STUDIES RELATED TO WILDERNESS

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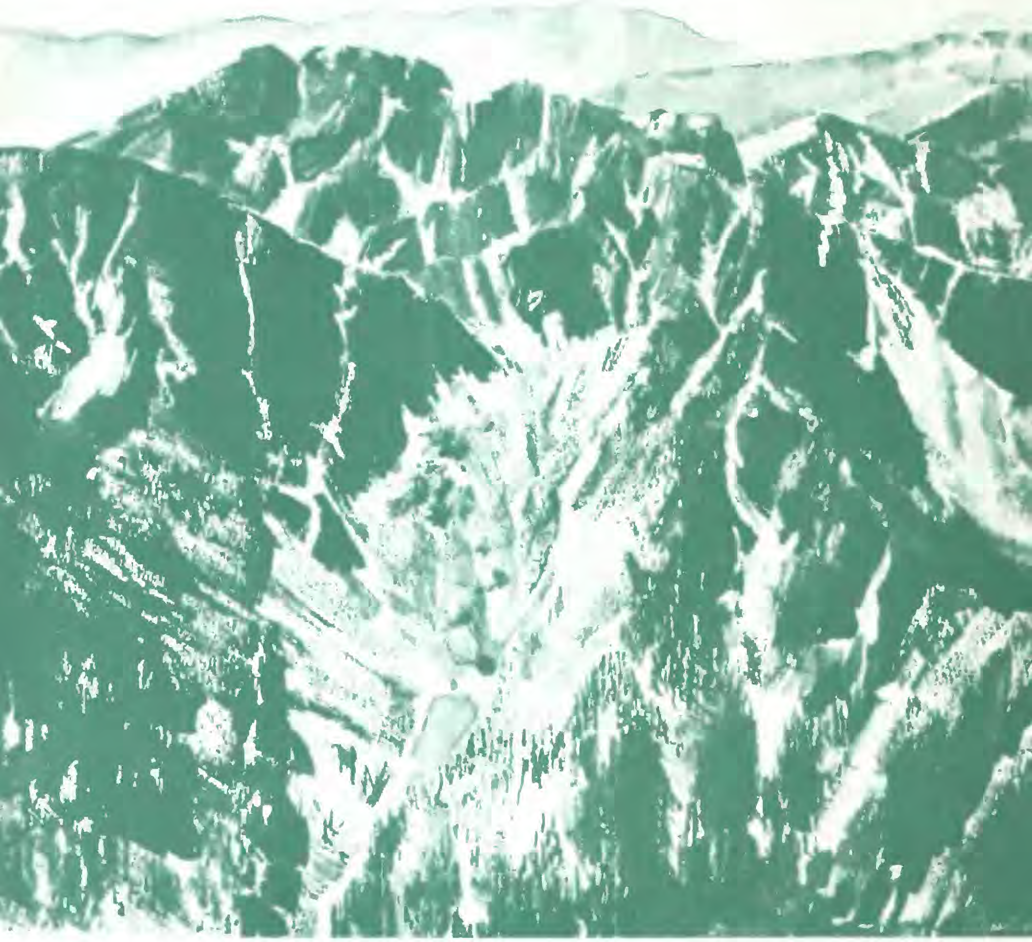
PRIMITIVE AREAS



AREAS ADJACENT TO CLOUD PEAK, WYOMING

GEOLOGICAL SURVEY BULLETIN 1391-D

Mineral Resources of Areas Adjacent to the Cloud Peak Primitive Area, Wyoming

By KENNETH SEGERSTROM, U.S. GEOLOGICAL SURVEY
and R. C. WEISNER, U.S. BUREAU OF MINES

With a section on AEROMAGNETIC INTERPRETATION
By DALLAS B. JACKSON, U.S. GEOLOGICAL SURVEY

STUDIES RELATED TO WILDERNESS — PRIMITIVE AREAS

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An evaluation of the mineral potential of proposed extensions to the Cloud Peak Primitive Area

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STUDIES RELATED TO WILDERNESS

PRIMITIVE AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Conference Report on Senate bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines are making mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System. Areas classed as "primitive" were not included in the Wilderness System, but the act provides that each primitive area be studied for its suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report presents the results of a mineral survey in eight proposed additions to the Cloud Peak Primitive Area, Wyo.

CONTENTS

ILLUSTRATIONS

TABLES

MINERAL RESOURCES OF AREAS ADJACENT TO THE CLOUD PEAK PRIMITIVE AREA, WYOMING

By KENNETH SEGERSTROM, U.S. Geological Survey, and R. C. WEISNER, U.S. Bureau of Mines

SUMMARY

A mineral survey of eight tracts near the Cloud Peak Primitive Area, Wyo., was made by the U.S. Geological Survey and the U.S. Bureau of Mines in 1972. An aeromagnetic survey was made in the same year by the U.S. Geological Survey. The eight tracts surveyed, identified as extensions A through H, lie along the flanks of the Bighorn Mountains in Big Horn, Johnson, and Sheridan Counties, Wyo.; they border the primitive area studied by the same agencies in 1970 (Kiilsgaard and others, 1972). The areas of the present study total approximately 133,000 acres (54,000 hectares), which, added to the 136,000 acres (55,000 hectares) of the officially designated Cloud Peak Primitive Area and to the 94,000 contiguous acres (38,000 hectares) that were studied in 1970, make a grand total of about 363,000 acres (147,000 hectares).

About 450 unpatented lode and placer claims have been recorded in the area, but nothing has been produced from these claims.

The eight extensions studied in 1972, like the original area studied in 1970, are underlain almost entirely by igneous and metamorphic rocks of Precambrian age, except for extension D. This area is underlain mostly by sedimentary rocks of Paleozoic age that dip gently westward into the Bighorn Basin. The area of extension A is fringed by the same types of Paleozoic rocks, but, there, they dip steeply eastward into the Powder River Basin. Glacial moraines fan out in all directions from the central highland of the Bighorn Mountains, covering bedrock in the flanking areas.

Geological, geochemical, and geophysical investigations, mine and prospect examinations, and analyses of samples of stream sediments and bedrock were all used in making a mineral appraisal of the study areas. The results of this work are the same as those obtained in 1970 from the Cloud Peak Primitive Area and vicinity: they show that the eight newly proposed extensions to the area are without economically significant mineral resources. These extensions, in common with the rest of the Bighorn Mountains area studied for wildnerness evaluation, are also without evidence for potential resources for coal, oil, gas, geothermal energy, or commercial quantities of nonmetallic minerals.

INTRODUCTION

This report describes the geology and mineral potential of eight areas, totaling about 133,000 acres (54,000 ha (hectares)), which have been proposed as extensions to the Cloud Peak Primitive Area and whose study was requested by the U.S. Forest Service (fig. 1). These tracts, listed and designated in table 1, lie along the flanks of the Bighorn Mountains in north-central Wyoming. The tracts are within the Bighorn National Forest in Big Horn, Johnson, and Sheridan Counties, and they border a larger area that was studied in 1970 by Kiilsgaard, Ericksen, Patten, and Bieniewski (1972). The present report supplements their reports by extending their findings outward from the Cloud Peak Primitive Area.

TABLE 1.—*Areas proposed as extensions to the Cloud Peak Primitive Area*

Designation used in this report (extension)	Location	Approximate area	
		Acres	Hectares
A	North Piney Creek to South Rock Creek, east and northeast flanks of Bighorn Mountains.	89,000	36,000
B	Upper part of East Tensleep Creek, south flank.	7,000	2,800
C	Bald Ridge, southwest flank	1,500	600
D	South and Middle Paint Rock Creeks, southwest flank.	13,500	5,500
E	Dry Medicine Lodge and Trapper Creeks, west flank.	10,500	4,300
F	Moraine and Willett Creeks, northwest flank.	4,500	1,800
G	Upper part of East Fork South Tongue River, north flank.	3,000	1,200
H	East Fork Big Goose Creek, north flank.	4,000	1,600
Total		133,000	53,800

TOPOGRAPHY AND ACCESS

Extension A, on the east and northeast flanks of the Bighorn Mountains, is by far the largest of the eight study tracts. It is characterized by a rolling subsummit surface, about 7,000–8,500 feet (2,000–2,600 m (metres)) above sea level, which is carved locally by streams in steep-walled gorges as much as 1,000 feet (about 300 m) deep. The V-shaped valleys of South Piney Creek and South Rock Creek provide rugged, picturesque landscapes, as do a

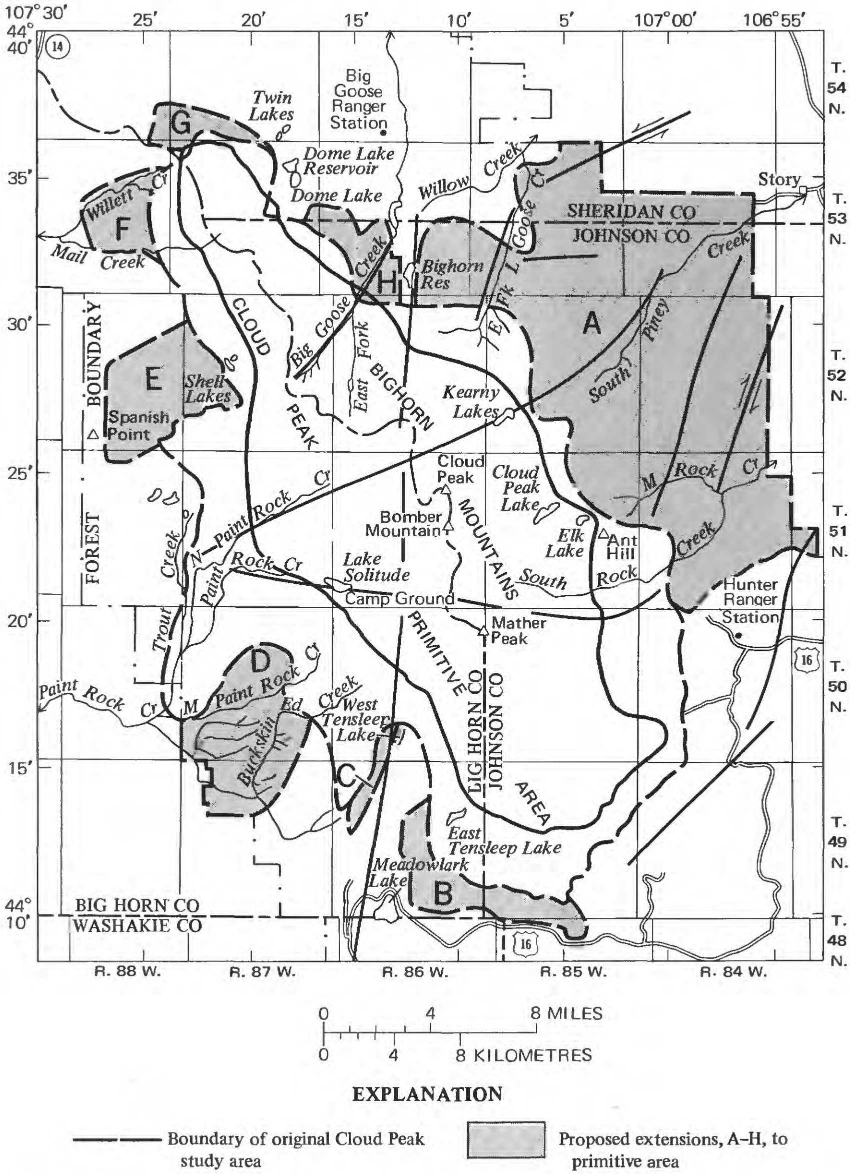

FIGURE 1.—Proposed extensions to the Cloud Peak Primitive Area, showing lineaments from an ERTS-1 photograph, taken October 16, 1972. Lineaments for which there is ground evidence of faulting have arrows that show relative movement.

number of small granite and gneiss knobs that project above the relatively flat-topped interfluves. The highest altitudes in extension A, about 9,400 feet (2,850 m), are along the west edge and on Little

Goose Peak in the northern part. The lowest altitude is about 5,600 feet (1,700 m) at the mouth of South Piney Creek canyon.

The area is drained by the northward- and eastward-flowing Little Goose Creek, North Piney Creek, South Piney Creek, North Rock Creek, and South Rock Creek, and their tributaries. Most of these streams are fed by springs and melting snow in the high country to the west, and have a strong, perennial flow. South Piney Creek is augmented in the summer by water released from Kearny Lakes and Willow Park Reservoir. The water from these streams is used for domestic purposes and irrigation of hay meadows east of the mountains and constitutes the most valuable natural resource of the area.

Two jeep roads cross extension A. One of them starts at the Fordyce Ranch, south of the town of Big Horn (fig. 1), and can be followed southward to Penrose Park, a distance of about 15 miles (25 km)—driving time 2 hours. An additional hour is required for negotiating the extremely rough road from Penrose Park to Kearny Lakes. The other road starts from the Little Piney Creek road, south of Story, and can be followed southwestward to Willow Park Reservoir, a distance of about 12 miles (20 km)—driving time, 1 hour. A jeep trail continues from the reservoir nearly to Cloud Peak Lake, 4.5 miles (7¼ km) farther, but it is so rocky that it is barely passable. A poor jeep trail leads into the south end of the area from the Paradise Ranch road for about 2 miles. The rest of the area is accessible only by foot or on horseback.

Extensions B and C are near the south end of the highest part of the Bighorn Mountains. Altitudes range from about 8,600 to 10,500 feet (2,600 to 3,200 m). The eastern part near Powder River Pass is moderately rugged, but much of the area is covered by moraines and is hummocky. Drainage is southward into tributaries of Tensleep Creek. Accessibility is better in these tracts than in any of the other study tracts because extension B is bordered on the south by U.S. Highway 16 and extension C is bordered on the east by a road that leads to West Tensleep Lake. Another road leads to Lake Creek Campground and a jeep trail goes up East Tensleep Creek.

Extension D is characterized by a surface of Madison Limestone which is inclined 7° SW., along the dip of the rock strata. This surface is cut by steep-walled canyons as much as 500 feet (about 150 m) deep in the southern and western parts. Altitudes range from 9,399 feet (2,867 m) at Ed Point to about 6,800 feet (2,075 m) at Middle Paint Rock Creek, at the west edge of the area. (See pl. 1.) A gravel-surfaced highway traverses the northeastern part of extension D, and a branch of the highway traverses the south end of the tract. Jeep roads lead to Buckskin Ed Creek and Middle Paint Rock Creek.

Extensions E and F are rugged areas on the west and northwest flanks of the Bighorn Mountains. Altitudes range from about 8,400 to10,800 feet (2,560 to 3,300 m). Drainage is westward into Shell and Paint Rock Creeks. Unimproved roads exist along and near the west edge of the tracts, but the access to most of the terrain is difficult.

Extension G is at the north end of the high central core of the Bighorn Mountains. Altitudes range from about 9,200 to 10,400 feet (2,800 to 3,170 m). Drainage is northward toward the Tongue River. Access is easy, because the area is small, and it is bordered on the north and west by automobile roads.

Extension H is on the northeast flank of the Bighorn Mountains at altitudes ranging from about 8,600 to 9,600 feet (2,620 to 2,930 m). Roads go along Babione and Antler Creeks and to Park and Bighorn Reservoirs. Access to extension H is by any of these routes.

CLIMATE

The climate of the Bighorn Mountains is conditioned by two principal factors: altitude and position relative to eastern or western slope. In general, precipitation increases and mean temperature decreases with increasing altitude. Most moisture-laden air masses come from the east, so that the east side of the range has more precipitation than the west side. Climatic data on the region are scanty, but Kiilsgaard and others (1972, p. C4) recorded the average annual precipitation of the Bighorn Mountains as 27 inches (686 mm (millimetres)).

PREVIOUS INVESTIGATIONS

The Bighorn Mountains were mapped and studied geologically during 1901-5, inclusive, by Darton (1906a-d).

Data on petrology, chemistry, and chronology of the Precambrian rocks have been reported by Osterwald (1955, 1959), Armbrustmacher (1966), Heimlich and Banks (1968), Heimlich (1969, 1971), Heimlich and Armstrong (1972), and Heimlich, Nelson, and Gallagher (1973).

Paleozoic and Mesozoic formations on the east flank of the Bighorn Mountains were described by Hose (1955) and Maher (1959).

Tertiary deposits in and adjacent to the Bighorn Mountains have been studied by Sharp (1948), Brown (1948), Osterwald (1949), Mapel (1959), Nelson (1968), and McKenna and Love (1972).

Quaternary deposits in the Bighorns were discussed by Matthes (1900) and Salisbury and Blackwelder (1903).

The structure of the Bighorn uplift has been extensively studied by Bucher, Chamberlin, and Thom (1933), Bucher, Thom, and Chamberlin (1934), Cloos and Cloos (1934), Wilson (1938), Demorest

(1941), Hoppin (1961), Hoppin and Palmquist (1965), Prucha, Graham, and Nickelsen (1965), Jennings (1967), Palmquist (1967), and Hudson (1969).

An evaluation of the mineral resources of the Cloud Peak Primitive Area was made by the U.S. Geological Survey and the U.S. Bureau of Mines in June-September 1970 (Kiilsgaard and others, 1972).

PRESENT INVESTIGATION

The present investigation of the eight proposed extensions to the primitive area is intended to supplement the investigations by Kiilsgaard and others (1972). The present report summarizes the results of fieldwork done in 1972 by Kenneth Segerstrom, D. E. Trimble, and W. R. Keefer, assisted by C. A. Kuharic, for the U.S. Geological Survey, and by R. C. Weisner, assisted by R. A. Beach, R. M. Adams, and A. G. Hite for the U.S. Bureau of Mines. The aeromagnetic interpretation was made by D. B. Jackson of the U.S. Geological Survey. T. J. Armbrustmacher, of the U.S. Geological Survey, studied and classified the mafic rocks.

Geologic mapping and geochemical sampling were done by the U.S. Geological Survey. Because much of the terrain is covered with dense stands of lodgepole pine, aerial photographs were extensively used to determine trends of rock structure. Supporting data for structural interpretations were obtained from the aeromagnetic survey and from earth-satellite imagery. About 400 stream-sediment samples and 150 rock samples were collected. Semiquantitative spectrographic analyses of these samples for 30 standard elements were made at the Denver, Colo., laboratories of the U.S. Geological Survey. All recorded mining claims in and near the eight study areas were examined in the field by the U.S. Bureau of Mines, and samples from mines and prospects were analyzed in the U.S. Bureau of Mines laboratories in Reno, Nev.

ACKNOWLEDGMENTS

We gratefully acknowledge the friendly help of R. A. Hoppin, of the State University of Iowa, who informed us of unpublished geologic work about the region, and of L. J. Maher, Jr., who made available his unpublished work on the stratigraphy of extension A. Stephen Hobbs, of the U.S. Forest Service, aided in the sampling work without compensation. Gene Rauch, a rancher near Buffalo, gave generously of his time to help us locate trails and mine prospects on the east side of the mountains.

GEOLOGY

GEOLOGIC SETTING

In the Bighorn uplift—the easternmost of several Laramide uplifts in northern Wyoming—rocks of Precambrian age are exposed.

These rocks are flanked by Paleozoic and Mesozoic sedimentary rocks, which in the study areas dip steeply eastward and gently westward away from the core of the uplift.

PRECAMBRIAN ROCKS

In all the extensions except D, the exposed rocks are largely Precambrian. In this report these rocks are divided into two groups. The older group consists of gneiss and granitic rocks of felsitic to intermediate composition. Light-gray biotite granite gneiss is the principal rock. This rock is very well foliated in extension B and in the southern part of extension A, and it grades into poorly foliated to massive gray biotite granite, quartz diorite, and quartz monzonite in the northwestern areas. The gradation from gneiss to relatively unfoliated rock occurs through a broad zone northwest of South Piney Creek, and, because the change in texture is not clearly accompanied by a change in composition, the zone is difficult to delineate; hence, the contact between gneiss and granitic rocks is queried on plate 1. The change from foliated to more massive rock, from south to north, has been reported by Heimlich and Banks (1968) and by Kiilsgaard and others (1972, p. C9-C10).

The younger group consists of mafic dikes, both metamorphosed and unmetamorphosed, that have holocrystalline to porphyritic textures. The dark-colored dikes generally form bold outcrops which contrast strongly with the light-colored rocks they intrude. Dikes were mapped and sampled in extensions A and E; no dikes were found in the other extensions. A large dike swarm is exposed northeast of Willow Creek Reservoir, in extension A.

The country rock and the metamorphosed dikes are cut by quartz, aplite, and pegmatite veins and stringers, none of them thick or persistent enough to warrant mapping at the scale of plate 1.

GNEISS AND MIGMATITE

Good outcrops of gneiss and migmatite are generally restricted to the crests of narrow ridges or to areas along deeply dissected streams; broad interfluves and shallow valleys or swales are typically mantled with angular residual rock debris and sandy soil. Picturesque outcrops of slabby-weathering gneiss abound in the Rock Creek drainage basin in extension A and near Powder River Pass in extension B. The slabs stand on end in the NE¼ sec. 32, T. 52 N., R. 84 W., and the SW¼ sec. 21, T. 51 N., R. 84 W., where long bladelike outcrops as thin as 3.3 feet (1 m) rise as much as 20-30 feet (about 6-10 m) above debris piles of fallen and broken slabs.

The gneiss is generally of uniform composition. Although compositional layers were seen in the primitive area by Kiilsgaard and others (1972, p. C10), no lithologic variations that could be convincingly attributed to bedding were observed during the present study. Amphibolite and schist are rare, and quartzite and marble do not seem to occur, although a few boulders of quartzite were seen in the moraine of South Piney Creek. South of the study areas, quartzite appears in the gneiss, and at the south end of the Precambrian outcrop area in the Bighorn Mountains, marble, calc-silicate rocks, and iron-formation are present (Palmquist, 1967, p. 286).

Petrographic descriptions of the gneiss as given by Kiilsgaard and others (1972, p. C10) and Hoppin (1961, p. 357-358) are applicable to many rocks in the tracts. The most common foliated rock is gray biotite quartz feldspar gneiss. Plagioclase (oligoclase-andesine) is the principal feldspar, although microcline may be dominant in some outcrops. Hornblende is much less abundant than biotite in extension A, except in xenoliths, and xenoliths are generally rare in that area. Migmatite is sparse in most parts of the study areas, but it is exposed at places in the gorge of South Piney Creek. There, granite appears to have engulfed the gneiss in the manner described by Kiilsgaard and others (1972, p. C11) for a locality west of Bomber Mountain, in the primitive area.

The gneiss near Powder River Pass "contains much dark, well-foliated hornblende rock, with interlayered coarse white feldspathic material" (Osterwald, 1959, p. 8). In the western part of extension B and in extension C, pink feldspar augen are common in the gneiss. Along the northeast edge of extension D, amphibolite and schist are interlayered with gneiss but not in bodies sufficiently large to be mapped at the 1:62,500 scale of plate 1.

GRANITIC ROCKS

Massive or slightly foliated rocks in the study tracts range in composition from granite through quartz monzonite and quartz diorite to diorite. Light- to medium-gray rocks of intermediate composition predominate. Northwest of the gorge of South Piney Creek, the dominant rock is quartz diorite. The average modal composition in volume-percent for 20 samples of quartz diorite taken from this area and adjacent areas to the west is as follows: Plagioclase, 57.3; microcline, 3.0; quartz, 31.3; biotite, 7.0; opaque accessories, 0.7, nonopaque accessories, 0.7 (Heimlich, 1969, p. 51).

Red granite as described by Kiilsgaard and others (1972, p. C11-C12), does not crop out in extension A and is rare or absent in the other seven tracts.

RADIOMETRIC AGES OF GNEISSIC AND GRANITIC ROCKS

K-Ar (potassium-argon) age dates have been determined for 29 biotite concentrates from gneissic and granitic rocks of the Bighorn

Mountains (Heimlich and Armstrong, 1972, p. 76). Twelve of the concentrates came from rocks within the eight study tracts of this report. The granitic-rock biotite dates average 2.75 b.y. (billion years), those for gneissic-rock biotites average 2.50 b.y., and the ages for all rocks range from 2.52 to 3.18 b.y. (Heimlich and Armstrong, 1972, p. 76). The difference between ages of biotites from gneiss and of those from granitic rocks is apparently due to greater leakage of argon from biotite in the gneiss. These age data are based on more recent and more numerous determinations than those of Heimlich and Banks (1968) and earlier workers but do not change the conclusion that "major regional metamorphism and granitization gave rise to the present rocks during a single metamorphic event about 2.75 b.y. ago" (Kiilsgaard and others, 1972, p. C13).

MAFIC DIKES

Mafic dikes are more conspicuous in the Cloud Peak Primitive Area than in adjacent extensions, in part because the dikes are better exposed in the core of the range, where most of the area is above timberline. Of the eight tracts, A-H, only extension A has many conspicuous dikes, and they are largely restricted to the central and southern parts of the area (pl. 1). The dikes are dark gray to black and generally 3.3-50 feet (1-15 m) thick; they tend to be very fine grained at the margins and coarser grained in the middle. They are generally more resistant to erosion than are the gneissic and granitic rocks they cut (pl. 1). Exceptionally, as in the S½ sec. 9, T. 52 N., R. 84 W., a dike is less resistant to weathering than is the enclosing quartz diorite, yet the dike appears to be lithologically indistinguishable from the resistant dikes.

Mafic dikes of the eastern Bighorn Mountains were studied by Armbrustmacher (1966), who also examined dike rocks of the primitive area (Kiilsgaard and others, 1972, p. C16-C17). Rocks from the eight extensions have also been studied by Armbrustmacher (unpub. data, 1973). Metamorphosed mafic dikes from the southern Bighorn Mountains outside the primitive area and its proposed extensions were studied by Heimlich, Nelson, and Gallagher (1973).

The types of dikes as recognized in the laboratory by Armbrustmacher were not mapped separately in the field. The dikes from which samples were classified by Armbrustmacher are designated as metadolerite or postmetamorphic quartz dolerite on plate 1 and in table 2.

RADIOMETRIC AGES OF MAFIC DIKES

Potassium-argon whole-rock ages of mafic dikes in the Bighorn Mountains, as determined by Condie, Leech, Baadsgaard (1969), ranged from 1.4 to 2.5 b.y. The oldest samples were metadolerite (T. J. Armbrustmacher, oral commun., 1973). A wide range of ages of mafic dikes in the Bighorn Mountains was determined also by Heimlich and Banks (1968).

PALEOZOIC SEDIMENTARY ROCKS

Paleozoic rocks form a marine sequence of which six map units are designated on plate 1. On both sides of the Bighorn Mountains the formations dip away from the Precambrian core so that, progressing outward from the range, successively younger beds are exposed. These rocks are exposed in most of extension D and in small parts of extension A.

In the present report, descriptions of the sedimentary sequence are largely those of Maher (1959; oral commun., 1972). Formation names are from Kiilsgaard and others (1972), and these differ slightly from those of Maher.

FLATHEAD SANDSTONE

The oldest sedimentary rocks in the study areas are yellow-brown to light-gray sandstones and silty shales about 220 feet (67 m) thick (Maher, 1959). These rocks are assigned to the Flathead Sandstone of early Middle Cambrian age (Howell and others, 1944) and overlie the Precambrian crystalline rocks with great unconformity. Locally, as in the NW¼ sec. 36, T. 53 N., R. 84 W., the mostly friable sandstone has been metamorphosed to quartzite. In general, however, the lowest sedimentary rocks in the local sequence are much less resistant to erosion than are the Precambrian rocks; thus, a notable topographic break occurs along the contact—the Flathead and immediately overlying rocks tend to form saddles and subsequent valleys.

On the west side of the range the Flathead Sandstone is described as about 250 feet (75 m) of coarse-grained gray quartz sandstone that weathers red brown (Kiilsgaard and others, 1972, p. C18).

The basal conglomerate, of well-rounded pebbles of massive quartz and Precambrian gneiss, is well exposed in a road-metal quarry on the north side of U.S. Highway 16, in the SE¼ sec. 3, T. 48 N., R. 86 W. Highly ferruginous lenses in the lower part of the formation represent places where precipitation from ground-water solutions was especially favored.

GROS VENTRE FORMATION AND GALLATIN LIMESTONE

The Gros Ventre Formation of Middle and Late Cambrian age and the Gallatin Limestone of Late Cambrian age conformably overlie the Flathead Sandstone. These formations consist of grayish-green glauconitic shale and sandstone and gray limestone. They have a combined thickness of about 780 feet (240 m) on the east side of the Bighorn Mountains (Maher, 1959), are poorly exposed, and mainly form gentle grass-covered slopes. On the west side of the range, along Paint Rock Creek, the thickness of the two formations totals 580 feet (177 m).

A striking characteristic of these formations is an edgewise limestone conglomerate, where the pebbles and cobbles tend to have their long dimension normal to the bedding plane rather than parallel to it; this unusual rock occurs in thin beds in the upper part of the map unit (the Gallatin Limestone).

The Gros Ventre outcrop area tends to be treeless because soil derived from the shale is much less permeable than soils derived from other rocks of the region, and, as a result, trees do not grow along the semiarid mountain front.

BIGHORN DOLOMITE

The Bighorn Dolomite of Late Ordovician age (Hose, 1955, p. 48) consists chiefly of dolomite but contains some interbeds of sandstone and limestone; it conformably overlies the Gallatin Limestone. The contact is marked by a sharp break in topography, from saddle-and-valley landforms below to cliff-rimmed ridges above. The thick-bedded Bighorn Dolomite is about 405 feet (137 m) thick (Maher, 1959) and holds up such outstanding landmarks as Ed Point (W½ sec. 27, T. 50 N., R. 87 W.) and Stone Mountain (W½ sec. 36, T. 52 N., R. 84 W.).

MADISON LIMESTONE

The Madison Limestone, of Mississippian age (Weller and others, 1948), unconformably overlies the Bighorn Dolomite and is itself dolomitic limestone and cliff-forming. Minor ferruginous and glauconitic lenses occur in the lower part of the formation. The Madison is 540 feet (165 m) thick (Maher, 1959). Because of its strong resistance to erosion and the lesser resistance of overlying rocks, the Madison Limestone is by far the most extensively exposed sedimentary rock within the extension areas. On the southwest flank of the Bighorn Mountains, where the dip of bedding is low, the outcrop area of the Madison is as much as 4 miles (6½ km) wide. There, deep canyons are rimmed by vertical walls of limestone and dolomite. On the east flank of the range, picturesque hogbacks steeply slope down to the plains and are gashed by water courses that plunge off the mountain front.

On the west flank of the Bighorn Mountains—the canyon wall of Paint Rock Creek—the Madison Limestone has a basal conglomeratic sandstone, about 2 feet (60 cm (centimetres)) thick, overlain by about 3 feet (90 cm) of sandy dolomite, which, in turn, is overlain by about 600 feet (183 m) of limestone and interbedded dolomite (Kiilsgaard and others, 1972, p. C21).

OTHER FORMATIONS OF PALEOZOIC AGE

Several post-Madison formations of Paleozoic age are present, but they are not divided on plate 1, because their outcrop area is very small. The names, age, abbreviated lithology, and approximate thickness are, in order of decreasing age: (1) Amsden Formation (Pennsylvanian), thin-bedded red dolomite, limestone, sandstone, and shale, 240 feet (73 m); (2) Tensleep Sandstone (Late Pennsylvanian and Early Permian), well-bedded and crossbedded white to reddish-brown sandstone, 260 feet (79 m); (3) red shale and gypsum sequence (Permian), 146 feet (44.5 m). These units crop out at three places along the east edge of extension A, where bedding is steep, and outcrop widths are very small. In extensions on the west flank of the range, the Amsden crops out only in the southwest corner of extension D, and the two younger units are not present there.

MESOZOIC SEDIMENTARY ROCKS

CHUGWATER FORMATION

Outcrops of reddish-brown sandy siltstone of the Triassic Chugwater Formation occur at the east edge of extension A, in the W½ sec. 26, T. 52 N., R. 84 W. The unit has a thickness of 740 feet (226 m) locally (Maher, 1959, p. 82).

MIDDLE AND (OR) UPPER TERTIARY DEPOSITS

In extension D, pebble gravel, sand, silt, and volcanic ash cover an area about 2 miles (3 km) long and one-third of a mile (one-half of a kilometre) wide to a maximum depth of 30-50 feet (10-15 m) along Buckskin Ed Creek (secs. 27 and 34, T. 50 N., R. 87 W.).

The deposits are at about 8,700 feet (2,650 m) above sea level and exhibit a hummocky surface. In one exposure, about 3.3 feet (1 m) of strongly cemented conglomerate with well-sorted and rounded pebbles of Precambrian rock is present; its lower contact is not exposed.

The conglomerate is overlain by massive white siltstone containing glass shards. The shards, of pyroclastic origin, have an index of refraction of slightly over 1.500, possibly indicative of a late Tertiary age (G. A. Izett, U.S. Geological Survey, written commun., September 1972). The ashy siltstone is locally interbedded with lenses of fine-grained sandstone. The maximum exposure in any cutbank is about 15 feet (5 m). Slump structures and differential iron-oxide staining, due to ground-water circulation in and around slump blocks, are characteristic of the exposures along Buckskin Ed Creek. Total thickness of exposed Tertiary beds there is about 40 feet (12 m).

White shard-rich sandstone on Dartons Bluff, about 9,000 feet (2,750 m) above sea level and 14 miles (22.5 km) southeast of Buckskin Ed Creek, contains fossil mammals of early Miocene age (McKenna and Love, 1972). Considering the similarities in lithology, subsummit surface setting, and altitude above sea level, it is probable that deposits at the two localities are correlative.

QUATERNARY DEPOSITS

Deposits of Quaternary age are of two major categories—glacial and colluvial. No attempt was made to subdivide the glacial deposits nor even to map most of the colluvial deposits. Valleys are narrow, and stream gradients are steep; thus, little alluvium is present.

GLACIAL DRIFT

Detailed studies of the glacial geology of the Bighorn Mountains were made in 1905 by Eliot Blackwelder, who reported on drift on the east side of the range, and by E. S. Bastin, who studied the drift on the west side. These workers divided the drift into early and late deposits; for the later deposits, terminal and lateral moraines are shown separately. Névé deposits, glacial lake deposits, and valley trains of later glacial age are also shown on their map (in Darton, 1906c, pl. 26).

The unit mapped as glacial drift on plate 1 is made up principally of well-preserved morainal deposits. Also included are late glacial lake deposits, outwash, terrace gravels, landslide debris, talus, and alluvium where these deposits are enclosed by the well-preserved moraines. This unit corresponds to the glacial drift of Kiilsgaard and others (1972, pl. 1). The moraines consist of coarse till with subrounded boulders of Precambrian rock as much as 15-20 feet (4.5-6 m) in diameter.

The lowest altitude of moraines in the Bighorn Mountains is about 6,200 feet (1,900 m) on Paint Rock Creek, in the W½ sec. 26, T. 50 N., R. 88 W. (Darton, 1906c, pl. 26; Kiilsgaard and others, 1972, pl. 1). The most extensive drift deposit in the eight study tracts extends down South Piney and Kearny Creeks to 7,100 feet (2,165 m) above sea level (pl. 1, area A). Glacial drift as mapped in the Cloud Peak Primitive Area and its proposed extensions is probably 90 percent Pinedale Till, deposited about 22,000 years ago (Richmond, 1965, p. 227).

COLLUVIUM

A veneer of colluvium masks bedrock outcrops on many slopes of the study tracts, but colluvium is mapped separately only where its thickness is several tens of feet (10 m or more). Mapped colluvium at the east edge of extension A, in secs. 14 and 23, T. 52 N., R. 84 W., contains abundant well-rounded cobbles and boulders of Precambrian rock derived from Tertiary gravels, which have been stripped away upslope, as well as from angular debris derived directly from the Precambrian outcrop area to the west.

STRUCTURE

The Cloud Peak Primitive Area and its proposed extensions lie athwart the central part of the broad Bighorn uplift of Laramide age. In this region the axis of the uplift trends northwest, and the northeast flank dips much more steeply than the southwest flank.

The salient structural feature of the region is the Bighorn uplift and its associated high-angle and thrust faults, but foliation of the gneiss and occurrence of Precambrian dikes along preexisting fractures indicate that the rocks were deformed before the uplift took place.

Foliation is expressed by mineral layering or by parallelism of biotite flakes. Strikes of foliation in the gneiss of the Bighorn Mountains change from nearly east in extension B to nearly north in extension A, as depicted by structure form lines (Heimlich, 1969, pl. 5). In extension A, mafic dikes and the foliation in the enclosing gneiss show the same swing in trend, from eastward in the southern part to northward in the northern part; some short "cross" dikes fill fractures that are normal to regional trends.

A major fault zone of the Bighorn Mountains crosses the Cloud Peak Primitive Area from North Paint Rock Creek through Kearny Lakes (Kiilsgaard and others, 1972, pl. 1). The zone, one of valleys and saddles, continues northeastward across half of extension A, where the zone is covered with glacial deposits, and the trend gradually changes from about N. 60° E. to N. 30° E. A mylonite gneiss crops out along the east bank of South Piney Creek, in the W½ sec. 32, T. 53 N., R. 84 W., where the fault emerges beneath the lower end of a moraine. The mylonite gneiss is indicative of Precambrian movement. Another major fault zone that crosses the primitive area from Medicine Lodge Creek (south of extension E) northeastward down East Fork Big Goose Creek extends through extension H, where much of the zone is covered with glacial deposits.

Three thrust faults have been mapped and studied along the east-central front of the Bighorn Mountains (Hoppin, 1961; Hudson, 1969). The Clear Creek thrust is south of extension A and is not shown on plate 1. Another thrust, which is unnamed, is in the southeast corner of extension A, between North Fork Sayles Creek and Johnson Creek. There, a wedge of Precambrian rocks about 1 mile wide is thrust northeastward over the Flathead Sandstone and younger rocks (pl. 1, from Hoppin, 1961).

The Piney Creek thrust extends beyond the northeastern limits of extension A (pl. 1; Hudson, 1969). There, a plate of Precambrian, Paleozoic, and Triassic rocks about 9 miles (14.5 km) wide is thrust northeastward over the Tertiary gravel on Moncreiffe Ridge (Sharp, 1948, p. 11) and older sedimentary rocks. The plate is terminated to the northwest and southeast by tear faults.

The southeastern right-lateral tear fault of the Piney Creek thrust brings Precambrian rocks in contact with the Chugwater Formation and older sedimentary rocks near the east-central edge of extension A. This fault is marked by a zone several feet to several tens of feet (probably about 1-10 m) wide of sheared but otherwise unaltered rock. Several springs emerge along the fault in the NW. cor. sec. 13, T. 52 N., R. 84 W. (Hudson, 1969, p. 286).

The northwestern left-lateral tear fault of the Piney Creek thrust is largely concealed by colluvium. In extension A, where it is entirely in Precambrian rocks, this fault is also marked by a zone of sheared but otherwise unaltered rock. The east-northeast-trending fault cuts across the local trend of foliation, but fracture cleavage has developed in the rocks parallel to the fault.

The northeast edge of the Piney Creek overthrust block is characterized by an arcuate pattern of magnetic lows, probably because the thrusting of sedimentary beds over other sedimentary beds increases the effect of low magnetic susceptibility of these rocks, as compared with that of the underlying crystalline rocks.

The Bighorn uplift was not guided by preexisting structures, as shown by the fact that the northwest strike of the uplift axis diverges strongly from the strike of principal fractures in the Precambrian core. However, tear faults associated with the Piney Creek thrust probably were guided by the Precambrian structure, as suggested by Hoppin (1961, p. 366).

The first Earth Resources Technology Satellite (ERTS-1) transmitted an exceptionally fine Multi-Spectral Scanner (MSS) image of the Bighorn Mountains and vicinity, on October 16, 1972. Pronounced lineaments appearing in this image are shown in figure 1. Most of these lineaments have been mapped at least partly as faults. A south-southwest-trending lineament west of West Tensleep and Meadowlark Lakes appears to aline with a mapped fault along Cross Creek in the primitive area, and it, in turn, projects through Bighorn Reservoir. An east-trending lineament near the township line between Tps. 50 and 51 N. alines with a mapped fault (Kiilsgaard and others, 1972, pl. 1) which passes through Lake

Solitude. North Rock Creek and East Fork Little Goose Creek are along lineaments which reflect faults. The tear faults of the Piney Creek thrust also appear as lineaments in the ERTS-1 image; they can be followed several miles farther in the image than on the ground.

GEOLOGIC HISTORY

Data are not sufficient to unfold in detail the long complex Precambrian history of the metamorphic and igneous rocks of the Bighorn Range. The Precambrian events included fracturing of the gneiss and granite, filling of the fractures with mafic dikes, metamorphism, further fracturing and mafic intrusion, and minor sulfide mineralization along some of the dikes and fractures. Probably, no further igneous or hydrothermal activity took place in the area after Precambrian time.

Erosion to a nearly level surface was followed by submergence and deposition of a long sequence of Paleozoic and Mesozoic rocks. Laramide orogeny produced upwarp of the Bighorn Mountains during Late Cretaceous to Eocene time. The sedimentary cover was stripped from the Precambrian core and to varying degrees from the flanks of the range during Eocene time and during a relatively brief episode of epeirogenic uplift in Oligocene time. Sediments representing the Eocene and Oligocene Epochs, as well as early Miocene time, were deposited locally on the flanks and generally in the basins on both sides of the range following the tectonically active episodes. The Oligocene and lower Miocene deposits are characterized by admixtures of ash from from volcanic centers in the Yellowstone National Park region. By mid-Miocene time erosion nearly to base level had produced a subsummit surface (McKenna and Love, 1972, p. 9). Renewed uplift in late Miocene and (or) early Pliocene time resulted in dissection of the subsummit surface, tilting and stripping of earlier Tertiary deposits on the flanks, and burial of the remaining flanking gravels and ash beds by coarse gravel. Finally, during the Quaternary Period, glaciation and fluvial erosion modified the landscape to its present configuration.

AEROMAGNETIC INTERPRETATION

By DALLAS B. JACKSON, U.S. Geological Survey

An airborne magnetometer survey of the Cloud Peak Primitive Area between lats 44°07′20″ N. and 44°37′30″ N. and longs 107° and 107°22′30″ W. was flown in 1970, and the aeromagnetic data were interpreted by Kiilsgaard and others (1972, p. C28-C32; pl. 1). Of the eight proposed extensions to the primitive area, four—B, C, D, and H—were included in the area flown in 1970. The other proposed extensions—A, E, F, and part of G—were flown in 1972 by the U.S. Geological Survey along north-south lines at about a 1-mile (1.6-km) spacing and at a barometric elevation of 12,000 feet (3,660 m); the results of the 1972 survey are shown on plate 1.

The Cloud Peak Primitive Area and the eight proposed extensions are topographically high areas underlain primarily by granite or granitic gneiss. The magnetic susceptibility of the granite and granitic gneiss is typical for rocks of these types and for four samples ranges from 0.29 to 1.29×10^{-3} cgs (centimetre-gram-second). There is a complete overlap of susceptibility values among the granite and granitic gneiss samples; however, the susceptibility of the one sample of dolerite, 4.54×10^{-3} cgs, is appreciably higher than that of either the granite or granitic gneiss (Kiilsgaard and others, 1972, p. C29). Sedimentary rocks, Quaternary to Cambrian in age, surround the primitive area and the proposed extensions. No data are available on the susceptibility of these rocks, but their susceptibilities would, in general, be much less than that of the Precambrian basement rocks. Therefore, it is not surprising that the Precambrian rocks of the primitive area and proposed extensions (pl. 1; Kiilsgaard and others, 1972, pl. 1) form an area of generally high magnetic relief and lower total field values around the margins. In addition, the higher elevation of the primitive area enhances the broad magnetic high.

Two magnetic highs are present in extension A; one projects northeastward and the other northward from the primitive area. The northeastward-projecting high, which is an extension of the Lake Winnie high, corresponds exactly to a broad high ridge between the valleys of Kearny Creek and East Fork Little Goose Creek. The other magnetic high corresponds in part to a ridge on the east side of the upper valley of South Piney Creek. The closures of the highs are only 50 and 110 gammas, respectively; magnetic gradients are low to the south, but where the ground surface drops off to the north, they steepen to about 100 gammas per mile. These gradients are due entirely to topography rather than to geologic structure or changing lithology.

Two low magnetic reentrants are present in extension A. One lies northwest of the Lake Winnie magnetic high and over East Fork Little Goose Creek, and the other lies over Kearny Creek east of Kearny Lakes. Both reentrants are adjacent to gradients from other magnetic features and may be formed simply by addition of edge effects; also, both reentrants are over topographically low areas that might enhance the troughlike appearance of the reentrants. However, both of these troughlike features are possibly related to destruction of susceptibility by oxidation of magnetite along zones of faulting. The magnetic reentrant northwest of the Lake Winnie high is coincident with a prominent lineament recognized on the ERTS-1 photographic image of October 16, 1972; this lineament may be the surface expression of a major fault, although preliminary surface mapping completed before the ERTS-1 photograph was taken revealed no evidence for such a fault. The axis of the magnetic reentrant over Kearny Creek does lie near the projected trend of a major fault that passes through Kearny Lakes to the northeast. Northeast of Kearny Lakes the fault is masked by glacial drift. The fact that the possible fault does not appear to modify the magnetic pattern where its projection passes through the southern nose of the Lake Winnie magnetic high indicates that topography, not destruction of susceptibility along faults, is the dominant control.

The magnetic gradients within the proposed extensions B, C, D, E, F, and G are probably caused by edge effects of the higher susceptibility mass of the Bighorn Mountains and by the high topographic relief to the north. An exception may be the closed magnetic high on the northern boundary of extension E at the headwaters of North Trapper Creek, which may be caused by a combination of topographic effects and an increase in rock susceptibility.

MINERAL RESOURCES

This investigation was conducted to appraise the mineral resources of eight proposed extensions to the Cloud Peak Primitive Area. The chief effort in field investigation was in sampling stream sediments and rock outcrops. During the course of sampling, a geologic reconnaissance of the extension areas was made, with emphasis on the search for evidence of mineral occurrences. The investigation included the examination of courthouse records of mining-claim locations within and adjacent to the extension areas, the compilation of the mining history of the general area, and a field evaluation of known claims and prospects.

MINERAL SETTING

The study tracts have been prospected to a minor degree. Gold and copper were the metals sought, but neither has been produced from the Bighorn Mountains. Of the few prospect pits that have been dug in the extension areas, more than half are on pegmatite veins where feldspar appears to be the commodity sought. Metallic mineral occurrences in the region outside the Cloud Peak Primitive Area have been listed by Kiilsgaard and others (1972, p. C55-C58).

GEOCHEMICAL SAMPLING AND ANALYTICAL TECHNIQUES

Stream sediments were favored samples because (1) they permit rapid sampling of a much larger area than do soil or rock samples, and (2) they act as concentrators of metals in solution in stream waters. Sand or silt was collected from the stream bottom at each locality, and the minus-80-mesh fractions were analyzed by a semiquantitative spectrographic method for the following 30 elements: iron, magnesium, calcium, titanium, manganese, silver, arsenic, gold, boron, barium, beryllium, bismuth, cadmium, cobalt, chromium, copper, lanthanum, molybdenum, niobium, nickel, lead, antimony, scandium, tin, strontium, vanadium, tungsten, yttrium, zinc, and zirconium.

Rock samples were taken of gneiss, granitic rocks, dike rocks, and a very few sedimentary rocks. The samples were split into two approximately equal parts—one for petrographic study and the other for spectrographic analysis.

The spectrographic analyses of samples collected by the U.S. Geological Survey were made by R. R. Carlson, W. D. Crim, and J. H. Reynolds of the U.S. Geological Survey.

EVALUATION OF SAMPLE DATA

None of the samples contained minerals or elements in sufficient concentrations to indicate mineral-resource potentials. Indeed, the entire Bighorn Mountains are singularly lacking in evidence of mineral occurrences, such as extensive areas of altered rock that characterize mineralized areas elsewhere in the Rocky Mountains.

Selected results of semiquantitative spectrographic analyses of all samples of metadolerite and quartz dolerite dikes and of granite and gneiss are given in tables 2 and 3, respectively. Results are given in parts per million (ppm). The two rock types in each table are listed together because they are compositionally indistinguishable. Of 30 elements sought, the concentrations of the 10 elements judged to be the most indicative of mineralization are shown. Upper range values for eight of the elements in stream sediments are given in table 4; only those samples that contained upper range values are listed. The upper range values are equivalent to mean values plus two standard deviations (Kiilsgaard and others, 1972, p. C36). Low-range values for the stream-sediment samples are not tabulated; nonetheless, all sample localities are plotted on plate 1 in order to show the overall coverage of the sampling program.

Spectrographic analyses of selected elements in 40 dike samples and 40 granitic and gneissic samples from extension A are given in table 5, together with crustal abundances of the same elements in similar rocks. The dike rocks have much more iron, magnesium, calcium, manganese, cobalt, chromium, copper, nickel, and vanadium, and notably less barium, lead, and strontium, than the rocks they intrude.

TABLE 2.—*Semiquantitative spectrographic analyses of elements in metadolerite and postmetamorphic quartz dolerite dikes in proposed extensions to the Cloud Peak Primitive Area*

[Lower sensitivity limit, in parts per million, is shown in parentheses; L indicates element was detected, but in an amount too small to determine. Classification of some dikes was by T. J. Armbrustmacher. All sample localities are in extension A except for those numbers preceded by "J," which are in extension E]

Sample	Semiquantitative spectrographic analyses (ppm) Co (5)	Cr (10)	Cu (5)	La (20)	Ni (5)	Pb (10)	Sc (5)	V (10)	Y (10)	Zr (10)
1/B1	70	200	150	L	150	L	50	300	50	150
B3	70	300	150	L	150	L	30	300	50	150
2/B4	70	700	150	L	150	L	50	500	30	100
2/B5	70	2,000	30	L	300	L	30	300	15	70
1/B7	70	500	150	L	150	L	50	700	30	70
1/B10	70	700	70	L	150	10	30	500	20	50
1/B11	70	500	150	L	150	L	30	700	20	50
B13	70	700	100	L	150	L	30	500	30	50
1/B14	70	150	150	L	150	L	30	500	30	50
1/B16	70	700	100	L	150	L	30	500	30	100
1/B17	70	300	70	L	150	L	30	300	30	70
1/B19	70	700	100	L	150	L	30	150	20	30
B21	70	200	150	L	150	L	50	500	30	70
2/B24	70	200	150	L	150	L	50	300	30	100
2/B27	70	200	150	L	200	10	30	300	30	150
2/B29	70	1,000	50	L	500	L	30	200	15	50
2/B30	70	700	150	20	500	10	30	200	20	150
1/B42	70	150	150	L	150	L	50	300	20	70
J108	70	150	70	L	30	10	30	200	20	100
J109	30	100	100	30	50	10	30	150	20	150
J120	70	200	150	L	150	L	50	300	30	70
J130	70	150	150	L	150	L	50	300	30	70
2/R3	70	200	200	L	100	L	50	500	50	150
1/R5	70	1,500	50	L	1,000	L	30	200	20	70
R6	70	500	70	20	150	L	30	200	30	100
1/R8	70	1,000	70	20	150	L	30	200	20	100
R9	70	3,000	100	L	1,500	L	30	200	15	70
1/11	70	500	100	L	200	L	30	300	30	70
2/R18	70	200	200	L	150	L	50	500	50	200
2/R24	70	200	200	L	150	L	30	300	20	30
R26	100	2,000	150	L	1,000	10	30	300	20	30
1/R27	70	200	150	L	100	10	30	300	50	150
1/R28	70	200	150	L	100	10	30	300	50	150
1/R35	70	500	150	L	150	L	50	300	50	100
1/R37	70	100	100	L	100	10	30	200	20	70
1/R39	70	1,000	150	L	500	10	30	200	20	200
1/R42	70	200	150	L	100	L	30	300	50	100
1/R48	70	700	100	L	150	L	30	200	30	70
R49	70	150	30	200	500	L	30	150	30	150
R50	70	500	50	70	150	20	30	200	70	150
1/R53	70	1,000	100	L	150	L	30	300	30	50
1/R54	70	500	150	L	150	L	50	300	30	50
1/R62	70	200	150	L	150	10	30	300	20	50
1/R63	70	1,000	200	L	150	L	30	300	30	50
1/R65	70	500	150	L	150	L	30	300	30	70
1/R66	70	1,000	150	L	150	L	30	300	30	70
1/R67	70	200	150	L	150	L	30	300	30	70
1/R68	70	200	100	L	150	L	30	300	30	100
R69	30	150	15	L	150	L	30	200	70	30

1/ Early metadolerite dike.

2/ Late, post-metamorphic dolerite dike.

Note: All other samples are of dikes which are either metadolerite or post-metamorphic dolerite without the distinction having been made.

TABLE 3.—*Semiquantitative spectrographic analyses, in parts per million, of granite and gneiss from proposed extensions to the Cloud Peak Primitive Area*

[Numbers in parentheses indicate lower limit of sensitivity, in parts per million, of the method used. Leaders (---) indicate values below the sensitivity limit. Sample localities B2–B32, B36–B43, R1–R40, and R47–R70 are in extension A; J5 and J44–J52 in extension B; J18A–J33B, J67–J79, and R43A and R43B in extension D; J106–J131 in extension E; J135–J151 in extension F; B33–B35, R44, and R45 in extension G]

	Semiquantitative spectrographic analyses (ppm)									
Sample	Co (5)	Cr (10)	Cu (5)	La (20)	Ni (5)	Pb (10)	Sc (5)	V (10)	Y (10)	Zr (10)
B2	10	10	---	---	20	10	5	50	---	200
B6	---	10	---	---	5	20	5	20	10	150
B8	5	---	5	---	5	10	---	20	---	50
B9	5	---	---	20	5	10	---	20	---	10
B12	5	---	---	20	5	10	---	10	---	100
B18	10	10	7	20	10	10	5	70	---	300
B20	5	---	---	20	5	---	5	50	---	30
B23	5	---	---	---	5	10	5	20	---	70
B25	10	10	5	70	10	30	5	50	---	100
B26	5	10	7	20	5	30	---	30	---	200
B28	10	20	20	20	15	20	5	30	---	300
B31	---	10	---	---	10	---	---	10	---	---
B32	---	15	10	---	10	10	---	70	---	300
B33	---	---	---	30	10	10	---	30	---	150
B34	5	---	---	50	5	50	5	50	10	150
B35	5	---	5	30	10	30	5	30	10	300
B36	5	---	20	---	10	30	---	10	---	50
B37	5	---	5	---	10	10	---	10	---	50
B38	5	---	5	20	5	10	---	50	---	200
B39	5	---	5	20	10	---	---	70	---	50
B40	10	10	5	50	10	10	10	100	---	150
B41	5	---	300	---	10	20	5	10	---	70
B43	5	---	---	---	5	10	---	70	---	500
J5	10	10	20	---	10	20	10	70	10	150
J18A	---	---	7	---	10	---	---	20	---	300
J18B	---	---	---	---	5	---	---	70	---	---
J20	---	10	5	---	5	---	---	30	10	10
1/ J25	10	---	30	---	15	---	---	100	10	100
J31	7	30	7	20	20	20	5	70	30	200
J33A	5	10	---	100	15	---	5	30	30	300
J33B	5	---	---	---	15	---	---	30	---	500
1/ J44	30	150	50	---	70	---	20	150	15	70
J50	5	---	20	---	10	30	5	50	---	100
J52	---	---	---	---	5	---	---	20	---	100
J67	5	150	15	---	50	20	30	300	30	700
J71	5	10	7	50	10	20	5	30	10	300
J72	5	30	15	50	20	---	10	70	30	300
J74	5	10	10	50	30	50	5	70	50	200
J75	5	70	50	50	20	50	10	50	20	300
J78	5	20	7	100	10	30	5	50	20	300
J79	5	10	7	---	10	---	5	50	30	20
J106	5	10	5	---	10	---	5	30	10	150
J107	5	10	---	20	10	10	5	30	---	50
J110	---	---	---	20	5	20	---	10	10	150
J117	10	30	---	50	10	---	10	100	20	300
J119	---	100	70	50	20	10	10	100	10	200
J131	---	10	7	---	10	20	---	10	---	70
J135	---	---	---	70	5	20	---	10	---	150
J147	10	10	---	20	10	15	5	50	---	150
J151	5	---	7	30	5	15	5	30	20	30
R1	5	---	---	---	10	20	5	30	10	150
R2	5	---	---	20	5	30	---	20	10	150
R4	5	---	5	---	10	---	5	70	---	150
R7	10	10	---	---	5	---	10	70	---	10
R10	5	20	5	---	30	---	5	70	---	100

1/ Sample consists of dump material from mine prospect.

TABLE 3.—*Semiquantitative spectrographic analyses, in parts per million, of granite and gneiss from proposed extensions to the Cloud Peak Primitive Area*—Continued

Sample	Semiquantitative spectrographic analyses (ppm)									
	Co (5)	Cr (10)	Cu (5)	La (20)	Ni (5)	Pb (10)	Sc (5)	V (10)	Y (10)	Zr (10)
R13	5	---	---	300	10	30	---	10	---	30
R14	10	10	---	---	10	---	10	100	---	150
R15	10	20	5	20	10	---	10	100	---	300
R16	10	20	7	70	10	10	5	100	---	150
R17	10	---	5	300	10	30	20	70	70	500
R19	10	20	5	20	30	15	15	100	30	200
R20	10	30	20	100	10	10	20	100	---	200
R21	10	---	10	30	5	10	10	70	---	150
R22	5	---	---	---	5	15	---	10	---	150
R23	5	10	5	---	5	10	---	50	---	150
R25	5	10	7	---	10	---	10	50	---	200
R30	30	50	10	70	30	---	30	150	15	150
R31	---	---	---	---	5	---	---	10	---	70
R33	---	---	---	70	5	10	---	10	---	150
R34	---	---	---	---	5	70	---	10	---	---
R36	---	10	---	---	10	10	---	10	---	30
R38	---	---	---	---	5	30	---	10	---	---
R40	5	20	7	20	15	---	15	100	10	100
R43A	15	50	30	---	10	---	10	100	---	30
R43B	10	100	7	70	20	20	10	70	50	500
R44	5	---	---	30	5	20	5	30	10	200
R45	5	---	---	30	7	30	5	20	10	100
R47	5	---	7	---	5	20	5	20	10	150
R51	---	150	---	100	20	20	20	150	20	150
R52	---	---	---	---	7	30	---	10	---	20
R55	20	10	7	---	50	10	15	70	---	150
R56	5	---	---	---	5	30	---	10	---	10
R59	---	---	---	70	15	50	---	10	---	20
R60	---	---	5	---	5	30	---	10	---	50
R61	15	10	30	---	5	30	10	100	---	300
R64	5	---	7	---	5	30	5	10	---	100
R70	5	---	---	30	7	30	5	30	10	150

TABLE 4.—*Semiquantitative spectrographic analyses, in parts per million, of selected elements in stream-sediment samples from proposed extensions to the Cloud Peak Primitive Area*

[Minimum upper range values, in parts per million, are shown in parentheses. Sample localities S1–S238, S253–S289, T1–T111, and T137–T161 are in extension A; K7 and K45–K57 in extension B: K3 and K4 in extension C; K23, K63, and K77 in extension D; K103–K121 in extension E; K133–K152 in extension F; S243–S252 and T122–T132 in extension G; T116–T120 in extension H. Leaders (---) indicate values are below those shown in parentheses for each element]

Sample	Semiquantitative spectrographic analyses (ppm)							
	Cr (200)	Cu (50)	La (150)	Pb (50)	Sc (20)	V (150)	Y (50)	Zr (1,000)
K3	---	---	---	---	---	150	---	---
K4	---	---	---	---	---	150	---	---
K7	---	---	---	50	---	150	---	---
K11	---	---	150	---	---	150	---	---
K13	---	---	---	---	---	150	---	---
K16	---	---	---	50	---	---	---	---
K17	---	---	---	---	---	---	50	---
K23	---	---	---	---	---	---	150	---
K45	---	---	---	---	20	150	---	---
[1]K46	---	---	---	---	---	150	---	---
K46A	---	---	150	50	---	---	---	---
K48	---	---	---	50	---	---	---	---

[1] Sample contained 0.5 ppm Ag.

TABLE 4.—*Semiquantitative spectrographic analyses, in parts per million, of selected elements in stream-sediment samples from proposed extensions to the Cloud Peak Primitive Area*—Continued

Sample	Semiquantitative spectrographic analyses (ppm)							
	Cr (200)	Cu (50)	La (150)	Pb (50)	Sc (20)	V (150)	Y (50)	Zr (1,000)
K53	---	---	---	---	---	150	---	---
K54	---	---	---	---	---	150	---	---
K55	---	---	---	---	---	150	---	---
K56	---	---	---	---	---	150	---	---
K57	---	---	---	---	---	150	---	---
K63	---	---	---	50	---	---	---	---
K77	---	---	---	---	---	150	---	1,000
K103	---	---	---	---	20	150	50	1,000
K116	---	---	---	---	---	---	---	1,000
K121	---	---	---	---	---	150	---	---
K133	---	---	---	---	---	---	50	1,000
K137	---	---	---	---	---	---	50	1,000
K150	---	---	---	---	---	150	---	---
2/K152	---	---	---	---	---	---	---	---
3/S1	---	---	---	---	---	---	---	---
S3	---	50	---	---	---	---	---	---
S8	---	---	---	---	---	150	---	---
S10	---	---	---	---	---	150	---	---
S14	---	50	---	---	---	---	---	---
S17	---	---	---	---	---	150	---	---
S23	---	---	---	---	---	150	---	---
S25	---	---	---	---	---	150	---	---
S26	---	---	---	---	---	150	---	---
S27	---	---	---	---	---	150	---	---
S29	---	---	---	---	---	150	---	---
S30	---	---	---	---	---	150	---	---
S31	---	---	---	---	---	150	---	---
S32	---	---	---	---	---	150	---	---
S33	---	---	---	---	---	150	---	---
S34	---	---	---	---	---	150	---	---
S35	---	---	---	---	---	150	---	---
S36	---	---	---	---	---	150	---	---
S37	---	---	---	---	---	150	---	---
S40	---	---	---	---	---	---	---	1,000
S44	---	---	---	---	---	150	---	---
S45	---	---	---	---	---	150	---	---
S96	---	---	200	---	---	150	---	1,000
S101	---	50	---	50	---	---	---	---
S113	---	---	---	---	---	---	---	1,000
S122	---	50	---	50	---	---	---	---
2/S124	---	---	---	---	---	---	---	---
S127	---	---	---	50	---	---	---	---
S128	---	---	---	50	---	---	---	---
S129	---	---	---	50	---	---	---	---
S131	---	---	---	50	---	---	---	---
S135	---	50	---	---	---	---	---	---
S137	---	---	---	50	---	---	---	---
S143	---	50	---	---	---	---	---	---
S161	---	---	---	---	20	---	---	---
S168	---	---	---	50	---	---	---	---
S172	---	50	---	---	---	---	---	---
S174	300	---	---	---	---	---	---	---
S175	200	---	---	---	---	---	---	---
S176	---	---	---	50	---	---	---	---
S179	200	---	---	---	---	---	---	---
S185	200	---	---	---	---	---	---	---
S199	---	50	---	---	---	---	---	---
S200	---	50	---	50	---	---	---	---
S201	300	---	---	---	---	---	---	---
S208	---	---	---	50	---	---	---	---
S209	---	---	---	50	---	---	---	---
S210	---	---	---	50	---	---	---	---

2/ Sample contained 0.7 ppm Ag.

3/ Sample contained 30 ppm Co.

TABLE 4.—*Semiquantitative spectrographic analyses, in parts per million, of selected elements in stream-sediment samples from proposed extensions to the Cloud Peak Primitive Area*—Continued

	Semiquantitative spectrographic analyses (ppm)							
Sample	Cr (200)	Cu (50)	La (150)	Pb (50)	Sc (20)	V (150)	Y (50)	Zr (1,000)
S211	---	---	---	70	---	---	---	---
S217	---	---	---	50	---	---	---	---
S219	---	50	---	50	---	---	---	---
S221	---	50	---	50	---	---	---	---
S223	---	---	---	50	---	---	---	---
S225	---	---	150	70	---	---	70	---
S227	---	50	150	50	---	---	70	---
S228	---	---	150	50	---	---	70	---
S232	---	---	150	---	---	---	70	---
S238	---	---	---	50	---	---	---	---
S243	---	---	---	50	---	---	---	---
S245a	---	---	200	---	---	---	100	---
S246	200	50	---	70	---	---	---	---
S248	---	50	---	---	---	---	---	---
S249	---	50	---	70	---	---	---	---
S250	---	---	150	---	---	---	---	---
S252	---	---	---	50	---	---	---	---
S253	---	---	---	50	---	---	---	---
S254	200	---	---	---	---	---	---	---
S255	200	---	---	---	---	150	---	---
S256	---	50	---	70	---	---	50	---
S257	---	50	---	70	---	---	50	---
S261	---	---	---	---	---	---	70	---
S264	---	50	---	---	---	---	---	---
S265	---	---	---	50	---	---	---	---
S267	---	---	---	50	---	---	---	---
S276	---	---	---	---	---	---	50	1,000
S287	---	---	---	---	---	---	50	---
S288	---	---	---	---	---	---	50	---
S289	---	---	---	---	---	---	70	---
T1	---	---	---	---	20	---	---	---
T2	---	50	---	---	20	---	---	1,000
T3	---	---	---	---	20	---	---	---
T4	---	---	---	---	20	---	---	---
T5	---	50	---	---	---	150	---	1,000
T6	---	---	---	---	20	---	---	---
T7	---	---	---	---	20	---	---	---
T8	---	---	---	---	20	---	---	---
T9	---	---	---	---	20	200	---	---
T10	---	---	---	---	20	---	---	---
T11	---	---	---	---	20	150	---	---
3/T12	---	---	50	---	20	---	---	---
T13	---	---	---	---	20	---	---	1,000
T14	---	---	---	---	20	---	---	1,000
T15	---	---	---	---	20	150	50	1,000
T16	---	---	---	---	20	---	---	1,000
T17	---	---	---	---	20	---	---	1,000
T18	---	---	---	---	20	---	---	1,000
T19	---	---	---	---	20	---	---	---
T22	---	---	---	---	20	150	---	1,000
T23	---	---	---	---	30	---	---	1,000
T24	---	---	---	---	30	---	50	---
T25	---	---	---	---	30	---	---	---
T26	---	---	---	---	30	---	50	1,000
T27	---	50	---	---	20	---	50	1,000
T28	---	---	---	---	----	200	---	---
T30	---	---	---	70	---	---	50	---
T32	---	---	---	---	20	---	70	---
T34	---	---	300	---	20	---	---	---
T35	---	---	---	50	20	---	50	1,000
T36	---	---	---	50	20	---	---	---

3/ Sample contained 30 ppm Co.

TABLE 4.—*Semiquantitative spectrographic analyses, in parts per million, of selected elements in stream-sediment samples from proposed extensions to the Cloud Peak Primitive Area*—Continued

Sample	Semiquantitative spectrographic analyses (ppm)							
	Cr (200)	Cu (50)	La (150)	Pb (50)	Sc (20)	V (150)	Y (50)	Zr (1,000)
T37	---	---	---	---	20	---	---	1,000
T38	---	---	---	---	20	---	---	---
T39	---	---	---	---	20	---	---	---
T40	200	---	---	---	20	---	---	---
T41	---	---	---	---	20	---	---	---
4/ T42	200	---	---	---	30	---	70	---
T46	---	---	---	---	---	---	50	---
T47	---	---	---	---	20	---	---	---
T54	---	---	---	---	---	150	---	---
T56	---	---	---	---	---	150	---	---
T57	---	---	---	---	20	200	---	---
T58	---	50	---	---	---	300	---	---
T59	---	---	---	---	---	200	---	---
T61	---	---	---	---	30	200	---	---
T62	---	---	---	---	20	200	---	---
T63	---	---	---	---	20	150	---	---
T64	---	50	---	---	20	200	50	---
T65	---	---	---	---	20	200	---	---
T66	---	---	---	---	20	150	---	---
T67	---	---	---	---	20	200	---	---
T68	---	---	---	---	---	150	---	---
4/ T69	---	---	---	---	---	150	---	1,000
4/ T76	---	---	---	---	---	200	---	1,000
4/ T77	---	---	---	---	---	200	---	---
T78	---	---	---	---	---	---	50	---
T81	---	50	---	---	---	---	---	---
T82	---	---	---	---	---	---	---	1,000
T86	---	---	300	50	---	---	50	---
T87	---	---	500	50	---	---	50	---
T89	---	---	---	---	---	---	50	---
T90	---	50	---	---	20	150	50	---
T91	---	---	200	50	20	150	50	---
T92	---	---	150	---	20	200	---	---
T94	---	---	150	50	---	---	70	---
T95	---	---	---	---	---	---	50	---
T97	---	---	300	70	---	---	50	---
T99	---	---	---	---	---	---	---	1,000
T100	---	---	---	---	20	---	50	1,000
T101	---	---	---	---	---	---	50	---
T102	---	---	200	50	---	---	---	---
T103	---	---	150	---	---	---	---	---
T108	---	---	---	---	---	---	50	---
T110	---	---	---	---	20	---	50	---
T111	---	---	300	---	20	200	70	---
T116	---	---	---	---	20	---	50	---
T118	---	---	---	70	20	---	50	1,000
T119	---	---	---	---	20	---	50	---
T120	---	---	---	---	20	200	---	---
T121	---	---	---	---	20	---	---	---
T122	---	---	---	---	---	150	---	---
T123	---	50	---	---	---	---	50	---
T124	---	---	---	---	---	---	70	---
T125	---	---	---	---	20	---	50	---
T126	---	50	---	---	20	150	70	---
T128	---	---	---	50	---	150	50	---
T129	---	---	---	---	---	---	50	---
T130	---	---	---	---	---	---	50	---
T131	---	---	---	---	20	---	70	---
T132	---	---	---	---	20	---	---	---
T137	---	---	---	---	---	150	---	---
T138	---	---	---	---	20	150	---	---

4/ Sample contained 100 ppm Ni.

TABLE 4.—*Semiquantitative spectrographic analyses, in parts per million, of selected elements in stream-sediment samples from proposed extensions to the Cloud Peak Primitive Area*—Continued

Sample	Semiquantitative spectrographic analyses (ppm) Cr (200)	Cu (50)	La (150)	Pb (50)	Sc (20)	V (150)	Y (50)	Zr (1,000)
T139	---	70	---	50	---	---	---	---
T142	---	---	---	---	20	---	---	---
T144	---	---	---	---	20	---	---	---
T145	---	---	---	---	---	---	50	---
T146	---	---	---	---	---	150	---	---
T148	---	---	---	---	20	---	---	---
T151	---	---	300	---	---	---	---	---
T155	---	70	---	70	---	---	---	---
T158	---	---	200	---	20	200	---	---
T161	---	---	---	---	20	---	---	---

TABLE 5—*Abundances of 14 elements in 80 rock samples from extension A as compared with crustal abundances of these elements in similar rocks*

Element	40 mafic dikes (mean)	Crustal abundance[1]	40 granitic and gneissic rocks (mean)	Crustal abundance[2]
		In percent		
Fe	16	8.56	2.9	2.7
Mg	7.3	4.5	1.0	.56
Ca	9.0	6.72	1.9	1.58
Ti	.75	.90	.28	.23
		In parts per million		
Mn	1,700	2,000	290	600
Ba	190	300	740	830
Co	71	45	7.7	5
Cr	670	200	12	25
Cu	130	100	4.7	20
Ni	260	160	13	8
Pb	2.6	8	14	20
Sr	130	440	480	300
V	330	200	60	40
Zr	88	100	160	200

[1]Data for basalts (Vinogradov, 1962).
[2]Data for felsic granites and granodiorites (Vinogradov, 1962).

The values of chromium, copper, nickel, scandium, and vanadium are consistently higher in the mafic-dike samples than in the granite and gneiss and the stream-sediment samples. The mafic rocks contain about 130 ppm copper (arithmetic mean), as compared with less than 5 ppm (arithmetic mean) in gneissic and granitic rocks. The only copper minerals that were detected megascopically are malachite and chrysocalla; in the E½ sec. 22, T. 53 N., R. 84 W.; for example, quartz veinlets that cut a mafic dike contain traces of these copper minerals. Descriptions of other copper occurrences in the Bighorn Mountains (Darton, 1906c, p. 114) indicate an association between copper-bearing quartz veins and mafic dikes. These veins do not have a potential mineral resource. The two stream-sediment samples containing 200-300 ppm of chromium were obviously affected by nearby mafic dikes.

Among other elements, lanthanum and lead are consistently higher in the granite and gneiss and stream-sediment samples than in the mafic-dike samples. Values of 150-500 ppm of lanthanum and 50-150 ppm of yttrium are noted in some of the stream-sediment samples. Concentrations of zirconium as great as 1,000 ppm are frequent in the stream-sediment samples, whereas the values in granite and gneiss samples do not exceed 500 ppm, and in the mafic-dike samples concentrations do not exceed 200 ppm. Gold and silver were found at or near the lower limit of detection (0.05 ppm Au and 0.5 ppm Ag) in stream-sediment samples, but the yardage of sediments is too small to have a resource potential.

In summary, the values of chromium, copper, lead, scandium, and vanadium are normal for types of rock they represent. The values of lanthanum, yttrium, and zirconium in some stream-sediment samples are much higher than normal, but this is due to concentration of monazite and zircons in the heavy mineral fraction.

Platinum and palladium were detected in three samples of mafic rock, R5, R9, and R26, which were selected for special analysis because of their relatively high chromium and nickel content. The values of platinum and palladium ranged from 7 to 15 ppb (parts per billion) each (about 3 to 7 cents per ton at 1973 prices), which, according to N. J Page of the U.S. Geological Survey (oral. commun., 1973), is close to background for the type of rock.

Ferruginous beds in the Flathead Sandstone and the lower part of the Madison Limestone are much too thin (3.3 ft (1 m)) and dispersed, and their grade (20 percent or less) is too low to be considered a potential resource for iron. Likewise, the glauconitic beds in the Gros Ventre Formation and Madison Limestone cannot be considered as having resource potential for phosphate minerals.

The geologic setting precludes the existence of extensive deposits of organic fuels. Nonmetallic commodities, such as feldspar, limestone, building stone, clay, sand, and gravel, are present, but these materials are readily available in large quantities in more accessible areas nearby.

MINING CLAIMS AND PROSPECTS

Land-status records of the U.S. Bureau of Land Management at Cheyenne, Wyo., show no patented mining claims or mineral survey for patent in the proposed extension areas, and there are no oil and gas leases. However, about 450 unpatented lode and placer claims have been recorded for these areas and vicinity in Big Horn, Johnson, and Sheridan Counties. These claims were plotted as accurately as possible from location notices, and a field search was made for them. No evidence of many of the claims could be found in the field. Some of them are very old; the earliest one was recorded in 1919. Descriptions of many of the claims are vague, and some claims, where mapped according to the recorded location notices, conflict with or overlap previous claims.

Results of semiquantitative spectrographic and fire-assay analyses of 80 samples are given in table 6, and sample localities are shown on plate 1. Because none of the samples contained minerals or elements in concentrations indicative of resource potential, only 38 samples are referred to in the text.

EXTENSION A

A group of claims, centering at the confluence of Willow Creek and West Fork Little Goose Creek in sec. 8, T. 53 N., R. 85 W., covers about 1,500 acres (600 ha) in the northwestern part of extension A. There, a pegmatite dike, bearing N. 5° E., has been explored by five shallow pits, in a line about one-fourth mile long, adjacent to the section line between secs. 8 and 9. Because the dike is poorly exposed, its dimensions and attitude could not be determined accurately; however, in the southernmost pit, it appears to be steeply dipping and 10-20 feet (3-6 m) wide. In an exposure about 5 by 10 feet (1.5 by 3 m), the pegmatite consists mainly of quartz, and it contains only small amounts of feldspar and mica. According to the U.S. Forest Service, recent claim locators plan to explore for feldspar by core drilling. A location notice dated July 13, 1972, for two claims called Spar Nos. 1 and 2, is posted at the pit. Six samples (3331-3336) taken from exposures in the pits and from a dump showed negligible metallic values.

A group of claims extends southward from Little Goose Peak in secs. 21 and 28, T. 53 N., R. 85 W. The claims probably were staked because of a prominent mafic dike that is exposed intermittently from the top of Little Goose Peak along its southern slope to Stockwell Creek, a distance of 1¼ miles (2 km). The dike is 15-20 feet (4.6-6.1 m) wide; it strikes N. 10° E. and dips about 83° E. A concrete foundation for crushing equipment was poured, roads were built, and several prospect pits were excavated at the foot of the mountain near an outcrop of the dike. Although considerable money and work were expended at these locations, resource values were not found. Three samples (3355-3357) of the dike material did not contain unusual mineral values for this type of rock.

TABLE 6.—*Analyses of U.S. Bureau of Mines samples from proposed extensions to the Cloud Peak Primitive Area, Wyo.*

[Samples were analyzed by semiquantitative spectrographic and fire-assay methods in the U.S. Bureau of Mines laboratories in Reno, Nev. The numbers in parentheses beneath the element symbols represent the estimated lower limit of detection for that element. An error of plus 100 percent, minus 50 percent of the reported concentration is assumed. Symbols used are M, more than 10 percent; >, more than the amount shown; <, less than the amount shown; Tr, trace; leaders (--) looked for but not found and hence may occur only in amounts below the lower detection limit. Sample localities are given below by township, range, and section (T.R.S.): thus T. 53 N., R. 84 W., sec. 16, is recorded as 53–84–16. The following elements (detection limit in ppm in parentheses) were looked for spectrographically but were not detected except as shown under remarks: Ag (10), As (1,000), Au (30), B (100), Be (10), Bi (40), Cd (400), Ga (300), Hf (80), In (100), La (100), Li (1,000), Mo (20), Nb (70), P (6,000), Pt (50), Re (50), Sb (300), Sc (50), Sn (20), Ta (80), Te (20,000), Tl (3,000), W (200), Y (10), and Zn (1,000). The following elements (detection limit in parts per million in parentheses) also were determined spectrographically but were found in quantities considered normal for materials in the region sampled and, hence, were not judged to be significant: Al (30), Ca (200), Mg (4), Na (2,000), and Si (30)]

		Assay (oz/ton)		Semiquantitative spectrographic analyses (ppm)										(percent)			
Sample	Location T. R. S.	Au	Ag	Ba (1,000)	Co (40)	Cr (30)	Cu (20)	Mn (30)	Ni (20)	Pb (100)	Sr (1,000)	V (60)	Zr (70)	Fe (0.004)	Ti (0.001)	Remarks	
3301	51-84-29	--	0.1	--	--	70	40	300	--	--	--	--	--	0.9	0.01	Quartz float	
3302	51-84-29	--	--	4,000	--	100	40	100	--	100	--	<60	--	1	.003	Pegmatite	
3303	51-84-29	--	--	--	--	100	40	500	--	--	<1,000	60	100	3	.1	Do.	
3304	51-84-29	--	--	1,000	--	100	40	500	--	100	<1,000	<60	100	3	.1	Stream sediment	
3305	53-84- 8	--	--	--	--	100	40	200	--	--	--	--	--	2	.1	Decomposed diorite	
3307	51-84-29	--	--	6,000	--	100	40	100	--	100	--	<60	--	1	.003	Pegmatite	
3308	51-84-10	--	--	--	--	300	40	500	80	100	<1,000	200	<70	2	.05	Stream sediment	
3309	51-84-30	Tr	Tr	--	80	300	400	2,000	200	100	--	500	100	>7	1.5	Mafic dike	<50 ppm Sc
3310	51-84-30	Tr	Tr	--	80	300	400	3,000	200	100	--	200	100	>7	1.5	Do.	<50 ppm Sc
3311	51-84-30	Tr	--	4,000	--	300	80	500	40	--	<1,000	<60	100	5	.4	Pegmatite	
3314	51-84-30	Tr	.2	--	40	100	300	2,000	200	--	<1,000	200	100	>7	1.5	Mafic dike	<50 ppm Sc
3315	51-84-30	Tr	Tr	--	--	300	40	1,000	40	100	<1,000	<60	100	5	.2	Dump sample	
3316	51-84-30	Tr	--	--	40	300	40	1,000	40	100	<1,000	60	100	5	.8	Altered gneiss	100 ppm B
3317	51-84-30	Tr	Tr	--	--	60	40	500	--	--	--	60	70	4	.1	Stream sediment	<10 ppm Ag
3318	51-84-30	Tr	.1	--	--	60	40	500	--	--	--	60	100	4	.2	Do.	<10 ppm Ag
3319	51-84-30	Tr	.1	--	--	60	40	300	--	--	--	60	100	4	.1	Altered gneiss	
3320	51-84-30	Tr	--	--	--	100	40	500	--	200	--	60	100	5	.2	Gneiss	
3321	51-84- 2	Tr	Tr	4,000	--	100	40	200	--	200	<1,000	60	70	3	.02	Pegmatite	
3322	51-84- 2	Tr	.1	2,000	--	100	40	300	--	200	--	60	70	7	.05	Selected specimen	
3323	51-84- 2	Tr	.1	1,000	--	60	40	500	80	200	<1,000	60	<70	5	.2	Stream sediment	
3324	51-84- 2	--	--	9,000	--	60	40	300	--	200	<1,000	60	70	3	.1	Pegmatite	<10 ppm Ag
3325	52-83-31	--	.1	--	--	60	40	500	40	200	--	60	100	3	.1	Stream sediment	100 ppm B
3326	53-86-12	--	Tr	2,000	--	60	40	500	40	200	--	60	70	4	.1	Do.	<10 ppm Ag
3327	53-86-12	--	.1	1,000	--	60	40	500	40	200	--	60	100	5	.2	Do.	<10 ppm Ag
3328	50-84- 6	--	.1	2,000	--	60	40	300	40	200	--	60	70	3	.1	Do.	
3329	51-84-31	--	.1	--	--	70	20	300	--	700	--	<60	<70	2	2	Do.	
3330	53-85- 8	--	.1	--	--	100	80	300	--	--	--	<60	70	3	2	Quartz vein	

TABLE 6.—*Analyses of U.S. Bureau of Mines samples from proposed extensions to the Cloud Peak Primitive Area, Wyo.* —Continued

Sample	Location T. R. S.	Assay (oz/ton) Au	Ag	Semiquantitative spectrographic analyses (ppm) Ba (1,000)	Co (40)	Cr (30)	Cu (20)	Mn (30)	Ni (20)	Pb (100)	Sr (1,000)	V (60)	Zr (70)	(percent) Fe (0.004)	Ti (0.001)	Remarks	
3331	53-85- 8	--	--	--	--	70	20	300	--	--	--	<60	100	3	2	Quartz	
3332	53-85- 8	--	--	--	--	70	20	100	--	<100	--	--	--	3	.1	Pegmatite	
3333	53-85- 8	--	.1	--	--	70	30	100	--	--	--	--	--	.4	.02	Quartz	
3334	53-85- 8	Tr	--	--	--	70	30	100	--	--	--	<60	70	.9	.2	Pegmatite	
3335	53-85- 8	Tr	--	--	--	70	20	100	--	--	--	<60	70	.9	.1	Do.	
3336	53-85- 8	Tr	.1	--	--	70	40	100	--	--	--	--	--	.9	.02	Dump sample	
3337	53-85- 9	--	Tr	--	--	70	30	100	--	--	--	<60	<70	.9	.1	Stream sediment	
3338	54-87-18	Tr	.1	--	--	100	300	100	--	--	--	<60	--	4	.01	Quartz	
3340	54-87-18	Tr	Tr	--	40	500	300	300	300	--	--	<60	--	6	.05	Pyrite-bearing schist	
3341	54-87-18	--	.1	--	--	500	600	200	100	--	--	<60	--	5	.05	Dump sample	
3342	54-87-18	--	.1	2,000	<40	100	80	200	--	--	--	<60	70	7	.1	Pit-floor sample	
3343	54-87-18	Tr	--	--	40	--	20	60	--	--	--	<60	70	M	.02	Quartz with limonite-pyrite	30 ppm Mo
3344	54-87-18	--	--	--	150	100	40	100	--	--	--	--	--	5	.003	Quartz with pyrite	
3345	53-86- 1	--	--	--	--	100	40	2,000	--	--	<1,000	<60	--	7	.1	Quartz	<100 ppm La
3346	53-86- 1	--	Tr	--	--	60	60	1,000	--	100	<1,000	<60	70	2	.01	Do.	20 ppm Be
3347	53-86- 1	Tr	Tr	--	--	60	20	2,000	--	100	<1,000	<60	<70	5	.1	Dump sample	<100 ppm La
3348	53-86- 1	Tr	--	4,000	--	100	80	500	--	200	<1,000	<60	100	4	.4	Mafic dike	
3349	53-86- 1	Tr	Tr	6,000	--	100	60	500	--	200	<1,000	<60	--	3	.1	Pit-wall sample	
3351	53-86-13	--	0.1	--	--	60	40	300	--	100	--	<60	--	3	.05	Stream sediment	
3352	53-85-18	--	.1	--	--	60	40	300	--	100	--	<60	100	2	.05	Do.	
3353	53-85-20	Tr	Tr	1,000	--	60	40	300	--	100	--	<60	<70	2	.05	Do.	
3354	53-85-28	Tr	Tr	1,000	--	60	40	300	--	100	<1,000	<60	70	2	.2	Pit-floor sample	<100 ppm La
3355	53-85-28	--	.1	--	40	500	160	2,000	300	--	--	200	100	M	.8	Mafic dike	50 ppm Sc

3356	53-85-22	Tr	--	--	--	100	40	500	--	--	<1,000	<60	100	4	.4	Pit-wall sample	
3357	53-85-21	--	--	--	80	300	160	2,000	200	--	--	200	100	>7	.8	Mafic dike	50 ppm Sc
3358	53-85-33	--	--	--	--	100	40	500	--	100	<1,000	<60	100	4	.4	Dump sample	<10 ppm Ag
3359	53-85-28	Tr	.1	--	--	300	60	500	--	400	--	<60	100	3	.1	Gneiss	
3360	53-85-28	--	--	2,000	--	300	80	500	--	200	--	<60	200	4	.2	Pegmatite	
3361	51-83-32	Tr	.1	1,000	--	100	40	500	--	--	<1,000	<60	100	3	.2	Dump sample	
3362	51-83-32	--	--	4,000	--	100	40	500	--	100	<1,000	<60	--	3	.1	Pegmatite	
3363	53-84-23	--	.1	1,000	--	300	40	500	50	100	<1,000	60	100	3	.2	Stream sediment	
3364	53-84-22	Tr	.1	1,000	--	300	40	500	50	100	<1,000	60	100	3	.2	Do.	
3365	53-84-22	Tr	.1	1,000	--	300	60	500	50	100	<1,000	60	100	3	.2	Do.	
3366	53-84-22	Tr	Tr	1,000	--	300	40	500	50	100	<1,000	60	100	3	.2	Pit sample	<10 ppm Ag
3367	53-84-23	Tr	.1	--	--	300	200	500	40	--	--	<60	70	4	.2	Stream sediment	100 ppm Y
3368	53-84-23	--	.3	--	--	300	40	500	40	--	--	<60	70	4	.2	Do.	100 ppm Y
3369	49-87-15	Tr	Tr	--	--	30	20	500	--	--	--	<60	<70	.5	.05	Limestone with chert	
3369A	53-84-23	Tr	.2	--	--	200	30	500	30	--	--	<60	70	4	.2	Stream sediment	
3370	49-87-15	Tr	.1	--	--	30	40	200	--	--	--	<60	<70	1	.1	Sandy clay subsoil	
3371	49-87-13	Tr	.1	--	--	--	--	200	--	--	--	<60	<70	.2	.01	Clay material	
3372	49-87-11	Tr	.1	--	--	--	--	60	--	--	--	<60	<70	--	.002	Travertine?	0.2% Si
3373	49-87-14	Tr	.2	--	--	--	20	500	--	--	--	<60	<70	.4	.02	Dump sample	
3374	49-87- 1	Tr	.3	--	--	60	40	200	--	100	--	<60	<70	M	.1	Glauconitic sandstone	
3375	50-87-36	Tr	.2	--	--	30	40	500	--	--	--	<60	<70	7	.02	Hematite-stained sand	
3376	50-87-25	Tr	.1	--	--	30	20	500	--	--	--	<60	<70	6	.01	Oolitic hematite	
3377	50-87-22	--	.2	2,000	--	60	40	500	--	200	--	<60	<70	4	.1	Stream sediment	
3378	50-87-17	Tr	.3	--	--	<30	20	200	--	--	--	<60	<70	.7	.01	Hematite-bearing sandstone	
3379	50-87-17	--	.3	5,000	--	100	80	50,000	--	--	--	<60	<70	1	.01	Manganese nodules in sandstone	<10 ppm Ag
3384	49-86-35	Tr	.2	--	--	30	40	200	--	--	--	<60	<70	1	.05	Quartz	200 ppm B
3385	49-86-35	Tr	.1	--	--	60	80	500	--	100	--	<60	<70	M	.05	Altered gneiss	200 ppm Sn
3386	54-87-18	Tr	.4	--	<40	300	160	200	80	--	--	<60	<70	4	.05	Pyrite-bearing quartz	
3387	54-87-19	Tr	.2	--	<40	1,000	600	200	400	--	--	<60	<70	7	.1	Dump sample	200 ppm Sn

A group of contiguous and overlapping claims extends along a north-trending ridge in secs. 21, 28, and 33, T. 53 N., R. 85 W., from one-fourth of a mile (0.4 km) north to 1¼ miles (2 km) south of Stockwell Creek. Metallic minerals appear to be confined to a few narrow quartz stringers in gneiss, and the only working in the area is a shallow prospect pit. No claim markers were observed, and three samples (3358-3360) taken in the area did not contain significant metal values.

About 12 contiguous unpatented lode and placer claims are recorded as being located along South Piney Creek, 2 miles (3.2 km) west of the State Fish Hatchery, in secs. 14, 15, 22, and 23, T. 53 N., R. 84 W. No prospect workings or claim markers were found in the area, however. Six stream-sediment samples and one pit sample (3363-3368 and 3369A) contained no unusual quantities of metals. Samples 3364, 3365, 3367, and 3369A contain abnormally high concentrations of black sand.

The Bishop mine is located on claims in sec. 35, T. 53 N., R. 86 W., near the headwaters of West Fork Little Goose Creek. The abandoned prospect and part of the unpatented claims lie within the extension area. The workings were examined during the previous investigation of the primitive area and were described by Kiilsgaard and others (1972, p. C55-C56). They concluded that the quartz samples contained negligible metallic values.

Three unpatented claims are located in secs. 1 and 2, T. 51 N., R. 84 W. A nearly vertical, 1-foot (0.3-m)-wide dike that strikes N. 25°E. is exposed in an excavation made for the pack trail above the west side of Middle Rock Creek, near the center of the three claims. Although minor amounts of magnetite and specular hematite occur in the dike material, no evidence of commercial mineral resources exists in the area. Three samples contained no unusual metal values (3321, 3323, and 3324).

EXTENSION B

Courthouse records show a group of unpatented lode and placer claims located near the east end of the tract in secs. 5, 6, and 7, T. 48 N., R. 85 W., at U.S. Highway 16. Neither location stakes nor prospect workings were observed in the field. Quartz and feldspar float was noted, suggesting pegmatites, but no dikes were in evidence in the area of the claims, and no evidence of resource potential occurs in the area covered by the claims.

Two small prospect pits are near the east edge of the tract, and another is near the center of unsurveyed sec. 33, T. 49 N., R. 85 W. Small quartz stringers in Precambrian gneiss are exposed in these pits, but there are no indications of mineral resources.

Two small prospect pits, on a north slope about 30 feet above Garnet Creek, are in the NW¼ of unsurveyed sec. 35, T. 49 N., R. 86 W. Quartz is exposed in one pit and altered gneiss with iron stain in the other. Two samples (3384 and 3385) from the pits did not contain anomalous metal values.

Glacial drift covers most of the northwestern part of extension B, and there is no evidence of mineral prospecting activity in the area.

EXTENSION C

No mining claims have been recorded, and no prospect workings or markers are evident in extension C.

EXTENSION D

Numerous unpatented lode and placer claims have been located in T. 49 N., R. 87 W., within and adjacent to extension D.

Clayey soil covers much of the area included in those claims. Local residents have said that a promoter once proposed to develop an operation producing clay and bentonite. This proposal may have been the reason for the large number of claims in the vicinity. The clay materials, however, could not be produced commercially because of high transportation costs to market. Negligible metal values were detected in five samples (3369-3373).

A claim was staked recently in the SE¼SE¼ sec. 11, T. 49 N., R. 87 W., apparently on a deposit that the locator believed to be commercial onyx, but the material appears to be a poor quality of banded travertine. The outcrop indicates that the deposit is small, and specimens observed have little, if any, commercial value.

The following prospects within or near extension D, neither of which is considered to have significant mineral potential, were discussed by Kiilsgaard and others (1972, p. C57-58): (1) South Paint Creek clay property (Pascal claims), 1¼ miles (2 km) outside extension D in sec. 13, T. 49 N., R. 87 W., and (2) Soldier Creek prospect (glauconite) in the SE¼ sec. 2, T. 49 N., R. 87 W.

EXTENSION E

Location notices for three unpatented claims in secs. 7 and 8, T. 52 N., R. 87 W., specify that the commercial minerals sought are "crystal rock and other minerals." No claim corner markers or prospect workings were noted in the area, and there is no evidence of potential mineral resources.

A prospect, about one-half mile (0.8 km) north of Dutch Oven Pass in the SE¼ sec. 19, T. 52 N., R. 87 W., was examined and sampled during the earlier study of the primitive area (Kiilsgaard and others, 1972, p. C56). They concluded that the quartz vein where exposed contains negligible metallic values.

Five lode and placer claims have been located in the NE¼ sec. 32, T. 52 N., R. 88 W., about 1 mile (1.6 km) outside the extension area between Spanish Point and Mill Creek. The claims, recorded in 1957 and 1961, have been worked sporadically over the years, by pick-and-shovel methods, for moss agate. The agate occurs as angular and rounded boulders mixed with clay, sand, and gravel. The material appears to be glacial drift that was deposited on the Madison Limestone. The glacial material, which varies greatly in thickness, is 60 feet (18 m) thick at the present pit. The operation, known as the Spanish Point agate mine, consists of one pit about 150 feet (46 m) in diameter. An operator is hired, and a small bulldozer is used for several weeks each year to clean the pit floor of waste from which marketable agate has been picked. Moss-agate boulders exposed by this operation range in diameter from a few inches (several centimetres) to 6 feet (1.8 m). A few hundred pounds of agate is marketed each year; commercial specimens have a market value of $0.75 per pound. The amount of marketable moss agate per ton of glacial drift is not known, but about 500,000 tons (450,000 metric tonnes) of drift remains at the pit site, and abundant chert float indicates the existence of two other pockets elsewhere on the claims that possibly contain commercial-quality agate. There is no evidence that a major operation ever will develop or that the deposits continue into the extension area. The deposits should continue to produce a small quantity of marketable moss agate.

EXTENSION F

Some workings, known as the Buckskin prospect, extend into extension F from the previous study area. The workings were examined and sampled during the mineral reconnaissance of the primitive area and were described by Kiilsgaard and others (1972, p. C39-C42), who concluded that a significant resource potential does not exist at this prospect.

No other claims are recorded in extension F, and reconnaissance disclosed neither prospect workings nor claim markers.

EXTENSION G

Numerous groups of unpatented mining claims are located north of extension G, and some are present in the area. Shallow prospect pits and a shallow shaft were examined. The claims and workings are located largely on glacial drift, which appears to be a veneer on Precambrian basement rocks. Specular hematite and pyrite were observed in specimens scattered throughout the drift and were probably the minerals that interested the claim locators. Other pits and trenches in the area were excavated in the basement rocks, apparently to explore pegmatite dikes for feldspar. Claim names, such as "Spar 1 and 2" and "White Spar," also indicate that the mineral of interest could have been feldspar. These claims were described by Kiilsgaard and others (1972, p. C55) in a section entitled, "Twin Lakes Feldspar Prospect." They concluded that an outcrop of pegmatite in this vicinity contains no unusual concentration of uranium or thorium. .

Nine samples (3338-3344, 3386, and 3387) of selected rock types from glacial drift and pit and dump samples taken in extension G contained negligible metal values.

EXTENSION H

Eighteen claims are located in the eastern part of extension H, which is underlain by Precambrian gneiss and Quaternary glacial deposits. Location notices, recorded for two groups of claims in secs. 28 and 33, T. 53 N., R. 86 W., specify "fluorspar" as the mineral of interest. There is very little evidence of significant fluorspar occurrences in the extension area.

GEOTHERMAL RESOURCES

None of the extension areas exhibit any evidence, such as thermal springs or young igneous rocks, of being a significant geothermal energy resource.

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