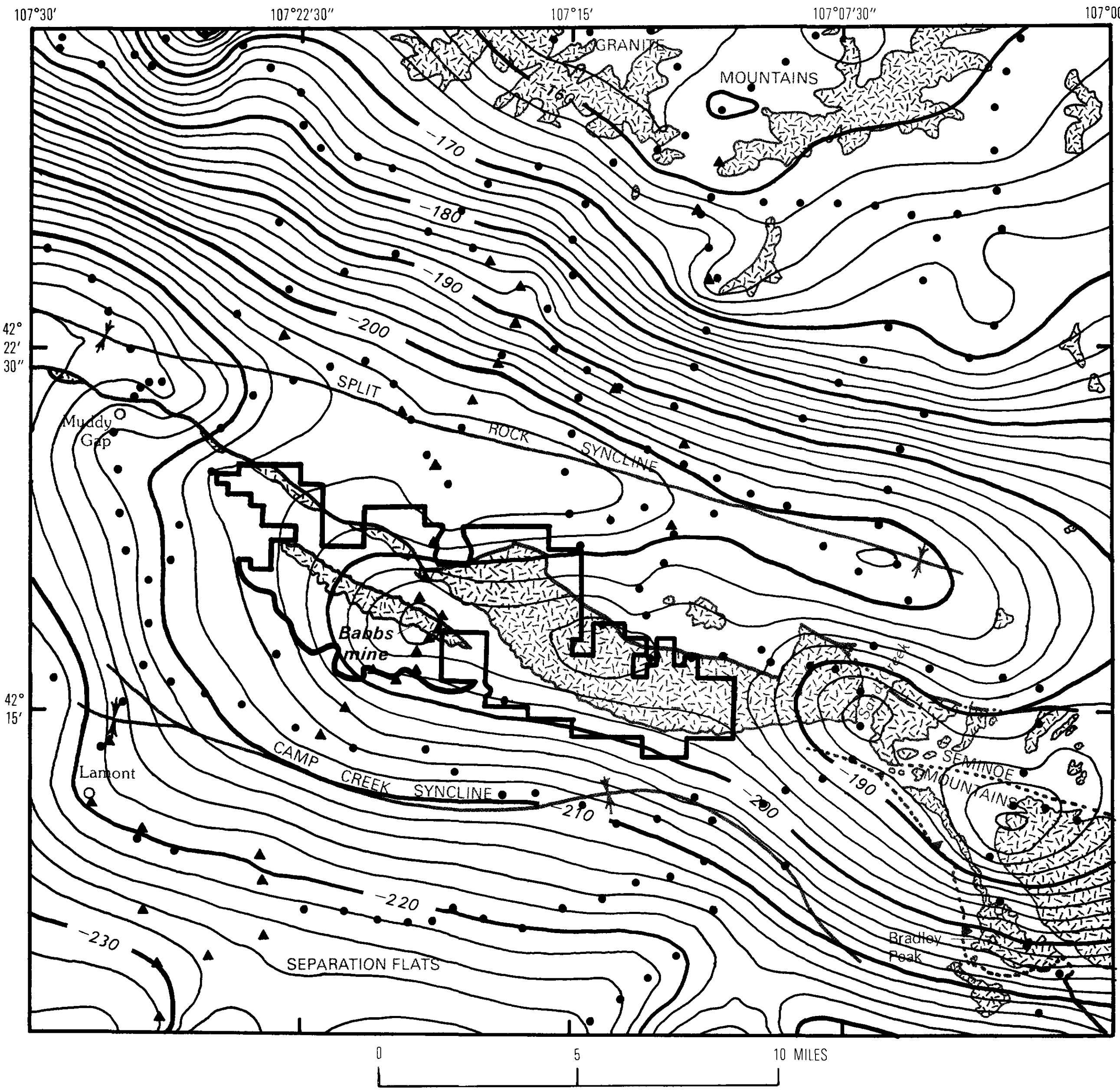
Within the Ferris Mountains Wilderness Study Area, copper, silver, and gold occur in widely scattered, very low concentrations along some quartz veins of limited extent, in thin diabase dikes, in small pods of epidote-quartz-chlorite rock or amphibolite in granite, and along discontinuous shears in crystalline rocks that compose the core of the mountains. In the Babbs mine area very low concentrations of silver, copper, and gold are present in quartz veins, in a dike, and along several fractures in granite. Copper, silver, and arsenic are present in anomalous concentrations in inclusions of metamorphic rocks with quartz veins in granite on the range crest at the head of Pete Creek and in the drainage basin of Garden Creek. Along the eastern margin of the area in drainages tributary to Miners Canyon, small anomalous concentrations of gold, silver, and arsenic are present in fractures and quartz veins in schist and granite. The occurrences cannot be traced geologically or geochemically beyond the limits of small veins or shears exposed on the surface or in prospect pits and adits. No anomalous concentrations of metals were detected in the remainder of the study area.

Geophysics

A reconnaissance gravity survey was conducted to provide information on the subsurface distribution of rock masses and the structural framework of the Ferris Mountains Wilderness Study Area. Gravity determinations along a single traverse across the mountains and selected measurements on the flanks were combined with data obtained previously by other Federal agencies to produce a small-scale complete Bouguer gravity anomaly map (fig. 3; D.M. Kulik, written commun., 1985).

In the wilderness study area, a gravity high (–200 to –192 milligals) extends from the Babbs mine area east-southeast nearly coincident with exposures of Archean crystalline rocks that form the core of the Ferris Mountains (fig. 3). Southeast from Sand Creek, the gravity high increases across the Precambrian core of the Seminoe Mountains. The steepest gradient from the high in the wilderness study area coincides with the south flank of the Ferris Mountains, where a nearly continuous succession of Paleozoic and Mesozoic sedimentary rocks dips steeply south off crystalline rocks of the mountain core into the Camp Creek syncline in the adjacent Separation Flats area.

On the north flank of the Ferris Mountains, a more gentle gravity gradient declines into an elongate west-northwest-trending low (–210 to –200 milligals) that coincides approximately with the trough of the Split Rock syncline. A succession of low-density upper Tertiary strata is exposed at the surface in the syncline; those strata are faulted on the south limb of the syncline against Precambrian crystalline rocks of the Ferris Mountains. The configuration of the gravity gradient on the north flank strongly suggests that north of range-front normal faults, Precambrian crystalline rocks are continuous beneath the upper Tertiary strata to the Granite Mountains. Discontinuous exposures of crystalline rocks among Tertiary strata in Arkansas Creek and the Granite Mountains on the north (fig. 1)



EXPLANATION

–190– Gravity contours—Contour interval 2 milligals

Gravity station

▲ Wilderness study area survey

● Previous survey by Federal agency

Geologic contact

Fault—Dotted where concealed; barbs on upper plate of thrust fault

Precambrian crystalline rocks

Figure 3. Map showing complete Bouguer gravity anomalies of the Ferris Mountains Wilderness Study Area and adjacent areas, south-central Wyoming. Gravity measurements by D.M. Kulik. Heavy black boundary is approximate boundary of study area.

support the interpretation of continuity. Such continuity, together with the structural position of Paleozoic and Mesozoic strata northwest of the upper reaches of Whiskey Creek (pl. 1), seem to preclude the occurrence of those strata beneath crystalline rocks anywhere along the north margin of the study area.

Resolution of the gravity survey is inadequate to identify and model either individual faults on the north flank or structures within the wilderness study area. Results of the gravity survey do not aid in either extending knowledge of the mineral occurrences or in identifying prospective new areas for other mineral occurrences. Further geophysical investigations could include seismic-reflection profiling from the trough of the Split Rock syncline south across the west end of the wilderness study area at Whiskey Creek and south along Cherry Creek to Youngs Pass and into Muddy Creek on the south flank of the mountains (pl. 1). Such profiles would help to identify the depth of penetration and geometry of faults that displace crystalline rock terranes across the mountains. Detailed magnetic surveys could more closely define the extent of mafic crystalline rocks, some of which might have associated veins, but results would likely be similar to the distribution defined by detailed geologic mapping of the present investigation.

Mineral and Energy Resource Potential

Metallic Minerals

Examination of rock types, geologic and petrologic settings, and mineral occurrences suggested that mineralization in crystalline rocks of the Ferris Mountains would be of the orogenic (hosted by metamorphic rocks) gold-quartz vein type. Elements such as gold, silver, antimony, mercury, arsenic, and sulfur are characteristic of such mineralization (Erickson, 1982), and rock near mineralized veins might be enriched in elements such as boron, barium, potassium, bismuth, tellurium, tungsten, copper, lead, zinc, and molybdenum.

Anomalous concentrations of elements characteristic of gold-quartz veins hosted by metamorphic rocks were identified at only five isolated sites in Precambrian crystalline rocks of the study area. At each site metallization occurred in sheared rock or veins of highly limited areal extent and none could be traced into adjacent host rocks. Anomalous concentrations of individual metallic elements such as copper (7,000 ppm (parts per million)) or silver (3 ppm) were identified at four other localities, but the mineralized rock could not be traced geologically or geochemically more than 1–2 ft at each locality.

On the ridge crest at the head of Pete Creek, lead (100–300 ppm), copper (1,000–20,000 ppm), arsenic (200–10,000 ppm), and silver (3–20 ppm) are concentrated relative to adjacent host granite in a narrow lens of greenstone and gneiss. Slightly higher, but nonetheless weak, concentrations are present in ferruginous silica gangue on the margins of the lens. Mineralization is highly discontinuous within the lens and terminates at its margin. The host granite is not mineralized.

In the Babbs mine area, rock and mineral sampling affirmed the presence of anomalous, but low concentrations of lead, silver, arsenic, and copper. Anomalous concentrations of those metals cannot be traced beyond thin quartz veins or fractures into the main body of the host granite. In the reconnaissance geochemical sampling of the area by the USGS, gold was not detected at a determination level of 0.05 ppm except in two samples from the upper excavations in the area. Those samples contained 0.05 and 2.5 ppm gold. Concentrations of 0.1 oz/t or less, at a detection level of 0.01 oz/t, were identified by the USBM in a few select samples from the middle and upper excavation levels in the area, but most samples were barren of gold. Concentrations of elements such as boron, barium, tungsten, or molybdenum, characteristic of trace-element halos associated with orogenic gold-quartz mineralization, were not detected. No anomalous metal concentrations were found in sediments in streams that drain the Babbs mine area.

In the drainage basin of Garden Creek in the southeastern part of the study area sheared chloritic amphibolite with stringers of chlorite schist and quartz contain anomalous concentrations of arsenic (100–10,000 ppm), silver (5–20 ppm), and copper (1,000–20,000 ppm). In a select sample containing copper oxide minerals, bismuth was concentrated (2,000 ppm), but no other characteristic trace element was concentrated in anomalous amounts. The lenticularity of the rock and mineralization seem to preclude the presence of a resource of copper, silver, or other metallic elements.

Anomalous concentrations of arsenic (55–10,000 ppm), silver (7–100 ppm), copper (10,000 ppm), and lead (500 ppm) are present in rocks at the head of Miners Canyon, about 250 ft inside the approximate boundary of the study area, and on the north side of the tributary north of Miners Canyon about 100 ft inside the approximate boundary of the study area. The latter locality contains 20 ppm gold, the only anomalous concentration of gold identified in that drainage. Samples are from iron-stained sheared schist and granite that contain thin quartz veins. The veins cannot be traced to the edge of exposures. Anomalous values for arsenic (170–10,000 ppm) and silver (2–70 ppm) are present locally in Miners Canyon and in the tributary drainage on the north, just east of the approximate boundary of the study area.

Our interpretation suggests that no significant metallic mineralization occurs in crystalline rocks of the core of the Ferris Mountains. The study area has low mineral resource potential, at a high level of certainty (level C) for the occurrence of gold, silver, copper, lead, zinc, iron, nickel, molybdenum, tungsten, lithium, beryllium, and manganese in the crystalline rocks.

Anomalous concentrations of metals were not identified from analyses of Cenozoic, Mesozoic, or Paleozoic sedimentary rocks in the remainder of the study area. Those rocks are not known to contain metals other than uranium and thorium in much of central and southern Wyoming. Stream-sediment samples from drainages in which sedimentary rocks are exposed in the study area contained no anomalous concentrations of any metals. We conclude that the study area has no mineral resource potential, at a high level of certainty (level D), for any metals in sedimentary rocks. The mineral potential of these strata for uranium and thorium is discussed below under energy minerals.

Nonmetallic Minerals

Formations containing carbonate rocks that might constitute sources for construction cement or refining flux were sampled to determine their calcium carbonate ($CaCO_3$) content. Five formations contain most of the carbonate rock of the area: the Madison Limestone, Amsden Formation, Tensleep Formation, Goose Egg Formation, and Alcova Limestone (table 1). Carbonate rocks of the Tensleep Formation are generally dolostone and unsuited as sources for cement. Carbonate rocks of the Amsden and Goose Egg Formations are dolomitic or have a sufficiently high content of silicate grains to make them unsuitable. The Alcova Limestone contains 85.0–89.2 percent calcium carbonate, but the unit is very thin and contains clay and silt partings that make it unsuited for cement. The Madison Limestone, thickest and most widespread carbonate unit of the study area, contains locally the highest purity of calcium carbonate: $CaCO_3$ commonly ranges from 85.0 to 96.7 percent. The calcium carbonate content varies vertically and laterally through the formation. In cherty lenses near the base of the unit, as little as 0.8 percent calcium carbonate is present; other thin intervals are predominantly dolostone. Because of vertical and lateral changes and resulting lenticularity of high $CaCO_3$ content, the mineral resource potential for cement and flux limestone is low, at a certainty level of C.

Four rock units, the Buck Spring Formation, Goose Egg Formation, Sundance Formation, and Mowry Shale, were closely examined and selectively analyzed to determine whether phosphate (P_2O_5) might be present. The Goose Egg Formation does not contain phosphate, and the Sundance and Mowry contain 0.11 percent or less in samples analyzed. Locally, in thin lenses consisting of accumulations of small brachiopod fossils in glauconitic siltstone, the Buck Spring Formation contains as much as 2.52 percent phosphate in select samples, but otherwise the formation contains less than 0.82 percent P_2O_5, only in the thin lenses. The lenses, about 2–60 ft long and generally at a single stratigraphic position in the lower part of the formation, are less than 2 in. (inches) thick; one lens is 4 in. thick. In view of the clearly identified and traced, narrowly confined geologic occurrences of very low concentrations of phosphate in the Ferris Mountains Wilderness Study Area, we conclude that the area has no mineral resource potential for phosphate, with a certainty level of D.

Nodules and thin lenses of gypsum are present near the base of the Goose Egg Formation and rarely in limestone and pale-red siltstone beds of the Amsden Formation (table 1). Patches of calcium sulfate cement were observed in thin sections of rocks from the Goose Egg Formation. Continuous beds of gypsum were not observed, and the rock facies do not indicate originally significant accumulation of that mineral. Thus the study area has no mineral resource potential, with a certainty level of D, for gypsum.

The Tensleep Sandstone and Darwin Sandstone Member of the Amsden Formation contain quartz-rich sandstone beds that are locally pure enough to be considered potential sources of silica. Sandstone of the Tensleep is generally cemented with calcite, or grains interlock along sutured boundaries, some silica being in the pore spaces. Iron oxide minerals and calcite bind silica grains in the Darwin Sandstone Member. Some clay is present locally in both units. The silica content varies markedly along strike in both units. At localities where the Tensleep Sandstone is sheared adjacent to faults such as on Cherry Creek on the north flank of the mountains, or is folded on the plunging nose of the Black Canyon anticline (pl. 1), the formation is cemented with silica and contains 96.5–98.5 percent silica. In similar structural settings the Darwin Sandstone Member locally contains 96.0–97.9 percent silica. Elsewhere, however, the silica content of the Tensleep ranges from 35.0 to 91.9 percent, most ranging from 84.5 to 91.9 percent; the Darwin generally contains about 65.0–80.2 percent silica. High silica content is narrowly limited in geographic and stratigraphic extent. Such factors as the limited distribution of high silica content, the presence of clay, iron, and carbonate impurities, and the extremely firm induration at sites of high silica content combine to indicate that the study area has low mineral resource potential for silica (certainty level C).

Energy Minerals

Economic deposits and mineral occurrences of uranium in Tertiary rocks west and northwest of the wilderness study area have been described (Stephens and Healey, 1964; Love, 1961, 1970), and rocks of the

Jurassic Morrison and Cretaceous Cloverly Formations contain uranium deposits in other parts of the Rocky Mountains. During the present study, local ranchers provided accounts of uranium exploration during the 1950's and purported uranium occurrences on the south flank of the Ferris Mountains. During the current resource assessment, however, no areas of anomalous radioactivity were detected by scintillometer in the field. Selected rock samples from the Morrison, Sundance, and Cloverly Formations and from the Thermopolis Shale were analyzed for uranium and thorium by the uranium fluorimetry method, but radioactive compounds were not detected. Although rock facies are suitable for mineralization, favorable chemical preparation of the rocks for accumulation was not identified, and no source for uranium was identified. Thus no mineral resource potential, at a certainty level of D, exists for uranium and thorium in the study area.

Neither coal nor lignite is present in sedimentary sequences in the study area, and no mineral resource potential for those commodities exists, at a certainty level of D.

Oil and Natural Gas

Sedimentary rocks exposed in the wilderness study area produce oil and natural gas in nearby fields southwest and south of the Ferris Mountains (fig. 1; table 1). The Lost Soldier oil field, about 9 mi southwest of the study area (fig. 1), has produced more than 188 million barrels of oil and more than 32 million cubic feet of gas. The field has had the largest recovery of oil per acre among Rocky Mountain oil fields (Wyoming Geological Association, 1961, p. 346). Wertz oil field, adjacent on the east (fig. 1), has produced important amounts of oil and gas from Paleozoic and Mesozoic rocks. About 3–4 mi south of the Ferris Mountains, five small oil fields (Bailey, west Mahoney, east Mahoney, west Ferris, and Ferris) are aligned on an east-southeast-trending elongate anticlinorium that approximately parallels the south flank of the mountains. These fields have produced gas from Mesozoic rocks and oil from Mesozoic and Paleozoic rocks exposed in the mountains. The Camp Creek syncline separates the anticlinorium from the uplift of the Ferris Mountains (fig. 1). Neither oil or gas seeps nor oil-saturated rock were observed in strata at the surface in the study area.

Several lines of evidence lead to the conclusion that the Ferris Mountains Wilderness Study Area has no potential (certainty level D) for the occurrence of oil and gas resources. Potential source rocks are not present to generate petroleum that might subsequently have been trapped in possible reservoir rocks in the area. Strata that serve as reservoirs for petroleum in nearby fields are steeply tilted along the flanks of the mountains, and their eroded edges are exposed in the study area at elevations nearly 6,000 ft higher than those strata that produce petroleum in anticlines to the south. Any oil or gas in the strata north of the trough of the Camp Creek syncline would have migrated upward toward the crest of folds in the mountains and been lost either by erosion of the strata from the crest or by evaporation through the eroded edges of the beds in the absence of a seal.

Archean igneous and metamorphic rocks that core the study area lie beneath productive sedimentary rocks throughout the region; the crystalline rocks themselves are neither potential source rocks nor suitable reservoir rocks for accumulation of petroleum. Only in the Lost Soldier oil field has petroleum been found in fractures in the crystalline rocks (Krampert, 1949). That petroleum demonstrably migrated downward along the fractures from overlying fully saturated Paleozoic sedimentary rocks into the uppermost part of the crystalline rocks and did not constitute a significant resource in the field. Erosion removed Paleozoic rocks from the core of the Ferris Mountains, exposing deep levels of the crystalline rocks. Potential for petroleum accumulation does not exist in crystalline rocks in the study area.

Recent published interpretations of the geologic structure on the north flank of the Ferris Mountains suggested that petroleum could be present in folded Mesozoic and Paleozoic rocks beneath granite on that flank (Lowell, 1978; Gries, 1983, 1985). The structure was interpreted as the continuation of a major mountain-flank thrust fault, the Emigrant Trail thrust fault (fig. 1), along which Archean crystalline rocks have been thrust south-southwest over folded sedimentary rocks. That interpretation was based on identification of folded sedimentary rocks beneath crystalline rocks 6–40 mi west and northwest of the Ferris Mountains (Wyoming Geological Association, 1951, p. 122; Blackstone, 1951; Van Houten, 1954; Stephens and Healey, 1964; Gudim, 1966; Reynolds, 1968a, b, 1976). Reynolds (1968a, b, 1976) documented that displacement of as much as 3–4 mi on the thrust fault 30 mi west of the Ferris Mountains diminishes eastward toward Muddy Gap; about 1 mi east of Muddy Gap the fault passes into the upright south-dipping limb of a broad uplift that is cored by Archean crystalline rocks. Those crystalline rocks form the basement continuously north and east from Whiskey Gap across the Granite Mountains (fig. 1; pl. 1). Mesozoic and Paleozoic rocks, overridden by the thrust fault west of Muddy Gap, are exposed progressively east of the gap in unfaulted succession until they demonstrably rest in depositional contact on the Archean crystalline rocks. From about 0.9 mi northwest of Whiskey Gap southeastward, no thrust fault is present. Along the north flank of the Ferris Mountains, no potential exists for the occurrence of petroleum along or beneath normal faults that juxtapose Archean crystalline rocks against crystalline rocks. Thus, in view also of the absence of potential farther south and southeast as documented above, the entire wilderness study area has no oil and gas resource potential, at a certainty level of D.

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APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

LOW mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

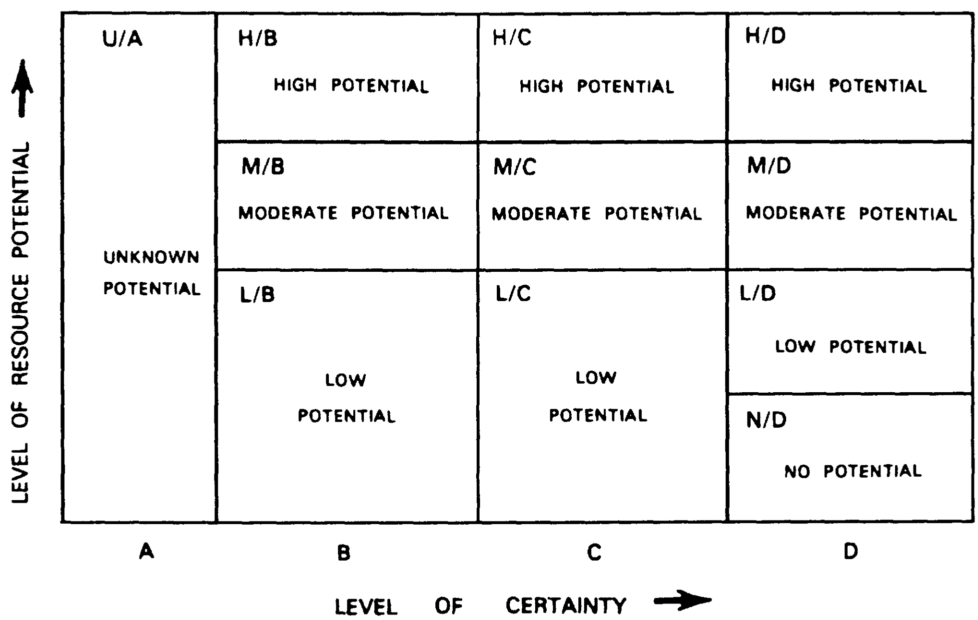
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign low, moderate, or high levels of resource potential.

NO mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

Levels of Certainty



A. Available information is not adequate for determination of the level of mineral resource potential.
B. Available information suggests the level of mineral resource potential.
C. Available information gives a good indication of the level of mineral resource potential.
D. Available information clearly defines the level of mineral resource potential.

Abstracted with minor modifications from:

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RESOURCE / RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from U. S. Bureau of Mines and U. S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U. S. Geological Survey Circular 831, p. 5.

GEOLOGIC TIME CHART
Terms and boundary ages used in this report

EON	ERA	PERIOD		EPOCH	BOUNDARY AGE IN MILLION YEARS
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~ 240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~ 330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~ 570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				3800?
pre-Archean[2]					4550

[1] Rocks older than 570 m.y. also called Precambrian, a time term without specific rank.

[2] Informal time term without specific rank.

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