STUDIES RELATED TO WILDERNESS
PRIMITIVE AREAS

ABSAROKA PRIMITIVE AREA, MONTANA

GEOLOGICAL SURVEY BULLETIN 1391-B

Mineral Resources of the Absaroka Primitive Area and Vicinity, Park and Sweet Grass Counties, Montana

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A mineral and geophysical survey of the area

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STUDIES RELATED TO WILDERNESS

PRIMITIVE AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Conference Report on Senate bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines are making mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System. Areas classed as "primitive" were not included in the Wilderness System, but the act provided that each primitive area should be studied for its suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of the Absaroka Primitive Area and vicinity, Mont., which includes some bordering areas that may come under discussion when the primitive area is considered for wilderness.

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MINERAL RESOURCES OF THE ABSAROKA PRIMITIVE AREA AND VICINITY, PARK AND SWEET GRASS COUNTIES, MONTANA

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SUMMARY

Geologic studies and a mineral appraisal were made of the Absaroka Primitive Area and contiguous areas in southwestern Montana as part of the program to investigate the resource potential of wilderness and primitive areas in the United States. This report is on an area of about 320 square miles, of which about 105 square miles is an established primitive area within the Gallatin National Forest. The area is in the northern part of the Absaroka Range along the northern boundary of Yellowstone National Park. All its major streams flow southward into the Yellowstone River within the Park from a divide having many peaks reaching altitudes of nearly 11,000 feet. On the west, north, and east, small mining districts have been prospected and mined since the 1880's for gold, silver, lead, copper, zinc, molybdenum, tungsten, and arsenic. Within the study area some gold was mined at Horseshoe Mountain before the turn of the century, and that locality has been restaked and reprospected periodically until recently.

The Absaroka study area is underlain by Precambrian schist and gneiss, Paleozoic sedimentary rocks, and both intrusive and extrusive igneous rocks of Tertiary age. These rocks are partly concealed by various types of unconsolidated Quaternary deposits. During Precambrian time an early sequence of sedimentary rocks was intensely folded and warped while undergoing metamorphism to gneiss and schist. Following was a long period during which there is no geologic record, except for minor igneous activity. During the Paleozoic Era, shallow seas periodically extended over the area. The sediments deposited in these seas during several geologic periods became chiefly shale and carbonate rocks. This sedimentary sequence is interrupted by minor unconformities. Thick sequences of upper Paleozoic and Mesozoic rocks are missing because of extensive erosion. In Late Cretaceous and early Tertiary time the area was uplifted into a major structural element, the Beartooth uplift, which included the Absaroka study area. Most Tertiary volcanic vents, associated intrusive rocks, and related mineral deposits in and near the study area are along a northwest-trending zone across the middle part of the uplift.

Aeromagnetic and gravity surveys were made of the Absaroka study area by the U.S. Geological Survey. Several strong, positive magnetic anomalies appear to coincide with the main Tertiary stocklike intrusive masses and several Precambrian intrusives. The

gravity data mostly delineate the contact between the Tertiary volcanics and the Precambrian crystalline rocks of the core of the uplift, as well as the Gardiner fault, a thrust fault that bounds the Beartooth uplift along its southwestern side. A gravity high in the valley of Hellroaring Creek, near the center of the study area, indicates the presence of dense Precambrian rock (metamorphosed iron carbonate formation) cut off along the Gardiner fault. A gravity low in the vicinity of Ash Mountain, in the western part of the study area, is most likely related to a volcanic vent and its associated intrusive plug.

Known mineral deposits in and peripheral to the Absaroka study area are: (1) the complex gold-silver-copper-lead-zinc ores of the New World (Cooke City) district; (2) the gold deposits of the Horseshoe Mountain area and the Independence (Cowles) district; (3) the complex ores of the emigrant-Mill Creek district, which are similar to those of the New World district, but with some significant occurrences of molybdenum; and (4) the gold-arsenic-tungsten deposits of the Jardine-Crevice Mountain district. In addition, gold occurrences similar to those at Jardine are in the vicinity of Hellroaring Ranger Station.

More than 1,200 samples were analyzed chemically or spectrographically for 30 elements. The 10 elements selected as being significant for a geochemical appraisal of the area, are as follows: gold, silver, arsenic, boron, copper, molybdenum, lead, tungsten, zinc, and citrate-soluble heavy metals — the last being the fraction of the heavy-metal content of a sample soluble in cold ammonium citrate. Statistical analysis of these data by log-probability plots of frequency distributions indicates that a small but different percentage of samples are anomalous for each element, and, as can be expected, many samples are anomalous in more than one element. Geographic plots by element show that most anomalous samples cluster in known mineralized terrane. Thus, elongate clusters of anomalous samples for almost all elements trend northwestward from Cooke City through areas of igneous intrusives and related mineralization. Other clusters clearly define the Jardine–Crevice Mountain district and the gold occurrence near Hellroaring Ranger Station, both of which appear to be spatially related to a prominent gravity high; the high, in turn, is probably caused by a zone of metamorphosed Precambrian iron carbonate.

Most mine and prospect workings are now caved or covered with overburden. Consequently, estimates of the mineral potential are based chiefly on dump samples and comparisons with nearby mines outside the study area. Adit-dump samples on Pine Creek contain as much as 1 ounce gold per ton and indicate that the area may be on a northern extension of the Jardine–Crevice Mountain district. Scheelite-bearing quartz veins, which cut diorite and schist on Oregon Mountain, contain tungsten values of 3 percent or more WO_3. Significant gold concentrations, possibly like those at Jardine, are in Precambrian schist at an old claim in the lower Hellroaring Creek area. Widely distributed anomalous metal values on old and new claims in the Horseshoe Mountain area indicate lode deposits that may be exploitable, whereas the small gold placers of Gold Run Creek in this area appear to be uneconomic at present.

Mineral occurrences in a belt extending northwestward from Cooke City through the New World mining district and the Horseshoe Mountain area to the Independence mining district are associated with Tertiary igneous activity. The upper part of these deposits may have substantial silver, as in the Independence district, whereas the lower part may be richer in copper. In the Emigrant–Mill Creek district porphyry molybdenum mineralization is in association with Tertiary intrusives and related low-gravity areas; similar mineralization may occur in the adjacent part of the Absaroka study area to the south (Ash Mountain).

The western part of the study area, in terrain peripheral to the Jardine–Crevice Mountain district and in the general vicinity of the Hellroaring Ranger Station, has some potential for gold-arsenic-tungsten deposits similar to those mined at Jardine and Crevice Mountain.

INTRODUCTION

LOCATION AND GEOGRAPHY

The Absaroka Primitive Area is in the Gardiner Ranger District of the Gallatin National Forest, Park County, Mont. (fig. 1), just north of Yellowstone National Park. The entire area covered by this report, referred to as the study area, includes a few square miles in Sweet Grass County (pl. 1). The study area is in the northern part of the Absaroka Range, a northwestward-trending mountain range that extends nearly 200 mi (miles) from Livingston, Mont., south to the vicinity of Dubois, Wyo. The northern part of the Absaroka Range is also known locally as

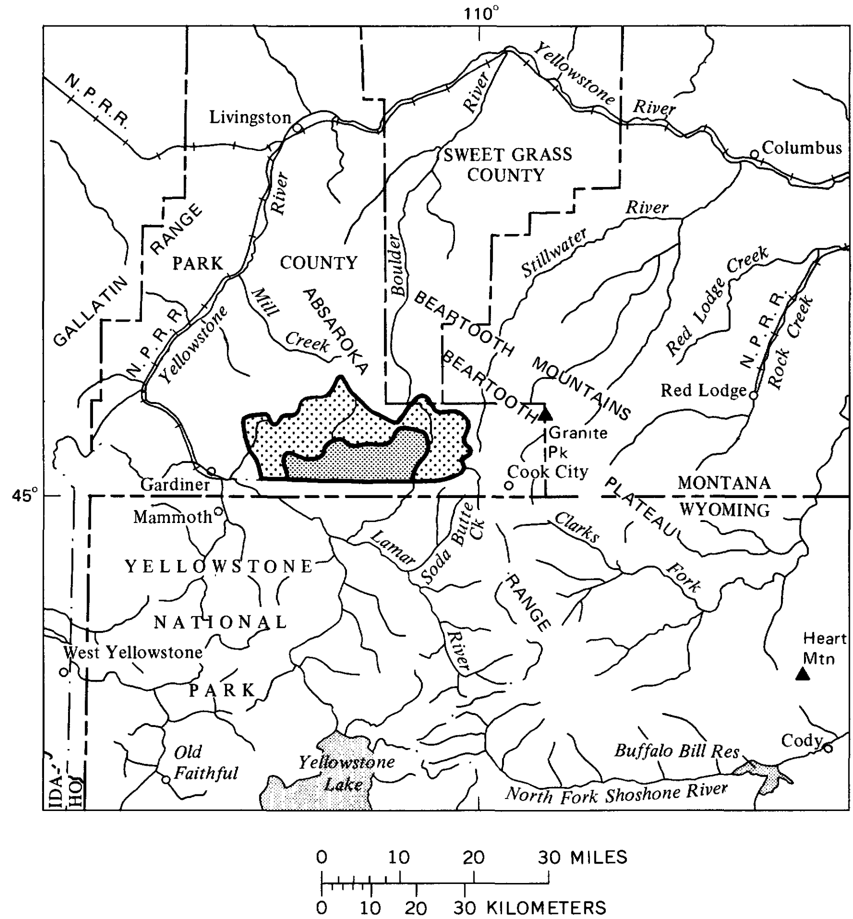


FIGURE 1. — Location of the Absaroka Primitive Area (dark shading) and the additional area studied (light shading).

the Snowy Range or Snowy Mountains. The study area is about 32 mi long east to west, about 16 mi wide north to south, and covers an area of 320 mi^2 (square miles) (204,800 acres), of which 105 mi^2 (62,784 acres) is the Absaroka Primitive Area (pl. 1, fig. 2).

In addition to the area investigated, as shown in figure 2, several small nearby mining districts were examined and sampled so that comparisons of the minerals in these samples could be made with mineral occurrences in the study area. These districts are the Jardine-Crevice Mountain district to the west, the Independence district to the northeast, and the New World (Cooke City) district to the east (fig. 2).

The principal towns near the Absaroka study area are Gardiner, at the north entrance to Yellowstone Park, and Silver Gate and Cooke City, near the northeast entrance to the park (figs. 1,2). Major highways to Gardiner and Cooke City provide access to the Absaroka area.

Trails into the area are accessible from several points. A graveled road to the settlement of Jardine, about 6 mi northeast of Gardiner, gives access to U.S. Forest Service trails into the area from the west. A dirt road from U.S. Highway 212 near Cooke City leads to Daisy Pass and access to Forest Service trails from the southeast. A dirt Road, extending southward up the Boulder River to the Independence mining district, gives access to trail heads along the north side of the study area (pl. 2).

The Absaroka study area is rugged mountainous terrane on the southwest flank of the highly dissected plateau of the Beartooth Mountains. Drainage is southward into the Yellowstone River. The major streams are, from west to east, Bear Creek, Crevice Creek, Hellroaring Creek, Buffalo Fork, and Slough Creek (fig. 2); of these Hellroaring and Slough Creeks are by far the largest.

The area is characterized by many broad undulating upland meadows, for example, the Buffalo Plateau between Buffalo Fork and Hellroaring Creek, which are bounded by glacial valleys and cirques. The maximum relief is more than 4,500 ft (feet); the lowest elevation is about 6,300 ft where Hellroaring Creek crosses into Yellowstone Park. The highest point is an unnamed peak on the divide near the head of Bull Creek; its altitude is more than 10,800 ft.

PREVIOUS INVESTIGATIONS

The geology of the Absaroka study area was mapped initially by Iddings and Weed (1894) in the 1880's and early 1890's for the Livingston Folio, scale 1:250,000. Mineral deposits are shown on the Economic Sheet of the Folio but are not described. Brief accounts of parts of the geology of the study were given in the early publications on Yellowstone National Park by Hague and his coworkers (1896, 1899). Emmons (1908) summarized the geology of the Independence stock area.

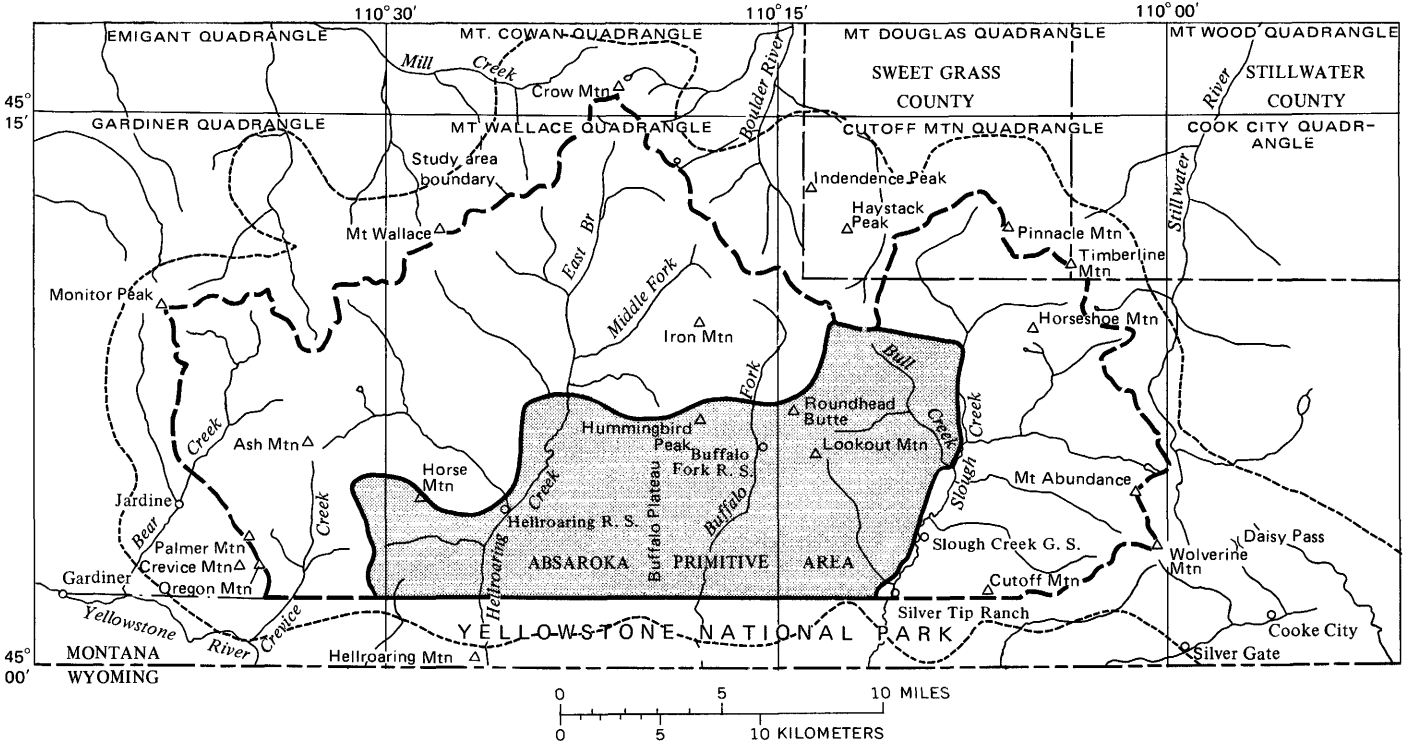


FIGURE 2. — Boundaries of the Absaroka Primitive Area (solid line), the study area (dashed line), and the area sampled geochemically (dotted line).

Brief reference is made to the deposits of the Jardine (Sheepeater) and Crevice (Crevasse) Mountain districts just outside the west end of the study area in several early volumes of Mineral Resources of the United States (U.S. Geol. Survey, 1906, p. 256; 1907, p. 284; 1908, p. 333). Perhaps the earliest geologic description of ore deposits was that by Winchel (1910), who briefly mentioned the geology and mineral deposits at Mineral Hill of the Jardine–Crevice Mountain district, in a summary on tungsten minerals in Montana. S. H. Cathcart (unpub. data, 1924) of the U.S. Geological Survey also studied the Jardine–Crevice Mountain district. Lovering (1930) made the earliest extensive study of the New World (Cooke City) mining district at the east end of the study area.

Many geologic studies have been made in the Absaroka Primitive area and vicinity since 1930. In the late 1930's, an extensive study was made of the gold-arsenic-tungsten deposits of the Jardine-Crevice Mountain district (Seager, 1944). Available information on the mines and mineral deposits of Park County, Mont., was summarized by Reed (1950). Robertson (1956) studied several mining districts of Montana, including those at Jardine and Cooke City, to determine the effectiveness of using geochemical prospecting of soils as an exploration tool. C. W. Brown (1961) mapped an area along the northern boundary of Yellowstone National Park, locally extending his mapping as much as a mile northward into the Absaroka study area. Foose, Wise, and Garbarini (1961) compiled available maps of the Beartooth Mountains, Montana and Wyoming, including the Absaroka study area, at a scale of 1 in. (inch) to 2 mi and discussed the geologic framework of the Beartooth uplift. Recent mapping by Rubel (1964, 1971) in the upper Buffalo Fork and Slough Creek drainage and by Courtis (1965) in the Cutoff Mountain-Mount Abundance area has been particularly helpful in our studies. L. E. Brown (1965) discussed the geology, mineralogy, age, and sulfur-isotope composition of the Jardine ores. Fraser, Waldrop, and Hyden (1969) published a map of the Gardiner area at a scale of 1:24,000 and briefly described the area's mineral deposits.

PRESENT INVESTIGATIONS AND ACKNOWLEDGMENTS

Our investigations, which were made to appraise the mineral-resource potential of the Absaroka study area, consisted of geochemical exploration, reconnaissance geologic mapping, gravity and aeromagnetic surveys, and the investigation of known claims, prospects, and mines. A reconnaissance geologic map of the study area was prepared at a scale of 1:62,500 (pl. 1), and the localities of all stream-sediment and rock samples are shown on a topographic map of the same scale (pl. 2). Aeromagnetic and gravity data were also compiled on a 1:62,500 base; this map was later reduced for inclusion in this report (figs. 8, 9).

Field study by the U.S. Geological Survey was carried out during July, August, and early September 1970 and during July and August 1971. We were ably assisted by David Frishman and Larry J. Smith in 1970 and by John H. Kramer and Edward T. Oaksford in 1971. Geology of the area south of Lake Abundance Creek, including the Silver Tip structure, is modified slightly from David M. Courtis (1965).

Fieldwork was carried out with the aid of horses and a helicopter. In 1970, most of the fieldwork was done from camps supplied by packstring. Duane Neal was packer and Bill Corbett wrangler. In 1971, transportation was chiefly by helicopter; Claire Merryweather proved to be a very capable pilot in the mountainous terrain, and Tom Flegal assisted with logistic support and mechanical problems.

The aeromagnetic data used in this report were obtained from parts of larger regional surveys made by the U.S. Geological Survey in 1967 and 1970. The gravity data are mostly from stations occupied by Peterson during August 1971.

Analyses of the geochemical samples were made by a U.S. Geological Survey mobile laboratory based in Cooke City, Mont., during the summers of 1970 and 1971. The laboratory team was led by Jim G. Friskin, who made the chemical analyses with the assistance of Jerry R. Hassemer, James P. Hoffman, and James H. Reynolds. Semiquantitative spectrographic analyses were made by Gordon W. Day and assistants Elmo F. Cooley and James M. Mitchell. Tom Heinz prepared the samples. Helen E. Eichler, Lamont O. Wilch, Steven K. McDanal, and others at the Survey's Denver laboratory aided materially in the computer processing and manipulation of the large volume of geochemical data.

We benefited from discussions with many fellow geologists and others about selected problems relating to geochemical and geological aspects of this study. Those deserving special mention are Harold J. Prostka and Willis H. Nelson, who have mapped south and east of the study area in Yellowstone Park and the North Absaroka Wilderness. William G. Pierce contributed with his extensive knowledge of the Heart Mountain and other detachment faults and related features of the region. James E. Elliott discussed various aspects of the New World mining district and contributed his geochemical data on stream sediments from the southern and western part of the district. John C. Antweiler, who is investigating the trace-element distribution in gold of various ores in the Western United States, furnished data about mining districts in the vicinity of the Absaroka Primitive Area, including those reported in table 2. Daniel N. Rubel, who has mapped extensively in the eastern part of the study area, and Kenneth L. Pierce, who drew on his studies at Yellowstone Park region, assisted in the interpretation of the Quaternary geology of the study area.

The fieldwork by the Bureau of Mines was conducted principally by Banister, Pattee, and J. S. Coffman. Part-time assistance was given by S. W. Schmauch, S. D. Brown, T. E. Long, and D. W. Smith.

The cooperation and assistance of all personnel of the U.S. Forest Service in the Gallatin National Forest in supporting the minerals study of the Absaroka Primitive Area have been invaluable. We mention only a few of the many persons who gave assistance: Jerry V. Adelblue and David H. Morton, District Rangers of the Gardiner District; R. G. "Sonny" Adkins, District Fire-Control Officer; Jerry Dombrovske and Brian Brandt, Foresters; and Joe Israel, Resident Ranger at the Cooke Station.

GEOLOGY

STRATIGRAPHY

Precambrian, Paleozoic, and Cenozoic rocks constitute the bedrock of the Absaroka study area (pl. 1). Mesozoic rocks are missing, though they occur a few miles outside the area, near Gardiner (Fraser and others, 1969). Precambrian crystalline basement rocks, unconformably overlain by erosional remnants of the Paleozoic sedimentary rocks and largely covered by a great thickness of lower Tertiary (Eocene) eruptive rocks, presumably underlie the entire area. Glacial deposits, landslide debris, alluvium, and soils of Quaternary age occur as consolidated veneer of variable thickness over much of the area (pl. 1).

PRECAMBRIAN ROCKS

The Precambrian rocks of the Absaroka study area (pl. 1) mostly crop out chiefly in the Slough Creek drainage in the eastern part of the study area and west of the divide between Hellroaring Creek and Buffalo Fork in the southwestern part of the area.

The main rock types in the Slough Creek area are coarse-grained granitic gneiss and interlayered schist that range from various shades of gray, some almost white, to shades of pink, to almost red. Zones of medium- to fine-grained gneiss are locally abundant. The dominant minerals are quartz, feldspars (microcline and plagioclase), biotite, and muscovite. Hornblende and lesser amounts of magnetite are widespread accessory minerals. Trace amounts of apatite, garnet, and zircon also are in most rock. The foliation or layering of the gneiss is a result of the concentration of light and dark minerals in alternating laminae or thicker layers. The light-colored schist is rich in muscovite, whereas the dark schist is rich in biotite and hornblende. Light and dark schist, ranging in thickness from a few inches to many tens of feet and interlayered with the granitic gneiss, is locally abundant in the Slough Creek area. Subordinate rock types are hornblende-rich gneiss and migmatite. These Precambrian metamorphic rocks are folded and, as indicated by foliation, the folds plunge southward.

The Precambrian rocks of the eastern part of the study area are locally cut by dikes of various compositions. Generally concordant pegmatitic bodies, with some large crystals, appear to be coarsely crystalline facies of granitic gneiss. Pegmatite also occurs as sharp-walled dikes that cut across foliation in the gneiss. Other dikes that cut the Precambrian rocks are chiefly mafic. Many of them are most likely Precambrian; some for example those in the vicinity of Horseshoe Mountain (pl. 1), are post-Precambrian, probably Tertiary.

In the western part of the study area the Precambrian terrane is mostly quartzose metasedimentary rocks: quartzite, commonly thinly laminated; quartz-biotite schist, in which quartz makes up about three-fourths of the rock; and biotite-quartz schist, in which biotite is predominant. Other distinctive quartzose rocks are quartz-cummingtonite schist, quartz-hornblende schist, and phyllitic schists and phyllites, in which the quartz composes as much as half the rock. Hornblende and cummingtonite commonly occur together. Where hornblende is espeically abundant, the texture indicates that the hornblende replaces the cummingtonite. Feldspars rarely make up more than 10 percent of the rock. Locally, muscovite is prominent in some of the schists, and biotite is altered to chlorite. Aplitic and pegmatitic zones in the granitized rocks on the south slopes of Crevice Mountain are reported (Seager, 1944) to contain andalusite and sillimanite, seemingly in minor amounts.

The cummingtonite schist, though restricted, is important economically because it is the main host rock of the gold, tungsten, and arsenic deposits at Jardine and bordering localities in this part of the study area.

PALEOZOIC ROCKS

Marine sedimentary rocks of Paleozoic age crop out chiefly in the south-central and southeastern parts of the Absaroka study area (pl. 1). They lie unconformably on the Precambrian crystalline basement. Erosion had stripped the Paleozoic strata from much of the area before it was buried by lower Tertiary volcanic rocks. The nine Paleozoic stratigraphic units that have been mapped in the study area are briefly described in table 1.

The Paleozoic section in the Absaroka study area has a maximum thickness of about 2,100 ft (feet) (table 1). The thickness varies considerably from place to place chiefly because of post-Paleozoic erosion, but also because of local relief on the Precambrian rocks of several tens to perhaps several hundreds of feet. The thickness of the basal Cambrian unit, the Flathead Sandstone, is highly variable, and locally it and at least part of the Wolsey Shale are absent. In these areas a younger Cambrian formation rests directly on Precambrian rocks. The lower part of the Cambrian sequence is absent near Lake Abundance

TABLE 1. — *Stratigraphy of Paleozoic rocks in the Absaroka Primitive Area, Mont.*

Geologic system	Name of stratigraphic unit	Maximum thickness (ft)	Lithology and remarks
Tertiary	Absaroka Volcanic Supergroup	---	Varied extrusive and intrusive rocks.
	. . . . UNCONFORMITY		
Mississippian	Madison Limestone	400	Limestone, locally dolomitic and cherty; massive to thin bedded, cliff forming, coarse to fine crystalline or aphanitic, light gray to tan, generally buff weathering.
	. . . . UNCONFORMITY		
Devonian	Three Forks Formation and Jefferson Limestone (undivided)	300+	Limestone and shale; limestone platy and locally dolomitic and sandy; color generally light gray to brown (shales gray green). Local channel filling several tens of feet thick of reddish calcareous sandstone at base on east side of Mount Abundance, probably Beartooth Butte Formation (Courtis, 1965; Dorf, 1934).
	. . . . UNCONFORMITY		
Ordovician	Bighorn Dolomite	250	Dolomite and dolomitic limestone; massive, cliff forming; coarse to fine crystalline (sugary); color generally gray to light gray, weathering to buff and tan and, locally, chalk white. Differential weathering in a distinctive gnarly, ropy-appearing surface. At the base is a 10-foot zone of yellow, thin-bedded, slabby, nodular, impure dolomite.
	. . . . UNCONFORMITY		
Cambrian	Grove Creek and Snowy Range Formations (undivided)	250	Limestone, generally thin-bedded, light-gray; interbedded with gray shale. Limestone aphanitic, locally broken to beds of flat-pebble conglomerate. At places color is greenish gray (glauconitic?). Some limestone beds several feet thick are made up almost entirely of polygonal algal columns as much as 1 foot in diameter.
	Pilgrim Limestone	125	Limestone, generally massive, cliff forming; light to dark gray, locally mottled; texture dominantly oolitic or coarse-grained (calcarenite); locally hydrothermally altered to dolomite. Toward base, limestone beds are thinner and formation contains more shale.
	Park Shale	400	Unit generally poorly exposed. Shale, interbedded with thin layers of limestone and sandstone; color locally purplish or greenish, particularly toward base.
	Meagher Limestone	125	Limestone, thin-bedded, with wavy bedding; generally forming steep slopes; brownish gray to dark gray, mottled; texture generally fine grained. Distinctive basal pisolitic bed mentioned by Hanson (1952, p. 14) not seen. Thickness variable because of gradation or intertonguing with overlying and underlying formations.
	Wolsey Shale	150	Shale, interbedded with sandy limestone and calcareous sandstone (amount of limestone increases toward base); gray to green, locally purplish; some beds contain abundant glauconite, other beds contain many fragments of phosphatic brachiopod shells. Upper and lower contacts gradational.
	Flathead Sandstone	100+	Sandstone, locally quartzitic and (or) arkosic; massive bedded, and generally not cliff forming; crossbedded, ripple marked; coarse- to fine-grained texture, with local beds and lenses of pebbles; color generally red to white, mottled. Grades upward into Wolsey Shale by increasing intercalation of thin-bedded glauconitic sandstone and greenish shale.
	. . . . UNCONFORMITY		
Precambrian	---	---	Gneiss and schist.

(Courtis, 1965), and also just outside the study area (Emmons, 1908, p. 198).

Not only did the prevolcanism erosion remove at least 2,100 ft of Paleozoic strata in some areas, but it also removed Mesozoic sedimentary rocks that may have been as thick as 20,000 ft. The prevolcanism surface has a relief of as much as 500 ft within distances of less than a mile and is marked by some landforms that may have been pre-Tertiary fault-line scarps.

TERTIARY IGNEOUS ROCKS

Volcanic, intrusive, and related volcanogenic sedimentary rocks of early Tertiary age are the most widely exposed rocks of the Absaroka study area (pl. 1). The drainage divide of Hellroaring Creek and Buffalo Fork are formed almost entirely by these rocks. At least several thousand feet of layered volcanic rocks are present locally, but erosion has removed them from much of the eastern part and from the low areas along the south edge of the area. Many intrusive bodies related to the volcanics cut the underlying Paleozoic and Precambrian rocks.

VOLCANIC AND RELATED SEDIMENTARY ROCKS

The volcanic rocks (pl. 1) are part of the Absaroka Volcanic Supergroup (Smedes and Prostka, 1972), that crops out widely in an area referred to as the Absaroka volcanic field or as the Absaroka–Gallatin volcanic province (Chadwick, 1970). The Absaroka Primitive Area is in the northern part of this field, which is known to extend for about 160 mi from the north edge of the Wind River Basin west of Thermopolis, Wyo., northwest to the northern part of the Gallatin Range southwest of Livingston, Mont. (fig. 3). According to Smedes and Prostka (1972), the Absaroka Supergroup consists largely of calc-alkaline andesitic and dacitic breccias, potassic-alkalic mafic lavas, and rhyodacitic tuffs.

The volcanic and related sedimentary rocks of the Absaroka study area consist chiefly of interlayered volcanic breccia lava flows and epiclastic and laharic deposits of intermediate composition typical of the Absaroka Volcanic Supergroup.

Three major sequences of these rocks can be recognized. From oldest to youngest these are: Dominantly volcaniclastic rocks of the Washburn Group; lava flows and ash-flows tuffs of the Mount Wallace Formation; and volcaniclastic rocks of the Wapiti and Langford Formations.

VOLCANICLASTIC ROCKS OF THE WASHBURN GROUP

The Washburn Group in the study area is divided into three map units (pl. 1): (1) vent facies consisting of *in situ* layered pyroclastic rocks, lava flows, agglomerates and agglutinates, and laharic or debris avalanche deposits; (2) near-vent epiclastic facies consisting largely of pyroclastic materials that were reworked or transported by alluvial processes; and (3) an undivided unit of both vent and epiclastic facies.

These extrusive rocks include ejecta of many eruptions from several sources within and adjacent to the study area. Three probable vents are recognized in the eastern part of the study area: hill 9064 on the ridge

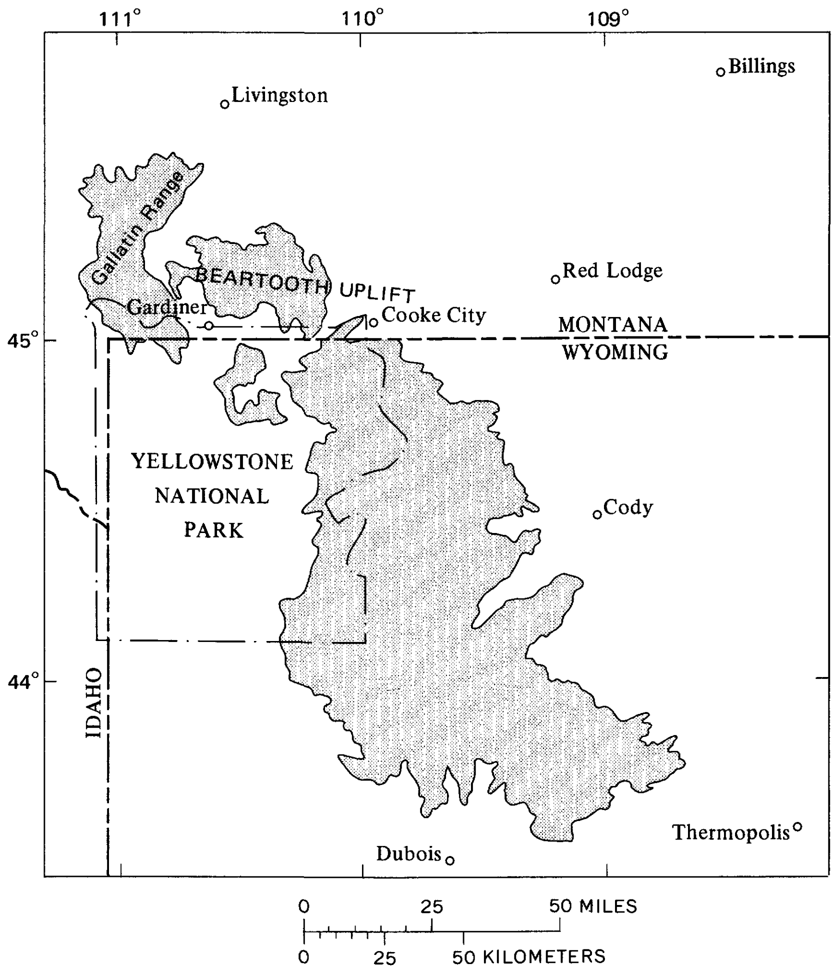


FIGURE 3. — Geographic extent of the Absaroka volcanic field (Smedes and Prostka, 1972).

3.2 mi west of Mount Abundance; hill 9694 3.3 mi north of Mount Abundance; and on the high divide at the head of North Fork of Bull Creek about 9 mi northwest of Mount Abundance. Intrusive bodies and associated vent-brecccia complexes are at the first two localities. Several large dacitic dikes, the structures and textures of which indicate that they were feeder dikes for some of the adjacent crystal-tuff breccia, are exposed at the third locality. These vents probably represented satellite eruptions on the flanks of large stratovolcanoes centered over the now eroded Tertiary stocks in the New World (Cooke City) and Independence mining districts (Courtis, 1965; Eyrich, 1969;

Rubel, 1971, p. 2484). Other eruptive centers in the Mill Creek drainage northwest of the study area may have been the major source of the volcanic rocks west of Hellroaring Creek. Ash Mountain, near Jardine, may have been an eruptive center and the source of the Slough Creek Tuff Member of the Mount Wallace Formation (Fraser and others, 1969, p. 43).

Vent Facies

Vent facies volcanic rocks, corresponding to both the "acid" and the "basic" andesitic breccias of Iddings and Weed (1894) and the "Group III Volcanics" of Rubel (1971), form the divide between the North Fork of Bull Creek (fig. 4) and the East Fork of the Boulder River. The "acid breccias" consist of a layered sequence of light-colored rhyodacitic lithic-tuff breccias about 500 ft thick. The breccia is composed largely of angular to subangular clasts of white to light-gray, porphyritic, fine-grained, aphanitic, hornblende rhyodacite set in a crystal lapilli-tuff matrix of the same color and composition. Fragments of flow-banded rhyolite, andesite, basalt, Precambrian rock, and Paleozoic limestone are also present. Some blocky fragments of rhyodacite are more than 7 ft across. Clasts and matrix are tightly bonded, and most fractures pass through matrix and fragments alike. The sequence appears to be well

FIGURE 4. — View toward the west in the headwater basin of North Fork of Bull Creek showing vent facies of the Washburn Group, corresponding to both the "acid" and the "basic" andesitic breccias of Iddings and Weed (1894) and the "Group III Volcanics" of Rubel (1971).

bedded when viewed from a distance, but on the outcrop the identity of individual layers is largely obscured by the coarse fragmental texture of the breccia.

An identical breccia is present near the head of Slough Creek on the divide west of Columbine Pass. Thin to very thick beds of very similar tuff breccia are intercalated with darker colored breccia higher in the vent-facies unit along the Sheepherder Peak divide, on the Roundhead Butte divide, and at the top of the vent-facies unit north of Iron Mountain.

Darker hued rocks, probably the "basic" andesitic breccias of Iddings and Weed (1894), compose the upper part of this vent-facies unit. They are mostly medium-light-gray to brownish- and yellowish-gray crystal-rich lithic-tuff breccias with subordinate thick to massive andesitic and basaltic flows and flow breccias, laharic breccias, agglomeratic and agglutinitic ejecta, layers of light-colored rhyodacitic-tuff breccia, and a few thin beds of pumiceous nonwelded and partly welded lapilli ash-flow tuff.

Along the Sheepherder Peak and Roundhead Butte divides this heterogeneous, crudely layered to chaotic sequence is more than 1,000 ft thick. The tuff breccias are mostly composed of dark-gray andesitic and basaltic fragments but generally include clasts of light-colored porphyritic rhyodacite, and scattered fragments of Precambrian rock and petrified wood. Scoria, perlitic ash, and small chunks of unflattened pumice are common constituents. Some coarse dark-colored boulder-breccia layers contain little matrix and contrast with medium-light-gray, fine crystalline lapilli-tuff layers of similar composition. In general, the lighter colored layers contain more matrix than clasts. Laharic deposits locally fill shallow to very large channels in this sequence, notably on Peak 10578 south of Sheepherder Peak. A thin bed of white, pumiceous, nonwelded, and pale-yellowish- to brownish-gray partly welded ash-flow tuff is interbedded with basal flows of the Mount Wallace Formation on the ridge north of Iron Mountain. Thin lapilli tuffs lower in this vent facies elsewhere may also represent ash-flow material.

Similar vent facies are present at the head of Wolverine Creek (Courtis, 1965) and along the upper Hellroaring Creek–Boulder River–Mill Creek divide.

Along the Sheepherder Peak divide, individual layers in the vent facies dip 10° to 25° or more southwest away from the stock at Independence Peak (pl. 1). In the southeast corner of the study area they dip westerly, away from the stocks in the New World (Cooke City) mining district. H. J. Prostka (oral commun., 1972) considers this vent facies unit to be equivalent to the Cathedral Cliffs Formation (Pierce, 1963a), and to the Lamar River Formation (Smedes and Prostka, 1972).

NEAR-VENT EPICLASTIC FACIES

Epiclastic deposits consist largely of pyroclastic vent-facies material that has been reworked by alluvial processes; locally, however, this unit (pl. 1) includes some air-fall tuff breccias and lava flows. Vent facies grade into, or intertongue with, the epiclastics, so at many places a clear distinction cannot be made. The transition between vent and epiclastic facies is shown on plate 1 only in a gross way; and a decision to refer to a facies as reworked — based on fragment attrition, abrasion, sorting, color change, extent of observable outcrop, or distant view — can be subject to much doubt. On Roundhead Butte, for example, the pyroclastics are clearly vent facies. At Lookout Mountain, less than 2 mi south, the rocks could be considered either vent or epiclastic facies. A mile or less south of Lookout Mountain, these deposits appear to be dominantly reworked or epiclastic. At the Yellowstone Park boundary 5 mi south of Lookout Mountain, equivalent rocks are represented by well-rounded pebble-boulder conglomerates of the Lamar River Formation (U.S. Geol. Survey, 1972).

VENT and EPICLASTIC FACIES

Rocks of the vent and epiclastic facies stratigraphically beneath the Mount Wallace Formation were not mapped separately in upper Hellroaring and Bear Creeks and are shown on the map (pl. 1) as volcaniclastic rocks undivided. They are as much as 1,800 ft thick along upper Hellroaring Creek and seem to have been derived mostly from sources in the Mill Creek area northwest of the study area. The lower part of this sequence is lighter colored and seems to be dominantly epiclastic deposits. The upper part is composed mostly of a darker vent facies interlayered with lava flows and basal flow breccias of the Mount Wallace Formation. The greater portion of this unit appears to consist of medium-light-gray to brownish- and olive or yellowish-gray airfall breccia with a lapilli-rich crystal-tuff matrix. The breccias are rudely stratified and contain abundant large angular clasts. The matrix generally contains unflattened pumice fragments. Thin beds of andesitic and basaltic lapilli tuff which have a finely crystalline pumiceous matrix are interlayered with the coarser tuff breccia. A thick bed of light-gray ashy tuff near the top of the divide at the head of Hellroaring Creek contains many logs of petrified wood. Some of the pyroclastic material at the head of Lambert and Thompson Creeks, and elsewhere, probably represents vent agglomerates. Epiclastic rocks consist mostly of near-vent conglomeratic facies interlayered with a few beds of air-fall tuff and tuff breccia. H. J. Prostka (oral commun., 1971) considered the lower part of this volcaniclastic unit to be equivalent to the Cathedral Cliffs Formation of the Washburn Group and the upper part to be a basal clastic facies of the Mount Wallace Formation, and hence a part of the Sunlight Group.

MOUNT WALLACE FORMATION

The Mount Wallace Formation (Smedes and Prostka, 1972) comprises a sequence of andesitic, basaltic, and dacitic lava flows and flow breccias, and a thick ash-flow tuff member. These rocks are equivalent to the "Group V Volcanics" of Rubel (1971) and the trachyandesite unit of Fraser, Waldrop, and Hyden (1969).

Three parts of the Mount Wallace Formation have been mapped: the lower flow sequence, the Slough Creek Tuff Member, and the upper flow sequence.

Lower Flow Sequence

A sequence of lava flows in the lower part of the Mount Wallace Formation (pl. 2) interfinger with underlying volcaniclastic rocks in the central and western parts of the study area. These flows also overlie Precambrian rocks in the southwestern part of the study area and locally overlie Paleozoic rocks. The flows range in thickness from several hundred feet on the Buffalo Fork divide to more than 1,700 feet thick in the Hellroaring Creek drainage. In the North Fork Basin area west of Hellroaring Creek the basal flows and flow breccias of this unit thin remarkedly and pinch out to the southeast, indicating a nearby source to the northwest. East of Hellroaring Creek these flows seem to be intercalated with similar flows originating as fissure eruptions at the head of the Middle Fork of Hellroaring Creek and the Buffalo Fork (Rubel, 1971, p. 2483). Similar flows on Roundhead Butte and Lookout Mountain ridge apparently were derived from vents to the north or northeast.

The lower flow sequence consist of many thick to massive flows and flow breccias of intermediate to mafic composition. Analytical data show that many of the flows have a high alkali content, most containing more potash than soda (Fraser and others, 1969, p. 41–43; Rubel, 1971, p. 2482). Most abundant are flows of trachyandesite, andesitic dacite, trachybasalt, and basaltic andesite; a trachyte flow occurs near Specimen Creek. Much or most of the sequence is composed of scoriaceous or clinkery flow breccias. Many flows contain abundant large phenocrysts of plagioclase and fewer subordinate phenocrysts of pyroxene; some are olivine-rich and others are dense, glassy, and sparsely porphyritic. Vesicular or amygdaloidal flows containing zeolite, calcite, quartz, and opaline silica are also present. A few light-gray lapilli tuffs containing unflattened pumice fragments are present near the base of this sequence in the upper Hellroaring Creek area.

Slough Creek Tuff Member

The Slough Creek Tuff Member of the Mount Wallace Formation is a welded and nonwelded, locally compound, cooling unit of rhyolitic ash-flow tuff. It was named for outcrops along the north boundary of

Yellowstone National Park by Smedes and Prostka (1972), and it is the most distinctive volcanic unit in the Absaroka study area. North of Ash Mountain, however, this member is so densely welded that in the absence of observable cooling units it is difficult to separate from underlying and overlying glassy porphyritic lava flows. This tuff was originally called a trachytic rhyolite by Iddings and Weed (1894); a trachyrhyolite by Fraser, Waldrop, and Hyden (1969); and a rhyodacite by Smedes and Prostka (1972). Analyses indicate a potassium-rich rock ranging from rhyolite to rhyodacite in composition.

Lithoidal to densely welded exposures of the Slough Creek Tuff Member range in color from light pinkish gray through shades of red and brown including black vitrophyres. The rock is mostly a crystal-rich lithic-tuff breccia that contains fragments of vitric tuff, andesite, and basalt. Somewhat altered phenocrysts of plagioclase and glassy sanidine are the most abundant constituent minerals. A little biotite, pyroxene, and grains of magnetite are also present. Collapsed, flattened, and stretched pumice fragments are locally visible. Zoned plagioclase phenocrysts, some with sanidine rims, are as much as 11 mm (millimeters) long, most are 2–4 mm. Fractured euhedral sanidine crystals, most 1–2 mm long, are ubiquitous. Iddings (in Hague and others, 1899, p. 321–325) gave a lengthy petrographic description of this rock with a chemical analysis of "trachy rhyolite" from the Jardine area.

At the head of the East Fork of Bear Creek a massive black rhyodacite vithrophyre porphyry, several hundred feet thick, caps peaks with summit elevations of 10,066 and 10,095 ft. The vitrophyre carries phenocrysts of plagioclase as much as 1 cm (centimeter) long and of sanidine 1–2 mm long. Pentagonal columnar joints characterize the upper part of this glassy zone. The vitrophyre overlies layers of yellowish- to light-olive-gray crystal-rich vitric tuff breccia and finely sorted ash. The breccia is largely composed of pumice, abundant crystals of sanidine, and vitrophyre lapilli. One thick nonwelded layer is composed of boulder-sized "bombs" and fragments of vitrophyre, some petrified wood, and carbonized organic material. Equivalent rocks form the top of the divide west of Castle and Fish Lakes where they include, from base to top, a zone of massive vitroclastic rocks, several hundred feet of grayish-red to purple densely welded rhyolite, and a massive black, columnar-jointed eutaxitic vitrophyre. Thin to thick conformable beds of nonwelded and partly welded tuff breccia, finely layered ashy tuff, and a thick heterogeneous, vitroclastic, agglomeratic and agglutinitic tuff breccia underlie the densely welded zones. The vitroclastic breccia at the base of this compound cooling unit is rich in vitrophyre "bombs" and spatters of lava, and it unconformably overlies dacitic flows and air-fall tuff breccias. Other exposures of nonwelded and partly welded tuff at the base of the Slough Creek Tuff Member are represented at the head of Horse Creek by white, chalky, clayey, sanidine, biotite tuff containing grains of black glass, and sandy tuff rich in grains and lapilli fragments of black vitrophyre; at the head of Darroch Creek by light-gray partly welded tuff with devitrified pumice and sanidine crystals in coarsely sorted layers containing lapilli to boulder-sized fragments of black vitrophyre and reddish-brown vitric tuff; and, locally, in the Telephone Basin area by nonwelded pumiceous lapilli, crystal tuff, and thick beds of friable pumice.

Nonwelded zones overlying densely welded tuff in the Ash Mountain area are represented by beds of white to pale-greenish, yellowish-, pinkish-, and brownish-gray crystal lapilli tuffs, and clayey ash. Some beds are characterized by chunks of uncollapsed pumice, all carry sanidine crystals, and some have a crystal-tuff matrix rich in plagioclase and magnetite. At the head of Crevice Creek above Fawn Lake these beds may be more than 100 ft. thick. Exposures of nonwelded Slough Creek Tuff Member are shown separately on plate 1 in the Ash Mountain area, but east of Hellroaring Creek the Slough Creek Tuff Member in the area of Iron Mountain consists of white to light-gray pumiceous, sanidine-rich nonwelded or partly welded lapilli tuffs containing devitrified pumice and a little biotite. Rubel (1971, p. 2483) gave a petrographic description of the feather-edge of the ash-flow sheet on Iron Mountain.

Upper Flow Sequence

A sequence of lava flows in the upper part of the Mount Wallace Formation overlying the Slough Creek Tuff Member in the study area is of much smaller areal extent than the flow sequence in the lower part of the formation. It consists largely of medium-dark-gray, brownish, or olive-gray trachybasalt and dacitic flows and flow breccia characterized by abundant phenocrysts of labradorite, as much as 14 mm long and making up 30–40 percent of the rock, augite, and a little biotite. The sequence includes some dense andesitic flows, and locally, a few thin beds of tuff breccia and pumice. A small mass of columnar olivine-bearing basalt and masses of ultramafic rocks on Horse Mountain may represent a more recent flow. The upper lava flows are about 650 ft thick at the Yellowstone Park boundary west of Slough Creek, where they underlie volcaniclastic deposits of the Wapiti Formation. The sequence caps most of the divide between Buffalo Fork and Hellroaring Creek. Exposures west of Hellroaring Creek are limited to small areas on the divide at the head of Horse Creek and on the plateau north of Horse Creek.

WAPITI AND LANGFORD FORMATIONS

Volcaniclastic rocks overlying the Mount Wallace Formation along the north boundary of Yellowstone National Park are, according to H. J. Prostka, part of the Wapiti and Langford Formations (Smedes and

Prostka, 1972). Rocks mapped as Langford Formation seem to consist largely of light-colored well-rounded loosely consolidated pebble-boulder conglomerates. Rocks mapped as Wapiti Formation are darker, consisting of light-gray to brownish- and purplish-gray volcaniclastic deposits that cap Cutoff Mountain and areas west of Slough Creek. These volcaniclastics seem to be composed largely of crudely layered, unsorted, heterogenous, rounded to subangular, pebble- to boulder-sized conglomerates ranging in composition from basalt to rhyolite. On the ridge south of Lookout Mountain much of the Wapiti Formation consists of medium- and brownish-gray conglomeratic near-vent epiclastics composed of subrounded basaltic and porphyritic andesite pebbles in a well-cemented "sandy" matrix of angular grains of many rock types and mineral varieties. Some beds of light-gray tuff are present in this sequence. Both formations include a few thin lava flows and locally abundant fragments of petrified wood. According to Smedes and Prostka (1972), the Wapiti intertongues with the Mount Wallace Formation, and the Langford Formation unconformably overlies older rocks.

INTRUSIVE ROCKS

Intrusive rocks of Tertiary age in the study area (pl. 1) form stocks, laccoliths, many dikes, several small plugs, and a few sills. They range in composition from basaltic andesite to rhyolite. Dikes range from limburgite to rhyodacite, but most seem to be andesite and rhyodacite. Most of the intrusives are in the Slough Creek-upper Buffalo Fork and Bear Creek–Ash Mountain areas, in the eastern and western parts of the study area, respectively.

Five units have been mapped: (1) intermediate to felsic intrusive bodies, (2) trachyrhyolite, (3) tuff breccia dike, (4) basaltic andesite plugs, and (5) intermediate to mafic dikes. The intermediate to felsic unit is subdivided into rhyodacitic porphyry, dacite and rhyodacite, and rhyolite and rhyodacite in an area of detailed mapping at Horseshoe Mountain (pl. 1).

INTERMEDIATE TO FELSIC INTRUSIVE BODIES

Many adjacent, or contiguous rhyodacitic intrusive bodies are shown on plate 1, along upper Buffalo Fork, Bull Creek, Slough Creek, Lost Creek, and Lake Abundance Creek. They are probably cupolas or dissected parts of a larger intrusive body underlying the eastern part of the Absaroka study area. The dominant rock type is porphyritic rhyodacite although the compostion ranges from dacite to rhyolite. Textural variations indicates that the bodies represent intrusions of more than one age; but field relationships and composition indicate them to be closely related in time and space.

Four continguous bodies of porphyritic rhyodacite, separated by surficial deposits, near the head of Buffalo Fork seem to represent the dissected roof of a laccolith. The rock is light to very light gray, locally pale red, and contains small, scattered euhedral to anhedral phenocrysts of feldspar and flakes of biotite. Locally, the rock is a hornblende-rich porphyry. The rock is conspicuously flow banded in places. Rubel (1971, p. 2476, 2483–2484) gave a petrographic description and chemical and modal analyses of this rock.

A more northerly, but contiguous body of hornblende rhyodacite porphyry lying southwest of Boulder pass is locally altered and cut by andesitic dikes. It most nearly resembles the rhyodacite intrusion at the head of the Middle Fork of Bull Creek and the intrusion at hill 9694.

Similar rhyodacitic bodies intrude Precambrian and younger rocks along the South Fork of Bull Creek. They probably represent a contiguous body exposed over an area of about 6 1/2 mi^2 and having a topographic relief of 1,800 ft. At the saddle north of Lookout Mountain, the intrusive underlies a roof pendant of Precambrian rock overlain by a remnant of Flathead Sandstone. Three miles to the east and 1,500 ft lower in elevation, the intrusive is in contact with domed Precambrian and Paleozoic rocks. The intrusive seems to be faulted on the southeast against a thick section of Paleozoic strata. This contact is alined with the shear zone in the Precambrian along the southeast side of Horseshoe Mountain. The intrusive is also in contact with Paleozoic rocks and it underlies Precambrian rock north of Bull Creek. One mile east of Lookout Mountain the roof of this intrusive body is horizontally flow banded and, when viewed from a distance, resembles a thick lava flow.

A pluglike body of hornblende porphyry, about one-fourth square mile in area, intrudes Paleozoic rocks and volcanic breccia at the head of the Middle Fork of Bull Creek. The rock is crowded with hornblende needles (as much as 6 mm across), and feldspar phenocrysts (as much as 5 mm) in a light-gray aphanitic groundmass. A dense, sparsely porphyritic "cap" on the west crest of the plug probably represents a chilled marginal zone. The plug rock is widely brecciated along the south side where it intrudes the Bighorn Dolomite. The plug is cut by serveral andesitic dikes.

Three very large hornblende dacite dikes and an underlying feeder body intrude pyroclastic vent facies on the east end of the Sheepherder Peak divide, at the head of the North Fork of Bull Creek. The bodies are well exposed over a vertical distance of 1,300 ft. The rock is light gray to greenish or yellowish gray, and contains about 5 percent megascopically visible crystals of hornblende, small, generally inconspicuous, white, glassy, feldspar phenocrysts and a little biotite. Phenocrysts make up 10 to at least 30 percent of the rock. The intrusives are locally rich in xenoliths and large crystal "clots," or segregations of hornblende. Similar rock crops out at about an 8,100-ft elevation east of the North

Fork of Bull Creek in proximity to the intrusive body along the South Fork of Bull Creek. Hornblende dacite at the top of the west dike has a porphyritic-trachytic texture and contains fresh, clear, angular crystals, crystal fragments, and microlites of oligoclase-andesine in a microcrystalline to cryptocrystalline, semifluidal groundmass. These dikes are probably a source for some of the light-colored tuff-breccia layers in the upper part of the vent-facies unit.

Along Lost Creek in the southeast corner of the study area, a rhyodacite body crosscuts Paleozoic and Precambrian rocks and has a topographic exposure of about 1,500 ft. It apparently welled up along the edge of the Silver Tip structure (this report, p. B32; and Rubel and Romberg, 1971) and spread out in the Wolsey and Park Shales to form a loccolithic body. Megascopically similar rock (rhyolite) intrudes Precambrian gneiss and schist within the Silver Tip structure on Slough Creek.

Hornlende rhyodacite porphyry intrudes Precambrian granite gneiss on Lake Abundance Creek and forms a laccolith in the Paleozoic strata on Mount Abundance. The intrusion has discordantly cut across, domed, and faulted the Paleozoic rocks; and it occurs as a thick sill in the Park Shale along the northeast slope of Mount Abundance. The rock is commonly light gray to olive or yellowish gray, with pale-orange and glassy phenocrysts of feldspar (as much as 9 mm), hornblende, and a little biotite. On Lake Abundance Creek the rock contains about 25 percent, megascopically visible, phenocrysts of feldspar and small crystals of fresh hornblende. The rock on Mount Abundance is more altered, with larger and more abundant needles of hornblende altered to chlorite and limonite, and fewer phenocrysts of feldspar. The rock most nearly resembles the porphyries at Horseshoe Mountain and those near the head of Slough Creek.

A small irregular body of hornblende rhyodacite has intruded and domed Precambrian and Paleozoic rocks on the south side of hill 9694 several miles north of Mount Abundance. The rhyodacite is autobrecciated in places and underlies varicolored, heterogeneous, andesitic, and dacitic breccias, agglomerates (?), and pumice tuffs. Field relationships indicate that the intrusive-extrusive rocks here represent a small volcanic center.

Intrusive rocks at Horseshoe Mountain form a complex laccolithic body of intermediate to felsic composition that is divided into three rock units on the inset map (pl. 1). The intrusion, probably originating from a cupola or feeder body flooring Horseshoe Basin, domed and faulted Paleozoic and Precambrian rocks. Patches of andesitic flows and flow breccias overlie parts of the intrusive body, and landslide(?) or fault(?) blocks of Paleozoic limestone over Precambrian gneiss are preserved locally on the soutwest flank of the dome. The fact that only volcanic deposits are present on top of the intrusive suggests that the porphyries on Horseshoe Mountain were intruded mainly along the contact between Tertiary volcanic rocks and the underlying Paleozoic-Precambrian basement.

Exposures of intrusive rock in the Horseshoe Mountain area show considerable variation in texture and color. All the rock is somewhat hydrothermally altered to sericite and kaolin; oxidation further obscures the original nature of the rock. In general, the fresher rock appears more or less porphyritic; phenocrysts of plagioclase and sanidine are mixed with prominent phenocrysts of chloritized hornblende, as much as 3 mm long, or biotite plates, as much as 3 mm across, or both. Much of the rock is speckled by phenocrysts that are less than 1 mm across. Propylitized rock on Horseshoe Mountain ridge, north and east of Horseshoe Basin, is gray white to yellowish orange, and locally greenish; in places hematite has replaced hornblende and the rock is mostly iron stained.

Zones of alteration appear to follow generally north-trending fractures that cross Horseshoe Mountain and that seem to be continuous with rhyodacitic dikes cutting the Precambrian on the north side of the mountain. Most of the dike samples contain a little pyrite but, with several exceptions, are not greatly altered. The part of the intrusion northeast of Horseshoe Basin appears to have elevated a rectangular block of Precambrian rock bounded on four sides by faults. The top of the Precambrian, as defined by overlying Paleozoic strata on the west slopes of Horseshoe Mountain, is some 400 ft below the Precambrian rock within this rectangular fault block. One or more strong shear zones bound the block on the north and southeast sides, and a series of parallel, northwest-trending dikes bound the block on the east. The prominent shear zone extending along the entire southeast side of Horseshoe Mountain is locally intruded by a porphyry dike several hundred feet wide near the east end of the mountain. Other irregular porphyry bodies, similar to but less altered than that at Horseshoe Mountain, cut Precambrian gneiss and Tertiary vent-facies breccia northwest of Horseshoe Mountain (pl. 1).

Rhyodacitic intrusives are widely exposed along upper Bear Creek, Darroch Creek, Pine Creek, near the head of Thompson Creek, and at the head of Crevice Creek in the western part of the study area (pl. 1). They intrude the Mount Wallace Formation and, locally southeast of Ash Mountain, have formed a thick laccolithic tongue over the Slough Creek Tuff Member. The rock ranges in composition from rhyolite to rhyodacite. It is very light to medium gray, locally pinkish to red and purple, and porphyritic with phenocrysts comprising a few percent to 40 percent of the rock. The phenocrysts, mostly subhedral to anhedral, are plagioclase, sanidine, biotite, and hornblende set in an aphanitic, holocrystalline, trachytic groundmass of feldspar microlites. Rock along the ridge south and west of Ash Mountain has some flow-banded, platy, and autoclastic zones. Locally along the margin of the intrusive, west of upper Bear Creek, the rock is a dense, light-brownish to yellowish-gray flow-banded, silica-rich, cryptocrystalline rhyolite. Analysis of a fine-grained porphyritic variety from Palmer Mountain indicates a composition in the quartz latitie range. Rapid rock analysis of six intrusive samples from Ash Mountain indicate a latitic to rhyodacitic composition.

A small plug of light-pinkish- to brownish-gray, dense, slightly porphyritic rock intrudes the volcanics near the lead of Hellroaring Creek. The rock is similar in appearance to other rhyodacitic or rhyolitic intrusions in the study area. Another plug, at the head of Mill Creek on the north edge of the study area, was described as a labradorite latite porphyry by Rubel (1964, p. 96–97; 1971, p. 2484). The rock of the Mill Creek plug is a medium- to dark-gray porphyry with phenocrysts of plagioclase, pyroxene, and considerable magnetite.

Several thick sills of light-gray, porphyritic rhyodacite(?) were intruded between basal flows of the Mount Wallace Formation on peak 10666 at the head of Clover and Silver Creeks. The sills may be related to an intrusive body several miles north of peak 10666 in the Mill Creek drainage basin. Highly altered and pyritized intrusive(?) rock, obscured by landslides, vegetation, and glacial material, is exposed along Grizzly Creek near its junction with Hellroaring Creek. The outcrops are adjacent to a wide fault zone in tuffaceous siltstone and shale (pl. 1).

TRACHYRHYOLITE

A large dikelike body, or plug, of trachyrhyolite "welded tuff" (fig. 5) is in contact with the stock at Ash Mountain (pl. 1). The trachrhyolite is cut by a large rhyodacitic dike near the summit and is overlain by about 250 ft of fluidal quartz latite on the summit of Ash Mountain. Field relationships and petrography indicate the intrusive "tuff" to be a source of the Slough Creek Tuff Member ash-flow sheet. The rock is vertically flow banded with inconspicuous small phenocrysts of sanidine and plagioclase, and, locally, a little biotite. The trachyrhyolite "welded tuff" is exposed over a vertical distance of about 1,000 ft on the west side of Ash Mountain. Samples were collected about 700 ft below the highest outcrops. In thin section the rock is a porphyry, with subhedral crystals and anhedral fragments of feldspar, foreign-rock fragments, distorted pumice fragments, shards, and magnetite grains in a fluidal glassy devitrified groundmass. The trachyrhyolite may represent an early eruptive phase of the Ash Mountain stock.

FIGURE 5. — Ash Mountain from the southwest showing intrusive trachyrhyolite "tuff" body (Tit) and tuff-breccia dike (tb); Ti, intermediate to flesic intrusive bodies.

TUFF-BRECCIA DIKE

A dike of white pumice tuff breccia cuts the trachyrhyolite "welded tuff" on the west side of Ash Mountain. The dike is about 200 ft wide, dips about 75° S., and is composed of large pumice fragments, sanidine(?) crystals, small rock fragments, and much magnetite.

BASALTIC ANDESITE PLUGS

Several small plugs of basaltic andesite intrude vent pyroclastics on the ridge between Wolverine and Lake Abundance Creeks, 3.2 mi west of Mount Abundance. The easternmost plug and adjacent breccia layers flare out above a steep conduit, giving the impression that the vent rocks dip inward toward the vent center. Precambrian rocks are widely brecciated around the north and west sides of the vent, and have evidently been domed, or faulted, several hundreds of feet in relation to the thick section of Paleozoic strata east of the vent. Rocks within the vent are a chaotic mixture of reddish-brown andesitic and very light gray, dacitic, pyroclastic breccias and agglomerates with xenoliths of limestone and gneiss (Courtis, 1965, p. 38–41). These plugs probably represent a local vent for the pyroclastic vent facies of the Washburn Group.

INTERMEDIATE TO MAFIC DIKES

Most of the dikes mapped on plate 1 are represented by medium- to dark-gray, olive or dark-greenish-gray, dense, andesitic or basaltic rock with phenocrysts of plagioclase and hornblende. The dikes range in width from a few feet to several hundred feet and many are traceable for several miles. Most of the dikes are located in the northern part of the study area, and most intrude Tertiary volcanic rocks, however, some of the dikes in the eastern part of the study area may be Precambrian in age.

Some intermediate dacitic-latitic dikes are continuous with, or petrographically similar to, intermediate and felsic intrusive bodies in the area and are so mapped (pl. 1).

QUATERNARY SURFICIAL DEPOSITS

Surficial deposits in the Absaroka study area are principally: glacial deposits, colluvial deposits, lacustrine and postglacial alluvial deposits, and landslide and slump deposits.

GLACIAL DEPOSITS

Although most of the study area was covered by ice, only a small part is now blanketed by glacial drift. Thick deposits of till and glaciofluvial deposits mantle a broad area in the Hellroaring Creek valley between the mouth of Horse Creek and the junction of the West and Middle Forks of Hellroaring Creek (pl. 1). East of Hellroaring Creek these deposits are characterized by hummocky topography and marshes. The linear ridges and swales parallel with Hellroaring Creek valley are probably kames, and kame terraces, of stratified drift, and ablation drift, all derived from a stagnating ice mass. Some of these features are shown as rows of small circles on plate 1. The deposits appear to be at least 100 ft thick over much of this area. Locally the deposits have slumped or have been involved in bedrock slides, particularly at elevations above 8,000 ft east of Hellroaring Creek. West of Hellroaring Creek the glacial deposits are partly covered by, and mixed with, landslide deposits. Similar glacial deposits occur elsewhere in the study area. K. L. Pierce (written commun., 1972) considers most glacial deposits in the area to be late Pinedale in age.

COLLUVIAL DEPOSITS

Postglacial talus and slope wash blanket the lower slopes of most valley walls and basins (pl. 1). Neoglacial rock glaciers, or active lobate talus streams, are on Ash Mountain, in the north-facing headwater cirques of the Boulder River, and elsewhere. Large talus aprons are in most of the higher cirques.

LACUSTRINE AND POSTGLACIAL ALLUVIAL DEPOSITS

Deposits of gravel, sand, and silt are almost entirely confined to meadow areas, alluvial fans at the mouth of some streams, and areas ponded by landslides and talus cones. Most prominent of these are the large marshes and meadows on Slough Creek, Buffalo Fork, Hellroaring Creek, and Grizzly Creek, and the alluvial fans at the mouths of Bull Creek, Wolverine Creek, and Lost Creek. These, and many smaller marshy areas probably contain lacustrine as well as coarser alluvial deposits. Many of the present lakes and most of the major stream meadows, which are former lakes, were created by landslide dams. These include Hidden Lake, the meadow adjacent to Hidden Lake on Buffalo Fork, the meadows on Hellroaring Creek near the mouths of Grizzly Creek and Middle Fork, the lakes and marshes near the head of Brundage Creek, Carpenter Lake, Charlie White Lake, and Thompson Lake. The lower meadow on Buffalo Fork is probably the site of a former lake in a glacier-scoured basin in rock, as is Frenchy's meadow on Slough Creek. Other ice-scoured bedrock basins containing lakes or meadows are Lake Abundance, the upper meadow on Lake Abundance Creek, the meadow on Specimen Creek, the small lake at the head of Wounded Man Creek, the cirque lakes north of Wounded Man Creek, Elk Lake, and Bridge Lake. The upper meadows on Buffalo Fork and the lower meadows on Lake Abundance Creek were probably formed behind morainal material.

LANDSLIDE AND SLUMP DEPOSITS

Many areas of large-scale landsliding occur within the study area. Large slumps, block slides, rockfalls, debris slides, and debris flows resulted from a combination of topographic, lithologic, structural, and hydrologic factors. These factors include: oversteepening of valley walls by glacial erosion; changes in slope stability due to weathering, water erosion, ground-water movement, and gravity separation along bedding, joint, or fault planes; effects of overloading of incompetent strata and unconsolidated materials, and perhaps earthquake shocks.

Very large landslides are on the east slope of Buffalo Fork near the Yellowstone National Park boundary, and on the west slope of Hellroaring Creek between Horse Creek and the junction area of Grizzly Creek and Hellroaring Creek. Each slide is 4-5 square miles in area and all are relatively active.

Elsewhere landslides locally dammed Horse Creek, clogged the West Fork of Horse Creek to form Charlie White Lake, and flowed across Bear Creek to form the meadows near Castle Lake and at the head of East Fork of Bear Creek. Other slides occur at the heads of Crevice and Specimen Creeks, at the mouth of Silver Creek, at the head of Beaver Creek, along upper Buffalo Fork, on the southwest slopes of Horseshoe Mountain and the ridge west of Mount Abundance.

STRUCTURE

The Absaroka study area has had a complex structural history, beginning in early Precambrian time. Structural deformation by intense folding and warping accompanied metamorphism of the Precambrian sedimentary rocks (pl. 1). Metamorphism has been dated at about 1.8 billion years ago, but earlier metamorphism may have taken place about 2.3 billion years ago or even earlier (Brown, 1965).

Axes of folds in the Precambrian rocks of the western sector of the area have a southerly plunge (Seager, 1944). In the Hellroaring Creek valley south of Hellroaring Ranger Station the strike of the foliation of the Precambrian schist and quartzite varies from about N. 5° W. to about N. 40° E. The dip ranges from 65° W. through vertical to about 70° E. A gravity high, centered over the lower part of the Hellroaring Creek drainage (fig. 9), is interpreted by Peterson (this report, p. B32) as a structural high plunging north. However, it can also be interpreted as a broad synform that plunges south-southwest and is cut off along the southeastward extension of the Gardiner fault. The axis of such a fold would be approximately parallel to the axis of a similar fold in the Jardine–Crevice Mountain district to the west. In the eastern part of the study area, the axes of Precambrian folds appear to plunge south-southeastward. These observations agree with those by Rubel (1964) and Butler (1966), who mapped areas in and adjacent to the Absaroka study area.

After the last Precambrian episode the region was not again subjected to deformation until the Laramide orogeny in Late Cretaceous and early Tertiary time, when uplift, folding, and faulting again took place. The Beartooth uplift, thus formed, is a northwest-trending 80- by 40-mi rectangular block of Precambrian crystalline rocks that extends across the Montana–Wyoming border east of the main Middle Rocky Mountains. The block is separated into two major segments by a structurally low area about 10 mi wide and 60 mi long that extends from southeast of the Sunlight Basin in Wyoming northwestward through Cooke City to the Emigrant–Mill Creek mining district near the northwestern border of the Beartooth block (Eyrich, 1969, fig. 3). There the structurally low area terminates against the west-trending Mill Creek–Boulder River fault (fig. 6).

The Heart Mountain detachment fault has been traced northwestward from near Cody, Wyo., to near the southeast edge of the Absaroka study area. According to W. G. Pierce (1941, 1957, 1960), when the Heart Mountain fault block broke loose and slid southeastward, it left a near-vertical cliff that he called the break-away fault. This break-away fault has been traced northward many miles in northeastern Yellowstone National Park and the adjacent part of Wyoming. It is visible in the cliffs south of the Northeast Entrance to the park, and it continues northward across Soda Butte Creek to the cliffs at the head of the Stillwater River (Pierce, oral commun., 1971). From there its continuation is not known, but it may have crossed

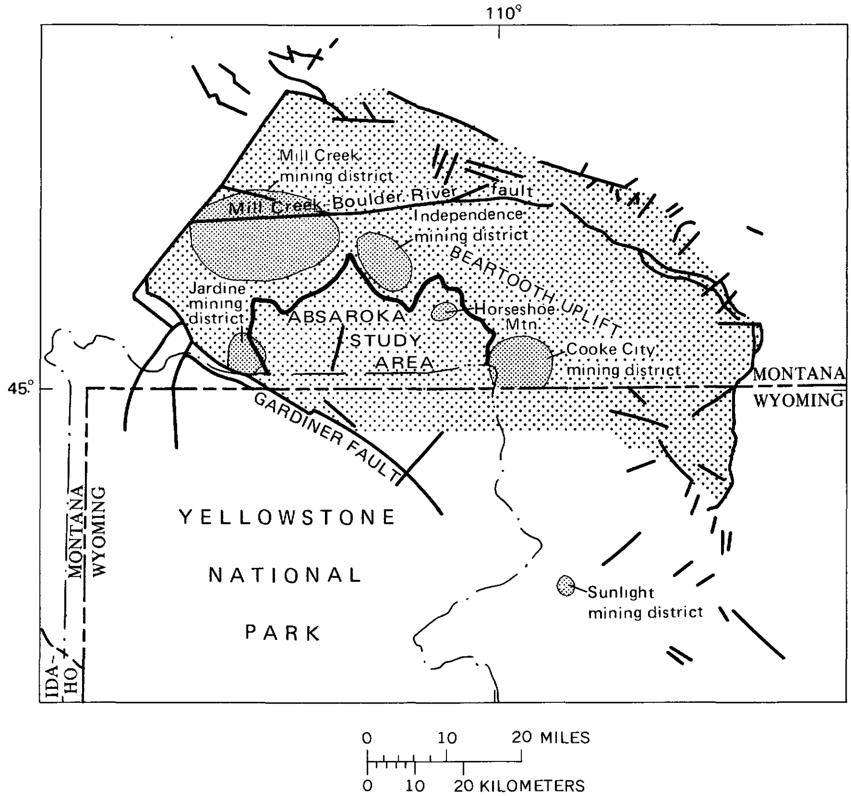


FIGURE 6 — Beartooth uplift (light shading) showing location of mining districts (dark shading). Heavy lines are major faults; Heart Mountain and related detachment faults not shown (modified from Eyrich, 1969, fig. 3).

Mount Abundance. The volcanic rocks that are now at the top and on the south flank of this peak may have filled the gap in front of the breakaway as they did to the south.

INTERPRETATION OF GEOPHYSICAL DATA

By DONALD L. PETERSON

The aeromagnetic data used in the geophysical investigation of the Absaroka study area are a part of more widespread regional surveys made by the U.S. Geological Survey in 1967 and 1970. South of lat 45°07′30″ N., the survey was flown along east-west lines at an average spacing of 1 mi and at a barometric altitude of 12,000 ft above sea level. The area to the north of lat 45°07′30″ N. was flown along north-south lines at the same spacing but at a barometric altitude of 13,500 ft. Total-intensity magnetic measurements were made with a continuously recording ASQ-10 fluxgate magnetometer installed in the tail boom of a Convair aircraft. The aeromagnetic data were originally plotted on a map at a scale of 1:62,500 and contoured at an interval of 20 gammas with respect to a uniform magnetic datum of 55,090 gammas. The significant magnetic features are readily seen at a contour interval of 100 gammas (fig. 7).

In August 1971, 38 gravity stations were occupied by helicopter traverses. The Bouguer gravity map (fig. 8), contoured at an interval of 5 mGal (milligals), is based on data from these stations and on data from earlier observations made by the U.S. Geological Survey along the west and south edges of the study area. Some of the stations are outside the map area. Vertical and horizontal positions of the stations were taken from U.S. Geological Survey topographic maps. The gravity stations were corrected for terrain effects to a distance of 167 km (kilometers) by methods described by Plouff (1966) and Sandberg (1958). The largest terrain correction for a station on the highest point of Cutoff Mountain exceeded 49 mGal. Bouguer values were calculated on the basis of an assumed density of 2.67 g/cm^3 (grams per cubic centimeter) for the rock between sea level and the stations. However, because the thick sequence of volcanic rock in the area probably has a smaller mean density, a profile was computed across the map (fig. 8) using a density of 2.45 g/cm^3. The gravity highs and lows remained but were more subdued after removal of topographic irregularities. Therefore, the gravity anomalies on figure 8 are accepted as real, but their amplitudes and configurations may be somewhat distorted. The gravity data are referenced to Woollard's (1958) airport base station WA 124 at Great Falls, Mont.

The magnetic and gravity contours are compared with the geologic map (pl. 1) to aid in relating the geophysical anomalies to the geology. Each anomaly discussed in the text is identified by a number on the maps: magnetic — fig. 7, Nos. 6, 7, 8, 10-15; gravity — fig. 8, Nos. 1-5, 9. No measurements of rock density and magnetic properties were made; however, it is readily apparent that most significant anomalous features on figures 7 and 8 are related to Tertiary intrusive rocks. Extreme variations in topographic relief and the generally high intensity of magnetization of the widespread volcanic rock make interpretations of the aeromagnetic map (fig. 7) somewhat questionable. Only magnetic anomalies believed to have the greatest geologic significance are discussed. Only gravity anomalies of larger horizontal dimensions are accurately expressed by the contours, because of the wide spacing of gravity stations.

A northwest magnetic trend shown near the southwest corner of the magnetic map (fig. 7) and a coincident gravity trend (fig. 8) with the amplitude of 15–20 mGal are expressions of the northwestward-

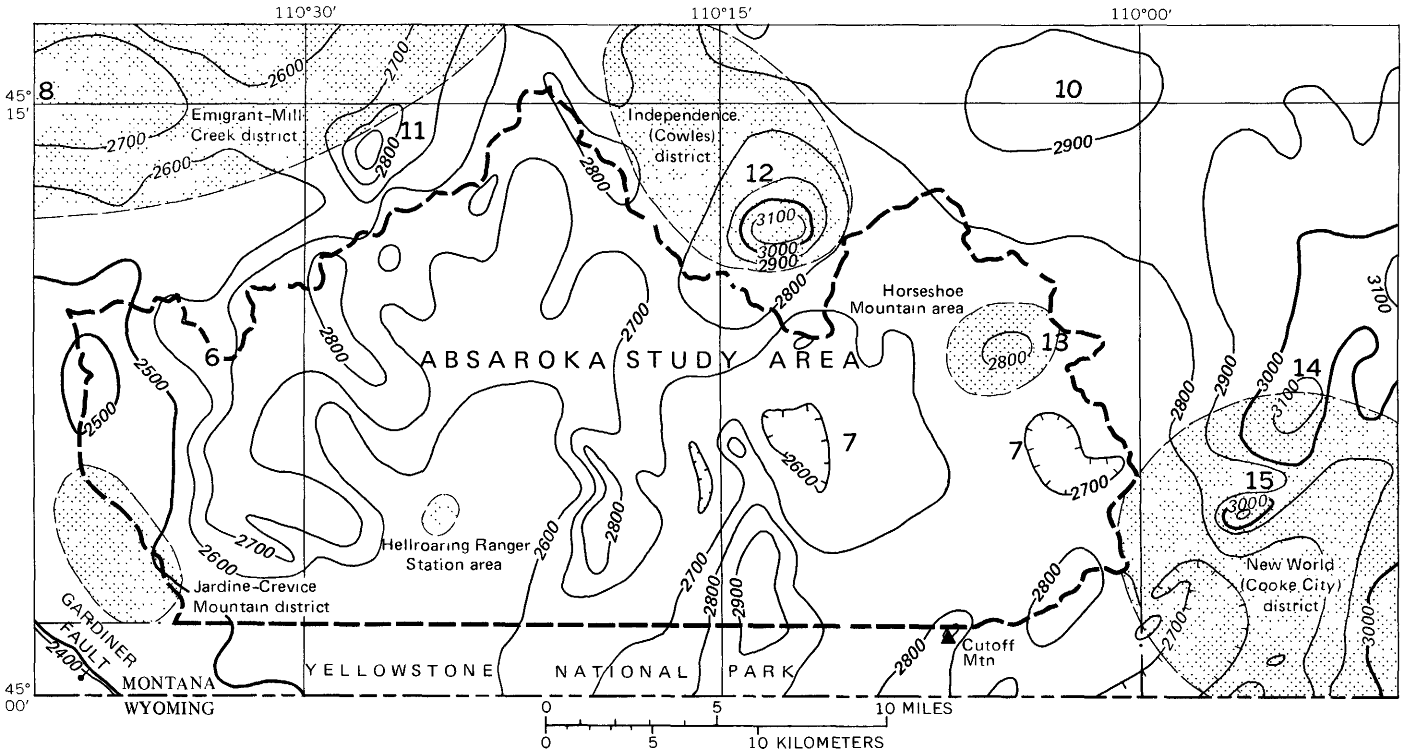


FIGURE 7. — Absaroka study area and vicinity showing the total-intensity magnetic field of the earth in gammas. Hachures indicate closed areas of lower intensity; contour interval 100 gammas; flight spacing about 1 mi; numbers identify anomalies discussed in text.

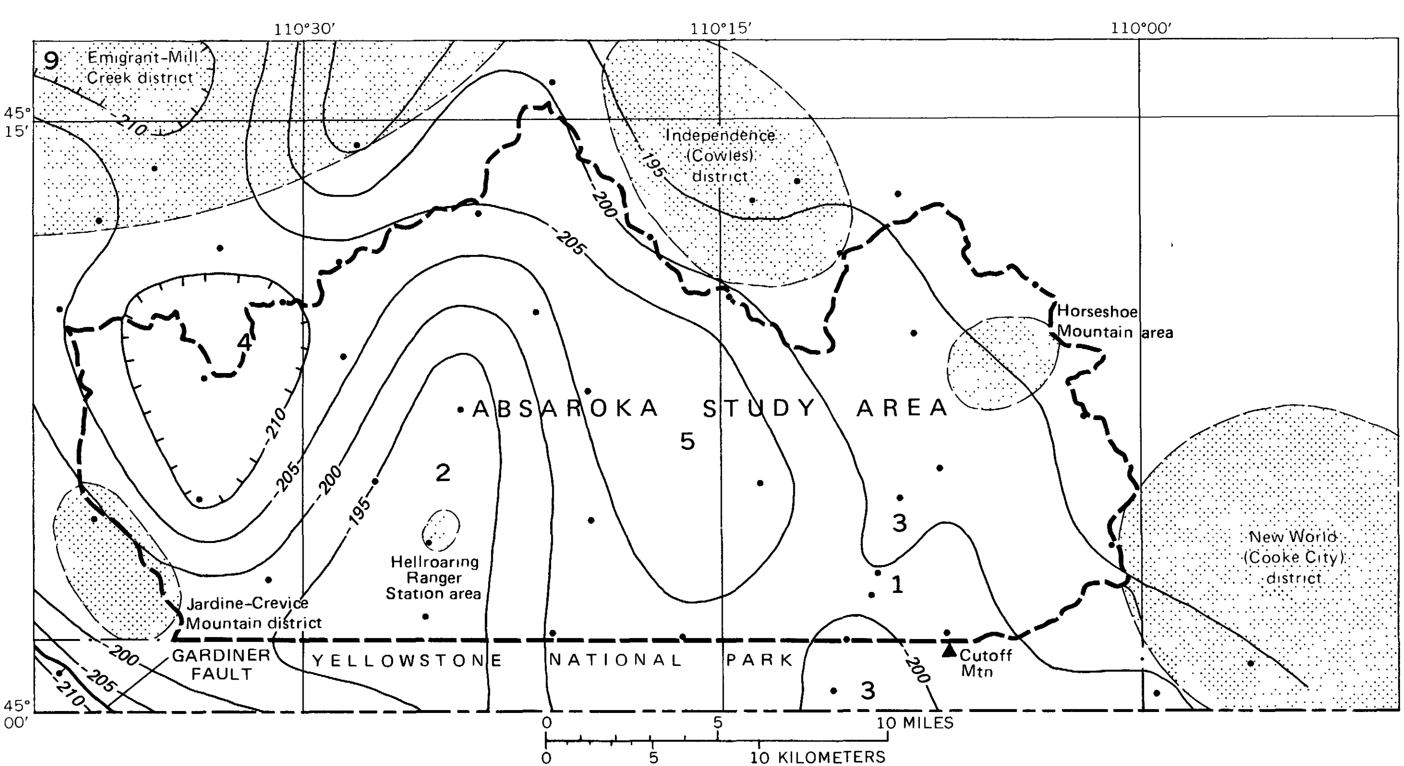


FIGURE 8. — Complete Bouguer gravity map of the Absaroka study area and vicinity. Hachures indicate closed areas of lower gravity; contour interval 5 mGal; solid dots, gravity stations; numbers identify anomalies discussed in text.

trending Gardiner fault. This fault is a high-angle reverse fault that separates the uplifted Beartooth Mountains block of Precambrian rocks on the northeast from the downdropped Yellowstone Valley block of Paleozoic and Mesozoic rocks on the southwest.

Gravity and magnetic trends along the northeastern part of the Absaroka study area approximately parallel the trends in the southwestern part. Several pronounced positive magnetic anomalies (Nos. 11–15) are located along the magnetic trend. The geophysical trends in this area coincide with the Cooke City structural zone (Bucher and others, 1934; Foose and others, 1961; Eyrich, 1969). The Cooke City zone is a major northwest-trending zone of faulting and downwarping in the prevolcanic rocks that transects the Beartooth Mountains between Clarks Fork Canyon and the junction of Mill Creek and the Yellowstone River. Narrow magnetic anomalies southwest of the zone contrast with broad anomalies to the northeast, indicating that the zone delineates the northeast boundary of the Absaroka volcanic province.

A gravity "saddle" (No. 1) is located over the Silver Tip structure along Slough Creek in the southeastern part of the area. Rubel and Romberg (1971) also made gravity observations that defined the saddle. They attributed the structure to a core of Precambrian metamorphic rocks that was differentially uplifted more than 2,500 m (meters) by molten igneous rocks.

A large gravity high (No. 2) is in the vicinity of the Hellroaring Creek drainage. Cambrian rocks along the east flank of the gravity high dip to the east. No Cambrian rocks are exposed along the west flank. The gravity high, Precambrian rock exposures in the area, and eastward-dipping Cambrian rocks indicate a structural high that plunges to the north. To the east, a smaller gravity high (No. 3) is located over the Slough Creek drainage.

A large gravity low (No. 4) which has about 15 mGal of negative relief is just north of Ash Mountain. Another poorly defined gravity low (No. 5) is to the east over the Buffalo Fork drainage. An irregular magnetic high (No. 6) coincides with the western gravity low (No. 4). A broad magnetic low (No. 7) with two areas of closure is along the east edge of the east gravity low (No. 5). These two anomalies may represent structurally low areas, but they also may, in part, indicate eruptive centers with thick accumulations of volcanic rocks, as indicated by the greater local abundance of intrusive rocks. The smaller magnetic anomalies in the vicinity of anomaly No. 6 may reflect satellite bodies of this inferred igneous center.

An east-trending magnetic high (No. 8) is located about 3 mi north of Mineral Mountain. A poorly defined gravity low (No. 9) is north of the magnetic anomaly. Tertiary intrusive rock is abundant in this area (Foose and others, 1961; Iddings and Weed, 1894), and the anomalies

(Nos. 8 and 9) may reflect a batholithic intrusion at depth. The broad east-trending magnetic high (No. 10) of the Absaroka study area is probably the expression of the Precambrian rocks of the Beartooth Plateau.

The five positive magnetic anomalies (Nos. 11–15) along the Cooke City structural zone probably are the expressions of sources at or very near the surface of the ground. A northeast-trending magnetic high (No. 11) of more than 200 gammas amplitude is 2 mi north of Mount Wallace. The anomaly may reflect a volcanic plug or other intrusive body. A gravity high, indicated by a single station, is near the peak of the magnetic anomaly and is probably related to the source of the magnetic anomaly. A pronounced magnetic high (No. 12) with an amplitude of more than 300 gammas is over the Independence volcano, which Rubel (1971) described as a major eruptive center in the northern part of the Absaroka volcanic province. The east-trending upper part of the anomaly may be partly a result of a positive topographic relief. Magnetic anomalies 13, 14, and 15 probably represent intrusive stocklike bodies.

Sites judged as favorable for ore deposits on the basis of geophysical evidence are along the Cooke City zone and in the vicinity of the magnetic anomaly (No. 6) near the west edge of the study area. Another magnetic anomaly (No. 8) and the corresponding gravity anomaly (No. 9) to the north are in an area of ore deposits that have been mined. This area is a favorable site for other, perhaps buried, ore deposits.

MINERAL RESOURCES

GEOLOGIC SETTING

Known major mineral resources exist in and immediately peripheral to the Absaroka study area (fig. 9). They are the gold-arsenic-tungsten ores of the Jardine–Crevice Mountain district, the gold deposits of the Independence district and the Horseshoe Mountain area, and the complex gold-silver-copper-lead-zinc ores of the New World (Cooke City) mining district, chiefly those of the mines and prospects in the headwater basin of the Stillwater River. Gold occurrences similar to the ores at Jardine are found near the Hellroaring Ranger Station.

NEW WORLD (COOKE CITY) DISTRICT

The New World district (fig. 9), near Cooke City, Mont., is at the east end of the Absaroka study area. Descriptions of the ore deposits that occur in the western part of the district, chiefly in and around the headwater basin of the Stillwater River, are found in reports by Lovering (1930), Reed (1950), and Eyrich (1969). Available records show that since 1900 the New World district has produced slightly more than 65,000 oz (ounces) of gold, nearly 500,000 oz of silver, and about 2,000, 1,500, and 600 short tons of copper, lead, and zinc, respectively.

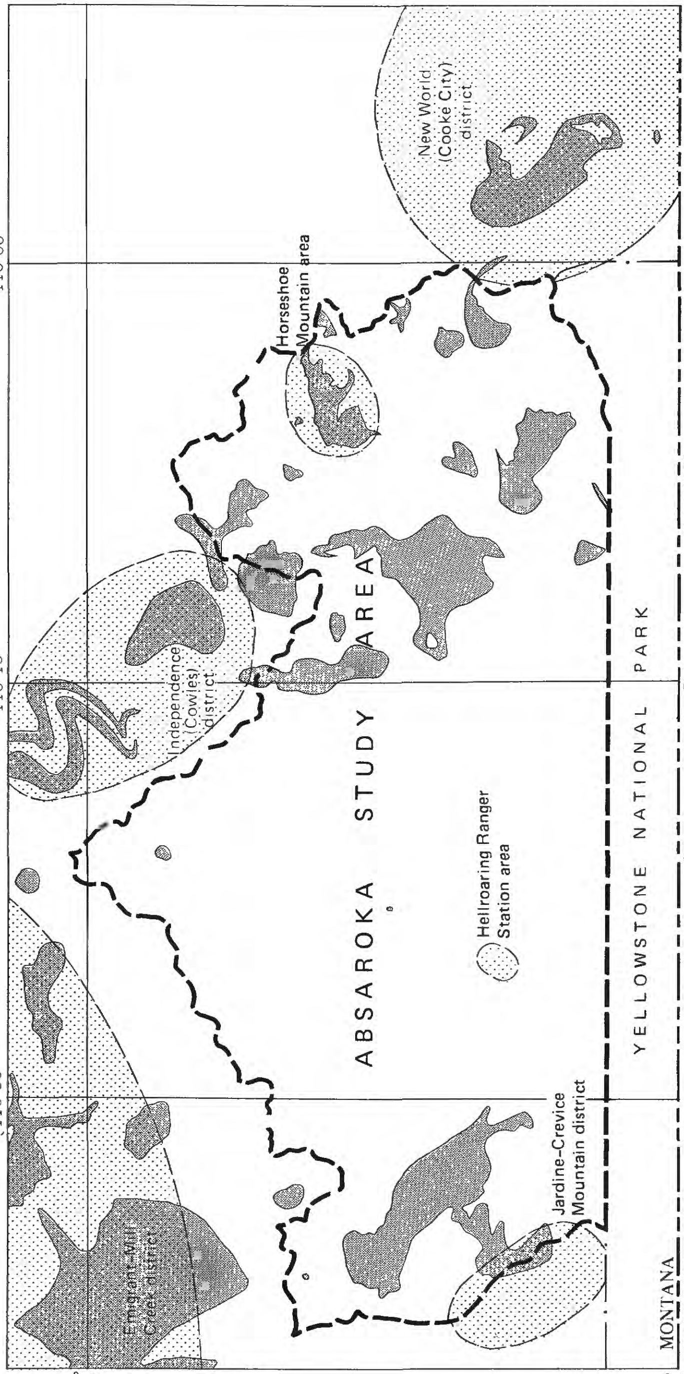


FIGURE 9 — Location of Tertiary intrusive rocks (dark shading) and mining districts or areas (light shading).

The complex gold-silver-copper-lead-zinc ores in this part of the district occur chiefly as vein, replacement, and disseminated deposits of early Tertiary age. Most of the metal produced has been from replacement deposits in the Meagher Limestone of Cambrian age. The higher temperature deposits, containing chiefly gold and copper values with abundant pyrite, are closely associated with breccia pipes. Moderate temperature lead-zinc-silver ores were deposited as replacement bodies along and out from fractures at great distances from the pipes, chiefly in the carbonate rocks. The higher temperature type of ore body is represented by the deposits in the vicinity of Henderson and Fisher Mountains (pl. 1), 2 mi east of the study area. The moderate-temperature type is represented by deposits in the Pilgrim Limestone that crops out on the bench from the headwaters of the Stillwater River through Wolverine Pass to the east side of Mount Abundance (pl. 1) (Eyrich, 1969; Lovering, 1930). These deposits can be examined in old mines and prospects.

HORSESHOE MOUNTAIN AREA

The Horseshoe Mountain mining area (fig. 9) is about midway between the Independence district on the northwest and the western part of the Cooke City district on the southeast. The deposits at Horseshoe Mountain were prospected for gold, mostly at the time of operations in the Independence district; some prospecting was done during the 1960's, and claims continue to be maintained. The deposits were described briefly by Rubel (1964, p. 177). Most gold in this area is in hydrothermally altered parts of the Tertiary dacitic-rhyolitic porphyries (see pl. 1), but some is in Precambrian gneiss and Flathead Sandstone. Metallic minerals are chiefly in silicified zones or quartz veins along north-, northwest-, and east-trending fracture zones. Pyrite and quartz are disseminated outward from the silicified fractures and, locally, in all the rock between the fractures. In addition to pyrite, minute grains of arsenopyrite(?) and galena(?) were seen in a few fresh dump specimens; flakes of molybdenite were found in an outcrop of Precambrian gneiss on the northwest flank of the mountain. The Ag:Au ratios (table 15) of pyritic material and its oxidized derivatives are highly variable, but silver is commonly much more abundant than gold in the fresh rock than in the weathered rock. The mineral associations are similar to those of the Independence district.

INDEPENDENCE (COWLES) DISTRICT

The Independence district (fig. 9) lies in the Boulder River drainage between the East Fork and the main headwaters of the Boulder River northeast of the Absaroka study area. The deposits were mentioned briefly by Iddings and Weed (1894) and Emmons (1908). Recently the deposits were described by Reed (1950) and Rubel (1964). The main deposits of the district are the quartz-gold veins of the dormant Independence and Hidden Treasure mines. These and other nearby mines and prospects are between Baboon Mountain and Independence Peak in the drainage of Basin Creek. Other deposits, explored mainly for lead-silver or molybdenum, also occur in the district (Reed, 1950, p. 54–58; Rubel, 1964, p. 178–180).

The quartz-gold ores occur both as narrow veins and as disseminations in adjacent silicified-sericitized wallrock. Most veins are along northwest-trending fractures in granodiorite and monzonite of the Haystack stock (Emmons, 1908; Rubel, 1964 and 1971). Disseminated sulfide minerals are along the north side of Basin Creek, on the old Hidden Treasure claims, in a zone about 900 ft long, 400 ft wide, and at least 200 ft deep that has been hydrothermally sericitized and kaolinized. The zone contains abundant disseminated pyrite and scattered small amounts of chalcopyrite, molybdenite, and galena. Early production records show that silver was probably 5–15 times more abundant than gold in ores that were smelted. Most of the gold and silver was recovered by smelting the pyrite concentrates. The free gold, won in the earliest days in mining, was from oxidized ores near the surface and from placers along Basin Creek. Tests of pyrite and pyritic rock fragments from mine dumps and tailings show a range of Ag:Au ratios from about 40:1 to 2:1. (See samples R70, R71, R75, R712, R713, R716, R718, and R723, pl. 2 and table 7.) Apparently, the less oxidized the ore, the higher the silver-gold ratio.

EMIGRANT-MILL CREEK DISTRICT

The Emigrant–Mill Creek district (fig. 9) lies northwest of the Absaroka study area, near the west end of the Mill Creek fault (Foose and others, 1961, pl. 1). None of the mineral deposits of this district were sampled; however, a few stream-sediment samples were taken from tributaries of Mill Creek heading at the Absaroka study area.

Geologically, the Emigrant–Mill Creek district is similar to the New World district (Iddings and Weed, 1894; Reed, 1950; Foose and others, 1961). Precambrian crystalline rocks are overlain by Paleozoic sedimentary and Tertiary volcanic rocks. All these rocks are cut by intrusives related to the volcanics: laccoliths, sills, dikes, small plugs, and larger stocklike bodies. Veins, fractures, and sheeted zones trend northeast or northwest. These structures, containing gold, silver, lead, zinc, and some copper, seem to be related to the larger discordant intrusives. Also present is a mineralized pipe in which molybdenum is found. Reed (1950, p. 52) reported this pipe to consist of trachyte porphyry, to have a diameter of 150 ft, and to have been explored vertically for more than 200 ft.

JARDINE-CREVICE MOUNTAIN DISTRICT

The gold-arsenic-tungsten deposits of the Jardine–Crevice Mountain district (fig. 9) were described by S. W. Cathcart (unpub. data, 1924), and Seager (1944) and discussed more recently by Reed (1950, p. 26–34), Weissenborn (1963, p. 122–123), and L. E. Brown (1965). The ore is in silicified zones of variable thickness formed by selective replacement of much-deformed and sheared (1) fissile biotite-quartz schist and biotite quartzite, and (2) quartz-cummingtonite schist, or their altered equivalents. The zones commonly are parallel to the schistosity of the country rock, which, for the most part, closely parallels the original bedding of the ancient sedimentary rocks. A few veins, however, cut across the schistosity, probably following premineral faults or fractures.

The veins, though numerous and widely distributed throughout the district, vary greatly in continuity and grade. They are the most abundant in two distinct belts. One extends somewhat east of north through Mineral Hill near Jardine; the other trends northerly through the summit of Crevice Mountain. The deposits have been worked primarily for gold; arsenic and tungsten have been recovered as byproducts. Some of the ores at Crevice Mountain, however, contain sufficient arsenic to be classed as an ore of that element and were mined as such briefly during World War II. The arsenic occurs as arsenopyrite, the most abundant of the sulfide minerals; other sulfides are pyrite and pyrrhotite and, in minor amounts, chalcopyrite, sphalerite, and galena. Native gold is associated with arsenopyrite. Scheelite, the tungsten mineral, is more abundant in the quartz-rich ore than in the sulfide-rich ores.

The western part of the district, or the Jardine area, is characterized by an asymmetrical faulted syncline that plunges gently south-southwest (Seager, 1944, p. 38-40). The western limb of this syncline is west of Jardine and dips about 80° E.; the eastern limb in general dips a few tens of degrees westward. The fault, known as the Bear Gulch fault, is normal, dips about 40°-45° W., and is post mineralization. Its displacement is unknown but probably does not exceed several hundred feet. Configuration of tunnels at the mine (Seager, 1944, pl. 8) indicates that the northern part of the mine is near the keel or axis of a syncline.

Near Crevice Mountain, in the southeastern part of the district, mineral showings are in an area about 1 mi wide that extends northward from the Yellowstone National Park boundary across the summit of the mountian for a distance of about 2 mi. Here, the structure is homoclinal, and the schistosity of the metamorphic rocks strikes about north and generally dips a few tens of degrees east. As at Jardine there are several mineralized zones. The eastward-dipping homocline at Crevice Mountain and the westward-dipping rocks at the Jardine mine are probably limbs of an anticline, the crest of which is between the two areas and which also plunges south. If that is correct, then the favorable ore-bearing zone — cummingtonite-bearing schist — would not occur to the north but might occur in the Crevice Creek and Hellroaring Creek area.

HELLROARING RANGER STATION AREA

Gold occurrences near Hellroaring Ranger Station (No. 6, fig. 7) are in garnetiferous quartz-cummingtonite and cummingtonite schists interlayered with biotite quartzite and quartz-biotite schist. These rocks are similar to those of the Jardine–Crevice Mountain district. The three mineralized zones contain quartz knots and stringers that are deeply weathered and iron stained. They are exposed only in shallow trenches dug before the turn of the century. The layering of the schist and quartzite in the area of the old pits strikes generally north and dips vertically or steeply to the east. The zones vary greatly in width, ranging from a few inches to 1½ ft. Their strike length is obscured by surficial material (pl. 1).

COMPOSITION OF GOLD IN DISTRICTS NEAR THE ABSAROKA PRIMITIVE AREA

In 1970, John C. Antweiler of the U.S. Geological Survey collected a suite of gold samples from mining districts in the vicinity of the Absaroka Primitive Area as part of a project to study the composition of native gold from mining districts in northwestern United States. Data on minor and trace elements found in this suite of samples are in table 2. Antweiler (written commun., 1972) concluded that of the ores sampled those having the highest depositional temperatures were from the vicinity of the Homestake mine at Henderson Mountain in the New World (Cooke City) district. The analyses also confirm Antweiler's belief that copper values in gold increase and silver values decrease as temperatures and pressures increase with depth of ore emplacement. Furthermore, the presence of significant though trace amounts of tin, molybdenum, and tungsten in the gold suggest hypothermal or high-temperature conditions. Antweiler observed that the gold in all the districts has a composition typical of gold ores related to late episodes of Tertiary igneous activity, except for the ore from Jardine. The Jardine ore seems to be much more complex and, in part at least, is Precambrian in age.

SAMPLING PROGRAM AND ANALYTICAL TECHNIQUES

Geochemical exploration in the Absaroka study area consisted of the systematic sampling of stream sediments, bedrock, and mineralized or alteration zones. The samples were analyzed spectrographically and chemically for selected elements, and statistical and geological evaluations of the analytical data were made.

TABLE 2. — *Composition of gold in districts near the Absaroka Primitive Area, Mont.*

[Compiled by J. C. Antweiler from semiquantitative spectrographic analyses by E. L. Mosier. All samples contained variable but not diagnostic trace quantities of Hg, Fe, Mn, Ti, Si, Ca, and Mg]

Locality	Number of analyses	Ranges: Ag (percent)	Ranges: Cu (ppm)	Mean values: Ag (percent)	Mean values: Cu (ppm)	Atomic proportions: Cu	Atomic proportions: Ag	Atomic proportions: Au	Atomic proportions: Au/Ag	Diagnostic trace elements detected, in order of decreasing abundance and importance
New World district										
Homestake mine---------	5	10.0-18.0	500-11,000	13.4	4,000	1	20	67	3.4	Bi, Pb, V, Zn, Cd.
Glengarry mine---------	5	3.0-17.0	350- 1,000	10.4	700	1	87	406	4.7	Bi, Pb, Sn, Te, As.
Lulu Pass--------------	5	12.5-18.0	250- 350	15.7	290	1	317	927	2.9	Bi, Pb.
Scotch Bonnet Mountain-	5	5.0-17.5	170- 500	13.8	385	1	210	705	3.4	Bi, Pb.
Horseshoe Mountain area										
----------------------	2	10.5-12.0	450- 3,000	11.3	1,700	1	81	388	4.3	Bi, Pb, Zn, Te.
Independence district										
Lower------------------	5	7.6-14.0	70- 1,400	9.8	830	1	322	1,720	5.2	Pb, Bi, V, Zn.
Upper------------------	5	20.0-32.0	250- 1,500	25.0	750	1	2,100	3,340	1.6	Bi, Pb, Sb, Te, Cr.
Emigrant district										
Great Eastern lode-----	3	6.5- 8.5	150- 250	7.5	200	1	218	1,430	6.6	Pb, Bi, Sb, Zn, Sn.
Arrastra Gulch---------	5	3.0-25.0	300- 400	15.4	330	1	275	816	3.0	Bi, Pb.
Emigrant Gulch---------	5	7.5-25.0	330- 1,750	14.3	910	1	133	282	3.5	Bi, Pb, Zn, Mo, Sb, As.
Jardine-Crevice Mountain district										
Jardine----------------	8	5.0-15.0	300- 3,000	10.7	950	1	67	298	4.4	As, Pb, Bi, Cd, Nb, Sb, W, Cr.

Stream-sediment samples were taken of clay- and silt-sized material where possible. At a few localities where no distinctly alluvial material was available, colluvium or soil was sampled. Each sample was screened, and only the 80-mesh fraction was analyzed. Pan concentrates of heavy minerals were made of a few stream sediments. All rock samples, from both unmineralized and mineralized showings, were crushed and pulverized but were not concentrated for analysis.

Stream-sediment sample localities are not evenly distributed throughout the area but tend to cluster because most samples were taken at stream junctions. Bedrock samples likewise tend to cluster because of the irregular distribution of outcrops and because some areas seem to warrant more study than others; mineralized areas were sampled most heavily.

The localities from which samples were taken are shown on plate 2; 789 samples of stream sediment and related materials and 420 samples of rock were collected. Fifteen concentrates were obtained by panning stream sediment. All 1,229 samples were analyzed semiquantitatively by spectrographic methods for 30 elements. Gold and arsenic, two elements of special interest in this area, are not readily detected in the range of values present with the spectrographic techniques employed, because the lower limit of detection is 10 ppm (parts per million) for gold and 200 ppm for arsenic. Consequently, the spectrographic analyses were supplemented by atomic-absorption spectroscopy for gold (lower detection limit 0.02 ppm) and by colorimetric chemical analysis for arsenic (lower detection limit 10 m). Bismuth, cadmium, antimony, and tin were also not detected or were detected in only a very few samples by the spectrographic technique, but a more sensitive technique was not used for these elements.

Almost all samples were analyzed chemically for gold-extractable, or citrate-soluble, heavy metals (cxHM). These analyses determine the amount of copper, lead, and zinc absorbed on the surfaces of the detrital grains in a sediment or soil.

Heavy-mineral concentrates were made by panning large samples of stream sediment from streams that drain several mineralized areas. Analyses of these samples showed that areas anomalous in gold could be detected just as readily with the minus-80-mesh stream-sediment samples that were not concentrated by panning, and the panning was discontinued.

The frequency distributions of 26 elements and cxHM are given for the two main categories of samples, stream sediments (including soils) in table 3 and rocks in table 4. The elements are mostly grouped according to chemical or mineralogical affinities, as well as by relative geochemical abundance and (or) similar lower detection limits. Thus, the more abundant and main rock-forming elements — calcium, iron, and magnesium — are classed with barium, strontium, and zinc. The rare-earth elements, lanthanum and yttrium, are grouped with niobium, scandium, and zirconium, and the ferroalloy metals, chromium, cobalt, manganese, nickel, titanium, vanadium, and tungsten, are grouped together. Both tables 3 and 4 show the frequency distributions of the elements and cxHM that were used to decide which samples would be considered anomalous for a mineral-resource evaluation.

TABLE 3. — *Frequency distributions of 26 elements and cold-extractable heavy metals in stream-sediment samples from the Absaroka Primitive Area and vicinity*

[Explanation; ppm, parts per million; *f*, frequency of number of samples of a particular value; c.f., cumulative frequency or the cumulative number of samples through a particular value; percent c.f., cumulative frequency calculated to 100 percent; number in parentheses after element symbol indicates lowermost or initial class value used for frequency distribution; N-L, number of samples below initial class; L, detected, but in amounts below sensitivity limit; G, number of samples having quantities exceeding values of last preceding occupied class interval]

Ppm	*f*	C.f.	Percent c.f.	*f*	C.f.	Percent cf.	*f*	C.f.	Percent c.f.
		Ba (100)			**Ca (500)**			**Fe (500)**	
N-L	0	0	0.00	0	0	0.00	0	0	0.00
100	0	0	.00	---	---	---	---	---	---
150	0	0	.00	---	---	---	---	---	---
200	4	4	.51	---	---	---	---	---	---
300	44	48	6.08	---	---	---	---	---	---
500	82	130	16.48	0	0	0.00	0	0	0.00
700	302	432	54.75	0	0	.00	0	0	.00
1000	193	625	79.21	6	6	.76	0	0	.00
1500	69	694	87.96	2	8	1.01	0	0	.00
2000	60	754	95.56	16	24	3.04	0	0	.00
3000	20	774	98.10	7	31	3.93	0	0	.00
5000	9	783	99.24	64	95	12.04	0	0	.00
7000	---	---	---	77	172	21.80	3	3	.38
10,000	---	---	---	136	308	39.04	35	38	4.82
15,000	---	---	---	19	327	41.44	13	51	6.46
20,000	---	---	---	186	513	65.02	147	198	25.10
30,000	---	---	---	112	625	79.21	130	328	41.57
50,000	---	---	---	83	708	89.73	221	549	69.58
70,000	---	---	---	22	730	92.52	52	601	76.17
100,000	---	---	---	46	776	98.35	70	671	85.04
150,000	---	---	---	9	785	99.49	111	782	99.11
200,000	---	---	---	4	789	100.00	7	789	100.00
G	6	789	100.00						
		Mg (200)			**Sr (100)**			**Zn (200)**	
N-L	0	0	0.00	1	1	0.13	765	765	96.96
100	---	---	---	30	31	3.93	---	---	---
150	---	---	---	19	50	6.34	---	---	---
200	0	0	.00	103	153	19.39	13	778	98.61
300	0	0	.00	173	326	41.32	8	786	99.62
500	0	0	.00	181	507	64.26	2	788	99.87
700	0	0	.00	160	667	84.54	1	789	100.00
1,000	0	0	.00	95	762	96.58			
1,500	0	0	.00	11	773	97.97			
2,000	10	10	1.27	13	786	99.62			
3,000	39	49	6.21	0	786	99.62			
5,000	93	142	18.00	2	788	99.87			
7,000	37	179	22.69	---	---	---			
10,000	222	401	50.82	---	---	---			
15,000	36	437	55.39	---	---	---			
20,000	166	603	76.43	---	---	---			
30,000	69	672	85.17	---	---	---			
50,000	51	723	91.63	---	---	---			
70,000	58	781	98.99	---	---	---			
100,000	8	789	100.00	---	---	---			
150,000				---	---	---			
200,000				---	---	---			
G				1	789	100.00			

TABLE 3. — *Frequency distributions in stream-sediment samples* — Continued

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.	f	C.f.	Percent c.f.
		La (20)			**Nb (10)**			**Sc (5)**	
N-L	61	61	7.73	585	585	74.14	0	0	0.00
5	---	---	---	---	---	---	25	25	3.17
7	---	---	---	---	---	---	178	203	25.73
10	---	---	---	147	732	92.78	170	373	47.28
15	---	---	---	10	742	94.04	221	594	75.29
20	534	595	75.41	33	775	98.23	108	702	88.97
30	86	681	86.31	13	788	99.87	80	782	99.11
50	61	742	94.04	1	789	100.00	6	788	99.87
70	33	775	98.23	---	---	---	1	789	100.00
100	3	778	98.61						
150	6	784	99.37						
200	4	788	99.87						
300	1	789	100.00						

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.
		Y (10)			**Zr (10)**	
N-L	7	7	0.89	0	0	0.00
5	---	---	---	---	---	---
7	---	---	---	---	---	---
10	118	125	15.84	0	0	0.00
15	221	346	43.85	0	0	.00
20	350	696	88.21	0	0	.00
30	81	777	98.48	19	19	2.41
50	9	786	99.62	48	67	8.49
70	1	787	99,75	124	191	24.21
100	2	789	100.00	283	474	60.08
150				114	588	74.52
200				100	688	87.20
300				65	753	95.44
500				32	785	99.49
700				1	786	99.62
1,000				2	788	99.87
G				1	789	100.00

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.	f	C.f.	Percent c.f.
		Co (5)			**Cr (10)**			**Mn (10)**	
N-L	1	1	0.13	0	0	0.00	0	0	0.00
5	52	53	6.72	---	---	---	---	---	---
7	9	62	7.86	---	---	---	---	---	---
10	240	302	38.28	3	3	0.38	0	0	0.00
15	77	379	48.04	1	4	.51	0	0	.00
20	189	568	71.99	13	17	2.15	0	0	.00
30	160	728	92.27	44	61	7.73	0	0	.00
50	52	780	98.86	64	125	15.84	0	0	.00
70	5	785	99.49	94	219	27.76	1	1	.13
100	4	789	100.00	106	325	41.19	5	6	.76
150				117	442	56.02	25	31	3.93
200				129	571	72.37	49	80	10.14
300				79	650	82.38	62	142	18.00
500				57	707	89.61	180	322	40.81
700				61	768	97.37	208	530	67.17
1,000				18	786	99.62	220	750	95.06
1,500				3	789	100.00	18	768	97.34
2,000							19	787	99.75
3,0000							0	787	99.75
5,000							2	789	100.00

TABLE 3. — *Frequency distributions in stream-sediment samples* — Continued

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.
		Ni (5)			Ti (20)	
N-L	0	0	0.00	0	0	0.00
5	7	7	.89	---	---	---
7	15	22	2.79	---	---	---
10	35	57	7.22	---	---	---
15	41	98	12.42	---	---	---
20	63	161	20.41	0	0	0.00
30	166	327	41.44	0	0	.00
50	201	528	66.92	0	0	.00
70	126	654	82.89	0	0	.00
100	92	746	94.55	0	0	.00
150	38	784	99.37	0	0	.00
200	4	788	99.87	0	0	.00
300	0	788	99.87	0	0	.00
500	1	789	100.00	1	1	.13
700				0	1	.13
1,000				37	38	4.82
1,500				36	74	9.38
2,000				187	261	33.08
3,000				114	375	47.53
5,000				220	595	75.41
7,000				144	739	93.66
10,000				37	776	98.35
G				13	789	100.00
		V (10)			W (50)	
N-L	0	0	0.00	778	778	98.61
5	---	---	---	---	---	---
7	---	---	---	---	---	---
10	1	1	0.13	---	---	---
15	0	1	.13	---	---	---
20	2	3	.38	---	---	---
30	13	16	2.03	---	---	---
50	58	74	9.38	2	780	98.86
70	245	319	40.43	2	782	99.11
100	315	634	80.35	2	784	99.37
150	28	662	83.90	4	788	99.87
200	90	752	95.31	1	789	100.00
300	24	776	98.35			
500	12	788	99.87			
700	1	789	100.00			

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.	f	C.f.	Percent c.f.
		As (10)			B (10)			Cu (5)	
N-L	606	606	85.59	464	464	58.81	0	0	0.00
5	---	---	---	---	---	---	72	72	9.13
7	---	---	---	---	---	---	67	139	17.62
10	52	658	92.92	226	690	87.45	202	341	43.22
15	0	658	92.94	38	728	92.27	135	476	60.33
20	24	682	96.33	37	765	96.96	105	581	73.64
30	7	689	97.32	10	775	98.23	16	597	75.67
50	4	693	97.88	3	778	98.61	59	656	83.14
70	9	702	99.15	1	779	98.73	46	702	88.97
100	1	703	99.29	9	788	99.87	17	719	91.13
150	1	704	99.44	0	788	99.87	9	728	92.27
200	2	706	99.72	1	789	100.00	10	738	93.54
300	0	706	99.72				9	747	94.68
500	0	706	99.72				15	762	96.58
700	0	706	99.72				9	771	97.72
1,000	0	706	99.72				16	787	99.75
1,500	0	706	99.72				1	788	99.87
2,000	0	706	99.72				1	789	100.00
3,000	1	707	99.86						
5,000	0	707	99.86						
G	1	708	100.00						

TABLE 3. — *Frequency distributions in stream-sediment samples* — Continued

Ppm	*f*	C.f.	Percent c.f.	*f*	C.f.	Percent cf.
		Mo (5)			**Pb (10)**	
N-L ----	740	740	93.79	7	7	0.89
5	9	749	94.93	---	---	---
7	11	760	96.32	---	---	---
10	11	771	97.72	80	87	11.03
15	10	781	98.99	147	234	29.66
20	3	784	99.37	242	476	60.33
30	1	785	99.49	150	626	79.34
50	0	785	99.49	63	689	87.33
70	3	788	99.87	52	741	93.92
100	0	788	99.87	21	762	96.58
150	1	789	100.00	12	774	98.10
200				11	785	99.49
300				1	786	99.62
500				1	787	99.75
700				1	788	99.87
1,000				0	788	99.87
1,500				0	788	99.87
2,000				1	789	100.00
		Au (.02)			**Ag (.5)**	
L -----	663	663	86.10	711	711	90.11
0.02	10	673	87.40	---	---	---
.03	0	673	87.40	---	---	---
.05	12	685	88.96	---	---	---
.07	11	696	90.39	---	---	---
0.1	12	708	91.95	---	---	---
.15	7	715	92.86	---	---	---
.2	8	723	93.90	---	---	---
.3	6	729	94.68	---	---	---
.5	13	742	96.36	13	724	91.76
.7	6	748	97.14	18	742	94.04
1	5	753	97.79	14	756	95.82
1.5	0	753	97.79	12	768	97.34
2	5	758	98.44	2	770	97.59
3	5	763	99.09	3	773	97.97
5	4	767	99.61	4	777	98.48
7	1	768	99.74	5	782	99.11
10	2	770	100.00	5	787	99.75
15				1	788	99.87
20				1	789	100.00
		cxHM (1)			**(Be (1)**	
L -----	10	10	1.41	554	554	70.22
0.02	---	---	---	---	---	---
.03	---	---	---	---	---	---
.05	---	---	---	---	---	---
.07	---	---	---	---	---	---
0.1	---	---	---	---	---	---
.15	---	---	---	---	---	---
.2	---	---	---	---	---	---
.3	---	---	---	---	---	---
.5	---	---	---	---	---	---
.7	---	---	---	---	---	---
1	208	218	30.70	208	762	96.58
1.5	0	218	30.70	22	784	99.37
2	251	469	66.06	5	789	100.00
3	153	622	87.61			
5	57	679	95.63			
7	6	685	96.48			
10	8	693	97.61			
15	8	701	98.73			
20	6	707	99.58			
30	1	708	99.72			
50	0	708	99.72			
70	0	708	99.72			
100	2	710	100.00			

TABLE 4. — *Frequency distributions of 26 elements and cold-extractable heavy metals in rock samples from the Absaroka Primitive Area and vicinity.*

[Explanation: ppm, parts per million; *f*, frequency of number of samples of a particular value; c.f., cumulative frequency or the cumulative number of samples through a particular value; percent c.f., cumulative frequency calculated to 100 percent; number in parentheses after element symbol indicates lowermost or initial class value used for frequency distribution; N-L, number of samples below initial class; L, detected, but in amounts below sensitivity limit; G, number of samples having quantities exceeding values of last preceding occupied class interval]

Ppm	*f*	C.f.	Percent c.f.	*f*	C.f.	Percent cf.	*f*	C.f.	Percent c.f.
		Ba (100)			**Ca (500)**			**Fe (500)**	
N-L	53	53	12.47	30	30	7.06	0	0	0.00
100	6	59	13.88	---	---	---	---	---	---
150	16	75	17.65	---	---	---	---	---	---
200	20	95	22.35	---	---	---	---	---	---
300	23	118	27.76	---	---	---	---	---	---
500	24	142	33.41	10	40	9.41	2	2	0.47
700	70	212	49.88	3	43	10.12	0	2	.47
1,000	74	286	67.29	26	69	16.24	4	6	1.41
1,500	56	342	80.47	0	69	16.24	0	6	1.41
2,000	30	372	87.53	14	83	19.53	9	15	3.53
3,000	17	389	91.53	8	91	21.41	8	23	5.41
5,000	27	416	97.88	36	127	29.88	13	36	8.47
7,000	---	---	---	25	152	35.76	7	43	10.12
10,000	---	---	---	60	212	49.88	57	100	23.53
15,000	---	---	---	2	214	50.35	10	110	25.88
20,000	---	---	---	69	283	66.59	65	175	41.18
30,000	---	---	---	43	326	76.71	47	222	52.24
50,000	---	---	---	29	355	83.53	71	293	68.94
70,000	---	---	---	7	362	85.18	28	321	75.53
100,000	---	---	---	42	404	95.06	40	361	84.94
150,000	---	---	---	11	415	97.65	39	400	94.12
200,000	---	---	---	9	424	99.76	15	415	97.65
G	9	425	100.00	1	425	100.00	10	425	100.00
		Mg (200)			**Sr (100)**			**Zn (200)**	
N-L	3	3	0.71	73	73	17.18	403	403	94.82
100	---	---	---	35	108	25.14	---	---	---
150	---	---	---	16	124	29.18	---	---	---
200	7	10	2.35	60	184	43.29	6	409	96.24
300	0	10	2.35	54	238	56.00	6	415	97.65
500	12	22	5.18	60	298	70.12	1	416	97.88
700	2	24	5.65	61	359	84.47	2	418	98.35
1,000	18	42	9.88	36	395	92.94	1	419	98.59
1,500	3	45	10.59	17	412	96.94	0	419	98.59
2,000	49	94	22.12	11	423	99.53	0	419	98.59
3,000	13	107	25.18	0	423	99.53	0	419	98.59
5,000	57	164	38.59	2	425	100.00	0	419	98.59
7,000	10	174	40.94				2	421	99.06
10,000	72	246	57.88				1	422	99.29
15,000	14	260	61.18				---	---	---
20,000	86	346	81.41				---	---	---
30,000	21	367	86.35				---	---	---
50,000	30	397	93.41				---	---	---
70,000	22	419	98.59				---	---	---
100,000	6	425	100.00				---	---	---
150,000							---	---	---
200,000							---	---	---
G							3	425	100.00
		La (20)			**Nb (10)**			**Sc (5)**	
N-L	130	130	30.59	323	323	76.00	83	83	19.53
5	---	---	---	---	---	---	86	169	39.76
7	---	---	---	---	---	---	47	216	50.82
10	---	---	---	74	397	93.41	82	298	70.12
15	---	---	---	74	397	93.41	82	298	70.12
20	150	280	65.88	24	424	99.76	43	392	92.24
30	42	322	75.76	1	425	100.00	21	413	97.18
50	39	361	84.94				7	420	98.82
70	56	417	98.12				4	424	99.76
100	8	425	100.00				1	425	100.00

TABLE 4. — *Frequency distributions of rock samples* — Continued

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.
		Y (10)			Zr (10)	
N-L	123	123	28.94	37	37	8.71
5	---	---	---	---	---	---
7	---	---	---	---	---	---
10	107	230	54.12	14	51	12.00
15	41	271	63.76	2	53	12.47
20	80	351	82.59	8	61	14.35
30	55	406	95.53	30	91	21.41
50	11	417	98.12	16	107	25.18
70	5	422	99.29	48	155	36.47
100	2	424	99.76	97	252	59.29
150	1	425	100.00	41	293	68.94
200				57	350	82.35
300				40	390	91.76
500				23	413	97.18
700				10	423	99.53
1,000				2	425	100.00
		Ni (5)			Ti (20)	
N-L	45	45	10.59	1	1	0.24
5	95	140	32.94	---	---	---
7	11	151	35.53	---	---	---
10	37	188	44.24	---	---	---
15	22	210	49.41	---	---	---
20	42	252	59.29	7	8	1.88
30	54	306	72.00	1	9	2.12
50	52	358	84.24	6	15	3.53
70	20	378	88.94	0	15	3.53
100	22	400	94.12	18	33	7.76
150	15	415	97.65	0	33	7.76
200	5	420	98.82	13	46	10.82
300	3	423	99.53	5	51	12.00
500	1	424	99.76	17	68	16.00
700	1	425	100.00	3	71	16.71
1,000				65	136	32.00
1,500				15	151	35.53
2,000				83	234	56.06
3,000				45	279	65.65
5,000				91	370	87.06
7,000				36	406	95.53
10,000				14	420	98.82
G				5	425	100.00
		Mo (5)			Pb (10)	
N-L	393	393	92.47	82	82	19.29
5	14	407	95.76	---	---	---
7	6	413	97.18	---	---	---
10	4	417	98.12	45	127	29.88
15	5	422	99.29	60	187	44.00
20	1	423	99.53	91	278	65.41
30	1	424	99.76	63	341	80.24
50	0	424	99.76	24	365	85.88
70	0	424	99.76	24	389	91.53
100	0	424	99.76	9	398	93.65
150	0	424	99.76	5	403	94.82
200	0	424	99.76	2	405	95.29
300	1	425	100.00	0	405	95.29
500				4	409	96.24
700				3	412	96.94
1,000				3	415	97.65
1,500				1	416	97.88
2,000				2	418	98.35
3,000				2	420	98.82
5,000				2	422	99.29
G				3	425	100.00

TABLE 4. — *Frequency distributions of rock samples* — Continued

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.
		V (10)			W (50)	
N-L	13	13	3.06	409	409	96.24
5	---	---	---	---	---	---
7	---	---	---	---	---	---
10	57	70	16.47	---	---	---
15	8	78	18.35	---	---	---
20	38	116	27.29	---	---	---
30	31	147	34.59	---	---	---
50	47	194	45.65	6	415	97.65
70	90	284	66.82	4	419	98.59
100	84	368	86.59	3	422	99.29
150	5	373	87.76	3	425	100.00
200	35	408	96.00			
300	12	420	98.82			
500	5	425	100.00			

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.	f	C.f.	Percent c.f.
		Co (5)			Cr (10)			Mn (10)	
N-L	68	68	16.00	73	73	17.18	1	1	0.24
5	93	161	37.88	---	---	---	---	---	---
7	45	206	48.47	---	---	---	---	---	---
10	88	294	69.18	41	114	26.82	8	9	2.12
15	22	316	74.35	15	129	30.35	2	11	2.59
20	31	347	81.65	27	156	36.31	10	21	4.94
30	43	390	91.76	45	201	47.29	12	33	7.76
50	13	403	94.82	31	232	54.59	12	45	10.59
70	10	413	97.18	42	274	64.47	13	58	13.65
100	8	421	99.06	32	306	72.00	32	90	21.18
150	3	424	99.76	27	333	78.35	47	137	32.24
200	0	424	99.76	42	375	88.24	44	181	42.59
300	1	425	100.00	21	396	93.18	46	227	53.41
500				16	412	96.94	57	284	66.82
700				8	420	98.82	57	341	80.24
1,000				4	424	99.76	47	388	91.29
1,500				0	424	99.76	11	399	93.88
2,000				1	425	100.00	12	411	96.71
3,000							0	411	96.71
5,000							5	416	97.88
7,000							---	---	---
10,000							---	---	---
G							9	425	100.00
		As (10)			B (10)			Cu (5)	
N-L	331	331	78.07	297	297	69.88	13	13	3.06
5	---	---	---	---	---	---	80	93	21.88
7	---	---	---	---	---	---	26	119	28.00
10	32	363	85.61	106	403	94.82	71	190	44.71
15	0	363	85.61	9	412	96.94	27	217	51.06
20	11	374	88.21	5	417	98.12	53	270	63.53
30	2	376	88.68	1	418	98.35	8	278	65.41
50	7	383	90.33	2	420	98.82	57	335	78.82
70	9	392	92.45	1	421	99.06	37	372	87.53
100	1	393	92.69	2	423	99.53	25	397	93.41
150	6	399	94.10	1	424	99.76	9	406	95.53
200	1	400	94.34	0	424	99.76	6	412	96.94
300	2	402	94.81	0	424	99.76	9	421	99.06
500	1	403	99.05	0	424	99.76	1	422	99.29
700	3	406	95.75	0	424	99.76	0	422	99.29
1,000	4	410	96.70	1	425	100.00	1	423	99.53
1,500	2	412	97.17				1	424	99.76
2,000	1	413	97.41				0	424	99.76
3,000	1	414	99.64				0	424	99.76
5,000	3	417	98.35				0	424	99.76
G	7	424	100.00				1	425	100.00

TABLE 4. — *Frequency distributions of rock samples* — Continued

Ppm	f	C.f.	Percent c.f.	f	C.f.	Percent cf.
		Au (.02)			Ag (.5)	
L	360	360	84.71	378	378	88.94
0.02	14	374	88.00	---	---	---
.03	0	374	88.00	---	---	---
.05	5	379	89.18	---	---	---
.07	5	384	90.35	---	---	---
0.1	10	394	92.71	---	---	---
.15	2	396	93.18	---	---	---
.2	7	403	94.82	---	---	---
.3	2	405	95.29	---	---	---
.5	1	406	95.53	3	381	89.65
.7	4	410	96.47	7	388	91.29
1	4	414	97.41	7	395	92.94
1.5	0	414	97.41	3	398	93.65
2	0	414	97.41	2	400	94.12
3	4	418	98.35	2	402	94.59
5	3	421	99.06	1	403	94.82
7	0	421	99.06	3	406	95.53
10	1	422	99.29	3	409	96.24
15	0	422	99.29	0	409	96.24
20	2	424	99.76	2	411	96.71
30	1	425	100.00	1	412	96.94
50				1	413	97.18
70				3	416	97.88
100				2	418	98.35
G				7	425	100.00
		cxHM (1)			Be (1)	
L	43	43	10.17	342	342	80.47
0.02	---	---	---	---	---	---
.03	---	---	---	---	---	---
.05	---	---	---	---	---	---
.07	---	---	---	---	---	---
0.1	---	---	---	---	---	---
.15	---	---	---	---	---	---
.2	---	---	---	---	---	---
.3	---	---	---	---	---	---
.5	---	---	---	---	---	---
.7	---	---	---	---	---	---
1	218	261	61.70	72	414	97.41
1.5	0	261	61.70	3	417	98.12
2	80	341	80.61	5	422	99.29
3	35	376	88.89	0	422	99.29
5	16	392	92.67	1	423	99.53
7	7	399	94.33	1	424	99.76
10	3	402	95.04	1	425	100.00
15	2	404	95.51			
20	5	409	96.69			
30	1	410	96.93			
50	1	411	97.16			
70	1	412	97.40			
100	3	415	98.11			
G	8	423	100.00			

EVALUATION OF SAMPLE DATA

A technique used to determine which samples are significant for a particular element involves the selection of a threshold value. Abundance values below the threshold are considered as normal or expectable for the particular type of material being sampled in a particular area and are called background. Samples with values at or above the threshold are considered to be anomalous. A geochemical anomaly was defined by Hawkes (1959) as " * * * an area where unusually high metal content, or some other chemical characteristic of a naturally occurring material, such as soil, indicates the presence of a mineral deposit in the vicinity."

The frequency distributions of the eight metals and the citrate-soluble heavy metals in the stream-sediment and rock samples (tables 3 and 4) have been plotted on log-probability (L–P) graphs and analyzed statistically. All these graphs indicate a mixing of geochemical populations (Tennant and White, 1959; Ericksen and others, 1970; Bölviken, 1971). This method of selecting a threshold for an element that has been concentrated in a mineral deposit is based on the concept that an ore deposit is a local, generally highly variable, anomalous concentration of a particular element superimposed on a less variable background abundance of that element in the country rock. Furthermore, as demonstrated by Bölviken (1971) and by Wedow and Ericksen (1971a, b), L–P graphs of such frequency distributions are not only nonlinear but suggest the mixing of two or more linear (lognormal) distributions in highly disproportionate amounts. Typically, such graphs show a distinctive flexure at the threshold value, beyond which the mass of the country-rock background data cannot mask the higher values of the more variable distribution of anomalous values related to mineral deposits. In a few of the L–P graphs there is the suggestion that the country rock itself has a bimodal distribution, a feature not unexpected because of the wide variety of rock types included in the data set. Such a mixture, however, does not conceal the sharp change in curvature due to the addition of the much smaller proportion of samples of mineralized rock.

Threshold values, which were chosen from the L–P graphs for the selected elements, are listed in table 5 along with the numbers and percentages of samples equal to or greater than that value in the particular data set. The number of samples above threshold is more than 5 percent for most elements and only tungsten is under the 2.5 percent value suggested by Hawkes and Webb (1962). These threshold values define the number of anomalous samples as ranging from 11 to 107 and from 13 to 65 per element for the stream sediments and rocks, respectively. The location coordinates and analytical data of all samples designated anomalous by this method are listed in table 6 for 249 stream-sediment samples and in table 7 for 160 rock samples. These samples amount to 31.5 and 37.5 percent of the total numbers of stream-sediment and rock samples, respectively, taken during the study. Because many samples, as can be expected, are anomalous in more than one element, the number of samples is less than the sums of the columns showing total number of samples in table 5. Analyses of the 15 pan-concentrate samples are given in table 6.

TABLE 5. — *Elements used for the selection of anomalous samples, their threshold values, and numbers and percentages of samples at or above threshold*

Element	Threshold (ppm)	Anomalous samples	
		Total number	Percentage of all samples
Stream-sediment samples			
Au----------	0.02	107	13.90
Ag----------	.5	78	9.89
CxHM--------	5	88	13.39
As----------	20	50	8.06
B-----------	20	61	7.73
Cu----------	100	87	11.03
Mo----------	5	49	6.21
Pb----------	100	48	6.08
W-----------	50	11	1.39
Zn----------	200	24	3.04
Rock samples			
Au----------	0.02	65	15.29
Ag----------	.5	47	11.06
CxHM--------	5	47	11.11
As----------	20	61	14.39
B-----------	20	13	3.06
Cu----------	100	53	12.47
Mo----------	5	32	7.53
Pb----------	100	36	8.47
W-----------	50	16	3.76
Zn----------	200	22	5.18

Only selected elements of the anomalous samples are given in this report (tables 6 and 7); all analytical data obtained by the U.S. Geological Survey, both tabulated and untabulated, have been placed on magnetic computer tape (Wedow and others, 1973) and are available through the National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151 at the expense of the user. The samples are identified by the field numbers shown on plate 2.

The geochemical data presented in this report are expressed in parts per million (ppm) and percent. In dealing with mines and prospects and their appraisal, the analytical values are given in ounces per ton (oz/ton) for gold and silver and in percent for the other metals. Table 8 shows selected conversion values relating parts per million to percent to ounces per ton, and ounces per ton to percent to parts per million.

The geographic distributions of the samples deemed anomalous for each of the nine elements (Au, Ag, As, B, Cu, Mo, Pb, W, Zn) and citrate-soluble heavy metals (cxHM) are shown in figures 10–19. Solid dots represent rock and mineral samples; open circles, stream-sediment and soil samples; hachured line, minus-200-mGal gravity contour (shown in fig. 9); hachures point to diminishing values. The grid used is based on the Montana Coordinate System, south zone.

Anomalous samples are clustered around mineralized centers along the Cooke City structural zone, in the Jardine–Crevice Mountain district, and near the Hellroaring Ranger Station.

GOLD

Most samples containing at least 0.02 ppm gold are from a zone about 5 mi wide trending northwest across the New World (Cooke City) district (fig. 10). Within the zone they tend to cluster in the areas of known gold-bearing deposits. Other clusters of samples with anomalous gold values are related to the mineral deposits in the Jardine–Crevice Mountain district and the Hellroaring Ranger Station area. Scattered high values in the stream sediments away from the known mineralized areas are partly a result of detrital gold in minor placer concentrations. However, clustering of sediment samples anomalous in gold in the headwaters of Slough Creek between the Horseshoe Mountain and Independence districts indicates a nearby bedrock source. Samples anomalous in gold between the New World district and Horseshoe Mountain may reflect mineral occurrences in the vicinity of the intrusive plug (pl. 1).

SILVER

Clusters of samples containing at least 0.5 ppm silver show a realtionship between silver and gold (fig. 11). The gold deposits in the Jardine-Crevice Mountain district differ from those in the other districts by almost entirely lacking anomalous silver values. Two anomalous samples (Q875–Q877, table 7) shown in this district (fig. 11) are of crushed ore from an old mill site. In the Horseshoe Mountain and Independence areas few stream-sediment samples contain anomalous silver as compared to the rock samples, despite the known high Ag:Au ratios in the ores. The highest silver values obtained (as much as 500 ppm) are from manganiferous gossans over lead-zinc deposits in the Pilgrim Limestone along the east side of Mount Abundance and southward into the headwater basin of the Stillwater River in the New World (Cooke City) district.

TABLE 6. — *Analyses of selected stream-sediment and pan-concentrate samples*

[The location coordinates are those of the Montana 10,000-Foot Grid System; number in parentheses after element symbol is the lower limit of analytical determinations; N, looked for but not detected; L, detected but below the

Sample	East coordinate (feet)	North coordinate (feet)	Semiquantitative spectrographic analyses (ppm) Mn (10)	Ag (.5)	B (10)	Ba (100)	Be (1)	Co (5)	Cr (10)
			Stream-sediment samples						
Q1	1,702,830	387,810	300	N	15	700	1	10	70
Q2	1,707,220	394,130	300	N	N	1,000	1	20	150
Q4	1,710,610	384,960	1,000	N	20	500	L	10	200
Q6	1,717,550	377,780	500	N	20	500	L	10	200
Q9	1,711,540	394,680	500	N	30	700	1	10	150
Q23	1,765,010	376,880	700	N	30	700	1	15	150
Q24	1,767,350	380,300	700	N	20	500	1	10	150
Q31	1,757,090	375,050	500	N	20	700	1	15	200
Q33	1,757,310	381,530	1,000	N	15	200	L	10	100
Q35	1,756,800	386,600	700	N	15	1,000	1	10	70
Q136	1,772,910	389,760	200	N	L	1,000	1	10	20
Q137	1,767,090	388,610	1,000	N	10	700	L	10	30
Q142	1,750,950	390,110	200	L	20	500	L	10	150
Q145	1,860,830	388,580	700	N	N	700	L	15	300
Q165	1,860,830	388,880	500	N	10	700	L	15	150
Q184	1,847,840	417,530	200	.7	15	700	1	10	100
Q185	1,849,280	418,640	5,000	N	L	700	L	50	200
Q186	1,850,780	417,710	500	L	L	500	L	10	100
Q187	1,850,910	416,090	200	L	10	700	L	10	70
Q188	1,852,320	413,350	500	N	10	300	L	10	70
Q192	1,872,190	391,540	1,000	1.5	10	700	1.5	15	70
Q193	1,895,540	411,060	1,500	L	15	300	1	30	70
Q194	1,894,590	408,430	500	L	10	300	1	5	20
Q196	1,844,570	421,200	500	L	15	500	1	10	30
Q201	1,834,930	434,650	200	N	L	700	1	10	50
Q202	1,834,930	435,660	200	N	L	300	1	5	50
Q203	1,834,080	435,670	200	N	L	700	L	20	200
Q205	1,830,960	432,960	150	N	L	300	L	10	150
Q206	1,829,680	432,970	150	N	L	500	L	5	30
Q207	1,829,450	431,150	100	N	L	300	L	5	20
Q215	1,858,870	374,410	1,000	L	15	1,000	L	10	200
Q216	1,854,540	372,010	1,000	N	15	1,000	L	20	300
Q220	1,874,070	394,160	300	L	10	1,000	L	5	70
Q221	1,871,190	392,860	1,000	7	L	700	L	10	300
Q227	1,809,190	385,750	700	N	10	700	L	10	100
Q306	1,769,520	381,290	700	N	20	1,000	L	20	150
Q318	1,761,620	394,040	700	N	L	700	L	20	70
Q319	1,865,700	397,560	300	N	15	700	L	20	150
Q347	1,744,340	389,280	1,000	N	10	700	1.5	10	30
Q396	1,765,760	391,860	150	N	N	700	L	10	70
Q401	1,754,930	410,930	200	N	N	700	1	10	30
Q402	1,751,690	421,800	150	L	L	700	1	10	20
Q419	1,846,800	403,060	200	N	L	700	1	5	70
Q420	1,854,030	401,890	500	N	20	700	1	10	70
Q422	1,856,740	399,540	300	N	20	700	1	5	50
Q423	1,859,250	398,410	300	N	20	700	1	5	50
Q426	1,859,280	414,110	150	N	L	700	L	15	70
Q429	1,856,640	415,950	300	N	L	300	L	5	50
Q430	1,856,930	415,850	300	N	10	300	1	10	50
Q441	1,850,370	421,560	100	N	L	500	L	10	70
Q450	1,846,480	427,770	500	N	20	500	1	10	50
Q451	1,845,980	428,180	1,000	N	20	500	1	10	70
Q453	1,840,270	431,060	1,000	N	10	500	1	15	30
Q501	1,887,800	371,000	2,000	.5	L	1,500	N	20	700
Q502	1,887,800	371,000	2,000	.5	L	1,000	N	20	700

1/ Sample contains less than 0.04 ppm gold.

2/ Sample contains less than 0.10 ppm gold.

from the Absaroka study area, Park and Sweet Grass Counties, Mont.

limit of determination; G. greater than the value shown; ---, not determined; Q prefix for samples Q1–Q928 does not appear on plate 2]

Sample	Semiquantitative spectrographic analyses--Continued (ppm)							Atomic absorption (ppm)	Chemical analyses (ppm)	
	Cu (5)	Mo (5)	Ni (5)	Pb (10)	V (10)	Zn (200)	Zr (10)	Au (.02)	CxHM (1)	As (10)
				Stream-sediment samples--Continued						
Q1	15	N	20	30	50	N	200	L	5	L
Q2	15	N	50	70	100	N	100	11	14	60
Q4	15	N	50	20	70	N	150	.12	L	60
Q6	15	N	50	10	70	N	100	.02	1	30
Q9	7	N	50	15	70	N	150	L	1	L
Q23	10	N	50	20	70	N	100	L	1	L
Q24	7	N	50	20	70	N	100	L	1	L
Q31	20	N	70	30	70	N	150	L	1	L
Q33	15	N	70	15	70	N	150	1/	5	L
Q35	10	N	50	20	70	N	150	L	1	20
Q136	7	N	7	20	30	N	100	2/	2	20
Q137	7	N	10	10	50	N	100	L	5	L
Q142	20	N	70	30	50	N	70	.20	5	150
Q145	10	N	70	15	100	N	30	L	1	20
Q165	10	N	70	20	100	N	30	L	1	60
Q184	10	N	20	70	70	N	100	.04	3	L
Q185	15	15	70	70	70	N	100	.02	5	L
Q186	50	7	50	50	70	N	50	.10	5	10
Q187	20	N	30	30	70	N	150	.04	1	L
Q188	7	N	20	20	70	N	150	.06	1	L
Q192	1,000	N	20	100	50	200	500	.60	90	10
Q193	200	15	30	30	100	N	100	L	9	10
Q194	200	7	5	50	100	N	70	L	11	L
Q196	15	N	15	70	50	N	100	L	7	10
Q201	7	N	15	20	70	N	70	.04	3	L
Q202	10	N	10	30	50	N	150	.15	3	L
Q203	10	N	70	15	70	N	70	.02	2	L
Q205	5	N	30	20	70	N	70	4	2	L
Q206	5	N	15	20	50	N	50	.08	3	L
Q207	10	N	10	15	50	N	50	.04	1	L
Q215	20	N	70	30	70	N	70	L	17	L
Q216	15	N	100	20	100	N	100	L	9	L
Q220	30	N	20	50	70	N	100	1	5	10
Q221	7	N	50	300	100	L	70	L	11	80
Q227	10	N	30	30	70	N	100	1/	5	L
Q306	10	N	50	30	70	N	100	L	1	L
Q318	10	N	30	20	100	N	100	L	5	L
Q319	10	N	30	15	70	N	100	.04	1	L
Q347	7	N	10	20	50	N	300	2/	5	L
Q396	7	N	15	15	70	N	100	.02	3	100
Q401	7	N	10	20	50	N	100	1/	2	80
Q402	10	N	5	20	30	N	100	.60	3	G5,000
Q419	5	N	30	15	70	N	100	.06	2	L
Q420	10	N	30	30	70	N	100	L	3	L
Q422	5	N	15	30	50	N	100	L	2	L
Q423	7	N	15	30	50	N	70	L	3	10
Q426	7	N	30	20	70	N	100	.70	2	L
Q429	5	N	10	50	50	N	30	.10	2	L
Q430	7	N	30	20	70	N	100	L	1	20
Q441	150	N	50	30	70	N	70	L	5	L
Q450	10	N	10	50	50	N	150	L	3	20
Q451	10	N	20	50	70	N	100	L	5	10
Q453	5	N	20	30	70	N	100	L	3	20
Q501	20	N	100	50	150	N	70	1/	---	---
Q502	15	N	100	30	150	N	70	1/	---	---

TABLE 6. — *Analysess of selected stream-sediment and pan-concentrate*

Sample	East coordinate (feet)	North coodinate (feet)	Semiquantitative spectrographic analyses (ppm) Mn (10)	Ag (.5)	B (10)	Ba (100)	Be (1)	Co (5)	Cr (10)
			Stream-sediment samples--Continued						
Q503	1,888,650	370,100	1,500	0.7	L	1,000	L	20	700
Q507	1,904,900	371,650	700	L	L	700	1	10	150
Q508	1,905,000	371,450	700	L	L	1,000	1	15	500
Q510	1,902,800	374,000	1,000	L	L	700	1	15	200
Q513	1,902,700	374,500	2,000	.7	L	700	L	15	300
Q514	1,901,200	375,650	1,500	.7	L	700	1	10	100
Q516	1,900,050	378,700	1,000	.7	L	1,000	1.5	10	100
Q518	1,897,000	381,600	1,500	1.5	10	700	1.5	15	100
Q519	1,897,000	381,600	1,000	.7	L	700	1.5	15	100
Q520	1,893,450	382,600	1,000	.7	L	1,000	1.5	15	100
Q522	1,891,200	384,400	700	1.5	L	700	1.5	10	200
Q523	1,890,600	384,600	1,000	1.5	20	1,000	2	50	200
Q524	1,887,650	386,250	700	.5	10	1,000	1.5	5	200
Q525	1,887,400	386,200	1,000	1.5	L	1,000	1.5	15	200
Q526	1,886,000	387,700	1,000	.7	10	1,000	1.5	20	150
Q527	1,885,750	387,300	300	1	L	1,000	L	5	150
Q528	1,885,800	387,600	700	1	L	1,000	L	10	150
Q529	1,886,100	387,250	700	1	L	700	L	10	200
Q530	1,884,700	389,000	700	1.5	L	1,000	L	15	200
Q532	1,890,150	372,900	700	.7	L	1,000	1	20	70
Q533	1,888,450	376,200	700	1.5	L	700	L	20	70
Q534	1,888,450	376,200	500	.5	L	700	1	10	70
Q535	1,886,100	378,050	1,000	.7	L	700	1	20	50
Q536	1,886,000	378,300	1,000	3	10	700	1	20	30
Q537	1,885,250	379,700	200	.5	N	700	1	10	50
Q538	1,884,900	380,200	150	.5	N	700	L	10	50
Q539	1,883,850	379,950	1,000	1	10	700	1	20	70
Q540	1,883,150	380,900	300	.7	L	500	L	10	50
Q541	1,883,150	380,900	500	.7	10	700	L	20	70
Q542	1,883,700	381,150	1,000	1	10	700	1	10	70
Q543	1,872,950	395,000	1,000	L	15	700	1	20	70
Q544	1,872,800	394,900	1,000	.7	15	700	1	15	70
Q546	1,872,050	392,150	700	1.5	10	700	L	20	70
Q547	1,872,150	389,850	700	1.5	10	1,000	1	20	50
Q548	1,872,350	389,400	500	L	20	500	L	10	200
Q549	1,873,500	387,500	500	.5	20	500	L	10	150
Q551	1,874,800	388,800	1,000	L	10	700	1	20	50
Q553	1,877,150	388,250	700	.7	10	700	L	10	70
Q554	1,878,100	388,700	1,000	.5	10	1,500	1	10	70
Q555	1,878,500	386,800	1,000	2	10	1,000	1	20	50
Q556	1,880,000	386,150	300	5	10	700	1	10	50
Q557	1,878,250	385,550	500	.7	30	700	1	10	100
Q558	1,892,750	373,150	1,000	10	10	700	1.5	10	100
Q559	1,891,500	373,000	1,000	1	10	700	1	10	100
Q560	1,889,750	372,600	500	1	L	700	L	15	100
4/Q561	1,886,750	371,600	500	.7	L	700	1	15	100
Q562	1,883,500	371,150	1,000	.7	L	700	L	20	300
Q564	1,878,000	368,500	1,000	.5	L	700	L	30	700
Q565	1,869,850	366,000	1,000	1.5	L	500	L	30	700
Q574	1,873,400	386,000	700	.5	20	700	1	10	100
Q575	1,891,500	393,550	1,000	L	10	700	1	20	500
Q577	1,902,700	374,500	500	L	10	500	1	10	70
Q578	1,902,700	374,500	1,000	L	10	500	1	15	50
Q579	1,902,700	374,500	500	L	L	300	1	10	50
Q580	1,901,200	375,650	1,000	L	L	500	1	15	70
Q581	1,901,200	375,650	500	L	L	300	1	10	50
Q602	1,774,790	377,790	500	N	30	700	1.5	10	70
Q644	1,756,310	436,740	1,000	N	L	500	L	30	150
Q664	1,730,000	386,300	150	N	L	700	1	10	30
Q665	1,728,250	382,800	200	N	N	700	1	10	30

3/ Sample contains less than 0.06 ppm gold.

4/ Sample contains 70 ppm tungsten.

samples from the Absaroka study area — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) Cu (5)	Mo (5)	Ni (5)	Pb (10)	V (10)	Zn (200)	Zr (10)	Atomic absorption (ppm) Au (.02)	Chemical analyses (ppm) CxHM (1)	As (10)
				Stream-sediment samples--Continued						
Q503	10	N	70	200	200	L	70	1/	---	---
Q507	200	N	50	30	70	L	70	1/	---	---
Q508	100	N	70	20	100	N	100	.02	---	---
Q510	500	7	70	50	100	L	150	.08	---	---
Q513	700	10	70	70	200	L	G1,000	12	---	---
Q514	700	10	50	50	100	L	100	4	---	---
Q516	1,000	10	50	70	50	L	70	.45	---	---
Q518	1,000	15	50	100	70	L	100	.35	---	---
Q519	1,000	15	50	70	70	N	100	.25	---	---
Q520	1,000	15	30	50	70	N	70	---	---	---
Q522	1,000	15	30	70	100	N	200	.50	---	---
Q523	200	10	100	70	70	200	200	.06	---	---
Q524	100	15	50	50	100	N	300	.15	---	---
Q525	500	20	50	100	70	L	100	.50	---	---
Q526	700	15	70	100	100	200	100	3/	---	---
Q527	500	150	50	70	70	N	100	.04	---	---
Q528	200	30	50	30	100	N	150	.70	---	---
Q529	500	20	20	70	100	N	100	1	---	---
Q530	500	N	70	50	100	N	100	3	---	---
Q532	500	10	30	150	70	L	200	.40	---	---
Q533	500	10	30	150	70	L	100	3	---	---
Q534	300	7	30	100	70	L	100	.08	---	---
Q535	500	7	30	100	70	L	100	.20	---	---
Q536	700	N	30	100	50	L	150	.20	---	---
Q537	700	70	30	200	70	N	150	.10	---	---
Q538	700	70	30	150	70	N	150	.15	---	---
Q539	500	N	50	150	100	300	100	2	---	---
Q540	200	N	20	70	70	300	100	.20	---	---
Q541	300	N	50	70	70	200	100	.50	---	---
Q542	200	N	30	100	70	300	100	.55	---	---
Q543	1,000	N	30	70	70	200	100	.08	---	---
Q544	1,000	N	30	70	70	200	150	.08	---	---
Q546	1,000	N	30	100	70	300	200	.80	---	---
Q547	1,000	N	30	100	70	300	100	.20	---	---
Q548	20	N	70	30	100	N	100	L	---	---
Q549	15	N	50	30	70	N	70	L	---	---
Q551	200	N	50	70	70	N	150	.10	---	---
Q553	500	7	30	100	50	N	150	.30	---	---
Q554	150	N	30	100	70	L	150	.08	---	---
Q555	300	N	50	200	50	300	100	.50	---	---
Q556	700	20	20	70	70	L	100	2	---	---
Q557	15	N	50	70	70	L	100	L	---	---
Q558	300	N	30	70	70	200	100	.10	---	---
Q559	300	N	30	70	70	L	100	.10	---	---
Q560	300	7	30	150	70	L	150	.35	---	---
Q561	500	N	30	70	70	L	100	.30	---	---
Q562	200	N	50	50	100	200	100	.10	---	---
Q564	150	N	70	150	150	L	150	.55	---	---
Q565	150	N	70	50	150	L	100	.45	---	---
Q574	10	N	50	100	70	L	50	L	---	---
Q575	50	N	100	150	100	L	100	L	---	---
Q577	500	7	30	50	70	L	70	.30	---	---
Q578	1,000	10	50	70	70	L	100	.15	---	---
Q579	700	5	30	70	70	L	70	1	---	---
Q580	700	7	30	50	50	L	50	2	---	---
Q581	1,000	10	30	70	70	L	50	.25	---	---
Q602	15	N	20	30	70	N	100	L	1	L
Q644	15	N	70	15	100	N	100	L	9	L
Q664	5	N	10	20	70	N	100	1/	1	30
Q665	5	N	7	20	50	N	100	L	2	20

TABLE 6. — *Analyses of selected stream-sediment and pan-concentrate*

Sample	East coordinate (feet)	North coordinate (feet)	Semiquantitative spectrographic analyses (ppm)						
			Mn (10)	Ag (.5)	B (10)	Ba (100)	Be (1)	Co (5)	Cr (10)
			Stream-sediment samples--Continued						
Q666	1,728,000	382,600	200	N	L	700	1	5	20
Q667	1,728,550	381,750	150	N	10	500	1	10	50
Q668	1,724,750	385,600	1,000	N	L	700	1	10	20
Q670	1,716,900	393,000	150	N	20	500	L	10	100
Q676	1,816,030	403,710	500	N	20	700	L	15	100
Q681	1,824,160	381,160	500	N	20	700	1	10	100
Q698	1,860,150	405,290	300	N	L	1,000	L	20	150
Q699	1,860,150	404,890	300	N	10	700	L	15	200
Q700	1,856,770	404,100	500	N	L	1,000	L	20	200
Q708	1,853,570	417,490	500	N	L	700	L	15	200
Q714	1,843,690	419,390	200	N	100	700	1	10	70
Q715	1,847,370	422,090	700	L	15	700	1	7	70
Q721	1,850,630	418,020	150	N	L	700	L	15	150
Q724	1,850,670	422,370	150	L	L	500	L	10	100
Q725	1,849,090	422,480	1,000	N	L	500	L	10	100
Q727	1,845,080	423,430	200	L	10	700	L	5	30
Q728	1,841,060	422,040	150	L	30	500	1	5	30
Q729	1,839,830	420,930	200	L	15	500	1	10	50
Q731	1,838,080	417,200	150	N	30	500	1	10	30
Q737	1,857,490	372,090	700	N	10	1,000	L	15	500
Q743	1,880,120	386,230	150	10	L	300	L	N	30
Q744	1,878,690	386,840	150	15	L	500	L	5	50
Q745	1,877,260	388,270	200	7	L	700	L	5	50
Q746	1,878,200	388,260	200	7	10	1,000	1	5	30
Q747	1,877,120	388,470	500	L	10	700	1	10	50
Q748	1,873,810	386,060	500	.7	20	700	1	10	100
Q749	1,873,670	387,480	700	L	30	700	1	15	70
Q750	1,872,390	389,620	700	1.5	10	700	1	10	30
Q758	1,869,000	387,410	700	N	20	500	1	10	70
Q760	1,869,300	388,120	700	N	10	700	L	15	200
Q762	1,869,560	396,420	1,000	N	10	700	L	15	200
Q809	1,738,540	407,280	1,500	N	10	700	1	20	70
Q837	1,701,670	416,900	200	N	10	500	L	10	100
Q839	1,700,650	411,140	500	N	10	200	L	10	150
Q840	1,701,010	411,330	500	N	N	700	L	10	150
Q842	1,702,820	407,050	1,000	N	N	500	1	10	30
Q843	1,702,880	406,240	700	N	L	1,000	1	20	100
Q845	1,717,110	393,180	1,000	N	20	200	1	15	150
Q846	1,711,880	393,460	1,000	N	15	700	1	10	70
Q851	1,701,990	419,220	700	L	70	500	1	5	70
Q859	1,824,910	393,810	200	N	30	300	1	5	70
Q867	1,837,060	404,950	200	N	L	700	L	10	100
Q872	1,834,850	398,080	500	N	L	1,000	L	20	200
Q880	1,850,850	417,510	200	N	L	300	L	10	70
Q888	1,842,540	418,890	500	N	20	700	1	10	50
Q889	1,845,920	420,180	200	L	10	300	1	5	30
Q908	1,864,760	375,590	500	N	L	700	L	15	500
Q909	1,865,572	379,230	500	N	10	1,000	L	10	300
Q911	1,878,110	385,630	1,000	7	10	1,000	1	10	70
Q913	1,878,560	388,770	300	10	15	1,000	1	50	50
Q914	1,872,120	391,540	1,000	3	15	2,000	1.5	20	100
Q915	1,879,180	384,510	2,000	5	30	500	1	10	100
Q928	1,843,600	387,990	500	N	20	500	L	10	200
R5	1,846,950	414,000	500	N	L	1,000	N	10	100
R8	1,863,200	418,400	500	N	L	500	L	7	70
R27	1,831,850	437,450	300	N	L	300	N	5	50
R29	1,795,950	429,200	1,000	N	L	3,000	L	30	500
R36	1,860,700	390,600	700	N	100	1,500	1	20	300
R37	1,863,200	395,400	1,000	N	20	2,000	L	20	500
R39	1,859,150	396,600	2,000	N	20	2,000	1	20	200

samples from the Absaroka study area — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) Cu (5)	Mo (5)	Ni (5)	Pb (10)	V (10)	Zn (200)	Zr (10)	Atomic absorption (ppm) Au (.02)	Chemical analyses (ppm) CxHM (1)	As (10)
					Stream-sediment samples--Continued					
Q666	5	N	10	15	20	N	100	L	3	20
Q667	5	N	20	15	30	N	70	L	2	60
Q668	5	N	7	15	20	N	70	L	5	L
Q670	10	N	50	15	70	N	100	L	3	L
Q676	7	N	50	20	70	N	100	L	2	L
Q681	10	N	30	20	70	N	200	L	3	L
Q698	15	N	70	10	100	N	70	.02	2	L
Q699	5	N	50	15	100	N	100	.04	1	L
Q700	7	N	70	15	100	N	70	.06	2	L
Q708	150	L	15	30	70	N	70	L	5	L
Q714	7	N	15	30	70	N	70	1/	2	L
Q715	10	N	30	50	70	L	100	L	9	10
Q721	150	5	50	20	100	N	100	L	2	L
Q724	100	5	50	70	70	N	50	L	3	L
Q725	20	N	70	70	70	N	50	L	5	L
Q727	10	N	15	50	30	N	100	L	5	L
Q728	5	N	15	70	30	L	70	.04	7	L
Q729	10	N	30	70	50	L	70	1/	5	L
Q731	7	N	15	30	30	N	100	L	2	L
Q737	15	N	70	15	70	N	70	L	5	L
Q743	1,000	10	5	50	50	L	100	4	14	L
Q744	1,000	10	7	100	70	L	100	4	14	60
Q745	1,000	10	7	70	50	L	200	7	14	60
Q746	500	5	10	200	50	L	150	.40	20	40
Q747	200	15	20	70	50	L	100	.50	9	30
Q748	30	N	50	70	70	L	150	1/	7	20
Q749	50	N	50	70	70	N	150	L	5	20
Q750	1,500	N	30	150	50	L	150	.15	35	20
Q758	15	N	50	30	70	N	100	L	2	L
Q760	15	N	70	20	100	N	150	.02	2	L
Q762	10	N	70	20	100	N	100	.02	3	L
Q809	10	N	30	20	100	N	150	L	7	L
Q837	7	N	50	15	70	N	100	L	2	20
Q839	15	N	50	15	70	N	100	L	3	20
Q840	20	N	50	20	70	N	100	L	3	20
Q842	5	N	10	10	70	N	100	L	5	L
Q843	10	N	50	15	100	N	100	L	3	20
Q845	15	N	70	10	70	N	200	L	3	L
Q846	5	N	20	10	70	N	100	2/	3	20
Q851	15	N	50	10	70	N	50	1/	4	10
Q859	7	N	30	20	70	N	100	1/	2	L
Q867	10	N	50	20	70	N	100	.02	1	L
Q872	10	N	50	20	100	N	70	1/	5	L
Q880	10	N	20	20	70	N	150	.10	2	L
Q888	7	N	15	20	50	N	100	L	2	L
Q889	10	N	30	30	70	L	100	.10	4	L
Q908	15	N	70	30	100	N	70	.02	1	L
Q909	10	N	70	30	100	N	100	.02	1	L
Q911	500	N	30	150	70	L	500	.15	17	30
Q913	500	7	50	200	70	L	300	3	17	L
Q914	2,000	N	70	150	70	300	70	2	100	30
Q915	20	N	50	200	70	500	150	.04	25	40
Q928	7	N	50	20	50	N	100	L	2	L
R5	10	N	30	30	70	N	100	L	5	N
R8	30	N	20	30	70	N	100	L	5	N
R27	5	70	10	10	30	N	100	L	3	20
R29	100	N	100	70	200	L	300	L	2	N
R36	50	N	70	20	70	N	300	L	3	N
R37	50	N	100	20	100	N	300	L	4	N
R39	50	N	70	70	100	N	300	L	5	N

TABLE 6. — *Analyses of selected stream-sediment and pan-concentrate*

Sample	East coordinate (feet)	North coordinate (feet)	Semiquantitative spectrographic analyses (ppm) Mn (10)	Ag (.5)	B (10)	Ba (100)	Be (1)	Co (5)	Cr (10)
			Stream-sediment samples--Continued						
R40	1,858,650	396,200	1,000	N	20	1,500	1	10	100
R44	1,869,100	390,700	1,000	N	20	1,500	L	30	700
R45	1,869,200	390,000	1,500	N	100	1,500	1	30	700
R53	1,736,050	416,700	2,000	N	L	2,000	L	10	50
R68	1,869,400	392,300	2,000	1	10	2,000	L	50	700
R72	1,813,350	445,350	1,000	10	10	2,000	L	50	500
R73	1,806,500	444,350	700	N	L	1,500	N	50	1,000
R74	1,819,100	441,400	1,000	2	L	1,500	L	30	700
R76	1,821,650	440,000	700	3	L	1,000	L	20	200
R85	1,771,600	463,650	1,000	N	L	5,000	N	30	700
R90	1,737,250	440,000	1,000	N	L	1,500	L	50	700
R98	1,755,600	412,700	1,000	N	L	1,000	L	30	200
R101	1,727,600	450,600	1,000	N	10	2,000	1	10	200
R107	1,813,100	382,050	2,000	N	10	G5,000	1	30	700
R111	1,776,700	408,450	5,000	N	L	1,500	2	50	200
R302	1,790,500	392,850	1,000	N	L	1,000	L	20	100
R320	1,771,850	448,100	1,000	N	L	2,000	N	50	200
R321	1,772,100	446,500	1,000	N	L	1,500	L	30	300
R322	1,771,450	445,000	1,000	N	L	2,000	N	50	700
R634	1,846,000	442,850	1,000	N	10	300	N	10	70
R646	1,859,850	430,300	200	N	L	300	N	5	30
R650	1,850,200	421,800	200	N	L	500	N	15	700
R654	1,795,800	429,000	1,000	N	L	3,000	N	30	500
R655	1,795,650	429,750	1,000	N	L	5,000	N	50	500
R667	1,840,500	427,100	1,000	N	L	1,500	L	10	150
R689	1,717,600	385,700	1,000	N	50	1,000	L	15	300
R690	1,714,950	386,350	1,500	N	20	1,000	L	10	200
R695	1,710,700	407,000	1,000	N	L	2,000	L	15	100
R696	1,712,150	405,650	2,000	N	L	2,000	L	15	100
R697	1,712,500	405,800	1,000	N	L	2,000	L	15	100
R698	1,713,000	403,700	1,000	N	L	1,500	L	15	100
R701	1,713,350	394,600	1,000	N	30	1,000	L	10	300
R703	1,869,500	391,500	700	L	50	1,000	2	10	200
R704	1,869,450	391,000	1,000	7	10	1,500	N	20	700
R705	1,869,450	391,000	1,000	1.5	L	2,000	N	30	700
R706	1,869,600	390,400	700	N	20	1,500	1	20	500
R711	1,814,800	444,550	1,000	L	10	1,500	1	30	500
R714	1,813,550	445,300	100	20	15	3,000	L	5	200
R719	1,813,350	445,500	700	.5	L	1,500	L	20	300
R720	1,812,500	445,200	1,000	.5	L	1,500	L	20	300
R721	1,809,650	445,250	700	.5	L	1,500	L	20	700
R722	1,809,650	445,250	1,000	1	10	3,000	L	30	700
R726	1,806,600	444,900	1,000	1	10	2,000	N	30	1,000
R727	1,820,150	443,350	700	N	L	1,500	L	30	500
R728	1,821,850	439,700	700	1	15	2,000	L	20	300
R755	1,761,800	394,400	2,000	1	10	1,000	L	30	700
R769	1,749,400	418,400	1,000	N	10	1,000	L	100	500
R779	1,723,800	441,300	1,000	N	10	2,000	L	50	500
R800	1,820,000	392,350	2,000	1	10	G5,000	L	30	500
R835	1,838,850	439,750	500	N	L	500	N	7	100
R843	1,807,350	425,200	1,000	N	L	200	N	100	200
R851	1,776,450	392,650	1,000	N	20	2,000	N	30	500
R863	1,840,900	427,200	1,000	N	L	1,500	L	10	200
R864	1,835,150	425,700	1,000	N	L	1,500	1	20	500
R865	1,841,850	438,100	1,000	N	10	700	1	20	200
R867	1,720,700	378,300	1,000	N	50	700	1	20	300
R868	1,720,200	378,350	1,000	N	20	700	L	10	300
R871	1,718,550	379,750	1,500	N	10	1,000	L	10	700
R878	1,716,050	383,300	1,000	N	10	1,000	L	10	1,000
R880	1,715,800	381,350	1,000	N	20	1,000	1	10	200

5/ Sample contains less than 0.05 ppm gold.

samples from the Absaroka study area — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) Cu (5)	Mo (5)	Ni (5)	Pb (10)	V (10)	Zn (200)	Zr (10)	Atomic absorption (ppm) Au (.02)	Chemical analyses (ppm) CxHM (1)	As (10)
Stream-sediment samples--Continued										
R40	70	N	50	70	200	N	300	L	4	N
R44	20	N	150	30	200	N	300	L	3	N
R45	70	N	150	70	200	N	500	L	3	N
R53	50	N	10	50	100	N	300	1/	5	N
R68	20	N	150	70	100	500	200	L	20	20
R72	300	7	70	500	100	L	300	.35	25	20
R73	10	N	150	10	200	N	200	.25	1	N
R74	70	N	100	200	100	300	30	.15	3	N
R76	30	5	100	100	100	L	200	L	2	N
R85	15	N	150	15	500	N	200	.10	1	N
R90	50	N	150	15	200	N	200	L	2	40
R98	20	N	30	20	200	200	100	L	1	N
R101	20	N	30	20	70	200	300	L	20	N
R107	50	N	100	70	300	N	500	L	5	N
R111	70	N	70	50	300	N	150	L	14	N
R302	70	N	30	30	70	N	200	L	5	N
R320	70	N	50	70	500	N	500	L	5	N
R321	70	N	50	70	200	200	500	L	2	N
R322	70	N	100	100	500	N	500	L	5	N
R634	20	N	30	30	100	N	200	L	7	N
R646	10	N	10	15	30	N	100	L	2	20
R650	150	5	50	50	70	N	50	L	3	40
R654	100	N	100	50	200	N	200	L	3	N
R655	200	N	100	50	200	N	200	L	2	N
R667	100	N	30	70	100	N	200	---	3	L
R689	20	N	50	20	70	N	300	L	2	N
R690	50	N	50	15	70	N	300	.02	2	N
R695	100	N	20	50	100	N	500	L	4	N
R696	70	N	20	50	200	N	500	1/	5	N
R697	100	N	30	50	200	N	300	L	5	L
R698	20	N	20	20	100	N	300	L	9	N
R701	70	N	30	20	70	N	200	L	1	L
R703	15	N	50	50	100	N	500	L	1	N
R704	20	N	150	100	100	L	200	L	4	N
R705	30	N	200	50	200	L	200	L	5	N
R706	20	N	150	20	100	L	200	L	2	L
R711	300	15	100	700	200	L	1,000	.65	22	N
R714	100	15	15	2,000	100	L	500	3	5	200
R719	70	5	70	200	100	L	300	.45	5	N
R720	300	7	70	200	100	L	500	.85	14	N
R721	70	5	70	150	200	L	200	.95	9	10
R722	70	L	100	200	200	L	500	.10	2	10
R726	70	N	100	100	500	N	200	3	9	10
R727	50	N	100	70	200	N	200	.06	3	N
R728	70	N	100	70	100	N	100	L	2	L
R755	30	N	100	15	300	L	100	L	3	N
R769	70	N	50	10	700	700	100	L	1	N
R779	50	N	100	15	500	200	100	L	1	N
R800	20	N	70	50	300	N	500	---	5	N
R835	10	N	30	30	50	N	70	L	5	N
R843	150	N	500	10	100	N	100	L	2	N
R851	100	N	70	50	200	N	500	L	2	N
R863	100	N	30	50	100	N	100	---	2	N
R864	150	N	150	100	200	N	300	L	2	N
R865	100	N	100	70	70	L	300	5/	5	N
R867	100	N	100	20	70	N	200	L	2	10
R868	100	N	100	20	100	N	300	1/	2	N
R871	100	N	100	15	200	N	500	L	2	20
R878	200	N	150	200	200	N	200	2	1	3,000
R880	70	N	100	30	100	N	200	L	2	20

TABLE 6. — *Analyses of selected stream-sediment and pan-concentrate*

Sample	East coordinate (feet)	North coordinate (feet)	Semiquantitative spectrographic analyses (ppm) Mn (10)	Ag (.5)	B (10)	Ba (100)	Be (1)	Co (5)	Cr (10)
		Stream-sediment samples--Continued							
R881	1,712,400	381,200	700	N	20	1,000	1	20	500
R882	1,711,050	382,900	1,000	N	10	1,000	1	20	500
R883	1,714,750	401,000	1,000	N	L	5,000	L	10	150
R889	1,714,450	391,900	1,000	N	20	5,000	L	10	300
6/R895	1,705,900	390,650	1,000	N	20	2,000	L	10	500
7/R907	1,871,600	384,000	1,000	N	20	2,000	L	30	700
R908	1,872,400	383,400	1,000	N	100	1,000	L	30	700
R909	1,872,350	383,850	1,000	N	100	1,000	L	30	700
6/R910	1,873,000	383,800	1,000	N	200	2,000	L	30	700
R911	1,873,100	383,500	1,000	N	100	1,000	L	20	700
R912	1,873,400	384,000	1,500	10	100	1,000	L	20	700
6/R913	1,873,450	383,800	700	5	100	700	1	20	500
R914	1,874,300	384,800	1,000	5	100	1,000	1	20	700
R915	1,874,350	385,100	1,000	1	20	1,500	L	30	1,000
		Panned-concentrate samples							
Q165	1,847,580	402,540	300	N	L	500	L	30	500
Q167	1,831,120	433,460	700	N	15	1,000	N	50	1,500
Q173	1,824,910	436,250	200	N	10	700	L	10	100
Q174	1,822,220	439,510	200	N	N	700	L	10	150
Q190	1,860,900	399,310	300	N	L	700	L	10	300
Q515	1,901,200	375,650	1,000	.7	L	1,000	L	15	200
Q521	1,893,450	382,600	1,000	.7	L	700	1.5	10	200
Q531	1,884,700	389,000	700	1	L	700	L	15	300
Q735	1,838,180	420,850	1,000	N	10	500	L	15	300
Q736	1,838,760	420,940	700	N	15	200	L	15	200
Q864	1,837,430	415,890	500	N	L	500	1	10	150
Q869	1,838,610	401,500	500	N	10	300	L	20	300
Q871	1,838,000	405,960	500	N	L	700	L	10	300
Q873	1,834,850	398,080	1,000	N	10	300	L	50	1,500
Q875	1,846,800	403,060	200	N	10	500	1	5	1,500

6/ Sample contains 150 ppm tungsten.

7/ Sample contains 200 ppm tungsten.

ARSENIC

Arsenic, chiefly in the form of arsenopyrite (FeAsS), has long been known to be associated with high-temperature gold in both vein and pyrometasomatic deposits (Lindgren, 1928, p. 637), and it is useful in the search for such deposits.

The close association of arsenic with both types of gold deposits in and near the Absaroka study area is shown by figure 12, in which all samples containing at least 20 ppm As are plotted. Most anomalous arsenic values in the deposits in the zone trending northwesterly from the New World (Cooke City) district are associated with the higher temperature deposits. Consequently, high arsenic values are more prevalent in the New World district than in the Horseshoe Mountain area and the Independence district (fig. 12).

Arsenic is more abundant in the Jardine-type ores than in the ores of the mining districts along the northeast side of the study area, as is

samples from the Absaroka study area — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm)							Atomic absorption (ppm)	Chemical analyses (ppm)	
	Cu (5)	Mo (5)	Ni (5)	Pb (10)	V (10)	Zn (200)	Zr (10)	Au (.02)	CxHM (1)	As (10)
				Stream-sediment samples--Continued						
R881	70	N	150	20	100	N	300	0.04	2	60
R882	100	N	150	70	100	N	300	.50	2	250
R883	100	N	20	70	100	N	500	1/	2	N
R889	50	N	50	20	200	N	500	1/	1	N
6/ R895	70	5	100	30	100	N	1,000	.04	3	N
7/ R907	20	N	150	100	300	N	300	L	3	10
R908	20	N	100	30	300	L	200	L	3	30
R909	20	N	100	50	300	L	200	L	3	20
6/ R910	1,000	N	150	50	300	L	500	L	2	30
R911	20	N	100	50	300	L	300	L	1	10
R912	20	N	100	150	200	L	300	L	11	10
6/ R913	20	N	100	30	200	N	300	L	2	10
R914	20	N	70	100	200	200	200	L	7	20
R915	50	N	200	70	200	N	150	L	4	10
				Panned-concentrate samples--Continued						
Q165	5	N	100	20	100	N	70	L	2	L
Q167	15	N	70	70	300	L	200	.55	1	L
Q173	10	N	30	30	100	N	100	.20	1	L
Q174	5	N	30	15	70	N	70	L	1	L
Q190	5	N	30	10	70	N	70	.30	3	L
Q515	700	10	50	50	100	N	70	2	---	---
Q521	700	10	30	30	100	N	100	5	---	---
Q531	700	N	50	20	150	N	100	---	---	---
Q735	5	N	50	L	100	N	150	L	2	100
Q736	5	N	20	30	100	N	300	L	1	L
Q864	15	N	50	30	100	N	200	L	1	L
Q869	7	N	70	20	200	N	500	16	2	L
Q871	10	N	50	15	100	N	70	.35	1	L
Q873	100	N	100	10	500	L	100	L	3	L
Q875	5	N	20	15	200	N	200	3	2	20

shown by the greater density of anomalous samples in and adjacent to both the Jardine–Crevice Mountain district and the Hellroaring Ranger Station area. Comparison of figures 10 and 12 shows that arsenic is more widely dispersed than gold in these two areas.

Sample Q402 (table 6) contains the unusually high values of 0.6 ppm Au and more than 5,000 ppm As (more than 10,000 ppm As by spectrographic methods). This is a stream-sediment sample from near Fish Lake in the headwater basin of Bear Creek (sample A, figs. 10 and 12). The site was resampled (R55 and R56, pl. 2) in 1971, but the new samples showed neither detectable Au nor As, and the high values are therefore attributed to analytical error or to an unusual natural concentration from glacial debris or volcanic ejecta.

BORON

Boron is a trace element that can be used as a pathfinder for high-temperature ore deposits (Boyle, 1971), where it occurs in the mineral tourmaline. It is also abundant in volcanic emanations, in rock found near volcanic vents, and in some sedimentary strata. Once freed physically or chemically from its bedrock source by weathering, boron occurs in stream sediments in resistant tourmaline grains, as a reprecipitated relatively insoluble calcium borate (chiefly in limestone terrane), or in clay particles.

TABLE 7. — *Analyses of selected rock samples from the Absaroka*

[The location coordinates are those of the Montana 10,000-Foot Grid System; number in parentheses after element-symbol is the lower limit of analytical determinations; N, looked for but not detected; L, detected but below the

Sample	East coordinate (feet)	North coordinate (feet)	Semiquantitative spectrographic analyses (ppm) Mn (10)	Ag (.5)	B (10)	Ba (100)	Be (1)	Co (5)	Cr (10)	Cu (5)	Mo (5)
Q5	1,716,910	378,500	500	1.5	10	100	L	100	300	10	N
Q27	1,763,660	383,890	2,000	N	L	500	N	100	2,000	20	N
Q28	1,762,000	383,100	20	N	N	50	N	5	L	L	N
Q30	1,862,040	386,440	300	N	50	200	N	30	500	5	N
Q41	1,766,290	394,490	1,000	N	L	150	N	50	30	200	N
Q71	1,793,960	383,870	200	N	N	70	N	10	20	5	N
Q72	1,736,940	417,230	150	N	10	1,500	1	10	15	10	5
Q74	1,731,930	417,600	2,000	N	10	1,500	1	10	15	10	5
Q76	1,732,060	416,680	300	N	10	700	L	15	30	10	N
Q77	1,735,390	418,970	500	N	10	1,000	1	10	10	5	5
Q128	1,709,970	395,300	20	L	L	20	N	N	10	20	N
Q129	1,709,970	395,300	150	N	L	150	N	10	200	5	N
Q130	1,709,970	395,300	300	L	L	20	L	N	70	150	N
Q131	1,709,970	395,300	200	L	L	150	N	5	100	100	N
Q132	1,708,400	391,070	150	N	L	150	L	20	150	5	N
Q138	1,720,200	390,450	50	N	N	30	N	N	L	5	N
Q141	1,708,650	390,850	200	L	10	150	L	10	70	70	N
Q148	1,846,640	391,310	70	N	N	N	L	N	L	5	N
Q149	1,841,970	391,140	1,500	L	10	100	1	50	30	300	N
Q175	1,816,100	443,620	70	100	10	100	L	5	300	300	N
Q177	1,845,930	421,800	200	L	10	500	1	10	70	10	7
Q178	1,846,270	419,570	150	L	L	300	L	10	30	70	5
Q179	1,846,780	419,970	2,000	L	10	1,500	L	10	30	10	N
Q181	1,847,640	420,570	50	L	10	300	L	N	50	20	N
Q195	1,844,560	420,900	700	N	15	500	1.5	10	70	50	N
Q197	1,846,640	421,190	300	N	10	500	L	5	L	5	N
Q199	1,856,100	419,800	1,000	N	10	150	L	50	30	150	N
Q211	1,895,520	407,110	1,000	N	L	150	L	50	30	150	N
Q213	1,894,890	410,350	150	20	L	1,000	L	30	L	G20,000	N
Q214	1,864,870	380,650	70	N	N	N	N	N	L	5	N
Q218	1,882,520	391,780	500	.7	L	700	L	10	70	300	N
Q223	1,871,190	392,360	200	L	N	300	L	5	30	7	N
Q229	1,803,980	380,430	700	N	L	700	L	10	70	15	N
Q236	1,864,820	395,440	150	N	N	N	L	5	L	5	N
Q237	1,864,820	395,440	150	N	N	N	L	N	N	5	N
Q238	1,864,250	396,450	50	N	10	300	L	N	L	5	N
Q239	1,868,180	393,190	1,500	.7	L	L	L	N	L	7	N
Q240	1,868,750	392,370	5,000	.7	N	50	L	N	L	5	N
Q241	1,868,750	392,370	G5,000	N	N	70	L	N	L	10	N
Q301	1,744,180	381,990	500	N	50	700	N	30	500	20	N
Q305	1,773,250	380,940	20	N	N	300	L	5	50	10	N
Q322	1,790,730	398,180	150	N	10	700	1	5	L	5	N
Q378	1,770,920	410,540	30	N	10	700	L	5	150	10	5
Q424	1,867,610	404,840	1,000	N	15	100	1	100	30	200	N
Q431	1,848,260	416,520	1,500	.7	L	700	L	5	70	20	L
Q435	1,845,990	419,370	100	L	10	1,000	L	5	30	7	5
Q438	1,847,350	419,860	30	L	10	700	L	5	70	30	N
Q440	1,849,220	420,150	20	N	10	1,000	L	5	20	5	N
Q442	1,849,720	419,850	100	N	N	700	L	10	50	200	N
Q446	1,853,800	420,220	150	N	L	150	L	10	15	5	N

The geographic distribution of the samples containing at least 20 ppm B (fig. 13), which are considered to be anomalous, shows much the same distribution as for arsenic, but fewer samples are anomalous in boron. As anticipated, boron is widespread in the Jardine-Crevice Mountain district and in the Hellroaring Ranger Station area. The dis-

minerals-study area, Park and Sweet Grass Counties. Mont.

limit of determination; G, greater than the value shown; ___, not determined; M, mineralized sample; Q prefix for samples Q1-Q928 does not appear on plate 2]

Sample	Semiquantitative spectrographic analyses--Continued (ppm)					Atomic absorption (ppm)	Chemical analyses (ppm)		Age	Sample material
	Ni (5)	Pb (10)	V (10)	Zn (200)	Zr (10)	Au (.02)	CxHM (1)	As (10)		
Q5	200	150	70	L	70	22	1	G5,000	p€	M, schist, quartz.
Q27	300	20	100	N	200	L	1	40	p€	Schist, quartz.
Q28	5	N	10	N	N	L	1	40	p€	Quartz vein.
Q30	200	N	100	N	70	L	1	60	p€	Do.
Q41	50	N	300	N	100	L	1	L	p€	Mafic dike.
Q71	5	10	15	N	20	.08	3	1,000	P	Limestone.
Q72	7	20	70	N	200	L	1	L	T	Tuff.
Q74	5	30	70	N	200	L	20	L	T	Lava flow.
Q76	7	20	100	N	200	L	7	L	T	Tuff.
Q77	7	30	50	N	200	L	2	10	T	Do.
Q128	5	N	L	N	N	.7	1	L	p€	M, quartz vein.
Q129	70	N	70	L	100	.10	1	L	p€	Do.
Q130	10	N	30	L	30	.80	9	N	p€	Do.
Q131	20	N	70	L	30	L	2	3,000	p€	Do.
Q132	100	15	70	L	100	.10	1	4,000	p€	M, schist, quartz.
Q138	5	N	L	L	N	L	1	20	p€	Quartz vein.
Q141	50	100	50	L	30	3	7	2,000	p€	M, schist, quartz.
Q148	N	10	10	N	N	.04	1	20	P	Limestone.
Q149	20	N	200	N	30	L	1	L	p€	Mafic dike float.
Q175	15	500	100	L	50	28	5	1,000	T	M, porphyry.
Q177	20	30	70	L	30	L	5	L	T	Do.
Q178	15	100	50	L	50	.02	3	L	T	Do.
Q179	30	100	70	L	30	.02	7	20	T	Do.
Q181	7	50	50	N	50	.10	1	L	T	Do.
Q195	15	70	70	N	200	.02	3	L	P	M, sandstone.
Q197	10	15	70	N	100	L	5	L	P	Do.
Q199	50	L	200	N	100	L	2	L	p€	Mafic dike.
Q211	30	N	200	L	150	L	3	L	p€	M, Cu-bearing, dump.
Q213	5	20	70	300	100	.08	35	30	p€	Do.
Q214	L	L	10	N	N	.08	1	L	P	Dolomite.
Q218	50	15	70	N	100	.10	3	L	T	M, porphyry.
Q223	10	70	20	N	30	L	5	L	P	Limestone.
Q229	50	15	70	N	100	.02	2	L	T	Lava flow.
Q236	20	20	15	N	N	L	3	30	P	M, limestone.
Q237	5	10	15	N	N	L	5	L	P	Do.
Q238	L	10	30	N	70	.02	2	L	T	Porphyry.
Q239	10	30	30	N	15	.02	7	150	P	M, limestone.
Q240	7	15	20	L	10	.02	25	300	P	M, Mn-bearing rock.
Q241	L	N	10	L	N	.02	100	150	P	Do.
Q301	100	10	100	N	100	L	L	10	p€	Schist.
Q305	5	N	20	N	150	L	L	20	P	Sandstone.
Q322	5	20	10	N	150	L	1	20	T	Tuff.
Q378	5	15	100	N	100	L	1	40	T	Porphyry.
Q424	70	15	70	N	15	L	2	L	p€	M, gneiss.
Q431	5	150	50	N	100	L	20	L	P	M, sandstone.
Q435	10	100	70	N	70	L	3	L	T	M, porphyry.
Q438	5	15	100	N	100	.04	2	L	T	Do.
Q440	5	N	30	N	100	.02	1	L	T	Do.
Q442	30	10	50	N	70	.08	5	L	T	Do.
Q446	15	L	70	N	100	.02	2	L	T	Do.

TABLE 7. — *Analyses of selected rock samples from*

Sample	East coordinate (feet)	North coordinate (feet)	Semiquantitative spectrographic analyses (ppm)								
			Mn (10)	Ag (.5)	B (10)	Ba (100)	Be (1)	Co (5)	Cr (10)	Cu (5)	Mo (5)
Q447	1,854,810	420,520	70	L	L	200	L	5	70	5	N
Q463	1,855,390	421,630	1,500	.7	10	150	L	70	500	150	N
Q671	1,710,750	391,600	20	N	N	20	N	N	L	5	N
Q717	1,849,140	419,350	70	N	N	300	L	5	150	15	N
Q719	1,849,850	419,040	1,000	N	N	700	L	20	300	15	N
Q754	1,880,250	383,390	500	200	N	N	N	5	L	G20,000	N
Q755	1,871,350	384,050	G5,000	100	L	N	N	N	N	150	N
Q756	1,872,140	383,440	2,000	3	N	N	N	N	L	15	N
Q757	1,871,640	384,960	G5,000	N	N	L	N	N	L	5	L
Q847	1,710,750	391,600	20	N	N	20	N	N	L	5	N
Q848	1,710,750	391,600	700	N	L	150	L	10	100	10	N
Q849	1,710,220	392,570	200	N	30	500	1	10	300	5	N
Q850	1,710,220	392,570	50	N	N	50	N	5	10	5	N
Q882	1,846,900	417,640	50	L	L	500	L	5	30	7	L
Q884	1,847,330	417,540	100	L	L	300	1	5	50	10	N
Q887	1,844,130	419,890	100	N	70	150	1.5	15	50	5	N
1/Q912	1,878,450	386,650	100	2	L	N	N	10	10	100	N
Q916	1,879,300	383,600	150	N	N	700	L	5	30	7	N
Q918	1,872,700	384,750	G5,000	300	N	N	N	N	30	300	N
Q919	1,872,700	384,750	5,000	70	N	N	N	N	N	20	N
Q931	1,868,680	392,170	2,000	L	N	N	N	N	N	5	N
Q932	1,868,680	392,170	G5,000	.7	N	N	N	N	L	5	N
R6	1,844,800	412,950	300	N	20	1,500	N	7	100	20	N
R17	1,862,000	416,700	1,000	N	L	300	N	100	700	150	N
R23	1,843,400	421,650	100	10	150	500	1	5	50	300	N
R24	1,843,400	421,650	30	3	10	300	L	5	30	100	N
R25	1,843,400	421,650	30	70	L	G5,000	N	N	30	500	15
R26	1,843,400	421,650	10	70	L	G5,000	N	N	30	1,000	10
R31	1,780,600	446,000	1,500	N	L	5,000	L	30	100	50	N
R43	1,868,700	391,700	G5,000	300	20	70	L	N	500	50	N
R48	1,708,600	416,450	500	N	10	3,000	1	7	15	100	N
2/R51	1,726,750	424,900	700	L	L	2,000	L	30	150	50	10
2/R57	1,727,500	402,600	1,000	N	L	2,000	1	15	30	50	5
R58	1,727,650	403,100	700	N	10	5,000	L	15	50	100	7
R63	1,712,100	396,400	2,000	N	10	200	N	100	1,000	200	N
R64	1,710,800	395,550	300	N	10	50	1	5	200	70	30
R65	1,868,800	391,500	G5,000	500	L	200	N	N	N	100	7
R66	1,868,800	391,500	G5,000	150	L	150	N	N	N	20	15
R67	1,868,880	391,500	G5,000	150	L	N	N	N	N	50	N
R70	1,813,750	446,050	1,000	1	L	2,000	N	10	200	70	N
R71	1,813,900	445,700	30	20	L	5,000	N	100	50	1,500	N
R75	1,819,150	441,650	500	10	10	1,500	L	20	100	20	N
R78	1,844,200	421,300	300	N	L	1,000	N	5	10	L	300
R108	1,865,250	412,300	700	N	L	200	N	100	50	70	N
R109	1,865,250	412,300	200	N	L	300	1	10	20	50	N
R323	1,770,350	410,800	1,000	N	10	3,000	L	10	70	50	7
R325	1,795,000	426,000	200	N	20	3,000	1	30	300	10	N
R327	1,825,400	379,100	1,000	.5	L	5,000	L	5	20	70	N
1/R331	1,733,750	428,300	700	N	10	3,000	L	7	15	70	5
2/R332	1,733,550	427,300	300	N	10	2,000	L	7	20	50	10
3/R333	1,724,300	401,500	700	N	10	5,000	L	5	30	50	10
R335	1,707,000	420,300	500	N	10	2,000	1	10	15	50	5
R343	1,725,400	393,800	100	1	1,000	500	L	150	300	20	15
R638	1,844,000	421,050	10	7	10	500	L	N	150	20	7
R639	1,843,950	421,400	10	1.5	L	500	N	N	150	50	N

1/ Sample contains 150 ppm tungsten.

2/ Sample contains 100 ppm tungsten.

3/ Sample contains 70 ppm tungsten.

the Absaroka minerals-study area — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm)					Atomic absorption (ppm)	Chemical analyses (ppm)		Age	Sample material
	Ni (5)	Pb (10)	V (10)	Zn (200)	Zr (10)	Au (.02)	CxHM (1)	As (10)		
Q447	10	L	70	N	70	0.06	1	L	p€	M, gneiss.
Q463	500	100	70	L	70	L	5	L	p€	M, mafic dike.
Q671	L	N	L	L	N	.02	L	L	p€	M, schist.
Q717	20	N	100	N	100	.02	1	L	T	M, porphyry.
Q719	150	10	70	N	100	.02	2	60	T	Do.
Q754	15	3,000	10	700	N	4	G100	20	T	Do.
Q755	5	2,000	15	7,000	N	3	G100	4,000	P	M, Mn-bearing rock.
Q756	5	100	10	500	N	L	90	80	P	M, limestone.
Q757	N	50	10	N	N	.04	G100	80	P	M, Mn-bearing rock.
Q847	L	N	L	L	N	L	1	30	p€	M, schist, quartz.
Q848	70	N	50	L	30	L	1	500	p€	Do.
Q849	100	15	70	L	30	.04	1	1,000	p€	Do.
Q850	10	N	10	N	N	.15	L	G5,000	p€	Do.
Q882	5	150	50	N	150	L	2	L	P	M, sandstone.
Q884	15	30	50	N	200	L	1	40	P	Do.
Q887	20	N	70	N	100	L	2	L	P	Do.
Q912	L	L	L	N	N	3	3	L	T	M, porphyry.
Q916	20	L	20	N	30	.02	3	L	T	Do.
Q918	5	2,000	70	7,000	100	.20	G100	150	T	M, Fe-bearing rock.
Q919	L	1,500	10	1,000	N	L	---	L	P	M, limestone.
Q931	L	20	10	N	N	L	40	40	P	M, Mn-bearing limestone.
Q932	L	70	20	L	N	L	100	150	P	Do.
R6	30	20	70	N	100	L	1	N	T	Porphyry.
R17	700	N	100	N	70	L	3	L	p€	Mafic dike.
R23	20	3,000	30	300	70	.04	25	20	p€	M, gneiss.
R24	5	700	50	N	100	.20	7	20	P	M, sandstone.
R25	10	1,000	10	300	100	1	20	800	P	Do.
R26	5	1,000	10	N	70	.85	35	800	P	Do.
R31	30	50	200	N	200	L	5	N	T	Breccia matrix.
R43	5	10,000	200	G10,000	30	.60	G100	1,600	P	M, dolomite.
R48	5	70	50	N	700	L	1	10	T	Tuff.
R51	30	N	100	N	200	L	2	N	T	Do.
R57	15	20	100	N	500	L	1	N	T	Tuff breccia.
R58	15	30	100	N	1,000	L	1	N	T	Do.
R63	150	N	500	L	100	L	2	N	p€	Diorite.
R64	30	N	100	N	30	L	1	60	p€	M, quartz vein.
R65	15	10,000	100	G10,000	10	L	G100	4,000	P	M, Mn-bearing vein.
R66	15	5,000	200	G10,000	N	L	G100	800	P	Do.
R67	5	5,000	30	10,000	N	L	G100	60	P	Do.
R70	50	150	50	N	200	.40	11	N	T	M, pyritic monzonite.
R71	100	1,000	10	L	200	20	60	N	T	M, pyritic tailings.
R75	30	150	100	N	100	.30	2	N	T	M, pyritic monzonite.
R78	5	50	20	N	100	L	2	N	p€	M, Mo-bearing gneiss.
R108	50	N	200	N	30	L	1	40	p€	Mafic dike.
R109	20	15	100	N	300	L	1	60	p€	Gneiss.
R323	10	20	300	N	200	L	2	N	p€	Mn-bearing breccia.
R325	50	20	200	N	300	L	1	N	T	Tuff.
R327	7	100	50	N	200	L	7	N	T	Porphyry.
R331	5	70	70	N	700	L	2	N	T	Do.
R332	10	30	70	N	700	L	1	N	T	Tuff.
R333	L	50	20	N	700	L	1	N	T	Tuff breccia.
R335	10	30	50	N	1,000	L	1	L	T	Do.
R343	20	7,000	300	N	300	L	14	20	T	Tuff(?).
R638	5	100	70	N	500	L	L	40	P	M, pyritic sandstone.
R639	5	50	30	N	300	L	5	L	P	Do.

TABLE 7. — *Analyses of selected rock samples from*

Sample	East coordinate (feet)	North coordinate (feet)	Semiquantitative spectrographic analyses (ppm)								
			Mn (10)	Ag (.5)	B (10)	Ba (100)	Be (1)	Co (5)	Cr (10)	Cu (5)	Mo (5)
R640	1,843,800	421,700	15	0.5	L	700	N	N	150	5	N
R641	1,843,400	421,650	10	30	L	200	N	N	20	200	L
R642	1,843,400	421,650	20	50	L	G5,000	N	N	30	300	20
R644	1,843,400	421,650	15	10	L	G5,000	N	N	30	300	15
R648	1,850,000	422,050	70	5	L	700	L	5	L	150	N
R649	1,850,000	422,050	20	1	L	1,000	L	5	10	150	N
R661	1,825,250	418,450	500	.5	100	200	7	5	100	100	N
R666	1,866,700	390,200	1,000	N	L	1,500	L	50	1,000	100	N
R670	1,844,100	435,550	2,000	N	L	700	L	150	15	10	N
R684	1,723,350	398,950	300	N	L	5,000	L	7	30	100	N
R686	1,718,500	396,200	1,000	N	10	5,000	L	30	200	100	N
R688	1,718,600	385,750	700	N	20	30	N	5	100	50	N
R691	1,714,550	388,600	700	N	L	500	L	20	500	100	N
R694	1,711,500	388,250	2,000	N	10	300	L	70	500	300	N
R702	1,713,700	395,100	1,500	N	L	500	N	150	1,000	100	N
R712	1,814,000	446,100	500	L	L	5,000	L	7	200	100	N
R713	1,814,000	446,100	200	7	15	1,500	L	10	300	5	N
R716	1,814,000	446,300	100	7	10	1,500	L	7	150	5	7
R717	1,814,000	446,300	100	150	20	1,500	L	100	200	70	15
R718	1,814,000	446,300	N	1	10	20	N	300	N	L	N
R723	1,809,750	445,100	50	2	L	500	N	10	100	50	N
R749	1,762,150	392,350	700	N	L	30	N	7	30	15	N
R750	1,762,150	392,350	700	N	L	100	N	5	30	100	N
R751	1,762,150	392,350	700	N	L	L	N	5	10	5	N
R752	1,762,100	393,100	1,000	N	L	50	N	N	150	30	N
R753	1,762,100	393,100	700	1	L	30	N	N	100	70	N
R760	1,762,500	393,800	500	N	10	200	N	7	200	100	N
R761	1,762,500	393,800	500	N	10	N	N	5	10	20	N
R762	1,762,500	393,800	700	N	10	N	N	5	20	50	N
R763	1,762,500	393,800	500	L	10	20	N	5	20	100	N
R764	1,762,500	393,800	700	N	10	20	N	5	15	5	N
R770	1,745,000	425,400	700	N	10	1,500	1	10	L	20	5
R786	1,725,400	393,800	700	N	10	1,500	2	7	20	20	5
R787	1,725,400	393,800	200	N	L	1,000	L	7	30	50	5
R790	1,725,400	393,800	700	1	10	1,000	L	7	30	15	N
3/R793	1,787,100	395,100	700	N	L	1,500	1	20	200	20	5
R794	1,786,700	395,250	700	N	L	3,000	L	30	300	100	N
R795	1,786,400	395,200	700	N	L	2,000	L	30	300	150	N
R798	1,782,300	382,500	500	N	L	3,000	L	30	300	50	5
R830	1,844,100	435,550	1,500	N	L	200	L	70	10	10	N
R845	1,843,400	421,650	10	1	L	1,000	N	N	100	5	N
R853	1,761,300	380,500	10	N	10	1,000	L	N	200	70	N
R859	1,831,400	411,400	1,000	N	L	2,000	L	30	700	100	N
R861	1,865,600	393,300	700	N	L	2,000	L	20	500	100	N
R869	1,720,800	378,550	5,000	N	100	500	L	7	700	70	N
3/R872	1,716,050	379,000	30	L	L	300	N	N	L	100	N
R873	1,716,050	379,000	30	L	L	500	N	N	200	100	N
4/R874	1,717,400	383,600	100	L	L	150	N	5	100	100	N
4/R875	1,717,400	383,600	1,000	.7	10	150	1	30	300	100	N
1/R876	1,717,400	383,600	1,000	1.5	10	150	L	15	300	100	N
1/R877	1,717,400	383,600	500	20	10	300	1	15	200	300	N
R879	1,716,850	383,050	20	L	L	30	N	N	N	70	N
R923	1,778,100	423,400	500	N	L	1,500	1	10	N	100	N
R924	1,763,750	423,200	1,000	N	10	2,000	L	20	200	200	N
R925	1,762,000	413,150	1,500	N	L	1,500	L	20	300	150	N

4/ Sample contains 50 ppm tungsten.

the Absaroka minerals-study area — Continued

Sample	Semiquantitative spectrographic analyses--Continued (ppm) Ni (5)	Pb (10)	V (10)	Zn (200)	Zr (10)	Atomic absorption (ppm) Au (.02)	Chemical analyses (ppm) CxHM (1)	As (10)	Age	Sample material
R640	5	100	20	N	200	L	2	L	P	M, pyritic sandstone.
R641	5	500	10	L	100	.20	17	150	P	M, limonitic sandstone.
R642	10	700	10	700	100	3	11	1,500	P	Do.
R644	5	500	30	200	70	.10	7	200	P	M, baritic sandstone.
R648	5	70	30	N	70	.30	4	10	p€	M, pyritic gneiss.
R649	5	20	50	N	10	.08	1	80	p€	M, Fe-stained gneiss.
R661	10	N	50	N	30	L	3	L	P	Dolomite.
R666	300	50	200	N	200	L	1	N	T	Mafic dike.
R670	50	N	500	300	30	L	1	N	p€	Nodular gneiss.
R684	20	50	50	N	300	L	1	N	T	Porphyry.
R686	50	20	200	N	300	L	1	N	T	Vitrophyre.
R688	30	N	30	N	20	.20	1	N	p€	M, schist.
R691	150	20	100	N	200	L	1	N	p€	Do.
R694	100	15	500	N	150	L	2	N	p€	Do.
R702	200	N	200	N	100	L	1	L	p€	Diorite.
R712	50	70	100	N	500	L	3	N	T	M, pyritic monzonite.
R713	50	10	100	N	300	1	1	N	T	Do.
R716	20	200	70	N	200	.20	1	N	T	Do.
R717	30	700	100	N	200	4	2	L	T	M, pyrite, sulfides.
R718	150	N	N	N	N	.10	N	N	T	M, pyrite crystals.
R723	30	20	50	N	200	L	2	N	P	Pyritic sandstone.
R749	70	N	70	200	N	.25	1	N	p€	M, schist, quartz.
R750	5	N	20	200	10	.10	1	N	p€	Do.
R751	5	N	10	300	30	L	L	N	p€	Do.
R752	20	N	30	N	10	.10	1	N	p€	Do.
R753	5	N	20	N	20	.60	1	160	p€	Do.
R760	50	N	50	300	30	.08	1	N	p€	Do.
R761	10	N	10	300	10	L	1	N	p€	Do.
R762	5	N	10	200	10	.20	1	N	p€	Do.
R763	5	N	10	L	10	.10	1	N	p€	Do.
R764	5	N	10	200	10	L	1	N	p€	Do.
R770	L	30	50	N	500	L	2	N	T	Andesite.
R786	5	50	50	N	500	L	1	10	T	Tuff.
R787	5	30	30	N	300	L	1	20	T	Do.
R790	5	200	100	N	300	L	1	20	T	Do.
R793	100	15	100	N	200	L	1	L	T	Do.
R794	50	20	200	N	300	L	1	10	T	Andesite.
R795	70	15	200	N	300	L	1	N	T	Do.
R798	50	20	200	N	300	L	L	N	T	Do.
R830	30	N	200	200	20	L	1	L	p€	Nodular gneiss.
R845	5	500	20	N	200	L	1	10	P	M, baritic sandstone.
R853	20	15	20	N	500	L	1	80	P	Sandstone.
R859	150	30	200	N	300	L	2	N	p€	Mafic dike.
R861	100	30	100	N	300	L	1	N	T	Vent breccia matrix.
R869	150	10	200	N	100	L	1	300	p€	Schist.
R872	30	30	10	L	N	.15	2	G5,000	p€	M, schist, quartz.
R873	20	10	50	L	50	.10	1	G5,000	p€	Do.
R874	30	N	20	L	10	L	1	1,000	p€	M, vein quartz.
R875	150	20	100	L	50	1	4	G5,000	p€	M, crushed rock mill.
R876	100	70	70	L	30	4	5	G5,000	p€	Do
R877	100	70	70	N	200	10	2	G5,000	p€	M, mill tailings.
R879	5	70	10	N	10	L	1	120	p€	M, vein quartz.
R923	20	30	150	N	200	L	L	N	T	Andesite flow.
R924	70	70	300	N	200	L	L	N	T	Do.
R925	70	30	300	N	200	L	L	N	T	Do.

TABLE 8. — *Conversions for analytical values of mine and prospect appraisals*

[Conversion of parts per million (ppm) to percent to ounces per ton (oz/ton), and vice versa. Conversion factors: 1 lb avoirdupois = 14.588 oz troy; 1 ppm = 0.0001 percent = 0.0291667 oz troy/short ton = 1 g/metric ton; 1 oz/ton (Au or Ag) = 34.286 ppm =0.0034286 percent]

Parts per million to percent to ounces per ton			Ounces per ton to percent to parts per million		
Ppm	Percent	Oz/ton	Oz/ton	Percent	Ppm
0.01	0.000001	0.0003	0.01	0.00003	0.3
.02	.000002	.0006	.02	.00007	.7
.05	.000005	.0015	.05	.00017	1.7
.10	.00001	.003	.10	.00034	3.4
.20	.00002	.006	.20	.00069	6.9
.30	.00003	.009	.30	.00103	10.3
.40	.00004	.012	.40	.00137	13.7
.50	.00005	.015	.50	.00171	17.1
.60	.00006	.017	.60	.00206	20.6
.70	.00007	.020	.70	.00240	24.0
.80	.00008	.023	.80	.00274	27.4
.90	.00009	.026	.90	.00309	30.9
1.0	.0001	.029	1.0	.00343	34.3
10.0	.001	.292	10.0	.03429	342.9
20.0	.002	.583	20.0	.06857	685.7
50.0	.005	1.458	50.0	.17143	1,714.0
100.0	.01	2.917	100.0	.34286	3,429.0
500.0	.05	14.583	500.0	1.71	17,143.0
1,000.0	.10	29.167	1,000.0	3.43	34,286.0
10,000.0	1.00	291.667	10,000.0	34.29	342,857.0

tribution of anomalous boron along the northeast side of the study area indicates a trend of decreasing temperature of formation of deposits from the New World district northwestward to the Independence district.

COPPER

Samples containing anomalous copper, determined to be at least 100 ppm (table 13), show about the same distribution (fig. 14) as gold. Most of the anomalous copper values in the Horseshoe Mountain area and in the Jardine and Independence districts are a result of the trace amounts of chalcopyrite in the gold deposits. The high-temperature gold-copper deposits in parts of the New World district are the chief source of many of the more anomalous samples in that district. The extremely high copper values in many stream sediments from the New World district are probably a result of reworking of postglacial organically precipitated native copper found in bog deposits below copper-rich ores (Lovering, 1927, 1930). Many single samples taken at scattered localities through the study area are only minimally above threshold and hence are probably more likely the few high values expected in the

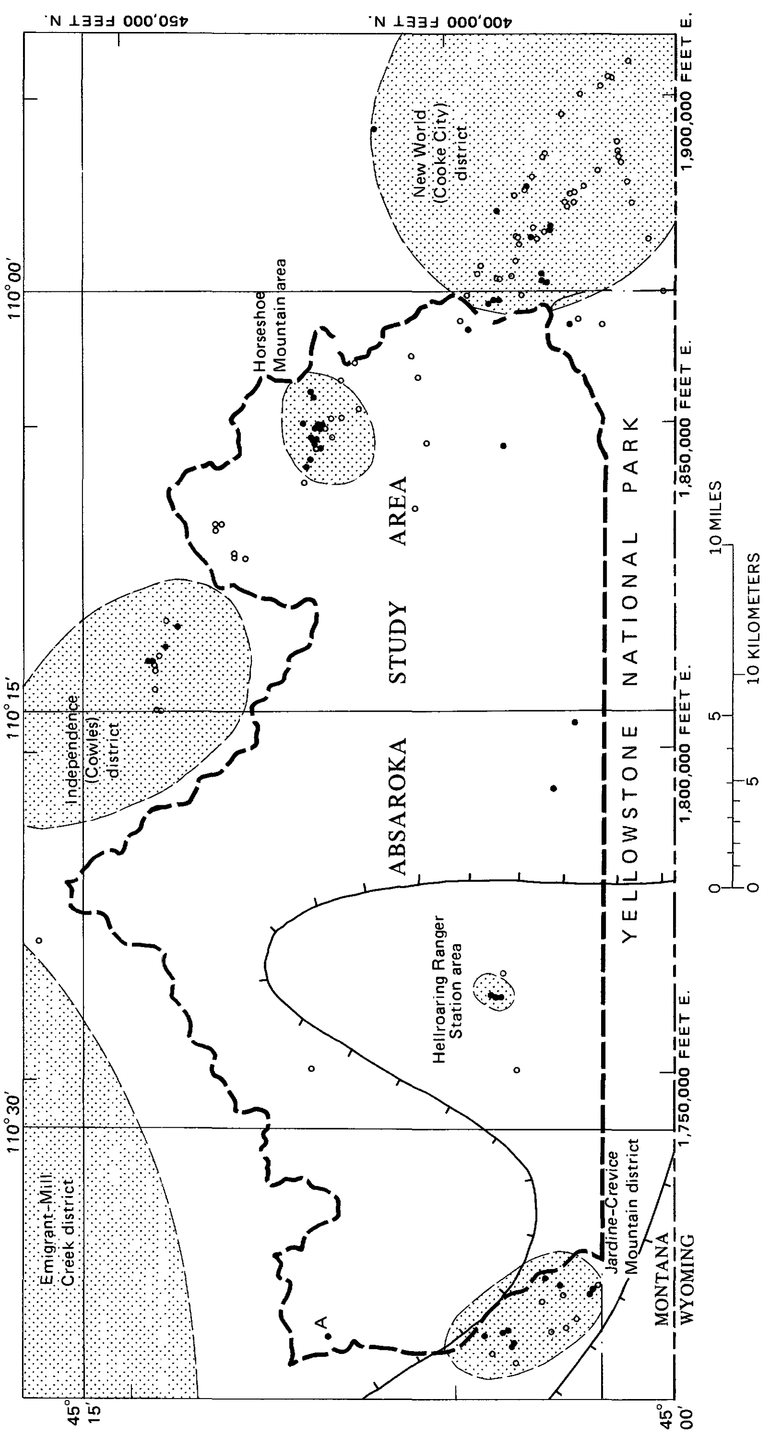


FIGURE 10. — Samples containing 0.02 ppm or more gold (Au) in and near the Absaroka study area.

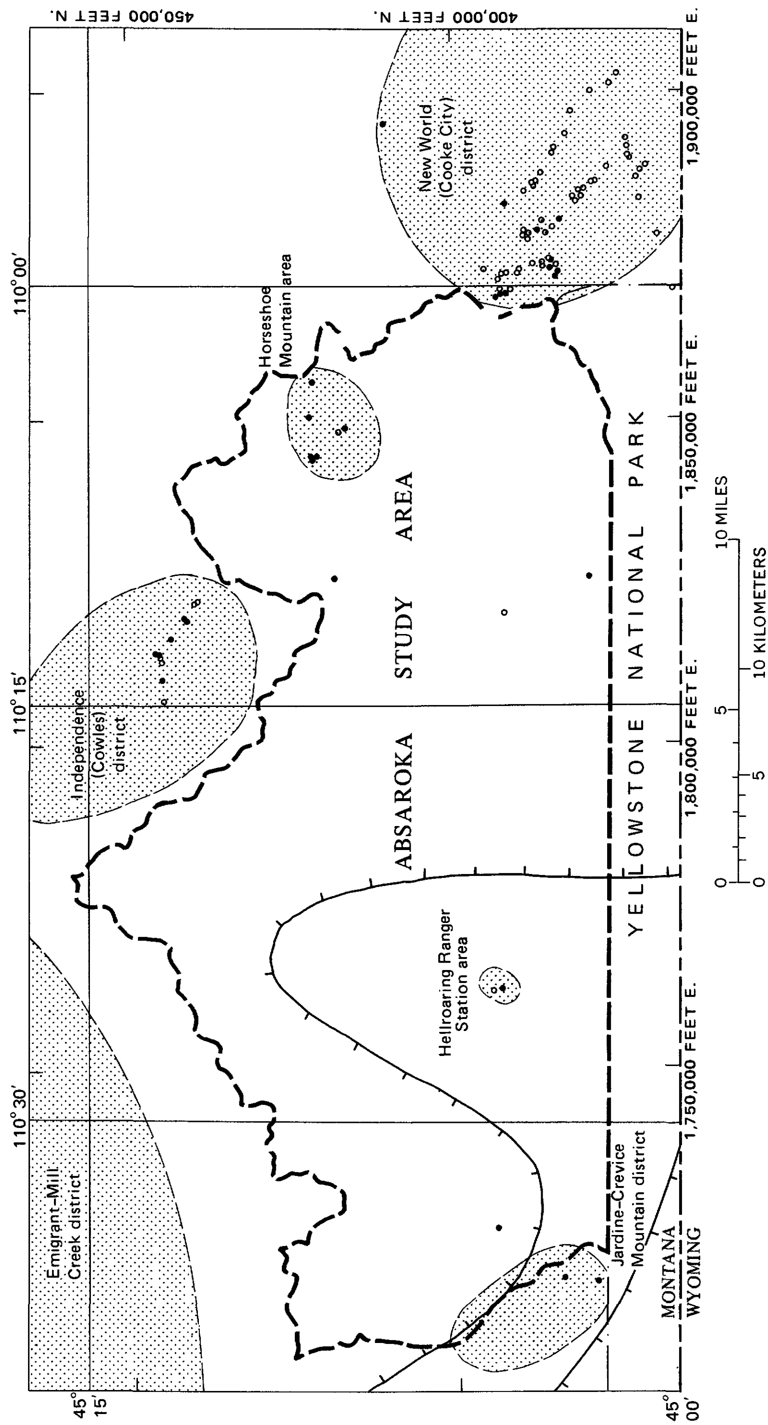


FIGURE 11. — Samples containing 0.5 ppm or more silver (Ag) in and near the Absaroka study area.

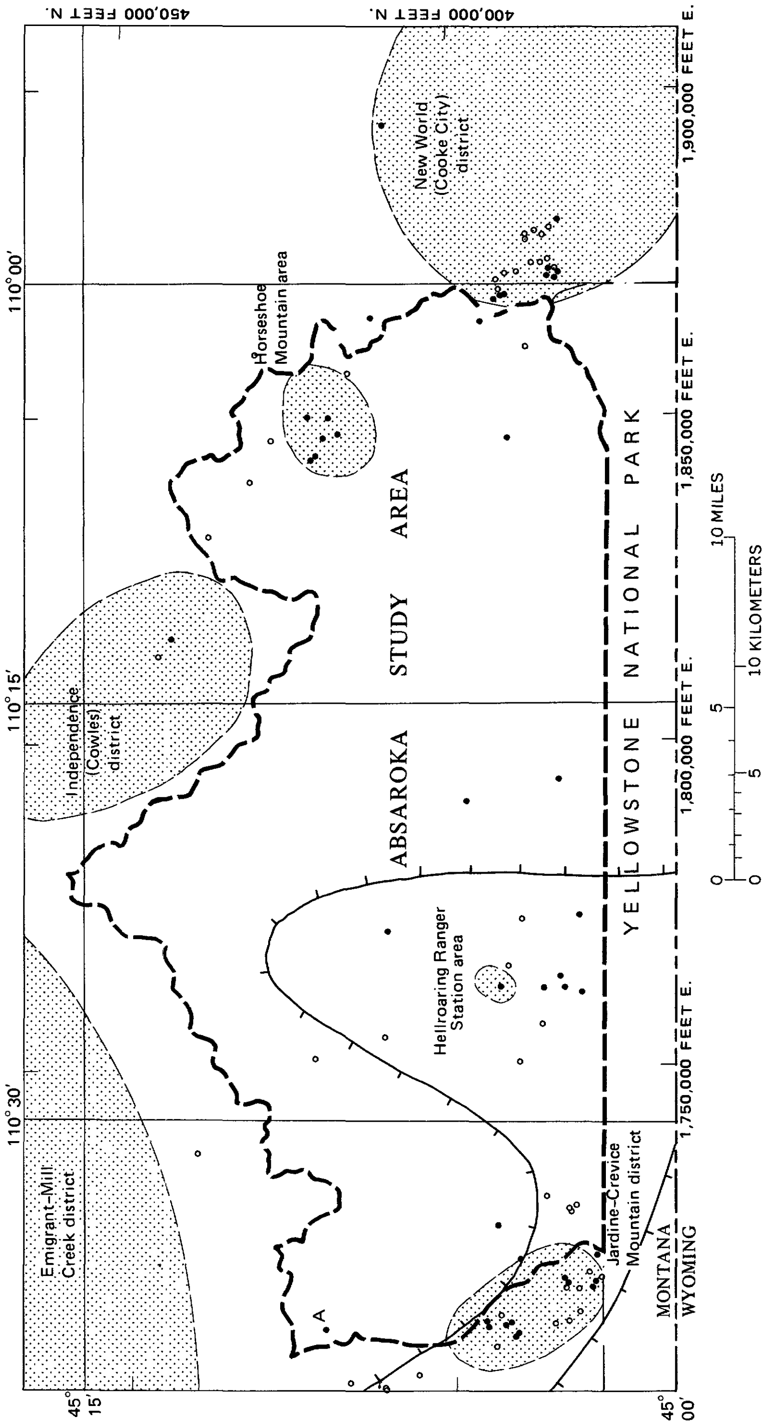


FIGURE 12. — Samples containing 20 ppm or more arsenic (As) in and near the Absaroka study area.

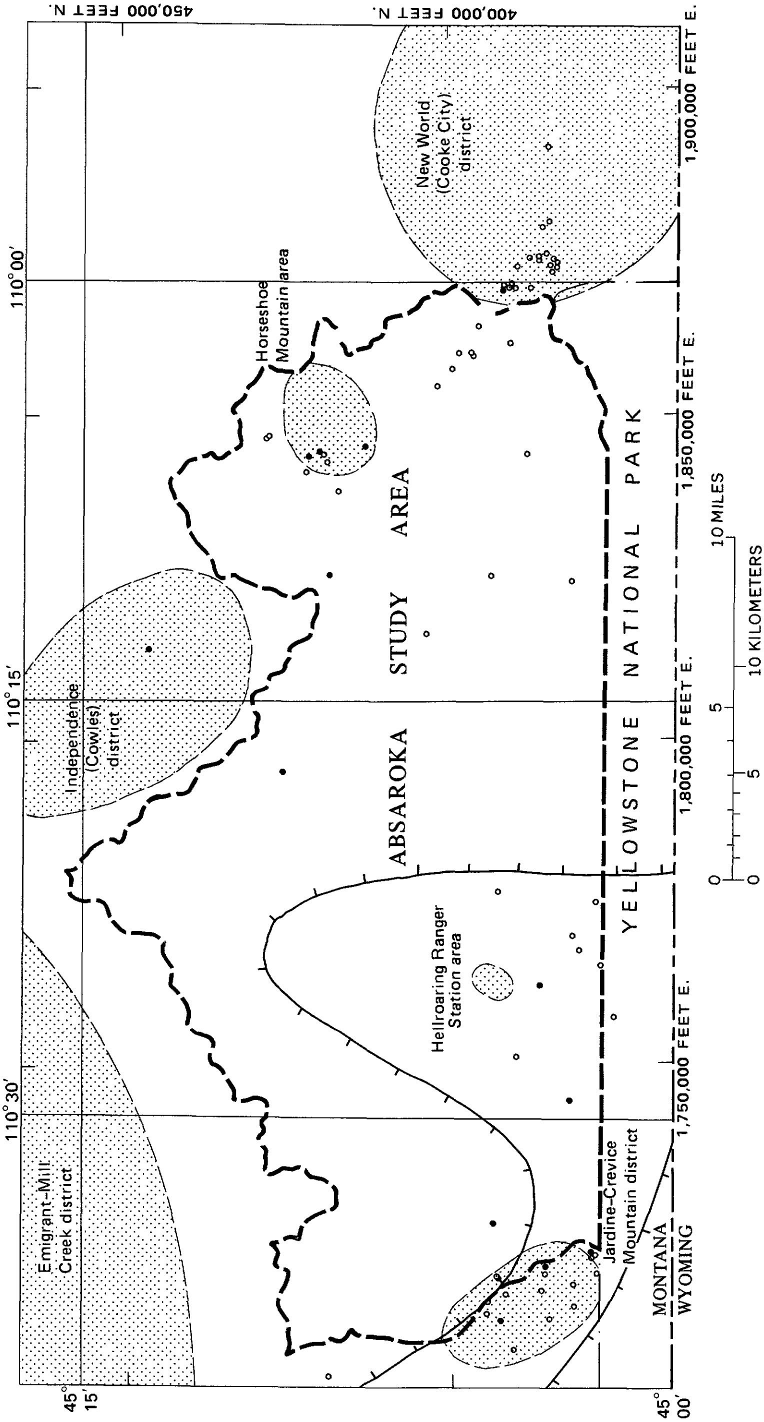


FIGURE 13. — Samples containing 20 ppm or more boron (B) in and near the Absaroka study area.

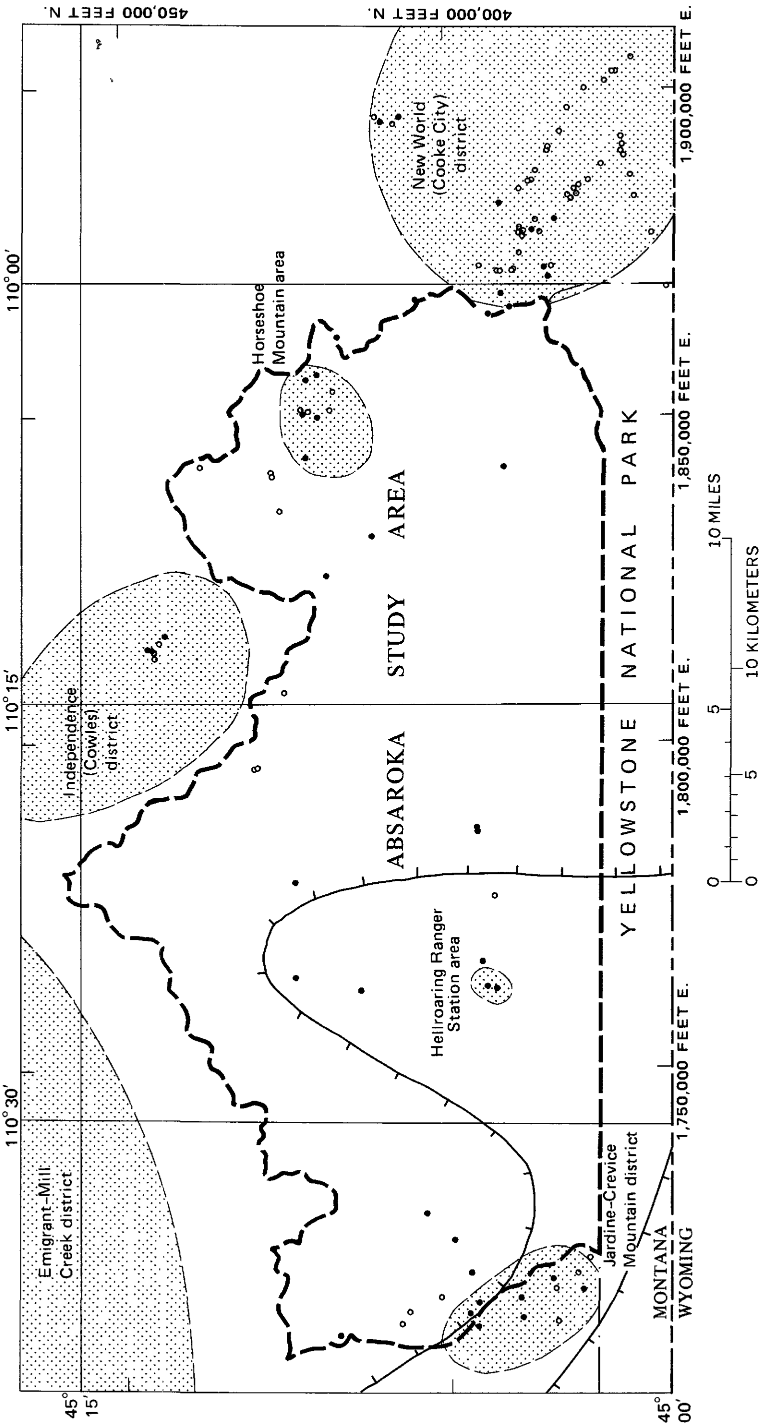


FIGURE 14. — Samples containing 100 ppm or more copper (Cu) in and near the Absaroka study area.

background distribution of copper rather than those related to possible ore deposits.

MOLYBDENUM

Trace molybdenum in amounts of 5 ppm or more is present in many samples from the New World, Horseshoe Mountain, and Independence districts (fig. 15). The highest value — 300 ppm Mo (sample R78, table 7, and pl. 2; sample B, fig. 15) — is from Precambrian gneiss that contained a thin quartz stringer in which small flakes of molybdenite (MoS_2) could be seen. This sample was collected from an outcrop on the northwest flank of Horseshoe Mountain not far from several prospect pits dug in the search for gold. No other molybdenite was observed, but samples from the prospect pits contain detectable molybdenum. Few samples with 5 ppm or more Mo were found associated with the gold ores of the Jardine–Crevice Mountain district (fig. 15). Rock samples containing anomalous molybdenum in the western part of the study area (fig. 15) are mostly welded ash flows and related rocks of the Slough Creek Tuff Member (pl. 1).

LEAD

Almost all samples with anomalous lead (100 ppm or more Pb; fig. 17) are associated with ores that contain visible galena. Included are samples of ores from the mining districts along the northeast side of the study area and the gold-arsenic-tungsten ores of the Jardine–Crevice Mountain district (Seager, 1944, p. 59). A sample of rhyodacite porphyry near the southern boundary of the study area on Slough Creek (sample C, fig. 16) contains 100 ppm Pb and 0.5 ppm Ag, probably in trace galena.

TUNGSTEN

Because of high detection limit of 50 ppm of tungsten by semiquantitative spectrographic analysis all samples with detectable tungsten are anomalous. Anomalous samples are clustered in the Jardine–Crevice Mountain and New World districts and in the vicinity of Horseshoe Mountain (fig. 17). Most samples, even those from the Jardine–Crevice Mountain district, where tungsten minerals are known, show less than 50 ppm W, indicating that the threshold for anomalous tungsten must be considerably less than 50 ppm. Other samples from the western part of the study area are chiefly those of the Slough Creek Tuff Member, which are also anomalous in trace molybdenum. The anomalous samples near Horseshoe Mountain are from an east-trending shear zone in Precambrian gneiss; of the two bedrock samples one is sheared gneiss and the other is of Tertiary rhyolitic intrusive adjacent to the shear zone.

ZINC

The geographic distribution of all samples containing 200 ppm or more Zn is shown in figure 18. This relatively high minimum anomalous

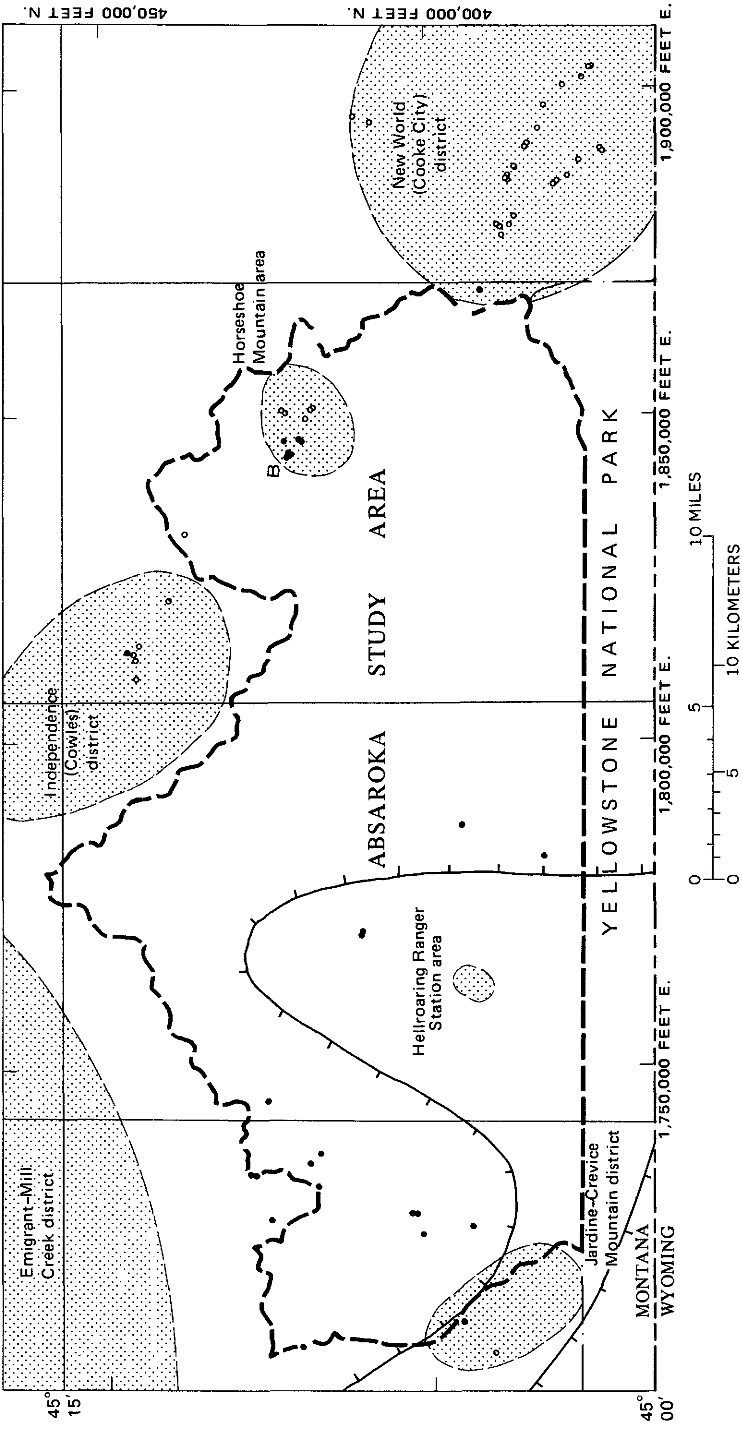


FIGURE 15. — Samples containing 5 ppm or more molybdenum (Mo) in and near the Absaroka study area.

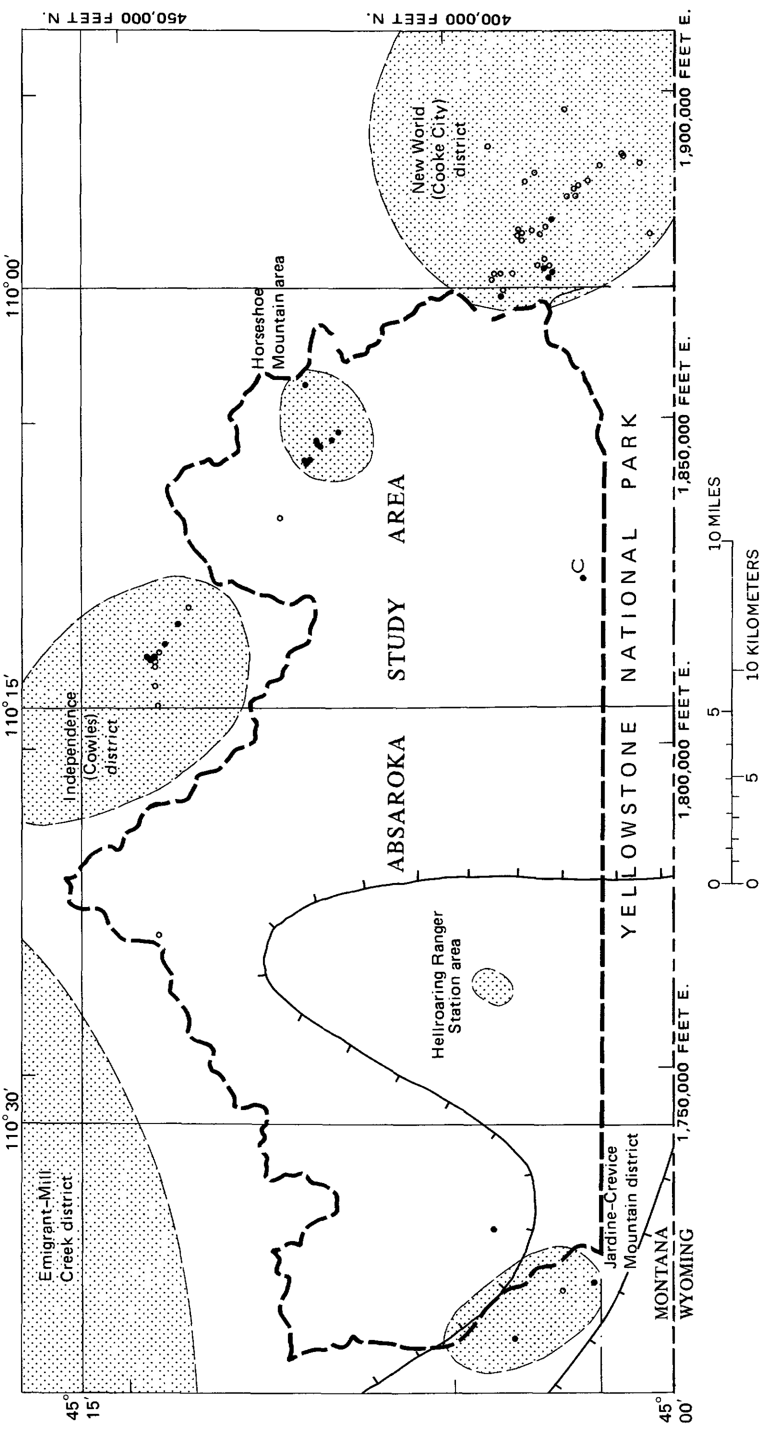


FIGURE 16. — Samples containing 100 ppm or more lead (Pb) in and near the Absaroka study area.

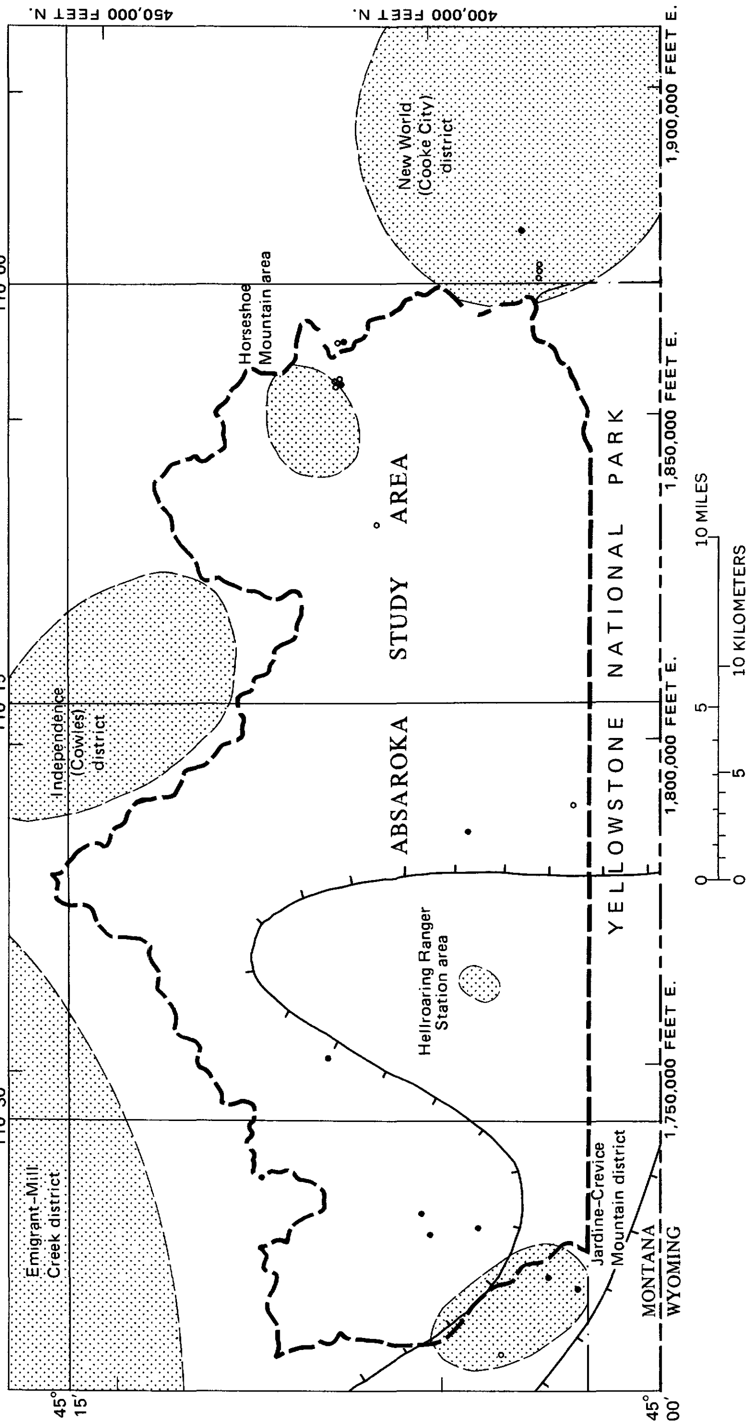


FIGURE 17. — Samples containing 50 ppm or more tungsten (W) in and near the Absaroka study area.

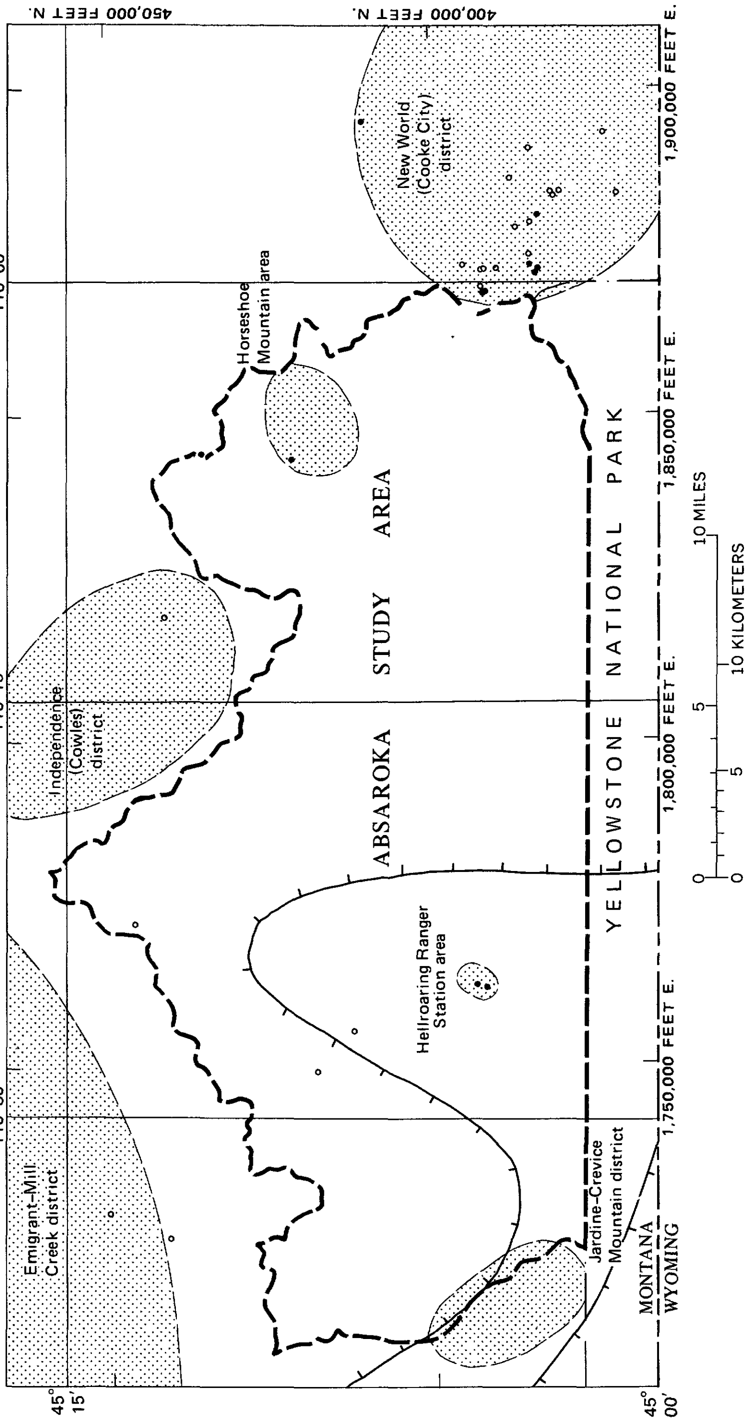


FIGURE 18. — Samples containing 200 ppm or more zinc (Zn) in and near the Absaroka study area.

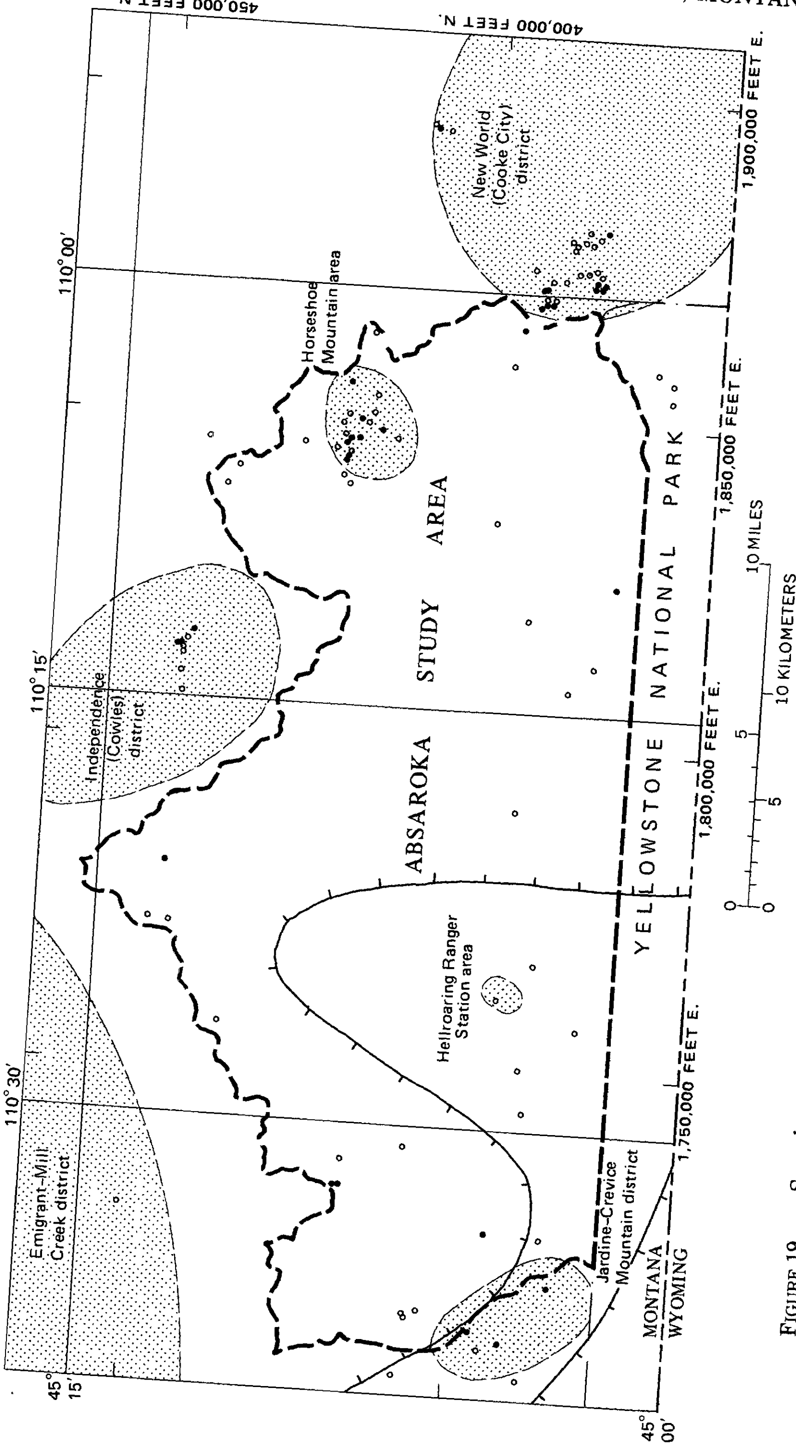


FIGURE 19. — Samples containing 20 ppm citrate-soluble heavy metals (cxHM) in and near the Absaroka study area.

value is the lower detection limit for zinc in semiquantitative spectrographic analysis. The actual minimum anomalous value is undoubtedly less than 100 ppm, but because of the close association of zinc with lead and copper in the mineral deposits of the area, it was not deemed necessary to use an analytical method with a greater sensitivity for zinc. Most high values for zinc are from the New World district.

COLD-EXTRACTABLE HEAVY METALS

Cold-extractable, or citrate-soluble, heavy metals (cxHM) are anomalous at values of 20 ppm or more (table 5, fig. 19). Most of the cxHM anomalous values, in both stream sediments and rocks, are closely associated with the known mineralized areas. However, other scattered samples, mostly of stream sediments, seem to be unrelated to mineral deposits and thus must be considered falsely anomalous.

EXAMINATION AND EVALUATION OF CLAIMS, PROSPECTS, AND MINES

During the 1969 and 1971 field seasons, the U.S. Bureau of Mines examined all known and reported mineral occurrences in the Absaroka study area. A search of county records in Park and Sweet Grass Counties showed approximately 400 mining claims in and near the study-area boundaries. Many claim locations represent a restaking of claims that had previously been abandoned.

Most prospects in the study area are at Horseshoe Mountain and in the Jardine–Crevice Mountain mining district, in the eastern part and at the western edge of the study area, respectively (fig. 20). About 200 lode and placer claims have been staked on Horseshoe Mountain and in nearby areas. More than 100 claims were recorded as being in and adjacent to the study area near Jardine and Crevice Mountain.

Mineral production in the study area has been negligible. A minor amount of placer gold was probably produced near Horseshoe Mountain and possibly some gold or tungsten was produced near the Jardine–Crevice Mountain district. Total value of gold, silver, copper, lead, and zinc production from adjacent mining districts to the west, east, and north of the study area is estimated at $10.5 million. No mining is allowed in Yellowstone National Park, south of the study area. Information on metallic minerals within the park is extremely scarce; some data on lode and placer gold deposits, however, are available.

Much of the prospecting and mining in and near the study area occurred near the turn of the century and again during the 1930's. Most of this activity was gold mining, which was stopped during World War II. Gold mining resumed after the war but failed because of the fixed gold price and rising costs of mining.

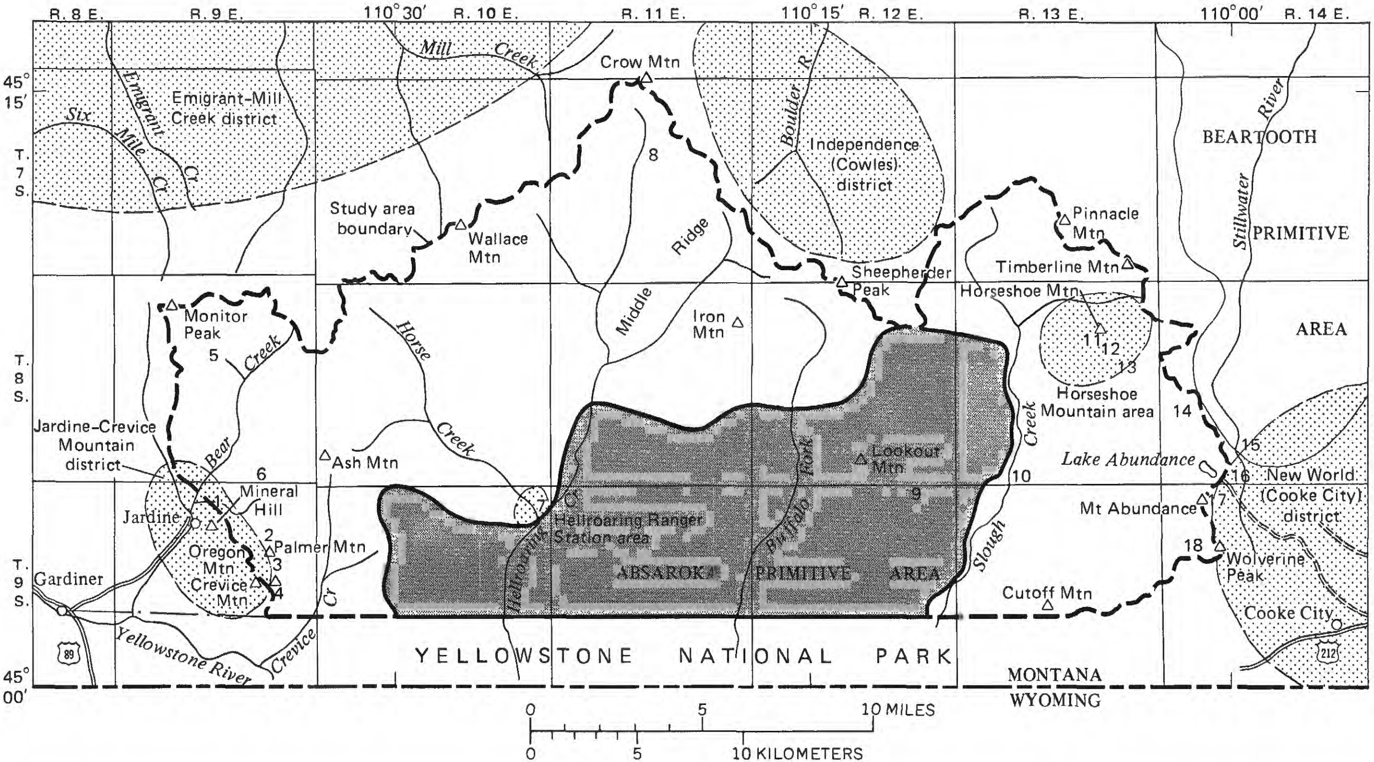


FIGURE 20. — Prospect areas in and near the Absaroka Primitive Area. Mineral prospect areas: 1, lower Pine Creek; 2, upper Pine Creek; 3, Palmer Mountain-Crevice Mountain saddle; 4, Oregon Mountain; 5, Castle Lake; 6, Logger trench; 7, lower Hellroaring; 8, upper Hellroaring; 9, Bears Den claim; 10, Slough Creek placer claims; 11, Horseshoe Mountain; 12, Gold Run Creek placers; 13, Rock Creek placers; 14, Grand Central claim; 15, Greenback; 16, Long Tom placer; 17, north end of Mount Abundance; and 18, Pig's Eye placer.

About 95 percent of the U.S. Bureau of Mines field investigations were along the west border of the study area and at Horseshoe Mountain because these areas have extensive prospect workings. Several workings just outside the study area were examined to determine if any mineralized structures extended into the area.

MINERAL DEPOSITS

The principal mineral commodities in the Absaroka study area are gold and tungsten. Other metals of value occur but none were found in significant quantity.

Low-grade disseminated gold deposits such as may occur within certain strata of the schist series in the Jardine–Crevice Mountain and Hellroaring Ranger Station areas may be minable in the future if large tonnages of material containing 0.2 oz gold can be delineated. Conceivably, the cut-off grade could be lowered to 0.1 oz or less if large tonnages suitable for open-pit mining were outlined and metallurgical recovery costs were simultaneously lowered through new technology, such as some form of heap leaching. Vein mining or other underground methods selectively mining narrow or otherwise limited stopes will continue to require gold content averaging at least 1 oz/ton unless the price of gold increases substantially.

The 1971 price of tungsten per short ton unit of WO_3 averaged $55. The domestic tungsten price is expected to remain approximately at this level for the near future. However, world prices are expected to trend upward as cumulative demand increases and Government stockpile sales are gradually terminated. Tungsten in the Precambrian schist of the study area could be mined only if tonnages adequate for bulk mining methods and averaging at least 0.3–0.5 percent WO_3 were found. Mining of narrow, high-grade veins would require an average grade of about 1 percent WO_3.

WESTERN PART OF ABSAROKA STUDY AREA

JARDINE–CREVICE MOUNTAIN DISTRICT

The principal workings at Jardine are about 0.5 mi southwest of the study area boundary; those of Crevice Mountain are about 1 mi west of the boundary (fig. 21). The small town of Jardine, just outside the study area, is about 5 mi by good all-weather gravel road from Gardiner. Most mine workings at Jardine are on the western slope of Mineral Hill east of Bear Creek at altitudes of about 7,000 to 7,200 ft. Mineral production from the Jardine mine until World War II was almost $5 million. Production was suspended during part of World War II and the mine was closed in 1948. Gold was the most important commodity, followed in decreasing order by arsenic, tungsten, silver, copper, and lead. Total gold production of the district is estimated to have exceeded 220,000 oz; however, data available are not reliable before 1901.

At Crevice Mountain, a few miles southeast of Jardine, most mine workings are at elevations ranging from 8,000 to 8,500 ft. Access is by fair to poor graveled roads that are generally blocked by snow during the winter months. An accurate accounting of production from this district is not possible, because some production may have been routed through mills at Jardine. Most of the gold production was around the turn of the century. Much work has been done since then but production has been small. Minor amounts of tungsten were produced during World Wars I and II and a reconnaissance exploration by the U.S. Bureau of Mines during and after World War II inferred a moderate tungsten resource, some of which may be suitable for open-pit mining (Reed, 1950, p. 33–34).

The most intensive prospecting was in areas of Precambrian schist, generally where cunningtonite schist borders altered highly fissile garnet schist. Quartz veins and silicified shear zones commonly lie along the schistosity and never, or only rarely, cross the layering. Gold also occurs in altered schist which may have only minor quartz veinlets. Arsenopyrite is the predominant sulfide mineral associated with the gold and quartz.

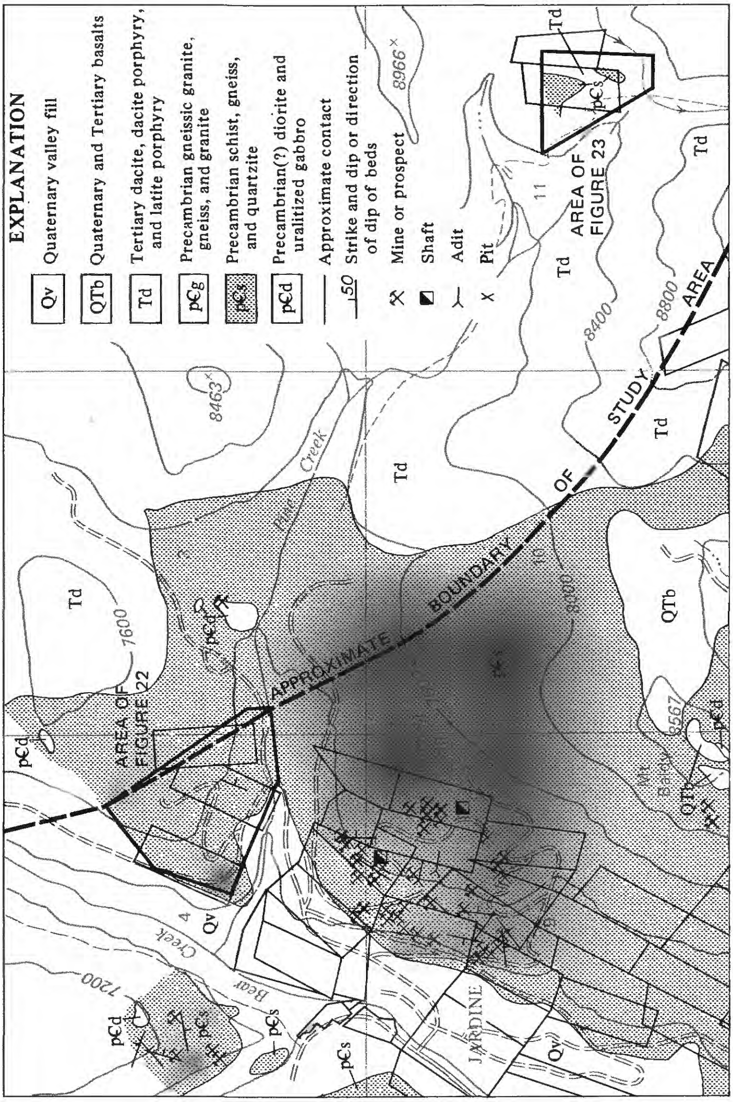
The principal prospected areas along the western boundary of the study area are discussed in more detail below.

LOWER PINE CREEK AREA

The area along lower Pine Creek had been extensively prospected for ore bodies similar to those at Mineral Hill 0.25–0.5 mi to the south (fig. 22). Most of the workings lie outside the study-area boundary, but the mineralized zone trends northward into the study area.

Most of the mapped area (fig. 22) is underlain by Precambrian schist, which seems to grade northward into diorite. Cummingtonite schist and fissile, contorted, highly altered, garnet schist commonly occur near the mineralized zones. Elsewhere, the schist is less fissile, more blocky, and less contorted and has a gray-green speckled appearance.

Extensive prospect workings shown in the southeastern part of figure 22 are within the study area. Large mine dumps just west of the cabin indicate caved adits more than 100 ft long. The largest dump, about 50 ft south-southwest of the old cabin, indicates an adit at least 200 ft long. Schist at the portal of the large caved adit is highly contorted and fractured. No large quartz veins are exposed at the portal, but about 50 percent of the material on the dump is quartz, indicating that the adit followed a quartz vein or zone for the entire distance. Arsenopyrite occurs in both schist and quartz. A grab sample of quartz and altered schist (sample 4, fig. 22 and table 9) assayed 0.17 oz gold per ton. The dump of another caved adit, 60 ft west of the cabin, has iron-stained vein quartz, which contains minor amounts of sulfide minerals. A grab


EXPLANATION
Qv Quaternary valley fill
QTb Quaternary and Tertiary basalts
Td Tertiary dacite, dacite porphyry, and latite porphyry
p€g Precambrian gneissic granite, gneiss, and granite
p€s Precambrian schist, gneiss, and quartzite
p€d Precambrian(?) diorite and uralitized gabbro
Approximate contact
50 Strike and dip or direction of dip of beds
Mine or prospect
Shaft
Adit
Pit
APPROXIMATE BOUNDARY OF STUDY AREA
AREA OF FIGURE 22
AREA OF FIGURE 23
R. 9 E.
JARDINE
Bear Creek
Pine Creek
Mt. Baldy
7200
7600
8400
8800
8463
8966
8567

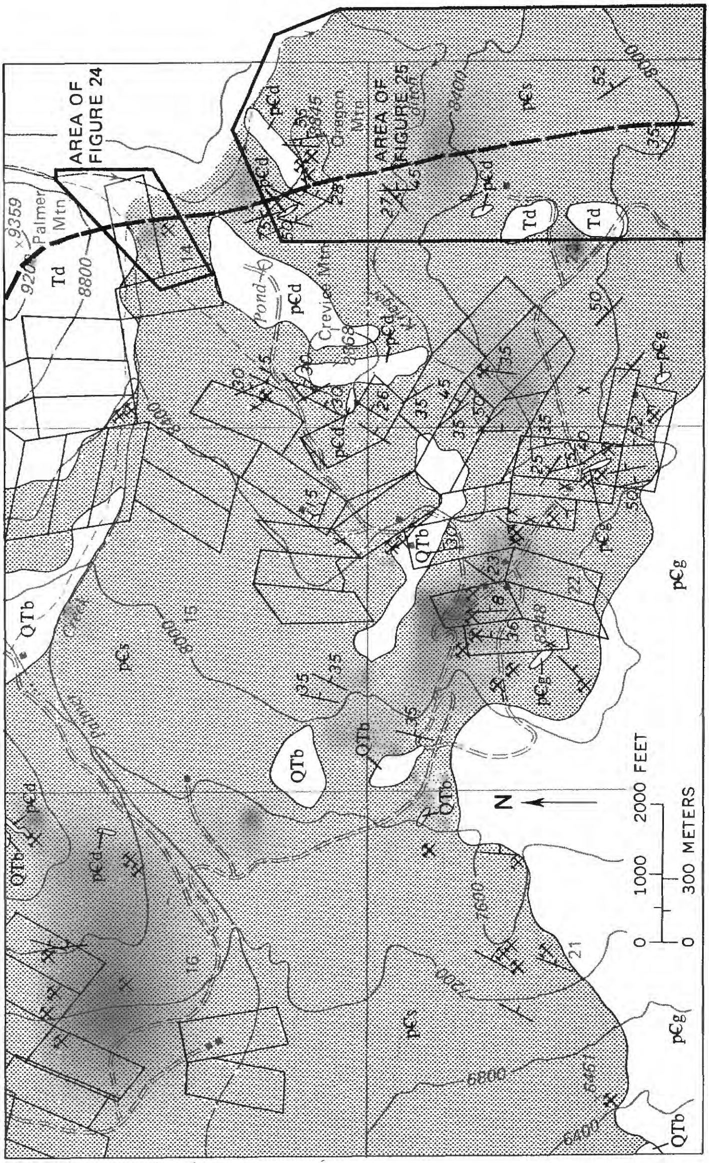


FIGURE 21. — Mining claims of the Jardine–Crevice Mountain district; from Seager (1944).

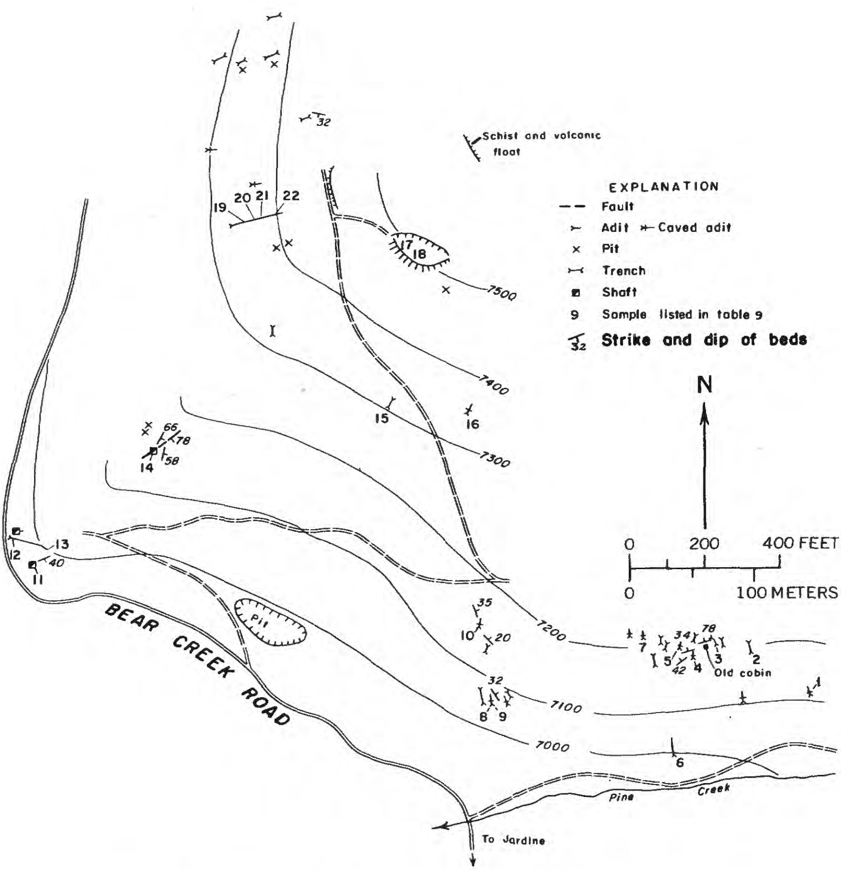


FIGURE 22 — Mines and prospects in the lower Pine Creek area.

sample (No. 5, fig. 22 and table 9) of dump material assayed 0.02 oz gold per ton.

Just east of the old cabin, a 60-ft-long curved trench exposes blocky schist. Exploration was apparently directed toward a contorted iron-stained zone in the schist. Iron-stained quartz is less abundant on this dump than on the dumps west of the cabin, but a dump grab sample (No. 3, fig. 22 and table 9) assayed <0.13 oz gold per ton. A trench farther east exposes a zone of silicified, contorted, blocky schist containing quartz veinlets. Quartz on the dump, though iron-stained, contains <0.01 oz gold per ton and <0.25 oz silver per ton (sample 2, fig. 22 and table 9). A caved adit about 180 ft southeast of the cabin was presumably driven to intersect the zones at a lower depth, but practically no quartz was observed on the dump. About 300 feet east-southeast of the cabin another large dump indicates that a caved adit

TABLE 9 — *Assays of gold and silver in samples from the lower Pine Creek area*

[Samples 12, 13, 19–22 from underground workings. <, less than]

Sample		Locality or length (ft)	Assay data		Remarks
Loc. No. (fig. 22)	Type		Gold (oz/ton)	Silver (oz/ton)	
1	Grab----------	Dump----	<0.01	<0.25	Schist and minor amounts of quartz.
2	---do----------	---do---	<.01	<.25	Quartz veinlets and schist.
3	---do----------	---do---	<.13	<.25	Iron-oxide-stained quartz veinlets in schist.
4	---do----------	---do---	.17	<.25	Quartz and sulfides in altered schist.
5	---do----------	---do---	.02	<.25	Quartz and sulfides in contorted schist.
6	---do----------	---do---	<.01	---	Schist and altered schist.
7	---do----------	---do---	.04	<.25	Iron-oxide stained quartz and schist.
8	---do----------	---do---	.34	.25	Quartz with sulfides in altered schist.
9	Grab (select)--	---do---	.99	.09	Quartz with sulfides.
10	---do----------	---do---	<.01	<.25	Sugary quartz and schist.
11	---do----------	--------	.05	<.25	Quartz and altered garnet schist.
12	Chip-----------	1.5	.01	<.25	Altered schist.
13	---do----------	1.7	.01	<.25	Altered schist and quartzite.
14	---do----------	2.0	<.01	<.25	Fault zone.
15	Grab-----------	Dump----	<.01	<.25	Schist and quartz.
16	---do----------	---do---	<.01	<.25	Quartz with sulfides.
17	---do----------	--------	<.01	<.25	Quartz and minor schist.
18	---do----------	--------	<.01	<.25	Cummingtonite schist.
19	Chip-----------	.9	<.01	<.25	Altered schist zone.
20	---do----------	.5	<.01	<.25	Altered fissile schist.
21	---do----------	.25	<.01	<.25	Fault breccia.
22	---do----------	.5	<.01	<.25	Quartz and schist.

was driven more than 200 feet through gray, blocky, less fissile schist. The schist contains garnets but only minor amounts of quartz (sample 1, fig. 22 and table 9).

The highest gold assays from the lower Pine Creek area were from a caved-adit dump in the center of a small group of adits and trenches about 600 ft north of the intersection of Pine Creek and the Bear Creek road (fig. 22). The size of the principal dump indicates an adit about 100 ft long. Material on the dump is gray-green schist and lesser amounts of highly altered schist, quartz, and sulfide minerals. A random grab sample of quartz, altered schist, and sulfides from the dump of the caved adit assayed 0.34 oz gold per ton (sample 8, fig. 22 and table 17). A selected sample of sulfide vein material assayed 0.99 oz gold per ton (sample 9, fig. 22 and table 17). Samples from the dump of another caved adit about 200 ft uphill, apparently driven to explore the same structure, showed negligible metal values.

Many adits, pits, and trenches explored quartz-bearing zones and altered schist along the ridge in the western part of the lower Pine Creek area (samples 11–22, fig. 22), but most are outside the study area. Metal values were insignificant.

A small prospect pit exposes a 1- to 1.5-ft-wide shear zone in uralitized gabbro in the SW1/4 sec. 3, T. 9 S., R. 9 E. (fig. 21), about 1,500 ft east of the area mapped in figure 22. Samples of the soft iron-stained rock in the shear zone and of the enclosing hard, unaltered gabbro did not contain detectable gold or silver.

Mineralized zones in the lower Pine Creek area may be the northern extension of deposits mined at Jardine. The northerly trend of ore deposits in Mineral Hill at Jardine is alined with the lower Pine Creek area, and certain geologic and mineralogic conditions of the two areas are similar. Comparable ore bodies are not exposed north of Pine Creek but this may reflect the lack of exploration rather than the absence of ore. Most of the dumps sampled had minor to negligible metal values but a few dumps at caved adits contained gold that might be considered ore grade. Because these adits are caved, the size of the mineralized structures could not be estimated.

UPPER PINE CREEK AREA

The upper Pine Creek area, which was prospected in the late 1880's and again during the 1930's, is about 0.5 mi north-northeast of Palmer Mountain (figs. 20, 21). Access from the Bear Creek road includes about 0.75 mi of road passable only to four-wheel drive vehicles and 2 mi of trail of moderate grade. Nearly all prospect workings in upper Pine Creek are in Precambrian schist, but Tertiary dacite or latite porphyry also is present (fig. 23).

The principal workings are a shaft and two large caved adits in the Empire and Vanity Fair claims on Empire Hill. Dump samples (Nos. 5–7, fig. 23 and table 10 contain moderate gold values. Size of the shaft dump indicates that the shaft may have been as much as 100 ft deep. Garnet schist exposed at the shaft is heavily iron stained. The dump is composed of garnet schist which contains abundant iron-stained quartz. The upper adit, about 70 ft south of the shaft, may have been about 200 ft long. Dump material consists of altered schist, some of which contains quartz veinlets. Dump sample 7 (table 10), fractured greenish quartz with arsenopyrite, assayed 0.3 oz gold/ton.

The lower adit, on the south side of Empire Hill, is 460 ft southwest of the shaft and was probably driven to explore the altered quartz-garnet schist zone at greater depth or to provide an ore haulage level. The adit started into the hill on a bearing of N. 50° E. and probably traversed 100–200 ft of volcanics before entering the Precambrian schist. Lack of quartz veinlets, negligible alteration, and few garnets in the schist on the dump indicate this lower adit may not have reached the ore zone.

Several hundred feet southeast of the main workings on Empire Hill is another group of diggings in schist. The largest dump is at a caved adit that was probably 150 ft long. Most of the dump material is quartz that shows minor iron-oxide stain (sample 10, fig. 23 and table 10). Rock on the toe of the dump indicates the face of the adit to be in blocky mica schist.

A vertical shaft, about 50 ft S. 70° W. from the portal of the caved adit is timbered and open though hidden by thick brush. The size of the dump indicates a depth of about 50 ft, but water has filled the shaft to

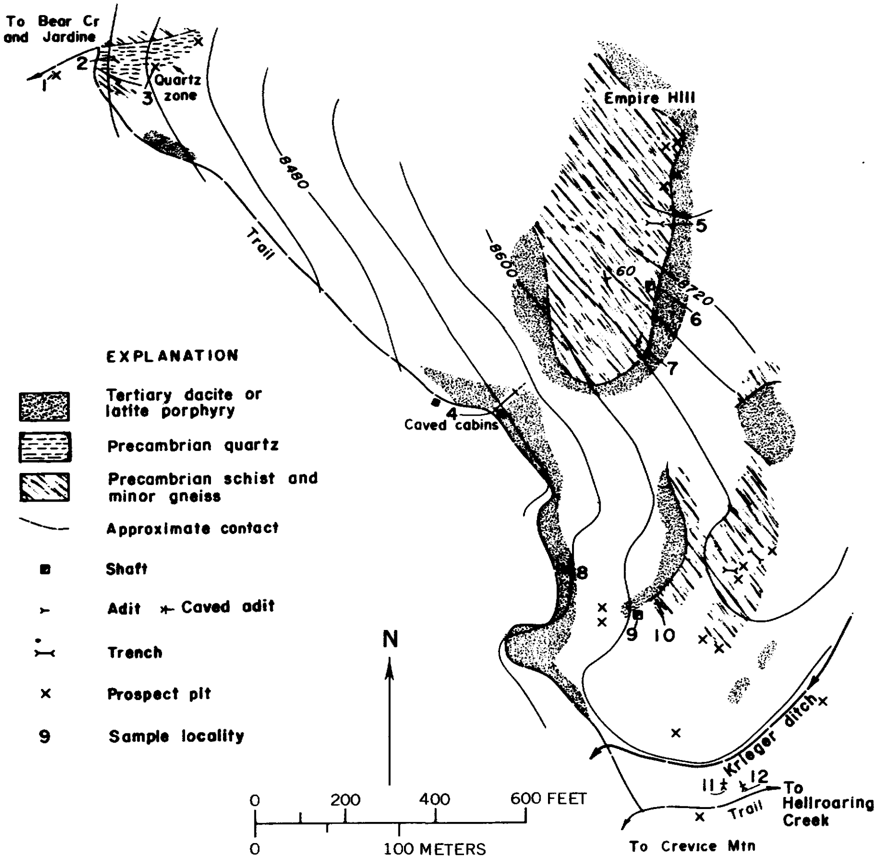


FIGURE 23. — Mines and prospects in the upper Pine Creek area.

within 12 ft of the collar. Material on the dump is unaltered mica schist. No garnet schist or vein quartz was seen.

Several shallow pits and trenches have been dug in schist about 300 feet northeast of the above shaft and adit. Two caved adits, about 450 ft S. 30° W. of the shaft, have small dumps indicative of 50–100 ft of underground workings (samples 11 and 12, fig. 23 and table 10).

Significant gold content in a zone of iron-oxide-stained quartz and altered garnet schist similar to those at the Jardine indicates that the Empire Hill area is favorable for the discovery of gold deposits. This area is geologically similar to the Mineral Hill area, except for the lack of cummingtonite schist. Size of the dumps indicates extensive underground prospecting. However, the workings are caved and no underground data are available to estimate tonnage and average grade of mineralized rock in place. The gold mineralization of Empire Hill might be in the same stratigraphic zone as the Mineral Hill area.

TABLE 10. — *Gold and silver values in dump samples from the upper Pine Creek area*

Sample No. (fig. 23)	Type	Assay data (ounces per ton) Gold	Silver	Remarks
1	Grab-----------	<0.01	<0.25	Quartz.
2	---do----------	<.01	<.25	Do.
3	Grab (select)--	.01	<.25	Iron-stained quartz and garnet schist.
4	Grab-----------	<.01	<.25	Gray-green schist.
5	---do----------	.09	.4	Quartz and schist.
6	---do----------	.02	.1	Mostly schist, minor quartz veinlets.
7	Grab (select)--	.30	.2	Quartz.
8	Grab-----------	<.01	<.25	Do.
9	---do----------	<.01	<.25	Mica schist.
10	Grab (select)--	<.01	<.25	Quartz and schist.
11	Grab-----------	<.01	<.25	Iron-oxide-stained quartz.
12	---do----------	<.01	<.25	Schist(?).

PALMER MOUNTAIN-CREVICE MOUNTAIN SADDLE AREA

Quartz veins and altered zones in Precambrian schist southwest of the saddle between Palmer Mountain and Crevice Mountain have been prospected for gold (fig. 24). The prospected area is underlain by schist that strikes northeasterly and dips steeply southeasterly. Near the south edge of the mapped area the direction of dip has reversed and is about 85° NW. Workings consist of several shallow prospect pits or trenches and two short adits. The trenches are partly filled, and the pits and adits are caved. Size of the dumps indicates that the adit on the north side of the hill (sample loc. 7, fig. 24) may be 100 ft long and the one on the east side (sample loc. 10, fig. 24) less than 40 ft long.

Along the crest of a hill shown in the southwestern part of figure 24 are several trenches, an adit, and a small pit in an easterly trending altered zone in schist. Foliation in the schist strikes west and dips more

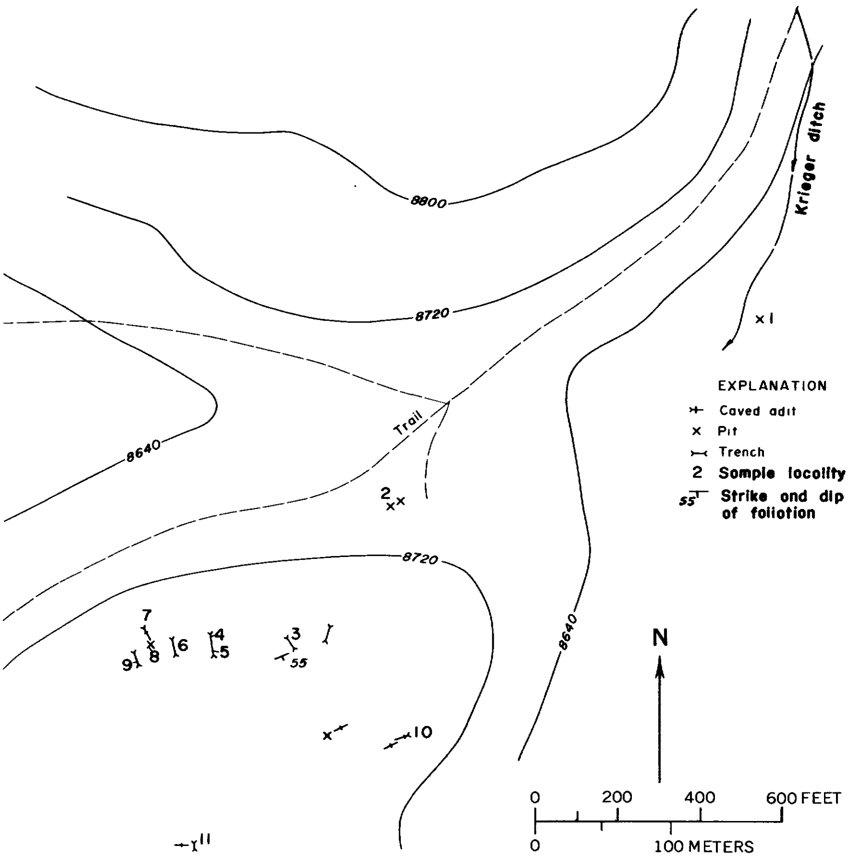


FIGURE 24. — Mines and prospects in the Palmer Mountain–Crevice Mountain saddle area.

than 55° S. The trenches are along a segment of this zone 400–500 ft long. Part of the altered zone is garnetiferous, and certain parts contain abundant quartz veinlets. Near the west end of the zone, quartz-garnet schist is bordered by a tourmaline zone. Garnets are as much as three-fourths of an inch across. The adjacent unaltered schist is hard, blocky, and green black. Neither the sample (No. 7, fig. 24 and table 11) of the unaltered schist nor other samples (Nos. 3–6, 8, and 9) from dumps at the altered zone contain significantly rich metals.

About 500 ft south of this altered zone a small trench exposes another westerly trending zone of altered schist. The schist, which dips almost vertical, is fissile and iron stained. A grab sample (No. 11, fig. 24 and table 11) of red-stained garnet schist and quartz from the dump contained 0.05 oz gold/ton. This was the highest gold assay obtained from the Palmer Mountain–Crevice Mountain saddle area.

TABLE 11. — *Assays of gold and silver in samples from the Palmer Mountain-Crevice Mountain saddle area*

[<, less than]

Sample		Locality and(or) length (ft)	Assay data		Remarks
Loc. No. (fig. 24)	Type		Gold (oz/ton)	Silver (oz/ton)	
1	Grab (select)--	Dump-------	<0.01	<0.25	Quartz and schist.
2	---do----------	---do------	<.01	<.25	Do.
3	Grab-----------	-----------	<.01	<.25	Quartz and garnet schist.
4	---do----------	30 (dump)--	<.01	.3	Soil and small schist pebbles.
5	---do----------	27 (dump)--	.01	<.25	Do.
6	---do----------	-----------	<.01	<.25	Mostly schist.
7	---do----------	-----------	.01	<.25	Mostly blocky schist.
8	Grab (select)--	-----------	<.01	<.25	Altered schist.
9	Chip-----------	-----------	<.01	<.25	Siliceous zone.
10	Grab (select)--	Dump-------	<.01	<.25	Quartz pieces.
11	---do----------	-----------	.05	<.25	Quartz and garnet schist.

Several samples were tested for tungsten but only trace amounts were detected.

OREGON MOUNTAIN AREA

The Oregon Mountain area includes several scattered prospects extending from the east peak of Oregon Mountain south and southeast for more than 1 mi (figs. 20, 21). Access is limited to a poor road or trails. Precambrian schist is the main country rock, but volcanic rocks crop out near the west edge of the area (fig. 25). Uralitized gabbro or diorite intrusives are common.

Numerous pits and trenches were dug near the top of Oregon Mountain to explore quartz veins in Precambrian schist; one trench is in uralitized gabbro. The contact between the two rock types is probably gradational. Most of the exploratory workings show small, discontinuous, dark, mottled quartz veins in schist. The schist is gray to greenish black and is commonly more silicified, altered, contorted, and fissile near the quartz veins, and more blocky and massive farther from the veins. Grab samples of quartz, schist, and gabbro contained very little or no detectable gold, silver, or tungsten (table 12).

Other pits, trenches, and possibly a short caved adit at the Tiny Jack prospect are along Krieger ditch about 800 ft northeast of the east knob of Oregon Mountain (figs. 25, 26), Diorite cliffs are above and below Krieger ditch about 150 ft north of a cabin. Below the ditch, diorite containing quartz veinlets 0.25–0.5 in. (inch) wide was excavated and treated in a small rocker. Some of the quartz stringers are stained with manganese oxide and iron oxide. Handtools, water pipe, and other small implements in the area attest to work within the past year or two. Assays of a chip sample (No. 14, fig. 26) across the quartz stringers showed traces of gold and silver, and 3.22 percent WO_3. A grab sample

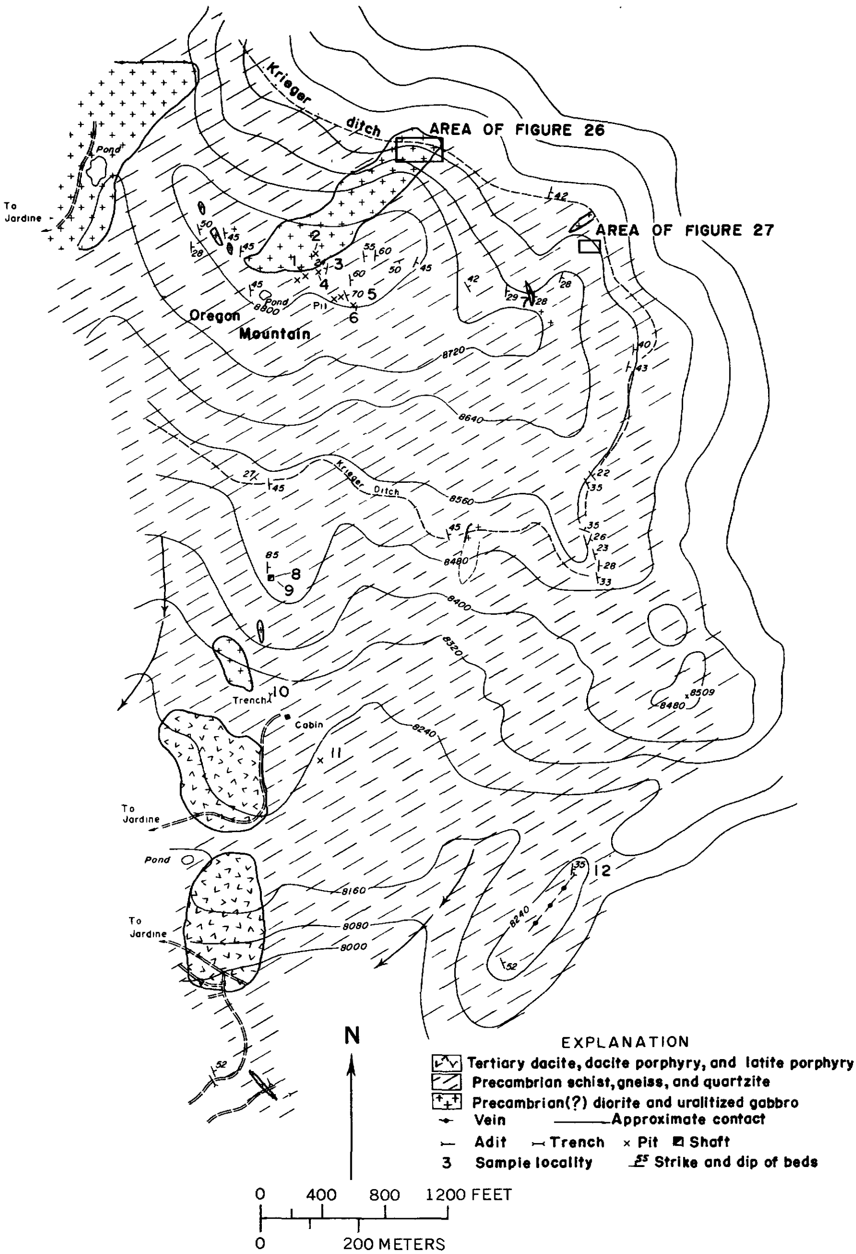


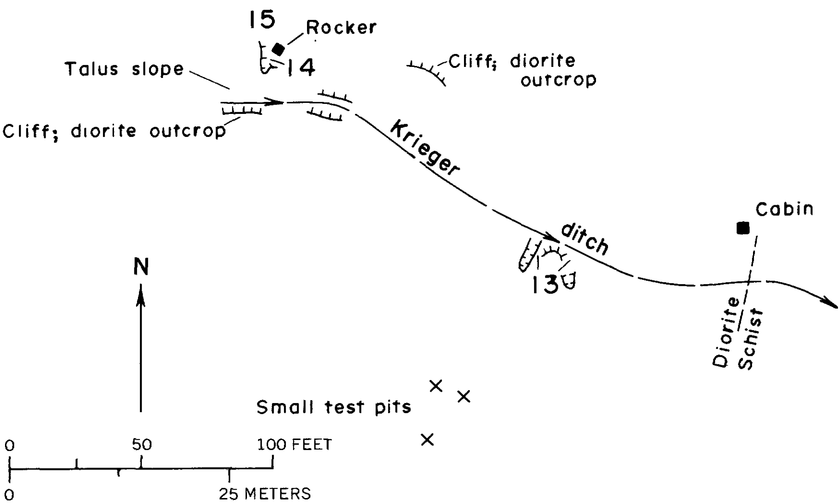
FIGURE 25. — Prospects in the Oregon Mountain area.

of "fines" rejected from the rocker assayed 0.01 oz gold/ton, a trace of silver, and 0.6 percent WO_3.

TABLE 12. — Assays of gold, silver, and tungsten in samples from the Oregon Mountain area

[Nd., not detected, <, less than]

Sample: Loc. No. (fig. 25)	Sample: Type	Locality or length (ft)	Assay data: Gold (oz/ton)	Assay data: Silver (oz/ton)	Tungsten (WO_3) (percent)	Remarks
1	Grab----------	Dump----	<0.01	0.25	<0.01	Dark mottled quartz and altered schist.
2	---do---------	---do---	<.01	<.25	<.01	Quartz and gabbro (diorite?).
3	---do---------	---do---	<.01	<.25	<.01	Dark mottled quartz.
4	---do---------	---do---	<.01	<.25	<.01	Gray-green-black silicified schist.
5	---do---------	--------	<.01	<.25	<.01	Quartz.
6	---do---------	Dump----	<.01	<.25	<.01	Black, massive, micaceous schist.
7	Grab (select)--	--------	<.01	<.25	<.01	Gabbro (diorite?); 0.04 percent copper.
8	Chip----------	1.5	<.01	<.25	Nd.	Altered schist and quartz.
9	---do---------	1.3	<.01	<.25	Nd.	Quartz vein.
10	---do---------	2.0	<.01	<.25	Nd.	Quartz vein and altered schist.
11	Grab----------	Dump----	<.01	.25	Nd.	Iron-oxide-stained quartz.
12	---do---------	--------	<.01	<.25	Nd.	Vuggy iron-oxide-stained quartz vein.



Sample No.	Type	Au (oz/ton)	Ag (oz/ton)	WO_3 (percent)	Remarks
13	Grab __	<0.01	<0.25	<0.01	Select grab from dumps.
14	Chip __	<0.01	<0.25	3.22	Chips of quartz stringers.
15	Grab __	<0.01	<0.25	<0.6	Rocker reject pile.

FIGURE 26. — Tiny Jack tungsten prospect, Oregon Mountain.

About 1,500 ft east of Oregon Mountain and a few feet above the Krieger ditch is the Krieger Ditch adit (fig. 27) that cuts three quartz zones in fissile and contorted schist. The first zone, about 10 ft from the portal, is a highly fractured, contorted vitreous quartz lens 1.2–4 ft thick. A smaller, irregular quartz lens, about 22 ft from the portal, is a

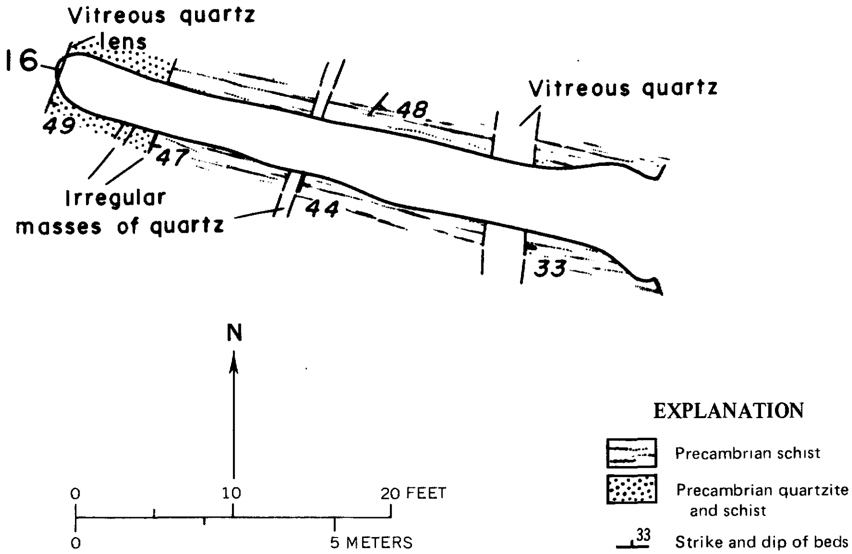


FIGURE 27. — Krieger Ditch adit, Oregon Mountain.

few inches to 1.4 ft thick and appears to be in a shear zone. A silicified shear zone at least 7.5 ft thick, at the face of the adit, contains discontinuous vitreous quartz lenses as much as 1.2 ft thick. A sample (No. 16) taken from the quartz lens at the face assayed traces of gold (<0.01 oz/ton) and silver (<0.3 oz/ton), and 0.19 percent WO_3. A 2-in.-wide shear zone 3 ft from the face of the adit contains an estimated 1 percent scheelite. This shear strikes N. 20° E. and dips 45° SE. and contains several drawn-out quartz lenses. Quartz lenses as much as 6 ft long and 3 ft wide are exposed in schist northeast of the Krieger Ditch adit, but they have not been explored.

A small shaft on quartz veins in schist, about 600 ft south of the Krieger ditch and 900 ft north of a cabin (fig. 25), is filled with water to within 5 ft of the surface. The small dump indicates the shaft is only 10–20 ft deep. Schist exposed here is moderately fissile, slightly contorted, and contains no visible ore minerals. A small quartz vein at the shaft and adjacent altered schist contained no detectable gold or silver (samples 8 and 9, fig. 25 and table 12).

A small prospect about 800 ft south of the shaft and 200 ft northwest of the cabin exposes zones of altered schist, garnet schist, and quartz veins. A sample (No. 10, fig. 25 and table 12) of a quartz vein and altered schist contained no detectable gold, silver, or tungsten. A prospect pit dug about 300 ft southeast of the cabin is completely in alluvium (sample 11, fig. 25 and table 12).

A short adit about 2,000 ft southeast of the cabin (sample loc. 12, fig. 25) explores the most persistent quartz vein observed in the Oregon Mountain area. The vein is 1.7–2 ft wide and can be traced for about 120 ft south-southwest from the adit. Host rock is a gray-green, fissile, iron-oxide-stained, micaceous schist, which is more blocky inside the adit than on the surface. Sample 12 (fig. 25, table 12) of the vein at the portal assayed <0.01 oz gold/ton.

Scheelite, possibly associated with quartz stringers occurs in diorite (?) near the top of Oregon Mountain (fig. 25). Scheelite also occurs as disseminated grains in schist at a small prospect 1 mi to the west-southwest (Reed, 1950, p. 33–34).

HELLROARING CREEK AREA

The Whitewood Girl claim, staked in 1895, is between Hellroaring Creek and Horse Creek about 0.5 mi from their confluence and a few hundred feet east-northeast of the Hellroaring Ranger Station (loc. 7, fig. 20). No subsequent work or claim staking in the area has been done. The Prospect is in Precambrian garnet-cummingtonite schist similar to that at Mineral Hill in the Jardine district. Foliation strikes north and dips steeply east. Two small prospect pits were found about 0.25 mi north of the creek junction. One pit exposes quartz veinlets in a sheared zone. Several small grab samples of iron-oxide stained quartz and related altered schist contain anomalous amounts of gold in the range 0.004–0.015 oz/ton. Although gold of these values is not commercial, the presence of anomalous gold and the lithology, which is similar to that of the Jardine district, indicate a potential for the discovery of commercial gold deposits.

Two claims, the Regina and the Red Chief, were staked west of Elk Creek in the upper Hellroaring Creek area in 1893. The only workings found in the area were two small prospect pits in a rhyolitic porphyry plug located between the main branch of Hellroaring Creek (West Fork) and the East Fork of West Fork (pl. 1; loc. 8, fig. 20). The plug is about 0.5 mi across. The porphyry is light pink and contains phenocrysts of feldspar as much as 7 mm long (most about 1 mm). Samples from the pits contained only traces of gold.

MISCELLANEOUS PROSPECTS

The Castle Lake area (loc. 5, fig. 20) is 5 mi north of Jardine and is reached by 3 mi of poor to good road and 3–3.5 mi of trail. The main rock in the area is a dark-brown-gray porphyritic volcanic rock that contains abundant phenocrysts of plagioclase. A green silicate mineral, tentatively identified as celadonite, at places colors some layers in the volcanics. The green stain somewhat resembles that imparted by copper minerals, but tests for copper and nickel were negative. Sixteen claims were recorded from this area in 1940, but a reconnaissance of the area, chiefly west and southwest of Castle Lake, failed to reveal any sign of the claims.

The Apex Ole claim was staked in sec. 35, T. 8 S., R. 9 E., an area about 2.5 mi northeast of Jardine (loc. 6, fig. 20). A search for the claim revealed a large bulldozer trench in an area that was logged 10–20 year ago. Access is by graveled road along Bear Creek and by dirt logging road leading east from the creek. Dacite prophyry exposed in the trench contains anomalous lead but the values are much too low to be of economic interest.

Many placer and lode claims were staked on the lower part of Crevice Creek and on some of the tributaries of the creek during the late 1800's, and these were apparently worked into the early 1900's. Most of the gold-bearing gravels along Crevice Creek are now within Yellowstone National Park, so no attempt has been made to evaluate them.

Several other areas were reported to have been claimed, but location descriptions were inadequate to find the prospects.

EASTERN PART OF ABSAROKA STUDY AREA

Most claim staking and prospecting in the eastern part of the Absaroka study area has been near Horseshoe Mountain, but a few prospects are near Mount Abundance (fig. 20). The New World district, which is at the east end of the study area, has yielded gold or gold-copper ore and small amounts of high-grade silver-lead ore. Exploration has been intense along the northern part of the New World district and northward during the last 5 years. Estimated production of the New World district and northward during the last 5 years. Estimated production of the New World district is 75,000 oz gold, slightly more than 500,000 oz silver, 2,089 tons copper, 1,615 tons lead, and 644 tons zinc. Production has been negligible since the early 1950's. Mining has been hindered by remote location, lack of adequate transportation, and difficult weather conditions.

HORSESHOE MOUNTAIN AREA

The Horseshoe Mountain area (loc. 11, fig. 20) is in T. 8 S., R. 13 E., between Wounded Man Creek on the north and Lake Abundance Creek on the south; both streams are tributaries of Slough Creek. Topography is moderately rugged. Elevations range from about 7,000 ft at the confluence of Slough and Lake Abundance Creeks to slightly more than 10,000 ft at the top of Horseshoe Mountain. Access from Cooke City is by truck road for about 10 mi and then by fair to poor trail for an additional 10 mi. Access from Independence (to the north) is by about 12 mi of very poor four-wheel-drive trail over the divide between Boulder River and Slough Creek. Snow limits access to the area from late July to late September.

Many mining claims have been staked and restaked in the Horseshoe Mountain area (fig. 28) since the 1890's and old caved prospect workings are scattered around the mountain. Many workings are in a cirque on the south side of the mountain. Many workings are in a cirque on the south side of the mountain near Horseshoe Lake (fig. 28). Placers in the Horseshoe Lake area were mined during the 1930's. Large groups of claims have since been located for uranium along Slough Creek between Lake Abundance Creek and Wounded Man Creek and up Wounded Man Creek for about 1.5 mi (pl. 2). In 1971, the only active claims on Horseshoe Mountain were the Lakeview group owned by Steven J. Kenney, of Hardin, Mont. The Gold Dollar lode claim was patented in 1910 but has not been worked in recent years.

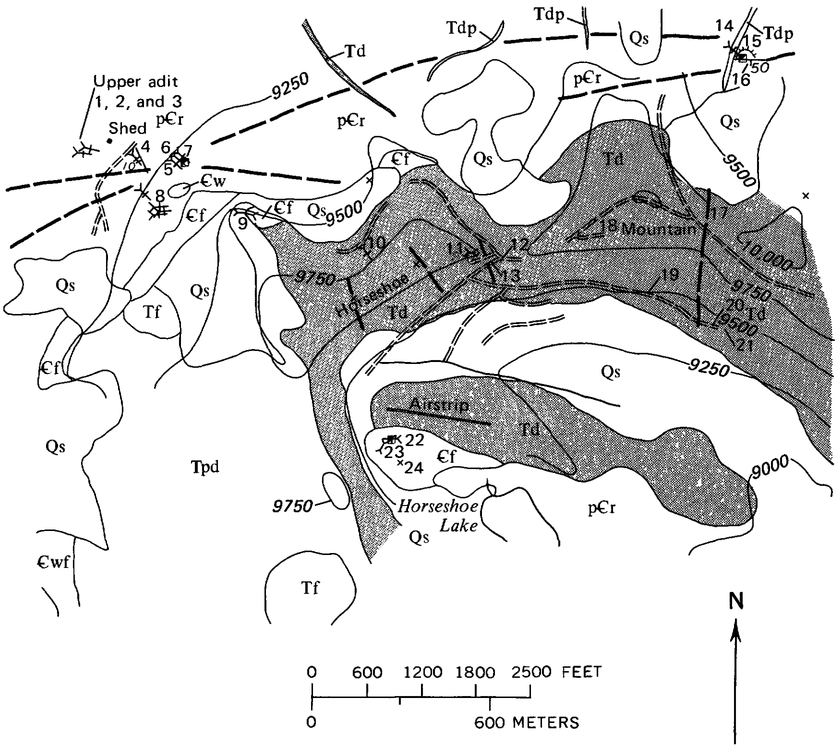
LODE DEPOSITS

Some of the oldest and most extensive prospect workings are on the northwest side of Horseshoe Mountain. Two adits were driven during the late 1800's or early 1900's in search of gold. An early owner installed a three-stamp mill powered by a steam engine, but apparently mining ceased before milling operations began. Prospectors have recently built a small shed about 200 ft northeast of the old mill. The material on the dumps of the adits is leached, altered, and iron oxide stained, and contains minor amounts of secondary quartz, barite, and pyrite. Grab samples from the dump of the upper adit, and of altered gneiss and quartzite from the portal walls (samples 1, 2, and 3, respectively, table 13, and fig. 28), contained minor amounts of gold, silver, copper, lead, and zinc.

A caved adit (loc. 4, fig. 28) about 400 ft east of the aforementioned adits is probably about 100 ft long, as judged by the size of the dump. The adit penetrated purple to tan quartzite that lacks evident metallic minerals.

About 500 ft east of the caved adit are three closely spaced, southeast-trending adits (locs. 5–7, fig. 28), also caved. Material on the dumps of the two more southwesterly adits is a white (bleached), locally iron-stained, fine-grained quartzite. Some of the bleached rock contains pyrite. The northeastern adit was driven on or through a quartzite-schist contact. Dump material consists of quartzite similar to that at the other two adits, but containing less pyrite, and dark fine-grained micaceous schist with sparse pyrite. About 100–150 ft southeast of these adits is a shallow shaft, apparently sunk to prospect the same zone. Dump material at the shaft is iron-oxide-stained white quartzite.

About 600 ft south-southwest of the three adits are four southeast-trending caved adits (loc. 8, fig. 28) that penetrate iron-stained granitic gneiss. A trench at locality 9 (fig. 28) exposes the contact between Tertiary intrusive rock and Paleozoic sandstone. Sandstone near the con-



EXPLANATION

Qs	Quaternary surficial deposits	€w	Wolsey Shale
	Tertiary rocks	€f	Flathead Sandstone
Tf	Lava flows	p€r	Precambrian rocks
Td	Rhyodacite and porphyritic dacite; includes small areas of dacite porphyry		Contact
Tpd	Rhyodacite porphyry; includes areas of nonporphyritic dacite		Fault
		10	Strike and dip of beds
			Caved adit
Tdp	Dikes of intermediate and basic composition	×	Pit
			Trench
€wf	Cambrian Wolsey Shale and Flathead Sandstone		Shaft
		9	Sample locality
			Bulldozer road

FIGURE 28. — Horseshoe mountain area prospects and sample localities (table 13).

tact contains traces of specular hematite or magnetite. A trench at locality 10 exposes iron-stained intrusive rock.

A vertical shaft about 5 ft across, and a caved adit about 200 ft to the northwest, are on the north side of Horseshoe Mountain (locs. 14–16, fig. 28), about 3,400 ft northeast of the saddle where the bulldozer road crosses into Horseshoe basin. The adit, about 50 ft lower than the shaft,

TABLE 13. — *Contents of gold, silver, and base metals in samples from the Horseshoe Mountain area*

[Copper, lead, and zinc contents determined by atomic absorption analyses, but only values of 0.01 percent and higher are reported. Tr., trace]

Sample		Assay data					Rock types
Loc. No. (fig. 28)	Type	Gold (oz/ton)	Silver (oz/ton)	Copper	Lead (percent)	Zinc	
1	Grab-----	Tr.	0.017	-	-	0.01	Altered quartzite(?) on dump.
2	---do----	0.003	.437	-	0.16	-	Altered gneiss at portal.
3	---do----	Tr.	Tr.	0.02	.04	-	Altered quartzite at portal.
4	Dump-----	Tr.	.023	-	-	-	Quartzite and cummingtonite(?).
5	---do----	Tr.	.012	-	-	-	Altered quartzite(?).
6	---do----	Tr.	.017	-	-	-	Micaceous schist with quartz stringers.
7	---do----	Tr.	.012	-	-	-	Quartzite or partially metamorphosed(?) granite.
8	---do----	Tr.	.017	-	.35	.06	Granite gneiss.
9	Grab-----	Tr.	.006	-	-	-	Sandstone.
10	---do----	Tr.	.017	-	-	-	Volcanics.
11	---do----	Tr.	.012	-	-	.01	Volcanics with disseminated pyrite.
12	---do----	Tr.	.023	-	-	.01	Altered volcanics.
13	---do----	Tr.	.017	-	-	.01	Do.
14	Dump-----	Tr.	.012	-	-	-	Quartzite(?).
15	---do----	.088	.017	.09	.08	.01	Pegmatite material with quartz-pyrite veins.
16	Outcrop--	Tr.	.017	-	-	.01	Quartz veinlets in schist 10 ft east of shaft.
17	Grab-----	Tr.	.017	-	-	-	Volcanics with minor green staining.
18	Outcrop--	.003	.012	-	-	-	Volcanics with pyrite veinlets.
19	---do----	Tr.	-	-	-	.01	Highly altered volcanics.
20	Grab-----	.004	.01	-	-	-	Rhyolite porphyry.
21	Outcrop--	Tr.	.012	-	-	-	Gabbro dike.
22	Dump-----	Tr.	.035	-	-	-	Sandstone.
23	Grab-----	Tr.	.006	-	-	-	Fossil-bearing sandstone.
24	---do----	Tr.	.029	-	-	-	Sandstone.

apparently was driven to intersect the shaft at depth. The shaft is open but its depth is unknown. Some of the work is recent, probably in the last 5 years. Apparently, pyrite-rich quartz veins in schist were explored, and massive pyrite is abundant on one small dump and is strewn about the area. A grab sample (No. 15, table 13) of pyritic material from the dump at the shaft contained 0.088 oz gold/ton, 0.017 oz silver/ton, 0.09 percent copper, 0.08 percent lead, and 0.01 percent zinc. The pyrite commonly occurs with quartz, although in places thin veins of pyrite are without associated quartz. Pyrite crystals as much as 3 mm across are abundant. Size of the pyrite veins within the shaft is uncertain, but veinlets as much as 0.5 in. thick are noted in material on the dump. Pyrite was not seen on the dump of the caved adit (sample 14, fig. 28 and table 13) which had been driven into a coarse-grained pegmatitic rock.

Bulldozer roads and trenches were cut along the crest of Horseshoe Mountain (fig. 28). A hand-dug trench (loc. 11, fig. 28 and table 13) exposes altered iron-oxide-stained intrusive rock. Nearby trenches also expose altered intrusive rocks, which at one point (sample 13, table 13) contain small quartz stringers, About 2,500 ft farther east along the ridgecrest (loc. 17) intrusive rocks are green as though stained by copper minerals. However, a sample (No. 17, table 13) of the material contained no detectable copper.

A nearly level bulldozer road crosses the south face of Horseshoe Mountain midway between the ridgecrest and the valley floor. The east end of the road stops about 30 ft short of a dark gabbroic dike cutting light-colored rhyolite porphyry (sample locs. 20 and 21, fig. 28, and table 13). The rhyolite is exposed westward along the roadcut. Small rust-colored specks in the intrusive rock are probably limonite from weathered pyrite. Several old, shallow, underground workings are about 300 ft south of the airstrip and about 1,200 ft northwest of Horseshoe Lake (locs. 22–24, fig. 28, and table 13). The workings consist of a vertical shaft and an adit on a bench of Cambrian sandstone. The shaft is probably about 20 ft deep; the adit, about 70 ft downslope, was driven directly toward the shaft. The size of the dump indicates that the adit probably extends beneath the shaft. Some pyrite is in the fine-grained sandstone on the dump. A bulldozer cut about 100 ft west-southwest of the shaft and adit exposes fossil-bearing sandstone stained with iron oxides, and an additional small cut or adit about 200 ft south also exposes sandstone. Semiquantitative spectrographic analysis of two of the sandstone samples indicates a zirconium content of about 0.1 percent.

PLACER DEPOSITS

GOLD RUN CREEK

Gold Run Creek (No. 12, fig. 20; fig. 29), a tributary of Rock Creek, heads in the Horseshoe Basin cirque. Claims were first staked here in 1887; and the entire stream area was claimed at one time or another. Gold Run Creek has an average gradient of 650 ft/mi. Alluvium has accumulated a short distance downstream from the cirque (loc. 25, fig. 29) and at its mouth (loc. 26, fig. 29). The alluvial gold comes from the lode deposits on Horseshoe Mountain. At the flat area on Gold Run Creek (loc. 25, fig. 29) are ruins of two cabins and an old ditch.

The alluvial bench along Gold Run Creek at locality 25 (fig. 29) has an average width of about 260 ft over a distance of 1,000 ft. The depth of the alluvium is estimated to be 5–20 ft, averaging about 15 ft. The pebbles and boulders in the alluvium are about 60 percent gneiss and 40 percent porphyritic rhyodacite. About 30 percent of the gravel is less than 1 in. across and only about 5 percent has a diameter greater than 2 ft. A select sample (No. 25, table 14), taken at the intersection of a dry wash and the stream, contained 22 cents in gold values per cubic yard (yd^3) (at \$48.75/oz). Estimated potential resources are 150,000 yd^3 of gravel averaging no more than 22 cents/yd^3.

At the mouth of Gold Run Creek is a patch of alluvium that was deposited where the stream gradient decreased to 260 ft/mi. The coarser part of the gravel contains about 50 percent pink granitic rock, 40 per-

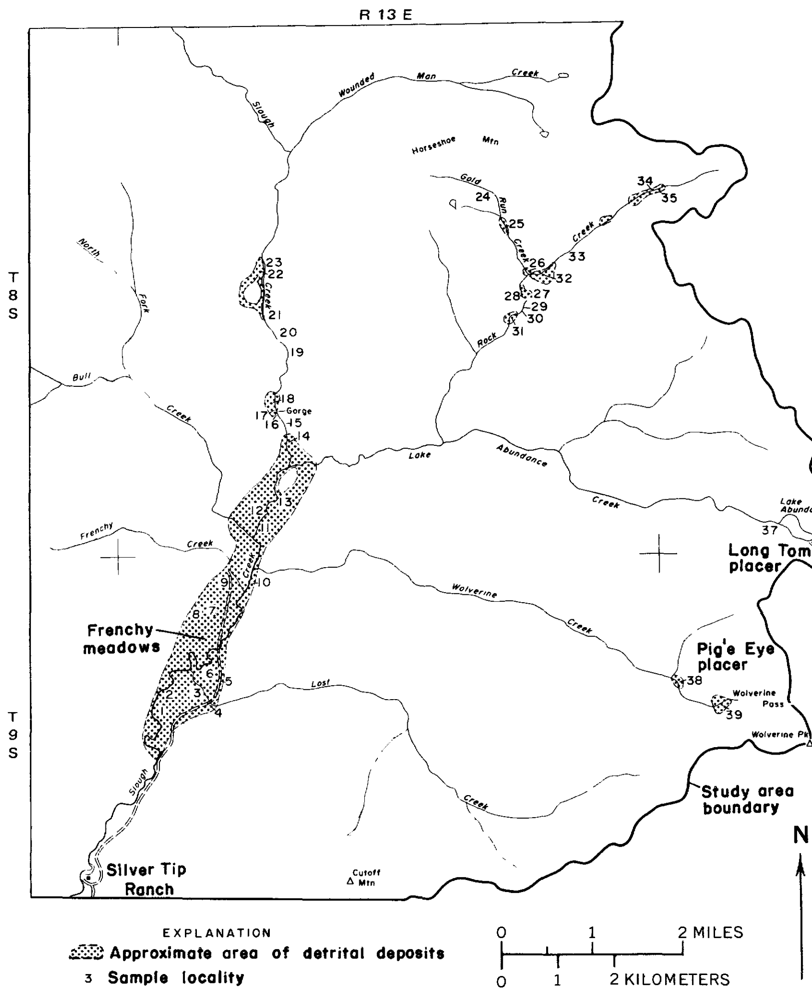


FIGURE 29. — Placer deposits in the Horseshoe Mountain–Slough Creek area.

cent andesite porphyry, and 10 percent gneiss. About 60 percent of the gravel is less than 1 in. across; only 5 percent is more than 1 ft across. A channel sample (No. 26, table 14) from the bank of a small pit where a few cubic yards were mined, contained 8 cents gold/yd^3.

ROCK CREEK

Rock Creek (No. 13, fig. 20; fig. 29), a tributary of Lake Abundance Creek, had a placer claim that was staked in 1906 and another staked in 1908. Descriptions of them, and other possible claims in this area, are vague. The lower end of Rock Creek drops rapidly and contains little alluvium; therefore, the claims were probably near the confluence of

TABLE 14. — *Placer sample data*

[Nd., not detected; Tr., trace]

Sample Loc. No. (fig. 30)	Sample interval from surface (ft)	Volume (cu ft)	Estimated gold values (cents per cu yd)[1]	Black sand concentrate (lbs per cu yd)	Sample locality or type
			Slough Creek claims		
1	0 - 6.2	6.20	Nd.	2.88	Test pit.
2	0 - 8.0	8.00	Tr.	1.56	Do.
3	0 - 5.7	5.70	Nd.	1.74	Do.
4	0 -15.3	15.30	Tr.	1.53	Do.
5	0 - 9.3	9.30	Tr.	.92	Do.
6	0 - 5.8	5.80	Tr.	1.05	Do.
7	0 - 6.6	6.60	Tr.	2.00	Do.
8	0 - 6.2	6.20	Tr.	.62	Do.
9	0 - 7.5	7.50	Nd.	1.56	Do.
10	0 -10.1	10.10	Tr.	.92	Do.
11	0 - 3.0	.36	1.0	6.65	Do.
12	0 - 3.0	.36	1.0	5.67	Do.
13	0 - 5.5	.36	.5	7.35	Channel sample on bedrock.
14	Grab----	.10	Nd.	8.40	Pan sample on bedrock.
15	---do---	.10	Nd.	3.10	Select pan sample.
16	0 - 3.0	.36	Nd.	3.40	Test pit.
17	0 - 2.2	.36	Tr.	4.16	Channel sample.
	11.5-14.0	.36	Nd.	3.02	Channel on bedrock.
18	Grab----	.55	Nd.	1.90	Sample on bedrock.
19	---do---	.10	Nd.	7.20	Pan sample on bedrock.
20	---do---	.10	Nd.	5.20	Select pan sample.
21	---do---	.10	Nd.	.20	Sample from riffle in streambed.
22	0 - 2.0	.36	.5	6.80	Channel near surface.
	2.0- 4.7	1.08	1.0	4.04	Channel on bedrock.
23	Grab----	.10	Nd.	15.84	Select pan sample.
			Gold Run Creek		
24	Grab----	0.10	Nd.	4.40	Select pan sample.
25	---do---	.20	22.0	11.00	Do.
26	2.0- 3.0	.20	8.0	1.10	Channel sample from bank of old working.
			Rock Creek		
27	Grab----	0.10	1.0	11.60	Select pan sample.
28	---do---	.10	1.0	1.80	Do.
29	---do---	.10	1.0	1.80	Sample from riffle in streambed.
30	0 - 1.5	.10	1.0	3.80	Channel from streambank.
31	Grab----	.10	1.0	4.16	Grab from 3 ft below surface.
32	---do---	.10	Nd.	3.60	Select pan sample.
33	---do---	.10	Nd.	.70	Sample from riffle in streambed.
34	---do---	.10	Nd.	2.70	Select pan sample.
35	---do---	.10	Nd.	.88	Do.
			Long Tom placer		
36	Grab----	0.10	Nd.	14.30	Select pan sample.
37	---do---	.10	Nd.	.50	Do.
			Pigs Eye placer		
38	Grab----	0.10	Nd.	12.10	Select pan sample.
39	---do---	.10	Nd.	.60	Do.

[1] Based on a gold price of $48.75 per ounce.

Gold Run Creek or farther upstream. Although the upper part of Rock Creek has a stream gradient averaging 265 ft/mile, gold was not detected in samples above the mouth of Gold Run Creek (samples 32–35, fig. 29 and table 14). Below the confluence, selected samples contained 1 cent in gold/yd^3 (samples 27–31). Alluvial deposits along the creek are not a potential source of gold.

MISCELLANEOUS PROSPECTS

SLOUGH CREEK PLACER CLAIMS

The Slough Creek placer (No.10, fig. 21; fig. 29), consisting of three claims and covering 480 acres, was recorded by David Boerman in 1890. The claims extended along Slough Creek for 2.1 mi north and for 4.4 mi south, from the mouth of Lake Abundance Creek. The south end of this claim group is partly covered by a homestead owned by the Silver Tip Ranch Corporation.

Slough Creek valley is a typical U-shaped glaciated valley. Stream gradient at the north end of the claims averages 150 ft/mile southward to a gorge 0.7 mi above the mouth of Lake Abundance Creek. The gradient increases through the gorge, but decreases to 166 ft/mile in the meadow south of the gorge. Detrital deposits above the meadow are glacial debris partly reworked by streams; the coarse alluvium consists of about 60 percent granite, 30 percent volcanic rock, and 10 percent metamorphic rock. The deposits above the meadow were sampled by trenching down the streambanks and by panning of material from behind boulders in the streambed. These deposits are estimated to contain 17 million yd^3 of gravel. They contain less than 0.5 cent gold/yd^3 and average 4.78 pounds of black sand/yd^3.

The large meadow (Frenchys meadow) on Slough Creek below Lake Abundance Creek (fig. 29) is estimated to contain 50 million yd^3 of gravel. It was sampled by test pitting, but the water table is at a relatively shallow depth and the test pits did not extend to bedrock where gold is usually concentrated. Samples obtained from the test pits were concentrated in a motorized vibrating sluice. All field concentrates were further concentrated on a Wilfley table in the laboratory. The gravel deposits of the meadow are estimated to average less than 0.5 cent gold/yd^3, on the basis of the shallow sampling done; no sample taken exceeded 1 cent gold/yd^3 (table 14). The black sand content of samples was 1.44lb/yd^3. Select pan samples from the streambed near the upper end of the meadow contain only 1 cent gold/yd^3; therefore, gold is apparently not being deposited in the meadow in significant amounts and is probably not concentrated to a significant extent at depth. The fact that the meadow was not mined in the early days supports this conclusion.

Petrographic analysis of selected Slough Creek samples indicates that the black sand concentrates consist of 17–62 percent magnetite, as much as 60 percent ferromagnesian silicate minerals, 2–5 percent ilmenite, a trace to 20 percent quartz, a trace to 2 percent garnet, and a trace each of zircon, sphene, pyrite, and chromite. No radioactive minerals were identified, and the concentrates are not radioactive. Therefore, the Slough Creek placer deposits probably do not contain economic concentrations of gold or of other minerals or metals.

LONG TOM PLACER

The Long Tom placer claim (No. 16, fig. 20; loc. 36, fig. 29) was located in 1889 on the meadow at the southeast end of Lake Abundance. The meadow slopes gently upward to a low pass which leads into the headwaters of the Stillwater River. Alluvium extends eastward from Lake Abundance, but only about one-half of this is within the study area. The gravel deposit is about 600 ft wide and may be as much as 30 ft deep in places, but the average depth is much less. The gravel composition is about 75 percent volcanic rock and 25 percent gneiss or other metamorphic rock. Subangularity of fragments indicates little reworking by stream action and therefore very little opportunity for the concentration of gold. Samples (Nos. 36 and 37, table 14) taken at the inlet and outlet of Lake Abundance did not contain detectable gold.

PIGS EYE PLACER

The Pigs Eye placer claim was located in 1890 along Wolverine Creek near Wolverine Pass (No. 18, fig. 20). Only two areas near the pass have accumulations of detritus (locs. 38 and 39, fig. 29). One area is in the cirque near the pass; the other is 1,500 ft downstream. The area at the cirque is roughly triangular, having maximum dimensions of 1,000 ft along the creek and 1,300 ft across the creek. The area of detritus farther west is oval, having a length of 1,000 ft and a maximum width of 800 ft. The depth of unconsolidated material in both areas averages less than 10 ft. The detritus is glacial drift that has been reworked to some extent by streams. Most of the material is subangular, and 40 percent is less than 1 in. across. The composition of the coarser fragments is about 75 percent volcanic rock and 25 percent limestone. Samples (Nos. 38 and 39, table 14) taken at selected points in the streambed did not contain detectable gold.

BEARS DEN LODE CLAIM

The Bears Den lode claim was staked on the east slope of Lookout Mountain (No. 9, fig. 20) in 1892. The claim lies about midway between Slough Creek and Tucker Creek, about 1 mi from each. Three small, old, sloughed prospect pits were found along the ridge between Slough and Tucker Creeks near the head of Frenchy Creek. The pits are about 100–200 feet below the ridgecrest. Prospect dumps are mostly soil covered but contain some fragments of dacite porphyry. Sloughed soil obscures rock in the pits. No metallic minerals were observed.

GRAND CENTRAL CLAIM

The Grand Central claim was staked in 1893 on a ridge between Slough Creek and the Stillwater River about 2.5 mi northwest of Lake Abundance (No. 14, fig. 20). One small pit and a small cut were found about 2 mi north-northwest of Lake Abundance and these may have been on this claim. The pit, about 5 ft across and sloughed to within

1.5–2 ft of the surface, is about 100 ft southwest of the ridgecrest. Its dump is soil and scattered small pieces of dark volcanic porphyry. A cliff of dark volcanic breccia and agglomerate crops out about 70 ft north of the pit. The cut is about 140 ft S. 75° E. of the pit and about 150 ft southwest of the ridgecrest. It is 10 ft long and infilled to within 1 ft of the surface. The dump is soil and a few scattered pieces of volcanic breccia. A grab sample of the breccia contained traces of gold and silver and a few hundredths of a percent lead . A few green- and blue-stained fragments of volcanic rock near the ridgecrest about 0.75 mi north-northwest of the prospect pit gave negative results when tested for copper and nickel.

GREENBACK PROSPECT

The Greenback prospect is on a rock knoll on the divide between the Stillwater River and Lake Abundance Creek (No. 15, fig. 20). It is 2,100 ft north of the east end of Lake Abundance and at an altitude of 8,675 ft. It is on one of four claims in this vicinity staked in 1908. The only digging here is an L-shaped pit, in a pegmatite dike, which cuts dark foliated gneiss and is, in turn, cut by narrower diabase dikes. The pegmatite is irregular but generally trends N. 70° W. and dips 80° N. to vertical. It crops out along strike for 130 ft and is 3–10 ft thick. The diabase dikes are 2 in. to 2 ft thick and parallel the trend of the pegmatite. The diabase contains disseminated grains of pyrite, which has oxidized and stained parts of the outcrop. Two chip samples cut across the pegmatite show trace gold and 0.1–0.4 oz silver/ton. A grab sample of the diabase with sulfides contains trace gold and 0.2 oz silver/ton. Spectrographic analyses of the samples showed no anomalous amounts of other metals.

PROSPECT AT NORTH END OF MOUNT ABUNDANCE

A small adit at the north end of Mount Abundance (No. 17, fig. 20) was driven to explore brecciated limestone near the top of the Pilgrim Limestone. The limestone is flat lying and appears to be terminated by a fault a few feet northwest of the adit. The west side of the fault is covered by soil cover, but large boulders of float indicate brecciated volcanic rock west of the fault. Limestone at the adit portal is fossiliferous; parts of the limestone are white and moderately blocky, whereas other parts are brecciated and contain green chert fragments. The adit is caved at the portal, but, as indicated by the size of the dump, it was 25–50 ft long. A sample of the breccia from the dump contains only traces of gold and silver, and a semiquantitative analysis of the sample did not reveal anomalous amounts of other metals.

REPORTED URANIUM OCCURRENCE

A large number of lode claims, reportedly staked in 1956 for uranium, are along or near Wounded Man Creek and near Slough Creek below

Wounded Man Creek to the mouth of Lake Abundance Creek (fig. 29). Very little work was done on the claims, and they soon became inactive. One claim discovery post was found during the field investigation. The post was on an outcrop of granitic rock near Slough Creek about 0.7 mi north from the mouth of Lake Abundance Creek. A sample of this granitic rock contained no detectable uranium. No significant radioactivity was noted in the area, and black sand concentrates from the gravels of Slough Creek were not radioactive.

POTENTIAL FOR MINERAL RESOURCES

Our investigation of the Absaroka study area did not result in discovery of new mineral deposits. Nevertheless, the geological, geophysical, and geochemical data and the evaluation of claims, prospects, and mines presented in this report indicate that certain parts of the study area have some potential for deposits containing gold, silver, copper, lead, zinc, tungsten, or molybdenum, or various combinations thereof. A discussion of the potential for these metals follows.

GOLD, SILVER, COPPER, LEAD, ZINC, TUNGSTEN, AND MOLYBDENUM

NEW WORLD-INDEPENDENCE MINERAL BELT

A belt several miles wide trending northwestward from Cooke City and including the New World and Independence mining districts and the Horseshoe Mountain area has potential for the discovery of new mineral deposits containing gold, silver, copper, and (or) molybdenum. Deposits containing zinc, lead, and tungsten may also be present. The northeastern part of the Absaroka study area lies within this mineral belt (fig. 9). The belt is marked by several discordant intrusive bodies that crop out along an axis connecting the plutonic ores of the ancient large stratovolcanoes centered on the New World and Independence districts.

Ore deposits along the New World-Independence belt are exposed only in their upper parts by erosion at the present surface. Consequently, the possibility for discovery of concealed ore deposits here is good. The deposits may be similar to the gold-copper deposits that were mined in the New World district during the 1940's and 1950's, in the vicinity of Daisy Pass, and for which substantial reserves are reported. The upper parts of the deposits, as for example those now exposed in the Independence district, may have substantial silver; lower parts of the deposits may be richer in copper.

The New World–Independence mineral belt extends into the Absaroka study area only in the vicinity of Horseshoe Mountain, including the drainages of upper Slough Creek, Wounded Man Creek, Rock Creek, and upper Lake Abundance Creek, as well as most of Mount Abundance and the extreme headwaters of Wolverine Creek. The

Meagher Limestone in the Mount Abundance area is a potential host of gold-copper ore such as that mined in the vicinity of Daisy Pass. Small placer deposits on Gold Run Creek contain significant gold values, but a great increase in the price of gold would be required for the mining of Gold Run Creek deposits to be profitable.

The mineral potential of the Emigrant-Mill Creek district, except for molybdenum showings in the vicinity of Ash Mountain (pl. 1), is all outside the Absaroka study area. At Ash Mountain, samples of Tertiary ash-flow tuff and related intrusives (fig. 11) contain, 5 ppm or more molybdenum, which appears to be anomalous for the study area. The gravity data (fig. 8) indicate the presence of a vent at Ash Mountain that is a satellite to the main volcanic center to the northwest, and, if such a vent is present, a molybdenum-bearing breccia pipe may exist at depth.

JARDINE-CREVICE MOUNTAIN DISTRICT AND HELLROARING RANGER STATION AREA

The western part of the Absaroka study area peripheral to the Jardine–Crevice Mountain mining district — specifically, the lower Pine Creek, upper Pine Creek, and Oregon Mountain areas, and the general vicinity of the Hellroaring Ranger Station — has significant potential for gold-arsenic-tungsten deposits similar to those mined at Jardine and Crevice Mountain. The favorable stratigraphic zone for these ores, which was folded into a south-plunging syncline at Jardine, is interpreted to be absent to the east in much of the Crevice Creek basin as a result of erosion. However, this favorable zone, or another of virtually the same lithology, probably underlies the lower part of the Hellroaring Creek drainage. The Precambrian structure here is also synclinal, according to one interpretation of the gravity data (fig. 8). If this interpretation is correct, then Jardine-type gold deposits may be more widespread than is now known. The anomalous amounts of gold near the Hellroaring Ranger Station and the attendant clusters of anomalous arsenic and boron (figs. 10, 12, 13) indicate a target for new gold deposits. Deposits of this type may also lie beneath the adjacent cover of younger Paleozoic and Tertiary rocks. One sample of quartz veins in diorite on Oregon Mountain contained 3.22 percent WO_3.

SILLIMANITE AND ANDALUSITE

Sillimanite and andalusite, two minerals of aluminum and silicon oxides with the same formula, are part of a refractory group of minerals used to make mullite, a high-temperature insulator. S. L. Groff (*in* U.S. Geol. Survey, 1963, p. 101) reported sillimanite deposits in the Jardine district. The deposits to which he referred are most likely the minor occurrences of sillimanite and andalusite in aplitic pegmatites at

Crevice Mountain (Seager, 1944), which do not have commercial value. Sillimanite group minerals were not observed elsewhere in the study area, and it is extremely unlikely that potential commercial deposits of these minerals exist here.

TRAVERTINE

Travertine has been quarried about 3 mi west of the study area from hot-spring deposits along the Gardiner fault. The deposits are in a zone about 4 mi long and 0.5 mi wide, extending northwestward from Gardiner. They are from but a few inches to as much as 40 ft thick and were formed by the precipitation of calcium carbonate from saturated heated solutions issuing from springs along the fault zone. Similar deposits were formed by the well-known hot spring at Mammoth, Yellowstone National Park. No deposits of this type were found in the Absaroka study area.

POTENTIAL FOR ENERGY SOURCES

Coal beds occur in rocks of Cretaceous age, chiefly in the Eagle Sandstone, in the region peripheral to the Absaroka study area, but no coal was found in the study area and no outcrops of coal-bearing rocks were seen. The nearest deposits are in the electric coal field 2–6 mi northwest of Gardiner, although some coal has been reported just north and east of town where the Cretaceous coal-bearing sandstones are exposed in the drag zone of the Gardiner fault (Fraser and others, 1969, p. 78–82, pl. 1). The absence of coal-bearing strata of Cretaceous age virtually precludes the presence of any coal deposits in the study area.

No hot springs or other indications of possible sources of thermal energy were found in the Absaroka study area, despite their abundance in nearby Yellowstone National Park.

Small quantities and traces of radioactive materials and the presence of anomalous radioactivity have been reported in the Precambrian rocks and in the basal beds of the Cambrian Flathead Sandstone in localities peripheral to the study area (Stow, 1953; Armstrong, 1957; U.S. Atomic Energy Comm., 1966). The basal Flathead Sandstone was tested along traverses in a low-flying helicopter, on foot, and on horseback using a LaRoe portable scintillometer. Samples from this zone showed no abnormal radioactivity when tested in the laboratory. All 425 rock samples and most of the 789 stream-sediment samples were checked for radioactivity by determining the equivalent uranium (eU) content. The values obtained ranged from less than 10 ppm to 60 ppm, amounts not unexpected for the rock types sampled. Although several lode claims for uranium were reportedly staked in the upper Slough Creek basin, no significant radioactivity was noted there.

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