

Mineral Resources of the Encampment River Canyon Wilderness Study Area, Carbon County, Wyoming



U.S. GEOLOGICAL SURVEY BULLETIN 1757-F



WYOMING

A small black square indicates the location of the study area in the southeastern corner of the state of Wyoming.

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Chapter F

Mineral Resources of the Encampment River Canyon Wilderness Study Area, Carbon County, Wyoming

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U.S. GEOLOGICAL SURVEY BULLETIN 1757

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
SOUTHERN WYOMING

DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary



U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

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STUDIES RELATED TO WILDERNESS

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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 Encampment River Canyon Wilderness Study Area (WY-030-301), Carbon County, Wyoming.

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Mineral Resources of the Encampment River Canyon Wilderness Study Area, Carbon County, Wyoming

By Edward A. du Bray, Viki Bankey, and
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ABSTRACT

The Encampment River Canyon Wilderness Study Area (WY-030-301), which is about 4 miles south of Encampment, Wyoming, contains 4,547 acres whose mineral endowment was jointly studied by the U.S. Bureau of Mines and U.S. Geological Survey in 1987. There are no identified resources in the study area. Resource potential for all undiscovered metallic commodities and for undiscovered industrial minerals is low. The study area has no potential for undiscovered energy resources, including oil and gas, coal, geothermal resources, and uranium.

SUMMARY

Character and Setting

The USGS (U.S. Geological Survey) and the USBM (U.S. Bureau of Mines) studied the mineral resource potential of 4,547 acres in the Encampment River

Canyon Wilderness Study Area (WY-030-301), Carbon County, Wyo., at the request of the BLM (U.S. Bureau of Land Management). In this report, the area studied is referred to as the "wilderness study area" or the "study area." Field studies of the study area were conducted during the summer of 1987 by USBM geologists and USGS geologists, geochemists, and geophysicists.

The Encampment River Canyon Wilderness Study Area is about 4 mi (miles) south of Encampment, Wyo. (fig. 1). The study area, which is accessible from numerous graded unpaved roads that intersect Wyoming State Route 230, is on the eastern slope of the Sierra Madre, the Continental Divide in this region. Elevations in the study area range between 7,200 and 8,545 ft (feet).

The study area is underlain by Archean felsic gneiss and Early Proterozoic quartzite (see geologic time chart in Appendix); both are intruded by minor Middle Proterozoic mafic plutonic rock. Gneiss occurs throughout the eastern and northwestern parts of the study area, whereas quartzite occurs in the western and southwestern parts. All lithologies are locally offset along high-angle faults.

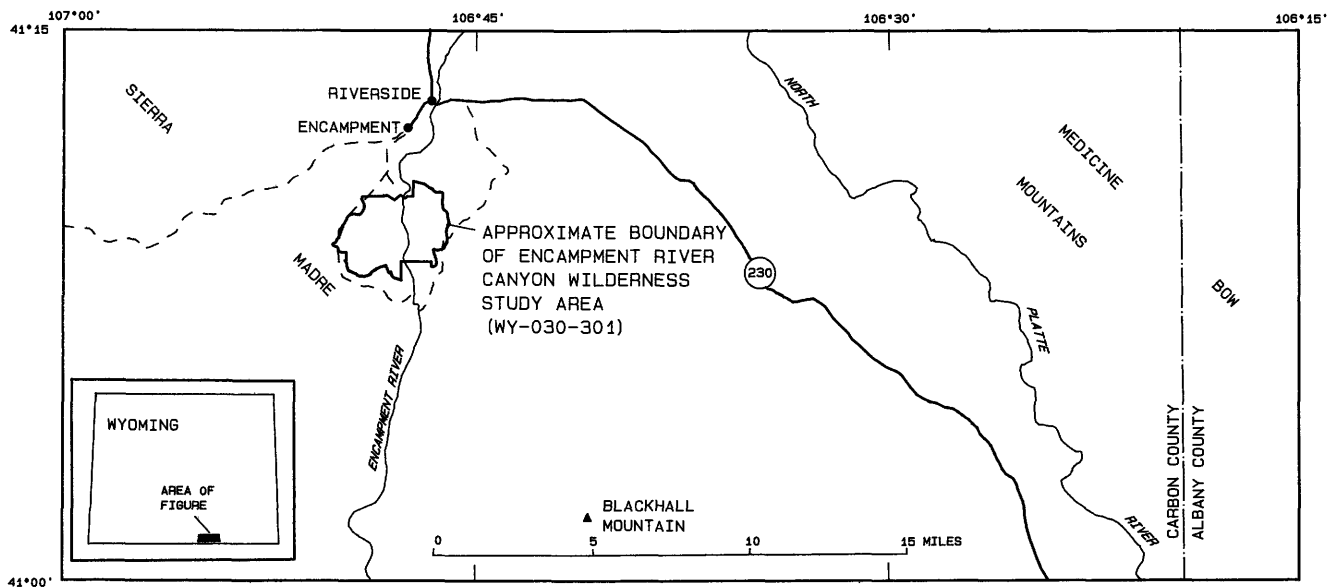


Figure 1. Index map showing location of the Encampment River Canyon Wilderness Study Area, Carbon County, Wyo. Dashed lines are selected unpaved roads.

Identified Mineral Resources

During the early 1900's, the original Encampment mining district was an important base-metal producer, encompassing more than 2,500 mines and prospects. The district comprised 25,000 mi², including the study area, and extended from the western slope of the Sierra Madre to the eastern slope of the Medicine Bow Mountains and south into Colorado. Within the district, massive sulfide deposits occur in Archean rocks, whereas stratabound sulfide deposits occur in Proterozoic rocks. (In this report, the term "deposit," unmodified, does not carry a connotation of economic value.) Most of the mines are located in the Sierra Madre 5–20 mi west of the town of Encampment, within the boundaries of what constitutes the presently accepted Encampment mining district. Total production of the district is not known, but it probably approached 20 million pounds of copper, and some zinc, lead, silver, and gold. From 1899 to 1908, 24 million pounds of copper were produced in Wyoming, nearly all from the original Encampment district (Hausel, 1986).

In southern Wyoming, small mines have produced uranium, vermiculite, copper, silver, platinum, palladium, and gold associated with quartz or pegmatite assemblages in Precambrian metamorphic host rocks. As a result, surface occurrences of siliceous rocks in southern Wyoming have been thoroughly examined, accounting for the number of prospects in the study area. No production from prospects in the study area is docu-

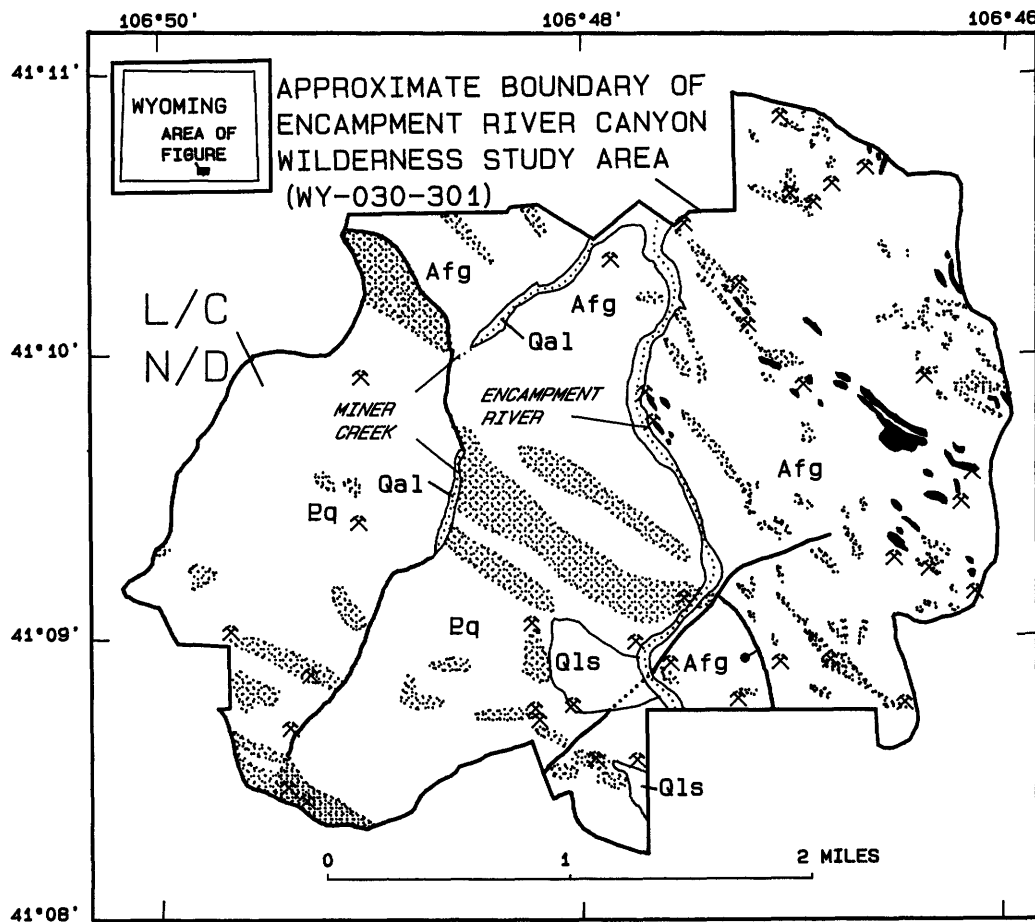
mented. Several claim blocks adjoin and overlap the study area boundary.

Small amounts of sand and gravel are present in alluvial deposits of the Encampment River canyon. These materials do not constitute a resource because of their small volume; abundant quantities are available immediately north of the study area where the Encampment River enters the broad and relatively flat valley of the North Platte River.

Mineral Resource Potential

The geologic environment in the Encampment River Canyon Wilderness Study Area is favorable for the occurrence of certain types of metallic mineral deposits, but the insignificant quantity of mineralized rock, lack of major geochemical anomalies not attributable to lithology, and absence of favorable geophysical characteristics indicate that mineral resource potential in the study area is low for all metals (fig. 2).

Energy resources, including oil and gas, coal, uranium, and geothermal resources, are unknown in the study area. The crystalline rocks that underlie the study area are neither source nor reservoir rocks for oil and gas; nor are they coal-bearing rocks. The structural setting of the study area is not appropriate to undiscovered resources of these commodities. The absence of uranium anomalies in the geochemical database and the failure of the aeroradiometric survey to identify anomalous uranium concentrations indicate no poten-



EXPLANATION

L/C	Geologic terrane having low mineral resource potential, with certainty level C, for all metals and industrial minerals
N/D	Geologic terrane having no resource potential, with certainty level D, for coal, oil and gas, geothermal resources, and uranium
Qal	Alluvium (Quaternary)
Qls	Landslide deposits (Quaternary)
	Pegmatite (Proterozoic)
	Mafic plutonic rock (Proterozoic)
Eq	Quartzite (Proterozoic)
Afg	Felsic gneiss (Archean)
	Contact
	Fault—Dotted where concealed
	Prospect pits, adits, and shafts
Levels of certainty	
C	Data indicate geologic environment and give good indication of level of resource potential but do not establish activity of resource-forming processes
D	Data clearly define geologic environment and level of resource potential

Figure 2. Map showing mineral resource potential and generalized geology for the Encampment River Canyon Wilderness Study Area, Carbon County, Wyo.

tial for uranium deposits in the study area. The absence of geothermal phenomena and the old age of rocks in the study area indicate that there is no potential for geothermal energy resources. Accordingly, there is no potential for energy resources in the study area (fig. 2).

Available geologic, geochemical, and geophysical data indicate low potential for undiscovered industrial mineral resources in the study area (fig. 2).

INTRODUCTION

The Encampment River Canyon Wilderness Study Area, about 4 mi south of Encampment, Wyo. (fig. 1), is accessible from graded unpaved roads that intersect Wyoming State Route 230. Travel in the study area is by way of a few rough jeep roads and on foot. The study area is located on the eastern slope of the Sierra Madre, part of the Continental Divide in this region, and is a gently rolling, dissected upland covered by grasses and sage; the highest north-facing slopes support stands of aspen and fir trees. The Encampment River flows south to north, through a 1,000-ft-deep canyon, across the study area. Elevations in the area range from about 7,200 ft in the Encampment River canyon to 8,545 ft on the adjacent canyon walls.

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study area and is the product of several 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 concentrations of metals and nonmetals, of unappraised industrial rocks and minerals, and of undiscovered energy resources (coal, oil, gas, oil shale, and geothermal resources). It is classified according to the system of Goudarzi (1984), which is shown in the Appendix of this report. The potential for undiscovered resources is studied by the USGS.

Investigations by the U.S. Bureau of Mines

USBM geologists searched the literature in which mining, mineral lease, and mining claim information has been compiled. Files at the BLM State Office in Cheyenne, Wyo., and the Carbon County Courthouse in Rawlins, Wyo., were reviewed for mining claim locations, patented mining claims, and oil and gas and geothermal energy leases and lease applications. Lessees, mine owners, and persons having knowledge of mineral occurrences and

mining activities in and near the study area were contacted. Field work by USBM personnel entailed examination of prospects and mines in and near the wilderness study area. Accessible mine workings were mapped, and mineralized areas and mine dumps were sampled. Detailed descriptions of analysis procedures and analytical results are presented by Ryan (1988), and complete analytical results are available for public inspection at the U.S. Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, Colo.

Investigations by the U.S. Geological Survey

The assessment of the mineral resource potential of the Encampment River Canyon Wilderness Study Area is based on data from many sources. Among these are geologic studies of the Sierra Madre and the Medicine Bow Mountains (Ferris, 1964; Houston and Ebbett, 1977; Graff, 1978; Houston and others, 1978; and du Bray, this report); geochemical studies by the USBM (Ryan, 1988) and the USGS (R.H. Hill, unpub. data, 1987); and interpretations of geophysical data including aeromagnetic and aeroradiometric data (Viki Bankey, this report) and Landsat Thematic Mapper data (Alta Walker, written commun., 1988).

APPRAISAL OF IDENTIFIED RESOURCES

By George S. Ryan U.S. Bureau of Mines

Malachite, azurite, and iron and manganese oxides along contacts of quartz or pegmatite pods and veins within the metamorphic rocks and mafic intrusive rocks are similar to contact mineral associations and assemblages present at mines and prospects at nearby mining districts. Most workings in the study area appear to be from turn-of-the-century operations; in many cases caving and extensive erosion have obliterated the source of mineralized rocks found in dumps. One adit was found open and was mapped and sampled, but no significant mineralized rock was noted and only minor structures were found. No claim notices were found in the courthouse that could be associated with the prospects found in the field.

Assay results for selected elements (Ryan, 1988, table 1) indicate that copper and manganese were the most widespread elements of interest. Copper concentrations in some samples would be significant if present in large ton-

nages; however, the restricted and limited occurrences observed indicate small tonnages. A single panned-concentrate sample was devoid of any elements of interest, and that absence indicates a lack of mineral concentrations in rocks upstream. Sixty-four chip and grab samples contained no element concentrations other than those expected as a consequence of surface observations of copper, iron, and manganese oxides and carbonates. Four samples that contained greater than 1 percent copper were from widely separated sample localities and associated with ubiquitous copper and iron oxide-stained rocks. Two of these samples contained 20.8 ppm (parts per million) silver and 1.55 ppm gold, respectively. These low concentrations and apparently restricted occurrences do not constitute a resource.

Although numerous prospect pits are present, no mineral resources were identified during the USBM investigation of the study area. Copper and manganese were present in samples from several widely spaced localities; however, these elements were not found in sufficient quantities to indicate a resource. Similarly, silver and gold were present in low concentrations and do not appear to represent a resource.

Metamorphic rocks in the study area are not conducive to the accumulation of hydrocarbons. Wilderness lands on the east flank of the Sierra Madre uplift have no known oil and gas potential (Spencer, 1983); nor are there oil and gas leases or lease applications in the study area.

Small amounts of sand and gravel are present in alluvial deposits of the Encampment River canyon, but steep, narrow drainage channels preclude major concentrations of sand and gravel deposits within the study area. Abundant material is available immediately north of the study area where the Encampment River enters the broad and relatively flat valley of the North Platte River.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

**By Edward A. du Bray, Viki Bankey, and
Randall H. Hill
U.S. Geological Survey**

Geology

Existing geologic maps at various scales (Ferris, 1964; Graff, 1978; Houston and Ebbett, 1977; and Houston and others, 1978) were employed in compilation of a preliminary geologic map of the study area prior to field work by USGS personnel. Outcrops were examined for signs of

mineralized rock. Samples of all rock units were collected for petrographic studies.

The Encampment River Canyon Wilderness Study Area is at the southern margin of the Archean Wyoming craton (Hills and Houston, 1979) and is adjacent to the Colorado Plateau physiographic province (Bickford and others, 1986) along the Cheyenne belt. The Cheyenne belt is an inferred suture zone at the southern edge of the North American craton along which lithospheric material was accreted during Proterozoic time. The study area is underlain by Archean felsic gneiss and Early Proterozoic quartzite; both are intruded by small bodies of Middle Proterozoic mafic plutonic rock. Gneiss occurs throughout the eastern and northwestern parts of the study area, whereas quartzite occurs in the western and southwestern parts. All lithologies are locally offset along high-angle faults.

Quartz-rich, biotite-muscovite felsic gneiss underlies much of the east half of the study area. The gneiss is moderately well foliated, as denoted by segregation banding, and is fine to medium grained. Anhedral quartz grains 0.004–0.1 in. in diameter and displaying strain-induced undulose extinction form about 80 percent of the gneiss. Albite-twinned, anhedral grains and some relict porphyroblasts of plagioclase (0.004–0.08 in. in diameter) form 5–30 percent of the gneiss. Light-tan to tan subhedral flakes of biotite (0.004–0.06 in. in diameter) form 5–10 percent of the rock. Colorless, subhedral muscovite (0.004–0.03 in. in diameter), stably intergrown with biotite, composes 3–5 percent of the rock. About 1 percent granular epidote (0.004–0.02 in. in diameter) was also identified. The gneiss contains trace amounts of apatite and sphene.

Rock that varies between quartzite and quartz-mica schist underlies the western third of the study area. This white- to buff-weathering rock is fine grained and finely laminated. It is composed of 90 percent anhedral quartz grains (0.004–0.01 in. in diameter) that display undulatory extinction. Subhedral, interstitial muscovite laths (less than 0.008 in. in diameter) form accumulations that impart a laminated texture to this lithology. The quartzite contains trace amounts of gridiron-twinned microcline.

Altered, mafic plutonic rock intrudes the felsic gneiss and the quartzite. The mafic plutonic rock is massive to weakly foliated, fine grained, and equigranular. It is principally (80–90 percent) composed of pale-brownish-green to pale-blue-green, anhedral actinolite grains (0.02–0.08 in. in diameter) that are probably pseudomorphs after pyroxene. Quartz, in anhedral grains (less than 0.008 in. in diameter) that display undulatory extinction, occurs interstitially as a trace constituent, forming as much as about 15 percent of the rock. Interstitial, albite-twinned plagioclase grains (0.016–0.08 in. in diameter) form as much as 5 percent of the mafic plutonic rock. About 5 percent subhedral

epidote (less than 0.004 in. in diameter) and trace amounts of sphene, apatite, and opaque oxides were also identified.

Numerous pegmatite dikes concordantly intrude felsic gneiss east of the Encampment River. The dikes have massive quartz cores, and large feldspar crystals concentrated along dike margins have altered to clay. Because this clay is highly susceptible to erosion, most evidence of feldspar in the dikes is absent and the dikes resemble massive quartz veins. The dikes contain sparse, fine-grained kyanite.

Geochemistry

In September of 1987, a reconnaissance geochemical survey (R.H. Hill, unpub. data) was conducted in the Encampment River Canyon Wilderness Study Area to aid evaluation of its mineral resource potential. Rocks, stream sediments, and heavy-mineral concentrates of stream sediment were selected as the sample media for evaluation.

Thirteen minus-60-mesh stream-sediment samples collected from active stream alluvium and 14 heavy-mineral panned concentrates derived from stream sediment were selected as primary sample media. The sediments are thought to represent a composite of the chemistry of rock and soil exposed in the drainage basin upstream from the sample site. Chemical analyses of such stream-sediment samples provide data useful in identifying those basins that contain unusually high concentrations of elements that may be related to mineral occurrences. In addition, studies have shown that heavy-mineral panned concentrates derived from stream sediment are useful in studying arid to semiarid environments or areas of rugged topography, where mechanical erosion predominates over chemical erosion (Bugrov and Shalaby, 1975; Overstreet and Marsh, 1981). Heavy-mineral-concentrate samples provide information about the chemistry of a limited number of minerals present in rock material eroded from the drainage basin upstream from each sample site. Preparation of heavy-mineral concentrates from stream sediments results in a concentration of mineral assemblages that may contain ore-forming and ore-related minerals. The selective concentration of these minerals permits determination of some elements that are not easily detected in bulk stream-sediment samples.

Seven fresh and unaltered rock samples were collected from outcrops to provide chemical and mineralogic information for rocks exposed near stream-sediment sample sites. In addition, a mine-dump sample was collected to provide information concerning the composition of mineralized rock present in the study area. The actual areal extent of the influence of each rock type on the chemistry of individual stream-sediment and panned-concentrate samples is indeterminate, though the sampling program

was designed to provide general information concerning the geochemical nature of the exposed lithologies.

The dry stream-sediment samples were sieved through 60-mesh stainless-steel sieves. The minus-60-mesh material was retained for analysis and pulverized with ceramic plates to at least minus-100 mesh prior to analysis. To produce the heavy-mineral concentrate, bulk stream sediment was first sieved through a 10-mesh screen. Approximately 25–30 pounds of the minus-10-mesh sediment was panned to remove most of the quartz, feldspar, organic material, and clay-sized material. These samples were then air dried, passed through a 30-mesh sieve, and separated into light and heavy fractions by means of bromoform (heavy liquid, specific gravity 2.86). The light fraction was discarded. The material of specific gravity greater than 2.86 was separated into three fractions (highly magnetic, weakly magnetic, and nonmagnetic) by means of a modified Frantz Isodynamic Magnetic Separator. The nonmagnetic fraction was hand ground and retained for emission spectrographic analysis. Rock samples were crushed and pulverized to at least minus-100 mesh with ceramic plates prior to analysis. Rock, stream-sediment, and nonmagnetic portions of the prepared heavy-mineral concentrate were analyzed for 35 elements by means of a semiquantitative, direct-current arc emission spectrographic method (Grimes and Marranzino, 1968); abundances of platinum and palladium in the concentrate samples were also determined by this method.

Threshold values, defined as the upper limit of normal background values, were determined for each element by inspection of frequency-distribution histograms for all sample media. The composite mine-dump rock sample was not included in construction of the histograms. A geochemical value greater than the threshold value is considered anomalous and worthy of consideration as a possible indicator of mineralized rock.

The primary criterion for delineating an area as anomalous is the presence of multi-element geochemical anomalies clustered within a restricted geographic region. Follow-up studies should, however, include isolated anomalous sample localities with geographically extensive, geochemically anomalous areas because the scale of sampling conducted for this study is so small that moderate-sized deposits could be indicated by a single sample site, or not be apparent at all. In addition, this study is a surface study and may not reflect the presence of mineralized rock at depth.

Heavy-mineral-concentrate samples from two sites in the southwestern part of the study area, one from a west-flowing stream and the other from a southeast-flowing stream (R.H. Hill, unpub. data, 1987), contained anomalous concentrations of beryllium (200 and 100 ppm, respectively), lead (300 and 200 ppm), tin (700 and 100

ppm), and tungsten (500 and 200 ppm). In addition, the stream-sediment sample from the west-flowing stream contained 500 ppm chromium and 100 ppm nickel. Anomalous elemental abundances in the heavy-mineral concentrates may result from weak hydrothermal alteration and mineralization of quartzite along thrust faults (Graff, 1978) that could have served as conduits for migrating hydrothermal fluids. Alternatively, the anomalies may arise from dense, detrital accessory minerals contained within quartzite and quartz-pebble conglomerate exposed in this area. Anomalous nickel and chromium abundances in the stream-sediment sample from the west-flowing stream are believed to represent detrital accumulations of chromite derived by mechanical weathering of nearby mafic plutonic rocks.

A heavy-mineral-concentrate sample from a site approximately 1 mi southwest of the confluence of Miner Creek and Encampment River (R.H. Hill, unpub. data, 1987), in a tributary of Miner Creek, contains 5,000 ppm barium, 100 ppm bismuth, and 150 ppm tungsten. These anomalous values may indicate weak metamorphism, hydrothermal alteration, and mineralization at the contact zone where quartzite is intruded by mafic plutonic rocks. Alternatively, the anomaly may be related to weak mineralization of rock in a thrust fault (Graff, 1978), which could have served as a conduit for migrating hydrothermal fluids, located upstream in the head of the drainage basin. Another heavy-mineral-concentrate sample from Miner Creek, near its confluence with Encampment River, contains 150 ppm tin and 100 ppm tungsten. These anomalous concentrations may indicate downstream transport of dense ore minerals from anomalous areas upstream.

Anomalous bismuth and tungsten abundances were determined for heavy-mineral-concentrate samples sporadically distributed in the study area. The source of these element anomalies is uncertain, although they may indicate weak metamorphism, hydrothermal alteration, and mineralization at the contact zone where quartzite and (or) felsic gneiss is intruded by mafic plutonic rocks.

Geophysics

A detailed aeromagnetic survey of the wilderness study area and vicinity was flown in 1979 by a fixed-wing aircraft at a nominal ground clearance of 400 ft. Flight traverses were oriented north-south and spaced 0.25 mi apart; these specifications provide 60 percent coverage of surface sources and 100 percent coverage of sources buried below 200 ft depth. After correction for diurnal effects and tie-line discrepancies, the International Geomagnetic Reference Field was removed. The resulting residual magnetic data were compiled and contoured by the contractor

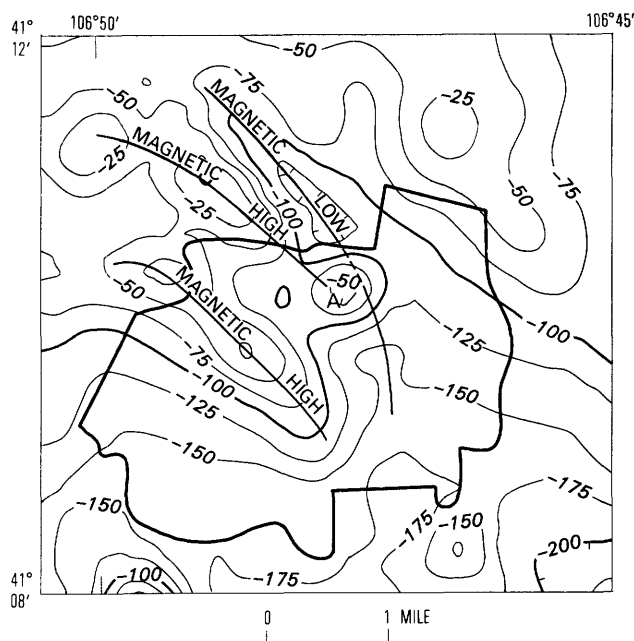


Figure 3. Residual aeromagnetic anomaly map of the Encampment River Canyon Wilderness Study Area and vicinity, Carbon County, Wyo. Heavy line is approximate boundary of wilderness study area. Contour interval 25 nanoteslas. A, aeromagnetic anomaly discussed in text; hachures indicate area of closed low.

(Bendix Field Engineering Corporation, 1983) to produce a regional aeromagnetic map. The map is useful in geologic interpretations of the region that contains the study area; a subset of the data was used to aid interpretation of the geology in the study area.

Aeromagnetic data (fig. 3) are useful in delineating concealed intrusive rocks that could be associated with mineral deposits. Aeromagnetic data for the Encampment River Canyon Wilderness Study Area are characterized by a northwest grain that corresponds with the outcrop pattern of northwest-trending mafic plutonic rock and pegmatite dikes. Specifically, two northwest-trending magnetic highs are associated with mafic plutonic rock; these highs are limited to the area underlain by this rock type. Mafic rocks in the southwestern part of the study area are not associated with magnetic anomalies, which suggests that the mafic plutonic rocks are variably magnetized. In the northeastern part of the study area and north of its boundary, a linear magnetic low trends northwest and is associated with pegmatite outcrops. Positive magnetic anomaly A causes discontinuity in the magnetic low in a region characterized by fewer pegmatite outcrops. Anomaly A is probably attributable to outcropping mafic plutonic rocks that are abundant in this area and more intensely magnetized than those that crop out to the east. Neither quartzite nor felsic gneiss in the study area appear to contain magnetic minerals, and no other magnetic anomalies were detected.

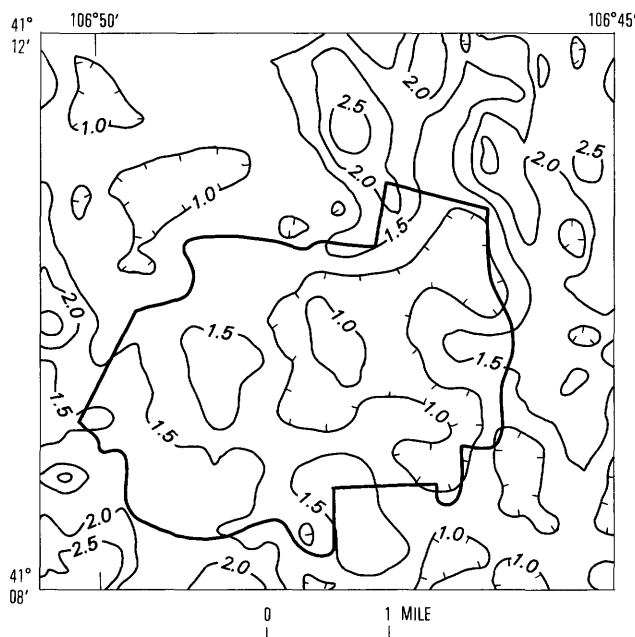


Figure 4. Uranium equivalent (eU) values for the Encampment River Canyon Wilderness Study Area and vicinity, Carbon County, Wyo. Heavy line is approximate boundary of wilderness study area. Contour interval 0.5 parts per million; hachures indicate area of closed low.

Aerial gamma-ray spectroscopy is a radiometric technique that provides an estimate of the near-surface (depth 0–20 in.) concentrations of uranium (U), thorium (Th), and potassium (K), and is used in exploration for uranium deposits. The occurrence of radioactive quartz-pebble conglomerate in the Medicine Bow Mountains and Sierra Madre necessitated a detailed aeroradiometric survey of the region to determine the extent and abundance of uranium. Aeroradiometric data for the study area (figs. 4–6) were obtained from traverses flown in 1979 by contractors working for the U.S. Department of Energy as part of the National Uranium Resource Evaluation (Bendix Field Engineering Corporation, 1983). The traverses are along north-south lines spaced 0.25 mi apart and have a nominal ground clearance of 400 ft. These specifications are sufficient to achieve 60 percent ground coverage. The U and Th values are "equivalent" values (eU and eTh) to account for possible disequilibrium in the decay series for those elements.

Some of the rock types in the study area, including felsic gneiss and quartzite, may have above-background radioactivity due to elevated abundances of the radioactive elements in potassium feldspar, mica, or accessory minerals. Uranium can become concentrated along fractures in quartz and feldspar. However, clean quartzite may be depleted in radioactive minerals and would approach background levels. In the study area none of the concentra-

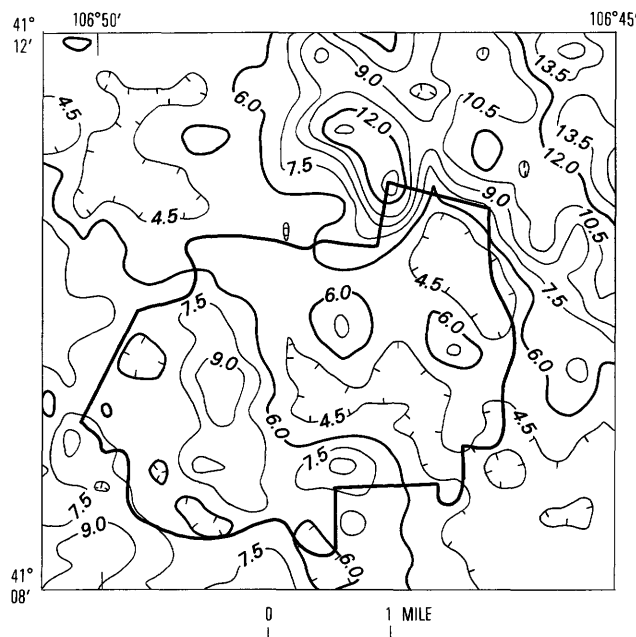


Figure 5. Thorium equivalent (eTh) values for the Encampment River Canyon Wilderness Study Area and vicinity, Carbon County, Wyo. Heavy line is approximate boundary of wilderness study area. Contour interval 1.5 parts per million; hachures indicate area of closed low.

tions of uranium, thorium, or potassium is anomalous where quartzite crops out. Concentrations range from 0.5 to 2.0 ppm eU, 4.0 to 13.5 ppm eTh, and 1.0 to 2.0 percent K. Observed radioactivity slightly exceeds background levels in and beyond the northern tip of the study area, where readings reach 2 ppm eU, 13.5 ppm eTh, and 2 percent K. The weakly anomalous radioactivity may be associated with minor segregations of radioactive minerals in pegmatite dikes; the radioactivity is orders of magnitude less intense than that associated with ore-grade radioactive mineral deposits.

Landsat Thematic Mapper data can be used to identify indications of mineralized or altered rock exposed at the Earth's surface. Data for seven spectral bands, analyzed individually, as composites, and as ratios, do not indicate the presence of mineralized or altered rock in the study area (Alta Walker, written commun., 1988).

Mineral and Energy Resources

Accumulated evidence suggests that there is low mineral resource potential, with level-C certainty, for undiscovered metallic mineral deposits in the Encampment River Canyon Wilderness Study Area (fig. 2). The geologic setting of the study area is favorable for various types of metalliferous deposits (including deposits of platinum-

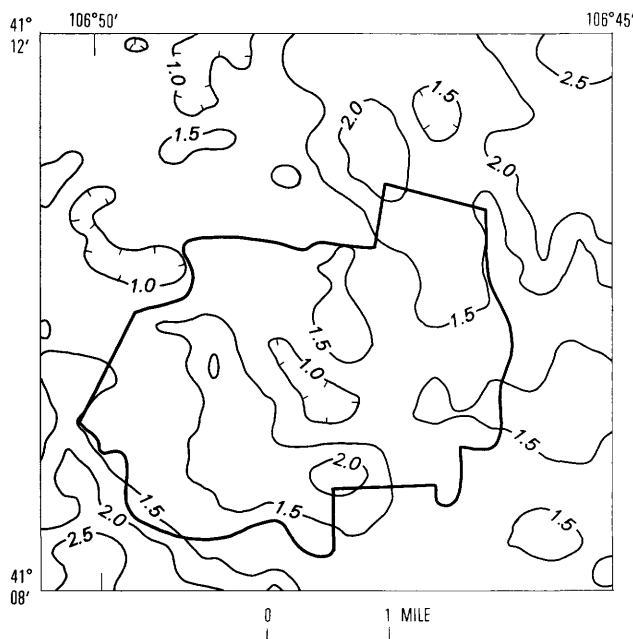


Figure 6. Potassium (K) values for the Encampment River Canyon Wilderness Study Area and vicinity, Carbon County, Wyo. Heavy line is approximate boundary of wilderness study area. Contour interval 0.5 parts per million; hachures indicate area of closed low.

group elements associated with mafic plutonic rock, deposits of gold and uranium in quartz-pebble conglomerate, massive and stratabound sulfide deposits, and pegmatite-hosted deposits), but supporting evidence and additional features indicative of favorability for the occurrence of deposits in the study area are absent. The quantity of mineralized rock, found at widely dispersed localities during field work, was minimal and the intensity of mineralization insignificant. Anomalous concentrations in the geochemical data are a function of lithologies present in the sampled drainage basins or reflect the presence of weakly, locally mineralized rock. Geophysical data do not indicate the presence of mineral deposits and geologic settings are not favorable for them. These findings suggest that the mineral resource potential for all metals in the wilderness study area is low, with level-C certainty.

Energy resources, including oil and gas, coal, uranium, and geothermal resources, are unknown in the study area. The crystalline rocks that underlie the study area are neither source nor reservoir rocks for oil and gas; nor are they coal-bearing rocks. The structural setting of the study area is not appropriate to undiscovered resources of these commodities. The absence of uranium-anomalous values in the geochemical database and the failure of the aeroradiometric survey to identify anomalous uranium concentrations indicate no potential for uranium deposits in the study area. The absence of geothermal phenomena and the old age of rocks in the study area indicate that there is no potential for geothermal resources. Accordingly, a

rating of no potential (with level-D certainty) for energy resources is assigned to the study area.

The geologic setting in the study area is not favorable for the occurrence of industrial mineral resources. Available geologic, geochemical, and geophysical data indicate low potential (with level-C certainty) for undiscovered industrial mineral resources.

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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

 LEVEL OF RESOURCE POTENTIAL	U/A	H/B HIGH POTENTIAL	H/C HIGH POTENTIAL	H/D HIGH POTENTIAL
	UNKNOWN POTENTIAL	M/B MODERATE POTENTIAL	M/C MODERATE POTENTIAL	M/D MODERATE POTENTIAL
		L/B LOW POTENTIAL	L/C LOW POTENTIAL	L/D LOW POTENTIAL
				N/D NO POTENTIAL
	A	B	C	D
	LEVEL 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:

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

Taylor, R. B., Stoneman, R. J., and Marsh, S. P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: *U.S. Geological Survey Bulletin* 1638, p. 40-42.

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RESOURCE/RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range	
	Measured	Indicated		(or)	
				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 McKelvey, 1972, Mineral resource estimates and public policy: American Scientist, v.60, p.32-40, and 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		
	Mesozoic	Cretaceous		Late Early	96	
		Jurassic		Late Middle Early		138
		Triassic		Late Middle Early	205	
		Paleozoic	Permian			Late Early
			Carboniferous Periods	Pennsylvanian	Late Middle Early	290
	Mississippian			Late Early	~ 330	
	Devonian		Late Middle Early	360		
	Silurian		Late Middle Early		410	
	Ordovician		Late Middle Early	435		
	Cambrian		Late Middle Early		500	
Proterozoic	Late Proterozoic			~ 570 ¹		
	Middle Proterozoic				900	
	Early Proterozoic					1600
Archean	Late Archean			2500		
	Middle Archean				3000	
	Early Archean					3400
pre-Archean ²		3800?				

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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