UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Mineral Resources of the Platte River Adjacent Wilderness Study Area, Jackson County, Colorado

By

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and

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

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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 Platte River Adjacent (CO-010-104) Wilderness Study Area, Jackson County, Colorado.

ABSTRACT

The Platte River Adjacent Wilderness Study Area (CO-010-104) consists of 30 acres in Jackson County, Colorado. No mineral occurences, energy resources, or industrial commodities are known to be present in the wilderness study area. The study area has a low mineral resource potential for undiscovered resources of fluorspar, beryl, mica, columbite-tantalite, vermiculite, copper, uranium, and geothermal energy, and no potential for oil, gas, carbon dioxide, or coal.

SUMMARY

The Platte River Adjacent Wilderness Study Area is located 16 mi (miles) north of Walden in Jackson County, Colorado (see figure 1). It consists of 30 acres of Bureau of Land Management (BLM) land adjacent to the U.S. Forest Service Platte River Wilderness Area overlooking the canyon of the North Platte River. Access to the area is by a dirt road from Colorado State Highway 125 across private land, or by rafting the North Platte River (figure 1). The put-in for the North Platte River is on BLM land 2.5 mi south of the study area.

The wilderness study area is underlain by the Precambrian (see geologic time scale in appendix) gneisses and granites of the Medicine Bow Mountains. There is no evidence of past mining activity within the boundaries of the wilderness study area, although several prospect pits and small adits exist within 0.5 mi of the south and southeast borders. The Northgate fluorspar district is located to the southeast of the study area.

No mineral occurrences, energy sources, or industrial commodities are present in the wilderness study area. None of the mineralized structures of the Northgate district extend into the study area, and the mineral resource potential for undiscovered fluorspar is considered low. Although a few pegmatites are present within the study area, their mineralogy is simple and the potential for undiscovered beryl, mica, and columbite-tantalite associated with pegmatites is considered to be low.

Vermiculite is present in small occurrences near the study area where mafic and ultramafic gneisses have been intruded by pegmatites. One such mafic gneiss is present adjacent to the southern border of the study area, but it lacks the diagnostic mineral assemblage of the vermiculite-producing bodies. The potential for undiscovered vermiculite within the study area therefore, is regarded as low.

Copper, in the form of malachite and chrysocolla, occurs in pegmatites and in mafic gneisses near the study area and throughout the Northgate district. No copper minerals were observed in pegmatites or in mafic gneisses in the study area and the potential for undiscovered copper is considered low.

Coal, oil, gas, carbon dioxide, uranium, and geothermal water are present in the vicinity of the study area, and some of these resources have been exploited. Because all sedimentary rocks have been removed from the wilderness study area by erosion, there is no potential for the discovery of resources of coal, oil, gas, or carbon dioxide. The geologic terrane of the study area is not favorable for the occurrence of uranium or geothermal resources, and their resource potential is regarded as low.

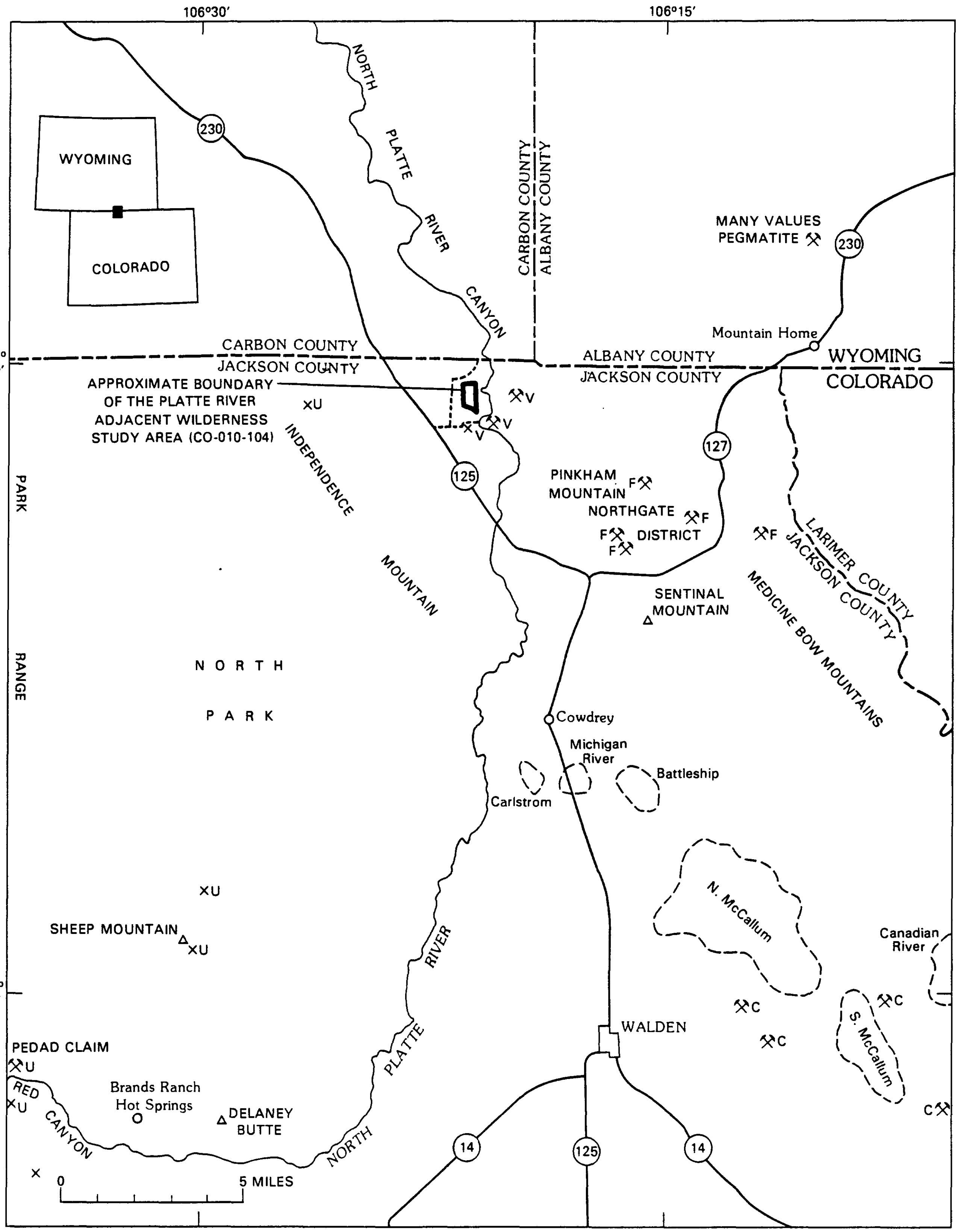

Figure 1. Map showing location of the Platte River Adjacent Wilderness Study Area, Jackson County, Colorado. Oil, gas, and carbon dioxide fields are outlined by long-dashed lines. Letters adjacent to mine symbols signify commodity mined: F = fluorspar, V = vermiculite, C = coal, U = uranium. Short-dashed lines represent dirt access roads.

INTRODUCTION

At the request of the Bureau of Land Management, the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) studied the Platte River Adjacent Wilderness Study Area (CO-010-104; 30 acres). This wilderness study area is adjacent to, and contiguous with, the U.S. Forest Service Platte River Wilderness Area. In this report the area studied is referred to as "the wilderness study area", or simply "the study area".

Access and setting

The study area is located 16 mi north of Walden, Colorado and 25 mi southeast of Riverside, Wyoming, in Jackson County, Colorado (fig. 1). It comprises 30 acres atop a knoll adjacent to, and overlooking the canyon of the North Platte River. Access to the study area is provided by a dirt road from Colorado State Highway 125 which passes through the Ginger Quill (Quaintance) Ranch -- permission to cross must be secured from the caretaker -- or by rafting the North Platte River.

The canyon of the North Platte River is cut into Precambrian gneisses and granites of the Medicine Bow Mountains. These gneisses are partly overlain by Tertiary fluvial deposits (Steven, 1957; 1960; Tweto, 1976). The wilderness study area is home to pine, aspen, fir, sage, countless wildflowers, antelope, deer, and many species of birds, including hawks and eagles. There has been only modest use of the study area for livestock grazing.

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 USBM and the USGS. Identified resources are classified according to the system of the U.S. Bureau of Mines and 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, industrial rocks and minerals, and undiscovered energy sources (coal, oil, gas, oil shale, tar sand, and geothermal sources). It is classified according to the system of Goudarzi (1984) and is shown in the appendix of this report. Undiscovered resources are studied by the USGS.

Investigations by the U.S. Bureau of Mines

The USBM investigation included a review of literature related to the mineral resources and mining activity in and near the study area. Mining claim information and land status records were obtained from the BLM State Office, Denver, Colorado. Two USBM geologists spent two field-days making a foot traverse of the study area, and a field examination of nearby mines, prospects, and mineral occurences.

Investigations by the U.S. Geological Survey

A geologic map (figure 2) of the study area was produced from published mapping by Steven (1957; 1960), Tweto (1976), and Snyder (1980) and field checked by R.P. Dickerson, M.I. Toth, and D.J. Maloney in July, 1988. Sampling and field investigations were carried out at this time as well. Due to the small size of the study area, virtually complete outcrop exposure, and lack of streams, no systematic geochemical stream-sediment sampling programs or regional geophysical surveys were conducted.

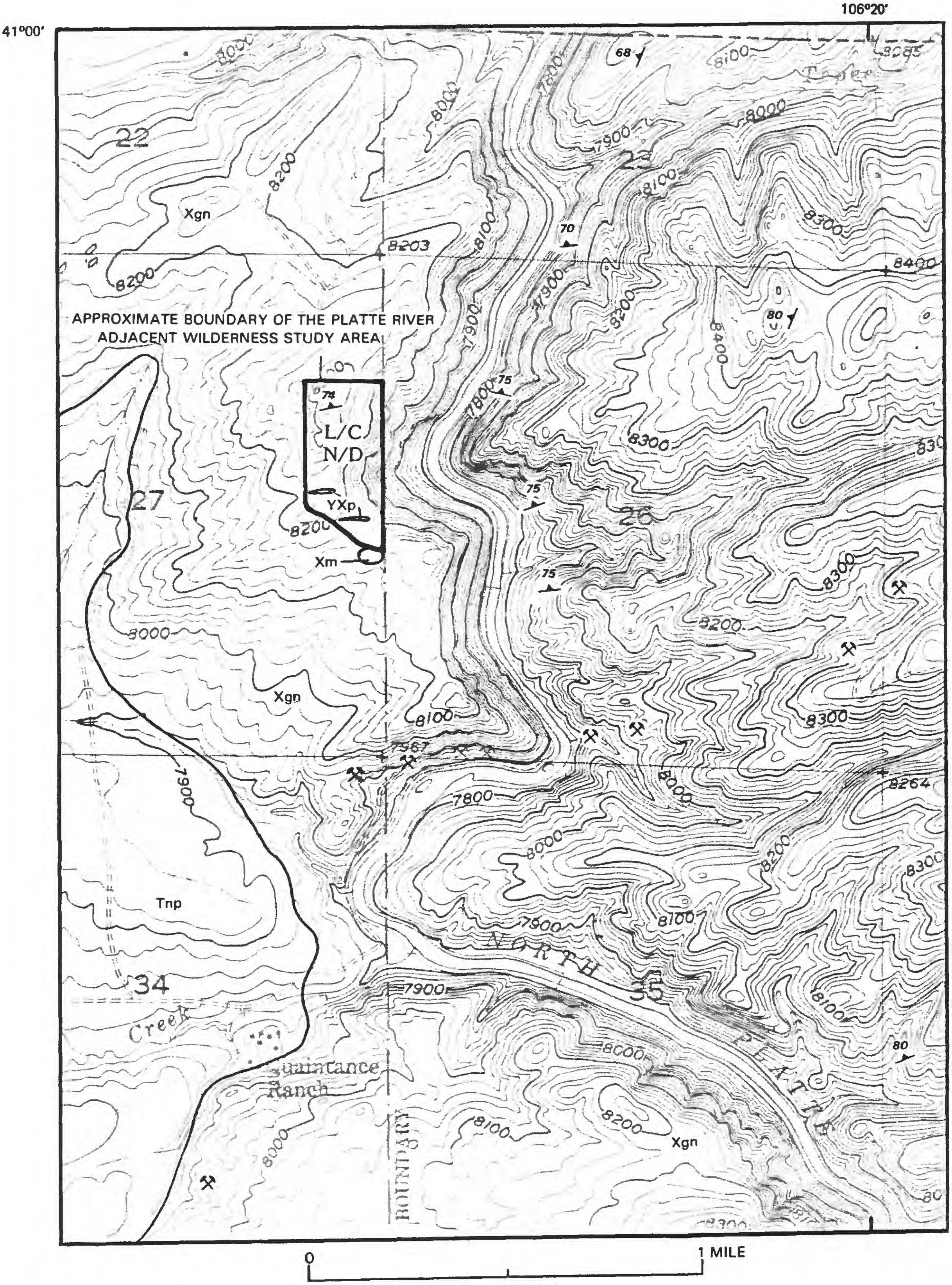

Figure 2. Map showing mineral resource potential, geology, and location of mines and quarries of the Platte River Adjacent Wilderness Study Area, Jackson County, Colorado. Geology modified after Snyder (1980), and Steven (1957, 1960). Base from U.S. Geological Survey Northgate quadrangle, Colorado and Wyoming, 1950, 1:24,000.

EXPLANATION OF MINERAL RESOURCE POTENTIAL

L/C **Geologic terrane having low mineral resource potential for uranium, fluorite, vermiculite, copper, beryl, columbite, tantalite, mica, and geothermal energy, with certainty level C**--Applies to entire study area

N/D **Geologic terrane having no mineral resource potential for oil and gas, carbon dioxide, and coal, with certainty level D**--Applies to entire study area

C **Available information gives good indication of level of resource potential**

D **Available information clearly defines level of resource potential**

DESCRIPTION OF MAP UNITS

Tnp **North Park Formation (Oligocene and Miocene)**--Gray, yellow, and buff, calcareous to noncalcareous siltstone, sandstone, and conglomerate, with some silicic ash beds

YXp **Pegmatite (Precambrian Y and X)**--Small intrusive bodies of coarsely crystalline quartz and feldspar. Age is uncertain but pegmatites crosscut all other Precambrian rocks

Xgn **Felsic to mafic gneiss (Precambrian X)**--Mainly layered pink and gray to dark gray felsic gneiss, with some mafic gneiss and amphibolite. Felsic gneiss consists largely of quartz and feldspar, with some muscovite, biotite, amphibole, garnet, and sillimanite. Mafic gneiss consists of amphibole, plagioclase, biotite, garnet, and minor epidote

Xm **Mafic and ultramafic gneiss (Precambrian X)**--Dark green to black gneiss consisting variously of amphibole, pyroxene, garnet, serpentine, and chlorite. May contain copper sulfides, azurite, or malachite

CORRELATION OF MAP UNITS

Tnp	}Miocene	} TERTIARY
unconformity		
YXp		} MIDDLE PROTEROZOIC
Xgn Xm		} EARLY PROTEROZOIC

MAP SYMBOLS

Contact

Strike and dip of foliation

Quarry or mine (vermiculite)

APPRAISAL OF IDENTIFIED RESOURCES

by John R. McDonnell, Jr.
U.S. Bureau of Mines

Mining activity

The study area is just outside the northwest boundary of the Northgate mining district (fig. 1), west of the North Platte River. Fluorspar, vermiculite, and copper minerals occur in the district, but only fluorspar has been developed commercially.

Fluorspar is the commercial name for the mineral fluorite and is the principal source of fluorine, which is used in the metallurgical, ceramic, and chemical industries. The Northgate fluorspar deposits are 5-6 mi southeast of the study area and occur as fracture filling and cement in north- to northwest-trending brecciated Laramide faults that cut the Precambrian gneiss complex. The veins were discovered and prospected about 1900, but the fluorite was not identified until 1918. Mining and prospecting continued intermittently until about 1973. Production information for the district indicates that about 600,000 tons of fluorspar were produced before the mines closed. (See Warne, 1947; Steven, 1960; Pelham, 1985; and Bureau of Mines file data.)

Vermiculite, a micaceous mineral used principally in lightweight aggregates, thermal insulation, and agricultural products, is exposed in prospects and workings within 0.5 mi south and southeast of the study area. The vermiculite occurs as irregular bodies in the gneiss and is locally associated with ultramafic masses that are near or cut by a pegmatite. No commercial-grade vermiculite is known to have been produced from these localities. (See Bush, 1951; Steven, 1960; Meisinger, 1985.)

Prospecting in the Northgate district before 1915 was prompted by widespread showings of copper minerals. Malachite and chrysocolla stains on weathered surfaces were derived from minor, scattered chalcopyrite in pegmatite bodies in the gneiss complex, but most pegmatites are barren of copper. No local copper production is known, as the copper-rich zones are less than a few feet in diameter. (See Steven, 1960.)

Oil was first discovered in North Park in 1925. The larger oil fields of North and South McCallum, Canadian River, and Battleship were discovered and developed in the 1950's (Carpen, 1957; Biggs, 1957; Grote, 1957; Saterdal, 1957). Since then eight more smaller fields have been discovered (Scanlon, 1983). Two of the fields, Michigan River and Carlstrom, lie within 12 miles of the study area.

Mineral Appraisal

Although the study area is adjacent to the Northgate mining district, no mining claims or leases are inside its boundary. While rocks in the study area are similar to those exposed in the surrounding area, the mineralized structures and zones in the Northgate mining district do not project into the study area. Field observations disclosed no mineral occurences, energy resources, or industrial commodities in the study area (McDonnell, 1989).

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

by Robert P. Dickerson
U.S. Geological Survey

Geology

The wilderness study area is located in the very northern part of North Park, Colorado (fig. 1). North Park is a Cenozoic structural basin bounded on the east and west by Precambrian crystalline rocks of the Medicine Bow and Park Ranges respectively, on the south by the Cenozoic volcanic rocks of the Rabbit Ears Range, and on the north by Precambrian crystalline rocks thrust over Cenozoic sedimentary rocks along the Independence Mountain thrust fault (Tweto, 1976). The North Park Basin formed during the Laramide orogeny about 60 m.y. ago, but has been subjected to structural deformation through much of the Cenozoic era (de la Montagne, 1957). The study area is located along the canyon of the North Platte River in autochthonous (rocks in place beneath thrusted rocks) Precambrian crystalline rocks northeast of the Independence Mountain thrust fault. Overlapping onto the Precambrian rocks just west of the study area, but not extending into it, are the fluvial conglomerates, sandstones, and siltstones of the Miocene North Park Formation (Tweto, 1979). Snyder (1980; 1987) assigned these rocks to the equivalent Miocene Browns Park Formation, whereas Tweto restricted use of the Browns Park to areas west of the Park Range. Several west- and northwest-trending normal faults occur 4 - 8 mi south and southeast of the study area, some of which contain fluorspar (Steven, 1960).

Two types of Precambrian rocks are exposed in the vicinity of the study area: high grade metamorphic rocks of Early Proterozoic age and intrusive igneous rocks of Early and Middle Proterozoic age. The metamorphic rocks are a bimodal suite of mafic and felsic gneisses. The mafic gneisses consist of amphibolites, and garnet- and hornblende-bearing mafic gneisses. The felsic gneisses consist of quartz and feldspar and may also contain biotite, muscovite, amphibole, garnet, and sillimanite (Steven, 1957; 1960; Snyder, 1980). The mafic and felsic gneisses occur in about equal amounts, and their protoliths were probably a bimodal suite of volcanic rocks. Also contained in the high grade metamorphic rock type are minor amounts of quartzite, calc-silicate gneiss, and serpentinized mafic rocks whose protoliths were probably quartzose sandstones, impure limestones, and hydrothermally altered metabasalts, respectively (Tweto, 1987; Snyder, 1987). The intrusive igneous rocks are the syntectonic quartz monzonites and granodiorites of Seven Lakes, dated at 1.7 b.y. (billion years) (Segerstrom and Young, 1972). These rocks often exhibit a gneissic texture with diffuse borders but may also be massive with sharp borders. All Precambrian rocks have been intruded by quartz- and feldspar-bearing pegmatites of various sizes.

The rocks in the study area are dominantly well-foliated, felsic metavolcanic gneisses consisting of quartz, feldspar, biotite and minor amounts of hornblende. Within this sequence there are numerous bands of amphibolite and amphibolitic gneiss from 6 inches to 6 feet thick. In the southern half of the study area there are several pegmatites up to 8 feet thick. These pegmatites contain only quartz and feldspar. Adjacent to the southern border of the study area there is a large mass of mafic gneiss similar to the mafic bodies located at mines and prospects 0.5 miles south and southeast of the study area.

Mineral and energy resources

Fluorspar

The Northgate fluorspar district is southeast of the wilderness study area (fig. 1). Two distinct types of fluorspar deposits are found in the Northgate district, and it is believed that the two types are genetically and temporally unrelated (Steven, 1960). The first type of deposit is at Independence Mountain southeast of the study area. Fluorite, quartz, and chalcedony occur in mineralized fault breccias along the Independence Mountain thrust fault and other Laramide age faults. Textures in this first type of deposit suggest that the quartz and fluorite were deposited episodically while there was still movement along the faults. The second type of fluorspar occurrence is at Pinkham Mountain southeast of the study area. Here fluorite and lesser amounts of quartz and chalcedony are found as wallrock-coatings and veins filling voids in Late Tertiary open faults in Precambrian quartz monzonite and sandstone of the Oligocene White River Formation. Silicified breccias are absent and there was no movement along these faults during mineralization (Steven, 1960). All of the ore produced and most of the reserves still found in the Northgate fluorspar district came from the second type of deposit (See Steven, 1960).

The fluorite- and quartz-bearing Laramide veins (Type 1) occur along east-west trending faults 4 or more miles south of the study area. The more productive Late Tertiary fluorite veins (Type 2) of the Northgate district, where they trend northwest in the direction of the study area, were mined at Pinkham Mountain. These veins attenuate several miles from the study area, and no fluorite bearing faults, veins, or fractures were observed in or near the study area. The study area is rated as having a low mineral resource potential for fluorspar, with a certainty level of C.

Pegmatites

About 13 mi northeast of the study area mica, beryl, and columbite-tantalite were produced from the "Many Values" pegmatite (fig. 1). This pegmatite is about 140 feet long, as much as 15 feet wide, and contains quartz, albite, muscovite, garnet, and tourmaline in addition to the minerals mentioned above. This is the only pegmatite that has proven productive in the northern North Park area (Hanley and others, 1950).

There are numerous pegmatites in and around the study area. Some pegmatites in the Northgate district contain copper in the form of malachite and chrysocolla (see copper section below). Some of the pegmatites south of the study area are associated with vermiculite deposits (see vermiculite section below). Pegmatites as much as 8 feet wide do occur within the study area but contain only quartz and feldspar. The resource potential for beryl, mica, and columbite-tantalite from pegmatite-type deposits within the study area is regarded as low, with a certainty level of C.

Vermiculite

Vermiculite is an expandable hydrous mica derived chiefly from near-surface weathering of biotite and phlogopite. Vermiculite deposits 0.5 - 1 mi south and southeast of the study area constitute one of the more intriguing mineral occurrences in the region. The vermiculite deposits are all associated with mafic and ultramafic rocks -- usually serpentinized and chloritized hornblendites -- that are intruded by or are adjacent to pegmatites. The mafic and ultramafic masses range from a few feet to 30 feet long and 10 - 15 feet wide. Besides chlorite and serpentine, these rocks may also contain biotite, tremolite-actinolite, olivine, and garnet. Commonly, there is an irregular to zoned pattern of alteration whereby the ultramafic mass of hornblendite or serpentine has been successively altered to chlorite, then to tremolite-actinolite, and finally to massive biotite and vermiculite. At several localities copper, in the form of malachite and chrysocolla, was observed coating fractures in the mafic and ultramafic rocks. These deposits are believed to have formed from the following sequence of events. Mafic and ultramafic metavolcanic rocks were altered after metamorphism to serpentine-, chlorite-, tremolite- and actinolite-, and biotite-bearing masses of rock by fluids associated with pegmatites. These masses were subsequently altered to vermiculite by near-surface weathering processes. (See Steven, 1960.)

No occurences of vermiculite or other altered mafic rocks were observed within the study area, although a large mass of mafic rocks is adjacent to pegmatites south of the study area boundary. Although the U.S. Forest Service Platte River Wilderness Area is reported to have moderate potential for vermiculite (Dickerson, 1986), the resource potential for vermiculite in the BLM wilderness study area is considered low, with a certainty level of C.

Copper

Copper in the form of malachite and chrysocolla coats fractures in unaltered mafic and ultramafic rocks at mines and prospects 0.5 - 1 mi south and southeast of the study area. Copper has also been reported in pegmatites south of the study area, but none was observed in pegmatites in and around the study area during field investigations for this report. Chalcopyrite and secondary malachite have been reported along the contacts of quartz monzonite intrusions, and at one location at Sentinal Mountain in breccia associated with a Laramide fault. Several mines around Sentinal Mountain in the Northgate district were developed in copper-bearing pegmatites, but the extent of production is unknown (Steven, 1960).

Recent work has centered on the concept that the copper originated from pre-metamorphic volcanogenic exhalative or epigenetic stratiform sulfide deposits (Sheridan and Raymond, 1984; Snyder, 1987). During metamorphism the sulfides were concentrated in amphibolite or calc-silicate gneiss. Such an origin would account for copper associated with mafic and ultramafic rocks. Copper may have been remobilized by fluids associated with intrusion of the syntectonic quartz monzonites, post-tectonic quartz monzonites, or pegmatites. This would account for copper associated with pegmatites. Copper is frequently found as malachite and chrysocolla on fracture surfaces of copper-bearing rocks.

Within the study area no copper minerals or host rocks for copper deposits were noted, though a potential host rock of mafic and ultramafic gneiss exists just south of the study area boundary. No structures that might act as conduits for fluids remobilizing copper were found in the study area. The study area is assigned a low potential for copper deposits, with a certainty level of C.

Oil, gas, carbon dioxide, and coal

Energy resources abound in nearby North Park and many of them have been utilized. Oil, gas, and carbon dioxide have been produced from several fields that are 10 - 50 miles south of the study area, and coal has been produced from underground and surface mines at several localities. The Brands Ranch hot springs is located 35 miles southwest of the study area (fig. 1). Several types of uranium occurrences are found in the north and west part of North Park.

Oil, gas, and carbon dioxide have been produced from Jurassic and Cretaceous formations at several localities in North Park. Two of the fields, Michigan River and Carlstrom, lie within 12 mi of the study area. Subbituminous coal has been produced from the Paleocene and Eocene Coalmont Formation at several localities east and northeast of Walden (fig. 1). Reserves of 450 million tons of mineable coal have been estimated for the North Park coal field (Vanderwilt, 1947).

All sedimentary rocks have been removed from the study area by erosion, consequently there is no mineral resource potential for oil, gas, carbon dioxide, or coal in the study area, at a certainty level of D.

Geothermal energy

The Brands Ranch hot springs is located between Delaney Butte and the Park Range, 13 mi west of Walden and about 35 mi southwest of the study area (fig. 1). At this location a 300 ft well was drilled into Cretaceous sedimentary rocks, penetrating an aquifer that yields 80 gallons of water per minute at a surface temperature of 107^{o} F (Pearl, 1980). The source of the heat for the hot springs is not known, as no Tertiary volcanic or intrusive rocks are known to exist for many miles around the hot springs (Tweto, 1976). As all sedimentary rocks have been removed from the study area, there is no possibility for geothermal water occurrences similar to the Brands Ranch hot springs. A low energy resource potential for fracture and fault-controlled geothermal water is present in the Precambrian crystalline rocks, with a certainty level of C.

Uranium

Uranium is found in several different modes at a number of places in the western and northern part of North Park. In the Northgate district and at Red Canyon in the east-central part of the Park Range, uranium occurs in fluorite-quartz veins and breccias along faults in Precambrian granites (fig. 1). A few tons of uranium ore has been produced from the deposits in Red Canyon, but none from the Northgate district (Nelson-Moore and others, 1978). Uranium occurs in peat bogs at Sheep Mountain approximately 16 mi southwest of the study area (Malan, 1957). There is a reported occurrence of uranium 4 miles west of the study area on Independence Mountain (Nelson-Moore and others, 1978), but no information is available as to the type of occurrence. The bedrock of the study area is similar to the host rocks in the Northgate district, though no mineral-bearing structural elements of the Northgate district were observed in the study area. Based on these considerations, and the proximity of the Northgate district and the Independence Mountain occurrence to the study area, a low mineral resource potential for undiscovered uranium is assigned to the study area, with a certainty level of C.

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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

<table>
<tr><td rowspan="4">LEVEL OF RESOURCE POTENTIAL ↑</td><td rowspan="4">U/A
UNKNOWN POTENTIAL</td><td>H/B
HIGH POTENTIAL</td><td>H/C
HIGH POTENTIAL</td><td>H/D
HIGH POTENTIAL</td></tr>
<tr><td>M/B
MODERATE POTENTIAL</td><td>M/C
MODERATE POTENTIAL</td><td>M/D
MODERATE POTENTIAL</td></tr>
<tr><td rowspan="2">L/B
LOW POTENTIAL</td><td rowspan="2">L/C
LOW POTENTIAL</td><td>L/D
LOW POTENTIAL</td></tr>
<tr><td>N/D
NO POTENTIAL</td></tr>
<tr><td></td><td>A</td><td>B</td><td>C</td><td>D</td></tr>
<tr><td></td><td colspan="4">LEVEL OF CERTAINTY →</td></tr>
</table>

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:

Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268–1270.

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Goudarzi, G. H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84–0787, p. 7, 8.

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.

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.

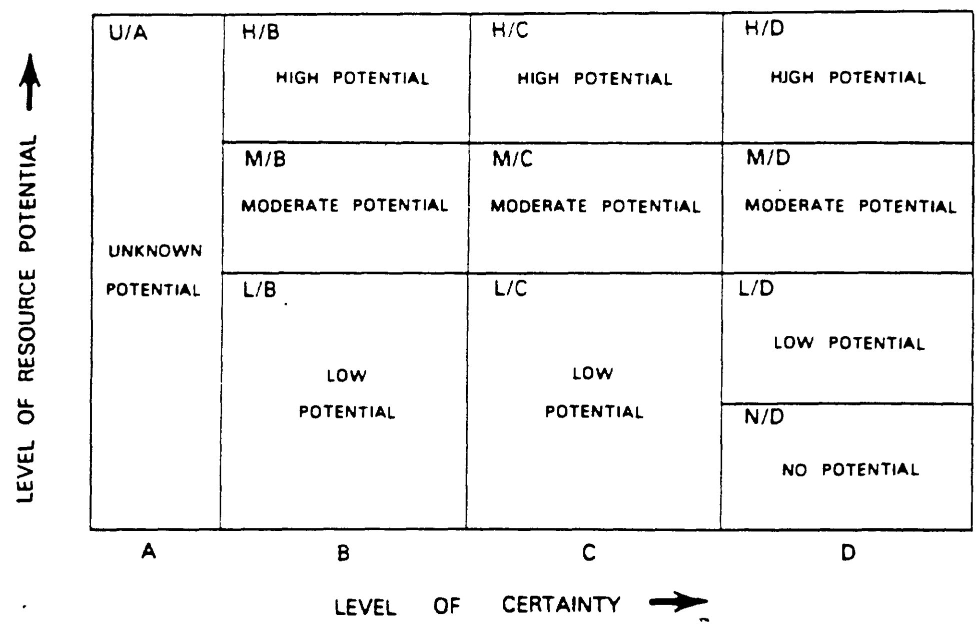
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application 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



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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.