Mineral Resources of the Flat Tops Primitive Area Colorado

GEOLOGICAL SURVEY BULLETIN 1230-C

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STUDIES RELATED TO WILDERNESS

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An evaluation of the mineral potential of the area

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STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88–577, Sept. 3, 1964) and the Conference Report on Senate bill 4, 88th Congress, direct the U.S. Geological Survey and the U.S. Bureau of Mines to make 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 provided that each primitive area should be studied for its suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This bulletin reports the results of a mineral survey in the Flat Tops primitive area, Colorado. The area discussed in the report corresponds to the area under consideration for wilderness status. It is not identical with the Flat Tops Primitive Area as defined because modifications of the boundary have been proposed for the area to be considered for wilderness status. The area that was studied is referred to in this report as the Flat Tops primitive area.

This bulletin is one of a series of similar reports on primitive areas.

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By W. W. Mallory, E. V. Post, P. J. Ruane, and W. L. Lehmbeck, U.S. Geological Survey, and R. B. Stotelmeyer, U.S. Bureau of Mines

SUMMARY

The Flat Tops primitive area is in northwest Colorado, in Garfield, Eagle, and Rio Blanco Counties. For purposes of this report, it is divided into two parts (1) the South Fork area, drained by the South Fork of the White River, and (2) the Pyramid area, in the northern part of the primitive area, where Pyramid Peak is a prominent landmark.

Rocks in the Flat Tops range in age from Precambrian to Quaternary. The South Fork area is part of a large structural dome of Precambrian crystalline rocks with a relatively thin cover of Paleozoic sedimentary rocks. It is capped by extensive basalt flows that form a broad, fairly level plateau. Remnants of basalt flows form high peaks and steep ridges in the Pyramid area.

The primitive area is about 50 miles northwest of the belt of mineral deposits that has produced most of the mineral wealth of Colorado. No prospects were located or worked in the primitive area during the early period of prospecting. The "Dade prospect" was staked in 1940, near the southern border. It contains iron and lead sulfides, but the vein is not considered large or rich enough to be worth mining. A so-called gold prospect was investigated by the Bureau of Mines but was found to be only an area of iron-stained and barren basalt.

Basalt of the kind forming the extensive caprock of the area is generally barren of mineral deposits in Colorado. In contrast, the Leadville Limestone, which lies below the basalt over a wide area, is an especially favorable host rock for mineral deposits in Colorado. Consequently, sampling was concentrated at the periphery of the basalt caprock, and hundreds of stream and soil samples were collected in the canyons and gullies that contain the Leadville and other sedimentary rocks in the search for concentrations of valuable minerals. These samples were analyzed by chemical and spectrographic methods that permitted detection of minute amounts of metals. A few localities were found to contain metallic concentrations somewhat higher than the low values that are common for the area. These anomalous areas were thoroughly investigated but no mineral deposits were discovered. No evidence of uranium has been found in the area.

Although it is theoretically possible that oil and gas could be present in the sedimentary rocks of the area, no structural or stratigraphic traps were identified. Hence, the presence of commercial quantities of oil and gas seems highly improbable.

The Mesaverde Formation, which contains coal in nearby localities, is not present within the boundary of the primitive area. There are no prospects for coal in the area.

Gypsum occurs in the southeastern part of the primitive area, beneath the thick basalt cap and under heavy accumulations of slide rock. It is, however, abundantly available in easily accessible deposits outside the area; hence the gypsum within the boundaries is of doubtful economic value.

No mineral deposits of commercial importance are known within the Flat Tops primitive area.

GEOLOGY AND MINERAL RESOURCES

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INTRODUCTION

LOCATION, GEOGRAPHY, AND ACCESS

The Flat Tops primitive area is in northwestern Colorado, in parts of Garfield, Eagle, and Rio Blanco Counties. Most of the part south of lat 40° is in the Glenwood Springs 30-minute quadrangle; a small part west of long 107°30′ is in the Grand Hogback 30-minute quadrangle. The remainder of the area is shown only by the Leadville and Craig topographic maps at the scale of 1:250,000 (fig. 1). The area that was studied occupies about 230 square miles and ranges in altitude from less than 8,000 feet in the canyon of the South Fork of the White River to 12,246 feet on Sheep Mountain. Most of the plateau, however, has an altitude of about 10,500–11,500 feet. The principal streams include the South Fork of the White River, the North Fork of the White River, and the East Fork of Williams Fork of the Yampa River. Numerous small ponds, lakes, and marshes are present on the flat upland.

For convenient reference the Flat Tops primitive area is divided in this report into two parts: (1) A larger part south of the 40th parallel, most of which is drained by the South Fork of the White River, is here termed the "South Fork area," and (2) a smaller extension north of the 40th parallel which contains such features as the Chinese Wall, Devils Causeway, Lost Lakes Peaks, and Pyramid Peak is here termed the "Pyramid area." All the South Fork area and the southern part of the Pyramid area lie within the White River National Forest. The central and northern part of the Pyramid area is in the Routt National Forest.

The Flat Tops primitive area contains no roads, but roads approach its borders from four directions. From the south it can be reached from U.S. Route 6 at Dotsero via a gravel road to Deep Lake, thence via a dirt road to the Budge Resort at The Meadows of the South Fork of the White River. From the north a good road extends from State Route 132 at Ripple Creek to the north end of Trappers Lake (fig. 2). From

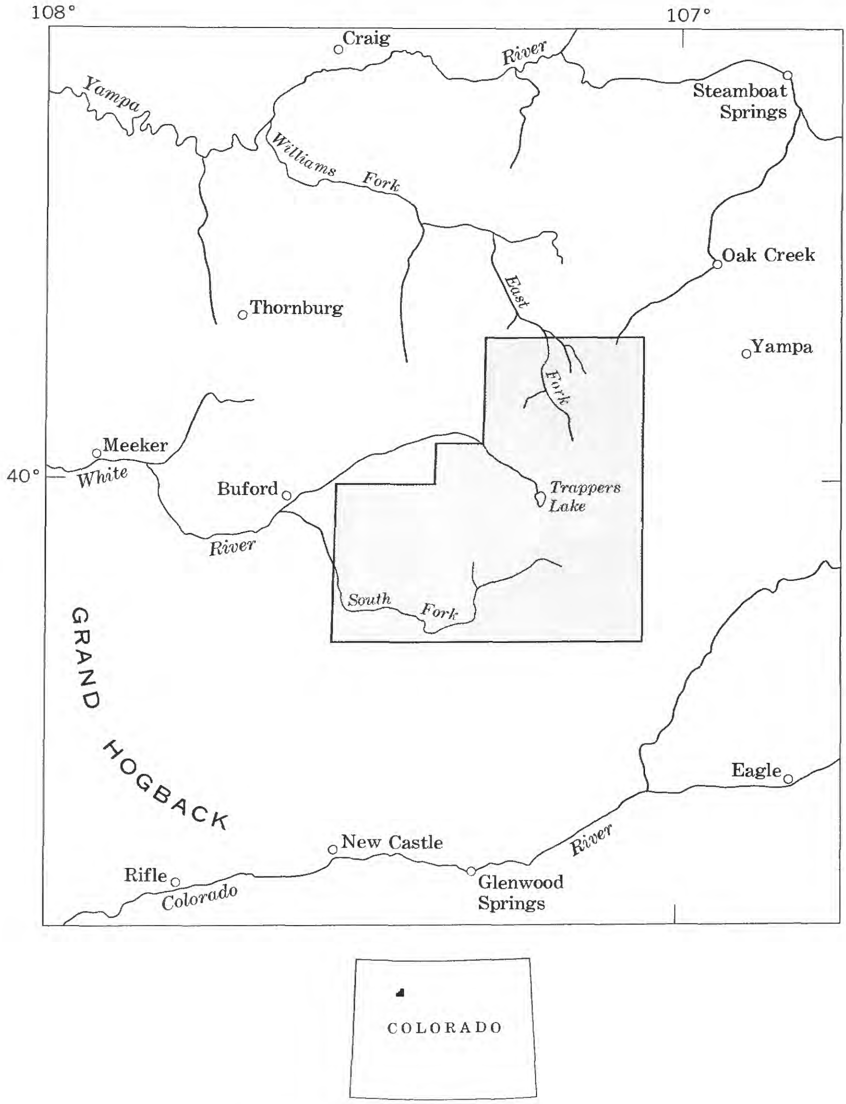

FIGURE 1.—Location of Flat Tops area.

the west a graded road leads to South Fork Campground. From the east a road from State Route 131 ends at Stillwater Reservoir.

A major part of the heavy timber on the plateau is dead owing to the ravages of the spruce bark beetle. Down timber is so plentiful that movement in the forests is difficult or locally impossible. As increasing numbers of standing dead trees fall, accessibility will become even more difficult.

FIGURE 2.—Trappers Lake in Flat Tops primitive area. The cliffs in the distance form part of the northern margin of the high plateau which makes up most of the primitive area. Photograph by Jack Rathbone, Denver, Colo.

INVESTIGATIONS

PREVIOUS STUDIES

A large part of the Flat Tops primitive area had already been mapped geologically at the time this investigation was made. An extensive area south of lat 40° was mapped by Bass and Northrop (1963) and certain areas north of lat 40° were mapped by Kucera (1962) and Sharps (1962). The Ogle Corporation, Denver, Colo., generously made available unpublished geologic and structural maps which cover most of the Pyramid area and vicinity.

PRESENT INVESTIGATION

For this study existing geologic maps were checked in the field and unmapped areas were examined in reconnaissance traverses supplemented by study of aerial photographs. Intensive effort was expended in collecting 475 samples for geochemical analysis to test for the presence of materials of economic interest. Search for oil, gas, coal, and gypsum was based on study of stratigraphy, structure, geomorphology, surface indications, and extrapolation of information from producing localities in the region. Field investigations for this study were done during July and August 1965 by the writers with the assistance of William P. McKay.

GEOLOGY

GEOLOGIC SETTING

The Flat Tops primitive area is in the northern part of the White River Plateau. Basically the plateau is a broad dome which forms the northeasternmost outpost of the Colorado Plateaus physiographic province. Adjacent east and south are the majestic Park and Sawatch Ranges, part of the Southern Rocky Mountains province. Northwest are the Uinta Mountains, one of the Middle Rocky Mountain ranges. Northward is the Washakie basin; west and south is the Piceance Creek basin—also part of the Colorado Plateaus province—which is separated from the White River Plateau by the Grand Hogback, a prominent monocline.

Rocks within the Flat Tops primitive area range in age from Precambrian through Quaternary. Most of the area is covered by thick basalt lava flows of Tertiary age, but in the Pyramid area the bedrock is gray shale of Late Cretaceous age. Sedimentary rocks have an aggregate thickness of about 14,900 feet; Paleozoic rocks total about 7,700 feet, Mesozoic rocks about 7,200 feet. The Tertiary basalt flows vary widely in thickness, but in places are as much as 1,500 feet thick (pl. 1).

ROCKS

PRECAMBRIAN ROCKS

Precambrian rocks are exposed deep in the canyon of the South Fork of the White River and its tributaries, Patterson Creek and Lost Solar Creek. These rocks are schist and gneiss that have been extensively intruded by granite and by pegmatite dikes. The contact with the overlying Cambrian rocks is sharply unconformable.

PALEOZOIC ROCKS

The Sawatch Quartzite and the overlying Dotsero and Manitou Formations are a closely related sequence that is Late Cambrian and Ordovician in age. These rocks are well exposed along the South Fork of the White River and its tributaries. The Sawatch Quartzite of Late Cambrian age is mainly even-bedded sandstone, quartzitic sandstone, and quartzite in beds 2–5 feet thick, interbedded with thin beds of light-gray shale. Thickness of the Sawatch is about 500 feet. It forms sheer cliffs 400–500 feet high.

The Dotsero Formation of Late Cambrian age consists of about 100 feet of thin-bedded tannish-gray dolomite and flat-pebble limestone conglomerate, interbedded with greenish-gray dolomitic shale partings. The basal contact is generally sharply defined at the top of the Sawatch Quartzite cliff. The lower part of the Dotsero Formation commonly forms slopes that recede from the underlying Sawatch. The upper beds are more resistant and form steeper slopes.

The Manitou Formation of Early Ordovician age contains about 80 feet of thin-bedded gray flat-pebble limestone conglomerate interbedded with greenish-gray calcareous shale and a few beds of limestone and dolomite. This sequence grades into a siliceous dolomite that weathers to light brown.

A paraconformity, representing a time lapse, separates the Manitou from the Chaffee Formation of Late Devonian age. The Chaffee is about 300 feet thick and consists of interbedded shale and quartzite in the lower third and massive limestone and dolomite in the upper two-thirds.

The Leadville Limestone of Mississippian age, overlying the Chaffee, is about 175 feet thick and consists chiefly of limestone. The basal beds are sandy, and the lower half of the formation contains much interbedded dolomite. The upper half is a massive gray coarsely oolitic limestone. The Leadville crops out in a prominent cliff throughout the region and commonly displays marked erosional relief on the disconformity at its upper surface.

Rocks of Pennsylvanian and Permian age vary in thickness and lithology within the mapped area. They include the Molas Formation, the Belden Shale, the Eagle Valley Evaporite, and the Maroon Formation. The Molas Formation is little more than a thin weathered zone lying unconformably on top of the karst surface of the underlying Leadville Limestone. The Belden Shale is more than 900 feet thick; the lower two-thirds is dark gray to black shale and limy shale, interbedded with thin beds of fossiliferous limestone; the upper one-third is fissile dark-gray shale and interbedded thin micaceous greenish-tan sandstone overlain by thick lenticular beds of arkosic gritstone, arkosic conglomerate, and fissile black shale. In the extreme southeastern part of the area, the Eagle Valley Evaporite, consisting of 1,500 feet of structurally contorted gypsum and fissile black shale, is exposed.

The Maroon Formation of Pennsylvanian and Permian age is not exposed within the primitive area but is known to exist beneath younger rocks in the northeastern and northern part of the area. As seen nearby, it is composed primarily of red interbedded arkosic sandstone, arkosic conglomerate, shale, sandstone, siltstone, and thin limestone beds. In a deep well near Poose Creek its maximum thickness is 6,000 feet. The Maroon thins northeast and southwest from this area. A unit of 200 feet of gray to tan sandstone that overlies the Maroon is commonly referred to as the Schoolhouse Tongue of Brill (1952) of the Weber Sandstone.

MESOZOIC ROCKS

Rocks of Triassic and Jurassic age are not exposed in the mapped area but are known to exist beneath younger rocks in the Pyramid area. The Moenkopi Formation, Early Triassic in age, is 525 feet of thin-bedded micaceous brick-red siltstone, shale, and thin limy sandstone. Unconformably overlying the Moenkopi is the Chinle Formation of Late Triassic age, which consists of 725 feet of red conglomerate, conglomeratic sandstone, siltstone, and shale. An erosional unconformity separates the Chinle from the overlying Entrada Sandstone of Late Jurassic age. The Entrada, a crossbedded eolian sandstone, comprises less than 50 feet of fine-grained to very fine grained grayish-pink sandstone, with a conglomerate zone at the base in some places. The Curtis Formation conformably overlies the Entrada and consists of about 50 feet of yellowish-gray to light-brownish-gray calcareous sandstone and small nodules or grains of glauconite. Its contact with the overlying Morrison Formation is transitional at places.

The Morrison Formation of Late Jurassic age contains about 460 feet of pale-green shale interbedded with maroon shale, light-gray sandstone, and a few beds of dark-gray limestone. The sandstone beds are most numerous in the lowest 100 feet of the formation. Thin beds of limestone are present at several horizons in the formation, but are most conspicuous about 140 feet above the base.

The Dakota Sandstone, of Early Cretaceous age, is about 150 feet thick and contains two units of light-colored sandstone separated by light-colored sandy shale and dark-gray shale. It rests disconformably on the Morrison Formation and in most places the contact is sharp. The Dakota is covered by basalt and surficial deposits within the primitive area but crops out about 2 miles northwest of the area in the Poose Creek anticline.

The Mancos Shale of Late Cretaceous age is 5,000 feet of gray shale with some thin sandstone and limestone beds. The Mancos is extensively exposed in the Pyramid area, but much of it has slumped and slid; hence it is shown on the map as landslide deposits.

CENOZOIC ROCKS

Basaltic lava flows and local intrusives, mid-Tertiary or younger in age, cover most of the Flat Tops area and have a maximum thickness of about 1,500 feet. In places volcanic ash or basaltic gravels separate the flows but generally the individual flows are in direct contact. The flows lie on an erosional surface of low relief that bevels the underlying sedimentary formations. Because these formations dip generally northeast, the rocks beneath the basalt are oldest in the southwestern part of the area and are progressively younger northeastward.

Surficial deposits of several kinds, including glacial, landslide, and talus deposits, cover a large part of the area. They are shown as a single unit on the map. The glacial deposits are moraines and outwash which occur on top of the plateau as well as in many of the peripheral valleys. Landslide deposits are widespread on the Mancos Shale in the Pyramid area, and a belt of talus or slide rock several hundred feet wide is present in many places at the foot of the basalt cliffs. Locally, the slide rock has dammed streams to form small swamps or marshes.

STRUCTURE

The South Fork area is part of the White River uplift—a broad dome 35 miles long and 20 miles wide. The highest part of the dome within the primitive area reaches a structural altitude of 12,000 feet on the Leadville Limestone in the vicinity of the South Fork of the White River at the southwest margin of the primitive area. Here faults break the rocks into numerous blocks. The northern limit of the dome can be placed at the 6,000-foot structure contour. Hence the South Fork area has structural relief of 6,000 feet.

On the higher parts of the dome the basalt flows lie nearly horizontally upon the sedimentary strata with an erosional discontinuity between them. At the eastern margin of the South Fork area where the sedimentary rocks dip more steeply, the basalt flows lie at a gentle angle to the underlying sedimentary rocks (pl. 1, northeastern end of section *A–A′*).

The Pyramid area, by contrast, is basically homoclinal (section *B–B′*). The sedimentary rocks beneath the flat-lying basalt cap dip northeast at about 1,000 feet per mile. The nearly homoclinal dip is interrupted by a narrow structural terrace caused by the southeastward-plunging Poose Creek anticline. A narrow belt in the Little Trappers Lake-Derby Peak area where the South Fork and the Pyramid areas adjoin is a structural terrace on which the sedimentary rocks are virtually horizontal.

MINERAL RESOURCES

No metallic minerals, coal, gypsum, or other materials have ever been produced within the boundaries of the primitive area, nor have any wells been drilled for oil or gas.

METALLIC MINERALS

The geologic environment of the Flat Tops is such that deposits of copper, lead, zinc, gold, and silver minerals conceivably could exist in rocks of Precambrian through Paleozoic age. Additionally, the Morrison Formation and Dakota Sandstone of Mesozoic age could contain deposits of uranium minerals. It is doubtful that rocks younger than the Dakota Sandstone would contain metallic mineral deposits. The Mancos Shale, being somewhat incompetent, does not fracture under stress to form either suitable channels for the introduction of ore minerals or sites for ore-mineral deposition. Nor is the Mancos Shale of the proper chemical composition to react with ore-bearing solutions and allow the formation of a mineral deposit. There are no known metallic mineral deposits elsewhere in Colorado in basalts of late Tertiary age similar to the basalts that cap the Flat Tops (Vanderwilt, 1947, p. 11).

Despite the theoretical possibility that deposits of metallic minerals could exist in the Flat Tops primitive area, there is little visible evidence of metallic minerals, as shown by the paucity of prospect pits in the area. The only known prospect is in sec. 29, T. 2 S., R. 89 W., in the vicinity of the confluence of Park Creek with the South Fork of the White River. It was worked as a lead-silver prospect by John Dade during the 1940's. There is no record of commercial production from this prospect, but hand specimens of rock containing galena and pyrite have been taken from it. The U.S. Bureau of Mines has made a detailed study of the Dade prospect (see section on "Economic appraisal").

To appraise the possibility of hidden mineral deposits in the area, 475 samples were collected for geochemical analysis. Sediment from the beds of both flowing and dry streams was sampled, as well as the colluvial soil of gullies. Panned concentrates of heavy minerals were taken from stream beds in areas believed to be underlain by potentially uranium-bearing rocks, and the areas were field checked for abnormal radioactivity with a portable scintillation counter. Inasmuch as most of the primitive area has a thick cap of barren basalt, most of the geochemical sampling was done near the borders, where older rocks that might be mineralized are exposed.

Stream-sediment and colluvial-soil samples were oven dried at 100°C and sieved to pass a ¼-millimeter screen prior to analysis. All samples were analyzed for citrate-soluble heavy metals and cold-acid-extractable copper by standard methods described by Ward, Lakin, Canney, and others (1963, p. 25–29). In general, those samples in which at least 9 ppm (parts per million) heavy metals was detected were further analyzed for total copper, lead, and zinc (Ward and others, 1963, p. 19–25). A few samples were analyzed spectrographically, and selected samples were analyzed for gold by the method of Lakin and Nakagawa (1965). The heavy-mineral concentrates were checked for the presence of uranium by a sodium fluoride fluorescence test.

The location and relative metal content of most samples are shown on plate 2. Some samples giving low geochemical values are omitted owing to the lack of space. The analyses of all samples are given in tables 1 and 2. Concentrations are reported in parts per million (1 ppm equals 0.0001 percent).

Plate 2 shows that nearly all samples had a citrate-soluble heavy-metal content of 3 ppm or less but that a few samples from areas underlain by rocks of Precambrian or Paleozoic age contained as much as 35 ppm. Most of the samples having relatively high concentrations were from the southwestern part of the study area near the closely faulted crest of the White River uplift and were obtained from streams draining the Leadville Limestone or underlying rocks.

A statistical tabulation of the citrate-soluble heavy-metal and cold-acid-extractable copper values (fig. 3) suggests that heavy-metal values of 4 ppm or more should be considered anomalous with respect to the remainder of the samples. Concentrations of cold-acid-extractable copper of 2 ppm or more are anomalous, being higher than those in 97 percent of the samples collected. Most of the anomalous values were field checked by collecting additional stream-sediment samples at intervals of approximately 200 feet upstream from the initial sample sites and analyzing the samples in the field, in the hope that high concentrations could be traced to their source. The strongest anomalies (11 ppm copper and 9 ppm or more heavy metals) are evaluated below.

Site 536.—The initial sample at site 536 was collected just east of the White River National Forest boundary about half a mile north of the South Fork Campground, from a small perennial stream that contains much fragmental calcareous tufa. The sample contained 35 ppm citrate-soluble heavy metals, but less than 0.5 ppm cold-acid-extractable

TABLE 1.—*Colorimetric analyses*

[Analyses by W. L. Lehmbeck; gold analyses by H. W. Lakin and H. M. Nakagawa]

Sample No.	Material[1]	Parts per million					
		cxHM[2]	cxCu[3]	Cu	Pb	Zn	Au
4-1	A	0.5	<0.5				
4-2	A	3	1				
4-3	A	2	1.5				
4-4	A	0.5	0.5				
4-5	A	0.5	1.5				
4-6	A	1	<0.5				
4-7	A	1	0.5				
4-8	A	2	3				
4-9	A	0.5	<0.5				
4-10	A	0.5	1				
4-11	A	3	1				
4-12	A	0.5	1.5				
4-13	A	0.5	<0.5				
4-14	A	0.5	1.5				
4-15	A	0.5	1				
4-16	A	0.5	<0.5				
4-17	A	0.5	<0.5				
4-18	A	1	<0.5				
4-19	A	3	<0.5				
4-20	A	0.5	1				
4-21	A	2	<0.5				
4-22	A	2	<0.5				
4-23	A	1	0.5				
4-24	A	1	0.5				
4-25	A	2	<0.5				
4-26	A	1	<0.5				
4-27	A	1	<0.5				
4-28	A	1	0.5				
4-29	A	1	<0.5				
4-30	A	1	<0.5				
4-31	A	<0.5	<0.5				
4-32	A	0.5	0.5				
4-33	A	0.5	0.5				
4-34	A	<0.5	0.5				
4-35	A	1.0	1				
4-36	A	0.5	<0.5				
4-37	A	1	<0.5				
4-38	A	0.5	<0.5				
4-39	A	0.5	<0.5				
4-40	A	<0.5	<0.5				
4-41	A	0.5	0.5				
4-42	A	0.5	<0.5				
4-43	A	<0.5	0.5				
4-44	A	<0.5	0.5				
4-45	A	0.5	<0.5				
4-46	A	0.5	<0.5				
4-47	A	0.5	<0.5				
4-48	A	1.0	<0.5				
4-49	A	<0.5	<0.5				
4-50	A	1	0.5				
4-51	A	1	<0.5				
4-52	A	0.5	<0.5				
4-53	A	0.5	1.5				
4-54	A	0.5	0.5				
4-55	A	1	0.5				
4-56	A	0.5	<0.5				
4-57	A	0.5	<0.5				
4-58	A	0.5	<0.5				
4-59	A	3	0.5				
4-60	A	5	0.5	15	10	150	<0.05
4-61	A	3	1.5				
4-62	A	2	1				
4-63	B	2	0.5				
4-64	A	0.5	1				
4-65	A	<0.5	<0.5				
4-66	A	0.5	0.5				
4-67	A	0.5	1				
4-68	A	1	0.5				
4-69	A	1	<0.5				
4-70	A	<0.5	3				
4-71	A	1.0	<0.5				
4-72	A	0.5	<0.5				
4-73	A	1	0.5				
4-74	A	0.5	<0.5				
4-75	A	0.5	1.5				
4-76	A	0.5	<0.5				
4-77	A	0.5	0.5				
4-80	A	1	0.5				
4-81	A	1	0.5				
4-82	A	1	3				
4-83	A	3	<0.5				
4-84	A	1	0.5				
4-85	A	2	<0.5				
4-86	A	0.5	<0.5				
4-87	A	2	<0.5				
4-88	A	0.5	<0.5				
4-89	A	1	<0.5				
4-90	A	0.5	<0.5				
4-91	A	2	<0.5				
4-92	A	1	<0.5				
4-93	A	<0.5	<0.5				
4-94	A	2	<0.5				
4-95	A	1	<0.5				
4-96	A	0.5	1				
4-97	A	1	<0.5				
4-98	A	0.5	<0.5				
4-99	A	0.5	<0.5				
4-100	A	0.5	<0.5				
4-101	A	0.5	0.5				
4-102	A	30	1	2	25	175	
4-104	A	1	0.5				
4-105	A	1	1				
4-106	A	2	1				
4-107	A	3	2				
4-108	A	2	<0.5				
4-109	A	0.5	<0.5				
4-110	A	2	0.5				
4-111	A	0.5	0.5				
4-112	A	0.5	1				
4-113	A	0.5	<0.5				
4-114	A	0.5	<0.5				
4-115	A	2	1				
4-116	A	2	<0.5				
4-117	A	0.5	1.5				
4-118	A	1	1				
4-119	A	0.5	<0.5				
4-120	A	0.5	1				
4-121	A	2	<0.5				
4-122	A	2	2				
4-123	A	3	<0.5				

See footnotes at end of table.

TABLE 1.—*Colorimetric analyses*—Continued

Sample No.	Material[1]	Parts per million					
		cxHM[2]	cxCu[3]	Cu	Pb	Zn	Au
4-124	A	1	0.5				
4-125	A	1	<0.5				
4-126	A	1	0.5				
4-127	A	2	1				
4-128	A	0.5	0.5				
4-129	A	0.5	0.5				
4-130	A	0.5	0.5				
4-131	B	3	<0.5				
4-132	A	2	1.5				
4-133	A	0.5	<0.5				
4-134	A	1	0.5				
4-135	A	0.5	<0.5				
4-136	A	7	<0.5				
4-137	A	2	0.5				
4-138	A	2	0.5				
4-139	A	2	<0.5				
4-140	A	1	<0.5				
4-141	A	0.5	0.5				
4-142	A	0.5	1				
4-143	A	1	0.5				
4-144	A	0.5	0.5				
4-145	A	<0.5	0.5				
4-146	A	1	2				
4-147	A	2	0.5				
4-148	A	<0.5	<0.5				
4-149	A	1	1				
4-150	A	0.5	1				
4-151	A	0.5	0.5				
4-152	A	1	0.5				
4-153	A	4	1				
4-154	A	1	0.5				
4-155	A	0.5	1				
4-156	A	0.5	1.5				
4-157	A	0.5	1				
4-158	A	0.5	0.5				
4-159	A	11	0.5	2	10	125	
4-160	A	14	1	2	10	125	
4-161	A	2	0.5				
4-162	A	2	1				
4-163	A	1	0.5				
4-164	A	0.5	1				
4-165	A	0.5	<0.5				
4-166	A	1	1				
4-167	A	1	1				
4-168	A	0.5	<0.5				
4-169	A	0.5	<0.5				
4-170	A	1	0.5				
4-171	A	3	0.5				
4-172	A	2	<0.5				
4-173	A	1	1				
4-174	A	1	0.5				
4-175	A	1	0.5				
4-176	A	0.5	0.5				
4-177	A	0.5	0.5				
4-178	A	1	<0.5				
4-179	A	0.5	0.5				
4-180	A	2	0.5				
4-181	A	0.5	<0.5				
4-182	A	0.5	<0.5				
4-183	A	1	<0.5				
4-184	A	0.5	<0.5				
4-185	A	1	<0.5				
4-186	A	1	0.5				
4-187	A	2	0.5				
4-188	A	1	1				
4-189	A	1	0.5				
4-190	A	0.5	1.5				
4-191	A	1	0.5				
4-192	A	1	0.5				
4-193	B	3	1				
4-194	B	3	0.5				
4-195	B	2	1				
4-196	A	11	<0.5	7	10	150	<0.05
4-197	B	2	0.5				
4-198	A	0.5	2				
4-199	B	4	<0.5				
4-200	A	0.5	1				
4-201	A	1	<0.5				
4-202	A	2	<0.5				
4-203	A	1	0.5				
4-204	A	1	0.5				
4-205	A	0.5	<0.5				
4-206	A	0.5	<0.5				
4-207	A	1	<0.5				
4-208	A	1	0.5				
4-209	A	0.5	<0.5				
4-210	A	0.5	<0.5				
4-211	A	0.5	1				
4-212	B	2	<0.5				
4-213	A	0.5	<0.5				
4-214	A	1	<0.5				
4-215	A	3	11	55	25	100	
4-216	A	1	0.5				
4-217	A	0.5	0.5				
4-218	A	0.5	<0.5				
4-219	A	1	1				
4-220	A	0.5	<0.5				
4-221	A	0.5	<0.5				
4-222	A	1	<0.5				
4-223	A	0.5	<0.5				
4-224	A	2	<0.5				
4-225	A	3	0.5				
4-226	A	1	<0.5				
4-227	A	2	0.5				
4-228	C	4	<0.5				
4-229	A	9	<0.5	15	35	175	
4-230	A	4	0.5				
4-231	A	3	<0.5				
4-232	A	2	<0.5				
4-233	A	3	0.5				
4-234	A	4	1.0				
4-235	A	2	0.5				
4-236	A	0.5	0.5				
4-237	A	<0.5	0.5				
4-238	A	2	1				
4-239	A	1	<0.5				
4-240	A	3	0.5				
4-241	A	0.5	<0.5				
4-242	A	1	<0.5				
4-243	A	1	0.5				

See footnotes at end of table.

TABLE 1.—*Colorimetric analyses*—Continued

Sample No.	Material[1/]	Parts per million					
		cxHM[2/]	cxCu[3/]	Cu	Pb	Zn	Au
4-244	C	2	<0.5				
4-245	A	1	0.5				
4-246	A	1	0.5				
4-247	A	1	1				
4-248	A	0.5	1				
4-249	A	2	0.5				
4-250	A	1	<0.5				
4-251	A	2	<0.5				
4-252	A	0.5	0.5				
4-253	A	1	0.5				
4-254	A	0.5	1				
4-255	B	1	0.5				
4-256	A	0.5	<0.5				
4-257	A	1	<0.5				
4-258	A	0.5	1				
4-259	A	1	1				
4-260	B	1	1.5				
4-261	A	0.5	1.5				
4-262	A	1	1				
4-263	A	0.5	<0.5				
4-264	A	1	<0.5				
4-265	A	0.5	<0.5				
4-266	A	1	0.5				
4-267	A	0.5	<0.5				
4-268	A	<0.5	0.5				
4-269	A	0.5	1				
4-270	A	0.5	0.5				
4-271	A	1	<0.5				
4-272	A	0.5	<0.5				
4-273	A	1	<0.5				
4-274	A	1	0.5				
4-275	A	1	0.5				
4-276	A	1	<0.5				
4-277	A	0.5	<0.5				
4-278	A	1	<0.5				
4-279	A	1	<0.5				
4-280	A	1	<0.5				
4-281	A	2	<0.5				
4-282	A	1	1				
4-283	A	0.5	<0.5				
4-284	A	0.5	<0.5				
4-285	A	<0.5	0.5				
4-286	A	1	0.5				
4-287	A	1	<0.5				
4-288	A	1	<0.5				
4-289	A	0.5	0.5				
4-290	A	1	<0.5				
4-291	A	0.5	1				
4-292	A	1	<0.5				
4-293	A	1	1.5				
4-294	A	1	<0.5				
4-295	A	0.5	<0.5				
4-296	A	1	0.5				
4-297	A	0.5	0.5				
4-298	A	<0.5	<0.5				
4-299	A	0.5	0.5				
4-300	A	1	0.5				
4-301	A	1	0.5				
4-302	A	2	<0.5				
4-303	A	2	<0.5				

Sample No.	Material[1/]	Parts per million					
		cxHM[2/]	cxCu[3/]	Cu	Pb	Zn	Au
4-304	A	2	0.5				
4-305	A	2	0.5				
4-306	A	0.5	<0.5				
4-307	A	0.5	0.5				
4-308	A	1	2				
4-309	A	0.5	<0.5				
4-310	A	1	<0.5				
4-311	A	0.5	<0.5				
4-312	A	2	0.5				
4-313	A	1	0.5				
4-314	A	1	<0.5				
4-315	A	0.5	<0.5				
4-316	A	0.5	0.5				
4-317	A	1	1				
4-318	A	1	0.5				
4-319	A	0.5	1				
4-320	A	0.5	<0.5				
4-321	A	1	0.5				
4-322	A	1	<0.5				
4-323	A	0.5	<0.5				
4-324	A	0.5	0.5				
4-325	A	0.5	0.5				
4-326	A	0.5	<0.5				
4-327	C	0.5	0.5				
4-328	A	0.5	1				
4-329	A	0.5	0.5				
4-330	A	<0.5	<0.5				
4-331	A	0.5	<0.5				
4-332	A	0.5	<0.5				
4-333	A	1	<0.5				
4-334	A	1	0.5				
4-335	A	0.5	0.5				
4-401	A	0.5	1				
4-402	A	5	0.5				
4-403	A	9	<0.5	2	25	125	<0.05
4-404	B	3	0.5				
4-405	A	0.5	0.5				
4-406	A	1	0.5				
4-407	A	2	<0.5				
4-408	B	1	<0.5				
4-409	A	1	<0.5				
4-410	A	0.5	<0.5				
4-411	A	0.5	<0.5				
4-412	A	1	<0.5				
4-413	A	2	<0.5				
4-414	A	7	<0.5				
4-415	A	2	<0.5				
4-416	A	1	<0.5				
4-417	A	2	<0.5				
4-418	A	1	<0.5				
4-419	A	1	<0.5				
4-420	A	0.5	<0.5				
4-421	A	1	<0.5				
4-422	A	0.5	0.5				
4-423	A	1	<0.5				
4-424	A	0.5	<0.5				
4-425	A	1	<0.5				
4-426	A	1	0.5				
4-427	A	0.5	<0.5				
4-428	A	<0.5	<0.5				

See footnotes at end of table.

TABLE 1.—*Colorimetric analyses*—Continued

Sample No.	Material[1]	Parts per million					
		cxHM[2]	cxCu[3]	Cu	Pb	Zn	Au
4-429	A	0.5	<0.5				
4-430	A	1	<0.5				
4-431	A	0.5	0.5				
4-432	A	0.5	<0.5				
4-433	A	0.5	<0.5				
4-434	A	0.5	<0.5				
4-435	A	1	0.5				
4-436	A	1	<0.5				
4-437	A	2	<0.5				
4-438	A	1	<0.5				
4-439	A	0.5	0.5				
4-440	A	1	0.5				
4-441	A	0.5	0.5				
4-442	A	0.5	0.5				
4-443	A	1	<0.5				
4-444	A	0.5	<0.5				
4-445	A	0.5	0.5				
4-446	A	0.5	<0.5				
4-447	A	1	<0.5				
4-448	A	0.5	<0.5				
4-449	A	0.5	0.5				
4-450	A	<0.5	<0.5				
4-451	A	0.5	<0.5				
4-452	A	0.5	0.5				
4-453	A	0.5	<0.5				
4-454	A	0.5	<0.5				
4-455	A	<0.5	<0.5				
4-456	A	0.5	<0.5				
4-457	A	1	0.5				
4-458	A	1	0.5				
4-459	A	0.5	<0.5				
4-460	A	0.5	<0.5				
4-461	A	0.5	<0.5				
4-462	A	1	0.5				
4-463	A	0.5	<0.5				
4-464	A	0.5	1				
4-465	A	1	<0.5				
4-466	A	0.5	1				
4-467	A	<0.5	1				
4-468	A	1	<0.5				
4-469	A	1	0.5				
4-470	A	1	<0.5				
4-471	A	1	0.5				
4-472	A	1	<0.5				
4-473	A	0.5	0.5				
4-474	A	1	<0.5				
4-475	A	<0.5	<0.5				
4-476	A	1	<0.5				
4-477	A	0.5	0.5				
4-478	A	9	<0.5	5	10	200	
4-479	A	1	<0.5				
4-480	A	0.5	<0.5				
4-481	A	9	<0.5				
4-501	A	0.5	0.5				
4-502	A	3	0.5				
4-503	A	1	<0.5				
4-504	A	1	<0.5				
4-505	A	0.5	0.5				
4-506	A	0.5	<0.5				
4-507	A	1	<0.5				
4-508	A	1	<0.5				
4-509	A	0.5	0.5				
4-510	A	0.5	<0.5				
4-511	A	0.5	<0.5				
4-512	A	1	0.5				
4-513	A	1	1				
4-514	A	0.5	0.5				
4-515	A	0.5	1				
4-516	A	0.5	0.5				
4-517	A	0.5	1				
4-518	A	0.5	0.5				
4-519	A	<0.5	<0.5				
4-520	A	1	<0.5				
4-521	A	0.5	<0.5				
4-522	A	1	0.5				
4-523	A	1	1				
4-524	A	1	0.5				
4-525	A	0.5	2				
4-526	A	0.5	1				
4-527	A	<0.5	0.5				
4-528	A	0.5	<0.5				
4-529	A	0.5	<0.5				
4-530	A	0.5	0.5				
4-531	A	1	<0.5				
4-532	A	0.5	<0.5				
4-533	A	1	0.5				
4-534	A	1	<0.5				
4-535	A	1	0.5				
4-536	A	35	<0.5	10	10	225	
4-537	A	1	<0.5				
4-538	A	1	1				
4-539	A	2	0.5				
4-540	A	0.5	0.5				
4-541	D	0.5	<0.5				
4-542	A	1	0.5				
4-543	A	0.5	<0.5				
4-544	A	1	0.5				
4-545	A	2	1				
4-546	D	1	<0.5				
4-547	A	>45	1	5	50	200	
4-548	A	22	1	5	10	150	
4-549	A	2	0.5	20	10	75	
4-550	A	0.5	3	5	10	75	
4-551	A	17	11	37	10	75	
4-552	A	9	30	55	10	50	
4-553	C	4	7				
4-554	B	7	4	15	10	50	
4-1001	A	2	<0.5				
4-1002	A	<0.5	<0.5				
4-1003	A	0.5	<0.5				
4-1004	A	0.5	<0.5				
4-1005	A	1	<0.5				

1 Material: A, stream sediment; B, colluvial soil; C, rock; D, panned concentrate.
2 Citrate-soluble heavy metals.
3 Cold-acid-extractable copper.

TABLE 2.—*Semiquantitative spectrographic analyses*

[n.d., not detected. In all samples: Zn, <200; Cd, <50; Sn, <10; Be, <1; Bi, <30; As, <1,000; Sb, <200; W, <200; Nb, <50. Analyses by Elwin L. Mosier]

Sample No.	Description	Percent			Parts per million																
		Fe	Mg	Ca	Ti	Mn	V	Zr	La	Ni	Cu	Pb	B	Y	Mo	Co	Ag	Ga	Sc	Cr	Ba	Sr
4-60	Stream sediment ..	7	1.5	3	10,000	1,000	200	500	n.d.	50	30	15	20	15	n.d.	15	0.07	10	15	100	700	500
4-196	......do............	5	2	20	3,000	1,000	70	700	n.d.	15	20	n.d.	20	20	n.d.	<10	<0.07	10	10	70	500	200
4-215	......do............	5	1.5	3	7,000	1,000	100	500	50	20	50	n.d.	30	50	<1	10	0.07	15	15	50	500	200
4-229	......do............	10	5	10	10,000	1,500	200	500	n.d.	100	50	15	30	30	1	20	0.1	20	15	200	700	700
4-403	......do............	2	0	2	2,000	1,000	50	500	50	10	20	10	30	20	n.d.	n.d.	<0.07	15	5	15	500	200
4-478	......do............	1.5	1	5	700	500	20	70	n.d.	1	5	n.d.	10	n.d.	n.d.	n.d.	<0.07	n.d.	n.d.	10	200	n.d.
4-481	......do............	5	2	5	7,000	1,500	150	100	n.d.	20	20	10	20	15	<1	10	0.5	15	10	70	1,000	500
4-536	......do............	1.5	0.7	>20	1,500	200	200	50	n.d.	10	5	n.d.	n.d.	10	n.d.	n.d.	0.15	n.d.	n.d.	20	300	300
4-547	......do............	2	2	7	2,000	700	50	100	n.d.	10	10	10	30	10	n.d.	n.d.	0.1	10	n.d.	15	500	n.d.
4-548	......do............	3	3	>20	5,000	1,000	100	700	n.d.	7	20	15	30	30	n.d.	n.d.	n.d.	15	7	20	500	200
4-551	......do............	7	2	3	7,000	1,000	200	1,000	70	20	50	n.d.	20	50	n.d.	10	0.15	15	20	50	500	200
4-552	Colluvium near site 215	7	2	10	7,000	1,500	200	1,000	70	15	50	n.d.	10	50	n.d.	20	<0.07	15	20	30	500	300
4-553	Gneissic granite with stringers of metallic minerals	5	1	3	2,000	500	50	200	n.d.	5	200	n.d.	n.d.	n.d.	n.d.	10	0.1	20	n.d.	5	1,000	500

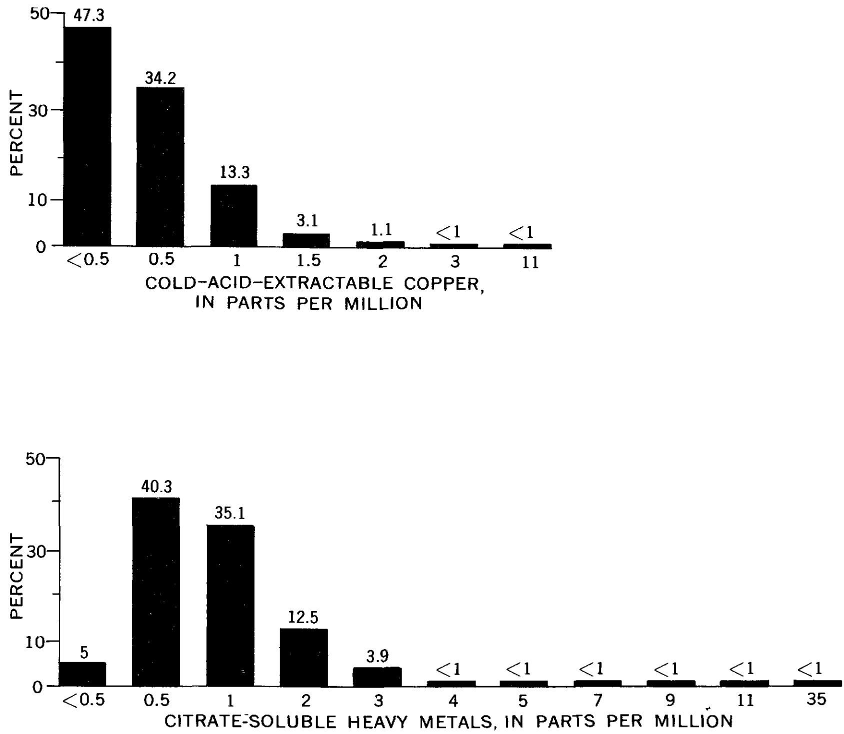

FIGURE 3.—Statistical distribution of cold-acid-extractable copper and citrate-soluble heavy metals.

copper, average amounts of copper and lead, 225 ppm zinc (about 1½ times the average amount), and 0.15 ppm silver (about twice the average amount normally detected in stream-sediment samples from this area) (tables 1, 2). The anomalous concentrations were traced about 400 feet upstream to a point where 45 ppm heavy metals was measured in sediment collected at the foot of a vertical cliff of Leadville Limestone. Stream water that carried the anomalous metal concentrations issued from a crevice in the limestone. Sediment at a spring about 250 feet farther northeast contained only 7 ppm heavy metals, which is considered to be a high background concentration. Without being able to trace the zinc-bearing spring water along its underground course to the source of the metals, it is difficult to assign significance to this anomaly. In the absence of alteration of the limestone in the vicinity, there appears to be little evidence of a significant mineral deposit.

Site 481.—Silty sand collected from the spring at the north end of the South Fork Campground contained 9 ppm heavy metals and 0.5 ppm silver—the highest silver value obtained from the Flat Tops area and about 7 times the average concentration in other samples from the area. The spring water is apparently derived from underflow in talus and must originate in the Leadville Limestone, but the limestone did not appear to be mineralized or altered in the vicinity. The source of the metals in the water is unknown; however the possibility of discovering a significant mineral deposit in this area appears slight.

Site 196.—A tributary on the south side of the South Fork of the White River contains sediment carrying 11 ppm heavy metals and average amounts of other elements. The anomalous heavy-metal concentration was traced upstream to the uppermost seeps issuing from the joints and bedding-plane fractures of the Sawatch Quartzite in the east fork of the stream. Silty sand with abundant fragments of calcareous tufa at this site contains more than 45 ppm heavy metals, 1 ppm cold-acid-extractable copper, 200 ppm zinc, 0.1 ppm silver, and average amounts of copper and lead. No alteration of the quartzite was noted. Sediment collected in the south fork of this stream contains only 3 ppm heavy metals, thus restricting the anomaly to the seep area in the east fork. Colluvial soil from the east fork above the seeps contains 11–17 ppm heavy metals and similar soil collected at the base of the Leadville Limestone contains only 3 ppm heavy metals. The Leadville Limestone is unaltered. The metals in the stream sediment apparently are being carried by the spring water seeping out of the Sawatch Quartzite, but the source of the metalliferous water is unknown. The water, which flows westward down the regional dip, must derive its metals from a source to the east. Thus, even if the ultimate source of the metals is rich enough to be of economic significance, it would undoubtedly be outside the primitive area.

Site 403.—Colluvial soil in a steep gully that is tributary to Lost Solar Creek from the west, about half a mile above its confluence with the South Fork of the White River, contains 9 ppm heavy metals. Because this gully drains across the Blair Mountain fault (Bass and Northrop, 1963, pl. 1) and is just north of a zone of highly fractured and altered granite, it was checked thoroughly. The granite west of the fault is moderately iron stained, pyritized, and altered to chlorite and epidote along fractures. This brecciated and altered zone appears to be restricted to the Blair Mountain fault. Soil over the altered granite contains only 1 ppm heavy metals, indicating that base metals are absent. Samples of colluvial soil in the gully were collected up to the base of an impassable cliff of Sawatch Quartzite. The uppermost sample contains only 7 ppm heavy metals—not a significant anomaly. The intermittent stream that flows down this gully may carry enough metals from a source higher in the geologic section to produce the 9-ppm value originally obtained, but there is no evidence of a significant mineral deposit in the area.

Site 215.—Highly organic silty clay was sampled from a spring issuing from the toe of a talus pile in a small gully cut in Precambrian gneissic granite on the northeast side of the South Fork of the White River about 1 mile north of the mouth of Patterson Creek. This sample (4–215, table 2) produced the highest cold-acid-extractable copper value obtained during the reconnaissance geochemical sampling—11 ppm—but contained only 3 ppm citrate-soluble heavy metals. Analyses for total metals showed 55 ppm copper, 25 ppm lead, 100 ppm zinc, and 0.07 ppm silver. Only the copper is considered somewhat above average, and that not highly so.

The field check of this anomalous sample led to seeps on the north wall of the gully in an area of strongly iron-stained granite. The canyon wall was impossible to climb, but examination of many talus blocks disclosed abundant epidotized veinlets, some of which include stringers of pyrite, magnetite, and chalcopyrite. As shown by a polished section examined by B. F. Leonard of the U.S. Geological Survey, the stringers also contain specular hematite, a few inclusions of pyrrhotite in the pyrite, and goethite pseudomorphous after pyrite with unaltered relict inclusions of chalcopyrite. This assemblage of minerals is suggestive of a fairly high temperature of formation, and very probably indicates that the minerals were formed during Precambrian time rather than after deposition of the overlying sedimentary rocks, for there is no evidence of any high-temperature alteration of the sedimentary rocks. Spectrographic analysis of the rock containing the stringer of metallic minerals (sample 4–553, table 2) shows no exceptional concentration of metals except copper. The copper value (200 ppm or 0.02 percent) is far below ore grade. The relatively high copper content of the stream sediment evidently results from deposition by ground water that has seeped through a multitude of small fissures in the granite, dissolving copper from the chalcopyrite scattered along the stringers. There is no evidence of a mineral deposit of commercial significance.

Site 229.—Sediment collected from the floor of an active spring in the upper part of Park Creek contains 9 ppm heavy metals, less than 0.5 ppm cold-acid-extractable copper, and average amounts of copper, lead, zinc, and silver. This spring rises at the approximate intersection of several faults. Sediment from a tributary to Park Creek from the southeast, which may flow along the trace of one of the intersecting faults, contains 4 ppm heavy metals and average amounts of other elements (sample 230). Rocks in the area are not noticeably altered; the area has no evident mineral potential.

Other sites with anomalous samples.—Samples 4–60 and 4–153, from sites 60 and 153 were collected along the south side of the Flat Tops area where the Leadville Limestone is exposed. According to Bass and Northrop (1963, pl. 1) faults cut the sedimentary rocks near site 60.

Such faults could provide access for mineralizing solutions. Both samples yielded slightly high citrate-soluble heavy-metal values (5 and 4 ppm, respectively) but analyses for total metals showed nothing anomalous. There appears to be no geochemical evidence of a significant mineral deposit at either site. Sample 4 from site 102, south of the area shown on plate 2, contained 30 ppm citrate-soluble heavy metals and 175 ppm zinc. It was collected 100 feet below a spring in which a rusty galvanized pipe was discovered, and the high content of zinc obviously represents contamination.

Sample 4–414, which contains 7 ppm heavy metals, was collected in a tributary to the Fraser Lake inlet to Trappers Lake. No bedrock is exposed in the area, and it is thus difficult to assess the meaning of this anomalous concentration. Inasmuch as the area drained by this stream apparently is underlain by Pennsylvanian and Permian rocks, which are not considered promising hosts for metallic mineral deposits, the anomalous concentration is not considered highly significant in terms of mineral potential.

The geochemical evaluation of the metallic mineral potential of the Flat Tops primitive area indicates that possibilities for the occurrence of an economically significant metallic mineral deposit in the area are extremely limited. As a whole, the metal values obtained by analysis of samples of stream sediment are low in comparison with values that one might reasonably expect for a significantly mineralized area. Aside from one prospect tunnel with little economic significance, metallic minerals were seen in only one occurrence, in small stringers of probable Precambrian age and of no economic significance. No evidence was noted of alteration of the country rock such as commonly occurs near significant mineral deposits. None of the few samples selected for gold analysis contained detectable amounts of this element.

The highest geochemical values were obtained from streams that drain the Leadville Limestone or older rocks along the strongly faulted crest of the White River uplift. Many of these streams are fed by springs issuing from the sedimentary rocks. The metals in the stream sediment evidently are carried in the spring water and could be derived from low-grade concentrations of metals. The faults along the crest of the White River uplift provide channelways for ground water to circulate through the rocks, carry away some of the metals, and eventually deposit them in stream sediment.

No radioactivity anomalies were discovered in the northeastern part of the primitive area, which was checked for uranium, nor was any evidence of uranium minerals disclosed by the sodium fluoride fluorescence test of the heavy-mineral concentrates. Uranium deposits have not been reported from the area by prospectors.

OIL AND GAS

The Flat Tops primitive area is underlain by sedimentary rocks that conceivably could contain gas and oil, but for several reasons the gas and oil potential is classed as poor.

In the distant geologic past the South Fork area was at a modest structural altitude similar to its surroundings. Later it was domed upward to its present high altitude. During and after the period of doming and uplift of the White River Plateau, oil and gas which may have been present in sedimentary rocks of the region probably migrated through permeable strata updip into the crestal area. Because the sedimentary rocks here are so nearly horizontal, oil and gas if once present must have existed in thin and widespread reservoirs.

The unusually high topographic altitude of the plateau (11,000 feet above sea level) caused Lost Solar Creek, Park Creek, and the South Fork of the White River to cut through the sedimentary layers and deep into the Precambrian basement at the structurally highest parts of the dome. Oil and gas pools which may once have been present found abundant escape routes to the atmosphere along the canyon walls many hundreds of thousands of years ago. Since that time meteoric water has percolated through the rocks and flushed out any remnants of oil, gas, or connate salt water which may not have found escape through the release of hydrostatic pressure.

Throughout the primitive area no vestiges of oil or gas seeps were seen, nor have any been reported by long-term residents or sportsmen. A few leases have been acquired, but no wells have been drilled. The chances for discovery of oil or gas in economic quantity in the South Fork area are rated low.

Prospects for oil and gas in the Pyramid area are better, but not good. Topographic elevation averages about 10,000 feet. The Leadville Limestone is buried at depths ranging from 3,000 feet above sea level to 2,000 feet below, and it is therefore found at depths from 7,000 to 12,000 feet below ground surface where connate fluids can be expected in the sedimentary strata.

Several formations may locally have adequate porosity to serve as reservoirs. Among these are the Dakota Sandstone, the Morrison Formation, the Entrada Sandstone, the Weber Sandstone, and possibly a few zones in the sandstone and limestone beds in sedimentary rocks older than Pennsylvanian. Structural attitude, however, is not favorable for oil or gas accumulation in the Pyramid area. Except on the Poose Creek anticlinal nose, the dip is homoclinal northeastward, a condition which would have allowed oil or gas to migrate southwest toward the South Fork area and to escape. Some fluids migrating southwest may have been diverted northwestward up the plunge of the Poose Creek anticlinal nose and beyond the boundary of the primitive area.

Phillips Petroleum Co. drilled a well (outside the primitive area) at or near the crest of this structure, but no significant shows of oil or gas were found.

A separate structural closure within the Pyramid area is implied on Kucera's map (1962) by an inlier of Dakota Sandstone on the axis of the Poose Creek anticline in secs. 24 and 25, T. 2 N., R. 88 W. (the vicinity of Blue Mountain Creek and Bridge Creek). Structural closure would suggest a reasonable possibility of oil and gas accumulation in porous formations at depth in this location. Hence, intensive search was made in the field for this outcrop. No indication of Dakota Sandstone could be found. Furthermore, 2 miles northwest of the primitive area boundary, the Dakota Sandstone can be observed dipping southeastward in a roadcut. The observed outcrop is on the axis of the Poose Creek anticline, which plunges to the southeast. Structural closure on the anticline, within the Pyramid area, therefore cannot be demonstrated by surface geology.

Two exploratory wells for oil and gas have been drilled on anticlines near the Pyramid area. These are (1) Phillips Petroleum Co. Poose Creek 1 in SE¼NW¼SE¼ sec. 10, T. 2 N., R. 88 W., about 2 miles northwest of the boundary of the primitive area, and (2) the Humble Oil and Refining Co. Government-Crosho Lake 1 in SE¼NE¼ sec. 13, T. 2 N., R. 87 W., about 2 miles northeast of the primitive area. The Phillips well was drilled into rocks of Cambrian age; the Humble well reached Precambrian basement. Neither well yielded any indication of oil or gas.

A 9-foot section of drill core from the upper part of the Weber Sandstone in the Phillips well consisted of hard quartzite with traces of gilsonite and water. No other zones in the hole were considered to merit testing by the Phillips Co. Because the Phillips well is at or near the crest of the Poose Creek anticline, this structure is considered tested for oil and gas. The Humble well was drilled on the Heart Lake anticline which also trends northwest, parallel to the Poose Creek anticline, and is outside the primitive area. A drill-stem test by the Humble Co. in the Frontier Sandstone Member of the Mancos Shale recovered only drilling mud. A similar test in the Dakota Sandstone by the Humble Co. recovered water-cut mud, and two other tests in beds of Pennsylvanian age recovered drilling mud and nonflammable gas, probably air or carbon dioxide.

The absence of demonstrable closed structure and the strong northeast homoclinal dip in the Pyramid area render this part of the primitive area unlikely for structural accumulation of oil or gas. There is a possibility that the Weber Sandstone thins to wedge edge within the Pyramid area, but the thinning takes place in a northeasterly direction, down the homoclinal dip. Hence this formation could not form a stratigraphic trap. All other formations present in the area have regional extent and fairly constant lithology and therefore do not invite exploration for stratigraphic accumulations of oil or gas. Oil is produced from fractured zones in the Mancos Shale in several places in Colorado, but methods of systematic exploration for this type of production have not been developed; hence it is not feasible to drill wells at random where this possibility is the sole objective. In view of the conditions outlined above, the Pyramid area must be considered economically unattractive for oil and gas.

COAL

Coal is produced in the Yampa field of northwestern Colorado from the Iles and Williams Fork Formations of the Mesaverde Group (Cretaceous) and from the Lance and Fort Union Formations (Tertiary). Because the Mancos Shale, which underlies the Mesaverde Group where both are present, is the youngest formation in the primitive area (except for the basalt caprock and the Quaternary surficial deposits), there are no prospects for coal. Production nearest to the area is in the vicinity of Oak Creek, about 15 miles from the Pyramid area.

GYPSUM

The Eagle Valley Evaporite is composed of gypsum in the vicinity of Turret Creek and W Mountain. It is not exposed within the primitive area, however, but is present beneath a thick cover of basalt. Adjacent to the primitive-area boundary the gypsum is covered for a mile or more by slide rock and gravel deposits. A few miles away in the valleys of the Colorado and Eagle Rivers, abundant and easily accessible outcrops of gypsum render the deeply buried deposits of the primitive area of questionable economic value.

Salt commonly occurs in the central parts of basins that contain gypsum and anhydrite. The gypsum in the primitive area seems to be located in the peripheral part of a basin; hence the presence of salt in commercial quantities is considered possible but remote.

ECONOMIC APPRAISAL

By Ronald B. Stotelmeyer, U.S. Bureau of Mines

INTRODUCTION

The U.S. Bureau of Mines mineral occurrence investigation consisted of the compilation of data on past mineral production through search of Federal and County records and interviews with local residents. In addition, minability of known deposits was determined by locating, mapping, and sampling two prospects in the primitive area reported to be sites of former mining activities (fig. 4). Also investigated were known occurrences of minerals adjacent to the primitive area.

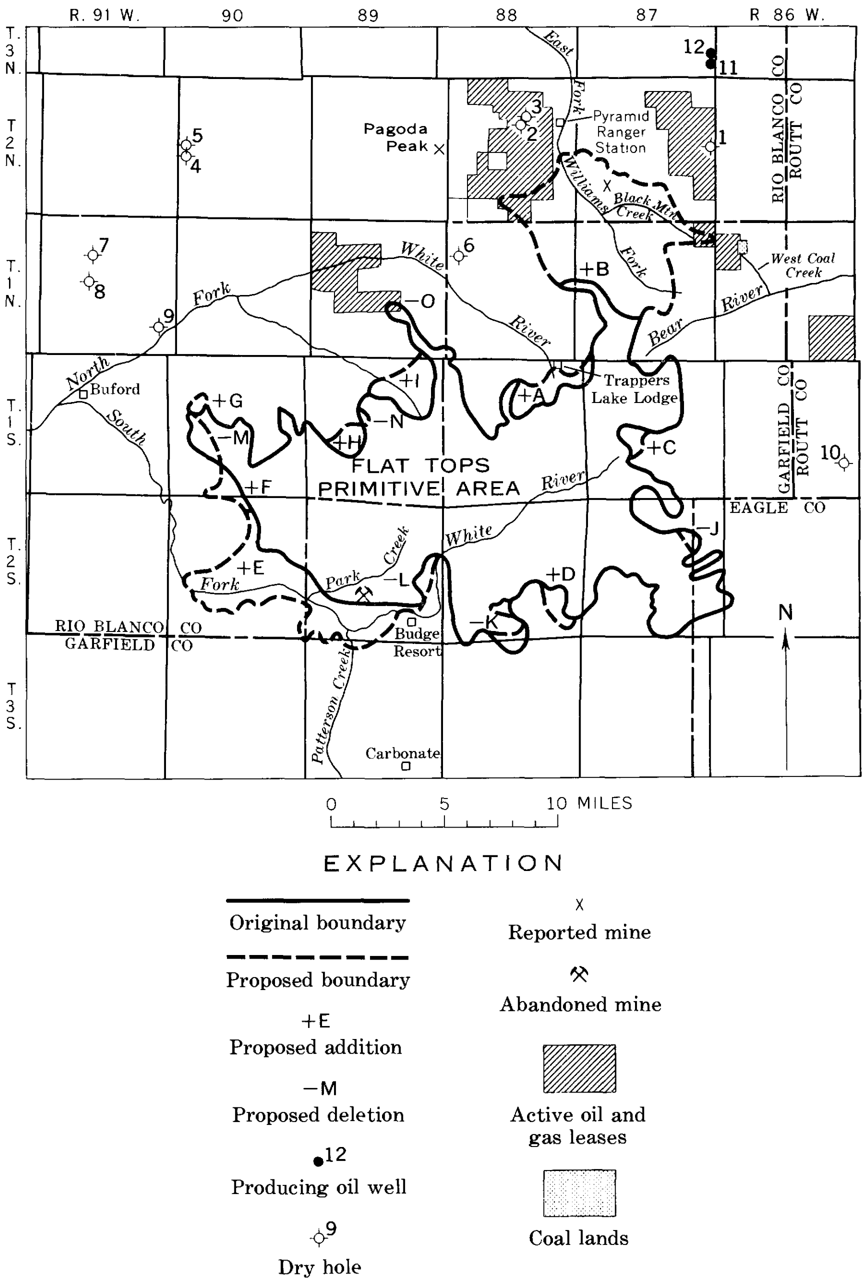

FIGURE 4.—Map of Flat Tops primitive area showing proposed boundary changes and sites of prospecting activity.

Investigations within the primitive area by the author included field trips made in August and September 1965. Travel within the area was by horseback and on foot.

The first field investigation consisted of general reconnaissance trips into the north half of the primitive area, jointly with William Mallory and Paul J. Ruane of the U.S Geological Survey. During the second field trip, a lead-silver prospect near the confluence of Park Creek and the South Fork of White River, shown as an abandoned mine in figure 4, was sampled and mapped. Robert L. Bolmer, U.S. Bureau of Mines, accompanied the author. The third field trip was made in company with Matthew J. Sheridan, U.S. Bureau of Mines, to examine a reported gold mine that had been mentioned by a forest ranger. This reported occurrence, near Black Mountain Creek in the part of Routt National Forest proposed for inclusion in the wilderness area, had been sighted on the second field trip but could not then be reached because of bad weather.

In addition to the field investigations within the area and interviews with local residents, U.S. Bureau of Land Management and U.S. Forest Service records, plus courthouse records in Eagle, Garfield, and Rio Blanco Counties, were examined.

The cooperation extended by the U.S. Forest Service, U.S. Bureau of Land Management, U.S. Geological Survey, and various county officials is gratefully acknowledged.

METALLIC MINERAL DEPOSITS

DADE PROSPECT

The location of the abandoned lead-silver prospect is shown in figure 4. Aerial photographs were used to determine the exact location of the prospect site (sec. 29, T. 2 S., R. 89 W., sixth principal meridian, unsurveyed). Bearings to the site are: from the confluence of Patterson Creek and the South Fork of the White River, N. 9°15′ E.; from the confluence of Park Creek and South Fork, S. 76°30′ E. The prospect entrance is at an approximate altitude of 10,000 feet on a steep slope 1,800 feet vertically above the South Fork of the White River. The prospect can be seen from the opposite canyon wall nearly 2 miles to the southwest. Available maps are not sufficiently detailed to determine if the prospect is in the primitive area or in proposed tract addition E. If the outcrop of the basalt capping defines the original boundary, the prospect is in the addition.

Two lode claims, the Mile High and Miners Dream, were located September 20, 1940, and recorded October 30, 1940, by Earl Cook and John B. Dade (both deceased). Presumably the claims were at the just-described site although no markers or monuments were found. A local resident confirmed that it was the Dade prospect. The locations of the two claims are recorded at the Garfield County Courthouse, Glenwood Springs, Colo., in book LR2A, pages 194 and 195. According to the records, "corner No. 1 of the Mile High is located approximately 3,600 feet southeasterly from the cabin known as the Nigger Cabin, said cabin being about 2,500 feet easterly from Park Creek, sec. 20, T. 2 S., R. 90 W. * * *." "Corner No. 1 of Miners Dream is located 4,200 feet southeasterly from the cabin * * *." The section and range differ from that plotted from field examination and probably represents an error on the part of the locators; the area is unsurveyed. Notices "In Lieu of Annual Labor" were filed June 16, 1942 (book 201, p. 397), and June 30, 1947 (book 228, p. 156).

No production from the prospect had been recorded by the U.S. Bureau of Mines. Rawleigh Dade, residing at Sizemore's Resort, Buford, Colo., stated that his father, John Dade, had recovered silver from the prospect. Local residents stated that lead had been recovered.

Workings consist of a 45.5-foot adit and small stoped areas. The prospect is at the base of the 100-foot-high cliffs of the Leadville (Mississippian) Limestone. Bearing of the adit is N. 10° E. The adit is 2.5 feet wide except at the principal stoped area where the width increases to 8.5 feet. The stope begins 15 feet from the portal and ends 23 feet from the portal. Other pockets have been mined in the two mineralized zones on both walls. The largest area is a pocket 4 feet square that extends into the wall 2 feet. Mining equipment at the site includes a wheelbarrow, pick, shovel, and handheld drill steel. It is not certain how much of the adit is a solution cavity and how much was excavated. No dump is present because of the steep slope of the canyon wall at the mouth of the adit; much slide material covers the slope.

Coarse crystalline calcite is exposed in a bed 12–24 inches thick near the bottom of the cliff formed by the Leadville Limestone. The bed extends along the entire face of the cliff, so far as could be determined. This bed is associated with the mineralization at the prospect site. The workings appear to be an artificial enlargement of a solution cavity formed where the calcite bed became vuggy. A crack extends from the roof of the adit to the top of the limestone cliff but does not appear to be related to the mineralization. The vugs are in two roughly parallel mineralized zones, which are each about 6 inches wide and are 2 feet apart. They are interconnected, particularly at the largest stoped area, and come together approximately 33 feet from the portal and disappear at the end of the adit. Galena occurs as aggregates of crystals, the largest individual crystals being half an inch square in cross section. Dogtooth calcite crystals, quartz crystals, and an unidentified reddish-brown mineral are present. Oxidation of sulfides is evident, and a green mineral, probably malachite, was seen.

Samples taken across each of the two 6-inch mineralized zones as-

TABLE 3.—*Chemical analyses of samples from abandoned lead-silver prospect*

Sample No.	Locality	Ounces		Percent			Parts per million
		Au	Ag	Cu	Pb	Zn	Au
RS1	Upper 6-inch zone	<0.005	1.94	0.03	24.5	0.10	......
RS2	Lower 6-inch zone	< .005	.28	.03	5.95	.05	......
RS4	Volcanic vent (central area)	......	.....	.....	.....	.....	<0.05
RS5	Volcanic vent (wallrock)	......	.....	.....	.....	.....	< .05

TABLE 4.—*Spectrographic analyses of samples from abandoned lead-silver prospect*

[Probable ranges, in percent: A, >10; B, 1–10; C, 0.1–1.0; D, 0.01–0.1; E, 0.001–0.01; F, 0.0001–0.001]

Sample No.	Locality	Ag	Al	Ba	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Pb	Rb	Si	Sr	Ti
RS3	Adit floor	D	C	F	A	..	..	D	C	D	B	C	E	..	B	..	B	D	E
RS4	Volcanic vent (central area)	..	B	D	B	D	E	E	B	B	B	D	B	D	D	E	A	D	C
RS5	Volcanic vent (wallrock)	..	B	D	B	D	D	E	B	B	B	D	B	D	D	F	A	D	C

sayed 24.5 and 5.95 percent lead and 1.94 and 0.28 ounces silver, respectively (table 3). A spectographic analysis was made of loose specimens from the adit floor (table 4). There is no recorded production from this prospect.

GOLD PROSPECT

Information regarding a so-called gold mine in proposed tract addition B (fig. 4) was checked by field examination. No evidence of a mine was found. There is a light-brown area in the basalt at the location of the reported mine; when viewed from a distance, it resembles an oxidized mine dump. The location was confirmed as the site of the reported gold mine by Gaylord Walters, U.S. Forest Service, Yampa district. The location is in sec. 29, T. 2 N., R. 87 W., S. 75° E. from Pagoda Peak and N. 30° E. from the west summit of Lost Lake Peaks (fig. 4). The stained area is at an altitude of approximately 10,700 feet, which is about 1,400 feet above the East Fork of Williams Fork of the Yampa River.

The "prospect" was reportedly worked by Bennett and Martin, at least 40 years ago. County records show no claim locations by the two men, and no production has been recorded.

The area is assumed to be a volcanic vent. The central weathered part, roughly oval, is elongated north-south, being 100 feet long and 300 feet wide. Basalt wallrock on the north side is heavily iron stained for 150 feet beyond the edge of the central "core," and on the south side is similarly stained for 50 feet. The central area consists of various rock types distinctively stratified. One bed, 5 feet thick, resembles a weathered sandstone and is probably a coarse volcanic tuff. Another bed, thickness unknown, resembles a sedimentary conglomerate. It contains rounded boulders and pebbles having an apparent composition and texture comparable to a granite or intermediate rock. All the rocks in the central area contain abundant ferromagnesian minerals that could have been the source of the overall oxidized appearance of the vent area.

Analyses of samples from the central area and the wallrock are given in tables 3 and 4.

URANIUM POSSIBILITIES

Interviews with local residents revealed that the Flat Tops primitive area had been extensively prospected for uranium, but no discoveries were made. Records of U.S. Forest Service surface-rights determinations show a large number of unpatented claims in T. 2 N., Rs. 91 and 92 W., between Uranium Peak and Sleepy Cat Peak, outside the primitive area. These claims and other isolated claims north of the primitive area were located for uranium and are in formations not exposed within the proposed boundaries.

PETROLEUM AND NATURAL GAS

Active oil and gas leases in the vicinity of the proposed area are shown in figure 4. Table 5 lists sections containing leases in each township and gives the status of past leasing activity. Active leases within the proposed tract addition B are as follows:

Township	Range	Section	Bureau of Land Management Entry No.	Date of lease
2 N.	88 W.	26, 27, 28, 34	017735	7-1-58
2 N.	88 W.	NE¼ 33	0117165	3-1-64
1 N.	87 W.	1	018428	5-1-58
1 N.	89 W.	22	107736	9-1-57

TABLE 5.—*Oil and gas leasing near the Flat Tops primitive area*

Township	Range	Section	Lease status
2 S.	86 W.	18, 19, 30	Terminated.
1 S.	87 W.	1, 2, 3, 11, 12	Terminated or withdrawn.
1 N.	86 W.	S½ 6, 7, 25, 26, 35, 36	Active.
1 N.	87 W.	1	Active. (Most of township was leased.)
1 N.	88 W.	....	Terminated.
1 N.	89 W.	S½ 6, 7, 8, 9, 17, 18, 20, 21, 22	Active. (Other leases have terminated.)
2 N.	87 W.	S½ 2, S½ 3, E½, 10, 11, 12, 13, 14, 23, 24, 25	Active. (Entire township was previously leased.)
2 N.	88 W.	SW¼ 2, S½ 3, 4, 5, NE¼ 9, NE¼, NW¼ 9, 10, 11, 14, 15, 16, E½ 20, S¼ 21, 22, 23, 26, 27, 28, 29, 31, NE¼ 33, 34	Active. (Other leases have terminated.)

None of the sections listed are entirely within the primitive area.

Wells drilled near the area are shown in figure 4. All were dry except three wells at locations 11 and 12, in sec. 25, T. 3 N., R. 87 W. Production from two wells at location 12 is from the Shinarump Member of the Chinle Formation, in the Pinnacle Field, and has totaled 98,000 barrels of oil and 14 million cubic feet of natural gas in the period 1960–64. The well at location 11 in the same field had an initial production in 1956 of 9 barrels of oil per day. Production was from the Dakota Formation and totaled 1,000 barrels of oil and 33 million cubic feet of natural gas through 1964. Late in 1963 the well was shut in, but production of gas continued, amounting to 10 million cubic feet in 1964.

COAL

An occurrence of coal near the east boundary of the proposed tract addition B (fig. 4) was verified by interview with the owner of private land containing the deposits. (This land is not in the primitive area.) Deep snow prevented a field investigation of the area. The private coal land, shown in figure 4, is in parts of secs. 5, 6, 7, 8, T. 1 N., R. 86 W., 12 miles by road from Yampa, Colo. The coal exposures are along the canyon walls of West Coal Creek. Because of the prevailing east dip of the strata west of the coal exposures, the coal-bearing beds are not present in the primitive area.

Blaine D. Whaley, Phippsburg, Colo., owns the property. The coal reportedly occurs as five flat-lying seams having shallow overburden. Maximum thickness of any one coal seam is 12 feet. Maximum distance between seams is 20 feet. According to local residents, the coal was mined in pioneer days for use in blacksmithing. The deposit is in a remote area and has never been commercially exploited.

Analyses (in percent) of the coal were made in November 1950 by Albert Keenan, Engineer of Mines, Golden, Colo., for M. F. Oliphant, Chatfield, Tex., as follows:

	Material sampled[1]			
	Top vein		2d vein (8 ft inside portal)	
	As received	Moisture free	As received	Moisture free
Moisture	5.69	.....	5.89	.....
Ash	3.01	3.19	7.88	8.37
Volatile	39.33	41.70	37.99	40.37
Fixed carbon	51.97	55.11	48.24	51.26
Total	100.00	100.00	100.00	100.00

[1] Btu: 11,000–13,000. Sulfur: 1.1 percent.

OTHER MINERALS

Records of the U.S. Geological Survey, Denver, Colo., show no mineral leasing activity, other than oil and gas, in the primitive area or in immediately adjacent areas.

The nearest patented lode claims are in sec. 35, T. 3 S., R. 89 W., approximately 5 miles south of the area. The claims were patented in 1890–95 and are near the site of the former town of Carbonate (fig. 4). No production figures are available.

Zeolites were observed in the basalt above the lead-silver prospect. Individual white spheres as large as three-quarters of an inch in diameter were present. In only a few locations was the mineral concentrated enough to be seen from a distance of 100 feet.

MINERAL POTENTIAL

Available data indicate little potential for oil and gas and no coal potential in the primitive area. At the Dade lead-silver prospect, a commercial operation is not feasible, on the basis of the observed mineral occurrence. A few hundred pounds of material in sight could possibly be mined, but the size of the deposit indicates it has no significant potential.

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