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Preliminary Report on the Mineral Resource Potential of the Teton Wilderness, Teton, Fremont, and Park Counties, Wyoming

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and

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with sections on

Geology

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Interpretation of Geophysical Data

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for description purposes only and does not imply endorsement by the USGS.

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STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting 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, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Teton Wilderness, Teton-Bridger National Forest, Teton, Fremont, and Park Counties, Wyo. The area was established as a wilderness by Public Law 88-577, September 3, 1964.

MINERAL RESOURCE POTENTIAL
SUMMARY STATEMENT

The Teton Wilderness is underlain mainly by several kinds of sedimentary rocks. Therefore mineral resources are most likely to be associated with processes involving sedimentation rather than igneous activity. Although a slight possibility exists for other types of mineral deposits, this investigation has shown that mineral commodities most likely to be present are oil and gas, gold in placers, phosphate, coal, gypsum, building stone, sand and gravel, and metals in black shales.

The area has a moderate resource potential for oil and gas in several anticlines, fault-trap structures, and stratigraphic traps. Most of the anticlines and fault-trap structures have at least several possible producing horizons within a depth range of 1,000 to 10,000 ft. The Wolverine and Whetstone anticlines are the largest, and the areas of these anticlines have the most likely resource potential for oil and gas. If the postulated Younts basin is filled with sedimentary rocks 20,000 ft thick, it also has a moderate resource potential for oil and gas.

The Teton Wilderness has a low to moderate resource potential for gold, mainly in placer deposits. Gold in significant quantities was found in alluvial deposits along several major streams that drain areas of gold-bearing conglomerate in the Harebell Formation and Pinyon Conglomerate. The wilderness has a low resource potential for copper, molybdenum, zinc, and other metals, which occur in small amounts in black shale at the base of the Amsden Formation, and for molybdenum in several black shale units of Eocene age. Several intrusions of Tertiary igneous rocks in the eastern part of the wilderness were examined for mineral deposits; no mineral deposits were observed, but geophysical and weak geochemical anomalies are associated with the intrusions of Younts Peak and Thunder Mountain.

Although copper prospects are present in Precambrian rocks along South Buffalo Fork River, the area has a low resource potential for copper in Precambrian crystalline rocks.

A part of the Jackson Hole coal field lies within the Teton Wilderness. Although coal beds occur at several localities in the Meeteetse and Mesaverde Formations, in the Sohare sequence, Bacon Ridge Sandstone, and Frontier Formation, the beds are not thick enough to consider the wilderness as having other than a low resource potential for coal. An unknown but small amount of coal was produced about 1910 by the U.S. Bureau of Reclamation from a mine on Pilgrim Creek, which is now within the wilderness.

Bentonite, gypsum, pumicite, phosphate, glauconite, building stone, and sand and gravel deposits are present in the wilderness, but are too remote or too low grade to be competitive with other deposits that are more accessible, of higher grade, or nearer to markets.

The wilderness has a low potential for geothermal resources.

INTRODUCTION

Location

The Teton Wilderness is located in Teton, Fremont, and Park Counties, Wyo. It was established by the U.S. Forest Service in 1955 and consists of 563,500 acres. The wilderness lies directly south and southeast of Yellowstone National Park and east of the Teton Corridor and Grand Teton National Park. It is entirely within the Teton-Bridger National Forest. The relation of the Teton Wilderness to topographic and geographic features is shown in figure 1 (some additional features appear in fig. 2). The area is mountainous, with maximum relief of more than 5,000 ft. U.S. Highway 26-287 skirts the southern margin. There are no roads within the wilderness.

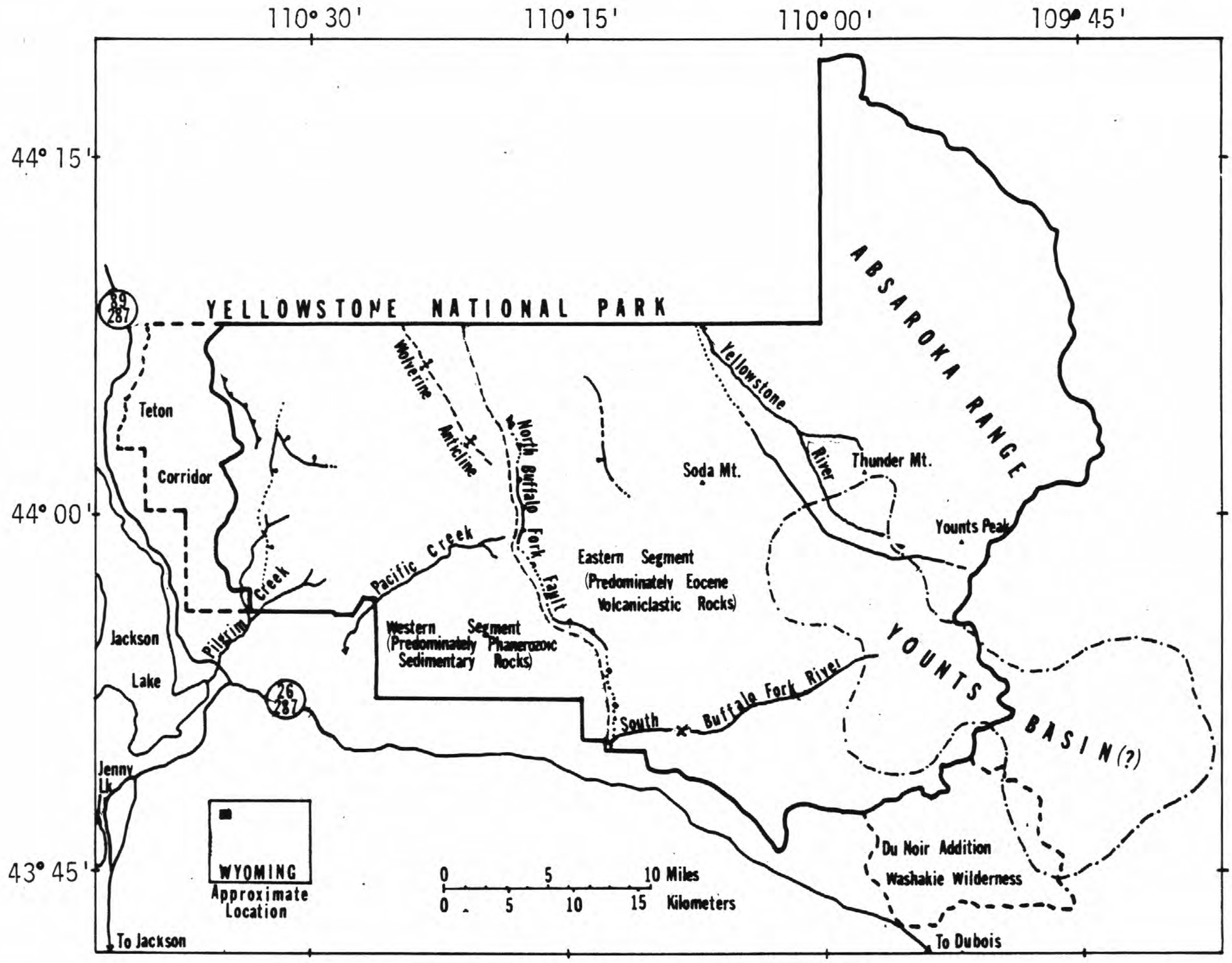
This report describes the most important features of the wilderness as they pertain to mineral resource potential.

The Teton Corridor (Love and others, 1975) and the Du Noir Addition to the Washakie Wilderness (Prostka and others, 1979), which are contiguous to the Teton Wilderness (fig. 1), were evaluated for mineral resources in conjunction with the Teton Wilderness study. Some aspects of the resource potential of those areas are pertinent to the Teton Wilderness and are discussed here.

Previous studies

Several published geologic maps and reports aided in the field study and preparation of this report. The Teton County reconnaissance geologic map (Love, 1956) covers all but the extreme eastern and northeastern part of the wilderness area. A block diagram and cross sections (Love and others, 1973) show the general structure of the western part of the area. The Teton Corridor geologic map (Love and others, 1975) bounds the west side of the wilderness. A map showing the geology of Yellowstone National Park, directly north of the western part of Teton Wilderness, was published by the U.S. Geological Survey in 1972. A more detailed map of pre-volcanic rocks in the park was made by Love and Keefer (1969), and these rocks were described in detail later (Love and Keefer, 1975). The stratigraphy of the Eocene volcanic rocks in the region was described by Smedes and Prostka (1972). Rhyolitic welded tuffs in the western part of the wilderness were mapped and classified by Christiansen and Blank (1972) in connection with Yellowstone National Park studies.

The oil and gas possibilities of this area were recognized in early geologic mapping; the Wildcat, Whetstone, Hancock, and Wolverine anticlines were mapped, detailed stratigraphic sections were measured, and extensive fossil collections were made (Love, Hose, and others, 1951). A detailed geologic map of the Spread Creek area, just south of the wilderness area, also was published (Love, Keefer, and others, 1951). Generalized geologic maps were published later (Love and others, 1955; Love, 1956). As a part of a



EXPLANATION

Approximate boundary of Teton Wilderness

Approximate boundary of other study areas

Approximate boundary of Younts basin

Normal fault--Bar and ball on downthrown side; dashed where approximately located; dotted where concealed

Thrust fault--Barbs on upper plate; dashed where approximately located; dotted where concealed

x Prospect

Figure 1.--Location of Teton Wilderness and contiguous study areas, northwest Wyoming.

metals investigation, additional mapping and stratigraphic studies were made between 1965 and 1971 (Antweiler and Love, 1967; Love, 1973; Lindsey, 1972).

Present studies

Field investigations were conducted during the summers of 1972-74. Primary emphasis was on obtaining adequate samples for chemical and spectrographic analyses from all mappable rock and alluvial units, and from springs that were suspected of having abnormal mineral content. Special attention was given to areas where geologic mapping and stratigraphic studies were incomplete. An aeromagnetic survey was made by the U.S. Geological Survey in 1967 and a gravity survey in 1974. Completion of a final report was delayed by fire in the U.S. Geological Survey, Building 25, Denver Federal Center, Denver, Colo., offices in March 1976, resulting in destruction of field notes, map compilations, analytical data, and rock and mineral specimens.

A mineral survey of the Teton Wilderness was made by the U.S. Bureau of Mines in 1972-74. The work consisted of: (1) a search of county, State, and Federal records for information on mining claims, mineral leases, mineral occurrences, and mineral production within the Teton Wilderness; (2) a review of the geology, mineral exploration, and mining history of the region; (3) a field reconnaissance that included searching for evidence of mineral deposits looking for signs of activities related to mineral exploitation, and collection of stream-sediment samples; and (4) taking cubic foot samples of Quaternary gravels and an examination of mining claims and prospects. U.S. Bureau of Mines samples were analyzed by the Reno Metallurgical Research Center, U.S. Bureau of Mines, Reno, Nev.

Acknowledgments

In addition to preparation of the section on geology, J. D. Love contributed significantly to several other parts of this report, most notably those on energy resources, geothermal resources, and radioactive springs.

Geologic assistants were Gregory K. Lee (1973-74), David Phelps (1973), Dan Fuqua (1974), and Joseph L. Weitz (1973-74). Volunteer geologic field assistance was provided by Ron and John Antweiler (1972-74). Emil Feuz and Bob Johnson furnished horses and greatly aided the work with their wrangling expertise and assistance with camp chores and sampling. Helicopter pilots Roman Ochotsky, Tom Rice, and Virgil Jones provided transportation in remote parts of the area.

We are indebted to W. B. Hall and Helaine Walsh for providing low-level, stereo, air-oblique color photography that facilitated advance planning of the field program, helped locate the best stratigraphic sections, and gave a different perspective to the intricate structure of many parts of the Teton Wilderness.

Samples were analyzed in mobile field laboratories of the U.S. Geological Survey by J. G. Viets, R. T. Hopkins, Jr., E. P. Welsch, G. W. Day, and W. D. Crim. Some nonroutine analyses, such as determination of phosphate content, organic content, and coal analyses, were made in the U.S. Geological Survey laboratories, Lakewood, Colo., and are noted in the analyses.

The U.S. Bureau of Mines fieldwork was done by Frank E. Williams. He was assisted by Donald D. Keill in 1972, by William P. Long in 1973, and by Henry C. Meeves, Peter M. Mesard, and Mark G. Mueller in 1974. Because of incapacitating illness, Mr. Williams was unable to complete the written part of this investigation; it was completed by Jimmie E. Jinks and Thomas D. Light.

GEOLOGY

By

J. D. Love and H. J. Prostka

Geologic setting

The rocks in the Teton Wilderness consist of a variety of crystalline, sedimentary, and igneous rocks ranging in age from Precambrian to Quaternary; many of the sedimentary rocks are of volcanic origin. The wilderness comprises two geologically different segments (fig. 1). The eastern segment consists of great thicknesses of Eocene stratified volcanogenic rocks that originated mainly from volcanic centers outside the wilderness. At three localities, weak base- and precious-metal mineralization accompanied the emplacement of intrusions that penetrated the volcanogenic sediments. The Eocene volcaniclastic rocks that comprise the Absaroka Range buried the Precambrian and Paleozoic core of the Washakie Range, which was uplifted in Laramide times. Subsequent erosion has exposed some of that range. The exposed Precambrian rocks are gneisses and schists; the Paleozoic rocks are mainly limestone, dolomite, and shale of marine sedimentary origin. The western segment consists chiefly of Mesozoic sedimentary rocks folded into north- and northwest-trending anticlines that were subsequently overlapped by middle and upper Cenozoic rocks. All these rocks were then tilted westward and faulted in late Cenozoic time. The major Cenozoic rocks are summarized in table 1, and the major Mesozoic and Paleozoic rocks are summarized in table 2. Quaternary deposits consist of alluvium along all the major streams, landslide debris, and a variety of glacial, terrace, and lake deposits.

The most voluminous Cenozoic rocks of the Teton Wilderness are the Eocene rocks of the Absaroka Volcanic Supergroup, which comprises the Gallatin-Absaroka volcanic province. These rocks are several thousand feet thick, and underlie most of the eastern two-thirds of the wilderness.

Most of the major plutons associated with the source areas of the Langford and Wiggins Formations lie a few miles outside the Teton Wilderness to the north and northeast. The plutons are irregular- to oval-shaped plugs approximately 0.5-3 mi in diameter, and are associated with swarms of dikes (Hague and others, 1899). The intrusive rocks are mainly andesite, granodiorite, diorite, and dacite, but also include some rhyodacite and rhyolite.

The Yellow Mountain intrusive complex, located within the Teton Wilderness near its eastern border, consists of a central plug of medium-grained granodiorite flanked by smaller plugs, sills, and radial dike swarms of andesite and dacite. The only extensive area of contact metamorphism and hydrothermally altered rock in the Teton Wilderness is associated with these intrusive rocks.

Two plugs of unweathered granodiorite porphyry, with little or no associated contact metamorphism or altered rock, are exposed along the eastern part of the Thorofare Plateau, one of them just west of Dell Creek, the other near Younts Peak.

Two small (less than 0.35 mi long) intrusive bodies of andesite on the southwest flank of Thunder Mountain are associated with small areas of hydrothermally altered rock, and traces of pyrite appear in the adjacent wallrocks.

A thick multiple dike of porphyritic rhyodacite, vitrophyre, and scoriaceous breccia is exposed in the west canyon wall of Yellowstone River about 4 mi west of Thunder Mountain. The dike can be traced upward into a lava-flow sequence in the Wiggins Formation. The dike and flows contain large

Table 1.--Cenozoic rocks in the Teton Wilderness

[Leaders (----) indicate no data]

Age	Formation	Approximate thickness (ft)	Description
Pliocene-----	Huckleberry Ridge Tuff of Yellowstone Group.	0-700	Rhyolitic ash-flow tuff, gray to brown, generally densely welded and devitrified but locally glassy or partly welded.
Do---------	Pyroxene andesite and basalt of Emerald Lake.	----	Dull-green, dark-gray, dark-red, and black pyroxene andesite and basalt intruded along the Buffalo Fork thrust fault.
Do---------	Conant Creek Tuff--------	300	Rhyolitic welded tuff, pale lavender, crystal poor, slabby, hard.
Tertiary(?)--	Rhyolite-----------------	500	Rhyolitic porphyry intrusion cutting Absaroka Volcanic Supergroup. Merges upward into extrusive lava flows.
Miocene------	Colter Formation---------	7,000	Mafic tuff and volcanic conglomerate, light-gray to green and brown, water laid.
Oligocene----	White River Formation----	0-100	Siltstone, white, nodular; limy and pale-green, white, and tan bentonitic claystone, vitric tuff, and pumice conglomerate.
Late Eocene--	Wiggins Formation--------	0-3,050	Volcanic conglomerate, brown and gray, water laid, interbedded with white tuffs, forms much of the higher part of the Absaroka Range; consists chiefly of mafic andesite and basalt boulders in a gray, coarse-crystal tuff matrix.
Eocene-------	Lava flows in Wiggins Formation.	600	Dark-gray lava flows and purple-orange scoriaceous flow breccias of rhyodacite and dacite.
Do---------	Two Ocean Formation------	0-600	Andesitic volcaniclastic strata, dark-colored, thick-bedded, coarse, chiefly sheet and channel-fill deposits of conglomerate, generally forming cliffs.
Do---------	Basalt breccia-----------	400 (or more)	Red, brown, and purple basalt breccia; some dikes and flows.
Do---------	Langford Formation-------	500 (or more)	Volcanic conglomerate and tuff; composed of boulders of andesite and basalt with lesser amounts of quartzite, granite, and locally, huge masses of limestone and dolomite.
Do---------	Lava flows in Langford Formation.	100-500	Dark-gray and reddish-brown vesicular lava flows and flank breccias of sparsely porphyritic andesite.
Do---------	Hominy Peak Formation----	0-1,000	Andesitic mudflow breccia, vent breccia, conglomerate, and sandstone, brown to dull green.
Do---------	Trout Peak Trachyandesite.	0-500	Massive trachyandesite and trachyandesite flows and volcaniclastic rocks.
Do---------	Aycross Formation-----	0-100	Gray, pink, green, and black bentonitic claystone; thin carbonaceous shale and coal beds; green, hard, slabby, tuffaceous sandstone, volcanic conglomerate, and hard siliceous white leaf-bearing tuff.

Table 2.--Paleozoic and Mesozoic rocks in the Teton Wilderness

Age	Formation	Approximate thickness (ft)	Description
Paleocene and Late Cretaceous.	Pinyon Conglomerate------	0-3,800	Quartzite boulder conglomerate, gray sandstone, dark-gray claystone, and white tuff.
Late Cretaceous.	Harebell Formation-------	0-11,000	Brown quartzite conglomerate; brown, gray, and dull-green sandstone; gray, dark-green, black claystone.
Do---------	Mesaverde Formation------	1,000 (or more)	White sandstone interbedded with thin, gray shale and sparse impure coal and bentonite beds.
Do---------	Sohare sequence-----------	2,400	Gray and brown sandstone, lenticular, fine-grained, interbedded with light- and dark-gray shale and siltstone; largely nonmarine; contains thin coal beds.
Do---------	Bacon Ridge Sandstone----	1,000-1,500	Tan to gray sandstone, fossiliferous, thick-bedded, fine-grained; contains several coal beds.
Do---------	Cody Shale---------------	1,400-2,200	Dull-gray shale interbedded with lesser amounts of gray siltstone and gray fine-grained slabby sandstone; marine.
Do---------	Frontier Formation-------	1,000	Gray sandstone interbedded with gray and black shale and thin coal beds.
Early Cretaceous.	Mowry Shale--------------	500-700	Dark-gray to black shale; very hard and brittle.
Do---------	Thermopolis Shale--------	20-100	Black shale, fine-grained, fissile, flaky.
Early Cretaceous and Late Jurassic.	Cloverly and Morrison(?) Formations.	575-995	Sandstone, siltstone, and claystone.
Late and Middle Jurassic.	Sundance Formation-------	475-695	Limy sandstone, limy shale, clayey limestone, and zones of red, soft, plastic shale, marine, highly fossiliferous.
Middle Jurassic.	Gypsum Spring Formation--	50-150	Dark-red shale, underlain by, and interbedded with, slabby gray dolomite and white gypsum.
Triassic-----	Chugwater Formation------	935-1,735	Ocher and purple claystone, red shale, purple limestone, pellet conglomerate, and red siltstone; red to salmon-pink, white porous sandstone; gray and purple, thin-bedded, hard limestone and dolomite with interbeds of white gypsum; red, gypsiferous siltstone containing some red shale partings.
Early Triassic.	Dinwoody Formation-------	200-600	Brownish-gray to olive-drab, hard, slabby, thin-bedded, fine-grained dolomitic sandstone and silty limestone.
Permian------	Phosphoria Formation-----	180-260	Black, phosphatic shale, mudstone, carbonate rock and sandstone; underlain by gray, cherty dolomite, mudstone, and sandstone, and at base a black phosphatic mudstone and shale.
Pennsylvanian and Mississippian.	Tensleep Sandstone and Amsden Formation.	765-1,050	Tensleep is light-gray, fine-grained sandstone; middle and lower parts contain many beds of very hard, fine-grained limestone and dolomite. Amsden is brick-red, red-brown, and green shale and siltstone interbedded with white to pink dolomite and limestone. Directly above Darwin Sandstone Member of Amsden is a 50-ft-thick black shale.
Late and Early Mississippian.	Madison Limestone--------	1,100-1,500	Light- to dark-gray limestone.
Late and Middle Devonian.	Darby Formation----------	285-350	Upper part is dolomitic siltstone and shale, dull yellow, gray-pink, and black; lower part is brown, fetid, vuggy, siliceous, brittle dolomite.
Late Ordovician.	Bighorn Dolomite--------	200-500	Light- and dark-gray, mottled, siliceous dolomite.
Late and Middle Cambrian.	Gallatin Limestone------	200-250	Dark-gray limestone.
Do---------	Park Shale Member of Gros Ventre Formation.	150-350	Olive-green shale, soft, flaky, micaceous; thin beds of flat-pebble conglomerate.
Do---------	Death Canyon Member of Gros Ventre Formation.	150-350	Blue-gray to dark-gray, fine-grained, hard, thin-bedded, cliff-forming limestone.
Middle Cambrian.	Wolsey Shale Member of Gros Ventre Formation.	100-130	Green to gray-green, highly fissile, micaceous shale.
Do---------	Flathead Sandstone-------	200-300	White, tan, brown, and maroon, crossbedded, locally conglomeratic sandstone.

phenocrysts of smoky quartz, plagioclase, biotite, and pyroxene, and the breccias contain abundant secondary calcite.

In the saddle between Angle Mountain and Breccia Peak is an elongate, irregular body of glassy flow-banded rhyodacite porphyry having minor associated wallrock alteration.

All but the highest parts of the Teton Wilderness were glaciated one or more times. As a result, bedrock is, in places, covered with extensive deposits of glacial debris, especially along the major drainage systems. Meltwater from the glaciers saturated thick sequences of plastic shale and caused enormous landslides that further obscure the bedrock.

Structure and geologic history

A major structural feature of the Teton Wilderness is the Buffalo Fork fault, which divides the wilderness into the geologically different eastern and western segments (fig. 1). The Buffalo Fork fault is a Laramide (Late Cretaceous-early Tertiary) thrust or high-angle reverse fault along which Precambrian and Paleozoic rocks of the Washakie Range rode up and over Mesozoic and Paleozoic rocks to the southwest. In early Eocene time, partial reversal of the Laramide displacement raised the southwest block, which limited the distribution of the basal volcanic units of the Absaroka Volcanic Supergroup to the northeast side of the fault. However, the next younger volcanic unit, the Langford Formation, was deposited extensively on both sides of the fault. Continued rise of the southwest block in post-Eocene, pre-late Pliocene time resulted in widespread stripping of the Langford Formation so that only scattered patches remain. The terrane west of the Buffalo Fork fault was block-faulted and tilted westward, as is indicated by westward dips of 10° of the Langford Formation on Pinyon Peak and as much as 65° in the Wolverine Creek-Coulter Creek area.

Several small remnants of the Oligocene White River Formation and the Miocene Colter Formation, as well as Pliocene-Pleistocene basalts, were preserved by late Cenozoic downfaulting in the Emerald Lake area along the Buffalo Fork fault.

Two very different types of major structural episodes separated by about 65 m.y. have involved rocks of the Teton Wilderness. The first, and most important for oil and gas potential, was Laramide compressional folding. The age of this folding has been determined within narrow limits on Gravel Peak, in the west-central part of the Teton Wilderness. Here the folding occurred about 70 m.y. ago. A series of northwest-trending anticlines and synclines, broken and overridden in places by thrust or reverse faults, developed in Cretaceous and underlying rocks. In addition, the southern flank of the Basin Creek uplift, a major upfold that developed in the Late Cretaceous largely in Yellowstone National Park, extends into the Teton Wilderness for several miles along the northwestern edge of the wilderness. The sequence of events, all in Maestrichtian (latest Cretaceous) or late Campanian time, has been reconstructed as follows (Love, 1977, fig. 3):

1. Deposition of 10,000 ft of the Harebell Formation, which contains many fossiliferous marine or brackish-water horizons throughout and thick quartzite-boulder gold-bearing conglomerates in its upper half. Fossils at this locality are of early Maestrichtian or late Campanian age.
2. Uplift of the Washakie Range, a fold that extends southeastward from Yellowstone Lake for 75 mi. The southeast margin of this fold is bounded by a thrust fault that put Paleozoic rocks on Upper Cretaceous rocks.

3. Erosion that accompanied and followed the uplifting until the Paleozoic core was exposed. A thickness of about 25,000 ft of rock was removed during the uplift before the next depositional event.
4. Deposition of the Pinyon Conglomerate, 4,000-5,000 ft thick, laid down above a 90° unconformity, across the overturned and eroded strata of the Harebell Formation. The basal part of the Pinyon contains a 100-ft-thick bed of biotite-rich tuff that J. D. Obradovich (oral commun., 1974) dated by the potassium-argon method as 67 ± 0.7 m.y. old.

Inasmuch as the Maestrichtian Age began about 70 m.y. ago, all four events must have occurred during a time span of about 3-6 m.y.

The second major structural episode involving the Teton Wilderness occurred during late Cenozoic time. Except for the Washakie Range, the rocks above the Cretaceous rocks were eroded in the Laramide anticlines in the western and northern parts of the wilderness. Next, Pleistocene welded tuffs, chiefly the Huckleberry Ridge Tuff (Christiansen and Blank, 1972), flowed southward from a source in Yellowstone National Park and buried valleys in the western and northwestern parts of the wilderness to a depth of 365 ft or more. At the base of these tuffs is a profound angular unconformity, in places more than 90°. After emplacement of the Huckleberry Ridge Tuff, the Jackson Hole structural block, which includes the southwestern part of the Teton Wilderness, hinged downward several thousand feet. The Huckleberry Ridge Tuff was broken up by many normal faults, most with a few tens to a few hundreds of feet of displacement. The Pilgrim Creek fault, however, may have as much as 10,000 ft of displacement, although some of this movement could have been prior to deposition of the Huckleberry Ridge Tuff.

The normal fault that approximately coincides with the trace of part of the Buffalo Fork thrust fault across the central part of the Teton Wilderness probably developed, in part at least, prior to 2 m.y. ago. The fault plane was intruded by pyroxene andesite and basalt with a potassium-argon age of 2 m.y. (Love and others, 1976). Displacement on this fault may be several thousand feet, with the east block downdropped.

During the Quaternary, westward tilting and tension faulting significantly distorted the much older Laramide structures. To obtain their original conformation, they now need to be rotated upward and clockwise (if reconstructions are oriented northward) as much as 30°. The effect of this secondary tilting on oil and gas accumulation and the resulting possibly tilted water tables and water drive is discussed in the mineral-resources section of this report.

The eastern segment of the Teton Wilderness has been mildly deformed into broad upwarps and downwarps, whose axes trend parallel to the structural grain of the underlying Washakie Range. A central downwarp, with a complex grabenlike axial fault zone, extends from Yellowstone River Valley southeastward through Ferry Lake to Buffalo Plateau and eastward into the late Tertiary syncline, mapped by Fisher and Ketner (1968), through the southern Absaroka Mountains. Northeast of this axial zone, the volcanic strata rise toward the intrusive centers beyond the northeastern wilderness boundary. Dips are generally from 3° to 10° southwest, but locally they are as much as 15° around the domed Yellow Mountain intrusive complex. No appreciable doming or structural disruption was noted around any of the other intrusive bodies in the Teton Wilderness.

Along the ragged southwest margin of the volcanic plateau, a gentle upwarp, whose axis trends parallel to the arcuate trace of the Buffalo Fork fault and about 4 mi northeast of it, is the locus of a broad zone of normal faults of small displacement and diverse trends. Dips in the volcanics along the limbs of this upwarp are less than 7°. The southeast limb is cut by the Buffalo Fork fault.

About 2 m.y. ago, two episodes of igneous activity occurred, one involving the northern and western parts of the Teton Wilderness, and the other the north-central part. Rhyolitic tuffs, later welded, flowed southward downhill from one or more huge calderas in Yellowstone National Park, completely across the western margin of the Teton Wilderness, and partly buried some of the older anticlines and conglomerate beds. The other igneous event was the intrusion of pyroxene andesite and basalt along the one major thrust fault (later reactivated by normal faulting) in the north-central part of the Teton Wilderness.

After emplacement of the Huckleberry Ridge Tuff 2 m.y. ago, and its subsequent tilting and faulting, came several episodes of glaciation. The older and larger ice masses moved southward across the Teton Wilderness from centers of accumulation in Yellowstone National Park and westward from centers in the Absaroka Range. The ice was probably more than 2,000 ft thick in some parts of the Teton Wilderness. The glacial debris obscures bedrock geology in large parts of the Teton Wilderness. The distribution of the ice has a significant bearing on mineral evaluation of the Teton Wilderness because, in many places, the ice picked up quartzite roundstones and finer grained gold-bearing sandstone associated with quartzite clasts and scattered or concentrated this debris along many major drainages. These occurrences are discussed in connection with gold deposits.

Another effect of the extensive glaciation was the development of enormous landslides where soft Cretaceous shale, tilted and faulted in Pleistocene time, was scoured by ice and then saturated with glacial meltwater.

Structure relating to oil and gas

Twelve anticlines, which may have entrapped oil and gas, lie entirely or partly within or just outside of the Teton Wilderness. The Bailey, Arizona Creek, Kitten, Reid, and Lizard Creek anticlines have been described previously (Love and others, 1975). The presence of several of the major anticlines was the basis for the U.S. Geological Survey fuels investigations of this general area in 1945, 1948, and 1949. Table 3 summarizes the most promising potential oil and gas source and reservoir rocks, their thickness, and estimates of their depths on the structurally higher parts of each anticline.

Possible oil and gas source and reservoir rocks in the western one-fourth of the Teton Wilderness are at least 4,500 ft thick, have an areal extent of 270 mi^2, and have a volume of 230 mi^3. These strata are chiefly marine and nonmarine sandstone and shale; some limestone and dolomite are in the lower part. They are folded into a series of anticlines and synclines, en echelon, trending north or northwest. Surface closure is slight or nonexistent at the north ends. Subsurface closure, and definition of other types of traps, if present, cannot be proven without detailed geophysical surveys.

Between 1975 and 1981, many new concepts pertaining to the relation of oil and gas accumulation to thrust faults were developed as a result of major discoveries of oil and gas in the Overthrust Belt of Wyoming, Utah, and Idaho. Another major discovery of gas beneath a 9,000-ft-thick thrust plate of Precambrian rocks on the Casper Arch of central Wyoming, further substantiates the existence of this kind of trap (Gries, 1981).

Table 3.--Depths to possible oil and gas reservoir rocks in subsurface parts of major anticlines in or near the Teton Wilderness[1]

[No boreholes have been drilled in any of these anticlines and no geophysical surveys (other than airborne magnetometer and gravity traverses) have been made in the area, so subsurface structure is unknown. All figures on thicknesses of rock units in the subsurface and depths to possible reservoir rocks are tentative estimates. Subsurface dips are not known so the footage intervals listed must be considered minimal. They represent stratigraphic thickness at the crestline of the fold and, in the absence of data to the contrary, the arbitrary assumption that there has been no flowage or faulting of incompetent beds. Depth figures are computed at the structurally highest visible part of the anticline. Cambrian, Ordovician, and Devonian rocks, having a combined thickness of 1,650 ft, are not included in this table because their reservoir characteristics are variable and their production is small in the nearby Bighorn Basin. This table does not imply that these rocks have oil and gas potential in the Teton Wilderness. Leaders (----) indicate no estimates]

Formation or member	Thickness (ft)	Anticlines: Possible depth[2] to top (to nearest 50 ft)[3] of reservoir rocks					
		Wildcat[4]	Whetstone[5]	Spread Creek[6]	Wolverine[7]	Hancock[8]	Rodent Creek[9]
Mesaverde-------	1,000	Exposed	500	Exposed	----	----	Eroded away
Bacon Ridge Sandstone.	1,600	--do----	3,500	--do----	1,200	1,200	Do.
Frontier--------	1,000	do----	6,800	2,400[4]	4,500	4,500	Exposed
Thermopolis (Muddy Sandstone Member).	50	1,400	8,450	3,900[4]	6,150	6,150	300
Cloverly ("Rusty Beds").	150	1,550	8,650	4,100[4]	6,300	6,300	450
Chugwater (Crow Mountain Sandstone Member)	85	2,750	10,000	5,300	7,600	7,600	1,750
Phosphoria------	200	3,850	11,200	6,400	8,650	8,650	2,850
Tensleep Sandstone.	380	4,050	11,400	6,600	8,850	8,850	3,050
Amsden (Darwin Sandstone Member)	50	4,600	11,950	7,150	9,400	9,400	3,450
Madison Limestone.	1,100	4,650	12,000	7,200	9,450	9,450	3,500

[1]Small, poorly defined, or highly faulted anticlines are not listed. These include Bailey, Arizona Creek, Lizard Creek, Kitten, Reid (all previously described by Love and others, 1975), and Onion Flats.

[2]Nearest local variations in thickness are used in depth estimates.

[3]Where post-Mesaverde rocks are present, the depth to Mesaverde and older formations is in an estimate that may be in error by several hundred to several thousand feet.

[4]Intervals interpreted from Travis-True well 2 mi south of wilderness boundary.

[5]This is a long anticline. On the basis of surface data, the structurally highest part of the crest cannot be determined; therefore, the depths listed are generalized estimates.

[6]Surface crest line entirely outside Teton Wilderness; depths estimated on crest line; only oil and gas potential in wilderness is on northeast flank of anticline.

[7]No north closure is certain. Site of estimated apex (if present) of crest line is about 4,200 ft southeast along the crest line from where it crosses the Yellowstone National Park boundary.

[8]No north closure south of Yellowstone National Park.

[9]Weak east flank.

Within the Teton Wilderness there are nine high-angle reverse or thrust faults involving thick sequences of Paleozoic and Mesozoic rocks. The largest and longest of these is the Buffalo Fork thrust fault; cross sections of the Buffalo Fork thrust fault have been published (Love and Keefer, 1975, pl. 1; Love, 1973, figs. 33, 34; Love and others, 1976, fig. 12). Other thrust faults previously named are the Box Creek, Rodent Creek, Wildcat, Bailey, and Arizona Creek thrust faults. The last four are discussed in connection with the adjacent anticlines of the same names (the Bailey and Arizona Creek faults are outside, east of, the wilderness). The unnamed thrust faults are smaller and not important to the present evaluation.

Because of the thickness and lithology of the sedimentary rocks (about 4,000 ft of Paleozoic strata, 6,500 ft of pre-Harebell Mesozoic rocks, and 5,000-11,000 ft of Harebell Formation) overridden by Precambrian and Lower Paleozoic rocks along the Buffalo Fork thrust fault, brecciation was likely, with possible oil and gas accumulations in fracture-pore zones sealed against the thrust fault. The minimum amount of displacement on the fault is 10,000 ft and in most places may be several times that amount. On outcrops along the fault trace, there is a zone of intense to moderate brecciation of rocks on both sides of the fault, the amount depending on the brittle or plastic nature of the rocks. Fault slices of Paleozoic and Mesozoic rocks, some several thousand feet out of stratigraphic position, have been dragged up along the major thrust. Where shale units are involved, they could effectively seal off the main and subsidiary fault planes, thereby preventing leakage of oil and gas.

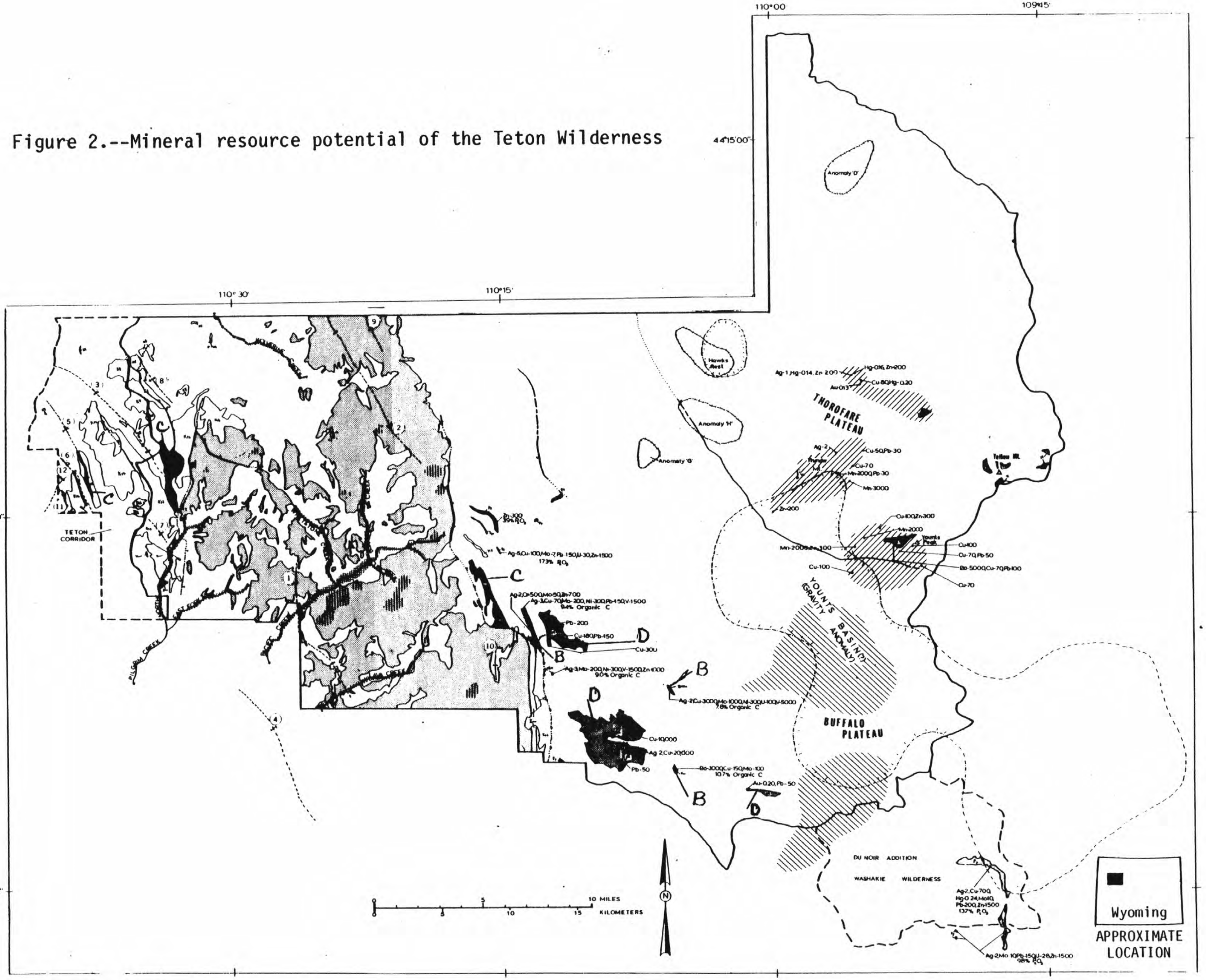
The structural patterns of many thrust blocks that have been drilled elsewhere in Wyoming show anticlines that have been overridden, and some of these contain major amounts of oil and gas. Therefore, the entire 25 mi segment of the Buffalo Fork thrust fault within the Teton Wilderness requires geophysical surveys for a final assessment of the possibility of oil and gas in subthrust traps.

The Washakie Range was uplifted, folded, thrust westward along the Buffalo Fork thrust fault, and deeply eroded, all in a short interval of time, after deposition of the Harebell Formation and prior to deposition of the Pinyon Conglomerate (Love, 1973). Some movement continued into middle Eocene time, as indicated by giant boulders of Precambrian and Paleozoic rocks that were carried westward from the Washakie Range during deposition of the Langford Formation.

The structurally deepest part of the downwarped area in the western part of the Teton Wilderness is between Pinyon Peak and Whetstone Mountain. The top of the Precambrian rocks in this area may now lie as much as 13,000 ft below sea level. Even in Late Cretaceous (Maestrichtian) time, about 69 m.y. ago, the uppermost strata in the Harebell Formation northwest of Whetstone Mountain were deposited in a semi-marine environment at the same time that the basal part of this same formation in the same area was 10,000 ft below sea level (Love, 1973). Oil and gas may have migrated upward and out of these deep sediments during the last 69 m.y., not only into anticlines, but also into fault, facies, and porosity traps.

The Younts basin(?) (fig. 2) is a gravity anomaly discovered by Dolores M. Kulik (see geophysical section, this report). The gravity data suggest a major elongate structural downwarp extending south-southeast from near the southeast corner of Yellowstone National Park, and east of the buried east flank of the Washakie Range. The general outline and orientation of this area appear to have a relation to anticlinal trends and to the nearest oil and gas fields on the west side of the Bighorn Basin and northwest arm of the Wind

Figure 2.--Mineral resource potential of the Teton Wilderness



EXPLANATION FOR FIGURE 2

APPROXIMATE BOUNDARY OF TETON WILDERNESS

APPROXIMATE BOUNDARY OF ADJACENT STUDY AREA

APPROXIMATE BOUNDARY OF POSTULATED YOUNTS BASIN--Geophysical anomaly may suggest basin at depth

AREA OF MODERATE RESOURCE POTENTIAL FOR OIL AND GAS--Anticlines numbered in order of assumed significance

1	Whetstone	7	Kitten
2	Wolverine	8	Rodent Creek
3	Wildcat	9	Hancock
4	Spread Creek	10	Onion Flats
5	Bailey	11	Reid
6	Arizona Creek	12	Lizard Creek

AREA OF LOW TO MODERATE RESOURCE POTENTIAL FOR GOLD AND HEAVY DETRITAL MINERALS INCLUDING MAGNETITE, ILMENITE, SPHENE, MONAZITE, ZIRCON, AND RUTILE

In placers in Quaternary alluvium

In Pinyon Conglomerate and Harebell Formation--Vertical pattern indicates area of higher concentration

B AREA OF MODERATE RESOURCE POTENTIAL FOR COPPER, LEAD, MOLYBDENUM, NICKEL, SILVER, URANIUM, VANADIUM, AND ZINC IN BLACK SHALE

C AREA OF LOW RESOURCE POTENTIAL FOR COAL IN SOHARE, BACON RIDGE, FRONTIER, OR MESAVERDE FORMATIONS

D AREA OF LOW RESOURCE POTENTIAL FOR COPPER, GOLD, OR LEAD IN PRECAMBRIAN ROCKS

GEOCHEMICAL ANOMALY--In pyroclastic rocks in Tertiary Absaroka volcanic field

WEAK GEOCHEMICAL ANOMALY--Apparently related to stratified volcanic rocks

Cu-100 ANOMALOUS GEOCHEMICAL VALUES--Values given in parts per million: Ag=silver, Ba=barium, Cu=copper, Hg=mercury, Mn=manganese, Mo=molybdenum, Pb=lead, U=uranium, V=vanadium, Zn=zinc; values given in percent: C=carbon, P_2O_5

AEROMAGNETIC ANOMALY

GRAVITY ANOMALY

FAULT--Bar and ball on downthrown side; dashed where approximately located; dotted where concealed

ANTICLINE

River Basin. The only way in which the stratigraphy and structure causing this anomaly can be substantiated or disproved is by sophisticated seismic work and by drilling. If it is indeed a basin filled with 20,000 ft or more of Paleozoic and Mesozoic sedimentary rocks under a relatively shallow volcaniclastic cover, it will drastically affect the evaluation of oil and gas possibilities, not only in the Teton Wilderness but also in the Washakie (South Absaroka) Wilderness to the east. Marginal to this possible downwarp, oil- and gas-bearing anticlines similar to those in the adjacent part of the Bighorn Basin could be expected.

Evaluation of possible facies and porosity traps depends largely on adequate regional and local data to define lateral lithologic and thickness variations in the rock units. Such data remain insufficient to permit a detailed evaluation of traps that might exist in an area of this size (300 mi^2) or a stratigraphic section this thick. Nevertheless, available stratigraphic summaries presented elsewhere (Love and Keefer, 1975; Love, Hose, and others, 1951; Love, Keefer, and others, 1951; Love, 1973; Love and others, 1975) provide sufficient data for a general evaluation of possible facies and porosity traps. Those formations or units which may include facies and porosity traps are (from oldest to youngest) Bighorn Dolomite, Madison Limestone, Tensleep Sandstone, Phosphoria Formation, Cloverly and Morrison(?) Formations, Muddy Sandstone Member of Thermopolis Shale, Sohare sequence, Mesaverde Formation, and the lower part of Harebell Formation. Inclusion of the Bighorn Dolomite is unusual, but there are several places along the Buffalo Fork thrust fault where it is a soft, porous, poorly cemented limestone, rather than the typically hard, tight siliceous dolomite.

To determine the locations of the most promising facies and porosity trends will require more detailed stratigraphic work than was possible for the wilderness evaluation and, in addition, sophisticated and expensive seismic studies, none of which has ever been done in the Teton Wilderness. Lacking these data, and in the complete absence of any drilling, we can only speculate that the most promising areas are on the updip sides of the basin deeps centered in the Pinyon Peak-Whetstone Mountain Area.

INTERPRETATION OF GEOPHYSICAL DATA

by

D. M. Kulik and L. A. Anderson

Aeromagnetic and gravity surveys were made of the Teton Wilderness as part of the mineral resource assessment. Previous geophysical studies were made in the adjacent Grand Teton National Park and vicinity (Behrendt and others, 1968). Magnetic anomalies, local in extent and not related to topography, are of principal interest in that they may indicate buried rock masses commonly associated with mineral deposits. The gravity data provide information on structural relationships and the subsurface distribution of rock types.

The distribution of the magnetic field in the Teton Wilderness is controlled largely by surface deposits of Absaroka derivation. Most anomalies can be correlated with variations in topography, but others may relate to changes in the composition of the rock.

The large-scale structural provinces of the area are delineated by the gravity data. An unexpected result of the gravity survey is recognition of a basin, here termed Younts basin, located between the Washakie and Absaroka Ranges (fig. 1). This is an area of relatively high elevation completely covered by pyroclastic materials. Evidence of its existence heretofore has only been speculative.

The aeromagnetic and gravity studies showed several geophysical anomalies. Positive magnetic anomalies (highs) in the vicinity of Thunder Mountain and Younts Peak appear to be related to granodiorite intrusions that are exposed in only very small outcrops. Another positive magnetic anomaly may be related to a mafic intrusion with surface expression that occurs on Soda Mountain. Two anomalies having negative polarity and located near the headwaters of the Yellowstone River may be related to silicic intrusions that do not have surface expression. Major gravity-low anomalies are associated with the intrusive granodiorite bodies on Thunder Mountain and Younts Peak. A gravity anomaly also occurs near the headwaters of the Yellowstone River and coincides with the magnetic low.

Near Hawks Rest and a plateau flanking the Yellowstone River there is a mutual correspondence between the magnetic and gravity data. The causative bodies may be igneous intrusions of a more silicic composition. Magnetically the anomalies are slightly negative, but gravity data suggest there must be a significant difference in the density of the materials. The body affiliated with Hawks Rest generates a negative gravity anomaly, whereas a positive gravity anomaly exists in conjunction with the topographic feature to the south. A density difference of about 0.3 g/cm^3 is required to produce the observed gravity change. Although the magnetic data may suggest that the inferred intrusive bodies were derived from the same source, the gravity data signify that the intrusions must be different in composition.

Other correlations between the data sets cannot be made except that a negative gravity anomaly exists over the east side of Two Ocean Plateau where a ridgelike positive magnetic anomaly is located. It is believed that this affiliation is fortuitous, in that the magnetic disturbance is caused by the surface rock whereas the gravity is controlled by rock at depth.

Possible exploration targets are in the area of the negative magnetic anomalies located near the headwaters of the Yellowstone River and south of Overlook Mountain in the northeastern part of the area.

The negative gravity anomalies over the Box Creek downwarp and the postulated Younts basin are interpreted to be caused by sedimentary sequences that contain strata that have significant oil and gas accumulations elsewhere in Wyoming. Structural traps may exist within the basins and at the boundaries. The northeast-trending basement structures, suggested by the gravity data in the South Fork Shoshone River and in the northern part of Box Creek downwarp, also could have produced structural traps for hydrocarbon accumulation within the basins. The geophysical data do not provide any real evidence that mineral deposits exist within the wilderness.

GEOCHEMISTRY

Sampling and analytical program

The U.S. Geological Survey collected more than 4,000 samples for chemical and spectrographic analyses. Samples of stream sediments were collected in all important drainages. These consisted of 660 silt-sized (minus 80-mesh) stream-sediment samples and 1,145 pan-concentrate samples (305 of which were collected solely for gold analyses). In addition, 113 soil samples were collected for evidence of mineralized rock, particularly along fault zones and in areas of altered rock, or intrusive contact zones. An important part of the sampling program was collection of 2,292 rock samples, which included individual unweathered, unaltered samples to represent the major stratigraphic and lithologic units as well as altered rock, and rock of possible commodity interest such as gypsum, phosphate rock, and black shale. The unaltered rock samples were used to establish a range of background values applicable to specific rock units. Most of the exposed rocks in the Teton Wilderness are either stratified pyroclastic rocks of Eocene age or Phanerozoic sedimentary rocks. Nonstratified igneous and metamorphic rocks occur in only a small part of the total area. To satisfactorily determine mineral resource potential and geochemistry, extensive bedrock sampling was necessary to supplement sampling of stream sediments in drainages and of soils because mineral deposits in sedimentary rocks are commonly not accompanied by dispersion halos.

The samples were analyzed for 31 elements by a six-step semiquantitative spectrographic procedure (Grimes and Marranzino, 1968), for gold using an atomic absorption procedure (Ward and others, 1969), for mercury using a laboratory mercury detector method (Vaughn and McCarthy, 1964), and for cold-extractable heavy metals (xcHM) using the Bloom test (Bloom, 1955). All samples were scanned for radioactivity with a scintillation counter, and those that showed more than background amounts of radioactivity were analyzed for equivalent uranium (eU); additionally, about one-fifth of the samples were analyzed for uranium and thorium using a delayed neutron activation procedure.

Standard coal analyses were made on coal samples collected from several parts of the wilderness area. Samples from the Phosphoria Formation were analyzed for phosphate and uranium. Samples of black shale collected near the base of the Amsden (Mississippian) Formation and from lake beds in the Aycross(?) Formation of Eocene age were analyzed for organic content and trace metals.

The geochemical data and relevant geologic parameters are stored on magnetic disc in the U.S. Geological Survey's computer in Denver, Colo. Computer printouts of data on several groupings of samples were studied to locate areas that might have mineral resource potential. Graphical analyses and statistical computations were also made by computer to help evaluate the mineral potential. A magnetic tape with the analytical data, together with appropriate geographic and geologic parameters, is available from the National Technical Information Service (McDanal and others, 1983). This tape also includes data generated in two areas contiguous to the Teton Wilderness, the Teton Corridor (Love and others, 1975) and the DuNoir study area (Prostka and others, 1979).

A total of 355 stream-sediment, channel, and other samples were taken by the U.S. Bureau of Mines throughout the Teton Wilderness from 1972-1974. Tailings from the pan-concentrate samples were analyzed for 43 elements by X-ray spectrography.

Gold sampling program

U.S. Geological Survey sampling to study the gold resource potential in alluvium in the wilderness consisted of (1) samples collected along all the major streams and their tributaries; (2) samples collected in 200-ft grid intervals using random numbers to determine the sample site in each interval across the large alluvial fan south of Gravel Mountain; (3) samples collected in 100-ft grid intervals using random numbers to determine the sample site in each interval on traverses across Lava Creek, Wolverine Creek, and Pacific Creek; (4) random samples collected in a checkerboard grid with squares 100 ft on a side across the valley of North Fork of Pilgrim Creek north of its confluence with the East Fork of Pilgrim Creek; (5) random samples collected horizontally and vertically on three terraces of different ages along the East

Fork of Pilgrim Creek immediately north of the wilderness boundary; (6) channel samples collected in trenches made by the U.S. Bureau of Mines in terraces at the confluence of Pacific and Whetstone Creeks; (7) non-representative, intentionally "high-graded" samples collected at sites thought to be favorable for gold accumulation along Pacific Creek south of the wilderness boundary and on Lava Creek south of Gravel Mountain. Data for these samples are summarized in table 5. Data for individual samples are available on a single tape from the National Technical Information Service (McDanal and others, 1983).

Many exposures of quartzite conglomerate and related sandstone and shale were sampled for gold. Several small samples from each locality commonly were combined, crushed, and ground prior to panning.

The U.S. Bureau of Mines collected 221 stream-sediment samples for the appraisal of gold resources. These samples were taken to evaluate the resource potential of several areas for heavy mineral deposits--especially the very fine grained (flour) gold which has been reported from the Harebell Formation, Pinyon Conglomerate, and Quaternary gravels (Antweiler and Love, 1967)--and to delineate areas for more detailed sampling.

The U.S. Bureau of Mines also took 124 samples of Quaternary gravels to evaluate gold content, and examined prospects on the Buffalo Fork River and the placer operation of Mr. Frank Allen on unpatented mining claims on Pacific Creek. West of the Continental Divide, channel samples were taken from 10 locations that were indicated by the stream-sediment sampling program to be the most favorable for the concentration of flour gold. None of the stream-sediment samples collected east of the Continental Divide assayed greater than 10 mg of gold per cubic meters so additional sampling was not undertaken in that part of the wilderness.

All stream-sediment samples were collected and panned in two half-size (12-in.) gold pans by two panners. Before panning, samples were screened through a 0.0232 in. (28-mesh) screen to eliminate coarse material. After panning, the material from both pans was combined, gold values were computed using a factor of 200 combined pans per cubic yard. The pan-concentrate samples were amalgamated and free-gold content determined.

Radioactive springs

Radioactive cold water has deposited moderately radioactive travertine at Soda Springs, about 1 mi east-northeast and upstream from the junction of the Soda Fork and North Buffalo Fork Rivers. There are two areas of active springs. The eastern one is the largest, having cold water (50°F) emerging from a pool 15 ft across and flowing at an estimated 32,000 gal/day (as of July 10, 1974). The water is highly astringent. Nonflammable gas with a sulfur odor continually bubbles up from many orifices. Precambrian bedrock on the north side of the spring is very dense, dark-green gneiss and greenstone, having foliation tilted steeply southeastward.

The radioactive travertine is on the southeast margin of the pool and is stained red and black because of iron- and manganese-rich layers. The maximum radioactivity measured was 1.0 MR/h, but averages throughout the travertine deposit range from 0.05 to 0.2 MR/h. A broad, bare mound of red, white, and brown travertine has been built up downslope from the main orifice.

The smaller of the two springs is about 400 ft west-northwest of the larger spring and flows about 24,000 gal/day (as of July 20, 1974) with a temperature of 46°F. The water is strongly astringent, but not as astringent as that from the larger spring. The travertine at this deposit is not as radioactive as that at the larger spring and there is not as much gas accompanying the water.

Analyses of samples of travertine and water indicate only traces of uranium. The source of radioactivity is probably radon gas and traces of radium.

Analytical results

Geochemical anomalies

Several techniques were used to identify anomalies and to evaluate their relationship to mineralized rock. In general, particularly in attempts to identify anomalies when a field laboratory and personnel were available for field-checking, samples that contained twice the background value of an element were considered anomalously high, as suggested by Boyle and others (1971).

Elements not commonly detected (gold, molybdenum, tin, and zinc) were at first considered anomalous if analytical values were above the lower limit of detection. However, because of the obvious lack of significance of many of these apparent anomalies, other, more subjective criteria were used to interpret the higher values. These criteria involved consideration of the geologic setting, the extent of sampling at localities where anomalies were indicated, and the kinds of samples that had the higher values. Very careful scrutiny was given to apparent anomalies in the eastern volcanic-rock segment of the wilderness because of the possibility that anomalies there could be related to mineral deposits not having observed geologic or geophysical expression. However, many apparent anomalies in the western segment of the wilderness are directly relatable to heavy minerals of detrital origin in the extensive quartzite conglomerate units. The heavy minerals (and commonly associated elements) are ilmenite (titanium), sphene (titanium, tin), grossularite garnet (tin), monazite (thorium, rare-earth elements), zircon (zirconium), powellite (molybdenum), and gold.

The threshold for anomalies was selected at two standard deviations above the geometric mean for samples whose cumulative frequency showed log-normal distribution of data, as suggested by Hawkes and Webb (1962). The break in slope of the cumulative-frequency curve was selected as the threshold for mixed populations of data in plots of cumulative frequency versus concentration level, according to the method of Tennant and White (1959). Table 4 lists the elements and threshold values selected for some of the data sets.

Most of the mineral resource potential of the Teton Wilderness is intimately linked with the sedimentary rocks; some weak geochemical anomalies also are associated with granodiorite intrusions on Thorofare Plateau west of Thunder Mountain on the northwest shoulder of Younts Peak (fig. 1), as discussed below, and near Yellow Mountain (fig. 2). The eastern segment had a few scattered geochemical anomalies elsewhere. Formations having geochemical anomalies in areas having possible resource potential in the rest of the wilderness are as follows: (1) gold in Pinyon Conglomerate, Harebell Formation, and related alluvium; (2) silver, gold, and copper in Precambrian rocks; (3) trace elements and hydrocarbons in black shale of the Amsden Formation; (4)trace elements and phosphate in the Phosphoria Formation; and (5) hydrocarbons and trace elements in the Aycross(?) Formation.

The analyses by the U.S. Bureau of Mines of the tailings from the pan-concentrate samples showed a few values that are considered slightly above background values, but no anomalous areas were identified. One sample had 0.3

Table 4.--Threshold values selected for identifying geochemical anomalies

[Values in parts per million (ppm)]

Sample medium or formation	Ag	Cu	Mo	Pb	Sn	Zn
Soil-------------------	1	50	5	100	10	100
Stream sediments------	1	50	5	100	10	100
Pan concentrates------	1	70	15	100	15	200
Welded tuff-----------	1	30	15	100	15	200
Wiggins Formation-----	1	70	15	100	10	200
Langford Formation----	1	70	15	100	10	200
Two Ocean Formation---	1	70	15	100	10	200
Aycross(?) Formation--	1	70	15	100	10	200
Pinyon Conglomerate---	1	50	15	100	10	200
Harebell Formation----	1	50	15	100	10	200
Amsden Formation------	1	50	15	100	10	200
Phosphoria Formation--	1	70	15	100	10	200
Precambrian rocks-----	1	100	15	100	10	200

percent copper, but all other samples ran 0.006 percent or less copper. Two samples had 0.2 percent chromium and 0.6 percent lead.

A petroliferous and metalliferous black shale, about 50 ft thick, was discovered in Mississippian rocks at three localities in the wilderness. These strata were studied and sampled in detail. They represent a unique shelf facies of Mississippian marine sediments and are unrecognized elsewhere in the region. They are possible source beds for oil and gas under the western half of the wilderness, and the results of our sampling show that locally they contain as much as 5 ppm silver, 3,000 ppm copper, 1,000 ppm molybdenum, and 1,500 ppm zinc.

A few samples that have slightly anomalously high values are from near the Thorofare Plateau and may be related to a granodiorite intrusion that has two small outcrops west of Thunder Mountain. A magnetic anomaly was also identified there. Eight bedrock samples (some with visible pyrite) collected from these outcrops show analytical values within the normal range of background values. A few soil samples collected from the head of the cirque east of Thunder Mountain have slightly high manganese or copper contents, but bedrock samples collected from outcrops between the soil samples have analytical values within the normal range of background values. Analyses of stream-sediment and pan-concentrate samples from Hidden Creek and Castle Creek, which drain part of Thorofare Plateau, indicate very minor geochemical anomalies for silver, gold, copper, and mercury. A stream-sediment sample at the head of Castle Creek contained 2 ppm of silver. Several pan-concentrate samples from the Hidden Creek basin had anomalously high mercury, two had anomalously high zinc, and one contained 0.13 ppm gold.

One sample collected near Younts Peak contained 100 ppm copper and other samples were slightly enriched in barium, lead, and zinc. A small granodiorite intrusion northwest of the summit of Younts Peak may have caused these metal enrichments.

Traces of gold were found in a pan concentrate of sediment from the Valley Fork of Thorofare Creek, which drains part of the Yellow Mountain intrusive complex. However, detailed followup sampling on and around Yellow Mountain failed to reveal anomalous concentrations of any metals. Dike swarms are common on the drainage divide at the headwaters of Thorofare Creek and Yellowstone River. Pyrite was evident in rocks near some of these dikes but no geochemically high anomalies were identified.

Several sediment samples from the headwaters of the South Buffalo Fork River and Cub Creek (fig. 1), around the Buffalo Plateau, had slightly high values for copper and zinc. These samples are mostly pan concentrates from drainages that are entirely within the stratified rocks of the Wiggins, Langford, Two Ocean, and Trout Peak Formations. No igneous intrusions were observed, nor were there any geophysical anomalies other than the large negative gravity anomaly associated with the postulated Younts basin. The high zinc values in concentrates are most likely the result of concentration of zinc in ferromagnesium silicate minerals such as pyroxene, amphibole, and olivine. High copper values are apparently related to flows of andesite in the Wiggins Formation and Trout Peak Trachyandesite. None of these areas are believed to have geochemically significant anomalies.

Gold

Gold was detected in many samples collected in the western segment of the wilderness (table 5). Because of the low crustal abundance and great value of gold, it was studied in detail. Where gold was detected in samples from the

Table 5.--Average values of gold recoverable by panning alluvial and terrace deposits in and near Teton Wilderness

Locality information[1]	Number of samples	Average for number of samples indicated: Au content (mg/m^3)	(oz/yd^3)	Value of Au in 1 yd^3: $100/oz (troy oz)	$600/oz (troy oz)	Sample with greatest amount of gold: Au content (mg/m^3)	(oz/yd^3)	Value of Au in 1 yd^3: $100/oz (troy oz)	$600/oz (troy oz)
Reconnaissance sampling of alluvial deposits along main streams and tributaries draining quartzite conglomerate									
North Fork Pilgrim Creek----------	24	166.6	0.0041	0.41	2.46	1,863.8	0.0458	4.58	27.49
East Fork Pilgrim Creek-----------	40	376.3	.0092	.93	5.55	8,828.3	.217	21.70	130.21
Pacific Creek-Wilderness boundary boundary to Gravel Creek--------	38	92.9	.0023	.23	1.37	510.1	.0125	1.25	7.52
Pacific Creek-Gravel Creek to Mink Creek----------------------	21	15.3	.0004	.04	.23	51.4	.0013	.13	.76
Whetstone Creek-------------------	17	59.8	.0015	.15	.88	307.4	.0075	.76	4.53
Gravel Creek----------------------	27	251.1	.0062	.62	3.70	3,923.7	.096	9.64	57.87
"Cub Creek"[2]----------------------	14	67.1	.0016	.16	.99	294.3	.0072	.72	4.34
Lava Creek------------------------	30	227.3	.0056	.56	3.35	1,471.4	.0362	3.62	21.70
Box Creek-------------------------	15	29.6	.0006	.06	.33	170.0	.0042	.42	2.51
Clear Creek-----------------------	17	7.1	.0002	.02	.10	44.6	.0011	.11	.66
Fox Creek-------------------------	12	5.0	.0001	.01	.07	21.2	.0052	.05	.31
Wolverine Creek-------------------	29	53.9	.0013	.13	.79	310.2	.0076	.76	4.58
Random sampling across alluvial fan									
Lava Creek fan--------------------	39	6.1	.0002	.02	.09	21.8	.0005	.05	.32
Random sampling on traverses across stream valleys									
Pacific Creek south of wilderness boundary-----------------------	25	21.7	.0005	.05	.32	124.5	.0031	.31	1.84
Pacific Creek south of wilderness boundary, 1,000 ft north of above--------------------------	22	30.9	.0008	.08	.46	137.3	.0034	.34	1.03
Pacific Creek below confluence with Whetstone Creek-----------	32	12.3	.0003	.03	.18	57.4	.0014	.14	.85
Pacific Creek at upper meadows----	23	32.6	.0008	.08	.48	242.5	.00596	.60	3.58
Pacific Creek at Gravel Creek confluence----------------------	16	10.2	.0003	.03	.15	50.9	.0012	.13	.75
Lava Creek------------------------	17	3.1	.0001	.01	.05	8.2	.0002	.02	.12
Wolverine Creek-------------------	19	4.7	.0001	.01	.07	13.0	.0003	.03	.19

Table 5.--Average values of gold recoverable by panning alluvial and terrace deposits in and near Teton Wilderness--Continued

Locality information[1]	Number of samples	Average for number of samples indicated: Au content (mg/m^3)	Average: Au content (oz/yd^3)	Average: Value of Au in 1 yd^3, $100/oz (troy oz)	Average: Value of Au in 1 yd^3, $600/oz (troy oz)	Sample with greatest amount of gold: Au content (mg/m^3)	Greatest: Au content (oz/yd^3)	Greatest: Value of Au in 1 yd^3, $100/oz (troy oz)	Greatest: Value of Au in 1 yd^3, $600/oz (troy oz)
Random grid sampling									
North Fork of Pilgrim Creek-------	18	23.5	.0006	.06	.35	261.6	.0064	.64	3.86
Random grid sampling of terraces									
Three terraces on East Fork of Pilgrim Creek------------------	61	5.1	.0001	.01	.08	14.9	.0004	.04	.22
Terraces at confluence of Pacific and Whetstone Creeks------------	13	13.9	.0003	.03	.20	49.4	.0012	.12	.73
Selective sampling of favorable sites									
Pacific Creek south of wilderness boundary------------------------	15	173.7	.0043	.43	2.56	1,765.7	.0434	4.34	26.04
Pacific Creek at Allen placer claim---------------------------	31	575.2	.0141	1.41	8.48	4,119.9	.1013	10.13	60.76
Pacific Creek at Allen placer claim, silt-laden moss----------	2	14,152.8	.3479	34.79	208.74	16,839.2	.3889	41.39	248.36
Channel sampling									
Vertical channel, Pacific Creek south of wilderness boundary----	12	28.3	.0007	.07	.42	118.5	.0029	.29	1.75
Vertical channel, Lava Creek south of Gravel Mountain--------	12	15.7	.0004	.04	.23	33.4	.0008	.08	.49

[1]Field notes and sample descriptions for some samples were destroyed by fire at U.S. Geological Survey, Building 25, Denver Federal Center, Denver, Colo., March 19, 1976. For analytical data for individual samples see McDanal and others (1983).

[2]Local name for stream that enters Pacific Creek opposite Gravel Creek.

eastern segment of the wilderness it was considered geochemically anomalous and perhaps indicative of hydrothermal mineralization.

The highest gold values were obtained from silt-laden moss on the Frank Allen placer claims. In recognition of the high gold content in moss at the edge of Pacific Creek, Mr. Allen systematically "stockpiled" streamside vegetation, particularly moss, in mounds along Pacific Creek. After allowing a year or two for the organic material to decay, he harvested the gold by shoveling and washing the remaining silt through sluices and other gold-recovery devices.

Sediment samples with high gold values were also obtained from both forks of Pilgrim Creek, Gravel Creek, and Lava Creek. These streams drain areas having enormous volumes of quartzite conglomerate such as those on Whetstone Mountain, Pinyon Peak, Gravel Mountain, Gravel Peak, and several unnamed mountains. Moss and other vegetation along these streams trap gold particles released during weathering of the conglomerate.

The average gold content of samples from localities that have many exposures of quartzite conglomerate and related sandstone and shale is shown in table 6. These averages were obtained by mathematical conversion of the gold content, determined by atomic absorption on the pan concentrates, to in-place material, based on the weight of the concentrate and the weight of the sample panned.

Gold was obtained in the composite sample of every group of samples except one (L66-55). This is highly significant because these data show that particulate gold occurs widely in these formations. Sampling the formations in other ways, such as in traverses or at random sites at many localities, also shows the ubiquitous distribution of gold in the Pinyon Conglomerate and Harebell Formations.

The gold content of the formations indicated by the small samples that we took is very low. The distribution of gold is always erratic in placer deposits, and much more detailed sampling than we have done would be required to determine whether high-grade enrichments occur, as seems likely. Some 1-lb samples contained several flakes of gold, but others had none. Taking the average of the gold content of a group of samples tends to obscure natural variations in gold content just as one analysis of a large sample at each site would; neither would show where the rock or sediment with the highest values occurs.

The data in table 6 suggest the gold content is generally greater in the upper units of the Harebell Formation or the lower part of the Bobcat Member of the Harebell (Love, 1973). Large units of quartzite conglomerate in the Pinyon Conglomerate, such as those near the summits of Pinyon Peak and Gravel Mountain, are evidently lower in gold content than sandstone and conglomerate beds much lower in the section. This observation suggests that (1) higher gold content is related to the well-known tendency of gold to be enriched at bedrock in placer deposits, and (2) less gold was available from the source area when the topmost parts of the conglomerate beds were deposited.

The analyses of the 221 pan-concentrate stream-sediment samples collected by the U.S. Bureau of Mines showed gold contents that ranged from below the limit of detection to 0.068T oz/yd^3. Concentrations of gold greater than 0.0032T oz/yd^3 were determined in 44 of those samples, and averaged 0.0012T oz/yd^3. The U.S. Bureau of Mines also collected 124 samples of bank gravels in the vicinity where those 44 samples with the highest values were obtained. Gold values ranged from 0.00001 to 0.002T oz/yd^3. The highest gold value for samples representing gravel 3 ft thick averaged 0.001T oz/yd^3.

Table 6.--Summary of amount and value of gold recoverable by crushing and panning outcrop samples from measured sections in the Pinyon Conglomerate and Harebell Formation

[Several samples at each locality were combined to obtain the summary values, as described in text]

Locality and sample information[1]	Sample identification	Number of samples combined	Au content computed to (ppb)	Au content computed to (mg/m^3)	Au content computed to (oz/yd^3)	Value of Au in 1 yd^3[3] $100/oz (troy oz)	Value of Au in 1 yd^3[3] $600/oz (troy oz)
Type section of Harebell Formation on Big Game Ridge[2]							
On hill, 10,065; about 470 ft of shale, claystone, minor conglomerate (units 21-47)----	W66-1	16	9.0	7.8	0.00019	0.02	0.12
On hill, 9,902; about 120 ft of sandstone and claystone (units 48-70)------------------	L66-65	5	1.5	1.3	.00003	<.01	.02
South of hill, 9,902; about 50 ft of sandstone and claystone (units 71-72)-------------	L66-66	4	37.7	32.8	.00081	.08	.48
Big Game Ridge; about 500 ft of sandstone, siltstone, and claystone (units 78-99)------	L66-67	23	.75	.7	.00002	<.01	.01
Principal reference section of Pinyon Canyon Conglomerate[3]							
Upper part of type Harebell Formation; about 200 ft of sandstone and claystone (units 1-4)--	L66-55	7	<.15	<.13	<.00003	<.01	<.01
Base of Pinyon Conglomerate; about 210 ft of sandstone and conglomerate (units 6-7)----	L66-56	7	15.0	13.1	.00032	.03	.19
Chiefly conglomerate, some sandstone; thickness about 950 ft (units 8-18)--------------	L66-51	21	23.4	20.4	.00050	.05	.30
Overlying conglomerate; about 440 ft thick (unit 20)-----------------------------------	L66-52	19	9.5	8.2	.00020	.02	.12
North span of Pinyon Peak; about 360 ft conglomerate and minor sandstone (units 22-30)	L66-54	20	8.7	7.6	.00018	.02	.11
Type section of Bobcat Member of Harbell Formation[4]							
Upper part of lower member of Harebell Formation and lower part of Bobcat Member; about 585 ft of conglomerate sandstone, claystone, and shale (units 1-21)------------	L66-40	40	29.1	25.4	.00062	.06	.37
Lower part of Bobcat Member; about 180 ft of conglomerate (units 23-26)----------------	L66-41	8	4.5	3.9	.00010	.01	.06
Upper part of Bobcat Member; about 350 ft chiefly conglomerate (units 28-38)-----------	L66-42	11	1.2	1.0	.00003	<.01	.02
Pinyon Conglomerate overlying Bobcat Member; about 1,000 ft of conglomerate (units 40-41)---	L67-26	15	.9	.8	.00002	<.01	.01
East Pilgrim Creek section[5]							
Lower part of Harebell Formation; about 350 ft of conglomerate, sandstone, and claystone (unit 1)---	L66-45	4	21.0	18.3	.00045	.04	.03
Conglomerate 80 ft thick and sandstone 20 ft thick Harebell Formation (units 3-5)------	L66-46	3	33.0	28.8	.00071	.07	.42
Bobcat Member; about 50 ft of conglomerate containing sandstone lenses (units 6-9)-----	L66-47	5	52.5	45.8	.00112	.11	.67
Bobcat Member; sandstone and shale, about 500 ft thick (units 10-15)-------------------	L66-44	7	15.0	13.1	.00032	.03	.19
Bobcat Member; about 4-5 ft of conglomerate--	L66-48	2	32.5	32.7	.00080	.08	.48
Bobcat Member; about 50 ft of sandstone--	L67-21	2	3.3	2.9	.00007	.01	.04
Bobcat Member; about 50 ft of conglomerate---	L67-20	2	5.3	4.6	.00011	.01	.07
Bobcat Member; about 50 ft of sandstone and conglomerate-------------------------------	L67-19	6	3.3	2.9	.00007	.01	.04
Bobcat Member; about 170 ft of sandstone and conglomerate (units 22-26)----------------	L67-17, 18	8	9.2	8.0	.00020	.02	.12
Bobcat Member; about 450 ft of conglomerate, sandstone, and claystone (units 27-36)----	L67-32	17	8.6	7.5	.00018	.02	.11
Top of Bobcat Member; about 236 ft of conglomerate and magnetite-rich sandstone (units 37-40)---	L67-35	9	14.4	12.6	.00031	.03	.18
Pinyon Conglomerate; about 500-600 ft of quartzite conglomerate------------------------	L67-34	18	11.4	9.9	.00024	.02	.15

Table 6.--Summary of amount and value of gold recoverable by crushing and panning outcrop samples from measured sections in the Pinyon Conglomerate and Harebell Formation--Continued

Locality and sample information[1]	Sample identi-fication	Number of samples combined	Au content computed to (ppb)	Au content computed to (mg/m^3)	Au content computed to (mg/yd^3)	Value of Au in 1 yd^3 $100/oz (troy oz)	Value of Au in 1 yd^3 $600/oz (troy oz)
Pacific Creek section[6]							
Lower member of Harebell Formation; about 565 ft, predominantly sandstone, some conglomerate (units 7-21)	L66-90	24	.9	.8	.00002	<.01	.01
Bobcat Member of Harebell Formation; about 825 ft, predominantly conglomerate (units 26-39)	L66-20	37	18.0	15.7	.00038	.04	.23
Pinyon Conglomerate; about 750 ft conglomerate and sandstone; samples predominantly sandstone (units 40-45)	L66-24	13	.5	.4	.00001	<.01	.01
Pinyon Conglomerate; about 535 ft, predominantly conglomerate (units 46-53)	L66-23	32	11.4	9.9	.00024	.02	.15
Gravel Mountain section[7]							
Lower member of Harebell Formation; about 1,100 ft of siltstone, sandstone, and sparse conglomerate	L66-82	21	42.8	37.3	.00091	.09	.55
Bobcat Member, Harebell Formation; about 920 ft of conglomerate, sandstone, and siltstone	L66-81	31	43.5	37.9	.00093	.09	.56
Pinyon Conglomerate; about 1,060 ft of conglomerate	L66-80	27	5.3	7.2	.00018	.02	.11

[1]Some original field notes and laboratory records were destroyed by fire at U.S. Geological Survey, Building 25, Denver Federal Center, Denver, Colo., March 19, 1976.

[2]Units 21-72, 78-99 of sec. 3, fig. 7 of Love (1973).

[3]Units 1-4, 6-18, 20, 22-30, of sec. 3A, fig. 7 of Love (1973).

[4]Units 1-21, 23-26, 28-38, 40-41 of sec. 4, fig. 7 of Love (1973).

[5]Units 1, 3-15, 22-40 of sec. 5, fig. 7 of Love (1973).

[6]Units 7-21, 26-53 of sec. 7, fig. 7 of Love (1973).

[7]Sec. 8, fig. 7 of Love (1973).

Thirty additional samples were taken at several localities to evaluate placer mining possibilities in more detail.

Although flour gold is consistently present in the Quaternary gravels and in the parent Harebell Formation and Pinyon Conglomerate, the distribution of the gold and the values obtained do not warrant further inquiry into mining and recovery methods at this time.

MINES AND MINERAL OCCURRENCES

Mineral resources

A map showing the mines and minerals of Wyoming (Wyoming Geological Survey, 1970) and a report on the mineral resources of Wyoming (Osterwald and others, 1966) locate and describe the known mineral resources of the State. Within the Teton Wilderness (not depicted in these publications), the map shows areas containing coal, limestone, bentonite, and phosphate; the map also shows one gold occurrence and one copper-gold occurrence. Coal, limestone, bentonite, and phosphate are also shown north, west, and south of the wilderness. The map shows an open-pit gold mine outside the southwest corner of the Teton Wilderness and also shows a gold occurrence within Grand Teton National Park; the mine probably represents placer mining operations on Pacific Creek. The Crouch gold prospect (gold, copper, lead, zinc) 4 mi north of the northeastern tip of the Teton Wilderness, and the Stinking Water region (molybdenum, copper, gold) 5 mi east of the Teton Wilderness are the only mining centers reported in the vicinity of the wilderness; both are in the Washakie Wilderness.

Mining claims and mineral leases

The U.S. Bureau of Mines searched county courthouse records, State records, and Federal public land records for information on mines, mining claims, and mineral leases. Courthouse records were checked for Teton, Park, and Fremont Counties; however, only Teton County records had notices on file of mining locations that were within the Teton Wilderness.

Approximately 50 placer mining claims were staked along Pacific and Whetstone Creeks in 1895. In the years 1905 through 1909, some 48 lode mining claims were staked along South Buffalo Fork between North Buffalo Fork and Cub Creek, and about 12 lode mining claims were staked along North Buffalo Fork near the mouth of Soda Creek. Four lode mining claims were staked on North Buffalo Fork in 1919 and 14 lode mining claims were staked on South Buffalo Fork in 1930. Since 1930, some 11 lode mining claims and 104 placer mining claims have been staked within the boundaries of the present Teton Wilderness. There are no patented mining claims within the Teton Wilderness.

There are no mineral leases or permits in effect within the Teton Wilderness, and public land records of the U.S. Bureau of Land Management indicate that no leases or permits have been issued in the past.

Mines and prospects

There are no active mines that produce metallic or nonmetallic minerals from rock units in the Teton Wilderness. Two copper mines were operated during the early 1900's near the southeast margin of the area, and gold placer prospects have been worked from time to time along major drainages in the southwestern part.

Two adits on South Buffalo Fork are believed to have been copper prospects. Both adits are in contact zones between gneiss and amphibolite schist in an outcrop of Precambrian rocks. The eastern adit is on the north side of South Buffalo Fork on the valley floor about 2.4 mi upstream from the junction with North Buffalo Fork. The adit is covered by a talus slide. The bearing of the adit is about N. 35° W. A 50-ton dump and the remains of a log cabin mark the site. Selected chips of copper-stained schist from the dump (sample 365) assayed 0.08 percent copper, a trace of gold, and no silver. A grab sample (366) of the dump on 5-ft centers assayed 50 ppm copper, a trace of gold, and no silver.

The western adit is on the south side of South Buffalo Fork 300 ft above the valley floor about 1.1 mi west-southwest of the eastern adit. The western adit was driven S. 47° W., 88 ft on a shear between gneiss and amphibolite schist. The adit is partly caved. A gouge zone 2- to 6-in. thick zone on the footwall of the shear was sampled and assayed 0.45 percent copper, a trace of gold, and no silver.

Energy resources

Several formations that produce oil and gas elsewhere in northwest Wyoming are present in the Teton Wilderness. However, no exploratory holes for oil and gas have been drilled within the wilderness.

The area within the present Teton Wilderness was temporarily withdrawn from oil and gas leasing by a Secretarial Order, August 15, 1947, and no leases have been issued since. Oil and gas leases are in effect south of the Teton Wilderness, and in T. 44 N., R. 110 W. leases abut the wilderness boundary.

One small flammable gas seep is known on the Whetstone anticline and another is on the east flank of the Bailey anticline. The nearest oil and gas test, the True-Travis Govt. No. 1, is 2.2 mi south of the wilderness in sec. 29, T. 45 N., R. 113 W. It was drilled in 1958 to a depth of 4,367 ft in the Cloverly-Morrison(?) sequence and encountered no major shows of oil or gas. Older and deeper units that might be productive (table 3) were not penetrated. The Spread Creek anticline a few miles south of the wilderness was also tested (Strikland, 1956). The holes were plugged and abandoned.

Large volumes of oil and gas have been produced in the Bighorn Basin 40-50 mi to the east from many anticlines similar to those in the Teton Wilderness and from correlative strata. This does not mean that oil and gas may necessarily be expected in the anticlines in the Teton Wilderness. Even larger anticlines lie south of the western part of the Teton Wilderness in Jackson Hole, many of which were drilled prior to 1982. The northeast flank of the largest, the Spread Creek anticline, extends into the southwest corner of the wilderness. This anticline has more closure and more possibly productive horizons than most anticlines in the wilderness, and, in addition, has some of the largest natural gas seeps in Wyoming. It has been tested by seven drill holes, some of which were apparently well located structurally; several encountered oil and gas shows, but only one was capable of small gas production as of 1980. The reasons for the lack of success at the drill sites are not known, but new reflection seismic data suggest that previously unrecognized large bedding-plane thrust faults may have displaced stratigraphic and structural traps.

If the Younts basin(?) gravity anomaly does indeed indicate a basin filled with Paleozoic and Mesozoic sedimentary rocks 20,000 ft thick under a shallow volcanic cover, the basin will be very important in evaluating oil and gas possibilities. Downwarp oil- and gas-bearing anticlines and stratigraphic traps, similar to those in the adjacent Bighorn Basin to the east, might exist along the margin of the basin.

Although Wyoming is one of the major producers of uranium, there is no indication that deposits of uranium or other nuclear source materials occur within the wilderness. The formations from which uranium is produced in other parts of Wyoming are not present in the wilderness.

In the Aycross(?) Formation in the southern part of the wilderness, dark-gray and black shale, coaly shale, claystone, and thin beds of oil shale are interlayered with beds of tuff, pebbles, coal, and carbonaceous shale. The oil yield of some of the oil shale is as high as 15.4 gal/ton of shale, but the overall resource potential of the area for oil shale is low.

Vitrain reflectance studies of black shale in several units of different ages in and near the Teton Wilderness show that these strata have been subjected to temperatures sufficient to promote maturation of hydrocarbons, but not high enough to result in metamorphism. Therefore, these shale units, aggregating a total thickness of several thousand feet (table 2), can be considered source rocks for oil and gas.

All the coal beds of interest are in the Bacon Ridge Sandstone and in the overlying Sohare sequence (informal name) in the western one-third of the Teton Wilderness. In addition, thin beds of impure coal occur in the lower part of the Frontier Formation in some places, and also in the Aycross(?) Formation near Holmes Cave. The U.S. Bureau of Reclamation and others operated several small coal mines in the Bacon Ridge Sandstone and Mesaverde Formation directly south of the wilderness in the early 1900's.

The lower part of the Frontier Formation near the southeast end of the Bailey anticline has one impure coal bed 2 ft thick. On Wildcat Peak, the coal-bearing Bacon Ridge Sandstone is well exposed and a detailed section was measured. An impure coal bed 2.7 ft thick occurs about 225 ft above the base; a second, 2.5 ft thick is 260 ft above the base; and a third, 3 ft thick is 580 ft above the base. A coal bed 5.5 ft thick a short interval stratigraphically higher in the exposure southeast of Wildcat Peak was sampled and analyzed (Love and others, 1975, B-33A, table 26; fig. 27). The highest quality coal in this seam, sample B-33, has a thickness of 1 ft.

In the Kitten measured section of the Bacon Ridge Sandstone on the west flank of the Wildcat anticline, a coal bed 2.5 ft thick is 207 ft above the base of the formation; a second, 3 ft thick is 241 ft above the base; and a third, 2.1 ft thick is 583 ft above the base of the formation. These coal beds probably correlate with the lower three coal beds in the Wildcat Peak section.

Several coal beds occur in the Bacon Ridge Sandstone in the section on Arizona Creek (Love and others, 1975, fig. 26, sec. 1). Three thin coal beds in the Bacon Ridge Sandstone were sampled along Bailey Creek Canyon 4 mi south-southeast of the Arizona Creek coals. The lower two are each less than 1 ft thick, but the uppermost is 2 ft of black shiny coal. Several coal beds also were measured and sampled in the Bacon Ridge Sandstone near Enos Creek.

A part of the western Teton Wilderness is underlain by the Jackson Hole coal field, which extends from Yellowstone National Park south to the Gros Ventre Range (Berryhill and others, 1950). The U.S. Bureau of Reclamation produced coal from the Mesaverde Formation at a site on Pilgrim Creek in the southwestern corner of the wilderness during the construction of an earth dam on Jackson Lake. Coal mining was later shifted to a site outside the present boundary of the wilderness on Buffalo Fork near the mouth of Lava Creek. Information on the extent of the workings and the amount of coal produced from the site of Pilgrim Creek is not available but production was apparently minor.

Gold

Gold is found in the Teton Wilderness in the Harebell Formation, the Pinyon Conglomerate, and the Quaternary gravels (Antweiler and Love, 1967). A few samples collected in the eastern volcanic rock segment of the wilderness as well as in and near the adjacent Du Noir Addition (fig. 1) had low gold values in lenses of quartzite gravel derived from the Pinyon Conglomerate and Harebell Formation (Prostka and others, 1979). Small amounts of gold also occur in Precambrian rocks.

The vast majority of samples with measurable gold values are of quartzite conglomerate and related alluvium of the Pinyon Conglomerate and Harebell Formation. This gold occurs as extremely small particles and resembles the flour gold in alluvium along the Snake River in Wyoming and Idaho. The fineness (parts per thousand) of flour gold is normally higher than the fineness of regular placer gold, and the following values have been reported for Snake River gold: Hill (1916), 930-951 fine with an average of 945; Hite (1933a), 954 fine; and Hite (1933b) 943 fine. Gold recovered in this investigation from Pacific Creek gravel has a fineness of 950. Finely divided gold occurs throughout thick sequences of the Pinyon and Harebell Formations (Antweiler and Love, 1967). The volume of gold-bearing conglomerate in the Teton Wilderness is at least 50 mi^3, and nearly all the streams in the western segment of the wilderness have gold-bearing alluvium derived from conglomerate. Several mountains are composed entirely of these rocks.

Other mineral occurrences

The Phosphoria Formation is poorly exposed in scattered outcrops along the west flank of the Washakie Range, but underlies the western one-third of the Teton Wilderness. The content of P_2O_5 in the Phosphoria is as much as 17.3 percent in the Teton Wilderness, as indicated by samples from a poorly exposed section at Enos Lake where the apparent thickness of the beds is 6 ft.

Gypsum crops out at only one locality in the Teton Wilderness but probably underlies the western one-third (375 mi^2) of the area. The gypsum is in a single bed within the Gypsum Spring Formation of Middle Jurassic age. Along all but one part of the one outcrop of the formation, the gypsum has been leached out by near-surface solution. Wells to the south of the wilderness, however, show that gypsum is invariably present in normal subsurface sections. The gypsum bed is too thin and too inaccessible to compete with much larger deposits in the Bighorn Basin to the east and in the Wind River Basin to the southeast.

Thin beds of generally impure bentonite are present in the Mowry Shale, Frontier Formation, Cody Shale, Bacon Ridge Sandstone, and Harebell Formation. All the bentonite beds are thin or inaccessible, and the bentonite impure, but their trace-element content is worth noting. Some beds have concentrations of silver (as much as 5 ppm), molybdenum, and tin (data set 15, in McDanal and others, 1983).

Sand and gravel deposits are not as plentiful in the western segment of the wilderness as they are elsewhere to the west and south in Jackson Hole, and there is no unique quality that would make them a consideration in a resource evaluation. The deposits of sand and gravel in the eastern segment of the wilderness tend to be poorly sorted; because they contain a high proportion of soft, readily weathered volcanic fragments, they are generally unsuitable for concrete and road metal.

The Flathead Formation is a possible source of attractive building stone at several localities on the north side of Angle Mountain, along the North Buffalo Fork, and on the south side of Terrace Mountain. All these localities, however, are remote; stone of comparable quality could be obtained much more readily at many other localities in northwestern Wyoming. The same statement applies to the Mississippian Madison Limestone and limestone in the Cambrian Gros Ventre Formation, on the flanks of the Washakie Range. The crystal-poor part of the Huckleberry Ridge Tuff has been used by residents of Teton County for building stone. It is colorful in some places (red, orange, pink, purple, and gray), lightweight, easily cut and shaped, and moderately durable. No quarries have been opened in or near the wilderness; all are farther south in Jackson Hole and are more accessible than those in the western part of the Teton Wilderness.

GEOTHERMAL RESOURCES

Two parts of the Teton Wilderness are of some geothermal interest. One is the part adjacent to the Teton Corridor area, which has been described (Love and others, 1975); no new data have been acquired since that report was issued.

The other area of interest is in the swampy floodplain of North Buffalo Fork River near its junction with Soda Fork. A series of dormant to active warm springs extends for a distance of about 1,500 ft and trend in a northeasterly direction. Mounds of calcareous travertine are as much as 4 ft high around some of the springs. Continuous streams of nonflammable gas emerge in hundreds of places in the area. No abnormal radioactivity was observed in the area.

Small amounts of hot water (113°F) flow from many of the orifices. The water commonly has a mildly astringent taste. One of the springs with the hottest water had a flow estimated to be 300 gal/day (as of July 20, 1974). Red algae are common in the hottest water. The main stream traversing the most active thermal area had an estimated flow of 250 gal/min (as of July 20, 1974). Another warm spring also emerges from the Madison Limestone directly east, across the North Buffalo Fork River. This spring is at the edge of the river and 300 ft downstream from the junction with Soda Fork, where the Madison strikes N. 5° W., and dips 45° W. The spring flows an estimated 20,000 gal/day of 92°F water (as of July 20, 1974). The orifice is stained rusty brown, and nonflammable gas boils up forcefully and continuously through the water.

It is thought that a branch of the Soda Fork fault cuts through the warm spring area and that meteoric water, heated by a thermal gradient, comes up along this fault. This area and these springs are considered to have a low geothermal resource potential.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

This investigation of the mineral resource potential of the Teton Wilderness has shown that mineral commodities most likely to be present are: (1) oil and gas; (2) metallic minerals, particularly gold in placers and copper; (3) coal, bentonite, gypsum, phosphorite, and building stone in sedimentary deposits; and (4) sand and gravel in surficial deposits. In addition, the possibility of uranium deposits, metals in black shales, and the geothermal resource potential of the area were evaluated.

Oil and gas

The Teton Wilderness has a moderate resource potential for oil and gas in several anticlines, fault-trap structures, and stratigraphic traps. Most of the anticlines and fault-trap structures have several possible producing horizons within a depth range of 1,000 to 10,000 ft. The Wolverine and Whetstone anticlines are the largest, and the resource potential for oil and gas is highest for the areas of those anticlines. If the postulated Younts basin is filled with sedimentary rocks 20,000 ft thick, it may have a high potential for oil and gas. As far as we can determine from surface exposures and inferred trends of anticlines, the Washakie Range has a low resource potential for oil and gas because Lower Paleozoic and Precambrian rocks that underlie the Absaroka volcanics are not known to be petroliferous in this area. Further, no oil seeps that would indicate buried source rocks have been observed in the volcaniclastic strata. Oil seeps, however, are known 20 mi northeast and 35 mi northwest of the Teton Wilderness, emerging from volcanic rocks of the Absaroka Range and the Yellowstone rhyolite plateau, respectively (Love and Good, 1970).

The resource potential for oil and gas of the anticline areas within the western one-fourth of the Teton Wilderness is probably comparable to the presently unproductive anticline areas to the south in Jackson Hole, because the rocks, structural patterns, and geologic history are similar. If, after thorough surface and geophysical studies and adequate new drilling, the anticlines south of the Teton Wilderness remain unproductive, those in the wilderness can also probably be considered as unfavorable prospects. On the other hand, if new drilling of anticlines to the south were to result in significant oil and gas production, the resource potential of the anticline areas in the wilderness should be reevaluated.

Metallic mineral resources

The Teton Wilderness has a low to moderate resource potential for gold. Significant quantities of gold were found in alluvial deposits along several major streams that drain gold-bearing conglomerates in the Harebell Formation and Pinyon Conglomerate. The wilderness has a low resource potential for copper, molybdenum, zinc, and other metals which occur in small amounts in black shale at the base of the Amsden Formation, and for molybdenum in several black shale units of Eocene age. Several intrusions of Tertiary igneous rocks in the eastern part of the wilderness were examined for mineral deposits and none were observed, but geophysical and weak geochemical anomalies are associated with the intrusions on Younts Peak and Thunder Mountain.

Although copper prospects are present in Precambrian rocks along South Buffalo Fork River, the area has a low resource potential for copper in Precambrian crystalline rocks.

Nonmetallic mineral resources

Phosphate is present in rocks that crop out within the Teton Wilderness, but Coffman and Service (1967) did not include any part of the wilderness in areas of western Wyoming that have either present potential or latent (not commercially available in the foreseeable future) potential for the production of phosphate. If samples of phosphatic shale 6 ft thick in the South Enos Lake section are indicative, this area might be considered to have a low resource potential for phosphate, but would definitely not be competitive with areas to the southwest that have thicker and higher grade phosphorites (Sheldon, 1963). According to Sheldon (1963) phosphorite in the Meade Peak Phosphatic Shale Member near the base of the Phosphoria is rarely more than 2 ft thick in or near the wilderness area.

A part of the Jackson Hole coal field lies within the Teton Wilderness. Coal beds occur at several localities in the Meeteetse and Mesaverde Formations, in the Sohare sequence, Bacon Ridge Sandstone, and Frontier Formation, but the beds are thin and the area has a low resource potential for coal.

Gypsum beds are thin and inaccessible in the wilderness; much larger and less remote deposits exist in the Bighorn Basin to the east and the Wind River Basin to the southeast.

Bentonite, pumicite, glauconite, building stone, and sand and gravel deposits are present in the wilderness, but the deposits of these materials are known in other areas that are much more accessible, of higher grade, and nearer to markets.

The Teton Wilderness has a low potential for geothermal resources. Warm springs near the North Buffalo Fork River are thought to be caused by heating of meteoric water by a thermal gradient along the Soda Creek fault.

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